DPP – 3 (Gravitation)

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Q 1. A body of mass m is taken from earth surface to the height h equal to radius of earth, the increase in potential energy will be -

(a) mgR (b) $\frac{1}{2}$mgR (c) 2 mgR (d) $\frac{1}{4}$mgR

Q 2. A small block of superdense material has mass 2 × 10^{24} kg. It is at a height h << R. It falls towards earth. Find its speed when it is at a height h/2 -

(a) $\sqrt{\frac{2gh}{3}}$ (b) $\sqrt{\frac{3gh}{4}}$ (c) $\sqrt{\frac{3gh}{5}}$ (d) $\sqrt{\frac{gh}{2}}$

Q 3. Which of the following statement(s) is/are correct

(a) An astronaut going from Earth to Moon will experience weightlessness once

(b) When a thin uniform spherical shell gradually shrinks maintaining its shape, the gravitational potential at the centre decreases

(c) In the case of spherical shell, the plot of potential versus distance from centre is continuous

(d) In the case of spherical shell, the plot of gravitational field intensity I versus distance from centre is continuous

Q 4. A person brings a mass of 1kg from infinity to a point A. Initially the mass was at rest but it moves at a speed of 2m/s as it reaches A. The work done by the person on the mass is –3J. The potential at A is-

(a) –3J/kg

(b) –2 J/kg

(c) –5 J/kg

(d) none of these

Q 5. A point P lies on the axis of a ring of mass M and radius a, at a distance a from its centre C. A small particle starts from P and reaches C under gravitational attraction only. Its speed at C will be -

(a) $\sqrt{\frac{2GM}{a}}$ (b) $\sqrt{\frac{2GM}{a}\left(1-\frac{1}{\sqrt{2}}\right)}$

(c) $\sqrt{\frac{2GM}{a}(\sqrt{2}-1)}$ (d) zero

Q 6. A body is projected vertically upwards from the earth's surface to reach a height 7R, where R is the Radius of earth. The velocity required to do so is–

(a) $\sqrt{\frac{7GM}{8R}}$ (b) $\sqrt{\frac{7GM}{4R}}$ (c) $\sqrt{\frac{8GM}{3R}}$ (d) $\sqrt{\frac{20}{11}\frac{GM}{R}}$

Q 7. A hole is drilled from the surface of earth to its centre. A particle is dropped from rest at the surface of earth. The speed of the particle when it reaches the centre of the earth in terms of its escape velocity on the surface of earth v_e is:

(a) $\frac{v_e}{2}$ (b) v_e (c) $\sqrt{2}v_e$ (d) $\frac{v_e}{\sqrt{2}}$

Q 8. The potential at the surface of a planet of mass M and radius R is assumed to be zero. Choose the most appropriate option:

(a) The potential at infinity is $\frac{GM}{R}$

(b) The potential at the centre of planet is $-\frac{GM}{R}$

(c) Both (a) and (b) are correct

(d) Both (a) and (b) are wrong

Q 9. Two bodies of masses m_1 and m_2 are initially at rest placed infinite distance apart. They are then allowed to move towards each other under mutual gravitational attraction. Their relative velocity when they are r distance apart is :

(a) $\sqrt{\frac{2G(m_1+m_2)}{r}}$ (b) $\sqrt{\frac{2Gm_1m_2}{(m_1+m_2)r}}$ (c) $\sqrt{\frac{G(m_1+m_2)}{r}}$ (d) $\sqrt{\frac{Gm_1m_2}{(m_1+m_2)r}}$

Q 10. A particle is projected from surface of a planet with speed v in vertically upward direction . This particle reaches to infinity with zero speed. If we project same particle at angle π/4 with vertical with same speed v

(a) It will move on elliptical path

(b) It will move to infinity with zero velocity

(c) It will move to infinity with nonzero velocity

(d) It will move on parabolic path

Q 11. A fixed gaseous planet attracts a light body from infinity . Velocity of light body at infinite is zero. Body reaches to surface of planet with speed v. if resistive forces are negligible ,velocity of body at centre of planet will be

(a) v

(b) 2v

(c) 3v/2

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

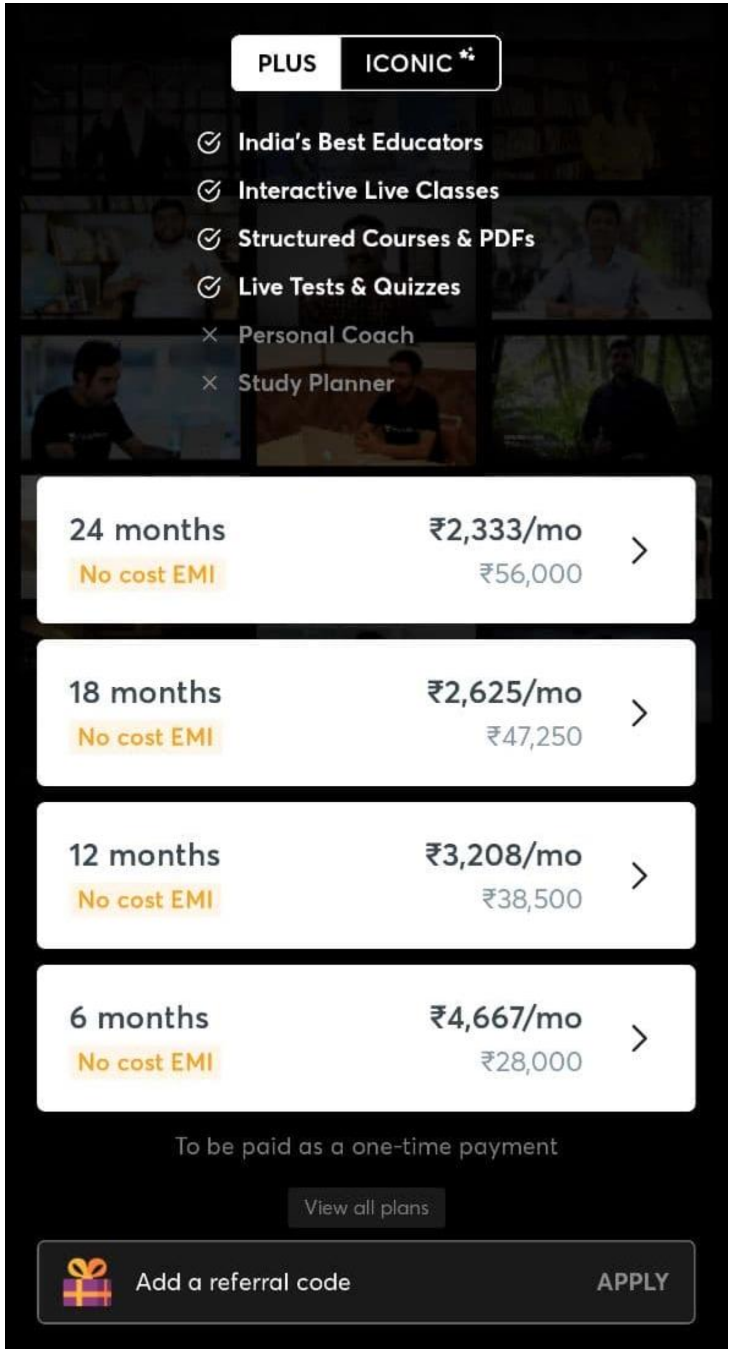
Q 12. A tunnel is dug along a chord of Earth having length $\sqrt{3}$R is radius of Earth. A small block is released in the tunnel from the surface of Earth. The particle comes to rest at the center of tunnel. Find coefficient of friction between the block and the surface of tunnel. Ignore the effect of rotation of Earth

(a) 0.22 (b) 0.67

(c) 0.86 (d) 0.99

Answer Key

Q.1 b	Q.2 b	Q.3 a, b, c	Q.4 c	Q.5 b
Q.6 b	Q.7 d	Q.8 c	Q.9 a	Q.10 b, d
Q.11 d	Q.12 c			



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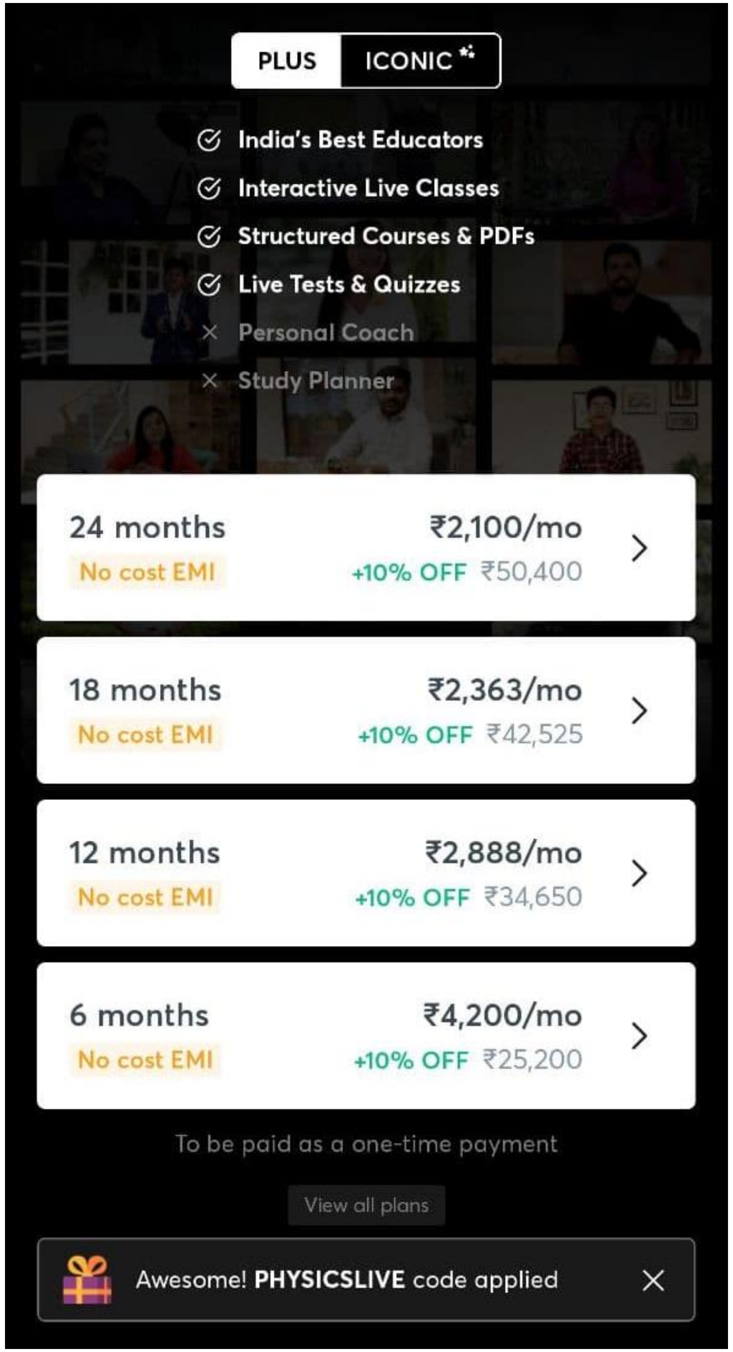

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Written Solution

DPP-3 Gravitation: Gravitational Potential & Potential Energy

By Physicsaholics Team

Q.1) A body of mass m is taken from earth surface to the height h equal to radius of earth, the increase in potential energy will be -

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

$\Delta U = \left(-\frac{GMm}{2R}\right) - \left(-\frac{GMm}{R}\right)$

$= \frac{GMm}{2R} = \frac{gmR}{2}$

(a) mgR

(b) $\frac{1}{2}$mgR ✓

(c) 2 mgR

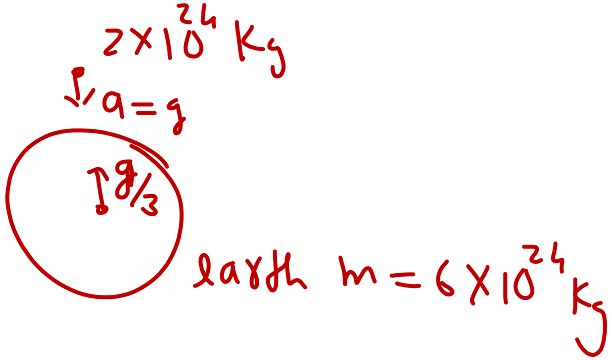
(d) $\frac{1}{4}$mgR

Q.2) A small block of superdense material has mass 2×10^{24} kg. It is at a height h << R. It falls towards earth. Find its speed when it is at a height h/2 -

force on block $= 2 \times 10^{24} g$

force " earth $= 2 \times 10^{24} g$.

acceleration of earth $= \frac{2 \times 10^{24} g}{6 \times 10^{24}} = g/3$



relative acceleration of block & earth $= g + g/3 = 4g/3$

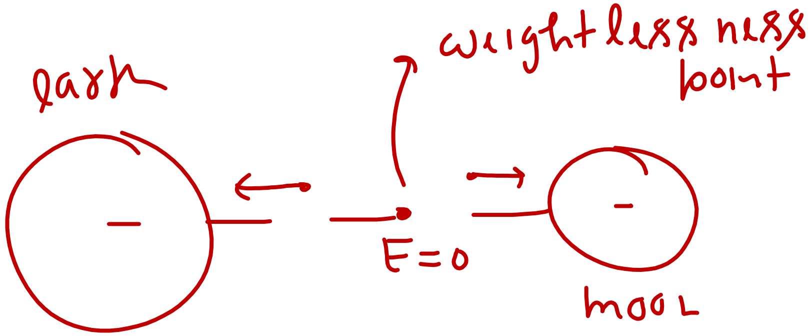
" displacement $= h/2$

(a) $\sqrt{\frac{2gh}{3}}$ (b) $\sqrt{\frac{3gh}{4}}$ ✓ (c) $\sqrt{\frac{3gh}{5}}$ (d) $\sqrt{\frac{gh}{2}}$

time of motion $\frac{h}{2} = \frac{1}{2}\left(\frac{4g}{3}\right)t^2 \Rightarrow t = \sqrt{\frac{3h}{4g}}$

velocity of block $= gt = \sqrt{\frac{3gh}{4}}$

Q.3) Which of the following statement(s) is/are correct

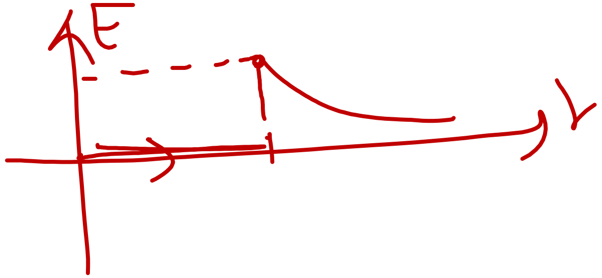


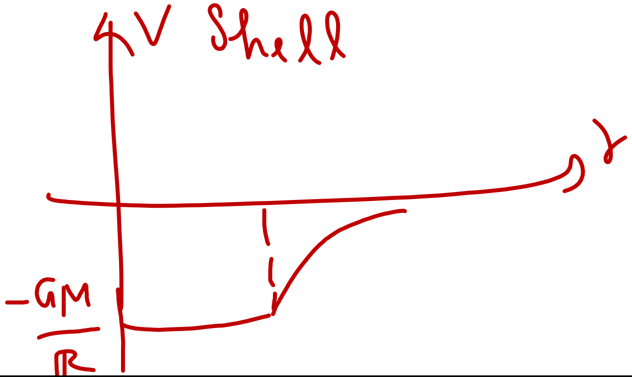
(a) An astronaut going from Earth to Moon will experience weightlessness once

(b) When a thin uniform spherical shell gradually shrinks maintaining its shape, the gravitational potential at the centre decreases $V = -\frac{GM}{R}$

(c) In the case of spherical shell, the plot of potential versus distance from centre is continuous

(d) In the case of spherical shell, the plot of gravitational field intensity I versus distance from centre is continuous





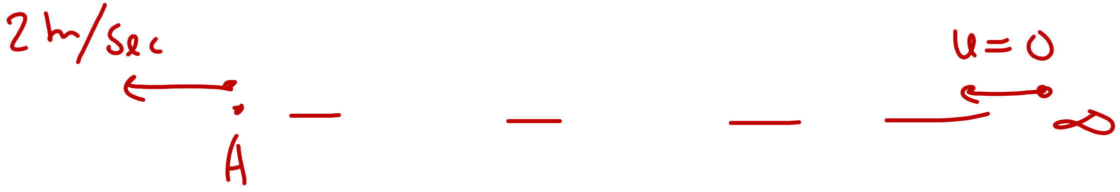
Q.4) A person brings a mass of 1kg from infinity to a point A. Initially the mass was at rest but it moves at a speed of 2m/s as it reaches A. The work done by the person on the mass is –3J. The potential at A is-

(a) –3J/kg

(b) –2 J/kg

(c) –5 J/kg

(d) none of these

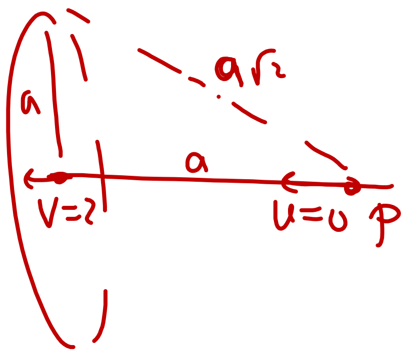


$$W_{man} = V_A + \frac{1}{2}mv^2$$

$$-3 = 1 \times V_A + \frac{1}{2} \times 1 \times 4$$

$$V_A = -5\ J/kg$$

Q.5) A point P lies on the axis of a ring of mass M and radius a, at a distance a from its centre C. A small particle starts from P and reaches C under gravitational attraction only. Its speed at C will be -



by COME I.

$$0 - m\frac{GM}{a\sqrt{2}} = \frac{1}{2}mv^2 - \frac{GM}{a}m$$

(a) $\sqrt{\frac{2GM}{a}}$

(b) $\sqrt{\frac{2GM}{a}\left(1-\frac{1}{\sqrt{2}}\right)}$ ✓

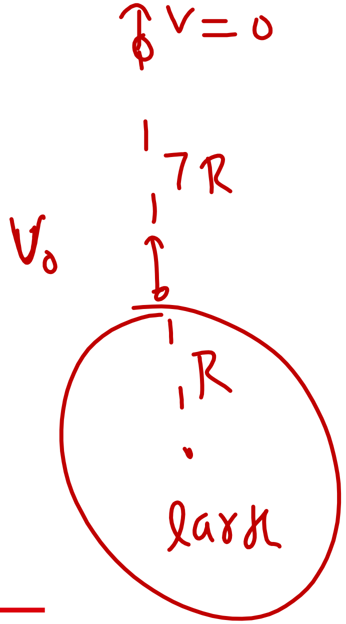
(c) $\sqrt{\frac{2GM}{a}\left(\sqrt{2}-1\right)}$

(d) zero

$$\frac{v^2}{2} = \frac{GM}{a}\left(1-\frac{1}{\sqrt{2}}\right)$$

$$v^2 = \frac{2GM}{a}\left(1-\frac{1}{\sqrt{2}}\right)$$

Q.6) A body is projected vertically upwards from the earth's surface to reach a height 7R, where R is the Radius of earth. The velocity required to do so is–



$$\frac{1}{2}mV_0^2 - \frac{GMm}{R} = 0 - \frac{GMm}{8R}$$

$$\frac{mV_0^2}{2} = 7\frac{GMm}{8R}$$

$$V_0 = \sqrt{\frac{7GM}{4R}}$$

(a) $\sqrt{\frac{7GM}{8R}}$

(b) $\sqrt{\frac{7GM}{4R}}$ ✓

(c) $\sqrt{\frac{8GM}{3R}}$

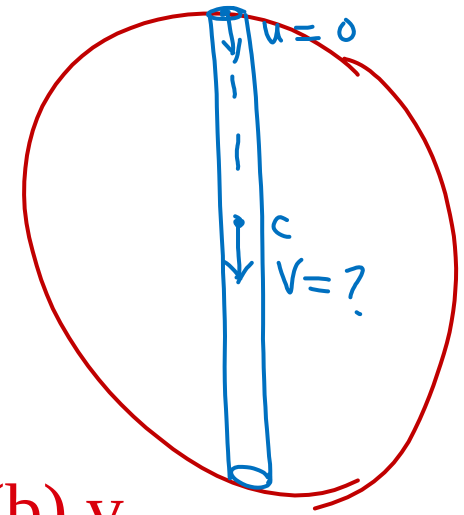
(d) $\sqrt{\frac{20}{11}\frac{GM}{R}}$

Q.7) A hole is drilled from the surface of earth to its centre. A particle is dropped from rest at the surface of earth. The speed of the particle when it reaches the centre of the earth in terms of its escape velocity on the surface of earth v_e is:

$T = 2\pi\sqrt{\frac{R}{g}}$

$\omega = \sqrt{\frac{g}{R}}$

$V = \omega R = \sqrt{gR}$



(a) $\frac{v_e}{2}$ (b) v_e (c) $\sqrt{2}v_e$ (d) $\frac{v_e}{\sqrt{2}}$ ✓

$V_e = \sqrt{2gR}$

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

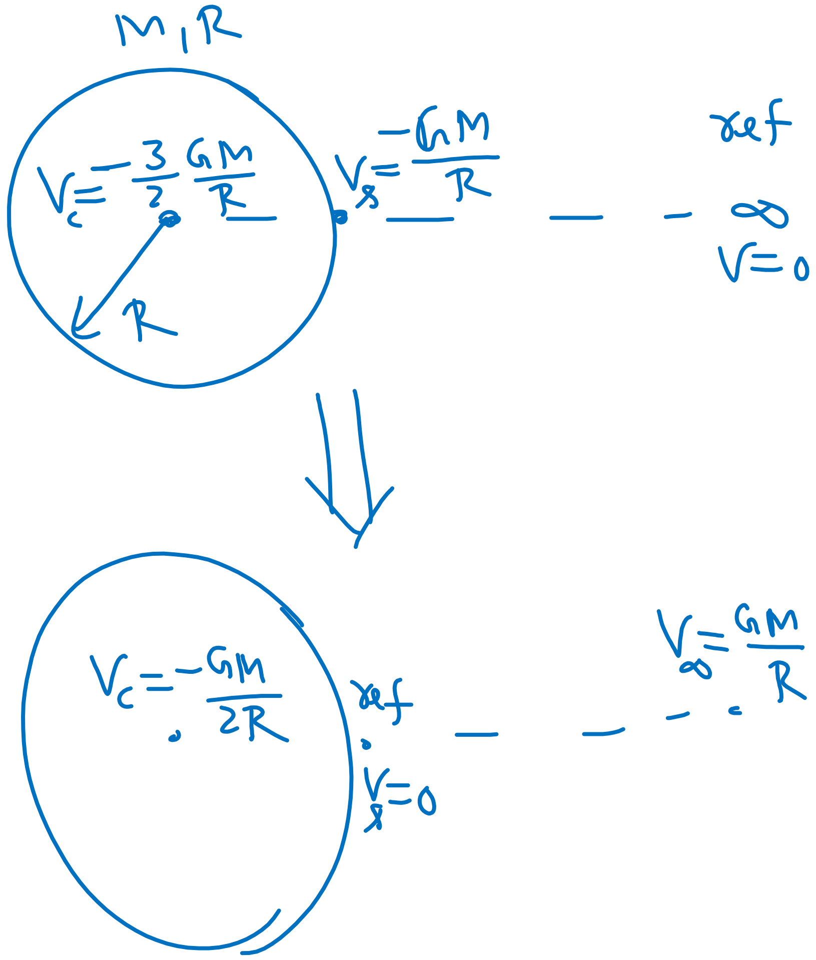
Q.8) The potential at the surface of a planet of mass M and radius R is assumed to be zero. Choose the most appropriate option:

(a) The potential at infinity is $\frac{GM}{R}$

(b) The potential at the centre of planet is $-\frac{GM}{2R}$

(c) Both (a) and (b) are correct

(d) Both (a) and (b) are wrong



Q.9) Two bodies of masses m_1 and m_2 are initially at rest placed infinite distance apart. They are then allowed to move towards each other under mutual gravitational attraction. Their relative velocity when they are r distance apart is :

m_1 $u = 0$ —— ∞ distance —— $u = 0$ m_2

by Conservation of mechanical energy from CM frame →

$V_{rel} = V_1 + V_2 = ?$

$$0 + 0 = -\frac{Gm_1m_2}{r} + \frac{1}{2}\mu V_{rel}^2$$

(a) $\sqrt{\frac{2G(m_1+m_2)}{r}}$ (b) $\sqrt{\frac{2Gm_1m_2}{(m_1+m_2)r}}$ (c) $\sqrt{\frac{G(m_1+m_2)}{r}}$ (d) $\sqrt{\frac{Gm_1m_2}{(m_1+m_2)r}}$

$$V_{rel}^2 = \frac{2Gm_1m_2}{r} \frac{(m_1+m_2)}{m_1m_2}$$

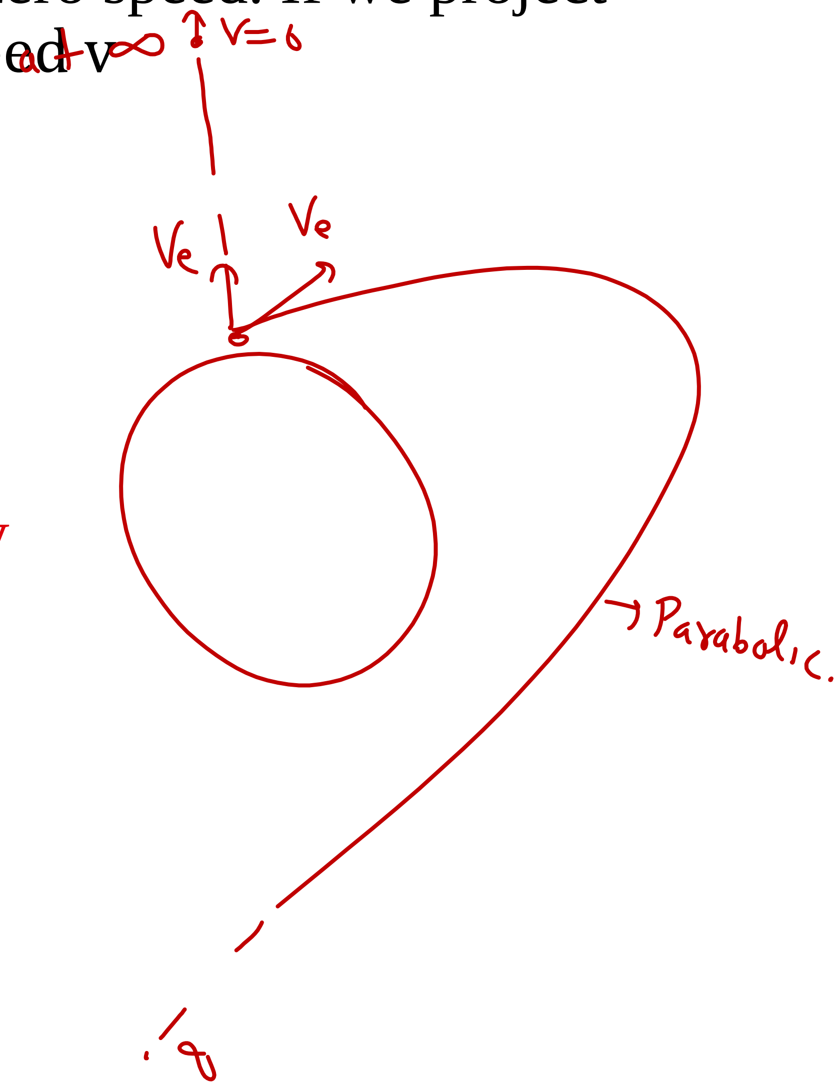
Q.10) A particle is projected from surface of a planet with speed v in vertically upward direction . This particle reaches to infinity with zero speed. If we project same particle at angle π/4 with vertical with same speed v

(a) It will move on elliptical path

(b) It will move to infinity with zero velocity

(c) It will move to infinity with nonzero velocity

(d) It will move on parabolic path



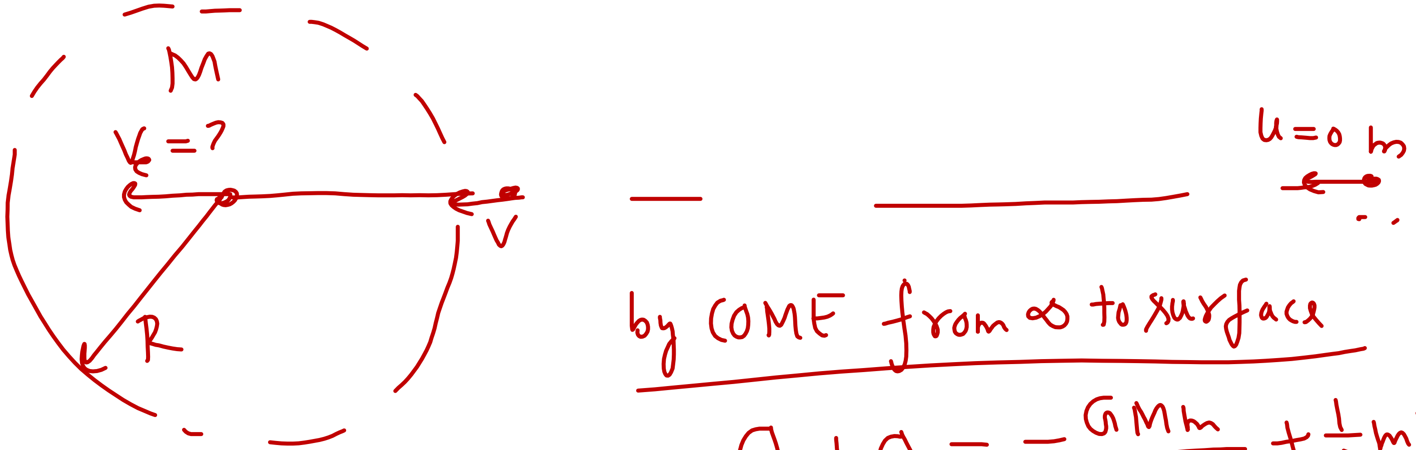
Q.11) A fixed gaseous planet attracts a light body from infinity . Velocity of light body at infinite is zero. Body reaches to surface of planet with speed v. if resistive forces are negligible ,velocity of body at centre of planet will be

(a) v

(b) 2v

(c) 3v/2

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



by COME from ∞ to surface

$$0 + 0 = -\frac{GMm}{R} + \frac{1}{2}mv^2$$

$$\frac{1}{2}mv^2 = \frac{GMm}{R} \quad \text{--- (I)}$$

by COME from ∞ to Centre

$$0 + 0 = -m\frac{3}{2}\frac{GM}{R} + \frac{1}{2}mV_c^2$$

$$\frac{1}{2}mV_c^2 = \frac{3}{2}\frac{GMm}{R} \quad \text{--- (II)}$$

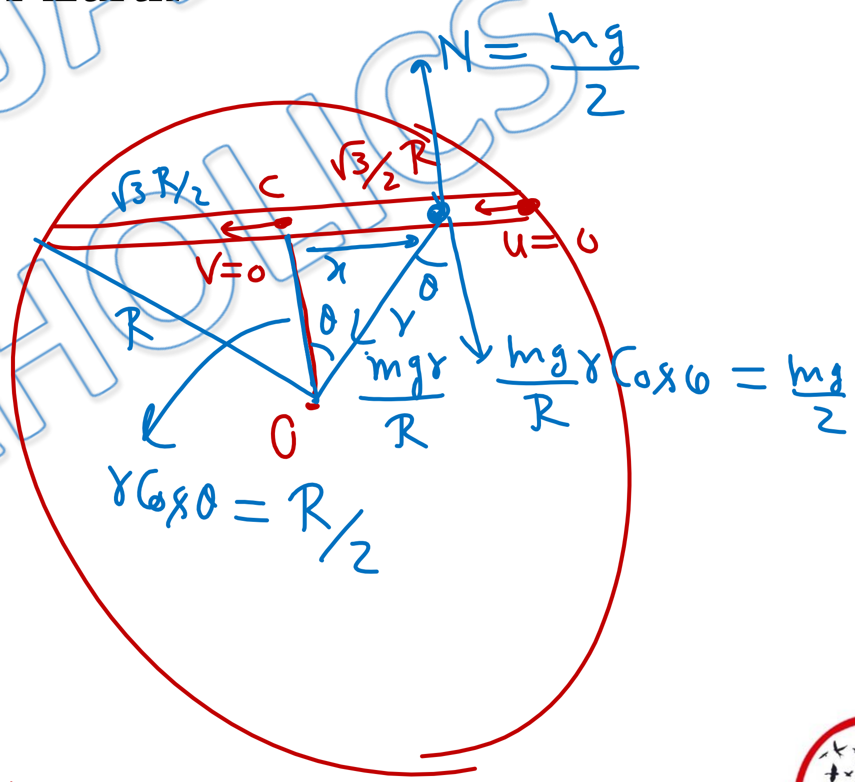
$$\frac{1}{2}mV_c^2 = \frac{3}{2} \times \frac{1}{2}mv^2$$

$$V_c = v\sqrt{\frac{3}{2}}$$

Inside sphere $U = -\frac{GMm}{2R^3}(3R^2 - r^2)$, $U_{surface} = -\frac{GMm}{R}$

Q.12) A tunnel is dug along a chord of Earth having length $\sqrt{3}$R is radius of Earth. A small block is released in the tunnel from the surface of Earth. The particle comes to rest at the center of tunnel. Find coefficient of friction between the block and the surface of tunnel. Ignore the effect of rotation of Earth

$f_r = \mu N = \frac{\mu mg}{2}$



(a) 0.22

(b) 0.67

(c) 0.86

(d) 0.99

$W_g + W_{fr} = K_f - K_i$

$U_i - U_f + W_{fr} = 0 - 0$

$W_{fr} = U_f - U_i$

$-\frac{\mu mg}{2}\frac{R\sqrt{3}}{2} = -\frac{GMm}{2R^3}\left(3R^2 - \frac{R^2}{4}\right) - \left(-\frac{GMm}{R}\right)$

$$-\frac{\mu m g R\sqrt{3}}{4} = -\frac{GMm \times 11}{8R} + \frac{GMm}{R}$$

$$\frac{\mu m R\sqrt{3}}{4} \times \frac{GM}{R^2} = \frac{3}{8}\frac{GMm}{R}$$

$$\mu\frac{\sqrt{3}}{4} = \frac{3}{8}$$

$$\boxed{\mu = \frac{\sqrt{3}}{2}} = \frac{1.73}{2} =$$

Ans. c

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