CBSE CLASS 9 SCIENCE

Chapter 9: Gravitation

Complete Concept & Question Bank

EXAM BOOSTER EDITION

SECTION 1: Chapter Overview

What is Gravitation?

Gravitation is the universal force of attraction that exists between any two objects possessing mass in the universe. It is the fundamental interaction responsible for keeping us grounded on Earth, governing the Moon's orbit, and holding the solar system together.

Importance of Gravitation in Daily Life

This natural phenomenon anchors everything to Earth's surface, stabilizes planetary pathways, drives ocean tides via lunar attraction, and allows fluids and objects to fall downward predictably.

Learning Outcomes

By the end of this chapter, you will be able to:

- Understand and apply the Universal Law of Gravitation mathematically.
- Differentiate comprehensively between mass and weight vectors.
- Calculate and track changes in acceleration due to gravity (g).
- Model free fall parameters using equations of linear acceleration.
- Explain upthrust, Archimedes' Principle, floatation thresholds, and relative density.

SECTION 2: Important Concepts

1. Universal Law of Gravitation

Every particle in the universe attracts every other particle with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their geometric centers.

$$F = G \times (m_1 \times m_2) / r^2$$

Where G is the Universal Gravitational Constant, valued at precisely $6.67 \times 10^{-11}\ N{\cdot}m^2/kg^2$ universally. This attraction acts linearly along the path intersecting both centers.

2. Acceleration Due to Gravity (g)

The uniform acceleration experienced by any body falling completely freely toward the Earth solely under the influence of its gravity. Near the surface, its value is taken as $g \approx 9.8\ m/s^2$.

$$g = GM / R^2$$

Note: The variable g is independent of the falling body's own mass. Because Earth is an oblate spheroid, its equatorial radius (R) is larger than its polar radius, making g slightly weaker at the equator and maximum at the poles.

3. Free Fall Equations of Motion

For an object moving purely under gravity's downward acceleration, standard equations are modified by substituting acceleration ($a = g$) and distance ($s = h$):

1. $v = u + gt$
2. $h = ut + \frac{1}{2}gt^2$
3. $v^2 = u^2 + 2gh$

4. Mass vs Weight

- **Mass:** The intrinsic measure of matter and inertia within an object. It remains static, scalar, and uniform throughout the universe. (Unit: kg).
- **Weight:** The variable gravitational force vector acting on that mass toward the planet's core. Defined as $W = mg$, it fluctuates depending on localized gravity fields. (Unit: Newton).

5. Thrust, Pressure, and Fluid Dynamics

Thrust: The net force vector exerted perpendicularly over a given surface plane.

Pressure: The concentration of that thrust distribution per unit area. $Pressure = Thrust / Area$. (SI Unit: Pascal or N/m^2).

Buoyancy & Upthrust: The inherent upward force applied by any fluid layer against a body completely or partially submerged inside it. Objects appear lighter when submerged because upthrust acts directly opposite to gravity.

6. Archimedes' Principle & Relative Density

When an object is immersed partially or fully in a fluid system, it encounters an upward buoyant force that exactly equals the total weight of the fluid that the object's volume manages to displace.

Relative Density (RD): The scalar ratio comparing a substance's absolute density against the baseline density of pure water. It is a unitless number used to evaluate whether an item sinks ($RD > 1$) or floats ($RD < 1$).

SECTION 3: Important Formula Sheet

Formula	Physical Description	Standard SI Unit
$F = G \cdot m_1 \cdot m_2 / r^2$	Universal Law of Gravitation	Newton (N)
$g = GM / R^2$	Acceleration due to local gravity field	m/s^2
$W = m \cdot g$	Gravitational Weight Vector	Newton (N)
$P = Thrust / Area$	Mechanical Pressure Distribution	Pascal (Pa) or N/m^2
$RD = \rho_{substance} / \rho_{water}$	Relative Density Ratio	Dimensionless (No Units)

SECTION 4: Top 30 Frequently Repeated Questions

Very Short Answer Type (1 Mark)

Q1. State the universal law of gravitation.

Ans: Every object in the universe attracts every other object with a force directly proportional to the product of their masses and inversely proportional to the square of the distance separating their centers.

Q2. What is the value and standard SI unit of the constant G?

Ans: $6.67 \times 10^{-11}\ N \cdot m^2/kg^2$.

Q3. What is the value of g on the Earth's surface?

Ans: Approximately $9.8\ m/s^2$.

Q9. Define thrust.

Ans: Thrust is defined as the net mechanical force acting completely perpendicularly on a surface boundary.

Short Answer Type (2-3 Marks)

Q14. Explain the relationship between G and g.

Ans: By equating the universal gravitational force equation to Newton's second law ($mg = GMm/R^2$), the mass of the object cancels out, revealing $g = GM/R^2$. Here, G is a global scalar constant, whereas g changes according to planetary mass (M) and radius (R).

Q15. The weight of a body is 60 N on Earth. What would be its mass and weight on the Moon?

Ans: Mass on Earth is $m = W/g = 60 / 10 = 6\ kg$. Since mass is invariant, its mass on the Moon remains $6\ kg$. The Moon's gravity is 1/6th of Earth's, so its Moon weight becomes $60 \times (1/6) = 10\ N$.

SECTION 5: Top 20 Most Expected Questions

Q1. Derive the relation between the acceleration due to gravity (g) and the universal gravitational constant (G).

Ans: Let an object of mass m rest on the surface of a planet with mass M and radius R.
According to the Universal Law of Gravitation, the force of attraction is: $F = GMm/R^2$.
From Newton's Second Law of Motion, we know force equals mass times acceleration: $F = mg$.
Equating these expressions: $mg = GMm/R^2$.
Dividing both sides by the object's mass m yields: $g = GM/R^2$.

Q4. An object is thrown vertically upwards with a velocity of 49 m/s. Calculate the maximum height reached and total travel time.

Ans: Given $u = 49\ m/s$, at the peak $v = 0\ m/s$, and $g = -9.8\ m/s^2$ (acting opposite to motion).
Using $v^2 = u^2 + 2gh \rightarrow 0 = 49^2 + 2(-9.8)h \rightarrow 19.6h = 2401 \rightarrow h = 122.5\ m$.
To find the ascent time (t_1): $v = u + gt \rightarrow 0 = 49 - 9.8t_1 \rightarrow t_1 = 5\ s$.
Total return time to the surface = $2 \times t_1 = 10\ s$.

SECTION 7: Most Important Numericals

Q1. Calculate the gravitational force between two objects of masses 10 kg and 20 kg separated by a distance of 5 m.

Ans: Apply $F = G \cdot m_1 \cdot m_2 / r^2$:

$F = (6.67 \times 10^{-11}) \times 10 \times 20 / 5^2$

$F = (6.67 \times 10^{-11}) \times 200 / 25 = 6.67 \times 10^{-11} \times 8 = 5.336 \times 10^{-10}$ N.

Q2. If the distance between two objects is doubled, how does the gravitational force change?

Ans: Force obeys an inverse-square relationship: $F \propto 1/r^2$. When distance transitions to $2r$, the new force scales to $1/(2r)^2 = 1/4r^2$. Thus, the gravitational force reduces by a factor of exactly four.

SECTION 8: Assertion & Reason Questions

Directions: Choose (a) if both Assertion and Reason are true and Reason is the correct explanation.

Q1. Assertion (A): The gravitational force between two bodies remains independent of the intervening fluid medium.
Reason (R): Gravitational force is structured around a universal fundamental constant G that ignores ambient matter properties.

Ans: (a) Both A and R are true, and R is the direct logical validation of A.

Q3. Assertion (A): A metallic body records a lower apparent weight score when measured inside water than in air.
Reason (R): Water exerts a vertically upward buoyant force vector matching the weight of the fluid pushed aside.

Ans: (a) Both A and R are true, and R explains why apparent weight falls ($W_{apparent} = W_{actual} - Buoyant\ Force$).

SECTION 10: Exam Booster Flash Points

Core Distinctions for the Exam Sheet

• **G vs g:** G is scalar, global, and unchanging (6.67×10^{-11}). g is a localized vector that drops to zero at the planet's core and changes with altitude or latitude.
• **Knife/Nail Physics:** A blunt tool has a larger contact surface area, which lowers the applied pressure ($P = F/A$) and makes cutting difficult. A sharp profile focuses force onto a minimal area to optimize pressure.
• **Floatation Check:** An item floats only if the fluid density surpasses the body's native density value. Ships float because their hollow architecture encloses air, reducing their average density below that of seawater.