## ALL PHYSICS FORMULAS PRO


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## Cyclic Quadrilateral Formula

A quadrilateral whose vertices lie on a single circle is called cyclic quadrilateral. This circle is called the circumcircle, and the vertices are known to be concyclic.

The sum of the products of opposite sides of a cyclic quadrilateral is equal to the product of the two diagonals. The opposite angle of a cyclic quadrilateral is supplementary.

The formula for the area of a cyclic quadrilateral is:
V(s-a) (s-b) (s-c) (s-d)
Where " $s$ " is called the semi-perimeter,
$s=a+b+c+d / 2$

## Example 1

Calculate the area of the quadrilateral when the sides of the quadrilateral are $30 \mathrm{~m}, 60 \mathrm{~m}, 70 \mathrm{~m}$ and 45 m .

## Solution

Given parameters are
$a=30 \mathrm{~m}$
$b=60 \mathrm{~m}$
$\mathrm{c}=70 \mathrm{~m}$
$d=45 \mathrm{~m}$
$s=a+b+c+d / 2$
$s=30+60+70+45 / 2$
$\mathrm{s}=102.5 \mathrm{~m}$

Area of cyclic quadrilateral is given by
$=\mathrm{V}(\mathrm{s}-\mathrm{a})(\mathrm{s}-\mathrm{b})(\mathrm{s}-\mathrm{c})(\mathrm{s}-\mathrm{d})$
$=V(102.5-30)(102.5-60)(102.5-70)(102.5-45)$
$=2399.60$ square meter

## Example 2

Calculate the area of the quadrilateral when the sides of the quadrilateral are $35 \mathrm{~m}, 77 \mathrm{~m}, 75 \mathrm{~m}$ and 43 m .

Solution
Given parameters are
$\mathrm{a}=35 \mathrm{~m}$
$\mathrm{b}=77 \mathrm{~m}$
$\mathrm{c}=75 \mathrm{~m}$
$d=43 \mathrm{~m}$
$s=a+b+c+d / 2$
$s=35+77+75+43 / 2$
$\mathrm{s}=115 \mathrm{~m}$

Area of cyclic quadrilateral is given by
$\mathrm{V}(\mathrm{s}-\mathrm{a})(\mathrm{s}-\mathrm{b})(\mathrm{s}-\mathrm{c})(\mathrm{s}-\mathrm{d})$
$=\vee(115-35)(115-77)(115-75)(115-43)$
2958.91 square meter.

## OHMS LAW FORMULA

Ohms law says that the current running through the conductor is directly proportional to the potential difference across its extremities as long as the temperature and other physical conditions are constant.

Ohms Law Formula is articulated as
$V=I R$

Where
Voltage is V and is measured in Volts,
The current flowing through the conductor is I and it represented in amperes, the resistance is R and is measured in ohms

Ohm's law formula (potential difference formula) is made use of to calculate the Resistance, Current and Voltage in any given circuit if any of the two quantities are given.

## Ohm's Law Solved Examples

Underneath are some numerical on ohms law which might be useful for you.

Problem 1: A potential difference of 10 V is applied across a conductor whose resistance is $25 \omega$. Calculate the current flowing through it?

## Answer:

Given: Potential difference $\mathrm{V}=10 \mathrm{~V}$,
Resistance $R=25 \omega$,
$V=I / R$
$V=10 / 25$
$\mathrm{V}=0.4 \mathrm{volts}$

Problem 2: If a conductors resistance is 50 ohm and the current passing through the is 5 A . Calculate the potential
difference?

## Answer:

Current I = 5 A ,
Resistance $R=50 \omega$,
Potential difference V = IR
$=5 \times 50$
$\mathrm{V}=250$ volts

## ENERGY LEVEL FORMULA

The structure of the atom was the much-debated topic in the mid-1920s. Numerous atomic models including the theory proposed by J.J Thompson and the discovery of nucleus by Ernest Rutherford had emerged. But it was Neil Bohr, who asserted that electrons revolved around a positively charged nucleus just like the planets around the sun. In Bohr model of the hydrogen atom, an assumption concerning the quantization of atoms was made which stated that electrons orbited the nucleus in specific orbits or shells with a fixed radius. Only those shells with a radius provided by the equation below were allowed, and it was impossible for electrons to exist between these shells. Mathematically, the allowed value of the atomic radius is given by the equation $r(n)=n \underline{2} \times r(\underline{1})$

In the next section, let us look at the formula used to calculate the energy of the electron in the $\mathrm{n}^{\text {th }}$ energy level.

## Energy of Electron Formula

Bohr calculated the energy of an electron in the nth level of the hydrogen atom by considering the electrons in circular, quantized orbits as $E(n)=-\underline{1} n \underline{2} \times \underline{13.6} \mathrm{eV}$ where 13.6 eV is the lowest possible energy of a hydrogen electron $\mathrm{E}(1)$.

An electron absorbs energy in the form of photons and gets excited to a higher energy level. After jumping to the higher energy level, also called the excited state, the excited electron is less stable, and therefore, would quickly emit a photon to come back to a lower and more stable energy level. The emitted energy is equivalent to the difference in energy between the two energy levels for a specific transition. The energy can be calculated using the following equation $h v=\Delta \mathrm{E}=(\underline{1} \mathrm{n} \underline{2}$ low $-\underline{1} \mathrm{n} \underline{2} h i g h) \underline{13.6 \mathrm{eV}}$

The formula for defining the energy levels of a hydrogen atom is given by

## $\mathrm{E}=\mathrm{E} \underline{\mathrm{O}} \mathrm{n} \underline{2}$

Where $E_{0}$ is 13.6 eV and n is $1,2,3 \ldots . .$. and so on

Summary

Value of the Atomic Radius $r(n)=n \underline{2} \times(\underline{1})$

Energy of an atom in the nth level of the hydrogen atom

$$
\mathrm{E}(\mathrm{n})=-\underline{1} \mathrm{n} \underline{2} \times 13.6 \mathrm{eV}
$$

The value of the energy emitted for a specific
transition is given by the equation

The formula for defining energy level

$$
\mathrm{E}=\mathrm{E} \underline{O} \mathrm{n} \underline{2}
$$

## INDUCTANCE FORMULA

The property of a conductor by which an alteration in current passing through it creates (induces) voltage or electromotive force in any nearby conductors (mutual inductance) and in both the conductor itself (self-inductance) is termed as Inductance. Inductance is described as opposing of changes of current. The inductance value is represented as $L$ and its unit is Henry. One Henry value is equivalent to the induced one volt by changing of current in one ampere per second in an inductance value. The inductance value is of two types. One is mutual inductance and another one is selfinductance. Let us see the applications of inductance value.

Formula for Inductance is given by
$L=\mu N^{2} A / l$

Where

L= inductance in Henry (H)
$\mu=$ permeability (Wb/A.m)
$\mathrm{N}=$ number of turns in the coil

A= area encircled by the coil $\left(m^{2}\right)$
I= length of the coil(m)

The voltage induced in a coil, ( V ) with an inductance of L is given by
$V=L \frac{d i}{d t}$
Where,
voltage is V (volts)
inductance value is $L$
the current is I (A)
time taken ( t )
The reactance of inductance is given by
$X=2 \pi f L$
Where,
Reactance is X in ohm ( $\Omega$ )
the frequency is $f$ in Hz , Inductance is L in Henry (H)

The total series inductance is

$$
L=L_{1}+L_{2}+L_{3}+\ldots . .+L_{n}
$$

The parallel inductance is
$\frac{1}{L}=\frac{1}{L_{1}}+\frac{1}{L_{2}}+\ldots \ldots+\frac{1}{L_{n}}$
Where, $L_{1}, L_{2}, L_{3} \ldots . .$.

Inductance - Solved Examples
Problem 1: Compute the equivalent resistance if inductors of $5 \mathrm{H}, 2 \mathrm{H}$ and 7 H are linked in series?

## Answer:

Known: $\mathrm{L}_{1}=5 \mathrm{H}, \mathrm{L}_{2}=2 \mathrm{H}, \mathrm{L}_{3}=7 \mathrm{H}$
The series inductance is articulated as
$\mathrm{L}=\mathrm{L}_{1}+\mathrm{L}_{2}+\mathrm{L}_{3}$
$=5 \mathrm{H}+2 \mathrm{H}+7 \mathrm{H}=14 \mathrm{H}$

Question 2: An inductor of 50 H is linked to a circuit and a frequency of 200 Hz is provided. Compute the reactance?

## Solution:

Known:

Reactance $\mathrm{X}=$ ? ,
frequency f $=200 \mathrm{~Hz}$,
inductance L = 50 Henry
The reactance is articulated as
$\mathrm{X}=2 \pi \mathrm{fL}$
$=2 \times 3.14 \times 200 \times 50$
$X=12560 \Omega$

## HEAT FORMULA

Heat is the transfer of kinetic energy from one medium or object to another or via energy source to a medium or object. This energy transfer can occur in three ways namely radiation, conduction and convection. Heat is a form of energy that produces change in temperature of any substance.

Heat by conduction takes place when two objects are in direct contact and temperature of one is higher than the other. The temperature tends to equalize that's the reason the heat conduction consists of the transfer of kinetic energy from warmer medium to a cooler one. The heat is denoted by $\mathbf{Q}$. Specific heat capacity is the amount of heat energy required to raise the temperature of a substance per unit of mass

The Specific Heat formula is given as
$c=\frac{Q}{m \times \Delta T}$

Where,
$m=$ mass of the body,
$C=$ specific heat,
$\Delta \mathrm{T}$ is the temperature difference.
Heat formula can be applied to find the heat transfer, mass, specific heat or temperature difference.

Heat is expressed in Joules (J).

Solved Examples
Determine the heat needed to raise a half kg of iron from
250 C to 600 C ?

## Solution:

Given parameters are
Mass m $=0.5 \mathrm{Kg}$,
Specific heat of iron $\mathrm{c}=0.43 \times 10^{3} \mathrm{~J} / \mathrm{Kg}^{0} \mathrm{C}$
, Temperature difference $\Lambda T=70^{0}-25^{0}=45^{\circ} \mathrm{C}$
the heat formula is given by
$Q=m \times c \times \Delta T$
$Q=0.5 \times 0.43 \times 10^{3} \times 45$
$=10.125 \times 10^{3} \mathrm{~J}$

## Example 2

Determine how much heat energy is lost if water of 5 Kg mass is cooled from $60^{\circ}$

C to $20^{\circ} \mathrm{C}$. Given Specific heat of water $\mathrm{C}=4.2 \times 10^{3} \mathrm{~J} / \mathrm{Kg}{ }^{0} \mathrm{C}$

## Solution:

Given parameters are,
Mass of water is 5 Kg ,
Specific heat of water C is $4.2 \times 10^{3} \mathrm{~J} / \mathrm{K} g^{0} \mathrm{C}$
Temperature difference $\Delta \mathrm{T}$ is $=40^{\circ}$

Heat energy formula is given by

$$
\begin{aligned}
& \mathrm{Q}=\mathrm{m} \times \mathrm{C} \times \Delta \mathrm{T} \\
& \begin{array}{r}
=5 \times 4.2 \times 10^{3} \times 40 \\
=84.0 \times 10^{3} \mathrm{~J}
\end{array}
\end{aligned}
$$

## HUBBLES LAW FORMULA

Hubble's Law Formula gives the relationship between the recessional velocity and the proper distance of the galaxy that is measured in mega parsecs.

Hubble's Law Formula is given by
$\mathrm{v}=\mathrm{HOr}$

Where,

HO=Hubble's Constant km/s/Mpc
$\mathrm{v}=$ Recessional Velocity km/s
$r$ = distance of a galaxy in Mpc

## LIGHTNING FORMULA

Air is the perfect medium for the sound to travel and the speed of the sound depends on factors like temperature and humidity. The lightning formula is dependent on the distance at which lightning happens, the speed of sound in air, time interval between flash and thunder.

To find the distance of lightning
$d=s^{*} t$

Where,
$\mathrm{d}=$ distance to the lightning
$s=$ speed of sound in air
$\mathrm{t}=$ elapsed time between lightning flash and thunder
Note: speed of sound ranges between 1100 to 1200 feet per second.

To find the speed of sound $s=d t$

Finding the time Interval between flash and thunder $\mathrm{t}=\mathrm{ds}$

## PERIMETER OF RHOMBUS FORMULA

When a Rhombus is concerned, it is a flat shape with four same sides and four angles that are NOT necessarily 90 degrees. A rhombus is often called as a diamond or diamond shaped. The total distance traveled along the border of a rhombus is the perimeter of a rhombus. We can also call a square as a rhombus, because it satisfies all the condition that a rhombus has.

Rhombus has:

- All sides of Equal length
- Opposite sides have to be parallel.
- The altitude is a distance at right angles to two sides.
- The diagonals of a rhombus bisect each other at 90 degrees.

The perimeter of a rhombus is given as:

$$
P=4 \times a
$$

## Solved Examples

Question: Find the perimeter of a rhombus having side as 5 cm ?

## Solution:

Given,
$a=5 \mathrm{~cm}$

Perimeter of a rhombus $=4 \times$ a
Perimeter of a rhombus $=4 \times 5$
Perimeter of a rhombus $=20$

## HEAT GAIN FORMULA

Heat is a form of energy and the power is the rate at which energy is used. The rate at which heat energy is utilized is measured in watts which can also be called as power loss. Heat gain via walls and roofs is affected by solar energy which is absorbed in the outer surface represented by the air temperature. It is the outdoor temperature which would generate the same heat gain through the element without solar energy since it exists with the actual air temperature.

The heat gain formula is given by, $q=1.10 \times c f m \times\left(t_{o}-t_{i}\right)$

Where,

- $q=$ sensible heat gain from the outside air in Btu/h
- $\mathrm{cfm}=$ flow rate of outside air entering the building
- $t_{0}=$ outside air temperature in $\circ \mathrm{F}$
- $t_{i}=$ inside air temperature in of


## Example 1

Calculate the sensible heat gain for a ventilation flow rate of $9,000 \mathrm{cfm}$ if the outside air temperature (to) is $88^{\circ} \mathrm{F}$ and the inside air temperature (ti) is $80^{\circ} \mathrm{F}$.

Solution:

Given data:
cfm $=9000$
$\mathrm{t}_{\mathrm{o}}=88$
$\mathrm{t}_{\mathrm{i}}=80$

Substitute in the given formula, we get
$q=1.10 \times c f m \times\left(t_{o}-t_{i}\right)$
$q=1.10 \times 9000 \times(88-80)$
$q=79200$

Therefore, the heat gain is 79200 .

## Example 2

Calculate the total heat gain due to the ventilation for 5000 cfm of air when the enthalpy of outside air is 35 and the enthalpy of the inside air is 30.0 .

Solution:
Given data:
$\mathrm{cfm}=5000$
$t_{0}=35$
$\mathrm{t}_{\mathrm{i}}=30$

Substitute in the corresponding formula,
$q=1.10 \times c f m \times\left(t_{o}-t_{i}\right)$
$q=1.10 \times 5000 \times(35-30)$
$q=27500$

Therefore, the heat gain is $\mathbf{2 7 5 0 0}$.

## FORMULA DYNAMICS FORMULA

As all of us know dynamics teaches us about the motion of anybody grounded on how the forces are exerted on it. Perhaps these equations were derived founded on experimenting the motion.

There are four elementary equations in dynamics specifically,
$v=u+a t$
$s=u t+\frac{1}{2} a t^{2}$
$s=v t-\frac{1}{2} a t^{2}$
$s=\frac{1}{2}(u+v) t$
$v^{2}=u^{2}+2 a s$
Where $u$ is initial velocity in $\mathrm{m} / \mathrm{s}$, $v$ is the final velocity in $\mathrm{m} / \mathrm{s}$,
$s$ is the distance travelled in $m$,
$a$ is the acceleration in $\mathrm{m} / \mathrm{s}^{2}$,
t is the time taken in s .

Dynamics Formulas are valuable in computing the unfamiliar physical quantity when some of these quantities are known.

## Dynamics Solved Examples

Underneath are given some problems based on dynamics you can refer to this while solving your assignment problems.

Problem 1: John throws a ball and it moves along the horizontal direction. If it travels a distance of 30 m in 2 s .

Calculate its acceleration.
Solution:

Known: u (Initial velocity) = 0,
$\mathrm{s}($ Distance traveled $)=30 \mathrm{~m}$,
$\mathrm{t}($ Time taken $)=2 \mathrm{~s}$

Distance travelled is given by
$s=u t+\frac{1}{2} a t^{2}$
$30=0+\frac{1}{2} a\left(2^{2}\right)$
$30=2 a$
Accelerationa $=15 \mathrm{~m} / \mathrm{s}^{2}$
Problem 2: If $v^{2}=u^{2}+2$ as and find the value of ' $v$ ',
if $u=0, a=3, s=150$ is given.

Solution:

Known: u (Initial velocity) = 0,
$\mathrm{s}($ Distance traveled $)=150 \mathrm{~m}$,
a (acceleration) $=3 \mathrm{~m} / \mathrm{s}^{2}$
$v^{2}=u^{2}+2 a s$
$v^{2}=0+(2 \times 3 \times 150)$
$v^{2}=(2 \times 3 \times 150)$
$v^{2}=900$

Final velocity $\mathrm{v}= \pm 30 \mathrm{~m} / \mathrm{s}$

## MASS FORMULA

Mass concept measures the quantity of matter existing in an object. It is a quantitative property of an object against the acceleration. The mass and weight of an object are not the same. The mola mass $(M)$ is a physical property and it is defined as the mass of one mole of the chemical substance or it is a ratio of the mass of a chemical compound to its amount of chemical substance. The unit of molar mass is $\mathrm{kg} / \mathrm{mol}$.

The mass formula is given as

$$
\text { Mass }=\rho \times v
$$

Where,
$\rho=$ density and
$v=$ the volume

The weight mass formula is given as
$m=w / g$

Where,
w= weight
$\mathrm{m}=$ mass
g = gravity

The mass formula is also given as
$m=F / a$

If acceleration itself is the gravity, then
$M=F / g$

Where,
$F=$ force

G = gravity

According to Einstein's mass-energy relation

$$
m=\left(E / c^{2}\right)
$$

Where,
$\mathrm{m}=$ mass

E = energy
$c=$ speed of light $\left(3 \times 10^{8} \mathrm{~m} / \mathrm{s}\right)$
The kinetic energy mass formula is given as
$K . E=1 / 2 m v^{2}$

Where,
$\mathrm{m}=$ mass,
$\mathrm{v}=$ velocity.
Example 1

Calculate the mass if the weight of a body is 80 N .

## Solution:

Given, weight of the body $=80 \mathrm{~N}$
The mass of the body is expressed by
$m=w / g$
$m=80 / 9.8$
$\mathrm{m}=8.163 \mathrm{~kg}$

## Example 2

Determine the mass of a body if the K.E is 70 J and velocity is $8 \mathrm{~m} / \mathrm{s}$.

Solution:

Given:
$K . E=70 \mathrm{~J}$
$\mathrm{v}=8 \mathrm{~m} / \mathrm{s}$

The mass is expressed by
$m=2 K . E / v^{2}$
$m=(2 \times 70) / 8^{2}$
$m=14 o / 64$

$$
\mathrm{m}=2.18 \mathrm{~kg}
$$

## INDUCED VOLTAGE FORMULA

The induced voltage is produced as a product of
electromagnetic induction. Electromagnetic induction is the procedure of producing emf (induced voltage) by exposing a conductor into a magnetic field. The induced voltage is described by making use of Faraday's law of induction. The induced voltage of a closed-circuit is described as the rate of change of magnetic flux through that closed circuit. Induced voltage formula is articulated as,
$\varepsilon=-N \frac{d \Phi_{B}}{d t}$
Where
$\varepsilon=$ Induced voltage
$\boldsymbol{N}=$ Total number of turns of the loop

ФB = B.A (Magnetic flux)
$B=$ Magnetic field

A = Area of the loop
$t=$ time

Induced Voltage Solved Example
Solved question of induced voltage is given below:
Problem 1: Consider a rectangular coil of 5 turns with a side length 0.5 m . This coil reaches the magnetic field 0.3 T within 10s. Compute the induced voltage?

Answer:

Known values are,
$N=5$
$\mathrm{I}=0.5 \mathrm{~m}$
$B=0.3 T$
$d t=10 s$

The formula for induced voltage is articulated as,

$$
\begin{aligned}
& \varepsilon=-N \frac{d \Phi_{B}}{d t} \\
& \Phi_{B}=B \cdot A=0.3 \times 0.5^{2}
\end{aligned}
$$

$$
=0.3 \times 0.25=0.075 \mathrm{Tm}^{2}
$$

$$
S o, \varepsilon=-5 \times \frac{0.075}{10}=-0.0375 \mathrm{~V}
$$

## DIFFRACTION GRATING FORMULA

A diffraction grating defines an optical component with a periodic structure which splits the light into various beams that travel in different directions. It is an alternative way to observe spectra other than a prism. Generally, when light is incident on the grating, the split light will have maxima at an angle $\theta$. The formula for diffraction grating is used to calculate the angle.

Diffraction grating formula
Where,
$\lambda n=d \operatorname{Sin} \theta_{n}$
$\mathrm{n}=$ order of grating,
$d=$ distance between two fringes or spectra
$\lambda=$ wavelength of light
$\theta$ = angle to maxima

Question 1: A diffraction grating is of width 5 cm and produces a deviation of $30^{\circ}$
in the second-order with the light of wavelength 580 nm . Find the slit spacing.

## Solution:

Given: Angle $\theta=30^{\circ}$, order $n=2$, wavelength $\lambda=580 n m$.
The slit spacing is given by,
$\lambda n=d \operatorname{Sin} \theta_{n}$
$d=2 \times 580 \times 10-9 / \sin 30^{0}$
$d=2.320 \times 10^{-6} \mathrm{~m}$

## BUOYANCY FORMULA

As stated by Archimedes, Buoyancy is the upward force experienced by the body when it is partially or fully immersed in the liquid. It is the upward force exerted by the liquid. The symbol of Buoyancy is $B$ or $F_{B}$.

It is a vector quantity and has both magnitude and direction. The unit of buoyancy is Newton [N]. Buoyancy is caused due to the change in pressure. The pressure is higher at the bottom of the object and decreases as we go up. The pressure at the bottom pushes the object up and the pressure above pushes it down. The net force due to the object acts upwards.

A popular example of Buoyancy is the ship floating in the water.


## Buoyant Force in terms of Pressure

Buoyant force $F_{b}$, in terms of pressure, is written as
$F_{b}=F 2-F 1$
Where,

F2 = force acting upwards
F1 = force acting downwards

Force, F=PA
$P=$ Pressure and
$A=A r e a$
In terms of Area Height and Volume, it is given by
$F_{b}=h_{2} \rho g-h_{1} \rho g$
Where
$\rho$ is the density of the fluid is $\rho$
g is the gravity
$V$ is the volume of the immersed part of the body in the fluid $h$ is the height of the immersed part
$A$ is the area

## RADIANT ENERGY FORMULA

The Radiant heat energy is a notion which is rather more nicely explained by Stefan's law. This law elucidates how the heat is radiated! It states that the amount of heat which is radiated (E) by a flawless black body for a second in a provided unit area is directly related to the fourth power of its absolute temperature ( $T$ ).

The Radiant heat energy formula is articulated as, $E \propto T^{4}$
or
$E=\sigma T^{4}$

Where,
Stefan's constant $\left(5.67 \times 10^{-8} \mathrm{~W} / \mathrm{m}^{2} / \mathrm{K}^{4}\right)$ is $\sigma$
Radiant energy is E

Absolute temperature is $T$ Radiant Energy Solved Problem

Problem 1: The surface temperature of the moon in the daytime is 123 Celsius. Compute the radiant heat energy for 1meter square area.

## Answer:

Known: T (Temperature) $=123^{\circ} \mathrm{C}=123+273 \mathrm{~K}=396 \mathrm{~K}$
$\sigma($ Stefans Constant $)=5.67 \times 10^{-8} \mathrm{~W} / \mathrm{m}^{2} / \mathrm{K}^{4}$
Radiant energy, $\mathbf{E}=\boldsymbol{\sigma} \mathbf{T}_{\mathbf{4}}$
$E=\left(5.67 \times 10^{-8}\right) \times(396)^{4}$
$\mathrm{E}=1394.32$.

Thus, the radiant heat energy is 1394.32.

## FROUDE NUMBER FORMULA

Froude number was titled after William Froude is a dimensionless number known as the ratio of characteristic velocity to the gravity wave velocity.
$F r=\frac{v}{c}$
Where the characteristic velocity is v and

The characteristic wave velocity is c , gravity in terms of the Froude number is articulated as,

$$
F r=\frac{v}{(g l)^{\frac{1}{2}}}
$$

Where,
Froude number is Fr, velocity is v , gravity is g , characteristic length is I.

It is used to determine the resistance of a partially moving bod $y$ that is immersed in water.

## Froude Number Solved Problems

Underneath are some of the solved problems based on Froude Number:

## Problem

1: Find the Froude number if the boat's length is 5 m and the velocity is $20 \mathrm{~m} / \mathrm{s}$.

## Answer:

Known: length I = 5m,

Velocity $\mathrm{v}=20 \mathrm{~m} / \mathrm{s}$

The Froude number is articulated as,
$\mathrm{Fr}=\mathrm{v}(\mathrm{gl}) 12$
$\mathrm{Fr}=20(9.8 \times 5) 12$
Fr=204.427
$\mathrm{F}_{\mathrm{r}}=\mathbf{2 . 8 6}$

Thus, the Froude number of the boat is $\mathbf{2 . 8 6}$.

# Problem 2: Calculate the velocity of the fish moving through 

 the water if its length 0.3 m and Froude number is 0.9 .
## Answer:

Known: I (length) $=0.3 \mathrm{~m}$
$\operatorname{Fr}($ Froude number $)=0.9$
The Froude number is given by,

$$
\mathrm{Fr}=\mathrm{v}(\mathrm{gl}) 12
$$

The velocity of the moving fish is
$\left.v=F_{r} \times(\mathrm{g})\right)^{(1 / 2)}$
$v=0.9 \times(9.8 \times 0.3)^{(0.5)}$
$v=0.9 \times 1.71$
$\mathrm{v}=1.539 \mathrm{~m} / \mathrm{s}$

Thus, the velocity of the moving fish is $1.59 \mathrm{~m} / \mathrm{s}$.

## LATENT HEAT FORMULA

Latent heat is the heat required to convert a solid into a liquid or vapour phase, or a liquid into a vapour phase. According to the different phase, it has different names like the heat of condensation, the heat of vaporization etc. The amount of heat energy absorbed or released for a phase change is known as latent heat.

The latent heat formula is given by,
$\mathrm{L}=\mathrm{Q} / \mathrm{M}$

Where,
$Q=$ amount of heat
$\mathrm{M}=$ mass of the substance

Example 1

Determine the latent heat of $5 \mathbf{k g}$ substance if the amount of heat for a phase change is $300 \mathrm{k} . \mathrm{cal}$.

Solution:

Given parameters are,
$\mathrm{Q}=300 \mathrm{k} . \mathrm{cal}$
$M=5 \mathrm{~kg}$
Formula for latent heat is given by,
$L=Q / M$
$\mathrm{L}=300 / 5$
$\mathrm{L}=60 \mathrm{k} . \mathrm{cal} / \mathrm{kg}$

## Example 2

The heat needed for a phase transfer of 2 kg substance is 400k.cal. Determine its latent heat.

Solution:

Given parameters are,
$\mathrm{Q}=400 \mathrm{k} . \mathrm{cal}$
$\mathrm{M}=2 \mathrm{~kg}$
Formula for latent heat is given by,
$L=Q / M$
$\mathrm{L}=400 / 2$
$\mathrm{L}=200 \mathrm{k} . \mathrm{cal} / \mathrm{kg}$

## CENTRIPETAL FORCE FORMULA

## Centripetal Force Formula

A force that acts on a body moving in a circular path and directed towards the centre around which the body is moving is called Centripetal force.

When an object travels around a circular path with a constant speed, it experiences an accelerating centripetal force towards the centre.

The equation for centripetal force is as shown below
$F_{c}=m v^{2} / r$
Where

Fc is the centripetal force
m is mass
v is velocity
$r$ is the radius of the path

## Example 1

A van of $1,250 \mathrm{Kg}$ is travelling at $50.0 \mathrm{~m} / \mathrm{s}$ covers a curve of radius 200 m . calculate the centripetal force.

## Solution

The given parameters are
Mass $=1,250 \mathrm{Kg}$

Radius $=200 \mathrm{~m}$

Velocity $=50.0 \mathrm{~m} / \mathrm{s}$
Substitute the values in the given formula
Centripetal Force
$F_{c}=m v^{2} / r$
$F_{c}=(1250)\left(50^{2}\right) / 200$
$\mathrm{Fc}=15,625 \mathrm{~N}$

## TEMPERATURE FORMULA

Temperature is the degree or intensity of the heat present in a substance or a system, expressed based on the comparative scale and shown by a thermometer.

In other words, Temperature is the measure of hotness or coldness of a body measured using Celsius, Kelvin, and Fahrenheit scales.

The change in temperature is based on the amount of heat released or absorbed. The S.I unit of temperature is Kelvin.

The Temperature formula is given by,

$$
\Delta \mathrm{T}=\mathrm{Q} / \mathrm{mc}
$$

Where,
$\Delta \mathrm{T}=$ temperature difference,
$Q=$ amount of heat absorbed or released,
$m=$ mass of the body,
$c=$ specific heat of the body.

## Example 1

Determine the temperature if 200 J of heat is released by the body of mass 6 Kg and has a specific heat of $0.8 \mathrm{~J} / \mathrm{Kg}^{\circ} \mathrm{C}$.

## Solution:

## Given:

Heat released $\mathrm{Q}=200 \mathrm{~J}$,

$$
\text { Mass m = } 6 \text { Kg, }
$$

Specific Heat c $=0.8 \mathrm{~J} / \mathrm{Kg}^{\circ} \mathrm{C}$
The temperature is given by $\Delta T=Q / m c$

$$
\begin{aligned}
& =200 / 6 \times 0.8 \\
& \Delta T=41.66^{\circ} \mathrm{C} .
\end{aligned}
$$

## Example 2

Determine the heat released when the temperature changes by 40 oC by a body of mass 3 Kg which has a specific heat of $0.7 \mathrm{~J} / \mathrm{kg}^{\circ} \mathrm{C}$.

## Solution:

## Given:

Temperature change $=40^{\circ} \mathrm{C}$,

$$
\begin{aligned}
& \text { Mass } \mathrm{m}=3 \mathrm{~kg}, \\
& \text { Specific heat } \mathrm{c}=0.7 \mathrm{~J} / \mathrm{kg}^{\circ} \mathrm{C} \text {, }
\end{aligned}
$$

The Heat released is given by formula $Q=m c \Delta T$

$$
\begin{aligned}
& =3 \times 0.7 \times 40 \\
& Q=84 \mathrm{~J}
\end{aligned}
$$

## TEMPERATURE FORMULA

The distance between consecutive crests of a wave, particularly the points of an electromagnetic wave is known as its wavelength. The wavelength and frequency are closely related. Higher the frequency, shorter is the wavelength. Since all the light waves move through a vacuum with the same speed, the number of wave crests passing by a given point per second depends on the wavelength.

The Wavelength is denoted by $\lambda$. The Wavelength Formula of any wave is given by

$$
\lambda=v / f
$$

Where,
$\mathbf{V}=$ velocity of the wave
f = frequency

The Wavelength is expressed in $\mathbf{m}$, velocity is expressed in $\mathbf{m} / \mathbf{s}$, frequency is expressed in Hz .

## Example 1

A harmonic wave is moving along a rope. The source generating the waves completes 50 to and fro motions in 20 s . A trough travels 3 m in 4 s ; determine the wavelength of the wave.

## Solution:

Time taken for 50 oscillations $=20 \mathrm{~s}$
Time for 1 oscillation, $\mathrm{t}=20 / 50=0.4 \mathrm{~s}$
Frequency of 1 oscillation, $f=1 / 0.4=2.5 \mathrm{~Hz}$

The wave travels a distance of 3 m in 4 s .
The wave speed is calculated by $v=3 / 4$

$$
=0.75 \mathrm{~ms}-1
$$

The wavelength formula is given by $\lambda=v / f$

$$
\begin{aligned}
& =0.75 / 2.5 \\
\lambda & =0.3 \mathrm{~m}
\end{aligned}
$$

## Example 2

The frequency of a tuning fork is 200 Hz and sound travels a distance of 20 m while tuning fork executes 30 vibrations. Determine the wavelength of sound.

## Solution

## Given:

Frequency f $=200 \mathrm{~Hz}$,

Distance d=20 m,
No of vibrations/ oscillations $=30$

Wavelength $\lambda=$ Distance / No of oscillations

$$
\begin{aligned}
& =20 / 30 \\
\lambda & =0.66 \mathrm{~ms}-1
\end{aligned}
$$

## WAVELENGTH FORMULA

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$$
=0.75 \mathrm{~ms}-1
$$

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$$
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& =0.75 / 2.5 \\
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$$

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## Solution

## Given:

Frequency f $=200 \mathrm{~Hz}$,

Distance d=20 m,
No of vibrations/ oscillations $=30$

Wavelength $\lambda=$ Distance / No of oscillations

$$
\begin{aligned}
& =20 / 30 \\
\lambda & =0.66 \mathrm{~ms}-1
\end{aligned}
$$

## ENERGY CONSUMPTION FORMULA

Energy consumption is the use of power or energy of a system by making use of supply. The consumption is done in Giga Joule per year, kilograms of oil equivalent per year ( $\mathrm{kg} / \mathrm{a}$ ) and in Watts.

The energy consumption formula is articulated as,
$E=P \times t / 1000$
Where,
E is energy in kilowatt-hours(kWh), $P$ is power in Watts, $t$ is hours

Energy Consumption Solved Problems
Here are some cracked examples based on Energy
Consumption:

Problem 1: Compute the energy consumption in a system that consumes 190 Watts of power and works for 3 hrs a day.

## Answer:

Given: Power P = 190 W, total number of hours $=3 \mathrm{hrs}$
$E=P \times t / 1000$
$\mathrm{E}=(190 * 3 * 60 * 60) / 1000$
$\mathrm{E}=2052 \mathrm{kWh}$

Therefore, the energy consumption is 2052 kWh

Problem 2: A toy car consumes energy of 500 Watts of power if it works for 2 hrs a day using it. Calculate the energy consumption a day.

## Answer:

Given: Power P = 500 W, total number of hours= 2 hrs
$E=P \times t / 1000$
$\mathrm{E}=(500 * 2 * 60 * 60) / 1000 . \ldots \quad \mathrm{E}=3600 \mathrm{kWh}$

## STATIC ELECTRICITY FORMULA

Static Electricity according To Coulomb's Law

The magnitude of the electrostatic force of attraction between two charges $q$ and $Q$ placed at a distance $r$ is given by the formula
$F=\frac{1}{4 \pi \epsilon_{0}} \frac{q Q}{r^{2}}=k_{0} \frac{q Q}{r^{2}}$

Where,
$F=$ magnitude of electrostatic force
$\varepsilon_{0}=$ Vacuum permittivity $=8.854 \times 10^{-12} \mathrm{C}^{2} \mathrm{~N}^{-1} \mathrm{~m}^{-2}$
$\mathrm{k}_{0}=$ Coulombs constant $=1 / 4 \pi \varepsilon_{0}$

## RESULTANT FORCE FORMULA

The resultant force is described as the total amount of force acting on the object or body along with direction if the body. The resultant force is zero when the object is at rest or it is travelling with the same velocity as the object. The resultant force should be equal for all the force since all the force is acting in the same direction.

If one force is acting perpendicular to another, the resultant force is determined by using the Pythagorean Theorem. The Resultant force formula is given by,

$$
F R=F 1+F 2+F 3
$$

Where

F1, F2, F3 are the three forces acting in the same direction on an object.

## Problem 1

Determine the FR when three forces such as $80 \mathrm{~N}, 100 \mathrm{~N}$ and 30 N are acting on an object simultaneously and 30 N force is opposite to the other two forces.

Solution:

Given:
$\mathrm{F} 1=80 \mathrm{~N}$
$\mathrm{F} 2=100 \mathrm{~N}$
$F 3=-30 N$

F3 is a negative value because it is acting opposite to the other two force

The formula for resultant force is
$F R=F 1+F 2+F 3$
$F R=80+100-30$
$F R=150 \mathrm{~N}$

## MASS FLOW RATE FORMULA

The mass flow rate is the mass of a liquid substance passing per unit time. In other words, Mass flow rate is defined as the rate of movement of liquid mass through a unit area. The mass flow is directly depended on the density, velocity of the liquid and area of cross-section. It is the movement of mass per unit time. The mass flow is denoted by $m$ and the units in $\mathrm{kg} / \mathrm{s}$.

The mass flow formula is given by,
$m=\rho V A$

Where
$\rho=$ density of fluid,
$\mathrm{V}=$ velocity of the liquid, and

A = area of cross-section

## Example 1

Determine the mass flow rate of a given fluid whose density is $800 \mathrm{~kg} / \mathrm{m}^{3}$, velocity and area of cross-section is $30 \mathrm{~m} / \mathrm{s}$ and $20 \mathrm{~cm}^{2}$ respectively.

Solution:

Given values are,
$\rho=800 \mathrm{~kg} / \mathrm{m}^{3}$
$\mathrm{V}=30 \mathrm{~m} / \mathrm{s}$ and
$\mathrm{A}=20 \mathrm{~cm}^{2}$
$=0.20 \mathrm{~m} 2$

The mass flow rate formula is given by,
$m=\rho V A$
$\mathrm{m}=800 \times 30 \times 0.20, \ldots . . \quad \mathrm{m}=4800 \mathrm{~kg} / \mathrm{s}$

## PROPAGATION CONSTANT

## FORMULA

Electromagnetic waves travel in the form of a sinusoidal wave. The measure of the change in its amplitude and phase per unit distance is called the propagation constant. Denoted by the Greek letter $\gamma$.

Propagation Constant for an electromagnetic wave is represented as
$\gamma=\alpha+i \beta$
$\gamma=$ propogation constant
$\alpha=$ attenuation constant
$\beta=$ phase constant

The attenuation constant $(\alpha)$ is the real part of the propagation constant. The phase constant $(\beta)$ is the imaginary part of the propagation constant.

## FRICTION FORMULA

Friction is the hindering force that comes into play when two items are interacting with each other.


Friction formula is typically given as
$F_{f}=\mu F_{n}$

The numeric's are, the magnitude of friction is $F_{f}$, the coefficient of friction is $\mu$ and the magnitude of the normal force is $F_{n}$.

The Normal force is equivalent to the weight of the given body. Therefore, the Normal force $\left(F_{n}\right)$ is articulated by:
$F_{n}=m g$
Where,
the mass of the object is m and g is the gravity.
Friction formula was made use of to compute the friction between any two given bodies.

## Friction Solved Examples

Underneath are problems on friction which helps to know where the formula can be used:

Problem 1: A child is pulling a box of mass 10 Kg . What is the standard force acting and also calculate the frictional force if the coefficient of friction $\mu$ is 0.3 ?

## Answer:

Given: Mass, m = 10 Kg ,
Normal force, $\mathrm{F}_{\mathrm{n}}=$ ?
Normal force is given by $F_{n}=m g$
$=10 \mathrm{Kg} \times 9.8 \mathrm{~m} / \mathrm{s}^{2}$
$=98 \mathrm{~N}$.
The Frictional force is articulated by $\mathrm{F}_{\mathrm{f}}=\mu \mathrm{F}_{\mathrm{n}}$
$=0.3 \times 98 \mathrm{~N}$.
$=29.4 \mathrm{~N}$.

Problem 2: Nancy of mass 40 Kg is slipping on the frost. If the coefficient of friction acting is 0.45 . Find the frictional force acting between her and frost layer?

## Answer:

Given: Mass m = 40 Kg ,
Coefficient of friction $\mu=0.3$,
The Normal force is articulated by $\mathrm{F}_{\mathrm{n}}=\mathrm{mg}$
$=40 \mathrm{Kg} \times 9.8 \mathrm{~m} / \mathrm{s}^{2}$
$=392 \mathrm{~N}$.
The Frictional force is articulated by $F_{f}=\mu F_{n}$
$=0.45 \times 392 \mathrm{~N}$
$=176.4 \mathrm{~N}$.

## RELATIVE VELOCITY FORMULA

Relative velocity is used to denote
the aircraft moving in the wind or boats moving through the water, etc. The velocity is measured within the object acco rding to the observer. It can be measured using the use of an i ntermediate reference frame. In simpler terms, this can be the vector sum of the velocities. The relative velocity formula is expressed as
$\vec{V}=\overrightarrow{V_{A B}}+\overrightarrow{V_{B C}}$
Where
$V_{A B}$ is the velocity with respect to $A$ and $B, V_{B C}$ is the velocity with respect to $B$ and $C$ and $V_{A C}$ is the velocity with respect to A and C.

Problem 1: A train travels with a speed of $70 \mathrm{~m} / \mathrm{s}$ with regards to the ground in the east direction. A spectator is moving with a speed of $-15 \mathrm{~m} / \mathrm{s}$ with regards to the train in the west direction. Determine the speed of man with respect to the ground?

## Answer:

From the problem, it is known that
$V_{B C}$ (Velocity of train with respect to ground) $=70 \mathrm{~m} / \mathrm{s}$
$V_{A B}($ Velocity of man with respect to train $)=-15 \mathrm{~m} / \mathrm{s}$
$\mathrm{V}_{\mathrm{AC}}$ (Velocity of a man with respect to ground) $=$ ?

Relative Velocity Formula is,
$\mathrm{V}_{\mathrm{AC}} \rightarrow=\mathrm{V}_{\mathrm{AB}} \rightarrow+\mathrm{V}_{\mathrm{BC}} \rightarrow$
$V_{A C} \rightarrow=-15+70=55 \mathrm{~m} / \mathrm{s}$
$\mathrm{V}_{\mathrm{AC}} \rightarrow=55 \mathrm{~m} / \mathrm{s}$

Problem 2: A boat moves with a speed of $40 \mathrm{~m} / \mathrm{s}$ with respect to water in the east direction. An observer is moving with a speed of $-5 \mathrm{~m} / \mathrm{s}$ with respect to the boat in the west direction. Compute the speed of man with respect to the water?

## Answer:

From the problem, it is known that
$V_{B C}$ (Velocity of boat with respect to water) $=40 \mathrm{~m} / \mathrm{s}$
$V_{A B}$ (Velocity of man with respect to boat) $=-5 \mathrm{~m} / \mathrm{s}$
(Velocity of a man with respect to water) $\mathrm{V}_{\mathrm{AC}}=$ ?
Formula for relative velocity is,
$\mathrm{V}_{\mathrm{AC}} \rightarrow=\mathrm{V}_{\mathrm{AB}} \rightarrow+\mathrm{V}_{\mathrm{BC}} \rightarrow$
$V_{A C} \rightarrow=-5+40=35 \mathrm{~m} / \mathrm{s}$
$\mathrm{V}_{\mathrm{AC}} \rightarrow=35 \mathrm{~m} / \mathrm{s}$

## BEAM DEFLECTION FORMULA

Deflection is the degree to which a particular structural element can be displaced by a considerable amount of load. It can be referred to an angle or distance.

The distance of deflection of a member under a load is directly related to the slope of the deflected shape of the member under that load. It can be calculated by integrating the function that describes the slope of the member under that load.

The Beam is a long piece of a body capable of holding the load by resisting the bending. The deflection of the beam towards a particular direction when force is applied on it is called Beam deflection.

Based on the type of deflection there are many beam deflection formulas given below,
w = uniform load (force/length units)
$\mathrm{V}=$ shear

I = moment of inertia
$E=$ modulus of elasticity
$d=$ deflection
$\mathrm{M}=$ moment

## PINNED-PINNED BEAM WITH UNIFORM LOAD


$V=w(L / 2-x)$
$M=w x / 2(L-x)$
$\delta=w x / 24 E I\left(L^{3}-2 L x^{2}+x^{3}\right)$
FIXED-FIXED BEAM WITH UNIFORM LOAD

$\mathrm{V}=\mathrm{W}(\mathrm{L} / 2-\mathrm{x})$
$M=W / 12\left(6 L x-L^{2}-6 x^{2}\right)$
$\delta=w x^{2} / 24 E I(L-x)^{2}$

# PINNED-FIXED BEAM WITH UNIFORM LOAD 



$$
V=w(3 L / 8-x)
$$

$$
M=w x(3 L / 8-x / 2)
$$

$$
\delta=w x / 48 E I\left(L^{3}-3 L x^{2}+2 x^{3}\right)
$$

FREE-FIXED BEAM WITH UNIFORM LOAD


$V=P b / L-P(x-a)^{0}$
$M=P b x / L-P(x-a)^{1}$
$\delta=P / 6 E I\left[b x 3 / L-a b x / L(2 L-a)-(x-a)^{3}\right]$
FIXED-FIXED BEAM WITH POINT LOAD

$V=P b^{2} / L^{3}(L+2 a)-P(x-a)^{0}$
$M=-P a b^{2} / L^{2}+P b^{2} x / L 3(L+2 a)-P(x-a)^{1}$
$\delta=P / 6 E I\left[b^{2} x^{3} / L^{3}(L+2 a)-3 a b 2 x 2 / L 2-(x-a)^{3}\right]$

$V=P b^{2} / 2 L^{3}(2 L+a)-P(x-a)^{0}$
$M=P b^{2} x / 2 L^{3}(2 L+a)-P(x-a)^{1}$
$\delta=\mathrm{P} / 6 \mathrm{EI}\left[\mathrm{b}^{2} x^{3} / 2 \mathrm{~L}^{3}(2 \mathrm{~L}+\mathrm{a})-3 a \mathrm{~b}^{2} x / 2 \mathrm{~L}-(x-a)^{3}\right]$
FREE-FIXED BEAM WITH POINT LOAD

$V=-P(x-a)^{0}$
$M=-P(x-a)^{1}$
$\delta=P / 6 E I\left[3 b^{2} x-2 L^{3}-a^{3}-(x-a)^{3}\right]$
Example 1
A pinned-pinned beam of length 50 cm is put under uniform load of 60 gms having $x$ as 5 cm . Determine the shear.

## Solution:

Given parameters are

Length L $=50 \mathrm{~cm}$
Uniform load w $=60$ gms
Displacement $\mathrm{x}=5 \mathrm{~cm}$
The shear is given by $V=w(L / 2-x)$
$=0.06 \mathrm{~kg}(0.5 / 2 \mathrm{~m}-0.05 \mathrm{~m})$
$=0.06 \mathrm{~kg}(0.25-0.05) \mathrm{m}$
$=0.012 \mathrm{kgm}$.
Question 2: n fixed-fixed beam of length 30 cm is put under uniform load of 200 gm having x as 20 cm . Determine the moment.

## Solution:

Given parameters are
Length $\mathrm{L}=30 \mathrm{~cm}$,
Uniform load w = 200 gms,

Displacement $\mathrm{x}=20 \mathrm{~cm}$

The moment is
$V=-w x^{2} / 2$
$=-0.2 \mathrm{~kg} \times 0.2^{2} / 2$
$=0.004 \mathrm{~kg} \mathrm{~m}^{2}$.

## HEAT LOSS FORMULA

Decrease of heat existing in space, resulting from heat transfer through walls, roof, windows and buildings surfaces or other factors is known as heat loss.

Heat loss is determined by multiplying the values of the surface area, the difference in temperatures of indoors and outdoors and the value of heat loss of the material.

The heat loss interests in the ventilation of hot processes which is known as convectional heat loss. The total heat loss of the object involves losses occurring by radiation, convection, and conduction.

Heat loss is measured by the units called Watts.

Heat loss formula is expressed by,
$q=(U \times A) \times \Delta t$

Where,
$\mathrm{q}=$ total heat loss through the building in Btu/hr,
$\mathrm{U}=$ Overall coefficient of heat transmission through the building,

A = the area in sq.ft of the building assembly with the coefficient of heat transmission $U$,
$\Delta t=$ temperature difference between inside and outside temperatures.

## Example 1

Determine the total heat loss from the building whose Area is 6.0 sq.ft, coefficient of heat transfer is 0.7 and the temperature difference is $25^{\circ} \mathrm{C}$.

Solution:

Given:
$U=0.7$
$\mathrm{A}=6.0 \mathrm{sq} . \mathrm{ft}$
$\Delta t=25^{\circ} \mathrm{C}$

Substitute these values in the given formula,
$q=(U \times A) \times \Delta t$
$q=0.7 \times 6.0 \times 25$
$q=105$ watts

## Example 2

Determine the total heat loss from the building whose coefficient of heat value is 265 watt; the Area is 4.30 meters and the value for $\Delta T$ is 1135 watts.

Solution:

Given:
$\mathrm{U}=265 \mathrm{watt}$
$A=4.30$ metres
$\Delta T=1135$ watts.

Substitute the values in the given formula,

$$
\begin{aligned}
& q=(U \times A) \times \Delta t \\
& q=265 \times 4.30 \times 1135 \\
& q=1293332.5 \text { watts }
\end{aligned}
$$

## ANGULAR MOMENTUM FORMULA

Definition: The degree to which a body rotates, gives its angular momentum. It is defined as the product of the moment of inertia " I " and the angular velocity " $\omega$ "
$L=I \omega$

Angular momentum in terms of Linear momentum can be written as
$L=r \times p$
where,
$r=$ length vector
$p=$ linear momentum

The unit for Angular momentum is given as kilogram meter square per second ( $\mathrm{kg} \mathrm{m}^{2} / \mathrm{s}$ ). Angular Momentum formula is
made use of in computing the angular momentum of the particle and also to find the parameters associated to it.

## Angular Momentum Numerical

Problem 1: A solid cylinder of mass 200 kg rotates about its axis with an angular speed of $100 \mathrm{~ms}^{-1}$. If the radius of the cylinder is 0.5 m . Compute the angular momentum of the cylinder about its axis?

## Answer:

Given: Mass M = 200 kg ,
Angular speed $\omega=100 \mathrm{~ms}^{-1}$,
Radius $r=0.5 \mathrm{~m}$,

Since it is a solid cylinder, Moment of Inertia I
$=\frac{m r^{2}}{2}$
$\mathrm{I}=200^{*} 0.5^{*} 0.5 / 2$
$\mathrm{I}=25 \mathrm{~kg} \mathrm{~m}{ }^{2}$

The angular momentum is given by $\mathrm{L}=I \omega$
$\mathrm{L}=25 \times 100$
$=2500 \mathrm{~kg} \mathrm{~m}^{2} / \mathrm{s}$

Problem 2: Compute the angular momentum of the rod of radius 1 m and mass 2 kg spinning with velocity $5 \mathrm{rad} / \mathrm{s}$ ?

## Answer:

Given: Radius $r=1 \mathrm{~m}$,
Mass M = 2 kg ,
Angular Velocity $\omega=5 \mathrm{rad} / \mathrm{s}$
The angular momentum is given as $L=I \omega$
$=\frac{m r^{2}}{2} \omega$
$=\frac{2 * 1^{2}}{2} 5$
$\mathrm{L}=5 \mathrm{~kg} \mathrm{~m}^{2} \mathrm{~s}^{-1}$

## GRAVITY FORMULA

Gravity also termed as gravitation, is a force that occurs among all material objects in the universe. For any two objects or units having non-zero mass, the force of gravity has a tendency to attract them toward each other. The Universal Law of Gravitation says that:

## All mass applies an attractive force on all other mass.

If the distance between two masses $\mathbf{m}_{1}$ and $\mathbf{m}_{\mathbf{2}}$ is $\mathbf{d}$ as shown in the diagram,

The gravity formula is articulated as
$F=\frac{G m_{1} m_{2}}{r^{2}}$

Where,
G is a constant equal to $6.67 \times 10^{-11} \mathrm{~N}-\mathrm{m}^{2} / \mathrm{kg}^{2}$,
$m_{1}$ is the mass of the body 1 ,
$m_{2}$ is the mass of body 2,
$r$ is the radius or distance amid the two bodies.

The gravitational force formula is very useful in computing gravity values, larger mass, larger radius, etc.

## Gravity Problems Solved Examples

Underneath are given some questions on gravity which helps one to comprehend the use of this formula.

Problem 1: Calculate the force due to gravitation being applied on two objects of mass 2 Kg and 5 Kg divided by the distance 5 cm ?

## Answer:

Given: Mass $\mathrm{m}_{1}=2 \mathrm{Kg}$,
Mass $\mathrm{m}_{2}=5 \mathrm{Kg}$,
Radius $\mathrm{r}=5 \mathrm{~cm}$.
Gravitational Constant G $=6.67 \times 10^{-11} \mathrm{Nm}^{2} / \mathrm{Kg}^{2}$

The force due to gravity are given by formula $F=\frac{G m_{1} m_{2}}{r^{2}}$

$$
\mathrm{F}=\frac{6.67 \times 10^{-11} \times 2 \times 5}{\left(5 \times 10^{-2}\right)^{2}}
$$

$=2.668 \times 10^{-7} \mathrm{~N}$

## MASS ENERGY FORMULA

According to Einstein's Theory, equivalent energy can be calculated using the mass ( m ) and the speed of light.

## $\mathrm{E}=\mathrm{mc} 2$

$\mathrm{E}=$ equivalent energy
$\mathrm{m}=$ mass in kg
$\mathrm{c} \cong 3 \times 108 \mathrm{~m} / \mathrm{s}$

## PROJECTILE MOTION FORMULA

The projection motion is one kind of motion. A projectile is an entity thrown into the air or into spa ce. A trajectory is a curved direction with which the projectile is moving. In a horizontal direction with constant velocity, the free-fall motion of any object is known as projectile motion.

Projectile Motion Formula or trajectory formula is formulated as

Horizontal distance, $x=V_{x 0} t$

Horizontal velocity, $V_{x}=V_{x 0}$

Vertical distance, $y=V_{y 0} t-\frac{1}{2} g t^{2}$

## Vertical velocity, $V_{y}=V_{y 0}-g t$

Where,
$\mathrm{V}_{\mathrm{x}}=$ the velocity (along the x -axis)
$\mathrm{V}_{\mathrm{xo}}=$ Initial velocity (along the x -axis)
$V_{y}=$ velocity (along the $y$-axis)
$\mathrm{V}_{\mathrm{yo}}=$ Initial velocity (along the y -axis)
$\mathrm{g}=$ acceleration due to gravity
$\mathrm{t}=$ Time taken

Equations related to the projectile motion is given as
Timeof Flight,$t=\frac{2 v_{0 \sin \theta}}{g}$
Maximum height reached, $H=\frac{v^{2} 2_{0 \sin 2 \theta}}{2 g}$
Horizontalrange, $R=\frac{v^{2_{0} \sin 2 \theta}}{g}$

Where
$\mathrm{V}_{\mathrm{o}}=$ Initial Velocity
$\operatorname{Sin} \theta=$ Component along the $y$-axis
$\operatorname{Cos} \theta=$ component along the $x$-axis
The formula of projectile motion is used to calculate the velocity, distance and the time observed in the projectile motion of the object.

Projectile Motion Solved Example
Problem 1: Johnson is standing on the top of the building and John is standing down. If Johnson tosses a ball with velocity $30 \mathrm{~m} / \mathrm{s}$ and at the angle of $70^{\circ}$ then at the time 3 s what height will the ball reach?

## Answer:

Given:

$$
V_{y o}=30 \mathrm{~m} / \mathrm{s}
$$

## $\Delta t=3 s$

The Vertical velocity in y-direction is expressed as
$V_{y}=V_{y o} \sin 70^{\circ}$
$V_{y}=30 \sin 70$
$\mathrm{V}_{\mathrm{y}}=\mathbf{2 3 . 2 2 \mathrm { m } / \mathrm { s }}$

## HEAT LOAD FORMULA

The heating load is the quantity of heat energy expected to be introduced to a particular space to retain the temperature wit hin an appropriate range. The cooling load is the quantity of heat energy need to be extracted from space in order to maintain the temperature within an appropriate range.

There are two types of heat sources are known, one is resulting in the internal heat load on the conditional area and the second one is resulting in an external heat load.

Heat sources which result in an internal heat like heat conduction through the glass, walls, etc. Heat sources which result in an external heat load, heat from any source added in the air after it leaves a space.

The heat load formula is given as,
Heat load $=Q=m \times C p \times \Delta T$

Where,
Q = Heat load (kW)
$m=$ mass flow rate (kg/s)
$\mathrm{Cp}=$ specific heat $\left(\mathrm{kJ} / \mathrm{kg} \mathrm{K}\right.$ or $\mathrm{kJ} / \mathrm{kg}{ }^{\circ} \mathrm{C}$ )
$\Delta \mathrm{T}=$ change in temperature $\left(\mathrm{K}\right.$ or $\left.{ }^{\circ} \mathrm{C}\right)$

## Example 1

Determine the heat load in the electric convector in which the rate of mass flow is 5.45 and Cp is 1000 and the enthalpy is from 21.5 to 26.55 .

Solution:

Given:
$M=5.45$
$C_{p}=1000$
$\mathrm{T}_{1}=26.55$
$\mathrm{T}_{2}=21.5$

Substituting in the formula

Heat load, $\mathbf{Q}=\mathbf{m} \times \mathbf{C p} \times \Delta \mathbf{T}$

$$
\begin{aligned}
& \mathrm{Q}=5.45 \times 1000 \times(26.55-21.5) \\
& \mathbf{Q}=27522.5 \mathrm{~W}
\end{aligned}
$$

## Example 2

Determine the heat load if the specific heat is 200 and enthalpy change from the temperature 31.5 to 26.55 and M is 4.45 .

Solution:

Given:
$M=4.45$
$C_{p}=200$
$\mathrm{T}_{1}=31.5$
$\mathrm{T}_{2}=26.55$
Substituting in the formula, Heat load, $Q=m \times C p \times \Delta T$

$$
\begin{aligned}
& \mathrm{Q}=4.45 \times 200 \times(31.5-26.55) \\
& \mathrm{Q}=4405 \mathrm{~W}
\end{aligned}
$$

## GRAVITATIONAL ACCELERATION

## FORMULA

## Definition:

Any object located in the field of the earth experiences a gravitational pull. Gravitational acceleration is described as the object receiving acceleration due to the force of gravity acting on it. It is represented by ' g ' and its unit is $\mathrm{m} / \mathrm{s}^{2}$.

Gravitational acceleration is a quantity of vector that is it has both magnitude and direction.

## Formula:

Using the following equation, the gravitational acceleration ac ting on anybody can be explained
$\mathrm{g}=\mathrm{GM} /(\mathrm{r}+\mathrm{h}) 2$
Here, $G$ is the universal gravitational constant ( $G=6.673 \times 10-$ 11 N.m2/Kg2.)
$M$ is the mass of the body whose gravitational force acts on th e given object under certain condition.
$r$ is the planet radius.
$h$ is the height of the object from the body surface.
When the object is on or near the surface of the body, the force of gravity acting on the object is almost constant and the following equation can be used.
$\mathrm{g}=\mathrm{GM} / \mathrm{r} 2$
Derivation:

From Newton's Second Law of Motion, we can write
$\mathrm{F}=\mathrm{ma}$

Here, F is the force acting on the object.
M is its mass and
' $a$ ' is the acceleration.
Also, as per Newton's Law of Gravity, we can write,
$\mathrm{Fg}=\mathrm{GMm} /(\mathrm{r}+\mathrm{h}) 2$
It is the gravitational force acting between two bodies lying in the gravitational field of each other. This force acts inwards and is attractive in nature. Each of the two bodies experiences the same force directed towards the other.

Using Newton's second law of motion, in order to find the acceleration of the body under this condition,
$a=F g / m$
Here, $m$ is the mass of the object for which the gravitational acceleration is to be calculated.
$\mathrm{a}=\mathrm{g}=\mathrm{GMm} /(\mathrm{r}+\mathrm{h}) 2 \mathrm{~m}$
$\mathrm{g}=\mathrm{GM} /(\mathrm{r}+\mathrm{h}) 2$
Also, the value of g is constant when the object is on or near the surface and there is no considerable change with the height. Hence we can write,
$\mathrm{g}=\mathrm{gM} / \mathrm{r} 2$

## Real Life examples:

Let us consider a satellite that has to revolve in the upper part of the atmosphere surrounding the Earth. In order to calculate the velocity with which it has to move so as to remain in its path, we must know the gravitational acceleration acting on the object.

Solved examples

## Example 1:

Calculate the acceleration due to gravity for an object placed at the surface of the Earth, given that, the radius of the Moon is $1.74 \times 10^{6} \mathrm{~m}$ and its mass is $7.35 \times 10^{22} \mathrm{~kg}$.

## Solution:

The radius of the moon, $r=1.74 \times 10^{6} \mathrm{~m}=1740000 \mathrm{~m}$
$r^{2}=3.0276 \times 10^{12} \mathrm{~m}$
The mass of moon $=7.35 \times 10^{22} \mathrm{~kg}$

Using the formula for the acceleration due to gravity, we write,
$\mathrm{g}=\mathrm{GM} / \mathrm{r} 2$
Upon substituting the values, we get,
$\mathrm{g}=(6.673 \times 10-11)(7.35 \times 1022) / 3.0276 \times 1012$
$g=\left(4.905 \times 10^{12}\right) /\left(3.0276 \times 10^{12}\right)$
$\mathrm{g}=1.620 \mathrm{~m} / \mathrm{s}^{2}$
The acceleration due to gravity is $1.620 \mathrm{~m} / \mathrm{s}^{2}$.

## Example 2:

The radius of the Earth is $6.38 \times 106 \mathrm{~m}$. The mass of the Earth is $5.98 \times 10^{24} \mathbf{~ k g}$. If a satellite is orbiting the Earth 250 km above the surface, what acceleration due to gravity does it experience?

Solution:

It can be seen that the satellite is present at a considerable height from the surface of the Earth; hence the height cannot be neglected. Using the first formula, we can write,
$R=r+h=\left(6.38 \times 10^{6} \mathrm{~m}\right)+(250 \mathrm{~km})$
$R=6380000+250000 \mathrm{~m}$
$R=6630000 \mathrm{~m}$

The acceleration due to the gravity of the satellite can be found from the formula:
$\mathrm{g}=\mathrm{GM} /(\mathrm{r}+\mathrm{h}) 2$
$\mathrm{g}=(6.673 \times 10-11)(5.98 \times 1024) /(6630000) 2$
$g=\left(3.9704 \times 10^{14}\right) /\left(4.396 \times 10^{13}\right)$
$\mathrm{g}=9.031 \mathrm{~m} / \mathrm{s}^{2}$

## RESISTANCE FORMULA

Resistance is the measure of opposition applied by any object to the flow of electric current. A resistor is an electronic constituent that is used in the circuit with the purpose of offering that specific amount of resistance.


The resistance of any object is computed making use of the formula:
$R=\frac{V}{I}$

In this case,
$v=$ Voltage across its ends
I = Current flowing through it

If the resistance's are linked in series, the series resistance is articulated as-
$R_{s}=R_{1}+R_{2}+R_{3}+\ldots .+R_{n}$
If resistance is connected in parallel, the parallel resistance is given by
$\frac{1}{R_{p}}=\frac{1}{R_{1}}+\frac{1}{R_{2}}+\frac{1}{R_{3}}+\ldots+\frac{1}{R_{n}}$
Where, $R_{1}, R_{2}, R_{3} \ldots \ldots . R_{n}$ is the given resistors. Resistance is measured in ohms $(\Omega)$.

Resistance Formula is used to compute the resistance across any given number of resistors in the circuit. It can similarly be made use of to compute the resistance in any given object.

## Resistance Solved Examples

Below are problems based on resistance which may be helpful for you.

Problem 1: Compute the resistance offered by the body if
2 mA of current is flowing having a potential difference of 2 V ?

## Answer:

Known:

I (Current) = 2mA,
$\mathrm{V}($ Potential difference $)=2 \mathrm{~V}$
The resistance is given by $R=\frac{V}{I}=\frac{2}{2 \times 10^{-3}}=1000 \Omega$
Problem 2: Compute the resistance if $5 \Omega$ and $2 \Omega$ are connected in parallel.

## Answer:

Known:

Resistance
$R_{1}=5 \Omega$,
$\mathrm{R}_{2}=2 \Omega$

The parallel resistance is articulated as

$$
\begin{aligned}
& \frac{1}{R_{p}}=\frac{1}{R_{1}}+\frac{1}{R_{2}} \\
& R_{p}=\frac{R_{1} R_{2}}{R_{1}+R_{2}}=\frac{5 \times 2}{5+2}=1.428 \Omega
\end{aligned}
$$

## AVERAGE SPEED FORMULA

The average speed is the total distance travelled by the object in the particular time interval.

The average speed is a scalar quantity. It is represented by the magnitude and does not have direction.

## Average Speed Formula

The formula for average speed is found by calculating the ratio of the total distance travelled by the body to the time taken to cover that distance.

The average speed equation is articulated as:
$S_{\text {avg }}=$ Total Distance travelled/Total Time taken
$S_{A V G}=\frac{D_{\text {total }}}{T_{\text {total }}} \ldots \ldots \ldots . .(2$
Equation (2) is the formula for an average speed of an object moving at a varying speed.

## Average Speed Solved Examples

Problem 1: A runner sprints at a track meet. He completes a 1000-meter lap in 1 minute 30 sec . After the finish, he is at the starting point. Calculate the average speed of the runner during this lap?

## Answer:

Given:

Total distance covered by the runner $=1000$ meters

Total time taken $=1$ minute 30 sec
$=90 \mathrm{sec}$
So, applying the formula for the average speed we have,
$S_{a v g}=1000 / 90$
$S_{a v g}=11.1 \mathrm{~m} / \mathrm{s}$

Problem 2: A car travels at a speed of $40 \mathrm{~km} / \mathrm{hr}$ for 2 hours and then decides to slow down to $30 \mathrm{~km} / \mathrm{hr}$ for the next 2 hours. What is the average speed?

D1 $=40$ * $2=80$ miles

D2 $=30$ * $2=60$ miles

Total distance D= D1+D2
$D=80+60$
$D=140$ miles
Average speed ${ }^{S_{\text {avg }}}=$ Total Distance travelled/Total Time taken
$=140 / 4$
$S_{a v g}=35 \mathrm{~m} / \mathrm{s}$

## CURRENT DENSITY FORMULA

The measure of the amount of electric charge per unit time that flows through the unit area of the cross-section. The Current density is a vector quantity. Therefore, it has both magnitude and direction. The S.I unit of Current density is $\mathrm{A} / \mathrm{m}^{2}$ and is denoted by the symbol J .

$\mathrm{J}=$ The flow of current over Cross Section area "A"

Current Density Formula is expressed as,
$\mathrm{J}=\mathrm{I} / \mathrm{A}$

Where,

I denote the current flowing through the conductor in Amperes and

A denotes the cross-section area in $\mathrm{m}^{2}$
Current density is expressed in $\mathrm{A} / \mathrm{m}^{2}$

## Example 1

A $5 \mathrm{~mm}^{2}$ copper wire has a current of 5 mA of current flowing through it. Determine the current density.

Solution

Given:

Total Current I is 5 mA
Total Area A is $5 \mathrm{~mm}^{2}$
The Current density J = I / A
$=5 \times 10^{-3} / 5 \times 10^{-3}$
$=1 \mathrm{~A} / \mathrm{m}^{2}$

## Example 2

Determine the current density of if 50 Amperes of current flows through the battery in an area of $10 \mathrm{~m}^{2}$ ?

Solution

Given:

Current I is 50 A ,
Area $A$ is $10 \mathrm{~m}^{2}$

The current density is given by $\mathrm{J}=50 / 10$
$\mathrm{J}=5 \mathrm{~A} / \mathrm{m}^{2}$.

## PRESSURE FORMULA

Pressure is the force applied by one object on another. It is symbolized by $\mathbf{P}$.

The pressure is articulated as force per unit area articulated as
$P=\frac{F}{A}$
Where,
F = Force applied by the body(N)
$A=$ Total area of the object $\left(m^{2}\right)$
Hydrostatic Pressure Formula can also be given by
$P=\rho \times g \times h$
Where,
the height is $h$,
density is $\rho$,
gravity is g

Pressure Formula is made use of to compute pressure, force, area, density, height and gravity if some of these numerics are provided. The unit of pressure is Pascal ( Pa ).

## Pressure Solved Examples

Underneath are problems based on pressure which may be helpful for you.

Problem 1: A 60 Kg girl wearing high heel shoes stabilizes herself on a single heel. The heel is rounded with a diameter of 1.5 cm . Calculate the pressure applied by the heel on the horizontal floor?

## Answer:

## Given:

Mass, m=60Kg

Radius $r=\frac{D}{2}=\frac{1.5 \times 10^{-2}}{2} m$

Pressure is given by $p=\frac{F}{A}$
Force $F=m$ and Area $A=\pi r^{2}$
$P=\frac{m g}{\pi r^{2}}$
$=\frac{60 \times 9.8}{3.142 \times\left(0.75 \times 10^{-2}\right)^{2}}$
$=3.32 \times 10^{6} \mathrm{~Pa}$.
Problem 2: A tank is filled with water is of height 1 m .
Compute the pressure exerted on the bottom of the tank.
(Acceleration due to Gravity $=9.8 \mathrm{~m} / \mathrm{s}^{2}$, Density of water $=$ $1000 \mathrm{~kg} / \mathrm{m}^{3}$ ).

## Answer:

Known:
Acceleration due to Gravity $=9.8 \mathrm{~m} / \mathrm{s}^{2}$
Density of water $=1000 \mathrm{~kg} / \mathrm{m}^{3}$,
The pressure is articulated as

$$
\begin{aligned}
& P=\rho \times g \times h \\
& P=1000 \times 9.8 \times 1 \mathrm{~m} \\
& P=9800 \text { Pascal. }
\end{aligned}
$$

## AVERAGE VELOCITY FORMULA

As the word states, Average Velocity is the average value of the known velocities. Displacement over total time is Average Velocity. The average speed of an object is described as the distance travelled divided by the time gone. A velocity is a vector unit, and average velocity can be described as the displacement divided by the time. The units for velocity can be understood from the definition to be meters/second or in common any distance unit over any time unit. The average speed of a body is described as the distance covered divided by the time elapsed.

It is useful in determining the average value of speed if the body is varying continuously for the given time intervals.

Average Velocity $=\frac{\text { Total distance traveled }}{\text { Total time taken }}$

It is known as $\mathbf{V}_{\text {av }}$. Average Velocity Formula fluctuates based on the given problem.
$V_{a v}=\frac{X_{f}-X_{i}}{t_{f}-t_{i}}$
If any distances $x_{i}$ and $x_{f}$ with their corresponding time intervals $t_{i}$ and $t_{f}$ are given we use the formula
$V_{a v}=\frac{U+V}{2}$
Where
$x_{i}=$ Initial Distance
$\mathrm{X}_{\mathrm{f}}=$ Final distance
$\mathrm{t}_{\mathrm{i}}=$ Initial time
$\mathrm{t}_{\mathrm{f}}=$ Final time
If final Velocity V and Initial velocity U are known, we make use of the formula

Where,
$U=$ Initial Velocity and
$\mathrm{V}=$ Final Velocity.
If there are diverse distances like $d_{1}, d_{2}, d_{3} \ldots \ldots . . d_{n}$ for diverse time intervals $t_{1}, t_{2}, t_{3}, \ldots t_{n}$ then
$V_{a v}=\frac{d_{1}+d_{2}+d_{3}+\ldots \ldots . d_{n}}{t_{1}+t_{2}+t_{3}+\ldots \ldots t_{n}}$

## Average Velocity Problem

Problem 1: A car is moving with an initial velocity of $30 \mathrm{~m} / \mathrm{s}$ and it touches its destiny at $80 \mathrm{~m} / \mathrm{s}$. Calculate its average velocity.

## Answer:

Given: Initial Velocity U $=30 \mathrm{~m} / \mathrm{s}$
Final velocity $\mathrm{V}=80 \mathrm{~m} / \mathrm{s}$
Average Velocity $V_{a v}=\frac{U+V}{2}$

Average velocity $\mathrm{V}_{\mathrm{av}}=(30+80) / 2$
Average velocity $\mathrm{V}_{\mathrm{av}}=55 \mathrm{~m} / \mathrm{s}$

## NEWTON'S SECOND LAW

## FORMULA

Newton's second law of motion is officially specified as the net force generated by an acceleration of a body is directly proportional to the magnitude and inversely proportional to the body mass. The magnitude will be in the same direction as the net force obtained by the body due to its acceleration.

In Physics, Newton's second law of motion is a very important law in order to study the matter and force. It gives the relationship between the mass and acceleration of the object in terms of force.

According to the law, force is equal to the product of acceleration and mass of the object.

The formula for Newton's second law is
$F=m a$

Wherein,
$\mathrm{m}=$ mass
a = acceleration

## Example 1

Determine the applied force of an object of 5 kg moving with a velocity of $10 \mathrm{~m} / \mathrm{s}$ ?

Solution:

Given
$\mathrm{m}=5 \mathrm{~kg}$ and
$\mathrm{a}=10 \mathrm{~m} / \mathrm{s}$

Newton's second law Formula is given by,
$F=m a$
$\mathrm{F}=5 \times 10$

## $F=50 \mathrm{~N}$

## Example 2

An object of 6 kg is moving with a velocity of $30 \mathrm{~m} / \mathrm{s}$. Determine its force.

Solution:

Given
$\mathrm{m}=6 \mathrm{~kg}$ and
$\mathrm{a}=30 \mathrm{~m} / \mathrm{s}$
Newton's second law Formula is given by,
$\mathrm{F}=\mathrm{ma}$
$F=6 \times 30$
$F=180 \mathrm{~N}$

## CIRCULAR VELOCITY FORMULA

The movement of an object along the circumference of a circle or rotation along its circular path is known as circular motion. The object may be moving in uniform motion and has a constant angular rate of rotation and speed or non-uniform motion with changing rate of rotation. Objects moving in circles possess a speed which is equal to the distance travelled per time of travel. By multiplying the rotational frequency with the circumference we can determine the average speed of the object.

The circular velocity formula is expressed as

$$
V_{c}=2 \pi r / T
$$

Where
$r$ denotes the radius of the circular orbit

T is the time period.

In terms of angular velocity $\omega$, the circular velocity is described
$V_{c}=\omega r$

Where,
$\omega$ denotes the angular velocity ( $\omega=2 \pi / T$ )
$r$ is the radius of the circular path

Solved Examples

## Example 1

Determine the circular velocity of a pebble tied to a thread of 0.75 m when swirled is rotating with the angular velocity of 45 radians /s

## Solution

Given parameters are,
Angular velocity $\omega=45 \mathrm{rad} / \mathrm{s}$

Radius $=0.75 \mathrm{~m}$

The circular velocity formula is given by
$V_{c}=\omega r$
$V_{c}=45 \times 0.75$
$V_{c}=33.75 \mathrm{~m} / \mathrm{s}$.

## Example 2

Determine the circular velocity of the earth if the distance from Sun to Earth is 149500000 km and period of earth revolution is 365.25 days.

## Solution

Given parameters are, Radius $r=1495 \times 10^{8} \mathrm{~m}$

Period T = 365.25 days
The circular velocity is expressed by

$$
\begin{aligned}
& V_{c}=2 \pi r / T \\
& V_{c}=(2)(3.14)\left(1495 * 10^{8}\right) / 365.25 \\
& \mathrm{~V}_{\mathrm{c}}=2.571 \times 10^{9} \mathrm{~m} / \mathrm{s} .
\end{aligned}
$$

## RESONANT FREQUENCY FORMULA

The resonant frequency is the frequency of a resonant circuit. The other name of the resonance circuit is a tank circuit of LC circuit. The resonant circuit consists of a parallel-connected capacitor and inductor in it. In order to generate a specific frequency or to consider a specific frequency from the complicated circuit a resonant circuit is being used. The formula of resonant frequency is
$\mathrm{fo}=12 \pi \mathrm{LC} V$
Where
$f_{o}=$ resonant frequency in Hz
L = Inductance

C = Capacitance

Resonant Frequency Solved Examples

Problem 1: Determine the resonant frequency of a circuit whose inductance is 35 mH and capacitance is $10 \mu \mathrm{~F}$ ?

Answer:

Given
$\mathrm{L}=35 \mathrm{mH}$ and
$C=10 \mu \mathrm{~F}$
The resonant frequency formula
$F o=12 \pi L C V$
fo $=12 \times 3.14 \times(\mathrm{V} 35 \times 10-3 \times 10 \times 10-6)$
$\mathrm{f}_{0}=\mathbf{2 6 9 . 1 6 ~ H z}$
Problem 2: The capacitance and inductance of a resonant circuit are given as 0.5 F and 1 H . Calculate the resonant frequency of the circuit?

Answer:

## Given

$L=1 H$ and
$\mathrm{C}=0.5 \mathrm{~F}$

The formula for resonant frequency is
fo $=12 \pi \mathrm{LC} V$
fo $=12 \times 3.14 \times 1 \times 0.5 \mathrm{~V}$
$\mathrm{f}_{0}=\mathbf{0 . 2 2 5 1 H z}$

## MAXWELL BOLTZMANN FORMULA

Maxwell Boltzmann Formula clearly describes the distribution of energy between identical particles but which are distinguishable.

Maxwell Boltzmann Formula
$f(E)=1 A e E k T$
Where,
$\mathrm{f}=$ Energy distribution
$E=$ energy of the system
$\mathrm{k}=$ Boltzmannconstant $=1.38 \times 10-23 \mathrm{~m} 2 \mathrm{~kg} / \mathrm{sK} 2$
T = Absolute Temperature in Kelvin

## SPECIFIC HEAT FORMULA

Specific Heat is used when we are referring to something particular. Heat capacity is the ratio of the quantity of heat required to alter the temperature by one degree Celsius. But when we consider a certain amount of mass we make use of the word Specific Heat or Specific Heat Capacity.

Specific Heat is the quantity of heat essential to raise the temperature of a gram of any substance by 1 degree Celsius.

Specific Heat formula is articulated as
$C=\Delta Q m \Delta T$
Where,
$\Delta Q$ is the heat gained or lost
$\Delta \mathrm{T}$ is the temperature difference
m is the mass

The temperature difference is given by $\Delta T=\left(T_{f}-T_{i}\right)$, where the final temperature is $T_{f}$ and the initial temperature is $T_{i}$.

Specific Heat formula is made use of to find the specific heat of any given material, its mass, heat gained or temperature difference if some of the variables are given. It is articulated in Joule/Kg Kelvin (J/Kg K).

## Specific Heat Solved Examples

Underneath are some questions based on specific heat which will be useful for you.

Problem 1: Calculate the heat required to raise 0.6 Kg of sand from $30^{\circ} \mathrm{C}$ to $90^{\circ} \mathrm{C}$ ? (Specific Heat of sand $=830 \mathrm{~J} / \mathrm{Kg}^{\circ} \mathrm{C}$ )

## Answer:

Known:

Mass of sand $m=0.6 \mathrm{Kg}$,
$\Delta \mathrm{T}$ (Temperature difference) $=90^{\circ} \mathrm{C}-30^{\circ} \mathrm{C}=60^{\circ} \mathrm{C}$
C (Specific Heat of sand $)=830 \mathrm{~J} / \mathrm{Kg}^{\circ} \mathrm{C}$

The specific heat is given by, $C=\Delta Q m \Delta T$ Henceforth, Heat required is given by $Q=C m \Delta T$
$=830 \mathrm{~J} / \mathrm{Kg}^{\circ} \mathrm{C} \times 0.6 \mathrm{Kg} \times 60^{\circ} \mathrm{C}$
$=29880 \mathrm{~J}$.

Problem 2: Compute the temperature difference if 50 Kg of water absorbs 500 K J of heat?

## Answer:

Known:
$m$ (Mass) $=50 \mathrm{Kg}$,
$Q$ (Heat transfer) $=500 \mathrm{KJ}$,
C (Specific Heat of water) $=4.2 \times 10^{3} \mathrm{~J} / \mathrm{Kg}^{\circ} \mathrm{C}$

The temperature difference is given by:
$\Delta \mathrm{T}=\mathrm{QCm}=500 \times 1034.3 \times 103 \times 50$

## MAGNETIC FIELD IN A SOLENOID

## FORMULA

A coil of wire which is designed to generate a strong magnetic field within the coil is called a solenoid. Wrapping the same wire many times around a cylinder creates a strong magnetic field when an electric current is passed through it. N denotes the number of turns the solenoid has. More the number of loops, stronger is the magnetic field.

A solenoid is a type of electromagnet whose intention is to produce a controlled magnetic field. If the purpose of a solenoid is to impede changes in the electric current, it can be more specifically classified as an inductor.

The formula for the magnetic field of a solenoid is given by, $B=\mu \mathrm{O} N / \mathrm{L}$

Where,
$N$ = number of turns in the solenoid
I = current in the coil
$\mathrm{L}=$ length of the coil.
Please note that the magnetic field in the coil is proportional to the applied current and number of turns per unit length.

## Example 1

Determine the magnetic field produced by the solenoid of length 80 cm under the number of turns of the coil is $\mathbf{3 6 0}$ and the current passing through is 15 A .

## Solution:

Given:

Number of turns $\mathrm{N}=360$
Current $\mathrm{I}=15 \mathrm{~A}$

Permeability $\mu \mathrm{o}=1.26 \times 10^{-7} \mathrm{~T} / \mathrm{m}$
Length L $=0.8 \mathrm{~m}$

The magnetic field in a solenoid formula is given by,
$B=\mu \mathrm{olN} / \mathrm{L}$
$B=\left(1.26 \times 10^{-7} \times 15 \times 360\right) / 0.8$
$B=8.505 \times 10^{-4} \mathrm{~N} /$ Amps m
The magnetic field generated by the solenoid is $8.505 \times$ $10^{-4} \mathrm{~N} /$ Amps m .

## Example 2

A solenoid of diameter 40 cm has a magnetic field of $2.9 \times$ $10^{-5} \mathrm{~N} / \mathrm{Amps} \mathrm{m}$. If it has 300 turns, determine the current flowing through it.

Solution:

Given:

No of turns $\mathrm{N}=300$

Length L $=0.4$ m
Magnetic field $B=2.9 \times 10^{-5} \mathrm{~N} /$ Amps m
The magnetic field formula is given by
$B=\mu \mathrm{olN} / \mathrm{L}$
The current flowing through the coil is expressed by
$\mathrm{I}=\mathrm{BL} / \mu \mathrm{oN}$
$I=\left(2.9 \times 10^{-5} \times 0.4\right) /\left(1.26 \times 10^{-7} \times 300\right)$
I = 306 mA

## LINEAR SPEED FORMULA

The speed with which an object moves in the linear path is termed as Linear speed. In easy words, it is the distance covered for a linear path in the given time.

Linear Speed Formula is articulated as:
$v=\frac{\Delta s}{\Delta t}$
Where,
the distance travelled is $s$ and the time taken is $t$

Linear Speed Formula in the sense of angular speed is articulated as
$\mathrm{v}=\mathrm{wr}$

Where
the angular speed is $\omega$ and the radius of the circular path is $r$

The Linear speed formula is made use of to compute the linear speed of any given object if its angular velocity and radius of the circular path are provided. Linear speed is articulated in meter per speed (m/s).

## Linear Speed Solved Examples

Underneath are some problems based on linear speed which may be helpful for you.

Problem 1: A body starting from rest moves with the acceleration of $5 \mathrm{rad} \mathrm{s}^{-2}$ in a circle of radius 3 m . Compute the linear speed after 5 s .

## Answer:

Acceleration $\mathrm{a}=5 \mathrm{rads}^{-2}$
Radius $r=3 \mathrm{~m}$

Time $t=5 s$

The angular velocity is given by
$\omega=\omega_{0}+a t$
$=0+5(5)$
$=25 \mathrm{rads}^{-1}$

The linear speed is given by
$v=r \omega$
$=3 \mathrm{~m} \times 25 \mathrm{rad} \mathrm{s}^{-1}$
$\mathrm{v}=75 \mathrm{~m} / \mathrm{s}$.

Problem 2: Compute the linear speed of a body moving at 50 rpm in a circular path having a radius of 2 m ?

Answer:

## Given

Angular velocity $\omega=50 \mathrm{rpm}$
$50 \times \frac{\pi}{30}$
$\omega=5.237 \mathrm{rad} / \mathrm{s}$

Radius $r=2 \mathrm{~m}$

The linear speed is given by
$v=r \omega$
$\mathrm{v}=2 \mathrm{~m} \times 5.237 \mathrm{rad} / \mathrm{s}$
$v=10.473 \mathrm{~m} / \mathrm{s}$

## STRESS FORMULA

We all come in touch with the word stress in our day-to-day life when some external thing has an impact on our state of mind. Likewise in Physics, stress is the external restoring force acting on per unit area.

Stress is denoted by $\sigma$. It is represented as $\mathbf{N} / \mathbf{m}^{2}$.
Stress formula is articulated as
$\sigma=\frac{F}{A}$
Where,
$\sigma=\operatorname{Stress}\left(\mathbf{N} / \mathrm{m}^{2}\right)$
F =Force applied
$A=A r e a$ on which force is acting
Stress formula is made use of to find stress applied on any given body if force and area on which force is exerted is given in the problem.

## Stress Solved Examples

Underneath are problems based on stress which may be useful for you.

Problem 1: Find the stress if a force of 50 N is acting on an area of $5 \mathrm{~mm}^{2}$ ?

Answer:

Given: Force F = 50 N ,
Area $\mathrm{A}=5 \mathrm{~mm}^{2}$
Stress, $\sigma=\frac{F}{A}$
$\sigma=\frac{50}{5 \times 10^{-6}}$
$\sigma=10 \times 10^{6} \mathrm{~N} / \mathrm{m}^{2}$
Problem 2: An elastic spring is given a force of 1000 N over an area of $0.2 \mathrm{~m}^{2}$. Calculate the stress?

## Answer:

Known:
$F$ (Force) $=1000 \mathrm{~N}$,
A (Area) $=0.2 \mathrm{~m}^{2}$
$\sigma=\frac{F}{A}$
$=\frac{1000 \mathrm{~N}}{0.2}$
$\sigma=5000 \mathrm{~N} / \mathrm{m}^{2}$

## DRAG FORCE FORMULA

## Drag Force Formula

Drag Force (D) is defined as the force that resists the motion of a body with fluid. If the motion of the body exists in the fluid-like air it is known as aerodynamic drag. And, if the fluid is water it is known as hydrodynamic drag. The drag force always acts in the opposite direction to the flow of fluid.

## Drag Coefficient Formula

Following is the formula used to calculate the drag coefficient:

## $\mathrm{D}=\mathrm{Cd} * \rho * \mathrm{~V} \underline{2} \mathrm{~A} \underline{2}$

Where,

- $C_{d}$ is the drag coefficient
- $\rho$ is the density of the medium in $\mathrm{kg} \cdot \mathrm{m}^{-3}$
- $V$ is the velocity of the body in $\mathrm{km} \cdot \mathrm{h}^{-1}$
- $A$ is the cross-sectional area in $\mathrm{m}^{2}$


## Solved Examples

Question 1. A car travels with a speed of $80 \mathrm{~km} . \mathrm{h}^{-1}$ with a drag coefficient of 0.25 . If the cross-sectional area is $6 \mathrm{~m}^{2}$, calculate the drag force.

## Solution:

Given:
Velocity, $\mathrm{V}=80 \mathrm{~km} \cdot \mathrm{~h}^{-1}$
Drag coefficient, $\mathrm{C}_{\mathrm{d}=} 0.25$
Cross-sectional area, $A=6 \mathrm{~m}^{2}$
Density of fluid, $\rho=1.2 \mathrm{~kg} \cdot \mathrm{~m}^{-3}$
The drag force is given as:
$D=C d * \rho * V \underline{2 A} \underline{2} D=\underline{0.25} * 1.2 * \underline{6400} * \underline{62 * 3600}$
$\mathrm{D}=1.6 \mathrm{~N}$

Question 2. A plane moves with the velocity of $600 \mathrm{~km} . \mathrm{h}^{-1}$ with a drag coefficient of 0.25 . If the cross-sectional area of the plane is $110 \mathrm{~m}^{2}$, calculate the drag force.

## Solution:

## Given:

Velocity, $\mathrm{V}=600 \mathrm{~km} . \mathrm{h}^{-1}$

Drag coefficient, $\mathrm{Cd}=0.25$
Density of fluid, $\rho=1.2 \mathrm{~kg} \cdot \mathrm{~m}^{-3}$
Cross-sectional area, $A=110 \mathrm{~m}^{2}$

The drag force is given as:
$\mathrm{D}=\mathrm{Cd} * \rho * \mathrm{~V} \underline{2} \mathrm{~A} \underline{2}$
$D=\underline{0.25} * \underline{1.2} \mathrm{kgm} \underline{2360000 \mathrm{mkm} 110 \mathrm{~m} \underline{22} * \underline{3600}}$
$\mathrm{D}=1650 \mathrm{~N}$

## Heat Index Formula

The Heat Index $(\mathrm{HI})$ is an equation combining air temperature and relative humidity to determine the equivalent temperatur e experienced by humans.

The heat index formula is based upon the temperature and relative humidity to indicate the air temperature perceived by the body. For instance, if the temperature is $32^{\circ} \mathrm{C}$ and $70 \%$ relative humidity, the heat index is $41^{\circ} \mathrm{C}$. This heat index has an implied humidity of $20 \%$. It's the value of the relative humidity for which the heat index formula shows $41^{\circ} \mathrm{C}$. A heat index temperature of $32^{\circ} \mathrm{C}$ holds implied relative humidity of 38\%.

The heat index formula is expressed as,
The heat index formula is expressed as,

$$
H I=c_{1}+c_{2} T+c_{3} R+c_{4} T R+c_{5} T_{2}+c_{6} R_{2}+c_{7} T_{2} R+c_{8} T R_{2}+c_{9} T_{2} R_{2}
$$

In this formula,
$\mathrm{HI}=$ heat index in degrees Fahrenheit
$R=$ Relative humidity
$\mathrm{T}=$ Temperature in $\circ \mathrm{F}$
$\mathrm{C}_{1}=-42.379$
$c_{2}=-2.04901523$
$c_{3}=-10.14333127$
$c_{4}=-0.22475541$
$c_{5}=-6.83783 \times 10^{-3}$
$\mathrm{C}_{6}=-5.481717 \times 10^{-2}$
$c_{7}=-1.22874 \times 10^{-3}$
$\mathrm{c}_{8}=8.5282 \times 10^{-4}$
$c_{9}=-1.99 \times 10^{-6}$
It is found that whenever HI values exceed above $40^{\circ} \mathrm{C}$ during different temperature and humidity ranges, there is a threat of heatstroke.
Example ..... 1
Determine the heat index if the temperature is $197 \circ \mathrm{~F}$ andthe relative humidity is $80 \%$.
Solution:
Given:
T ..... =
$R=80 \%$
Substituting the values in the given formula,
$H I=c_{1}+c_{2} T+c_{3} R+c_{4} T R+c_{5} T_{2}+c_{6} R_{2}+c_{7} T_{2} R+c_{8} T R_{2}+c_{9} T_{2} R_{2}$
Heat Index (HI) $=1410.25^{\circ} \mathrm{F}$

Therefore, the heat index is 1410.25 Fahrenheit.

## Example 2

Determine the heat index for the relative humidity of $86 \%$ and the temperature of 850C.

Solution:

Given:

| T | $=$ |
| :--- | ---: |
| $\mathrm{T}=$ | $85^{\circ} \mathrm{C}$ |
| $\mathrm{R}=86 \%$ | $185^{\circ} \mathrm{F}$, |

Substituting the values in the given formula, $H I=C_{1}+c_{2} T+c_{3} R+c_{4} T R+c_{5} T_{2}+c_{6} R_{2}+c_{7} T_{2} R+c_{8} T R_{2}+c_{9} T_{2} R_{2}$

Heat Index $=1273.47{ }^{\circ} \mathrm{F}$

## INSTANTANEOUS SPEED FORMULA

The speedometer gives the record of speed for each instant of time. This gives the illustration of instantaneous speed. Instantaneous speed is the speed of a particle in the movement at any desired instant of time. Its formula is articulated as
$S_{\text {inst }}=\lim _{\lim _{t \rightarrow T}} \frac{d x}{d t}$
Where,

- t is the time taken
- x is the displacement

Instantaneous speed formula

It is made use of to calculate the rate of change of displacement for any given instant of time. It is articulated in meter per second (m/s).

Instantaneous Speed Solved Examples

Below are some problems based on instantaneous speed which may be helpful for you.

Problem 1: A particle experiences the displacement given by the function $x(t)=10 t^{2}-5 t+1$. Compute its instantaneous speed at time $t=3 \mathrm{~s}$.

## Answer:

## Given :

The function is given by $x(t)=10 t^{2}-5 t+1$
$t=3 s$

The instantaneous speed is given by

$$
\begin{aligned}
& S_{\text {inst }}=\lim _{\lim _{t \rightarrow T}} \frac{d x}{d t} \\
& \lim _{t \rightarrow 3} \frac{d\left(10 t^{2}-5 t+1\right)}{d t} \\
& \lim _{t \rightarrow 3}(20 t-5) \\
& \mathrm{S}_{\text {inst }}=(20(3)-5) \\
& \mathrm{S}_{\text {inst }}=60-5 \\
& \mathrm{~s}_{\text {inst }}=55 \mathrm{~m} / \mathrm{s}
\end{aligned}
$$

## CHARGE DENSITY FORMULA

The charge density is the measure of electric charge per unit area of a surface, or per unit volume of a body or field.

The charge density tells us how much charge is stored in a particular field. Charge density can be determined in terms of volume, area or length.

Depending on the nature of the surface charge density is given as the following

Linear Charge Density
$\lambda=q / l$
Where $q$ is the charge and $I$ is the length over which it is distributed
S.I unit of Linear charge density is coulomb/m

Surface Charge Density
$\sigma=q / A$
where $q$ is the charge and $A$ is the area over which it is distributed
S.I unit of Linear charge density is coulomb/ $/ m^{2}$

Volume Charge Density
$\rho=q / v$
where q is the charge and V is the volume over which it is distributed
S.I unit of Linear charge density is coulomb $/ m^{3}$

## Solved Example

Find the charge density if a charge of 8 C is present in a cube of $4 \mathrm{~m}^{3}$

## Solution

Given :

Charge $\mathrm{q}=8 \mathrm{C}$
Volume $\mathrm{v}=4 \mathrm{~m}^{3}$
The charge density formula is given by
$\rho=q / v$
$=8 / 4$
Charge density $\rho=2 \mathrm{C} / \mathrm{m}^{3}$

## WIND ENERGY FORMULA

Wind energy is a kind of solar energy. Wind energy describes the process by which wind is used to produce electricity. The wind turbines convert the kinetic energy present in the wind to mechanical power.

Wind energy is a renewable source of energy that determines the total power in the wind. The wind turbines which convert kinetic energy to mechanical power, wherein the mechanical power is converted into electricity which acts as a useful source.

The wind energy formula is given by,
$P=\frac{1}{2} \rho A V^{3}$
Where,
$P$ = power,
$\rho=$ air density,
$\mathrm{A}=$ swept area of blades given by $A=\pi r^{2}$
where $r$ is the radius of the blades.
$\mathrm{V}=$ velocity of the wind.

## Example 1

Determine the power in the wind if the wind speed is $20 \mathrm{~m} / \mathrm{s}$ and blade length is 50 m .

## Solution:

Given:

Wind speed $v=20 \mathrm{~m} / \mathrm{s}$,
Blade length $\mathrm{I}=50 \mathrm{~m}$,

Air density $\rho=1.23 \mathrm{~kg} / \mathrm{m}$.
The area is given by, $A=\pi r^{2}$
$A=\pi \times 2500$
$=7850 \mathrm{~m}$

The wind power formula is given as,
$P=\frac{1}{2} \rho A V^{3}$
$P=\frac{1}{2}(1.23)(7850) 20^{3}$
P = 38622 W

Example 2

A wind turbine travels with the speed is $10 \mathrm{~m} / \mathrm{s}$ and has a blade length of 20 m . Determine wind power.

Solution:

Given:

Wind speed $v=10 \mathrm{~m} / \mathrm{s}$,

Blade length $\mathrm{I}=20 \mathrm{~m}$,
air density $\rho=1.23 \mathrm{~kg} / \mathrm{m} 3$,
area , $A=\pi r^{2}$

$$
\begin{aligned}
& =\pi \times 400 \\
& =1256 \mathrm{~m}^{2}
\end{aligned}
$$

The wind power formula is given as,

$$
P=\frac{1}{2} \rho A V^{3}
$$

$=0.5 \times 1.23 \times 1256 \times 1000$
$P=772440 \mathrm{~W}$.

## TORQUE FORMULA

When we take a wrench and fix a bolt; the force exerted alters the rotational moment along an axis. This is what is termed as Torque.

Torque is described as the turning effect of force on the axis of rotation. In brief, it is a moment of force. It is characterized by $\tau$.

Torque formula is articulated as
$\tau=F \times d$
Where,
Force applied = F
From the axis of rotation the perpendicular distance of force $=$ d

The Magnitude of torque is articulated as
$\tau=F d \sin \theta$
Where $\theta$ is the angle between the force applied and the axis of rotation.

The SI unit for torque is Newton-meter (Nm).

## Torque Solved Examples

Underneath are some problems on torque which gives one an idea of how to calculate the terminologies related to torque.

Problem 1: The width of a door is 40 cm . If it is released by exerting a force of 2 N at its edge (away from the hinges).Compute the torque produced which causes the door to open.

## Answer:

Force applied $=\mathrm{F}=2 \mathrm{~N}$
Length of lever arm $=d=40 \mathrm{~cm}$

Torque $=0.40 \mathrm{~m}$ (as distance amid the line of action of force and axis of rotation is 40 cm )

Torque $=\mathrm{F} \times \mathrm{d}$
$=0.40 \times 20$
Torque $=8 \mathrm{Nm}$.

Problem 2: The Classroom door is of width 50 cm . If the Handle of the door is 20 cm from the edge and the Force of 5 N is applied on the handle. Compute the torque.

## Answer:

The handle of the door is located at 20 cm . Thus, the line of action is $20 / 2=10 \mathrm{~cm}$.

Measurement of the lever arm $=\mathrm{d}=50-10=40 \mathrm{~cm}=0.4 \mathrm{~m}$
Force exerted $=2 \mathrm{~N}$
Torque $=\mathrm{F} \times \mathrm{d}$
$=2 \times 0.4$
Torque $=0.8 \mathrm{Nm}$.

## HEAT OF REACTION FORMULA

The heat of reaction which is also known as Reaction Enthalpy that is the difference in the enthalpy of a specific chemical reaction that is obtained at a constant pressure. It is the thermodynamic unit of measurement applied in measuring the total amount of energy per mole either produced or released in a reaction.

Heat of a chemical reaction can therefore be defined as the heat evolved in the surroundings or absorbed when the reaction takes place at constant pressure and temperature. The total amount of heat absorbed or evolved is measured in Joule (J). Mostly heat transfer takes place between the reacting system as one medium and surrounding as the other in chemical reactions.

Please note that the amount of heat energy before and after the chemical change remains same. In other words, the heat
lost or gained in a reacting system is equal to heat lost or gained in the surrounding.

Therefore, the heat of reaction formula is given by
$Q=m c \Delta T$

Where,
$m$ is the mass of the medium,
$c$ is the specific heat capacity of the medium,
$\Delta T$ is the difference in temperature of the medium.

## Example 1

Calculate the heat change which accompanies the combustion of ethanol when a certain mass of a substance is burnt in air to raise the temperature of $\mathbf{2 0 0 g}$ of water initially at $28^{\circ} \mathrm{C}$ to $42^{\circ} \mathrm{C}$, given that the specific heat capacity of water is $4.2 \mathrm{Jg}^{-1} \mathrm{~K}^{-1}$.

Solution:

Given parameters are
$\mathrm{m}=200 \mathrm{~g}$
$\mathrm{c}=4.2 \mathrm{Jg}^{-1} \mathrm{~K}^{-1}$
$\Delta T=42-28$
$\Delta T=14^{\circ} \mathrm{C}$ or 14 K

According to the question, a certain mass of ethanol is burnt to raise the temperature of water, which means heat absorbed by water is evolved from the combustion reaction of ethanol.

Heat lost in the combustion reaction is equal to heat gain by water.

Quantity of heat changed can be given by
$Q=m c \Delta T$
$Q=200 \times 4.2 \times 14$

Therefore, $\mathrm{Q}=11760 \mathrm{~J}$

## Example 2:

If Sodium chloride is dissolved in 100 g of water at $25^{\circ} \mathrm{C}$, the solution obtained after proper stirring have a temperature of $21^{\circ} \mathrm{C}$. Determine the heat change during the process of dissolution if a specific heat capacity of the solution is assumed to be $4.18 \mathrm{Jg}-1 \mathrm{~K}-1$.

Solution:

Given parameters are,
$m=100 \mathrm{~g}$
$\mathrm{c}=4.18 \mathrm{~J} \mathrm{~g}-1 \mathrm{~K}-1$
$\Delta T=25-21$
$=4 \mathrm{~K}$

The process involves drop in temperature which indicates that dissolution of salt absorbed heat from the system.

Since Heat absorbed by the salt is equal to Heat lost by water

We have the formula,
$Q=m C \Delta T$
$Q=100 \times 4.18 \times 4$
Therefore, $\mathbf{Q}=\mathbf{- 1 6 7 2} \mathrm{J}$

## SPRING CONSTANT FORMULA

According to Hooke's law, the force required to compress or extend a spring is directly proportional to the distance it is stretched.

Spring Constant Formula
The formula of spring constant is given as:

Formula

$$
F=-k x
$$

SI unit
N. $\mathrm{m}^{-1}$

Where,

- $F$ is the restoring force of the spring directed towards the equilibrium
- $k$ is the spring constant in N.m ${ }^{-1}$
- x is the displacement of the spring from its equilibrium position

In other words, the spring constant is the force applied if the displacement in the spring is unity. If a force F is considered that stretches the spring so that it displaces the equilibrium position by x .

Spring Constant Dimensional Formula

We know that, $F=-k x$

Therefore, $\mathrm{k}=-\mathrm{Fx}$
Dimension of $\mathrm{F}=\left[\mathrm{MLT}^{-2}\right]$

Dimension of $x=[L]$

Therefore, dimension of $\mathrm{k}=\mathrm{k}=-[\mathrm{MLT}-\underline{2}][\mathrm{L}]=-[\mathrm{MT}-\underline{2}]$


The Spring Constant Formula is given as, k=-Fx where,

- F = Force applied,
- $\mathbf{x}=$ displacement by the spring
- The negative sign shows that the restoring force is opposite to the displacement

It is expressed in Newton per meter ( $\mathrm{N} / \mathrm{m}$ ).

Solved Examples

Example 1 A spring with load 5 Kg is stretched by 40 cm .
Determine its spring constant.
Solution:
Given:
Mass m = 5 Kg

Displacement $\mathrm{x}=40 \mathrm{~cm}$

We know that,

Force $F=m a=5 \times 0.4=2 N$
The spring constant is given as:
$\mathrm{k}=-\mathrm{Fx}$
$=-2 / 0.4=-5 \mathrm{~N} / \mathrm{m}$
Example 2 A boy weighing 20 pounds stretches a spring by 50 cm . Determine the spring constant of the spring.

## Solution:

## Given:

Mass $m=20 \mathrm{lbs}=20 / 2.2=9.09 \mathrm{Kg}$

Displacement $\mathrm{x}=50 \mathrm{~cm}$
The force $\mathrm{F}=\mathrm{ma}=9.09 \times 9.8=89.082 \mathrm{~N}$

The spring constant formula is given by: $\mathrm{k}=-\mathrm{Fx}$
$=-89.082 / 0.5=-178.164 \mathrm{~N} / \mathrm{m}$.

## ENERGY MOMENTUM FORMULA

Consider a particle or macroscopic body having mass $m_{0}$ having the momentum of magnitude $p$ and total energy $E$, the Energy-momentum formula is given by
$E=(p 2 c 2)+(m 0 c 2) 2------------\quad-\quad$ -
Where:

E = Energy
$\mathrm{p}=$ momentum
C = speed of light
$\mathrm{m0}=$ rest mass

## ANGULAR VELOCITY FORMULA

Angular velocity is a vector quantity and is described as the rate of change of angular displacement which specifies the angular speed or rotational speed of an object and the axis about which the object is rotating. The amount of change of angular displacement of the particle at a given period of time is called angular velocity. The track of the angular velocity vector is vertical to the plane of rotation, in a direction which is usually indicated by the right-hand rule. It is articulated as
$\omega=\frac{d \Theta}{d t}$
Where,

- $\mathrm{d} \theta$ is the change in angular displacement
- $d t$ is the change in time $t$

Relationship Between Angular Velocity and Linear Velocity
The Angular Velocity and Linear Velocity is articulated by the formula
$\omega=\frac{v}{r}$
where,

- v is the linear velocity
- $r$ is the radius of the circular path

Angular velocity is articulated in radian per second (rad/s).
Angular Velocity formula is used to compute the angular velocity of any moving body.

## Angular Velocity Numericals

## Solved Example

Problem 1: Calculate the angular velocity of a particle moving along the straight line given by $\theta=3 t^{3}+6 t+2$ when $t=5 s$.

## Answer:

## Given:

$\theta=3 t^{3}+6 t+2$
$t=5 \mathrm{~s}$

The angular velocity is given by $\omega=\frac{d \Theta}{d t}=9 t^{2}+6$
$\omega=9\left(5^{2}\right)+6$
$\omega=225+6$
$\omega=231$ units/sec

## ANGULAR SPEED

Angular speed is the measure of how fast the central angle of a rotating body changes with respect to time. In this short piece of article, let us learn more angular speed formula, the relationship between angular speed and linear speed along with a few angular speed problems.

What is Angular Speed?
Angular speed is defined as the rate of change of angular displacement and is given by the expression
$\omega=\theta t$
where $\theta$ is the angular displacement
t is the time
$\omega$ is the angular speed

The unit of angular speed is radian per second. Both angular speed and angular velocity are represented by the same formula. But it should be noted that angular velocity is different from the angular speed. Angular velocity is a vector quantity that expresses both direction and magnitude while angular speed expresses the magnitude only.

## Angular Speed Formula

A scalar measure of rotation rate is known as Angular Speed $(\omega)$. In one complete rotation, angular distance travelled is $2 \pi$ and time is time period $(T)$ then, the angular speed is given by,

AngularSpeed $=\underline{2} \pi$ T.
From the above equation, we can concur that $\omega$ is equivalent to $2 \pi f$, where $1 / T$ is equivalent to $f$ (frequency).

Thus, the rotation rate is also articulated as an angular frequency.

$$
\text { Average speed }=\frac{\text { Distance }}{\text { Time }}=\frac{\text { Circumference }}{\text { Time }}
$$

Relationship Between Angular Speed and Linear Speed
Let the object be traveling in a round path of radius $r$ and angular displacement be $\theta$ then we have, angle, $\theta=\operatorname{arc} /$ radius


We know that linear speed, $\mathbf{V}=\mathbf{S} / \mathbf{t}$,
where $S$ is linear displacement of arc, and
$\theta=S / r$
Thus, linear speed $V=(\theta \cdot r) / t$
$=r .(\theta / t)$
$V=r \omega$

Hence, Angular speed,
$\omega=\mathrm{V} / \mathrm{r}$
Where V is equivalent to the linear speed

This is the relation amongst angular speed, linear speed, and radius of the circular path.

From this relation, one can compute this speed.

Angular Speed of Earth

Our Earth takes about 365.25 days to finish one revolution around the Sun, now translate days into seconds,
$\mathrm{T}=365.25 \times 24 \times 60 \times 60=31557600$ seconds
Angular speed $=2 \pi / T$
Therefore,
Hence,
$\omega=1.99 \times 10^{-7}$ radians /seconds .

Unit of Angular Speed
Angular Speed is articulated as,
$\omega=\mathrm{V} / \mathrm{r}$
Where,
linear speed is equivalent to $V$
the radius of the circular path is equivalent to $r$
We get linear speed,
$V=r .(\theta / t)$
$\therefore \omega=(\theta / \mathrm{t})$
$\theta$ is articulated in radians.
So the elementary unit for this Speed is Radians per second or rps or rad/s.

## ANGULAR DISPLACEMENT

In physics, Curvilinear motion is an unavoidable part. The motion of an object along a curved path is studied under circular motion or curvilinear motion. In the case of linear motion, the difference between the initial point and final point is termed as displacement. Thus the circular motion equivalence of displacement is Angular displacement. Represented using Greek letter $\theta$. Measured using the unit degree or radian.

## Angular Displacement Definition

Angular displacement is defined as "the angle in radians (degrees, revolutions) through which a point or line has been rotated in a specified sense about a specified axis". It is the angle of the movement of a body in a circular path.

What Is Angular Displacement?
It is the angle made by a body while moving in a circular path. Before we go any further into the topic, we have to understand what is meant by rotational motion. When a rigid body is rotating about its own axis, the motion ceases to become a particle. It is so because in a circular path velocity and acceleration can change at any time. The rotation of rigid bodies or bodies which will remain constant throughout the duration of rotation, over a fixed axis is called rotational motion.

The angle made by the body from its point of rest at any point in the rotational motion is the angular displacement.


For example- If a dancer dancing around a pole does one full rotation; his or her angular rotation will be $\underline{360}^{\circ}$. On the other hand, he or she makes half a rotation; the displacement will be $1800^{\circ}$.

It is a vector quantity, which means that it has both magnitude and direction.

For example, an displacement of $360^{\circ}$, clockwise is very different from $360^{\circ}$, counter-clockwise.

## Unit Of Angular Displacement

The unit for this is Radian or Degrees. Two pi radian equals to $360^{\circ}$. The SI unit of displacement is meter. But the as angular displacement involves curvilinear motion. An SI unit of angular displacement is Radian or Degrees.

Measurement of Angular Displacement

## Angular displacement



It can be measured by using a simple formula. The formula is:
$\theta=s r$, where,
$\theta$ is the angular displacement,
$s$ is the distance travelled by the body, and
$r$ is the radius of the circle along which it is moving.
In simpler words, the displacement of object is the distance travelled by it around the circumference of a circle divided by its radius.

## ANGULAR MOMENTUM

Momentum is the product of mass and the velocity of the object. Any object moving with mass possesses momentum. The only difference in angular momentum is that it deals with rotating or spinning objects. So is it the rotational equivalent of linear momentum?

## What is Angular Momentum?

If you try to get on a bicycle and try to balance without a kickstand you are probably going to fall off. But once you start pedalling, these wheels pick up angular momentum. They are going to resist change, thereby balancing gets easier.

Angular momentum is defined as:

The property of any rotating object given by moment of inertia times angular velocity.

It is the property of a rotating body given by the product of the moment of inertia and the angular velocity of the rotating object. It is a vector quantity, which implies that here along with magnitude, direction is also considered.

The angular momentum is a vector

## Symbol

quantity, denoted by $\mathrm{L}^{\rightarrow}$

Units
It is measured using SI base units: $\mathrm{Kg} \cdot \mathrm{m}^{2} \cdot \mathrm{~s}^{-1}$

Dimensional
formula
The dimensional formula is: $[\mathrm{M}][\mathrm{L}]^{2}[T]^{-1}$

## Angular Momentum Formula

Angular momentum can be experienced by an object in two situations. They are:

Point object: The object accelerating around a fixed point. For example, Earth revolving around the sun. Here the angular momentum is given by:
$\stackrel{\rightharpoonup}{C}=r \times p \rightarrow$

Where,

- $\quad L^{\rightarrow}$ is the angular velocity
- $r$ is the radius (distance between the object and the fixed point about which it revolves)
- $\overrightarrow{p^{-}}$is the linear momentum.

Extended object: The object, which is rotating about a fixed point. For example, Earth rotating about its axis. Here the angular momentum is given by:
$\vec{L}=\mid \times \omega \vec{~}$

Where,

- $L^{\rightarrow}$ is the angular momentum.
- I is the rotational inertia.
- $\omega^{\overrightarrow{ }}$ is the angular velocity.


Angular Momentum Formula

Angular Momentum Quantum Number

Angular momentum quantum number is synonymous to Azimuthal quantum number or secondary quantum number. It is a quantum number of an atomic orbital which decides the angular momentum and describes the size and shape of the orbital. The typical value ranges from $\mathbf{0}$ to 1.

Angular Momentum and Torque
Consider the same point mass attached to a string, the string is tied to a point, and now if we exert a torque on the point mass, it will start rotating around the centre,


The particle of mass $m$ will travel with a perpendicular velocity $\mathrm{V} \perp$ which is the velocity that is perpendicular to the radius of the circle; $r$ is the distance of the particle for the centre of its rotation. The magnitude of $L \rightarrow$ is given by:

$$
\begin{aligned}
L & =r m v \sin \varphi \\
& =r p \perp \\
& =r m v \perp
\end{aligned}
$$

$=r \perp p$
$=r \perp m v$

Where,

- $\Phi$ is the angle between $r \rightarrow$ and $p \rightarrow$
- $\mathrm{p} \perp$ and $\mathrm{v} \perp$ are the components of $\mathrm{p} \rightarrow$ and $\mathrm{v} \rightarrow$ perpendicular to $r \rightarrow$.
- $r \perp$ is the perpendicular distance between the fixed point and the extension of $p \rightarrow$.

Notice the equation $L=r \perp m v$ the angular momentum of the body only changes when there is a net torque applied on it. So, when there is no torque applied, the perpendicular velocity of the body will depend upon the radius of the circle. I.e. the distance from the centre of mass of the body to the centre of the circle. Thus,

1. for shorter radius, velocity will be high.
2. for higher radius, velocity will be low. as to conserve the angular momentum of the body.

Right-Hand Rule


Right-Hand Rule
The direction of angular momentum is given by the right-hand rule, which states that:

- If you position your right hand such that the fingers are in the direction of $r$.
- Then curl them around your palm such that they point towards the direction of Linear momentum(p).
- The outstretched thumb gives the direction of angular momentum(L).


## Examples of Angular Momentum

We knowingly or unknowingly come across this property in many instances. Some examples are explained below.

## Ice-skater

When an ice-skater goes for a spin she starts off with her hands and legs far apart from the centre of her body. But when she needs more angular velocity to spin, she gets her hands and leg closer to her body. Hence, her angular momentum is conserved and she spins faster.

## Gyroscope

A gyroscope uses the principle of angular momentum to maintain its orientation. It utilises a spinning wheel which has 3 degrees of freedom. When it is rotated at high speed it locks on to the orientation, and it won't deviate from its orientation. This is useful in space applications where the attitude of a spacecraft is a really important factor to be controlled.

Angular Momentum Questions (FAQs)
Q1: Calculate the angular momentum of a pulley of $\mathbf{2} \mathbf{~ k g}$, radius 0.1 m , rotating at a constant angular velocity of 4 rad/sec.

Ans: Substitute the given values like $\mathrm{m}=2 \mathrm{~kg}$ and $\mathrm{r}=0.1 \mathrm{~m}$ in $\mathrm{I}=1 / 2 \mathrm{mr}^{2}$ (formula of the moment of inertia) we get $\mathrm{I}=0.01$ kg.m ${ }^{2}$

Angular momentum is given by $\mathrm{L}=\mathrm{I} \omega$, thus, substituting the values we get $\mathrm{L}=0.04 \mathrm{~kg} . \mathrm{m}^{2} . \mathrm{s}^{-1}$.

Q2: Give the expression for Angular momentum.
Ans: $\vec{L}^{\vec{\prime}}=1 \times \omega$ or $\overrightarrow{L^{\prime}}=r \times p^{\vec{\prime}}$
Q3: For an isolated rotating body, how are angular velocity and radius related?

Ans: For an isolated rotating body angular velocity is inversely proportional to the radius.

Q5: Write the dimensional formula for Angular momentum.
Ans: The dimensional formula is $\mathrm{ML}^{2} \mathrm{~T}^{-1}$

Q6: When an ice-skater goes for a spin, what happens to her spinning speed when she stretches her hands?

Ans: Spinning speed reduces.
Q7: How can an ice-skater increase his/her spinning speed?

Ans: By bringing hands closer, thus reducing the radius increases the angular velocity.

Q8: If the moment of inertia of an isolated system is halved.
What happens to its angular velocity?
Ans: Angular velocity will be doubled.
Q9: Calculate the angular moment of the object. When an object with the moment of inertia $\mathrm{I}=\mathbf{5} \mathbf{~ k g} \cdot \mathrm{m}^{\mathbf{2}}$ is made to rotate 1 rad/sec speed.

Ans: Substituting the given value in formula $\mathrm{L}=\| \omega$ we get $\mathrm{L}=5 \mathrm{~kg} . \mathrm{m}^{2} . \mathrm{s}^{-1}$.

## BERNOULLIS EQUATION FORMULA

## What is Bernoulli's equation?

Water in a hydraulic system exhibits two types of energy kinetic and potential. Kinetic energy is when water is in motion and potential is when there is water pressure. The sum of both kinetic and potential forms is the total energy of water. According to Bernoulli's principle, the total energy of the liquid remains constant and hence when water flows in a system increases, the pressure must decrease.

Bernoulli's principle states that for an inviscid flow of a nonconducting fluid, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or decrease in the potential energy. Bernoulli's principle can be applied to various types of liquid flow, resulting in what is denoted as Bernoulli's equation. The simple form of Bernoulli's principle is applicable for incompressible flows.

## Bernoulli's Equation Formula

Following is the formula of Bernoulli's equation:

## $\mathrm{P}+\underline{12} \rho \mathrm{v} \underline{2}+\rho g h=$ constant

Where,

- $P$ is the pressure
- $v$ is the velocity of the fluid
- $\rho$ is the density of the fluid
- $h$ is the height of the pipe from which the fluid is flowing


## POTENTIAL ENERGY OF A SPRING

## FORMULA

In the usual position (i.e., when not stretched), there is no energy in the spring. But, when the position is altered from its usual position, the spring is able to store energy by the virtue of its position. This stored energy is known as potential energy. The potential energy of the spring is the potential energy stored as a result of deformation of a particular elastic object, or a spring. It describes the work done to stretch the spring and depends on the spring constant k and the distance stretched.

The Potential energy of a spring is given by, $P . E=1 / 2 k x^{2}$

Where,
$\mathrm{k}=$ spring constant
x = spring displacement

Example 1: Determine the potential energy of a spring whose spring constant is $200 \mathrm{~N} / \mathrm{m}$ and the displacement is 0.8 m .

Solution:

Given parameters are
$\mathrm{k}=200 \mathrm{~N} / \mathrm{m}$
$x=0.8 m$

Potential energy of a string formula is given by
P.E $=1 / 2 k x^{2}$
$P . E=1 / 2\left(200 \times(0.8)^{2}\right)$
$P . E=64 \mathrm{~J}$

Example 2: The spring constant and displacement of a
stretched string is $100 \mathrm{~N} / \mathrm{m}$ and 0.5 m respectively. Determine the potential energy stored in the stretched string.

## Solution:

Given parameters are
$\mathrm{k}=100 \mathrm{~N} / \mathrm{m}$
$x=0.5 m$

Potential energy of a string formula is given by,
P.E $=1 / 2 k x^{2}$
$P . E=1 / 2 \times\left(100 \times(0.5)^{2}\right)$
$P . E=12.5 \mathrm{~J}$

## SOUND PRESSURE LEVEL FORMULA

Sound pressure is the pressure applied by the sound waves. The sound pressure level is the ratio of the actual sound pressure and the reference level which is the lowest intensity sound that can be heard by maximum people. In other words, a sound pressure level decides the amount of pressure on the sound. It provides the logarithmic measures of rms value of the sound pressure to the reference value of the sound.

It is expressed in (dB).

The sound pressure level formula is expressed by
$L_{p}=20 \log _{10}\left(p_{\text {rms }} / p_{\text {ref }}\right)$
Where,
$P_{r m s}=$ root mean square sound pressure in Pa ,
$\mathrm{p}_{\text {ref }}=$ reference sound pressure in $\mathrm{P}_{\mathrm{a}} .\left(20 \mu \mathrm{P}_{\mathrm{a}}\right)$

Example 2: Determine the sound pressure level if the rms pressure value is given as $30 \mu \mathrm{P}$.

Solution:

Given
$\mathrm{P}_{\mathrm{rms}}=30 \mu \mathrm{P}_{\mathrm{a}}$
$\mathrm{p}_{\text {ref }}=20 \mu \mathrm{P}_{\mathrm{a}}$

The sound pressure level formula is given by
$L_{p}=20 \log _{10}\left(p_{\text {rms }} / p_{\text {ref }}\right)$
$L_{p}=20 \log 10(30 / 20)$
$L_{p}=3.52 \mathrm{~dB}$

## INSTANTANEOUS VELOCITY

## FORMULA

Let us imagine a cyclist riding; his velocities differ unceasingly dependent on distance, time etc. At one particular moment if we want to find his velocity it's not anything but instantaneous velocity. Instantaneous Velocity Formula is made use of to determine the instantaneous velocity of the given body at any specific instant. It is articulated as:

InstantaneousVelocity $=\lim \Delta t \rightarrow 0 \Delta x \Delta t=d x d t$
Wherewith respect to time $\mathbf{t}, \mathbf{x}$ is the given function. The Instantaneous Velocity is articulated in $\mathbf{m} / \mathbf{s}$. If any numerical contains the function of form $f(x)$, the instantaneous velocity is calculated using the overhead formula.

Underneath are some numerical grounded on the instantaneous velocity which aids in understanding the formula properly.

Problem 1: Calculate the Instantaneous Velocity of a particle traveling along a straight line for time $t=3 s$ with a function $x$ $=5 t^{2}+2 t+3$ ?

## Answer:

Given: The function is $x=5 t^{2}+2 t+32 t$
Distinguishing the given function with respect to $t$, we get Instantaneous Velocity
$V_{\text {inst }}=\frac{d x}{d t}$
$=\frac{d\left(5 t^{2+2 t+3}\right)}{d t}$
$\mathrm{V}_{\text {inst }}=10 \mathrm{t}+2$

For time $\mathrm{t}=3 \mathrm{~s}$, the instaneous velocity is $\mathrm{V}(\mathrm{t})=10 \mathrm{t}+2$
$V(3)=10(3)+2$
$V(3)=32 \mathrm{~m} / \mathrm{s}$
instaneous Velocity for the given function is $32 \mathrm{~m} / \mathrm{s}$.
Problem 2: The motion of the car is provided by the function $x=4 t^{2}+10 t+6$. Compute its Instantaneous Velocity at time $t$ $=5 \mathrm{~s}$.

## Answer:

Given: The function is $x=4 t^{2}+10 t+6$.
Differentiating the provided function with respect to $t$, we get
$V_{\text {inst }}=\frac{d x}{d t}$
$=\frac{d\left(4 t^{2+10 t+6}\right)}{d t}$
For time $t=5 s$, the Instantaneous Velocity is articulated as,
$V(t)=8 t+10$

$$
V(5)=8(5)+10
$$

$$
\mathrm{V}(5)=50 \mathrm{~m} / \mathrm{s} .
$$

## KINEMATIC VISCOSITY FORMULA

Viscosity is a concept where fluid shows struggle against a flowing, which is being distorted due to extensional stress forces or shear stress. Kinematic viscosity is the sort which is computed by calculating the ratio of the fluid mass density to the dynamic fluid, viscosity or absolute fluid viscosity. It is from time to time known as momentum diffusivity. The units of kinematic viscosity are established on time and area. It is the ratio of the area of time; henceforth it is $\mathrm{m} 22 / \mathrm{s}$ or $\mathrm{ft} 22 / \mathrm{s}$.

The kinematic viscosity formula is expressed as,
$v=\mu / \rho$
Where $\mu=$ absolute or dynamic viscosity,
$\rho=$ density
Kinematic Viscosity Solved Problem

Problem 1: A fluid with absolute viscosity of $0.98 \mathrm{Ns} / \mathrm{m}^{2}$ and kinematic viscosity of $3 \mathrm{~m}^{2} / \mathrm{s}$. Determine the density of fluid?

Answer:
Given
Absolute viscosity $\mu=0.98 \mathrm{Ns} / \mathrm{m}^{2}$
kinematic viscosity $\mathrm{v}=3 \mathrm{~m}^{2} / \mathrm{s}$
$v=\mu / \rho$
The density is given by,
$\rho=v / \mu$
$\rho=3 /(0.98)$
$\rho=3.0612 \mathrm{~kg} / \mathrm{m}^{3}$
Therefore, the density of a fluid is $3.0612 \mathrm{~kg} / \mathrm{m}^{3}$.

## FREE FALL FORMULA

Freefall as the term says, is a body falling freely because of the gravitational pull of our earth.

Imagine a body with velocity (v) is falling freely from a height (h) for time ( t ) seconds because of gravity ( g ).

Free Fall Formulas are three in number and are articulated as
$h=\frac{1}{2} g t^{2}$
$v^{2}=2 g h$
$v=g t$

Freefall is independent of the mass of the body. It depends onl y on the height and the duration the body is flung for.

## Free-fall Related Solved Examples

Underneath are given questions on free fall which may be useful for you.

Problem 1: Calculate the body height if it has a mass of $\mathbf{2} \mathbf{~ k g ~ a ~}$ nd after 7 seconds it reaches the ground?

## Answer:

Given: Height $\mathrm{h}=$ ?
Time $\mathrm{t}=7 \mathrm{~s}$
We all are acquainted with the fact that free fall is independent of mass.

Hence it is given as
$h=12 \mathrm{gt} 2$
$h=0.5 \times 9.8 \times(7)^{2}$
$\mathrm{h}=240.1 \mathrm{~m}$

Problem 2: The cotton falls after 3 s and iron falls after 5 s .
Which is moving with higher velocity?
Answer:

The Velocity in free fall is autonomous of mass.
$V$ (Velocity of iron $)=g t=9.8 \mathrm{~m} / \mathrm{s}^{2} \times 5 \mathrm{~s}=49 \mathrm{~m} / \mathrm{s}$
V (Velocity of cotton) $=\mathrm{gt}=9.8 \mathrm{~m} / \mathrm{s}^{2} \times 3 \mathrm{~s}=29.4 \mathrm{~m} / \mathrm{s}$.

The Velocity of iron is more than cotton.

## INELASTIC COLLISION FORMULA

The crash in which kinetic energy of the system is not conserved but the momentum is conserved, then that collision is termed as Inelastic Collision.


During Collision


Inelastic Collision Formula is articulated as

$$
m_{1} u_{1}+m_{2} u_{2}=\left(m_{1}+m_{2}\right) v
$$

Where
mass of body $1=m_{1}$
mass of body $2=m_{2}$
The initial velocity of body $1=u_{1}$
The initial velocity of body $2=u_{2}$
The final velocity of both the bodies $=v$
The final velocity for Inelastic collision is articulated as
$v=\frac{m_{1} u_{1}+m_{2} u_{2}}{m_{1}+m_{2}}$
Inelastic collision formula is made use of to find the velocity and mass related to the inelastic collision.

## Inelastic Collision - Solved Example

Problem 1: Compute the final velocity if an object of mass 2
Kg with initial velocity $3 \mathrm{~ms}^{-1}$ hits an other object of mass 3
Kg at rest? (Collision is inelastic)

## Answer:

Known:
$m_{1}$ (Mass) $=2 \mathrm{Kg}$,
$\mathrm{m}_{2}$ (Mass) $=3 \mathrm{Kg}$
$\mathrm{u}_{1}$ (Initial Velocity of first mass) $=3 \mathrm{~ms}^{-1}$
$\mathrm{u}_{2}$ (Initial velocity of second mass) $=0$
The Final Velocity is given by $v=\frac{m_{1} u_{1}+m_{2} u_{2}}{m_{1}+m_{2}}$
$=\frac{2 \times 3+0}{2+3}$
$v=6 / 5$
$\mathrm{v}=1.2 \mathrm{~m} / \mathrm{s}$

## DE BROGLIE WAVELENGTH

## FORMULA

De-Broglie waves explain about the nature of the wave related to the particle. Einstein explained the momentum (p) of a photon with the given formula
$p=m c---(1)$
$\mathrm{c}=$ speed of light.
The energy ( E ) of a photon is given as
$E=m c^{2}$,
$E=h \lambda$
$\mathrm{h} \lambda=\mathrm{mc}^{2}$
$m=h \lambda / c^{2}----(2)$
h= Planck's constant ( $6.62607015 \times 10^{-34} \mathrm{Js}$ )
$\lambda=$ wavelength of light

Substituting equation (2) in equation (1) we get
$p=h / \lambda$

Rewriting the equation we get
$\lambda=h / p$
$\lambda=h / m v$
m is the mass
$v$ is the velocity

De Broglie Wavelength Formula is used to calculate the wavelength and momentum in any given problems based on this concept.

Solved Examples

Question 1: Find the wavelength of an electron moving with a speed of $2 \times 10^{6} \mathrm{~ms}-1$.

Solution:

## Given:

Velocity of the electron, $\mathrm{v}=2 \times 10^{6} \mathrm{~ms}-1$
Mass of electron, $\mathrm{m}=9.1 \times 10^{-31} \mathrm{Kg}$
Planck's Constant, $\mathrm{h}=6.62607015 \times 10^{-34} \mathrm{Js}$
The de-Broglie wavelength is given by $\lambda=h / m v$
$=6.62607015 \times 10^{-34} /\left(2 \times 10^{6}\right)\left(9.1 \times 10^{-31}\right)$
$\lambda=0.364 \times 10^{9} \mathrm{~m}$

## SPEED OF SOUND FORMULA

The speed of sound is defined as the travelled by the sound wave that propagates per unit time through an elastic medium. In a perpendicular medium, the speed of the sound depends on the elasticity and density of the medium. If the speed of the sound is greater than the elasticity is more and density is less.

The formula of the speed of sound formula is expressed as
$c=\sqrt{\gamma \times \frac{P}{\rho}}$
Where
$P=$ pressure
$\rho=$ density
$\gamma=$ Ratio of specific heat.

## Example 1

The sound wave with density $0.043 \mathrm{~kg} / \mathrm{m}^{3}$ and pressure of 3 kPa having the temp $3^{0} \mathrm{C}$ travels in the air. Find out the speed of the sound?

Solution:

Given:
Temperature $\mathrm{T}=276 \mathrm{~K}$
Density $\rho=0.043 \mathrm{~kg} / \mathrm{m} 3$
Pressure $\mathrm{p}=3 \mathrm{kPa}=3000 \mathrm{~Pa}$

The ratio of specific heat in air $=1.4$
The formula for speed of sound is
$c=\sqrt{\gamma \times \frac{P}{\rho}}$
$c=\mathrm{V} \gamma \times \mathrm{P} \rho$
$c=\sqrt{ } 1.4 \times 3000 / 0.043$. Therefore, speed of sound $=312.52$ $\mathrm{m} / \mathrm{s}$

## INDUCTIVE REACTANCE FORMULA

Inductive reactance or simply reactance is not anything but the resistance of an inductive circuit. An inductor competes against the current in a coil which alters the direction and Instantaneous magnitude. This opposition is comparable to resistance but always possesses a phase shift between voltage and current and dissipate zero power. As it has some alteration from the resistance, it is termed as reactance. And it is denoted as XL. The SI unit is the ohm. The formula for reactance is given as

$$
X_{L}=2 \pi f L
$$

Where the frequency is $f, L$ is the inductance and $X_{L}$ is the inductive reactance.

## Inductive Reactance Solved Examples

Problem 1: An inductor of 2 H is connected to a circuit at a frequency of 50 Hz . Compute the inductive reactance of this circuit?

Answer:
The given parameters are,
$\mathrm{f}=50 \mathrm{~Hz}$
$\mathrm{L}=2 \mathrm{H}$
Inductive reactance formula is given as,
$X_{L}=2 \pi f L$
$X_{L}=2 \times 3.14 \times 50 \times 2$
$\mathrm{X}_{\mathrm{L}}=628 \Omega$

Problem 2: At what frequency does a 250 mH inductor have $3.5 \mathrm{k} \Omega$ of reactance?

## Answer:

The known parameters are,
$X_{L}=3.5 \mathrm{k} \Omega=3500 \Omega$
$f=$ ? and
$\mathrm{L}=250 \mathrm{mH}=0.25 \mathrm{H}$

Inductive reactance formula is articulated as,
$X_{L}=2 \pi f L$
$\mathrm{f}=\mathrm{XL} 2 \pi \mathrm{~L}$
$\mathrm{f}=35002 \times 3.14 \times 0.25$
$\mathrm{f}=2229 \mathrm{~Hz}$

## GREGORY NEWTON FORMULA

Gregory Newton's is a forward difference formula which is applied to calculate finite difference identity. Regarding the first value f0 and the power of the forward difference $\Delta$, Gregory Newton's forward formula gives an interpolated value between the tabulated points. The interpolated value is expressed by \{fp\}. By applying the forward difference operator and forward difference table, this method simplifies the calculations involved in the polynomial approximation of functions which are called spaced data points.

The Formula states for $a \in[0,1]$
Question 1

## $\mathrm{f}(\mathrm{a})$ with the following data points,

xi $\quad 0 \quad 1 \quad 2$

## $\begin{array}{llll}\text { fi } & 1 & 7 & 23\end{array}$

Solution:

Forward difference table,

| xi | fi | $\Delta \mathrm{fi}$ | $\Delta 2 \mathrm{fi}$ |
| :--- | :---: | :---: | :---: |
| 0 | 1 |  |  |
| 1 | 7 | 6 |  |
| 2 | 23 | 16 | 10 |
| $\mathrm{a}=2$ |  |  |  |

According to Gregory Newton's forward difference formula,
$f(0.5)=1+2 \times 6+2(2-1) \times(10 / 2)+2(2-1) \times(2-2) \times(6 / 6)$
$=13+10+0$
$=23$

Therefore, $\mathbf{f}(\mathbf{2})=\mathbf{2 3}$
Question 2
$\mathrm{f}(\mathrm{a})$ with the following data points,
xi
0
1
2
Fi
1
7
23

Solution:

Forward difference table,
Xi
fi
$\Delta \mathrm{fi}$
$\Delta 2 \mathrm{fi}$
0
1
1
7
6

## 2 <br> $a=0.5$

 23 16 10According to Gregory Newton's forward difference formula,
$f(0.5)=1+0.5 \times 6+0.5(0.5-1) \times 10 / 2+0.5(0.5-1) \times(0.5-$
2) $\times 6 / 6$
$=1+3+2.5 \times(-0.5)+(-0.25)(-1.5)$
$=(0.5) 3+2(0.5) 2+3(0.5)+1$
$=0.125+0.5+1.5+1$
Therefore, $\mathrm{f}(0.5)=3.125$

## EMF FORMULA

The EMF or electromotive force is the energy supplied by a battery or a cell per coulomb $(Q)$ of charge passing through it.

The magnitude of emf is equal to V (potential difference) across the cell terminals when there is no current flowing through the circuit.
$e=E / Q$
Where, e = emf or electromotive force (V), W = Energy (Joules), and Q denotes charge (coulombs). Both emf (electromotive force) and pd (potential difference) are measured in V (Volts)

Electromotive force (emf) formula can also be written as,
$\mathrm{e}=\mathrm{IR}+\mathrm{Ir}$ or, $\mathrm{e}=\mathrm{V}+\mathrm{Ir}$

Where,
$e$ is the electromotive force (Volts),

I = current (A),
$R=$ Load resistance,
$r$ is the internal resistance of cell measured in ohms.

## Difference between EMF and Potential Difference?

The amount of energy (any form) changed into energy
(electrical) per coulomb of charge is termed as EMF whereas the potential difference is the amount of energy (electrical) that is changed into other forms of energy per coulomb of charge. Cell, solar cell, battery, generator, thermocouple, dynamo, etc are examples of sources of emf.

Solved Examples

Example: Find the terminal potential difference of a cell when it is connected to a 9-ohm load with cell emf $=2$ Volts and resistance (internal) 1 ohm?

Sol:

## Given

emf $=2$

External resistance $=9$ ohm

Internal resistance = 1 ohm

Since $I=V / R$

And $R=$ External resistance + Internal resistance $=9+1=10$
Ohm

Now, $\mathrm{I}=2 / 10=0.2$ Ampere
$e=V+I r$
$2=\mathrm{V}+(0.2) 1$
$V=2-0.2$

Therefore, the external resistor gets , $\mathrm{V}=1.8$ Volts

If we draw a graph of V (terminal potential difference) Vs
current (I) in the circuit, we obtain a -ve gradient straight line.

Also, The intercept of the straight line on $y$-axis denotes the electromotive force of the cell or battery and the graph gradient denotes the internal resistance $(r)$ of the battery or cell.

## WEIGHT FORMULA

Weight is not anything but the force gravity experiences. It is represented by W and Newton is it's SI unit. It is articulated as the product of mass and acceleration due to gravity. So the weight of a given object will show variation according to the gravity in that particular space. So, objects with similar mass appear in different weights across different planets. The formula for weight is articulated as,

$$
\mathrm{W}=\mathrm{mg}
$$

Where,

Weight of the object $=\mathrm{W}$
Mass of the object $=m$
Acceleration due to gravity $=\mathrm{g}$

## Solved Examples

Numerical associated to weight calculations are provided underneath:

Problem 1: Compute the weight of a body on the moon if the mass is 60 Kg ? g is given as $1.625 \mathrm{~m} / \mathrm{s}^{2}$.

## Answer:

It is known that,
$\mathrm{m}=60 \mathrm{~kg}$ and
$\mathrm{g}=1.625 \mathrm{~m} / \mathrm{s}^{2}$

Formula for weight is,
$\mathrm{W}=\mathrm{mg}$
$\mathrm{W}=60 \times 1.625$
$\mathrm{W}=97.5 \mathrm{~N}$

Problem 2: Compute the weight of a body on earth whose mass is 25 kg ?

Answer:

It is known that,
$\mathrm{m}=25 \mathrm{~kg}$ and
$\mathrm{g}=9.8 \mathrm{~m} / \mathrm{s}^{2}$
Formula for weight is,
$\mathrm{W}=\mathrm{mg}$
$W=25 \times 9.8$
$W=245 \mathrm{~N}$

## FLOW RATE FORMULA

As we all know, liquids flow. One can say how slow or fast it flows. But can someone tell at what rate Fluid flows? To compute that let's study the flow rate. The flow rate of a liquid is how much fluid passes through an area in a particular time. Flow rate can be articulated in either in terms of velocity and cross-sectional area, or time and volume. As liquids are incompressible, the rate of flow into an area must be equivalent to the rate of flow out of an area. This is identified as the equation of continuity.

Flow rate is the quantity of fluid flowing in the specified time. It is expressed in litres per meter (lpm) or gallons per metre (gpm) . It is articulated as
$Q=A v$

Where,
the flow area is A and
the flow velocity is v .
Flow rate can also be articulated as in a given time ( $\mathbf{t}$ ) the capacity of fluid stored (C). It is also articulated as
$Q=\frac{C}{t}$
Where,
the capacity of fluid stored is C and the time taken to flow is $t$

Flow rate formula has extensive applications in fluid dynamics to compute the velocity, area or flow rate.

## Flow Rate Solved Examples

Provided underneath are the questions grounded on flow rate which may be useful for you.

Problem 1: Compute the flow rate of fluid if it is moving with the velocity of $20 \mathrm{~m} / \mathrm{s}$ through a tube of diameter 0.03 m .

## Answer:

Velocity of fluid flow $v=20 \mathrm{~m} / \mathrm{s}$

Diameter of pipe $d=0.03 \mathrm{~m}$
Area of cross-section of the pipe, $A=\frac{\pi}{4} d^{2}$
$A=\{(3.14) / 4\}(0.03)(0.03)$
$A=(0.785)(0.0009)$
$\mathrm{A}=0.000706 \mathrm{~m}^{2}$

Flow rate is given by $\mathrm{Q}=\mathrm{vA}=(20)(0.000706)$
$\mathrm{Q}=\mathbf{O}^{0.014139 \mathrm{~m}^{3} / \mathrm{s}}$

## NET FORCE FORMULA

The net force is defined as is the sum of all the forces acting on an object. Net force can accelerate a mass. Some or the other force acts on anybody either at rest or motion. The net force is a term used in a system when there is a significant number of forces.

If N is the number of forces acting on a body, the net force formula is given by,

$$
F_{\text {Net }}=F_{1}+F_{2}+F_{3} \ldots+F N
$$

Where,
$F_{1}, F_{2}, F_{3} \ldots . . \mathrm{FN}$ is the forces acting on a body.

Net force when a body is at rest:


When the body is at rest, the net force formula is given by,

$$
\mathbf{F}_{\mathrm{Net}}=\mathbf{F}_{\mathrm{a}}+\mathbf{F}_{\mathrm{g}} .
$$

Where,
$\mathrm{F}_{\mathrm{a}}=$ applied force,

Fg = gravitational force.
Net force when a body is in motion:


When a force is applied on the body, not only the applied force is acting there are many other forces like gravitational force Fg , frictional force Ff and the normal force that balances the other force.

Therefore, the net force formula is given by,
$F_{\text {Net }}=F_{a}+F_{g}+F_{f}+F N$.
Where,
$\mathrm{F}_{\mathrm{a}}=$ applied force,
$\mathrm{F}_{\mathrm{g}}=$ gravitational force,
$F_{f}=$ frictional force,
$\mathrm{FN}=$ normal force.

## Example 1

In a tug of war, a fat man pulls with a force of 100 N on a side, and a lean man pulls with 90 N on the other side. Determine the net force.

Solution:

Given:

Force F1= 100 N

Force F2 $=-90 \mathrm{~N}$

The net force formula is given by
$\mathrm{F}_{\text {Net }}=\mathrm{F}_{1}+\mathrm{F}_{2}$
$\mathrm{F}_{\text {Net }}=100-90$
$\mathrm{F}_{\text {Net }}=10 \mathrm{~N}$
Therefore, the net force is 10 N .

## Example 2

A toy car is at rest, and a force of $70 \mathbf{N}$ is applied to it. If the frictional force of $\mathbf{2 0} \mathbf{N}$, determine the net force.

Solution:

Given:

Applied force Fa $=70 \mathrm{~N}$

Frictional force $\mathrm{Ff}=-20 \mathrm{~N}$

The net force formula is given by

$$
\begin{aligned}
& \mathrm{F}_{\mathrm{Net}}=\mathrm{Fa}+\mathrm{F}_{\mathrm{f}} \\
& \mathrm{~F}_{\mathrm{Net}}=70-20 \\
& \mathrm{~F}_{\mathrm{Net}}=50 \mathrm{~N}
\end{aligned}
$$

Therefore, the net force is 50 N

## REYNOLDS NUMBER FORMULA

Reynolds number is a dimensionless value which is applied in fluid mechanics to represent whether the fluid flow in a duct or pat a body is steady or turbulent. This value is obtained by comparing the inertial force with the viscous force.

The Reynolds number id denoted by Re.
Reynolds number is given by
Reynolds Number = Inertial Force / Viscous Force
The Reynolds number formula is expressed by,
$R_{e}=\frac{\rho V L}{\mu}$
Where,
$\rho=$ Fluid density

V = Fluid velocity
$\mu=$ Fluid viscosity
$\mathrm{L}=$ length or diameter of the fluid.

Reynolds number formula is used to determine the velocity, diameter and viscosity of the fluid.

The Kind of flow is based on the value of Re

1. If $\mathrm{Re}<2000$, the flow is called Laminar
2. If $\operatorname{Re}>4000$, the flow is called turbulent
3. If $2000<\operatorname{Re}<4000$, the flow is called transition.

## Example 1

Calculate the Reynolds number if a liquid of viscosity 0.5 $\mathrm{Ns} / \mathrm{m} 2$ and relative density of $500 \mathrm{Kg} / \mathrm{m} 3$ through a 10 mm pipe flows with a Velocity of $3 \mathrm{~m} / \mathrm{s}$.

Solution

Given:
$\mu=0.5 \mathrm{Ns} / \mathrm{m} 2$
$\rho=500 \mathrm{Kg} / \mathrm{m} 3$
$\mathrm{L}=10 \times 10^{-3} \mathrm{~m}$
$\mathrm{V}=3 \mathrm{~m} / \mathrm{s}$

The Reynolds formula is
$R_{e}=\rho V L / \mu$
$R_{e}=\left(500 \times 3 \times 10 \times 10^{-3}\right) / 0.5$
$R_{e}=15000 \times 10^{-3} / 0.5$
$\mathrm{R}_{\mathrm{e}}=\mathbf{3 0}$

Here, we notice that the value of Reynolds number is less than 2000, therefore the flow of liquid is laminar.

## LORENTZ FACTOR FORMULA



The diagram shows the fixed frame in 3-dimensional view, with 3 directions $x, y$ and $z$ respectively.

Consider the Moving frame where $x^{\prime}$ is moving with the primed frame with the velocity $v$ in the $x$ direction.

The reference frames coincide at $\mathrm{t}=\mathrm{t}^{\prime}=0$.
$x^{\prime}=x-v t 1-v 2 c 2 v$
$y^{\prime}=y$
$z^{\prime}=z$
$\mathrm{t}^{\prime}=\mathrm{t}-\mathrm{vxc} 21-\mathrm{v} 2 \mathrm{c} 2 \mathrm{v}$

Where,
$\beta=\mathrm{vc}$
$\gamma=$ Lorentzfactor
$\mathrm{p}=11-\mathrm{v} 2 \mathrm{c} 2 \mathrm{~V}$

## Surface Tension Formula

Surface tension is a word which is linked to the liquid surface. It is a physical property of liquids, in which the molecules are drawn onto every side. This is a type of dragging force per unit length. On the surface of the liquids, there is no other molecules surround each atom. So the surface layer gets attracted inwards.

The formula for finding surface tension is articulated as,
$T=\frac{F}{l}$

Where,
$\mathrm{T}=$ surface tension( $\mathrm{N} / \mathrm{m}$ )
$\mathrm{F}=$ force per unit length ( N )

I=length in which force act(m)

## Surface Tension Solved Examples

Solved numerical related to surface tension are provided underneath:

Problem 1: Compute the surface tension of a given liquid whose dragging force is 5 N and length in which the force acts is 2 cm ?

## Answer:

Known values are,
$\mathrm{F}=5 \mathrm{~N}$ and $\mathrm{I}=2 \mathrm{~cm}$
The formula for surface tension is,
$T=\frac{F}{l}$
$\mathrm{T}=5 / 2 . \quad \mathrm{T}=2.5 \mathrm{~N} / \mathrm{cm}$

## GAY LUSSAC LAW FORMULA

In 1808, the French chemist Joseph Louis Gay-Lussac reported the results of new experiments together with a generalization known today as Gay-Lussac's law of combining gases.

The volume of gas is directly proportional to the Kelvin temperature if the volume is kept constant.
$\mathrm{V} \underline{1} \mathrm{~T} \underline{1}=\mathrm{V} \underline{2} \mathrm{~T} \underline{2}$

Where, ${ }_{v_{1}}=$ original volume ${ }_{\mathrm{v} 2}=$ final volume $\mathrm{T}_{1}=$ original temperature $(\mathrm{K}) \mathrm{T}_{2}=$ final temperature $(\mathrm{K})$

Gay-Lussac's Law is applicable only to gases. The volumes of liquids or solids involved in the reactants or products are not governed by Gay Lussac's law.

## Gay Lussac Law Formula Solved Examples

Some of the solved problems based on Gay Lussac Law Formula are given below.

Question 1: What is the volume of a quantity of gas at $27^{\circ} \mathrm{C}$ if its volume was 400 mL at $0^{\circ} \mathrm{C}$ ? The pressure remains constant.

## Solution:

Since the temperature increased, the volume increased. Here we must use a temperature factor greater than 1 , that is 300/273

The temperature must be in degrees kelvin.
$20^{\circ} \mathrm{C}+273=300 \mathrm{~K}$
$0^{\circ} \mathrm{C}+273=273 \mathrm{~K}$
$400 \mathrm{~mL} \times \underline{300} K \underline{273 \mathrm{~K}}=439.5 \mathrm{~mL}$

Question 2: Solve Gay-Lussac's Law to get an expression for the unknown volume. Substitute the appropriate data into the formula.
$\mathrm{V}_{1}=400 \mathrm{~mL} \mathrm{~V}_{2}=? \mathrm{~mL} \mathrm{~T}_{1}=0^{\circ} \mathrm{CT}_{2}=27^{\circ} \mathrm{C}$
Solution: $\mathrm{V}_{1}=400 \mathrm{~mL} \mathrm{~V}_{2}=$ ? mL
$\mathrm{T}_{1}=0^{\circ} \mathrm{C}+273=273 \mathrm{~K}$
$\mathrm{T}_{2}=27^{\circ} \mathrm{C}+273=300 \mathrm{~K}$

Substitute all the values in the corresponding formula
$\mathrm{V} \underline{1} \underline{T}=\mathrm{V} \underline{2} T \underline{2}$
$\mathrm{V}_{2}=(400 \mathrm{~mL} \times 300) / 273$
$\mathrm{V}_{2}=439.56 \mathrm{~mL}$

## SPECIAL THEORY OF RELATIVITY

## FORMULA

According to Einstein's Theory, equivalent energy can be calculated using the mass ( m ) and the speed of light.
$\mathrm{E}=\mathrm{mc} 2$
$\mathrm{E}=$ equivalent energy
$\mathrm{m}=$ mass in kg
$\mathrm{c} \cong 3 \times 108 \mathrm{~m} / \mathrm{s}$
According to Einstein in Quantum fields which carry a certain amount of energy. In an empty space, the amount of energy gets larger as the fields get large. Hence energy and mass are equivalent.

## RELATIVISTIC MASS FORMULA

The mass concept dialogue is a very standard one in physics. The well-known special theory of relativity voices a lot more about relativistic mass when there are comparative measurements of length and time in dissimilar frames. The relative change in mass is also perceived when the body is in motion. This concept is relativistic mass. Comparable to length contraction and time dilation a thing called mass increase happens when the object is in motion.

The relativistic mass formula is articulated as, $m=m \underline{01}-v \underline{2} c \underline{2} v$

Where, the rest mass is $\mathbf{m}_{0}$, the velocity of the moving body is $\mathbf{v}$,

Velocity of light is c

## Solved Examples

Problem 1: An object in motion has a mass of 12 kg and travels in the air with velocity 0.82 . What would be its rest mass?

## Answer:

Known:
(Mass) $\mathrm{m}=12 \mathrm{~kg}$,
(Velocity) $\mathrm{v}=0.82 \mathrm{c}$,
$\mathrm{c}=3 \times 1088 \mathrm{~m} / \mathrm{s} 22$.

The relativistic mass formula is articulated as,
$m=m \underline{01}-v \underline{2} c \underline{2} v \underline{12}=m \underline{01}-(\underline{0.82}) \underline{2} c \underline{2} c \underline{2} v$

Rest mass, $\mathrm{m}_{\mathrm{o}}=7.2 \mathrm{~kg}$ (approximately)

Thus, the rest mass of the given object is $7.2 \mathbf{~ k g}$.

Problem 2: A particle of mass $1.67 \times 10^{-24} \mathrm{~kg}$ travels with velocity 0.65 . Compute its rest mass?

## Answer:

Given: Mass $\mathrm{m}=1.67 \times 10^{-24} \mathrm{~kg}, \mathrm{v}=0.65 \mathrm{c}, \mathrm{c}=3 \times 10^{8} \mathrm{~m} / \mathrm{s}^{2}$.
The relativistic mass formula is articulated as, $m=m \underline{01}-v \underline{2} c \underline{2} v \underline{1.67} \times \underline{10}-\underline{24}=m \underline{01}-(\underline{0.65}) \underline{2} c \underline{2} c \underline{2} v$ Rest mass, $m_{0}=1.26 \times 10^{-24} \mathrm{~kg}$ (approximately).

Thus, the rest mass of the particle is $1.26 \times 10^{-\mathbf{2 4}} \mathbf{~ k g}$.

## KELVIN TO CELSIUS FORMULA

Two most widely used temperature measurement scales in th e thermometer industry are the Kelvin and Celsius scale. The v alue of one degree on the Kelvin scale is identical to the value of one degree on the Celsius scale that is the temperature differential or change is identical on both scales.
$0^{\circ}$ Celsius $=273.15$ Kelvin
The relation can be used to convert Celsius into Kelvin:

Celsius $=($ Kelvin $\mathbf{- 2 7 3 . 1 5})$

Or

Kelvin = (Celsius + 273.15)

The formula of Kelvin to Celsius is used to change the temperature given in Kelvin to Celsius.

Solved Example

## Problem 1: Convert the following temperature from Kelvin

 into Celsius(a) 50 K
(b) 390 K
(c) 353 K

## Answer:

(a) $50 \mathrm{~K}=(50-273.15)=-223.15^{\circ} \mathrm{C}$
(b) $390 \mathrm{~K}=(390-273.15)=116.85^{\circ} \mathrm{C}$
(c) $353 \mathrm{~K}=(353-273.15)=79.85^{\circ} \mathrm{C}$

## REFLECTION AND RAY MODEL OF

## LIGHT FORMULA

A ray of light will be reflected from a smooth surface in such a manner that the angle incident ray makes normal to the reflecting surface at the point of incidence which is precisely same as the angle that the ray which is reflected makes with normal. Also, the ray reflected along with the incident ray and the normal to the reflecting surface all lie on the same plane defined at the incident point and it shows $\boldsymbol{\theta}_{\mathbf{i}}=\boldsymbol{\theta}_{\mathrm{r}}$.

Human and other animals 'visual capacity is the result of the $c$ omplicated interaction of light, eyes, and brain. Humans can see the light due to light from a body will pass across space and impact our eyes. As the light reaches our eyes, messages are transmitted to our gray matter and the information is deciphered by our brain to interpret the size, position and
movement of the object we are studying. If a ray of light could be observed entering and reflecting off of a flat mirror, then the way of the reflection of the light would follow a standard law known as the law of reflection.

The ray model is very useful while studying the reflection of light, refraction of light and various images created by lenses, spherical mirrors and plane mirrors.

## Regular Reflection:

If the reflection takes place from a perfect plane surface, then we term it as regular reflection. The reflected light has a larger intensity in a particular direction and negligible intensity in all other directions.

## Diffused Reflection:

If the reflection takes place from an irregular or rough surface the regular feature of light is not observed and although at
every point the light ray gets reflected the overall effect observed is basically cancellation and overlapping of all reflected rays resulting in a diffused reflection.

Solved Examples
Some Examples on Reflection and Ray Model of Light
Problem 1: Angle of incident for a plane mirror at the point of incidence is perceived to be 48 degrees with the normal. What is the angle of reflection?

## Answer:

(at the point of incident with normal) Angle of incidence $=$ angle of reflection. So, angle of reflection $=48$ degrees (with normal)

Problem 2: The angle of reflection with the normal at the point of incident is perceived to be 108 degrees. What is the angle of incidence?

## Answer:

Angle of incidence $=$ angle of reflection

Thus, angle of incidence = 108 degrees (with normal)

## POWER FORMULA

The capacity to do work is termed as Energy. The Energy expended to do work in unit time is termed as Power. It is represented as $\mathbf{P}$.

Power Formula is articulated as,
$P=\frac{E}{t}$
$P=\frac{W}{t}$
or,

Where,
The Energy Consumed to do work = E
Work done $=\mathbf{W}$
Time taken $=\mathbf{t}$

In any electrical circuit, the power is computed making use of these three formulas

In regards to Voltage and current, it is articulated as

$$
P=V \times I
$$

In regards to current and resistance, it is articulated as
$P=I^{2} R$
In regards to voltage and resistance, it is articulated as
$P=\frac{V^{2}}{R}$
Where,
Voltage applied across the two ends $=\mathrm{V}$,
Current flowing in the circuit $=I$ and
Resistance $=R$.

The Power Formula is made use of to compute the Power, Resistance, Voltage or current in any electrical circuit. It is articulated in watts.

## Power Solved Examples

Underneath are some solved samples on Power which help comprehend these formulas.

Problem 1: An electric machine makes use of 300 J of energy to do work in 10s. How much power does it use?

## Answer:

Known: Work done $=\mathrm{W}=300 \mathrm{~J}$,
Time taken $\mathrm{t}=10 \mathrm{~s}$.
Power used by it is given by $P=\frac{W}{t}=\frac{300 \mathrm{~J}}{10 \mathrm{~s}}=30 \mathrm{Watts}$
Problem 2: John is who has a mass of 60 kg runs up to 12 m high in 40 seconds. Compute his power.

## Answer:

Known: $m$ (mass) $=60 \mathrm{~kg}$,
$h($ Height $)=12 \mathrm{~m}$,
t (time taken) $=40$ seconds .

Power is given by $P=\frac{\text { Workdone }}{\text { timetaken }}$
$\mathrm{P}=\mathrm{mgh} / \mathrm{t}$
$-60 \times 9.8 \times 12$
40
$=588 \mathrm{Watts}$

## SNELLS LAW FORMULA

Snell's law tells us the degree of refraction and relation between the angle of incidence, the angle of refraction and refractive indices of a given pair of media. We know that light experiences the refraction or bending when it travels from one medium to another medium. Snell's law predicts the degree of the bend. It is also known as the law of refraction. In 1621, Willebrord Snell discovered the law of refraction, hence called Snell's law.

Snell's law is defined as "The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant, for the light of a given colour and for the given pair of media". Snell's law formula is expressed as:

## sinisinr=constant $=\mu$

Where $i$ is the angle of incidence and $r$ is the angle of refraction. This constant value is called the refractive index of the second medium with respect to the first.

The following is a diagrammatic representation:


Snell's law formula is derived from Fermat's principle. Fermat's principle states that "light travels in the shortest path that takes the least time".

$$
n_{1} \sin \theta_{1}=n_{2} \sin \theta_{2}
$$

The normal on the surface is used to gauge the angles that the refracted ray creates at the contact point. $\boldsymbol{n 1}$ and $\boldsymbol{n 2}$ are the
two different mediums that will impact the refraction. $\theta 1$ is the angle of incidence; $\theta 2$ is the angle of refraction.

## Applications of Snell's Law Formula in Real Life:

Snell's law has a wide range of applications in physics especially in the branch of optics. It is used in optical apparatus such as eyeglasses, contact lenses, cameras, rainbows. There is an instrument called a refractometer that uses Snell's law to calculate the refractive index of liquids. It is used all the time in the candy-making industry.

## Solved Examples:

Question 1: If a ray is refracted at an angle of $14^{\circ}$ and the refractive index is 1.2 , compute the angle of incidence.

Solution: Given,
Angle of refraction, $r=14^{\circ}$
Refractive index, $\mu=1.2$

Using Snell's law formula,
sinisinr $=\mu$
$\operatorname{sinisin} 14=1.2$
$\operatorname{sini}=1.2 \times \sin 14$
$=1.2 \times 0.24$
sini=0.28
$i=\sin -\underline{1}(\underline{0.288)}=\underline{16.7}$

Question 2: If the angle of incidence is $25^{\circ}$ and angle of refraction is $32^{\circ}$, find the refractive index of the media.

Solution: Given,
Angle of incidence, $\mathrm{i}=25^{\circ}$
Angle of refraction, $r=32^{\circ}$

Using Snell's law formula,
sinisinr $=\mu$
$\sin 25 \sin 32=\mu$
$\underline{0.42260 .5299}=\mu$
$\mu=\underline{0.7975} \cong \underline{\underline{0.8}}$

## TERMINAL VELOCITY FORMULA

Terminal velocity is the highest velocity that can be attained by an object when it falls through the air. It happens when the sum of the dragged force (Fd) and buoyancy is equal to the downward force of gravity (FG) acting on the body. The object holds zero acceleration since the net force acting is zero.

Terminal Velocity Formula is given as
$V_{\text {terminal }}=\sqrt{2} g h$
Where,
$\mathbf{g}=$ acceleration due to gravity,
$\mathbf{h}=$ height from the ground

Terminal velocity formula is applied to calculate terminal velocity, acceleration due to gravity or height if any of these quantities are known.

Terminal velocity is expressed in meter per second ( $\mathrm{m} / \mathrm{s}$ ).

## Example 1

A man is at the height of 2000 m from the ground. What would be his terminal velocity?

## Solution:

Given:

Height h=2000 m,

The terminal velocity formula is given by
$V=\mathrm{V} 2 \times 9.8 \times 2000$
$=\mathrm{V} 39200$
$=197.98 \mathrm{~m} / \mathrm{s}$.

## Example 2

Determine the height of the body if its terminal velocity is 100 $\mathrm{m} / \mathrm{s}$.

Solution:

Given:

Terminal velocity , $\mathrm{V}=100 \mathrm{~m} / \mathrm{s}$
The height is given by
$h=v^{2} / 2 g$
$=10000 / 9.8 \times 2$
$h=510.204 \mathrm{~m}$.

## GRAM FORMULA MASS

The gram formula mass of a compound is the amount of that compound that has the same mass in grams as the formula mass in atomic mass unit. An atom of each element has a characteristic mass and in like manner each molecule of a compound has a characteristic formula mass.

When the formula mass of an ionic compound is determined by the addition of its component atomic masses and expressed in grams, it is called the Gram Formula Mass.

Gram Formula Mass is mathematically expressed as
Gram formula mass $=\frac{\text { mass of the solute }}{\text { formula mass of the solute }}$

## Gram Formula Mass Problems

Solved problems based on gram formula mass are given below.

Solved Examples
Question 1: Find the gram formula mass of 1 mol of
$\mathrm{KAl}\left(\mathrm{SO}_{4}\right)_{2} \cdot \mathbf{1 2 \mathrm { H } _ { 2 } \mathrm { O }}$ ?
Solution:
$1 \mathrm{~K}=39$
$1 \mathrm{Al}=27$
$2\left(\mathrm{SO}_{4}\right)=192=2(32+16 \times 4)$
$12 \mathrm{H}_{2} \mathrm{O}=216=12(2+16)$
Therefore the gram formula mass is
$1 \mathrm{~mol}=474 \mathrm{~g}$
Question 2: Find the gram formula mass of 1 mole of $\mathrm{CaCO}_{3}$ ?

Solution:
$1 \mathrm{Ca}=40$
$1 \mathrm{C}=12$
$30=48=3 \times 16$
Therefore the gram formula mass of $\mathrm{CaCO}_{3}$ is
$\mathrm{CaCO}_{3}=100$ formula mass
$\mathrm{CaCO}_{3}=100 \mathrm{~g}=$ gram formula weight.

## REFRACTION FORMULA

Light travels in a straight line, and we are aware of that. This is true on the condition that the light rays are travelling in the same medium, having the same density throughout. What occurs when light enters from one transparent medium to another? Does it still travel along a straight line path or changes its direction? A ray of light, travelling from water into the air and gets diverted (refracted) away from the normal (as it passes from a denser medium 'water' into rarer medium 'air'). Another ray of light gets refracted in another direction. The two refracted rays when produced backwards, appear to meet at a point nearer to the water surface than the original point. The image formed is termed as a virtual image.

Therefore, the immersed part of the stick gives the impression of being raised and bent, forms a virtual image. Thus, we see that when the light rays are made to go from one transparent
medium to another transparent medium, the light rays alter their direction at the boundary separating the two media. In the above instance, when light rays travelling in the water go into another medium, i.e. air, they alter their direction on entering the air. The bending of light when it passes obliquely from one transparent medium to another is termed as Refraction of light.

In other words, the alteration in the direction of light when it crosses through obliquely from one see-through medium to another is termed as refraction of light.

A transparent substance in which light travels is known as a medium. A medium in which light's speed is more is known as an optically rarer medium. Air is an optically rarer medium compared to glass and water. A medium in which light's speed is less is termed as an optically denser medium. An optically denser medium than water and air would be glass. Different media are believed to have different optical densities. The
speed of light depends on the optical density of the medium. Bigger the difference in the speeds of light in the two mediums, larger will be the deviation in the track of light in the secondary medium. In other words, there will be bigger refraction of light.

## Laws of Refraction of Light

The refraction of light in travelling from one medium to another takes place according to two laws which are termed as the laws of refraction of light.

The First Law of refraction: The normal, the incident ray, and refracted ray at the point of incidence, all lie in a similar plane.

The Second Law of refraction: The second law of refraction provides a relationship amid the angle of refraction and the angle of incidence. This relationship was perceived experimentally by Willebrod Snell in 1621. Thus, the second law of refraction is termed as Snell's law of refraction.

Conferring to Snell's law of refraction of light, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant for the light of a given colour and for a given pair of media.

If $i$ is the angle of incidence and $r$ is the angle of refraction then according to Snell's law of refraction of light,
$\frac{\sin i}{\sin r}=$ constant
This constant value is termed as the refractive index of the second medium with regards to the first.

## RELATIVITY FORMULA

As per the theory of Special relativity, length, time, momentum, and energy depends on the velocity of one reference frame relative to another. A person on a spaceship moving almost closer to the speed of light will measure length, time, momentum, and energy differently than an observer that is outside the ship. The Lorentz factor $(\gamma)$ is the factor by which time, length, and relativistic mass change for an object while that object is moving

The following equation is used very often in special relativity:
$\gamma=\frac{1}{\sqrt{1-\beta^{2}}}$
where $\beta=v / c$
$v$ is the relative velocity between two internal frames
c is the speed of light ( $\mathrm{c}=3 \times 10^{8} \mathrm{~m} / \mathrm{s}$ )

For two frames at rest, $\gamma=1$, and increases with the relative velocity between the two inertial frames. As the relative velocity approaches the speed of light, $\gamma \rightarrow \infty$.

## HEAT OF HYDRATION FORMULA

The heat of hydration is described as the quantity of energy produced when one mole of ions undergo a hydration process. It is a specific form of dissolution energy and the solvent used is water.

The enthalpy of a hydrated salt is the change in heat when 1 mole of an anhydrous substance combines with a requisite number of water molecules to form the hydrate. The heat of hydration can be determined if the heat of the solutions of anhydrous salt and the hydrated forms are known.

Anhydrous salts readily combine with water to form hydrates and dissolve with the evolution of heat. The only difference between hydrate and anhydrous salt is the heat is evolved as the heat of hydration in the formation of hydrates.

The heat of hydration formula is given by:

Heat of hydration $=\left(\Delta H_{\text {solution }}-\Delta H_{\text {lattice energy }}\right)$
Where
$\Delta \mathrm{H}_{\text {solution }}=$ Heat of the solution
$\Delta H_{\text {lattice energy }}=$ Lattice energy of the solution

## Example 1

The sodium chloride lattice enthalpy is $\Delta \mathrm{H}$ for $\mathrm{NaCl} \rightarrow \rightarrow$
$\mathrm{Na}^{+}+\mathrm{Cl}^{-}$is $700 \mathrm{~kJ} / \mathrm{mol}$. To make 1 M NaCl the solution heat is
$+5.0 \mathrm{~kJ} / \mathrm{mol}$. Determine the heat of hydration of $\mathrm{Na}+$ and $\mathrm{Cl}-$, where the heat of hydration of Cl - is $-300 \mathrm{~kJ} / \mathrm{mol}$.

Solution:

Given data

Lattice energy $=700 \mathrm{~kJ} / \mathrm{mol}$
Heat of solution $=5.0 \mathrm{~kJ} / \mathrm{mol}$
Heat of hydration of $\mathrm{Cl}^{-}=-300 \mathrm{~kJ} / \mathrm{mol}$

Substitute the values in the given formula
Heat of hydration $=\left(\Delta \mathrm{H}_{\text {solution }}-\Delta \mathrm{H}_{\text {lattice energy }}\right)$

$$
=5-700
$$

Therefore, Heat of hydration $=-695$
Heat of hydration of $\mathrm{Na}^{+}+\mathrm{Cl}^{-}=-695$
Heat of hydration of $\mathrm{Na}^{+}=-695-(-300)$
Therefore, Heat of hydration of Na+=-395

## WAVE FORMULA

A wave is sensed when a source vibrates and disturbs a particle on the way in the medium. This can be seen in ripples in water when its surface is touched, in tuning fork, etc. This generates a wave pattern that starts to move along the medium from particle to particle. The frequency at which each particle vibrates is equal to the frequency at which the source vibrates. In one period, the source is capable of displacing the first particle upward from the rest, back to rest, downward from rest and finally back to rest. This whole back and forth motion makes one complete wave cycle. Every wave has its own wavelength, frequency, speed and time period.

The wave formula for the velocity of sound is given by,
$V=f \boldsymbol{\lambda}$

Where,
$v=$ velocity of the wave,
$f=$ frequency of the wave,
$\lambda=$ wavelength.

Solved Examples

## Example 1

A light wave travels with a wavelength of 700 nm . Determine its frequency.

## Solution:

Given:

Wavelength $\lambda=700 \mathrm{~nm}$,
Velocity of light v $=3 \times 10^{8} \mathrm{~m} / \mathrm{s}$

The frequency is calculated by,
$f=v / \lambda$
$=3 \times 10^{8} / 700 \times 10^{-9}$
$\mathrm{f}=4.2 \times 10^{14} \mathrm{~Hz}$.
Therefore, the frequency of the light wave is $4.2 \times 10^{14} \mathrm{~Hz}$
Example 2: A sound wave has a wavelength of 2.5 mm . Determine its frequency.

## Solution:

Given:

Wavelength $\lambda=2.5 \mathrm{~cm}$,
Velocity of sound $v=343.2 \mathrm{~m} / \mathrm{s}$.
The frequency is calculated by,
$f=v / \lambda$
$\mathrm{f}=343.2 / 2.5 \times 10^{-2}$
$\mathrm{f}=13.72 \mathrm{kHz}$.

Therefore, the frequency of the sound wave is 13.72 kHz.

## FORCE OF ATTRACTION FORMULA

Force of attraction is a force that pulls the body near due to its attraction. There are numerous attractive forces prevailing in nature. Some of them are magnetic force, electric force, electrostatic force and gravitational force. Gravitational force is very well-identified instance force of attraction as it draws objects towards itself regardless of its distance. Newton's universal law of gravitation clarifies a lot more about how this force performs. It states that every mass that occurs in the universe attracts some or the other mass in the universe. It validates the fact that anyone thrown up comes down.

Let's take two masses $\mathrm{m}_{1}$ and $\mathrm{m}_{2}$ parted by a spaced.


The formula for the force of attraction is articulated as,
$F g=G m 1 m 2 d 2$

Where,
$F$ is force of attraction
G is the gravitational constant $\left(6.67 \times 10^{-11} \mathrm{Nm}^{2} / \mathrm{kg}^{2}\right)$, the mass of object 1 is $m_{1}$, the mass of object 2 is $\mathrm{m}_{2}$, the distance between two objects is d .

This formula aids out in calculating the force acting amongst any two bodies having a greater mass since in smaller masses this force is insignificant.

Force of Attraction Related Solved Problems

Underneath are given some samples on the force of attraction:

Problem 1: Compute the gravitational force acts amongst two bodies of masses $\mathbf{2 0 , 0 0 0} \mathrm{kg}$ and $50,000 \mathrm{~kg}$ parted by a distance of 50 m .

Answer:

Known:
mass $\mathrm{m}_{1}=20000 \mathrm{~kg}$,
mass $\mathrm{m}_{2}=50000 \mathrm{~kg}$,
radius $r=50 \mathrm{~m}$,

Gravitational constant G $=6.67 \times 10^{-11} \mathrm{Nm}^{2} / \mathrm{kg}^{2}$
The force due to gravity is articulated as,
$\mathrm{Fg}=\mathrm{Gm} 1 \mathrm{~m} 2 \mathrm{r} 2$
$F=\frac{6.67 \times 10^{-11} \mathrm{Nm}^{2} / \mathrm{Kg}^{2} \times 20000 \times 50000}{50^{2}}$

$$
F=2.67 \times 10^{-5} \mathrm{~N}
$$

Therefore, the gravitational force is $2.67 \times 10^{-5} \mathrm{~N}$ between the tw

Problem 2: A body of weight 80 kg is $\mathbf{2 ~ m}$ far away from the body of weight 50 kg . Calculate the gravitational force acting between them.

## Answer:

Known:
mass $\mathrm{m}_{1}=80 \mathrm{~kg}$,
mass $\mathrm{m}_{2}=50 \mathrm{~kg}$,
radius $r=2 \mathrm{~m}$,

Gravitational constant G $=6.67 \times 10^{-11} \mathrm{Nm}^{2} / \mathrm{kg}^{2}$

Fg=Gm1m2r2
$\mathrm{F}=(6.67 \times 10-11) \times 80 \mathrm{Kg} \times 50 \mathrm{Kg} 22$
$F=6.67 \times 10^{-8} \mathrm{~N}$
Therefore, $6.67 \times 10^{-8} \mathrm{~N}$ of gravitational force acts between the two bodies

# CYLINDRICAL CAPACITOR 

## FORMULA

The capacitor is used to store large amounts of electric current in a small space. Capacitors include wide applications in electric juicers, electric motors, flour mills and other electrical instruments. The potential difference between each capacitor varies. There are many electrical circuits where capacitors are to be grouped accordingly to get the desired capacitance. There are two common modes including capacitors in series and capacitors in parallel. The unit of capacitance is Farad (F).


It is often used to store the electric charge. The Cylindrical capacitor is a type of capacitor that possess the shape of a cylinder having an inner radius as $a$ and outer radius as $b$.

The formula for the cylindrical capacitor is

$$
C=2 \pi \epsilon_{0} L / \ln \left(\frac{b}{a}\right)
$$

Where,

C= capacitance of the cylinder
$\mathrm{L}=$ length of the cylinder
$\mathrm{a}=$ inner radius of the cylinder,
$b=$ outer radius of the cylinder
$\epsilon_{0}=$ permittivity of free space $\left(8.85 \times 10^{-12}\right)$
Problem 1: A Cylindrical capacitor having a length of 8 cm is made of two concentric rings with an inner radius as 3 cm and outer radius as 6 cm . Find the capacitance of the capacitor.

## Answer:

Given:

Length $\mathrm{L}=8 \mathrm{~cm}$
inner radius $\mathrm{a}=3 \mathrm{~cm}$
outer radius $\mathrm{b}=6 \mathrm{~cm}$

Formula for cylindrical capacitor is
$C=2 \pi \epsilon_{0} L / \ln \left(\frac{b}{a}\right)$

$$
\begin{aligned}
& C=(2)(3.14)\left(8.85 * 10^{-12}\right)\left(8 * 10^{-2}\right) / \ln \left(\frac{6}{3}\right) \\
& C=444.62 \times 10^{-14} / 0.301 \\
& C=1.477 \times 10^{-11} \mathrm{~F} .
\end{aligned}
$$

## ELECTRICAL FORMULAS

Electrical is the branch of physics dealing with electricity, electronics and electromagnetism. Electrical formulas play a great role in finding the parameter value in any electrical circuits. Most commonly used electrical formulas are formulas related to voltage, current, power, resistance etc.

Volt is a unit of electrical potential or motive force - potential is required to send one ampere of current through one ohm of resistance. Watt is a unit of electrical energy or power - one watt is the product of one ampere and one volt - one ampere of current flowing under the force of one volt gives one watt of energy

Below are given some commonly used Electrical formulas which may be helpful for you.

| Quantity | Formula |
| :--- | :--- |
| Charge | $\mathrm{Q}=\mathrm{C} \times \mathrm{V}$ |
| Capacitance | $\mathrm{C}=\mathrm{QV}$ |
| Inductance | $\mathrm{V}_{\mathrm{L}}=-\mathrm{L}$ didt |
| Voltage | $\mathrm{V}=\mathrm{IR}$ |
| Current | $\mathrm{I}=\mathrm{VR}$ |
| Resistance | $\mathrm{R}=\mathrm{VI}$ |
| Power (C) |  |
| Conductance | $\mathrm{G}=\underline{1} \mathrm{R}$ |

$$
\mathrm{Z}^{2}=\mathrm{R}^{2}+\left(\mathrm{x}_{\mathrm{L}}-\mathrm{x}_{\mathrm{c}}\right)^{2}
$$

Impedance

Resonant

$$
\mathrm{f}=\underline{12} \pi \mathrm{LCV}
$$

Hertz (Hz)
ohm ( $\omega$ )
Hertz (Hz)

Frequency

Electrical Formulas helps us to calculate the parameters related to electrical in any electrical components.

Electrical Problems

Problem based on Electrical which may be helpful for you are given below.

Solved Examples
Question1: A wire carrying a current of 4 Amperes is having resistance of $5 \omega$. Calculate the potential difference across its
ends.

## Solution:

Given: Current $\mathrm{I}=4 \mathrm{~A}$,
Resistance $\mathrm{R}=5 \omega$
The Potential difference is given by $\mathrm{V}=\mathrm{IR}$
$=4 \mathrm{~A} \times 5 \omega$
$=20 \mathrm{~V}$.
Question2: Calculate the charge across the capacitor 5 mF and the voltage applied is 25 V .

## Solution:

Given: Capacitance of the capacitor $\mathrm{C}=5 \mathrm{mF}$,
Voltage applied $\mathrm{V}=25 \mathrm{~V}$,
The Charge across the capacitor is given by $\mathrm{Q}=\mathrm{CV}$
$=5 \mathrm{mF} \times 25 \mathrm{~V}$
$=125 \times 10^{-3} \mathrm{C}$
$=0.125 \mathrm{C}$.

## SPEED DISTANCE TIME FORMULA

Speed is a very rudimentary concept in motion which is all about how slow or fast an object travel. We define speed as distance divided by time. Distance is directly proportionate to Velocity when time is constant. Speed, distance, and time numerical ask us to solve for one of the three variables with certain information known. In these questions, we deal with objects moving at either constant speeds or average speeds.

Speed Distance Time Formula is mathematically articulated as:
$\mathrm{x}=\mathrm{dt}$

Where,
the Speed is $\mathbf{x}$ in $\mathrm{m} / \mathrm{s}$,
the Distance travelled is $\mathbf{d}$ in m , t is the time taken in s .

Distance travelled formula is articulated as

$$
d=x t
$$

If any of the two variables among speed, distance and time is provided, we can use this formula and find the unknown numeric

## Solved Examples

Underneath are solved problems based on speed distance and time formula:

Problem 1: Lilly is driving a scooter with a speed of $6 \mathrm{~km} / \mathrm{hr}$ for 2 hr . How much distance will she travel?

## Answer:

Given: Speed of the scooter $x=6 \mathrm{~km} / \mathrm{hr}$
Time taken $\mathrm{t}=2 \mathrm{hr}$
Distance traveled d=?

Speed DIstance time formula is given as
$x=d t$

Distance traveled d $=x \times t$
$\mathrm{d}=6 \mathrm{~km} / \mathrm{hr} \times 2 \mathrm{hr}$
$\mathrm{d}=12 \mathrm{~km}$

## FRICTION LOSS FORMULA

Friction is the resistance required for moving a body through an external surface. But the friction loss is connected to the flow of liquid through a pipe. In other sense, it is a kind of energy loss because of the friction inside the tube. It is intimately related to the velocity and viscosity of the fluid.

Friction loss can be articulated as $h_{1}$ as friction loss is nothing but the energy or head loss. Friction loss formula is articulated as,
$h_{1}=f \times \frac{L}{D} \times \frac{v^{2}}{2 g}$

Where,
the friction factor is $\mathbf{f}$ the length of pipe is $\mathbf{L}$ the inner diameter of the pipe is $\mathbf{D}$
the velocity of liquid is $\mathbf{v}$
the gravitational constant is $\mathbf{g}$
the friction loss is $\mathbf{h}_{\mathbf{l}}$
Friction Loss Solved Examples

Answered problems of friction loss are stated below.

Problem 1: Compute the friction loss, if the inner diameter and length of the pipe are 0.3 m and 30 m , respectively. It is also given that the friction factor and velocity of the liquid is 0.4 and $25 \mathrm{~m} / \mathrm{s}$ ?

## Answer:

Given that,
Length of the pipe, $L=30 \mathrm{~m}$; internal diameter of the pipe, $\mathrm{D}=$ 0.3 m ;
velocity of the liquid, $v=25 \mathrm{~m} / \mathrm{s}$;
friction factor, $\mathrm{f}=0.4$
$\mathrm{g}=9.8 \mathrm{~m} / \mathrm{s}$
The friction loss formula is,
$h_{1}=f \times \frac{L}{D} \times \frac{v^{2}}{2 g}$
$h_{1}=0.4 \times \frac{30}{0.3} \times \frac{25^{2}}{2 \times 9.8}=1275.51 \mathrm{~m}$
Problem 2: Compute the friction loss if the friction factor is 0.3 and velocity of the flow is $50 \mathrm{~m} / \mathrm{s}$. Given numeric are the length of the pipe 20 m , inner diameter 0.5 m and gravitational constant $9.8 \mathrm{~m} / \mathrm{s}$.

## Answer:

Known factors are the velocity of flow is $50 \mathrm{~m} / \mathrm{s}$, length of the pipe 20 m , inner diameter 0.5 m , friction factor 0.3 and gravitational constant $9.8 \mathrm{~m} / \mathrm{s}$,

The friction loss formula is articulated as,

$$
\begin{aligned}
& h_{1}=f \times \frac{L}{D} \times \frac{v^{2}}{2 g} \\
& h_{1}=0.3 \times \frac{20}{0.5} \times \frac{50^{2}}{2 \times 9.8}=1530.61 \mathrm{~m}
\end{aligned}
$$

## POSITION FORMULA

When something travels from one point to the other, this is known as displacement. Presuming the golf ball moves from position $\mathrm{x}_{1}$ to position $\mathrm{x}_{2}$.

Position formula is represented as
$\Delta_{x}=x_{2}-x_{1}$
Where the first position of the body is $\mathrm{x}_{1}$, the second position after undergoing displacement is $x_{2}$ the rate of change in the displacement when a change in position takes place is $\Delta x$

If the body changes its position after time $t$ the rate of change in position at any moment of time $\mathrm{t}, \mathbf{x}(\mathrm{t})$ is articulated as,
$x(t)=\frac{1}{2} \alpha t^{2}+v_{0} t+X_{\circ}$

Where,
the position of the body with time $t$ is $x(t)$
the initial velocity of the body is $v 0$
the acceleration the body possesses is $\alpha$
the initial position of the body is $x_{0}$

Position Formula Solved Examples
Problem 1: A person travels 30m distance. Calculate the position of the person at the end time $6 s$ if the initial velocity of the person is $4 \mathrm{~m} / \mathrm{s}$ and angular acceleration is $3 \mathrm{~m} / \mathrm{s}^{2}$.

## Answer:

Known :
$\mathrm{v}_{0}=4 \mathrm{~m} / \mathrm{s}$
$\mathrm{x}_{0}=30 \mathrm{~m}$
$\alpha=3 \mathrm{~m} / \mathrm{s}^{2}$
$t=6 s$

The change in position of the person at time $t$ is
$x(t)=\frac{1}{2} \alpha t^{2}+v_{0} t+X_{\circ}$
$x(6)=0.5 \times 3 \times(6)^{2}+4 \times 6+30$
$X(6)=54+24+30$
$X(6)=108 \mathrm{~m}$

## ESCAPE SPEED FORMULA

Velocity or Escape speed is the speed of a body at which the total of the kinetic energy and gravitational potential energy is zero. In a different sense, it can be described as the speed required to break the gravitational attraction. The formula for escape speed is articulated as,
$\mathrm{Ve}=\underline{2} \mathrm{GMr}----\mathrm{V}$

Where
$\mathbf{G}$ is the gravitational constant
$\mathbf{M}$ is the mass of the planet
$r$ is the distance from the centre of gravity.

## Escape Speed Solved Examples

Let us discuss some numerical on escape speed to learn more about this concept.

Problem 1: The mass of the Jupiter is given as $1.898 \times 10^{27} \mathrm{Kg}$ and the radius is given as 71492 km . Compute the escape speed?

## Answer:

Known parameters are,
Mass of the Jupiter, $\mathrm{M}=1.898 \times 10^{27} \mathrm{~kg}$
Radius, $\mathrm{r}=71492 \mathrm{~km}$
$\mathrm{G}=6.673 \times 10^{-11} \mathrm{~m}^{3} / \mathrm{kgs}^{2}$
Formula for escape speed is,
ve= $\underline{2} G M r----v$
 $188.23 \mathrm{~km} / \mathrm{s}$

## Frustum Of A Right Circular Cone Formula

Frustum of a right circular cone is that portion of right circular cone included between the base and a section parallel to the base not passing through the vertex.


## Properties of Frustum of Right Circular Cone

- The altitude of a frustum of a right circular cone is the perpendicular distance between the two bases. It is denoted by h .
- All elements of a frustum of a right circular cone are equal. It is denoted by L .

The formula of Frustum of a Right Circular Cone
$C S A=\pi s\left(R_{1}+R_{2}\right)$
$T S A=\pi s\left(R_{1}+R_{2}\right)+\pi R_{1}{ }^{2}+\pi R_{2}{ }^{2}$
VOlume, $\mathrm{V}=\pi \mathrm{h} \underline{3}(\mathrm{R} \underline{2}+\mathrm{Rr}+\mathrm{r} \underline{2})$

## Solved Examples

Question: Find the volume of a frustum of a right circular cone with height 20, lower base radius 34 and top radius 19 ?

## Solution:

Given
$h=20$
$R=34$
$r=19$
$V=\pi h \underline{3}(R \underline{2}+R r+r \underline{2})$
$V=\pi \times \underline{203}(\underline{342}+\underline{34} \times \underline{19}+\underline{192})$
$V=14420 \pi$

## ANGULAR ACCELERATION

## FORMULA

Definition: Angular acceleration of an object undergoing circular motion is defined as the rate with which its angular velocity changes with time. Angular acceleration is also referred to as rotational acceleration. It is a vector quantity, that is, it has both magnitude and direction.

Angular acceleration is denoted by $\alpha$ and is expressed in the units of rad/s2 or radians per second square.

Formula:

Angular acceleration can be expressed as given below,
$\alpha=d \omega d t$
And also in terms of the double differentiation of the angular displacement, as given below,
$\alpha=\mathrm{d} \underline{2} \theta \mathrm{dt} \underline{2}$
Derivation:

Angular acceleration is the rate of change of angular velocity with respect to time, or we can write it as,
$\alpha=d \omega d t$
Here, $\alpha$ is the angular acceleration that is to be calculated, in terms of rad/s2, $\omega$ is the angular velocity given in terms of $\mathrm{rad} / \mathrm{s}$ and t is the time taken expressed in terms of seconds.

Angular velocity as we know can be expressed as given below.
$\omega=\mathrm{vr}$

Here, $\omega$ is the angular velocity in terms of rad/s, v is the linear velocity and $r$ is the radius of the path taken.

Angular Velocity can also be expressed as the change in angular displacement with respect to time, as given below.
$\omega=\theta t$
Where $\theta$ is the angular rotation of the object and $t$ is the total time taken.

Using the above formula, we can write angular acceleration $\alpha$ as
$\alpha=d \underline{2} \theta d t \underline{2}$

Solved Examples

## Example 1:

An ant is sitting at the edge of a rotating circular disc. It's angular velocity changes at the rate of $60 \mathrm{rad} / \mathrm{s}$ for 10 seconds. Calculate its angular acceleration during this time?

## Solution:

Given: The change in angular velocity is equal to $d \omega=60$ $\mathrm{rad} / \mathrm{s}$. The time taken for this change to occur is equal to $\mathrm{t}=$ 10s.

Using the formula for angular acceleration and substituting the above values, we get,
$\alpha=d \omega d t=\underline{305}=\underline{6} \mathrm{rad} / \mathrm{s} \underline{2}$

## Example 2:

The rear wheel of a motorcycle has an angular acceleration of $20 \mathrm{rad} / \mathrm{s} 2$ in a second. What can be said about its angular velocity?

## Answer:

Given: The angular acceleration of the wheel is equal to $\alpha=$ $10 \mathrm{rad} / \mathrm{s} \underline{2}$,

Time taken $\mathrm{t}=1 \mathrm{~s}$,
According to the formula for angular acceleration,
$\alpha=d \omega d t$
Upon substituting the values, we get,

Angular velocity d is
$d \omega=\alpha d t$
$\mathrm{d} \omega=20 \times 1=20 \mathrm{rad} / \mathrm{s}$

## GROSS PROFIT FORMULA

The gross profit formula is the total revenue minus cost of things sold. It is the company's profit before all interest and tax payments. Gross profit is also called gross margin. Find below the formula to calculate the gross profit of a company.

Formula for Gross Profit

The gross profit formula is given as:

Gross Profit = Revenue $\boldsymbol{-}$ Cost of Goods Sold

Gross Profit $=$ Revenue - Cost of goods sold

Example Questions Using Gross Profit Formula
Question 1: If the cost of a fan is 5.30 dollar and sold at 7.90 dollars. Find the gross profit?

## Solution:

Given Revenue = \$5.30
Selling price = \$7.90

## Gross Profit $=$ Revenue $\boldsymbol{-}$ Cost of Goods

Gross Profit $=7.90-5.30$
Gross Profit $=\$ 2.6$

Question 2: If the cost of a toy is 6.70 dollar and sold at 10.00 dollar. Find the gross profit?

## Solution:

Given Revenue $=\$ 6.70$
Selling price = \$10
Gross Profit $=10-6.70$
Gross Profit $=\$ 3.3$

## INSTANTANEOUS RATE OF CHANGE

## FORMULA

The instantaneous rate of change is the change in the rate at a particular instant and it is same as the change in the derivative value at a specific point. For a graph, the instantaneous rate of change at a specific point is the same as the tangent line slope. That is it is a curve slope.

Another way to better grasp this definition is with the differen tial quotient and limits. The average rate of $y$ shift with respec $t$ to $x$ is the quotient of difference.

The Formula of Instantaneous Rate of Change represented with limit exists in,
$f^{\prime}(a)=\lim _{\Delta x \rightarrow 0} \frac{\Delta y}{\Delta x}=\lim _{x \rightarrow 0} \frac{t(a+h)-(t(a))}{h}$

With respect to $x$, when $x=a$ and $y=f(x)$

## Instantaneous Rate of Change - Solved Example

Problem 1: Compute the Instantaneous rate of change of the function $f(x)=3 x^{2}+12$ at $x=4$ ?

## Answer:

Known Function,
$y=f(x)=3 x^{2}+12$
$f^{\prime}(x)=3(2 x)+0$
$f^{\prime}(x)=6 x$
Thus, the instantaneous rate of change at $x=4$
$f^{\prime}(4)=6(4)$
$f^{\prime}(4)=24$
Problem 2: Compute the Instantaneous rate of change of the function $f(x)=5 x^{3}-4 x^{2}+2 x+1$ at $x=2$ ?

Answer:

Known Function,
$y=f(x)=5 x^{3}-4 x^{2}+2 x+1$
$f^{\prime}(x)=5\left(3 x^{2}\right)-4(2 x)+2+0$
$f^{\prime}(x)=15 x^{2}-8 x+2$
Thus, the instantaneous rate of change at $x=2$
$f^{\prime}(2)=15(2)^{2}-8(2)+2=60-16+2=46$
$f^{\prime}(2)=46$

## HEAT TRANSFER FORMULA

Heat transfer is a process is known as the exchange of heat from a high-temperature body to a low-temperature body. As we know heat is a kinetic energy parameter, included by the particles in the given system. As a system temperature increases the kinetic energy of the particle in the system also increases. The energy of the particle from the one system to other system is transferred when these systems are brought into contact with one another.

The following equation relates to the heat transferred from one system to another
$Q=c \times m \times \Delta T$
Where
$Q=$ Heat supplied to the system
$m=$ mass of the system
$c=$ Specific heat capacity of the system and
$\Delta \mathrm{T}=$ Change in temperature of the system.

The transfer of heat occurs through three different processes, which are mentioned below.

1. Conduction
2. Convection
3. Radiation.

## Conduction:

Heat transferred by the process of conduction can be expressed by the following equation,

Q $=k A$ (THot - TCold) ) $d$
$Q=$ Heat transferred
$\mathrm{K}=$ Thermal conductivity
$\mathrm{T}_{\text {нот }}=$ Hot temperature
$\mathrm{T}_{\text {coLD }}=$ Cold Temperature
$\mathrm{t}=$ Time
$A=$ Area of the surface
$d=$ Thickness of the material

## Convection:

Heat transferred by the process of convection can be expressed by the following equation,

## Q=HcA(THOT-TCOLD)

Here, Hc is the heat transfer coefficient.

## Radiation:

The Heat transferred by the process of radiation can be given by the following expression,
$\mathrm{Q}=\sigma($ THot $\underline{4}-$ TCold 4 ) A
Here $\sigma$ is known as Stefan Boltzmann Constant.

Derivation:

From the definition of specific heat capacity, we can say that, it is the total amount of heat that is to be supplied to a unit mass of the system, so as to increase its temperature by 1 degree Celsius.

Now, the total heat to be supplied to the system can be given as,
$Q=c \times m \times \Delta T$
Real Life Example: Let us consider a pitcher of water that is to be heated till its temperature rises from the room temperature to 100 degree Celsius. In this case, as we know the mass of the water and its specific heat capacity at the given conditions, we can use the above mentioned formula to calculate the amount of heat to be supplied.

## Example 1

Let us consider two water columns at different temperatures, one being at $40^{\circ} \mathrm{C}$ and the other
being at $20^{\circ} \mathrm{C}$. As both the water columns are separated by a glass wall of area 1 m by 2 m and a thickness of 0.003 m . Calculate the amount of heat transfer. (Thermal Conductivity of glass is $1.4 \mathrm{~W} / \mathrm{mK}$ )

## Solution:

According to question,
Thermal Conductivity of glass $=1.4 \mathrm{~W} / \mathrm{mK}$.
Also, the temperature of the first column is $T_{h}=40^{\circ} \mathrm{C}$ and The temperature of the second column is $\mathrm{T}_{\mathrm{c}}=20^{\circ} \mathrm{C}$.

Area of the wall separating both the columns $=1 \mathrm{~m} \times 2 \mathrm{~m}=2$ $\mathrm{m}^{2}$

Using the heat transfer equation for conduction, we can write,
Q $=k A$ (THot-TCold) $d$
$\mathrm{Q}=1.4 \times 2 \times 200.003=18667 \mathrm{~W}$

## Example 2

A system weighing 5 Kgs is heated from its initial temperature of $30^{\circ} \mathrm{C}$ to its final temperature of $60^{\circ} \mathrm{C}$. Calculated the total heat gained by the system. (Specific heat of the system $=0.45 \mathrm{~kJ} / \mathrm{Kg} \mathrm{K}$ )

## Solution:

According to question,
The Initial temperature of the system, $\mathrm{Ti}=30^{\circ} \mathrm{C}$
The Final temperature of the system, $\mathrm{Tf}=60^{\circ} \mathrm{C}$
Mass of the system, $m=5 \mathrm{~kg}$

The total heat gained by the system can be calculated by using the formula for heat transfer as mentioned above,
$\mathrm{Q}=\mathrm{c} \times \mathrm{m} \times \Delta \mathrm{T}$
$\mathrm{Q}=5 \times 0.45 \times 30$
$\mathrm{Q}=67.5 \mathrm{~J}$

## ANGLE BETWEEN TWO VECTORS

## FORMULA

If the two vectors are assumed as $\vec{a}$ and $b^{\vec{~}}$ then the dot created is articulated as $\vec{a} . \mathrm{b}^{\vec{\prime}}$. Let's suppose these two vectors are separated by angle $\theta$. To know what's the angle measurement we solve with the below formula

we know that the dot product of two product is given as
$\vec{a} \cdot b \vec{b}=|a \vec{a}||b \vec{b}| \cos \theta$

Thus, the angle between two vectors formula is given by $\theta=\cos -1 a \vec{a} \cdot b^{\vec{~}}|a \vec{a}|\left|b^{\vec{~}}\right|$

Where $\theta$ is the angle between $a \vec{a}$ and $b \vec{~}$

Angle Between Two Vectors Examples

Let's see some samples on the angle between two vectors:

## Example 1:

Compute the angle between two vectors $3 i+4 j-k$ and $2 i-j$ +k .

## Solution:

Let
$\vec{a}=3 i+4 j-k$ and
$b^{\vec{~}}=2 i-j+k$

The dot product is defined as
$\vec{a} \cdot b^{\vec{n}}=(3 i+4 j-k) \cdot(2 i-j+k)$
$=(3)(2)+(4)(-1)+(-1)(1)$
$=6-4-1$
$=1$

Thus, $\vec{a} \cdot b^{\vec{~}}=1$
The Magnitude of vectors is given by


The angle between the two vectors is
$\theta=\cos -\underline{1} a \vec{a} \cdot b^{\vec{~}}|a \vec{a}|\left|b^{\vec{~}}\right|$
$\theta=\cos -11(\underline{5.09)}(\underline{2.45})$
$\theta=\cos -\underline{1112.47}$
$\theta=\cos -1(0.0802)$
$\theta=85.39 \circ$

## Example 2:

Find the angle between two vectors $5 \mathrm{i}-\mathrm{j}+\mathrm{k}$ and $\mathrm{i}+\mathrm{j}-\mathrm{k}$.

## Solution:

Let
$\vec{a}=5 i-j+k$ and
$\vec{b}=i+j-k$
The dot product is defined as
$\vec{a} \cdot \vec{b}=(5 i-j+k)(i+j-k)$
$a \vec{b} \cdot(5)(1)+(-1)(1)+(1)(-1)$
$\vec{a} \cdot b^{\vec{b}}=5-1-1$
$\vec{a} \cdot b \vec{b}=3$

The Magnitude of vectors is given by

$$
|a \vec{a}|=(\underline{52}+(-\underline{1}) \underline{2}+\underline{12})--------------27=-v=\underline{5.19}
$$

#  

The angle between the two vectors is
$\theta=\cos -1 a \vec{a} \cdot b^{\vec{~}}|a \vec{a}||b|$
$\theta=\cos -13(5.19)(1.73)$
$\theta=\cos -138.97$
$\theta=\cos -1(0.334)$
$\theta=\underline{70.48}{ }^{\circ}$

## PERCENT ERROR FORMULA

Percent error formula is the absolute value of the difference of the measured value and the actual value divided by the actual value and multiplied by 100 . Why percent error is required? There may be a slight manufacturing error in measuring instruments. They can never be assumed to be exact. To get to know to what extend error is there, we go for this percent error formula.

Formula for Percent Error
The formula to calculate Percent Error is:

Percentage Error = (Approximate Value - Exact Value / Exact Va

## Solved Examples

Question 1: A scale measures wrongly a value as 8 cm due to some marginal errors. Calculate the percentage error if the actual measurement of the value is 12 cm .

## Solution:

Given,
Approximate value $=8 \mathrm{~cm}$
Exact value $=12 \mathrm{~cm}$
Percentage Error $=($ Approximate Value - Exact Value $/$ Exact Value $\times 100$ )

Percentage Error $=(8-12) / 12 \times 100$
$=-33.3 \%$

## VELOCITY FORMULA

## Velocity Formula

The speed of a body in a specific direction is the measure of Velocity.

It is represented by $\mathbf{V}$ and is articulated as
$V=\frac{s}{t}$
Where,
$\mathrm{s}=$ displacement
$\mathrm{t}=$ time taken

Since displacement is conveyed in meters and time taken in seconds. Velocity is articulated in meters/second or $\mathrm{m} / \mathrm{s}$.

In any numerical if any of these two quantities are given we can calculate the missing quantity by making use of this formula.

## Velocity Solved Examples

Underneath are given the velocity based problems which helps you to understand more about it.

Problem 1: A plane moves the distance of 500 Km in 1 hr .
Calculate its velocity?
Answer:

Displacement $\mathrm{S}=500 \mathrm{~km}=500 \times 103 \mathrm{~m}$,
Time taken $\mathrm{t}=1 \mathrm{hr}=60 \times 60=3600 \mathrm{~s}$.
Velocity is given by $V=\frac{s}{t}=\frac{500 \times 10^{3}}{3600}=139 \mathrm{~m} / \mathrm{s}$
Problem 2: A submarine descends 150 ft in 3 seconds. Find the Velocity of submarine?

## Answer:

Known:

Distance traveled $\mathrm{S}=-150 \mathrm{ft}$,
Time taken $t=3$ seconds

Velocity is given by $V=\frac{s}{t}=\frac{-150 \mathrm{ft}}{3 \mathrm{~s}}=-50 \mathrm{ft} / \mathrm{s}$

## FLUID MECHANICS FORMULA

Fluid mechanics could be defined as the division of engineering science which deals with the behaviour of the fluid in both motion and rest situations.

Fluid mechanics is one of the four divisions of mechanics namely quantum mechanics, relative mechanism, fluid mechanics and elastic body mechanics.

Fluid mechanics is separated into three distinct classes. These are statics, kinematics, and the dynamics out of which static and dynamics are then divided into a compressible and incompressible flow. These are furthermore split into turbulent and laminar forms.

Fluid mechanics is grounded upon five principles of physics and they are as follows:

1. Conservation of linear momentum
2. Conservation of angular momentum
3. Conservation of energy
4. Conservation of mass
5. Conservation of thermodynamics

In fluid mechanics, if the speed of flow of a liquid if not too huge then it generally flows in coats with regular gradation in their respective velocities and therefore called streamline flow. While if the rate of flow is too high then numerous irregularities begin to show and do not flow in layers which we term as turbulent flow. The turbulence commences after the critical velocity which is given by a relation
$V_{c}=\frac{k \eta}{\sigma r}$
Where,
$\mathrm{V}_{\mathrm{c}}=$ Critical velocity
$\mathrm{k}=$ Reynolds number
$\eta=$ coefficient of viscosity of the fluid
$\sigma=$ density of the fluid
$r=$ radius of the tube

If the velocity of the fluid reaches a value such that the
Reynolds number gets a value greater than(>)4000 then the flow is turbulent.

# POWER FACTOR FORMULA FOR 

## SINGLE PHASE

Power factor is only related to the AC circuit. DC circuit will not have power face since there is zero frequency and phase angle difference between current and voltage.

Power Factor is given by the cosine of the angle between voltage and current
$\mathrm{P}=\mathrm{VI} \operatorname{Cos} \theta$

Rearranging the above formula we get
$\operatorname{Cos} \theta=\mathrm{P} / \mathrm{VI}$

Therefore,
$\operatorname{Cos} \theta=$ True Power/Apparent Power

Where,
$\operatorname{Cos} \theta=$ Power factor
$P=$ Power in Watts
$\mathrm{V}=$ Voltages in Volts

I = Current in Amperes
The true power is given in terms of Watts and the Apparent power is given in terms of Volt-Amperes or Watts

The power factor in an AC circuit is also given by the ratio of Resistance and Impedence
$\operatorname{Cos} \theta=R / Z$

Where,
$R=$ Resistance in ohms

Z = Impedance
Impedance $(Z)$ is the total resistance in the AC circuit and is given by
$\mathrm{Z}=\mathrm{v}\left[\mathrm{R}^{2}+\left(\mathrm{X}_{\mathrm{L}}+\mathrm{X}_{\mathrm{c}}\right)^{2}\right]$
Where,
$R=$ resistance
$X_{L}=$ inductive reactance
$\mathrm{X}_{\mathrm{c}}=$ capacitive reactance
Here, it is noted that single phase power factor is less than 1.
Note: For a purely resistive circuit, the power factor is 1.

## CIRCLE FORMULA

Circle is a particular shape and defined as the set of points in a plane placed at equal distance from a single point called the center of the circle. We use the circle formula to calculate the area, diameter, and circumference of a circle. The length between any point on the circle and its center is known as its radius.Any line that passes through the center of the circle and connects two points of the circle is known as the diameter of the circle. Radius is half the length of a diameter of the circle. Area of the circle describes the amount of space covered by the circle and the length of the boundary of the circle is known as its circumference.


> Where,

- $r$ denotes the radius of the circle.
- d indicates the diameter of the circle.
- c indicates circumference of the circle.

Formulas Related to Circles
The Circle Formulas are expressed as,
Diameter of a Circle $D=2 \times r$

Circumference of a
Circle

$$
C=2 \times \pi \times r
$$

Area of a Circle $A=\pi \times r^{2}$

## Example Question Using the Circle Formulas

## Example 1

A circle has a radius 8 cm . Calculate its diameter, area and circumference.

## Solution

Given parameters are,

Radius, $r=8 \mathrm{~cm}$

Diameter of a circle is given by
$2 r$
$=2 \times 8 \mathrm{~cm}$
$=16 \mathrm{~cm}$

Area of a circle is given by
$\pi r^{2}$
$=\pi \times 64$
$=201.088 \mathrm{~cm}^{2}$

Circumference of a circle is given by
$2 \pi r$
$=2 \times \pi \times 8$
$=50.272 \mathrm{~cm}$

## Example 2

Find the diameter, area and circumference of a circle of radius 15 cm .

Solution

Given parameters are
Radius of a circle, $r=15 \mathrm{~cm}$

Diameter of a circle is given by
$2 r$
$=2 \times 15$
$=30 \mathrm{~cm}$

Area of a circle is given by
$\pi r^{2}$
$=\pi \times 15^{2}$
$=\pi \times 225$
$=706.95 \mathrm{~cm}^{2}$

Circumference of a circle
$=2 \pi r$
$=2 \times \pi \times 15$
$=94.26 \mathrm{~cm}$

## LENGTH CONTRACTION FORMULA

Length contraction is considered when an object has travelled with the velocity of light. So, relativity arrives into the picture. Therefore, one can say that length contraction happens when an object is travelling at the speed of light. This is described as the decrease in length if a body is travelling with the velocity of light linked to the observer. The formula for length contraction is articulated as
$L=L_{0} \sqrt{1-\frac{v^{2}}{c^{2}}}$

Where $L$ is the length of an object with is in relativistic speed, $\mathrm{L}_{0}$ is the length of an object at rest, $\boldsymbol{c}$ is the velocity of light and $\boldsymbol{v}$ is the velocity of the object.

## Length Contraction Solved Example

Problem 1: Compute the contracted length of an object whose initial length 10 m and travel with a velocity 0.75 c ?

Answer:

Given parameters are,
$\mathrm{L}_{0}=10 \mathrm{~m}$
$v=0.75 c$
$c=$ Speed of light $\left(3.0 \times 10^{8} \mathrm{~m} / \mathrm{s}\right)$

The formula for length contraction is
$10 \times \sqrt{1-\frac{0.75 c^{c}}{c^{2}}}$
$L=10 \times V 1-(0.75)^{2}$
$\mathrm{L}=10 \times \mathrm{V}(\mathrm{o} .438)$
$\mathrm{L}=6.618 \mathrm{~m}$.

## HEAT CAPACITY FORMULA

Heat capacity is the heat required to increase an object tempe rature by one degree.

Heat gain or loss results to changes in temperature, state and performance of the work. Heat is a transfer of energy. The heat capacity of a defined object is usually expres sed in joules or calories and temperature in Kelvin or Celsius.

Heat Capacity formula is expressed by,
$c=\frac{\Delta Q}{\Delta T}$
Wherein,
$\Delta \mathrm{Q}=$ amount of heat transferred,
$\Delta T=$ temperature difference.
Heat Capacity problem can be applied to calculate the heat capacity, mass or temperature difference of any given
substance.
Heat Capacity is described in Joule per Kelvin (J/K).
Please note that in Heat capacity, we consider the specific amount of mass and that mass can be any amount.

## Example 1

Determine the heat capacity of copper of mass 70 g and the temperature difference is $20^{\circ} \mathrm{C}$ if 300 J of heat is lost.

## Solution:

Given parameters are,
Mass $m=70 \mathrm{~g}$,
Temperature difference $\mathrm{T}=20^{\circ} \mathrm{C}$,
Heat lost $\Delta \mathrm{Q}=300 \mathrm{~J}$
the Heat capacity formula is given by
$c=\Delta Q / \Delta T$
c= $300 / 20$
$\mathrm{c}=15 \mathrm{~J} /{ }^{\circ} \mathrm{C}$

## Example 2

Determine the heat capacity of 3000 J of heat is used to heat the iron rod of mass 10 Kg from $20^{\circ} \mathrm{C}$ to $40^{\circ} \mathrm{C}$.

Solution:

Given parameters are
Mass m = 10 Kg ,
Temperature difference $\Delta \mathrm{T}=20^{\circ} \mathrm{C}$,
Heat lost $\Delta \mathrm{Q}=3000 \mathrm{~J}$
The Heat capacity formula is given by
$\mathrm{c}=\Delta \mathrm{Q} / \Delta \mathrm{T}$
c= $3000 / 20$
$\mathrm{c}=150 \mathrm{~J} /{ }^{\circ} \mathrm{C}$

## STOPPING DISTANCE FORMULA

## Stopping Distance Formula

When the body is moving with a certain velocity and suddenly brakes are applied. You would have noticed that the body stops completely after covering a certain distance. This is called the stopping distance.

The stopping distance is the distance travelled between the time when the body decides to stop a moving vehicle and the time when the vehicle stops completely. The stopping distance depends on factors including road surface, and reflexes of the car's driver and it is denoted by d .

Stopping Distance formula is given by,
$d=\frac{v^{2}}{2 \mu g}$

Where,
$\mathrm{d}=$ stopping distance (m)
$\mathrm{v}=$ velocity $(\mathrm{m} / \mathrm{s})$
$\mu=$ friction coefficient
$\mathrm{g}=$ acceleration due to gravity $\left(9.8 \mathrm{~m} / \mathrm{s}^{2}\right)$
The stopping distance formula is also given by,
$d=k v^{2}$

Where,
$\mathrm{k}=\mathrm{a}$ constant of proportionality
$\mathrm{v}=$ velocity

## Example 1

A car is moving with a velocity of $40 \mathrm{~m} / \mathrm{s}$ and suddenly applies brakes. Determine the constant of proportionality if the body covers a distance of 10 m before coming to rest.

## Solution:

## Given:

Velocity, $\mathrm{v}=40 \mathrm{~m} / \mathrm{s}$

Stopping distance, $\mathrm{d}=10 \mathrm{~m}$

The constant of proportionality is given by the formula,
$k=d / v^{2}$
= $10 / 1600$
$=0.00625$.

## Example 2

A bike moves with a velocity of $15 \mathrm{~m} / \mathrm{s}$ and applies a brake.
Calculate its stopping distance if the constant of proportionality is 0.9.

Solution:

Given:

Velocity, $\mathrm{v}=15 \mathrm{~m} / \mathrm{s}$

Constant of proportionality $\mathrm{k}=0.9$,
The stopping distance is given by

$$
\begin{aligned}
d & =k v^{2} \\
= & 0.9 \times 225 \\
\mathrm{~d} & =202.5 \mathrm{~m}
\end{aligned}
$$

## WATER PRESSURE FORMULA

The pressure is defined as the force applied which is perpendicular to the surface of the object per area over which the force is distributed. The Gauge pressure is the pressure relative to ambient pressure. Various units are applied to express pressure. Some of which derives from a unit of force per unit area. The SI unit of pressure is Pascal (Pa). Similarly, water pressure is the term used to describe the strength of water flow through a channel or pipe.

The water pressure formula and SI unit are given as:
Formula Water pressure $=\rho \mathrm{gh}$

SI unit Pa

Where,

- $\mathrm{P}=$ water pressure in Pa
- $\rho=$ density of water in $\mathrm{kg} \cdot \mathrm{m}^{-3}$
- $\mathrm{g}=$ gravitational force in $9.81 \mathrm{~m} . \mathrm{s}^{-2}$
- $h=$ height in $m$

The loss of water pressure can also be calculated. The water pressure loss formula due to height $h$ is given as:

Pressure loss $=0.4335 \times \mathrm{h}$

Where,

- $h$ denotes the height

Solved Example

## Example 1

A tank of height 6 m is filled with water. Calculate the pressure on the tank at its bottom.

## Solution:

## Given:

Density of water, $\rho=1000 \mathrm{~kg} / \mathrm{m}^{3}$
Acceleration due to gravity, $g=9.8 \mathrm{~m} / \mathrm{s}^{2}$
Height, $h=6 m$

The water pressure formula on the tank is given by,
$P=\rho g h=1000 \times 9.8 \times 6=58800 \mathrm{~Pa}$.

## Example 2

A waterfall has a height of 200 m . Determine the pressure loss when it reaches the surface.

## Solution:

Given:
Density of water, $\rho=1000 \mathrm{~kg} / \mathrm{m}^{3}$
Acceleration due to gravity, $g=9.8 \mathrm{~m} / \mathrm{s}^{2}$
Height, $\mathrm{h}=200 \mathrm{~m}$

The pressure loss formula is given by Pressure loss $=0.4335$ $\times 200=86.7 \mathrm{~Pa}$.

## THERMAL ENERGY FORMULA

## Thermal Energy Formula

Thermal energy is the energy generated from heat. This heat is produced by the movement of small particles within an object. The faster the particles move, the more the heat is generated.

Thermal energy is responsible for the temperature of the system and a part of the total energy of the system which is the sum of potential energy and kinetic energy.

The thermal energy is usually expressed by Q . It is directly proportional to the mass of the substance, temperature difference and the specific heat.

The SI unit of thermal energy is Joules(J).

The thermal energy formula is given by
$Q=m c \Delta T$
Where
$\mathrm{Q}=$ thermal energy,
$\mathrm{m}=$ mass of the given substance,
c = specific heat, and
$\Delta \mathbf{T}=$ temperature difference.

## Example 1

Determine the thermal energy of a substance whose mass is 6 kg and specific heat is $0.030 \mathrm{~J} / \mathrm{kg}^{\circ} \mathrm{c}$. The temperature difference of this system is given as $20^{\circ} \mathrm{C}$.

## Solution:

Given:
$\mathrm{m}=6 \mathrm{~kg}$,
$\mathrm{c}=0.030 \mathrm{~J} / \mathrm{kg}^{\circ} \mathrm{C}$,
$\Delta T=20^{\circ} \mathrm{C}$

The thermal energy formula is given by,
$Q=m c \Delta T$
$=6 \times 0.030 \times 20$
$Q=3.6 \mathrm{~J}$

## Example 2

A 5 kg substance undergoes temperature difference of $60^{\circ} \mathrm{C}$ whose specific heat is $0.07 \mathrm{~J} / \mathrm{kg}^{\circ} \mathrm{C}$, Determine the thermal energy.

## Solution:

Given:
$m=5 \mathrm{~kg}$,
$\mathrm{c}=0.07 \mathrm{~J} / \mathrm{kg}^{\circ} \mathrm{C}$,
$\Delta \mathrm{T}=60^{\circ} \mathrm{C}$

The for thermal energy formula is given by,
$Q=m c \Delta T$
$=5 \times 0.07 \times 60$
$Q=21 \mathrm{~J}$

## AMPERES LAW FORMULA

Ampere's law came to existence in 1826. The law talks about the sum of the magnetic field across a closed hoop which is carrying
current. Ampere's law can be useful when measuring a high degree of symmetry for magnetic fields with current distributi ons.

Ampere's Law Formula
$\oint \mathrm{B}^{\rightarrow \mathrm{dl} \rightarrow=\mu \underline{\mathrm{O}}, ~}$

Notations Used In Ampere's Law Formula

- $B$ is the magnetic field
- $L$ is the infinitesimal length
- I is the current flowing through the closed-loop
- $\mu$ is the permeability

Solved Example

Question 1: Compute the magnetic field of a long straight wire that has a circular loop with a radius of 0.05 m . 2amp is the reading of the current flowing through this closed loop.

## Solution:

Given
$R=0.05 m$

I = 2amp
$\mu_{0}=4 \pi \times 10^{-7} N / A^{2}$
Ampere's law formula is
$\oint \mathrm{B}^{\mathrm{dl}} \rightarrow=\mu \underline{\mathrm{O}}$

In the case of long straight wire

$$
\begin{aligned}
& \oint \overrightarrow{d l}=2 \Pi R=2 \times 3.14 \times 0.05=0.314 \\
& B \oint \overrightarrow{d l}=\mu_{0} I \\
& \vec{B}=\frac{\mu_{0} I}{2 \pi R} \\
& \vec{B}=\frac{4 \pi \times 10^{-7} \times 2}{0.314}=8 \times 10^{-6} \mathrm{~T}
\end{aligned}
$$

## STATIC FRICTION FORMULA

Let us imagine a car at rest. To start it without making use of the accelerator, one will have to use a lot of force.

This is static friction! Here the object at rest is made to move to conflict the frictional force.

Static friction is the resistive force perceived in a body which is at rest. It is articulated as
$F_{s}=\mu_{s} F_{n}$
Where,
static friction is $\mathrm{F}_{\mathrm{s}}$,
the coefficient of static friction is $\mu_{\mathrm{s}}$
the normal force is $F_{n}$
Static Friction Formula helps one to compute the frictional force, co-efficient of friction or normal force in any asked numerical.

## Static Friction Solved Examples

Underneath are numerical on static friction which helps to comprehend where one can use this formula:

Problem 1: A force of 200 N is exerted on a snacks box of 5 kg still on the floor. If the coefficient of friction is 0.3 , Calculate the static friction.

## Answer:

Known:
Fn (Normal force) $=200 \mathrm{~N}$,
$\mu_{\mathrm{s}}($ Coefficient of friction $)=0.3$,
Static friction is given by $F_{s}=\mu_{s} F_{n}$
$=0.3 \times 200 \mathrm{~N}$
$\mathrm{F}_{\mathrm{s}}=60 \mathrm{~N}$.
Problem 2: Amy is hauling a toy car of mass 4 kg which was at rest earlier on the floor. If 50 N is the value of the static
frictional force, calculate the friction coefficient?

## Answer:

Known:
$m$ (Mass) $=4 \mathrm{~kg}$,
$\mathrm{F}_{\mathrm{s}}$ (static frictional force) $=50 \mathrm{~N}$,
$F_{\mathrm{n}}$ (Normal force) $=\mathrm{mg}$
$=4 \mathrm{Kg} \times 9.8 \mathrm{~m} / \mathrm{s}^{2}$
$F_{\mathrm{n}}=39 \mathrm{~N}$
$\mu_{\mathrm{s}}=\mathrm{F}_{\mathrm{s}} / \mathrm{F}_{\mathrm{n}}$
$\mu_{\mathrm{s}}=50 / 39$
$\mu_{\mathrm{s}}=1.282$

## EFFICIENCY FORMULA

Efficiency is the ratio of the work performed by a machine or in a process to the total energy expended or heat consumed.

Efficiency refers to how close we can get to a particular outcome of the given input with as much less wastage as possible. Efficiency is the ability to minimize wasting materials, energy, efforts, and time in performing something or producing the desired result.

Efficiency can be determined quantitatively by the ratio of useful output to total input. The ratio of energy transferred to a useful form compared to the total energy supplied initially is called the efficiency of the device.

Efficiency is denoted by $\eta$.
Efficiency formula regarding Work is given as
$\eta=\frac{\text { Work Output }}{\text { Work Input }} \times 100 \%$
Efficiency formula regarding Energy is given as
$\eta=\frac{\text { Energy Output }}{\text { Energy Input }} \times 100 \%$
The efficiency formula is applied to calculate the efficiency of any given input. It has no unit and expressed in percentage.

Numericals

## Example 1

If a cyclist puts 600 J of work on his bicycle and the bicycle gives out 140 J of useful work. Calculate the efficiency of a cyclist.

## Solution:

Given:

Work Input $=600 \mathrm{~J}$,

Work Output $=140 \mathrm{~J}$
The efficiency is given as
$\eta=\{$ Work Output / Work Input $\} \times 100 \%$
$=\{140 / 600\} \times 100 \%$
$=23.3 \%$

## Example 2

A heat engine gives out 500 J of heat energy as useful work.
Determine the energy supplied to it as input if its efficiency is 40\%.

## Solution:

Given:

Energy output = 500 J
Efficiency $\eta=40 \%$
Efficiency $\eta=\{$ Energy Output $/$ Energy Input $\} \times 100$ \%
$\therefore$ Energy input = Energy Output $/ \eta$

$$
\begin{aligned}
& =500 / 0.40 \\
& =1250 \mathrm{~J}
\end{aligned}
$$

## SOIL EROSION FORMULA

The loss of soil mass over time for a specific land mass is known as soil erosion. It affects farming, construction projects and house owners living near oceans, rivers and terrestrial slopes. To predict the soil erosion due to water, scientists developed a formula known as the Universal Soil loss equation. Soil erosion formula foretells the long-term average annual rate of erosion on a field slope based on soil type, rainfall pattern, topography, management practices and crop system. In the article, let us discuss the soil erosion formula.

## Universal Soil Loss Equation

The universal soil loss equation predicts the annual soil loss per unit area. The universal soil loss equation is given by
$A=R \times K \times L \times S \times C P$
Here, $\mathbf{A}$ is the estimated annual soil loss
$\mathbf{R}$ is the rainfall and runoff factor representing the summed erosive potential of all rainfall events in a year.

L is the slope length
$\mathbf{S}$ is the slope steepness
$\mathbf{K}$ is the soil erodibility factor representing units of soil loss per unit of soil erosivity

CP characterizes conservation management and land cover practices.

## Using the Soil Erosion Formula

To use the universal soil equation, one needs to obtain the value of the $R$ factor from the local station. Determine the kind of soil and assign a value for the K factor. Measure the length of the slope of the land and identify the percentage of the slope to derive the LS factor. If the land is not used for crops, then the C and P factors are generally equal to one.

These factors vary between zero and one if the land is actively farmed and tilled.

## PHOTON ENERGY FORMULA

The quantum of electromagnetic radiation is known as a phot on. The phrase quantum means to the smallest elementary un it of quantity and one amount of electromagnetic energy is called a photon.

A photon is characterized either by wavelength $(\lambda)$ or an equivalent energy E .

The energy of a photon is inversely proportional to the wavelength of a photon.

The Photon energy formula is given by,
$E=\frac{h c}{\lambda}$
Where
$\mathbf{E}=$ photon energy,
$\mathbf{h}=$ Planck's constant $\left(6.626 \times 10^{-34} \mathrm{Js}\right)$
$\mathbf{c}=$ speed of the light and
$\lambda=$ wavelength of the light.

## Example 1

Determine the photon energy if the wavelength is 650 nm .
Solution:

Given parameters are
$\lambda=650 \mathrm{~nm}$
$\mathrm{c}=3 \times 108 \times 10^{8} \mathrm{~m} / \mathrm{s}$
$h=6.626 \times 10-34 \times 10^{-34} \mathrm{Js}$

Photon energy formula is given by,
$E=h c / \lambda$
$E=6.626 \times 10^{-34} \times 3 \times 10^{8} / 650 \times 10^{-9}$
$E=19.878 \times 10^{28} / 650 \times 10^{-9}$
$E=0.030 \times 10^{-17} \mathrm{~J}$

## Example 2:

If the energy of a photon is $350 \times 10-10 \mathrm{~J}$, determine the wavelength of that photon.

Solution:

Given parameters are,
$E=350 \times 10^{-10} \mathrm{~J}$
$\mathrm{c}=3 \times 10^{8} \mathrm{~m} / \mathrm{s}$
$h=6.626 \times 10^{-34} \mathrm{Js}$

Photon energy formula is given by,
$E=h c / \lambda$
$\lambda=h c / E$
$\lambda=6.626 \times 10^{-34} \times 3 \times 10^{8} / 350 \times 10^{-10}$
$\lambda=19.87 \times 10^{-28} / 350 \times 10^{-10}$
$\lambda=0.056 \times 10^{-16} \mathrm{~m}$

## NORMAL FORCE FORMULA

The normal force is a force of contact. When two surfaces are not in connection, a normal force cannot be exerted on one another. For example, consider a table and a container, when they are not in contact not possible to exert normal force on one another. But when two objects are touching one another they exert normal force on one another verticle to the contacting surface. Here normal denotes to perpendicular.

The normal force is equal to the weight of the body during deceleration. when the body is about fall, depends on the location of the body on the ground. The normal force is represented by $\mathbf{F}_{\mathrm{N}}$ and measured in terms of $\mathbf{N}$ (newtons)

An object during rest on the flat surface the normal force $\mathbf{F}_{\mathrm{N}}$ is
$F_{N}=m g$
Where
$\mathrm{g}=$ gravitational force
$\mathrm{m}=$ mass is m

A force acting on a falling object it drops at an angle of $\theta$, then the $F_{N}$ is greater than the formulated weight,
$\mathbf{F}_{\mathrm{N}}=\mathbf{m g}+\mathbf{F} \sin \theta$
Where
the normal force is $F_{N}$
the mass of the body is $m$
gravitational force is g
the angle with which body falls is $\theta$
A force tugs the object towards upward, and then $F_{N}$ is less than its weight
$\mathbf{F}_{\mathrm{N}}=\mathbf{m g}-\mathbf{F} \sin \theta$
Where
the normal force is $\mathbf{F}_{\mathrm{N}}$
the mass of the body is $m$
gravitational force is g
the angle with which body moves up is $\theta$
An object placed on an inclined plane then normal force $F_{N}$ is
$\mathbf{F}_{\mathrm{N}}=\mathbf{m g} \cos \theta$
Where,
the normal force is $F_{N}$
the mass of the body is $m$
gravitational force is g
The angle of the inclined surface is $\theta$
Normal Force Solved Problem

Problem 1: A text-book of mass 1.7 kg is kept on the table.
calculate the normal force being applied on the book.

## Solution:

## Given:

$\mathrm{m}=1.7 \mathrm{~kg}$

# w.k.tg (gravitational force) $=9.8 \mathrm{~ms}^{-2}$ 

The normal force is
$\mathrm{F}_{\mathrm{N}}=\mathrm{mg}$
$F_{N}=1.7 \times 9.8$
$\mathrm{F}_{\mathrm{N}}=16.66 \mathrm{~N}$
Thus, the normal force being applied on the textbook is 16.66 N.

## SHEAR MODULUS FORMULA

A lateral deformation is observed in the object when a shear force is applied to it. The elastic coefficient is known as shear modulus of rigidity. Shear modulus rigidity is the measurement of the rigidity of the object and it is obtained by measuring the ratio of shear stress of the object to the shear strain of the object.

Shear Modulus Formula
$\mathrm{G}=\mathrm{FIA} \Delta \mathrm{x}$

Notations Used In Shear Modulus Formula

- G is shear modulus in $\mathrm{N} \cdot \mathrm{m}^{-2}$
- F is the force acting on the body
- I is the initial length
- $\Delta x$ is the change in length
- A is the area


A shear modulus is applicable for the small deformation of the material by applying less shearing force which is capable to return to its original state. However not for the large sharing force because it results in permanent deformations of the object.

## Example:

Shear modulus value for Steel is $7.9 \times 10^{10}$
Shear modulus value for plywood is $6.2 \times 10^{8}$

From the above explanation, it is clear that steel is more rigid than plywood.

Shear Modulus Unit And Dimension

SI unit Pa

Dimensional formula
$M^{1} L^{-1} T^{-2}$

Solved Example:
Question 1: Compute the Shear modulus, if the stress experienced by a body is $5 \times 10^{4} \mathrm{Nm}^{2}$ and strain is $4 \times 10^{-2}$.

## Solution:

Given
Stress $=5 \times 10^{4} \mathrm{Nm}^{2}$
Strain $=4 \times 10^{-2}$

ShearModulus (G) =Shear stress/Shear strain
ShearModulus (G) $=\left(5 \times 10^{4}\right) /\left(4 \times 10^{-2}\right)$
ShearModulus (G) $=1.25 \times 10^{6} \mathrm{Nm}^{2}$

## WORK DONE BY GRAVITY

## FORMULA

Gravity is defined as the force that attracts a body towards the earth or towards any other physical body having mass.

If a particular object is falling, the particle is bound to point in the direction of gravity. The magnitude of the falling body depends on the mass, gravitational constant and height from which it is falling.

The Work done by gravity formula is given by,
$W g=-m g(\Delta h)$

Where,
$\mathrm{m}=\mathrm{mass}$,
g = gravity,
h= height

The negative sign shows that the particle is dropping from a height $\Delta h$ vertically in the direction of gravity.

If $\theta$ is the angle made when the body falls, the work done by gravity is given by,
$\mathbf{W}=\mathrm{mg} \mathrm{h} \cos \theta$
Where the theta is the angle made when the body falls.

## Example 1

A 15 kg box falls at angle $25 \circ$ from a height of 10 m .
Determine the work done by gravity.

## Solution:

## Given:

Mass m = 10 kg ,
angle =
The work done by gravity formula is given by,
$W=m g h \cos \theta$
$W=15 \times 9.8 \times 10 \times \cos 25^{0}$
$=15 \times 9.8 \times 10 \times 0.9063$
$=1332 \mathrm{~J}$

Therefore, the work done by gravity is $\mathbf{1 3 3 2} \mathbf{~ J}$.

## Example 2

A boy drags a 10 kg box across the frictionless surface. He applies a force of 30 N at an angle of $30^{\circ}$
to the horizontal for 6 m . Determine the work done by gravity.

## Solution:

Given:

Mass m = 10 kg ,
Force F = 30 N ,
angle $\theta=30^{\circ}$

Displacement $\mathrm{s}=6 \mathrm{~m}$
The work done by gravity formula is,
$W=m g h \cos \theta$
$W=10 \times 9.8 \times 6 \times \cos 30^{0}$
$W=10 \times 9.8 \times 6 \times 0.866$
the work done by gravity is 509.208J

## FRICTION FORCE FORMULA

Friction is a repelling force when one body is slipping through a surface. Friction is because of the contact between two surfaces. If frictional force is great, the movement of objects through the surface is not in a smooth manner. All through this movement, the kinetic energy is transformed to heat energy. The friction force is a derived force and not like gravitation i.e. a fundamental force. The formula for friction force is,
$F_{f}=\mu F_{n}$
Where $F_{f}$ is the friction, $\mu$ is the coefficient of friction force and $F_{n}$ is the normal force. It is a vector quantity.

## Friction Force - Solved Examples

Let us answer some problems with a friction force.

Problem 1: An object of mass 10 kg is moving through a surface. Compute the friction force if the coefficient of friction is 0.2 ?

Answer:

Known variables are,
$\mathrm{m}=10 \mathrm{~kg}$ and $\mu=0.2$
Friction force formula is,
$\mathrm{F}_{\mathrm{f}}=\mu \mathrm{F}_{\mathrm{n}}$
Fn can be computed as,
$\mathrm{Fn}=\mathrm{mg}$
$=10 \times 9.81=98.1 \mathrm{~N}$
So, $F_{f}=0.2 \times 98.1=19.62 \mathrm{~N}$

Friction force $\mathrm{F}_{\mathrm{f}}$ is $\mathbf{1 9 . 6 2 N}$

Problem 2: Calculate the friction force of a 5 kg body which is moving through a surface with a friction coefficient 0.3 ?

Answer:

Known variables are,
$\mathrm{m}=5 \mathrm{~kg}$ and $\mu=0.3$
Friction force formula is, $\mathrm{F}_{\mathrm{f}}=\mu \mathrm{F}_{\mathrm{n}}$
$\mathrm{F}_{\mathrm{n}}$ can be computed as,
$\mathrm{F}_{\mathrm{n}}=\mathrm{mg}$
$=5 \times 9.81=49.05 \mathrm{~N}$
So, $\mathrm{Ff}=0.3 \times 49.05=14.715 \mathrm{~N}$
Friction force $\mathrm{F}_{\mathrm{f}}$ is $\mathbf{1 4 . 7 1 5 N}$

## CELL POTENTIAL FORMULA

The driving force of the electron flow from anode to cathode shows a potential drop in the energy of the electrons moving into the wire. The difference in potential energy between the anode and cathode is known as the cell potential in a voltaic cell.

The formula for cell potential is
$E_{\text {cell }}^{0}=E_{\text {reduction }}^{0}+E_{\text {oxidation }}^{0}$
Problem 1: A concentration cell was created by immersing two silver electrodes in 0.05 M and 0.1 M AgNO solution. Write cell representation, cell reactions and find the EMF of the concentration cell.

Answer:

The cell representation:
$A g^{1+}\left|A g^{0}\right|\left|A g^{1+}\right| A g^{0}$

The cell reactions:
$A(-): A g^{0}=A g^{1+}+1 e$
$C(+): A g^{1+}+1 e=A g^{0}$
To find the EMF of a concentration element, you must use the following formula:
$E=\frac{R T}{F} X \ln \left(\frac{c_{1}}{c_{2}}\right)$
c1>c2
Therefore, $\mathrm{E}=0.08 \mathrm{~V}$

## CRITICAL VELOCITY FORMULA

Critical velocity is the speed and direction at which the flow of a liquid through a tube changes from smooth to turbulent. Determining the critical velocity depends on multiple variables, but it is the Reynolds number that characterizes the flow of the liquid through a tube as either turbulent or laminar. The Reynolds number is a dimensionless variable, which means that it has no units attached to it. In this article, we shall be discussing the critical velocity formula.

How to Calculate Critical Velocity?

The formula to calculate the critical velocity of a liquid flowing through a tube is given by

Critical velocity (Vc) $=K \quad \eta / \rho r$
Where
$\mathrm{V}_{\mathrm{c}}$ is the critical velocity

K is the Reynold's number
$\eta$ is the coefficient of the viscosity of the liquid
$r$ is the radius of the tube through which the liquid flows
$\rho$ is the density of the liquid
Depending on the value of Reynold's number, the flow type can be decided as follows:

- If $K$ is between 0 to 2000, the flow is laminar or streamlined.
- If $K$ is between 2000 to 3000 , the flow is turbulent or unstable
- If $K$ is above 3000 , the flow is highly unstable


## ESCAPE VELOCITY FORMULA

## What is escape velocity?

Escape Velocity is the minimum velocity required by a body to be projected to overcome the gravitational pull of the earth. It is the minimum velocity required by an object to escape the gravitational field that is, escape the land without ever falling back. An object that has this velocity at the earth's surface will totally escape the earth's gravitational field ignoring the losses due to the atmosphere.

For example, a spacecraft leaving the surface of Earth needs to go at 7 miles per second, or around 25,000 miles per hour to leave without falling back to the surface.


Escape velocity formula is given
$V=\sqrt{\frac{2 G M}{R}}$

Wherein,
$\mathrm{V}=$ escape velocity
$\mathrm{G}=$ gravitational constant is $6.67408 \times 10^{-11} \mathrm{~m}^{3} \mathrm{~kg}^{-1} \mathrm{~s}^{-2}$
$M=$ mass of the planet
$R=$ radius from the centre of gravity

An alternative expression for the escape velocity particularly useful at the surface on the body is

$$
V_{e s c}=g R^{2}
$$

Where g is the acceleration due to the gravity of earth.

Hence Escape velocity is also given by

$$
V_{e s c}=\sqrt{2 g R}
$$

It is expressed in $\mathrm{m} / \mathrm{s}$ and escape velocity of earth is 11,200 $\mathrm{m} / \mathrm{s}$.

Escape velocity formula is applied in finding escape velocity of anybody or any planet, if mass and radius is known.

## Solved Examples

Example 1

Determine the escape velocity of the Jupiter if its radius is 7149 Km and mass is $1.898 \times 10^{27} \mathrm{Kg}$

Solution:
Given: Mass $\mathrm{M}=1.898 \times 10^{27} \mathrm{Kg}$,
Radius $\mathrm{R}=7149 \mathrm{Km}$
Gravitational Constant G $=6.67408 \times 10^{-11} \mathrm{~m}^{3} \mathrm{~kg}^{-1} \mathrm{~s}^{-2}$
Escape Velocity is given as
Vesc $=$ V2GM $/ R$
$=\sqrt{ } 2 \times 6.67408 \times 10^{-11} \times 1.898 \times 10^{27} / 7149$
50.3 km/s

Example 2
Determine the escape velocity of the moon if Mass is $7.35 \times$ 1022 Kg and radius is $1.5 \times 10^{6} \mathrm{~m}$.

Solution:

Given
$\mathrm{M}=7.35 \times 1022 \mathrm{Kg}$,
$R=1.5 \times 106 \mathrm{~m}$

Escape Velocity formula is given by
Vesc $=$ V2GMR
$=\sqrt{ } 2 \times 6.673 \times 10^{-11} \times 7.35 \times 1022 / 1.5 \times 10^{6}$
$=7.59 \times 10^{5} \mathrm{~m} / \mathrm{s}$

## ACCELERATION FORMULA

One may have perceived that pushing a terminally ill bus can give it a sudden start. That's because lift provides upward push when it starts. Here Velocity changes and this is acceleration! Henceforth, the frame accelerates. Acceleration is described as the rate of change of velocity of an object. A body's acceleration is the final result of all the forces being applied on the body, as defined by Newton's Second Law. Acceleration is a vector quantity that is described as the frequency at which a body's velocity changes.

Acceleration is the rate of change in velocity to the change in time. It is denoted by symbol a and is articulated as-
$a=\frac{\text { change in velocity }}{\text { Time taken }}$

Meter per Second Square or $\mathrm{m} / \mathrm{s}^{2}$ is the S.I unit for Acceleration,

If $t$ (time taken), $v$ (final velocity) and $u$ (initial velocity) are provided. Then the acceleration is given by the formula
$v=u+a t$
$v^{2}=u^{2}+2 a s$
$s=u t+\frac{1}{2} a t^{2}$
Where,
Final Velocity $=v$
Initial velocity $=u$
acceleration $=\mathrm{a}$
time taken $=\mathrm{t}$
distance traveled $=s$
Acceleration Solved Examples

Underneath we have provided some sample numerical based on acceleration which might aid you to get an idea of how the formula is made use of:

Problem 1: A toy car accelerates from $3 \mathrm{~m} / \mathrm{s}$ to $5 \mathrm{~m} / \mathrm{s}$ in 5 s .
What is its acceleration?

## Answer:

Given: Initial Velocity $u=3 \mathrm{~m} / \mathrm{s}$,
Final Velocity $\mathrm{v}=5 \mathrm{~m} / \mathrm{s}$,
Time taken $\mathrm{t}=5 \mathrm{~s}$.
The Acceleration is given by $a=\frac{v-u}{t}$
$=\frac{5-3}{5}$
$=\frac{2}{5}$
$0.4 \mathrm{~m} / \mathrm{s}^{2}$

Problem 2: A stone is released into the river from a bridge. It takes 4 s for the stone to touch the river's water surface.

Compute the height of the bridge from the water level.

## Answer:

(Initial Velocity) $\mathrm{u}=0$ (because the stone was at rest),
$\mathrm{t}=4 \mathrm{~s}$ ( t is Time taken)
$\mathrm{a}=\mathrm{g}=9.8 \mathrm{~m} / \mathrm{s}^{2}$, ( a is Acceleration due to gravity) distance traveled by stone $=$ Height of bridge $=s$

The distance covered is articulated by
$s=u t+\frac{1}{2} g t^{2}$
$\mathrm{s}=0+1 / 2 \times 9.8 \times 4=19.6 \mathrm{~m} / \mathrm{s}^{2}$
Therefore, $\mathrm{s}=19.6 \mathrm{~m} / \mathrm{s}^{2}$

## DISPLACEMENT FORMULA

Displacement is calculated as the shortest distance between starting and final point which prefers straight-line path over curved paths.

Suppose a body is moving in two different directions $x$ and $y$ then Resultant Displacement will be
$S=\sqrt{x^{2}+y^{2}}$
It gives the shortcut paths for the given original paths.
$S=v t$
$S=\frac{1}{2}(u+v) t$
$S=u t+\frac{1}{2} a t^{2}$
Here,
$u=$ Initial velocity
$v=$ final velocity
a = acceleration
$\mathrm{t}=$ time taken.

Solved Examples
Problem 1: The path distance from the garden to a school is
5 m west and then 4 m south. A builder wants to build a short distance path for it. Find

Solution:
Given: Distance to the west $x=5 \mathrm{~m}$

Distance to the south $\mathrm{y}=4 \mathrm{~m}$.


Displacement is given by
$S=\sqrt{x^{2}+y^{2}}$
$s=\sqrt{5^{2}+4^{2}}$
$s=6.403 \mathrm{~m}$.

The builder can build a path for displacement length of 6.7 m .
Question 2: A girl walks from the corridor to the gate she moves 3 m to the north opposite from her house then takes a left turn and walks for 5 m . then she takes right turn and moves for 6 m and reaches the gate. What is the displacement, magnitude, and distance covered by her?

## Solution:

Total distance traveled $d=3 m+5 m+6 m=14 m$.

A magnitude of the displacement can be obtained by visualizing the walking. The actual path from $A$ to $B$ as $3 m$ then from $B$ to $D$ as $5 m$ and finally from $D$ to $E$ as $6 m$.


So, the magnitude of resultant displacement is $|S|$
$=\sqrt{A C^{2}+C E^{2}}$

From figure $A C=A B+B C=3 m+6 m=9 m$
$B D=C E=5 m$
$|\mathrm{S}|=\mathrm{V} 92+52=10.29 \mathrm{~m}$.

The direction of Resultant displacement is South East.

## KINEMATICS FORMULAS

Kinematics Formula is altogether about the motion of bodies at points, devoid of considering the cause because of which it happens. Kinematic formulas are three to be precise:
$v=v_{0}+a t$
$v^{2}=v^{2}{ }_{0}+2 a\left(x-x_{0}\right)$
At this juncture,
$x$ and $x_{0}$ are Final and Initial displacements articulated in $m$,
$v_{0}$ and $v$ are initial and final velocity articulated in $m / s$, acceleration is a and articulated in $\mathrm{m} / \mathrm{s}^{2}$, the time taken is t in s .

Kinematics Formulas - 2D

2 dimensional or 2D kinematics equations is all about expressing the same equations in x and y directions:

In x direction the Kinematics formulas is articulated as:
$v_{x}=v_{x o}+a_{x} t$
$x=x_{0}+v_{\mathrm{xo}} t+1212 \mathrm{a}_{\mathrm{x}} \mathrm{t}^{2}$
$v x^{2}=v_{x} 0+2 a x\left(x-x_{0}\right)$
In y-direction the Kinematic formula is articulated as:
$v_{y}=v_{y o}+a_{y} t$
$y=x_{0}+v_{y o} t+1212 a_{y} t^{2}$
$v_{y}{ }^{2}=v_{y_{0}}{ }^{2}+2 a y\left(y-y_{0}\right)$

Kinematics Formulas for Projectile Motion

Imagine a projectile motion as presented in the figure. Thus, the kinematics formulas are:

In x-direction:
$\mathrm{v}_{\mathrm{x}}=\mathrm{v}_{\mathrm{x}}$
$\mathrm{x}=\mathrm{x}_{\mathrm{o}}+\mathrm{v}_{\mathrm{x} 0}$

In $y$-direction:
$v_{y}=v_{y o}-g t$
$y=y_{o}+v_{y o} t-1212 g t^{2}$
$v_{y}{ }^{2}=v_{y o}{ }^{2}-2 g\left(y-y_{0}\right)$

Kinematic Equation Formulas
$v=v \underline{0}+a t$

## $\Delta x=(v+v \underline{02}) t$

## $\Delta x=v \underline{0} t+\underline{12} \mathrm{at} \underline{2}$

$\mathrm{v} \underline{2}=\mathrm{v} \underline{20}+\underline{2} \mathrm{a} \Delta \mathrm{x}$

Kinematics Solved Example

Problem 1: A car with initial velocity zero experiences a uniform acceleration of $7 \mathrm{~m} / \mathrm{s}^{2}$ for the time interval $\mathrm{t}=\mathbf{5 \mathrm { s }}$.

Calculate its distance covered?

## Answer:

Given parameters
$\mathrm{v}_{\mathrm{o}}=0$
$t=5 s$
$\mathrm{a}=7 \mathrm{~m} / \mathrm{s}^{2}$

To find the Distance covered S.

By using the Kinematic Equation, one can determine that
$S=v_{0} t+\frac{1}{2} a t^{2}$
$S=0 \times 5+\left(0.5 \times 7 \times 5^{2}\right)$
$\mathrm{S}=87.5 \mathrm{~m}$

## HORSEPOWER FORMULA

Horsepower is an imperial unit of power of an engine. It is defined as the work done per unit time. The term Horsepower was invented by James Watt. It is a unit power that compares the power of a machine to the horse muscle power. Earlier it was used to measure steam engine power output compared to the power of draft horses. Later it was expanded to different types of piston engines, electric motors, turbines and other machinery.

One Horsepower equals to $33,000 \mathrm{lb} . \mathrm{ft} / \mathrm{min}$.
Horsepower formula is given as
Horsepower (HP) $=($ Torque $\times$ Speed $) / 5252$

There is another Horsepower formula related to the weight given as

Horse Power $(H P)=W$ eight $\times\left(\frac{\text { Velocity }}{234}\right)^{2}$
This formula is applied to calculate the speed or velocity at the end of the run. Weight includes the mass of the whole body.

## Example 1

Determine the horsepower of a car which moves with a speed of 600 revolutions per minute and has a torque of 100 pound-foot.

Solution:
Given
parameters are

Torque $=$ 100 pound-foot

Speed $=600$ revolutions per minute>

Horsepower formula is given by
Horsepower $=($ Torque $\times$ Speed $) / 5252$
$H P=(100 \times 600) / 5252$

$$
H P=60000 / 5252
$$

$$
H P=1.142 \mathrm{hp}
$$

Example
Calculate the speed of the vehicle if its horsepower is 0.865
hp and torque is 250 pound-foot.

Solution:

Given parameters are
Torque $=250$ pound-foot

Horsepower (HP) = 0.865 hp

The speed is given as
Speed $=($ Horsepower $\times 5252) /$ Torque
Speed $=(0.865 \times 5252) / 250$
Speed $=4542.98 / 250$

Speed = 18.17 revolutions per min

## BEAT FREQUENCY FORMULA

Beat is produced when two waves of nearby frequencies superimpose when they travel in the same path. This causes a periodic variation of intensity of the resultant wave.

The beat frequency is the number of beats produced per second.

## Beat Frequency Formula:

The formula for beat frequency is the difference in frequency of the two superimposed waves.
$f_{b}=|f 2-f 1|$
$f_{1}$ and $f_{2}$ are the frequency of two waves

## Beat Frequency Problems

Problem 1: Compute the beat frequency if the two frequencies of waves are 750 Hz and 380 Hz respectively?

## Answer:

Given parameters are,
$f_{2}=800 \mathrm{~Hz}$ and $f 1=400 \mathrm{~Hz}$
The beat frequency is given by,
$\mathrm{f}_{\mathrm{b}}=|\mathrm{f} 2-\mathrm{f} 1|$
$f_{b}=|800-400|=400 \mathrm{~Hz}$
Problem 2: Compute the beat frequency if the wave frequencies are 550 Hz and 1000 Hz respectively?

## Answer:

Known numerics are,
$f_{1}=550 \mathrm{~Hz}$ and $f_{2}=1000 \mathrm{~Hz}$
Thus, the beat frequency is articulated by,
$\mathrm{f}_{\mathrm{b}}=|\mathrm{f} 2-\mathrm{f} 1|$
$f_{b}=|1000-550|=450 \mathrm{~Hz}$

## HEAT INPUT FORMULA

Under the arc welding process, heat input and arc energy are the measures of energy that has been supplied to the piece to form a weld. Both are measured in units of energy per unit length.

It refers to a characteristic or dimension such as weld length, a bead, the diameter of a weld spot or cross-section. The amount of heat input which goes into a weld is determined as a function of time.

The heat input formula is given by,
HeatInput=60×Current $\times$ Volts $1000 \times$ (distancetravelledin/min)
The accurate measurement of arc voltage is the difficulty here, but we mostly measure load voltage at the output terminals of the current source.

## Example1

You weld at 400 inches and 39 volts per minute. The weld is 35 inches long, and welding takes 4 minutes. While welding y ou find that the system shows an amperage of 425. Which is your input heat?

## Solution:

Travel speed=Length of the weld Time to weld
Travel speed $=35 / 4$
Travel speed $=8.75$ inches per min
Heat Input $=60 \times$ Current $\times$ Volts $1000 \times($ distance travelled in/min)

Heat Input $=60 \times 425 \times 391000 \times(8.75)$
Heat input $=113.65 \mathrm{KJ} /$ in

## CONSERVATION OF ENERGY

## FORMULA

Energy is the ability to do work. Practically, energy is required to perform every activity or work that you do in your day to day life. Energy is also required for vehicles to move, machines to run, bulbs to glow, etc. Energy is very crucial for the existence of human beings. And it exists in various forms. Different forms of energy are electrical energy, tidal energy, light energy, chemical energy, gravitational energy and nuclear energy, heat energy. One form of energy can easily be transferred to another. In this section, we will learn about the law of conservation of energy, the conservation of energy formula and its derivation along with some examples.

## Law of Conservation of Energy

According to the law of conservation of energy, the total energy of an isolated system remains conserved over time. In this definition, the isolated system refers to as a thermodynamic system so designed that no matter or energy can pass through it.

## Conservation of Energy Formula

Energy spent in one act = Energy gained in the related act

For a given system, we can write,

## Ein-Eout=$\Delta$ Esys

As we know, the net amount of energy transfer into or out of any system occurs in the form of heat ( Q ), mass ( m ) and work (W). Hence, we can rewrite the aforementioned equation as:

Ein-Eout=Q-W

Upon dividing all the terms into both sides of the equation by the mass of the system, the equation represents the law of conservation of energy on a unit mass basis, as shown below:
$Q-W=\Delta u$
Thus, we can write the conservation of energy rate equation as:

Q-W=dUdt

## Real-Life Example

We can take the example of a windmill. The mechanical energy of wind rotates the turbines of a windmill, which in turn rotate the shaft of an electric generator, thus generating electrical energy. Here, we observe that the mechanical energy of wind gets converted into electrical energy.

## Solved Examples

Problem: The initial energy and the final energy of a system can be given by $2.95 \times 10^{-3}$ and $5.86 \times 10^{-3}$ respectively. Find the energy conservation of the system.

## Solution:

We can use the following formula to compute the energy conservation of the system:
$\Delta$ Esys=Ein-Eout
$\Delta \mathrm{E}=(\underline{5.83} \times \underline{10}-\underline{3})-(\underline{2.95} \times 103)$
Thus, $\Delta \mathrm{E}=\underline{2.91} \times \underline{10} \underline{-3}$
Problem: A particle of charge equal to that of electron and the charge is $1.67 \times 10^{-27}$ and mass of the particle is $1.30 \times 10^{-27} \mathrm{~kg}$.

Compute the law of conservation of energy.

## Solution:

As per the law of conservation of energy formula, we have:
$\mathrm{Q}-\mathrm{W}=\Delta \mathrm{Esys}$
Or $\Delta$ Esys $=\mathrm{Q}-\mathrm{W}=(\underline{1.67} \times 1027)-(\underline{1.30} \times 1027)=\underline{0.37} \times 1027$

## SURFACE CHARGE DENSITY

## FORMULA

According to electromagnetism, charge density is defined as a measure of electric charge per unit volume of the space in one, two or three dimensions. To be specific, the linear surface or volume charge density is the amount of electric charge per surface area or volume, respectively.

Surface charge describes the electric potential difference between the inner and outer surface of different states like solid and liquid, liquid and gas or gas and liquid. The surface charge density is present only in conducting surfaces and describes the whole amount of charge q per unit area A.

Hence, the Surface charge density formula is given by, $\sigma=q / A$.

Where,
$\sigma=$ surface charge density $\left(C \cdot m^{-2}\right)$
$\mathbf{q}=$ charge $\{$ Coulomb(C) $\}$
$A=$ surface area $\left(\mathrm{m}^{2}\right)$

## Example 1

Calculate the surface charge density of a conductor whose charge is 5 C in an area of $10 \mathrm{~m}^{2}$

## Solution:

Given:

Charge $q=5 \mathrm{C}$,
Area $A=10 \mathrm{~m}^{2}$
Surface charge density formula is given by,
$\sigma=q / A$
$=5 / 10$

Therefore, $\sigma=0.5 \mathrm{C} / \mathrm{m} 2$

## Example 2

Calculate the surface charge density of sphere whose charge is 12 C and radius is 9 cm .

## Solution:

Given:

Charge q = 12 C ,
Radius $\mathrm{r}=9 \mathrm{~cm}$.
The surface charge density formula is given by,
$\sigma=q / A$
For a sphere, area $A=4 \pi r^{2}$
$A=4 \pi(0.09)^{2}$
$\mathrm{A}=0.1017 \mathrm{~m} 2$

Surface charge density, $\sigma=q / A$
$\sigma=12 / 0.1017$
$=117.994$
Therefore, $\sigma=117.994 \mathrm{C} \cdot \mathrm{m}^{-2}$

## WAVE ENERGY FORMULA

You may have been near to any seashore if you stay close to such places. When the wind passes on the water surface, it leads to the pressure difference between the upper and bottom wind that results in the generation of waves. Wave energy is the energy that is gained by the waves. When the wind blows on the seashore, it shifts its energy to these waves. These waves carry a lot of power which we call wave power.

The Wave energy density formula according to linear wave theory is
$E=\rho g H^{2} / 16$

Where,
$E=$ mean wave energy density,
$\mathrm{H}=$ wave height,
$\rho=$ water density,
$\mathrm{g}=$ acceleration due to gravity.

The wave power formula in terms of wave energy is given by,
$P=E_{c g}$

Where,
$\mathrm{cg}=$ group velocity in $\mathrm{m} / \mathrm{s}$.

Solved Numericals

## Example 1

A wave in a seashore travels with a height of 5 m . Determine the wave energy density.

## Solution:

Given:
$E=\rho g H^{2} / 16$

Wave height $\mathrm{H}=5 \mathrm{~m}$,
Water density $\rho=999.97 \mathrm{~kg} / \mathrm{m} 3$,
Gravity g $=9.8 \mathrm{~m} / \mathrm{s} 2$
The wave energy formula is given by,
$E=999.97 \times 9.8 \times 25 / 16$
$E=15312 \mathrm{~J}$

## Example 2

A huge wave travels with the energy of 8000 J. Determine its wave height.

## Solution:

Given:

Wave energy E = 8000J,

Water density $\rho=999.97 \mathrm{~kg} / \mathrm{m} 3$,
Gravity g $=9.8 \mathrm{~m} / \mathrm{s} 2$

The wave height is calculated by wave energy formula,
$H=V 16 E / \rho g$
$=\mathrm{V} 16 \times 8000 /(999.97 \times 9.8)$
H = 357.7/9799.70

The wave height of the wave is 0.0365 m

## AVERAGE ACCELERATION

## FORMULA

Acceleration: Acceleration is defined as the rate of change of velocity. It is usually denoted by ' $a$ ' and is measured in the units of $\mathrm{m} / \mathrm{s} 2$.

Average Acceleration: For a particular interval, the average acceleration is defined as the change in velocity for that particular interval. Unlike acceleration, the average acceleration is calculated for a given interval.

Formula:

Average acceleration is calculated by the following formula,

Average Acceleration $=\Delta v / \Delta t$ Here, $\Delta v$ is the change in velocity and $\Delta t$ is the total time over which the velocity is changing.

> Average Acceleration $=\mathrm{vf}-\mathrm{vi} / \mathrm{tf}-\mathrm{ti}$
> Where,
> $v_{f}=$ final velocity
> $v_{i}=$ initial velocity
> $t_{i}=$ initial time
> $t_{f}=$ final time

Also, if the object shows different velocities, such as v1, v2, v3...vn for different time intervals such as t1, t2,
t3...t3 respectively, the average acceleration is calculated using the following formula,

Average Acceleration=v1+v2+v3+.....+vn/t1+t2+t3+....+tn

## Real-Life Example

If the velocity of a marble increases from 0 to $60 \mathrm{~cm} / \mathrm{s}$ in 3 seconds, its average acceleration would be $20 \frac{\mathrm{~cm}}{\mathrm{~s}^{2}}$. Meaning that the marble's velocity will go up by $20 \mathrm{~cm} / \mathrm{s}$ each second.

## Average acceleration Problems

Example 1: A bus accelerates with an initial velocity of $10 \mathrm{~m} / \mathrm{s}$ for 5 s then $20 \mathrm{~m} / \mathrm{s}$ for 4 s finally for $15 \mathrm{~m} / \mathrm{s}$ for 8 s . What can be said about the average acceleration of the bus?

## Solution:

It is given that, the velocities of the bus at different time intervals is, $\mathrm{v} 1=10 \mathrm{~m} / \mathrm{s}, \mathrm{v} 2=20 \mathrm{~m} / \mathrm{s}, \mathrm{v} 3=15 \mathrm{~m} / \mathrm{s}$

The time intervals for which the object possesses these velocities are t1 $=5 \mathrm{~s}, \mathrm{t} 2=4 \mathrm{~s}, \mathrm{t} 3=8 \mathrm{~s}$

Hence, over the interval, the total velocity can be given as the sum of these velocities.
$\Delta v=10+20+15=45 \mathrm{~ms}$
Similarly, the total time interval can be given as the sum of these intervals,
$\Delta t=t 1+t 2+t 3=5+4+8=17 \mathrm{~s}$
Using the above formula for average acceleration, we get,

Average Acceleration $=\Delta v / \Delta t$
Average Acceleration $=4517=2.65 \mathrm{~ms} 2$
Question 2: A sparrow, while going back to its nest accelerates to $6 \mathrm{~m} / \mathrm{s}$ from $3 \mathrm{~m} / \mathrm{s}$ in 5 s . What can we say about its average acceleration?

## Solution:

Given: The initial velocity, vi=3m/s
The final velocity, $\mathrm{vf}=6 \mathrm{~m} / \mathrm{s}$
Total time for which the acceleration takes place, $t=5$

S

Average Acceleration $=\mathrm{vf}-\mathrm{vi} / \mathrm{tf}-\mathrm{ti}$
Average Acceleration $=6-35=0.6 \mathrm{~ms} 2$

## TRANSFORMER FORMULA

In other words, the transformer transforms the energy from one circuit to another. This occurs through electromagnetic induction. It is known as an efficient voltage converter, which can reduce the high voltage to low voltage and vice versa. A good-condition transformer consists of two windings, namely primary winding and secondary winding. There are two types of the transformer; step up and step down transformers.

The transformer formula is given by,

## Where

Vp = primary voltage,

Vs = secondary voltage,

Np = number of turns in the primary

Ns = number of turns in the secondary

Solved Examples

## Example 1

The number of primary and secondary windings is 60 and 100 respectively. The secondary voltage is given by 250 V , determine the primary voltage.

## Solution:

Given:
$N p=60$,
$N s=100$
$\mathrm{Vs}=250 \mathrm{~V}$
The transformer formula is given by,
$\mathrm{Vp} / \mathrm{Vs}=\mathrm{Np} / \mathrm{Ns}$
$\mathrm{Vp}=\mathrm{Np} / \mathrm{Ns} \times \mathrm{Vs}$
$=60 / 100 \times 250$
$V p=150 V$

## Example 2

The number of primary and secondary windings is 100 and 350 respectively. The primary voltage is given by 200V, determine the secondary voltage.

## Solution:

Given:

Np = 100,

Ns = 350 and
$V p=200 V$

The transformer formula is given by,
$\mathrm{Vp} / \mathrm{Vs}=\mathrm{Np} / \mathrm{Ns}$
$\mathrm{Vs}=\mathrm{Vp} \times \mathrm{Ns} / \mathrm{Np}$

$$
V s=200 \times 350 / 100
$$

$$
\mathrm{Vs}=700 \mathrm{~V}
$$

## HEAT RELEASE RATE FORMULA

The Heat Release Rate is the crucial parameter to characterize a fire. There is a variety of methods to estimate the heat release rate. The most used techniques are based on mass balance. When the heat of combustion of fuel is known, the measure of mass loss can be evaluated.

The heat produced by the burning sample is precisely accompanied by the reduction in the heat generated by the burner. The rate of heat release of the sample is measured by recording the decrease in the flow of gas. The constant temperature of the system removes the impact of inertia and permits a rapid change in the heat release rate.

The record of heat release rate is a measure of what would be released into the lit room. The heat release rate formula from the first law of thermodynamics is given by,

$$
\Delta \mathbf{Q}_{\mathrm{c}}=\Delta \mathbf{W}+\Delta \mathbf{Q} h+\Delta \mathbf{U}
$$

Wherein,
$\mathrm{Q}_{\mathrm{c}}$ is the Chemical energy released in $\mathrm{KJ} / \mathrm{Kg}$
W is the Work output in $\mathrm{KJ} / \mathrm{Kg}$
$\mathrm{Q}_{\mathrm{h}}$ is the Heat transfer in $\mathrm{KJ} / \mathrm{Kg}$
U is the Internal energy of the contents in $\mathrm{KJ} / \mathrm{Kg}$

## Example 1

Determine the heat released of a cylinder whose internal energy is $245 \mathrm{KJ} / \mathrm{Kg}$ and heat transfer is $420 \mathrm{KJ} / \mathrm{Kg}$ for the work $280 \mathrm{KJ} / \mathrm{Kg}$.

## Solution:

Given parameters are
Work $=280 \mathrm{KJ} / \mathrm{Kg}$

Internal energy $=245 \mathrm{KJ} / \mathrm{Kg}$

Heat transfer $=420 \mathrm{KJ} / \mathrm{Kg}$

Substitute all the values in the given formula.
$\Delta \mathrm{Q}_{\mathrm{c}}=\Delta \mathrm{W}+\Delta \mathrm{Q}_{\mathrm{h}}+\Delta \mathrm{U}$
$=280+420+245$
$=945 \mathrm{KJ} / \mathrm{Kg}$
Therefore, Heat release rate $=945 \mathrm{KJ} / \mathrm{Kg}$

## Example 2

The heat produced in a burner is $280 \mathrm{KJ} / \mathrm{Kg}$ and internal energy is $430 \mathrm{KJ} / \mathrm{Kg}$. Determine the heat transfer for the work done $260 \mathrm{KJ} / \mathrm{Kg}$.

## Solution:

Given parameters are,
Work $=260 \mathrm{KJ} / \mathrm{Kg}$

Internal energy $=430 \mathrm{KJ} / \mathrm{Kg}$

Heat transfer $=280 \mathrm{KJ} / \mathrm{Kg}$

Substitute all the values in the given formula.
$\Delta \mathrm{Q}_{\mathrm{c}}=\Delta \mathrm{W}+\Delta \mathrm{Q}_{\mathrm{h}}+\Delta \mathrm{U}$
$=260+430+280$

Therefore, heat release rate $=970 \mathrm{KJ} / \mathrm{Kg}$

## HEAT OF VAPORIZATION FORMULA

## What is Heat of Vaporization?

The Heat of Vaporization is the quantity of heat that needs to be absorbed to vaporize a particular quantity of liquid at a constant temperature. If the solutions of vapour and liquid states are compared, the kinetic energy of the steam is proved to be higher than the kinetic energy of the fluid.

In other words, the heat of vaporization is the total amount of heat required to turn a particular quantity of liquid into vapour without any rise in the temperature of the fluid.

## Heat of Vaporization Formula

Based on entropy and enthalpy of vaporization and relationship among them, the Heat of vaporization formula can be written as
$H_{v}=q / m$

Wherein,

Hv = vaporization heat
$m=$ mass of the substance
$q=$ heat

## Example1

If the heat of vaporization for $\mathrm{H}_{2} \mathrm{O}$ is $2357 \mathrm{~J} / \mathrm{g}$, calculate the total amount of heat energy that required to vaporize 145 grams of $\mathrm{H}_{2} \mathrm{O}$.

Solution:
The heat of vaporization formula
$H_{v}=\frac{q}{m}$
$q=H_{v} \times m$
$q=2357 \times 145$

Therefore $\mathbf{q}=341765 \mathrm{~J}$

## ELECTRIC FIELD FORMULA

Electric Field is the region produced by an electric charge around it whose influence is observed when another charge is brought in that region where the field exists.


The force $\mathbf{F}$ experienced by electric charge $\mathbf{q}$ describes the Electric field lines.

The Electric Field formula is expressed by
$E=\frac{F}{q}$

If $\mathbf{q}$ and $\mathbf{Q}$ are two charges separated by distance $\mathbf{r}$, the Electric force is given by
$F=\frac{K q Q}{r^{2}}$
$E=\frac{K q Q}{r^{2} q}$
When we substitute the electric force formula in the electric field formula, we get Electric Field Formula which is given by,

If the Voltage $V$ is supplied across the given distance $r$, then the electric field formula is given as
$E=\frac{V}{r}$
The Electric field is measured in N/C.

## Example 1

A force of 5 N is acting on the charge $6 \mu \mathrm{C}$ at any point.
Determine the electric field intensity at that point.
Solution

## Given

Force F = 5 N
Charge $q=6 \mu \mathrm{C}$
Electric field formula is given by
$E=F / q$
$=5 \mathrm{~N} / 6 \times 10^{-6} \mathrm{C}$
$\mathrm{E}=8.33 \times 10^{5} \mathrm{~N} / \mathrm{C}$.

## KINETIC FRICTION FORMULA

We witness in our day-to-day life the frictional force taking place in moving bodies which are in interaction. This is called kinetic friction. Rolling friction and sliding friction falls under this topic.

The Retarding force observed as kinetic
friction in the two moving aircraft as they touch with each oth er. The kinetic friction is expressed as
$F_{k}=\mu_{k} F_{n}$
Where
the coefficient of kinetic friction is $\mu \mathrm{k}$ the normal force is $\mathrm{F}_{\mathrm{n}}$

Kinetic friction formula is handy for questions to compute the friction amid the bodies which are in motion.

The related concepts of friction are listed below in the table:

Friction: Laws Of Friction

Friction and Its Application

Sliding Friction

Kinetic Friction Solved Example

Problem 1:A boy is playing volleyball then calculate the kinetic friction if the friction coefficient is 0.8 and thrown with the force of 200N?

Answer:

Given:
$\mu \mathrm{k}=0.8$
$\mathrm{F}_{\mathrm{n}}=200 \mathrm{~N}$
The formula of kinetic friction is

$$
\begin{aligned}
& \mathrm{F}_{\mathrm{k}}=\mu \mathrm{k} \mathrm{~F}_{\mathrm{n}} \\
& \mathrm{~F}_{\mathrm{k}}=0.8 \times 200
\end{aligned}
$$

$$
F_{k}=160 \mathrm{~N}
$$

## RELATIVISTIC DOPPLER EFFECT

## FORMULA

The Doppler Effect is the effect perceived when energy waves like light waves or sound waves travel with regards to an observer. There will be an alteration in frequency. An upward shift in frequency for an approaching source and a downward shift in frequency in the case of a retreating source. The relativistic Doppler Effect is some alteration in frequency caused when there is relativistic motion between observer and source.

The relativistic Doppler Effect formula is articulated as,
$\mathrm{v}^{\prime}=\mathrm{v} 1+\mathrm{vc} 1-\mathrm{vc}----\mathrm{V}$
if $\beta=v / c$ then relativistic doppler effect formula is articulated as,
$v^{\prime}=v 1+\beta 1-\beta---v$

Where,
The Apparent frequency (the frequency of observer) is $v^{\prime}$,
The Real frequency (frequency of the source) is $v$.
The observer's velocity vis,
The speed of light is c .
For a moving source and a moving observer, the formula of frequency according to Doppler's effect is given by:
$f=\left(\frac{c+v_{r}}{c+v_{s}}\right) f_{0}$
Where:
$c$ is the velocity of waves in the medium
Vr is the velocity of the receiver relative to the medium
Vs is the velocity of the source relative to the medium

## Problem 1:

A source is moving towards observer with a speed of $40 \mathrm{~m} / \mathrm{s}$ and having frequency 240 Hz and observer is moving towards the source with a velocity of $40 \mathrm{~m} / \mathrm{s}$. What is the apparent frequency heard by the observer, if the velocity of sound is $340 \mathrm{~m} / \mathrm{s}$ ?

## Answer:

given:
$\mathrm{Vs}=40 \mathrm{~m} / \mathrm{s}$
$\mathrm{Vr}=40 \mathrm{~m} / \mathrm{s}$
$\mathrm{c}=340 \mathrm{~m} / \mathrm{s}$
$\mathrm{fO}=240 \mathrm{~Hz}$

The source and observer are approaching each other, therefore the velocity of the source Vs is negative and the velocity of the listener Vr is positive.
$f=\left(\frac{c+v_{r}}{c+v_{s}}\right) f_{0}$

$$
f=\left(\frac{340+40}{340-40}\right) 240
$$

$$
f=304 \mathrm{~Hz}
$$

## STRAIN FORMULA

The consequence of stress is what is termed as strain. The strain is the measure of how much distortion has befallen on the body compared to its initial shape due to the action of the force. It is denoted by $\epsilon$.

Strain Formula is articulated as,
$\operatorname{Strain}(\epsilon)=\frac{x}{L}$
Where,
Change in dimension $=x$,
Original dimension $=\mathrm{L}$.
There are three sorts of strain
The longitudinal strain is the ratio of change in length to the original length.

Longitudinal strain $(\epsilon)=\frac{\Delta l}{l}$

Where,
Change in length $=\Delta I$
Original length $=1$
Shearing strain is the ratio of change in angle to which it is turned to its distance from the fixed layer.

Volumetric strain is the ratio of change in volume to the original volume.

Where $\Delta \mathbf{V}=$ Change in Volume,
V = Original volume.

## Strain Solved Examples

Underneath are numerical founded on strain formula which might be useful for you.

Problem 1: An elastic band of length 5 cm is stretched such that its length increases by 2 mm . Compute the strain.

## Answer:

Known:
$x$ (Change in length $)=2 \mathrm{~mm}$,
L (Original length $)=5 \mathrm{~cm}$
$=2 \times 10^{-3} / 5 \times 10^{-2}$

Problem 2: An iron bar 3m long is heated. It stretches by 0.5 mm . Compute the strain.

## Answer:

Known:
$x$ (Change in length $)=0.5 \mathrm{~mm}$,
$\mathrm{L}($ Original length $)=3 \mathrm{~m}$

The consequence of stress is what is termed as strain. The strain is the measure of how much distortion has befallen on the body compared to its initial shape due to the action of the force. It is denoted by $\epsilon$.

Strain Formula is articulated as,
$\operatorname{Strain}(\epsilon)=\frac{x}{L}$
Where,
Change in dimension $=x$,
Original dimension $=\mathrm{L}$.
There are three sorts of strain
The longitudinal strain is the ratio of change in length to the original length.

Longitudinal $\operatorname{strain}(\epsilon)=\frac{\Delta l}{l}$
Where,

Change in length $=\Delta I$
Original length $=1$
Shearing strain is the ratio of change in angle to which it is turned to its distance from the fixed layer.

Shearing strain $(\epsilon)=\frac{\Delta l}{l}$
Volumetric strain is the ratio of change in volume to the original volume.

Volumetric strain $(\epsilon)=\frac{\Delta V}{V}$
Where $\Delta \mathbf{V}=$ Change in Volume,
V = Original volume.

## Strain Solved Examples

Underneath are numerical founded on strain formula which might be useful for you?

Problem 1: An elastic band of length 5 cm is stretched such that its length increases by 2 mm . compute the strain.

## Answer:

Known:
$x$ (Change in length $)=2 \mathrm{~mm}$,
L (Original length $)=5 \mathrm{~cm}$
Strain is given by $\epsilon=\frac{x}{L}$
$=2 \times 10^{-3} / 5 \times 10^{-2}$
$=4 \times 10^{-2}$
Problem 2: An iron bar 3 m long is heated. It stretches by 0.5 mm . Compute the strain.

## Answer:

Known:
$x$ (Change in length $)=0.5 \mathrm{~mm}$,
L (Original length) $=3 \mathrm{~m}$

Strain is given by $\epsilon=\frac{x}{L}$
$=\frac{5 \times 10^{-3}}{3}$
$=1.67 \times 10^{-3}$

## ABSOLUTE PRESSURE FORMULA

When any pressure is detected above the absolute zero of pressure, it is labelled as absolute pressure. It is measured using a barometer, and it is equal to measuring pressure plus the atmospheric pressure.

Diagram showing absolute pressure, vacuum and gauge
Absolute pressure formula ( $\mathrm{p}_{\mathrm{abs}}$ ) is given by,
$\mathbf{P}_{\text {abs }}=\mathbf{P a t m}^{\text {at }}+\mathbf{P}_{\text {gauge }}$
where $p_{\text {gauge }}$ is the gauge pressure
$\mathrm{p}_{\mathrm{atm}}$ is atmospheric pressure.

The vacuum pressure is articulated as,

Vacuum Pressure = Atmospheric Pressure - Absolute

## Pressure

At sea level, it is around $\mathbf{1 4 . 7}$ pounds per square inch.

## Solved Examples

## Let's see some examples of absolute pressure:

Problem 1: A pressure gauge measures the $\mathrm{p}_{\text {gauge }}$ reading as 31 psi. If the atmospheric pressure is 14.2 psi. Compute the absolute pressure that corresponds to $\mathrm{p}_{\text {gauge }}$ reading.

## Answer:

Given:
$\mathrm{p}_{\text {atm }}$ (Atmospheric pressure) $=14.2 \mathrm{psi}$
$\mathrm{p}_{\text {gauge }}($ Gauge pressure $)=31 \mathrm{psi}$
Absolute pressure $\left(p_{\text {abs }}\right)=p_{\text {atm }}+p_{\text {gauge }}$
$=14.2 \mathrm{psi}+31 \mathrm{psi}$
$\mathrm{p}_{\text {gauge }}=45.2 \mathrm{psi}$
Problem 2: The psia pressure instrument gives the reading as 35.8 psi. If the atmospheric pressure is 15 psi , calculate the corresponding guage pressure.

## Answer:

## Given:

Atmospheric pressure $\mathrm{p}_{\mathrm{atm}}=15 \mathrm{psi}$
Absolute pressure $\mathrm{p}_{\mathrm{abs}}=35.8 \mathrm{psi}$

The Gauge pressure is
$p_{\text {gauge }}=35.8 \mathrm{psi}-15 \mathrm{psi}$
gauge $=20.8 \mathrm{psi}$.

## IMPULSE FORMULA

## Impulse Formula

A car is travelling at full speed. It crashes into the barrier, because of the negligence of the driver.

Here the huge force is applied on the wall by the car in a very little time interval which we term as an impulse.

Impulse is the big force acting for a very small interval of time. It is represented by $\vec{J} \mathrm{~J} \rightarrow$.

Impulse Formula is articulated as
$J=F \times t$
Where,

- Force applied is given as F
- Time interval throughout which force is applied is given ast.

Impulse can also be articulated as the rate of change of momentum.
$J=m \times v$
Where,

- Mass of the body is given as m
- Velocity with which body is moving is given as v .

Velocity is articulated as
$v=v_{f}-v_{i}$
Where,

- Initial Velocity is given as $\mathrm{v}_{\mathrm{i}}$
- Final Velocity is given as $\mathrm{v}_{\mathrm{f}}$.

Therefore, the Impulsive force is articulated as
$f=m \frac{v_{f}-v_{i}}{t}$
Impulse is articulated in $\mathrm{Kgms}^{-1}$ and Impulsive force is articulated in Newton(N).

Impulse-momentum formula

Impulse-momentum formula is obtained from impulsemomentum theorem which states that change in momentum of an object is equal to impulse applied on the object. The formula is given as follows:

$$
\text { Impulse-momentum formula } \mathrm{J}=\Delta \mathrm{p}
$$

$$
\text { When the mass is constant } \quad \mathrm{F} \Delta \mathrm{t}=\mathrm{m} \Delta \mathrm{v}
$$

When the mass is varying
$F d t=m d v+v d m$

As the SI unit of impulse and momentum are equal, it is given as $\mathrm{Ns}=\mathrm{kg} \cdot \mathrm{m} . \mathrm{s}^{-1}$

Solved Samples
Below are some problems on impulse:

Problem 1: A batsman knocks back a ball straight in the direction towards the bowler without altering its initial speed of $12 \mathrm{~m} / \mathrm{s}$. If the mass of the ball is 0.15 kg , calculate the impulse imparted to the ball?

## Answer:

Given:
$v_{i}($ Initial Velocity $)=12 \mathrm{~m} / \mathrm{s}$,
$\mathrm{V}_{\mathrm{f}}($ Final Velocity $)=-12 \mathrm{~m} / \mathrm{s}$, $m$ (mass) $=0.15 \mathrm{~kg}$,

J ( Impulse) $=$ ?
Impulse is articulated as
$J=m v_{f}-m v_{i}$
$=m\left(v_{f}-v_{i}\right)$
$=0.15 \mathrm{Kg}(-12-12) \mathrm{m} / \mathrm{s}$
$J=-3.6 N$.

Problem 2: A golfer hits a ball of mass 45 g at a speed of $40 \mathrm{~m} / \mathrm{s}$. The golf club is in contact with the ball for 3 s .

Compute the average force applied by the club on the ball?

## Answer:

$m$ (Mass) $=0.045 \mathrm{~kg}$,
$\mathrm{v}_{\mathrm{i}}$ (Initial Velocity) $=0$,
$\mathrm{v}_{\mathrm{f}}($ Final Velocity $)=40 \mathrm{~m} / \mathrm{s}$,
Impulse Force $F=m a=m \frac{v_{f}-v_{i}}{t}$
$=0.045 \times \frac{40}{.003}$
$F=600 \mathrm{~N}$

## ELASTIC COLLISION FORMULA

An encounter between two bodies in which the total kinetic energy of both the bodies after the encounter is equal to their total kinetic energy before the encounter is called Elastic collision. Elastic collisions occur only when there is no net conversion of kinetic energy into different forms. A perfectly elastic collision is one wherein there no loss of kinetic energy during the collision. In an elastic collision, conservation of momentum and conservation of kinetic energy can be observed.

If two elastic bodies of masses $\mathrm{m} 1, \mathrm{~m} 2$ with initial velocity u 1 and u 2 approaching towards each other undergo collision.

The Elastic Collision formula of momentum is given
$m_{1} u_{1}+m_{2} u_{2}=m_{1} v_{1}+m_{2} v_{2}$

Where,
m1 = Mass of 1st body
m2 = Mass of 2nd body
u1 =Initial velocity of 1st body
$u 2=$ Initial velocity of the second body
v1 = Final velocity of the first body
v2 = Final velocity of the second body
It says "Momentum before the collision is equal to momentum after the collision."

The Elastic Collision formula of kinetic energy is given by
$1 / 2 m_{1} u_{1}^{2}+1 / 2 m_{2} u_{2}^{2}=1 / 2 m_{1} v_{1}^{2}+1 / 2 m_{2} v_{2}^{2}$

Elastic Collision formula is applied to calculate the mass or velocity of the elastic bodies.

Solved Examples

## Example 1

If the ball has a mass 5 Kg and moving with the velocity of 12 $\mathrm{m} / \mathrm{s}$ collides with a stationary ball of mass 7 kg and comes to rest. Calculate the velocity of the ball of mass 7 Kg ball after the collision.

## Solution:

Given parameters are

Mass of 1st ball, m1 is 5 kg

Initial Velocity of the first ball, u1 is $12 \mathrm{~m} / \mathrm{s}$

Mass of the second ball, m2 is 7 kg

Initial velocity of the second ball, u2 is 0
Final Velocity of first ball, v1 is 0
Final Velocity of the second ball, v2 =?

The elastic collision formula is given as
$1 / 2 m 1 u 1^{2}+1 / 2 m 2 u 2^{2}=1 / 2 m 1 v 1^{2}+1 / 2 m 2 v 2^{2}$
$\left\{1 \times 5 \times(12)^{2}\right\} / 2+(1 \times 7 \times 0) / 2=(1 \times 5 \times 0) / 2+(1 \times 7) / 2 \times$ $\mathrm{v} 2^{2}$
$360=3.5 \mathrm{v}^{2}$
$v^{2}=102.85$
$\mathrm{v}=\mathrm{V} 102.85$
$=10.141 \mathrm{~m} / \mathrm{s}$

## Example 2

A 10 Kg block is moving with an initial velocity of $12 \mathrm{~m} / \mathrm{s}$ with 8 Kg wooden block moving towards the first block with velocity $4 \mathrm{~m} / \mathrm{s}$. The second body comes to rest after the collision. Determine the final velocity of first body

## Solution:

Given parameters are
Mass of 1st ball, m 1 is 10 kg
Initial Velocity of the first ball, $u 1$ is $12 \mathrm{~m} / \mathrm{s}$

Mass of the 2 nd ball, m 2 is 8 kg
Initial velocity of the second ball, $u 2$ is $4 \mathrm{~m} / \mathrm{s}$
Final Velocity of 2nd ball, v2 is 0
Final Velocity of the first ball, v1 =?
The Elastic collision formula is given as
$m 1 u 1+m 2 u 2=m 1 v 1+m 2 v 2$
$(10 \times 12)+(8 \times 4)=(10 \times v 1)+(8 \times 0)$
$120+32=10 \mathrm{v} 1+0$
$152=10 \mathrm{v} 1$
$\therefore \mathrm{v} 1=15.2 \mathrm{~m} / \mathrm{s}$

## WAVE SPEED FORMULA

A wave is defined as a kind of disturbance in a moving medium, for example, the waves of the ocean move in a medium and can see the movement of wave crest from one point to the other in a given time period. The motion of an object can be described regarding the speed which describes the velocity of the object.

A wave is visualized when a source vibrates and disturbs a particle in the medium. This can usually be seen in the case of tuning fork or ripples in water when a body is dropped, etc.

The number of waves travelled in one second is the frequency and the time period is the reciprocal of the frequency of the waves. Wavelength is the distance between the corresponding points in any two consecutive waves.

The Wave speed formula which involves wavelength and frequency is given by:
$v=f \lambda$

Where,
$v=$ velocity of the wave,
$f=$ frequency of the wave,
$\lambda=$ wavelength.

## Example1

A light wave travels with a wavelength of 600 nm . Determine its frequency.

## Solution:

Given:

Wavelength $\lambda=600 \mathrm{~nm}$,
Velocity of light $v=3 \times 10^{8} \mathrm{~m} / \mathrm{s}^{2}$

The frequency is calculated by,
$f=v / \lambda$
$=3 \times 10^{8} / 600 \times 10^{-9}$
$f=5 \times 10^{14} \mathrm{~Hz}$
The frequency of the light wave is $f=5 \times 10^{14} \mathrm{~Hz}$

## Example 2

A sound wave has a wavelength of 1.5 mm . Determine its frequency.

## Solution:

## Given:

Wavelength $\lambda=1.5 \mathrm{~mm}$,
Velocity of sound $v=343.2 \mathrm{~m} / \mathrm{s}$.
The frequency is calculated by,

$$
f=v / \lambda
$$

$=343.2 / 1.5 \times 10^{-3}$
$f=228 \times 10^{3} \mathrm{~Hz}$
The frequency of the light wave is $f=228 \times 10^{3} \mathrm{~Hz}$

## HEAT RATE FORMULA

The heat rate is defined as the total amount of energy required to produce one kilowatt-hour (kWh) of electricity by an electric generator or power plant.

It is the input rate required for generating unit power. The hea $t$ rate can also be described as the ratio of thermal inputs to el ectrical output. The lower the heat rate higher the efficiency. In thermal generating system, incoming and outgoing energy typically exist in the same value or unit. The heat amount is proportional to the input of chemical energy divided by the liberated electrical energy.

The formula of heat rate is
$R h=W s \times c \times \Delta T$

Where,
$R h$ is heat rate in btu/hr,

Ws is steam flow in lb/hr,
$\mathrm{c}=$ specific heat capacity in btu/lb ${ }^{\circ} \mathrm{F}$,
$\Delta \mathrm{T}$ is the temperature difference in ${ }^{\circ} \mathrm{F}$.
Question 1: Calculate the heat rate if steam enters a turbine at $400^{\circ} \mathrm{F}$ at atmospheric pressure and leaves the turbine at $200^{\circ}$ F. Steam at 500 lb flows through the turbine each hour during normal operation.

Solution:

Given parameters are,
$\mathrm{Ws}=500 \mathrm{lbs} / \mathrm{hr}$
$c=0.48$
$\mathrm{T}_{\text {in }}=400^{\circ} \mathrm{F}$
$\mathrm{T}_{\text {out }}=200^{\circ} \mathrm{F}$
$\Delta T=400-200$
$\Delta T=200^{\circ} \mathrm{F}$

We have the Formula,
$R h=W s \times c \times \Delta T$
$R h=500 \times 0.48 \times 200$

Therefore, $\mathrm{Rh}=48000 \mathrm{btu} / \mathrm{hr}$

## AIR RESISTANCE FORMULA

As we understand, the air resistance decreases the speed of a plane while moving.

Air resistance is a force that is caused due to air when an object moves through it. This force acts in the opposite direction to a body passing through the air. Air resistance exerts a frictional force against the moving body. As a body moves, air resistance decelerates it down. The quicker the body's motion, the superior the air resistance applied against it. Air resistance impacts all moving objects like bicycles, car, trains, rockets, aeroplanes and even alive bodies.

Its formula is given as,
$F_{a i r}=-c v^{2}$
Where,

F is the force of air resistance
c is the force constant
$v$ is the object's velocity

The negative sign indicates that the direction of air resistance is opposite to the direction of motion of the object.

Air Resistance Formula is made use of in finding the air resistance, air constant and velocity of the body if some of these numerics are known. This formula has wide applications in aeronautics.

## Air Resistance Solved Examples

Problem 1: A plane moving with a velocity of $50 \mathrm{~ms}^{-1}$ has a force constant of 0.05 . Calculate its air resistance.

## Answer:

Given:

Velocity of air, $\mathrm{v}=40 \mathrm{~ms}^{-1}$,
Force constant, $\mathrm{c}=0.05$
The Force of air is given by $\mathrm{F}=-\mathrm{cv}^{2}=0.05 \times 1600=-80 \mathrm{~N}$ Problem 2: An object is travelling at a speed of $20 \mathrm{~ms}^{-1}$. The object experiences a force of 50 N . Calculate the force constant.

## Answer:

Given:
Velocity of air, $\mathrm{v}=20 \mathrm{~ms}^{-1}$
Force of air, $\mathrm{F}=50 \mathrm{~N}$
The force constant is given by
$c=\frac{F}{v^{2}}=\frac{50}{20^{2}}=0.125$

## ELASTIC POTENTIAL ENERGY

## FORMULA

Elastic potential energy is the potential energy stored by stretching or compressing an elastic object by an external force such as the stretching of a spring. It is equal to the work done to stretch the spring which depends on the spring constant k and the distance stretched.

According to Hooke's law, the force applied to stretch the spring is directly proportional to the amount of stretch.

In other words,
Force required to stretch the spring is directly proportional to its displacement. It is given as
$\mathrm{F}=\mathrm{kx}$

Wherein,
$\mathrm{k}=$ spring constant
$\mathrm{x}=$ displacement

The Elastic Potential Energy Formula of the spring stretched is given as
P.E $=\frac{1}{2} k x^{2}$

Where,
P.E = elastic potential energy and it's expressed in Joule.

## Example 1

A compressed spring has the potential energy of 20 J and its spring constant is $200 \mathrm{~N} / \mathrm{m}$. Calculate the displacement of the spring.

Solution:

## Given:

Potential energy P.E = 40 J ,

Spring Constant k=200N/m,

The Potential energy formula is given by
P.E $=\frac{1}{2} k x^{2}$
the displacement is given by
$x=$ V $2 P . E / k$
$=\sqrt{ } 2 \times 40 / 200$
$=0.632 \mathrm{~m}$

## Example 2

The vertical spring is linked to a load of mass 5 kg which is compressed by 10 m . Determine the force constant of the spring.

## Solution:

Given: Mass m = 5kg
Distance $\mathrm{x}=10 \mathrm{~m}$

Force formula is given by
$F=m a$
$=5 \mathrm{~kg} \times 9.8 \mathrm{~m} / \mathrm{s}^{2}$
$=49 \mathrm{~N}$

Force in the stretched spring is
$F=k x$

Force Constant k is given by
$=F / x$
= $49 / 10$
$=4.9 \mathrm{~N} / \mathrm{m}$

## GRAVITATIONAL FORCE FORMULA

There are many forces in the world, plenty of pushes and pulls . One still pushes or pulls something, only the field. There are only four
fundamental forces in physics from which all new phenomena are derived: gravitational force, electromagnetic force, strong force and weak force.

Newton's law of gravity states that the gravitational force amo ng two bodies is proportionate to their masses and inversely $r$ elated to the square of the distance among them. All bodies, counting you, are tugging on every other body in the whole universe! This phenomenon is termed as Newton's Universal Law of Gravitation.

The universal law of gravitation states that:
Everybody in the universe pulls every other body with a forc e that is directly proportional to their mass-
produced and inversely proportional to the distance square b etween them.

The Gravitational force formula is given by
$F=\frac{G m_{1} m_{2}}{r^{2}}$
Where,
G is universal gravitational constant, $m_{1}$ and $m_{2}$ are mass of bodies
$r$ is the radius between the two masses
Gravitational Force Problems
Let's go through some gravitational force problems:
Solved Examples
Problem 1: Calculate the gravitational force if the mass of the sun is $1.99 \times 10^{30} \mathrm{~kg}$ and earth is $5.97 \times 10^{\mathbf{2 4}} \mathrm{kg}$ separated by the distance $1.5 \times 10^{11} \mathrm{~m}$ ? (Gravitational constant $\mathrm{G}=$ $6.673 \times 10^{-11} \mathrm{Nm}^{2} / \mathrm{Kg}^{2}$ )

## Answer:

The gravitational force is given by
$F=\frac{G m_{1} m_{2}}{r^{2}}$
$=\frac{6.673 \times 10^{-11} \mathrm{Nm}^{2} / \mathrm{Kg}^{2} \times 1.99 \times 10^{30} \mathrm{~kg} \times 5.97 \times 10^{24} \mathrm{lkg}}{\left(1.5 \times 10^{11} \mathrm{~m}\right)^{2}}$
$F=\left(7.93 \times 10^{44}\right) /\left(2.25 \times 10^{22}\right)$
$\mathrm{F}=3.5 \times 10^{22} \mathrm{~N}$

Problem 2: What will be the force of gravity in between two balls of mass 2 kg and 3 kg separated by 2 m distance?

Answer:

The gravitational force is given by
$F=\frac{G m_{1} m_{2}}{r^{2}}$
$=\frac{6.673 \times 10^{-11} \mathrm{Nm}^{2} / \mathrm{Kg}^{2} \times 2 \mathrm{~kg} \times 3 \mathrm{~kg}}{\left(2 \mathrm{~m}^{2}\right)} \quad \mathrm{F}=1 \times 10^{-10} \mathrm{~N}$

## MAGNETIC FIELD STRENGTH

## FORMULA

The magnetic field generated by the currents is usually termed as the magnetic field $B . B$ is sometimes called the magnetic flux density or the magnetic induction. The magnetic field is measured in Tesla. But when these fields produced are passing through the magnetic material, which has a magnetic field of its own, uncertainty can arise about what part of the magnetic field comes from external current and what part comes from the magnetic material itself. Therefore, we define a term called magnetic field strength $(\mathrm{H})$ to explain the concept. H has the unit amperes/meter.

The relationship between the magnetic field $(B)$ and the magnetic field strength $(\mathrm{H})$ is given by
$\mathrm{H}=\mathrm{B} / \mu_{\mathrm{m}}=\mathrm{B} / \mu_{0}-\mathrm{M}$

Where,
$\mathrm{M}=$ magnetisation of the material
$\mu_{0}=$ magnetic permeability of space

## SPECIFIC GRAVITY FORMULA

Specific Gravity gives information about the weight and density of the object. It can be calculated by comparing the weight, mass and density of the given object with water of the same amount at $4^{\circ} \mathrm{C}$.

Specific Gravity Formula is expressed as
Specific gravity $=\frac{\text { Mass of unit volume of the substance }}{\text { Mass of unit volume of water }}$
or
Specific gravity $=\frac{\text { weight of the substance }}{\text { Weight of the equal amount of water }}$
or

$$
\text { Specific gravity }=\frac{\text { Density of substance }}{\text { Density of equal volume of water }}
$$

Specific gravity is a unitless measurement. The density of water is $1000 \mathrm{Kg} / \mathrm{m}^{3}$

Specific gravity Solved Examples
Problem 1: If the density of iron is $7850 \mathrm{~kg} / \mathrm{m}^{3}$, what is its specific gravity?

Answer:

## Given:

Density of iron $=7850 \mathrm{Kg} / \mathrm{m}^{3}$,
Density of water $=1000 \mathrm{Kg} / \mathrm{m}^{3}$
Specific gravity $=\frac{\text { Density of given substance }}{\text { Density of equal volume of water }}$
$=\frac{7850}{1000}=7.85$
Problem 2: Compute the specific gravity if the density of granite is $174.8 \mathrm{lbs} / \mathrm{ft}^{3}$ and density of water is $62.4 \mathrm{lb} / \mathrm{ft}^{3}$ ?

Answer:

Known:

Density of granite $=174.8 \mathrm{lbs} / \mathrm{ft}^{3}$ Density of water $=62.4 \mathrm{lbs} / \mathrm{ft}^{3}$

Specific gravity $=\frac{\text { Density of given substance }}{\text { Density of equal volume of water }}$
$=\frac{174}{62.4}=2.8$

## HEAT FLUX FORMULA

## Heat Flux formula

Heat flux is the amount of heat transferred per unit area per unit time to or from a surface. Basically, it is a derived quantity since it involves the principle of two quantities viz. the amount of heat transfer per unit time and the area to or from which the heat transfer occurs.

The derived SI unit of heat rate is joule per second or watt. Heat flux density describes the heat rate per unit area. In SI unit of heat flux density is measured in $W / \mathrm{m}^{2}$. Heat flux is a vector quantity.

Fourier's law is an important application of these concepts.
For a pure solid substance, the conductive heat flux $\mathrm{JH}_{\mathrm{c}}$ in one dimension is expressed by Fourier's law.

## $J H c=\lambda d T d Z$

Where,

- $\mathrm{JH}_{\mathrm{c}}=$ conductive heat flux
- $\mathrm{T}=$ temperature
- $\lambda=$ thermal conductivity constant


## Heat Flow Rate Formula

The heat flow rate is defined as the amount of heat transferred per unit time in the material. The heat flow rate in a rod depends on the cross-sectional area of the rod, the temperature difference between both the ends and the length of the rod. Following is the formula used to calculate the heat flow rate of any material:

## $Q=-k(A I)(\Delta T)$

Where,

- $Q$ is the heat transfer per unit time
- k is the thermal conductivity
- A is the cross-sectional area
- I is the length of the material
- $\Delta \mathrm{T}$ is the temperature difference


## Solved Examples

## Example 1

One face of a copper plate is 5 cm thick and maintained at $500^{\circ} \mathrm{C}$, and the other face is maintained at $100^{\circ} \mathrm{C}$. Calculate the heat transferred through the plate.

## Solution:

Given parameters are, coefficient of thermal conductivity of copper, $\lambda=385$,
$d T=500-100=400$
$d x=5$

Substitute the values in the given formula
$\mathrm{JH}_{\mathrm{c}}=\lambda \mathrm{dT} / \mathrm{dZ}$
$\mathrm{JH}_{\mathrm{c}}=385 \times 400 / 5$
$\mathrm{JH}_{\mathrm{c}}=30,800 \mathrm{MW}$

## MEASUREMENT FORMULAS

Measurements are used to measure something. It is the estimation of ratios of quantity. It is made by comparing a quantity with a standard unit. They are used to find the size, length or amount of something. Measurement Formulas are used to find the distance, area, surface area, volume, circumference etc. They also include some conversion formulas like conversion of an inch to feet, meter to miles etc.

Some of the Measurement Formulas are given below:

Measurement Problems

Some solved problems based on measurements are given below:

## Solved Examples

Question 1: Find the area of a triangle with base 3 units and height 8 units?

Solution:

Base $=3$ units
Height $=8$ units
Area of a Triangle $=$ base $*$ height $\underline{2}=\underline{3} \times \underline{82}$
$=\underline{242}$
$=12$ sq.units
Question 2: Find the distance between two points $(2,3)$ and
$(7,5)$ ?
Solution:
$\left(x_{1}, y_{1}\right)=(2,3)$
$\left(x_{2}, y_{2}\right)=(7,5)$
Distance between the points $=(x \underline{2}-x \underline{1}) \underline{2}+(y \underline{2}-$

$=\underline{29}--\mathrm{V}$
$=5.39$ units

## POTENTIAL ENERGY FORMULA

## Potential Energy Definition

Potential energy is defined as the energy stored in an object. Potential energy can be divided into many types; Gravitational potential energy, Electric Potential Energy, Elastic Potential energy etc. Here the gravitational potential energy is defined as the energy possessed by an object by virtue of its position relative to others. Elastic potential energy is defined as the energy possessed by virtue of stresses within its body and an electric potential is defined as the energy possessed by an object by virtue of the total charge stored within.

## Potential Energy Formula

The formula for gravitational potential energy is given below.

$$
\mathrm{PE}=\mathrm{mgh}
$$

Where,

- PE is the potential energy of the object in Joules, J
- $m$ is the mass of the object in kg
- $g$ is the acceleration due to gravity in $\mathrm{ms}^{-2}$
- $h$ is the height of the object with respect to the reference point in $m$.


## Example Of Potential Energy

We all know that dams are constructed on rivers for the generation of electricity. But do you know the reason behind this? Here, the potential energy possessed by water is used to harness electrical energy. Water raised to a certain height gains potential energy with respect to the ground due to the gravitational force acting on it. This energy is used to turn the
blades of turbines positioned in the dams that eventually helps in the generation of electricity.

## Derivation Of Potential Energy

As per the potential energy function for a conservative force, the force acting on an object can be given as,
$F=d U d x d U=-F d x \int \times \underline{2} \times \underline{1} U=-\int \times \underline{2} \times \underline{1} F d x$

Here the force acting on the object can be given as
$\mathrm{F}=\mathrm{mg}$, and the distance from the point of reference can be given as h.

Substituting these values, we get,
$U=-[m g(h \underline{1}-h \underline{2})] U=[m g(h \underline{2}-h \underline{1})]$

Here, h 1 is the height of the point of reference and h 2 is the height at which the object is positioned.

## Solved Examples

Example 1: A ball of mass 0.8 kg is dragged in the upward direction on an inclined plane. Calculate the total potential energy gained by this ball given that the height of the wedge is 0.2 meter.

## Solution:

It is given that mass of the object $m=0.8 \mathrm{~kg}$.
Since the potential energy of the object is only dependent on its height from the reference position, we can say that,

$$
\mathrm{PE}=\mathrm{mgh}
$$

Where,
$\mathrm{m}=0.2 \mathrm{~kg}$
$\mathrm{g}=10 \mathrm{~m} / \mathrm{s}^{2}$
$\mathrm{h}=0.2 \mathrm{~m}$.
$P E=0.8 \times 10 \times 0.2$
$P E=1.6 \mathrm{~J}$

Example 2: A wagon loaded with iron blocks is pushed up an inclined plane to its highest point. The total mass of the wagon is 50 kg and the height of the topmost point from the ground is 5 meters. What is the total potential energy of the wagon at the top?

## Solution:

Given:
$\mathrm{m}=50 \mathrm{~kg}$
$\mathrm{g}=10 \mathrm{~m} / \mathrm{s}^{2}$
$\mathrm{h}=5 \mathrm{~m}$

Substituting the above values in the formula, we get,
$P E=50 \times 10 \times 5$
$P E=250 \mathrm{~J}$

## Energy Formula

Energy is defined as the ability to do work. And there is no fixed formula for energy as it is expressed in different forms like kinetic energy, potential energy, sound energy etc. The SI unit of energy is Joules and the dimensional formula is given as:

Dimensional formula of energy: $\mathrm{M}^{1} \mathrm{~L}^{2} \mathrm{~T}^{-2}$

## AMPLITUDE FORMULA

The amplitude of a wave is the maximum displacement of the particle of the medium from its equilibrium position. It is represented by A. The Amplitude formula can be written as
$y=\operatorname{ASin}(\omega t+\phi)$
where,
$y$ is the displacement of the wave in metres

A is the amplitude of the wave in metres
$\omega$ is the angular frequency given by
$\omega=\frac{2 \pi}{T}$
$\Phi$ is the phase difference

## Amplitude Solved Examples

Problem 1: If $y=5 \sin \omega t$ represents the wave, find the amplitude of the wave.

## Solution:

Given: $y=5 \sin \omega t$
The equation is of the form
$y=A \sin \omega t$

Henceforth, the amplitude is $\mathrm{A}=5$.

Problem 2: The equation of a progressive wave is given by $y=5 \operatorname{Sin}(10 \pi t-0.1 \pi x)$ where x and y are in metres. Find the value of Amplitude

Given: $y=5 \operatorname{Sin}(10 \pi t-0.1 \pi x)$
The equation is in the form of $y=A \operatorname{Sin}(\omega t+\phi)$
Henceforth, the amplitude is $\mathrm{A}=5$.

## RELATIVE MOTION FORMULA

Relative motion is the motion which is computed on the grounds of motion of an object in contrast to another moving motion. The relative term is not conferring to earth but is basically the velocity of the object taken as static when equated to other moving bodies.

Similarly, when an object moves it also alters its position constantly and that is in relative to some reference point generally a detection instrument or maybe a separator.

Let us assume the velocity of object A comparative to B is ' $v$ ' then the velocity of object $B$ comparative to $A$ is ' $-v$ '

## Situation One:

Two objects are moving in the same direction then the relative motion is an object with greater speed - object with minor speed.

Relative speed $=$ Speed of object $A$ (better speed) - speed of object B (lesser speed)

Situation Two:
One object is moving, though the other one is being stationary.

Relative speed $=$ Speed of moving object $\boldsymbol{-}$ stationary object (zero)

Situation Three:

Both objects are moving in the opposite direction Relative speed $=$ Speed of object A + speed of object B

## DISTANCE TRAVELED FORMULA

Distance Traveled defines how much path an object has covered to reach its destination in a given period. The formula for distance travelled is given
$d=v t$
Where,
d = distance travelled
$\mathrm{v}=$ Velocity
$\mathrm{t}=$ time taken to travel

The distance-travelled formula can be applied to calculate the distance of driving a car or swimming laps in a pool. While driving a car, the distance will be calculated in miles or kilometres, the rate is in miles per hour or kilometres per
hour, and time is in hours. While swimming laps in a pool, the distance will be calculated in laps.

## Solved Examples

Question 1: A heavily loaded truck travels at a velocity of 60 miles per hour. Calculate the total time taken by the truck to travel a distance of 200 miles?

Answer:

Given: Velocity = 60 miles per hour

Displacement d=200 miles
we know,
displacement $\mathrm{d}=\mathrm{vt}$

The time taken is given by
$t=d / v$
= 200/60, $\quad t=3.33$ hours

## TANGENTIAL VELOCITY FORMULA

Tangential velocity is the linear speed of any object moving along a circular path. A point on the outside edge of a turntable moves a greater distance in one complete rotation than a point near to the centre. When a body moves in a circular path at a distance $r$ from the centre, the body's velocity is directed tangentially at any instant. This is known as tangential velocity. In other words, the linear velocity is its tangential velocity at any instant.

## Tangential Velocity Formula is given by,

$V_{r}=r \omega$
Where,
$r=$ radius of circular path and
$\omega$ = angular velocity

Tangential velocity formula is applied in calculating the tangential velocity of any object moving in a circular path.

It is expressed in meter per second (m/s).

Example 1

If the angular velocity of a wheel is $40 \mathrm{rad} / \mathrm{s}$, and the wheel diameter is 60 cm , calculate the tangential velocity.

## Solution:

## Given:

Radius, $r=1 / 2$ of diameter of 60 cm
$r=30 \mathrm{~cm}=0.30 \mathrm{~m}$

Angular velocity, $\omega=40 \mathrm{rad} / \mathrm{s}$.

Tangential velocity formula is given by,
$V_{r}=r \omega$
$=40 \times 0.30$

$$
V r=12 \mathrm{~m} / \mathrm{s}
$$

## Example 2

If a wheel moves at $10 \mathrm{~m} / \mathrm{sec}$, and its angular velocity is 5 radians/sec, calculate the radius of the wheel.

## Solution:

## Given:

Tangential velocity, $\mathrm{Vr}=10 \mathrm{~m} / \mathrm{sec}$

Angular velocity, $\omega$, = 5 radians $/ \mathrm{sec}$.
the formula for tangential velocity is given by,
$V r=\omega r$
$V r / \omega=r$
$10 / 5=r$
$r=2 \mathrm{~m}$

## POYNTING VECTOR FORMULA

Poynting Vector represents the direction of energy-flux density in an electromagnetic field

Poynting Vector formula is represented by
$\vec{S}=\frac{1}{\mu_{0}}(\underset{E}{\vec{B}} \times \underset{B}{\vec{~}})$
$S=\frac{1}{\mu_{0}} E B \sin \theta$
Where,
$S=$ Poynting Vector

E = Electric Field
$B=$ Magnetic Field
$\mu_{0}=$ vacuum permeability $=1.257 \times 10^{-6}$ henry/ meter
Poynting Vector is the cross product of electric and magnetic fields.

## LINEAR MOMENTUM FORMULA

Linear momentum is the vector quantity and defined as the product of the mass of an object, $m$, and its velocity, v . The letter ' $\mathbf{p}$ ' is applied to express it and used as momentum for short. Please note that the body's momentum is always in the same direction as its velocity vector. It's a conserved quantity which means that the total momentum of a system is constant. The units of linear momentum are $\mathrm{kg} \mathrm{m} / \mathrm{s}$.

The linear momentum formula is given by,

$$
P=m v
$$

## Where,

$\mathrm{m}=$ mass
v = velocity

## Example 1

Determine the linear momentum of a body whose mass is 10 kg moving with a speed of $20 \mathrm{~m} / \mathrm{s}$.

Solution:
Given parameters are,
$\mathrm{m}=10 \mathrm{~kg}$
$\mathrm{v}=20 \mathrm{~m} / \mathrm{s}$

Linear momentum formula is expressed as,
$P=m v$
$p=10 \times 20$
$p=200 \mathrm{kgm} / \mathrm{s}$

## Example 2

The linear momentum of a body is $40 \mathrm{~kg} \mathrm{~m} / \mathrm{s}$ and the mass of the object is 5 kg . Determine the velocity of the object.

Solution:

Given parameters are,
$m=5 \mathrm{~kg}$
$P=40 \mathrm{kgm} / \mathrm{s}$
Linear momentum formula is given by,

$$
P=m v
$$

$$
v=P / m
$$

$$
v=40 / 5
$$

$$
v=8 \mathrm{~m} / \mathrm{s}
$$

## BUFFER SOLUTION FORMULA

A buffer solution is an aqueous solution consisting of a weak acid and its conjugated base mixture or vice verse. There is a minute change in its pH when a little or medium amount of strong base or acid is added to it and that is why it is used to avoid changes in the pH of a solution.

The pH value of the water solvent is 7 , but if we add a few drops of HCl or NaOH solution, its pH decreases or increases respectively. Therefore it is necessary to have solutions whose pH does not change even on the addition of strong alkalies or strong acids. Such solutions are called buffer solutions.

Buffer capacity is the capacity of a buffer solution to resist change in its pH . The equation is given by,
$\mathrm{pH}=\mathrm{pKa}+\log [$ Salt $] /[$ Acid $]$

The pH of any acidic buffer solution is always less than 7 and the pH of any basic buffer solution is always greater than 7 .

## Example 1

Determine the ratio of concentrations of Formate ion and formic acid in a buffer solution so that its pH is required to be 4? Identify the pH of this buffer to have the maximum buffer capacity? Ka of formic acid is $1.8 \times 10-4$.

## Solution

We have the equation
$\mathrm{pH}=\mathrm{pKa}+\log [$ Salt $] /[$ Acid $]$
$4=-\log \left(1.8 \times 10^{-4}\right)+\log [$ Formate $] /[$ Formic acid]

4 = 3.74 + log [Formate] / [Formic acid]
$\log [$ Formate $] /[$ Formic acid $]=4-3.74=0.26$
[Formate] / [Formic acid]= 1.8

The buffer capacity would be maximum near the pKa of the acid.

For maximum buffer capacity
$\mathrm{pH}=\mathrm{pKa}=-\log \mathrm{Ka}$
$=-\log \left(1.8 \times 10^{-4}\right)$
$=3.74$
buffer capacity $=3.74$

## Example 2

Calculate the volume of 0.2 M solution of acetic acid that needs to be added to 100 ml of 0.2 M solution of sodium acetate to obtain a buffer solution of pH 5.00 . pKa of acetic acid is 4.74.

## Solution

We have the equation,
$\mathrm{pH}=\mathrm{pKa}+\log [$ Salt $] /[$ Acid $]$
$\log [$ Salt $] /[$ Acid $]=\mathrm{pH}-\mathrm{pKa}$
$=5-4.74$
$=0.26$
[Salt] / [Acid] = 1.82
Number of moles of sodium acetate
$=100 \times 0.2 / 1000$
$=0.02 \mathrm{~mol}$

Let volume of 0.2 M acetic acid added $=\mathrm{V} \mathrm{mL}$

Number of moles of acetic acid $=\mathrm{V} \times 0.2 / 1000$
$0.02 / V \times 0.2 / 1000=1.82$

Therefore,
$\mathrm{V}=0.02 \times 1000 / 0.2 \times 1.82$
$=55 \mathrm{~mL}$

55 mL of acetic acid is added

## MAXWELL BOLTZMANN

## DISTRIBUTION FORMULA

Not all the air molecules surrounding us travel at the same speed. Some air molecules travel faster, some move at a moderate speed and few others will hardly move at all. Hence, instead of asking the speed of any particular gas molecule we ask the distribution of speed in gas at a particular temperature. James Maxwell and Ludwig Boltzmann came up with a theory to show how the speeds of the molecule are distributed for an ideal gas. In the next section, we shall be discussing the Maxwell Boltzmann distribution formula in detail.

Maxwell Boltzmann Distribution Equation
The average kinetic energy of the gas molecules is given by the equation
$\mathrm{Ek}=32 \mathrm{kBT}=\underline{32 \mathrm{kNAT}}$
where $E_{-} k$ is the average kinetic energy of the gas molecules
$k_{B}$ is the Boltzmann's constant which is equal
to $\underline{1.38} \times \underline{10}-\underline{23} \mathrm{JK}-1$
$R$ is the universal gas constant which is equal to $8.314 \mathrm{~J} / \mathrm{K} / \mathrm{mol}$
$N_{A}$ is the Avagadro's constant which is equal to $\underline{6.023} \times \underline{1023} \mathrm{~mol}-1$

Example:

1. What is the average speed of hydrogen molecules on the earth?

## Solution:

Let us consider the temperature on earth to be 300 K .

The mass of a hydrogen molecule is $\underline{2} \times \underline{1.67} \times \underline{10}-\underline{27} \mathrm{~kg}$ The kinetic energy of the gas molecules is given by the equation
$E k=32 \mathrm{kBT}$

Substituting the values in the equation, we get
$\mathrm{Ek}=\underline{32} \times \underline{1.38} \times \underline{10}-\underline{23} \times \underline{300}=\underline{6.21} \times \underline{10}-\underline{21} \mathrm{~J}$

To find the velocity from the average kinetic energy we use the formula
$\mathrm{Ek}=\underline{12 \mathrm{mv}} \underline{2}$

Reaaranging the formula, we get
$\mathrm{v} \underline{2}=\underline{2} \mathrm{Ekm}$
$V^{2}=(2)\left(\underline{6.21} \times \underline{10^{-21}}\right) /\left(\underline{2} \times \underline{1.67} \times 10^{-27}\right)$
$V=V\left(12.42 \times \underline{10^{6}}\right) / 3.34$
$V=\sqrt{ } 3.71 \times \underline{10^{6}}$
$V=1.92 \times \underline{10^{3}}$
Therefore, the average velocity is $\mathrm{V}_{\mathrm{rms}}=1928 \mathrm{~m} / \mathrm{s}$.

## ANGULAR DISPLACEMENT

## FORMULA

Definition: Angular displacement is the angle measured in radians and is defined as the shortest angle between the initial and the final points for a given object undergoing circular motion about a fixed point. Angular Displacement is a vector quantity. It has both direction and magnitude. It is represented by a circular arrow pointing from the initial point to the final point that is either clockwise or anti-clockwise in direction.

Formula: Angular displacement of a point can be given by using the following formula,

Angular displacement $=\theta \mathrm{f}-\theta \mathrm{i}$
Where,
$\theta=s / r$

Here, $\theta$ is the angular displacement of the object through which the movement has occurred, s is the distance covered by the object on the circular path and $r$ is the radius of curvature of the given path.

When the acceleration of the object ( $\alpha$ ), the initial angular velocity $(\omega)$ and the time $(\mathrm{t})$ at which the displacement is to be calculated is known, we can use the following formula.
$\theta=w t+\underline{1} / \underline{2} \alpha t \underline{2}$
Derivation:

Let us consider an object ' $A$ ' undergoing linear motion with initial velocity ' $u$ ' and acceleration ' $a$ '. Let us say, after time $t$, the final velocity of the object is ' $v$ ' and the total displacement of the object is ' $s$ '.

We know that acceleration is defined as the rate of change of velocity. Therefore,
$a=d v d t$

$$
\begin{aligned}
& d v=a d t \\
& \text { Integrating on both sides, } \\
& \text { } \begin{array}{l}
\text { vudv=aftOdt } \\
v \text {-u=at } \\
\text { Also, } \\
a=d v d t \\
a=d v d x * d x d t \\
\text { since } v=d x / d t \text {, we can write, } \\
a=v d v d x \\
v d v=a d x
\end{array}
\end{aligned}
$$

Upon integrating both the sides, we get
$\int v u v d v=a \int s \underline{O} d x$
$\mathrm{v} \underline{2}-\mathrm{u} \underline{2}=\underline{2} \mathrm{as}$
Substituting the value of $u$ from the equation 1 into the second equation, we get,
$v \underline{2}-(v-a t) \underline{2}=\underline{2} a s$
$\underline{2}$ vat-a $\underline{2} t \underline{2}=\underline{2}$ as
Dividing both the sides of the equation by 2 a , we get,
$s=v t-12 a t \underline{2}$

Upon substituting the value of $v$ instead of $u$ we get,
$s=u t+\underline{12}$ at $\underline{2}$

Numericals

Problem 1:

1) Neena goes around a circular track that has a diameter of 7 m . If she runs around the entire track for a distance of 50 m , what is her angular displacement?

## Answer:

According to question, Neena's linear displacement, $s=50 \mathrm{~m}$.

Also, the diameter of the curved path, $\mathrm{d}=7 \mathrm{~m}$

As we know that, $d=2 r$, so $r=7 / 2=3.5 \mathrm{~m}$

And according to the formula for angular displacement,
$\theta=s r$
$\theta=50 \mathrm{~m} / 3.5 \mathrm{~m}$
$\theta=14.28$ radians

Problem 2
2) Rohit bought a pizza of radius of 0.5 m . A fly lands on the pizza and walks around the edge for a distance of 80 cm .

Calculate the angular displacement of the fly?

## Answer:

According to question, the distance travelled by the fly on the pizza is $s=80 \mathrm{~cm}=0.08 \mathrm{~m}$.

The radius of the pizza is given to be, $r=0.5 \mathrm{~m}$.

Using the formula for angular displacement,
$\theta=s r$
$\theta=0.08 \mathrm{~m} / 0.5 \mathrm{~m}$
$\theta=0.16$ radians

## ROTATIONAL INERTIA FORMULA

The rotational inertia is a property of any object which rotates. In the case of linear motion, the rotational inertia is known as an analog of mass. The moment of inertia depends not only on the mass and shape of the object but also on the axis of rotation. The rotational inertia is various with the object depending on the rotational axis.

The formula for rotational inertia is
$\mathrm{I}=\mathrm{mr}^{2}$

Where

I = rotational inertia
$\mathrm{m}=$ mass of the object
$r=$ radius of the circular path

## Example 1

Determine the moment of inertia of the object with mass 20 kg and rotating around the radius 8 m ?

Solution:

Given
$\mathrm{m}=20 \mathrm{~kg}$
$r=8 m$

The formula Rotational inertia is
$I=m r^{2}$
$1=20 \times 8^{2}$
$\mathrm{I}=1280 \mathrm{kgm}^{2}$

## Work Formula

Work is said to be done when an object experiences displacement. It is represented by W.

Work Formula is articulated as
$W=F . d$

W=F.d. $\cos \theta$

Where,
F =force applied
d= displacement
$\theta=$ angle between force and direction of motion

Work formula is made use of to compute work done, force or displacement in any problem. It is articulated in Nm.

## Work Solved Examples

Underneath are numerical on work which helps out to comprehend the concept better.

Problem 1: Compute the work done if 10 N of force acts on the body showing the displacement of 2 m ?

## Answer:

Known:

F (Force) $=10 \mathrm{~N}$,
$d($ Displacement $)=2 m$,
W (Work done) $=F \times d$
$=10 \mathrm{~N} \times 2 \mathrm{~m}$
$=20 \mathrm{Nm}$.

Problem 2: Compute work done for 2-newton force and 3metre displacement and the angle between force and displacement is 45 degree?

## Answer:

Known: Force F = 2N,
Displacement d=3m,

$$
\theta=45^{\circ}
$$

Work done,
$W=F d \cos \theta$
$=2 \mathrm{~N} \times 3 \mathrm{~m} \cos 45^{\circ}$
$\mathrm{W}=3.51 \mathrm{Nm}$.

## CAPACITANCE FORMULA

Capacitance is used to describe how much charge any conductor can hold. It represents the ratio of the charge flowing across the conductor to the potential applied. Capacitors are the conductors used for holding charges.

Capacitance is the ability of a substance to store an electrical charge. Any object that can be electrically charged shows capacitance. A parallel-plate capacitor is the common form of the energy storage device. Capacitance is exhibited by a parallel plate arrangement and defined in terms of charge storage. When a capacitor is charged completely, there is a potential difference between its plates, and larger the area of the plates and/or smaller the distance between them, greater will be the charge of the capacitor and greater will be its Capacitance.

Capacitance Formula is expressed as

## $\mathrm{C}=\mathrm{Q} / \mathrm{V}$

Where,

Q denotes the charge of the conductor,
V denotes the potential applied across the conductor and
C is proportionality constant, called capacitance
If the capacitors are connected in series, the capacitance formula is expressed by

$$
C s=1 / C 1+1 / C 2
$$

If capacitors are connected in parallel, the capacitance formula is expressed by
$\mathrm{Cp}=\mathrm{C} 1+\mathrm{C} 2$
Where C1,C2,C3 $\qquad$ Cn are the capacitors and Capacitance is expressed in Farads

## Example 1

Determine the capacitance of the capacitor if 5 coulomb of charge is flowing and 2 V of potential is applied.

## Solution

Given parameters are
Charge Q is 5 C ,
Voltage applied V is 2 V
the Capacitance formula is given by
$C=Q / V$
$=5 / 2$
$=2.5 \mathrm{~F}$

## Example 2

Determine the capacitance if capacitors 6 F and 5 F are connected
(i) In series and
(ii) In parallel

## Solution

The capacitance in series formula is given by
$C s=1 / C 1+1 / C 2$
$=\mathrm{C} 1+\mathrm{C} 2 / \mathrm{C} 1 \mathrm{C} 2$
$=6+5 / 30$

Cs $=0.367 \mathrm{~F}$

The capacitance in parallel formula is given by

$$
\begin{aligned}
C p & =C 1+C 2 \\
& =6+5 \\
C p & =11 F
\end{aligned}
$$

## TIME CONSTANT FORMULA

All electronic circuits experience some kind of "time-delay" between its output and input when a voltage, either DC or AC is applied to it. This delay is termed as the Time Constant or the time delay of an electric circuit. The resultant time constant of an electric circuit depends on reactive components either inductive or capacitive connected to it. The capacitor charges up when a DC voltage (increasing) is applied to it while it is discharged. The capacitor discharges (opposite direction) when the voltage is decreased. Due to these properties of a capacitor, they act like small batteries and are capable of releasing or storing the energy as required. The charge of the capacitor plate is given as $Q=V C$. This charging and discharging of capacitors doesn't happen instantly but take a certain amount of time. The time required in charging or discharging the capacitor to a specific
percentage of its highest supply value is called as its Time Constant, denoted by Tau ( $\tau$ ).

Universal Time Constant Formula
Change $=($ Final - Start $)\left(1-\frac{1}{e^{t / \tau}}\right)$

Where

Final = Value of calculated variable after infinite time

Start = Initial value of the calculated variable
$\mathrm{e}=$ Euler'snumber (2.7182818)
$\mathrm{t}=$ Time in seconds
$\tau=$ Time constant for the circuit in seconds

Follow the following steps to analyse an $R C$ and $L / R$ circuit
Step 1: Determine the time constant of the circuit

Step 2: Identify the quantity to be calculated (the quantity whose change is opposed by the reactive component)

Step 3: Find the starting and final values of that quantity.

Step 4: Substitute all the values determined in the Universal Time Constant formula and then find Change in quantity.

Step 5: If the starting value is zero then the change in quantity is equal to the value calculated using the formula. If not, add the change to the starting value to find the answer.

## TIME DILATION FORMULA

According to the theory of relativity, time dilation is defined as the difference between the elapsed time of the two events measured by either moving relative to each other located differently from gravitational mass or masses.

Let's consider a clock kept in two different observers. One observer is at rest and the other is moving along with the speed of light. The existence of time difference between the two clocks is known as time dilation.

The time dilation formula is given by,
$T=\frac{T_{0}}{\sqrt{1-\frac{V^{2}}{C^{2}}}}$
Where

T = time observed,

T0 = time observed at rest,
$\mathbf{v}=$ velocity of the object
$\mathbf{c}=$ velocity of light in vacuum $\left(3 \times 10^{8} \mathrm{~m} / \mathrm{s}^{2}\right)$

Solved Examples

## Example 1

Determine the relativistic time, if TO is 7 years and the velocity of the object is 0.55 c .

## Solution:

Given:
TO = 7 years
$v=0.55 c$

The Formula for time dilation is given by,
$T=\frac{T_{0}}{\sqrt{1-\frac{V^{2}}{C^{2}}}}$

$$
\begin{aligned}
& T=\frac{7}{\sqrt{1-\frac{\left(0.55^{2}\right)\left(3^{2} \times 10^{16}\right)}{3^{2} \times 10^{16}}}} \\
& T=\frac{7}{\sqrt{1-0.55^{2}}}
\end{aligned}
$$

$$
\mathrm{T}=7 / 0.8351
$$

$$
\text { T = } 8.38 \text { years }
$$

## MOMENT FORMULA

Moment refers to a very short period of time. If you consider a see-saw, putting weights on both sides makes it to be in a balanced moment. If you put extra weight or less weight, on one hand, the see-saw is no more balanced, and this is known as the unbalanced moment.

The measure of turning effect is known as torque. The force which acts on the body of the torque is known as moment of force.

The moment formula is given by

Moment of force $=\mathrm{Fx}$ d
Wherein,
$F$ is the force applied, and
$d$ is the distance from the fixed axis.

Moment of force is expressed in Nm.

Moment of force formula can be applied to calculate the moment of force for balanced as well as unbalanced forces.

## Solved Examples

## Example 1

A 200 cm meter rule is pivoted at the middle point (at 50 cm point). If the weight of 10 N is hanged from the 30 cm mark and a weight of 20 N is hanged from its 60 cm mark, identify whether the meter rule will remain balanced over its pivot or not.

## Solution:

According to the principle of moments, when an object is in rotational equilibrium, then

Total anticlockwise moments = Total clockwise moments
Total anticlockwise moments:
Length of lever arm $=(50-30)=20 \mathrm{~cm}$
$=0.20 \mathrm{~m}$

Since the length of the lever arm is the distance from its midpoint, where its balanced force applied $=10 \mathrm{~N}$

Anticlockwise moment = Lever arm x Force applied
$=0.20 \times 10=2 \mathrm{Nm}$

Clockwise moment: Length of lever arm = (60-50)
$=10 \mathrm{~cm}$
$=0.10 \mathrm{~m}$.

Since length of lever arm is the distance from the mid-point, about which balanced Force applied $=20 \mathrm{~N}$

Clockwise moment = lever arm x force applied

$$
=0.10 \times 20=2 \mathrm{Nm}
$$

Therefore,

Since the total anti-clockwise moment = total clockwise moment $=2 \mathrm{Nm}$, according to the principle of moments, it is in rotational equilibrium ie, the meter rule remains balanced about its pivot.

## Example 2

A 500 cm meter rule is pivoted at its middle point. If a weight of 2 N is hanged from the 20 cm point, Calculate the amount of weight required to be applied at the 80 cm mark to keep it in a balanced position.

## Solution:

According to the principle of moments, To keep an object in rotational equilibrium, the sum of anticlockwise moments and clockwise moments acting should be equal. Therefore, the amount of weight to be hanged from the 80 cm mark must be able to generate a clockwise moment equal to the
anticlockwise moment generated by the weight hanged on the left side of the meter rule.

Anticlockwise moment :
Length of lever arm = (50-20)
$=30 \mathrm{~cm}$
$=0.30 \mathrm{~m}$

Since the length of the lever arm is the distance from its midpoint, where it is balanced

Force applied $=2 \mathrm{~N}$
Anticlockwise moment = lever arm x force applied
$=0.30 \times 2 \mathrm{~N}$
$=0.6 \mathrm{Nm}$

Clockwise moment:
length of lever arm $=(80-50)$
$=30 \mathrm{~cm}$
$=0.30 \mathrm{~m}$

Since the length of the lever arm is the distance from its Force applied.

Let it be ' $F$ '.

Thus, clockwise moment $=$ F x 0.30
$=0.30 \mathrm{~F} \mathrm{Nm}$

Clockwise moment = Anticlockwise moment
$0.30 \mathrm{~F}=0.6$
$\mathrm{F}=2 \mathrm{~N}$
A weight of 2 N needs to be hanged from 80 cm point to keep the meter rule balanced.

## VOLTAGE DROP FORMULA

Voltage drop specifies how the supplied energy from a voltage source is reduced as electric current flows through the elements that do not supply voltage (passive elements) of the electrical circuits. The voltage drop across conductors, across connectors and internal resistances of the source is unwanted since the supply energy is lost. The voltage drop across active circuit elements and loads are desired since the supplied power performs efficient work.

The voltage drop formula is given by,
$V=I Z$

Where,
I = Current in amperes
$\mathrm{Z}=$ impedance in $\Omega$

## Example 1:

A current of 9A flows through a circuit that carries a resistance of $10 \Omega$. Determine the voltage drop across the circuit.

## Solution:

Given:

Current I = 9A,
Impedance Z = $10 \Omega$
the voltage drop formula is given by
$V=I Z$
$=9 \times 10$
$\mathrm{V}=90 \mathrm{v}$.

## Example 2

A lamp of $15 \Omega$ and $30 \Omega$ are connected in series. A current of
4 A is made to flow through it. Determine the voltage drop.

Solution:

## Given:

Resistance $Z=(15+30) \Omega$

$$
\mathrm{Z}=45 \Omega,
$$

Current $\mathrm{I}=4 \mathrm{~A}$
The voltage drop formula is given by,

$$
V=I Z
$$

$$
=4 \times 45
$$

$$
\mathrm{V}=180 \mathrm{~V}
$$

## SPHERICAL CAPACITOR FORMULA

Formula To Find The Capacitance Of The Spherical Capacitor
$C=\frac{Q}{\Delta V}=\frac{4 \pi \epsilon_{0}}{\left[\frac{1}{r_{1}}-\frac{1}{r_{2}}\right]}$

Where,

C = Capacitance
Q = Charge
$\mathrm{V}=$ Voltage
$r_{1}=$ inner radius
$r_{2}=$ outer radius
$\varepsilon_{0}=\operatorname{Permittivity}\left(8.85 \times 10^{-12} \mathrm{~F} / \mathrm{m}\right)$

## MOLAR CONCENTRATION

## FORMULA

Molar concentration is the most effective way of describing a solute concentration in a solution. Molarity is described as the total number of moles of solute dissolved in per litre of solution,i.e., $\mathrm{M}=\mathrm{mol} / \mathrm{L}$. All moles measurements are applied to determine the volume of moles in the solution that is the molar concentration.

The molar concentration formula is given by,

$$
\text { Molar Concentration }=\frac{\text { Amount in moles }}{\text { Volume of Solution }}
$$

## Example 1

Determine the molar concentration of NaOH for the reaction between HCl and NaOH .

## Solution:

The balanced chemical equation can be framed as, $\mathrm{HCl}+\mathrm{NaOH} \rightarrow \mathrm{NaCl}+\mathrm{H}_{2} \mathrm{O}$

For an acid
$n(\mathrm{HCl})=\left(35.0 / 1000 \mathrm{dm}^{3}\right) \times 0.250 \mathrm{~mol} \mathrm{dm}^{-3}$
$=8.75 \times 10^{-3} \mathrm{~mol}$
The mole ratio $\mathrm{NaOH}: \mathrm{HCl}=1: 1$.
The amount of NaOH present in moles is $8.75 \times 10^{-3} \mathrm{~mol}$.
Now we have the equation,
Molar Concentration $=\frac{\text { Amount in moles }}{\text { Volume of Solution }}$
First convert the volume of aqueous NaOH into $\mathrm{dm}-3$
$25 \mathrm{~cm} 3=25 / 1000 \mathrm{dm}^{3}$

$$
=25 \times 10^{-3} \mathrm{dm}^{3}
$$

Therefore, the molar concentration of NaOH

$$
=8.75 \times 10^{-3} / 25.0 \times 10^{-3}
$$

Molar concentration of $\mathrm{NaOH}=0.350 \mathrm{~mol} \mathrm{dm}^{-3}$

## Example 2

The concentration of $\mathrm{Ca}(\mathrm{HCO} 3) 2$ is $0.85 \mathrm{gmol} / \mathrm{L}$. Convert this concentration into geq/L.

Solution:

## Given :

$[\mathrm{C}]=0.85 \mathrm{gmol} / \mathrm{L}$
$[C] e q=[C][M M] /$ eq.mass
$M M=40.1(2)+2\{1+12+3(16)\}$
$=202.2$

Number of reference species $=2$
Therefore, eq.mass $=\mathrm{Ca}\left(\mathrm{HCO}_{3}\right)_{2} / 2$

$$
=202.2 / 2
$$

$[C] e q=0.85[202.2] / 202.2 / 2$
$=1.7 \mathrm{geq} / \mathrm{L}$

## SOUND INTENSITY FORMULA

Sound intensity is described as sound per unit area perpendic ular to the path of the sound waves and which is represented by I . The sound intensity SI unit is $\mathrm{W} / \mathrm{m}^{2}$ (watt per square meter).

The SI unit of sound intensity is watt per square meter (W/m2). The standard definition is the calculation of noise sound intensity in the air at the listener position as a quantity of sound energy.

The Formula for sound intensity is expressed as
$I=\frac{P}{A}$
Where
$\mathbf{P}=$ sound power

A = area

In order to measure the sound intensity level, need to compare the given sound intensity value with standard intensity value.

The formula of Sound Intensity Level is expressed as
$\mathrm{IL}=\underline{10} \log \underline{10 \mid I \underline{0}}$
Where

I = sound intensity and
lo = reference intensity

The unit of sound intensity is expressed in decibels (dB)

Solved examples on Sound Intensity

## Example 1

A person whistles with the power of $0.9 \times 10^{-4} \mathrm{~W}$. Calculate the sound intensity at a distance of 7 m .

Solution:

Given
$P=0.9 \times 10^{-4} W$
$\mathrm{A}=7 \mathrm{~m}$

Sound intensity formula is
$I=P / A$
$\mathrm{I}=0.9 \times 10^{-4} / 7$
$\mathrm{I}=1.28 \times 10^{-5} \mathrm{~W} / \mathrm{m}^{2}$

## Example 2

Determine the intensity level which is equivalent to an intensity $1 \mathrm{nW} / \mathrm{m}^{2}$.

Solution:
Intensity Level formula is given by
$\mathrm{IL}=10 \log _{10} \mathrm{I} / \mathrm{I}_{0}$
Here
$\mathrm{I}=1 \mathrm{nWm}-2=1 \times 10^{-9} \mathrm{Wm}^{-2}$
$\mathrm{I}_{\mathrm{o}}=10^{-12} \mathrm{Wm}^{-2}$
$I_{L}=10 \log _{10}\left(1 \times 10^{-9}\right) / 10^{-12}$
$I_{L}=10 \log _{10} 10^{3}$
$I_{L}=30$.

## ELECTRICAL RESISTANCE FORMULA

Electrical resistance is a quantity that measures the opposition offered by a device or a material to the flow of current through it. The S.I unit of resistance is ohms $(\Omega)$. A resistor is an electric component that is used to offer the desired resistance in a circuit. In this article, we shall be discussing the various electrical resistance formula used to find the resistance offered by a conductor to the flow of current.

## Formula For Electrical Resistance

When we know the length and the cross-sectional area of a conductor, the electrical resistance of a conductor is the product of the resistivity of the conductor and the conductor's length divided by the conductor's cross-sectional area. Mathematically, it is represented as follows:
$R=\rho I A$

Where, $R$ is the resistance
$\rho$ is the resistivity of the conductor

I is the length of the conductor
A is the area of the cross-section of the conductor

From the above formula, it is understood that the resistance is directly proportional to the length of the conductor and inversely proportional to the area of the conductor. This formula can be better understood with a water pipe analogy as follows:

- When the pipe is longer, the length is bigger and hence the resistance to the flow of water is high.
- When the pipe is wider, the area of the pipe is bigger and hence the resistance to the flow of water is low.

Calculation of Resistance Using Ohm's Law
The electrical resistance of a conductor can be calculated with Ohms law when the current and the voltage drop across it is known. The formula to calculate the resistance using Ohm's Law is given as follows:
$\mathrm{R}=\mathrm{VI}$
Where $\mathbf{R}$ is the resistance of the resistor $\mathbf{R}$ in ohms ( $\Omega$ ),
$\mathbf{V}$ is the voltage drop in the resistor in volts
$I$ is the current flowing through the resistor (A)

Electrical Resistance Problems

Example 1: In an electric circuit, a current of 6.00 A is flowing through a resistor. The voltage drop from one end of the resistor to the other is 150 V . What is the value of the resistance?

Solution:

Here, we know the current and the voltage drop across the conductor hence we can use the Ohm's law to find the resistance as follows:
$\mathrm{R}=\mathrm{VI}$

Substituting the values in the above equation, we get
$R=\underline{150} V \underline{6} A=\underline{25} \Omega$

The resistance of the resistor in the circuit is $\underline{25} \Omega$.

## CONTINUOUS COMPOUND

## INTEREST FORMULA

The continuous compound interest formula is used to determine the interest earned on an account that is constantly compounded, necessarily leading to an infinite amount of compounding periods. The effect of compounding is earning interest on investment, or at times paying interest on a debt that is reinvested to earn additional money that would not have been gained based on the principal balance alone. Learn more about compound interest here and understand the underlying principles in detail

By earning interest on prior interest, one can earn at an exponential rate. The continuous compounding formula takes this effect of compounding to the furthest limit. Instead of compounding interest on a monthly, quarterly, or annual
basis, continuous compounding will efficiently reinvest gains perpetually.

## Formula for Continuous Compound Interest

$$
A=P \times e^{r t}
$$

Where,

- A = Amount of money after a certain amount of time
- $P=$ Principle or the amount of money you start with
- $\mathrm{e}=$ Napier's number, which is approximately 2.7183
- $r=$ Interest rate and is always represented as a decimal
- $t=$ Amount of time in years


## Solved Examples

Question 1: An amount of Rs. 2340.00 is deposited in a bank paying an annual interest rate of $3.1 \%$, compounded continuously. Find the balance after 3 years.

## Solution:

Use the continuous compound interest formula,

Given $\mathrm{P}=2340$
$r=(3.1 / 100)=0.031$
$t=3$

Use the continuous compound interest formula,
$A=P e^{r t}$

Given,
$P=2340$
$r=3.1=(3.1 / 100)=0.031$
$t=3$

Here: e stands for the Napier's number, which is approximately 2.7183 .

However, one does not have to plug this value in the formula, as the calculator has a built-in key for e. Therefore,
$A=2340 e^{0.031(3)} \approx 2568.06$

So, the balance after 3 years is approximately Rs. 2,568.06.

## BREWSTERS LAW FORMULA

When unpolarized light of certain wavelength is incident upon the surface of a transparent substance it experiences maximum plane polarization at the angle of incidence whose tangent is the refractive index of the substance.

The specific value of angle of incidence at which the reflected light is completely polarised is called as the polarising angle
$\mu=\tan i p$
where,
$\mu=$ Refractive index of the medium
ip = polarizing angle

Solved Examples
Problem 1: A certain polarizer has a refractive index of 1.33.
Find the polarization angle and angle of refraction?

Answer:

Refractive index of the polarizer $=1.33$

The Brewster's law is $\mu=\tan$ ip
ip $=\tan -1$ (1.33)
ip $=53.06$
Now, Angle of refraction
It is given that ip + ir = 90 degrees
Thus, angle of refraction or ir $=90-53.06$

Angle of refraction $=36.94$

## BANKING OF ROAD FORMULA

The phenomena in which the edges of the curved roads are raised above the inner edge to provide the necessary centripetal force to the vehicles so that they take a safe turn. The various terminologies used in the case of banking of roads are:

- Banked Turn - It is defined as the turn or change of direction in which the vehicle inclines towards inside.
- Bank Angle - The angle at which the vehicle is inclined is defined as the bank angle.

In the next section, let us look at the formula for the angle of banking.

## Angle of Banking Formula

The velocity of a vehicle on a curved banked road

## $v=(r g(\tan \Theta+\mu s)) \underline{1}-\mu S \tan \theta----v$

For a given pair of roads, and tyre $\mu \mathrm{s}=\tan \lambda$, where $\lambda$ is the angle of friction, the velocity of $v=r g \tan (\Theta+\lambda)----------v$ a vehicle on a curved banked road is

The safe velocity on an unbanked road is given by the vmax $=\mu \times r \times g--------V$ expression

The expression for the angle of banking of road is given by

$$
\Theta=\tan -\underline{1 v} \underline{2} \mathrm{rg}
$$

The expression for the safe velocity on the banked road is vmax=rgtan $\Theta-------V$ given by

Centripetal Force
$F=m v^{2} / r=m \omega^{2} r$

Roads are most often banked for the average speed of vehicles passing over them. Nevertheless, if the speed of a vehicle is lesser or more than this, the self-adjusting state friction will operate between tyre and road and vehicle will not skid.

## MOMENTUM FORMULA

According to newton's law of motion, all moving bodies continue to be in the state of rest or motion unless interfered by some external force. The same principle can be applied to momentum i.e, if the mass and velocity of an object remain the same, then the momentum of the object remains constant.

Momentum is associated with the mass of the moving body and can be defined as the quantity of motion measured as a product of mass and velocity.

The momentum formula is given by,
$p=m v$
Where,
$p$ is the momentum of the body, m is the mass of the body and
$v$ is the velocity of the body.
The S.I unit for momentum is $\mathrm{Kgms}^{-1}$.

## Example 1

A car of mass 600 Kg is moving with a velocity of $10 \mathrm{~m} / \mathrm{s}$. Determine its Momentum.

Solution:

## Given:

Mass, m = 600 Kg ,

Velocity, $\mathrm{v}=10 \mathrm{~m} / \mathrm{s}$

Momentum is given as
$p=m v$
$=600 \times 10$
$=6000 \mathrm{Kgms}^{-1}$.

Example 2

A bike is moving at the rate of $30 \mathrm{~m} / \mathrm{s}$ carrying a momentum of $5000 \mathrm{kgm} / \mathrm{s}$. Determine its mass.

## Solution:

Given:

Velocity $\mathrm{v}=30 \mathrm{~m} / \mathrm{s}$,
Momentum $\mathrm{p}=5000 \mathrm{kgm} / \mathrm{s}$,

Momentum is given as
$p=m \times v$

Mass, $m=p / v$
$=5000 / 30$
$\mathrm{m}=166.66 \mathrm{Kg}$

## MAGNETISM FORMULA

Magnetic Effect of Electric Field is the property where an electric field is produced around a current-carrying conductor. This effect was first demonstrated by Prof H.C Oersted in the year 1820. He observed deflection in the magnetic needle when it is kept next to a current-carrying conductor. The direction in which the needle deflects is given by Ampere's law.

Using Ampere's Law, the strength of the magnetic field surrounding a long straight current-carrying wire is given by
$B=\mu 012 \pi d$

Where
$B=$ Strength of the magnetic field
d = distance

I = current in wire
$\mu 0=$ permittivity of free space

## $\mathrm{F}=\| \mathrm{I} \mathrm{B} \sin \theta$

This is the equation for magnetic force on a length I of wire carrying a current I in a uniform magnetic field B

## CENTRIPETAL ACCELERATION

## FORMULA

## Definition

For an object undergoing a circular motion or curvilinear motion experiences, a force directed towards the centre of curvature of the path. Here, the velocity of the object may be constant or changing throughout, but the direction of the tangential velocity always changes throughout the motion. Since velocity is a vector quantity, the change in direction changes the velocity. The rate of change of tangential velocity is defined as the centripetal acceleration. Since the centripetal force, responsible for the circular motion of the object acts inwards, the centripetal acceleration also acts inwards, along the radius vector of the circular path.

Formula

As mentioned above, the centripetal acceleration is defined as the rate of change of tangential velocity, we can write it as,

Centripetal Acceleration = rate of change of tangential velocity

We can also write it as,
$a_{c}=\lim _{\Delta} t->0 \frac{\Delta v t}{\Delta t}$

The centripetal force acting on an object moving on a circular or curvilinear path is given as,
$F=\frac{m V^{2} t}{r}=m \omega^{2} r$

So, the acceleration acting on the object can be given as,
$a_{c}=V_{t}^{2}=\omega^{2} r$

Also, as we know, the tangential acceleration is given as,
$a_{t}=r \alpha$

Where,
$r=$ radius of curvature,
$\alpha=$ angular acceleration and
$\omega=$ angular speed.
The total acceleration in a circular path is
$a_{\text {total }}=\sqrt{a_{c}^{2}+a_{t}^{2}}=\sqrt{r^{2} \omega^{4}+r^{2} \alpha^{2}}$

## Real-Life Example

The most common real-life application of the centripetal acceleration and force that you can easily relate to is that of the roller coasters. Unlike the previously used circular loops, the roller coasters are today designed with the teardropshaped clothoid loops. Centripetal acceleration is experienced in the clothoid loops.

## Solved Examples

Example 1: A plane is circulating around a path of radius 4 km .
The speed of the jet is a constant $10 \mathrm{~km} / \mathrm{s}$. What is the centripetal acceleration?

Solution:
Radius of the circular path $=4 \mathrm{~km}=4 \times 1000 \mathrm{~m}=4000 \mathrm{~m}$
Velocity $=10 \mathrm{~km} / \mathrm{sec}=10 \times 1000 \mathrm{~m} / \mathrm{sec}=10,000 \mathrm{~m} / \mathrm{sec}$
Therefore, centripetal acceleration
$\frac{v^{2}}{r}=\frac{(10000)^{2}}{4000}=25000 \mathrm{~m} / \mathrm{sec}^{2}$

Example 2: A ball has a mass of 0.2 kg . It moves around a circular path of radius (r) 80 cm . Calculate the centripetal force given that it completes 1 round in every 3 seconds.

Solution:

Mass of the ball $=0.2 \mathrm{~kg}$

Radius of the path $=80 \mathrm{~cm}=0.8 \mathrm{~m}$,
Path velocity
$\frac{2 \pi r}{3}=\frac{(2 \pi \times 0.8)}{3}=1.67 \mathrm{~m} / \mathrm{s}$

Now, we can calculate the centripetal acceleration by using the formula:
$a_{c}=\frac{v^{2}}{r}=\frac{1.67 \times 1.67}{0.8}=3.504 \mathrm{~m} / \mathrm{s}^{2}$

Centripetal Force is given by:
$F_{c}=m a_{c}=0.2 \mathrm{~kg} \times 3.504 \mathrm{~m} / \mathrm{s}^{2}$
$=0.7008 \mathrm{kgm} / \mathrm{s} 2$

## COEFFICIENT OF STATIC FRICTION

## FORMULA

Static Friction is friction which is experienced when an object is placed on a surface. And, Kinetic friction is due to the movement of an object on a surface. Friction is well characterized by the coefficient of friction and is explained as the ratio between the frictional force and the normal force. This helps the object to lie on a surface. The coefficient of static friction is a scalar quantity and denoted as $\mu \mathrm{s}$.

The formula for the coefficient of static friction is expressed as
$\mu_{\mathrm{s}}=\mathrm{F} / \mathrm{N}$
Where
$\mu_{\mathrm{s}}=$ coefficient of static friction
$\mathrm{F}=$ static frictional force
$\mathrm{N}=$ normal force

Solved Examples on Static Frictions
Question 1: An object having a mass of 10kg is placed on a smooth surface. Static friction between these two surfaces is given as the 15 N . Find the coefficient of static friction?

Solution:

Given
$m=10 \mathrm{~kg}$
$F=30 N$
$\mu_{\mathrm{s}}=$ ?
We know that,

Normal force, $\mathrm{N}=\mathrm{mg}$

So, $N=10 \times 9.81=98.1 \mathrm{~N}$

The formula for coefficient of static friction is,
$\mu_{\mathrm{s}}=\mathrm{F} / \mathrm{N}$
$\mu_{\mathrm{s}}=30 / 98.1$
$\mu_{\mathrm{s}}=0.305$

Question 2: The normal force and the static frictional force of an object are 50 N and 80 N respectively. Find the coefficient of static friction?

Solution:

Given
$N=50 N$
$\mathrm{F}=80 \mathrm{~N}$ and $\mu_{\mathrm{s}}=$ ?

The formula for coefficient of static friction is
$\mu_{s}=F / N$
$\mu_{\mathrm{s}}=80 / 50$
$\mu_{\mathrm{s}}=1.6$

## ORBITAL SPEED FORMULA

The orbital speed of the object is the speed at which it orbits around the barycenter of a system which is usually around a massive body. Around the sun orbital speed of the earth is $108,000 \mathrm{~km} / \mathrm{h}$.

The orbital speed formula is provided by,
$v_{o r b i t}=\sqrt{\frac{G M}{R}}$
Where,
G = gravitational constant
$M=$ mass of the planet
$r=$ radius .

Example 1
The mass of an object is given as $8.35 \times 10^{22} \mathrm{Kg}$ and the radius is given as $2.7 \times 10^{6} \mathrm{~m}$. Find the orbital speed.

## Solution:

## Given:

$M=8.35 \times 10^{22} \mathrm{~kg}$
$R=2.7 \times 10^{6} \mathrm{~m}$
$\mathrm{G}=6.673 \times 10-11 \mathrm{~m}^{3} / \mathrm{kgs}^{2}$

Orbital speed equation is given by,
$v_{\text {orbit }}=\mathrm{VGM} / \mathrm{R}$
$v_{\text {orbit }}=v 6.673 \times 10-11 \times 8.35 \times 1022 / 2.7 \times 106$
$v_{\text {orbit }}=20.636 \times 106 \mathrm{~m} / \mathrm{s}$.

## POISEUILLES LAW FORMULA

The law of Poiseuille states that the flow of liquid depends on the following variables such as the length of the tube(L), radius $(r)$, pressure gradient $(\Delta P)$ and the viscosity of the fluid $(\eta)$ in accordance with their relationship.

The entire relation or the Poiseuille's Law formula is given by $Q=\Delta P \pi r^{4} / 8 \eta l$

Wherein,

## The Pressure

Gradient ( $\Delta \mathrm{P}$ ) Shows the pressure differential between the tw o ends of the tube, defined by the fact that every fluid will alw ays flow from the high pressure $\left(\mathrm{P}_{1}\right)$ to the low-pressure area $\left(P_{2}\right)$ and the flow rate is calculated by the $\Delta P=P_{1}-P_{2}$.

The radius of the narrow tube:

The flow of liquid direct changes with the radius to the power four.

Viscosity ( n ):
The flow rate of the fluid is inversely proportional to the viscosity of the fluid.

Length of the arrow tube (L):
The flow rate of the fluid is inversely proportional to the length of the narrow tube.

## Resistance(R):

The resistance is calculated by $8 \mathrm{Ln} / \pi r^{4}$ and hence the Poiseuille's law is
$Q=(\Delta P) R$

## Example 1:

The blood flow through a large artery of radius $\mathbf{2 . 5} \mathbf{~ m m}$ is found to be $\mathbf{2 0} \mathbf{c m}$ long. The pressure across the artery ends is 380 Pa , calculate the blood's average speed.

Solution:
The blood viscosity $\eta=0.0027 \mathrm{~N} . \mathrm{s} / \mathrm{m} 2$

Radius $=2.5 \mathrm{~mm}$
$\mathrm{I}=20 \mathrm{~cm}$

The difference of pressure $=380 \mathrm{~Pa}(\mathrm{P} 1-\mathrm{P} 2)$

The average speed is given by
$Q=\Delta P \pi r^{4} / 8 \eta l$
$\mathrm{Q}=\left(380 \times 3.906 \times 10^{-11} \times 3.14\right) /(8 \times 0.0027 \times 0.20)$

The average speed becomes $1.0789 \mathrm{~m} / \mathrm{s}$

## ELECTRIC POWER FORMULA

Electric power can be described as the rate of doing work.
The SI unit for power is watt is denoted as $\mathbf{P}$. Power formula connects the time, voltage and charge. Individuals can alter the formula using Ohm's law. The formula for power is articulated as
$P=V I$
The power formula written in terms of Ohm's law is

$$
P=I^{2} R
$$

(or)
$P=V^{2} / R$

Where
the electric charge is Q
the voltage is V
the time is $t$
the resistance is $R$

## Electric Power Solved Examples

Let us check out the numerical of electric power in detail in this segment.

Problem 1: If the current and voltage of an electric circuit are given as 2.5 A and 10 V respectively. Calculate the electrical power?

## Answer:

Given measures are,
$\mathrm{I}=2.5 \mathrm{~A}$ and $\mathrm{V}=10 \mathrm{~V}$
The formula for electric power is,
$\mathrm{P}=\mathrm{VI}$
$P=10 \times 2.5=25 w a t t s$

Problem 2: Calculate the power of an electrical circuit consisting of resistance $3 \Omega$ and a current 4A flowing through

## this circuit?

## Answer:

Given parameters are,
$\mathrm{I}=4 \mathrm{~A}$ and $\mathrm{R}=3 \Omega$
Electric power formula is,
$P=I^{2} R$
$P=4^{2} \times 3$
$P=16 \times 3=48$ watts

## LIGHT WAVES AND COLOR

## FORMULA

The visible light is released and absorbed by a small packet called photons and shows both wave and particles characteristics and this property are known as wave-particle duality.

Light waves can be measured in two different ways

- The amplitude of the wave
- Frequency of the wave along with the number of waves per second.

These waves are categorized according to the frequencies that have similar characteristics in the electromagnetic spectrum of the light. The subcategories of each spectrum vary according to the wave frequency.

The colour of these lights depends on the reflection quality from the objects on which the white light falls on. For example, the white wall appears because the wall reflects back all the colours.

Any particular colour that looks from any surface is the colour that is reflected from the object when the light falls on it.

The lightwave and colour formula is given by:
$c=v \times \lambda$
where,
c = speed of light
$v=$ frequency
$\lambda=$ wavelength

## Example 1

Calculate the frequency of the violet colour whose wavelength is 400 nm .

## Solution

Given:

Wavelength $=400 \mathrm{~nm}$
We know that $c($ Speed of Light $)=v($ Frequency $) \times \lambda$ (Wavelength)
$v=c / \lambda$
$v=\left(3 \times 10^{8}\right) /\left(4.00 \times 10^{7}\right)$
Therefore, frequency $=7.5 \mathrm{~Hz}$

## Example 2:

Determine the wavelength and predict the colour of light which has a frequency of $6.00 \times 10^{14} \mathrm{~Hz}$, given the speed of light is $3 \times 10^{8} \mathrm{~m} / \mathrm{s}$.

Solution:

Given:

Frequency $=6.00 \times 10^{14} \mathrm{~Hz}$

We know that, $C$ (speed of light ) $=v($ frequency $) \times \lambda($ wavelength)
$\lambda=c / v$
$\lambda=\left(3 \times 10^{8}\right) /\left(6.00 \times 10^{14}\right)$
Therefore, $\lambda$ (wavelength) $=0.5 \times 10^{-6}$
$=5000 \times 10^{-9} \mathrm{~m}$
$=5000 \mathrm{~nm}$

The colour of the wavelength of $\mathbf{5 0 0 0} \mathbf{~ n m}$ is green.

## ENERGY DENSITY FORMULA

Energy Density is defined as the total amount of energy in a system per unit volume. For example, the number of calories per gram of food. Foodstuffs that has low energy density provide less energy per gram of food which means that you can eat more of them since there are fewer calories.

It is denoted by letter U .
Magnetic and electric fields can also store energy.
In the case of the electric field or capacitor, the energy density formula is given by
$U=\frac{1}{2} \epsilon_{0} E^{2}$
$E=E$ is the electric field
$\varepsilon_{0}=$ permittivity of free space

The energy density formula in case of magnetic field or inductor is given by,
$U=\frac{1}{2 \mu_{0}} B^{2}$
$B=$ Magnetic field
$\mu_{0}=$ permeability of free space
Regarding electromagnetic waves, both magnetic and electric field are equally involved in contributing to energy density. Therefore, the formula of energy density is the sum of the energy density of the electric and magnetic field.

## Example 1:

Find the energy density of a capacitor if its electric field, $E=5$ V/m.

## Solution:

Given,
$\mathrm{E}=5 \mathrm{~V} / \mathrm{m}$

We know that,
$\epsilon 0=8.8541 \times 10^{-12} \mathrm{~F} / \mathrm{m}$
The energy density formula of the capacitor is given by

$$
U=\frac{1}{2} \epsilon_{0} E^{2}
$$

$$
=\left(1 \times 8.8541 \times 10^{-12} \times 5^{2}\right) / 2
$$

$$
\mathrm{U}=1.10 \times 10^{-10} \mathrm{FV}^{2} / \mathrm{m}^{3}
$$

## Example 2:

Find the energy density of an inductor whose magnetic field is 0.7 T .

Solution

Given,
$B=0.5 T$

We know that,
$\mu_{0}=1.25 \times 10^{-6} N A^{-2}$
Energy density formula for inductor is given as,
$U=\left\{1 / 2 \mu_{0}\right\}^{*} B^{2}$
$U=\left[\times 1.25 \times 10^{-6} 0.5^{2}\right] / 2$
$U=9.947 \times 10^{4} A^{2} T / N$

## DECELERATION FORMULA

You must have noticed that often we slow down the speed of our bikes during heavy traffic when more bikes are obstructing us. So, a decrease in speed as the body moves away from the starting point is defined as Deceleration.

It is expressed as
Deceleration $=\frac{\text { Final time }- \text { Initial time }}{\text { Timetaken }}$
Deceleration also is known as negative acceleration. Hence it is denoted by $-\mathbf{a}$.

If starting velocity, final velocity and time taken are given, Deceleration Formula is given by
$a=\frac{v-u}{t}$
If initial velocity, final velocity and distance travelled are given, deceleration is given by
$a=\frac{v^{2}-u^{2}}{2 s}$
Where,
$v=$ final velocity,
$u=$ initial velocity,
$\mathrm{t}=$ time taken,
$s=$ distance covered.

Deceleration Formula is used to calculate the deceleration of the given body in motion. It is expressed in meter per second square ( $\mathrm{m} / \mathrm{s}^{2}$ ).

Solved Examples
Question 1: An automobile moving with a uniform velocity of 54 Kmph is brought to rest in travelling a distance of 5 m . Calculate the deceleration produced by brakes?

Given: Initial velocity u = 54 Kmph ,
Final velocity $\mathrm{v}=0$
Distance covered $\mathrm{s}=5 \mathrm{~m}$
We know that $v^{2}=u^{2}+2$ as
Deceleration $a=v^{2}-u^{2} / 2 s$
$=-(54000)^{2} / 2(5)$
$a=-291.6 \times 10^{6} \mathrm{~m} / \mathrm{s}^{2}$

## MOMENTUM AND ITS

## CONSERVATION FORMULA

Momentum is the tendency of the object to be in motion and therefore is a vector quantity. It is determined by the product of the mass of the object and its velocity. If both the objects are not experiencing any external forces, then the total momentum of the objects before and after the interaction is the same. This relation under the fundamental law of physics is known as the conservation of momentum.

This fundamental law of physics can be applied to explain the phenomenon of collision and explosion. The momentum formula is given by,

Momentum ( P ) = mass ( m ) x velocity ( v )
Conservation of momentum can be described by

P1 (before) $+P_{2}$ (before) $=P_{1}$ (after) $+P_{2}$ (after)
This equation is valid for the object that undergoes collision.
Example 2
A ball of 1 kg is moving at a speed of $5 \mathrm{~m} / \mathrm{s}$ collides with a cricket bat of 2.5 Kg swung at a speed of $1.5 \mathrm{~m} / \mathrm{s}$. right after the collision the cricket bat swings at a speed of $1.5 \mathrm{~m} / \mathrm{s}$.

Calculate the magnitude and the velocity of the cricket ball.
Solution:

Given:
$\mathrm{m} 1=1 \mathrm{~kg}$
$\mathrm{m} 2=2.5 \mathrm{~kg}$
$\mathrm{v} 1=5 \mathrm{~m} / \mathrm{s}$
$\mathrm{v} 2=1.5 \mathrm{~m} / \mathrm{s}$
The relation between the colliding bodies is given by,

## P1 (before) + P2 (before) = P1 (after) + P2 (after)

The momentum relation is expressed by,
$(\mathrm{m} 1 \mathrm{v} 1)$ before $+(\mathrm{m} 2 \mathrm{v} 2)$ before $=(\mathrm{m} 1 \mathrm{v} 1)$ after + (m2 v2) after
v 1 (after) $=[(\mathrm{m} 1 \mathrm{v} 1)$ before $+(\mathrm{m} 2 \mathrm{v} 2)$ before-(m2v2)after] / (m1)after

$$
\begin{aligned}
& =1 \times 5+2.5 \times-1.5-2.5 \times 1.5 / 1 \\
& =-2.5
\end{aligned}
$$

Therefore, v1 (after) = - $\mathbf{2 . 5} \mathbf{~ m} / \mathrm{s}$

The negative sign shows that it travels in the opposite direction.

## DISTANCE SPEED TIME FORMULA

Speed is the rate at which an object moves. It's a very basic concept in motion and all about how fast or slow an object can move. Speed is simply Distance divided by the time where Distance is directly proportional to Velocity when time is constant. Problems related to Speed, Distance, and Time, will ask you to calculate for one of three variables given.

The formula for Speed Distance Time is mathematically given as:

Speed = Distance/Time

Where
$x=$ Speed in $\mathrm{m} / \mathrm{s}$,
$d=$ Distance travelled in $m$,
$\mathrm{t}=$ time taken in s .

Distance travelled formula
$d=x t$

If any of the two values among speed, distance and time are given, we can use this formula and find the unknown quantity.

## Solved Examples

Question 1: Lilly is driving a scooter with a speed of $6 \mathrm{~km} / \mathrm{hr}$ for 2 hr . Calculate the distance travelled by her?

Solution:

Given:
Speed of the scooter $x=6 \mathrm{~km} / \mathrm{hr}$
Time taken, $\mathrm{t}=2 \mathrm{hr}$
Distance travelled d=?
Speed distance time formula is given as
$d=x t$

Distance travelled d=xxt

$$
\begin{aligned}
& =6 \mathrm{~km} / \mathrm{hr} \times 2 \mathrm{hr} \\
& =12 \mathrm{~km} .
\end{aligned}
$$

Question 2: A man has covered a distance of 80 miles in 4 hours. Calculate the speed of the bike?

Solution:
Given: Distance Covered d=80 miles,
Time taken, $\mathrm{t}=4$ hours
Speed is calculated using the formula: $x=d / t$

$$
\begin{aligned}
& =80 / 4 \\
& =20 \text { miles } / \mathrm{hr} .
\end{aligned}
$$

Question 3: In a cycle race, a cyclist is moving with a speed of $2 \mathrm{~km} / \mathrm{hr}$. He has to cover a distance of 5 km . Calculate the time will he need to reach his destiny?

Solution:

Given: Speed $\mathrm{x}=2 \mathrm{~km} / \mathrm{hr}$,

Distance Covered d = 5 km ,
time taken $\mathrm{t}=$ ?

Speed is given by formula: $x=d x t$
Time taken $\mathrm{t}=\mathrm{x} / \mathrm{d}$
$=2 / 5$
$=0.4 \mathrm{hr}$
Time taken by the Cyclist $=0.4 \mathrm{hr}$

## HEAT OF FUSION FORMULA

Heat of fusion of a substance is the change in its enthalpy by providing energy, typically heat, to a specific quantity of the substance to change its state from a solid to a liquid keeping pressure constant.

The heat of fusion of a sample is the measure of the amount of heat that needs to be introduced to convert its crystalline fraction into the disordered state. It is uniquely dependent upon the degree of crystallinity of the substance and the theoretical heat of fusion of a sample which is $100 \%$ crystalline.

For example, heat gained by ice is equal to the heat lost by the water.

The Heat of fusion is denoted by $\Delta \mathrm{Hf}$

The heat of fusion formula is given as
$q=m \cdot \Delta H f$
Where $q$ is heat energy
m is mass
$\Delta \mathrm{Hf}$ is the heat of fusion

Solved Examples
Example 1
Calculate the heat in Joules required to melt 26 grams of ice.
Given that heat of fusion of water $=334 \mathrm{~J} / \mathrm{g}=80 \mathrm{cal} / \mathrm{g}$
Solution
Given parameters are
Mass, $\mathrm{m}=26 \mathrm{~g}$
We know that
$q=m \cdot \Delta H f$
$q=(26 \mathrm{~g}) \times(334 \mathrm{~J} / \mathrm{g})$
$=8736 \mathrm{~J}$

$$
\begin{aligned}
& q=m \cdot \Delta H f \\
& q=(26 \mathrm{~g}) x(80 \mathrm{cal} / \mathrm{g}) \\
& q=2080 \mathrm{cal}
\end{aligned}
$$

## HEAT CONDUCTION FORMULA

Heat Conduction is the heat transfer from one solid to another which has a different temperature as they come into contact with each other. For example, when we touch a hot water bot tle, or when we rub our hands, we warm our hands.

The principle of energy conservation and Fourier's law of heat conduction is applied to derive different forms of the differential equation which govern the temperature distribution in a stationary medium. Fourier's law of conduction of heat is an empirical law based on the observation.

Fourier's law of conduction of heat is expressed as
$Q \propto A \times(d t / d x)$
Where,
$Q=$ heat flow through a body per unit time (in watts $W$ )
$A=$ Surface area of heat flow m2,
$\mathrm{dt}=$ Temperature difference in ${ }^{\circ} \mathrm{C}$ or K $d x=$ Thickness of the body in the direction of flow, $m$.

Hence, we can express the Heat Conduction formula by
$Q=-k \times A(d t / d x)$
Where
$\mathrm{k}=$ thermal conductivity of the body and it is a Constant of proportionality

Example 1
Calculate the rate of heat transfer per square meter of the surface of a corkboard having 5 cm thickness, and a temperature difference of 750 C is applied across the board.

The value of thermal conductivity $(\mathrm{k})$ is $-0.4 \mathrm{~W} / \mathrm{mc}$.
Solution:

Given parameters are,
$k=-0.4$
$A=5 \mathrm{~cm}$
$(d t / d x)=75 o C$
By Substituting in the corresponding formula, we get
$Q=-k \cdot A(d t / d x)$
$=-(-0.4)(5)(75)$
Hence, $\mathbf{Q}=150 \mathbf{W}$

## KINETIC ENERGY FORMULA

Kinetic energy is the energy possessed by a body due to its motion. Kinetic Energy Formula is articulated as
$K . E=\frac{1}{2} m v^{2}$

Where,
Mass of the body $=\mathbf{m}$,
The velocity with which the body is travelling is $\mathbf{v}$.
The Kinetic energy is articulated in $\mathrm{Kgm}^{2} / \mathrm{s}^{2}$
Kinetic energy formula is used to compute the mass, velocity or kinetic energy of the body if any of the two numerics are given.

## Kinetic Energy Solved Examples

Underneath are questions on Kinetic energy which aids one to understand where they can use these questions.

Problem 1: A car is travelling at a velocity of $10 \mathrm{~m} / \mathrm{s}$ and it has a mass of 250 Kg . Compute its Kinetic energy?

## Answer:

Given: Mass of the body $\mathrm{m}=250 \mathrm{Kg}$,
Velocity $\mathrm{v}=10 \mathrm{~m} / \mathrm{s}$,
Kinetic energy is given by
$K . E=\frac{1}{2} \times 250 \mathrm{~kg}(10 \mathrm{~m} / \mathrm{s})^{2}$
$=12500 \mathrm{kgm}^{2} \mathrm{~s}^{2}$
Problem 2: A man is transporting a trolley of mass 6 Kg and having Kinetic energy of 40 J. Compute its Velocity with which he is running?

## Answer:

Given: Mass, $m=6 \mathrm{Kg}$
Kinetic energy K.E = 60 J
Velocity $\mathrm{v}=\sqrt{\frac{2 K \cdot E}{m}}$
$=\sqrt{\frac{2 \times 40 J}{6 k g}}$
$=\sqrt{13.33}$
$=3.65 \mathrm{~m} / \mathrm{s}$
The man is running with the velocity of $3.65 \mathrm{~m} / \mathrm{s}$

## WAVE POWER FORMULA

Wave power is the energy carried by the wind waves and consumption of that energy to do useful work, for example, electricity generation, pumping of water into the reservoirs or water desalination. A machine capable of exploiting wave power is known as a wave energy converter. Wave power is different from the diurnal flux of tidal power and the steady gyre of ocean currents. On the whole, wave power is energy transport by the wave surface of the ocean.

The Wave power formula is given by,
$P=\frac{\rho g^{2} T h^{2} l}{32 \pi}$
Where,
$P=$ power of water wave present in-depth (Watts)
$\rho=$ water density (1.025 kg/m3),
$\mathrm{g}=$ acceleration due to gravity ( $9.8 \mathrm{~m} / \mathrm{s} 2$ ),
$\mathrm{T}=$ wave period,
$\mathrm{h}=$ wave height,
I = length of the wavefront.

Solved Examples

## Example 1

The tides move with a power of 30 Watts crossing the great height of 20 m in 1 s . Determine the length of the wave.

## Solution:

Given:

Power p = 30 Watts,
Height h=20 m,
Wave period $\mathrm{T}=1 \mathrm{~s}$.

The Wave power formula is expressed by,
$P=\frac{\rho g^{2} T h^{2} l}{32 \pi}$
$l=32 \pi p / \rho g^{2} T h^{2}$

$$
=(32 \times 3.14 \times 30) /\left(1.025 \times 1 \times 9.8^{2} \times 20^{2}\right)
$$

$I=3014.4 / 39376$

Length $\mathrm{I}=0.076 \mathrm{~m}=7.6 \mathrm{~cm}$.

The length of the wave is 7.6 cm .

## INVERSE SQUARE LAW FORMULA

Inverse Square Law says that the strength of light (intensity) is proportional inversely to the square of the distance.

Inverse Square Law Formula is articulated as
$\mid \propto 1$ d $\underline{2}$

Where the distance is $\mathbf{d}$, the intensity of the radiation is $\mathbf{I}$.

At distances $d_{1}$ and $d_{2}, l_{1}$ and $I_{2}$ are intensities of light respectively. Then Inverse-square law is articulated as:
$1 \underline{1} \underline{2} \propto d \underline{2} d \underline{21}$

Inverse-square law formula is handy in finding distance or intensity of any given radiation. The intensity is articulated in Lumen or candela and distance is given in meters. It has widespread applications in problems grounded on the light.

## Inverse Square Law Solved Examples

Underneath are some problems based on an inverse square law which may be useful for you.

Problem 1: The intensity of a monochromatic light are in the ratio 16:1. Calculate the second distance if the first distance is 6 m ?

## Answer:

Known:
$I_{1}: I_{2}=16: 1$,
$\mathrm{d}_{1}=6 \mathrm{~m}$,
$d_{2}=$ ?
$1 \underline{1} \mid \underline{2} \propto d \underline{22} d \underline{21}$

Distance, $\mathrm{d} \underline{2}=\mid \underline{1} \mathrm{~d} \underline{21} \underline{\underline{2}} \underline{---V}$
$d_{2}=\sqrt{\frac{16 \times 36}{1}} \ldots \ldots . . \quad \mathrm{d} 2=24 \mathrm{~m}$

## CAPACITIVE REACTANCE FORMULA

A capacitor is a device used to store electrical energy. The capacitance of a capacitor determines the amount of charging a capacitor can achieve. The measure of the opposition to alternating current by the capacitor is called Capacitive Reactance. The unit of Capacitive Reactance is Ohms like resistance. The symbol of Capacitive Reactance is $\mathrm{X}_{\mathrm{C}}$.

Capacitive Reactance Formula is expressed by
$X_{c}=\frac{1}{2 \Pi f c}$
Where in,
$\mathrm{X}_{\mathrm{C}}$ is the capacitance reactance measured in ohms
$\mathrm{C}=$ capacitance in farads
f = frequency in hertz

Solved Examples

## Example 1

Calculate the capacitive reactance if 40 mF is connected to a frequency generator of 50 Hz signal.

## Solution

According to given parameters
$\mathrm{C}=40 \mathrm{mF}$
$\mathrm{F}=50 \mathrm{~Hz}$
The capacitance reactance formula is given by
$X c=1 / 2 \pi f C$
$=1 / 2 \times 3.14 \times 40 \times 10^{-3} \times 50$
$=0.07961 \Omega$

Example 2

Calculate the reactance of capacitance in an AC circuit wherein the input signal has a frequency of 100 Hz and a capacitor has a capacitance of 1000 mF in a circuit.

## Solution

Given
$\mathrm{F}=100 \mathrm{~Hz}$
$\mathrm{C}=1000 \mathrm{mF}$

The capacitance reactance formula is given by
$x c=1 / 2 \pi f c$
$x c=1 / 2 \times 3.14 \times 100 \times 1000 \times 10^{-3}$
$=1.5 \times 10^{-3} \Omega$
Hence, the capacitive reactance is $1.5 \times 10^{-3} \Omega$

## CONE FORMULA

Cone is a three-dimensional structure having a circular base where a set of line segments, connecting all of the points on the base to a common point called apex. A cone can be seen as a set of non-congruent circular discs that are stacked on one another such that ratio of the radius of adjacent discs remains constant. You can think of a cone as a triangle which is being rotated about one of its vertices. There is a predefined set of formulas for the calculation of curved surface area and total surface area of a cone which is collectively called as cone formula.


## Curved surface area of a cone $=\pi r l$

Total surface area of a cone $=\pi r(l+r)$

$$
\text { |=h́ㄴ+r2 } \underline{-}-----V
$$

Where, $r$ is the base radius, $h$ is the height and $/$ is the slant height of the cone.

## Derivation:

In order to calculate the curved surface area and total surface area of a cone, we divide it into a circular base and the top slanted part. The area of the slanted part gives you the curved surface area. Total surface area is the sum of this circular base and curved surface areas.

## Area of the circular base:

The base is a simple circle and we know that area of a circle is given as:

## Area of a circle $=\pi r^{2}$

Where $\boldsymbol{r}$ is the base radius of the cone

## Area of the curved surface:

Now if open the curved top and cut into small pieces, so that each cut portion is a small triangle, whose height is the slant height / of the cone.

Now the area of each triangle $=1 / 2 \times$ base of each triangle $\times I$.
$\therefore$ Area of the curved surface $=$ sum of the areas of all the triangles
$=\underline{12} \times b \underline{1} \times 1+\underline{12 \times b} 2 \times 1+\underline{12} \times b \underline{3} \times 1+$ $+\underline{12 \times b n \times 1}$
$=\underline{12} \mid(b 1+b \underline{2}+b \underline{3}+. . . . .+b n)$
= $\underline{12 \mid(c u r v e d s u r f a c e) ~}$

From the figure, we know that, the curved surface is equivalent to the perimeter of the base of the cone.

The circumference of the base of the cone $=\underline{2} \pi r$
$\therefore$ Area of the curved surface $=\underline{12} \times 1 \times \underline{2} \pi r$
Area of the curved surface $=\pi r l$
Total Surface Area of a Cone = Area of the circular base + Area of the curved surface

Total Surface Area of a Cone $=\pi r \underline{2}+\pi r \mid$
Total surface area of a cone $=\pi r(I+r)$

## Solved Examples:

Question 1: Find the total surface area of a cone, if radius is 8.2 cm and height is 16 cm .

Solution: Given,

Radius $\mathrm{r}=8.2 \mathrm{~cm}$

Height $\mathrm{h}=16 \mathrm{~cm}$

$\mathrm{I}=\underline{162}+\mathbf{8 . 2 2 - - - - - - - \sqrt { } )}$
$\mathrm{I}=17.98 \mathrm{~cm}$
Total surface area of a cone $=\pi r(l+r)$
Total surface area of a cone $=3.14 \times 8.2(17.98+8.2)$
$=674.4 \mathrm{~cm}^{2}$

Question 2: Calculate the curved surface of a cone having base radius 5 cm and a slant height of 20 cm . (Take $\pi=\underline{227}$ )

Solution: Given,

Radius $\mathrm{r}=8 \mathrm{~cm}$

Slant height $\mathrm{I}=20 \mathrm{~cm}$

Using the formula of curved surface area of a cone,

Area of the curved surface $=\pi r l$

Area of the curved surface $=\underline{227} \times \underline{5} \times \underline{20}=\underline{314.08} \mathrm{~cm} \underline{2}$

# RESISTOR SERIES PARALLEL 

## FORMULA

To calculate the total resistance of the series circuit $R t=R \underline{1}+R \underline{2}+R \underline{3}$

Where,
$\mathrm{R}_{\mathrm{t}=}$ Total Resistance
R1 = Resistance 1
R2 = Resistance 2

R3 = Resistance 3

Total Resistance Of 2 Resistors Connected parallel
$R t=R \underline{1} \underline{2} \underline{R} \underline{1}+R \underline{2}$

Where,
$\mathrm{R}_{\mathrm{t}=}$ Total Resistance

R1 = Resistance 1
R2 = Resistance 2

Total Resistance Of 3 or more Resistors Connected parallel
$\underline{1} R t=\underline{1} R \underline{1}+\underline{1} R \underline{2}+\underline{1} R \underline{3}+-$
Where,
$\mathrm{R}_{\mathrm{t}=\text { Total }}$ Resistance
R1 = Resistance 1

R2 = Resistance 2

R3 = Resistance 3

## POLARIZATION FORMULA

The electromagnetic wave is characterized by its wave phase, frequency, and direction of propagation of transverse field oscillation which consists of transverse electric and magnetic components. The plane that uses the transverse electric vector is associated with a quantity known as the polarization plane. Light is a transverse electromagnetic wave, but any natural light can be considered as unpolarized since the propagation of all the planes are equally probable. Therefore, based on the position of the polarizer we get horizontal or vertical polarized light. Polarized light is a condition where when each light waves are placed parallel to each other. It is possible to polarize only transverse waves and that light is built up by transverse waves.

The degree of polarization completely depends on the matter and the angle at which the light is reflected. All the substances
that could polarize light are known as a polarizer and the phenomenon is known as polarization.

Polarization angle or Brewster's angle formula is given by:

$$
\tan \theta=n_{2} / n_{1}
$$

Where,
$\mathrm{n}_{1}=$ initial medium
$\mathrm{n}_{2}=$ other medium.
$I=I_{o} \cos 2 \theta$

## Example 1

Determine the value of polarizing light angles when the refractive index of green colour glass is 1.515 and that of violet colour is 1.521.

Solution:

## Given:

$\mathrm{n}_{1}=1.515$
$\mathrm{n}_{2}=1.521$
The $\mathrm{in}_{1}=\tan ^{-1}(1.515)$
$=56^{\circ} 57^{\prime}$

The $\mathrm{in}_{2}=\tan ^{-1}(1.521)$
$=56068^{\prime}$

## FREQUENCY FORMULA

Frequency is the revolutions per second or number of wave cycles. The Formula for period ( $T$ ) in terms of frequency is articulated as:

If one considers any wave in terms of wavelength and velocity the Frequency Formula is articulated as
$f=\frac{v}{\lambda}$

Where,
the frequency of the wave is $f$, the wave velocity or wave speed is $V$, the wavelength of the wave is $\lambda$.

If the light wave is considered, then the frequency is articulated as
$f=\frac{c}{\lambda}$

Where cis the velocity of light.
Frequency in terms of angular frequency is articulated as
$f=\frac{\omega}{2 \pi}$
Where $\omega$ is the angular frequency.
The formula for the frequency of a wave is used to find frequency $(\mathrm{f})$, time period $(\mathrm{T})$, wave speed $(\mathrm{V})$ and wavelength ( $\lambda$ ). The Frequency is expressed in Hertz (Hz).

## Frequency Formula Solved Examples

Underneath are given some questions based on frequency formula which may be useful for you.

Problem 1: The light wave has a wavelength of 500 nm .
Compute its frequency?

## Answer:

Given: Velocity of light, $v=3 \times 10^{8} \mathrm{~m} / \mathrm{s}$,
Wavelength, $\lambda=500 \mathrm{~nm}$
Frequency is given by
$f=\frac{v}{\lambda}$
$f=\frac{V}{\lambda}=\frac{3 \times 10^{8}}{500 \times 10^{-9}}=6 \times 10^{14} h z$

## ELECTRIC CURRENT FORMULA

Electric current is nothing but the rate of change of electric charge through a circuit. This current is related to the voltage and resistance of a circuit. It can be represented by I and the SI unit is Amperes. Electric current relates the electric charge and the time.

According to Ohm's law, the electric current formula will be,

$$
\mathrm{I}=\mathrm{VR}
$$

Where,

- V is the voltage
- $R$ is the resistance
- I is the current


## Electric Current Problems

Let us discuss the problems related to electric current.
Question 1: Calculate the current through the circuit in which the voltage and resistance be 15 V and $3 \Omega$ respectively?

Solution:The given parameters are,
$V=15 \mathrm{~V}$
$R=3 \Omega$
The equation for current using Ohm's law is, I=VR
$\mathrm{I}=\underline{153}=5 \mathrm{~A}$
Question 2: The voltage and resistance of a circuit are given as 10 V and $4 \Omega$ respectively. Calculate the current through the circuit?

Solution:The given parameters are,
$V=10 \mathrm{~V}$
$R=4 \Omega$
The equation for current using Ohm's law is,
I=VR
$I=\underline{104}=2.5 \mathrm{~A}$

## MOLAR MASS FORMULA

The mole is a counting unit to specify the number of atoms, molecules, ions or formula units in a particular chemical compound. It is similar to other counting units like a pair (2) and a dozen (12). One mole of a compound contains Avogadro's number ( $6.02214076 \times 10^{23} \mathrm{~mol}$ ) of molecules or formula units. The molar mass of a compound defines the mass of 1 mole of that particular substance and number of grams per mole of a compound. In other words, the molar mass is the total mass of all the atoms in grams that make a mole of a particular molecule. Therefore, the units of molar mass are grams/mole.

## How to find the molar mass of a compound?

Step 1. Make use of the chemical formula to determine the number of atoms of each element in the compound.

Step 2. Multiply the atomic weight of each element with its number of atoms present in the compound.

Step 3. Add up all and assign unit as grams/mole.

Example. 1 What is the molar mass of sodium
carbonate, $\mathrm{Na}_{2} \mathrm{CO}_{3}$ ?
Solution Since sodium carbonate contains two atoms sodium, one atom of carbon and three atoms of oxygen. The molecular weight would be
$\mathrm{Na}: 2 \times 23.0=46$
$C: 1 \times 12.0=12$
$0: 3 \times 16=48$

When we add up the total values i.e, $46+12+48=106$

Therefore, the molar mass of Na 2 CO 3 is $106 \mathrm{~g} / \mathrm{mole}$.

Example 2.Identify the molar mass of calcium nitrate, $\mathrm{Ca}\left(\mathrm{NO}_{3}\right)_{2}$ ?

Solution: Since calcium nitrate contains one atom of calcium, two atoms of nitrogen and six atoms of oxygen.

Ca: $1 \times 40.1=40.1$
$N: 2 \times 14.0=28$
$0: 6 \times 16.0=96$
If we add all, $40.1+14+16=164.1$

Therefore, the molar mass of $\mathrm{Ca}(\mathrm{NO}) 2$ is $164.1 \mathrm{~g} / \mathrm{mol}$.
Note that the subscript two after the parentheses specifies that there are 2 nitrate ions (NO3-). Multiply the number of atoms with the subscripts outside the parenthesis. Subscripts outside the () affect only the atoms inside the () and not the Ca ion.

## HEISENBERG UNCERTAINTY

## PRINCIPLE FORMULA

Quantum mechanics is the discipline of measurements on the minuscule scale. Those measurements are in macro and microphysics can lead to very diverse consequences. Heisenberg uncertainty principle or basically uncertainty principle is a vital concept in Quantum mechanics. The uncertainty principle says that both the position and momentum of a particle cannot be determined at the same time and accurately. The result of position and momentum is at all times greater than $\mathrm{h} / 4 \pi$. The formula for Heisenberg Uncertainty principle is articulated as,
$\Delta x \Delta p \geq \frac{h}{4 \pi}$

Where
$h$ is the Planck's constant ( $6.62607004 \times 10^{-34} \mathrm{~m}^{2} \mathrm{~kg} / \mathrm{s}$ )
$\Delta p$ is the uncertainty in momentum
$\Delta x$ is the uncertainty in position

## Heisenberg Uncertainty Principle Problems

We'll go through the questions of the Heisenberg Uncertainty principle.

Solved Examples
Problem 1: The uncertainty in the momentum $\Delta p$ of a ball travelling at $20 \mathrm{~m} / \mathrm{s}$ is $1 \times 10-6$ of its momentum. Calculate the uncertainty in position $\Delta x$ ? Mass of the ball is given as 0.5 kg .

## Answer:

Known numerics are,
$v=20 \mathrm{~m} / \mathrm{s}$,
$m=0.5 \mathrm{~kg}$,
$\mathrm{h}=6.62607004 \times 10^{-34} \mathrm{~m}^{2} \mathrm{~kg} / \mathrm{s}$
$\Delta p=p \times 1 \times 10-6$
As we know that,
$P=m \times v=0.5 \times 20=10 \mathrm{kgm} / \mathrm{s}$
$\Delta p=10 \times 1 \times 10-6$
$\Delta p=10^{-5}$
Heisenberg Uncertainty principle formula is given as,
$\Delta x \Delta p \geq \frac{h}{4 \pi}$
$\Delta \times \geq \frac{h}{4 \pi \Delta p}$
$\Delta \times \geq \frac{6.626 \times 10^{-34}}{4 \times 3.14 \times 10^{-5}}=0.527 \times 10^{-29} \mathrm{~m}$

## HEAT OF SOLUTION FORMULA

The heat solution is defined as the difference in the enthalpy related to the dissolving substance in a solvent at constant pressure which is leading in infinite dilution. The unit of solution enthalpy is $\mathrm{KJ} / \mathrm{mol}$.

The enthalpy change is observed when the solute is dissolved in the solvent. When solid or gas is dissolved in the solvent the heat is absorbed. This process is known as heat dissolution or heat solution. The heat solution is measured in terms of a calorimeter.

The formula of the heat of solution is expressed as,
$\Delta H_{\text {water }}=$ mass $_{\text {water }} \times \Delta T_{\text {water }} \times$ specific heat ${ }_{\text {water }}$
Where
$\Delta \mathrm{H}=$ heat change
mass water = sample mass
$\Delta T=$ temperature difference
Specific heat $=0.004184 \mathrm{~kJ} / \mathrm{g}^{\circ} \mathrm{C}$.

## Example 1

The heat absorbed when hydrated salt $\left(\mathrm{Na}_{2} \mathrm{CO}_{3} .10 \mathrm{H}_{2} \mathrm{O}\right)$ is dissolved at 291K isothermally in a large quantity of water is 65 KJ per mole solute. Determine the heat of crystallization of $1 \mathrm{~kg} \mathrm{Na} \mathbf{2 O}_{3} \cdot \mathbf{1 0 \mathrm { H } _ { 2 }} \mathbf{O}$.

Solution:

Given data:
$\mathrm{m}=65 \mathrm{~kJ}$ per mol
$\Delta T=291 K$
Specific heat $=0.004184 \mathrm{KJ} / \mathrm{g}^{\circ} \mathrm{C}$
Substitute in the given formula, we get
$\Delta$ Hwater $=$ mass $_{\text {water }} \times \Delta \mathrm{T}_{\text {water }} \times$ specific heat water
$=65 \times 291 \times 0.004184$

Therefore, $\Delta \mathrm{H}_{\text {water }}=79.140 \mathrm{~kJ} / \mathrm{Kg}$ solute

## LENS MAKERS FORMULA

The lens maker formula is utilized to create a lens with a defined focal length. A lens has two curved surfaces, but both are not exactly same. By using the lens maker's formula you can determine the focal length of the specific lens if you know the parameters such as refractive index and radius of curvature.
$\frac{1}{f}=(\mu-1)\left(\frac{1}{R_{1}}-\frac{1}{R_{2}}\right)$
Where,
$f=$ Len focal length
$\mu=$ Refractive index of the material
R1 and R2 = radius of curvature of both surfaces

## Example 1:

Determine the focal length of the lens with refractive index is given 2 and radius of curvature of two surfaces respectively 20 cm and -35 cm .

Solution:

Given
$\mu=2$
$\mathrm{R}_{1}=30 \mathrm{~cm}$
$R_{2}=-45 \mathrm{~cm}$

Lens maker's formula is
$1 / \mathrm{f}=(\mu-1)(1 / \mathrm{R} 1-1 / \mathrm{R} 2)$
$=1(1 / 30+1 / 45)$
$=0.03+0.022$
$=0.052$

So, $f=1 / 0.052, \quad f=19.23 \mathrm{~cm}$

## ROTATIONAL KINETIC ENERGY

## FORMULA

Rotational kinetic energy is the energy which the body absorb s by virtue of its rotation. Through the work-energy theory, the term for linear and rotational kinetic energy can be developed in a parallel way. Consider the contrast that occurs between a constant torque exerted on a flywheel with a moment of inertia I and a constant force exerted on a mass m , both starting from rest.

Starting from the rest, in case of linear motion, according to Newton's second law, acceleration is equal to the ratio of the final velocity and time. The average velocity is half of the final velocity which represents the work done on the object gives it a kinetic energy equivalent to the work done on the object.

Starting from the rest, in case of rotation motion, according to Newton's second law, the angular acceleration ratio of the final angular velocity with time. The average angular velocity is equivalent to the half of the final angular velocity.

Accordingly, the rotational kinetic energy provided to the flyw heel is equal to the work done by the torque. (Rotational work $=\tau \theta$ and angular acceleration= $\alpha$ provided to the flywheel) Rotational Kinetic Energy Formula is expressed as Ek=12lw2 Where

Moment of inertia $=1$ and
Angular velocity of the rotating body $=\omega$
Rotational kinetic energy formula is made use of to calculate the rotational kinetic energy of the body in rotational motion. It is expressed in Joules (J).

Rotational kinetic Energy Problem
Solved Example

Problem 1: Calculate the rotational kinetic energy if angular velocity is $7.29 \times 10^{-5} \mathrm{rad} \mathrm{s}^{-1}$ and moment of inertia is $8.04 \times 10^{37} \mathrm{kgm}^{2}$.

## Answer:

Known:
(Angular velocity) $\omega=7.29 \times 10^{-5} \mathrm{rad} \mathrm{s}^{-1}$,
(Moment of inertia) I $=8.04 \times 10^{37} \mathrm{kgm}^{2}$
The rotational kinetic energy is $\mathrm{Ek}=12 \mathrm{lw} 2$
$=1 / 2 * 8.04 * 10^{37 \mathrm{kgm} 2} *\left(7.29 * 10^{-5} \mathrm{rad} / \mathrm{s}\right)^{2}$
$=2.13 \times 10^{29} \mathrm{~J}$

# WAVELENGTH TO FREQUENCY 

## FORMULA

The wavelength of any sinusoidal wave is defined as the spatial period of the wave, that is, the distance over the shape of the wave repeats itself. The wavelength is denoted by a Greek letter lambda ( $\lambda$ ) and is calculated in the units of length or metre.

Frequency is defined as the number of time a recurring event occurs in one second. For a sinusoidal wave, we define frequency as the number of cycles or crest or trough completed in one second. Frequency is denoted by $f$ or $v$ and is calculated in the units of Hertz.

As we know, for a sinusoidal wave moving at a fixed speed, the wavelength of the wave is inversely proportional to its frequency.

The formula for Wavelength to Frequency

The wavelength to frequency formula is given by
Speed = Frequency x Wavelength
Wavelength=(Speed of the wave)/(Frequency of the wave)
As mentioned above, all the quantities are represented by a symbol. The symbolic representation of the formula given above can be seen as:
$C=f \times \lambda$

In terms of wavelength to frequency, the formula is given as:
$\lambda=c f$

Where,

- $\lambda$ is the wavelength of the wave under consideration expressed in the units of a metre,
- $C$ is the speed of the wave in the given medium, expressed in terms of $\mathrm{m} / \mathrm{s}$
- $f$ is the frequency of the wave expressed in terms of Hertz.

Wavelength To Frequency Solved Examples
Example 1 In an experiment, the wavelength of a photon particle was observed to be 500 nm . What can be said about the frequency of the wave?

Solution: Given, the wavelength of the photon particle $=500$ nm.

In order to calculate the frequency of the photon particle, we use the formula given above.

## $f=c \lambda$

As we know, the speed of light is $\mathrm{c}=3 \times 10^{8}$

Substituting the known values in the equation above, we get that,
$\mathrm{f}=\underline{3} * 108500 * \underline{10}-\underline{9}$
$f=6 \times 10^{-4} \mathrm{~Hz}$
The frequency of the wave is equal to $6 \times 10^{-4} \mathrm{~Hz}$.
Example 2 For a light ray having a wavelength equal to 200 nm , calculate the frequency.

Solution: Given, the wavelength of the light ray $=200 \mathrm{~nm}$. In order to calculate the frequency of the light ray, we use the formula given above.

## $f=c \lambda$

As we know, the speed of light is $\mathrm{c}=3 \times 10^{8}$.
Substituting the known values in the equation above, we get that,

## $\mathrm{f}=\underline{3} * \underline{108200} * \underline{10}-\underline{9}$

$\mathrm{f}=1.5 \times 10^{14} \mathrm{~Hz}$
The frequency of the wave is equal to $1.5 \times 10^{14} \mathrm{~Hz}$.

## CALORIMETRY FORMULA

Calorimetry defines the act of measuring different changes in state variables of a body for deriving the heat transfer related to the changes of its states. This Calorimetry is performed with a calorimeter.

## Formula for Calorimetry

$Q=m C \Delta T$

Where
$\mathrm{Q}=$ heat evolved ( heat absorbed - heat released) in joules (J)
$\mathrm{m}=$ mass in kilograms (kg)
$\mathrm{c}=$ specific heat capacity in $\mathrm{J} / \mathrm{kg} \cdot{ }^{\circ} \mathrm{C}($ or J $/ \mathrm{kg} \cdot \mathrm{K})$
$\Delta \mathrm{T}=$ temperature change in ${ }^{\circ} \mathrm{C}$ (or K$)$

## Solved Examples

Problem 1: one gram of sodium hydroxide $(\mathrm{NaOH})$ is dissolved in 40 mL of water at $30^{\circ} \mathrm{C}$. Let the heat capacity of water at this temperature is $4.184 \mathrm{~J} / \mathrm{kg} \cdot{ }^{\circ} \mathrm{C}$ and 40 mL water has a mass of 40 grams or 0.04 kg . If the temperature of the solution increases to $35.32^{\circ} \mathrm{C}$. How much heat is gained by the calorimeter?

You have $\mathrm{Q}=\mathrm{mc} \Delta \mathrm{T}=(0.04)(4.184)\left(35.32-30^{\circ} \mathrm{C}\right)$
$=0.890 \mathrm{~kJ}$

## LATENT HEAT OF FUSION

## FORMULA

The amount of heat gained by a solid object to convert it into a liquid without any further increase in the temperature is known as latent heat of fusion. The content of latent heat is complex in the case of sea ice because it is possible for sea ice and brine to exist together at any temperature and melt at a temperature other than Ooc when bathed in a concentrated salt solution, just like it occurs in the walls of brine cells when brine cells migration occurs. If m kg of solid converts to a fluid at a constant temperature that is its melting point, the heat consumed by the substance or the latent heat of fusion formula is expressed as

$$
Q=m \times L
$$

Wherein
$\mathrm{L}=$ specific latent heat of fusion of substance.

The temperature of the substance changes from $\mathrm{t}_{1}$ (low temperature) to $\mathrm{t}_{2}$ (high
temperature) the heat which the material absorbs or releases is expressed as

$$
\mathrm{Q}=\mathrm{mc} \Delta \mathrm{t}
$$

$$
Q=m c\left(t_{2}-t_{1}\right)
$$

The total amount of heat absorbed or liberated by the material is $Q=m L+m c \Delta t$

## Example 1

A piece of metal at $20^{\circ} \mathrm{C}$ has a mass of 60 g . When it is immersed in a current of steam at $100^{\circ} \mathrm{C}, 0.5 \mathrm{~g}$ of steam is condensed on it. Determine the specific heat of metal, given that the latent heat of steam $=540 \mathrm{cal} / \mathrm{g}$.

## Solution:

Let c be the specific heat of the metal.

Heat gained by the metal
$Q=m c \Delta t$
$Q=60 \times c \times(100-20)$
$\mathrm{Q}=60 \times \mathrm{c} \times 80 \mathrm{cal}$
The heat released by the steam
$Q=m \times L$
$Q=0.5 \times 540 \mathrm{cal}$

By the principle of mixtures,

Heat given is equal to Heat taken
$0.5 \times 540=60 \times c \times 80$
$\mathrm{c}=0.056 \mathrm{cal} / \mathrm{g}^{\circ} \mathrm{C}$

## MECHANICAL ENERGY FORMULA

Mechanical energy is the total amount of kinetic energy and potential energy of an object that is used to do a specific work. Mechanical energy can also be defined as the energy of an element due to its position or motion or both. The potential energy of an object is due to its position and kinetic energy is due to its motion. The potential energy of an object is zero when it is in the movement and kinetic energy is zero when the object is in rest.

The formula of mechanical energy is
$M . E=K . E+P . E$
$M . E=1 / 2 m v 2+m g h$
Where
$\mathbf{m}=$ mass of an object
$\mathbf{v}=$ velocity of that object
$\mathbf{g}=$ acceleration due to gravity
h = height of an object.

## Example 1

A man is sitting on a 20 m height building and his mass is 50 kg . Calculate the mechanical energy?

## Solution:

Given parameters are,
$\mathrm{m}=50 \mathrm{~kg}$
$h=20 \mathrm{~m}$
the man is not moving, therefore, $\mathrm{K} . \mathrm{E}=0$

The formula of mechanical energy
$M . E=1 / 2 m v 2+m g h$
Since K.E is 0 , the equation becomes,
$M . E=m g h$
$M . E=50 \times 9.81 \times 20$
M.E = 9810 J

# MOMENTUM OF PHOTON 

## FORMULA

Photon is a type of elementary particle which has a zero rest mass and moves with a speed of light in the vacuum. Einstein explained the momentum ( p ) of a photon with the given formula. The energy and momentum of a photon are related by the equation
$E=p c$.
where,
$E=$ energy of the photon
$p=$ momentum of the photon
c = speed of light
The momentum of Photon in terms of wavelength is given by the following derivation
$p=m c--(1)$

The energy ( E ) of a photon is given as
$\mathrm{E}=\mathrm{mc}^{2}$,
$E=h v($ frequency,$v=c / \lambda)$
Therefore,
$E=h c / \lambda$
$\mathrm{hc} / \lambda=\mathrm{mc}^{2}$
$m=h / \lambda c----(2)$
substituting equation (2) in equation (1) we get
$p=h / \lambda$
$\mathrm{E}=$ photon energy
$h=$ Planck's constant $\left(6.62607015 \times 10^{-34} \mathrm{Js}\right)$
$\lambda=$ wavelength of light

Photon momentum is comparatively small value to measure.

An electron with the same momentum has a $1460 \mathrm{~m} / \mathrm{s}$ velocity, which is non-relativistic

## THERMAL EXPANSION FORMULA

Thermal expansion describes the tendency of an object to change its dimension either in length, area or volume due to heat. Heating up a substance increases its kinetic energy.

Depending on the type of expansion thermal expansion is of 3 types- Linear expansion, Area expansion, and Volume expansion.

Linear expansion is the change in length due to heat. Linear expansion formula is given as,
$\frac{\Delta L}{L_{o}}=\alpha_{L} \Delta T$
Where,

L0 = original length,

L = expanded length,
$\alpha=$ length expansion coefficient,
$\Delta \mathrm{T}=$ temperature difference,
$\Delta L=$ change in length

Volume expansion is the change in volume due to
temperature. Volume expansion formula is given as
$\frac{\Delta V}{V_{o}}=\alpha_{V} \Delta T$

Where,

V0 = original volume,
$\mathrm{V}=$ expanded volume,
$\alpha v=$ volume expansion coefficient,
$\Delta T=$ temperature difference,
$\Delta V=$ change in volume after expansion

Area expansion occurs is the change in area due to
temperature change. Area expansion formula is given as,
$\frac{\Delta A}{A_{o}}=\alpha_{A} \Delta T$
Where,

A = original area,
$\Delta A=$ change in the area,
$\alpha A=$ area expansion coefficient,
$\Delta T=$ temperature difference,
$A 0=$ expanded area.

Solved Examples

## Example 1

A rod of length 5 m heated to $40^{\circ} \mathrm{C}$. If the length of increases to 7 m after some time. Find the expansion coefficient. Room temperature is $30^{\circ} \mathrm{C}$.

Solution:

## Given:

Initial length Lo $=5 \mathrm{~m}$,

Expanded length L=7m

Change in length $\Delta L=7-5=2 m$

Temperature difference $\Delta \mathrm{T}=40^{\circ} \mathrm{C}-30^{\circ} \mathrm{C}=10^{\circ} \mathrm{C}$
Absolute temperature $\mathrm{T}=10^{\circ} \mathrm{C}+\mathbf{2 7 3}=283 \mathrm{~K}$

The linear expansion formula is given by,
$\frac{\Delta L}{L_{o}}=\alpha_{L} \Delta T$
$\therefore$ Length expansion coefficient is given by,

$$
\begin{aligned}
\alpha_{L} & =\frac{\Delta L}{L_{0} \times \Delta T} \\
& =2 / 5 \times 283 \\
\alpha_{L} & =14 \times 10^{-4} K^{-1}
\end{aligned}
$$

## HOOKES LAW FORMULA

Hooke's law states that the force required to extend or compress a spring by some distance is directly proportional to that distance. The stiffness of the spring is a constant factor characteristic. The property of elasticity states that it takes twice the much force to stretch a spring twice as long. This linear dependence of displacement on stretching is known as Hooke's law. This law is named after 17th-century British physicist Robert Hooke.

It says that the amount of stress we apply on any object is equal to that amount of strain is observed on it, which means Stress $\propto$ Strain.

Hooke's Law Formula is given as
$F=-K x$

Where,
$\mathrm{F}=$ amount of force applied in N ,
$x=$ displacement in the spring in $m$,
$\mathrm{k}=$ spring constant or force constant.
Hooke's law formula can be applied to determine the force constant, displacement and force in a stretched spring.

## Example 1

A spring is stretched by 10 cm and has a force constant of 2 $\mathrm{cm} /$ dyne. Determine the Force applied.

## Solution:

Given parameters are

Force constant k is $2 \mathrm{~cm} /$ dyne,

Extension $\mathrm{x}=10 \mathrm{~cm}$.

The force applied formula is given by
$F=-k x$
$=-2 \times 10 \mathrm{~cm}$
$=-20 \mathrm{~N}$

## Example 2

Determine the force constant if a force of 100 N is stretching a spring by 0.8 m .

Solution:

Given parameters are

Force F = 100 N ,
Extension, $x=0.2 \mathrm{~m}$.
the force constant formula is given by
$k=-F / x$
$=-100 / 0.8$
$\mathrm{k}=-125 \mathrm{~N} / \mathrm{m}$.

## SPRING FORCE FORMULA

Spring is a tool used daily by many of us and their inertia are frequently neglected by assuming it as massless. It's an extremely casual activity that a Spring when strained, undergoes displacement when it is compacted it gets compressed and when it is free it comes to its equilibrium position. This fact tells us that spring exerts an equal as well as an opposite force on a body which compresses or stretches it.

The Spring force formula is given by,
$F=k(x-x 00)$.

Where, the spring force is F, the equilibrium position is $\mathrm{x}_{0}$ the displacement of the spring from its position at equilibrium is x ,
the spring constant is $k$.
The negative sign tells that the visualized spring force is a restoring force and acts in the opposite direction.

Spring Force Solved Problems
Problem 1: A spring has length $\mathbf{2 2} \mathbf{~ c m} / \mathrm{s}$. If it is loaded with 2 kg , it gets stretched by $38 \mathrm{~cm} / \mathrm{s}$. Compute its spring constant.

## Answer:

Known:
(Mass) m = 2 kg
(initial length) $x o=22 \mathrm{~cm}$
(displacement) $x=38 \mathrm{~cm}$

Final displacement $=x-x o=38 \mathrm{~cm}-22 \mathrm{~cm}=16 \mathrm{~cm}=0.16 \mathrm{~m}$

The spring force is articulated as,
$\mathrm{F}=\mathrm{ma}$
$\mathrm{F}=2 \mathrm{~kg} \times 0.16 \mathrm{~m}$
$\mathrm{F}=0.32 \mathrm{~N}$

The spring constant is articulated as,
$k=-\frac{F}{x-x_{0}}$
$k=-\frac{0.32 N}{0.16 m}$
$\mathrm{k}=-2 \mathrm{~N} / \mathrm{m}$

Thus, the spring constant is $\mathbf{- 2} \mathbf{N} / \mathrm{m}$.
Problem 2: If a body is stretched by 2 m with force 100 N . calculate its spring constant.

## Answer:

Known:
(Displacement) $x=2 m$
(force) $\mathrm{F}=100 \mathrm{~N}$
The spring constant is articulated as,
$k=-\frac{F}{x}$
$k=-\frac{100 N}{2 m}$
$\mathrm{k}=-50 \mathrm{~N} / \mathrm{m}$
Thus, the spring constant is $\mathbf{- 5 0} \mathrm{N} / \mathrm{m}$.

## ELECTRICITY FORMULAS

Electricity is the flow of charge in a conductor from anode to cathode. Electricity has varied applications It acts as a tool to provide power to electrical devices. We can say the flow of charge builds up the current which we call as Electricity. To understand how the Electricity is generated, we need to understand the various basic parameters related to it like the voltage, current, resistance, conductivity and relation among them.

Some of the commonly used Electricity formulae are listed below.

## Quantity <br> Formulas <br> Unit

$$
1=Q / t
$$

Current I

> Q = Charge

Amperes (A)
$t=$ time taken

$$
V=E / Q
$$

or
Voltage V

$$
\mathrm{V}=\mathrm{W} / \mathrm{Q} \quad \operatorname{Volts}(\mathrm{~V})
$$

$\mathrm{E}=$ Energy, W =
Work done
$R=\rho l / A$

Resistance R
$\rho=$ Resistivity,
Ohm ( $\Omega$ )
I length,
$\mathrm{A}=\mathrm{Area}$

Resistance $\mathrm{R} \quad \mathrm{R}=\mathrm{V} / \mathrm{l} \quad$ ohm ( $\Omega$ )
Power P
$\mathrm{P}=\mathrm{VI}$
Watts (W)

Conductivity
sigma $=1 / \rho \quad$ Siemens per meter $(\mathrm{S} / \mathrm{m})$
$\sigma$

Electricity Formulas are applied in calculating the unknown electrical parameters from the known in electric circuits.

Solved Examples

## Example 1

Determine the current flowing through the electric heater has p.d of 220 V and resistance is $70 \Omega$.

Solution:

## Given:

Resistance $\mathrm{R}=70 \Omega$
Voltage V $=220 \mathrm{~V}$
The current formula is given by
$\mathrm{I}=\mathrm{V} / \mathrm{R}$
$=220 / 70$
$\mathrm{I}=3.1428 \mathrm{~A}$

## Example 2

An electrical lamp lights for 4 hours and draws a current of 0.5
A. Calculate the amount of charge flowing through the lamp.

## Solution:

Current I = 0.5 A

Time taken $t=4$ hours
$\mathrm{t}=4 \times 3600=14400 \mathrm{~s}$,

Charge $Q=I \times t$
$=0.5 \times 14400$
$Q=7200 \mathrm{C}$

## UNIVERSAL GRAVITATION

## FORMULA

The law of universal gravitation states that any two objects in the universe attract each other with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

It's a general Physics law derived from the observations by Isaac Newton. In modern language, the law states: every point mass attracts another single point mass by a force pointing along the line intersecting both the ends.

The universal gravitation force formula is given by
$F=\frac{G m_{1} m_{2}}{r^{2}}$

Where,
$\mathrm{F}=$ Force of attraction between two objects (N)
$\mathrm{G}=$ universal gravitational constant $=6.67259 \times 10^{-11} \mathrm{~N}$ $\mathrm{m}^{2} / \mathrm{kg}^{2}$.
$\mathrm{m} 1, \mathrm{~m} 1=$ two different masses (Kg)
$r=$ is the distance between them

Solved Numericals

## Example 1

Determine the gravitational force if two masses are 30 kg and 50 kg separated by a distance 4 m .
$\mathrm{G}=6.67259 \times 10^{-11} \mathrm{~N} \mathrm{~m}^{2} / \mathrm{kg}^{2}$.

## Solution:

Given:
$\mathrm{m} 1=30 \mathrm{~kg}, \mathrm{~m} 2=50 \mathrm{~kg}$
$r=4 m$ and
$\mathrm{G}=6.67259 \times 10^{-11} \mathrm{~N} \mathrm{~m}^{2} / \mathrm{kg}^{2}$.

Universal gravitation formula is given by,
$F=\frac{G m_{1} m_{2}}{r^{2}}$
$=\left[6.673 \times 10^{-11} \times 30 \times 50\right] / 16$
$F=62.55 \times 10^{-11} \mathrm{~N}$

## Example 2

Determine the gravitational force if the mass of two bodies are 80 kg and 200 kg and they are separated by a distance of 6 m .

## Solution:

Given:
$\mathrm{m} 1=80 \mathrm{~kg}, \mathrm{~m} 2=100 \mathrm{~kg}$,
$r=6 \mathrm{~m}$ and
$\mathrm{G}=6.67259 \times 10^{-11} \mathrm{~N} \mathrm{~m}^{2} / \mathrm{kg}^{2}$.
Universal gravitation formula is given by,

## $\mathrm{F}=\mathrm{Gm} 1 \mathrm{~m} 2 / \mathrm{r} 2$

$=6.673 \times 10^{-11} \times 80 \times 100 / 36$
$F=148.28 \times 10^{-11} \mathrm{~N}$

## DOPPLER SHIFT FORMULA

A Doppler shift is a phenomenon of a change in frequency based on the observer's point of view. The most common analogy of this is standing on the side of the road and listen to a passing car. As the car approaches, there is a definitive sound. As the car passes, the sound changes to a lower frequency. This is called a Doppler Shift. There are two types of Doppler shifts:

- Red-Shift or a shift of frequency to a lower wavelength (away from the observer)
- Blue-Shift or a shift of frequency to a higher wavelength (toward the observer)

This is the equation for Doppler shift
$\frac{\Delta \lambda}{\lambda_{0}}=\frac{v}{c}$
$\Delta \lambda=$ wavelength shift
$\lambda_{0}=$ wavelength of the source not moving
$v=$ velocity of the source
c = Speed of light
Apparent Frequency formula is given by
$f^{\prime}=\frac{\left(v+v_{0}\right)}{\left(v-v_{s}\right)} f$
$f=$ actual frequency of the sound wave
$f^{\prime}=$ observed frequency
$v=$ speed of sound waves
$v_{0}=$ velocity of observer
$v_{s}=$ velocity of the source
Question 1: A source and listener are moving towards each other with a speed of $54 \mathrm{~km} / \mathrm{hr}$. If the true frequency of sound emitted by the source is 500 Hz , calculate the observed frequency when both source and listener are moving towards each other.

Velocity of sound in air $=330 \mathrm{~ms}^{-1}$.

## Solution:

Given: True frequency, f=500 Hz,
Velocity of sound, $\mathrm{v}_{\mathrm{s}}=54 \mathrm{~km} / \mathrm{hr}=54 \times 1000 / 3600=15 \mathrm{~ms}^{-1}$,
Velocity of listener, $\mathrm{v} 0=15 \mathrm{~ms}^{-1}$
Source and observer moving towards each other
$f^{\prime}=\frac{\left(v+v_{0}\right)}{\left(v-v_{s}\right)} f$
$f^{\prime}=\frac{(330+15)}{(330-15)} 500$
$=[345 / 315] 500$
$=1.095 / 500$
$f^{\prime}=0.00219 \mathrm{~Hz}$

## OSCILLATORY MOTION FORMULA

A motion is said to be oscillatory if it is repetitive in which an object repeats the same movement over and over. In the absence of friction, the body can be in oscillation forever. But in reality, the system settles in the state of equilibrium eventually. Let's learn the calculation of the frequency of oscillatory motion.

Example: loaded spring, the motion of a pendulum.
Here the frequency of the oscillatory motion is calculated by
$f=1 T$
Where,
$\mathrm{f}=$ frequency measured in Hz
One hertz is equal to one oscillation cycle per second
$\mathrm{T}=$ time period of motion of waves

## RESISTIVITY FORMULA

Simply resistivity or Electrical resistivity is the resistance of the flow of current from one end to the other in a material. Electrical resistivity is a simply accessible and informative quantity to describe the material. It is the reciprocal of electrical conductivity. The resistivity is represented as $\rho$ and it is directly proportional to the material resistance and length. Resistivity is inversely proportional to the area of cross-section of the given material. The resistivity formula is expressed as
$\rho=\frac{R A}{l}$
Where $\rho$ is the resistivity, $\boldsymbol{R}$ is the resistance, $\boldsymbol{I}$ is the length of the material and $\boldsymbol{A}$ is the area of cross-section.

Resistivity Solved Examples
Problem 1: Compute the resistivity of the given material whose resistance is $2 \Omega$; area of cross-section and length are
$25 \mathrm{~cm}^{2}$ and 15 cm respectively?
Answer:
Given
$R=2 \Omega$
$\mathrm{I}=15 \mathrm{~cm}=0.15 \mathrm{~m}$
$A=25 \mathrm{~cm}^{2}=0.25 \mathrm{~m}^{2}$

Resistivity formula is
$\rho=\frac{R A}{l}$
$\rho=\frac{2 \times 0.25}{0.15}=3.333 \Omega \mathrm{~m}$
Problem 2: The length and area of wire are given as 0.2 m and
$0.5 \mathrm{~m}^{2}$ respectively. The resistance of that wire is $3 \Omega$, calculate the resistivity?

Answer:

Given
$R=3 \Omega$
$\mathrm{I}=0.2 \mathrm{~m}$ and
$A=0.5 \mathrm{~m}^{2}$

Resistivity formula is
$\rho=\frac{R A}{l}$
$\rho=\frac{3 \times 0.5}{0.2}=7.5 \Omega \mathrm{~m}$

## SUPERPOSITION FORMULA

For example:
If the response produced by input A is X and that produced by input $B$ is $Y$, then the response produced by input $A+B$ is $X+Y$.

## According to the Principle of Superposition

It is noted that the net displacement is the algebraic sum of displacements of individual waves.

Consider two waves are travelling alone and the displacement of these two waves can be represented by $\mathrm{y} 1(\mathrm{x}, \mathrm{t})$ and $\mathrm{y} 2(\mathrm{x}, \mathrm{t})$.

When these two waves overlap, the resultant displacement can be given as $y(x, t)$.
$y(x, t)=y 1(x, t)+y 2(x, t)$
The resultant wave is calculated by considering the sum of wave functions of travelling waves
$y 1=f 1(x-v t)$
$y 2=f 2(x-v t)$
$y n=f n(x-v t)$
Hence,
$y=f 1(x-v t)+f 2(x-v t)+\ldots . . . . . . . . .+f n(x-v t)$
We can conclude,
$y=\sum n i=1 \quad \mathrm{fi}(x-v t)$

Let us consider a wave travelling along a stretched string given by, $y 1(x, t)=A \sin (k x-\omega t)$ and another wave, shifted from the first by a phase $\phi$, given as $y 2(x, t)=A \sin (k x-\omega t+\phi)$

Hence resultant displacement
$y(x, t)=A \sin (k x-\omega t)+A \sin (k x-\omega t+\phi)$

This can be written as
$y(x, t)=\underline{2} A \cos \underline{12} \varphi \sin (k x-w t+\underline{12} \varphi)$

We can conclude that the resultant wave is sinusoidal and travels in $x$ direction.

The phase angle is half of the phase difference of the individual waves and the amplitude as $\underline{2} \cos \underline{12} \varphi$ times the amplitudes of the original waves.

## RADIO WAVES FORMULA

## To Calculate The Speed Of Radio Wave

Radio waves are the large spectrum waves that can be transmitted from transmitters and received from the receivers. They have frequency ranging from 300 GHz to as Iow as 3 kHz.

Radio waves are used in computer networks, radar, radio communication and broadcasting.

Speed of Wave = Wavelength X Frequency

Where,

Speed of radio waves is as similar to electromagnetic waves = 2.997\times $\left.10^{\wedge}\{8\} \backslash, \mathrm{m} / \mathrm{s} \backslash\right)$

Usually the frequencies of radio waves are in the range of 88~108 MHz

Typically between
$3.14 \times 109 \sim 2.78 \times 109 \mathrm{~nm}$

## PASCALS PRINCIPLE FORMULA

In a fluid, static pressure is exerted on the container of the wall and the fluid. Such forces operate vertically to the container wall. The pressure is distributed unequally in all areas of the fluid when external pressure is applied to the fluid. This principle is known as Pascal's principle named after the Physicist Blaise Pascal. The theory of the Pascal applies only to the external pressure and the pressure at the bottom is higher than the top within the fluid.

According to Pascal's principle, the force per unit area describes an external pressure which is transmitted through fluid and the formula is written as,
$\frac{F_{1}}{A_{1}}=\frac{F_{2}}{A_{2}}$

## Example 1:

For a hydraulic device, a piston has a cross-sectional area of 30 square centimetres moving an incompressible liquid with a force of 60 N . The other end of the hydraulic pipe is attached to a 2 nd piston with a 60 square centimeter crosssectional area. Determine the force on the second piston?

Solution:

Given
$\mathrm{F} 1=60 \mathrm{~N}$

A1 $=30$ square centimeters

A2 $=60$ square centimeters

Insert the given values to calculate the force on the second piston:
$F_{2}=A_{2} \times F_{1} / A_{1}$
$F=60 \times 60 / 30$
$F=120 \mathrm{~N}$

## INITIAL VELOCITY FORMULA

The velocity at which motion start is termed as Initial Velocity. It is the velocity at time interval $\mathrm{t}=0$ and it is represented by u .

They are four initial velocity formulas.
(1) If final time, acceleration and velocity are provided. The initial velocity is articulated as,

$$
\mathbf{u}=\mathrm{v}-\mathrm{at}
$$

(2) If final velocity, acceleration, and distance are provided we make use of
$u^{2}=v^{2}-2 a s$
(3) If distance, acceleration and time are provided. The initial velocity is
$u=s t-12$ at

Where,
Initial velocity = u,
Final Velocity = v,
time taken $=\mathrm{t}$,
distance travelled or displacement = s,
acceleration $=\mathrm{a}$
(4) If final velocity, distance and time are provided then initial velocity is
$u=2(s t)-v$

Initial Velocity formula is made use of to find the initial velocity of the body if some of the quantities are given. Initial velocity is articulated in meter per second (m/s).

Initial Velocity Solved Examples

Below are some problems based on Initial velocity which may be helpful for you.

Problem 1: Johny completes the bicycle ride with the final velocity of $10 \mathrm{~ms}^{-1}$ and acceleration $2 \mathrm{~ms}^{-2}$ within 3 s .

Calculate the initial velocity.

## Answer:

Given:
$v($ Final velocity $)=10 \mathrm{~ms}^{-1}$
$\mathrm{a}($ Acceleration $)=2 \mathrm{~ms}^{-2}$
$\mathrm{t}($ Time taken $)=3 \mathrm{~s}$
u (Initial velocity) = ?
v (Final velocity) $=\mathbf{u}+$ at
u (Initial velocity) = v-at
$u=10-(2 \times 3)$
$\mathrm{u}=4 \mathrm{~ms}^{-1}$
$\therefore$ (Initial velocity) $\mathrm{u}=4 \mathrm{~ms}^{-1}$
Problem 2: A man covers a distance of 100 m . If he has a final velocity of $40 \mathrm{~ms}^{-1}$ and has acceleration of $6 \mathrm{~ms}^{-2}$.

Compute his initial velocity?

## Answer:

Given:

Distance $\mathrm{s}=100 \mathrm{~m}$
(Final velocity) $\mathrm{v}=40 \mathrm{~ms}^{-1}$
(Acceleration) $\mathrm{a}=6 \mathrm{~ms}^{-2}$
(Initial velocity) $u^{2}=v^{2}-2 a s$
$u^{2}=1600-(2 \times 6 \times 100)$
$u^{2}=1600-1200$
$\mathrm{u}^{2}=400 \mathrm{~ms}^{-1}$
$\therefore$ (Initial velocity) $\mathrm{u}=20 \mathrm{~ms}^{-1}$.

## MAGNETIC DECLINATION

## FORMULA

Magnetic declination is defined as the angle between magnetic north and true north on the horizontal plane, which is not constant and keeps changing depending upon the position on the earth's surface and time. The Greek letter $\delta$ is used as the symbol for magnetic declination and is also known as magnetic variation.

Magnetic Declination is also referred to as the magnetic variation. Magnetic Declination is represented in the Greek word.
$\delta=$ MagneticDeclination

Magnetic Declination is associated with the year, longitude and latitude of a given location.

Calculation Of Magnetic Declination
Following are the different ways used to calculate the magnetic declination:

- Using the declination calculator: The information such as year, latitude and longitude of the given location should be provided and the calculator gives the declination on the basis of magnetic reference field models.
- Using a magnetic declination chart: A magnetic declination chart is a map with the earth's magnetic fields available on it.
- Using a compass: There are three types of bearing, they are true, magnetic and compass bearing. A compass can be used to calculate the declination as it is one of the errors of the compass and the other is magnetic variation. These three are related by:
$\mathrm{T}=\mathrm{M}+\mathrm{V}$
$M=C+D$
$\mathrm{T}=\mathrm{C}+\mathrm{V}+\mathrm{D}$ (which is a general equation relating compass and true bearings)

Where,

C = Compass Bearing

M = Magnetic Bearing
$\mathrm{T}=$ True Bearing
$\mathrm{V}=$ Variation

D = Compass Deviation

## BULK MODULUS FORMULA

Bulk modulus is the modulus associated with volume strain. The strain equal to the change in volume divided by the original volume is called volume strain. The change in the relative volume of the object when a unit compressive or tensile stress acts on the surface of the object uniformly is called Bulk modulus. The units for the bulk modulus is the Pascal. The Bulk modulus helps us understand how an object reacts when compressed from all sides equally.

Bulk modulus formula
$K=V(\Delta P) / \Delta V$
Where,

K= bulk modulus in Pascal
$\Delta \mathrm{P}$ denotes the change in pressure in Pascal
$\Delta V$ denotes the change in volume in $m^{3}$
$V$ denotes the actual volume of the object in $\mathrm{m}^{3}$

## Example 1

In ammunition testing centre the pressure is found to be 255
MPa. Calculate the change in volume of the piece of the copper piece when subjected to this pressure in percentage. The bulk modulus of copper is $1.38 \times 10^{11} \mathrm{~Pa}$.

## Solution

The pressure in the testing centre is 255 MPa .
Bulk modulus, $\mathrm{K}=\mathrm{V}(\mathbf{\Delta P}) / \Delta \mathrm{V}$
Substituting the values,

$$
(\Delta V / V)=255 \times 10^{6} / 1.38 \times 10^{11} \times 100
$$

Therefore, the change in volume percentage is $0.184 \%$

## COP FORMULA

How to calculate COP?

In reference to the standard heat engine, Coefficient of Performance is given by
$\mathrm{K}=\mathrm{QcWin}$

Where,
k = Coefficient of Performance
$Q_{c}=$ Heat dispelled from the system
$\mathrm{W}_{\text {in }}=$ Work input to the system
If no work was input to the system $\left(\mathrm{W}_{\text {in }}=0\right)$ the Coefficient of Performance would equal infinity.

Hence,
$K<\infty$

## TENSION FORMULA

Tension is nothing but the drawing force acting on the body when it is hung from objects like chain, cable, string etc. It is represented by $\mathbf{T}$ (occasionally also symbolized as $\mathbf{F}_{\mathbf{t}}$ ).

Tension formula is articulated as

T=mg+ma

Where,
$\mathrm{T}=$ tension ( N or $\mathrm{kg}-\mathrm{m} / \mathrm{s}^{2}$ )
$g=$ acceleration due to gravity $\left(9.8 \mathrm{~m} / \mathrm{s}^{2}\right)$
$m=$ Mass of the body
a = Acceleration of the moving body
If the body is travelling upward, the tension will be $\mathrm{T}=\mathrm{mg}+$ ma

If the body is travelling downward, the tension will be $\mathrm{T}=\mathrm{mg}$

- ma

If the tension is equivalent to the weight of body $\mathrm{T}=\mathrm{mg}$
Tension Formula is made use of to find the tension force acting on any object. It is useful for problems. Tension is a force so it is expressed in Newtons (N).

## Tension Solved Examples

Underneath are questions based on tension which may be useful for you.

Problem 1: A 8 Kg mass is dangling at the end of a string. If the acceleration of the mass is

1. $3 \mathrm{~m} / \mathrm{s}^{2} \mathrm{in}$ the upward direction
2. $3 \mathrm{~m} / \mathrm{s}^{2}$ in a downward direction

Find the tension in the string.

## Answer:

Known:
$m$ (Mass of the hanging body) $=8 \mathrm{Kg}$,
(a) If the body is travelling in the upward direction the tension force is articulated as
$\mathrm{T}=\mathrm{mg}+\mathrm{ma}=8 \times 9.8+8 \times 3=102.4 \mathrm{~N}$
(b) If the body is traveling in down direction, the tension force is articulated as
$\mathrm{T}=\mathrm{mg}-\mathrm{ma}=8 \times 9.8-8 \times 3=54.4 \mathrm{~N}$

## ANGULAR SPEED FORMULA

Speed is all about how slow or fast an object moves. Angular speed is the speed of the object in rotational motion.

Angular Speed Formula computes the distance covered by the body in terms of revolutions or rotations to the time taken. It is represented by $\omega$ and is given as

Angularspeed $(\omega)=\frac{\text { Totaldistancecovered }}{\text { Totaltimetaken }}=\frac{\theta}{t}$
Distance travelled is represented as $\theta$ and is measured in radians. The time taken is measured in terms of seconds. Therefore, the Angular speed is articulated in radians per seconds or rad/s.

Angular speed for a single complete rotation is known as $\omega=\frac{2 \pi}{t}$

The connection between Angular speed and Linear Speed is $v=R \omega$

Where,

Linear speed $=\mathrm{v}$
The radius of the circular path $=\mathrm{R}$

## Angular Speed Numericals

Problem 1: Earth takes 365 days to complete a revolution around the sun. Calculate its angular speed.

## Answer:

Angular speed $(\omega)=\frac{\text { Totaldistancecovered }}{\text { Totaltimetaken }}=\frac{\theta}{t}$
where $\theta=2 \pi$
$\mathrm{t}=365$ * 24 * 60 * 60
$=31536000 \mathrm{~s}$
$\therefore$ Angular Speed $(\omega)=\frac{2 \pi}{31536000}$
$=1.9923 \times 10^{-7} \mathrm{rad} / \mathrm{s}$.

Problem 2: The wheel of a wagon of radius 1 m is travelling with the speed of 5 m per second. Calculate its angular speed. Solution:

Given: Linear speed $V=5 \mathrm{~m} / \mathrm{s}$, Radius of Circular path $r=1 \mathrm{~m}$

The Angular Speed $\omega=\frac{V}{r}$
$=\frac{5 \mathrm{~m} / \mathrm{s}}{1 \mathrm{~m}}$
$=5 \mathrm{rad} / \mathrm{s}$.

## MECHANICAL ADVANTAGE

## FORMULA

## A

mechanical advantage is a form of calculation that measures $t$ he amplified force taken by the mechanical system.

It gives the ratio between the force applied to the load and the force needed to overcome the given force. It is a unitless expression since the two ratio quantities are the force.

Mechanical advantage is also defined as the force created by the machine to the for applied on it. The formula of mechanical advantage is given as
$M A=\frac{F_{B}}{F_{A}}$
Wherein,
MA is the mechanical advantage,
$F_{B}=$ force of the object and
$\mathrm{F}_{\mathrm{A}}=$ effort to overcome the force of the object.

## Example 1

Estimate the mechanical advantage if 400 N force is needed to overcome the load of 900N.

Solution:
$\mathrm{F}_{\mathrm{A}}=400 \mathrm{~N}$
$\mathrm{F}_{\mathrm{B}}=900 \mathrm{~N}$

The formula of mechanical advantage is
$M A=F_{B} / F_{A}$
$M A=900 / 400$
$M A=2.25$

## BROWNIAN MOTION FORMULA

In a fluid, the particles move in a random direction. These particles collide with each other when they move. Brownian Motion refers to the random movement of the small particles that are suspended in fluids.

The Formula To Calculate Diffusion Constant
$D=R T N a \underline{6} \pi \eta a=k B T \underline{6} \pi \eta a$

Where,
$R$ is the gas constant
$\mathrm{Na}=6.06 \times 10^{23} \mathrm{~mol}^{-1}$ referred to as Avogadro's number
T is the temperature
$\eta$ is the viscosity of the liquid
a is the radius of the Brownian particle
$k B=R / N A$ is Boltzmans constant

Considering a large Brownian particle immersed in a fluid of much smaller particles (atoms). The radius of the Brownian particle is typically $10-9 \mathrm{~m}<\mathrm{a}<5 \times 10-7 \mathrm{~m}$.

## INTENSITY FORMULA

Intensity is the quantity of energy the wave conveys per unit time across a surface of unit area and it is also equivalent to the energy density multiplied by the wave speed. It is generally measured with units of watts per square meter. Intensity will depend on the strength and amplitude of a wave. Intensity is represented as I. The formula for intensity is articulated by,
$I=\frac{P}{A}$
Where $\mathbf{I}$ is the intensity, $\mathbf{P}$ is the power and $\mathbf{A}$ is the area of cross-section.

## Intensity Solved Examples

Let us discuss the questions related to intensity.

Problem 1: Calculate the intensity of a wave whose power is 25 KW and the area of cross-section is $35 \times 10^{6} \mathrm{~m}^{2}$ ?

## Answer:

Known measures are,
$P=25 K W=25 \times 10^{3} \mathrm{~W}, \mathrm{~A}=35 \times 10^{6} \mathrm{~m}^{2}$
Intensity formula is,
$I=\frac{P}{A}$
$I=25 \times 10^{3} / 35 \times 10^{6}$
$=7.14 \times 10^{-2} \mathrm{~W} / \mathrm{m}^{2}$

Problem 2: Calculate the power of a wave whose intensity and area of the cross-section are $30 \times 10^{-5} \mathrm{~W} / \mathrm{m}^{2}$ and $50 \mathrm{~m}^{2}$ respectively?

## Answer:

Known quantities are,
$\mathrm{I}=30 \times 10^{-5} \mathrm{~W} / \mathrm{m}^{2}$ and $\mathrm{A}=50 \mathrm{~m}^{2}$
Intensity formula is,
$I=\frac{P}{A}$
$P=1 \times A$
$P=30 \times 10^{-5} \times 50$
$P=0.015 W$

## TANGENTIAL ACCELERATION

## FORMULA

The concept of tangential acceleration is used to measure the change in the tangential velocity of a point with a specific radius with the change in time. The linear and tangential accelerations are the same but in the tangential direction which leads to the circular motion. Tangential acceleration is defined as the rate of change of tangential velocity of the matter in the circular path.

Tangential Acceleration Formula
$a t=\Delta v \Delta t$

Formula for Tangential Acceleration In Terms Of Distance
at=d2sdt2 Or
at=v.dvds

Notations Used In The Formula

- $a_{t}$ is the tangential acceleration
- $\Delta v$ is the change in the angular velocity
- $\Delta t$ is the change in time
- v is the linear velocity
- $s$ is the distance covered
- t is the time taken

The formula of tangential acceleration is used to calculate the tangential acceleration and related parameters and the unit is $\mathrm{m} / \mathrm{s}^{2}$

## Linear Acceleration Formula

Linear acceleration is defined as the uniform acceleration caused by a moving body in a straight line. There are three equations that are important in linear acceleration depending upon the parameters like initial and final velocity, displacement, time and acceleration.

Following is the table explain all the three equations that are used in linear acceleration:

First equation of motion

Second equation of motion

The third equation of motion
$\mathrm{v}=\mathrm{u}+\mathrm{at}$
$s=u t+12 a t \underline{2}$
$\mathrm{v} \underline{2}=\mathrm{u} \underline{2}+2 \mathrm{as}$

Notations Used In The Formula

- $u$ is the initial velocity
- $a$ is the acceleration
- t is the time taken
- v is the final velocity
- $s$ is the acceleration

Solved Example

## Example 1:

With a speed of $20 \mathrm{~m} / \mathrm{s}$ to $80 \mathrm{~m} / \mathrm{s}$ in 30 s , a body accelerates uniformly on a circular path. Calculate the acceleration to ta ngential.

Solution:

Given parameters
$\mathrm{v}_{\mathrm{i}}=20 \mathrm{~m} / \mathrm{s}$
$\mathrm{v}_{\mathrm{f}}=80 \mathrm{~m} / \mathrm{s}$
$d_{v}=v_{f}-v_{i}=80-20=60 \mathrm{~m} / \mathrm{s}$
$d_{t}=t_{f}-t_{i}=30-0=30 \mathrm{sec}$

The formula of tangential acceleration is
$a_{t}=d_{v} / d_{t}$
$a_{t}=60 / 30$
$a_{t}=2 \mathrm{~m} / \mathrm{s}^{2}$

## DYNAMIC VISCOSITY FORMULA

Dynamic Viscosity Formula for a fluid defines its internal resistance to flow due to some shearing force. A tangential force which acts when one horizontal plane moves with another one. The viscosity acts an important fluid property while analyzing the liquid behaviour and fluid motion near solid boundaries.

The formula for Dynamic Viscosity
$\mu=\tau y / u$
Where,
$u=$ shear velocity ( $\mathrm{m} / \mathrm{s}$ )
$y=$ distance between the layers
$\tau=$ shearing stress
$\mu=$ dynamic viscosity

The SI unit for Dynamic Viscosity $=\mathrm{Ns} / \mathrm{m}^{2}$

Solved Example
Question: A fluid moves along length 0.75 m with velocity $2 \mathrm{~m} / \mathrm{s}$ and has shearing stress of $2 \mathrm{~N} / \mathrm{m} 22$. Find its dynamic viscosity.

## Solution:

Given: Shear velocity $u=2 \mathrm{~m} / \mathrm{s}$, length $\mathrm{y}=0.75 \mathrm{~m}$, shearing stress $\tau=2 \mathrm{Ns} / \mathrm{m}^{2}$

The shearing stress is given by,
$\mu=\tau y / u$
$\mu=2 * 0.75 / 2$
$\mu=0.75 \mathrm{Ns} / \mathrm{m}^{2}$
Therefore, the dynamic viscosity $=0.75 \mathrm{Ns} / \mathrm{m}^{2}$

## COMBUSTION FORMULA

## Combustion Formula

## What is combustion?

Combustion is a rapid chemical reaction of a substance with oxygen involving the production of heat and light. Combustion is an exothermic reaction accompanied by the development of heat so that temperature rises considerably.

Combustion reaction with insufficient oxygen produces carbon monoxide instead of carbon dioxide. In general combustion processes oxidation-reduction reactions where the oxidizing agent is the oxidant and the reducing agent is the fuel.

Combustion Formula is expressed by
The heat of combustion $=$ Heat of formation of products Heat of formation of reactants.

The easiest way to identify a combustion reaction is that the products always contain carbon dioxide and water.

- Complete Combustion is the oxidation of hydrocarbon producing only carbon dioxide and water. Example for clean combustion is burning of candle wax, where the heat from the wick vaporizes wax (a hydrocarbon), which reacts with oxygen to release carbon dioxide and water
- Incomplete Combustion is hydrocarbon oxidation that produces carbon monoxide and/or carbon (soot) along with carbon dioxide. Example of incomplete combustion is the burning of coal, where a lot of soot and carbon monoxide is released.


## Example 1

Combustion of methane
$\mathrm{CH}_{4}(\mathrm{~g})+2 \mathrm{O}_{2}(\mathrm{~g}) \rightarrow \mathrm{CO}_{2}(\mathrm{~g})+2 \mathrm{H}_{2} \mathrm{O}(\mathrm{g})$

## Example 2

Burning of naphthalene
$\mathrm{C}_{10} \mathrm{H}_{8}+12 \mathrm{O}_{2} \rightarrow 10 \mathrm{CO}_{2}+4 \mathrm{H}_{2} \mathrm{O}$
Example 3
Combustion of ethane

$$
2 \mathrm{C}_{2} \mathrm{H}_{6}+7 \mathrm{O}_{2} \rightarrow 4 \mathrm{CO}_{2}+6 \mathrm{H}_{2} \mathrm{O}
$$

## Example 4

Combustion of butane (found in lighters)
$2 \mathrm{C}_{4} \mathrm{H}_{10}(\mathrm{~g})+13 \mathrm{O}_{2}(\mathrm{~g}) \rightarrow 8 \mathrm{CO}_{2}(\mathrm{~g})+10 \mathrm{H}_{2} \mathrm{O}(\mathrm{g})$

## Example 5

Combustion of methanol (wood alcohol)
$2 \mathrm{CH}_{3} \mathrm{OH}(\mathrm{g})+3 \mathrm{O}_{2}(\mathrm{~g}) \rightarrow 2 \mathrm{CO}_{2}(\mathrm{~g})+4 \mathrm{H}_{2} \mathrm{O}(\mathrm{g})$

## CENTROID FORMULA

Centroid formula is used to determine the coordinates of a triangle's centroid. The centroid of a triangle is the center of the triangle which can be determined as the point of intersection of all the three medians of a triangle. The median is a line drawn from the midpoint of any one side to the opposite vertex. It should be noted that the centroid divides all the medians of the triangle in 2:1 ratio.

## Centroid Formula

The Centroid Formula is given by

Formula for
Centroid

$$
C=\left[\left(x_{1}+x_{2}+x_{3}\right) / 3,\left(y_{1}+y_{2}+y_{3}\right) / 3\right]
$$

Where,

- C denotes centroid of the triangle.
- $x_{1}, x_{2}, x_{3}$ are the $x$-coordinates of the vertices of a triangle.
- $y_{1}, y_{2}, y_{3}$ are the $y$-coordinates of the vertices of a triangle.

Solved Example Questions From Centroid Formula

## Example 1:

Determine the centroid of a triangle whose vertices are $(5,3)$,
$(6,1)$ and $(7,8)$.

## Solution

Given parameters are,
$\left(x_{1}, y_{1}\right)=(5,3)$
$\left(x_{2}, y_{2}\right)=(6,1)$
$\left(x_{3}, y_{3}\right)=(7,8)$
The centroid formula is given by
$C=\left[\left(x_{1}+x_{2}+x_{3}\right) / 3,\left(y_{1}+y_{2}+y_{3}\right) / 3\right)$
$C=[(5+6+7) / 3,(3+1+8) / 3]$
$C=(18 / 3,12 / 3)$
$C=(6,4)$

## Example 2:

Calculate the centroid of a triangle whose vertices are $(9,0)$,
$(2,8)$ and $(1,4)$.

Solution

Given parameters are
$\left(x_{1}, y_{1}\right)=(9,0)$
$\left(x_{2}, y_{2}\right)=(2,8)$
$\left(x_{3}, y_{3}\right)=(1,4)$
The centroid formula is given by,
$C=\left[\left(x_{1}+x_{2}+x_{3}\right) / 3,\left(y_{1}+y_{2}+y_{3}\right) / 3\right]$
$C=[(9+2+1) / 3,(0+8+4) / 3]$
$C=(12 / 3,12 / 3)$
$C=(4,4)$
Example 3: If the $(2,2)$ are coordinates of the centroid of a triangle whose vertices are ( 0,4 ), $(-2,0)$ and $(p, 2)$, then find the value of $p$.

Solution:
Given vertices of a triangle are:
$\left(\mathrm{x}_{1}, \mathrm{y}_{1}\right)=(0,4)$
$\left(x_{2}, y_{2}\right)=(-2,0)$
$\left(x_{3}, y_{3}\right)=(p, 2)$
Centroid $=(x, y)=(2,2)$
Using the centroid formula,
$(x, y)=\left[\left(x_{1}+x_{2}+x_{3}\right) / 3,\left(y_{1}+y_{2}+y_{3}\right) / 3\right]$
$(2,2)=[(0-2+p) / 3,(4+0+2) / 3]$
$(2,2)=[(p-2) / 3,6 / 3)]$
Equating the $x$-coordinates,
$(p-2) / 3=2$
$\mathrm{p}-2=2 \times 3$
$p=6+2$
$\mathrm{p}=8$
Hence, the value of $p=8$

# UNIFORM CIRCULAR MOTION 

## FORMULA

## What is uniform circular motion?

The term circular is applied to describe the motion in a curved path. The motion of an object along a circular path covering equal distance along the circumference in the same interval of time is known as uniform circular motion. In any uniform circular motion, the speed remains constant, but the direction of the velocity changes.

The tangential speed at every point on the circumference is found to be constant in a uniform circular motion, and the tangential velocity vector is tangent at every point over the circumference.

Tangential velocity is the vector formed to the tangential speed; therefore, the magnitude remains constant and equal to the tangential speed of the uniform circular motion.

The Tangential speed of the uniform circular motion is given by,
$v=2 \pi r / T$

The centripetal acceleration is given by,
$a=v^{2} / r$

Where,
$\mathrm{v}=$ tangential velocity
$R=$ radius
$\mathrm{T}=$ period (Time required to take one complete circle)
$a=$ centripetal acceleration
Any object moving in uniform circular motion also has an angular velocity.

The object's velocity changes continuously and therefore there is an acceleration in the circular motion, and this acceleration is always directed towards the centre of the circle which is termed as centripetal acceleration.

Solved Numericals

## Example 1

A racer is moving with a constant tangential speed of $50 \mathrm{~m} / \mathrm{s}$, takes one lap around a circular track in 40 seconds. Calculate the magnitude of the acceleration of the car.

## Solution:

## Given:

Speed v $=50 \mathrm{~m} / \mathrm{s}$
$\mathrm{T}=40$ seconds.

We know that,

Acceleration,
$a=v^{2} / r$
$\mathrm{T}=2 \pi \mathrm{r} / \mathrm{v}$

Therefore, $r=\operatorname{Tv} / 2 \pi$

When both the formulas are combined, we get
$a=v 2 /(\operatorname{Tv} / 2 \pi)=v /(T / 2 \pi)$
$=50 /[40 / 6.28]$
$\mathrm{a}=7.86 \mathrm{~m} / \mathrm{s}^{2}$

## Example 2:

An object moving in a circular motion has a centripetal acceleration of $20 \mathrm{~m} / \mathrm{s} 2$. If the radius of the motion is 0.5 m , calculate the frequency of the motion.

Solution:

Given:

Acceleration $=20 \mathrm{~m} / \mathrm{s} 2$

Radius $=0.5 \mathrm{~m}$

We know that
$a=v^{2} / r$
$20=v^{2} / 0.5$
$v=3.16 \mathrm{~m} / \mathrm{s}$
$v=2 \pi r / t$
$3.16=(2)(3.14)(0.5) / t$
$3.16=3.14 / t$
$T=1.006$

Frequency, $f=1 / t=1 / 1.006$
Therefore, $\mathrm{f}=0.99 \mathrm{~Hz}$

## EQUIVALENT RESISTANCE

## FORMULA

The equivalent resistance is where the aggregate resistance connected either in parallel or series is calculated. Essentially, the circuit is designed either in Series or Parallel. Electrical resistance shows how much energy one needs when you move the charges/current through your devices. If you require lots of energy, then the resistance necessary is also high. The equivalent resistance of a network is that single resistor that could replace the entire network in such a way that for a certain applied voltage V you get the same current I as you were getting for a network.

Equivalent resistance formula for series resistance is given by,

$$
R=R_{1}+R_{2}+\ldots+R_{n}
$$

Equivalent resistance formula for parallel resistance is articulated as,
$\frac{1}{R_{p}}=\frac{1}{R_{1}}+\frac{1}{R_{2}}+\frac{1}{R_{3}}+\ldots+\frac{1}{R_{n}}$
Where, R1, R2.....Rn the given resistors.
Equivalent Resistance Examples
Let's see some examples of equivalent resistance numerical:
Solved Examples
Problem 1: What is the equivalent resistance if $3 \Omega, 20 \Omega$ and $32 \Omega$ are connected in series.

Answer:

Equivalent resistance in series is given by
$R=R_{1}+R_{2}+\ldots \ldots+R_{n}$
$=3 \Omega+20 \Omega+32 \Omega$
$R=55 \Omega$.

Problem 2: What is the equivalent resistance if $34 \Omega$ and $20 \Omega$ are connected in parallel.

Answer:

Equivalent resistance in parallel is given by
$\frac{1}{R_{p}}=\frac{1}{R_{1}}+\frac{1}{R_{2}}+\frac{1}{R_{3}}+\ldots+\frac{1}{R_{n}}$
$\frac{1}{R_{p}}=\frac{1}{34}+\frac{1}{20}$

Or
$R p=R 1 R 2 R 1+R 2$
$1 R p=0.029+0.05$
$1 R p=0.079$
$R_{p}=12.66 \Omega$

## REFRACTIVE INDEX FORMULA

The refractive index of a medium is defined as how the light travels through that medium. It is a dimensionless measure. It defines how much a light ray can be bent when it enters from one medium to the other. Snell's law clarifies the relation between the angle of incidence and angle of refraction. So, there are two formulas for calculating the refractive index of a medium. Let us imagine that a ray of light is travelling from a medium a to another medium $b$. Then conferring from Snell's law,
$\sin i$
$\overline{\sin r}=n$
here $\mathbf{n}$ is a constant value which is recognized as the refractive index of medium ' $b$ ', in regards to medium ' $a$ '.

The refractive index has no units as it is a ratio of two similar quantities.

Refractive index of a medium is also defined as the ratio of the speed of light in air or vacuum and the speed of light in that medium. If the speed of light in air is c and the speed of light in the medium is $v$ then the refractive index of the medium is articulated as,
$n=\frac{\text { speed of light in vacuum }}{\text { speed of light in medium }}=\frac{c}{v}$
Refractive Index Solved Examples
Let us discuss the questions of the refractive index of a medium.

Problem 1: A light ray is transient through a medium to another one. The angle of incident is provided as $30^{\circ}$ and the angle of refraction is $50^{\circ}$. Compute the refractive index of the second medium?

Answer:

Given parameters
i (Angle of incidence) $=30^{\circ}$ and
$r($ angle of refraction $)=50^{\circ}$

The formula for refractive index is articulated as,
$n=\frac{\sin i}{\sin r}$
$n=\frac{\sin 30}{\sin 50}$
$n=\frac{0.5}{0.7660}=0.6527$
Problem 2: Compute the refractive index of the medium if the speed of light in a medium is $2 \times 10^{8} \mathrm{~m} / \mathrm{s}$ ?

## Answer:

It is known that,
$v($ Speed of light in medium $)=2 \times 10^{8} \mathrm{~m} / \mathrm{s}$,
c (Speed of light in vacuum) $=3 \times 10^{8} \mathrm{~m} / \mathrm{s}$
The formula of refractive index of the medium is,

$$
\begin{aligned}
& n=\frac{c}{v} \\
& n=\frac{3 \times 108}{2 \times 108}=1.5
\end{aligned}
$$

## OPTICS FORMULA

Optics describes the light propagation in terms of the light ray. The light ray in geometrical optics is an instrument which is used to approximate models of how the light will propagate. Light rays tend to bend at the interface of two different medium where the refractive index changes. The geometrical optics gives us the rules for light propagating through optical devices.

The geometrical optics could be made used to explain the geometrical imaging and aberrations.

The lens is one of such optical device with axial symmetry which allows and refracts light ray to either converge or diverge the light beam.

The formula for a thin lens is as follows:
$\underline{1} \mathrm{f}=\underline{1} \mathrm{v}+\underline{1} \mathrm{u}$

Where
fis the focal length of the thin lens
$\mathbf{v}$ is the image distance
$\mathbf{u}$ is the object distance.
Magnification of lens is the process by which an object is enlarged in appearance without increasing the size physically.

The formula which helps in getting the thin lens magnification is given by $m=$ hiho

Height of image height of object
Power of lens (dioptre) = $\underline{1 f}$ (in meters)

Solved Examples
Question 1: A short-sighted person can see clearly at a distance of 20 cm . Calculate the lens power essential for the person to see as far as 60 cm ?

## Solution:

The power required for a far point of 60 cm is
$1 / f=1 / u+1 / v$

$$
=1 / 60-1 / 20
$$

$$
=-2 / 60
$$

$$
1 / f=-1 / 30
$$

$f=-30 \mathrm{~cm}=0.30 \mathrm{~m}$

Power $D=1 / f=1 / 0.30$

Power=3 dioptres

## LATTICE ENERGY FORMULA

The total potential energy of the ionic compounds which is also referred to the lattice energy $U_{\mathrm{L}}$ per mole may be defined as the sum of the electrostatic and repulsive energy. The Born-Lande equation provides lattice energy.

Lattice Energy Formula per mole is symbolized as
$U_{L}=\left(\frac{N_{A} \alpha Z^{2} e^{2}}{4 \pi \varepsilon_{0} r^{2} o}\right)\left(1-\frac{1}{n}\right)$
$\mathrm{N}_{\mathrm{A}}=$ Avogadro's constant $\left(6.022 \times 10^{22}\right)$
$\alpha=$ Madelung constant
$\mathrm{e}=$ Electron charge $\left(1.6022 \times 10^{-19} \mathrm{C}\right)$
$\mathrm{Z}^{+}$and $\mathrm{Z}^{-}=$Cation and anion charge
$\epsilon_{\mathrm{o}}=$ Permittivity of free space
$\mathrm{n}=$ Born Exponent
$r_{0}=$ Closest ion distance
$\mathrm{U}_{\mathrm{L}}=$ equilibrium value of the lattice energy

## Lattice Energy Solved Examples

Solved questions based on lattice energy are provided below.

## Problem 1: Compute the Lattice energy of NaCl by using Born-Lande equation.

Given
$\alpha=1.74756$
$\mathrm{Z}^{-}=-1$ (the $\mathrm{Cl}^{-}$ions charge)
$\mathrm{Z}^{+}=+1$ (the charge of the $\mathrm{Na}^{+}$ion)
$\mathrm{N}_{\mathrm{A}}=6.022 \times 10^{23}$ ion pairs $\mathrm{mol}^{-1}$
$\mathrm{C}=1.60210 \times 10^{-19} \mathrm{C}$ (the charge on the electron)
$\pi=3.14159$
$\varepsilon \circ=8.854185 \times 10^{-12} \mathrm{C}^{2} \mathrm{~J}^{-1} \mathrm{~m}^{-1}$
$r_{0}=2.81 \times 10^{-10} \mathrm{~m}$, the sum of radii of Born-Lande equation.
$\mathrm{Na}^{+}$and Cl ${ }^{-}$
$\mathrm{n}=8$ the average of the values for $\mathrm{Na}^{+}$and $\mathrm{Cl}^{-}$.

## Answer:

Using the Born-Lande equation.
$U_{L}=\left(\frac{N_{A} \alpha Z^{2} e^{2}}{4 \pi \varepsilon_{0} r^{2} o}\right)\left(1-\frac{1}{n}\right)$
Substitute all the values in the equation
$\mathrm{U}_{\mathrm{L}}=-755 \mathrm{KJmol}^{-1}$
Problem 2: The lattice energy of AgBr is $895 \mathrm{KJ} \mathrm{mol}^{-1}$. Predict the Lattice energy of the isomorphous Agl using Born-Lande equation. The numerics of $r_{c}+r_{a}$ is 321pm for AgBr and 342pm for Agl.

## Answer:

If the only variance between AgBr and Ag were in the size of the anion, one would expect the lattice energies to be relational to the inverse ratio of $r_{c}+r_{a}$. Henceforth we expect the Lattice energy of Agl to be
$=(895)\left(\frac{321}{342}\right)=840$ K Jmole $^{-1}$

## DC VOLTAGE DROP FORMULA

The Voltage Drop Formula is used in the calculation of voltage drop in the electrical circuit. Voltage drop is the decrease in electric potential while the electric current moves through the circuit. The decrease in voltage in the circuit is caused due to impedance.

The formula for DC voltage drop is
$V=I R$

Where
$\boldsymbol{V}=$ Voltage drop in the circuit

I = current through the circuit
$\mathbf{R}=$ resistance

## Solved Examples

Question 1: Calculate the dc voltage drop if 50 Ampere current flows through the wire of resistance 5 ohms.

Solution:

Given:

Current $\mathrm{I}=50 \mathrm{~A}$

Resistance $\mathrm{R}=5$ ohms

Voltage drop is given by
$V=I R$
$V=(50)(5)$
$\mathrm{V}=250$ volts

## VOLTAGE DIVIDER FORMULA

The voltage divider is the series of resistors or capacitors that can be tapped at any intermediate point to generate a specific fraction of the voltage applied between its ends.

It consists of an electric circuit composed of two resistors and one input voltage supply. Below figure shows a simple voltage divider. In this circuit, two resistors are connected in series. The output voltage of the voltage divider is a function of the input voltage. This circuit helps to determine how the input voltage divides among the components in the circuit.

The voltage divider formula is given by,
$V_{\text {out }}=\frac{R_{b}}{R_{a}+R_{b}} V_{\text {in }}$
Where,

Vout = output voltage
$\mathbf{R}_{\mathrm{a}}$ and $\mathbf{R}_{\mathrm{b}}=$ resistors
$\mathbf{V}_{\text {in }}=$ input voltage

Solved Examples

## Example 1

Determine the output voltage of the voltage divider circuit whose $R_{a}$ and $R_{b}$ are $6 \Omega$ and $8 \Omega$ respectively and the input voltage is 10 v .

## Solution:

Given:
$R_{a}=6 \Omega$,
$R_{b}=8 \Omega$
$V_{\text {in }}=10 \mathrm{~V}$

Voltage divider formula is given by,
$V_{\text {out }}=\frac{R_{b}}{R_{a}+R_{b}} V_{\text {in }}$
$=[8 /(6+8)] 10$
$\mathrm{V}_{\text {out }}=5.71 \mathrm{~V}$

## Example 2

The value of the input voltage of a voltage divider is 20 V , and the resistors are $5 \Omega$ and $7 \Omega$. Determine the output voltage.

## Solution:

Given:
$R_{a}=5 \Omega$,
$R_{b}=7 \Omega$
$V_{\text {in }}=20 \mathrm{~V}$
Voltage divider formula is given by,
$V_{\text {out }}=\frac{R_{b}}{R_{a}+R_{b}} V_{\text {in }}$
$=[7 /(5+7)] 20$

Vout $=11.66 \mathrm{~V}$

## DOPPLER EFFECT FORMULA

Doppler Effect defines the apparent change in the frequency of sound when the observer and the medium both are in relative motion. It's a wave phenomenon which holds not just for sound waves but also for electromagnetic waves like microwaves, visible light, and microwaves. It depends on three factors - Velocity of the source, Velocity of the medium and Velocity of the observer.

Formula
$f^{\prime}=\left(\frac{v+v_{0}}{v-v_{s}}\right) f$
f '= observed frequency
$\mathrm{f}=$ actual frequency of the sound wave
$V$ = speed of the sound wave

Vo = velocity of the observer

Vs = velocity of the source

## Solved Examples

## Question:

A Submarine travels through water at a speed of $8.00 \mathrm{~m} / \mathrm{s}$, emitting a sonar wave at a frequency of 1400 Hz . The speed of sound in the water is $530 \mathrm{~m} / \mathrm{s}$. A second submarine is located such that both submarines are travelling directly towards each other. The second submarine is moving at $6.00 \mathrm{~m} / \mathrm{s}$.
(A) What is the frequency detected by an observer riding on the second submarine as the first submarine approaches it?
(B) The submarine barely misses each other and pass. What frequency is detected by an observer riding on the second submarine as the subs recede from it?
(C) When both the submarine approaches each other, some of the sounds from the first submarine reflects from the second
submarine and returns to it. If the sound were to be detected by a first submarine, what is its frequency?

## Solution:

Given: Frequency f = 1400 Hz ,

Velocity of first submarine, $\mathrm{V}_{\mathrm{s}}=8 \mathrm{~m} / \mathrm{s}$,

Velocity of second submarine, $\mathrm{V}_{\mathrm{o}}=6 \mathrm{~m} / \mathrm{s}$.

Speed of sound in water V $=530 \mathrm{~m} / \mathrm{s}$
(A) The Apparent frequency is given by,
$f^{\prime}=\left(\frac{v+v_{0}}{v-v_{s}}\right) f$
$f^{\prime}=\left(\frac{530+6}{530-8}\right) 1400$
$f^{\prime}=1437.54 \mathrm{~Hz}$.
(B) To find Doppler-shifted frequency heard by the observer in second submarine:
$f^{\prime}=\left(\frac{v+v_{0}}{v-v_{s}}\right) f$
$f^{\prime}=\left(\frac{530+(-6)}{530-(-8)}\right) 1400$
$f^{\prime}=1363.56 \mathrm{~Hz}$.
(C)The Sound of apparent frequency 1436.5 Hz found in part
(A) is reflected from a moving source (sub B) and detected by a moving observer
$f^{\prime \prime}=\left(\frac{v+v_{0}}{v-v_{s}}\right) f^{\prime}$
$f^{\prime \prime}=\left(\frac{530+6}{530-8}\right) 1437.54$
$\mathrm{f}^{\prime \prime}=1476 \mathrm{~Hz}$

## AVERAGE FORCE FORMULA

## Average Force Formula

The force applied by a body that's travelling at a definite velocity (rate of speed) for a definite period of time is the average force. The word 'average' is made use of to specify that this velocity is not an accurately measured or 'instantaneous' velocity. Therefore, the mass of the body multiplied by the average velocity over the definite time is equivalent to average force.

For a particular interval of time $\mathbf{t}$, the force is described as the frequency of change of momentum. It is hard to compute the rate of change if the time interval is minor. There the term, average force makes an entrance.

Over a period of intervals $(\Delta t)$ the rate of change of momentum is Average force. It is given by
$F=m\left(v_{f}-v_{i}\right) / \Delta t$

Where,
the mass of the body is $m$,
the final momentum is $\mathrm{v}_{\mathrm{f}}$,
the initial momentum is $v_{i}$,
the change in time is $\Delta \mathrm{t}$.

The Average Force Formula aids one in getting the rate of change of momentum for any number of time intervals ( $\Delta \mathrm{t}$ ). Expressed in Newton (N).

## Average Force - Samples

Problem 1: A child throws bowling ball having a mass of 5 kg and it rolls with a velocity of $4 \mathrm{~m} / \mathrm{s}$ for 1 s . Compute its average force?

## Answer:

Known: Mass of bowling ball $\mathrm{m}=5 \mathrm{~kg}$,
Initial velocity $\mathrm{v}_{\mathrm{i}}=0$
Final velocity $\mathrm{v}_{\mathrm{f}}=4 \mathrm{~m} / \mathrm{s}$
The Average force is given by
$F=m\left(v_{f}-v_{i}\right) / \Delta t$
$F=5(4-0) / 1$
$\mathrm{F}=20 \mathrm{~N}$

Problem 2: A rubber ball of mass 0.25 kg rolls over the gravel with velocity $1.5 \mathrm{~m} / \mathrm{s}$ and halts after 2 s . Compute its average force?

## Answer:

Known: $\mathrm{m}=0.25 \mathrm{~kg}$, (Mass of the ball)
$v=1.5 \mathrm{~m} / \mathrm{s}$, (Velocity of ball)

The Average force is given by
$\mathrm{F}=\mathrm{m}\left(\mathrm{v}_{\mathrm{f}-} \mathrm{v}_{\mathrm{i}}\right) / \Delta \mathrm{t}, \quad \mathrm{F}=0.25(1.5-0) / 2=0.1875 \mathrm{~N}$

## STRAIN ENERGY FORMULA

## Strain Energy Formula

Strain energy is defined as the energy stored in a body due to deformation. The strain energy per unit volume is known as strain energy density and the area under the stress-strain curve towards the point of deformation. When the applied force is released, the whole system returns to its original shape. It is usually denoted by U .

The strain energy formula is given as,
$\mathrm{U}=\mathrm{F} \delta / 2$

Where,
$\delta=$ compression,

F = force applied.

When stress $\sigma$ is proportional to strain $\epsilon$, the strain energy formula is given by,
$U=\frac{1}{2} V \sigma \varepsilon$
Where,
$\sigma=$ stress
$\varepsilon=$ strain
$\mathrm{V}=$ volume of body
Regarding young's modulus $E$, the strain energy formula is given as,
$\mathrm{U}=\mathrm{\sigma}^{2} / 2 \mathrm{E} \times \mathrm{V}$.
Where,
$\sigma=$ stress,
$E=$ young's modulus,
V = volume of body.

## Example 1

When a force of 1000 N is applied on a body, it gets compressed by 1.2 mm . Determine the strain energy.

## Solution:

Given:

Force F = 1000 N,
Compression $\delta=1.2 \mathrm{~mm}$

Strain energy formula is given by,
$U=F \delta / 2$
$=1000 \times 1.2 \times 10^{-3} / 2$
Therefore, $\mathrm{U}=0.6 \mathrm{~J}$.

## Example 2

A rod of area $90 \mathrm{~mm}^{2}$ has a length of 3 m . Determine the strain energy if the stress of 300 MPa is applied when stretched. Young's modulus is given as 200 GPa.

## Solution:

Given:
Area $\mathrm{A}=90 \mathrm{~mm}^{2}$

Length $\mathrm{I}=3 \mathrm{~m}$
Stress $\sigma=300 \mathrm{MPa}$

Young's modulus E = 200 GPa

Volume V is given by the formula

V = area*length
$=\left(90 \times 10^{-6}\right) \times 3$
$\mathrm{V}=270 \times 10^{-6} \mathrm{~m}^{3}$
The strain energy formula is given as,
$U=\sigma^{2} / 2 E \times V$
$=\left(300 \times 10^{6}\right)^{2} / 2 \times 200 \times 10^{9} \times 270 \times 10^{-6}$
Therefore, $\mathrm{U}=83.3 \times 10^{6} \mathrm{~J}$
Therefore, the strain energy of the rod is $83.3 \times 10^{6} \mathrm{~J}$

## PRESSURE DROP FORMULA

Pressure drop describes the difference in the pressure between two points of a network carrying fluid. Pressure drop occurs when the frictional force caused by the resistance to flow acting on the fluid as it flows through the tube.

It has a relation between viscosity and velocity of the liquid. The main factors that determine the resistance to the liquid flow are fluid velocity through the pipe and the fluid viscosity. Pressure drop is proportional to the frictional shear forces within the pipe network.

The Pressure drop is denoted by J.
The pressure drop formula is given by
$J=f L v^{2} / 2 g D$
$J=\frac{f L v^{2}}{2 g D}$

Where,
$\mathrm{J}=$ pressure drop
$\mathrm{f}=$ friction factor
$L=$ length of the tube
$v=$ velocity of the fluid
$\mathrm{g}=$ acceleration due to gravity
$D=$ inner diameter of the tube
Example 1
Determine the pressure drop of a fluid whose velocity is
$60 \mathrm{~m} / \mathrm{s}$. The length of the tube is 20 m ; the inner diameter is given as 0.1 m , and the friction factor is 0.5 .

Solution:

Given
$f=0.5$
$\mathrm{L}=20 \mathrm{~m}$
$v=60 \mathrm{~m} / \mathrm{s}$
$\mathrm{g}=9.8 \mathrm{~m} / \mathrm{s}$
$D=0.1 m$

Pressure drop formula is given by,
$J=f L v^{2} / 2 g D$
$J=\left(0.5 \times 20 \times 60^{2}\right) /(2 \times 9.8 \times 0.1)$
$\mathrm{J}=36000 / 1.96$
$\mathrm{J}=18367.34 \mathrm{~Pa}$

Example 2
Determine the pressure drop of a liquid whose velocity is
$10 \mathrm{~m} / \mathrm{s}$. The length of the tube is 4 m ; the inner diameter is given as 0.5 m , and the friction factor is 0.3 .

Solution:

## Given

$f=0.3$
$\mathrm{L}=4 \mathrm{~m}$
$v=10 \mathrm{~m} / \mathrm{s}$
$\mathrm{g}=9.8 \mathrm{~m} / \mathrm{s}$
$D=0.5 m$
Pressure drop formula is given by,
$J=f L v^{2} / 2 g D$
$J=(0.3 \times 4 \times 100) /(2 \times 9.8 \times 0.5)$
$\mathrm{J}=120 / 9.8$
$\mathrm{J}=12.24 \mathrm{~Pa}$.

