DPP – 2 (Gravitation)

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Q 1. Two particles of masses m and 2m are at a distance 3r apart at the ends of a straight-line AB. C is the center of mass of the system. The magnitude of the gravitational intensity due to the masses at C is

(a) zero (b) $\frac{7Gm}{4r^2}$

(c) $\frac{9Gm}{4r^2}$ (d) $\frac{3Gm}{2r^2}$

Q 2. The distance of the centers of moon and the earth is D. The mass of the earth is 81 times the mass of the moon. At what distance from the center of the earth, the gravitational force will be zero:

(a) $\frac{D}{2}$ (b) $\frac{2D}{3}$

(c) $\frac{4D}{3}$ (d) $\frac{9D}{10}$

Q 3. A point mass M is at a distance S from an infinitely long and thin rod of linear density D. If G is the gravitational constant, then gravitational force between the point mass and the rod is

(a) $2\frac{MGD}{S}$ (b) $\frac{MGD}{S}$

(c) $\frac{MGD}{2S}$ (d) $\frac{2MGD}{3S}$

Q 4. The gravitational field due to a solid sphere of radius R and mass M at a point distant R/2 from the center of the sphere is

(a) zero (b) $\frac{GM}{2R^2}$

(c) $\frac{GM}{R^2}$ (d) $\frac{4GM}{R^2}$

Q 5. The height above the surface of earth at which the gravitational field intensity is reduced to 1% of its value on the surface of earth is: [R_e = radius of earth]

(a) $100R_e$ (b) $10R_e$

(c) $99R_e$ (d) $9R_e$

Q 6. The mass of the moon is 734×10^{20}kg and the radius is 1.74×10^6m. The gravitational field strength at its surface is :

(a) 1.45 N/kg (b) 1.55 N/kg

(c) 1.75 N/kg (d) 1.62 N/kg

Q 7. If earth is supposed to be a sphere of radius R, if g_{30} is value of acceleration due to gravity at latitude of 30° and g at the equator, the value of $g - g_{30°}$ [ω = angular velocity of rotation of earth about its axis, R = radius of earth]

(a) $\frac{5}{4}\omega^2 R$ (b) $\frac{3}{4}\omega^2 R$

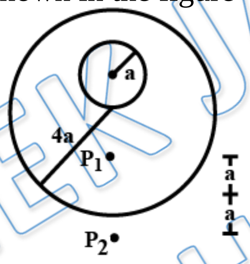
(c) $\omega^2 R$ (d) $\frac{1}{4}\omega^2 R$

Q 8. A tunnel is dug along a diameter of the earth. The force on a particle of mass m placed in the tunnel at a distance x from the center is: [M_e = mass of earth, R = radius of earth]

(a) $\frac{GM_e m}{R^3}x$ (b) $\frac{GM_e m}{R^2}x$

(c) $\frac{GM_e m}{R^3 x}$ (d) $\frac{GM_e}{R^3 x}$

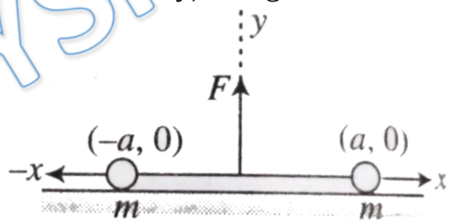
Q 9. A uniform metal sphere of radius a and mass M is surrounded by a thin uniform spherical shell of equal mass and radius 4a (figure) The center of the shell falls on the surface of the inner sphere. P_1 is at a distance 4a from center of metal sphere. Find the gravitational field at the point P_2 shown in the figure

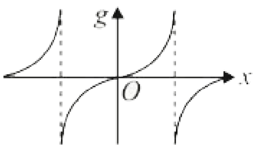


(a) $\frac{61GM}{900a^2}$ (b) $\frac{16GM}{3a^2}$

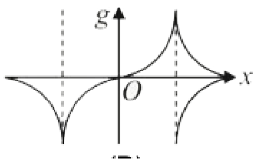
(c) $\frac{35GM}{161a^2}$ (d) $\frac{51GM}{90a^2}$

Q 10. Two identical spherical balls each of mass m are placed as shown in figure. Plot the variation of g (gravitational intensity) along the x-axis.





(a)



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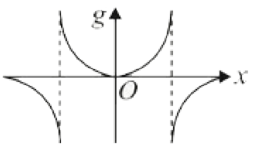
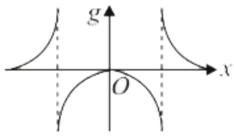


(c)



(d)

Q 11. At what height from surface of earth the gravitational field reduces by 75 % the gravitational field at the surface of earth ?
(a) R (b) 2R
(c) 3R (d) 4R

Q 12. The gravitational field in a region is given by $\vec{E} = 5\hat{\imath} + 12\hat{\jmath}$ (in N/Kg). Find the magnitude of the gravitational force acting on a particle of mass 2kg placed at the origin.
(a) 26 N (b) 30 N
(c) 20 N (d) 35 N

Q 13. The gravitational field in a region is $(10\hat{\imath} - 10\hat{\jmath})$ N/kg. Find the work done by gravitational force to shift slowly a particle of mass 1kg from point (1m, 1m) to a point (2m, -2m).
(a) 10 J (b) -10 J
(c) -40 J (d) 40 J

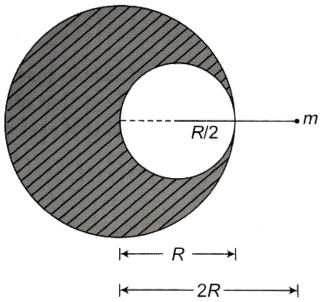
Q 14. Two planets have the same average density, but their radii are R_1 and R_2. If acceleration due to gravity on these planets be g_1 and g_2 respectively, then
(a) $\frac{g_1}{g_2} = \frac{R_1}{R_2}$ (b) $\frac{g_1}{g_2} = \frac{R_2}{R_1}$
(c) $\frac{g_1}{g_2} = \frac{R_1^2}{R_2^2}$ (d) $\frac{g_1}{g_2} = \frac{R_1^3}{R_2^3}$

Q 15. Let the acceleration due to gravity be g_1 at a height h above the earth's surface, and g_2 at a depth d below the earth's surface. If $g_1 = g_2$, h<<R and d<<R then
(a) h = d (b) h = 2d
(c) 2h = d (d) it is not possible for g_1 to be equal to g_2

Q 16. What would be the value of acceleration due to gravity at a point 5 km below the earth's surface?
$(R_e = 6400\text{km}, g_E = 9.8\ m/s^2)$
(a) 9.6 m/s^2 (b) 9.79 m/s^2
(c) 9.89 m/s^2 (d) 10 m/s^2

Q 17. What will be the acceleration due to gravity at a distance of 3200 km below the surface of the earth ? [Take $R_e = 6400$ km]
(a) 2.7 m/s^2 (b) 4.9 m/s^2
(c) 9.8 m/s^2 (d) 19.6 m/s^2

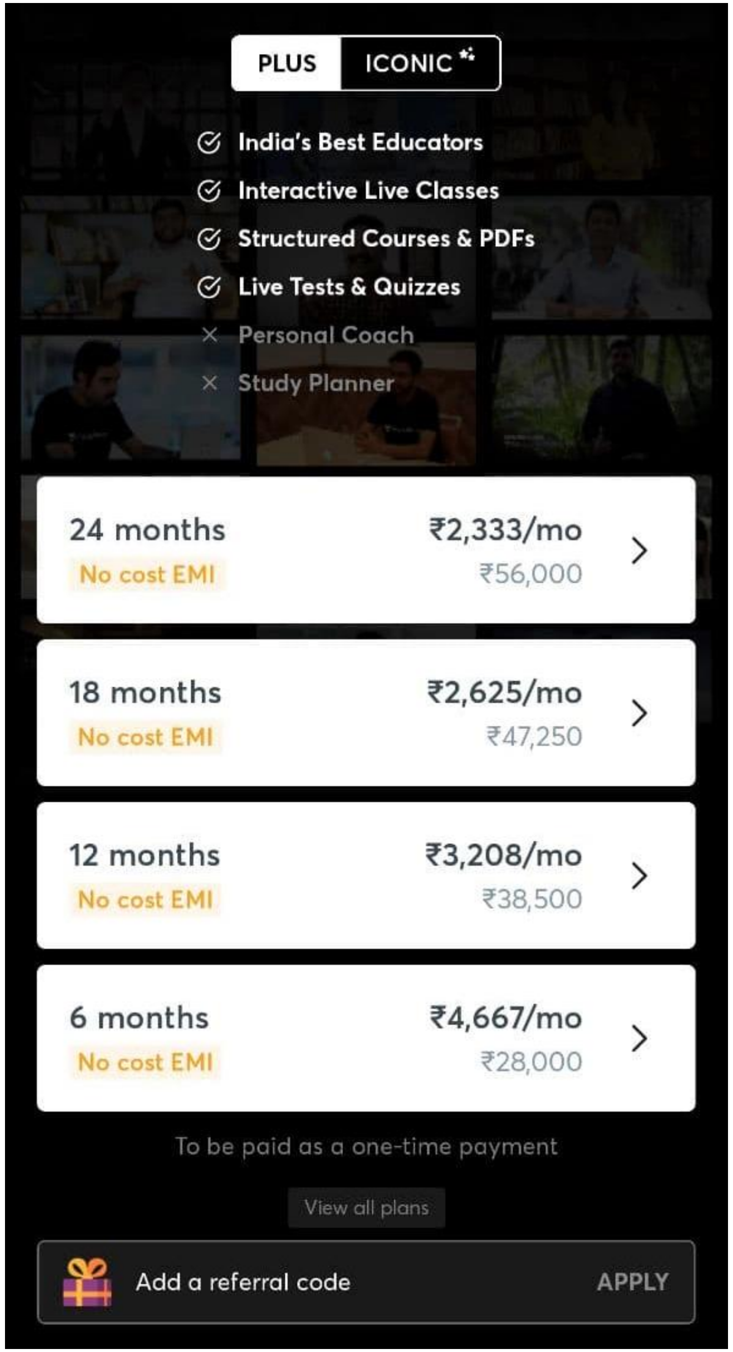
Q 18. From a solid sphere of mass M and radius R, a solid sphere of radius R/2 is removed as shown. Find gravitational force on mass m as shown



(a) $\frac{5}{12}\frac{GMm}{R^2}$ towards left
(b) $\frac{7}{36}\frac{GMm}{R^2}$ towards left
(c) $\frac{3}{17}\frac{GMm}{R^2}$ towards right
(d) $\frac{9}{11}\frac{GMm}{R^2}$ towards right

Answer Key

Q.1 b	Q.2 d	Q.3 a	Q.4 b	Q.5 d
Q.6 d	Q.7 d	Q.8 a	Q.9 a	Q.10 a
Q.11 a	Q.12 a	Q.13 d	Q.14 a	Q.15 c
Q.16 b	Q.17 b	Q.18 b		



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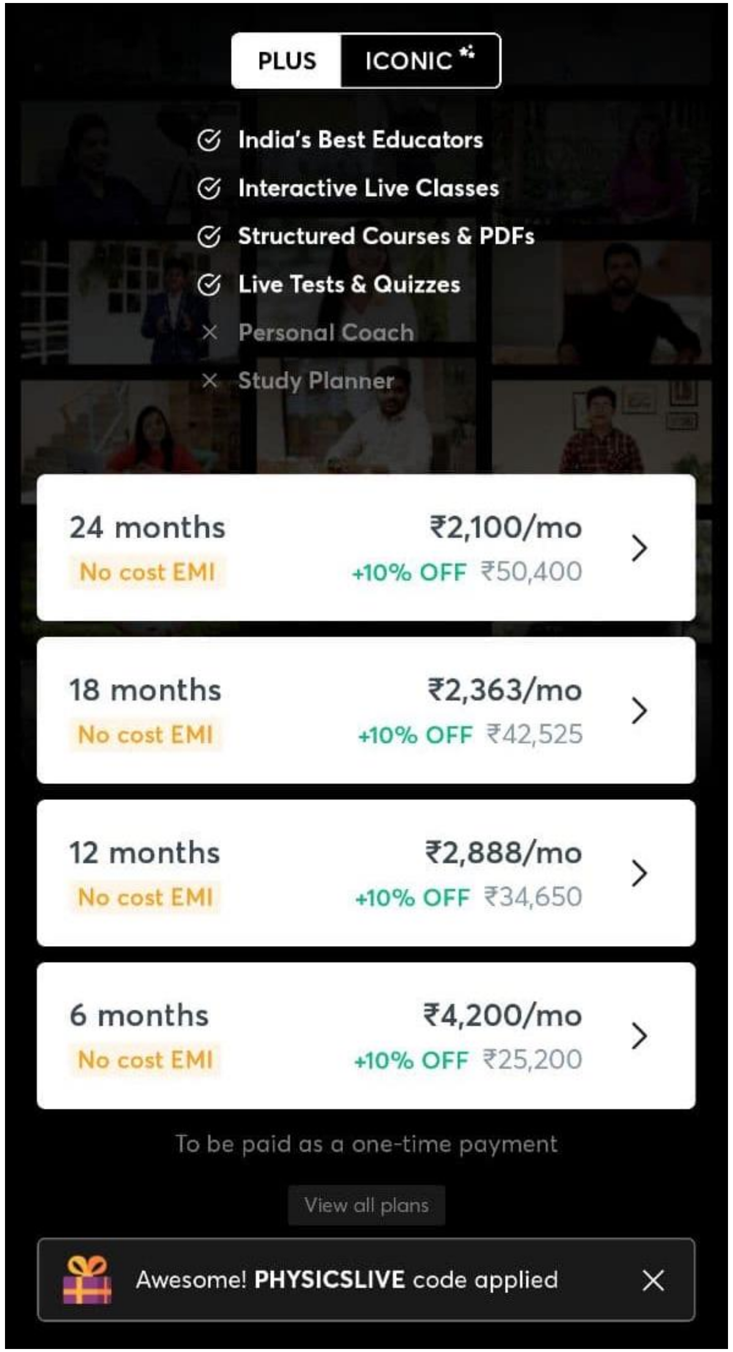

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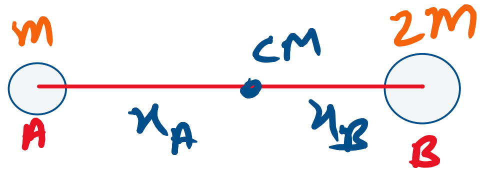
Written Solution

DPP-2 Gravitation: Gravitational Field

By Physicsaholics Team

Solution: 1



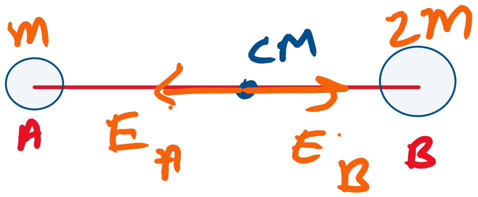
$$x_A + x_B = 3r$$

$$x_A = \frac{(2m)(3r)}{(2m+m)}$$

$$x_A = \frac{6mr}{3m}$$

$$\boxed{x_A = 2r}$$

so, $\boxed{x_B = r}$



$$E_A = \frac{Gm}{(2r)^2} = \frac{Gm}{4r^2} \quad \text{(towards Left)}$$

$$E_B = \frac{G(2m)}{(r)^2} = \frac{2Gm}{r^2} \quad \text{(towards right)}$$

$$E = E_B - E_A = \frac{2Gm}{r^2} - \frac{Gm}{4r^2} = \frac{7Gm}{4r^2}$$

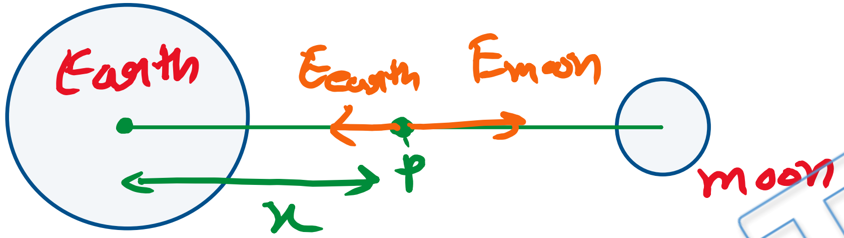
$$\boxed{E = \frac{7Gm}{4r^2}}$$ Ans

Ans. b

Solution: 2

$r = D$

$m_e = 81\, m_m$



Let; at point (P), $E_P = 0$

$E_P = E_{earth} - E_{moon} = 0$

$E_{earth} = E_{moon}$

$$\frac{G m_e}{(x)^2} = \frac{G m_m}{(D-x)^2}$$

$$\frac{81 m_m}{x^2} = \frac{m_m}{(D-x)^2}$$

$$\frac{81}{x^2} = \frac{1}{(D-x)^2}$$

$$\frac{9}{x} = \frac{1}{D-x}$$

$$\frac{9}{x} = \frac{1}{D-x}$$

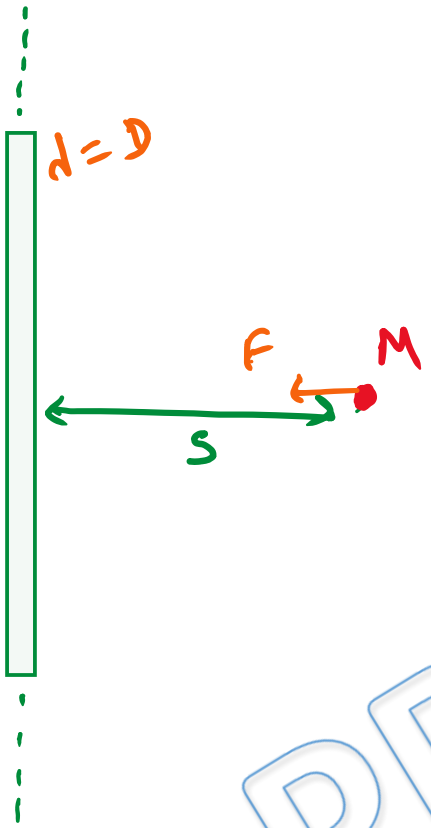
$$9D - 9x = x$$

$$9D = 10x$$

$$\boxed{x = \frac{9D}{10}} \text{ Ans}$$

Ans. d

Solution: 3



$$F = ME$$

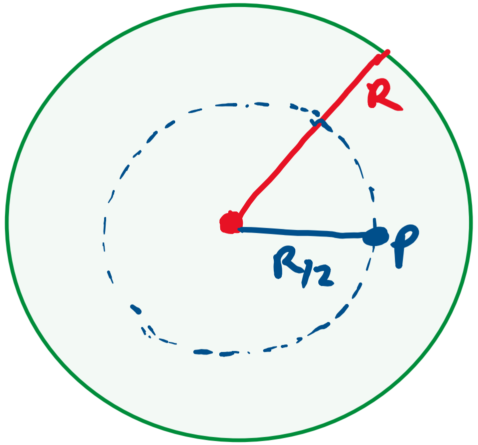
$$E = \frac{2GD}{s}$$

so, $F = M\left(\frac{2GD}{s}\right)$

$$\boxed{F = \frac{2MGD}{s}}$$ Ans.

Ans. a

Solution: 4



$$E_p = \frac{GMx}{R^3}$$

$$x = R/2$$

$$E_p = \frac{GM(R/2)}{R^3}$$

$$\boxed{E_p = \frac{GM}{2R^2}}$$ Ans

Ans. b

Solution: 5

at a height 'h' from surface:

$$g = \frac{GM}{(R_e+h)^2}$$

at surface of earth;

$$g_e = \frac{GM}{R_e^2}$$

∵ given; $g = 1\%$ of g_e

$$\frac{GM}{(R_e+h)^2} = \frac{1}{100}\frac{GM}{R_e^2}$$

$$\frac{1}{R_e+h} = \frac{1}{10}\cdot\frac{1}{R_e}$$

$$10R_e = R_e + h$$

$$\boxed{h = 9R_e}$$ Ans.

Ans. d

Solution: 6

$$g = \frac{G M_m}{(R_m)^2}$$

$$g = \frac{6.675\times10^{-11} \times 734\times10^{20}}{(1.74\times10^{6})^2}$$

$$g = 1618.26\times10^{-3}$$

$$\boxed{g = 1.62\ N/kg}$$ Ans

Ans. d

Solution: 7

$g_0 = 9.8\ m/sec^2 \rightarrow$ at pole.

$$g_{eff} = g_0 - R\omega^2 \cos^2\theta$$

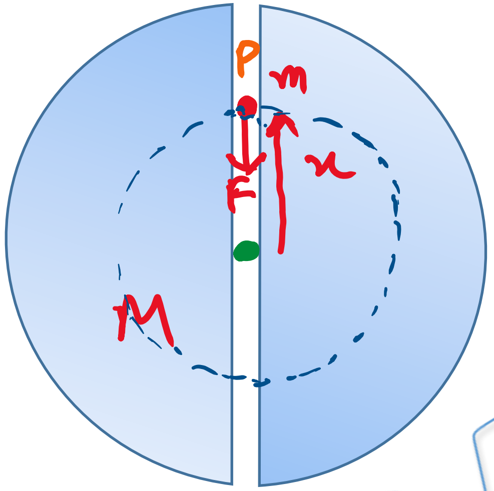
$$g - g_{30} = \frac{R\omega^2}{4}$$

$$g_{30^\circ} = g_0 - \frac{3R\omega^2}{4}$$

$$g = g_0 - R\omega^2$$

Ans. d

Solution: 8



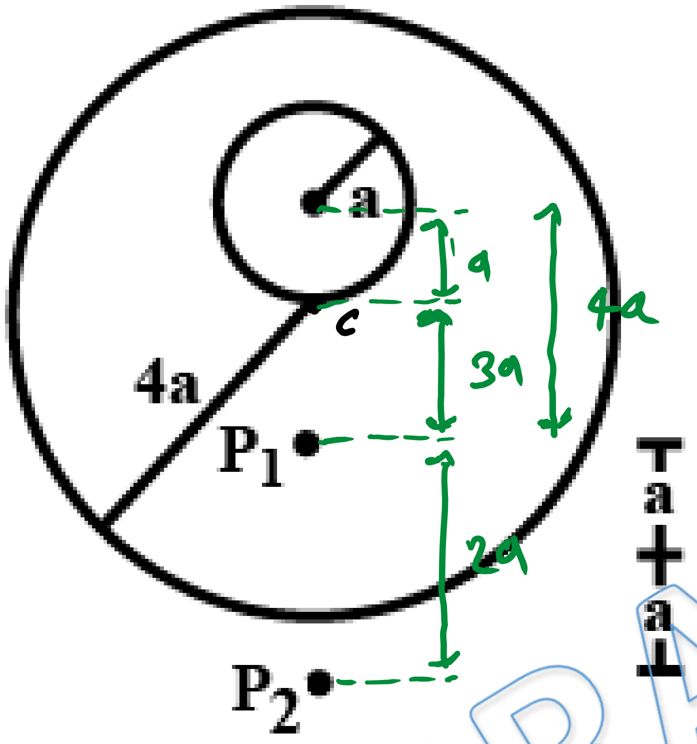
gravitational field at point 'P':

$$E = \frac{GM_e x}{R_e^3}$$

so; $F = \frac{GM_e m}{R^3} x$ Ans.

Ans. a

Solution: 9



$E = E_1 + E_2$

$= \frac{GM}{(6a)^2} + \frac{GM}{(5a)^2}$

$= \frac{GM}{a^2}\left[\frac{1}{36} + \frac{1}{25}\right]$

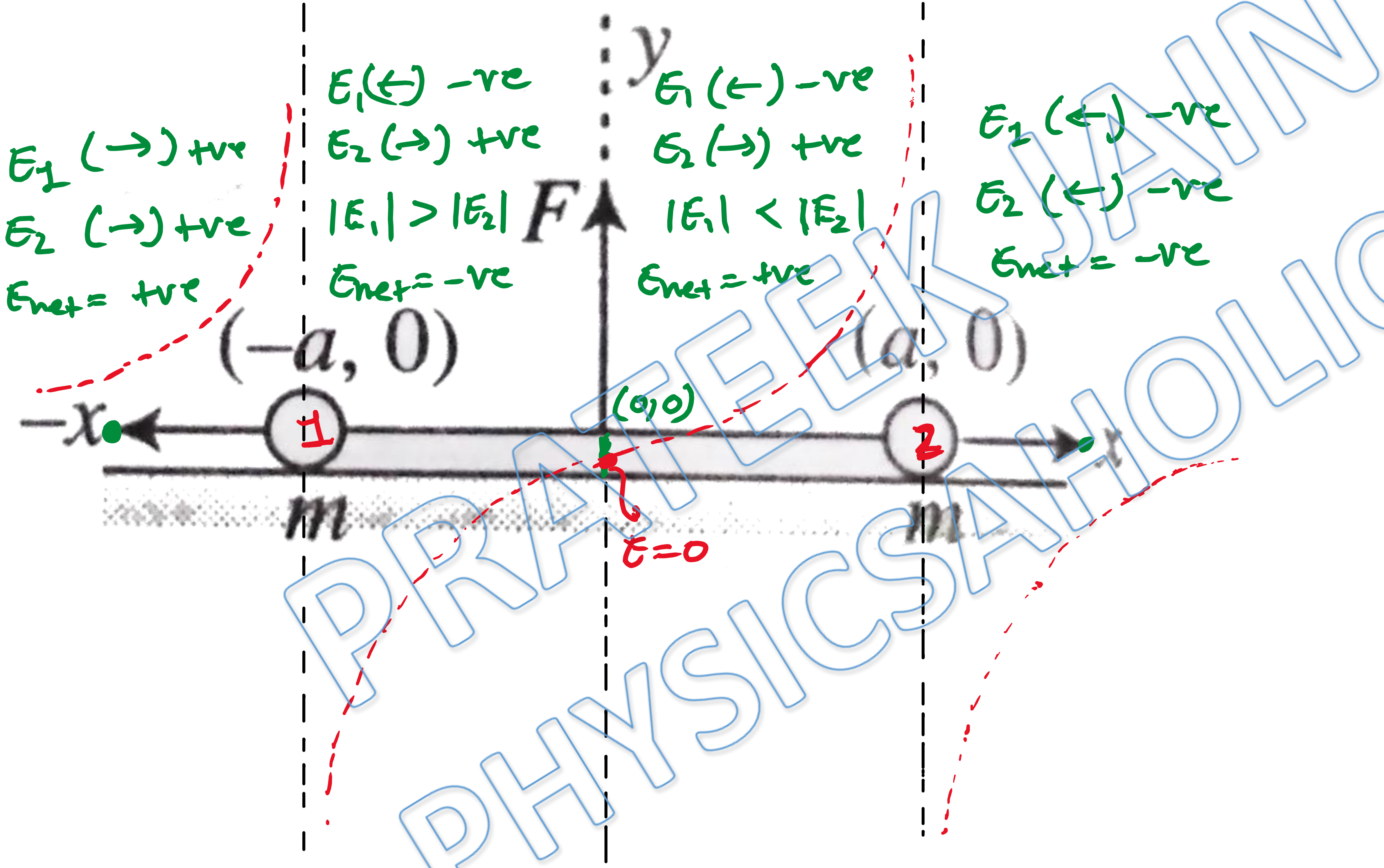
$= \frac{GM}{a^2}\left[\frac{25+36}{36 \times 25}\right]$

$$E = \frac{61\,GM}{900\,a^2}$$

at point 'P_2'; gravitational field is due to both; metal sphere (E_1) & shell (E_2)

Ans. a

Solution: 10



Ans. a

Solution: 11

at surface:

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

at height 'h' from surface:

$$g = \frac{GM}{(R+h)^2}$$

given, gravitational field is reduced by 75%, means remains 25% of g_e

so, $g = \frac{25}{100} g_e$

$$\frac{GM}{(R+h)^2} = \frac{25}{100}\frac{GM}{R^2} \Rightarrow \frac{1}{R+h} = \frac{5}{10}\left(\frac{1}{R}\right)$$

$$10R = 5R + 5h$$

$$\boxed{h = R} \quad \text{Ans}$$

Ans. a

Solution: 12

$\vec{E} = 5\hat{i} + 12\hat{j}$ (N/kg)

$\vec{F} = m\vec{E}$

$\vec{F} = 2(5\hat{i} + 12\hat{j})$

$\vec{F} = 10\hat{i} + 24\hat{j}$

$F = \sqrt{(10)^2 + (24)^2}$

$F = \sqrt{(100) + (576)}$

$F = \sqrt{676}$

$F = 26\ N$ Ans

Ans. a

Solution: 13

$$W = \int \vec{F} \cdot d\vec{s}$$

$$\vec{F} = m\vec{E}$$

$$= 1(10\hat{i} - 10\hat{j})$$

$$\vec{F} = (10\hat{i} - 10\hat{j})\,N$$

$$W = \int_{(1,1)}^{(2,-2)} (10\hat{i} - 10\hat{j}) \cdot (dx\hat{i} + dy\hat{j})$$

$$W = \left[10x - 10y\right]_{(1,1)}^{(2,-2)}$$

$$W = \left[(10\times 2) - (10\times(-2))\right] - \left[10\times 1 - 10\times 1\right]$$

$$W = [20 + 20] - [10 - 10]$$

$$\boxed{W = 40\,J} \quad \text{Ans}$$

Ans. d

Solution: 14

given; $\rho_1 = \rho_2$

$$g = \frac{GM}{R^2} = \frac{G\left(\rho \times \frac{4}{3}\pi R^3\right)}{R^2}$$

$$g = \frac{4}{3}\pi \rho G R$$

$$g \propto R \quad \left[\because \rho = \text{same} \;\&\; \frac{4}{3}\pi G = \text{Const.}\right]$$

$$\boxed{\frac{g_1}{g_2} = \frac{R_1}{R_2}} \quad \text{Ans}$$

Ans. a

Solution: 15

$$g_1 = g_0\left(1 - \frac{2h}{R}\right)$$

$$g_2 = g_0\left(1 - \frac{d}{R}\right)$$

given; $g_1 = g_2$

$$\Rightarrow \quad g_0\left(1 - \frac{2h}{R}\right) = g_0\left(1 - \frac{d}{R}\right)$$

$$1 - \frac{2h}{R} = 1 - \frac{d}{R}$$

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

$$\boxed{d = 2h} \text{ Ans}$$

Ans. c

Solution: 16

$$g_E = \frac{GM}{R_e^2} = 9.8\ m/s^2 \quad \text{--- (1)}$$

$$\& \quad g = \frac{GM}{(R_e+h)^2} \quad \text{--- (2)}$$

$$\frac{(1)}{(2)} \Rightarrow \quad \frac{g_E}{g} = \frac{GM/R_e^2}{GM/(R_e+h)^2}$$

$$\frac{9.8}{g} = \frac{(R_e+h)^2}{(R_e)^2}$$

$$\frac{9.8}{g} = \left(\frac{6400+5}{6400}\right)^2 = \left(\frac{6405}{6400}\right)^2$$

$$g = 9.8 \times \left(\frac{6400}{6405}\right)^2$$

$$\boxed{g = 9.79\ m/s^2}$$

or

$$g = g_E\left(1 - \frac{2h}{R}\right)$$

$$= 9.8\left(1 - \frac{2\times 5}{6400}\right)$$

$$= 9.8\left(1 - \frac{10}{6400}\right)$$

$$= 9.8\left(1 - \frac{1}{640}\right)$$

$$g = 9.8\left(\frac{639}{640}\right)$$

$$\boxed{g \simeq 9.79\ m/s^2}$$

Ans. b

Solution: 17

below the surface of earth;

$$g = \frac{GM}{R^3}x \quad \text{—①}$$

on surface of earth

$$g_0 = \frac{GM}{R^2} \quad \text{—②}$$

$$\frac{②}{①} \Rightarrow \frac{g_0}{g} = \frac{GM/R^2}{GMx/R^3} = \frac{R}{x}$$

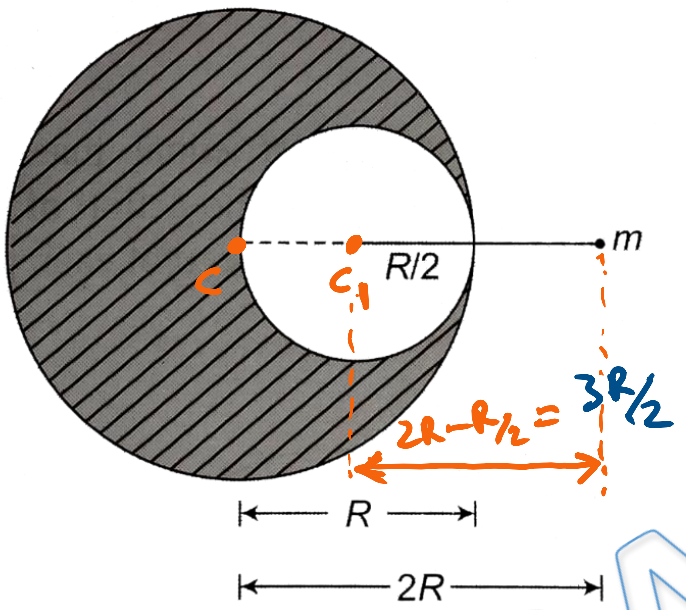
$$\frac{9.8}{g} = \frac{6400}{3200}$$

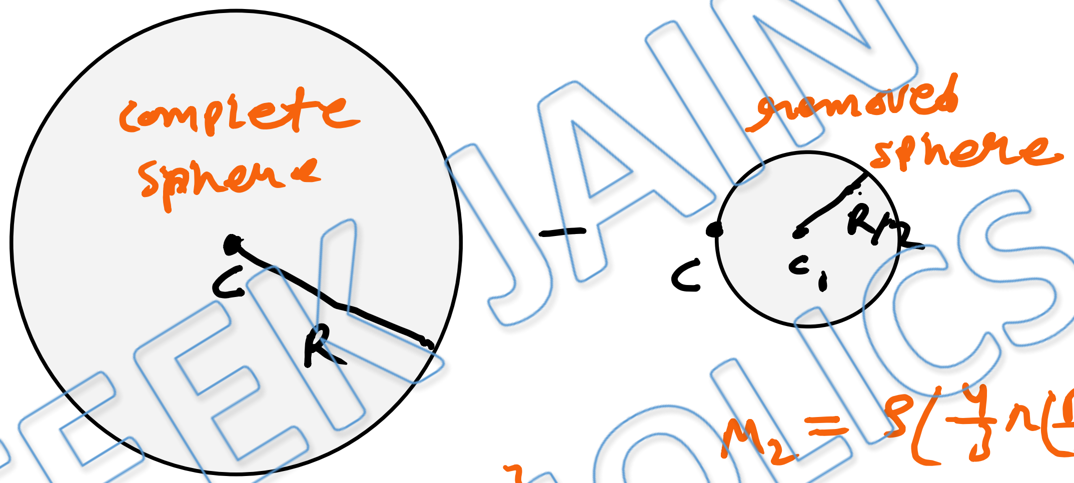
$$g = \frac{9.8}{2}$$

$$\boxed{g = 4.9\ m/s^2} \text{ Ans}$$

Ans. b

Solution: 18





$$M_1 = M = \rho \frac{4}{3}\pi R^3$$

$$M_2 = \rho\left(\frac{4}{3}\pi\left(\frac{R}{2}\right)^3\right) = \rho\left(\frac{4}{3}\pi R^3\right) \times \frac{1}{8} = \frac{M}{8}$$

$$F = F_1 - F_2$$

$$\Rightarrow F = F_1 - F_2$$

$$F = \frac{GM_1 m}{(2R)^2} - \frac{GM_2 m}{(3R/2)^2}$$

$$F = \frac{Gm}{R^2}\left[\frac{M}{4} - \frac{M/8}{(3/2)^2}\right]$$

$$\Rightarrow F = \frac{Gm}{R^2}\left[\frac{M}{4} - \frac{M}{18}\right] = \frac{Gm}{R^2}\left[\frac{14M}{72}\right]$$

$$\boxed{F = \frac{7GMm}{36R^2}}$$ Ans

attractive force towards left.

Ans. b

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