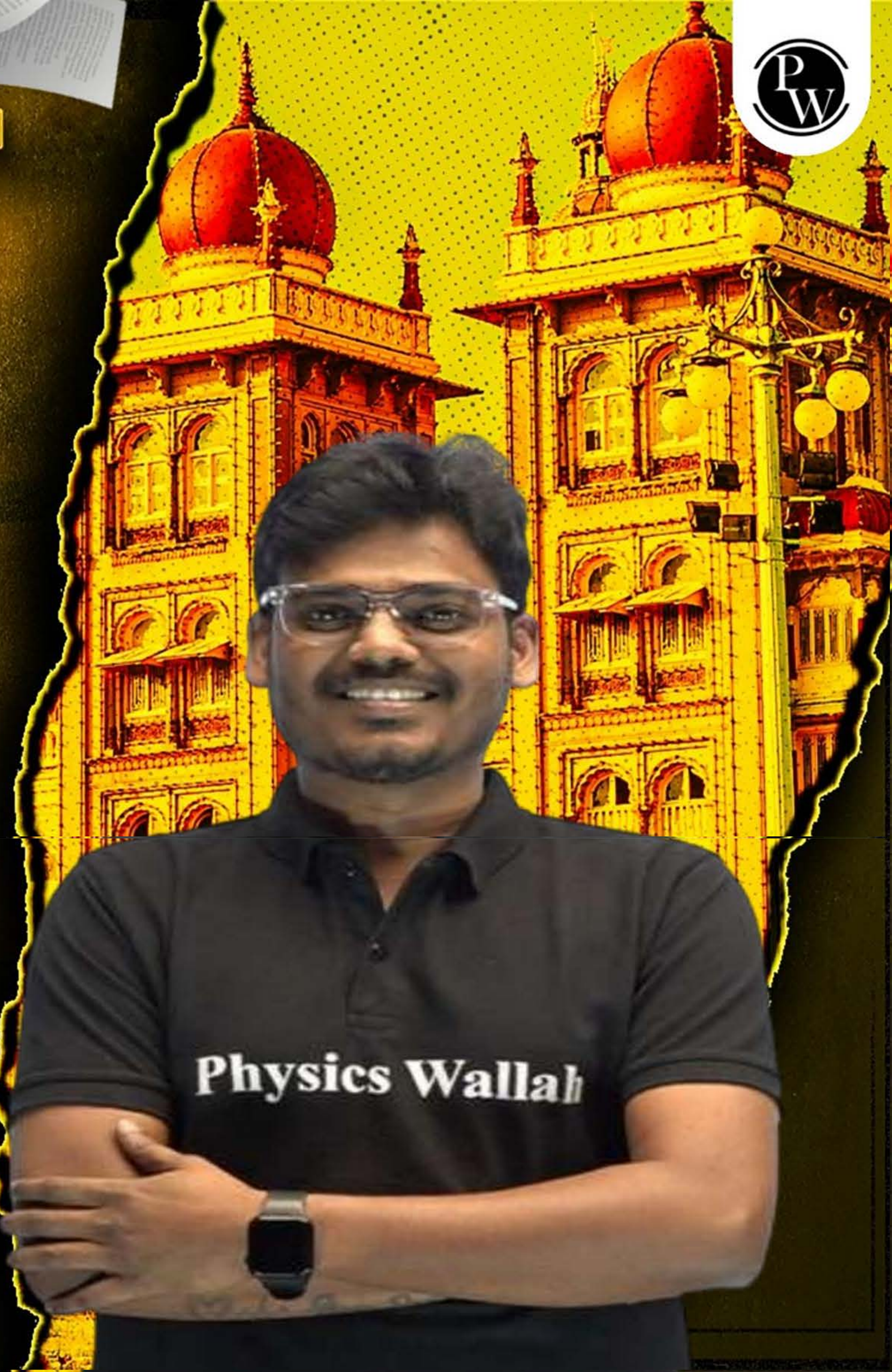
# ULTIMATE KCET

## CRASH COURSE 2026

Physics | Lecture : 01

**Gravitation & Mechanical properties of solids**

By: AK Sir



# Recap *of previous lecture*

1. UNIFORM CIRCULAR MOTION
2. VERTICAL CIRCULAR MOTION
3. COM & COLLISION
4. SYSTEM OF PARTICLES AND ROTATIONAL MOTION

# Topics

*to be covered*

1. GRAVITATION
2. QUESTIONS ON GRAVITATION
3. MECHANICAL PROPERTIES OF SOLIDS
4. QUESTION MPOS

$q \rightarrow$ mass

$K \rightarrow G$.

E & F

$F = K\frac{q_1 q_2}{r^2}$

$r > R$

$r = R$

$r < R$

PEC

$U = -K\frac{q_1 q_2}{r}$

**Gravitations**

Atom

$K.E = \frac{Ke^2}{2r}$

$P.E = -\frac{Ke^2}{r}$

$T.E = -\frac{Ke^2}{2r}$

$K.E = \left|\frac{P.E}{2}\right|$

$T.E = |K.E|$

# Gravitation

Newton's universal law of gravitation.

$$\boxed{F = G\frac{Mm}{R^2}} \quad \text{OR} \quad \boxed{F = G\frac{m_1 m_2}{r^2}}$$

$G = 6.675 \times 10^{-11}\ Nm^2/kg^2$

↳ Universal constant

Acceleration due to gravity.

$g = 9.8\ m/s^2$

$g = 9.8\ N/kg$

$$\boxed{g = \frac{GM}{R^2}}$$

*

g-variable

$F = mg$

$\frac{GMm}{R^2} = mg$

Weight $(W = mg)$

↓

g-Variable

mass $(m)$

Relationship between g and G

in terms density

$D = \frac{M}{V}$

$g = \frac{G}{R^2} \times DV = \frac{GD}{\cancel{R^2}} \times \frac{4}{3}\pi R^3$

$$\boxed{g = \frac{4\pi}{3} GDR}$$

$$\boxed{\begin{matrix} g \propto D \\ g \propto R \end{matrix}}$$

# ACCELERATION DUE TO GRAVITY[g]

Trick If $g_h = g_d$

$\boxed{d = 2h}$

$R = 6400\,km$ Variation in 'g' due to height (h)

**Upto 5 km**
Near Earth surface

$g_s = \frac{GM}{R^2}$

$g_s = 9.8\,m/s^2$
$\simeq 10\,m/s^2$

**5 km < h < 500 km**

$g_h = g_s\left(1 - \frac{2h}{R}\right)$


**h > 500km**

$g_h = \frac{g_s}{\left(1+\frac{h}{R}\right)^2}$

**At the Depth**

$g_d = g_s\left(1 - \frac{d}{R}\right)$

At centre $d = R$

$g_d = 0 \rightarrow$ weightlessness

$$U = -K\frac{q_1 q_2}{r}.$$

# Gravitation

Gravitational potential energy:

$$\boxed{U = -\frac{GMm}{r}.}$$

$$r = R + h$$

Gravitational potential energy of a body at height $h$ above the surface of the earth

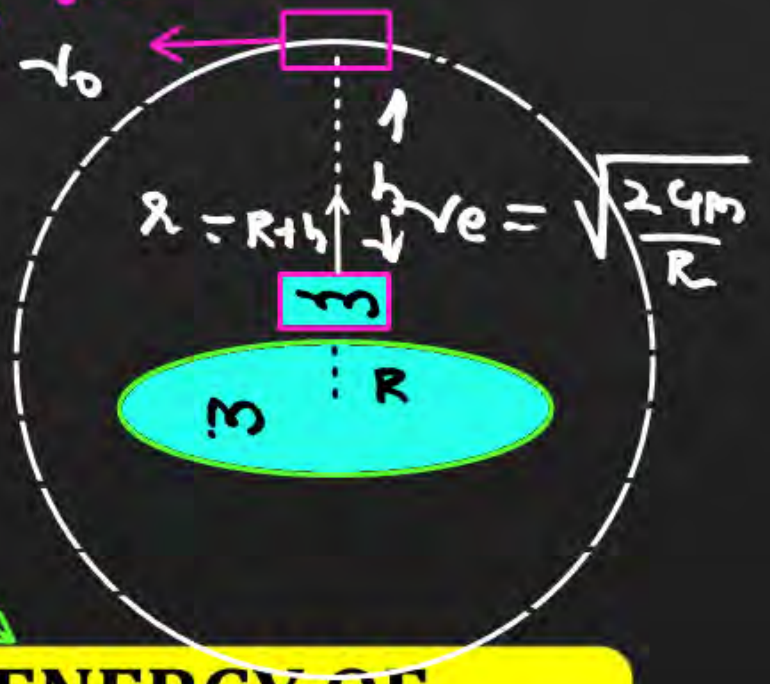
* $$\boxed{U = -\frac{GMm}{R+h}}$$

on the surface of planet $h \to 0$

* $$\boxed{U = -\frac{GMm}{R}}$$

# SATELLITE MOTION

→ compare with motion of Electron in an orbit in-Atom.




## MOTION OF A SATELLITE

### ESCAPE VELOCITY

* $v_e = \sqrt{\frac{2GM}{R}}$

$\boxed{v_e = 11.2 \text{ km/s}}$

### ORBITAL VELOCITY

* $v_o = \sqrt{\frac{GM}{r}} = \sqrt{\frac{GM}{R+h}}$

$v_o = \sqrt{2gr}$

### ENERGY OF SATELLITE

T.E = K.E + P.E

# ENERGY OF SATELLITE

## ENERGY OF SATELLITE

$K.E = \frac{Ke^2}{2r}$

$P.E = -\frac{K.e.e}{r} = -\frac{Ke^2}{r}$

### KINETIC ENERGY

$\boxed{K.E = \frac{GMm}{2r}}$

$K.E = \frac{GMm}{2(R+h)}$

$T.E = K.E + P.E$

$\boxed{T.E = -\frac{GMm}{2r}}$

$K.E = \left|\frac{P.E}{2}\right|$

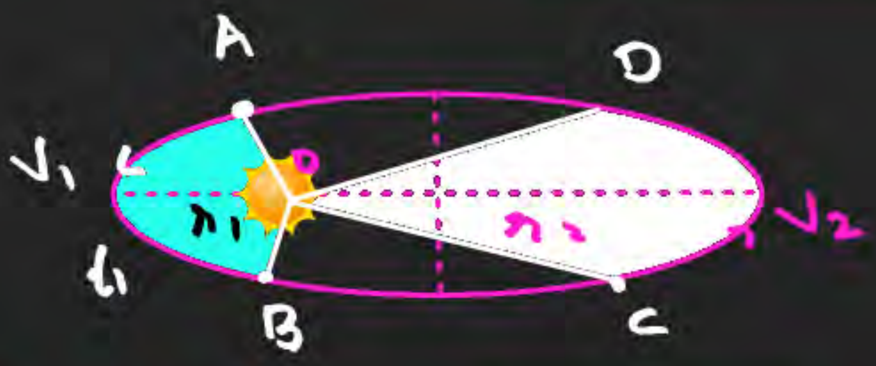
$T.E = |K.E|$

### POTENTIAL ENERGY

$\boxed{P.E = -\frac{GMm}{r}}$

# KEPLER'S LAWS

Area => OAB = OCD    $\boxed{v_1 r_1 = v_2 r_2}$




$F = \frac{mv^2}{r}$ , $\boxed{v \propto \frac{1}{r}}$

KEPLER'S LAWS

$\tau = \frac{dL}{dt}$

$0 = \frac{dL}{dt} \Rightarrow L = \text{const}$

**LAW OF ORBITS**

↳ Elliptical orbit

**LAW OF AREAS**

$\frac{dA}{dt} = \frac{L}{2m} = \text{constant}$

L - Angular momentum

L = constant

**LAW OF PERIODS**

$T = 2\pi\sqrt{\frac{r^3}{GM}}$

* $\boxed{T^2 \propto r^3}$

## QUESTION

Newton's law of gravitation:

**A** Is not applicable out side the solar system

**B** Is used to govern the motion of satellites only

**C** Control the rotational motion of satellites and planets

**D** Control the rotational motion of electrons in atoms

QUESTION

Gravitational force between two masses at a distance 'd' apart is $\boxed{6N.}$ If these masses are taken to moon and kept at same separation, then the force between them will become:

$F = \frac{GMm}{R^2}$

A 1 N

B 1/6 N

C 36 N

D $\boxed{6\ N}$

QUESTION

G.

The value of universal gravitational constant G depends upon:

A. Nature of material of two bodies ✗

B. Heat constant of two bodies ✗

C. Acceleration of two bodies ✗

D. None of these

QUESTION

If the distance between two masses is doubled, the gravitational attraction between them

$F = \frac{GMm}{R^2}$ $F' = \frac{GMm}{(2R)^2} = \frac{F}{4}$

(A) Is doubled

(B) Becomes four times

(C) Is reduced to half

(D) Is reduced to a quarter

QUESTION

The gravitational force between two stones of mass 1 kg each separated by a distance of 1 metre in vacuum is

(A) Zero

(B) $6.675 \times 10^{-5}$ *newton*

(C) $\boxed{6.675 \times 10^{-11} \textit{ newton}}$

(D) $6.675 \times 10^{-8}$ *newton*

$F = \frac{G \cdot m_1 \cdot m_2}{r^2} = \frac{6.675 \times 10^{-11} \times 1 \times 1}{1^2}$

$\boxed{F = 6.675 \times 10^{-11} N}$

QUESTION

$E = \frac{F}{q}$

A body of mass 60 g experiences a gravitational force of 3.0 N when placed at a particular point. The magnitude of the gravitational field intensity at that point is:

$E_g = \frac{F}{m} = \frac{3}{60 \times 10^{-3}} = \frac{3 \times 10^3}{60} = \frac{3000}{60}$

(A) 0.05 N/kg

(B) $\boxed{50 \text{ N/kg}}$

(C) 20 N/kg

(D) 180 N/kg

$\boxed{E_g = 50 \text{ N/kg}}$

## QUESTION

Two spheres of masses m and M are situated in air and the gravitational force between them is F. The space around the masses is now filled with a liquid of specific gravity 3. The gravitational force will now be:

(A) F/3

(B) F/g

(C) 3F

(D) F

## QUESTION

Two astronauts are floating in gravitational free space after having lost contact with their spaceship. The two will

(A) Keep floating at the same distance between them

(B) $\boxed{\text{Move towards each other}}$

(C) Move away from each other

(D) Will become stationary

## QUESTION

Two bodies of masses $m_1 = 5$ kg and $m_2 = 10$ kg are placed on $x$-axis 2 $m$ apart. If origin has to be taken at mass $m_1$, the gravitational force on $m_2$ is represented as

(A) $\frac{-15G}{4}\hat{\imath}$

(B) $\boxed{\frac{-25G}{2}\hat{\imath}}$

(C) $\frac{20G}{6}\hat{\imath}$

(D) $\frac{-30G}{4}\hat{\imath}$

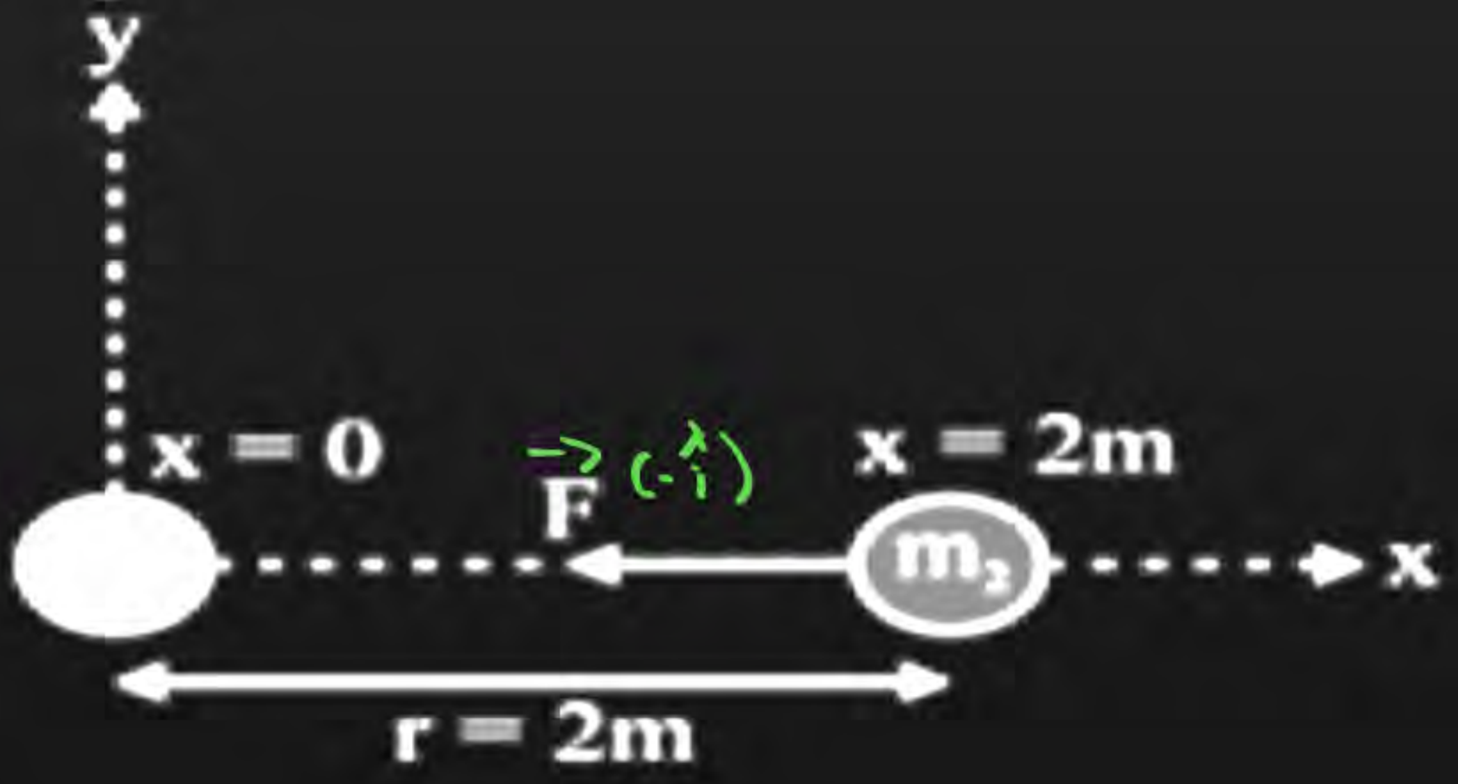
$F = G\frac{m_1 m_2}{r^2}$

$F = G \times \frac{5 \times 10}{2^2}$

$F = G \times 5 \times \frac{10^{5}}{4_{2}} = \frac{25}{2}G$

$\vec{F} = \frac{25}{2}G(-\hat{i})$

$\boxed{\vec{F} = -\frac{25}{2}G\hat{i}}$



QUESTION

$W = mg$

A body weight 72 N on the surface of the earth. What is the gravitational force on it, at a height equal to half of radius of the earth?

$h = \frac{R}{2}$ 3200 Km

$h > 500$ Km

A. $\boxed{32 \text{ N}}$

B. 30 N

C. 24 N

D. 48 N

$$g_h = \frac{g_s}{\left(1+\frac{h}{R}\right)^2} = \frac{g_s}{\left(1+\frac{R}{2R}\right)^2} = \frac{g_s}{\left(\frac{3}{2}\right)^2}$$

$$g_h = \frac{4}{9} g_s$$

$$mg_h = \frac{4}{9} \times mg_s$$

$$W_h = \frac{4}{9} \times W_s = \frac{4}{9} \times 72$$

$$\boxed{W_h = 32 N}$$

**QUESTION**

A body weight 200 N on the surface of the earth. How much will it weight half way down to the center of the earth?

$d = \frac{R}{2}$

(A) 200 N

(B) 250 N

(C) $\boxed{100\text{ N}}$

(D) 150 N

$g_d = g_s\left(1 - \frac{d}{R}\right)$

$g_d = g_s\left(1 - \frac{\cancel{R}}{2 \times \cancel{R}}\right)$

$g_d = g_s\left(\frac{1}{2}\right) = \frac{g_s}{2}$

$mg_d = \frac{mg_s}{2}$

$W_d = \frac{W_s}{2} = \frac{200}{2}$

$\boxed{W_d = 100\text{ N}}$

QUESTION

$h = 1\,km$

The acceleration due to gravity at a $\boxed{\text{height 1 km}}$ above the earth is the same as at a depth d below the surface of earth. Then:

A. d = 1/2 km

B. d = 1 km

C. d = 3/2 km

D. $\boxed{\text{d = 2 km}}$

$$g_h = g_d$$

$$\Rightarrow \quad d = 2h$$

$$d = 2 \times 1$$

$$\boxed{d = 2\,km}$$

## QUESTION

When a body is taken from the equator to the poles, $\boxed{\text{its weight}}$ $W = mg$

A. Remains constant ✗

B. $\boxed{\text{Increases}}$

C. Decreases

D. Increases at N-pole and decreases at S-pole

$g_p > g_e$

$W_p > W_e$

QUESTION

The depth at which the effective value of acceleration due to gravity is g/4 is

A. R

B. $\boxed{3R/4}$

C. R/2

D. R/4

$g_d = g_s\left(1 - \frac{d}{R}\right)$

$\frac{\cancel{g}}{4} = \cancel{g}\left(1 - \frac{d}{R}\right)$

$\frac{1}{4} = 1 - \frac{d}{R}$

$\frac{d}{R} = 1 - \frac{1}{4} = \frac{3}{4}$

$\boxed{d = \frac{3R}{4}}$

QUESTION

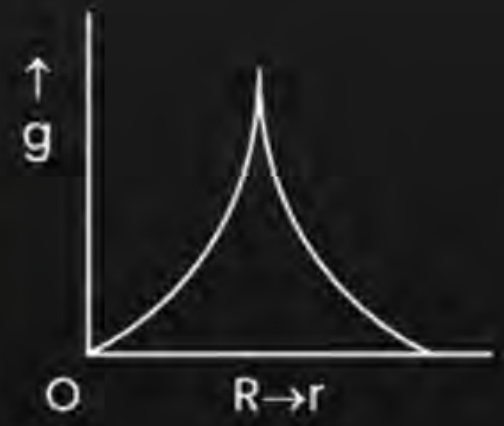
Starting from the center of the earth having radius R, the variation of g (acceleration due to gravity) is shown by:

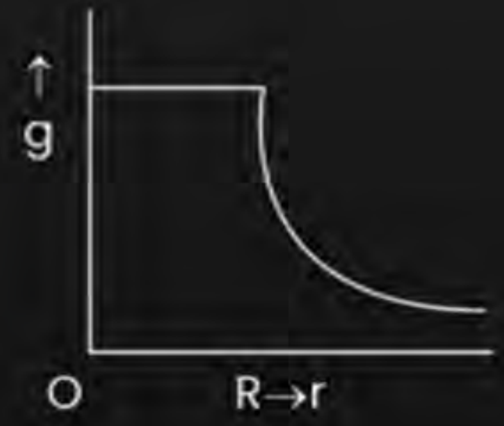
(A)



(B)



(C)



(D)


**QUESTION**

Assuming that the gravitational potential energy of an object at infinity is zero, the change in potential energy (final-initial) of an object of mass m, when taken to a height h from the surface of earth (of radius R) is given by:

(A) –GMm/R + h

(B) $\boxed{\text{GMmh/R(R + h)}}$

(C) mgh

(D) GMm/R + h

$$U = -\frac{GMm}{r}, \quad r = R+h$$

$$U_i = -\frac{GMm}{R}, \quad h \to 0$$

$$U_f = -\frac{GMm}{R+h}$$

$$\Delta U = U_f - U_i = -\frac{GMm}{R+h} - \left(-\frac{GMm}{R}\right)$$

$$\Delta U = \frac{GMm}{R} - \frac{GMm}{R+h}$$

$$\Delta U = GMm\left(\frac{1}{R} - \frac{1}{R+h}\right)$$

$$\Delta U = GMm\left(\frac{R+h-R}{R(R+h)}\right)$$

$$\boxed{\Delta U = \frac{GMmh}{R(R+h)}}$$

QUESTION

$h = 2R$

A body of mass m taken from the earth's surface to the height equal to twice the radius (R) of the earth. The change in potential energy of body will be:

(A) mg2R

(B) $\boxed{2/3 \text{ mgR}}$

(C) 3 mgR

(D) 1/3 mgR

$$\Delta U = \frac{GMmh}{R(R+h)}$$

$$\Delta U = \frac{GMm \times 2\cancel{R}}{\cancel{R}(R+2R)} = \frac{2GMm}{3R}$$

$$\Delta U = \frac{2}{3}\left(\frac{GM}{R}\right)m \times \frac{R}{R}$$

$$\Delta U = \frac{2}{3}\left(\frac{GM}{R^2}\right)mR = \boxed{\frac{2}{3}mgR}$$

**QUESTION**

$K.E = \frac{P.E}{2}$

$U = -m$ $h \to 0$

$U = 0$

Escape velocity of a 1 kg body on a planet is 100 m/s. potential energy of body at that planet is:

$E_i = E_f$

$K_i + U_i = K_f + \cancel{U_f}$

$K_i = U_f$

(A) $\boxed{-5000\text{ J}}$

(B) $-1000$ J

(C) $-2400$ J

(D) $-10000$ J

$U = -\frac{GMm}{2} = -(K.E)$

$U = -\left(\frac{1}{2}mv_e^2\right)$

$U = -\frac{1}{2} \times 1 \times (100)^2 = -\frac{10{,}000}{2}$

$\boxed{U = -5000\text{ J}}$

**QUESTION**

Escape velocity of a body from earth is 11.2 Km/s. Escape velocity when thrown at angle of 45° from horizontal will be

↳ Independent

(A) $\boxed{11.2 \text{ km/s}}$

(B) 22.4 km/s

(C) $11.2/\sqrt{2}$ km/s

(D) $11.2\sqrt{2}$ km/s

QUESTION

$M_p = 100M$

The escape velocity form the earth is 11.2 km/s then mass of another planet is 100 times of mass of earth and its radius is 4 times the radius of earth. The escape velocity for the planet is

$R_p = 4R$

(A) $\boxed{56.0 \text{ km/s}}$

(B) 280 km/s

(C) 112 km/s

(D) 11.2 km/s

$(V_e)_E = \sqrt{\frac{2GM}{R}} = 11.2 \text{ km/s}$

$(V_e)_p = \sqrt{\frac{2GM_p}{R_p}}$

$= \sqrt{\frac{2G \times 100M}{4R}}$

$= \frac{10}{2}\sqrt{\frac{2GM}{R}} = 5 \times (V_e)_E$

$(V_e)_p = 5 \times 11.2$

$\boxed{= 56 \text{ km/s}}$

QUESTION

$h \to 0$

The orbital velocity of an artificial satellite in a circular orbit $\boxed{\text{just above}}$ the earth's surface is $v$. For a satellite orbiting at an altitude of half of the earth's radius, the orbital velocity is

$h = \frac{R}{2}$

(A) $\frac{3}{2}v$

(B) $\sqrt{\frac{3}{2}}v$

(C) $\boxed{\sqrt{\frac{2}{3}}v}$

(D) $\frac{2}{3}v$

$v_0 = \sqrt{\frac{GM}{r}} \to h \to 0$

$v_0 = \sqrt{\frac{GM}{R+h}} = \sqrt{\frac{GM}{R}}$ — (1)

$(v_0)_s = \sqrt{\frac{GM}{R+\frac{R}{2}}} = \sqrt{\frac{GM}{\frac{2R+R}{2}}}$

$(v_0)_s = \sqrt{\frac{2}{3}}\sqrt{\frac{GM}{R}} = \sqrt{\frac{2}{3}}\,v_0$

$\boxed{(v_0)_s = \sqrt{\frac{2}{3}}\,v}$

## QUESTION

If $v_0$ be the orbital velocity of an artificial satellite orbiting just above the earth's surface, then the orbital velocity of the same satellite orbiting at an altitude equal to earth's radius is

[H.W]

(A) $v_0\sqrt{\dfrac{2}{3}}$

(B) $v_0\sqrt{\dfrac{3}{2}}$

(C) $v_0\sqrt{2}$

(D) $\dfrac{v_o}{\sqrt{2}}$

## QUESTION

Two artificial satellites of masses $m_1$ and $m_2$ are moving with speed $v_1$ and $v_2$ in orbits of radii $r_1$ and $r_2$ respectively. If $r_1 > r_2$ then which of the following statements in true

$r \propto \frac{1}{v}$ $v \propto \frac{1}{r}$

(A) $v_1 = v_2$

$r_1 > r_2$

(B) $v_1 > v_2$

$v_1 < v_2$

(C) $\boxed{v_1 < v_2}$

$v_2 > v_1$

(D) $v_1/r_2 = v_2/r_2$

QUESTION

A satellite of earth of mass 'm' is taken orbital radius 2R to 3R, then minimum work done is

**(A)** $\frac{GMm}{6R}$

**(B)** $\boxed{\frac{GMm}{12R}}$

**(C)** $\frac{GMm}{24R}$

**(D)** $\frac{GMm}{3R}$

$W = \Delta U = U_f - U_i$

$W = \frac{GMm}{3R} - \frac{GMm}{4R}$

$W = \frac{GMm}{R}\left[\frac{1}{3} - \frac{1}{4}\right]$

$|W| = \frac{GMm}{R}\left[\frac{4-3}{12}\right]$

$\boxed{W = \frac{GMm}{12R}}$

$W = \Delta U = U_f - U_i$

$U = -\frac{GMm}{r}, \; r = R+h$

$U_i = -\frac{GMm}{R+2R} = -\frac{GMm}{3R}$

$U_f = -\frac{GMm}{R+3R} = -\frac{GMm}{4R}$

QUESTION

For a satellite moving in a orbit around the earth, the ratio of kinetic energy to potential energy is

$K.E = \frac{P.E}{2}$

A) 2

B) $\boxed{1/2}$

C) $1/\sqrt{2}$

D) $.\sqrt{2}$

$$\boxed{\frac{K.E}{P.E} = \frac{1}{2}}$$

QUESTION

A satellite of mass m revolves in a circular orbit of radius R a round a planet of mass M. Its total energy E is

(A) $\boxed{-\dfrac{GMm}{2R}}$

(B) $+\dfrac{GMm}{3R}$

(C) $-\dfrac{GMm}{R}$

(D) $+\dfrac{GMm}{R}$

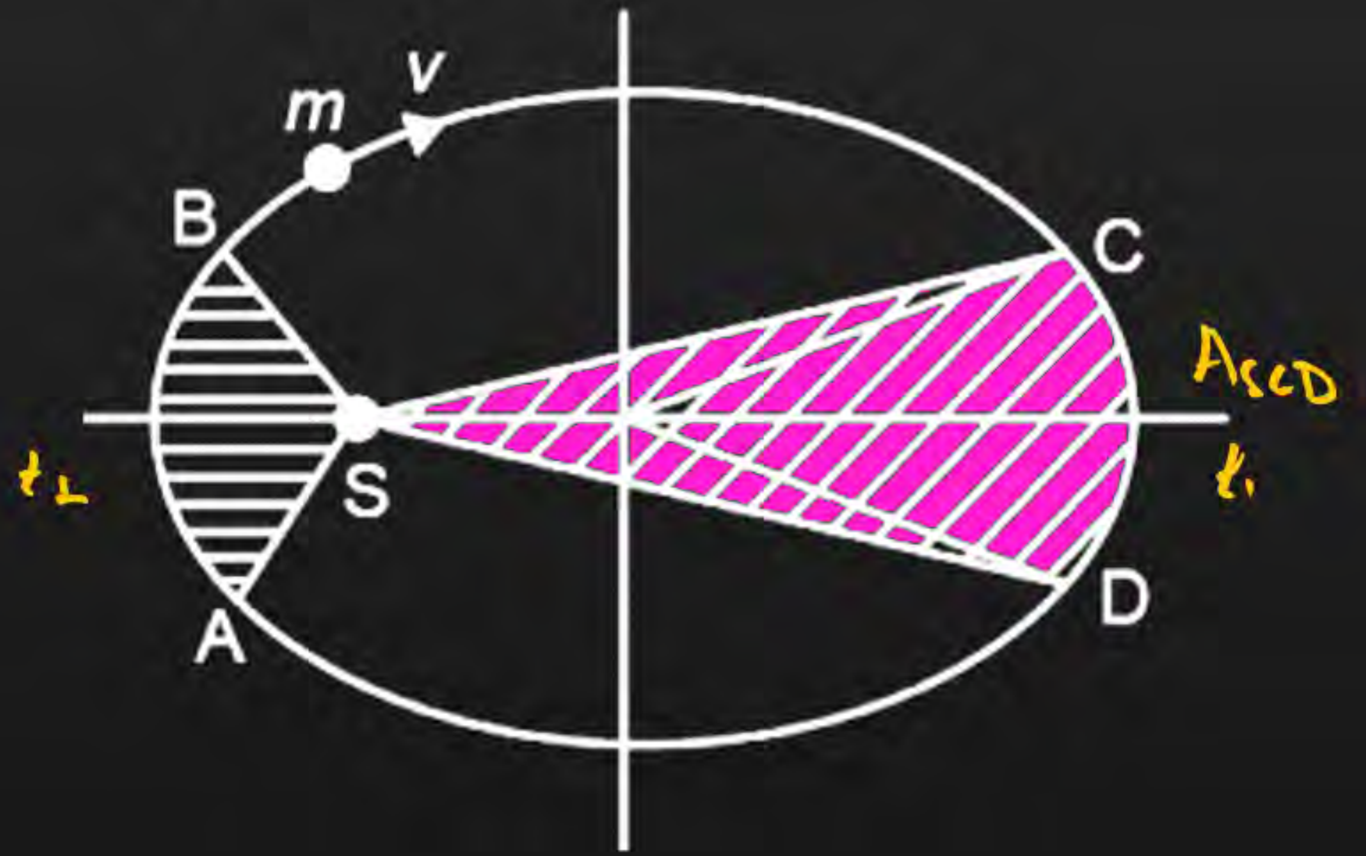
$T.E = -K.E$

$= -\dfrac{GMm}{2R}$

$\boxed{= -\dfrac{GMm}{2R}}$

## QUESTION

The figure shows elliptical orbital of a planet m about the sun S. The shaded area SCD is twice the shaded are SAB. If $t_1$ is the time for the planet to move from C to D and $t_2$ is the time to move from A to B then.




(A) $t_1 = t_2$

(B) $t_1 < t_2$

(C) $t_1 = 4t_2$

(D) $\boxed{t_1 = 2t_2}$

$A_{SCD} = 2A_{SAB}$

$\frac{dA}{dt} = \frac{L}{2m} = \text{const}$

$\frac{A_{SCD}}{t_1} = \frac{A_{SAB}}{t_2}$

$\frac{2\cancel{A_{SAB}}}{t_1} = \frac{\cancel{A_{SAB}}}{t_2}$

$\boxed{t_1 = 2t_2}$

QUESTION

In adjoining figure earth goes around the sun in elliptical orbit on which point the orbital speed is maximum:

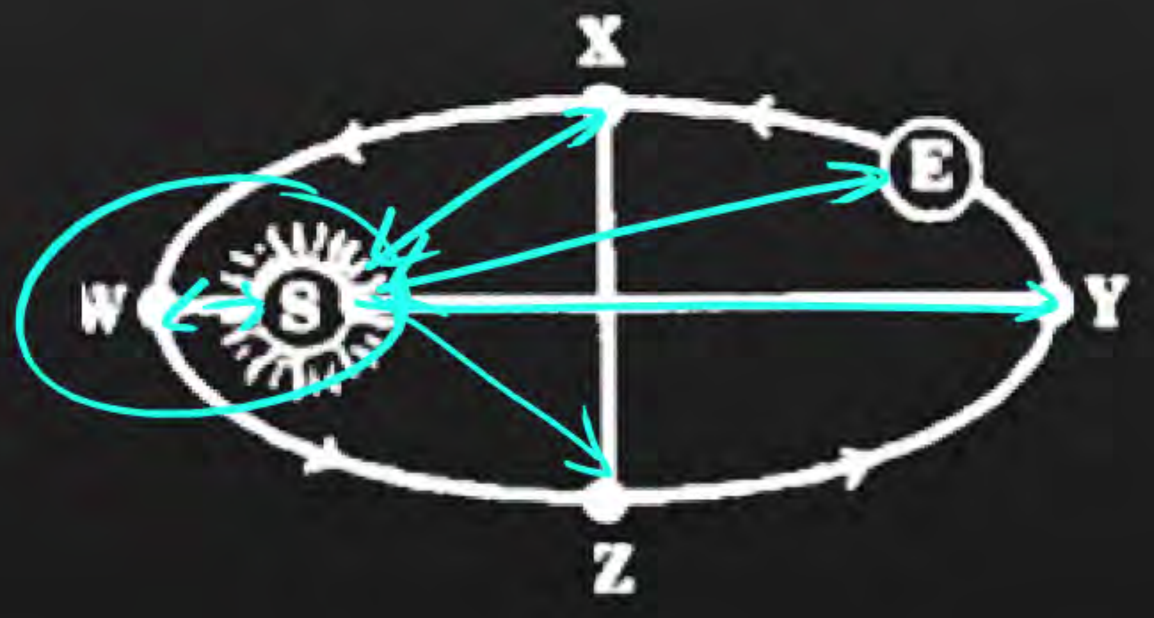
(A) On W

(B) On X

(C) On Y

(D) On Z

$V \propto \frac{1}{r}$



**QUESTION**

Two ordinary satellites are revolving round the earth in same elliptical orbit, then which of the following quantities is conserved :

(A) Velocity

(B) Angular velocity

(C) Angular momentum

(D) None of above

QUESTION

The maximum and minimum distance of a comet from the sun are $8 \times 10^{12}$ m and $1.6 \times 10^{12}$m respecting. If its velocity when it is nearest to the sun is 60 m/s then what will be its velocity in m/s, When it is farthest?

$v_1 r_1 = v_2 r_2$

(A) $\boxed{12}$

(B) 60

(C) 112

(D) 6

## QUESTION

$T_1 = 1$

The earth revolves around the sun in one year. If distance between them becomes double, the time period of revolution will be

$T_2$

(A) $4\sqrt{2}$ Years

(B) $\boxed{2\sqrt{2} \text{ Years}}$

(C) 4 Years

(D) 8 Years

$$T^2 \propto r^3$$

$$\left(\frac{T_2}{T_1}\right)^2 = \left(\frac{r_2}{r_1}\right)^3 = \left(\frac{2r}{r}\right)^3 = 8$$

$$T_2^2 = 8T_1^2 = 8T^2$$

$$T_2 = \sqrt{8}\,T$$

$$T_2 = \sqrt{4\times 2}\,T = \boxed{2\sqrt{2}\,T}$$

## QUESTION

Near the earth's surface time period of a satellite is 1.4 hrs. Find its time period if it is at the distance '4R' from the centre of earth: [H.W]

A. 32 hrs.

B. $\left(\frac{1}{8\sqrt{2}}\right) hrs$

C. $8\sqrt{2}$ hrs.

D. 16 hrs.

# Mechanical Properties of Solids

# Mechanical properties of solids

Hooke's law

$\sigma \propto \varepsilon$, $\sigma = E\varepsilon$, $\boxed{E = \frac{\sigma}{\varepsilon}}$

Young's modulus

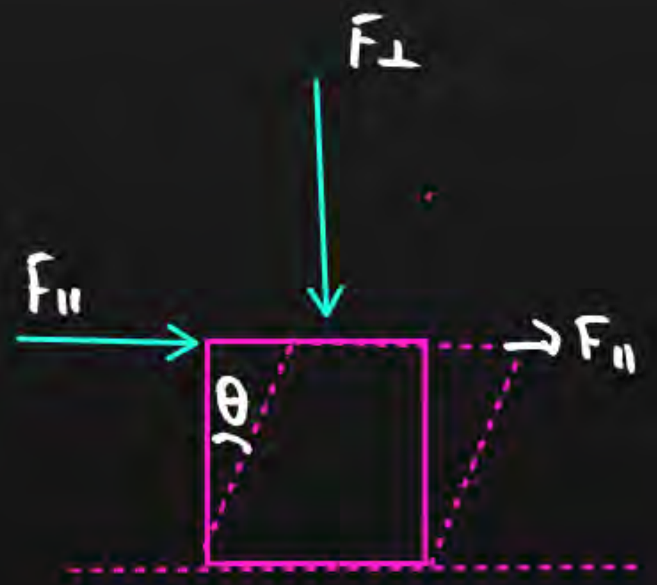
↳ Length

$Y = \frac{\sigma_{long}}{\varepsilon_{long}} = \frac{F/A}{\Delta L/L} \Rightarrow [M^1L^{-1}T^{-2}]$

Bulk modulus, $B$

↳ Volume

$B = \frac{\sigma_v}{\varepsilon_v} = \frac{F/A}{\frac{\Delta V}{V}} = \frac{P}{-\frac{\Delta V}{V}} = -\frac{PV}{\Delta V} \rightarrow$ Hydrolic




Modulus of rigidity, $\eta$

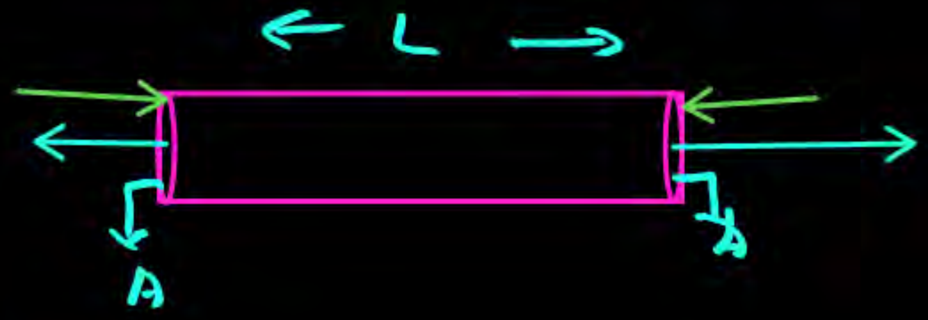
↳ Area

✓

$\boxed{\eta = \frac{\tau_s}{\varepsilon_s} = \frac{F_\parallel/A}{\theta}}$ shape

$\sigma = \frac{F}{A}$ , $\frac{N}{m^2} \Rightarrow \frac{M^1L^1T^{-2}}{L^2}$

## Stress & Strain




$$\varepsilon = \frac{\text{change Dimensions}}{\text{Original Dimension}} = \frac{\Delta L}{L} = \frac{\Delta A}{A} = \frac{\Delta V}{V}$$

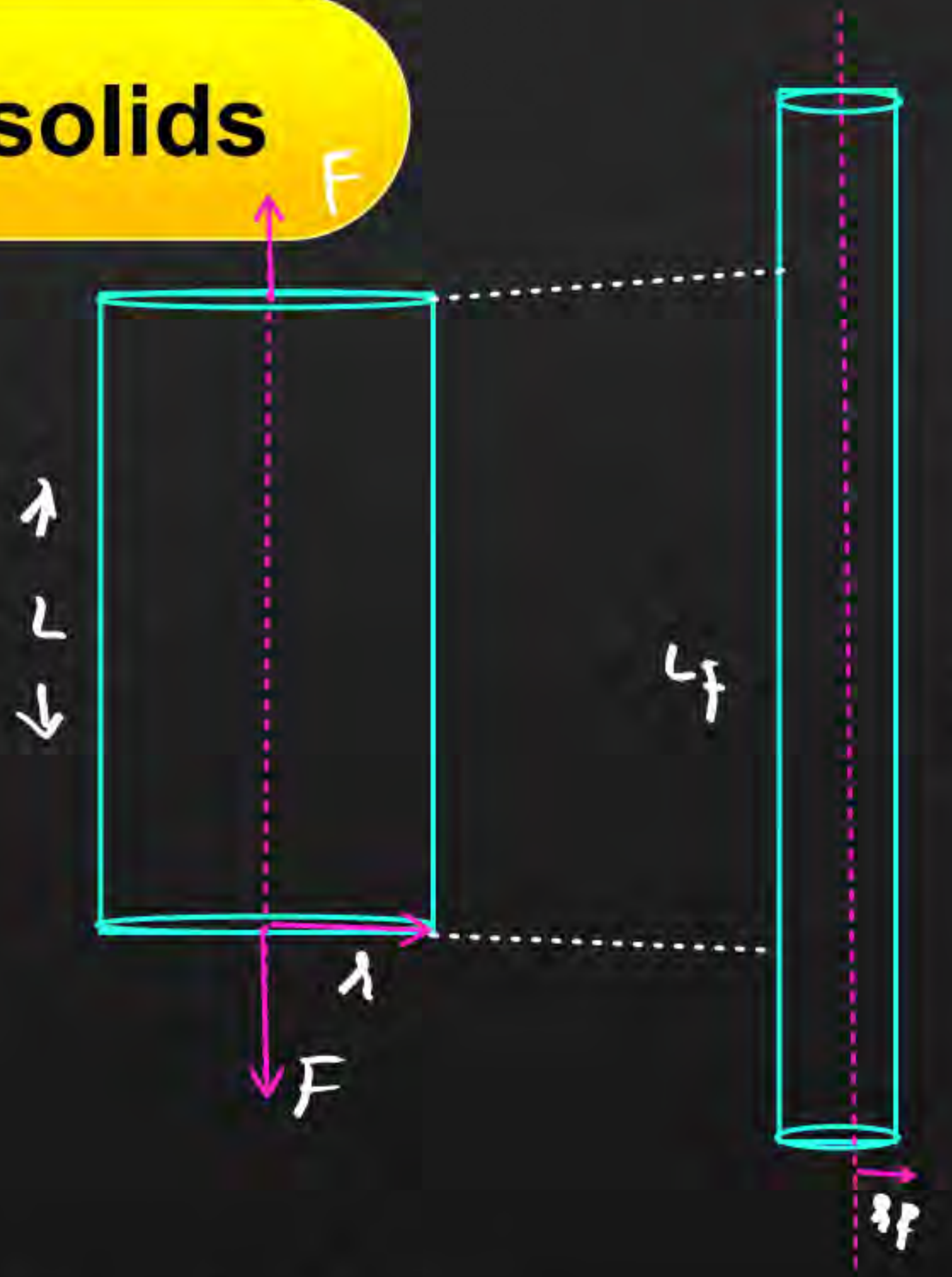
$[M^1L^{-1}T^{-2}]$

- Longitudinal (Length)
- Shear (Area)
- Volumetric (Volume)

# Mechanical properties of solids

Compressibility $(K)$ $\boxed{K = \frac{1}{B}}$

Poisson's ratio, $\sigma$ $= \dfrac{\text{Lateral strain } (\varepsilon_{Lat})}{\text{Longitudinal strain } (\varepsilon_L)} = \dfrac{\frac{\Delta\lambda}{\lambda}}{\frac{\Delta L}{L}}$




$\frac{\Delta L}{L} = \varepsilon_L$

$\frac{\Delta \lambda}{\lambda} = \varepsilon_{lat}$

Work done in a stretched wire, $\boxed{W = \frac{1}{2} F \times \Delta L}$

$\boxed{U = \frac{1}{2} \sigma \varepsilon \times Vol}$

Elastic potential energy stored per unit volume of a stretched wire,

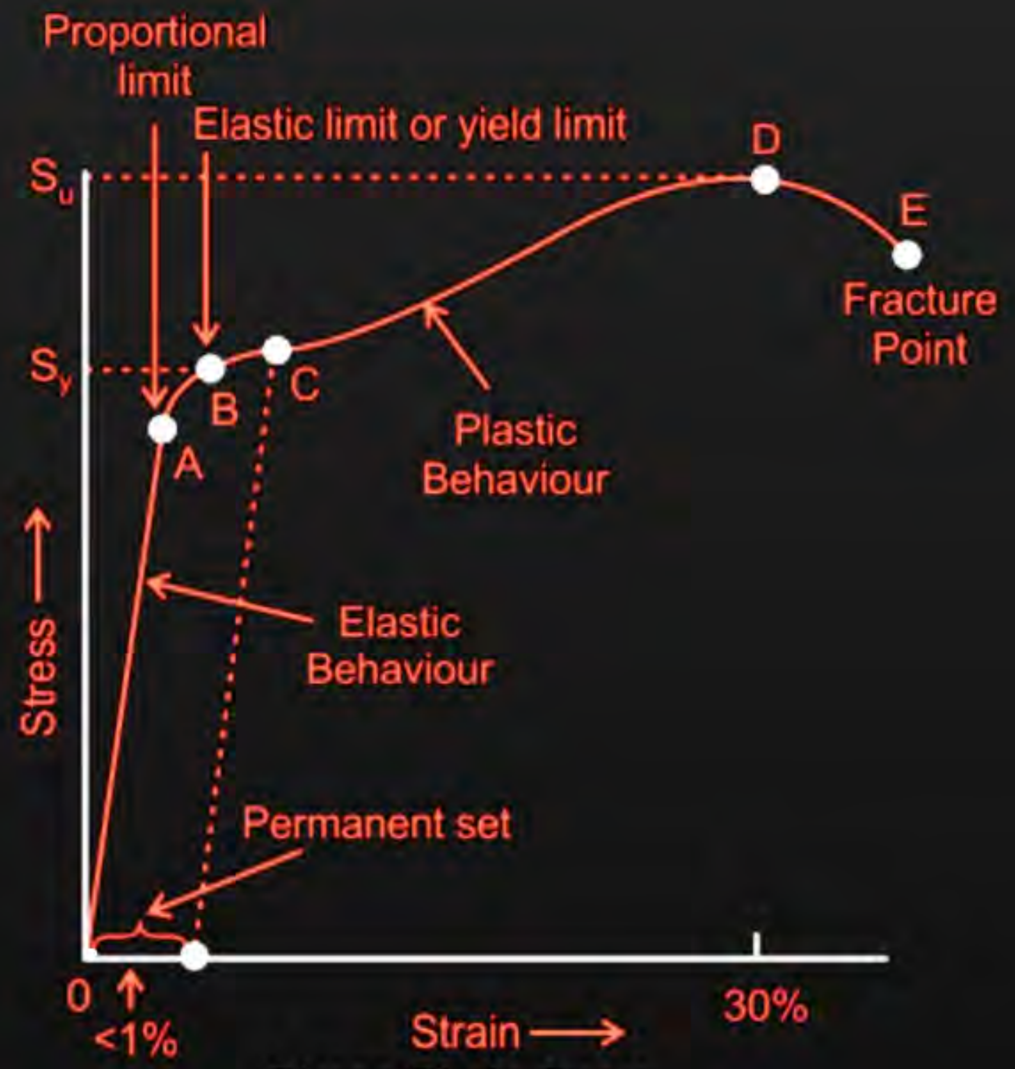
$\boxed{E_d = \frac{U}{Vol} = \frac{1}{2} \sigma \varepsilon}$

# STRESS VS STRAIN GRAPH

The relation between the stress and the strain for a given material under tensile stress can be found experimentally

$\sigma \propto \varepsilon$

$\boxed{Y = \frac{\sigma}{\varepsilon}}$



Stress-Strain Curve

**QUESTION**

A stretched wire of a material whose young's modulus $Y = 2 \times 10^{11}\ \text{Nm}^{-2}$ has poisson's ratio 0.25. Its lateral strain $\varepsilon_{lat} = 10^{-3}$ The elastic energy density of the wire is

(A) $\boxed{16 \times 10^5\ \text{Jm}^{-3}}$

(B) $1 \times 10^5\ \text{Jm}^{-3}$

(C) $4 \times 10^5\ \text{Jm}^{-3}$

(D) $8 \times 10^5\ \text{Jm}^{-3}$

$$E_d = \frac{1}{2}\sigma_L \varepsilon_L = \frac{1}{2} Y \varepsilon_L \varepsilon_L \quad -(1)$$

$$Y = \frac{\sigma_L}{\varepsilon_L}$$

$$\sigma_L = Y \varepsilon_L$$

$$\rho = \frac{\varepsilon_{lat}}{\varepsilon_L}$$

$$\varepsilon_l = \frac{\varepsilon_{lat}}{\rho} = \frac{10^{-3}}{0.25} = 4 \times 10^{-3}$$

$$= \frac{1}{2} \times 2 \times 10^{11} \times 4 \times 10^{-3} \times 4 \times 10^{-3}$$

$$\boxed{= 16 \times 10^5}$$

## QUESTION

A metallic rod breaks when strain produced is 0.2%. The Young's modulus of the material of the rod $7 \times 10^{9}\ \mathrm{N/m^{2}}$. The area of cross- section to support a load of $10^{4}$ N is

(A) $7.1 \times 10^{-6}\ \mathrm{m^{2}}$

(B) $\boxed{7.1 \times 10^{-4}\ \mathrm{m^{2}}}$

(C) $7.1 \times 10^{-2}\ \mathrm{m^{2}}$

(D) $7.1 \times 10^{-8}\ \mathrm{m^{2}}$

$$Y = \frac{\sigma_L}{\varepsilon_L} = \frac{F/A}{\varepsilon_L} = \frac{F}{A\,\varepsilon_L}$$

$$A = \frac{F}{Y\varepsilon_L} = \frac{10^4}{7\times10^9 \times \frac{0.2}{100}} = \frac{10^4 \times 100}{1.4\times10^9}$$

$$\boxed{A = 0.714\times10^{-3} = 7.14\times10^{-4}}$$

QUESTION

Young's modulus of a perfect rigid body is

$\varepsilon = 0$

A. Zero

$Y = \frac{\sigma}{\varepsilon} = \frac{\sigma}{0}$

B. Unity

$\boxed{Y = \infty}$

C. Infinity

D. Between (a) and (b)

## QUESTION

$\Delta V = 0$

A wire is stretched such that its $\boxed{\text{volume remains constant}}$. The poission's ratio of the material of the wire is

(A) 0.50

(B) $\boxed{-0.50}$

(C) 025

(D) –025

$$\rho = \frac{\varepsilon_{lat}}{\varepsilon_L} = \frac{\Delta r/r}{\Delta L/L}$$

$$V = \pi r^2 L$$

$$\Delta V = \pi\, 2r.\Delta r\, L + \pi r^2 \Delta L$$

$$\frac{\Delta V}{V} = \frac{2\cancel{\pi} \cancel{r} \cancel{L}\, \Delta r}{\cancel{\pi} r^{\cancel{2}} \cancel{L}} + \frac{\cancel{\pi r^2}\, \Delta L}{\cancel{\pi r^2} L}$$

$$\frac{\Delta V}{V} = 2\frac{\Delta r}{r} + \frac{\Delta L}{L}$$

$$0 = 2\frac{\Delta r}{r} + \frac{\Delta L}{L}$$

$$\frac{\Delta L}{L} = -2\frac{\Delta r}{r}.$$

$$\rho = \frac{\Delta r/r}{-2\,\Delta r/r} = -\frac{1}{2}$$

$$\boxed{\rho = -0.5}$$

QUESTION

$F$

Two wires A and B are stretched by the $\boxed{\text{same load.}}$ If the area of cross-section of wire A is double that of B, then the stress on B is

$A_A = 2A_B$

A. Equal to that on A

B. $\boxed{\text{Twice that on A}}$

C. Half that on A

D. Four times that on A

$\sigma = \frac{F}{A} \quad \sigma \propto \frac{1}{A}$

$\frac{\sigma_B}{\sigma_A} = \frac{A_A}{A_B} = \frac{2A_B}{A_B} = 2$

$\boxed{\sigma_B = 2\sigma_A}$

QUESTION

'Young's modulus is defined as the ratio of

A. hydraulic stress and hydraulic strain

B. shearing stress and shearing strain

C. tensile stress and longitudinal strain

D. bulk stress and longitudinal strain

QUESTION

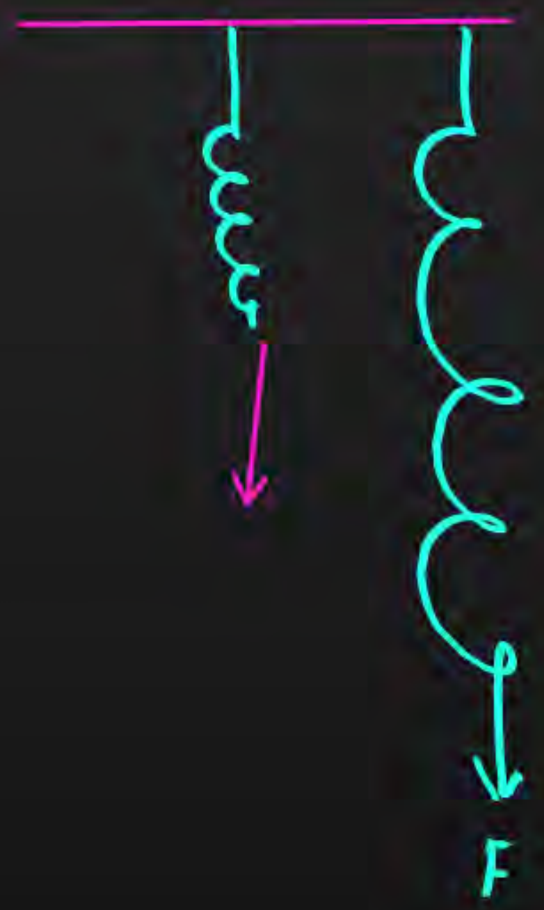
A spring is stretched by applying a load to its free end. The strain produced in the spring is

(A) volumetric

(B) shear

(C) longitudinal and shear

(D) longitudinal



QUESTION

Which of the following substances has the highest elasticity?

A Sponge

B Steel

C Rubber

D Copper

$Y_{steel} > Y_{iron}$

QUESTION

The dimensions of two wires A and B are the same. But their materials are different. their load-extension graphs are shown. If YA and YB are the values of Young's modulus of elasticity of A & B

A. $\boxed{Y_A > Y_B}$

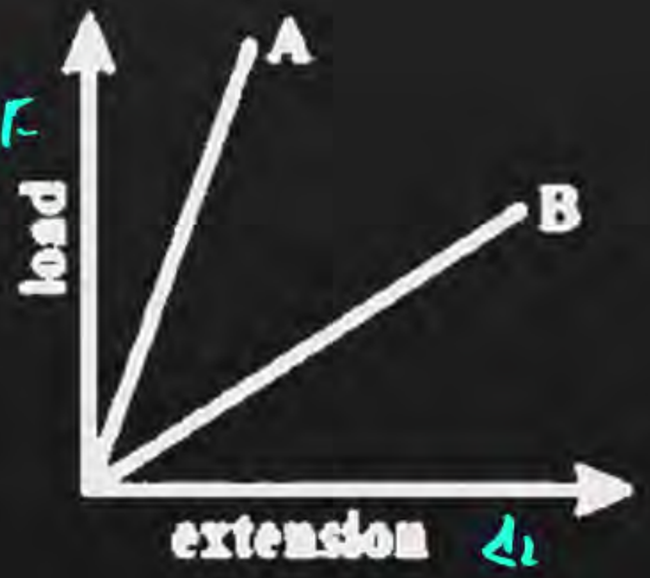
B. $Y_A < Y_B$

C. $Y_A = Y_B$

D. $Y_B = 2Y_A$

$$Y = \frac{\sigma}{\varepsilon} = \frac{F/A}{\frac{\Delta L}{L}} = \frac{FL}{A\,\Delta L} \propto \frac{F}{\Delta L} = \text{slope}$$

$Y_A > Y_B$



QUESTION

A ball falling in a lake of depth $\overset{h}{\boxed{200\text{m}}}$ shows $\overset{\frac{\Delta v}{v}}{0.1\%}$ decrease in its volume at the bottom. What is the bulk modulus of the material of the ball

(A) $\boxed{19.6 \times 10^{8}\ \text{N/m}^2}$

(B) $19.6 \times 10^{-10}\ \text{N/m}^2$

(C) $19.6 \times 10^{10}\ \text{N/m}^2$

(D) $19.6 \times 10^{-8}\ \text{N/m}^2$

$$B = (-)\frac{P}{\frac{\Delta v}{v}} = \frac{\rho g h}{\frac{\Delta v}{v}} = \frac{1000 \times 9.8 \times 200}{\frac{0.1}{100}}$$

$$B = \frac{100 \times 1000 \times 9.8 \times 200 \times 10}{1}$$

$$\boxed{B = 19.6 \times 10^{8}}$$

## QUESTION

$r = \frac{d}{2} = 2 \times 10^{-3}$

The diameter of a brass rod is 4 mm and Young's modulus of brass is $9 \times 10^{10}\ \text{N}/(\text{m}^2)$. The force required to stretch by 0.1% of its length is:

(A) $\boxed{360\,\pi N}$ ✓

(B) $36\,N$

(C) $144\,\pi \times 10^3\,\text{N}$

(D) $36\,\pi \times 10^2\,\text{N}$

$$Y = \frac{F}{A\frac{\Delta L}{L}}$$

$$F = YA\frac{\Delta L}{L} = 9 \times 10^{10} \times \pi r^2 \times \frac{0.1}{100} \times \frac{10}{10}$$

$$F = 9 \times 10^{10} \times \pi \times (2 \times 10^{-3})^2 \times \frac{1}{1000}$$

$$F = 9 \times 4 \times \pi \times 10^{10-6-2-1}$$

$$F = 36\pi \times 10^{1}$$

$$\boxed{F = 360\pi\ N}$$

QUESTION

H.W $\quad Y = \frac{FL}{A\Delta L}$

The Young's modulus of steel is twice that of brass. Two wires of same length and of same area of cross section, one of steel and another of brass are suspended from the same roof. If we want the lower ends of the wires to be at the same level, then the weights added to the steel and brass wires must be in the ratio of

A. 1 : 1

B. 1 : 2

C. 2 : 1

D. 4 : 1

QUESTION

Copper of fixed volume $V$; is drawn into wire of length $\ell$. When this wire is subjected to a constant force '$F$', the extension produced in the wire $\Delta\ell$ Which of the following graphs is a straight line?

$$Y = \frac{FL}{A\,\Delta L} \qquad V = A\ell$$

$$A = \frac{V}{\ell}$$

A) $\Delta\ell$ verses $1/\ell$

B) $\Delta\ell$ verses $\ell^2$

C) $\Delta\ell$ verses $1/\ell^2$

D) $\Delta\ell$ verses $\ell$

$$F = YA\frac{\Delta L}{L}$$

$$F = Y\frac{V}{L}\frac{\Delta L}{L}$$

$$F = YV\frac{\Delta L}{L^2} \Rightarrow \Delta L = \frac{F}{YV}L^2$$

$$\boxed{\Delta L \propto L^2}$$

## QUESTION

The bulk modulus of a spherical object is 'B'. If it is subjected to uniform pressure '$p$' the fractional decrease in radius is

**A** B/3p

**B** 3p/B

**C** $\boxed{\text{p/3B}}$

**D** p/B

$$B = -\frac{P}{\frac{\Delta V}{V}} = -\frac{P}{3\frac{\Delta r}{r}} \Rightarrow \boxed{\frac{\Delta r}{r} = -\frac{P}{3B}}$$

$$V = \frac{4}{3}\pi r^3$$

$$\Delta V = \frac{4}{3}\pi \times 3r^2 \Delta r.$$

$$\frac{\Delta V}{V} = \frac{\cancel{\frac{4}{3}}\cancel{\pi} \times 3\cancel{r^2}\Delta r}{\cancel{\frac{4}{3}}\cancel{\pi} r^3} = 3\frac{\Delta r}{r}$$

QUESTION

If 'S' is stress and 'Y' is Young's modulus of material the energy stored in the wire per unit volume is

A. $S/2Y$

B. $2Y/S^2$

C. $\boxed{S^2/2Y}$

D. $2S^2/Y$

$$E_d = \frac{U}{Vol} = \frac{1}{2}\sigma\varepsilon = \frac{1}{2}\sigma \times \frac{\sigma}{Y} = \frac{\sigma^2}{2Y}$$

$$Y = \frac{\sigma}{\varepsilon}$$

$$\varepsilon = \frac{\sigma}{Y}$$

$$\boxed{E_d = \frac{S^2}{2Y}}$$

## QUESTION

An increases in pressure required to decreases the 200 litres volume of a liquid by 0.004% in container is: (Bulk modulus of the liquid = 2100 M Pa)

(A) 188 kPa

(B) 8.4 kPa

(C) 18.8 kPa

(D) $\boxed{\text{84 kPa}}$

$$B = -\frac{P}{\frac{\Delta V}{V}}$$

$$P = -B\frac{\Delta V}{V}$$

$$P = -2100 \times 10^6 \times \left(\frac{0.004}{100}\right)$$

$$P = 8.4 \times 10^{6-2} = 8.4 \times 10^4$$

$$P = 84 \times 10^3 \text{ Pa}$$

$$\boxed{P = 84 \text{ kPa}}$$

QUESTION

$r = \frac{d}{2}$

$d_1 : d_2$

Two wires of the same material and length but diameters in the ratio 1: 2 are stretched by the same force. The potential energy per unit volume for the two wires when stretched will be in the ratio

$F$

$$\boxed{\frac{E_1}{E_2} = \left(\frac{d_2}{d_1}\right)^2 = \left(\frac{2}{1}\right)^2 = \frac{4}{1}}$$

A. 16 : 1

$Y = \frac{FL}{A\Delta L}$

B. $\boxed{4 : 1}$

$E_d = \frac{U}{Vol} = \frac{1}{2}\sigma\varepsilon = \frac{1}{2}\frac{F}{A}\varepsilon$

C. 2 : 1

$E_d \propto \frac{1}{A} \propto \frac{1}{\pi r^2} \propto \frac{1}{d^2}$

D. 1 : 1

QUESTION

A mass of 0.5 kg is Suspended from wire, then length of wire increase by 3 mm then find out work done;

(A) $4.5 \times 10^{3}$ J

(B) $\boxed{7.3 \times 10^{-3} \text{ J}}$

(C) $9.3 \times 10^{-2}$ J

(D) $2.5 \times 10^{-2}$ J

$$W = \frac{1}{2} F \Delta L$$

$$W = \frac{1}{2} \times mg \times \Delta L$$

$$W = \frac{1}{2} \times 0.5 \times 9.8 \times 3 \times 10^{-3}$$

$$\boxed{W = 7.35 \times 10^{-3} \text{ J}}$$

# Thank You