Orbital and Escape Velocities

1. **A space-ship entering the earth's atmosphere is likely to catch fire, this is due to**

   1) Surface tension of air

   2) Viscosity of air

   3) Greater proportional of O_2 in the atmosphere at higher height

   4) High temperature of upper atmosphere

2. **If an astronaut comes out of the artificial satellite, then**

   1) He flies off tangentially

   2) He falls to the earth

   3) He performs SHM

   4) He continues to move along the satellite in the same orbit.

3. **There is no atmosphere on moon because**

   1) It is closer to earth

   2) It revolves round the earth

   3) It gets light from the earth

   4) RMS speed of any gas molecule is greater than the escape velocity on the surface of the moon.

4. **A satellite is revolving around the earth in a circular orbit with a uniform speed. If the gravitational force suddenly disappears, then the satellite will**

   1) Continue to move in the same orbit with that speed

   2) Move tangentially to the orbit with that speed

   3) Move away from the earth normally to the orbit

   4) Fall down on the earth

5. To have an earth satellite synchronous with the rotation of the earth, it must be launched at a proper height

1) From West to East in equatorial plane

2) From South to North in equatorial plane

3) From East to West in equatorial plane

4) From North to South in equatorial plane

6. The period of geostationary artificial satellite of the earth is

1) 24hr 2) 48hr 3) 12hr 4) Zero

7. When a satellite is going round the earth in a circular orbit of radius 'r' and with a velocity V. If it loses some of the energy, then

1) r and v both will increase 2) r and v both will decrease

3) r will decrease and v will increase 4) r will increase and v will decrease

8. The time period of an earth satellite in circular orbit is independent of

1) The mass of the satellite

2) Neither the mass of the satellite nor the radius of its orbit

3) Both the mass of the satellite and radius of the orbit

4) Radius of the orbit

9. The weight of a body (W) is measured using a spring balance, and then the ratio $\frac{W}{g}$ gives

1) Inertial mass 2) Gravitational mass

3) Non-inertial mass 4) Relativistic mass

10. When a satellite is lifted from a lower orbit to a higher orbit

a) Gravitational potential energy increases b) KE increases

c) Gravitational PE decreases d) KE increases

1) a is only correct 2) a & d are correct

3) a and c are correct 4) a & b are correct

11. **A: The gravitational mass and inertial mass are equal.**

R: Physical laws are equivalent in an appropriately accelerated frame of reference and in an inertial frame.

1) Both (A) and (R) are true and (R) is the 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.

12. **A: For a satellite to escape from its orbit, its velocity should be increased by 41.4%.**

R: Orbital velocity and escape velocity are related as $V_e = \sqrt{2}\, v_0$.

1) Both (A) and (R) are true and (R) is the 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.

13. **A: There is no atmosphere on the moon surface.**

R: RMS speed of the gas molecules is greater than the escape velocity on moon.

1) Both (A) and (R) are true and (R) is the 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.

14. **A: A particle of mass ‘m’ dropped into a hole made along the diameter of the earth from one end to the other and possesses simple harmonic motion.**

R: Gravitational force between any two particles is inversely proportional to the square of the distance between them.

1) Both (A) and (R) are true and (R) is the 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.

15. (A): If the earth starts rotating with a time period of 84 minutes then objects on the equator would become weightless.

(R): This time period is identical with that of a surface satellite.

(1) Both A and R are true and R is the correct explanation of A.

(2) Both A and R are true but R is not the correct explanation of A

(3) A is true but R is false.

(4) A is false but R is true.

16. Match the following items (R = radius of earth).

List - I	List - II
(a) Ratio of g at depth R/2 and a height R/2	**(e) 17:1**
(b) Ratio of earth's potential at the earth's surface and at the centre.	**(f) 1:55**
(c) Ratio of time period of geocentric satellite and the surface satellite	**(g) 9:8**
(d) Ratio of escape velocity from earth's surface and sun's surface.	**(h) 2:3**

(1) a-h, b-g, c-e, d-f (2) a-h, b-g, c-f, d-e

(3) a-g, b-h, c-e, d-f (4) a-g, b-h, c-f, d-e

17. Two satellites A and B go round the earth in circular 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) $\left(\frac{R_A}{R_B}\right)^2$

18. **The amount of work done in lifting a body of mass 'm' from the surface of the earth to a height equal to twice the radius of the earth is**

1) $\frac{2GMm}{3R}$ 2) $\frac{3GMm}{2R}$ 3) $\frac{5GMm}{3R}$ 4) $\frac{3GMm}{5R}$

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

1) 6.67 x 10^{-10}J 2) 6.67 x 10^{-9}J

3) 3.33 x 10^{-10}J 4) 13.34 x 10^{-10}J

20. **A body of mass 'm' is raised from the surface of earth to a point which is at a height nR from the surface of the earth. The change in PE is**

1) nmgR 2) $\frac{2mgR}{n}$ 3) $\frac{n}{n+1}mgR$ 4) $\frac{mgR}{n}$

21. **The escape velocity of a body on the earth's surface is V_e. A body is thrown vertically up with a speed of (kV_e) (k<1). The maximum height reached by the body above the earth is**

1) $R\left(\frac{k^2}{1-k^2}\right)$ 2) $R^2\frac{k^2}{(1-k^2)}$ 3) $R\left(\frac{1-k^2}{k}\right)$ 4) $\frac{R}{k^2}$

22. **The velocity with which a body should be projected from the surface of the earth such that it reaches a maximum height equal to n times the radius R of the earth is**

1) $\sqrt{\frac{n}{n+1}\frac{GM}{R}}$ 2) $\sqrt{\frac{nGM}{R}}$ 3) $\sqrt{\frac{2n}{n+1}\frac{GM}{R}}$ 4) $\sqrt{\frac{GM}{nR}}$

23. **The KE required to project a body of mass 'm' from the earth's surface to infinity is**

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

24. **The escape velocity for a body projected vertically upwards from the surface of earth is 11kms^{-1}. If the same body is projected at an angle of 45^{0} with the vertical, the escape velocity will be**

1) $11\sqrt{2}$ kms^{-1} 2) 22kms^{-1} 3) 11kms^{-1} 4) $11/\sqrt{2}$ kms^{-1}

25. **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 increases to ten times is**

1) 6.4 2) 64 3) 640 4) 4800

26. **A small particle of mass m lies on the axis of a ring of mass M and radius a, at a distance a from the centre. The particle reaches the centre under gravitational attraction only. Its sped at the centre will be - - -**

(1) $\sqrt{\frac{2GM}{a}}$ (2) $\sqrt{\frac{2GM}{a}(\sqrt{2}-1)}$ (3) $\sqrt{\frac{2GM}{a}\left(1-\frac{1}{\sqrt{2}}\right)}$ (4) 0

27. **A planet of mass 'm' revolves elliptical orbit around the sum so that its maximum and minimum distance from the sun are a, b respectively. The angular momentum of the planet relative to the sun is**

1) $m\sqrt{\frac{2GM}{ab(a+b)}}$ 2) $m\sqrt{\frac{2GMab}{(a+b)}}$ 3) $\sqrt{\frac{2GMab}{(a+b)}}$ 4) $\sqrt{\frac{2GMmab}{(a+b)}}$

28 **The gravitational potential energy of a body of mass ‘m’ at the earth’s surface $-mgR_e$. Its gravitational potential energy at a height R_e from the earth’s surface will be (Here R_e is the radius of the earth)**

1) $-2\,mgR_e$ 2) $2\,mgR_e$ 3) $\frac{1}{2}mgR_e$ 4) $-\frac{1}{2}mgR_e$

29. **Escape velocity of a body of 1 kg mass on a planet is 100 m/sec. Gravitational Potential energy of the body at the Planet is**

1) – 5000 J 2) – 1000 J 3) – 2400 J 4) 5000 J

30. The ratio of the K.E. required to be given to the satellite to escape earth's gravitational field to the K.E. required to be given so that the satellite moves in a circular orbit just above earth atmosphere is

1) One 2) Two 3) Half 4) Infinity

Key

1) 2	2) 4	3) 4	4) 2	5) 1	6) 1	7) 3	8) 1	9) 2	10) 4
11) 1	12) 2	13) 1	14) 2	15) 1	16) 3	17) 3	18) 1	19) 1	20) 3
21) 1	22) 3	23) 3	24) 3	25) 2	26) 3	27) 2	28) 4	29) 1	30) 2

Hints

17. $V_0 \propto \frac{1}{\sqrt{r}}$ $r_a = R_A + R_E$, $r_b = R_B + R_E$

18. $U_1 = \frac{-GMm}{R}, U_2 = \frac{-GMm}{R+2R} = -\frac{GMm}{3R}$

$W = U_2 - U_1 = \frac{2GMm}{3R}$

19. $W = U = \frac{GMm}{R}$

$$= \frac{6.67\times10^{-11}\times100\times10\times10^{-3}}{10\times10^{-2}} = 6.67 \text{ x } 10^{-10} \text{ J}$$

20. $U_1 = \frac{-GMm}{R}, U_2 = \frac{-GMm}{nR}$

$$\Delta PE = U_1 - U_1 = \frac{-GMm}{R} - \frac{GMm}{(nR+R)}$$

$$= \frac{-GMm}{R} - \left(1 - \frac{1}{(n+1)}\right) = \frac{n}{n+1}\frac{GMm}{R}$$

$$= \left(\frac{n}{n+1}\right) mgR$$

21. $h = \frac{v^2 R}{2gR - v^2}$

22. TE must be conserved

$$\frac{-GMm}{R} + \frac{1}{2}mv^2 = \frac{-GMm}{R+hR}$$

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

$$\therefore V = \sqrt{\frac{2n}{n+1}\frac{GM}{R}}$$

23. $KE = \frac{1}{2}m\,(V_e)^2 = \frac{1}{2}m\left(\sqrt{2gR}\right)^2 = mgR$

24. $V_e^1 = 11kms^{-1}$ *only*

Because V_e is independent of the direction of projection

25. $V \propto \frac{1}{\sqrt{R}} \left(\frac{V_2}{V_1}\right)^2 = \frac{R_1}{R_2}$

$$R_2 = R_1\left(\frac{V_1}{V_2}\right)^2 = 6400\times\frac{1}{100}$$

26. According to law of conservation of energy

$$W = \frac{1}{2}mv^2 = \frac{+GMm}{\sqrt{2}a} - \frac{GMm}{a}$$

$$W = \frac{1}{2}mv^2 = \left(-V_0 - V_P\right)m$$

$$= \left[\frac{-GMm}{a} + \frac{GMm}{\sqrt{2}a}\right]$$

Or $v = \sqrt{\frac{2GM}{a}\left(1 - \frac{1}{\sqrt{2}}\right)}$

27. $\frac{2}{r} = \frac{1}{r_1} + \frac{1}{r_2}$

$$L = mvr = m\sqrt{\frac{GM}{r}}r = m\sqrt{\frac{2GMab}{(a+b)}}$$

28. $\Delta U = U_2 - U_1 = \frac{mgh}{1 + \frac{h}{R_e}} = \frac{mgR_e}{1 + \frac{R_e}{R_e}} = \frac{mgR_e}{2}$

$$\Rightarrow U_2 - (-mgR_e) = \frac{mgR_e}{2} \Rightarrow \quad U_2 = -\frac{1}{2}mgR_e$$

29. $v_e = \sqrt{\frac{2GM}{R}} = 100 \Rightarrow \frac{GM}{R} = 5000$

Potential energy $U = -\frac{GMm}{R} = -5000\ J$

30. K.E. required for satellite to escape from earth's gravitational field

$$\frac{1}{2}mv_e^2 = \frac{1}{2}m\left(\sqrt{\frac{2GM}{R}}\right)^2 = \frac{GMm}{R}$$

K.E. required for satellite to move in circular orbit

$$\frac{1}{2}mv_0^2 = \frac{1}{2}m\left(\sqrt{\frac{GM}{R}}\right)^2 = \frac{GMm}{2R}$$

The ratio between these two energies = 2