GRAVITATION

1. There is a concentric hole of radius R in a solid sphere of radius 2R. Mass of remaining portion is M, then the gravitational potential at centre is

   (a) $\frac{-5GM}{7R}$ (b) $\frac{-7GM}{14R}$ (c) $\frac{-3GM}{7R}$ (d) $\frac{-9GM}{14R}$

Answer: (d)

Potential at centre due to a solid sphere of radius r and mass m is $v = -\frac{3Gm}{2r}$

Here required potential = (Potential due to sphere of radius 2R) − (Potential due to sphere of radius R)

2. The height at which the acceleration due to gravity becomes $\frac{g}{9}$ (where g = the acceleration due to gravity on the surface of the earth) in terms of R, the radius of the earth, is

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

Answer: (a)

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

$\therefore \frac{GM}{9R^2} = \frac{GM}{(R+h)^2}$

$\Rightarrow 3R = R + h$

$\Rightarrow h = 2R$

3. Which of the following statement is absolutely correct about mass –

(a) More the mass of a body connected with spring balance more will be the elongation in spring balance.

(b) More the mass of body kept in one pan of beam balance more the mass has to be kept on the other pan to keep beam horizontal.

(c) More the mass of a body, lesser will be its acceleration for a given force.

(d) All of the above

Answer: (c)

Consider the situation in gravity free space.

4. A body of mass m and radius r falls on earth from a great height. If M is mass and R is the radius of earth while $r = \frac{R}{100}$ then the acceleration of the body when it hits the earth is: (acceleration due to gravity at earth surface is g)

(a) g (b) 0.98 g (c) $\frac{g}{0.98}$ (d) 9.8g

Answer: (b)

$$a = \frac{GM}{x^2} = \frac{GM}{(R+r)^2} = \frac{GM}{\left(R + \frac{R}{100}\right)^2} = \frac{GM}{\left(\frac{101}{100}\right)^2 R^2} = 0.98g$$

5. If suddenly the gravitational force of attraction between earth and a satellite revolving around it becomes zero, then the satellite will

(a) continue to move in its orbit with same velocity.

(b) move tangentially to the original orbit in the same velocity.

(c) become stationary in its orbit.

(d) move towards the earth.

Answer: (b)

Move tangentially to orbit due to inertia of direction.

6. A man weight W on the surface of the earth. What is his weight at a height equal to R?

(a) W (b) $\frac{W}{2}$ (c) $\frac{W}{4}$ (d) $\frac{W}{8}$

Answer: (c)

$$\frac{W_h}{W} = \frac{mg_h}{mg} = \frac{g_h}{g} = \frac{R^2}{(R+R)^2}$$

$$W_h = \frac{W}{4}$$

7. With what angular velocity the earth should spin in order that a body lying at 45°latitude may become weightless?

(a) $\sqrt{\frac{g}{R}}$ (b) $\sqrt{\frac{2g}{R}}$

(c) $2\sqrt{\frac{g}{R}}$ (d) None of these

Answer: (b)

$0 = g - R\omega^2 \cos^2 45°$

$\frac{R\omega^2}{2} = g$ or $\omega = \sqrt{\frac{2g}{R}}$

8. Two bodies of masses 10 kg and 100 kg are separated by a distance of 2m. The gravitational potential at the mid-point of the line joining the two bodies is:

(a) -7.3×10^{-7} J/kg
(b) -7.3×10^{-8} J/kg
(c) -7.3×10^{-9} J/kg
(d) -7.3×10^{-6} J/kg

Answer: (c)

Gravitational potential

$= \frac{-G\times10}{1} - \frac{G\times100}{1} = -110G$

$= -110\times6.67\times10^{-11}\,Jkg^{-1}$

$= -7.3\times10^{-9}$ J/kg

9. The kinetic energy needed to project a body of mass m from the earth's surface to infinity is

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

Answer: (c)

$E_R - \frac{GMm}{R} = 0$

or $E_R = \frac{GMm}{R}$

or $E_R = \frac{gR^2m}{R}$

or $E_R = mgR$

10. The distance of Neptune and Saturn from the Sun are nearly 10^{13}m and 10^{12}m respectively. Their periodic times will be in the ratio

(a) 10 (b) 100 (c) $10\sqrt{10}$ (d) 1000

Answer: (c)

$$\frac{T_n^2}{T_s^2} = \frac{R_n^3}{R_s^3}$$

$$\frac{T_n}{T_s} = \left(\frac{10^{13}}{10^{12}}\right)^{3/2} = (\sqrt{10})^3 = 10\sqrt{10}$$

11. The velocity with which a projectile must be fired so that it escapes Earth's gravitation does not depend on

(a) mass of the earth

(b) mass of the projectile

(c) radius of the projectile's orbit

(d) gravitational constant

Answer: (b)

$v = \sqrt{\frac{2GM}{R}}$, v does not depends mass of the projectile.

12. The ratio of the accelerations due to gravity on two planets P_1&P_2 is K_1. The ratio of their respective radii is K_2. The ratio of their respective escape velocities is

(a) $\sqrt{K_1K_2}$ (b) $2\sqrt{K_1K_2}$ (c) $\sqrt{\frac{K_1}{K_2}}$ (d) $\sqrt{\frac{K_2}{K_1}}$

Answer: (a)

$$\frac{v_1}{v_2} = \sqrt{\frac{2g_1R_1}{2g_2R_2}} = \sqrt{K_1K_2}$$

13. A man weighs W on the surface of the earth. What is his weight at a height equal to R? R→Radius of earth)

(a) W (b) W/2 (c) W/4 (d) W/8

Answer: (c)

$$\frac{W_h}{W} = \frac{mg_h}{mg} = \frac{g_h}{g} = \frac{R^2}{(R+R)^2} = W_h = \frac{W}{4}$$

14. The earth's radius is R and acceleration due to gravity at its surface is g. If a body of mass m is sent to a height of R/4 from the earth's surface, the minimum speed with which the body must be thrown to reach a height of R/4 above the surface of the earth is

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

Answer: (a)

$$\frac{1}{2}mv^2 = \Delta U = \frac{1}{} mgR$$

$$v = \sqrt{\frac{2gR}{5}}$$

15. When a body is taken from the equator to the poles, its weight

(a) Remains same

(b) increases

(c) decreases

(d) increase at N-pole & decreases at S-pole

Answer: (b)

Because acceleration due to gravity increase so weight also increased.

16. A small satellite is revolving near earth's surface. Its orbital velocity will be nearly

(a) 8 km/s (b) 11.2 km/s (c) 4 km/s (d) 6 km/s

Answer: (a)

These satellite have $v_0 = \sqrt{\frac{GM}{R}} = \sqrt{gR} = 8$ km/s.

17. A Geostationary satellite is revolving around the earth. To make it escape from gravitational field of earth, its velocity must be increased

(a) 100% (b) 41.4% (c)50% (d) 59.6%

Answer: (b)

$v_e = \sqrt{2} v_0 = 1.414 v_0$ %increase in orbital velocity

18. If the radius of earth were shrink by 1%,its mass remaining th same, the acceleration due to gravity on the earth's surface would

(a) Decreased by 2%
(b) Remain unchanged
(c) Increased by 2%
(d) Increased by 1%

Answer: (c)

$g = \frac{GM}{R^2}$ if mass is constant or $g \propto \frac{1}{R^2}$

$g = -2 \times \%\text{change in } R = -2 \times (-1\%) = +2\%$

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

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

Answer: (b)

$$\Delta U = \frac{mgh}{1 + \frac{h}{R}}$$

 h = R

So $\Delta U = \frac{mgR}{2}$

20. A comet travels around the sun in elliptical orbit. Its mass is 108kgwhen away its speed is 2×104ms−1.Find the change in KE when it has reached 5×1010maway from the sun

(a) 38×108J (b) 48×108J (c) 58×108J (d) 56×108J

Answer: (b)

$$v1r1 = v2r2 \Rightarrow v2 = \frac{2\times10^4 \times 2.5\times10^{11}}{5\times1010} = 10^5$$

$$\Delta KE = \frac{1}{2}\times108[(105)2-4\times108]=48\times108J$$

21. A satellite orbits a planet, moving very close to its surface. By what maximum factor can its kinetic energy be increased suddenly, without change in direction, such that it still remains in orbit?

(a) 1.5 (b) $\sqrt{2}$ (c) 2 (d) 3

Answer: (c)

For an orbit close to planet's surface, $\frac{mv^2}{R} = mg$

For escape velocity, $v^2_{max} = 2gR \quad \therefore \frac{v^2_{max}}{v^2} = 2$

22. Two satellites A and B, the ratio of their masses being 3:1, are in the circular orbits of radii r and 4r. The ratio of total mechanical energy of A to that of B is

(a) $\frac{1}{3}$ (b) 3 (c) $\frac{3}{4}$ (d) 12

Answer: (d)

$E = -\frac{GMm}{2r}$ or $E \propto \frac{m}{r}$

$\therefore \frac{E_1}{E_2} = \frac{3}{1} \times \frac{4}{1} = \frac{12}{1} = 12$

23. Two particles each of mass m are placed at A and C as such AB = BC = L. The gravitational force on the third particle placed at D at a distance L metre on the perpendicular bisector of the line AC, is

(a) $\frac{Gm^2}{\sqrt{2}L^2}$ along BD (b) $\frac{Gm^2}{\sqrt{2}L^2}$ along DB

along AC

(c) $\frac{Gm^2}{L^2}$ (d) none of these

Answer: (b)

Angle $\angle ADC = 90°$

$\Rightarrow$ distance AC = DC = $2\sqrt{\ }$

$\Rightarrow F_{AB} \perp F_{CD}$

24. If the radius of the earth becomes half of its present value (mass remaining the same), the new length of the day would be

(a) 6 hours (b) 12 hours (c) 48 hours (d) 96 hours

Answer: (a)

$$J = I\omega = \left(\frac{2}{5} M R^2\right)\left(\frac{2\pi}{T}\right)$$

$$\therefore T \propto R^2$$

25. Two electrons are revolving around a nucleus at distances 'r' and '4r'. The ratio of their periods is

(a) 1:4 (b) 4:1 (c) 8:1 (d) 1:8

Answer: (d)

$$\frac{r_1}{r_2} = \frac{1}{4} = \frac{n_1^2}{n_2^2} \Rightarrow \frac{n_1}{n_2} = \frac{1}{2}$$

$$\frac{T_1}{T_2} = \frac{n_1^3}{n_2^3} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$$

26. The escape velocity of a projectile from the earth is approximately

(a) 7 km/sec (b) 112 km/sec

(c) 11.2 km/sec (d) 1.1 km/sec

Answer: (c)

Escape velocity $\sqrt{\frac{2GM_e}{R_e}} = 11.2$ km/s

27. If the distance between two masses is doubled, gravitational attraction between them

(a) is doubled (b) becomes four times

(c) is reduced to half (d) is reduced to a quarter

Answer: (d)

$F = \frac{GM_1M_2}{R^2}$, R is doubled, so $F \propto \frac{1}{R^2}$ so F becomes 1/4th of its present value.

28. The value of 'g' on poles is

(a) Maximum (b) Minimum

(c) Zero (d) None of the above

Answer: (a)

$g = \frac{GM_e}{R_e^2}$ so R_e for poles is minimum so g is maximum.

29. If the speed of rotation of earth about its axis increases, then the weight of the body at the equator will

(a) increase

(b) decrease

(c) remain unchanged

(d) sometimes decrease and sometimes increase

Answer: (b)

Due to rotation, the effective value of g is $g' = g - \omega^2 R \cos^2\lambda$. Now, ω increases so g' will decrease & so weight $= mg'$ will reduce

30. The two moving particles collide and clump together on a smooth horizontal surface. The following statements are given below (a) Mechanical energy is conserved. (b) Total energy is conserved. (c) Work done by the system is positive (d) Work done by the system is negative. Choose the correct option. (A) (a) and (c) are correct. (C) (a) and (d) are correct.

(B) (b) and (c) are correct.
(D) (b) and (d) are correct.

Answer: (d)

It is obvious for 2 mass system, whether it is elastic, inelastic or perfectly elastic. Total energy of system will remain conserved. But final kinetic energy will be less than initial K.E. So work done by the system will be negative.

31. Find the work done to take a particle of mass m from surface of the earth to a height equal to 2R

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

Answer: (d)

$$W = \Delta(PE) = GMm\left(\frac{1}{R} - \frac{1}{3R}\right)$$

$$= \frac{2GMm}{3R} = \frac{2}{3} g m R$$

32. What is the shortest possible period of an Earth satellite in circular orbit ?

(a) $2\pi\sqrt{\frac{R}{g}}$ (b) zero (c) 1 day (d) 1 year

Answer: (a)

$$T = 2\pi\sqrt{\frac{(R+h)^3}{GM}}$$

T will be minimum if h = 0

$$\therefore T_{min} = 2\pi\sqrt{\frac{R^3}{gR^2}} \text{ or } T_{min} = 2\pi\sqrt{\frac{R}{g}}$$

33. Two satellite A and B go round a planet P in circular orbits having radii 4R and R respectively. If the speed of satellite A is 3v, the speed of satellite B will be

(a) 12 v (b) 6 v (c) 4 v/3 (d) 3 v/2

Answer: (b)

The speed of satellite is called orbital speed orbital speed

$$v_0 = \sqrt{\frac{GM_e}{R_e}} \Rightarrow v \propto \frac{1}{\sqrt{R}} \Rightarrow \frac{v_B}{v_A} = \sqrt{\frac{R_A}{R_B}}$$

$$\frac{v_B}{3v} = \sqrt{\frac{4R}{R}} \Rightarrow v_B = 6v$$

34. 2 kg body falls from infinity to the surface of earth what will be the kinetic energy of the body on reaching the surface of Earth? (Assume escape velocity to be 1024J

(a) 108J (b) 1016J (c) 1020J (d) 1024J

Answer: (a)

Kineticenergy $=\frac{1}{2}mv_e^2=\frac{1}{2}\cdot 2.10^4.10^4 J=10^8 J$

35. The ratio of the accelerations due gravity on two planets P_1&P_2 is k_1. The ratio of their respective radii is k_2. The ratio of their respective escape velocities is

(a) $\sqrt{k_1k_2}$ (b) $\sqrt{2k_1k_2}$ (c) $\sqrt{\frac{k_1}{k_2}}$ (d) $\sqrt{\frac{k_2}{k_1}}$

Answer: (a)

$$\frac{V_1}{V_2}=\sqrt{\frac{2g_1R_1}{2g_2R_2}}=\sqrt{K_1K_2}$$

36. The weight of the body at the centre of the earth is

(a) zero (b) infinite

(c) same as on the surface (d) None of these

Answer: (a)

Because g at centre of the earth is zero so weight = mg is also zero.

37. The depth d at which the value of acceleration due to gravity becomes $\frac{1}{n}$ times the value at the surface, is

[R = Radius of earth]

(a) $\frac{R}{n}$ (b) $R\left(\frac{n-1}{n}\right)$ (c) $\frac{R}{n^2}$ (d) $R\left(\frac{n}{n+1}\right)$

Answer: (b)

Due to depth

$g\left(1-\frac{d}{R}\right)$

$g' = g/n$

$\Rightarrow \frac{g}{n} = g\left(1 - \frac{d}{R}\right) \Rightarrow \frac{d}{R} = 1 - \frac{1}{n} = \left(\frac{n-1}{n}\right)$

$\Rightarrow d = R\left(\frac{n-1}{n}\right)$

38. The acceleration due to the gravity on the moon is one sixth that on earth. If the average density of moon is three fifth that of earth, the moon's radius in terms of earth's radius Re is

(a) 0.16Re (b) 0.27Re (c) 0.32Re (d) 0.36Re

Answer: (b)

We know

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

$$\frac{g_{Moon}}{g_{earth}} = \frac{\frac{4}{3}\pi G R_{Moon} \rho_{Moon}}{\frac{4}{3}\pi G R_e \rho_e}$$

$$\Rightarrow \frac{g/6}{g} = \frac{4}{3}\pi G R_m \rho_m \Big/ \frac{4}{3}\pi G R_e \rho_e$$

$$\Rightarrow R_M = \frac{5}{18} R_e = 0.27\ R_e$$

39. The diameters of two planets are in the ratio of 4:1& mean density have ratio 1:2,then the ratio of g on the planets will be

(a) 1:2 (b) 1:4 (c) 2:1 (d) 4:1

Answer: (c)

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

given R1:R2=4:1&ρ1:ρ2=1:2

so $\frac{g_1}{g_2} = \frac{\frac{4}{3}\pi G R_1 \rho_1}{\frac{4}{3}\pi G R_2 \rho_2} = \frac{2}{1}$

40. When you move from equator to pole, the value of acceleration due to gravity (g)

(a) increases
(b) decreases
(c) remains the same
(d) increases then decreases

Answer: (a)

From eq.

$g' = g - \omega^2 R_e \cos^2 \lambda$

Where λ is the latitude which is 0° at equator and 90° at the poles. Therefore g′ is maximum at poles and minimum at equator. Hence value of g increases while going from the equator poles.

41. A satellite of the sun is in circular orbit around the sun, midway between the sun and the earth. Then

(a) The period of the satellite is nearly 229 days
(b) The period of the satellite is nearly 129 days
(c) The speed of the satellite equal the escape velocity of the earth.
(d) The acceleration of the satellite is four times the acceleration of the earth.

Answer: (b)

$T^2 \propto r^3$

$\frac{T_1}{T_2} = \left(\frac{r}{r/2}\right)^{3/2}$

$\frac{365 \text{ days}}{T} = 2\sqrt{2}; T = \frac{365}{2\sqrt{2}}$ days $\Rightarrow 129$ days

42. The change in the value of g at a height h above the surface of the earth is the same as at a depth d below the surface of earth. When both d and h are much smaller than the radius of earth, then which of the following is correct?

(a) d=2h (b) d=h (c) $d = \frac{h}{2}$ (d) $d = \frac{3h}{2}$

Answer: (a)

$\Delta g_1 = \Delta g_2$

$\Rightarrow g\left(\frac{2h}{R}\right) = g\frac{d}{R}$

$\Rightarrow d = 2h$

43. A particle of mass 10 g is kept on the surface of a uniform sphere of mass 100 kg and radius 10 cm. Find the work to be done against the gravitational force between them to take the particle far away from the sphere. (you may take $G = 6.67\times10^{-11} Nm^2/kg^2$)

(a) 6.67×10^{-9} J (b) 6.67×10^{-10} J

(c) 13.34×10^{-10} J (d) 3.33×10^{-10} J

Answer: (b)

$$W = \Delta U = 0 - \left(-\frac{GMm}{R}\right) = \frac{6.67\times10^{-11}\times100\times10^{-2}}{10^{-1}} = 6.67\times10^{-10} J$$

44. Average density of the earth

(a) is directly proportional to g

(b) is inversely proportional to g

(c) does not depend on g

(d) is a complex function of g

Answer: (a)

Average density of earth $= \frac{3g}{4\pi GR}$

So, Average density of the earth is directly proportional to g.

45. The binding energy of a particle of mass m with a planet, when it is on the planets surface, is $\frac{1}{2}mv_0^2$. A tunnel is dug along a diameter of the planet and the particle is dropped into it from the surface, when the body reaches the centre of the planet, its speed is

(a) v_0 (b) $\frac{v_0}{\sqrt{2}}$ (c) Zero (d) $\frac{v_0}{2}$

Answer: (b)

The motion of the particle within the tunnel is simple harmonic. At mean position all of its energy is K.E. which is equal to half of Binding Energy.