

Gravitation and Mechanical properties of solids

- Q1** Which one of the following represents the correct dimensions of the gravitational constant?
- (A) $[M^{-1} L^3 T^{-2}]$
 (B) $[MLT^{-1}]$
 (C) $[ML^{-1} T^{-2}]$
 (D) $[ML^{-2} T^{-2}]$
- Q2** What is the angular velocity of the earth?
- (A) $\frac{2\pi}{86400} \text{ rad/s}$
 (B) $\frac{2\pi}{3600} \text{ rad/s}$
 (C) $\frac{2\pi}{24} \text{ rad/s}$
 (D) $\frac{2\pi}{6400} \text{ rad/s}$
- Q3** If the earth were to cease rotating about its own axis. The increase in the value of g in C.G.S. system at a place of latitude of 45° will be
- (A) 2.68 (B) 1.68
 (C) 3.36 (D) 0.34
- Q4** The radius of a planet is R and its density is ρ . The escape velocity of a body from the surface of the planet is proportional to
- (A) $V_e \propto R\sqrt{\rho}$
 (B) $V_e \propto \frac{1}{\sqrt{\rho R}}$
 (C) $V_e \propto \rho R$
 (D) $V_e \propto \frac{\sqrt{\rho}}{R}$
- Q5** For a satellite moving in an orbit around the earth the ratio of kinetic energy to magnitude of potential energy is
- (A) $\frac{1}{\sqrt{2}}$ (B) 2
 (C) $\sqrt{2}$ (D) $\frac{1}{2}$
- Q6** Gravitational potential at a point on the surface of spherical shell is $-\frac{20 \text{ J}}{\text{kg}}$. Then, gravitational potential at the centre of shell is
- (A) $-20 \frac{\text{J}}{\text{kg}}$
 (B) $+20 \frac{\text{J}}{\text{kg}}$
 (C) $0 \frac{\text{J}}{\text{kg}}$
 (D) $-10 \frac{\text{J}}{\text{kg}}$
- Q7** The S.I. unit of gravitational potential is
- (A) J (B) Jkg^{-1}
 (C) Jkg (D) Jkg^{-2}
- Q8** A satellite is orbiting close to the earth and has a kinetic energy K . The minimum extra kinetic energy required by it to just overcome the gravitation pull of the earth is
- (A) $2K$ (B) $2\sqrt{2}K$
 (C) K (D) $\sqrt{3}K$
- Q9** At what temperature will the rms speed of oxygen molecules become just sufficient for escaping from the Earth's atmosphere? (Given : Mass of oxygen molecule (m) = 2.76×10^{-26} kg, Boltzmann's constant $k_B = 1.38 \times 10^{-23} \text{ J K}^{-1}$).
- (A) $2.508 \times 10^4 \text{ K}$
 (B) $8.360 \times 10^4 \text{ K}$
 (C) $5.016 \times 10^4 \text{ K}$
 (D) $1.254 \times 10^4 \text{ K}$
- Q10** If the density of a small planet is the same as that of earth, while the radius of the planet is 0.2 times that of the earth, the gravitational acceleration of the surface of that planet is
- (A) 0.2 g (B) 0.4 g
 (C) 2g (D) 4g



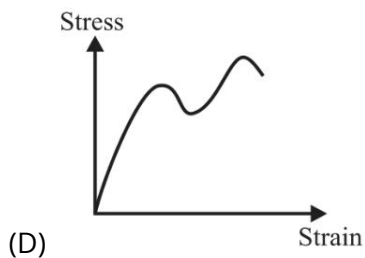
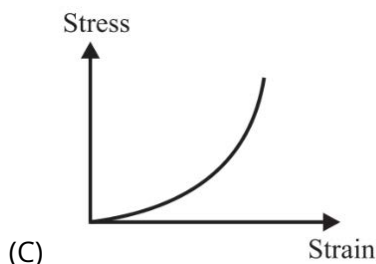
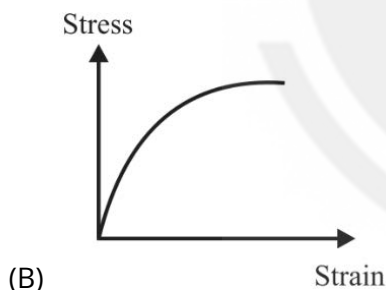
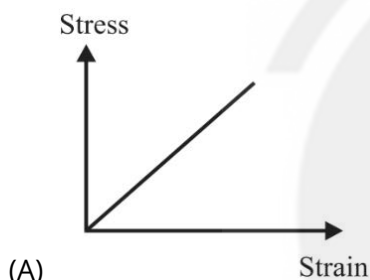
- Q11** The gravitational field intensity at a point $10,000 \text{ km}$ from the centre of the Earth is 4.8 N kg^{-1} . The gravitational potential at that point is
 (A) $-4.8 \times 10^7 \text{ J kg}^{-1}$
 (B) $-2.4 \times 10^7 \text{ J kg}^{-1}$
 (C) $4.8 \times 10^6 \text{ J kg}^{-1}$
 (D) $3.6 \times 10^6 \text{ J kg}^{-1}$
- Q12** The orbital velocity of a satellite close to the earth is V . The orbital velocity at a height $1/4^{\text{th}}$ of earth's radius is
 (A) $\frac{2V}{5}$ (B) $\frac{5V}{2}$
 (C) $\frac{2V}{\sqrt{5}}$ (D) $\frac{\sqrt{5}V}{2}$
- Q13** The gravitational force between two stones of mass 1 kg each separated by a distance of 1 metre in vacuum is nearly:
 (A) Zero
 (B) $6.67 \times 10^{-5} \text{ newton}$
 (C) $6.67 \times 10^{-11} \text{ newton}$
 (D) $6.67 \times 10^{-8} \text{ newton}$
- Q14** The radius of earth is about 6400 km and that of mars is about 3200 km . The mass of the earth is about 10 times of the mass. The object weighs 200 N on earth surface, then its weight on the surface of mars will be
 (A) 80 N (B) 40 N
 (C) 20 N (D) 8 N
- Q15** At the surface of a certain planet acceleration due to gravity is one quarter of that on earth. If a brass ball is transported on this planet, then which one of the following statements is not correct?
 (A) The brass ball has the same mass on the other planet as on earth.
 (B) The mass of the brass ball on this planet is a quarter of its mass as measured on earth.
 (C) The weight of the brass ball on this planet is a quarter of the weight as measured on earth.
 (D) The brass ball has the same volume on the other planet as on earth.
- Q16** A metallic rod breaks when strain produced is 0.2% . The Young's modulus of the material of the rod is $7 \times 10^9 \text{ N / m}^2$. The area of section of support a load of 10^4 N is
 (A) $7.1 \times 10^{-4} \text{ m}^2$
 (B) $7.1 \times 10^{-2} \text{ m}^2$
 (C) $7.1 \times 10^{-8} \text{ m}^2$
 (D) $7.1 \times 10^{-6} \text{ m}^2$
- Q17** A spherical ball contracts in volume by 0.01% when subjected to a normal uniform pressure of 100 atmosphere. The bulk modulus of its material in dyne / cm^2 is
 (A) 10×10^{12}
 (B) 100×10^2
 (C) 1×10^{12}
 (D) 2.0×10^{11}
- Q18** The only elastic modulus that applies to fluids is:
 (A) Young's modulus
 (B) Shear modulus
 (C) Modulus of rigidity
 (D) Bulk modulus



Q19 The substances having very short plastic region are
 (A) Ductile
 (B) Brittle
 (C) Malleable
 (D) All of these

Q20 Two wires are made of the same metal. The length of the first wire is two times that of the second wire and its diameter is half of the second wire. If equal loads are applied on both the wires, find the ratio of increase in their lengths.
 (A) 4
 (B) 2
 (C) 8
 (D) 16

Q21 Which of the following graphs represents stress-strain variation for elastomers?



Q22 The ratio of the lengths of two wires A and B of same material is 1 : 2 and the ratio of their diameter is 2 : 1. They are stretched by the same force, then the ratio of increase in length will be-
 (A) 2 : 1
 (B) 1 : 4
 (C) 1 : 8
 (D) 8 : 1

Q23 Two wires of the same material and same mass are stretched by the same force. Their lengths are in the ratio 2:3. Then their elongations are in the ratio
 (A) 3 : 2
 (B) 2 : 3
 (C) 4 : 9
 (D) 9 : 4

Q24 For a given material, the Young's modulus is 2.8 times that of the modulus of rigidity, Its Poisson's ratio is
 (A) 2.4
 (B) 1.2
 (C) 0.4
 (D) 0.2

Q25 The isothermal bulk modulus of a perfect gas at atmospheric pressure is
 (A) $1.03 \times 10^5 \text{ N/m}^2$
 (B) $1.0 \times 10^4 \text{ N/m}^2$
 (C) $1.03 \times 10^{11} \text{ N/m}^2$
 (D) $1.03 \times 10^{10} \text{ N/m}^2$

Q26 S.I unit of stress is
 (A) Newton/metre
 (B) $\text{Newton}^2/\text{metre}$
 (C) $\text{Newton}/\text{metre}^2$
 (D) $\text{Newton}/\text{metre}^3$

Q27 A force of 100N increases the length of a given wire by 0.1 mm. Then the force required to increase its length by 0.25 mm is
 (A) 50 N
 (B) 150 N
 (C) 250 N
 (D) 500 N



- Q28** Elasticity is the property due to which
- (A) a body opposes its deformation
 - (B) body remains in equilibrium under deforming unbalanced forces
 - (C) liquids have finite volume
 - (D) gases expand and contract
- Q29** Choose the correct statement from the following:
- (A) Elastic forces are always conservative.
 - (B) Elastic forces are not always conservative.
 - (C) Elastic forces are conservative only when Hooke's law is obeyed.
 - (D) Elastic forces may be conservative even when Hooke's law is not obeyed.

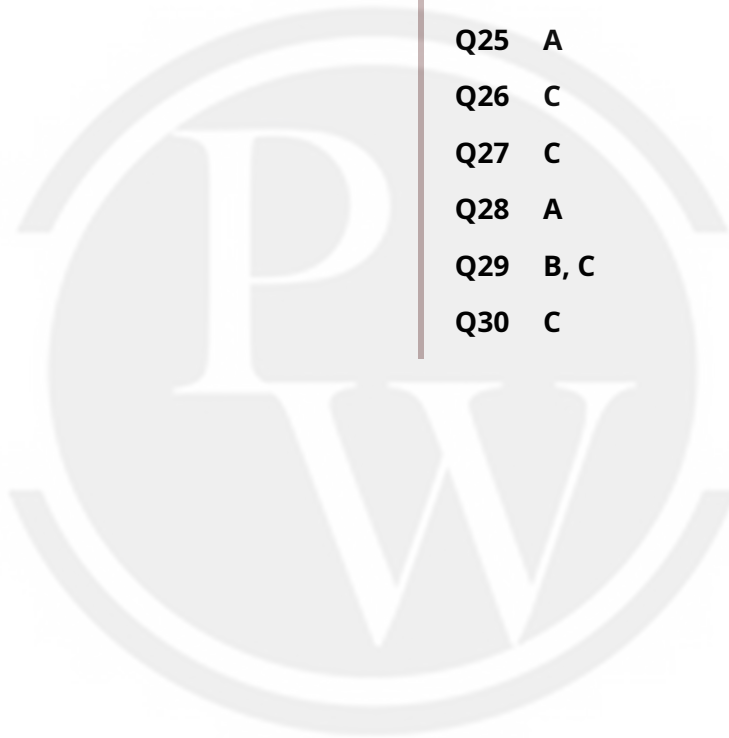
- Q30** The ratio of lateral strain to the longitudinal strain in a stretched wire is
- (A) shear strain
 - (B) compressibility
 - (C) Poisson's ratio
 - (D) Young's modulus



Answer Key

Q1 A
Q2 A
Q3 B
Q4 A
Q5 D
Q6 A
Q7 B
Q8 C
Q9 B
Q10 A
Q11 A
Q12 C
Q13 C
Q14 A
Q15 B

Q16 A
Q17 C
Q18 D
Q19 B
Q20 C
Q21 C
Q22 C
Q23 C
Q24 C
Q25 A
Q26 C
Q27 C
Q28 A
Q29 B, C
Q30 C



Hints & Solutions

Note: scan the QR code to watch video solution

Q1 Text Solution:

$$G = \frac{Fd^2}{m_1 m_2} [G] = [M^{-1} L^3 T^{-2}]$$

Video Solution:



Q2 Text Solution:

$$\omega = \frac{\theta}{t} = \frac{2\pi}{86400} \text{ rad/s}$$

Video Solution:



Q3 Text Solution:

Given,

$$\lambda = 45^\circ, R = 6400 \times 10^3 \text{ m}$$

$$\therefore \omega = \frac{2\pi}{T}$$

$$\omega = \frac{2\pi}{24 \times 60 \times 60} \quad (\because T = 24 \text{ hr})$$

The value of acceleration due to gravity with latitude λ due to rotation of earth is,

$$g' = g - R\omega^2 \cos^2 \lambda$$

$$g' - g = -R\omega^2 \cos^2 \lambda$$

$$g - g' = 6400 \times 10^3 \times \left(\frac{2 \times 3.14}{24 \times 60 \times 60} \right)^2 \times (\cos^2 45^\circ)$$

$$g - g' = \frac{6400 \times 10^3 \times 4 \times 3.14 \times 3.14}{24 \times 60 \times 60 \times 24 \times 60 \times 60} \times \frac{1}{2}$$

$$= 16.89 \times 10^{-3} \text{ m/sec}^2$$

$$= 16.89 \times 10^{-1} \text{ cm/sec}^2$$

$$= 1.68 \text{ cm/sec}^2$$

Video Solution:



Q4 Text Solution:

$$: V_c = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2G \cdot \frac{4}{3} \pi R^3 \rho}{R}}$$

$$= \sqrt{\frac{8}{3} G \pi \rho R^2} = 2R \sqrt{\frac{2}{3} G \pi \rho}$$

$$\text{Thus, } V_c \propto R \sqrt{\rho}$$

Video Solution:



Q5 Text Solution:

$$K. E = \frac{1}{2} m v_0^2$$

$$= \frac{1}{2} m \left(\sqrt{\frac{GM}{r}} \right)^2 = \frac{GMm}{2r} \quad (\because v_0 = \sqrt{\frac{GM}{r}})$$

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

$$\left| \frac{P. E.}{K. E.} \right| = \frac{GMm}{r} \therefore \frac{K. E.}{|P. E.}| = \frac{1}{2}$$

Video Solution:



Q6 Text Solution:

Gravitational field intensity is zero inside the spherical shell. Potential on the surface is same as inside the spherical shell.

Video Solution:



Q7 Text Solution:

The S.I. unit of gravitational potential is Jkg^{-1}

Video Solution:



Q8 Text Solution:

We know that escape velocity

$$V_e = \sqrt{2}V_0$$

$V_0 \rightarrow$ orbital velocity

When satellite is in orbit;

Kinetic energy required to escape;

$$K' = \frac{1}{2}mv_e^2 = mv_0^2 = 2K$$

Extra Kinetic energy = $2K - K = K$

Video Solution:



Q9 Text Solution:

Escape velocity from the Earth's surface is

$$v_{\text{escape}} = 11200 \text{ m s}^{-1}$$

Let at temperature T , oxygen molecule attains escape velocity.

$$\begin{aligned} \text{So, } v_{\text{escape}} &= \sqrt{\frac{3k_B T}{m_{O_2}}} = 11200 \\ &= \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times T}{2.76 \times 10^{-26}}} \\ &= T = 8.360 \times 10^4 \text{ K} \end{aligned}$$

Video Solution:



Q10 Text Solution:

Given,

Radius of planet = 0.2 times of the earth's radius

$$\text{Acceleration due to gravity (g)} = \frac{GM}{R^2}$$

$$\text{Mass of planet, } m = \rho d = d \times \frac{4}{3}\pi R^3$$

Where, d = density of the planet for earth

$$g = \frac{4}{3}\pi dGR$$

$$\therefore d' = d \text{ and } R' = 0.2R$$

$$\therefore g' = \frac{4}{3}\pi d' GR'$$

$$\frac{4}{3}\pi dG(0.2R) = 0.2 \left(\frac{4}{3}\pi dGR \right)$$

From equation (i)

$$g' = 0.2g$$

Video Solution:



Q11 Text Solution:

$$V = -Ir = -4.8 \times 10000 \times 10^3 = -4.8 \times 10^7 \text{ J/kg}$$

Video Solution:



Q12 Text Solution:

$$v = \sqrt{\frac{GM}{R}} = V$$

$$v' = \sqrt{\frac{GM}{(R+R/4)}} = \sqrt{\frac{4GM}{5R}} = \frac{2}{\sqrt{5}} \sqrt{\frac{GM}{R}}$$

$$= \frac{2}{\sqrt{5}} V$$

Video Solution:



Q13 Text Solution:

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

$$= 6.67 \times \frac{1 \times 1}{1^2} \times 10^{-11} = 6.67 \times 10^{-11} \text{ N}$$

Video Solution:



Q14 Text Solution:

Radius of earth (R_e) = 6400 km
 Radius of mars (R_m) = 3200 km
 Mass of earth (M_e) = 10 time of object
 Weight of the object on earth (W_e) = 200 N

$$\frac{W_m}{W_e} = \frac{Mg_m}{Mg_e} = \frac{g_m}{g_e}$$

$$\frac{W_m}{W_e} = \frac{GM_m \times (R_e)^2}{(R_m)^2 \times GM_e}$$

$$\frac{W_m}{W_e} = \frac{M_m (R_e)^2}{M_e (R_m)^2} \{ \because M_e = 10M_m \}$$

$$= \frac{1}{10} \times (2)^2 \left[\because \frac{R_e}{R_m} = \frac{6400}{3200} = 2 \right]$$

$$\frac{W_m}{W_e} = \frac{4}{10} = \frac{2}{5}$$

$$W_m = W_e \times \frac{2}{5}$$

$$W_m = 200 \times \frac{2}{5} = 80\text{N}$$

Video Solution:



Q15 Text Solution:

mass doesnot depend on acceleration due to gravity

Video Solution:



Q16 Text Solution:

Stress= Strain XY
 thus, Maximum stress
 $= \frac{0.2}{100} \times 7 \times 10^9 = 1.4 \times 10^7$
 Now, F orce = stress \times Area
 thus, $10^4 = 1.4 \times 10^7 \times A$, or $A = 7.14 \times 10^{-4} \text{ m}^2$

Video Solution:



Q17 Text Solution:

$$\frac{\Delta V}{V} = \frac{0.01}{100}$$

$$P = 100 \times 1.01 \times 10^6 \text{ dyne / cm}^2$$

$$K = \frac{P}{\frac{\Delta V}{V}} = \frac{100 \times 1.01 \times 10^6}{\frac{0.01}{100}} = 10^{12} \text{ dyne / cm}^2.$$

Video Solution:



Q18 Text Solution:

The only elastic modulus that applies to fluids is Bulk modulus.

Video Solution:



Q19 Text Solution:

Substance with short plastic region are brittle because less amount of permanent deformation could be done in them.

Video Solution:



Q20 Text Solution:

(3)

$$Y = \frac{F}{\frac{\Delta \ell}{\ell}} \Rightarrow \Delta \ell = \frac{F \ell}{AY} = \frac{F \ell}{\pi r^2 Y}$$

$$\frac{\Delta \ell_1}{\Delta \ell_2} = \frac{4F \ell_1}{\pi d_1^2 Y} \times \frac{\pi d_2^2 Y}{4F \ell_2}$$

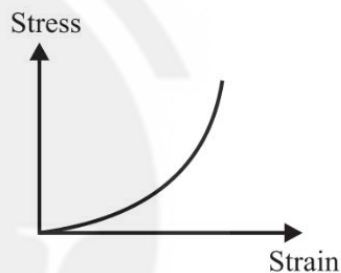
$$= \frac{\ell_1}{\ell_2} \times \frac{d_2^2}{d_1^2} = \frac{2}{1} \times 2^2 = 8$$

Video Solution:



Q21 Text Solution:

For elastomers



Video Solution:



Q22 Text Solution:

$$l = \frac{FL}{AY}$$

$$\Rightarrow l \propto \frac{L}{d^2}$$

$$\Rightarrow \frac{l_1}{l_2} = \frac{L_1}{L_2} \times \left(\frac{d_2}{d_1}\right)^2$$

$$= \frac{1}{2} \times \left(\frac{1}{2}\right)^2 = \frac{1}{8}$$

Video Solution:



Q23 Text Solution:

Elongation of wire when stretched by a force

$$\text{i.e., } e = \frac{Fl}{AY} \Rightarrow e \propto \frac{l}{A}$$

As the mass is same, volume is also same

$$\text{i.e., } A_1 l_1 = A_2 l_2 \text{ or } l \propto \frac{1}{A} \text{ or } A \propto \frac{1}{l} \text{ then}$$

$$e \propto l^2 \text{ and } \frac{e_1}{e_2} = \frac{l_1^2}{l_2^2} = \frac{4}{9}$$

Video Solution:



Q24 Text Solution:

where the symbols have their usual meanings.

$$\text{Given: } Y = 2.8\eta$$

$$\therefore 2.8\eta = 2\eta(1 + \sigma)$$

$$LA = 1 + \sigma \text{ or } \sigma = 1.4 - 1 = 0.4$$

Video Solution:



Q25 Text Solution:

$$1.03 \times 10^5 \text{ Nm}^{-2}$$

Video Solution:



Q26 Text Solution:

$$\text{Newton/metre}^2$$

Video Solution:



Q27 Text Solution:

$$F_2 = F_1 \times \frac{e_2}{e_1} = 100 \times \frac{0.25}{0.1} = 250 \text{ N}$$

Video Solution:



Q28 Text Solution:

An intrinsic property of a body due to which it regains its original shape and size after applied force is removed is called elasticity

Video Solution:



Q29 Video Solution:



Q30 Text Solution:

poisson's ratio = lateral strain/longitudinal strain

Video Solution:



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