PHYSICS

BOOKS - PEARSON IIT JEE FOUNDATION

GRAVITATION

Example

1. Calculate the gravitational force of attraction between a car of mass 600 kg and a

bike of mass 100 kg separated by a distance of 20 m

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2. The mass of the Earth is 6×10^{24} kg and its radius is 6400 km. Find the acceleration due to gravity on the surface of the Earth.

A. $9.77ms^{-2}$

B. $8.77ms^{-2}$

C. $10.77ms^{-2}$

D. $7.77ms^{-2}$

Answer: A

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3. The mass and radius of the planet Jupiter are 2×10^{27} kg and 7×10^{7} m, respectively. Calculate the acceleration due to gravity on the surface of Jupiter.

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4. Calculate the acceleration due to gravity at a height of 1600 km from the surface of the Earth. (Given acceleration due to gravity on the surface of the Earth $g_0 = 9.8ms^{-2}$ and radius of earth, R = 6400 km).

A. $6.27m/s^2$

B. $3.28m/s^2$

C. $5.36m/s^2$

D. $4.86m/s^2$

Answer: A

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5. Given that the radius of the Earth and acceleration due to gravity on the surface of the Earth as 6400 km and $9.8ms^{-2}$, respectively, find the acceleration due to gravity at a height of 5 km from the surface of the Earth.

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6. Given radius of the Earth and acceleration due to gravity on the surface of the Earth as 6400 km and $9.8ms^{-2}$, respectively. Find the acceleration due to gravity at a depth of 1600 km from the surface of the Earth.

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Very Short Answer Type Questions

1. Define free fall.

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2. Define an artificial satellite.

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3. When does a body experience o free fall?

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4. The leaning tower of PISA does not collapse inspite of being in a slanting position. Then the building is said to be in _____ equilibrium.

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5. What is a geostationay satellite and what is its time period?

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6. State Newton's universal law of gravitation

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7. What is the effect of mass of the body on acceleration due to gravity (g)?

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8. On Mount Everest, the value of the acceleration due to gravity is _____ than its

value in Kashmir valley.

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9. State Newton's inverse square law.

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10. Where does the C.G. of regular shaped bodies lie?

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11. State S.I. and C.G.S. units of 'G' and mention its value in both the systems.

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12. State Kepler's 1st law of planetary motion.

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13. A spring balance measures the _____ of a body.

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14. Time period of revolution of a planet is 1000 days. If the distance between the sun and planet is altered such that 8000 days on it will make one year, then this altered distance is _____ the original distance.

A. $1/2$

B. $1/3$

C. $1/4$

D. $3/4$

Answer: C

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15. State Kepler's 2nd law of planetary motion.

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16. What do you understant by the position of a body?

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17. Define escape velocity of an object.

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18. State Kepler's 3rd law of planetary motion.

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19. Irregularity in the motion of a star is know as a _____ .

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20. If the ratio of the weights of a body of mass 'm' measured on two different planets 'A' and 'B' is 1 : 2 and the ratio of radii of two planets 'A' and 'B' is 2 : 4, respectively, then the ratio of the masses of two planets is, respectively _____ .

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21. Define mass, weight and centre of gravity.

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22. Define the following.

(a) stable equilibrium

(b) unstable equilibrium

(c) neutral equilibrium

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23. Geotropism was discovered by

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24. What do you mean by acceleration due to gravity?

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25. Define the time period of a satellite

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26. How does altitude affect 'g'?

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27. The time period of a geostationary satellite is

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28. Geotropism is the phenomenon which shows the effect of _____ on plants.

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29. What is the effect of latitude of 'g'?

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30. What is wobble?

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Short Answer Type Questions

1. How is gravitation used to detect the presence of a binary star or a planet which is bound to a star?

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2. Calculate the acceleration due to gravity on a planet of mass 2×10^{27} kg and radius

14×10^7 m.

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3. Explain how the apparent weight of a person, taking a ride in a roller-coaster varies.

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4. If the mass of the Earth is decreased by 10% keeping it size constant, how is the weight of a body on the Earth affected?

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5. Compare mass and weight.

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6. Weights of two bodies are 20N and 30N. If they are separated by a distance of 2 m, what is the force of gravitation acting between them?

(Take $g = 10ms^{-2}$)

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7. How does the centre of mass of bodies affect the force of gravitation between them?

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8. A bowl with a semi spherical base is designed such that its centre of gravity is located at the centre of curvature of the spherical part. Explain giving reasons, to which state of equilibrium the bowl belongs. If the

bowl is filled with water upto the centre of gravity, explain how the equilibrium state would be affcted/unaffcted.

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9. What is equilibrium? State the conditions required to keep a body in equilibrium.

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10. Mass of moon is 7.3×10^{22} kg and its radius is1.74×10^{6} m. Find the value of the acceleration due to gravity on the moon.

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11. If the distance between the Earth and the sun shrinks to half the present distance, then find the new duration of the year.

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12. The mean distance of two planets A and B from the sun is 2 and 4 times the distance of the Earth from the sun, respectively. Find the ratio of the time taken by the two planets to make one revolution around the sun.

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13. State the conditions for stable, unstable and neutral equilibria.

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14. A body weighs 98 N on the Earth. How much does it weigh on the moon?

(Take $g_E = 9.8ms^{-2}$, $g_m = 1.61ms^{-2}$)

A. 15.5 kg

B. 16.1 kg

C. 16.8 kg

D. 18.6 kg

Answer: B

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15. Give one practical examples of the equilibrium of bodies in our daily life.

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Essay Type Questions

1. Explain how the centre of gravity of an irregular lamina is determined.

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2. Geotropism is

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3. State Kepler's laws of planetary motion.

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4. Write a note on artificial satellite.

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5. Derive Newton's inverse square law.

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Level 1

1. The weight of a body on the surface of moon is 1/6th of that on the Earth's surface. It is because acceleration due to gravit on the surface of moon is six times that on the surface of the Earth.

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2. The dimensional formula of universal gravitational constant 'G' $\left[M^{-1}L^{3}T^{-2}\right]$.

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3. If a heavenly object like an asteroid or a planetoid revolving around the sun moves into an orbit of smaller radius, its speed increases.

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4. Acceleration due to gravity vanishes at an altitude equal to half the radius of the Earth.

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5. For any given body, the centre of the mass of a body always coincides with its centre of gravity.

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6. The direction of motion of an artificial satellite revoling in a geostationary orbit is opposite to the direction of the Earth's rotation.

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7. The ratio of 'g' on two known planets 'A' and 'B' is x : y. If two identical bodies are projected with the same velocity on these planets, then the ratio of their time of descent is _____. (Neglect atmospheric resistance).

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8. According to Kepler's laws of planetary motion, the orbits of planets are of _____ shape.

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9. Two satellites of identical masses orbit the Earth at different heights. The ratio of their distance from the centre of earth is d : 1 and

the ratio of the acceleration due to gravity at those heights is g : 1. Then the ratio of their orbital velocities is _____ .

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10. A football floating on the waves of ocean water is an example of ___ equilibrium.

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11. Newton's inverse square law is deduced from Kepler's _____ law of planetary motion.

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12. All the particles of a shuttle cock execute complicated motion, but its _____ describes the simplest path when it is projected.

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13. The law that helps in determining the masses of the stars present in a double star is _____.

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14. Match the entries given in Column A with appropriate ones in Column B

	Column A			Column B
A	g_h	( )	a.	Outside the body
B	$T^2 \alpha R^3$	( )	b.	24 hours
C	Centre of mass of a hollow sphere	( )	c.	6.67×10^{-11} N $m^2 kg^{-2}$
D	Universal gravitational constant	( )	d.	Kepler's law of periods
E	Time period of a geostationary satellite	( )	e.	$g_0\left(1-\frac{2h}{R}\right)$
F	Weight	( )	f.	Effect of latitude on 'g'.
G	Centre of gravity of a Boomerang	( )	g.	Mass
H	Common balance	( )	h.	$\sqrt{\frac{GM}{R}}$
I	$g_{equator} < g_{poles}$	( )	i.	Geometrical centre
J	Orbital velocity	( )	j.	Vector

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15. When a spring balance, which showed a reading of 30 divisions on earth, is taken to the moon, will show (for the same body)

A. 180 divisions

B. 6 divisions

C. 150 divisions

D. 5 divisions

Answer: D

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16. The place where the value of 'g' is unaffected by the increased (or) decrease in the speed of rotation of the Earth about its own axis is

A. equator

B. poles

C. tropic of Cancer

D. tropic of Capricorn

Answer: B

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17. The centre of gravity C.G. of the bob of a given simple pendulum is at position 'x' on earth. What is its new position on the surface of the moon?

A. It remains at the same position 'x'

B. It is above the position 'x'

C. It is below the position 'x'

D. It shifts towards surface of the bob.

Answer: A

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18. The weight of a body of mass 3 kg at a height of 12.8×10^6 m from the surface of the Earth is _____.

A. 9.75 N

B. 1.46 N

C. 3.26 N

D. 4.36 N

Answer: C

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19. If the gravitational force between two bodies of masses 10 kg and 100 kg separated by a distance 10 m is 6.67×10^{-10} N, then the force between the given masses would be _____ N if they are placed in a geostationary satellite without change in the distance between them.

A. 3.335×10^{-10}

B. 3.335×10^{-11}

C. 6.67×10^{-10}

D. 6.67×10^{-11}

Answer: C

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20. A circus artist rides a bicycle, on a rope tied horizontally. This is an example of ____ equilibrium.

A. neutral

B. stable

C. unstable

D. dynamic

Answer: C

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21. If the acceleration due to gravity on a planet is $6.67ms^{-2}$ and its radius is 4×10^6 m, then the mass of the planet is _____ .

A. $16 \times 10^{23} kg$

B. $726 \times 10^{23} kg$

C. $16 \times 10^{24} kg$

D. $26 \times 10^{24} kg$

Answer: A

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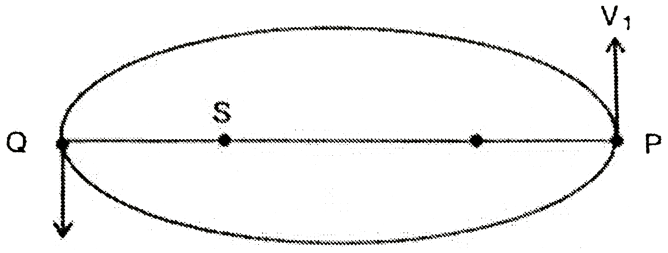
22. The figure shown below is an elliptical orbit along which a planet revolves round the sun. Let the velocity of the planet at points P and Q

be $V_1 \text{and} V_2$ respectively. Then, the possible relationship between magnitudes of $'V_1'$ and $'V_2'$ is



A. $V_1 < V_2$

B. $V_1 = V_2$

C. $V_1 > V_2$

D. Both 1 and 2

Answer: A

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23. What is the relation between the period of rotation (R_T) and periond of revolution (R_V) of moon?

A. $R_T = R_V$

B. $R_V > R_T$

C. $R_V < R_T$

D. No relation exists

Answer: A

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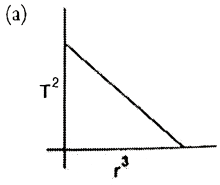
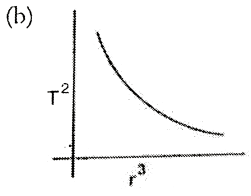
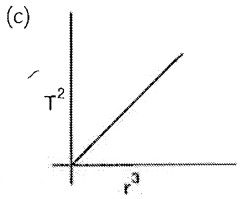
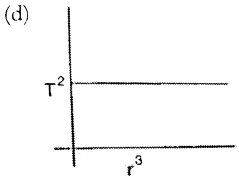
24. Which of the following graphs is true for the motion of a satellite revolving round the Earth. ('T" is the time period of a satellite and 'r' is the distance of the satellite from the Earth).

A. 

B. 

C. 

D. 

Answer: C

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25. One revolution of a given planet around the sun is 1000 days. If the distance between the planet and the sun is made $\frac{1}{4}$th of

original value, then how many days will make one year?

A. 180 days

B. 400 days

C. 125 days

D. 250 days

Answer: C

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26. A cone and a cylinder having same base area and height are placed on a horizontal surface. What is the ratio of the heights of centre of gravity of the cone and the cylinder from the surface?

A. 5 : 3

B. 3 : 5

C. 3 : 2

D. 1 : 2

Answer: D

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27. A geostationary satellite is going round the Earth in an orbit. Then, which of the following statements are true?

(A) It is like a freely falling body.

(B) It posseses acceleration throughtout its journey.

(C) Its is moving with constant speed.

(D) It is moving with constant velocity

A. ABC

B. BCD

C. CDA

D. DAB

Answer: A

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28. The length of a seconds pendulum on the surface of the Earth is 100 cm. Find the length of the seconds pendulum on the surface of

the moon.

$$\left(\text{Take, } g_M = \frac{1}{6} g_E\right)$$

A. 1.66 m

B. 16.6 cm

C. 33.2 cm

D. 3.32 m

Answer: B

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29. If the force between bodies of mass 2 kg and 4 kg, separated by a distance 4 m, is 3.335×10^{-11} N, then the force between them if the bodies are shifted to the moon without altering the distance between them will be _____.

A. 0.03335 N

B. $3.335 \times 10^{-11} N$

C. $5.558 \times 10^{-12} N$

D. $6.28 \times 10^{-12} N$

Answer: B

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30. The weight of a body of mass 3 kg at the centre of the Earth is _____.

A. 9.75 N

B. 1.46 N

C. zero

D. 4.36 N

Answer: C

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31. Acceleration due to gravity of a body is independent of

A. mass of the body.

B. altitude of the body.

C. latitude of the body.

D. depth below the Earth's surface.

Answer: A

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32. If the ratio of the masses of two planets is 2 : 3 and the ratio of their radii are 4 : 7, then the inverse ratio of their accelerations due to gravity will be

A. 49 : 24

B. 7 : 8

C. 24 : 49

D. 8 : 7

Answer: C

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33. What is the relation between period of rotation (R_T) of earth and period of revolution (R_r) for a geostationary satellite?

A. $R_T = R_r$

B. $R_T < R_r$

C. $R_T > R_r$

D. No relationship

Answer: A

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34. Spring balance measures _____ of a body in air.

A. actual weight of a body

B. apparent weight of a body

C. mass of a body

D. both mass and weight of a body

Answer: A

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35. According to Newton's Universal law of gravitation, the gravitational force between two bodies is

A. always attractive and depends on their masses.

B. depends on the distance between them.

C. does not depend on the medium between the bodies.

D. All of above.

Answer: D

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36. The ratio of the masses of two planets is 1 : 10 and the ratio of their diameters is 1 : 2. If the length of a seconds pendulum on the first planet is 0.4 m, then the length of the seconds pendulum on the second planet is _____.

A. 10 cm

B. 0.5 m

C. 10 m

D. 1.0 m

Answer: D

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37. The value of acceleration due to gravity on the Earth at a distance of 29,000 km from the surgace is $0.3ms^{-2}$. The value of acceleration due to gravity at the same height on a planet whose mass is 66.70×10^{22} kg and diameter is 8700 km is _____ ms_{-2}.

$\left(\text{Take} G = 6.67 \times 10^{-11} Nm^2 kg^{-2}\right)$

A. 0.05

B. 0.04

C. 0.06

D. 0.09

Answer: B

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38. As it falls, the acceleration of a body dropped from the height equal to that of radius of earth,

A. remains the same

B. decreases

C. increases

D. initially increases then decreases

Answer: C

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39. Which is not correct about escape velocity?

A. Escape velocity of a body depends on its mass.

B. Escape velocity of a body is greater than its orbital velocity.

C. Escape velocity of a body is different on different planets.

D. Escape velocity of a body on a planet depends on the mass of the planet.

Answer: A

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40. The line joining the centre of gravity of a cuboid and the centre of the Earth will fall within the base of the body even after being disturbed by an external force. Then the body is said to be in _____.

A. neutral equilibrium

B. stable equilibrium

C. unstable equilibrium

D. dynamic equilibrium

Answer: B

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41. According to Kepler's second law of planetary motion,

A. the line joining the centers of a planet's orbit and the planet covers equal areas in equal intervals of time.

B. the line joining the centers of sun and the planet covers equal area in equal intervals of time.

C. a planet covers equal distances along its orbit in equal intervals of time.

D. area swept by the average radius of orbit of each planet in the solar system is equal.

Answer: B

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42. If the time period of revolution of a planet is increased to $3\sqrt{3}$ times its present value, the percentage increase in its radius of the orbit of revolution is

A. 50

B. 100

C. 200

D. 400

Answer: C

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43. If the acceleration due to gravity at a height 'h' from the surface of the Earth is 96% less than its value on the surface, then h = ____R where R is the radius of the Earth.

A. 1

B. 2

C. 3

D. 4

Answer: D

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44. Given $g_d = g\left(1 - \frac{d}{R}\right)$ where gd and g are the accelerations due to gravity at a depth 'd' km, and on the surface of the Earth, respectively, R is the radius of the Earth, then the depth at which $g_d = \frac{g}{2}$ is_____.

A. R

B. $\frac{R}{2}$

C. $\frac{R}{3}$

D. $\frac{R}{4}$

Answer: B

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Level 2

1. Given that d_e, d_m are densities of the Earth and moon, respectively, D_e, D_m are the diameters of the Earth and the moon,

respectively. $g_e \text{and} g_m$ are the acceleration due to gravity on the surface of the Earth and moon, respectively. Find the ratio of $g_m \text{and} g_e$

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2. A cylindrical vessel containing liquid is placed on the floor of an elevator. When the elevator is mad to acceleration equal to g, disscuss how the centre of gravity of the system containg vessel and liquid changes. Also, discuss how the centre of gravity of the

system containing vessel and liquid changes when the elevator accelerates in the downward direction. Also discuss how the 'weight' would vary in each case.

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3. A hollow sphere is taken as bob of a simple pendulum. This hollow sphere is filled with fine sand. There is a small hole at the bottom of this sphere through which the fine sand leaks

out. How does the time period of this simple pendulum alter? Discuss.

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4. Two satellites of one metric ton and twelve metric tons masses are revolving around the Earth. The heights of these two satellites from the Earth are 1600 km and 25600 km, respectively. What is the ratio of their time periods and what is the ratio of the

accelerations due to gravity at those heights?

(Radius of the Earth = 6400km)

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5. A body of mass 10 kg is dropped from a height of 10 m on a planet, whose mass and radius are double that of the Earth. Find the maximum kinetic energy the body can possess.

$\left(\text{Take} g_E = 10 ms^{-2}\right)$

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6. The escape velocity of a satellite from the surface of a planet is $\sqrt{2}$ times the orbital velocity of the satellite. If the ratio of the masses of two given planets is 1 : 4 and that of their radii is 1 : 2, respectively, then find the ratio of escape velocities of a satellite from the surfaces of two planets.

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7. Find the height from the surface of the moon where the value of 'g' is equal to the

value of 'g' at a height of 57,600 km from the surface of the Earth.

(Take, mass of the Earth, $M_E = 6 \times 10^{24}$ kg, Mass of the moon, $M_m = 7.3 \times 10^{22}$ kg, radius of the Earth, $R_E = 6400$ and radius of the moon, $R_m = 1740km$)

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8. What is the value of the acceleration due to gravity at a height equal to half of the radius of the Earth? Can we use the formula

$g_h = g_0\left(1 - \frac{2h}{R}\right)$? Explain

(take $g_0 = 9.8 ms^{-2}$).

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9. The Earth exerts more force on heavier bodies than on lighter bodies, Why is it then that when dropped, heavier bodies don't fall faster than lighter bodies?

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10. A coke can of negligible mass is in the shape of a cylinder. Its volume is 500 ml and its base area is $\frac{100}{3} cm^2$. A person consumes nearly 25 ml of coke for every sip. After he consumes 12 sips of the drink, what is the height of the center of gravity of the can from its base when placed vertically? If the mass of the can is not negligible, how would this answer vary?

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11. If two bodies od masses 1kg and 4kg are released from the heights where gravitational force on them is equal, then find the height of the heavier body if the lighter body is dropped from a height of 1 km. Take radius of earth as 6400 km.

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12. A mine worker measures his weight inside a mine and finds that it has decreased by 0.05% of that on the surface of the Earth. Then,find

the depth of the mine

(Take the radius of the Earth = 6400 km and acceleration due to gravity on the surface of the Earth, $g = 9.8ms^{-2}$).

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13. If the orbital velocity of the moon is 1020 m s^{-1}, find the time taken by the moon to complete one revolution around the Earth. Explain why this period is different from the period that is observed from the Earth, which

is 29.5 days.

(Take the distance of the moon from the Earth as $3.4 \times 10^8 m$, and $\frac{1}{86400} = 1.157 \times 10^{-5}$)

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14. Two asteroids (heavenly bodies) of equal masses revolve diametricallly opposite to each other in a circle of radius 100 km. If mass of each astreroid is 10^{10} kg, then what would their velocites be

(Take $G = 6.67 \times 10^{-11} Nm^2 kg^{-2}$).

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15. What would the length of a seconds pendulum on the surface of the Earth be if the mass of the Earth remains constant but its volume shrinks to $\frac{1}{8}$th of its original volume. ltBrgt (Take orignal value of acceleration due to gravity as $9.8ms^{-2}$)

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16. Find the ratio of the upthrust on a certain body offered by a liquid placed on the surface of the Earth and on the surface of the moon.

(Take $g_m = \frac{1}{6} g_E$)

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17. When a spring balance, showing a reading of 100 divisions at equator for a body, is taken to the poles, then find the reading shown by it

(Take $\frac{g_p}{g_E} = 1.01$)

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18. Two satellites 'A' and 'B' of masses ten and twenty metric tons revolve around the Earth at two different height h_1 and h_2 from the surface of the Earth. If earth's gravitational pull on these two satellites at these heights is equal, then find the ratio of their distances from the centre of the Earth . (Radius of the Earth = 6400 km)

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19. Acceleration due to gravity on the surface of the Earth is $9.8ms^{-2}$. Find its new vallue if both the radius and mass increase by 20%.

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20. A person can jump to a height of 3 m at the equator of the Earth. Considering the same initial velocity for jumping, to what height can he jump at the poles? The radius of the Earth at the poles and the equator is 6357

km 6378 km, respectively.

Given, $\frac{6357}{6378} = 0.9967$

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21. The weight of a person on the surface of the Earth is 490 N. Find his weight on the surface of Jupiter and the moon. Also, compare it with his weight on the Earth.

Mass of moon $= 7.3 \times 10^{22}$ kg,

Mass of Jupiter $= 1.96 \times 10^{27}$ kg,

Radius of moon $= 1.74 \times 10^{6}$ m and radius of

Jupiter $= 7 \times 10^7$ m

$G = 6.67 \times 10^{-11} Nm^2 kg^{-2}$ ltBrgt Given,

$\frac{1}{1.742} = 0.33 \text{and ge} = 9.8 ms^{-2}$

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22. A sphere and a cube having same volume and height of cube is equal to the radius of the sphere placed on a horizontal surface. What is the ratio of the heights of their centre of gravities from the surface?

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23. The leaning tower of PISA does not collapse inspite of being in a slanting position. Explain.

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24. A cylinder and a hollow sphere are placed on a surface. If the height of the cylinder is equal to the diameter of the sphere, what is the ratio of the heights of centre of gravity of

the cylinder and the sphere from the surfaced?

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25. A Person stood in an accelerating elevartor. Explain how the apparent weight of this person varies.

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Level 3

1. For planets revolving round the sun, show that $T^2 \propto r^3$, where T is the time period of revolution of the planet and r is its distance from the sun.

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2. It is well known that there exists a gravitational force of attraction between the Earth and the sun. Then, why does the Earth not collide with the sun? Is it possible for

three bodies of equal mass to be at rest relative to each other? Explain.

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3. A water tank has a capacity of 1000 litres. It is in the shape of a cylinder. The length of the cylinder is 1 metre. An electric motor pump set is used to fill the water in the tank. This pumpset lifts 120 litres of water per minute. What is the velocity in the shift of centre of gravity of the water tank?

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4. What is the force acting on a body of mass 10,000 kg on earth, due to the gravity of the sun? Also find the force on the body due to the gravity of the moon. Which exerts more force, the sun or the moon?

Mass of the sun $= 2 \times 10^{30}$ kg,

Mass of the moon $= 7.3 \times 10^{22}$ kg,

Distance between the sun and the Earth $= 1.5 \times 10^{11} m$

Distance between the moon and the Earth

$= 3.84 \times 10^8 m$

Radius of the Earth $= 6.4 \times 10^6 m$

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5. A man weighs 'W' on the surface of the earth and his weight at a height 'R' from surface of the earth is (R is Radius of the earth)

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6. At a height (h) from the surface of the Earth, a simple pendulum of length 1/2 m oscillates with a frequency equal to 0.5 Hz. Then find the value of 'h' . Take, mass of the Earth, $M = 6 \times 10^{24}$ kg, radius of the Earth, $R = 6400km$ and $\pi^2 = 10$.

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7. An athlete can jump to a maximum height of 4 m on the surface of the Earth. Considering

the same initial velocity for jumping, to what heighr can he jump from the surface of the moon? [Take, acceleration due to gravity on earth (gE) as $9.8ms^{-2}$ and acceleration due to gravity on the surface of moon as $\frac{1}{6}g_E$]

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8. If two spheres of mass 100 tonne each, revolve diametrically opposite to each other in a circle of radius 1 m, what should be their velocities? (Take $g = 6.67 \times 10^{-11} Nm^2 kg^{-2}$)

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9. The orbital velocity of a satellite is given by the expression $V =$ sqrt((GM)/(R + h))`, here M is the mass of the Earth, R is the radius of the Earth and 'h' is the height of the satellite from the surface of the Earth. Explain the reasons why the geostationary satellite is not possible to set in orbit around the Earth at two different heights from the surface of the Earth.

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10. A body is dropped from a height of 40 m from the surface of the Earth. Its final velocity is 28 m s^{-1}. What would be the final velocity of the body, if it is dropped from the same height on another planet where the acceleration due to gravity is 2.5 m s^{-2}. Assume atmospheric conditions to be similar. (Take earth = 10 m s^{-2})

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