GRAVITATION

- **Newton's Law of Gravitation:** Every particle in the universe attracts every other particle with a force. The force of attraction between two masses is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

$$F = G\frac{m_1 m_2}{d^2}$$

where m_1 and m_2 are masses of two particles d is the distance of separation between their centres and G is universal gravitational constant Value of $G = 6.67\times10^{-11}$ Nm^2kg^{-2} (or) 6.67×10^{-8} dyne $cm^2 g^{-2}$

- Gravitational foce acts along the line joining the centres of the bodies.
- Gravitational force between two particles is independent of the properties of intervening medium and the presence of other bodies.
- The value of G is same for a) all pairs of bodies b) all types of media
- G is a scalar quantity with dimensional formula $M^{-1}L^3T^{-2}$
- Kepler's laws can be deduced from Newton's law of gravitation.
- If two identical spheres each of radius 'r' made up of same material are kept in contact with each other, the gravitational force acting between them

$$F = \frac{Gm_1m_2}{(2r)^2} = \frac{G\left[\frac{4}{3}\pi r^3\rho\right]^2}{(2r)^2}$$

$\Rightarrow F \alpha r^4$

- If two identical spheres each of radius 'r' made up of same material are separated by a constant distance then $\Rightarrow F \propto r^6$
- If two bodies of masses m_1 and m_2 are separated by a distance 'd' then the distance to the null point 'P' from m_1 is

$$x = \frac{d}{\sqrt{\frac{m_2}{m_1}}+1}$$

- (a) Gravitational force is always attractive
b) It is a conservative force. Workdone by it is path independent. The workdone in moving a particle around a closed path under the action of gravitational force is zero.
c) If two particles of equal mass 'm' are placed at the two vertices of an equilateral triangle of side 'a', then the resultant gravitational force on unit mass placed at the third vertex is given by

$$F = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$= \sqrt{3}F \quad [\because F_1 = F_2]$$

$$\sqrt{3}\left[\frac{Gm}{a^2}\right]$$

- a) Range of gravitational force> Range of electromagnetic force> Range of nuclear force
b) Strength of nuclear force> strength of electromagnetic force> strength of gravitational force.
- Relation between g & G
a) The acceleration due to gravity 'g' on the surface of a planet of mass M and radius R is

$$g = \frac{GM}{R^2}$$

where G = universal gravitational constant

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

where ρ is density of the planet

- **Orbital velocity**
- The velocity of a satellite revolving around earth of mass M and radius R in a circular orbit of radius 'r' at a height 'h' from the surface of earth is called orbital velocity.

$$V_o = \sqrt{\frac{GM}{r}} = \sqrt{\frac{GM}{(R+h)}} = \sqrt{\frac{gR^2}{(R+h)}}$$

when $h << R$ then, $V_o = \sqrt{\frac{GM}{R}} = \sqrt{gR}$

- For two satellites revolving around the earth in different cicular orbits of radii r_1 and r_2 at vertical heights h_1 and h_2

$$\frac{V_1}{V_2} = \sqrt{\frac{r_2}{r_1}} = \sqrt{\frac{R+h_2}{R+h_1}}$$

- Orbital velocity $V_0 = 7.92\ kms^{-1} \approx 8 kms^{-1}$ (close to the surface of earth)
- It is independent of mass of the satellite and angle of its projection. It is always along the tangent to the orbit.
- Close to the surface of planet, $V_e = \sqrt{2}\ V_0$
- If the speed of the orbiting body is made $\sqrt{2}$ times its inital velocity or velocity is increased by 41% or its KE is doubled, then the body will escape.
- If the speed of the orbiting body 'V' is such that $V_o < V < V_e$ then its orbit changes from circle to ellipse
- Time period of revolution $T = \frac{2\pi}{\omega} = \frac{2\pi r}{V_0}$

$$\Rightarrow T = \frac{2\pi r}{R}\sqrt{\frac{r}{g}}$$

- Time peirod is independent of mass of the orbiting body and depends on mass of the planet and radius of the orbit.
- $T^2 = 4\pi^2 \frac{r^3}{GM} \Rightarrow \frac{T^2}{r^3} =$ Constant, which is Kepler's third law of planetary motion.
- If a satellite is revolving close to the surface of the earth, then the radius of the orbit is taken as the radius of earth.

$$\therefore T = 2\pi\sqrt{\frac{R}{g}} = 84.6 \text{min}$$

- If a satellite revolves round the earth from west to East in the equatorial plane with a period equal to the period of rotation of earth, then it appears to be stationary. This orbit is known as 'Parking Orbit' and the satellite is known as 'Geostationary Satellite'
- The velocity of geo-stationary satellite relative to earth is zero.
- The velocity of geo-stattionary satellite is 3.1 kms^{-1}
- Radius of parking orbit is 42,400 km.
- The height of the parking orbit above the surface of the earth is 36,000 km
- **Escape velocity**
- The velocity required for a body to escape into space from earth's gravity is called escape velocity.

$$v_e = \sqrt{\frac{2GM}{R}} = \sqrt{2gR} = \sqrt{2G\left[\frac{4\pi R^3 \rho}{3R}\right]}$$

$$= 2R\sqrt{\frac{2}{3}G\pi\rho} \quad \textit{where } \rho \textit{ is density of earth}$$

- From earth's surface, $V_e = 11.2$ Kms $^{-1}$

  From the surface of the moon $V_e = 2.38$ Kms $^{-1}$
- Escape velocity is independent of mass of the projected body and angle of its projection.
- Escape velocity on a planet of mass M_1 and radius R_1 is given by

$$V_e^1 = V_e\sqrt{\left[\frac{M_1}{M}\right]\left[\frac{R}{R_1}\right]}$$

$$\Rightarrow V_e^1 = V_e\left[\frac{R_1}{R}\right]\left[\frac{\rho_1}{\rho}\right]$$

Where ρ_1 is density of the planet

- A planet will have atomosphere if the velocity of the molecules (C_{rms}) in its atmosphere is less than escape velocity
- There is no atmosphere on the surface of the moon since the escape velocity on the surface of the moon is less.
- Sufficient amount of hydrogen is present in the atmosphere of the sun since the escape velocity on the sun is very high.
- If a body is projected with a velocity less than the value of escape velocity $(V < V_e)$ it will reach a certain height and then either may move in an orbit around the planet or may fall back to the planet.
- If a body is projected with a velocity greater than the escape velocity $(V > V_e)$ then by conservation of energy

$$\frac{1}{2}mV^2 - \frac{GMm}{R} = \frac{1}{2}mV_1^2$$

$$\Rightarrow V_1^2 = V^2 - \frac{2GM}{R} = V^2 - V_e^2 \left[\because V_e^2 = \frac{2GM}{R} \right]$$

$$\Rightarrow V_1 = \sqrt{V^2 - V_e^2}$$

i.e., the body will move in interplanetary or interstellar space with a velocity $\sqrt{V^2 - V_e^2}$

- **Energy of statellite :**
- Gravitational potential is the work done in moving unit mass from the point to infinity against gravitational force. $V = \frac{-GM}{r}$
- Gravitational potential Energy (GPE) of a body on the surface of the earth $U = \frac{-GMm}{R}$

  where $M =$ mass of earth

  $m =$ mass of the body

  $R =$ radius of earth
- Gravitational potential energy of a body at an altitude 'h' is $U = \frac{-GMm}{(R+h)}$
- the work done or change in potential energy when a body of mass 'm' is displaced from a height h_1 to h_2 with respect to the surface of earth is

$$W = \Delta PE = GMm\left[\frac{1}{(R+h_1)} - \frac{1}{(R+h_2)}\right]$$

$$= mgR^2\left[\frac{1}{R+h_1} - \frac{1}{R+h_2}\right]$$

- If a body of mass 'm' is displaced from the surface of earth to infinity then the change in its potential energy is

  $\Delta PE = mgR$

  where R is radius of earth
- Potential Energy at the centre of the earth is minimum but not zero.
- For a satellite orbiting close to the surface of earth

  $(i)\ KE = \frac{1}{2}\frac{GMm}{R}$

  $(ii)\ PE = -\frac{GMm}{R}$

  $(iii)\ KE = \frac{PE}{2}$ (or) $PE = 2(KE)$

  numerically.

  (iv) Total Energy $= KE + PE = \frac{-GMm}{2R}$
- A surface satellite possesses both KE and PE

  $i)$ For a satellite in the orbit

  $(i)\ PE > KE$

  (ii) The energy to be supplied to it to escape into space is called binding energy (BE)

  $BE = \frac{GMm}{R}$
- When the total energy of a satellite is zero, it escapes into space in a parabolic path.
- When a body escapes into space, its $KE = PE$
- The KE required to make a body escape into space is

  $KE = \frac{GMm}{R} = mgR$
- When a satellite is lifted from a lower orbit to higher orbit then a) its PE increases and b) KE decreases
- The amount of workdone in lifting a body from the surface of the earth to a height 'h' is

$$W = \frac{GMm}{R\left[1 + \frac{R}{h}\right]}$$

- **Geostationary satellites:**
- **Conditions for geo-stationary satellite:**
- The plane of obit of the satellite should coincide with geo-equatorial plane

  $ii)$ The direction of revolution of satellite should be same as the direction of rotation of earth (ie., from West to East)

  $iii)$ The time period of revolution of the satellite should be 24 hr
- Time period of revolution of geo-stationary satellite with respect to earth is infinity

- When a satellite is revolving around the earth in a fixed orbit then the astronant inside the satellite experiences weightlessness or zero apparent weight because zero normal reaction is exerted by the satellite on the astronaut and both have equal acceleration towards the centre of the earth.
- The shape of the orbit of a satellite depends on its velocity V. Let V_o be the orbital velocity for a circular orbit

$i)$ If $V < V_o$ the satellite falls to the ground like a projectile in a parabolic path

$ii)$ If $V = V_o$ then the orbit is circular

$iii)$ If $V > V_o$ but $V < V_e$ then the orbit is elliptical

$iv)$ If $V = V_e$ then the orbit is parabolic

- If $V > V_e$ then the orbit is hyperbolic

- **Uses of Geo-sationary satellites:**

(i) to photograph different regions on earth's surface

(ii) for weather forecast

(iii) for telecommunication, television transmission

(iv) to locate the places of mineral deposits on the earth.

(v) for spying purpose

(vi) to study different experiments in weightless conditions.

Note : A minimum of 3geo-sationary satellites at an angular separation of 120^0 are required for live telecast of a programme all around the earth.

- **Gravitational Field :-**

a) The concept of gravitational field is used to overcome the difficulties encountered in universal law of gravitation.

b) Einstein considered gravitational field as a distortion of 'space' due to the presence of matter.

- **Gravitational field strength :-** a) It is defiend as the gravitational force acting on a unit mass kept at a point in the gravitational field.

b) If M is the mass of a body producing gravitational field and 'r' is the distance of the point in the field from the centre of mass of the body, then

$$E_G = \frac{GM}{r^2}$$

c) Units of gravitational field strength are Nkg^{-1} or ms^{-2} and dimensional formula is LT^{-2}

d) It is a vector quantity, It is always directed radially towards the centre of mass of the body producing the field.

Note :- In the earth's gravitational field, the acceleration due to gravity 'g' may be considered as the gravitational field strength.

- **Propagation of gravitational field :-**

a) According to Einstein's general theory of relativity, whenever a body with mass is accelerated, the gravitational field around it undergoes rapid changes.

b) Just as photon in electromagnetic field, a quantum of energy is associated with gravitational field called 'graviton'.

c) gravitons, like photons would be mass less, electrically uncharged particles, travelling at the speed of light and would be emitted by highly accelerating and extremely massive objects such as stars.

d) Gravitational fields are propagated with the help of gravitons with speed of light.

- **Black Hole :**

a) During the dying stage of a massive star, supernova is formed.

b) If the core of supernova exceeds about two solar masses, it continues to contract.

c) The gravitational field of the collapsing star is predicted to be so powerful that neither matter nor light can escape it.

d) The "star" then collapses to a black hole

e) It is a point of zero volume and infinite mass.

f) It is hidden by an event horizon at a distance called Schwarzschild radius.

g) Black holes remain hypothetical, but observations suggest that such phenomena may possibly exist in the star system Cygnus -X-1 and center of our Galaxy.

- **Schewarzschild Radius :**

a) It is given by $R_s = \frac{2GM}{c^2}$, where 'c' is velocity of light, G universal gravitational constant and 'M' the mass of the star that forms the black hole.

b) This equation implies that any star with mass 'M' can become a black hole if it can achieve

Schwarzschild radius.

- **STAGES IN THE BLACK HOLE FORMATION :**

Massive Star
↓ (Energy source i.e, hydrogen decreases)
Red giant stage
↓ (Material particles blown off)
White dwarf stage
↓ (Chandra Sekhar limit exceed)
Super Nova
↓ (Further core collapse)
Neutron Star
↓ (Further core collapse)
Black hole

● Black hole formation is the last stage of the life cycle of a massive star.
● When the energy source i.e, hydrogen availability decreases, its core starts to shrink because of gravity resulting in the formation of a Red giant.
● At Red giant stage diameter becomes many more times the diameter of the original massive star due to nuclear fusion.
● After several million years, hydrogen available in the 'red giant' is exhausted completely.
● The 'red giant' now releases material particles present in it and forms a relatively dim star, known as 'white dwarf.
● At white dwarf state all the remaining material will be packed into a small volume, i.e., about one millionth the size of the original star, due to the strong gravitational pull.
● When the mass of the white dwarf exceeds about 1.4 times the mass of the Sun (Chandrasekhar's limit) it collapses further and the core temperature rises over 100 billion degrees.
● At this stage the repulsive force between mulei overcomes the attraction force of gravity giving out an explosive shock wave, known as 'supernova'.
i) After 'supernova' stage, depending upon the mass of the original star, pressure inside the 'left over' core becomes very large.
j) At this stage pressure electrons are forced to combine with protons reducing whole of the star into a dense ball of neutrons, known as 'Neutron Star'.
● If mass of original star is very large, say 10 or more times the mass of the Sun, even neutrons will not be able to withstand, the core collapses and finally a black hole is formed.

- **FRAME OF REFERENCE :**

i) A system of coordinate axes attached to an observer with the help of which the motion of an object can be described is called a frame of reference.
ii) The Cartesian system of coordinate axes can be considered as the simplest frame of reference. In this system the position of an object at any moment can be described by three coordinates (x,y,z) along the three coordinate axes X, Y,Z.

- **INERTIAL FRAMES OF REFERENCE :**

● Frames that move with constant velocity with respect to each other are called "inertial frames of reference".
● An inertial reference frame is one in which Newton's first law (law of inertia) is valid i.e 'no force no acceleration" is true.
● When two observers from their respective inertial frames are watching an object, they report i) different positions (s) ii) different velocities (v) iii) same acceleration (a)
● In Newtonian mechanics, invariant quantities are mass, force, acceleration and time. For all observers in inertial frames these will have same value.
● The laws of physics are same in all inertial frames of reference.
f) A frame of reference attached to the earth may be considered as an inertial frame of reference, though strictly speaking it is a non-inertial frame.

- **NON-INERTIAL FRAMES OF REFERENCE :** Frames that move with acceleration are called "non-inertial frames of reference".

Ex. A lift carrying a person and moving up with acceleration.

CONCEPTUAL QUESTIONS

1. Following physical quantity of a planet that revolves around Sun in an elliptical orbit is constant.
1) Kinetic energy 2) Potential energy
3) Angular momentum 4) All
2. If the universal gravitational constant decreases uniformly with time, then a satellite in orbit will still maintain its
1) weight 2) tangential speed
3) period of revolution 4) angular momentum
3. Two satellites of masses m_1 and m_2 ($m_1 > m_2$) are revolving around earth in circular orbits of radii r_1 and r_2 ($r_1 > r_2$) respectively. Which of the following statements is true regarding their velocities V_1 and V_2.
1) $V_1 = V_2$ 2) $V_1 < V_2$
3) $V_1 > V_2$ 4) $\frac{V_1}{r_1} = \frac{V_2}{r_2}$

4. If the area swept by the line joining the sun and the earth from Feb 1 to Feb 7 is 'A', then the area swept by the radius vector from Feb 7 to Feb 28 is
1) A 2) 2A 3) 3A 4) 4A

5. Two equal masses separated by a distance (d) attract each other with a force (F). If one unit of mass is transferred from one of them to the other, the force
1) does not change 2) decreases by (G/d^2)
3) becomes d^2 times 4) increases by $(2G/d^2)$

6. If F_g and F_e are gravitational and electrostatic forces between two electrons at a distance 0.1 m then F_g / F_e is in the order of
1) 10^{43} 2) 10^{-43} 3) 10^{35} 4) 10^{-35}

7. Out of the following interactions the weakest is
1) gravitational 2) electromagnetic
3) nuclear 4) electrostatic

8. If the mean radius of earth is R, its angular velocity is ω and the acceleration due to gravity at the surface of the earth is 'g' then the cube of the radius of the orbit of a satellite will be
1) $\frac{Rg}{\omega^2}$ 2) $\frac{R^2 g}{\omega}$ 3) $\frac{R^2 g}{\omega^2}$ 4) $\frac{R^2\omega}{g}$

9. The gravitational field is a conservative field. The work done in this field by moving an object from one point to another
1) depends on the end-points only
2) depends on the path along which the object is moved
3) depends on the end-points as well as the path between the points.
4) is not zero when the object is brought back to its initial position.

10. The tidal waves in the sea are primarily due to
1) the gravitational effect of the moon on the earth
2) the gravitational effect of the sun on the earth
3) the gravitational effect of the venus on the earth
4) the atmospheric effect of the earth itself

11. A hole is drilled through the earth along a diameter and a stone is dropped into it. When the stone is at the centre of the earth, it has finite
1) weight 2) acceleration 3) P.E. 4) mass

12. If R=radius of the earth and g =acceleration due to gravity on the surface of the earth, the acceleration due to gravity at a distance r (<R) from the centre of the earth is proportional to
1) r 2) r^2 3) r^{-2} 4) r^{-1}

13. If R=radiusof the earth and g=acceleration due to gravity on the surface of the earth, the acceleration due to gravity at a distance r (>R) from the centre of the earth is proportional to
1) r 2) r^2 3) r^{-2} 4) r^{-1}

14. For a satellite projected from the earth's surface with a velocity greater than orbital velocity the nature of the path it takes when its energy is negative, zero and positive respectively is
1) Elliptical, parabolic and hyperbolic
2) Hyperbolic, parabolic and elliptical
3) Elliptical, circular and parabolic
4) Parabolic, circular and Elliptical

15. The period of a satellite moving in circular orbit near the surface of a planet is independent of
1) mass of the planet 2) radius of the planet
3) mass of the satellite 4) density of planet

16. Out of the following statements, the one which correctly describes a satellite orbiting about the earth is
1) There is no force acting on the satellite
2) The acceleration and velocity of the satellite are roughly in the same direction
3) The satellite is always accelerating about the earth
4) The satellite must fall, back to earth when its fuel is exhausted.

17. When an astronaut goes out of his space-ship into the space he will
1) Fall freely on the earth
2) Go upwards
3) Continue to move along with the satellite in the same orbit.
4) Go spiral to the earth

18. A body is dropped from a height equal to radius of the earth. The velocity acquired by it before touching the ground is
1) $V=\sqrt{2gR}$ 2) V=gR 3) $V=\sqrt{gR}$ 4) V=2gR

19. The earth retains its atmosphere. This is due to
1) The special shape of the earth
2) The escape velocity being greater than the mean speed of the molecules of the atmospheric gases.
3) The escape velocity being smaller than the mean speed of the molecules of the atmospheric gases.
4) The sun's gravitational effect.

20. Ratio of the radius of a planet A to that of planet B is 'r'. The ratio of accelerations due to gravity for the two planets is x. The ratio of the escape velocities from the two planets is
1) $\sqrt{rx}$ 2) $\sqrt{r/x}$ 3) $\sqrt{r}$ 4) $\sqrt{x/r}$

21. For a planet revolving round the sun, when it is nearest to the sun is
1) K.E. is min and P.E. is max.
2) Both K.E. and P.E. are min
3) K.E. is max. and P.E. is min
4) K.E. and P.E. are equal

22. When the height of a satellite increases from the surface of the earth.
1) PE decreases, KE increases
2) PE decreases, KE decreases
3) PE increases, KE decreases
4) PE increases, KE increases

23. When a satellite going round the earth in a circular orbit of radius r and speed v loses some of its energy, then r and v change as
1) r decreases, v increases
2) both decrease 3) both increase
4) r increases, v decreases

24. If a satellite is moved from one stable circular orbit to a farther stable circular orbit, then the following quantity increases
1) Gravitational force 2) Gravitational P.E.
3) linear orbital speed
4) Centripetal acceleration

25. The energy required to remove an earth satellite of mass 'm' from its orbit of radius 'r' to infinity is
1) $\frac{GMm}{r}$ 2) $\frac{-GMm}{2r}$ 3) $\frac{GMm}{2r}$ 4) $\frac{Mm}{2r}$

26. Assume that a satellite is revolving around earth in a circular orbit almost close to the surface of earth. The time period of revolution of satellite is (Radius of earth is 6400 km, g = 9.8 ms^{-2})
1) 5068 sec2) 5068 min 3) 24 hour 4) 1 year

27. A body has weight (w) on the ground. The work which must be done to lift it to a height equal to the radius of the earth is
1) equal to WR 2) greater than WR
3) less than WR 4) we can't say

28. Moon is revolving in a circular orbit with a uniform velocity V_0. If the gravitational force suddenly disappears, the moon will
1) continue to move in the same orbit
2) move with a velocity V_0 tangentially to the orbit
3) fall down freely 4) ultimately comes to rest

29. The time period of revolution of geostationary satellite with respect to earth is
1) 24 hrs 2) 1 year 3) Infinity 4) Zero

30. A relay satellite transmits the television programme from one part of the world to another part continuously because its period
1) is greater than the period of the earth about its axis
2) is less than period of rotation of the earth about its axis.
3) has no relation with the period of rotation of the earth about its axis.
4) is equal to the period of rotation of the earth about its axis.

31. A synchronous satellite should be at a proper height moving
1) From West to East in equatorial plane
2) From South to North in polar plane
3) From East to West in equatorial plane
4) From North to South in polar plane

32. The orbital angular velocity vector of a geostationary satellite and the spin angular velocity vector of the earth are
1) always in the same direction
2) always in opposite direction
3) always mutually perpendicular
4) inclined at 23 1/2° to each other

33. Stars having masses more than 5 times the solar the mass end their lives as
1) White dwarfs 2) Red giants
3) Black dwarfs 4) Black holes

34. Of the following, which one has the core of highest density?
1) Neutron star 2) White dwarf
3) Yellow star 4) Red giant

35. The radius of a black hole $\left(R_B\right)$ and its Schwartzchild radius $\left(R_S\right)$ are related as
1) $R_B > R_S$ 2) $R_B \geq R_S$
3) $R_B \leq R_S$ 4) $R_B = R_S =$ Infinity

36. A black hole has
1) zero volume and zero density
2) zero density and infinite volume
3) zero volume and infinite density
4) infinite volume and infinite density

37. The boundary of a black hole is called
1) event horizon 2) Schwartzchild radius
3) Chandra sekhar limit 4) Einstein's space time

38. If M is mass of the sun, then the mass of a white dwarf star may be
1) M 2) 2M 3) 3M 4) 4M

39. Chandra Sekhar limit is about
1) 2.4 times the solar mass
2) 1.4 times the solar mass
3) 14 times the solar mass
4) 24 times the solar mass

40. During the transformation of a massive star ultimately into a black hole, which of the following sequence is correct?
1) Red giant stage, supernova stage, white dwarf stage
2) White dwarf stage, red giant stage, supernova stage
3) White dwarf stage, supernova stage, red giant stage
4) Red giant stage, white dwarf stage, supernova stage

41. Pseudo force also called fictitious force such as centrifugal force arises only in
1) Inertial frames
2)Non-intertial frames
3) Both inertial and non-inertial frames
4) Rigid frames

42. The speed at which the gravitational field propagates is
1) Equal to the speed of light in vacuum
2) Less that the speed of light in vacuum
3) More than the speed of light in vacuum
4) Either less or more than the speed of light in vacuum

KEY

1. 3	2.4	3.2	4.3	5.2
6.2	7.1	8.3	9.1	10.1
11.4	12.1	13.3	14.1	15.3
16.3	17.3	18.3	19.2	20.1
21.3	22.3	23.1	24.2	25.3
26.1	27.1	28.2	29.3	30.4
31.1	32.1	33.4	34.1	35.3
36.3	37.1	38.1	39.2	40.4
41.3	42.1			

LEVEL - I

NEWTON'S UNIVERSAL LAW OF GRAVITATION :

1. The gravitational force between two bodies is $6.67x10^{-7}$N when the distance between their centres is 10 m. If the mass of first body is 800 kg, then the mass of second body is
1) 1000 kg 2) 1250 kg 3) 1500 kg 4) 2000kg

2. A 3 kg mass and a 4 kg mass are placed on x and y axes at a distance of 1 metre from the origin and a 1 kg mass is placed at the origin. Then the resultant gravitational force on 1 kg mass is
1) 7G 2) G 3) 5G 4) 3G

3. Two metal spheres of same material and radius 'r' are in contact with each other. The gravitational force of attraction between the spheres is given by
1) $F = Kr^4$ 2) $F=K / r^3$ 3) $F=K / 4r^2$ 4) Kr^2

4. Two particles of equal mass move in a circle of radius 'r'under the action of their mutual gravitational attraction. If the mass of each particle is m, the speed of each particle is
1) $\sqrt{\frac{Gm}{r}}$ 2) $\sqrt{\frac{Gm}{2r}}$ 3) $\sqrt{\frac{Gm}{4r}}$ 4) $\sqrt{\frac{2Gm}{r}}$

ORBITAL VELOCITY - ESCAPE VELOCITY :

5. A satellite of mass 'm' revolves round the earth of mass 'M' in a circular orbit of radius 'r' with an angular velocity 'ω'. If the angular velocity is ω/8 the radius of the orbit will be
1) 4r 2) 2r 3) 8r 4) r

6. A particle falls towards earth from infinity. The velocity with which it reaches earth's surface is.
1) v = 2gR 2) $v = \sqrt{2gR}$
3) $v = \sqrt{gR}$ 4) v = R/g

7. The escape velocity on a planet is 'v'. If the radius of the planet contracts to 1/4th of present value without any change in its mass, the escape velocity will be
1) halved 2) doubled
3) quadrupled 4) becomes one fourth

8. The escape velocity from the earth for a rocket is 11.2 km/s ignoring air resistance. The escape velocity of 10 mg grain of sand from the earth will be
1) 0.112 km/s 2) 11.2 km/s
3) 1.12 km/s 4) 0.0112 kms^{-1}

9. The escape velocity from the surface of the earth of radius R and density ρ
1) $2R\sqrt{\frac{2\pi \rho G}{3}}$ 2) $2\sqrt{\frac{2\pi \rho G}{3}}$
3) $2\pi\sqrt{\frac{R}{g}}$ 4) $\sqrt{\frac{2\pi G\rho}{R^2}}$

10. A body is projected vertically up from surface of the earth with a velocity half of escape velocity. The ratio of its maximum height of ascent and radius of earth is
1) 1 : 1 2) 1 : 2 3) 1 : 3 4) 1 : 4

11. Two satellites are revolving round the earth in circular orbits of radii in the ratio 1 :2. Their orbital velocities are in the ratio of
1) 1 : 2 2) $\sqrt{2}:1$ 3) $2\sqrt{2}:1$ 4) 8 : 1

12. If the mass of earth were 4 times the present mass, the mass of the moon were half the present mass and the moon were revolving round the earth at the same present distance, the time period of revolution of the moon would be
1) 56 days 2) 28 days 3) 14 days 4) 7 days

ENERGY OF A SATELLITE

13. Two satellites of masses 400 kg, 500 kg are revolving around earth in different circular orbits of radii r_1, r_2 such that their kinetic energies are equal. The ratio of r_1, r_2 is
1) 4 : 5 2) 16 : 25 3) 5 : 4 4) 25 : 16

14. The K.E. of a satellite is 10^4 J, its P.E. is
1) -10^4 J 2) 2×10^4 J
3) -2×10^4 J 4) -4×10^4 J

15. A satellite moves around the earth in a circular orbit with speed 'V'. If 'm' is mass of the satellite then its total energy is
1) $\frac{1}{2}mv^2$ 2) mv^2 3) $-\frac{1}{2}mv^2$ 4) $\frac{3}{2}mv^2$

16. If R is radius of the earth and W is work done in lifting a body from the ground to an altitude R, the work which should be done in lifting it further to twice that altitude is
1) W/2 2) W 3) W/3 4) 3W

GEOSTATIONARY SATELLITE

17. A satellite is orbiting round the earth. If both gravitational force and centripetal force on the satellite is 'F' then net force acting on the satellite to revolve round the earth is
1) F/2 2) F 3) 2F 4) Zero

18. The minimum number of geostationary satellites required to televise a programme all over the earth is
1) 2 2) 6 3) 4 4) 3

BLACK HOLES

19. If two stars of masses in the ratio 2 : 3 become black holes, their radii will be in the ratio of
1) 4 : 9 2) 3 :2 3) 2:3 4) 9 :4

20. When a star of mass $9\times10^{30}\,kg$ ends as a black hole, the Schwartzschild radius of the star is $\left(G = 6.7\times10^{-11}\,Nm^2kg^{-2}\right)$
1) 13.4 m 2) 6.7 m 3) 13.4 km 4) 26.8 km

21. Two lead spheres of same radius are in contact with each other. The gravitational force of attraction between them is F. If two lead spheres of double the previous radius are in contact with each other, the gravitational force of attraction between them will be
1) 2F 2) 32F 3) 8F 4) 16F

22. Two particles of masses 'm' and '2m' are at a distance '3r' apart at the ends of a straight line AB. C is the centre of mass of the system. The magnitude of the gravitational intensity due to the masses at C is
1) Zero 2) $\frac{7Gm}{4r^2}$ 3) $\frac{9Gm}{4r^2}$ 4) $\frac{3Gm}{2r^2}$

23. Two masses 'M' and '4M' are at a distance 'r' apart on the line joining them, 'P' is point where the resultant gravitational intesity is zero (such a point called null point). The distance of 'P' from the mass 'M' is
1) $\frac{r}{5}$ 2) $\frac{r}{3}$ 3) $\frac{2r}{3}$ 4) $\frac{4r}{5}$

24. Two stars have masses $5\times10^{30}\,kg$ and $7.5\times10^{30}\,kg$ respectively. If they ultimately convert into black holes, the ratio of Schwartzschild ratio of the black holes is
1) 2:3 2) 4:9 3) 3:2 4) 9:4

KEY

1. 2	2.3	3.1	4.1	5.1
6.2	7.2	8.2	9.1	10.3
11.3	12.3	13.1	14.3	15.3
16.1	17.2	18.4	19.3	20.3
21.4	22.2	23.2	24.1	

LEVEL - II

NEWTON'S LAW OF GRAVITATION

25. If the mass of one particle is increased by 50 % and the mass of another particle is decreased by 50 %, the force between them
1) decreases by 25% 2) decreases by 75 %
3) increases by 25% 4) does not change

26. The gravitational force between two bodies is decreased by 36 % when the distance between them is increased by 3m. The initial distance between them is
1) 6 m 2) 9 m 3) 12 m 4) 15 m

27. If the distance between two bodies is increased by 25%, then the % change in the gravitational force is
1) Decreases by 36% 2) Increases by 36 %
3) Increases by 64% 4) Decreases by 64 %

28. Masses 2 kg and 8 kg are 18 cm apart. The point where the gravitational field due to them is zero is
1) 6 cm from 8 kg mass
2) 6 cm from 2 kg mass
3) 1.8 cm from 8 kg mass
4) 9 cm from each mass

29. Mass of the earth is 81 times that of the moon. If the distance between the centre of the earth and the center of moon is d then the distance from the centre of the earth at which gravitational field strength due to earth - moon system is zero is
1) d/81 2) 9d/10 3) d/10 4) 8d/9

30. Two lead balls of masses m and 5m having radii R and 2R are separated by 12R. If they attract each other by gravitational force, the distance covered by small sphere before they touch each other is
1) 10 R 2) 7.5 R 3) 9 R 4) 2.5 R

ORBITAL VELOCITY & ESCAPE VELOCITY

31. A satellite is revolving around earth in a circular orbit of radius equal to diameter of earth. The minimum % increase in the speed of that satellite so that it escapes from earth's gravity is
1) 100 % 2) 82.8 % 3) 50 % 4) 41.4 %

32. The speed of a satellite that revolves around earth at a height 3R from earth's surface is (g = 10 m/s^2 at the surface of earth, radius of earth R = 6400 km.)

1) $2\sqrt{2}$ kms^{-1} 2) 4 kms^{-1}

3) $4\sqrt{2}$ kms^{-1} 4) 8 kms^{-1}

33. Two satellites P, Q are revolving around earth in different circular orbits. The velocity of P is twice the velocity of Q. If the height of P from earth's surface is 1600 km. The radius of orbit of Q is (radius of earth R =6400 km).

1) 1600 km 2) 20000 km
3) 32000 km 4) 40000 km

34. Two satellites M and N go around the earth in circular orbits at heights of R_M and R_N respectively from the surface of the earth. Assuming the earth to be a uniform sphere of radius R_E, the ratio of the velocities of the satellites $\frac{V_M}{V_N}$ is

1) $\left(\frac{R_M}{R_N}\right)^2$ 2) $\sqrt{\frac{R_N + R_E}{R_M + R_E}}$

3) $\frac{R_N + R_E}{R_M + R_E}$ 4) $\sqrt{\frac{R_N}{R_M}}$

35. The escape velocity from an altitude equal to radius of earth above earth's surface is (escape velocity from surface of earth is 11.2kms^{-1})

1) 5.6 kms^{-1} 2) 7.92 kms^{-1}
3) 2.8 kms^{-1} 4) 11.2 kms^{-1}

36. A particle is kept at rest at a distance R (Earth's radius) above the earth's surface. The minimum speed with which it should be projected so that it does not return is

1) $\sqrt{\frac{GM}{R}}$ 2) $\sqrt{\frac{GM}{2R}}$ 3) $\sqrt{\frac{GM}{3R}}$ 4) $\sqrt{\frac{GM}{4R}}$

37. If the radius of the earth is reduced by 1 % keeping the mass constant. The escape velocity will

1) increase by 0.5% 2) decrease by 0.5%
3) decrease by 11% 4) remain same

38. The radius of the earth is R and acceleration due to gravity at its surface is g. The minimum speed with which a body must be thrown from the surface of the earth so as to reach a height of R/4 is

1) $\sqrt{gR}$ 2) $\sqrt{\frac{gR}{2}}$ 3) $\sqrt{\frac{gR}{5}}$ 4) $\sqrt{\frac{2gR}{5}}$

39. A space-ship is launched into a circular orbit close to the surface of the earth. The additional velocity now to be imparted to the space-ship in the orbit to overcome the gravitational pull is

1) 11.2 km/sec 2) 8 km/sec
3) 3.2 km/sec 4) 1.414 x 8 km/sec

40. The moon escapes for ever, if the minimum increase in its velocity is

1) 200 % 2) 41.4 % 3) 50 % 4) 100 %

ENERGY OF A SATELLITE AND GEOSTATIONARY SATELLITE

41. The gravitational P.E. of a rocket of mass 100 kg at a distance of 10^7 m from the earths centre is -4 x 10^9J. The weight of the rocket at a distance of 10^9 m from the centre of the earth is

1) 4 x 10^{-2} N 2) 4 x 10^{-9} N
3) 4 x 10^{-6} N 4) 4 x 10^{-3} N

42. A man weighs 75 kg on the surface of the earth. His weight in a geostationary satellite is

1) infinity 2) 150 kg 3) zero 4) 75/2 kg

43. Two identical particles each of mass 'm' start moving towards each other from rest from infinite separation under gravitational attraction. Their relative velocity of approach at separation 'r' is

1) $\sqrt{\frac{Gm}{r}}$ 2) $\sqrt{\frac{2Gm}{r}}$ 3) $2\sqrt{\frac{Gm}{r}}$ 4) $\sqrt{\frac{Gm}{2r}}$

44. Three identical particles each of mass "m" are arranged at the corners of an equilateral triangle of side "L". If they are to be in equilibrium, the speed with which they must revolve under the influence of one another's gravity in a circular orbit circumscribing the triangle is

1) $\sqrt{\frac{3Gm}{L}}$ 2) $\sqrt{\frac{Gm}{L}}$ 3) $\sqrt{\frac{Gm}{3L}}$ 4) $\sqrt{\frac{3Gm}{L^2}}$

45. A small body is initially at a distance 'r' from the centre of earth. 'r' is greater than the radius of the earth. If it takes W joule of work to move the body from this position to another position at a distance 2r measured from the centre of earth, how many joules would be required to move it from this position to a new position at a distance of 3r from the centre of the earth.

1) W/5 2) W/3 3) W/2 4) W/6

46. The mass of the sun is approximately $2x10^{30}\,kg$. The Schwarzschild radius for the mass of a star that is ten times the mass of sun is nearly

1) 3km 2) 30 km 3) 300 km 4) 0.3 km

KEY

25. 1	26.3	27.1	28.2	29.2
30.2	31.4	32.2	33.3	34.2
35.2	36.1	37.1	38.4	39.3
40.2	41.1	42.3	43.3	44.2
45.2	46.2			

HINTS

25. $F_1 = G\frac{m_1 m_2}{d^2}$

$and \ F_2 = G\frac{\left(m_1 + \frac{m_1}{2}\right)\left(m_2 - \frac{m_2}{2}\right)}{d^2}$

26. $\frac{F_1}{F_2} = \frac{d_2^2}{d_1^2}$

take $F_2 = F_1 - \left(\frac{36}{100}\right)F_1;\ d_2 = \left(d_1 + 3\right)$

28. $x = \frac{d}{\sqrt{\frac{m_2}{m_1} + 1}}$ from the lesser mass

30. Effective distance = 9R
Distance travelled by smaller mass = x

$\therefore x = \left[\frac{m_2}{m_1 + m_2}\right](9R)$

32. 'g' at a height 4R = $\frac{g}{16}$

and $V_0 = \sqrt{g(4R)} = \sqrt{\frac{g}{16}(4R)}$

33. We know $V_P = 2V_Q$

and $R_P = 8000$

$\sqrt{\frac{GM}{R_P}} = 2\sqrt{\frac{GM}{R_Q}} \Rightarrow R_Q = 4R_P$

34. Orbital velocity $V_o \propto \frac{1}{\sqrt{R}}$

37. $\frac{\Delta V}{V} = \frac{-1}{2}\frac{\Delta R}{R}$

39. Additional velocity $= V_{esc} - V_{orb}$

41. GPE = $\frac{-GMm}{R}$ and g= $\frac{GM}{R^2}$

45. Work done = change in PE

46. $R_S = \frac{2GM}{C^2}$

LEVEL - III

47. Escape velocity from the surface of earth is 11.2 km/sec. The escape velocity from the surface of a planet whose mass is half of the mass of earth, but density 4 times the density of earth is
1) 2.8 kms^{-1} 2) 5.6 kms^{-1}
3) 7.92 kms^{-1} 4) 11.2 kms^{-1}

48. The escape velocity from the earth is 11 km/sec. The escape velocity from a planet having twice the radius and same density as earth is
1) 22 km/sec 2) 15.5 km/sec
3) 11 km/sec 4) 5.5 km/sec

49. The escape velocity of a body from earth is 11.2 km/s. If a body is projected with a velocity twice its escape velocity, then the velocity of the body at infinity is
1) 19.4 km/s 2) 194 km/s
3) 1.94 km/s 4) 0.194 km/s

50. If an artificial satellite is moving in a circular orbit around the earth with a speed equal to half the magnitude of the escape velocity from the earth, the height of the satellite above the surface of the earth is
1) 2R 2) R/2 3) R 4) R/4

51. The change in the P.E. when a body of mass 'm' is displaced from earth's surface to a vertical height equal to radius of earth (g = acceleration due to gravity on earth surface) is
1) $\frac{mgR}{2}$ 2) $\frac{2mgR}{3}$ 3) $\frac{3mgR}{4}$ 4) $\frac{mgR}{3}$

52. A satellite of mass 'm' is revolving around earth in a circular orbit at a height R from earth's surface. The minimum energy required to shift the same satellite into bigger orbit whose radius is twice that of initial orbit is (M, R are mass and radius of earth).
1) $\frac{GMm}{2R}$ 2) $\frac{GMm}{4R}$ 3) $\frac{GMm}{6R}$ 4) $\frac{GMm}{8R}$

53. The K.E. of a satellite in an orbit close to the surface of the earth is E. Its max K.E. so as to escape from the gravitational field of the earth is.
1) 2E 2) 4E 3) $2\sqrt{2}$ E 4) $\sqrt{2}$ E

54. The work done to increase the radius of orbit of a satellite of mass 'm' revolving around a planet of mass M from orbit of radius R into another orbit of radius 3R is
1) $\frac{GMm}{3R}$ 2) $\frac{GMm}{R}$ 3) $\frac{GMm}{6R}$ 4) $\frac{GMm}{24R}$

55. K.E. of an orbiting satellite is K. The min additional K.E. required so that it goes to infinity is
1) K 2) 2K 3) 3K 4) K/2

56. A stone is dropped from a height equal to nR, where R is the radius of the earth, from the surface of the earth. The velocity of the stone on reaching the surface of the earth is
1) $\sqrt{\frac{2g(n+1)R}{n}}$ 2) $\sqrt{\frac{2gR}{n+1}}$
3) $\sqrt{\frac{2gnR}{n+1}}$ 4) $\sqrt{2gnR}$

57. The altitude of geostationary satellite is nearly 6 times the radius of the earth. The period of revolution of an identical satellite revolving at an altitude 0.75 times the radius of the earth will be
1) 4 hrs 2) 3 hrs 3) 12 hrs 4) 2 hrs

58. A satellite is geostationary in a particular orbit. It is allowed to go to another orbit having orbital radius 2 times that of the earlier orbit from the centre of the earth. The time period in the second orbit is
1) 48hrs 2) 24hrs 3) $48\sqrt{2}$ hrs 4) $24\sqrt{2}$ hrs

59. Explorer- 38, a radio-activity research satellite of mass 200 kg circles the earth in an orbit of radius 3R/2, where R is the radius of the earth. Assuming the gravitational pull on a mass of 1 kg at the earth's surface to be 10 N, the pull on the satellite is
1) 889 N 2) 4500 N 3) 9000 N 4) None

60. A geo-stationary satellite is orbitting the earth at a height 6R above the surface of the earth, where R is the radius of earth. The time period of another satellite revolving around earth at a height 2.5 R from earth's surface is
1) $12\sqrt{2}$ Hr. b 2) 12 hr 3) $6\sqrt{2}$ hr 4) 6 hr

61. Particles each of mass M are placed along x-axis at x=1m, x=2m, x=4m, x=8m,..... etc to infinity. Gravitational field strength at the origin due to this system of particles is
1) 2GM 2) 2GM/3 3) 4GM/3 4) 5GM/4

62. Three particles, each of mass 'm' are situated at the vertices of an equilateral triangle of side 'a'. The only forces acting on the particles are their mutual gravitational forces. It is desired that each particle should move in a circle while maintaining the original mutual separation 'a'. Then their time period of revolution is
1) $2\pi\sqrt{\frac{a^2}{3Gm}}$ 2) $2\pi\sqrt{\frac{a^3}{3Gm}}$
3) $2\pi\sqrt{\frac{3a^4}{Gm}}$ 4) $2\pi\sqrt{\frac{a^4}{Gm}}$

63. If d is the distance between the centres of the earth of mass M_1 and moon of mass M_2, then the velocity with which a body should be projected from the mid point of the line joining the earth and the moon, so that it just escapes is
1) $\sqrt{\frac{G(M_1+M_2)}{d}}$ 2) $\sqrt{\frac{G(M_1+M_2)}{2d}}$
3) $\sqrt{\frac{2G(M_1+M_2)}{d}}$ 4) $\sqrt{\frac{4G(M_1+M_2)}{d}}$

64. Particles of masses m_1 and m_2 are at a fixed distance apart. If the gravitational field strength at m_1 and m_2 are I_1 and I_2 respectively. Then,
1) $m_1I_1 + m_2I_2 = 0$ 2) $m_1I_2 + m_2I_1 = 0$
3) $m_1I_1 - m_2I_2 = 0$ 4) $m_1I_2 - m_2I_1 = 0$

KEY

47. 4	48.1	49.1	50.3	51.1
52.4	53.1	54.1	55.1	56.3
57.2	58.3	59.1	60.3	61.3
62.2	63.4	64.1		

HINTS

48. From $g=\frac{4}{3}\pi\rho GR, \frac{g_1}{g_2}=\frac{1}{2}$

from $\frac{V_1}{V_2}=\sqrt{\frac{2gR}{2(2g)(2R)}}$

$V_2=2V_1=22kms^{-1}$

49. Velocity at infinity

$V_\infty=\sqrt{V^2-V_e^2}=\sqrt{\left[2(11.2)\right]^2-(11.2)^2}$

50. $\sqrt{\frac{GM}{R+h}}=\frac{1}{2}\left[\sqrt{\frac{2GM}{R}}\right]$

51. $\Delta PE=\frac{GMm}{R}\left[1-\frac{1}{2}\right]=\frac{GMm}{2R}$

But

$gR=\frac{GM}{R}$

$\therefore \Delta PE=\frac{mgR}{2}$

56. $\frac{1}{2}mv^2=\frac{(mg)Rh}{(R+h)}=\frac{(mg)R(nR)}{(R+nR)}$

57. $\frac{T_1}{T_2}=\sqrt{\frac{R_1^3}{R_2^3}}$

58. $\frac{T_1}{T_2}=\sqrt{\frac{R_1^3}{R_2^3}}=\sqrt{\frac{R^3}{(2R)^3}}$

59. $\frac{g_1}{g_2}=\frac{R_2^2}{R_1^2}=\frac{\left(\frac{3}{2}R\right)^2}{R^2}=\frac{9}{4}$

$\therefore g_2=\frac{4g}{9}$

Weight = $200\left[\left(\frac{4}{9}\right)g\right]=\frac{8000}{9}=889N$

60. $\frac{T_1}{T_2}=\sqrt{\frac{R_1^3}{R_2^3}}=\sqrt{\frac{(7R)^3}{\left(\frac{7R}{2}\right)^3}}$

61. $E_G=GM\left[\frac{1}{1^2}+\frac{1}{2^2}+\frac{1}{4^2}+.............\right]$

$= GM\left[\frac{1}{1-r}\right] = \frac{4}{3}GM$

62. $mr\omega^2 = \sqrt{3}\frac{Gm^2}{a^2}$ and $r = \frac{a}{\sqrt{3}}$

63. PE at mid point = $\frac{-2GMm}{d}\left(M_1 + M_2\right)$

$\Rightarrow \frac{1}{2}mV_e^2 = \frac{2Gm}{d}\left(M_1 + M_2\right)$

64. $I_1 = \frac{Gm_2}{d^2}$ and $I_2 = \frac{Gm_1}{d^2}$

$\therefore \frac{G}{d^2} = \frac{I_1}{m_2} = \frac{-I_2}{m_1}$

NEW MODEL QUESTIONS

65. Match List I with List II

List - I	List - II
a) White Dwarf	e) 1.4 solar masses
b) Northern star	f) Mass of star must be greater than 10 solar masses
c) Black holes	g) Mass of the star must be less than 10 solar masses
d) Chandra Sekhar limit	h) Mass of remaining star is greater than 3 solar masses

1) $a-g, b-f, c-h, d-e$
2) $a-f, b-g, c-e, d-h$
3) $a-g, b-f, c-e, d-h$
4) $a-f, b-e, c-g, d-h$

66. Which of the following is true for a satellite in a circular orbit
a) It is freely falling body b) Its speed is constant
c) It suffers no acceleration
d) It does not require energy for motion in the orbit
1) a,b and c 2) a,b and d
3) a and b 4) a,b,c and d

67. Inside a uniform spherical shell
a) Gravitational potential is zero
b) Gravitational field is zero
c) Gravitational potential is constant
d) Gravitational field is constant
1) a and b 2) b and d 3) b and c 4) a and c

68. When a planet moves around the sun :
a) Its angular momentum remains constant
b) It moves faster when it is nearer to the sun
c) Its total energy increases when it goes nearer to the sun.
d) Its potential energy decreases when it goes nearer to the sun.
1) only a and b are true 2) only b and c are true
3) only a, b and d are true 4) all are true

69. The magnitudes of the gravitational field at distances r_1 and r_2 from the centre of a uniform sphere of radius R and mass M are F_1 and F_2 respectively. Then :
a) $\frac{F_1}{F_2} = \frac{r_1}{r_2}$ if $r_1 < R$ and $r_2 < R$
b) $\frac{F_1}{F_2} = \frac{r_2^2}{r_1^2}$ if $r_1 > R$ and $r_2 > R$
c) $\frac{F_1}{F_2} = \frac{r_1}{r_2}$ if $r_1 > R$ and $r_2 > R$
d) $\frac{F_1}{F_2} = \frac{r_1^2}{r_2^2}$ if $r_1 < R$ and $r_2 < R$
1) only a and b are true 2) only b and c are true
3) only a,b and d are true 4) all are true

70. A satellite is revolving round the earth in an elliptical obit :
a) Gravitational force exerted by earth is equal to centripetal force at some points only.
b) Power associated with gravitational force is zero at every point
c) Work done by gravitational force is zero in some small parts of the orbit.
d) At some points, magnitude of gravitational force is greater than that of centripetal force.
1) Only a and b are true
2) Only b and c are true
3) Only a, b and d are true
4) Only a,c and d are true

71. Let V, T, L, K and r denote the speed, time period, angular momentum, kinetic energy and radius of satellite in a circular orbit, their
a) $V \alpha r^{-1}$ b) $L \alpha r^{1/2}$ c) $T \alpha r^{3/2}$ d) $K \alpha r^{-2}$
1) Only a and b are true 2) Only b and c are true
3) Only a, b and d are true
4) Only a,b and care true

Assertion & Reason :

72. A) : For a planet revolving around the sun its velocity is more when it is closest to the sun.
R) : Law of conservation of angular momentum is the underlying principle
1) Both A and R are true and R is correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

73. A) : A body is first taken along a smooth inclined plane through a certain height. In the next case it is lifted vertically upwards to same height, work done by gravity in both cases is same
R) : Gravitational force is conservative force
1) Both A and R are true and R is correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

74. A) : When a body is dropped into a tunnel dug along the diameter of the earth it executes simple harmonic motion.
R) : At any position, magnitude of Gravitational force experienced by the body is directly propotional to the displacement of the body as measured from center of the earth.
1) Both A and R are true and R is correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false
4) A is false but R is true

75. A): A satellite revolving round the earth with uniform speed moves tangentially to the orbit with same speed when gravity suddenly disappears.
R) : This is due to inertia of motion
1) Both A and R are true and R is correct explanation of A
2) Both A and R are true and R is not the correct explanation of A
3) A is true but R is false 4) A is false but R is true

KEY

65. 1	66.2	67.3	68.3	69.1
70.4	71.2	72.1	73.1	74.1
75.2				

PREVIOUS EAMCET QUESTIONS ENGINEERING & MEDICAL

1. A spaceship is launched into a circular orbit of radius 'R' close to the surface of earth. The additional velocity to be imparted to the spaceship in the orbit to overcome the earth's gravitational pull is : (g = acceleration due to gravity) (Med-2004)
1) 1.414Rg 2) $1.414\sqrt{Rg}$
3) 0.414Rg 4) $4\pi \times 10^4$

2. The eacape velocity of a body on the earth's surface is V_E. A body is thrown up with a speed $\sqrt{5}V_E$. Assuming that the sun and planets do not influence the motion of the body, velocity of the body at infinite distance is (Eng-2004)
1) 0 2) V_E 3) $\sqrt{2}V_E$ 4) $2V_E$

3. The radius in kilometers, to which the present radius of the earth (R = 6400 km) is to be compressed so that the escape velocity is increased ten times is : (Med. 2003)
1) 6.4 2) 64 3) 640 4) 4800

4. A satellite is launched into a circular orbit of radius "R" around the earth while a second satellite is launched into an orbit of radius 1.02 R. The percentage difference in the time periods of the two satellites is : (Eng-2003)
1) 0.7 2) 1.0 3) 1.5 4) 8

5. Two satellites S_1 and S_2 are revolving round a planet in coplanar and concentric circular orbits of radii R_1 and R_2 in the same direction respectively. Their respective periods of revolution are 1 hr. and 8 hr. The radius of the orbit of satellite S_1 is equal to 10^4 km. Their relative speed when they are closest, in kmph is : (Med-2002)
1) $\frac{\pi}{2}\times 10^4$ 2) $\pi \times 10^4$ 3) $2\pi \times 10^4$ 4) $4\pi \times 10^4$

6. A body is projected up with a velocity equal to 3/4 th of the escape velocity from the surface of the earth. The height it reaches is __.
(Radius of the earth is R) **2002E**
1) 10R/9 2) 9R/7 3) 9R/8 4) 10R/3

2001E

7. Mass M is divided into two parts Xm and (1–X)m. For a given seperation the value of X for which the gravitational attraction between the two pieces becomes maximum is
1) 1/2 2) 3/5 3) 1 4) 2

2001M

8. When a satellite going around the earth in a circular orbit of radius r and speed v loses some of its energy , then
1) r and v both increase 2) r and v both decrease
3) r will increase and v will decrease
4) r will decrease and v will increase

1999M

9. Two satellites of masses 50 kgs and 100 kgs revolve around the earth in circular orbit of radii 9R and 16 R respectively, where 'R' is the radius of the earth. The speeds of the two satellites will be in the ratio. **1999M**
1) 3/4 2) 4/3 3) 9/16 4) 16/9

10. The escape velocities on two planets of masses m_1 and m_2 and having same radius are v_1 and v_2 respectively then

1) $\frac{v_1}{v_2} = \frac{m_1}{m_2}$ 2) $\frac{v_2}{v_1} = \frac{m_1}{m_2}$

3) $\frac{v_1}{v_2} = \left(\frac{m_1}{m_2}\right)^2$ 4) $\frac{v_1}{v_2} = \sqrt{\frac{m_1}{m_2}}$

1998E

11. A satellite is revolving near the earth's surface. Its orbital velocity is
1) 5.8 km/s 2) 18.4 km/s
3) 11.2 km/s 4) 8.0 km/s

1998M

12. The ratio of the escape velocity and the orbital velocity is

1) $\sqrt{2}$ 2) $\frac{1}{\sqrt{2}}$ 3) 2 4) 1/2

1998M

13. The escape velocity of a sphere of mass 'm' is given by

1) $\sqrt{\frac{2GMm}{R_e}}$ 2) $\frac{2GM}{R_e^2}$ 3) $\sqrt{\frac{2GMm}{R_e^2}}$ 4) $\sqrt{\frac{2GM}{R_e}}$

1998M

14. The radius vector drawn from the sun to a planet sweeps out ___ areas in equal time
1) equal 2) unequal 3) greater 4) less

1996E

15. The escape velocity of a body from the earth is u. What is the escape velocity from a planet whose mass and radius are twice those of the earth?
1) 2u 2) u 3) 4u 4) 16 u

1995E

16. The orbital speed for an earth satelite near the surface of the earth is 7 km/sec. If the radius of the orbit is 4 times the radius of the earth, the orbital speed would be
1) 3.5 km/sec 2) 7 km/sec
3) $7\sqrt{2}$ km/sec 4) 14 km/sec

1994E

17. A geostationary satellite has an orbital period of
1) 2 hours 2) 6 hours 3) 24 hours 4) 12 hours

18. The escape velocity of an object on a planet whose radius is 4 times that of the earth and 'g' value 9 times that on the earth, in $km.s^{-1}$, is
1) 33.6 2) 67.2 3) 16.8 4) 25.2

1993M

19. The satellite is orbiting a planet at a certain height in a circular orbit. If the mass of the planet is reduced to half, the satellite would **1993M**
1) fall on the planet2) go to orbit of smaller radius
3) go to orbit of higher radius
4) escape from the planet

20. The acceleration due to gravity on the surface of moon is 1/6 that on the earth and the diameter of the earth is 4 times the diameter of the moon. The ratio of the escape velocity of the moon to that of the earth is
1) 1 : 4 2) 4 : 1 3) 5 : 1 4) 1 : 5

1992E

21. Two satellites A and B go round the earth in ciruclar orbits at a height of R_A and R_B respectively from the surface of the earth. Assume the earth to be a uniform sphere of radius R_E. The ratio of the magnitudes of the velocities of the satellites V_A / V_B is

1) $\sqrt{\frac{R_B}{R_A}}$ 2) $\frac{R_B + R_E}{(R_A + R_E)}$ 3) $\sqrt{\frac{(R_B + R_E)}{(R_A + R_E)}}$ 4) $\left(\frac{R_A}{R_B}\right)^2$

1991E

22. If the escape velocity on earth is 11.2 km/sec, its value for a planet having double the radius and 8 times the mass of earth is ..... m./sec.

1990E

23. The escape velocity from the earth for a rocket is 11.2 km/sec. Ignoring the air resistance, the escape velocity of 10 mg grain of sand from the earth will be
1) 0.112 km/sec 2) 11.2 km/sec
3) 1.12 km/sec 4) None

1989E

24. The orbital period of oscillation of an artificial satellite revolving in a geostationary orbit is ...

1988E

25. If the earth is at one-fourth of its present distance from the sun, the duration of the year would be
1) Half the present year
2) One-eigth the present year
3) One-fourth the present year
4) One -sixteenth the present year

1984E

26. The mass of the earth is 9 times that of Mars. The radius of the earth is twice that of Mars. The escape velocity of the earth is 12 km/sec. The escape velocity on Mars is ... km/sec.

KEY

1. 4	2.4	3.2	4.4	5.2
6.2	7.1	8.4	9.2	10.4
11.4	12.1	13.4	14.1	15.2
16.1	17.3	18.2	19.4	20.4
21.3	22. 22.4m/sec		23.2	
24.24hrs	25.2	26. $4\sqrt{2}$		

QUESTIONS FROM OTHER COMPETETIVE EXAMS

1. A satellite of mass m revolves around the earth of radius R at a height x from its surface. If g is the acceleration due to gravity on the surface of the earth, the orbital speed of the satellite is [AIEEE-2004]

1) gx 2) $\left(\frac{gR^2}{R+x}\right)^{1/2}$ 3) $\frac{gR^2}{R+x}$ 4) $\frac{gR}{R-x}$

2. If 'g' is acceleration due to gravity on the earth's surface, the gain in the potential energy of an object of mass 'm' raised from the surface of the earth to a height equal to the radius 'R' of the earth is [AIEEE -2004]

1) 2 mgR 2) mgR 3) mgR/4 4) mgR/2

3. Suppose the gravitational force varies inversely as the nth power of distance, then the time period of a planet in circular orbit of radius 'R' around the sun will be proportional to [AIEEE -2004]

1) $R^{\left(\frac{n+1}{2}\right)}$ 2) $R^{\left(\frac{n-2}{2}\right)}$ 3) R^n $R^{\left(\frac{n-1}{2}\right)}$

4. The escape velocity for a body projected vertically upwards from the surface of earth is 11 km/s. If the body is projected at an angle of 45^0 with the vertical, the escape velocity will be [AIEEE -2003]

1) $11\sqrt{2}$ km/s 2) 22 km/s

3) 11 km/s 4) $11\sqrt{2}$ km/s

5. The time period of satellite of earth is 5 hr. If the separation between earth and the satellite is increased to 4 times the previous value, the new time period will become. [AIEEE -2003]

1) 10 hours 2) 80 hours 3) 40 hours 4) 20 hours

6. A geo-stationary satellite orbits around the earth in a circular orbit of radius 36000 km. Then, the period of spy satellite orbiting a few hundred kilometers above theearth's surface ($R_{earth} = 64000$ km) will become. [IIT Screening 2002]

1) $(1/2)$ hr 2) 1 hr 3) 2 hr 4) 4 hr

7. The ratio of the radii of planets A and B is K_1 and ratio of accelerations due to gravity on them is K_2 The ratio of escape velocities from them will be [BHU -2002]

1) K_1K_2 2 $\sqrt{K_1K_2}$ 3) $\sqrt{\frac{K_1}{K_2}}$ 4) $\sqrt{\frac{K_2}{K_1}}$

8. The kinetic energy needed to project a body of mass m from earth's surface (radius R) to infinity is [AIEEE -2002]

1) $\frac{mgR}{2}$ 2) $2mgR$ 3) mgR 4) $\frac{mgR}{4}$

9. The escape velocity of a body depends upon its mass as [AIEEE -2002]

1) m^0 2) m^1 3) m^3 4) m^2

10. Energy required to move a body of mass 'm' from an orbit of radius 2R to 3R is [AIEEE -2002]

1) $\frac{GMm}{2R^2}$ 2) $\frac{GMm}{3R^2}$ 3) $\frac{GMm}{8R}$ 4) $\frac{GMm}{6R}$

11. If suddenly the gravitational force of attraction between earth and satellite revolving around it becomes zero, then the satellite will [AIEEE -2002]

1) Continue to move in its orbit with same velocity
2) Move tangential to the original orbit with the same velocity
3) Becomes sationary in its orbit
4) Move towards the earth

12. The angular velocity of rotation of a star (of mass M and radius R) at which the matter will start escaping from its equator is

1) $\sqrt{\frac{2GR}{M}}$ 2) $\sqrt{\frac{2GM}{R^3}}$ 3) $\sqrt{\frac{2GM}{R}}$ 4) $\sqrt{\frac{2GM^2}{R}}$

13. The time of revolution of planet A around the sun is 8 times that of another planet B. The distannce of planet A from the sun is how many times greater than that of the planet B from the sun [AIEEE -2002]

1) 2 2) 3 3)4 4) 5

14. The distance of Neptune and saturn from the Sun are respectively. 10^{13} and 10^{12} meters and their periodic times are respectively T_n and T_s. If their orbits are assumed to be circular, the value of T_n/T_s is [MP PMT-2001]

1)100 2) $10\sqrt{10}$ 3) $\frac{1}{10\sqrt{10}}$ 4) 10

15. Assume that the acceleration due to gravity on the surface of the moon is 0.2 times the acceleration due to gravity on the surface of the earth. If R_e is the maximum,range of a projelctile on the earth's surface, what is the maximum range on the surface of the moon for the same velocity of projection [Kerala PET-2001]

1) $0.2R_e$ 2) $2R_e$ 3) $0.5R_e$ 4) $5R_e$

16. The period of revolution of an earth's satellite close to the surface of earth is 90 minutes. The period of another earth's satellite in an orbit at a distance of three times earth's radius from its surface will be [J&K CET-2001]

1) 90 minutes` 2) $90\times\sqrt{8}$ minutes

3) 270 minutes 4) 720 minutes

17 If the spinning speed of earth is increased then the weight of the body at equator [UP CP MT-2000,AFMC-2002]
1) Does not change 2) Doubles
3) Decreases 4) Increases

18 A space craft is launched in a circular orbit very close to earth. What additional velocity should be given to the space craft so that it might escape the earth's gravitational pull [CPMT-2001]
1) 20.2 Kms^{-1} 2) $3.25 kms^{-1}$
3) $8 kms^{-1}$ 4) $11.2 kms^{-1}$

19. Which of the following is the evidence to show that there must be a force acting on earth and directed towards Sun? **(AFMC 2000)**
1) Apparent motion of sun round the earth
2) Phenomenon of day and night
3) Revolution of earth round the Sun
4) Deviation of the falling body towards earth

20. 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 is **(AIIMS 2000)**
1) 33 km/s 2) $11/\sqrt{3}$ km/s
3) $11\sqrt{3}\, kms^{-1}$ 4) $11 kms^{-1}$

21. The period of revolution of a certain planet in an orbit of radius R is T. Its period of revolution in an orbit of radius 4R will be **(MPPMPT 1998)**
1) 2T 2) $2\sqrt{2}\,T$ 3) 4T 4) 8T

22. A tunnel is dug along a diameter of the earth. The force on a particle of mass 'm' placed in the tunnel at a distance x from the centre is **(CPMT 1997)**
1) $\frac{GM_e m}{R^3}x$ 2) $\frac{GM_e m}{R^2}x$ 3) $\frac{GM_e m}{R^3 x}$ 4) $\frac{GM_e m R^3}{x}$

23. A body of mass 5 kg is taken into space. Its mass becomes. **(Raj PMT -1997)**
1) 5 kg 2) 10 kg 3) 2 kg 4) 30 kg

24. Consider earth to be a homogeneous sphere. Scientist A goes deep down in a mine and scientist B goes high up in a baloon. The gravitational field measured by **(CBSE - 1997)**
1) A goes on decreasing and that of B goes on increasing
2) B goes on decreasing and that of A goes on increasing
3) Each decreases at the same rate
4) Each decreases at different rates.

25. A planet moves around the sun. At a given point P, it is closest from the sun at a distance d_1, and has a speed v_1. At another point Q, when it is farthest from the sun at a distance d_2, its speed will be **(AFMC-1997)**
1) $\frac{d_1^2 v_1}{d_2}$ 2) $\frac{d_2 v_1}{d_1}$ **3)** $\frac{d_1 v_1}{d_2}$ 4) $\frac{d_2^2 v_1}{d_1^2}$

26. A satellite is moving in a circular orbit round the earth. If gravitational pull suddenly disappears, then it **(AIIMS 1997)**
1) Continuous to move with the same speed along the same path
2) Moves with the same velocity tangential to original orbit.
3) Falls down with increasing velocity.
4) Comes to rest after moving certain distance along original path.

27. A space-ship entering the earth's atmosphere is likely to catch fire. This is due to **(CPMT 1997)**
1) The surface tension of air2) The viscosity of air
3) The high temperature of upper atmosphere
4) The greater portion of oxygen in the atmosphere at greater height.

28. An astronaut orbiting the earth in a circular orbit 120 km above the surface of earth, gently drops a ball from the space-ship. The ball will **(CPMT 1996)**
1) Move randomly in space
2) Move along with the space-ship
3) Fall vertically down to earth
4) Move away from the earth

29. A missile is launched with a velocity less than the escape velocity. The sum of its kinetic and potential energies is **(MNR 1996)**
1) Positive 2) Negative 3) Zero
4) May be positive or negative depending upon its initial velocity

30. A particle hanging from a spring stretches it by 1 cm at earth's surface. Radius of earth is 6400 km. At a place 800 km above the earth's surface, the same particle will stretch the spring by **(AMU 1995)**
1) 0.79 cm2) 1.2 cm 3) 4 cm 4) 17 cm

KEY

1. 2	2.4	3.1	4.3	5.3
6.3	7.2	8.3	9.1	10.4
11.2	12.2	13.3	14.2	15.4
16.2	17.3	18.2	19.3	20.4
21.4	22.1	23.1	24.4	25.3
26.2	27.2	28.2	29.2	30.1