Gravitation

Question1

The escape velocity for earth is v. A planet having 9 times mass that of earth and radius, 16 times that of earth, has the escape velocity of:

[NEET 2024 Re]

Options:

A.

V/3

B.

2v/3

C.

3V/4

D.

9v/4

Answer: C

Solution:

Escape velocity of object from planet is given by

$$(v_e)_p = \sqrt{\frac{2GM_p}{R_p}}$$

$$\therefore \ (v_e)_p \propto \sqrt{\frac{M_p}{R_p}}$$

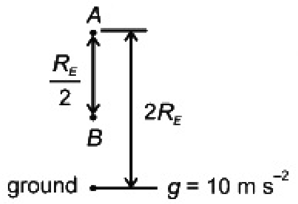
Now, $M_p = 9M_e$ and $R_p = 16R_e$ (given)

$$\frac{(v_e)_p}{(v_e)_e} = \sqrt{\frac{M_p}{R_p} \times \frac{R_e}{M_e}} = \sqrt{\frac{9M_e}{16R_e} \times \frac{R_e}{M_e}} = \sqrt{\frac{9}{16}} = \frac{3}{4}$$

$$\Rightarrow \ (v_e)_p = \frac{3}{4}v$$

Question2

An object of mass 100 kg falls from point A to B as shown in figure. The change in its weight, corrected to the nearest integer is (R_E is the radius of the earth)



[NEET 2024 Re]

Options:

A.

49N

B.

89N

C.

5N

D.

10N

Answer: A

Solution:

$$Mg' = Mg\frac{R^2}{(R+h)^2}$$

At A $\quad Mg' = Mg\frac{R^2}{(R+2R)^2} = \frac{Mg}{9}$

At B $\quad Mg' = Mg\frac{R}{\left(R+\frac{3R}{2}\right)^2} = \frac{Mg\,.\,4}{25}$

Change in weight $= Mg\frac{4}{25} - \frac{Mg}{9} = 49\ N$

Question3

The mass of a planet is 1/10th that of the earth and its diameter is half that of the earth. The acceleration due to gravity on that planet is:

[NEET 2024]

Options:

A.

19.6m s^{-2}

B.

9.8m s^{-2}

C.

4.9m s^{-2}

D.

3.92m s^{-2}

Answer: D

Solution:

$$g' = \frac{GM'}{R'^2} = \frac{GM}{10\left(\frac{R}{2}\right)^2}$$

$$= \frac{4}{10}\frac{GM}{R^2} = 0.4 \times 9.8$$

$$= 3.92 \text{m } s^{-2}$$

Question4

The minimum energy required to launch a satellite of mass m from the surface of earth of mass M and radius R in a circular orbit at an altitude of 2R from the surface of the earth is:

[NEET 2024]

Options:

A.

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

B.

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

C.

$\frac{GmM}{2R}$

D.

$\frac{GmM}{3R}$

Answer: A

Solution:

Apply energy conservation,

$$U_i + K_i = U_f + K_t$$

$$\Rightarrow -\frac{GMm}{R} + K_i = -\frac{GMm}{3R} + \frac{1}{2}mv^2$$

$$\Rightarrow -\frac{GMm}{R} + K_i = -\frac{GMm}{3R} + \frac{1}{2} \times m \times \frac{GM}{3R}$$

$$\Rightarrow K_i = -\frac{1}{6}\frac{GMm}{R} + \frac{GMm}{R}$$

$$K_i = \frac{5}{6}\frac{GMm}{R}$$

Question5

Two bodies of mass m and 9m are placed at a distance R. The gravitational potential on the line joining the bodies where the gravitational field equals zero, will be (G= gravitational constant)

[NEET 2023]

Options:

A.

$-\frac{12Gm}{R}$

B.

$-\frac{16Gm}{R}$

C.

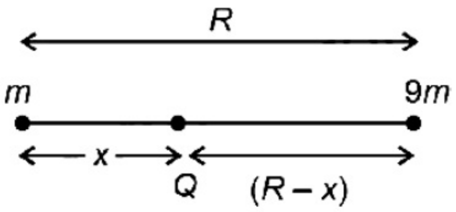
$-\frac{20Gm}{R}$

D.

$-\frac{8Gm}{R}$

Answer: B

Solution:



Let electric field at point Q be zero

So,

$$\frac{Gm}{x^2} = \frac{G(9m)}{(R-x)^2}$$

$$\frac{(R-x)^2}{x^2} = 9$$

$$x = \frac{R}{4}$$

$$V_P = \frac{-Gm}{x} - \frac{G(9m)}{R-x}$$

$$V_P = \frac{-Gm}{\frac{R}{4}} - \frac{G(9m)}{\frac{3R}{4}}$$

$$= \frac{-4Gm}{R} - \frac{12Gm}{R}$$

$$= \frac{-16Gm}{R}$$

Question6

A satellite is orbiting just above the surface of the earth with period T. If d is the density of the earth and G is the universal constant of gravitation, the quantity 3π/Gd represents

[NEET 2023]

Options:

A.

T^2

B.

T^3

C.

√T

D.

T

Answer: A

Solution:

Time period of satellite above earth surface

$$T = 2\pi\sqrt{\frac{R^3}{GM}} = 2\pi\sqrt{\frac{R^3}{Gd\,\frac{4}{3}\pi R^3}}$$

$$T = 2\pi\sqrt{\frac{3}{4\pi Gd}}$$

$$T = \sqrt{\frac{3\pi}{Gd}}\quad T^2 = \frac{3\pi}{Gd}$$

Question7

The escape velocity of a body on the earth surface is 11.2km/ s. If the same body is projected upward with velocity 22.4km/ s, the velocity of this body at infinite distance from the centre of the earth will be:

[NEET 2023 mpr]

Options:

A.

11.2√2km/ s

B.

Zero

C.

11.2km/ s

D.

11.2√3km/ s

Answer: D

Solution:

$$V_\infty = \sqrt{V^2 - V_e^2}$$

Given than

$$V = 2V_e$$

So,

$$V_\infty = \sqrt{(2V_e)^2 - V_e^2}$$

$$V_\infty = \sqrt{3}V_e = 11.2\sqrt{3}\ \text{km}/s$$

Question8

If R is the radius of the earth and g is the acceleration due to gravity on

the earth surface. Then the mean density of the earth will be :

[NEET 2023 mpr]

Options:

A.

πRG/12g

B.

3πR/4gG

C.

3g/4πRG

D.

4πG/3gR

Answer: C

Solution:

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

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

Question9

A body of mass 60g experiences a gravitational force of 3.0N , when placed at a particular point. The magnitude of the gravitational field intensity at that point is
[NEET-2022]

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Options:

A. 0.05N / kg

B. 50N / kg

C. 20N / kg

D. 180N / kg

Answer: B

Solution:

$F = mE_G$

$3 = \frac{60}{1000} E_G$

$E_G = 50 N/kg$

Question10

Match List-I with List-II

	List-I		List-II
(a)	Gravitational constant (G)	(i)	$[L^2T^{-2}]$
(b)	Gravitational potential energy	(ii)	$[M^{-1}L^3T^{-2}]$
(c)	Gravitational potential	(iii)	$[LT^{-2}]$
(d)	Gravitational intensity	(iv)	$[ML^2T^{-2}]$

Choose the correct answer from the options given below [NEET-2022]

Options:

A. (a) - (ii), (b) - (i), (c) - (iv), (d) - (iii)

B. (a) - (ii), (b) - (iv), (c) - (i), (d) - (iii)

C. (a) - (ii), (b) - (iv), (c) - (iii), (d) - (i)

D. (a) - (iv), (b) - (ii), (c) - (i), (d) - (iii)

Answer: B

Solution:

(a) $[G] = \frac{Fr^2}{m_1 m_2}$

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

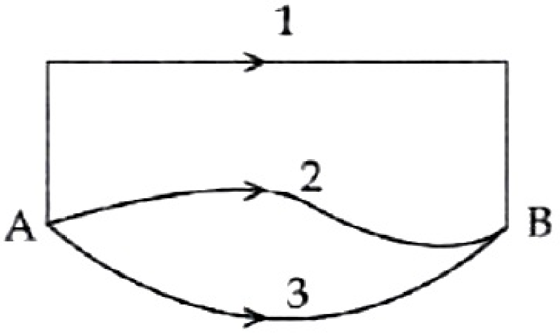
(b) Gravitational potential energy $= [ML^2T^{-2}]$

(c) Gravitational potential $= \frac{PE}{m} = [L^2T^{-2}]$

(d) Gravitational field intensity $= \frac{F}{m} = [L^{-2}]$

Question11

A gravitational field is present in a region and a mass is shifted from A to B through different paths as shown. If W_1, W_2 and W_3 represent the work done by the gravitational force along the respective paths, then:



[NEET Re-2022]

Options:

A. $W_1 < W_2 < W_3$

B. $W_1 = W_2 = W_3$

C. $W_1 > W_2 > W_3$

D. $W_1 > W_3 > W_2$

Answer: B

Solution:

Solution :

Gravitational force is a conservative force work done by conservative force is path independent.

Hence, $\therefore W_1 = W_2 = W_3$

Question12

In a gravitational field, the gravitational potential is given by, $V = -\frac{K}{X}(J / kg)$.
The gravitational field intensity at point (2, 0, 3)m is :
[NEET Re-2022]

Options:

A. $+\frac{K}{4}$

B. $+\frac{K}{2}$

C. $-\frac{K}{2}$

D. $-\frac{K}{4}$

Answer: D

Solution:

Solution :

$v(x) = -\frac{K}{x}$

$E_g = -\frac{dv}{dx} = -\frac{d}{dx}\left(\frac{-K}{x}\right)$

$\vec{E}_g = -\frac{K}{x^2}\hat{i}$

Now $\left|\vec{E}_g(2, 0, 3)\right| = \frac{-K}{(2)^2} = \frac{-K}{4}$

Question13

The ratio of Coulomb's electrostatic force to the gravitational force between an electron and a proton separated by some distance is 2.4×10^{39}. The ratio of the proportionality constant, K $= \frac{1}{4\pi\varepsilon_0}$ to the Gravitational constant G is nearly (Given that the charge of the proton and electron each $= 1.6 \times 10^{-19}$C, the mass of the electron $= 9.11 \times 10^{-31}$ kg, the mass of the proton $= 1.67 \times 10^{-27}$ kg) : [NEET Re-2022]

Options:

A. 10

B. 10^{20}

C. 10^{30}

D. 10^{40}

Answer: B

Solution:

Solution :

$$\frac{F_G}{F_G} = \frac{\frac{kq_1q_2}{r^2}}{\frac{Gm_1m_2}{r^2}} = \frac{k}{G}\frac{(1.6\times10^{-19})^2}{(1.67\times9.11)\times10^{-58}}$$

$$2.4\times10^{39} = \frac{k}{G}\frac{1.6\times1.6\times10^{-38}}{(1.67\times9.11)\times10^{-58}}$$

$$\frac{k}{G}\approx10^{20}$$

Question14

The escape velocity from the Earth's surface is v.
The escape velocity from the surface of another planet having a radius, four times that of Earth and same mass density is
[NEET 2021]

Options:

A. v

B. 2v

C. 3v

D. 4v

Answer: D

Solution:

Solution:
Escape velocity from the Earth's surface

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

$$= \sqrt{\frac{2G\rho\frac{4}{3}\pi R^3}{R}}$$

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

$v_e \propto R$ (For same density)

$$\frac{v}{v_1} = \frac{R}{4R}$$

$$v_1 = 4v$$

Question15

A particle of mass ' m ' is projected with a velocity $v = kV_e (k < 1)$ from the surface of the earth.
(V_e = escape velocity)
The maximum height above the surface reached by the particle is

[NEET 2021]

Options:

A. $R\left(\frac{k}{1-k}\right)^2$

B. $R\left(\frac{k}{1+k}\right)^2$

C. $\frac{R^2k}{1+k}$

D. $\frac{Rk^2}{1-k^2}$

Answer: D

Solution:

Solution:
given $v = kV_e$
where, $k < 1$
Thus, $v < V_e$
From conservation of mechanical energy,
$\frac{1}{2}mv^2 - \frac{GmM}{R} = -\frac{GmM}{(R+h)}$
$\Rightarrow \frac{v^2}{2} = \frac{GM}{R} - \frac{(GM)}{(R+h)} = \frac{h}{R(R+h)}GM$
$\Rightarrow \frac{1}{2}k^2V_e^2 = \frac{GMh}{R(R+h)}$
We know, $V_e = \sqrt{\frac{2GM}{R}}$
$\Rightarrow \frac{1}{2}k^2\left(\frac{2GM}{R}\right) = \frac{GMh}{R(R+h)}$
$k^2 = \frac{h}{(R+h)}$
$Rk^2 + hk^2 = h$
$Rk^2 = h(1-k^2)$
$\therefore h = \frac{Rk^2}{(1-k^2)}$

Question16

A body weighs 72N on the surface of the earth. What is the gravitational force on it, at a height equal to half the radius of the earth?
(2020)

Options:

A. 32N

B. 30N

C. 24N

D. 48N

Answer: A

Solution:

Solution:
Weight of a body on the surface of the earth,
$W_S = mgs = 72N$

Acceleration due to gravity, g varies with height, $h = \frac{R}{2}$(given)

$W_h = \frac{mgs}{\left(1 + \frac{h}{R}\right)^2} = \frac{72}{\left(1 + \frac{R/2}{R}\right)^2} = \frac{72}{(3/2)^2}$

$= \frac{4}{9} \times 72 = 32N$

Question17

The work done to raise a mass m from the surface of the earth to a height h, which is equal to the radius of the earth, is (NEET 2019)

Options:

A. $\frac{3}{2}mgR$

B. mgR

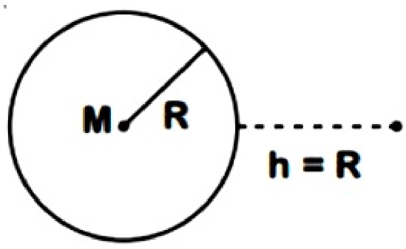
C. 2mgR

D. $\frac{1}{2}mgR$

Answer: D

Solution:

Solution:
Initial potential energy at earths surface is $U_i = \frac{-GMm}{R}$
Final potential energy at height $h = R$
$U_f = \frac{-GMm}{2R}$
As work done = change in PE
$\therefore W = U_f - U_i$
$= \frac{GMm}{2R}$
$(\because GM = gR^2)$
$= \frac{gR^2m}{2R} = \frac{mgR}{2}$



Question18

A body weighs 200N on the surface of the earth. How much will it weigh half way down to the centre of the earth ?
(NEET 2019)

Options:

A. 100N

B. 150N

C. 200N

D. 250N

Answer: A

Solution:

Solution:
Acceleration due to gravity at a depth, d
$g_d = g\left(1 - \frac{d}{R}\right)$

For $d = R/2 \Rightarrow g_d = g\left(1 - \frac{R/2}{R}\right) = \frac{g}{2}$

Required weight $W' = mg_d = \frac{mg}{2} = \frac{W}{2} = \frac{200}{2} = 100N$

Question19

The time period of a geostationary satellite is 24h, at a height $6R_E$ (R_E . is radius of earth) from surface of earth. The time period of another satellite whose height is $2.5R_E$ from surface will be,
(OD NEET 2019)

Options:

A. $6\sqrt{2}h$

B. $12\sqrt{2}h$

C. $\frac{24}{2.5}h$

D. $\frac{12}{2.5}h$

Answer: A

Solution:

Solution:
Time period of Geostationary satellite is,

$$T = 2\pi\sqrt{\frac{a^3}{GM}} \Rightarrow T^2 \propto a^3$$

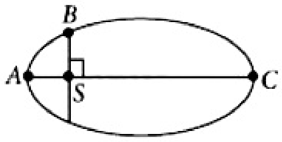
$$\therefore \frac{T_1^{\ 2}}{T_2^{\ 2}} = \frac{a_1^{\ 3}}{a_2^{\ 3}} \Rightarrow \frac{(24)^2}{T_2^{\ 2}} = \frac{(7R_E)^3}{(3.5R_E)^3}$$

$$\Rightarrow T_2^{\ 2} = \frac{(24)^2 \times (3.5)^3}{(7)^3}$$

$$\Rightarrow T_2 = \frac{\sqrt{(24)^2}}{\sqrt{8}} = 6\sqrt{2}h$$

Question20

The kinetic energies of a planet in an elliptical orbit about the Sun, at positions A, B and C are K_A, K_B and K_C, respectively. AC is the major axis and SB is perpendicular to AC at the position of the Sun S as shown in the figure. Then
(NEET 2018)



Options:

A. $K_A < K_B < K_C$

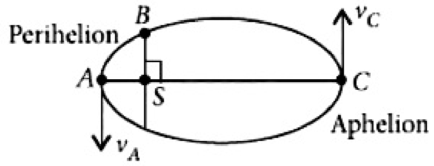
B. $K_A > K_B > K_C$

C. $K_B < K_A < K_C$

D. $K_B > K_A > K_C$

Answer: B

Solution:



Point A is perihelion and C is aphelion .
So, $v_A > v_B > v_C$
As kinetic energy
$K = 1/2mv^2$
or $K \propto v^2$ So, $K_A > K_B > K_C$

Question21

If the mass of the Sun were ten times smaller and the universal gravitational constant were ten times larger in magnitude, which of the following is not correct?
(NEET 2018)

Options:

A. Raindrops will fall faster.

B. Walking on the ground would become more difficult.

C. Time period of a simple pendulum on the Earth would decrease.

D. ′g′ on the Earth will not change.

Answer: D

Solution:

Solution:
′g′ on the earth will not change.
If universal gravitational constant become term then $G' = 10G$
Acceleration due to gravity, $,g = \frac{Gm}{R^2}$
So, Acceleration due to gravity increases.

Question22

The acceleration due to gravity at a height 1 km above the earth is the same of earth. Then as at a depth d below the surface
(2017 NEET)

Options:

A. $d = 1$ km

B. $d = \frac{3}{2}$km

C. d $= 2km$

D. d $= \frac{1}{2}km$

Answer: C

Solution:

Solution:
Acceteration due to gravity at height h,
$g_n = g_0\left(1 - \frac{2h}{R}\right) h = 1km$
Acceleration due to gravity at depth d,
$d_d = g_0\left(1 - \frac{d}{R}\right)$
$g_h = g_d$
$g_0\left(1 - \frac{2h}{R}\right) = g_0\left(1 - \frac{d}{R}\right)$
$\rightarrow d = 2h$
$= 2 \times 1km$
$d = 2km$

Question23

Two astronauts are floating in gravitational free space after having lost contact with their spaceship. The two will (2017 NEET)

Options:

A. move towards each other.

B. move away from each other.

C. will become stationary.

D. keep floating at the same distance between them.

Answer: A

Solution:

Solution:
Since two astronauts are floating in gravitational free space. The only force acting on the two astronauts is the gravitational pull of their masses,
$F = Gm_1m_2$,
which is attractive in nature.
Hence they move towards each other.

Question24

At what height from the surface of earth the gravitation potential and

the value of g are -5.4×10^7J kg^{-2} and $6.0ms^{-2}$ respectively? Take the radius of earth as 6400 km.
(2016 NEET Phase-I)

Options:

A. 1400 km

B. 2000 km

C. 2600 km

D. 1600 km

Answer: C

Solution:

Solution:
Gravitation potential at a height h from the surface of earth, $V_h = -5.4 \times 10^7 \text{J kg}^{-2}$
At the same point acceleration due to gravity,
$g_h = 6ms^{-2}$
$R = 6400km = 6.4 \times 10^6 m$
We know, $V_h = -\frac{GM}{(R+h)}$,
$g_h = \frac{GM}{(R+h)^2} = -\frac{V_h}{R+h} \Rightarrow R + h = -\frac{V_h}{g_h}$
$\therefore h = -\frac{V_h}{g_h} - R = -\frac{(-5.4 \times 10^7)}{6} = -6.4 \times 10^6$

$= 9 \times 10^6 - 6.4 \times 10^6 = 2600km$

Question25

The ratio of escape velocity at earth (v_e) to the escape velocity at a planet (v_p) whose radius and mean density are twice as that of earth is
(2016 NEET Phase-I)

Options:

A. 1 : 4

B. $1 : \sqrt{2}$

C. 1 : 2

D. $1 : 2\sqrt{2}$

Answer: D

Solution:

As escape velocity.

$v = \frac{\sqrt{2GM}}{R} = \sqrt{\frac{2G}{R} \cdot \frac{4\pi R^3}{3}\rho} = R\sqrt{\frac{8\pi G}{3}\rho}$

$\therefore \frac{v_e}{v_p} = \frac{R_e}{R_p} \times \sqrt{\frac{\rho_e}{\rho_p}} = \frac{1}{2} \times \sqrt{\frac{1}{2}} = \frac{1}{2\sqrt{2}}$

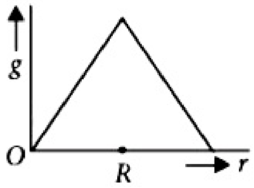
$(\because R_p = 2R_e$ and $\rho_p = 2\rho_e)$

Question26

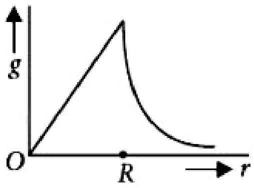
Starting from the centre of the earth having radius R, the variation of ^acceleration due to gravity) is shown by (2016 NEET Phase-II)

Options:

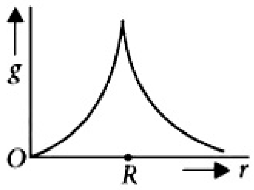
A.



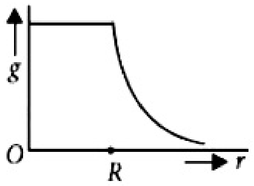
B.



C.



D.

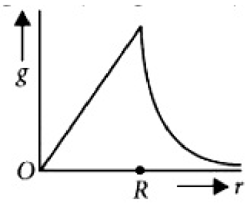


Answer: B

Solution:

Solution:
Acceleration due to gravity is given by

$$g = \begin{cases} \frac{4}{3}\pi\rho G r & ; \ r \le R \\ \frac{4}{3}\frac{\pi\rho R^3 G}{r^2} & ; \ r > R \end{cases}$$



Question27

A satellite of mass m is orbiting the earth (of radius R) at a height h from its surface. The total energy of the satellite in terms of g_0, the value of acceleration due to gravity at the earth's surface, is (2016 NEET Phase-II)

Options:

A. $\frac{mg_0R^2}{2(R+h)}$

B. $-\frac{mg_0R^2}{2(R+h)}$

C. $\frac{2mg_0R^2}{(R+h)}$

D. $-\frac{2mg_0R^2}{(R+h)}$

Answer: B

Solution:

Solution:
Total energy of satellite at height h from the earth surface,

$E = PE + KE = -\frac{GMm}{(R+h)} + \frac{1}{2}mv^2$......(i)

Also, $\frac{mv^2}{(R+h)} = \frac{GMm}{(R+h)^2}$ or $v^2 = \frac{GM}{R+h}$......(ii)

From eqns. (i) and (ii),

$E = -\frac{GMm}{(R+h)} + \frac{1}{2}\frac{GMm}{(R+h)} = -\frac{1}{2}\frac{GMm}{(R+h)}$

$= -\frac{1}{2}\frac{GM}{R^2} \times \frac{mR^2}{(R+h)} = -\frac{mg_0R^2}{2(R+h)} \quad \left(\because g_0 = \frac{GM}{R^2}\right)$

Question28

A remote-sensing satellite of earth revolves in a circular orbit at a

height of 0.25×10^6 m above the surface of earth. If earth's radius is 6.38×10^6m and $g = 9.8ms^{-2}$,then the orbital speed of the satellite is (2015)

Options:

A. $9.13kms^{-1}$

B. $6.67kms^{-1}$

C. $7.76kms^{-1}$

D. $8.56kms^{-1}$

Answer: C

Solution:

Solution:

The orbital velocity of the satellite is $v = \sqrt{\frac{GM}{R+h}}$

where M = mass of earth and R = radius of earth.

so, $v = \sqrt{\frac{6.67 \times 10^{-11} \times (6 \times 10^{24})}{(6.4 \times 10^6) + (0.25 \times 10^6)}} = 7.76km / s$

Question29

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, (2015)

Options:

A. the linear momentum of 5 remains constant in magnitude.

B. the acceleration of S is always directed towards the centre of the earth.

C. the angular momentum of S about the centre of the earth changes in direction, but its magnitude remains constant.

D. the total mechanical energy of S varies periodically with time.

Answer: B

Solution:

Solution:
The gravitational force on the satellite S acts towards the centre of the earth, so the acceleration of the satellite S is always directed towards the centre of the earth.

Question30

Kepler's third law states that square of period of revolution (T) of a planet around the sun, is proportional to third power of average distance r between sun and planet i.e.
$T^2 = K r^3$ here K is constant
If the masses of sun and planet are M and m respectively then as per Newton's law of gravitation force of attraction between them is
$F = \frac{GMm}{r^2}$,here G is gravitational constant.
The relation between G and K is described as
(2015)

Options:

A. $K = G$

B. $K = \frac{1}{G}$

C. $GK = 4\pi^2$

D. $GMK = 4\pi^2$

Answer: D

Solution:

Solution:
Gravitational force of attraction between sun and planet provides centripetal force for the orbit of planet.
$\therefore \frac{GMm}{r^2} = \frac{mv^2}{r}$
$v^2 = \frac{GM}{r}$..........(i)
Time period of the planet is given by
$T = \frac{2\pi r}{v}$, $T^2 = \frac{4\pi^2 r^2}{v^2}$
$T^2 = \frac{4\pi^2 r^2}{\left(\frac{GM}{r}\right)}$ [Using equation (i)]
$T^2 = \frac{4\pi^2 r^3}{GM}$..........(ii)

According to question,
$T^2 = K r^3$..........(iii)
Comparing equations (ii) and (iii), we get
$K = \frac{4\pi^2}{GM}$ $\therefore GMK = 4\pi^2$

Question31

Two spherical bodies of mass M and 5M and radii R and 2R are released in free space with initial separation between their centres equal to 12R. If they attract each other due to gravitational force only, then the

distance covered by the smaller body before collision is (2015)

Options:

A. 7.5 R

B. 1.5 R

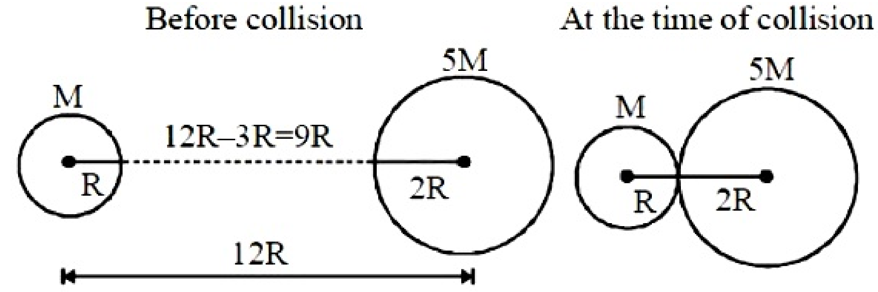
C. 2.5 R

D. 4.5 R

Answer: A

Solution:

Solution:
(b) Let the distance moved by spherical body of mass M is x_1 and by spherical body of mass $5m$ is x_2 As their C.M. will remain stationary
So, $(M)(x_1) = (5M)(x_2)$ or, $x_1 = 5x_2$



$x_1 + x_2 = 9R$
So, $x_1 = 7.5R$

Question32

A black hole is an object whose gravitational field is so strong that even light cannot escape from it. To what approximate radius would earth (mass=5.98 × 10^{24}kg) have to be compressed to be a black hole? (2014)

Options:

A. 10^{-9} m

B. 10^{-6} m

C. 10^{-2} m

D. 100 m

Answer: C

Solution:

Light cannot escape from a black hole, $v_{esc} = c$

$$\sqrt{\frac{2GM}{R}} = c \text{ or } R = \frac{2GM}{c^2}$$

$$R = \frac{2 \times 6.67 \times 10^{-11} N\,m^2 kg^{-2} \times 5.98 \times 10^{24} kg}{(3 \times 10^8 ms^{-1})^2}$$

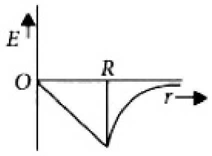
$$= 8.86 \times 10^{-3} m \approx 10^{-2} m$$

Question33

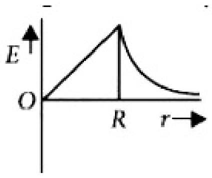
Dependence of intensity of gravitational field (E) of earth with distance (r) from centre of earth is correctly represented by (2014)

Options:

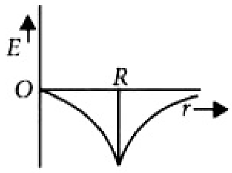
A.



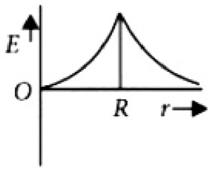
B.



C.



D.



Answer: A

Solution:

Solution:
For a point inside the earth i.e. $r < R$

$$E = = -\frac{GM}{R^3} r$$

where M and R be mass and radius of the earth respectively.
At the centre, $r = 0$

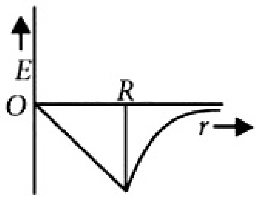
For a point outside the earth i.e. r>R,

$E = -\frac{GM}{r^2}$

On the surface of the earth i.e. $r = R$,

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

The variation of E with distance r from the centre is as shown in the figure.



Question34

Infinite number of bodies, each of mass 2 kg are situated on x-axis at distances 1 m, 2 m, 4 m, 8 m ,..., respectively, from the origin. The resulting gravitational potential due to this system at the origin will be (2013 NEET)

Options:

A. $-\frac{4}{3}G$

B. $-4G$

C. $-G$

D. $-\frac{8}{3}G$

Answer: B

Solution:

Solution:

The resulting gravitational potential at the origin O due to each of mass 2 kg located at positions as shown in figure is

$V = -\frac{G \times 2}{1} - \frac{G \times 2}{2} - \frac{G \times 2}{4} - \frac{G \times 2}{8} - - \ldots\ldots$

$= -2G\left[1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \ldots\right] = -2G\left[\frac{1}{1 - \frac{1}{2}}\right]$

$= -2G\left[\frac{2}{1}\right] = -4G$

Question35

A body of mass 'm' is taken from/the earth's surface to the height equal to twice the radius (R) of the earth. The change in potential energy of body will be

(2013 NEET)

©

Options:

A. 3mgR

B. $\frac{1}{3}$mgR

C. mg2R

D. $\frac{2}{3}$mgR

Answer: D

Solution:

Solution:
Gravitational potential energy at any point at a distance r from the centre of the earth is
$U = -\frac{GMm}{r}$
where M and m be masses of the earth and the body respectively. At the surface of the earth, r = R
$\therefore U_i = -\frac{GMm}{R}$
At height h from the surface,
$r = R + h = R + 2R$ $\because$h=2R(Given)
$= 3R$
$\therefore U_f = -\frac{GMm}{3R}$
Change in potential energy,
$\Delta U = U_f - U_i$
$= -\frac{GMm}{3R} - \left(-\frac{GMm}{R}\right) = \frac{GMm}{R}\left(1 - \frac{1}{3}\right) = \frac{2}{3}\frac{GMm}{R}$
$= \frac{2}{3}mgR \quad \left(\because g = \frac{GM}{R^2}\right)$

Question36

The radius of a planet is twice the radius of earth. Both have almost equal average mass-densities. V_P and V_E are escape velocities of the planet and the earth, respectively, then
(KN NEET 2013)

©

Options:

A. $V_P = 1.5V_E$

B. $V_P = 2V_E$

C. $V_E = 3V_P$

D. $V_E = 1.5V_P$

Answer: B

Solution:

Here, $R_p = 2R_E$, $\rho_E = \rho_P$

Escape velocity of the earth, V_E

$$= \sqrt{\frac{2GM_E}{R_E}} = \sqrt{\frac{2G}{R_E}\left(\frac{4}{3}\pi R_E{}^3\rho_E\right)} = R_E\sqrt{\frac{8}{3}\pi G\rho_E}$$

Escape velocity of the planet

$$V_P = \sqrt{\frac{2GM_P}{R_P}} = \sqrt{\frac{2G}{R_P}\left(\frac{4}{3}\pi R_P{}^3\rho_P\right)} = R_P\sqrt{\frac{8}{3}\pi G\rho_P}$$

Divide (i) by (ii), we get

$$\frac{V_E}{V_P} = \frac{R_E}{R_P}\sqrt{\frac{\rho_E}{\rho_P}} = \frac{R_E}{2R_E}\sqrt{\frac{\rho_E}{\rho_E}} = \frac{1}{2} \text{ or } V_P = 2V_E$$

Question37

A particle of mass ′m′ is kept at rest at a height ′3R′ from the surface of earth, where ′R′ is radius of earth and ′M′ is mass of earth. The minimum speed with which it should be projected, so that it does not return back, is (g is acceleration due to gravity on the surface of earth) (KN NEET 2013)

Options:

A. $\left(\frac{GM}{2R}\right)^{1/2}$

B. $\left(\frac{gR}{4}\right)^{1/2}$

C. $\left(\frac{2g}{R}\right)^{1/2}$

D. $\left(\frac{GM}{R}\right)^{1/2}$

Answer: A

Solution:

Solution:

The minimum speed with which the particle should be projected from the surface of the earth so that it does not return back isknown as escape speed and it is given by

$$v_e = \sqrt{\frac{2GM}{(R+h)}} \text{ Here, } h = 3R$$

$$\therefore v_e = \sqrt{\frac{2GM}{(R+3R)}} = \sqrt{\frac{2GM}{4R}} = \sqrt{\frac{GM}{2R}}$$

$$= \sqrt{\frac{gR}{2}}\left(\because g = \frac{GM}{R^2}\right)$$

Question38

The height at which the weight of a body becomes $\frac{1}{16}$th its weight on the surface of earth (radius R), is
(2012)

©

Options:

A. 5 R

B. 15 R

C. 3 R

D. 4 R

Answer: C

Solution:

Solution:
Acceleration due to gravity at a height h from the surface of earth is
$g' = \frac{g}{\left(1 + \frac{h}{R}\right)^2}$..........(i)
where g is the acceleration due to gravity at the surface of earth and R is the radius of earth.
Multiplying by m (mass of the body) on both sides in (i), we get
$mg' = \frac{mg}{\left(1 + \frac{h}{R}\right)^2}$
$\therefore$ Weight of body at height h ,$W' = mg'$
Weight of body at surface of earth, W= mg
According to question,$W' = \frac{1}{16}W$
$\therefore \frac{1}{16} = \frac{1}{\left(1 + \frac{h}{R}\right)^2}$ or $\left(1 + \frac{h}{R}\right)^2 = 16$ or $1 + \frac{h}{R} = 4$
or $\frac{h}{R} = 3$ or $h = 3R$

Question39

A spherical planet has a mass M_p and diameter D_p.A particle of mass m falling freely near the surface of this planet will experience an acceleration due to gravity, equal to
(2012)

©

Options:

A. $\frac{4GM_p}{D_p^2}$

B. $\frac{GM_p m}{D_p^2}$

C. $\frac{GM_p}{D_p^2}$

D. $\frac{4GM_p m}{D_p^2}$

Answer: A

Solution:

Solution:
Gravitational force acting on particle of mass m is

$$F = \frac{GM_p}{\left(\frac{D_p}{2}\right)^2}$$

Acceleration due to gravity experience by the particle is

$$g = \frac{F}{m} = \frac{GM_p}{\left(\frac{D_p}{2}\right)^2} = \frac{4GM_p}{D_p^2}$$

Question40

A geostationary satellite is orbiting the earth at a height of 5R above that surface of the earth, R being the radius of the earth. The time period of another satellite in hours at a height of 2R from the surface of the earth is
(2012)

Options:

A. 5

B. 10

C. $6\sqrt{2}$

D. $\frac{6}{\sqrt{2}}$

Answer: C

Solution:

Solution:

According to Kepler's third law $T^2 \propto r^{\frac{3}{2}}$

$$\therefore \frac{T_2}{T_1} = \left(\frac{r_2}{r_1}\right)^{\frac{3}{2}} = \left(\frac{R + 2R}{R + 5R}\right)^{\frac{3}{2}} = \frac{1}{2^{\frac{3}{2}}}$$

$\frac{T_2}{24} = \frac{1}{2^{\frac{3}{2}}}$ or $T_2 = \frac{24}{2^{\frac{3}{2}}} = \frac{24}{2\sqrt{2}} = 6\sqrt{2}$ hours

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Question41

If v_e is escape velocity and v_o is orbital velocity of a satellite for orbit close to the earth's surface, then these are related by
(2012 Mains)

Options:

A. $v_o = \sqrt{2}v_e$

B. $v_o = v_e$

C. $v_e = \sqrt{2v_o}$

D. $v_e = \sqrt{2}v_o$

Answer: D

Solution:

Solution:

Escape velocity, $v_e = \sqrt{\frac{2GM}{R}}$........(i)

where M and R be the mass and radius of the earth respectively. The orbital velocity of a satellite close to the earth's surface is

$v_o = \frac{\sqrt{GM}}{R}$...........(ii)

From (i) and (ii), we get

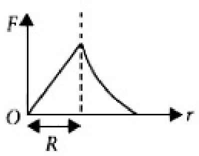
$v_e = \sqrt{2}v_o$

Question42

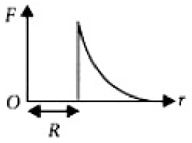
Which one of the following plots represents the variation of gravitational field on a particle with distance r due to a thin spherical shell of radius R ? (r is measured from the centre of the spherical shell)
(2012 Mains)

Options:

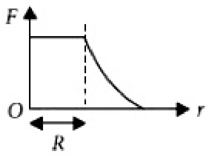
A.



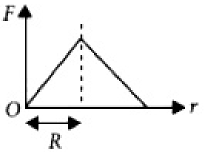
B.



C.



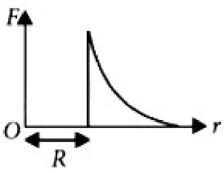
D.



Answer: B

Solution:

Solution:
Gravitational field due to the thin spherical shell Inside the shell,
$F = 0$ (For r < R)
On the surface of the shell
$F = \frac{GM}{R^2}$ (For $r = R$)
Outside the shell,
$F = \frac{GM}{r^2}$ (For r > R)
The variation of F with distance r from the centre is as shown in the figure.



Question43

A planet moving along an elliptical orbit is closest to the sun at a distance r_1 and farthest away at a distance of r_2.If v_1 and v_2 are the linear velocities at these points respectively,then the ratio $\frac{v_1}{v_2}$ is (2011)

Options:

A. $\left(\frac{r_1}{r_2}\right)^2$

B. $\frac{r_2}{r_1}$

C. $\left(\frac{r_2}{r_1}\right)^2$

D. $\frac{r_1}{r_2}$

Answer: B

Solution:

Solution:
According to the law of conservation of angular momentum
$L_1 = L_2$
$mv_1r_1 = mv_2r_2 \Rightarrow v_1r_1 = v_2r_2$
$\frac{v_1}{v_2} = \frac{r_2}{r_1}$

Question44

A particle of mass m is thrown upwards from the surface of the earth, with a velocity u. The mass and the radius of the earth are, respectively, M and R.G is gravitational constant and g is acceleration due to gravity on the surface of the earth. The minimum value of u so that the particle does not return back to earth, is
(2011 Mains)

Options:

A. $\sqrt{\frac{2GM}{R^2}}$

B. $\sqrt{\frac{2GM}{R}}$

C. $\sqrt{\frac{2gM}{R^2}}$

D. $\sqrt{2gR^2}$

Answer: B

Solution:

Solution:
According to law of conservation of mechanical energy
$\frac{1}{2}mu^2 - \frac{GM\,m}{R} = 0$ or $u^2 = \frac{2GM}{R}$
$u = \sqrt{\frac{2Gm}{R}} = \sqrt{2gR} \qquad \left(\because g = \frac{GM}{R^2}\right)$

Question45

A particle of mass M is situated at the centre of a spherical shell of same mass and radius a. The magnitude of the gravitational potential at a point situated at a/2 distance from the centre, will be
(2011 Mains)

Options:

A. $\frac{GM}{a}$

B. $\frac{2GM}{a}$

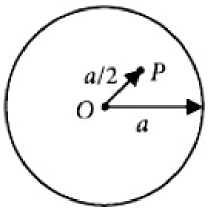
C. $\frac{3GM}{a}$

D. $\frac{4GM}{a}$

Answer: C

Solution:

Solution:



Here,
Mass of a particle = M
Mass of a spherical shell = M
Radius of a spherical shell = a
Let O be centre of a spherical shell. Gravitational potential at point P due to particle at O is

$$V_1 = -\frac{GM}{\frac{a}{2}}$$

Gravitational potential at point P due to spherical shell is

$$V_2 = -\frac{GM}{a}$$

Hence, total gravitational potential at point P is

$$V = V_1 + V_2$$

$$= -\frac{GM}{\frac{a}{2}} + \left(\frac{-GM}{a}\right) = -\frac{2GM}{a} - \frac{GM}{a} = \frac{-3GM}{a}$$

$$|V| = \frac{3GM}{a}$$

Question46

The radii of circular orbits of two satellites A and B of the earth, are 4R and R, respectively. If the speed of satellite A is 3V, then the speed of satellite B will be
(2010)

Options:

A. $\frac{3V}{4}$

B. 6V

C. 12V

D. $\frac{3V}{2}$

Answer: B

Solution:

Solution:
Orbital speed of the satellite around the earth is
$v = \sqrt{\frac{GM}{r}}$
Where,
G = universal gravitational constant
M = mass of earth
r = radius of the orbit of the satellite
For satellite A
$r_A = 4R, v_A = 3V$
$v_A = \sqrt{\frac{GM}{r_A}}$ ....(i)
For satellite B
$r_B = R, v_B = ?$
$v_B = \sqrt{\frac{GM}{r_B}}$...........(ii)
Dividing equation (ii) by equation (i), we get
$v_B = 3V\sqrt{\frac{4R}{R}}$
$v_B = 6V$

Question47

A man of 50 kg mass is standing in a gravity free space at a height of 10 m above the floor. He throws a stone of 0.5 kg mass downwards with a speed 2 m/s. When the stone reaches the floor, the distance of the man above the floor will be (2010)

Options:

A. 9.9 m

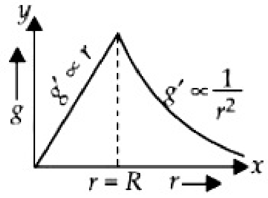
B. 10.1 m

C. 10 m

D. 20 m

Answer: B

Solution:



Since the man is in gravity free space, force on man + stone system is zero.
Therefore centre of mass of the system remains at rest. Let the man goes x m above when the stone reaches the floor, then

$M_{man} \times x = M_{stone} \times 10,\ x = \frac{0.5}{50} \times 10 = 0.1\text{m}$

Therefore final height of man above floor $= 10 + x = 10 + 0.1 = 10.1\text{m}$

Question48

The additional kinetic energy to be provided to a satellite of mass m revolving around a planet of mass M, to transfer it from a circular orbit of radius R_1 to another of radius $R_2 (R_2 > R_1)$ is
(2010 Mains)

Options:

A. $GmM\left(\frac{1}{{R_1}^2} - \frac{1}{{R_2}^2}\right)$

B. $GmM\left(\frac{1}{{R_1}^2} - \frac{1}{{R_2}^2}\right)$

C. $2GmM\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

D. $\frac{1}{2}GmM\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

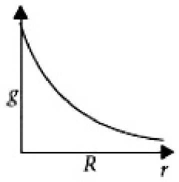
Answer: D

Question49

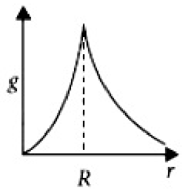
The dependence of acceleration due to gravity g on the distance r from the centre of the earth, assumed to be a sphere of radius R of uniform density is as shown in figures below
The correct figure
(2010 Mains)

Options:

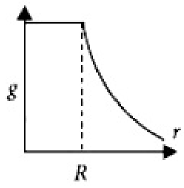
A.



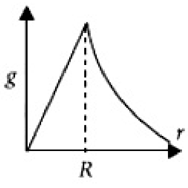
B.



C.



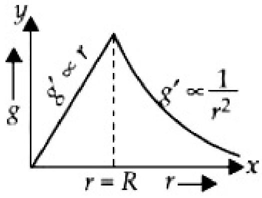
D.



Answer: D

Solution:

Solution:



The acceleration due to gravity at a depth d below surface of earth is

$g' = \frac{GM}{R^2}\left(1 - \frac{d}{R}\right) = g\left(1 - \frac{d}{R}\right)$

$g' = 0$ at $d = R$

i.e., acceleration due to gravity is zero at the centre of earth. Thus, the variation in value of g with r is

For $r > R$

$g' = \frac{g}{\left(1 + \frac{h}{R}\right)^2} = \frac{gR^2}{r^2} \Rightarrow g' \propto \frac{1}{r^2}$

Here, $R + h = r$

For $r < R$, $g' = g\left(1 - \frac{d}{R}\right) = \frac{gr}{R}$

Here, $R - d = r \Rightarrow g' \propto r$

Therefore, the variation of g with distance from centre of the earth will be as shown in the figure.

Question50

(1) Centre of gravity (C.G.) of a body is the point at which the weight of the body acts.
(2) Centre of mass coincides with the centre of gravity if the earth is assumed to have infinitely large radius.
(3) To evaluate the gravitational field intensity due to any body at an external point, the entire mass of the body can be considered to be concentrated at its C.G.
(4) The radius of gyration of any body rotating about an axis is the length of the perpendicular dropped from the C.G. of the body to the axis.
Which one of the following pairs of statements is correct?
(2010 Mains)

Options:

A. (4) and (1)

B. (1) and (2)

C. (2) and (3)

D. (3) and (4)

Answer: B

Solution:

Solution:
Hint: center of gravity (CG) of a body is a point at which the entire weight of the body concentrates. Centre of the mass (CM) coincides with the center gravity (CG) only when the mass is distributed uniformly over the body. The gravitational field acting on the body can be calculated by considering the body as a point mass.

The Centre of gravity of a body is defined as the point where the whole weight of the body is supposed to act. A body supported at its center of gravity remains balanced and it is in mechanical equilibrium. The reaction R at the point of support is equal and opposite to the total weight MG of the body. Hence, there is a translational equilibrium. Also, the total gravitational torque on the body at the center of gravity is zero. Hence, there is a rotational equilibrium. The center of gravity of the body coincides with the center of mass in uniform gravity (constant value of acceleration due to gravity)or gravity-free space.

the remaining two statements are wrong. The radius of gyration of a body about an axis is defined as the distance from the axis of rotation to the mass point whose mass is equal to the mass of the whole body and whose moment of inertia is equal to the moment of inertia of the whole body about the same axis.

Correct options are (1) and (2)

Question51

A particle of mass M is situated at the center of a spherical shell of same mass and radius a. The gravitational potential at a point situated at $\frac{a}{2}$ distance from the center,will be
(2010)

Options:

A. $-\frac{3GM}{a}$

B. $-\frac{2GM}{a}$

C. $-\frac{GM}{a}$

D. $-\frac{4GM}{a}$

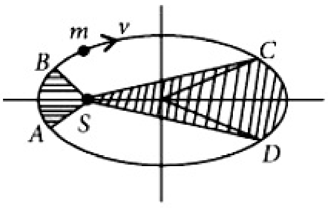
Answer: A

Solution:

Solution:
Here, mass of the particle = M
Mass of the spherical shell = M
Radius of the spherical shell = a
Point P is at distance $\frac{a}{2}$ from the center of the shell as shown in the figure.
Gravitational potential at point P due to particle at O is
$V_1 = -\frac{GM}{\left(\frac{a}{2}\right)}$
Gravitational potential at point P due to spherical shell is
$V_2 = -\frac{GM}{a}$
Hence, total gravitational potential at the point P is
$V = V_1 + V_2 = -\frac{GM}{\left(\frac{a}{2}\right)} + \left(-\frac{GM}{a}\right)$
$= -\frac{2GM}{a} - \frac{GM}{a}$
$= -\frac{3GM}{a}$

Question52

The figure shows elliptical orbit of a planet m about the sun S. The shaded area SCD is twice the shaded area SAB. If t_1 is the time for the planet to move from C to D and t_2 is the time to move from A to B then



(2009)

Options:

A. $t_1 = 4t_2$

B. $t_1 = 2t_2$

C. $t_1 = t_2$

D. $t_1 > t_2$

Answer: B

Solution:

Solution:
Equal areas are swept in equal time.
t_1 the time taken to go from C to D = t_2
where t_2 is the time taken to go from A to B.
As it is given that area SCD = 2SAB.

Question53

Two satellites of earth, S_1 and S_2 are moving in the same orbit. The mass of S_1 is four times the mass of S_2. Which one of the following statements is true?
(2007)

Options:

A. The potential energies of earth and satellite in the two cases are equal.

B. S_1 and S_2 are moving with the same speed.

C. The kinetic energies of the two satellites are equal.

D. The time period of S_1 is four times that of S_2

Answer: B

Solution:

Solution:
The satellite of mass m is moving in a circular orbit of radius r.
∴ Kinetic energy of the satellite, $K = \frac{GMm}{2r}$ .....(i)
Potential energy of the satellite, $U = \frac{-GMm}{r}$ ....(ii)
Orbital speed of satellite, $v = \sqrt{\frac{GM}{r}}$ ....(iii)
Time-period of satellite,
$T = \left[\left(\frac{4\pi^2}{GM}\right) r^3 t\right]^{\frac{1}{2}}$ .....(iv)
Given $m_{S_1} = 4m_{S_2}$
since M, r is same for both the satellites S_1 and S_2
∴ From equation (ii), we get $U \propto m$

$\therefore \frac{U_{S_1}}{U_{S_2}} = \frac{m_{S_1}}{m_{S_2}} = 4$ or, $U_{S_1} = 4U_{S_2}$
Option (a) is wrong.
From (iii), since v is independent of the mass of a satellite, the orbital speed is same for both satellites S_1 and S_2
Hence option (b) is correct.
From (i), we get $K \propto m$
$\therefore \frac{K_{S_1}}{K_{S_2}} = \frac{m_{S_1}}{m_{S_2}} = 4$ or, $K_{S_1} = 4K_{S_2}$
Hence option (c) is wrong.
From (iv), since T is independent of the mass of a satellite, time period is same for both the satellites S_1 and S_2. Hence option(d) is wrong.

Question54

The earth is assumed to be a sphere of radius R. A platform is arranged at a height R from the surface of the earth. The escape velocity of a body from this platform is f v, where v is its escape velocity from the surface of the Earth. The value of f is
(2006)

Options:

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

B. $\sqrt{2}$

C. $\frac{1}{\sqrt{2}}$

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

Answer: C

Solution:

Solution:
Escape velocity of the body from the surface of earth is $v = \sqrt{2gR}$
For escape velocity of the body from the platform, potential energy + kinetic energy $= 0$
$-\frac{GM\,m}{2R} + \frac{1}{2}mv^2 = 0$
$\Rightarrow f\,v_{escape} = \sqrt{\frac{GM}{R^2}.R} = \sqrt{gR} = f\,v$
From the surface of the earth, $v_{escape} = \sqrt{2gR}$
$\therefore f\,v_{escape} = \frac{v_{escape}}{\sqrt{2}}. \therefore f = \frac{1}{\sqrt{2}}$

Question55

Imagine a new planet having the same density as that of earth but it is 3 times bigger than the earth in size. If the acceleration due to gravity on the surface of earth is g and that on the surface of the new planet is g′,

then
(2005)

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Options:

A. $g' = \frac{g}{9}$

B. $g' = 27g$

C. $g' = 9g$

D. $g' = 3g$

Answer: D

Solution:

Solution:

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

$\frac{g'}{g} = \frac{3R}{R} \Rightarrow g' = 3g$

Question56

For a satellite moving in an orbit around the earth, the ratio of kinetic energy to potential energy is
(2005)

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Options:

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

B. $\frac{1}{\sqrt{2}}$

C. 2

D. sqrt 2

Answer: A

Solution:

Solution:

$-\frac{GM\,m}{R^2} + m\omega^2 R = 0 \Rightarrow \frac{GM\,m}{R^2} = m\omega^2 R$

$K.E. = \frac{1}{2} I\omega^2 = \frac{1}{2} mR^2\omega^2 = \frac{GM\,m}{2R}$

$P.E. = -\frac{GM\,m}{R}$

$\therefore K.E. = frac\frac{|P.E.|}{2}$ or, $\frac{K.E.}{|P.E.|} = \frac{1}{2}$

Question57

The density of a newly discovered planet is twice that of earth. The acceleration due to gravity at the surface of the planet is equal to that at the surface of the earth. If the radius of the earth is R, the radius of the planet would be
(2004)

Options:

A. 2R

B. 4R

C. $\frac{1}{4}R$

D. $\frac{1}{2}R$

Answer: D

Solution:

Solution:
From equation of acceleration due to gravity.

$$g_e = \frac{GM_e}{R_e^2} = \frac{G\left(\frac{4}{3}\right)\pi R_e^3}{R_e^2}\rho_e$$

$g_e \propto R_e \rho_e$

Acceleration due to gravity of planet $g_p \propto R_p \rho_p$

$R_e \rho_e = R_p \rho_p \Rightarrow R_e \rho_e = R_p 2 \rho_e$

$\Rightarrow R_p = \frac{1}{2}R \quad (\because R_e = R)$

Question58

Two spheres of masses m and M are situated in air and the gravitational force between them is F. The space around the masses is now filled with a liquid of specific gravity 3. The gravitational force will now be
(2003)

Options:

A. 3F

B. F

C. $\frac{F}{3}$

D. $\frac{F}{9}$

Answer: B

Solution:

Solution:
The gravitational force does not depend upon the medium in which objects are placed.

Question59

The acceleration due to gravity on the planet A is 9 times the acceleration due to gravity on planet B. A man jumps to a height of 2m on the surface of A. What is the height of jump by the same person on the planet B ?
(2003)

Options:

A. $\left(\frac{2}{9}\right)$ m

B. 18m

C. 6m

D. $\left(\frac{2}{3}\right)$

Answer: B

Solution:

Solution:
The velocity of the mass while reaching the surface of both the planets will be same.
i.e., $\sqrt{2g'h'} = \sqrt{2gh}$
$\sqrt{2 \times g' \times h'} = \sqrt{2 \times 9g' \times 2} \Rightarrow 2h' = 36$
$\Rightarrow h' = 18\text{m}$

Question60

A body of mass m is placed on earth's surface which is taken from earth surface to a height of h = 3R, then change in gravitational potential energy is
(2003)

Options:

A. $\frac{mgR}{4}$

B. $\frac{2}{3}mgR$

C. $\frac{3}{4}mgR$

D. $\frac{mgR}{2}$

Answer: C

Solution:

Solution:

Gravitational potential energy on earth's surface $= -\frac{GMm}{R}$, where M and R are the mass and radius of the earth respectively, m is the mass of the body and G is the universal gravitational constant.

Gravitational potential energy at a height $h = 3R$

$= -\frac{GMm}{R+h} = -\frac{GMm}{R+3R} = -\frac{GMm}{4R}$

Change in potential energy

$= -\frac{GMm}{4R} - \left(-\frac{GMm}{R}\right)$

$= -\frac{GMm}{4R} + \frac{GMm}{R} = \frac{3}{4}\frac{GMm}{R} = \frac{3}{4}mgR$

Question61

With what velocity should a particle be projected so that its height becomes equal to radius of earth? (2001)

Options:

A. $\left(\frac{GM}{R}\right)^{\frac{1}{2}}$

B. $\left(\frac{8GM}{R}\right)^{\frac{1}{2}}$

C. $\left(\frac{2GM}{R}\right)^{\frac{1}{2}}$

D. $\left(\frac{4GM}{R}\right)^{\frac{1}{2}}$

Answer: A

Solution:

Use $v^2 = \frac{2gh}{1 + \frac{h}{R}}$ given $h = R$

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

Question62

For a planet having mass equal to mass of the earth but radius is one fourth of radius of the earth. The escape velocity for this planet will be (2000)

Options:

A. 11.2 km / s

B. 22.4 km / s

C. 5.6 km / s

D. 44.8 km / s

Answer: B

Solution:

Solution:

$v_e = \sqrt{2gR} = \sqrt{\frac{2GM}{R}} \because R_P = \frac{1}{4}R_e$

$v_P = 2v_e = 2 \times 11.2 = 22.4\ km / s$

Question63

Gravitational force is required for (2000)

Options:

A. stirring of liquid

B. convection

C. conduction

D. radiation

Answer: B

Question64

A body of weight 72N moves from the surface of earth at a height half of the radius of earth, then gravitational force exerted on it will be (2000)

Options:

A. 36N

B. 32N

C. 144N

D. 50N .

Answer: B

Solution:

$$F_{surface} = G\frac{M\,m}{R_e^{\,2}}$$

$$F_{R_e/2} = G\frac{M\,m}{(R_e + R_e/2)^2} = \frac{4}{9} \times F_{surface}$$

$$= \frac{4}{9} \times 72 = 32N$$

Question65

The escape velocity of a sphere of mass m is given by ($G =$ Universal gravitational constant; $M_e =$ Mass of the earth and $R_e =$ Radius of the earth)
(1999)

Options:

A. $\sqrt{\frac{2GM_e m}{R_e}}$

B. $\sqrt{\frac{2GM_e}{R_e}}$

C. $\sqrt{\frac{GM_e}{R_e}}$

D. $\sqrt{\frac{2GM_e + R_e}{R_e}}$

Answer: B

Question66

The escape velocity of a body on the surface of the earth is 11.2 km / s. If the earth's massincreases to twice its present value and radius of the earth becomes half, the escape velocity becomes (1997)

Options:

A. 22.4 km / s

B. 44.8 km / s

C. 5.6 km / s

D. 11.2 km / s

Answer: A

Solution:

Solution:
Escape velocity of a body $(v_e) = 11.2$ km / s; New mass of the earth $M_e' = 2M_e$ and new radius of the earth $R_e' = 0.5R_e$.

Escape velocity $(v_e) = \sqrt{\frac{2GM_e}{R_e}} \propto \sqrt{\frac{M_e}{R_e}}$

Therefore $\frac{v_e}{v_e'} = \sqrt{\frac{M_e}{R_e} \times \frac{0.5R_e}{2M_e}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$

or, $v_e' = 2v_e = 22.4$ km / s

Question67

The period of revolution of planet A around the sun is 8 times that of B. The distance of A from the sun is how many times greater than that of B from the sun? (1997)

Options:

A. 4

B. 5

C. 2

D. 3

Answer: A

Solution:

Solution:
Period of revolution of planet A, $(T_A) = 8T_B$. According to Kepler's III law of planetary motion $T^2 \propto R^3$.

Therefore $= \left(\frac{r_A}{r_B}\right)^3 = \left(\frac{T_A}{T_B}\right)^2 = \left(\frac{8T_B}{T_B}\right)^2 = 64$

or $\frac{r_A}{r_B} = 4$ or $r_A = 4r_B$

Question68

What will be the formula of mass of the earth in terms of g, R and G? (1996)

Options:

A. $G\frac{R}{g}$

B. $g\frac{R^2}{G}$

C. $g^2\frac{R}{G}$

D. $G\frac{g}{R}$

Answer: B

Solution:

Solution:

Question69

A ball is dropped from a spacecraft revolving around the earth at a height of 120km. What will happen to the ball? (1996)

Options:

A. it will fall down to the earth gradually

B. it will go very far in the space

C. it will continue to move with the same speed along the original orbit of spacecraft

D. it will move with the same speed, tangentially to the spacecraft.

Answer: C

Solution:

Solution:
since no external torque is applied therefore, according to law of conservation of angular momentum, the ball will continue to move with the same angular velocity along the original orbit of the spacecraft.

Question70

The acceleration due to gravity g and mean density of the earth ρ are related by which of the following relations? (where G is the gravitational constant and R is the radius of the earth.) (1995)

Options:

A. $\rho = \frac{3g}{4\pi GR}$

B. $\rho = \frac{3g}{4\pi GR^3}$

C. $\rho = \frac{4\pi gR^2}{3G}$

D. $\rho = \frac{4\pi gR^3}{3G}$

Answer: A

Solution:

Solution:

Acceleration due to gravity (g) $= G \times \frac{M}{R^2} = G\frac{\left(\frac{4}{3}\right)\pi R^3 \times \rho}{R^2} = G \times 43\pi R \times \rho$

or $\rho = \frac{3g}{4\pi GR}$

Question71

Two particles of equal mass go around a circle of radius R under the

action of their mutual gravitational attraction. The speed v of each particle is
(1995)

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Options:

A. $\frac{1}{2}\sqrt{\frac{Gm}{R}}$

B. $\sqrt{\frac{4Gm}{R}}$

C. $\frac{1}{2R}\sqrt{\frac{1}{Gm}}$

D. $\sqrt{\frac{Gm}{R}}$

Answer: A

Solution:

Solution:
The force between the two masses, $F = -G\frac{mm}{4R^2}$.
This force will provide the necessary centripetal force for the masses to go around a circle, then
$\frac{Gmm}{4R^2} = \frac{mv^2}{R} \Rightarrow v^2 = \frac{Gm}{4R} \Rightarrow v = \frac{1}{2}\sqrt{\frac{Gm}{R}}$.

Question72

The earth (mass $= 6 \times 10^{24}$kg) revolves around the sun with an angular velocity of 2×10^{-7} rad / s in a circular orbit of radius 1.5×10^{8} km. The force exerted by the sun on the earth, in newton, is
(1995)

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Options:

A. 36×10^{21}

B. 27×10^{39}

C. zero

D. 18×10^{25}

Answer: A

Solution:

Mass (m) = 6×10^{24}kg ;
Angular velocity (ω) = 2×10^{-7} rad / s and radius (r) = 1.5×10^{8}km = 1.5×10^{11}m.
Force exerted on the earth = $mR\omega^2$
= $(6 \times 10^{24}) \times (1.5 \times 10^{11}) \times (2 \times 10^{-7})^2$
= 36×10^{21}N

Question73

The radius of earth is about 6400km and that of mars is 3200km. The mass of the earth is about 10 times mass of mars. Anobject weighs 200N on the surface of earth. Its weight on the surface of mars will be (1994)

Options:

A. 20N

B. 8N

C. 80N

D. 40N .

Answer: C

Solution:

Solution:
Radius of earth (R_e) = 6400km Radius of mars (R_m) = 3200km; Mass of earth (M_e) = $10M_m$ and weight of the object on earth (W_e) = 200N .

$$\frac{W_m}{W_e} = \frac{mg_m}{mg_e} = \frac{M_m}{M_e} \times \left(\frac{R_e}{R_m}\right)^2 = \frac{1}{10} \times (2)^2 = \frac{2}{5}$$

or $W_m = W_e \times \frac{2}{5} = 200 \times 0.4 = 80N$

Question74

The distance of two planets from the sun are 10^{13}m and 10^{12}m respectively. The ratio of time periods of the planets is (1994, 1988)

Options:

A. $\sqrt{10}$

B. $10\sqrt{10}$

C. 10

D. $\frac{1}{\sqrt{10}}$.

Answer: B

Solution:

Solution:
Distance of two planets from sun, $r_1 = 10^{13}m$ and $r_2 = 10^{12}m$
Relation between time period (T) and distance of the planet from the sun is $T^2 \propto r^3$ or $T \propto r^{3/2}$.
Therefore $= \frac{T_1}{T_2} = \left(\frac{r_1}{r_2}\right)^{3/2} = \left(\frac{10^{13}}{10^{12}}\right)^{3/2} = 10^{\frac{3}{2}}$
$= 10\sqrt{10}$

Question75

If the gravitational force between two objects were proportional to $\frac{1}{R}$ (and not as $\frac{1}{R^2}$), where R is the distance between them, then a particle in a circular path (under such a force) would have its orbital speed v , proportional to
(1994, 1989)

Options:

A. R

B. R_0 (independent of R)

C. $\frac{1}{R^2}$

D. $\frac{1}{R}$

Answer: B

Solution:

Solution:
Centripetal force $(F) = \frac{mv^2}{R}$ and the gravitational force $(F) = \frac{GMm}{R^2} = \frac{GMm}{R}$(where $R^2 \to R$). since $\frac{mv^2}{R} = \frac{GMm}{R}$
thereforev $= \sqrt{GM}$. Thus velocity v is independent of R

Question76

A satellite in force free space sweeps stationary interplanetary dust at a rate of $\frac{dM}{dt} = \alpha v$, where M is mass and v is the speed of satellite and alpha is a constant. The acceleration of satellite is

(1994)

Options:

A. $\frac{-\alpha v^2}{2M}$

B. $-\alpha v^2$

C. $\frac{-2\alpha v^2}{M}$

D. $\frac{-\alpha v^2}{M}$

Answer: D

Solution:

Solution:

Rate of change of mass $= \frac{dM}{dt} = \alpha v$.

Retarding force = Rate of change of momentum = Velocity × Rate of change in mass $= -v \times \frac{dM}{dt}$

$= -v \times \alpha v = -\alpha v^2$. (Minus sign of v due to deceleration)

Therefore, acceleration $= -\frac{\alpha v^2}{M}$.

Question77

The escape velocity from earth is 11.2 km / s If a body is to be projected in a direction making an angle 45° to the vertical, then the escape velocity is
(1993)

Options:

A. 11.2×2 km / s

B. 11.2 km / s

C. $\frac{11.2}{\sqrt{2}}$ km / s

D. $11.2\sqrt{2}$ km / s

Answer: B

Solution:

Solution:
Escape velocity does not depend on the angle of projection.

Question78

**A satellite A of mass m is at a distance of r from the surface of the earth. Another satellite B of mass 2m is at a distance of 2r from the earth's centre. Their time periods are in the ratio of
(1993)**

Options:

A. 1: 2

B. 1: 16

C. 1: 32

D. $1 : 2\sqrt{2}$

Answer: D

Solution:

Solution:
Time period does not depend on themass.
As $T^2 \propto r^3$.
$\frac{T_A}{T_B} = \frac{r^{3/2}}{2^{3/2} r^{3/2}} = 1 : 2\sqrt{2}$

Question79

**The mean radius of earth is R, its angular speed on its own axis is ω and the acceleration due to gravity at earth's surface is g. What will be the radius of the orbit of a geostationary satellite?
(1992)**

Options:

A. $(R^2 g / \omega^2)^{1/3}$

B. $(R g / \omega^2)^{1/3}$

C. $(R^2 \omega^2 / g)^{1/3}$

D. $(R^2 g / \omega)^{1/3}$

Answer: A

Solution:

$\frac{GMm}{r^2} = m\omega^2 r \Rightarrow r^3 = \frac{GM}{\omega^2} = \frac{gR^2}{\omega^2}$
$\therefore r = (gR^2 / \omega^2)^{1/3}$.

Question80

The satellite of mass m is orbiting around the earth in a circular orbit with a velocity v. What will be its total energy?
(1991)

Options:

A. $\left(\frac{3}{4}\right) mv^2$

B. $\left(\frac{1}{2}\right) mv^2$

C. mv^2

D. $-\left(\frac{1}{2}\right) mv^2$

Answer: D

Solution:

Solution:
Total energy $= -K.E. = -\frac{1}{2}mv^2$

Question81

A planet is moving in an elliptical orbit around the sun. If T, V, E and L stand respectively for its kinetic energy, gravitational potential energy, total energy and magnitude of angular momentum about the centre of force, which of the following is correct?
(1990)

Options:

A. T is conserved

B. V is always positive

C. E is always negative

D. L is conserved but direction of vector L changes continuously.

Answer: C

Solution:

Solution:
In a circular or elliptical orbital motion torque is always acting parallel to velocity. So, angular momentum is conserved. In attractive field, potential energy and the total energy is negative. Kinetic energy increases with increase is velocity. If the motion is in a plane, the direction of L does not change.

Question82

For a satellite escape velocity is 11 km / s. If the satellite is launched at an angle of 60° with the vertical, then escape velocity will be (1989)

Options:

A. 11 km / s

B. $11\sqrt{3}$ km / s

C. $\frac{11}{\sqrt{3}}$ km / s

D. 33 km / s

Answer: A

Solution:

Solution:
since escape velocity ($v_e = \sqrt{2gR_e}$) is independent of angle of projection, so it will not change.

Question83

The largest and the shortest distance of the earth from the sun are r_1 and r_2. Its distance from the sun when it is at perpendicular to the major-axis of the orbit drawn from the sun is (1988)

Options:

A. $\frac{r_1 + r_2}{4}$

B. $\frac{r_1 + r_2}{r_1 - r_2}$

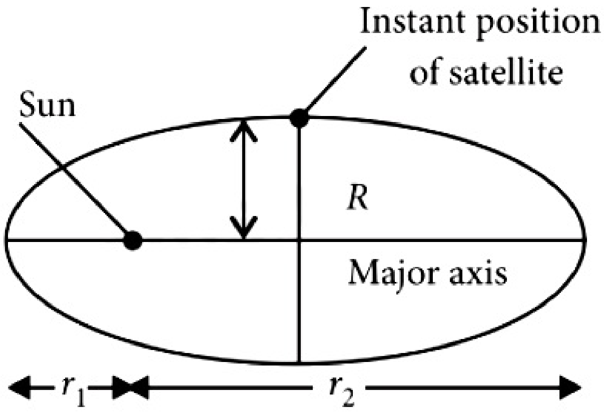
C. $\frac{2r_1r_2}{r_1 + r_2}$

D. $\frac{r_1 + r_2}{3}$

Answer: C

Solution:

Solution:



Applying the properties of ellipse, we have

$$\frac{2}{R} = \frac{1}{r_1} + \frac{1}{r_2} = \frac{r_1 + r_2}{r_1r_2}$$

$$R = \frac{2r_1r_2}{r_1 + r_2}$$
