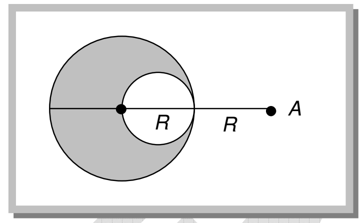
Gravitation Assignment

1. A solid sphere of uniform density and radius *R* applies a gravitational force of attraction equal to F_1 on a particle placed at *A*, distance $2R$ from the centre of the sphere. A spherical cavity of radius *R*/2 is now made in the sphere as shown in the figure. The sphere with cavity now applies a gravitational force F_2 on the same particle placed at *A*. The ratio F_2 / F_1 will be



(a) 1/2
(b) 3
(c) 7
(d) 7/9

2. Three uniform spheres of mass *M* and radius *R* each are kept in such a way that each touches the other two. The magnitude of the gravitational force on any of the spheres due to the other two is

(a) $\frac{\sqrt{3}}{4}\frac{GM^2}{R^2}$ (b) $\frac{3}{2}\frac{GM^2}{R^2}$ (c) $\frac{\sqrt{3}GM^2}{R^2}$ (d) $\frac{\sqrt{3}}{2}\frac{GM^2}{R^2}$

3. A mass of 10*kg* is balanced on a sensitive physical balance. A 1000 *kg* mass is placed below 10 *kg* mass at a distance of 1*m*. How much additional mass will be required for balancing the physical balance

(a) $66 \times 10^{-15}\,kg$ (b) $6.7 \times 10^{-8}\,kg$ (c) $66 \times 10^{-12}\,kg$ (d) $6.7 \times 10^{-6}\,kg$

4. Let *g* be the acceleration due to gravity at earth's surface and *K* be the rotational kinetic energy of the earth. Suppose the earth's radius decreases by 2% keeping all other quantities same, then

(a) *g* decreases by 2% and *K* decreases by 4% (b) *g* decreases by 4% and *K* increases by 2%
(c) *g* increases by 4% and *K* decreases by 4% (d) *g* decreases by 4% and *K* increase by 4%

5. Clock *A* based on spring oscillations and a clock *B* based on oscillations of simple pendulum are synchronised on earth. Both are taken to mars whose mass is 0.1 times the mass of earth and radius is half that of earth. Which of the following statement is correct

(a) Both will show same time
(b) Time measured in clock *A* will be greater than that in clock *B*
(c) Time measured in clock *B* will be greater than that in clock *A*
(d) Clock *A* will stop and clock *B* will show time as it shows on earth

6. A simple pendulum has a time period T_1 when on earth's surface and T_2 when taken to a height *R* above the earth's surface, where *R* is the radius of earth. The value of T_2 / T_1 is

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

7. A pendulum clock is set to give correct time at the sea level. This clock is moved to hill station at an altitude of 2500*m* above the sea level. In order to keep correct time of the hill station, the length of the pendulum

(a) Has to be reduced (b) Has to be increased
(c) Needs no adjustment (d) Needs no adjustment but its mass has to be increased

8. Which of the following correctly indicates the approximate effective values of *g* on various parts of a journey to the moon (values are in *metres/sec*^{2})

	Before take off from earth	One minute after lift – off	In earth orbit	on the moon
(a)	9.80	9.80	0	1.6
(b)	9.80	0.98	0	1.6
(c)	9.80	0.00	0	9.8×6
(d)	9.80	7.00	0	1.6

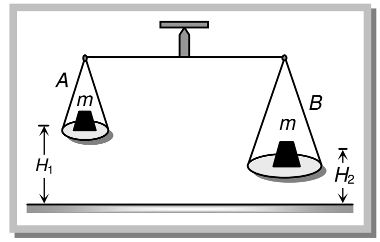
9. Two blocks of masses *m* each are hung from a balance. The scale pan *A* is at height H_1 whereas scale pan *B* is at height H_2. The error in weighing when $H_1 > H_2$ and *R* being the radius of earth is

(a) $mg\left(\frac{1-2H_1}{R}\right)$

(b) $2mg\left(\frac{H_1}{R}-\frac{H_2}{R}\right)$

(c) $2mg\left(\frac{H_2}{R}-\frac{H_1}{R}\right)$

(d) $2mg\,\frac{H_2H_1}{H_1+H_2}$



10. A particle would take a time t to move down a straight tunnel from the surface of earth (supposed to be a homogeneous sphere) to its centre. If gravity were to remain constant this time would be t'. The ratio of $\frac{t}{t'}$ will be

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

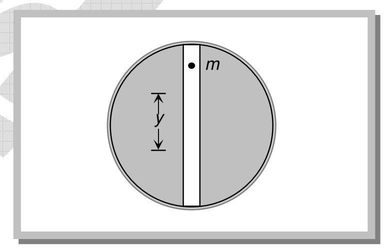
11. Suppose a vertical tunnel is dug along the diameter of earth assumed to be a sphere of uniform mass having density ρ. If a body of mass m is thrown in this tunnel, its acceleration at a distance y from the centre is given by

(a) $\frac{4\pi}{3}G\rho ym$

(b) $\frac{3}{4}\pi G\rho y$

(c) $\frac{4}{3}\pi\rho y$

(d) $\frac{4}{3}\pi G\rho y$



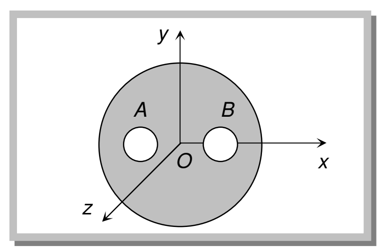
12. A tunnel is dug along the diameter of the earth. If a particle of mass m is situated in the tunnel at a distance x from the centre of earth then gravitational force acting on it, will be

(a) $\frac{GM_em}{R_e^3}x$ (b) $\frac{GM_em}{R_e^2}$ (c) $\frac{GM_em}{x^2}$ (d) $\frac{GM_em}{(R_e+x)^2}$

13. The acceleration due to gravity increases by 0.5% when we go from the equator to the poles. What will be the time period of the pendulum at the equator which beats seconds at the poles

(a) 1.950 s (b) 1.995 s (c) 2.050 s (d) 2.005 s

14. A solid sphere of uniform density and radius 4 units is located with its centre at the origin O of coordinates. Two spheres of equal radii 1 unit with their centres at $A(-2, 0, 0)$ and $B(2, 0, 0)$ respectively are taken out of the solid leaving behind spherical cavities as shown in figure



(a) The gravitational force due to this object at the origin is zero

(b) The gravitational force at the point $B(2, 0, 0)$ is zero

(c) The gravitational potential is the same at all points of the circle $y^2+z^2=36$

(d) The gravitational potential is the same at all points on the circle $y^2+z^2=4$

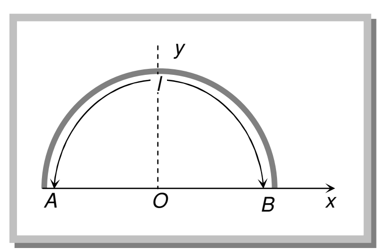
15. Gravitational field at the centre of a semicircle formed by a thin wire AB of mass m and length l is

(a) $\frac{Gm}{l}$ along x axis

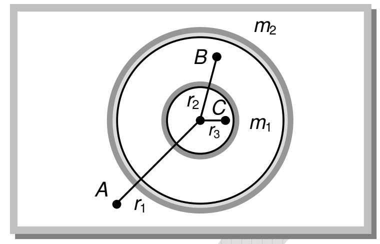
(b) $\frac{Gm}{\pi l}$ along y axis

(c) $\frac{2\pi Gm}{l^2}$ along x axis

(d) $\frac{2\pi Gm}{l^2}$ along y axis



16. Two concentric shells of different masses m_1 and m_2 are having a sliding particle of mass *m*. The forces on the particle at position *A*, *B* and *C* are



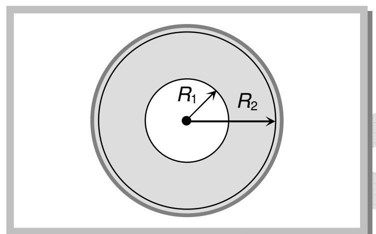
(a) $0, \frac{Gm_1}{r_2^2}, \frac{G(m_1+m_2)m}{r_1^2}$

(b) $\frac{Gm_2}{r_2^2}, 0, \frac{Gm_1}{r_1^2}$

(c) $\frac{G(m_1+m_2)m}{r_1^2}, \frac{Gm_2}{r_2^2}, 0$

(d) $\frac{G(m_1+m_2)m}{r_1^2}, \frac{Gm_1}{r_2^2}, 0$

17. A sphere of mass *M* and radius R_2 has a concentric cavity of radius R_1 as shown in figure. The force *F* exerted by the sphere on a particle of mass m located at a distance r from the centre of sphere varies as $(0 \le r \le \infty)$



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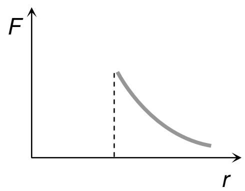

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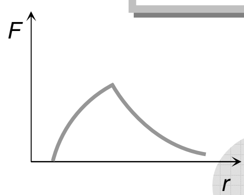

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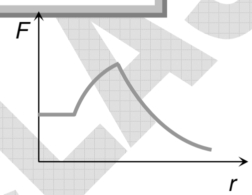

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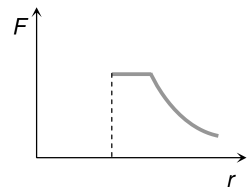
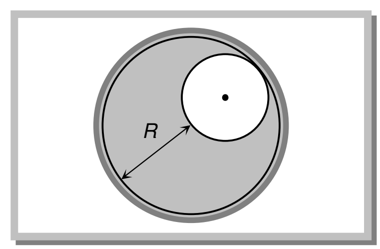


18. A spherical hole is made in a solid sphere of radius *R*. The mass of the sphere before hollowing was *M*. The gravitational field at the centre of the hole due to the remaining mass is



(a) Zero

(b) $\frac{GM}{8R^2}$

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

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

19. A point *P* lies on the axis of a ring of mass *M* and radius *a,* at a distance *a* from its centre *C*. A small particle starts from *P* and reaches *C* under gravitational attraction only. Its speed at *C* will be

(a) $\sqrt{\frac{2GM}{a}}$ (b) $\sqrt{\frac{2GM}{a}\left(1-\frac{1}{\sqrt{2}}\right)}$ (c) $\sqrt{\frac{2GM}{a}(\sqrt{2}-1)}$ (d) Zero

20. A person brings a mass of 1 *kg* from infinity to a point *A*. Initially the mass was at rest but it moves with a speed of 2 *m/s* as it reaches *A*. The work done by the person on the mass is – 3 *J*. The potential of *A* is

(a) – 3 *J/kg* (b) – 2 *J/kg* (c) – 5 *J/kg* (d) – 7 *J/kg*

21. A thin rod of length *L* is bent to form a semicircle. The mass of the rod is *M*. What will be the gravitational potential at the centre of the circle

(a) $-\frac{GM}{L}$ (b) $-\frac{GM}{2\pi L}$ (c) $-\frac{\pi GM}{2L}$ (d) $-\frac{\pi GM}{L}$

22. A ball of mass *m* is fired vertically upwards from the surface of the earth with velocity nv_e, where v_e is the escape velocity and $n < 1$. Neglecting air resistance, to what height will the ball rise? (Take radius of the earth as *R*)

(a) R/n^2 (b) $R/(1-n^2)$ (c) $Rn^2/(1-n^2)$ (d) Rn^2

23. The masses and radii of the earth and moon are M_1, R_1 and M_2, R_2 respectively. Their centres are distance *d* apart. The minimum velocity with which a particle of mass *m* should be projected from a point midway between their centres so that it escape to infinity is

(a) $2\sqrt{\frac{G}{d}(M_1+M_2)}$ (b) $2\sqrt{\frac{2G}{d}(M_1+M_2)}$ (c) $2\sqrt{\frac{Gm}{d}(M_1+M_2)}$ (d) $2\sqrt{\frac{Gm(M_1+M_2)}{d(R_1+R_2)}}$

24. A body is projected with a velocity $2v_e$, where v_e is the escape velocity. Its velocity when it escapes the gravitational field of the earth is

(a) $\sqrt{7}v_e$ (b) $\sqrt{5}v_e$ (c) $\sqrt{3}v_e$ (d) v_e

25. The radius and mass of earth are increased by 0.5%. Which of the following statement is false at the surface of the earth

(a) *g* will increase (b) *g* will decrease

(c) Escape velocity will remain unchanged (d) Potential energy will remain unchanged

26. Two identical thin rings each of radius *R* are coaxially placed at a distance *R*. If the rings have a uniform mass distribution and each has mass m_1 and m_2 respectively, then the work done in moving a mass *m* from centre of one ring to that of the other is

(a) Zero (b) $\frac{Gm(m_1-m_2)(\sqrt{2}-1)}{\sqrt{2}R}$ (c) $\frac{Gm\sqrt{2}(m_1-m_2)}{R}$ (d) $\frac{Gm_1m_2(\sqrt{2}+1)}{m_2R}$

27. When a satellite going round earth in a circular orbit of radius *r* and speed *v*, losses some of its energy. Then *r* and *v* change as

(a) *r* and *v* both will increase (b) *r* and *v* both will decrease

(c) *r* will decrease and *v* will increase (d) *r* will increase and *v* will decrease

28. A satellite is revolving around a planet of mass *M* in an elliptical orbit of semi-major axis *a*. The orbital velocity of the satellite at a distance *r* from the focus will be

(a) $\left[GM\left(\frac{2}{r}-\frac{1}{a}\right)\right]^{1/2}$ (b) $\left[GM\left(\frac{1}{r}-\frac{2}{a}\right)\right]^{1/2}$ (c) $\left[GM\left(\frac{2}{r^2}-\frac{1}{a^2}\right)\right]^{1/2}$ (d) $\left[GM\left(\frac{1}{r^2}-\frac{2}{a^2}\right)\right]^{1/2}$

29. A geostationary satellite orbits around the earth in a circular orbit of radius 36000 *km*. Then, the time period of a satellite orbiting a few hundred *kilometres* above the earth's surface $(R_{Earth}=6400\ km)$ will approximately be

(a) 1/2 *h* (b) 1 *h* (c) 2 *h* (d) 4 *h*

30. If the distance between the earth and the sun becomes half its present value, the number of days in a year would have been

(a) 64.5 (b) 129 (c) 182.5 (d) 730

31. A satellite is launched into a circular orbit of radius *R* around the earth. A second satellite is launched into an orbit of radius (1.01) *R*. The period of the second satellite is larger than that of the first one by approximately

(a) 0.5% (b) 1.0% (c) 1.5% (d) 3.0%

32. A satellite moves eastwards very near the surface of the earth in the equatorial plane of the earth with speed v_0. Another satellite moves at the same height with the same speed in the equatorial plane but westwards. If *R* = radius of the earth about its own axis, then the difference in the two time period as observed on the earth will be approximately equal to

(a) $\frac{4\pi Rv_0}{R^2\omega^4-v_0^2}$ (b) $\frac{4\pi Rv_0}{R^2\omega^2-v_0^2}$ (c) $\frac{4\pi Rv_0}{R^2\omega^2+v_0^2}$ (d) $\frac{2\pi Rv_0}{R^2\omega^2+v_0^2}$

33. A "*double star*" is a composite system of two stars rotating about their centre of mass under their mutual gravitational attraction. Let us consider such a "*double star*" which has two stars of masses *m* and 2*m* at separation *l*. If *T* is the time period of rotation about their centre of mass then,

(a) $T=2\pi\sqrt{\frac{l^3}{mG}}$ (b) $T=2\pi\sqrt{\frac{l^3}{2mG}}$ (c) $T=2\pi\sqrt{\frac{l^3}{3mG}}$ (d) $T=2\pi\sqrt{\frac{l^3}{4mG}}$

34. A space probe projected from the earth moves round the moon in a circular orbit at a distance equal to its radius $R_{moon}=\frac{R}{4}$ where *R* = radius of the earth. Its rocket launcher moves in circular orbit around the earth at a distance equal to *R* from its surface. The ratio of the times taken for one revolution by the probe and the rocket launcher is $\left(M_{moon}=\frac{M}{80}, \text{where } M=\text{mass of the earth}\right)$

(a) $\sqrt{3}:2$ (b) $\sqrt{5}:2$ (c) 1 : 1 (d) $2:\sqrt{3}$

35. If the angular velocity of a planet about its own axis is halved, the distance of geostationary satellite of this planet from the centre of the planet will become

(a) $(2)^{1/3}$ times (b) $(2)^{3/2}$ times (c) $(2)^{2/3}$ times (d) 4 times

36. By what percent the energy of a satellite has to be increased to shift it from an orbit of radius *r* to $\frac{3}{2}r$

(a) 66.7% (b) 33.3% (c) 15% (d) 20.3%

37. A mass *m* is raised from the surface of the earth to a point distant $\beta R(\beta > 1)$ from the centre of the earth and then put into a circular orbit to make it an artificial satellite. The total work done to complete this job is

(a) $mgR(2\beta - 1)$ (b) $mgR(2\beta + 1)$ (c) $mgR(\beta + 1)$ (d) $mgR\frac{2\beta - 1}{2\beta}$

38. Imagine a light planet revolving around a very massive star in a circular orbit of radius *R* with a period of revolution *T*. If the gravitational force of attraction between planet and star is proportional to $R^{-5/2}$, then T^2 is proportional to

(a) R^3 (b) $R^{7/2}$ (c) $R^{5/2}$ (d) $R^{3/2}$

39. A binary star has stars of masses *m* and *nm* (where *n* is a numerical factor) having separation of their centres as *r*. If these stars revolve because of gravitational force of each other, the period of revolution is given by

(a) $\frac{2\pi r^{3/2}}{\left(\frac{Gnm^2}{(n+1)m}\right)^{\frac{1}{2}}}$ (b) $\frac{2\pi r^{1/2}}{\left(\frac{G(n+1)m}{nm}\right)^{\frac{1}{2}}}$ (c) $\frac{2\pi r^3}{\frac{2}{3}GMn}$ (d) $\frac{2\pi r^{3/2}}{\left(\frac{2}{3}GMn\right)^{2/3}}$

40. A planet moves in an elliptical orbit around one of the foci. The ratio of maximum velocity v_{max} and minimum velocity v_{min} in terms of eccentricity *e* of the ellipse is given by

(a) $\frac{1-e}{1+e}$ (b) $\frac{e-1}{e+1}$ (c) $\frac{1+e}{1-e}$ (d) $\frac{e}{e-1}$

41. The satellites S_1 and S_2 describe circular orbits of radii *r* and 2*r* respectively around a planet. If the orbital angular velocity of S_1 is ω, that of S_2 is

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

42. A satellite of mass *m* is circulating around the earth with constant angular velocity. If radius of the orbit is R_0 and mass of the earth *M,* the angular momentum about the centre of the earth is

(a) $m\sqrt{GMR_0}$ (b) $M\sqrt{GmR_0}$ (c) $m\sqrt{\frac{GM}{R_0}}$ (d) $M\sqrt{\frac{GM}{R_0}}$

43. A planet of mass *m* is moving in an elliptical path about the sun. Its maximum and minimum distances from the sun are r_1 and r_2 respectively. If M_s is the mass of sun then the angular momentum of this planet about the center of sun will be

(a) $\sqrt{\frac{2GM_s}{(r_1+r_2)}}$ (b) $2GM_s m\sqrt{\frac{r_1 r_2}{(r_1+r_2)}}$ (c) $m\sqrt{\frac{2GM_s r_1 r_2}{(r_1+r_2)}}$ (d) $m\sqrt{\frac{2GM_s m(r_1+r_2)}{r_1 r_2}}$

44. The minimum energy required to launch a satellite of mass *m* from the surface of earth of radius *R* in a circular orbit at an altitude 2 *R* is (mass of earth is *M*)

(a) $\frac{5GmM}{6R}$ (b) $\frac{2GmM}{3R}$ (c) $\frac{GmM}{2R}$ (d) $\frac{GmM}{3R}$

45. The masses of moon and earth are $7.36 \times 10^{22}\ kg$ and $5.98 \times 10^{24}\ kg$ respectively and their mean separation is $3.82 \times 10^5\ km$. The energy required to break the earth-moon system is

(a) $12.4 \times 10^{32}\ J$ (b) $3.84 \times 10^{28}\ J$ (c) $5.36 \times 10^{24}\ J$ (d) $2.96 \times 10^{20}\ J$

46. A body placed at a distance R_0 form the centre of earth, starts moving from rest. The velocity of the body on reaching at the earth's surface will be (R_e = radius of earth and M_e = mass of earth)

(a) $GM_e\left(\frac{1}{R_e} - \frac{1}{R_0}\right)$ (b) $2GM_e\left(\frac{1}{R_e} - \frac{1}{R_0}\right)$ (c) $GM_e\sqrt{\frac{1}{R_e} - \frac{1}{R_0}}$ (d) $\sqrt{2GM_e\left(\frac{1}{R_e} - \frac{1}{R_0}\right)}$

47. For the moon to cease to remain the earth's satellite its orbital velocity has to increase by a factor of

(a) 2 (b) $\sqrt{2}$ (c) $1/\sqrt{2}$ (d) $\sqrt{3}$

48. Two artificial satellites *A* and *B* are at a distances r_A and r_B above the earth's surface. If the radius of earth is *R,* then the ratio of their speeds will be

(a) $\left(\frac{r_B + R}{r_A + R}\right)^{1/2}$ (b) $\left(\frac{r_B + R}{r_A + R}\right)^2$ (c) $\left(\frac{r_B}{r_A}\right)^2$ (d) $\left(\frac{r_B}{r_A}\right)^{1/2}$

49. There are two bodies of masses 100 *kg* and 10000 *kg* separated by a distance 1 *m*. At what distance from the smaller body, the intensity of gravitational field will be zero

(a) $\frac{1}{9}m$ (b) $\frac{1}{10}m$ (c) $\frac{1}{11}m$ (d) $\frac{10}{11}m$

50. Which one of the following graphs represents correctly the variation of the gravitational field (F) with the distance (r) from the centre of a spherical shell of mass M and radius a

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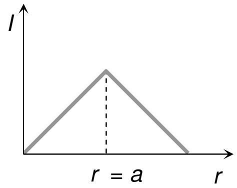

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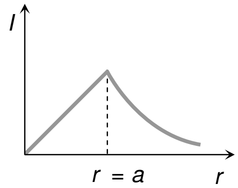

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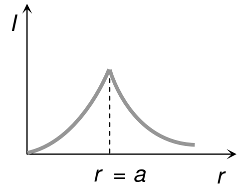

(d)