DPP – 4 (Gravitation)

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Q 1. An astronaut orbiting the earth in a circular orbit 120 km above the surface of earth, gently drops a spoon out of space-ship. The spoon will
(a) Fall vertically down to the earth
(b) Move towards the moon
(c) Will move along with space-ship
(d) Will move in an irregular way then fall down to earth

Q 2. A satellite of mass m, initially at rest on the earth, is launched into a circular orbit at a height equal to the radius of the earth. The minimum energy required is
(a) $\frac{\sqrt{3}}{4}mgR$ (b) $\frac{1}{2}mgR$
(c) $\frac{1}{4}mgR$ (d) $\frac{3}{4}mgR$

Q 3. A period of geostationary satellite is
(a) 24 hr (b) 12 hr
(c) 30 hr (d) 48 hr

Q 4. A satellite of mass m is orbiting close to the surface of the earth Radius R=6400 km has kinetic energy K. The corresponding kinetic energy of the satellite to escape from the earths gravitational field is
(a) K (b) 2K
(c) mgR (d) mK

Q 5. Two satellites of masses m_1 and m_2 $(m_1 > m_2)$ are revolving the earth in circular orbits of radius r_1 and r_2 $(r_1 > r_2)$ respectively. Which of the following statement is true regarding their velocities V_1 and V_2
(a) $V_1 = V_2$ (b) $V_1 < V_2$
(c) $V_1 > V_2$ (d) $\frac{V_1}{r_1} = \frac{V_2}{r_2}$

Q 6. A geostationary satellite can be installed :
(a) Over the north or south pole
(b) Over any city on the equator
(c) In an orbit marking an angle of 43.3° with the equator plane
(d) In an orbit marking an angle of 66.5° with the equatorial plane

Q 7. An artificial satellite revolves round the earth at a height of 1000km. The radius of the earth is 6.38×10^3 km. Mass of the earth = 6×10^{24}kg, G = $6.67 \times 10^{-11}\ Nm^2/kg^2$. Find the orbital speed and period of revolution of the satellite

(a) 7364 m/s, 6297 s (b) 1064 m/s, 6297 s
(c) 9364 m/s, 9297 s (d) 8364 m/s, 7297 s

Q 8. A satellite S is moving in an elliptical orbit around the earth. The mass of the satellite is very small compared to the mass of the earth. Then

(a) the acceleration of `S` is always directed towards the center of the earth
(b) the angular momentum of `S` about the center of the earth changes in direction, but its magnitude remains constant
(c) the total mechanical energy of `S` varies periodically with time
(d) the linear momentum of `S` remains constant in magnitude

Q 9. If an artificial satellite is moving in a circular orbit around earth with speed equal to one fourth of V_e from earth, then height of the satellite above the surface of the earth is (R = radius of earth)

(a) 7R (b) 4R
(c) 3R (d) R

Q 10. An artificial satellite is moving in a circular orbit around the earth with a speed equal to half the magnitude of escape velocity from the earth. If the satellite is stopped suddenly in its orbit and allowed to fall freely onto the earth, find the speed with which it hits the surface of the earth. (R = radius of earth)

(a) $\sqrt{gR}$ (b) $\sqrt{\frac{gR}{2}}$
(c) $\sqrt{\frac{g}{R}}$ (d) $\sqrt{\frac{gM}{R}}$

Q 11. The orbital speed of an artificial satellite very close to the surface of the earth is V_o. Then the orbital speed of another artificial satellite at a height equal to three times the radius of the earth from surface is

(a) $4V_o$ (b) $2V_o$
(c) $0.5V_o$ (d) $4V_o$

Q 12. A satellite with kinetic energy E_k is revolving round the earth in a circular orbit. How much more kinetic energy should be given to it so that it may just escape into outer space

(a) E_k (b) $2E_k$
(c) $\frac{1}{2}E_k$ (d) $3E_k$

Q 13. If V_e and V_0 represent the escape velocity and orbital velocity of a satellite corresponding to a circular orbit of radius R, then

(a) $V_e = V_o$ (b) $\sqrt{2}V_o = V_e$
(c) $V_e = \frac{V_o}{\sqrt{2}}$ (d) V_e and V_o are not related

Q 14. The angular velocity of rotation of a star (mass M and radius R), such that the matter will start escaping from its equator is:

(a) $\sqrt{\frac{2GR}{M}}$ (b) $\sqrt{\frac{GM}{R^3}}$

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

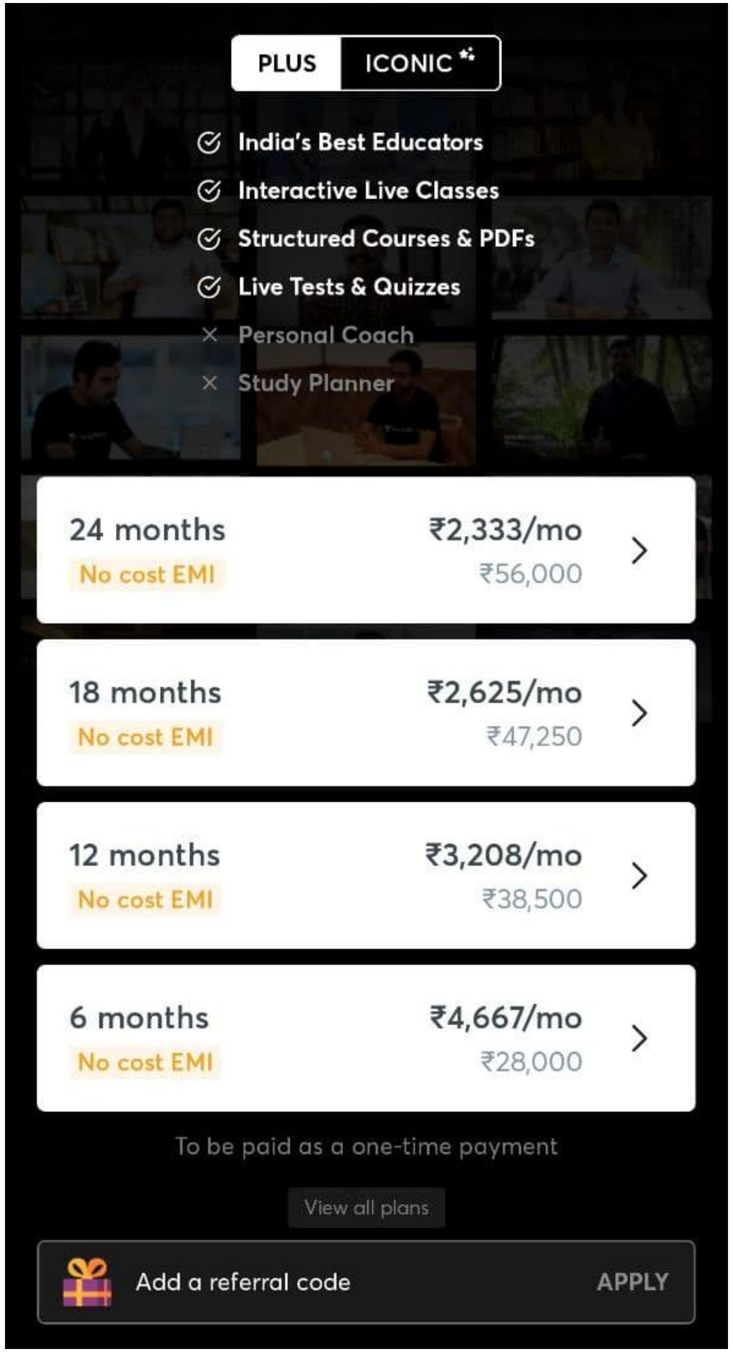
Q 15. The escape velocity on a planet is equal to the orbital velocity (on surface) on another planet . If the radii of two planets are equal, determine the ratio of acceleration due to gravity on the two planets

(a) 5 : 2 (b) 3 : 4

(c) 2 : 3 (d) 1 : 2

Answer Key

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



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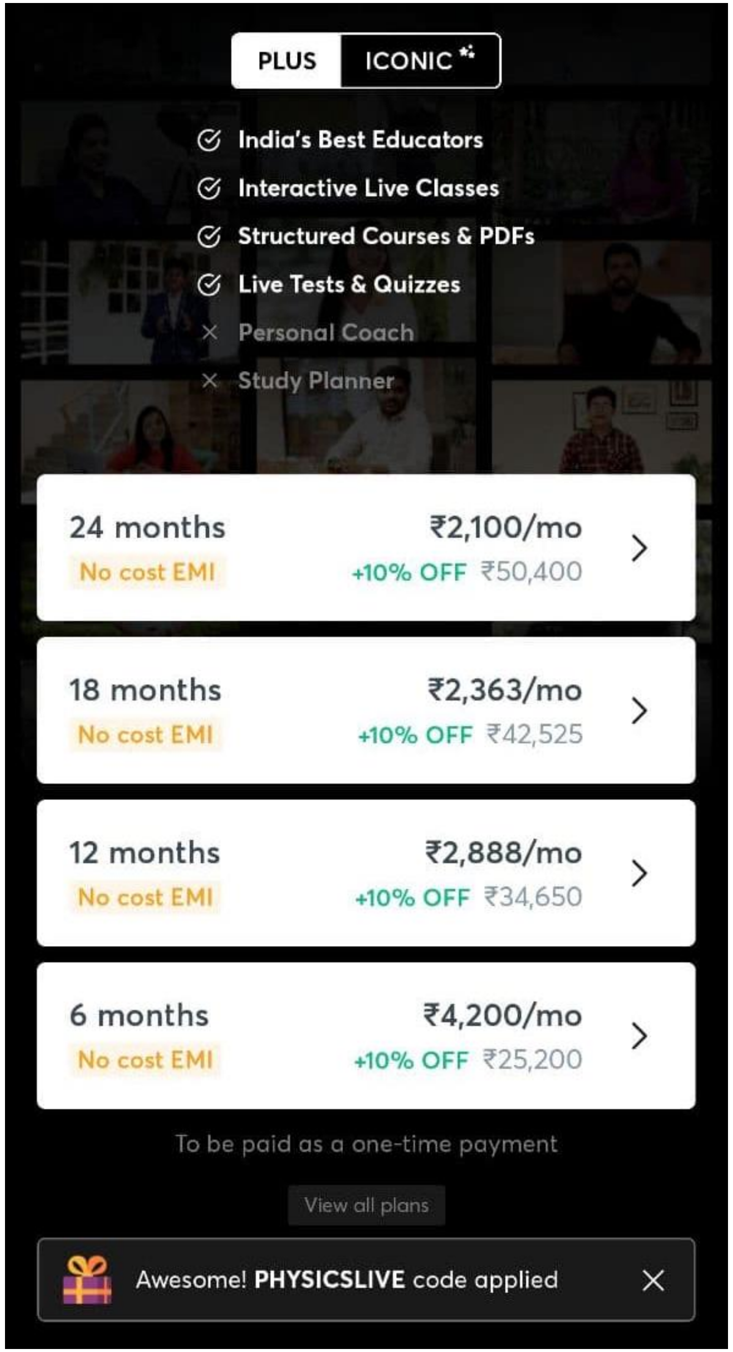

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Written Solution

DPP-4 Gravitation: Escape Velocity, Orbital Velocity, Geostationary Satellite

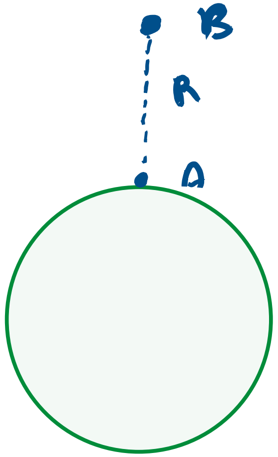
By Physicsaholics Team

Solution: 1

The velocity of the spoon will be equal to the orbital velocity when dropped out of the spaceship.

Ans. c

Solution: 2



$$U_A + E = U_B + KE_B$$

$$v_B = \sqrt{\frac{GM}{2R}}$$

$$E = U_B - U_A + KE_B$$

$$= -\frac{GMm}{2R} - \left(-\frac{GMm}{R}\right) + \frac{1}{2}mv_B^2$$

$$= \frac{GMm}{2R} + \frac{1}{2}m\left(\frac{GM}{2R}\right) =$$

$$= \frac{3GMm}{4R} = \frac{3m(gR^2)}{4R}$$

$$\boxed{E = \frac{3mgR}{4}}$$ Ans

Ans. d

Solution: 3

A geostationary satellite is an earth-orbiting satellite, placed at an altitude nearly 35,800 kilometers directly above the equator, that revolves in the same direction as the earth rotates (from west to east). The time period of revolution of a geostationary satellite around earth is same as that rotation of earth about its own axis i.e. 24 hours.

Ans. a

Solution: 4

$\because \quad V_e = \sqrt{2}\, V$

so, $(KE)_e = \frac{1}{2} m V_e^2$

$K = \frac{1}{2} m V^2$

$(KE)_e = \frac{1}{2} m (\sqrt{2}\, V)^2$

$(KE)_e = m V^2$

$\boxed{(KE)_e = 2K}$ Ans

Ans. b

Solution: 5

$$v_1 = \sqrt{\frac{GM}{r_1}}$$

$$v_2 = \sqrt{\frac{GM}{r_2}}$$

$$\because \quad r_1 > r_2$$

$$\text{so;} \quad \boxed{v_1 < v_2} \text{ Ans}$$

Ans. b

Solution: 6

orbiting near the equator allows the satellite to match the speed of Earth's spin which is at same lattitube.

so; A geostationary satellite can be installed over any city on the equator.

Ans. b

Solution: 7

$h = 1000\ km = 1 \times 10^3\ km$

$v = \sqrt{\frac{GM}{r}}$

$r = R + h = 7.38 \times 10^3\ km = 7.38 \times 10^6\ m$

$$v = \sqrt{\frac{6.67 \times 10^{-11} \times 6 \times 10^{24}}{7.38 \times 10^6}}$$

$$v = \sqrt{54.23 \times 10^6}$$

$$v = 7.364 \times 10^3\ m/s$$

$$\boxed{v = 7364\ m/s}\ \text{Ans}$$

$$T = \frac{2\pi r}{v} = \frac{2 \times \pi \times 7.38 \times 10^6}{7364}$$

$$\boxed{T \approx 6297\ sec}\ \text{Ans}$$

Ans. a

Solution: 8

As gravitational force on satellite due to earth acts always towards the center of earth, thus acceleration of S is always directed towards the center of the earth.

Also, as there is no external force so according to conservation of energy , total mechanical energy of S is constant always.

Also, as in the absence of external torque L is constant in magnitude and direction.

And as r and v varies with time in elliptical orbit, linear momentum also changes with magnitude.

Ans. a

Solution: 9

given, $v = \frac{v_e}{4} = \frac{1}{4}\sqrt{\frac{2GM}{R}}$

$F_c = \frac{mv^2}{r}$

$\frac{GM\cancel{m}}{r^{\cancel{2}}} = \frac{\cancel{m}v^2}{\cancel{r}}$

$\frac{GM}{r} = v^2 = \left(\frac{v_e}{4}\right)^2$

$\frac{GM}{r} = \frac{1}{16}\left(\sqrt{\frac{2GM}{R}}\right)^2$

$\frac{\cancel{GM}}{r} = \frac{1}{\cancel{16}_8}\frac{\cancel{2GM}}{R}$

$\boxed{r = 8R}$

height from surface

$h = r - R$

$h = 8R - R$

$\boxed{h = 7R}$ Ans.

Ans. a

Solution: 10

$$v = \frac{v_e}{2} = \frac{1}{2}\sqrt{\frac{2GM}{R}}$$

$$F_c = \frac{mv^2}{r}$$

$$\frac{GM\cancel{m}}{r^{\cancel{2}}} = \frac{\cancel{m}v^2}{\cancel{r}}$$

$$\frac{GM}{r} = v^2 = \left(\frac{v_e}{2}\right)^2$$

$$\frac{GM}{r} = \frac{1}{4}\left(\sqrt{\frac{2GM}{R}}\right)^2$$

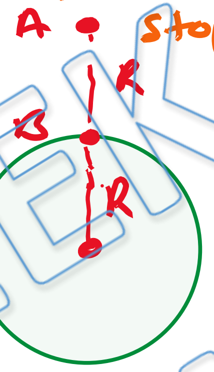
$$\frac{\cancel{GM}}{r} = \frac{1}{\cancel{4}_2}\,\frac{\cancel{2}\cancel{GM}}{R}$$

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

height from surface

$$h = r - R$$

$$\boxed{h = R}$$



$A \to B$

$$(U + KE)_A = (U + KE)_B$$

$$-\frac{GM\cancel{m}}{2R} + 0 = -\frac{GM\cancel{m}}{R} + \frac{1}{2}\cancel{m}v^2$$

$$\frac{GM}{R} - \frac{GM}{2R} = \frac{v^2}{2}$$

$$\frac{GM}{\cancel{2}R} = \frac{v^2}{\cancel{2}} \Rightarrow \boxed{v = \sqrt{\frac{GM}{R}}}$$

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

$$v = \sqrt{\frac{gR^2}{R}}$$

$$\boxed{v = \sqrt{gR}} \text{ Ans}$$

Ans. a

Solution: 11

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

$$V_2 = \sqrt{\frac{GM}{(R+3R)}}$$

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

$$= \frac{1}{2}\sqrt{\frac{GM}{R}}$$

$$\boxed{V_2 = \frac{V_0}{2}}$$ Ans.

Ans. c

Solution: 12

let vel = v

$v = \sqrt{\frac{GM}{r}}$

$E_k = \frac{1}{2}m(v)^2$

To escape into outer space

$v_e = \sqrt{2}\, v$

$E = \frac{1}{2}mv_e^2 = \frac{1}{2}m(\sqrt{2}v)^2$

$E = 2\left(\frac{1}{2}mv^2\right)$

$\boxed{E = 2E_k}$

$\Delta E = E - E_k \Rightarrow \boxed{\Delta E = E_k}$ Ans.

Ans. a

Solution: 13

$$v_o = \sqrt{\frac{GM}{r}}$$

$$\boxed{v_e = \sqrt{2}\, v_o} \quad \text{As.}$$

Ans. b

Solution: 14

escape velocity; $v_e = \sqrt{\frac{2GM}{R}}$

let angular velocity $= \omega$

then ; $v = \omega r$

$\omega = \frac{v}{r}$

$$\omega = \frac{\sqrt{\frac{2GM}{R}}}{R}$$

$$\boxed{\omega = \sqrt{\frac{2GM}{R^3}}}$$ Ans

Ans. b

Solution: 15

Planet - 1

escape velocity

$$V_1 = \sqrt{\frac{2GM_1}{R_1}}$$

Planet - 2

orbital velocity

$$V_2 = \sqrt{\frac{GM_2}{R}}$$

$$V_1 = V_2$$

$$\sqrt{\frac{2GM_1}{R_1}} = \sqrt{\frac{GM_2}{R_2}}$$

$$\frac{2GM_1}{\cancel{R_1}} = \frac{GM_2}{\cancel{R_2}}$$

$\because R_1 = R_2$ (given)

so; $2\,GM_1 = GM_2$

$$2\,g_1 R_1^2 = g_2 R_2^2$$

$$\Rightarrow 2\,g_1 \cancel{R_1^2} = g_2 \cancel{R_2^2}$$

$[\because R_1 = R_2]$

so;

$$\boxed{\frac{g_1}{g_2} = \frac{1}{2}}$$ Ans.

Ans. d

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Chalo Niklo