Gravitation JEE Main PYQ - 3

Total Time: 1 Hour : 15 Minute **Total Marks:** 120

Instructions

Instructions

1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Gravitation

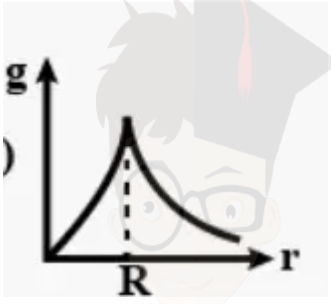
1. The elongation of a wire on the surface of the earth is 10^{-4}m. The same wire of same dimensions is elongated by 6×10^{-5}m on another planet. The acceleration due to gravity on the planet will be ___ ms^{-2}. (Take acceleration due to gravity on the surface of earth = 10 ms^{-2}) **(+4, -1)**

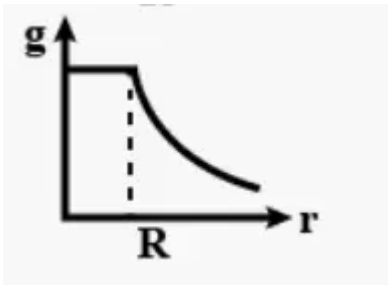
---

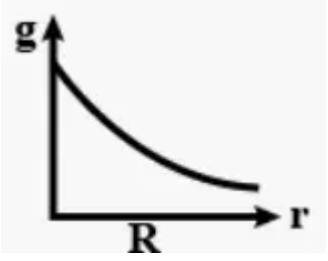
2. A ball of mass 0.5 kg is dropped from the height of 10 m. The height, at which the magnitude of velocity becomes equal to the magnitude of acceleration due to gravity, is ___ m.
[Use g = 10 m/s^2] **(+4, -1)**

---

3. The variation of acceleration due to gravity (g) with distance (r) from the center of the earth is correctly represented by
(Given R = radius of earth) **(+4, -1)**

a. 

b. 

c. 

d. 

---

4. **Assertion:** The angular velocity of the moon revolving around the earth is more than that of the earth revolving around the Sun. **(+4, -1)**
Reason: The time taken by the moon to revolve around the earth is less than the time taken by the earth to revolve around the sun.

   a. Both Assertion (A) and Reason (R) are the true and Reason (R) is a correct explanation of Assertion (A).

   b. Both Assertion (A) and Reason (R) are the true but Reason (R) is not a correct explanation of Assertion (A).

   c. Assertion (A) is true and Reason (R) is false.

   d. Assertion (A) is false and Reason (R)

---

5. The area of cross section of the rope used to lift a load by a crane is 2.5×10^{-4} m^2. The maximum lifting capacity of the crane is 10 metric tons. To increase the lifting capacity of the crane to 25 metric tons, The required area of cross section of the rope should be **(+4, -1)**

   a. $6.25 \times 10^{-4}\ m^2$

   b. $10 \times 10^{-4}\ m^2$

   c. $1 \times 10^{-4}\ m^2$

   d. $1.67 \times 10^{-4}\ m^2$

---

6. The time period of a satellite revolving around earth in a given orbit is 7 hours. If the radius of orbit is increased to three times its previous value, then approximate new time period of the satellite will be **(+4, -1)**

a. 40 hours

b. 36 hours

c. 30 hours

d. 25 hours

---

7. Two planets *A* and *B* of equal mass are having their period of revolutions T_A and T_B such that $T_A = 2T_B$. These planets are revolving in the circular orbits of radii r_A and r_B respectively. Which out of the following would be the correct relationship of their orbits? **(+4, -1)**

a. $2r_A^2 = r_B^3$

b. $r_A^3 = 2r_B^3$

c. $r_A^3 = 4r_B^3$

d. $T_A^2 - T_B^2 = \frac{\pi^2}{GM}(r_B^3 - 4r_A^3)$

---

8. The percentage decrease in the weight of a rocket, when taken to a height of 32 km above the surface of earth will, be:
(Radius of earth = 6400 km) **(+4, -1)**

a. 1%

b. 3%

c. 4%

d. 0.50%

---

9. A body is projected vertically upwards from the surface of earth with a velocity equal to one third of escape velocity. The maximum height attained by the body will be: **(+4, -1)**

a. 800 km

b. 1600 km

c. 2133 km

d. 4800 km

---

10. A ball of mass $0.15\ kg$ hits the wall with its initial speed of $12\ ms^{-1}$ and bounces back without changing its initial speed. If the force applied by the wall on the ball during the contact is $100\ N$, calculate the time duration of the contact of ball with the wall. **(+4, -1)**

a. 0.018 s

b. 0.036 s

c. 0.009 s

d. 0.072 s

---

11. Given below are two statements: One is labelled as Assertion A and the other is labelled as Reason R. **(+4, -1)**

Assertion A: If we move from poles to equator, the direction of acceleration due to gravity of earth always points towards the center of earth without any variation in its magnitude.

Reason R: At equator, the direction of acceleration due to the gravity is towards the center of earth.

In the light of above statements, choose the correct answer from the options given below

a. Both A and R are true and R is the correct explanation of A.

b. Both A and R are true but R is NOT the correct explanation of A.

c. A is true but R is false.

d. A is false but R is true.

---

12. **Given below are two statements.** **(+4, -1)**

Statement-I: The law of gravitation holds good for any pair of bodies in the universe.

Statement-II: The weight of any person becomes zero when the person is at the centre of the earth.

In the light of the above statements, choose the *correct* answer from the options given below

a. Both Statement I and Statement II are true

b. Both Statement I and Statement II are false

c. Statement I is true but Statement II is false

d. Statement I is false but Statement II is true

---

13. The approximate height from the surface of the earth at which the weight of the body becomes $\frac{1}{3}$ of its weight on the surface of earth is [Radius of earth R = 6400 km and $\sqrt{3}$=1.732] **(+4, -1)**

a. 3840 km

b. 4685 km

c. 2133 km

d. 4267 km

---

14. The height of any point P above the surface of earth is equal to diameter of earth. The value of acceleration due to gravity at point P will be (Given g = acceleration due to gravity at the surface of earth). **(+4, -1)**

a. $\frac{g}{2}$

b. $\frac{g}{4}$

c. $\frac{g}{3}$

d. $\frac{g}{9}$

15. The percentage decrease in the weight of a rocket, when taken to a height of $32\,km$ above the surface of earth will, be : (Radius of earth $= 6400\,km$) **(+4, -1)**

a. 1%

b. 3%

c. 4%

d. 0.5%

---

16. If the radius of earth shrinks by 2% while its mass remains same The acceleration due to gravity on the earth's surface will approximately : **(+4, -1)**

a. decrease by 2%

b. decrease by 4%

c. increase by 2%

d. increase by 4%

---

17. The escape velocities of two planets A and B are in the ratio $1:2$ If the ratio of their radii respectively is $1:3$, then the ratio of acceleration due to gravity of planet A to the acceleration of gravity of planet B will be : **(+4, -1)**

a. $\frac{3}{2}$

b. $\frac{2}{3}$

c. $\frac{3}{4}$

d. $\frac{4}{3}$

---

18. Given below are two statements, one is labelled as Assertion A and the other is labelled as Reason R Assertion (A): Acceleration due to gravity is minimum at equator. Reason (R): Rotation of earth influences acceleration. In the light **(+4, -1)**

of the above statements, choose the correct answer from the options given below

a. A is correct, R is correct explanation of A

b. A is correct, R is incorrect explanation of A

c. A is correct and R is incorrect

d. Both A and R are incorrect

---

19. A planet has double the mass of the earth. Its average density is equal to that of the earth. An object weighing W on earth will weigh on that planet: **(+4, -1)**

a. 1

b. $(2)^{\frac{1}{3}}$

c. $(2)^{-\frac{1}{3}}$

d. 2

---

20. Given below are two statements, one is labelled as Assertion A and the other is labelled as Reason R Assertion (A): Earth has atmosphere and moon doesn't Reason (R): escape speed on moon is less than that Earth. In the light of the above statements, choose the correct answer from the options given below **(+4, -1)**

a. (A) and (R) are correct and (R) is the correct explanation of (A)

b. (A) and (R) are correct and (R) is not the correct explanation of (A)

c. (A) is true but (R) is false

d. (A) and (R) both are false

---

21. An object weighs 200N at the surface of earth. Find the weight at a depth of $\frac{R}{2}$, where R is radius of earth **(+4, -1)**

a. 100N

b. 300N

c. 50N

d. 150N

---

22. Which of the following expressions give the value of acceleration due to gravity (g') at the altitude h above the surface of Earth. (R = radius of Earth, g = acceleration due to gravity at surface of Earth) **(+4, -1)**

a. $g' = g\left(1 - \frac{h^2}{2R^2}\right)$

b. $g' = g\left(1 - \frac{2h}{R}\right)$

c. $g' = g\left(1 - \frac{h}{2R}\right)$

d. $g' = g\left(1 - \frac{2h^2}{R^2}\right)$

---

23. Suppose a situation in which two planets orbits around the sun in the same orbit. If the mass of plant 1 is twice the mass of planet 2, then what do they have same? **(+4, -1)**

a. Potential energy

b. Kinetic energy

c. Total energy

d. Velocity

---

24. Two identical particles each of mass m, move in circular path due to their own mutual gravitational force. Find the velocity of the particle if the radius of the circular path is a. **(+4, -1)**

a. $\frac{\sqrt{4Gm}}{a}$

b. $\frac{\sqrt{Gm}}{2a}$

c. $\frac{\sqrt{2Gm}}{a}$

d. $\frac{\sqrt{Gm}}{4a}$

---

25. If a planet has mass equal to 16 times the mass of earth, and radius equal to 4 times that of earth. The ratio of escape speed of a planet to that of earth is? **(+4, -1)**

a. 2:1

b. 1:2

c. $\sqrt{2}$:1

d. 4:1

---

26. Choose the incorrect statement from the given statements. **(+4, -1)**

a. Planets revolve around the Sun with constant linear speed.

b. Energy of the planet in elliptical orbit is constant.

c. Satellites in circular motion have constant energy.

d. Body falling towards the Earth results in negligible displacement of the Earth.

---

27. **The weight of a body on the surface of the earth is 100 N. The gravitational force on it when taken at a height, from the surface of earth, equal to one-fourth the radius of the earth is:** **(+4, -1)**

a. 25 N

b. 64 N

c. 100 N

d. 50 N

---

28. A planet has density same as that of Earth and mass is twice that of Earth. If the weight of an object on Earth is "W" then the weight on the planet is: **(+4, -1)**

a. $2^{\frac{2}{3}}W$

b. $2^{\frac{1}{3}}W$

c. $2^{\frac{4}{3}}W$

d. W

---

29. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R). **(+4, -1)**

Assertion (A): Earth has atmosphere and moon doesn't

Reason (R): escape speed on moon is less than that of Earth.

In the light of the above statements, choose the correct answer from the options given below:

a. (A) and (R) are correct and (R) is the correct explanation of (A)

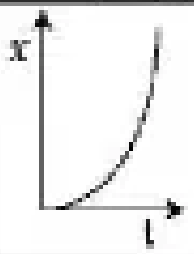
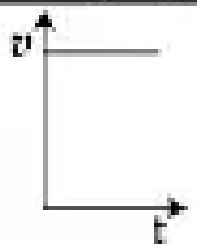
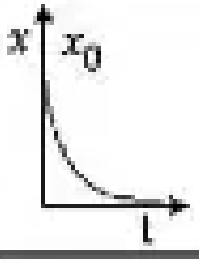
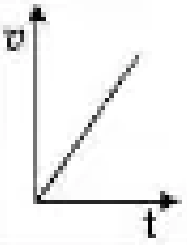
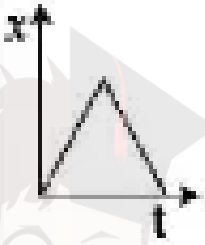
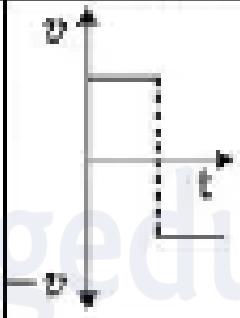
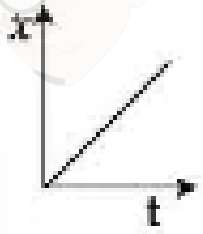
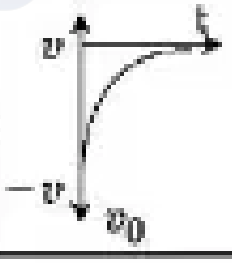
b. (A) and (R) are correct and (R) is not the correct explanation of (A)

c. (A) is true but (R) is false

d. (A) and (R) both are false

---

30. Match Column-I with Column-II : Choose the correct answer from the options given below: **(+4, -1)**

Column-I (x-t graphs)		Column-II (v-t graphs)	
A.		I.	
B.		II.	
C.		III.	
D.		IV.	

a. A- I, B-III, C-IV, D-II

b. A- II, B-IV, C-III, D-I

c. A- II, B-III, C-IV, D-I

d. A- I, B-II, C-III, D-IV

Answers

1. **Answer: 6 - 6**

Explanation:

$\Delta I = \frac{M' g I}{2Ay}$
$\Rightarrow \Delta l \ \propto \ g$
$\Rightarrow \frac{g_p}{g_e} = \frac{\Delta I_p}{\Delta I_e} = \frac{6\times10^{-5}}{10\times10^{-5}}$
$\Rightarrow \ g_p \ = 6m/s^2 \ as \ g_e \ = 10m/s^2$

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2) \ldots . (1)$
- $(F \propto 1/r^2) \ldots . (2)$

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2 \ldots . (7)$

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

2. **Answer: 5 - 5**

Explanation:

$gt = g$
$\Rightarrow t = 1sec$
$\Delta h = \frac{1}{2}gt^2 = \frac{1}{2} \times 5 \times 12^2 = 5\,\mathrm{m}$
$\therefore h = H - \Delta h$
$= 10–5 = 5m$

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ . . . . (1)
- $(F \propto 1/r^2)$ . . . . (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ . . . . (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

3. Answer: a

Explanation:

For $r < R$

$g = \frac{Gmr}{R^3} = Cr$ (C=Constant)

For $r > R$

$g = \frac{Gm}{R^2} = \frac{C}{r^2}$ $(C = Constant)$

So, for the above equations the best suited graph is as given in option (A)

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ . . . . (1)
- $(F \propto 1/r^2)$ . . . . (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ . . . . (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

4. Answer: a

Explanation:

The question involves understanding the concept of angular velocity within the context of celestial bodies—specifically, the Moon revolving around the Earth and the Earth revolving around the Sun.

Angular Velocity Explanation:

- Angular velocity (ω) is defined as the rate of change of the angular displacement and is usually measured in radians per second.
- The formula to calculate angular velocity is $\omega = \frac{2\pi}{T}$, where T is the period of revolution.

Comparison:

- For the Moon revolving around the Earth, the time period T_{moon} is approximately 27.3 days.
- For the Earth revolving around the Sun, the time period T_{earth} is approximately 365.25 days.

Since $T_{\text{moon}} < T_{\text{earth}}$, it follows that the Moon has a greater angular velocity because:

$$\omega_{\text{moon}} = \frac{2\pi}{T_{\text{moon}}} > \frac{2\pi}{T_{\text{earth}}} = \omega_{\text{earth}}$$

Analysis of Assertion and Reason:

- **Assertion (A):** The angular velocity of the moon revolving around the Earth is more than that of the Earth revolving around the Sun. **This is true**, as calculated above.
- **Reason (R):** The time taken by the Moon to revolve around the Earth is less than the time taken by the Earth to revolve around the Sun. **This is true** and it properly explains why the angular velocity of the Moon is greater.

Thus, the correct answer is: **Both Assertion (A) and Reason (R) are true and Reason (R) is a correct explanation of Assertion (A).**

Concepts:

1. Gravitational Potential Energy:

The work which a body needs to do, against the force of gravity, in order to bring that body into a particular space is called Gravitational potential energy. The stored is the result of the gravitational attraction of the Earth for the object. The GPE of the massive ball of a demolition machine depends on two variables - the mass of the ball and the height to which it is raised. There is a direct relation between GPE and the mass of an object. More massive objects have greater GPE. Also, there is a direct

relation between GPE and the height of an object. The higher that an object is elevated, the greater the GPE. The relationship is expressed in the following manner:

PE_{grav} = mass x g x height

PE_{grav} = m x g x h

Where,

m is the mass of the object,

h is the height of the object

g is the gravitational field strength (9.8 N/kg on Earth) - sometimes referred to as the acceleration of gravity.

---

5. **Answer: a**

Explanation:

area of cross section of the rope :

$= \frac{25}{10} \times 2.5 \times 10^{-4} \left[A_2 = \frac{W_2}{W_1} A_1\right]$

$= 6.25 \times 10^{-4}\ m^2$

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ .... (1)
- $(F \propto 1/r^2)$ .... (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2 \ldots . (7)$

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

6. **Answer: b**

Explanation:

The correct answer is (B) : 36 hours
$T_2^2 = (\frac{R_2}{R_1})^3 T^2{}_1$
$\Rightarrow T_2 = (3)^{3/2} \times 7 \approx 5.2 \times 7$
T2 ≅ 36 hrs

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2) \ldots . (1)$
- $(F \propto 1/r^2) \ldots . (2)$

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2 \ldots . (7)$

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

7. Answer: c

Explanation:

The correct answer is (C) : $r_A^3 = 4r_B^3$
$T_A = 2T_B$
Now
$T_A^2 \propto r_A^3$
$\Rightarrow (\frac{r_A}{r_B})^3 = (\frac{T_A}{T_B})^2$
$\Rightarrow r_A^3 = 4r_B^3$

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ . . . . (1)
- $(F \propto 1/r^2)$ . . . . (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ . . . . (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

8. **Answer: a**

Explanation:

We know that,

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

The percentage decrease in the weight of a rocket,

$\Rightarrow \frac{\Delta g}{g} = 2\frac{\Delta r}{r}$

$\Rightarrow \frac{\Delta g}{g} \times 100 = 2 \times \frac{32}{6400} \times 100$

$\Rightarrow \frac{\Delta g}{g} = 1$

% decrease in weight = 1

So, the correct option is (A): 1

Concepts:

1. **Gravitation:**

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ . . . . (1)
- $(F \propto 1/r^2)$ . . . . (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ . . . . (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

9. **Answer: a**

Explanation:

As per the theory of conservation of energy

$$-\frac{GM_em}{R_e}+\frac{1}{2}m\left(\frac{1}{3}\sqrt{\frac{2Gm_e}{R_e)}}\right)^2=-\frac{GM_em}{R_e+h}$$

$$-\frac{GM_em}{R_e}+\frac{GM_em}{9R_e}=-\frac{GM_em}{R_e+h}$$

$$\frac{8}{9R_e}=\frac{1}{R_e+h}$$

Therefore, the maximum height attained by the body will be:

$$\Rightarrow h=\frac{R_e}{8}$$

$$=\frac{6400}{8}$$

$$=800\ km$$

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ .... (1)
- $(F \propto 1/r^2)$ .... (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ .... (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

10. Answer: b

Explanation:

Force applied by the wall on the ball during the contact is = $100\ N$

$\Rightarrow \Delta P = 2 \times 0.15 \times 12$

$= 3.6$

Hence, $t = \frac{3.6}{100}$

$= 0.036\ s$

Hence, the correct option is (B): $0.036\ s$

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ .... (1)
- $(F \propto 1/r^2)$ .... (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2 \ldots . (7)$

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

11. Answer: d

Explanation:

The correct answer is (D): A is false but R is true.
$g' = g_0 - \omega^2 R\cos^2\theta$
θ = latitude.

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2) \ldots . (1)$
- $(F \propto 1/r^2) \ldots . (2)$

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2 \ldots . (7)$

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

12. **Answer: a**

Explanation:

Statement-I is true as law of gravitation is a universal law

Statement-II is also true as gravitational field at centre of earth is zero.

Therefore, the correct option is (A): **Both Statement I and Statement II are true**

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ . . . . (1)
- $(F \propto 1/r^2)$ . . . . (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ . . . . (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

13. **Answer: b**

Explanation:

According to the given information

$\frac{GM}{(R+h)^2} = \frac{1}{3} \times \frac{GM}{R^2}$

$\Rightarrow$ R+h=$\sqrt{3}$ R

$\Rightarrow$ h=($\sqrt{3}$-1)R~4685 km

The correct option is (B) : 4685 km

Concepts:

1. Gravitational Potential Energy:

The work which a body needs to do, against the force of gravity, in order to bring that body into a particular space is called **Gravitational potential energy**. The stored is the result of the gravitational attraction of the Earth for the object. The GPE of the massive ball of a demolition machine depends on two variables - the mass of the ball and the height to which it is raised. There is a direct relation between GPE and the mass of an object. More massive objects have greater GPE. Also, there is a direct relation between GPE and the height of an object. The higher that an object is elevated, the greater the GPE. The relationship is expressed in the following manner:

PE_{grav} = mass x g x height

PE_{grav} = m x g x h

Where,

m is the mass of the object,

h is the height of the object

g is the gravitational field strength (9.8 N/kg on Earth) - sometimes referred to as the acceleration of gravity.

---

14. Answer: d

Explanation:

We know that

$g' = \frac{GM}{(R+h)^2}$

Given $h = 2R$

$g' = \frac{GM}{(R+2R)^2}$

$g' = \frac{GM}{(3R)^2}$

$g' = \frac{GM}{9R^2}$

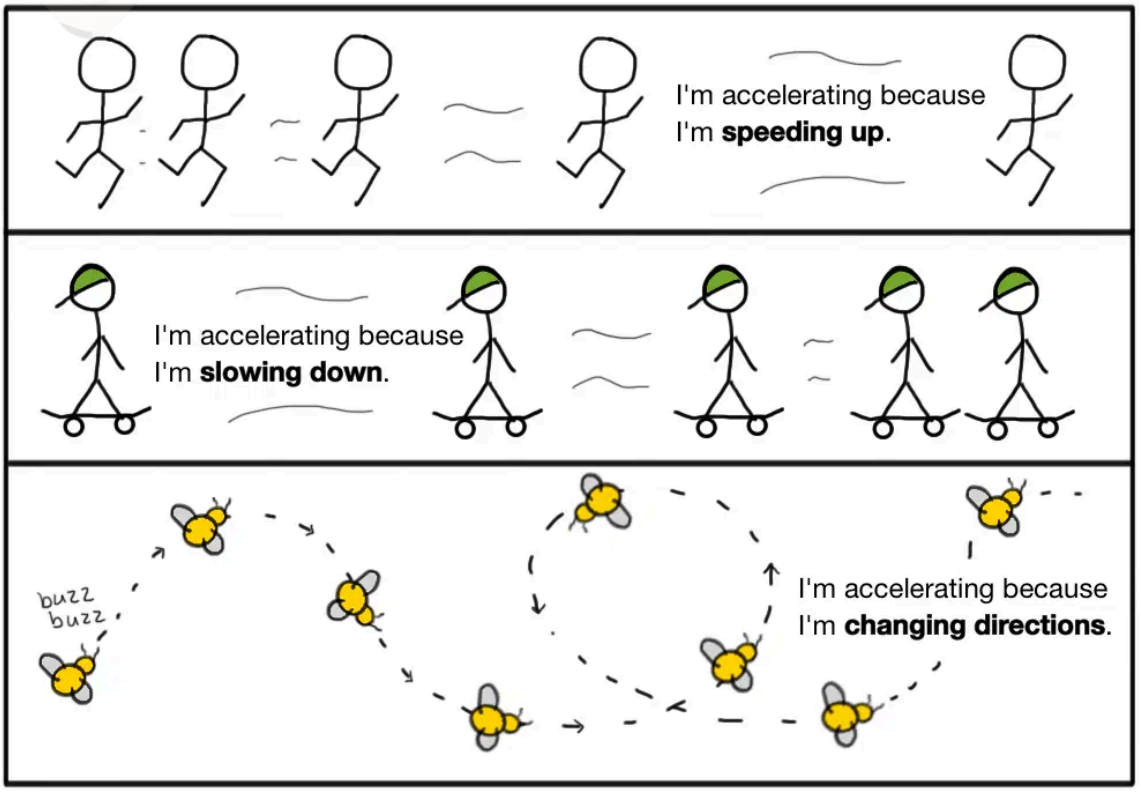
$g' = \frac{g}{9}$

so, the correct option is (D): $\frac{g}{9}$

Concepts:

1. Acceleration:

In the real world, everything is always in motion. Objects move at a variable or a constant speed. When someone steps on the accelerator or applies brakes on a car, the speed of the car increases or decreases and the direction of the car changes. In physics, these changes in velocity or directional magnitude of a moving object are represented by acceleration.



15. **Answer: a**

Explanation:

The correct option is(A): 1%.

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ . . . . (1)
- $(F \propto 1/r^2)$ . . . . (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ . . . . (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

16. **Answer: d**

Explanation:

From the given options the correct answer is option (D): increase by 4%

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ . . . . (1)
- $(F \propto 1/r^2)$ . . . . (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ . . . . (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

17. Answer: c

Explanation:

Step 1: Recall the Formula for Escape Velocity

The escape velocity (V_e) of a planet is given by:

$$V_e = \sqrt{\frac{2GM}{R}}$$

where G is the gravitational constant, M is the mass of the planet, and R is the radius of the planet. We can also express the mass M in terms of density (ρ) and volume:

$$M = \rho \times \frac{4}{3}\pi R^3$$

Substituting this into the escape velocity formula gives:

$$V_e = \sqrt{\frac{2G(\rho \times \frac{4}{3}\pi R^3)}{R}} = \sqrt{\frac{8G\pi}{3}R^2} = C\sqrt{\rho R}$$

where C is a constant.

Step 2: Set Up the Ratio of Escape Velocities

Let V_{e1} and V_{e2} be the escape velocities of planets A and B respectively, and let R_1 and R_2 be their radii, and ρ_1 and ρ_2 their densities. Given:

$$\frac{V_{e1}}{V_{e2}} = \frac{C\sqrt{\rho_1 R_1}}{C\sqrt{\rho_2 R_2}} = \frac{1}{2}$$

and

$$\frac{R_1}{R_2} = \frac{1}{3},$$

we have:

$$\sqrt{\frac{\rho_1 R_1}{\rho_2 R_2}} = \frac{1}{2}$$

$$\frac{\rho_1 R_1}{\rho_2 R_2} = \frac{1}{4}$$

$$\frac{\rho_1}{\rho_2} = \frac{1}{4} \times \frac{R_2}{R_1} = \frac{1}{4} \times 3 = \frac{3}{4}.$$

Step 3: Recall the Formula for Acceleration Due to Gravity

The acceleration due to gravity (g) on a planet is given by:

$$g = \frac{GM}{R^2} = \frac{G \times \frac{4}{3}\pi R^3 \rho}{R^2} = \frac{4\pi G \rho R}{3} = C\rho R,$$

where $C = \frac{4\pi G}{3}$ is a constant.

Step 4: Find the Ratio of Accelerations Due to Gravity

Let g_1 and g_2 be the accelerations due to gravity on planets A and B, respectively. Then:

$$\frac{g_1}{g_2} = \frac{C\rho_1 R_1}{C\rho_2 R_2} = \frac{\rho_1 R_1}{\rho_2 R_2} = \frac{1}{4} \times \frac{R_2}{R_1} = \frac{R_1}{R_2} \times \frac{\rho_1}{\rho_2} = \frac{1}{4} \times 3 = \frac{3}{4}.$$

Conclusion:

The ratio of the acceleration due to gravity of planet A to that of planet B is $\frac{3}{4}$ (Option 3).

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ . . . . (1)
- $(F \propto 1/r^2)$ . . . . (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ . . . . (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

18. Answer: a

Explanation:

The correct answer is option (A) A is correct, R is correct explanation of A

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ . . . . (1)
- $(F \propto 1/r^2)$ . . . . (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ . . . . (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

19. Answer: b

Explanation:

The correct answer is option (B): $(2)^{\frac{1}{3}}$

$$\frac{g_p}{g_e} = \frac{GM_p / R_p^2}{GM_e / R_e^2} = \frac{\left(M_p / \rho_p^2\right)^{1/3}}{\left(M_e / \rho_e^2\right)^{1/3}}$$

$$= \left(M_p / M_e\right)^{1/3}$$

$$= (2)^{1/3}$$

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ . . . . (1)
- $(F \propto 1/r^2)$ . . . . (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ . . . . (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

20. Answer: a

Explanation:

The correct answer is option (A): (A) and (R) are correct and (R) is the correct explanation of (A)

Both (A) and (R), are true and the escape speed on the moon is less due to its small radius and acceleration due to gravity as compared to earth.

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ . . . . (1)
- $(F \propto 1/r^2)$ . . . . (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2 \ldots . (7)$

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

21. Answer: a

Explanation:

Given the weight of the object on the surface of the Earth, mg = 200 N
Where, m is the mass of the object and g is acceleration due to gravity on the surface of the earth.
The variation of acceleration due to gravity (g) with the depth (d) from the surface of the Earth is given by
$gd=g_1-dR$
Where
gd is the acceleration due to gravity at depth d
R is the radius of the Earth
At depth d = $\frac{R}{2}$, acceleration due to gravity is given by
$gd=g_1-\frac{R}{2R}=g_2$
Multiplying both sides by mass of the object, then we get
mgd = $\frac{mg}{2}$
But, mg = 200 N
Therefore, Weight of the object at depth R/2 is given by
mgd = $\frac{200}{2}$ = 100 N
Answer. A

Concepts:

1. Newtons Law of Gravitation:

Gravitational Force

Gravitational force is a central force that depends only on the position of the test mass from the source mass and always acts along the line joining the centers of the two masses.

Newton's Law of Gravitation:

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- **Directly proportional** to the product of their masses i.e. $F \propto (M_1M_2)$ .... (1)
- **Inversely proportional** to the square of the distance between their center i.e. $(F \propto 1/r^2)$ .... (2)

By combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ .... (7)

Or, $f(r) = GM_1M_2/r^2$ [f(r)is a variable, Non-contact, and conservative force]

---

22. Answer: b

Explanation:

The acceleration due to gravity at a height h above the Earth's surface is:

$$g' = \frac{GM}{(R+h)^2}.$$

Using the binomial expansion for $(1+\frac{h}{R})^2$, neglecting higher-order terms:

$$\frac{1}{(1+\frac{h}{R})^2} \approx 1 - \frac{2h}{R}.$$

Substituting this approximation:

$$g' = \frac{GM}{R^2}\left(1 - \frac{2h}{R}\right).$$

Since $g = \frac{GM}{R^2}$, we can write:

$$g' = g\left(1 - \frac{2h}{R}\right).$$

Final Answer: The acceleration due to gravity is:

$$\boxed{g' = g\left(1 - \frac{2h}{R}\right).}$$

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ .... (1)
- $(F \propto 1/r^2)$ .... (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ .... (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

23. Answer: a

Explanation:

The correct option is (D): Velocity

$$v = \sqrt{\frac{GM}{r}}\ ;\ M = \text{mass of sun}$$

$$\text{P.E.} = -\frac{GMm}{r}$$

m, different so different P.E.

$$\text{K.E.} = \frac{1}{2}mv^2$$

m, different so different K.E.

T.E. will be different.

Concepts:

1. **Keplers Laws:**

Kepler's laws of planetary motion are three laws describing the motion of planets around the sun.

Kepler First law – The Law of Orbits

All the planets revolve around the sun in elliptical orbits having the sun at one of the foci.

Kepler's Second Law – The Law of Equal Areas

It states that the radius vector drawn from the sun to the planet sweeps out equal areas in equal intervals of time.

Kepler's Third Law – The Law of Periods

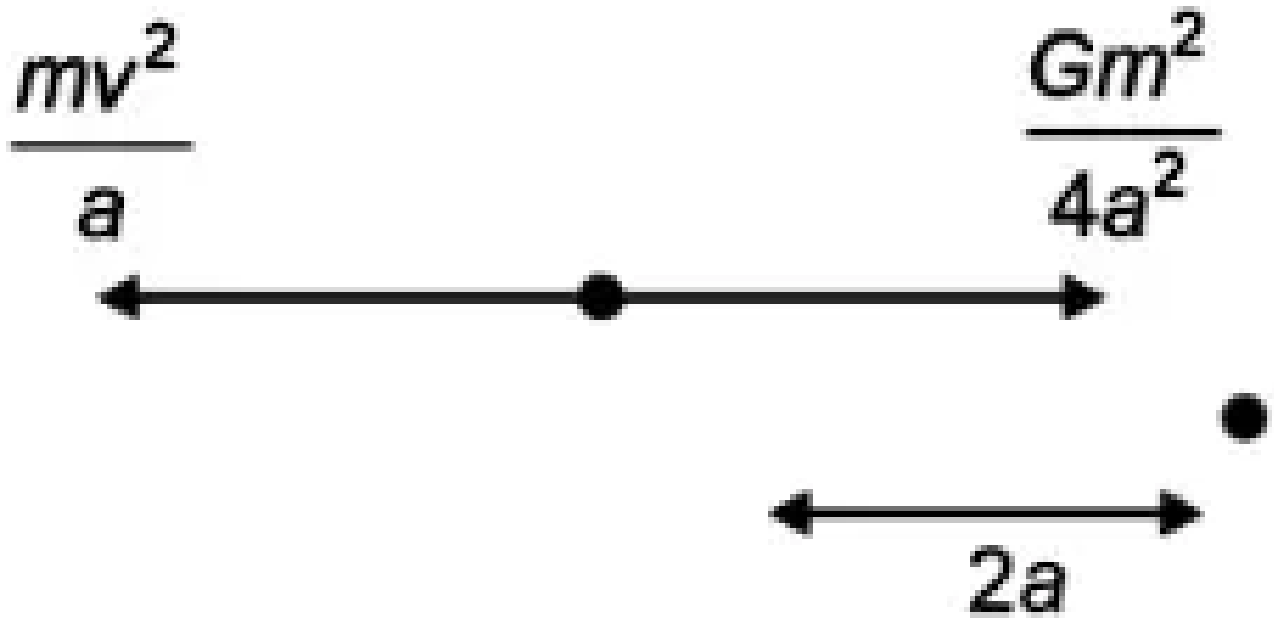
It states that the square of the time period of revolution of a planet is directly proportional to the cube of its semi-major axis.

$$T^2 \propto a^3$$

---

24. Answer: d

Explanation:



$\frac{mv^2}{a} = \frac{Gm^2}{4a^2}$

$\Rightarrow v = \sqrt{\frac{Gm}{4a}}$

Hence the correct option is (D): $\frac{\sqrt{Gm}}{4a}$

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ .... (1)
- $(F \propto 1/r^2)$ .... (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ .... (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

---

25. Answer: a

Explanation:

Solution:
The escape velocity is given by the formula:

$$v_e = \sqrt{\frac{2GM}{R}}$$

where:

v_e is the escape velocity

G is the gravitational constant

M is the mass of the celestial body

R is the radius of the celestial body

Let:

M_p be the mass of the planet

R_p be the radius of the planet

M_e be the mass of the Earth

R_e be the radius of the Earth

v_{ep} be the escape velocity of the planet

v_{ee} be the escape velocity of the Earth

Given:

$M_p = 16M_e$

$R_p = 4R_e$

Escape velocity of Earth:

$$v_{ee} = \sqrt{\frac{2GM_e}{R_e}}$$

Escape velocity of the planet:

$$v_{ep} = \sqrt{\frac{2GM_p}{R_p}}$$

Ratio:

$$\frac{v_{ep}}{v_{ee}} = \frac{\sqrt{\frac{2GM_p}{R_p}}}{\sqrt{\frac{2GM_e}{R_e}}} = \sqrt{\frac{M_pR_e}{M_eR_p}}$$

Substitute the given values:

$$\frac{v_{ep}}{v_{ee}} = \sqrt{\frac{16M_eR_e}{M_e4R_e}} = \sqrt{\frac{16}{4}} = \sqrt{4} = 2$$

Therefore, the ratio of the escape velocity of the planet to the escape velocity of Earth is 2:1.

The correct answer is (2) 2:1.

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ .... (1)
- $(F \propto 1/r^2)$ .... (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ .... (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

26. **Answer: a**

Explanation:

The incorrect option is (A): Planets revolve around the Sun with constant linear speed.
The correct answer should be Planet revolves around the Sun in elliptical orbit with variable speed.

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ . . . . (1)
- $(F \propto 1/r^2)$ . . . . (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ . . . . (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

27. **Answer: b**

Explanation:

Using Newton's formula:

$$F = \frac{GMm}{r^2}$$

At surface of the earth,

$$F = \frac{GMm}{R_e^2} \quad (\text{eq. } 1)$$

At $r = R_e + \frac{R_e}{4} = \frac{5R_e}{4}$,

$$F' = \frac{GMm}{\left(\frac{5R_e}{4}\right)^2} = \frac{16GMm}{25R_e^2}$$

Thus,

$$F' = \frac{16}{25}F = \frac{16}{25} \times 100 = 64\,N$$

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ .... (1)
- $(F \propto 1/r^2)$ .... (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ .... (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

28. **Answer: b**

Explanation:

The correct option is(B): $2^{\frac{1}{3}}W$

Planet with the mass M has radius as R and Planet with mass 2M has radius as R'

$\rho\frac{4}{3}\pi R^3 = M$

$\rho\frac{4}{3}\pi R'^3 = 2M$

$\Rightarrow R' = 2^{\frac{1}{3}}R$

$= 2\frac{GM}{2^{\frac{2}{3}}R^2} = 2^{\frac{1}{3}}\frac{Gm}{R^2} = 2^{\frac{1}{2}}W$

$W' = 2^{\frac{1}{3}}W$

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ .... (1)
- $(F \propto 1/r^2)$ .... (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ .... (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

29. **Answer: a**

Explanation:

The correct option is (A): (A) and (R) are correct and (R) is the correct explanation of (A)

$V_{esc} = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2G}{R} \times \frac{\rho 4}{3}\pi R^3}$

$V_{esc} \propto R$

As the moon's radius is very small as compared to earth. V_{esc} at the moon is quite low and the gas molecules attains escape velocity at normal temperature on the moon.

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ .... (1)
- $(F \propto 1/r^2)$ .... (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ .... (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.

30. **Answer: b**

Explanation:

$\frac{dx}{dt}$ = slope ≥ 0 always increasing
(A - II)
$\frac{dx}{dt} < 0$; and at $t \to \infty \frac{dx}{dt} \to 0$
(B - IV)
$\frac{dx}{dt} > 0$ for first half $\frac{dx}{dt} < 0$ for second half.
(C - III)
$\frac{dx}{dt} =$ constant
(D - I)

Concepts:

1. Gravitation:

In mechanics, the universal force of attraction acting between all matter is known as **Gravity**, also called **gravitation**, . It is the weakest known force in nature.

Newton's Law of Gravitation

According to Newton's law of gravitation, "Every particle in the universe attracts every other particle with a force whose magnitude is,

- $F \propto (M_1M_2)$ . . . . (1)
- $(F \propto 1/r^2)$ . . . . (2)

On combining equations (1) and (2) we get,

$F \propto M_1M_2/r^2$

$F = G \times [M_1M_2]/r^2$ . . . . (7)

Or, $f(r) = GM_1M_2/r^2$

The dimension formula of G is $[M^{-1}L^3T^{-2}]$.