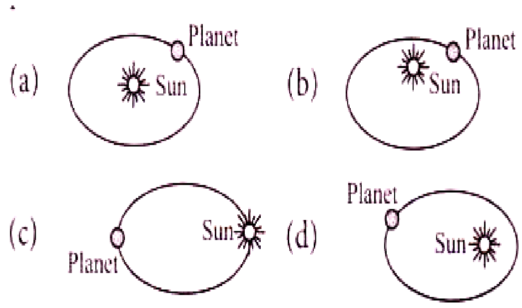
INTRODUCTION

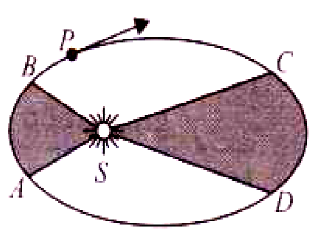
KEPLER'S LAWS

1. Which of the following orbits is a possible orbit for a planet?



2. Kepler's second law is a consequence of
   a) conservation of energy
   b) conservation of linear momentum
   c) conservation of angular momentum
   d) conservation of mass

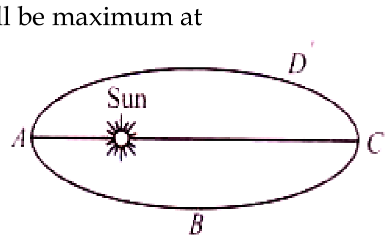
3. Figure shows elliptical orbit of a planet P about the sun S. The shaded area SCD is twice the shaded area SAB. If t_1 is the time for the planet to move from C to D and t_2 is the time to move from A to B, then



   a) $t_1 = t_2$ b) $t_1 = 2t_2$
   c) $t_1 = 4t_2$ d) $t_1 > t_2$

4. The areal velocity and the angular momentum of the planet are related by which of the following ?
   (Where m_p is the mass of the planet)
   a) $\frac{\Delta \vec{A}}{\Delta t} = \frac{\vec{L}}{2m_p}$ b) $\frac{\Delta \vec{A}}{\Delta t} = \frac{\vec{L}}{m_p}$
   c) $\frac{\Delta \vec{A}}{\Delta t} = \frac{\vec{L}}{m_p}$ d) $\frac{\Delta \vec{A}}{\Delta t} = \frac{\vec{L}}{\sqrt{2}m_p}$

5. A planet revolves around the sun in an elliptical orbit. The linear speed of the planet will be maximum at



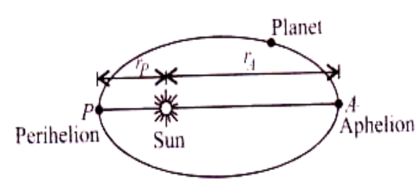
   a) A   b) B
   c) C   d) D

6. Which of the following Kepler's is also known as harmonic law?
   a) First law   b) Second law
   c) Third law   d) None of these

7. If a graph is plotted between T^2 and r^3 for a planet, then its slope will be (where M_s is the mass of the sun)
   a) $\frac{4\pi^2}{GM_s}$ b) $\frac{GM_s}{4\pi}$
   c) $4\pi GM_s$ d) GM_s

8. A geostationary satellite is orbiting the earth at a height 6R above the surface of earth, where R is the radius of the earth. The time period of another satellite at a height of 2.5 R from the surface of earth in hours is
   a) $3\sqrt{2}h$ b) $1.5\sqrt{2}h$
   c) $6\sqrt{2}h$ d) $12\sqrt{2}h$

9. Assuming that earth and mars move in circular orbits around the sun, with the martian orbit being 1.52 times the orbital radius of the earth. The length of the martian year in days is



   a) $(1.52)^{2/3} \times 365$ b) $(1.52)^{3/2} \times 365$
   c) $(1.52)^2 \times 365$ d) $(1.52)^3 \times 365$

10. A Saturn year is 29.5 times the earth year. How far is the Saturn from the sun if the earth is $1.5 \times 10^8 km$ away from the sun?
    a) $1.4 \times 10^6 km$ b) $1.4 \times 10^7 km$
    c) $1.4 \times 10^8 km$ d) $1.4 \times 10^9 km$

11. The period of moon's rotation around the earth is nearly 29 days. If moon's mass were 2 fold its present value, and all other things remain unchanged, the period of Moon's rotation would be nearly
    a) $29\sqrt{2} days$ b) $\frac{29}{\sqrt{2}} days$
    c) $29 \times 2 days$ d) 29 days

12. Average distance of the earth from the sun is L_1. If one year of the earth-= D days, one year of another planet whose average distance from the sun is L_2 will be
    a) $D\left(\frac{L_2}{L_1}\right)^{1/2} days$
    b) $D\left(\frac{L_2}{L_1}\right)^{3/.2} days$

c) $D\left(\frac{L_2}{L_1}\right)^{2/3} days$ d) $D\left(\frac{L_2}{L_1}\right) days$

13. A planet revolves around the sun in an elliptical orbit of eccentricity e. If T is the time period of the planet, then the time spent by the planet between the ends of the minor axis and major axis close to the sun is

a) $\frac{T\pi}{2e}$ b) $T\left(\frac{2e}{\pi}-1\right)$

c) $\frac{Te}{2\pi}$ d) $T\left(\frac{1}{4}-\frac{e}{2\pi}\right)$

14. A planet revolves around the sun in an elliptical orbit. If v_p and v_a are the velocities of the planet at the perigee and apogee respectively, then the eccentricity of elliptical orbit is given by

a) $\frac{v_p}{v_a}$ b) $\frac{v_a - v_p}{v_a + v_p}$

c) $\frac{v_{p+Va}}{v_p - va}$ d) $\frac{v_p - v_a}{v_p + v_a}$

15. A satellite is in an elliptic orbit around the earth with aphelion of $6R_p$ and perihelion of $2R_p$, where R_E is the radius of the earth. The eccentricity of the orbit is

a) $\frac{1}{2}$ b) $\frac{1}{3}$

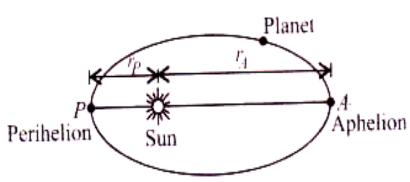
c) $\frac{1}{4}$ d) $\frac{1}{6}$

16. In the question number 15, the ratio of the velocity of the satellite at apogee and perigee is

a) $\frac{1}{2}$ b) $\frac{1}{3}$

c) $\frac{1}{4}$ d) $\frac{1}{6}$

17. A planet orbits the sun in an elliptical path as shown in the figure, Let v_p and v_A be speed of the planet when at perihelion and aphelion respectively. Which of the following relations is correct?



a) $\frac{r_p}{r_A} = \frac{v_A}{v_p}$ b) $\frac{r_p}{r_A} = \frac{v_p}{v_A}$

c) $\frac{r_p}{r_A} = \sqrt{\frac{v_p}{v_A}}$ d) $\frac{r_p}{r_A} = \sqrt{\frac{v_a}{v_p}}$

UNIVERSAL LAW OF NGRVITATION

18. Which of the following statement sis correct regarding the gravitational force?

a) The gravitational force is dependent on the intervening medium.
b) The gravitational force is a non-conservative force.
c) The gravitational force forms action-reaction pair.
d) the gravitation al force is a non – central force.

19. Match the Column I with Column II .

Column I		Column II	
(A)	Kepler's first law	(p)	$T^2 \propto a^2$
(B)	Kepler's second law	(q)	Inverse square law
(c)	Kepler's third law	(r)	Orbit of planet is elliptical
(d)	Newton's law of gravitation	(s)	Law of conservation of angular momentum

a) A-s, B-p, C-q, D-r
b) A-p, B-q, C-r, D-s
c) A-r, B-s, C-p, D-q
d) A-s, B-p, C-q, D-s

20. A mass is placed at point P lies on the axis of a ring of mass M and radius R at a distance R from its centre. The gravitational force on mass m is

a) $\frac{GMm}{\sqrt{2}R^2}$ b) $\frac{GMm}{2R^2}$

c) $\frac{GMm}{2\sqrt{2}R^2}$ d) $\frac{GMm}{4R^2}$

21. 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

a) 3F b) F

c) $\frac{F}{3}$ d) $\frac{F}{9}$

22. A point mass m is placed inside a spherical shell of radius R and mass M at a distance $\frac{R}{2}$ from the centre of the cell .
The gravitational force exerted by the shell on the point mass is

a) $\frac{GMm}{R^2}$ b) $\frac{2GMn}{R^2}$

c) Zero d) $\frac{4GMm}{r^2}$

23. Two starts of masses m_1 and m_2 are parts of a binary star system. The radii of their orbits are r_1
and r_2 respectively, measured from the centre of mass of the system. The magnitude of gravitational force m_1 exerts on m_2 is

a) $\frac{m_1 m_2 G}{(r_1+r_2)^2}$ b) $\frac{m_1 G}{(r_1+r_2)^2}$

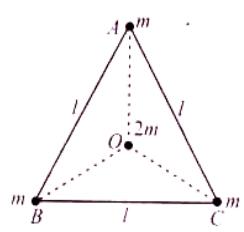
c) $\frac{m_2 G}{(r_1+r_2)^2}$ d) $\frac{G(m_1+m_2)}{(r+r_2)^2}$

24. Two identical spheres each of mass M and radius R are separated by a distance 10 R. The gravitational force on mass m placed at the midpoint of the line joining the centres of the spheres is

a) zero b) $\frac{2GMm}{25R^2}$

c) $\frac{GMm}{25R^2}$ d) $\frac{GMm}{100R^2}$

25. Three masses each of mass m are placed at the vertices if an equilateral triangle ABC of side l as shown in figure. The force acting on a mass 2m placed at the centroid O of the triangle is



a) zero b) $\frac{3GM^2}{l^2}$

c) $\frac{5Gm^2}{l^2}$ d) $\frac{7Gm^2}{l^2}$

26. In the question number 25, if the mass placed at vertex. A is doubled, then the force acting on the mass 2m placed at the centroid O is

a) zero b) $\frac{2Gm^2}{l^2}$

c) $\frac{5Gm^2}{l^2}$ d) $\frac{6Gm^2}{l^2}$

27. Six point masses each of mass m are placed at the vertices of a regular hexagon of side l . The force acting on any of the masses is

a) $\frac{Gm^2}{l^2}\left[\frac{5}{4}+\frac{1}{\sqrt{3}}\right]$

b) $\frac{Gm^2}{l^2}\left[\frac{3}{4}+\frac{1}{\sqrt{3}}\right]$

c) $\frac{Gm^2}{l^2}\left[\frac{5}{4}-\frac{1}{\sqrt{3}}\right]$

d) $\frac{Gm^2}{l^2}\left[\frac{3}{4}-\frac{1}{\sqrt{3}}\right]$

28. Two point masses A and B having masses in the ratio 4:3 are separated by a distance of 1m. When another point mass C of mass M is placed in between A and B, the force between A and C is
$\left(\frac{1}{3}\right)^{rd}$ of the force between B and C. Then the distance of C from A is

a) $\frac{2}{3}m$ b) $\frac{1}{3}m$

c) $\frac{1}{4}m$ d) $\frac{2}{7}m$

29. A research satellite of mass 200 kg circles the earth in an orbit radius $\frac{3R_E}{2}$, where R_E, where R_E is the radius of the earth. Assuming the
gravitational pull on a mass of 1 kg on the earth's surface to be 10N, the pull on the satellite will be

a) 890 N b) 889 N
c) 885N D) 892 N

30. The mass of moon is 1% of mass of earth. The ratio of gravitational pull of earth on moon and that of moon on earth will be

a) 1:1 b) 1:10
c) 1:100 d) 2:1

31. A small planet is revolving around a very massive star in a circular orbit of radius R with a period of revolution T. If the gravitational force between the planet and the star were proportional to $R^{-5/2}$, then T would be proportional to

a) $R^{3/2}$ b) $R^{3/5}$
c) $R^{7/2}$ d) $R^{7/4}$

THE GRAVITATIOANL CONSTANT

32. Which of the following statements is correct regarding the universal constant G?
a) G has same value in all systems of units.
b) The value of G is same everywhere in the universe.
c) The value of g was first experimentally determined by Johannes Kepler.
d) G is a vector quantity.

33. Mass of the earth has been determined through
a) use of kepler's $\frac{T^2}{R^3}$ constancy law
b) sampling the density of earth's crust and using earth's radius

c) Cavendish's determination of G and using earth's radius and g at its surface
d) use of periods of satellites at different above earth's surface

ACCELERATION DUE TO GRAVITY OF THE EARTH

34. Radius of earth is 6400km and that of mars is 3200 km. Mass of mars is 0.1 that of earth's mass.

Then the acceleration due to gravity on mars is
nearly

a) $1m/s^2$ b) $2.5m/s^2$
c) $4m/s^2$ d) $5m/s^2$

35. The ratio of radii of earth to another planet is 2/3 and the ratio of their mean densities is 4/5. If an astronaut can jump to a maximum height of 1.5 m on the earth, with the same effort, the maximum height he can jump on the planet is
a) 1m b) 0.8 m
c) 0.5 m d) 1.25 m

36. If the mass of sun were ten times smaller and gravitational constant G were ten times larger
in magnitudes, then which one of the following statements is incorrect?
a) Walking on ground would become more difficult.
b) The acceleration due to gravity on earth will not change.
c) Raindrops will fall much faster.
d) Airplanes will have to travel much faster.

37. If M_E is the mass of the earth and R_E its radius, the ratio of the acceleration due to gravity and the gravitational constant is

a) $\frac{R_E^2}{M_E}$ b) $\frac{M_E}{R_E^2}$

c) $M_E R_E^2$ d) $\frac{M_E}{R_E}$

38. The acceleration due to gravity g and density of the earth p are related by which of the following relations?
(where G is the gravitational constant and R_E
is the radius of the earth)

a) $\rho = \frac{4\pi G R_E}{3g}$ b) $\rho = \frac{3g}{4\pi G R_E}$

c) $\rho = \frac{3G}{4\pi g R_E}$ d) $\rho = \frac{4\pi g R_E}{3G}$

39. The mass of the moon is $(1/8)$ of the earth but the gravitational pull is (1/6) of the earth. It is due to the fact that
a) moon is the satellite of the earth
b) the radius of the earth is (8/6) of the moon
c) the radius of the earth is $\left(\sqrt{8/6}\right)$ of the moon
d) the radius of the moon is (6/8) of the earth

ACCELERATION DUE TO GRAVITY BELOW AND ABOVE THE SURFACE OF EARTH

40. Value of g is
a) maximum at poles
b) maximum at equator
c) same everywhere
d) minimum at poles

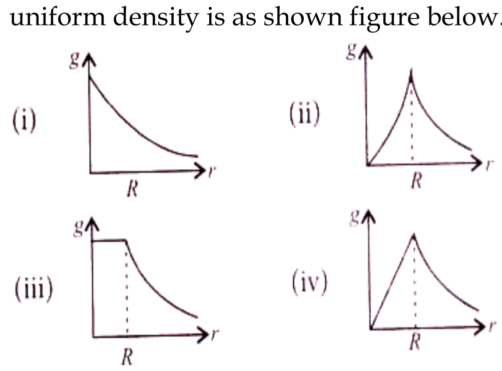
41. Earth is fattened at the poles and bulges at the equator. This is due to the fact that
a) the earth revolves around the sun in an elliptical orbit.
b) the angular velocity of spinning about its axis
is more at the equator
c) the centrifugal force is more at the equator than at poles.
d) none of these.

42. The acceleration due to gravity at the poles and the equator is g_p and g_e respectively. If the earth is a sphere of radius R_E and rotating about its axis with angular speed ω, then $g_p - g_e$ is given by

a) $\frac{\omega^2}{R_E}$ b) $\frac{\omega^2}{R_E^2}$

c) $\omega^2 R_E{}^2$ d) $\omega^2 R_E$

43. 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 figure below.



The correct figure is
a) (i) b) (ii)
c) (iii) d) (iv)

44. Which of the following statements is correct?
a) Acceleration due to gravity increases with increasing altitude.

b) Acceleration due to gravity increases with increasing depth.
c) Acceleration due to gravity increases with
increasing latitutde.
d) Acceleration due to gravity is independent of the mass of the earth.

45. A body hanging from a spring stretches it but 1cm at the earth's surface. How much will the same body stretch the spring at a place 16400 km above the earth's surface? (Radius of the earth=
6400km)
a) 1.28 cm b) 0.64 cm
c) 3.6 cm d) 0.12 cm

46. A body weights 250 N on the surface of the earth. How much will weight half way down to the centre of the earth?
a) 125 N b) 150 N
c) 175 N d) 250 N

47. A body weights 72 N on the surface of the earth.
What is the gravitational force on it due to the earth at a height equal to half the radius of the earth?
a) 16 N b) 28 N
c) 32 N d) 72 N

48. Two spheres each of mass M and radius r are separated by a distance of r. The gravitational potential at the midpoint of the line joining the centres of the spheres is
a) $-\frac{GM}{r}$ b) $-\frac{3GM}{r}$
c) $-\frac{GM}{2r}$ d) $-\frac{4GM}{r}$

49. A particle of mass M is situated at the centre of a spherical shell of same mass and radius R. the gravitational potential at a point situated at $\frac{R}{2}$
distance from the centre will be
a) $-\frac{3GM}{R}$ b) $-\frac{2GM}{R}$
c) $-\frac{GM}{R}$ d) $-\frac{4GM}{R}$

50. A particle of mass m is placed at the centre of a uniform spherical shell of mass 3m and radius R.
the gravitational potential on the surface will be shell is
a) $-\frac{Gm}{R}$ b) $-\frac{3Gm}{R}$
c) $-\frac{4Gm}{R}$ d) $-\frac{2Gm}{R}$

51. Four particles each of mass m are placed at the vertices of a square of side l. The potential energy of the system is
a) $-\frac{\sqrt{2}Gm^2}{l}\left(2-\frac{1}{\sqrt{2}}\right)$
b) $-\frac{2Gm^2}{l}\left(2+\frac{1}{\sqrt{2}}\right)$
c) $-\frac{\sqrt{2}Gm^2}{l}\left(\sqrt{2}+\frac{1}{\sqrt{2}}\right)$
d) $-\frac{2Gm^2}{l}\left(\sqrt{2}-\frac{1}{\sqrt{2}}\right)$

52. In the question number 51, the potential at the
centre is
a) $-2\frac{Gm}{l}$ b) $-3\sqrt{2}\frac{Gm}{l}$
c) $-2\sqrt{2}\frac{Gm}{l}$ d) $-4\sqrt{2}\frac{Gm}{l}$

53. The change in potential energy when a body of mass m is raised to a height nR_E from earth's surface is (R_E = radius of the earth)
a) $mgR_E\left(\frac{n}{(n-1)}\right)$ b) mgR_E
c) $mgR_E\left(\frac{n}{(n+1)}\right)$ d) $\frac{mgR_E}{m}$

54. The mass of the earth is $6\times10^{24}kg$ and that of the moon is $7.4\times10^{22}kg$. The potential energy of the system is $-7.79\times10^{28}J$. The mean distance between the earth and moon is
(G= $6.67\times10^{-11}Nm^2kg^{-2}$)
a) $3.8\times10^{8}m$ b) $3.37\times10^{8}m$
c) $7.60\times10^{4}m$ d) $1.9\times10^{2}m$

ESCAPE SPEED

55. The escape velocity of a body from the earth depends on
1) the mass of the body
ii) the location form where it is projected
iii) the direction of projection
iv) the height of the location from where the body is launched
a) (i) and (ii) b) (ii) and (iv)
c) (i) and (iii) d) 9iii) and (iv)

56. The escape velocity form the surface of the earth is (where R_E is the radius of the earth)
a) $\sqrt{2gR_E}$ b) $\sqrt{gR_E}$
c) $2\sqrt{gR_E}$ d) $\sqrt{3gR_E}$

57. If V_e is escape velocity and v_e is orbital velocity of a satellite for orbit close to the earth's surface.
Then these are related by
a) $v_o=\sqrt{2}v_e$ b) $v_o=v_e$

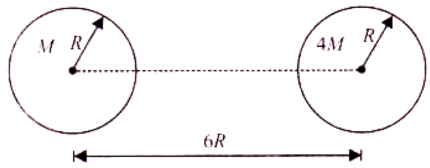
c) $v_e = \frac{v_o}{2}$ d) $v_e = \sqrt{2}v_o$

58. A projectile is fired vertically upwards from the surface of earth with a velocity of kv_e where v_e is the escape velocity and k<1.Neglecting air resistance, the minimum height to which it will rise, measured from the centre of the earth, is
(R_E = radius earth)

a) $\frac{R_E}{1-k^2}$ b) $\frac{R_E}{k^2}$

c) $\frac{1-k^2}{R_E}$ d) $\frac{k^2}{R_E}$

59. Two uniform solid spheres of equal radii R, but mass M and 4M have a centre to centre separation 6R, as shown in figure. A projectile of mass m is projected form the surface of the sphere of mass M directly towards the centre of the second sphere. The minimum speed of the projectile so that it reaches that surface of the second sphere is



a) $\sqrt{\frac{4}{5}\frac{GM}{R}}$ b) $\sqrt{\frac{5}{4}\frac{GM}{R}}$

c) $\sqrt{\frac{3}{5}\frac{GM}{R}}$ d) $\sqrt{\frac{5}{3}\frac{GM}{R}}$

60. The escape speed of a body on the earth's surface is $11.2kms^{-1}$.A body is projected with thrice of this speed. The speed of the body when it escapes the gravitational pull of earth is

a) $11.2kms^{-1}$ b) $22.4\sqrt{2}kms^{-1}$

c) $\frac{22.4}{\sqrt{2}}kms^{-1}$ d) $22.4\sqrt{3}kms^{-1}$

61. The escape velocity of 10 g body from the earth is $11.2kms^{-1}$. Ignoring air resistance, the escape velocity of 10 kg of the iron ball form the earth will be

a) $0.0112kms^{-1}$ b) $0.112kms^{-1}$

c) $11.2kms^{-1}$ d) $0.56kms^{-1}$

EARTH SATELLITE

62. Which of the following statements is correct about satellite?

a) A satellite cannot move in a sable orbit in a plane passing through the earth's centre.
b) Geostationary satellites are launched in the equatorial plane.
c) We can use just one geostationary satellite for global communication around the globe.
d) The speed of satellite increases with an increase in the radius of its orbit.

63. The time period of an earth satellite in a circular
orbit of radius R is 2 days and its orbital velocity is v_0. If time period of another satellite in a circular orbit is 16 days then

a) its radius of orbit is 4R and orbital velocity is
v_0.

b) its radius of orbits is 4R and orbital velocity is
$\frac{v_0}{2}$.

c) its radius of orbits is 2R and orbital velocity is v_0.

d) its radius of orbits is 2R and orbital velocity is
$\frac{v_0}{2}$.

64. The time period T of the moon of planet mars
$(massM_m)$ is related to its orbital radius R as
(G= Gravitational constant)

a) $T^2 = \frac{4\pi^2 R^3}{GM_m}$ b) $T^2 = \frac{4\pi^2 GR^3}{M_m}$

c) $T^2 = \frac{2\pi R^3 G}{M_m}$ d)
$T^2 = 4\pi M_m GR^3$

65. A synchronous satellite goes around the earth once in every 24 h. What is the radius of orbit of the synchronous satellite in terms of the earth's radius?
(Given: Mass of the earth, $M_E = 5.98\times10^{24}kg$, radius of the earth, $R_E = 6.37\times10^6 m$, universal constant of gravitation, $G = 6.67\times10^{-11}Nm^2kg^{-2}$)

a) $2.4R_E$ b) $3.6R_E$

c) $4.8R_E$ d0 $6.6R_E$

ENERGY OF AN ORBITING SATELLITE

66. Match the Column I with column II.
For a satellite in circular orbit,

Column I		Column II	
(A)	Kinetic energy	(p)	$-\frac{GM_E}{2r}$
(B)	Potential energy	(q)	$\sqrt{\frac{GM_p}{r}}$

(C)	Total energy	(r)	$-\frac{GM_E pi}{r}$
(D)	Orbital velocity	(s)	$\frac{GM_E}{2r}m$

(where M_E is the mass of the earth, m is mass of the satellite and r is the radius of the orbit)

a) A-r, B-s, C-q, D-p
b) A-q, B-p, C-r, D-s
c) A-p, B-q, C-s, D-r
d) A-s, B-r, C-p, D-q

67. A satellite is orbiting the earth in a circular orbit of radius r. Its

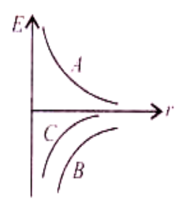
a) kinetic energy varies as r

b) angular momentum varies as $\frac{1}{\sqrt{r}}$

c) linear momentum varies as $\frac{1}{r}$

d) frequency of revolution varies as $\frac{1}{r^{\frac{3}{2}}}$

68. Figure shows the variations of energy E with the orbit radius r of a satellite in a circular motion. Choose the correct statement



a) A shows the kinetic energy, B shows the total energy and C the potential energy of the satellite

b) A and B are kinetic energy and potential energy respectively and C the total energy of the satellite

c) A and B are the potential energy and kinetic energy respectively and C the total energy of the satellite

d) C and A are the kinetic and potential energies and B the total energy of the satellite

69. 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?

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 S_2

70. In motion of an object under the gravitational influence of another object. Which of the following quantities is not conserved?

a) Angular momentum

b) Mass of an object

c) Total mechanical energy

d) Linear momentum

71. A comet orbits the sun in a highly elliptical orbit. Which of the following quantities remains constant throughout its orbit?

i) Linear speed ii) Angular speed

iii) Angular momentum

iv) Kinetic energy

v) Potential energy vi) Total energy

a) (i), (ii), (iii) b) (iii), (iv), (v)

c) (iii) and (vi) d) (ii), (iii) and (vi)

72. A satellite of mass m is in a circular orbit of radius $2R_E$ about the earth. The energy required to transfer it to a circular orbit of radius $4R_E$ is

(where M_E ×and R_E is the mass and radius of the earth respectively)

a) $\frac{GM_E m}{2R_E}$ b) $\frac{GM_E m}{4R_E}$

c) $\frac{GM_E m}{8R_E}$ d) $\frac{GM_E m}{16R_E}$

73. In the question number 72, the change in potential energy is

a) $\frac{GM_E m}{2R_E}$ b) $\frac{GM_E m}{4R_E}$

c) $\frac{GM_E m}{8R_E}$ d) $\frac{GM_E m}{R_E}$

74. 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 $R_2\left(R_2 > R_1\right)$ is :

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

b) $GmM\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

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

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

75. A satellite of mass m orbits the earth at a height h above the surface of the earth. Ho w much energy must be expended to rocket the satellite out of earth's gravitational influence?

(where M_E and R_E be mass and radius of the earth respectively)

a) $\frac{GM_Em}{4(R_E+h)}$ b) $\frac{GM_Em}{2(R_E+h)}$

c) $\frac{GM_Em}{(R_E+h)}$ d) $\frac{2GM_Em}{(R_E+h)}$

76. For a satellite moving in an orbit around the earth, the ratio of its potential energy to kinetic energy is

a) 1 b) −1

c) 2 d) −2

77. An artificial satellite moving in a circular orbit around the earth has a total energy E_o. Its potential energy is

a) $-E_o$ b) E_o

c) $2E_o$ d) $-2E_o$

78. A rocket is fired vertically from the surface of the earth with a speed v. How far from the earth does the rocket go before returning to the earth?

(where R_E is the radius of the earth and g is acceleration due to gravity)

a) $\frac{R_Ev^2}{gR_E-v^2}$ b) $\frac{R_Ev^2}{gR_E+v^2}$

c) $\frac{R_Ev^2}{2gR_E-v^2}$ d) $\frac{R_Ev^2}{2gR_E+v^2}$

79. An asteroid of mass m is approaching earth, initially at a distance $10R_E$ with speed v_i. It hits earth with a speed v_f (R_E and M_E are radius and mass of earth) then,

a) $v_f^2=v_i^2+\frac{2Gm}{R_E}\left(1+\frac{1}{10}\right)$

b) $v_f^2=v_i^2+\frac{2GM_E}{R_E}\left(1+\frac{1}{10}\right)$

c) $v_f^2=v_i^2+\frac{2GM_E}{R_E}\left(1-\frac{1}{10}\right)$

d) $v_f^2=v_i^2+\frac{2Gm}{R_E}\left(1-\frac{1}{10}\right)$

80. Two stars each of mass M and radius R are approaching each other for a head- on collision. They start approaching each other when their separation is $r>>R$. If their speeds at this separation are negligible, the speed v with which they collide would be

a) $v=\sqrt{GM\left(\frac{1}{R}-\frac{1}{r}\right)}$

b) $v=\sqrt{GM\left(\frac{1}{2R}-\frac{1}{r}\right)}$ v

c) $v=\sqrt{GM\left(\frac{1}{R}+\frac{1}{r}\right)}$

d) $v=\sqrt{GM\left(\frac{1}{2R}+\frac{1}{r}\right)}$

GEOSTATIONARY AND POLAR SATELLITES

81. Which of the following statements is correct regarding a geostationary satellite?

a) A geostationary satellite goes around the earth in east- west direction

b) A geostationary satellite goes around the earth in west- east direction

c) The time- period of a geostationary satellite is 48 hours.

d) The angle between the equatorial plane and the orbital plane of geostationary satellite is 90^o

82. Which one of the following statements is correct?

a) The energy required to rocket an orbiting satellite out of earth's gravitational influence is more than the energy required to project a stationary object at the same height (as the satellite) out of earth's influence.

b) If the zero of potential energy is at infinity, the total energy of an orbiting satellite is negative of potential energy.

c) The first artificial satellite sputnik I was launched in the year 1950

d) The orbital speed of the SYNCOMS (Synchronous communications satellite) is $3.07\times10^2 ms^{-1}$

83. Which of the following statements is incorrect regarding the polar satellite?

a) A polar satellite goes around the earth's pole in north- south direction

b) Polar satellites are used to study topography of Moon, Venus and Mars.

c) A polar satellite is a high altitude satellite

d) The time period of polar satellite is about 100 minutes

84. The orbit of geostationary satellite is circular, the time period of satellite depends on (i) mass of the satellite (ii) mass of the earth (iii) radius of the orbit (iv) height of the satellite from the surface of the earth

a) (i) only b) (i) and (ii)

c) (i), (ii) and (iii) d) (ii), (iii) and (iv)

85. LANDSAT series of satellite move in near polar orbits at an altitude of

a) $3600km$ b) $3000km$

c) $918km$ d) $512km$

86. The height of a geostationary satellite is

a) $1000km$ b) $32000km$

c) $36000km$ d) $850km$

87. A satellite is to be placed in equatorial geostationary orbit around earth for communication. The height of such a satellite is

$[M_E = 6\times10^{25}kg, R_E = 6400km, T = 24h, G = 6.67\times10^{-11}Nm^2kg^{-2}]$

a) $3.57\times10^5 m$ b) $3.57\times10^6 m$

c) $3.57\times10^7 m$ d) $3.57\times10^8 m$

WEIGHTLESSNESS

88. An astronaut experiences weightlessness in a space satellite. It is because

a) the gravitational force is small at the location in space

b) the gravitational force is large at that location in space

c) the astronaut experiences no gravity

d) the gravitational force is infinitely large at that location in space

89. Weightlessness in satellite is due to

a) zero gravitational acceleration

b) zero acceleration

c) zero mass d) none of these

MISCELLANEOUS QUESTIONS

90. Two identical spheres of radius R made of the same material are kept at a distance d apart. Then the gravitational attraction between them is proportional to

a) d^{-2} b) d^2

c) d^4 d) d

91. The time interval between two successive noon when sun passes through zenith point (meridian) is known as

a) sidereal day b) mean solar day

c) solar year d) lunar month

92. Which of the following planets has two moons phobos and deimos?

a) Jupiter b) Saturn

c) Mars d) Earth

93. Black Hole is

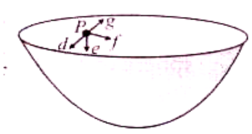
a) super surface atmosphere

b) ozone layer

c) super dense planetary material

d) none of these

94. The direction of gravitational intensity at point P of a hemispherical shell of uniform mass density is indicated by the arrow



a) d b) e

c) f d) g

95. The angular speed of rotation of the earth is

a) $7.3\times10^{-5}rads^{-1}$

b) $7.3\times10^{-4}rads^{-1}$

c) $7.3\times10^{-6}rads^{-1}$

d) $7.3\times10^{-3}rads^{-1}$

96. A non- homogeneous sphere of radius R has the following density variation:

$$\rho\begin{cases}\rho_o; r\le R/3\\ \rho_o/2; (R/3)<r\le(3R/4)\\ \rho_o/8; (3R/4)<r\le R\end{cases}$$

The gravitational field at a distance $2R$ from the centre of the sphere is

a) $0.1\pi GR\rho_o$ b) $0.2\pi GR\rho_o$

c) $0.3\pi GR\rho_o$ d) $0.4\pi GR\rho_o$

97. The gravitational field intensity at a point $10,000km$ from the centre of the earth is $4.8Nkg^{-1}$. The gravitational potential at that point is

a) $-4.8\times10^7 Jkg^{-1}$

b) $-2.4\times10^7 Jkg^{-1}$

c) $4.8\times10^{6}Jkg^{-1}$

d) $3.6\times10^{6}Jkg^{-1}$

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

a) $\sqrt{2gR}$ b) $\sqrt{gR}$

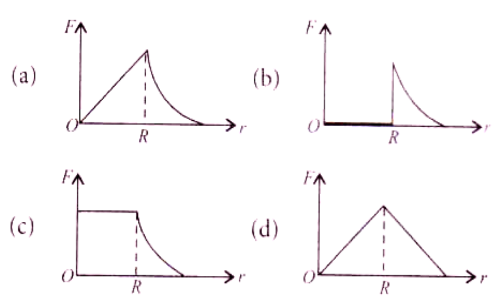
c) $\sqrt{gR/2}$ d) $\sqrt{gR}\left(\sqrt{2}-1\right)$

99. From a solid sphere of mass M and radius R, a spherical portion of radius $\frac{R}{2}$ is removed, as shown in the figure. Taking gravitational potential $V=0\ at\ r=\infty$, the potential at the centre of the cavity thus formed is (G= gravitational constant)

a) $\frac{-2GM}{3R}$ b) $\frac{-2GM}{R}$

c) $\frac{-GM}{2R}$ d) $\frac{-GM}{R}$

100. Which one of the following plots represents the variation of gravitational field F 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).



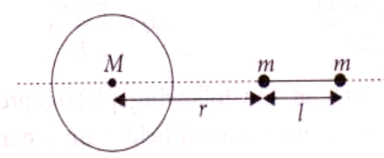
HOTS HIGHER ORDER THINKING SKILLS

1. A bullet is fired vertically upwards with velocity v from the surface of a spherical planet. When it reaches its maximum height, its acceleration due to the planet's gravity is $\frac{1}{4}^{th}$ of its value at the surface of the planet. If the escape velocity from the planet is $v_{esc}=v\sqrt{N}$, then the value of N is (ignore energy loss due to atmosphere)

a) 2 b) 3

c) 4 d) 5

2. A large spherical mass M is fixed at one position and two identical point masses m are kept on a line passing through the centre of M (see figure). The point masses are connected by a rigid massless rod of length/ and this assembly is free to move along the line connecting them. All three masses interact only through their mutual gravitational interaction. When the point mass nearer to M is at a distance $r=3l$ from M, the tension in the rod is zero for $m=k\left(\frac{M}{288}\right)$. The value of k is



a) 5 b) 6

c) 7 d) 8

3. Two satellites S_1 and S_2 revolve round a planet in coplanar circular orbits in the same sense. Their periods of revolution are 1 hour and 8 hour respectively. The radius of the orbit of S_1 is $10^{4}km$. When S_2 is closest to S_1, the speed of S_2 relative to $S_1 (in\, km/h)$

a) $\pi\times10^{4}$ b) $-\pi\times10^{4}$

c) $\pi\times10^{5}$ d) $-\pi\times10^{5}$

4. In the question number 3, the angular speed of S_2 as actually observed by an astronaut in S_1 (in rad/sec)

a) 3×10^{-4} b) 3×10^{-5}

c) 3×10^{-6} d) 3×10^{-7}

5. The ratio of earth's orbital angular momentum (about the sun) to its mass is $4.4\times10^{15}m^{2}/s$. The area enclosed by earth's orbit approximately is (in m^2)

a) 6.94×10^{22} b) 6.94×10^{23}

c) 7.94×10^{22} d) 7.94×10^{23}

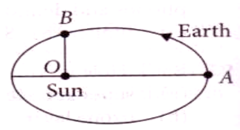
6. A particle of mass m is subjected to an attractive central force of magnitude $\frac{k}{r^2}$, k being a constant. If at the instant when the particle is at an extreme position in its closed orbit, at a distance a from the centre

of force, its speed is $\left(\frac{k}{2ma}\right)$, if the distance of other extreme position is b. Then $\frac{a}{b}$ is

a) 2 b) 3

c) 4 d) 5

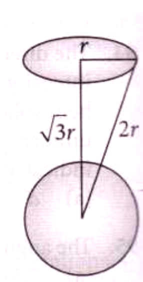
7. The earth moves around the Sun in an elliptical orbit as shown figure. The ratio $\frac{OA}{OB}=x$. The ratio of the speed of the earth at B to that at A is nearly



a) $\sqrt{x}$ b) x

c) $x\sqrt{x}$ d) x^2

8. A uniform ring of mass m and radius r is placed directly above a uniform sphere of mass M and of equal radius. The centre of the ring is directly above the centre of the sphere at a distance $r\sqrt{3}$ as shown in the figure. The gravitational force exerted by the sphere on the ring will be



a) $\frac{GMm}{8r^2}$ b) $\frac{GMm}{4r^2}$

c) $\sqrt{3}\frac{GMm}{8r^2}$ d) $\frac{gMm}{8r^3\sqrt{3}}$

9. Three particles are projected vertically upward from a point on the surface of earth with velocities

$$v_1=\sqrt{\frac{2gR}{3}};v_2=\sqrt{gR};v_3=\sqrt{\frac{4gR}{3}}$$

respectively, where g is acceleration due to gravity on the surface of earth. If the maximum height attained are $h_1,h_2\ and\ h_3$ respectively, then $h_1:h_2:h_3$ is

a) $1:2:3$ b) $2:3:4$

c) $1:2:4$ d) $1:3:5$

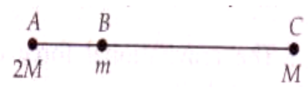
10. The density of core of a planet is ρ_1 and that of the outer shell is ρ_2. The radii of core and that of the planet are R and 2R respectively. Gravitational acceleration at the surface of planet is same as at a depth. The ratio between $\frac{\rho_1}{\rho_2}$ is

a) 2.3 b) 4.5

c) 3.2 d) 5.4

NCERT EXEMPLAR PROBLEMS

1. The earth is an approximate sphere. If the interior contained matter which is not of the same density everywhere, then on the surface of the earth, the acceleration due to gravity.
   a) will be directed towards the centre but not the same everywhere
   b) will have the same value everywhere but not directed towards the centre
   c) will be same everywhere in magnitude directed towards the centre
   d) cannot be zero at any point
2. As observed from earth, the sun appears to move in an approximate circular orbit. For the motion of another planet like mercury as observed from earth, this would
   a) be similarly true
   b) not be true because the force between earth and mercury is not inverse square law
   c) not be true because the major gravitational force on mercury is due to sun
   d) not be true because mercury is influenced by forces other than gravitational forces
3. Different points in earth are at slightly different distances from the sun and hence experience different forces due to gravitation. For a rigid body, we know that if various forces act at various points in it, the resultant motion is as if a net force acts on the centre of mass causing translation and a net torque at the centre of mass causing rotation around an axis through the centre of mass. For the earth sun- system (approximating the earth as a uniform density sphere)
   a) the torque is zero
   b) the torque causes the earth to spin
   c) the rigid body result is not applicable since the earth is not even approximately a rigid body
   d) the torque causes the earth to move around the sun.
4. Satellites orbiting the earth have finite life and sometimes debris of satellites fall to the earth. This is because,
   a) the solar cells and batteries in satellites run out.
   b) the laws of gravitation predict a trajectory spiralling inwards.
   c) of viscous forces causing the speed of satellite and hence height to gradually decrease
   d) of collisions with other satellites.
5. Both earth and moon are subjected to the gravitational force of the sun. As observed from the sun, the orbit of the moon
   a) will be elliptical
   b) will not be strictly elliptical because the total gravitational force on it is not central
   c) is not elliptical but will necessarily be a closed curve
   d) deviates considerably from being elliptical due to influence of planets other than earth
6. In our solar system, the inter- planetary region has chunks of matter (much smaller in size compared to planets) called asteroids. They
   a) will not move around the sun since they have very small masses compared to sun
   b) will move in an irregular way because of their small masses and will drift away into outer space
   c) will move around the sun in closed orbits but not obey Kepler's laws
   d) will move in orbits like planets and obey Kepler's laws
7. Choose the wrong option,
   a) Inertial mass is a measure of difficulty of accelerating a body by an external force whereas the gravitational mass is relevant in determining the gravitational force on it by an external mass
   b) That the gravitational mass and inertial mass are equal is an experimental result
   c) That the acceleration due to the gravity on earth is the same for all bodies and is due to the equality of gravitational mass and inertial mass
   d) Gravitational mass of a particle like proton can depend on the presence of neighbouring heavy objects but the inertial mass cannot
8. Particles of masses $2M, m$ and M are respectively at points A, B and C with $AB = \frac{1}{2}(BC)$. m is much- much smaller than M and at time $t = 0$, they are all at rest. At subsequent times before any collision takes place



a) m will remain at rest

b) m will move towards M

c) m will move towards 2M

d) m will have oscillatory motion

ASSERTION & REASON CORNER

Directions:

In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as:

(a) If both assertion and reason are true and reason is the correct explanation of assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of assertion

(c) If assertion is true but reason is false

(d) If both assertion and reason are false

1. **Assertion**: The planets move slower when they are farther from the Sun than when they are nearer.

   Reason: Angular velocity of a planet is a constant quantity.

2. **Assertion**: A central force is such that the force on the planet is along the vector joining the sun and the planet.

   Reason: Conservation of angular momentum is valid for any central force.

3. **Assertion**: The motion of a particle under the central force is always confined to a plane.

   Reason: Angular momentum is always conserved in the motion under a central force.

4. **Assertion**: The time period of revolution of a satellite close to surface of earth is smaller than that revolving away from surface of earth.

   Reason: The square of time period of revolution of a satellite is directly proportional to cube of its orbital radius.

5. **Assertion**: When distance between two bodies is doubled and also mass of each body is doubled, gravitational force between them remains the same.

   Reason: According to Newton's law of gravitation, force is directly proportional to product of the mass of bodies and inversely proportional to the square of the distance between them.

6. **Assertion**: The principle of superposition is not valid for gravitational forces.

   Reason: Gravitational forces are non-conservative

7. **Assertion**: The gravitational force on a particle inside a spherical shell is zero.

   Reason: The shell shields other bodies outside it from exerting gravitational forces on a particle inside.

8. **Assertion**: The force between two finite rigid bodies is not necessarily along the line joining their centre of mass.

   Reason: Gravitational force between two particles is central.

9. **Assertion**: A man sitting in a closed cabin which is falling freely does not experience any gravity.

   Reason: Inertial and gravitational mass are equivalent.

10. **Assertion**: For a free falling object, the net external force is just the weight of the object.

    Reason: In this case the downward acceleration of the object is equal to the acceleration due to gravity.

11. **Assertion**: The total energy of a satellite is negative.

    Reason: Gravitational potential energy of an object is negative.

12. **Assertion**: Moon has no atmosphere.

    Reason: The escape velocity for moon is less than that for earth.

13. **Assertion**: The gravitational attraction of moon is much less than that of earth.

    Reason: Moon is the natural satellite of the earth.

14. **Assertion**: Astronauts in a satellite moving around the earth are in a weightless condition.

    Reason: The satellite and its contents are falling freely at the same rate.

15. **Assertion**: Geostationary satellites appear fixed from any point on earth.

    Reason: The time period of geostationary satellite is 24 hours.

ANSWER KEY

MCQs CORNER

1. D)	2. C)	3. B)	4. A)	5. A)
6. C)	7. A)	8. C)	9. B)	10. D)
11. D)	12. B)	13. D)	14. D)	15. A)
16. B)	17. A)	18. C)	19. C)	20. C)
21. B)	22. C)	23. A)	24. A)	25. A)
26. D)	27. A)	28. A)	29. B)	30. A)
31. D)	32. B)	33. C)	34. C)	35. B)
36. B)	37. B)	38. B)	39. C)	40. A)
41. C)	42. D)	43. D)	44. C)	45. B)
46. A)	47. C)	48. D)	49. A)	50. C)
51. B)	52. D)	53. C)	54. A)	55. B)
56. A)	57. D)	58. A)	59. C)	60. B)
61. C)	62. B)	63. B)	64. A)	65. D)
66. D)	67. D)	68. B)	69. B)	70. D)
71. C)	72. C)	73. B)	74. D)	75. B)
76. D)	77. C)	78. C)	79. C)	80. B)
81. B)	82. D)	83. C)	84. D)	85. C)
86. C)	87. C)	88. C)	89. A)	90. A)
91. B)	92. C)	93. C)	94. B)	95. A)
96. A)	97. A)	98. D)	99. D)	100.B)

HOTS

1. A)	2. C)	3. B)	4. A)	5. A)
6. B)	7. B)	8. C)	9. C)	10. A)

NCERT EXEMPLAR PROBLEMS

1. D)	2. C)	3. A)	4. C)	5. B)
6. D)	7. D)	8. C)		

ASSERTION & REASON CORNER

1. C)	2. B)	3. A)	4 A)	5. A)
6. D)	7. C)	8. B)	9. B)	10. A)
11. B)	12. A)	13. B)	14. A)	15. A)