

Chapter - 2

1. Tick (✓) the best answer

a. Which of the following is the correct relation between masses of two bodies and gravitational force between them?

- i. $F \propto \frac{m_1}{m_2}$
- ii. $F \propto \frac{m_2}{m_1}$
- iii. $F \propto \frac{1}{(m_1 m_2)^2}$
- iv. $F \propto m_1 m_2$ ✓

b. If the gravitational force between two bodies lying on the earth is 72N, what will be gravitational force on the surface of the moon?

- i. 12N ✓
- ii. 720N
- iii. 72N
- iv. 7.2N

(Explanation : Earth's to moon gravitational force is in ratio 1:6) ($\frac{g_e}{g_m} = \frac{9.8}{1.67}$ (1 & 6))

c. If the both masses are doubled and distance between their centres is also doubled, what will be the effect in gravitational force?

∴

$$m_1 = 2m_1 \quad d = 2d$$

$$m_2 = 2m_2$$

$$F = \frac{G m_1 m_2}{d^2} = \frac{G 2m_1 2m_2}{(2d)^2} = \frac{G 4m_1 m_2}{4d^2} = F$$

- i. There will be no change ✓
- ii. Force increase by 16 times
- iii. Force increase by 4 times
- iv. Force decrease by one-fourth

d. In which of the following places will you find your highest weight?

- KechnaKabal of ghapa (terai region) ✓
- Top of mt. everest (weight decreases in higher places)
- Rara lake
- Kathmandu valley

Explanation: Ghapa is at lowest point out of options.

f. What is value of Gravitational constant on surface of moon?

- 1.67 m/s^2
- 9.8 m/s^2
- $6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$ ✓
- $1.11 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$

Q. What is the relation between weight of a body and acceleration due to gravity?

- i. $W \propto 1$
- ii. $W \propto g_f$
- iii. $W \propto g$ ✓
- iv. $W \propto \frac{1}{g}$

Explanation \rightarrow $[W = mg]$

h) When does a falling object have zero acceleration?



- i. Freefall
- ii. weightlessness
- iii. When weight of body is equal to the air resistance. ✓
- iv. When weight of body is less than air resistance.

Explanation \rightarrow i) Under freefall there will be acceleration, ii) In weightlessness force is only not felt, iii) upper and lower force is equal so net force is 0 $a = \frac{F}{m} = \frac{0}{m} = 0$

iv) body will decelerate.

i. While observing a body at each second of free fall, which of the following conclusion is correct?

- i. acceleration increases uniformly (acceleration is constant)
- ii. velocity increases uniformly ✓ (a is constant)
- iii. Distance increases uniformly (v increases & is not constant)
- iv. Displacement increases uniformly (same as iii)

2 Answer these questions in one sentence

a. Define gravity

→ The force with which the earth or any heavy body attracts other object towards its centre is called gravity.

b. What is gravitation?

→ Gravitation is defined as the force of attraction between any two objects of the universe due to their masses.

c. State Newton's law universal law of gravitation

→ Newton's universal law of gravitation states that every object in the universe attracts every other object with a force proportional to the product of their masses and inversely proportional to the square of distance between them.

d. Why is there no atmosphere on the moon?

→ Gravity ^{on the moon} is too weak to hold onto gas molecule.

e. Although USA lies just opposite of Nepal in a globe, people of both the countries have their head facing the sky ^{while} standing? Why?

→ Gravity of Earth pulls everything towards center of the Earth so down is always towards center and up is always sky.

- f. What is the effect of gravity on the falling object?
- Effect Acceleration due to gravity is the effect of gravity on the falling object
- g. Write the factors that affect gravity of planet.
- Mass of planet, Radius of planet, affect the gravity of planet.
- h. What is freefall?
- Falling of body under the effect of gravity without any external resistance is called freefall.
- i. Give an example of free fall.
- A body falling in vacuum is an example of freefall.
- j. What is weightlessness?
- Weightlessness of body is a state in which the body experiences having no weight.

3. Answer these questions in brief

a. What are the factors that affect the gravitational force between celestial bodies?

→ The factors that affect gravitational force between celestial bodies are:-

1. mass of bodies → Greater mass increases gravitational force.

2. Distance between them → It reduces gravitational force.

b. What is Newton's gravitational constant (G)? Write down its numeric value and SI unit.

→ Universal gravitational constant (G) may be defined as the force of gravitation between any two bodies of each unit mass separated by unit distance from their centres.

The SI unit of universal constant (G) is Nm^2/kg^2 .

Numeric value of Newton's gravitational constant is $6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$

c. write down the nature of gravitational force.
→ The nature of gravitational force is given below:-

1. Attractive → It always pull objects toward each other.
2. Universal → Acts between all objects in universe with mass.
3. Weak force → ~~It~~ is needs very big masses to show noticeable effects.

d. The value of universal gravitation constant is $6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$. what does it mean?
→ The gravitational force between two objects of 1 kg each mass, kept at 1 meter apart is 6.67×10^{-11} newtons.

e. calculate the change in the gravitational force between any two objects when the distance between them is doubled.

→ The change in gravitational force between any two objects when the distance between them is doubled is given as:-

Suppose,

m_1 and m_2 be masses separated by distance 'd'. Now, According to newton's law of gravitation Force is ' F_1 ' is given by:-

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

Given → $d = 2d$ now, change in force of gravitation F_2 is :

$$F_2 = \frac{G m_1 m_2}{(2d)^2}$$

$$F_2 = \frac{G m_1 m_2}{4d^2}$$

$$F_2 = 4 \cdot \frac{1}{4} \frac{G m_1 m_2}{d^2}$$

$$F_2 = \frac{1}{4} F_1$$

It shows that force of gravitation between two bodies decreases by four times when distance between them is doubled.

f. what is acceleration due to gravity? What are the values of 'g' on equatorial region and polar region of the earth?

→ The acceleration produced on a freely falling body due to the influence of gravity is called acceleration due to gravity.

The value of 'g' at the pole is 9.83 m/s^2 and value of 'g' at the equator is 9.78 m/s^2 .

g. Derive an expression to show that the acceleration due to gravity of the earth is inversely proportional to the square of its radius.

→

Suppose an object of mass ' m_2 ' is placed on the surface of earth. Let the mass of earth be ' m_1 ' and its radius ' R '.

According to Newton's universal law of gravitation, the force of gravitation between the earth and object is given by:-

$$F = \frac{G m_1 m_2}{R^2} \quad (i)$$

When an object is allowed to fall freely toward the earth, it falls with acceleration equal to 'g'. Again according to Newton's second law of motion, the force applied by the earth 'F' is obtained as follows:-

$$F = mg \quad (ii)$$

Force obtained from equation (i) and equation (ii) are identical. Hence,

$$mg = \frac{G m m}{R^2}$$

$$g = \frac{G m}{R^2}$$

since G and m are constants for Earth.

$$g \propto \frac{1}{R^2}$$

h) when a man travels from hilly region to terai region, what will happen to his weight? Explain with reason.

→ The values of g increases as we go from higher altitude to lower altitude due to g being inversely proportional to the square of distance from the Earth's center given by:-

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

where,

$$\text{weight} = mg$$

so, when a man moves from hilly region to terai region his weight increases slightly.

i) In which condition do a feather and coin dropped from the same height fall at the same speed, why?

→ In vacuum, feather and coin dropped from same height fall at same speed because acceleration of freely falling bodies remains same for all bodies irrespective of their masses given by :-

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

m = mass of heavenly body

R = Radius of heavenly body

3. How does parachute fall towards surface of moon?

→ Parachute falls freely on the surface of moon due to absence of external resistance of air.

4. What are conditions necessary for weightlessness?

→ Conditions necessary for weightlessness are given as:-

- A body feels weightlessness during freefall because of lack of reaction force.
- A body experience weightlessness when it is null point in space.
- When a body is inside spaceship which is orbiting around a heavenly body, it feels weightlessness.

4. Give reasons

a. Newton's law of gravitation is called universal law.
→ This law is called universal law because it is applicable to all bodies in the universe.

b. G is called universal gravitational constant.
→ G is called universal gravitational constant because its value $6.67 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$ is constant throughout the universe.

c. The effect of gravitation on the liquid is ^{felt} more than on the solid.
→ Since the liquids have weaker intermolecular forces of attraction, they are loosely bound which makes them easy to move whereas on solid they have strong intermolecular forces of attraction, so, effect of gravitation on the liquid is felt more than on the solid.

d. Tides are observed on the sea but not on a lake.

→ The gravitational force of attraction between any two masses is directly proportional to the product of their masses. Since there is huge mass of water in the sea they experience greater force of attraction. However, water of small lakes cannot experience gravitational pull because of its less mass and tides don't occur.

- e. The possibility of getting hurt is more if jumped from greater height.
 → Since earth is pulling objects at its centre at acceleration 9.8 m/s^2 which means greater falling velocity from greater height causing stronger impact than from smaller height.
- f. If the same object is dropped from same height separately on the pole and equatorial region of the earth, the object will fall faster at the polar region.
 → The earth is not perfectly round, it is flattened at pole and bulged at the equator; thus the radius at pole is less, whereas more at equator. As a result, value of 'g' of the earth is more at the pole and less at the equator. Because of the higher value of g at the pole, a body falls slightly faster at the pole than at the equator.
- g. A feather and marble reach the ground simultaneously inside vacuum.
 → Acceleration due to gravity is affected by mass and radius of heavenly body given by:-
- $$g = \frac{GM}{R^2}$$
- Since, feather and marble are masses of smaller bodies which are being pulled towards centre aren't mattered factors of acceleration due to gravity they will fall simultaneously inside vacuum as no external air resistance to affect freefall of those bodies.

h. A feather and coin fall simultaneously on the surface of the moon.

→ moon doesn't have atmosphere, there is no air resistance which will affect falling of feather and coin. Feather and coin will fall freely and as acceleration due to gravity doesn't depends upon falling masses of falling objects. So, they fall simultaneously.

i. The weight of backpack decreases gradually while climbing mt. sagarmatha.

→ since, acceleration due to gravity decreases with increase in height from its surface and weight is product of mass & acceleration due to gravity, decrease in acceleration due to gravity means decrease in weight of backpack, mt. everest being upper than surface of Earth.

j. Value of 'g' is more at terai than at hilly region
→ acceleration due to gravity 'g' is given by

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

where m is mass of heavenly body.

R is Radius of Earth. heavenly body.

h is height above earth's surface or heavenly body.

Since, at terai is h is ^{less} than hilly region value of 'g' is more at terai, g being inversely proportional to $(R+h)^2$.

K. The value of 'g' varies from place to place on the surface of earth.

→ The earth is not perfectly round, it is flattened at pole and bulged at the equator. Now value of 'g' is given by

$$g \propto \frac{1}{R^2}$$

Value of R varies from place to place on earth surface. Therefore 'g' of earth is inversely proportional to the square of its radius.

L. Weight of body is found less at the top of mountain than at the bottom of it.

→ Value of 'g' is less at the top of mountain than at the bottom of it and weight (w) is given as:-

$$w = mg$$

where,

m is mass of smaller body.

$$\text{so, } w \propto g$$

As g is weight is directly proportional to g . Weight of body is found less at the top of mountain than at the bottom of it.

Q.

m It is difficult to lift a larger stone than a smaller one on the surface of the earth

→ A larger stone has more mass than smaller one and their weight (w) is given by product of mass of its (m) and acceleration due to gravity of Earth (g)

$$w = mg$$

Since, larger stone has greater mass it will be weigh more and force should be applied to lift larger than smaller one so, it's difficult to lift a larger stone than smaller one.

n. A person can jump higher on moon's surface than on earth's surface.

→ Moon's gravity is about 6 times less than that of earth which means less weight of person on moon's surface than on earth's surface because of the less force is required to jump on moon's surface allowing person to jump higher on moon's surface than on Earth's surface.

o. The mass of Jupiter is 319 times more than that of earth but its gravity is only 2.5 times more than that of earth.

→ Since, gravity depends on both mass and Radius of body, its 'g' is given by

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

Even though Jupiter's mass is huge, its radius is also huge and since gravity decreases with square of radius the increase in gravity is only 2.5 times that of Earth.

p. It is difficult to drink water inside an artificial satellite in the space.

→ Because of microgravity in the satellite, in the absence of gravity, water does not flow downward like on earth, so water doesn't flow naturally into the mouth. So, it is difficult to drink water inside an artificial satellite in the space.

q. A parachutist can land safely after jumping out from a flying aeroplane.

→ When a parachutist jumps out from a flying plane with a parachute, the resistance given by air to the parachute will be considerably high because of its large size. During the fall downward force and upthrust will be equal. As a result velocity of falling parachute will be low and balanced. Thus parachutist can land safely.

- Q. An astronaut can feel weightlessness in an artificial satellite but not on the moon.
- An astronaut feels weightlessness in an artificial satellite because the satellite and the astronaut are both falling freely around the Earth. Since they fall together, astronaut doesn't feel any force but on moon moon has its gravity. So, we have some weight on moon.

7.

i) Galileo's free fall experiment
ii) Second figure shows correct phenomenon.
This is because Galileo proved that all objects fall at the same rate under gravity regardless of their mass.

iii. The conclusion is that all objects fall at same acceleration due to gravity and rate of fall doesn't depend on their masses.

b. Yes, there is difference between gravitational force when the earth moves from position A to position B.

This is because gravitational force is inversely proportional to the square of distance between them two objects

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

- At position A Earth is farther from sun
- At position B Earth is closer from sun
So, more gravitational force at point B than A.