Gravitation JEE Main PYQ - 1

Total Time: 25 Minute **Total Marks:** 40

Instructions

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1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

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Gravitation

1. What is the minimum energy required to launch a satellite of mass m from the surface of a planet of mass M and radius R in a circular orbit at an altitude of $2R$? **(+4, -1)**

[2013]

a. $\frac{5GmM}{6R}$

b. $\frac{2GmM}{3R}$

c. $\frac{GmM}{2R}$

d. $\frac{GmM}{3R}$

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2. Planet A has mass M and radius R. Planet B has half the mass and half the radius of Planet A. If the escape velocities from the Planets A and B are v_A and v_B, respectively, then $\frac{v_A}{v_B} = \frac{n}{4}$. The value of n is : **(+4, -1)**

[9 Jan. 2020 II]

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a. 3

b. 1

c. 2

d. 4

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3. Consider two solid spheres of radii $R, = 1m$, $R_2 = 2m$ and masses M_1 and M_2, respectively. The gravitational field due to sphere (1) and (2) are shown. The value of $\frac{m_1}{m_2}$ is : **(+4, -1)**

[8•Jan.•2020•I]

a. $\frac{2}{3}$

b. $\frac{1}{6}$

c. $\frac{1}{2}$

d. $\frac{1}{3}$

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4. A test particle is moving in a circular orbit in the gravitational field produced by a mass density $\rho(r) = \frac{K}{r^2}$. Identify the correct relation between the radius R of the particle's orbit and it's period T : **(+4, -1)**

[8 April 2019 II]

a. T/R^2 is a constant

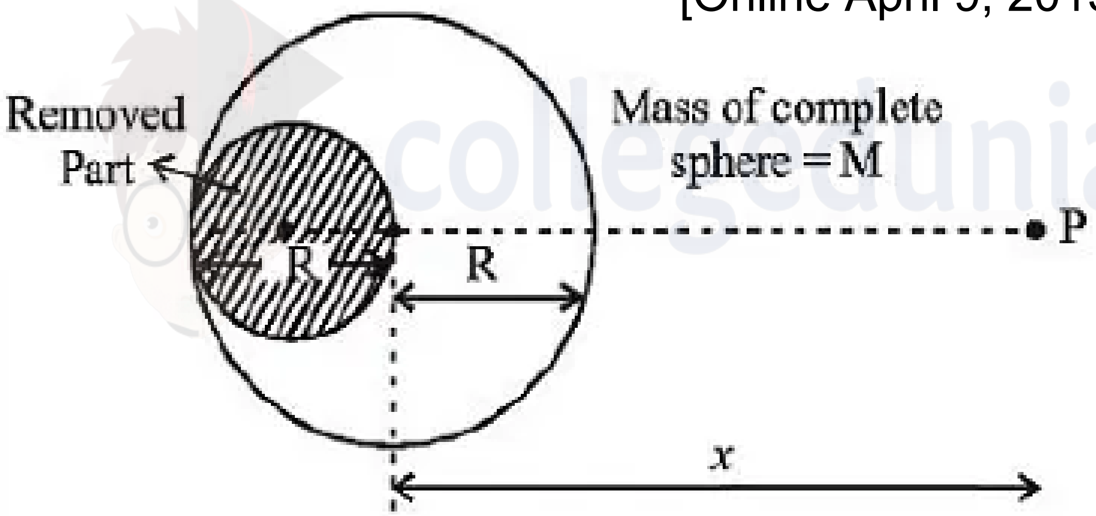
b. TR is a constant

c. T^2/R^3 is a constant

d. T/R is a constant

5. The gravitational field, due to the 'left over part' of a uniform sphere (from which a part as shown, has been 'removed out'), at a very far off point, P, located as shown, would be (nearly): **(+4, -1)**

[Online April 9, 2013]



a. $\frac{5}{6}\frac{GM}{x^2}$

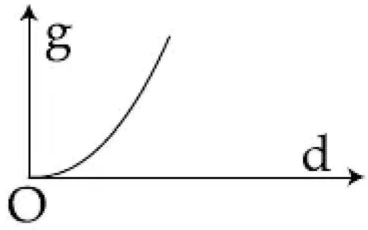
b. $\frac{8}{9}\frac{GM}{x^2}$

c. $\frac{7}{8}\frac{GM}{x^2}$

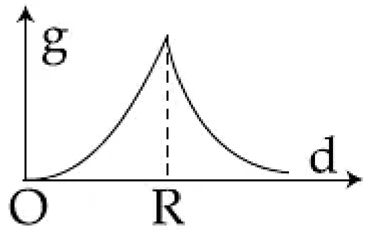
d. $\frac{6}{7}\frac{GM}{x^2}$

6. The variation of acceleration due to gravity g with distance d from centre of the earth is best represented by (R = Earth?s radius) : **(+4, -1)**

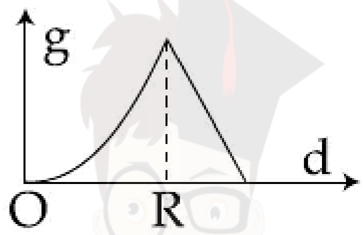
[Online May 7, 2012]



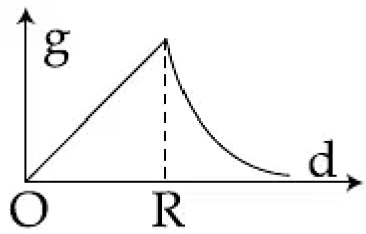
a.



b.



c.



d.

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7. A particle is moving with a uniform speed in a circular orbit of radius R in a central force inversely proportional to the nth power of R. If the period of rotation of the particle is T then - **(+4, -1)**

a. $T \propto R^{3/2}$ for any n

b. $T \propto R^{\frac{n}{2}+1}$

c. $T \propto R^{(n+1)/2}$

d. $T \propto R^{\frac{n}{2}}$

---

8. A satellite is revolving in a circular orbit at a height ' h' from the earth's surface (radius of earth $R; h << R$). The minimum increase in its orbital velocity required, so that the satellite could escape from the earth?s gravitational field, is close to : (Neglect the effect of atmosphere.) **(+4, -1)**

[2016]

a. $\sqrt{2\,gR}$

b. $\sqrt{g\,R}$

c. $\sqrt{g\,R/2}$

d. $\sqrt{gR}(\sqrt{2}-1)$

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9. A satellite of mass M is in a circular orbit of radius R about the centre of the earth. A meteorite of the same mass, falling towards the earth, collides with the satellite completely inelastically. The speeds of the satellite and the meteorite are the same, just before the collision. The subsequent motion of the combined body will be : **(+4, -1)**

[12 Jan. 2019 I]

a. in a circular orbit of a different radius

b. in the same circular orbit of radius R

c. in an elliptical orbit

d. such that it escapes to infinity

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10. A solid sphere of mass $'M'$ and radius $'a'$ is surrounded by a uniform concentric spherical shell of thickness $2a$ and mass $2M$. The gravitational field at distance $'3a'$ from the centre will be : **(+4, -1)**

[9•April•2019•I]

a. $\frac{2GM}{9a^2}$

b. $\frac{GM}{3a^2}$

c. $\frac{GM}{9a^2}$

d. $\frac{2GM}{3a^2}$

Answers

1. **Answer: a**

Explanation:

E = Energy of satellite - energy of mass on the surface of planet
$= -\frac{GMm}{2r} - \left(-\frac{GMm}{R} \right)$
Here, r = R + 2R = 2>R
Substituting in about equation we get. $E = \frac{5GMm}{6R}$

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ . . . . (1)
- $(F \propto 1/r^2)$ . . . . (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ . . . . (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

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2. **Answer: d**

Explanation:

$V_e = \sqrt{\frac{2GM}{R}}$ (Escape velocity)

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

$V_B = \sqrt{\frac{2G[M/2]}{R/2}} = \sqrt{\frac{2GM}{R}}$

$\frac{V_A}{V_B} = 1 = \frac{n}{4} \Rightarrow n = 4$

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3. **Answer: b**

Explanation:

Gravitational field on the surface of a solid sphere $I_g = \frac{GM}{R^2}$
By the graph
$\frac{GM_1}{(1)^2} = 2$
and $\frac{GM_2}{(2)^2} = 3$
On solving
$\frac{M_1}{M_2} = \frac{1}{6}$

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4. Answer: d

Explanation:

$m=\int_0^R \rho 4\pi r^2 dr$
$m=4\pi KR$
$v \propto \sqrt{4\pi K}$
$\frac{T}{R}=\frac{2\pi}{\sqrt{4\pi K}}$

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5. **Answer: c**

Explanation:

Let mass of smaller sphere (which has to be removed) is m
Radius $=\frac{R}{2}$ (from figure)
$\frac{M}{\frac{4}{3}\pi R^3}=\frac{m}{\frac{4}{3}\pi\left(\frac{R}{2}\right)^3}$
$\Rightarrow m=\frac{M}{8}$

Mass of the left over part of the sphere

$M' = M - \frac{M}{8} = \frac{7}{8}M$

Therefore gravitational field due to the left over part of the sphere

$= \frac{GM'}{X^2} = \frac{7}{8}\frac{GM}{x^2}$

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6. Answer: d

Explanation:

Variation of g inside earth surface

$d < R = g = \frac{Gm}{R^2}.d$

$d = R = g_s = \frac{Gm}{R^2}$

$d > R = g = \frac{Gm}{d^2}$

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7. **Answer: c**

Explanation:

$$m\omega^2 R = kR^{-n} = \frac{k}{R^n}$$
$$\Rightarrow \frac{1}{T^2} \propto \frac{1}{R^{n+1}}$$
$$\Rightarrow T \propto R^{\left(\frac{n+1}{2}\right)}$$

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8. **Answer: d**

Explanation:

Orbital velocity $v = \sqrt{\frac{GM}{R+h}} = \sqrt{\frac{GM}{R}}$ as h < < R
Velocity required to escape
$\frac{1}{2}mv'^2 = \frac{GMm}{R+h}; v' = \sqrt{\frac{2GM}{R+h}} = \sqrt{\frac{2GM}{R}} \, (h << R)$
∴ Increase in velocity
$v' - v = \sqrt{\frac{2GM}{R}} - \sqrt{\frac{GM}{R}} = \sqrt{2gR} - \sqrt{gR} = \sqrt{gR}\left(\sqrt{2} - 1\right)$

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9. **Answer: c**

Explanation:

If $V < V_o$, then satellite does not remain in it's circular path rather it traces a spiral path and falls on earth
$V = V_e$
satellite move along parabolic path
- wherein
$V = V_o$
Satellite revolves in circular path
$V > V_e$
Satellite will move along a hyperbolic path
Apply momentum conservation

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10. **Answer: b**

Explanation:

We use gauss's Law for gravitation
$g.4\pi r^2$ = (Mass enclosed) $4\pi G$
$g = \frac{3M4\pi G}{4\pi(3a)^2}$
$= \frac{MG}{3a^2}$
Option (2)

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