SINDH TEXTBOOK BOARD | CLASS 9

9th Class Physics Notes Sindh Textbook Board Full Book Notes

Complete chapter-wise study notes with original practice questions and an MCQ answer key

These notes follow the nine units of the Sindh Textbook Board (STBB) Physics book for Class 9, in the order given below.
They cover the course for all Sindh boards: Karachi, Hyderabad, Sukkur, Larkana and Mirpurkhas.

Prepared for students of the Boards of Intermediate and Secondary Education in Sindh (Karachi, Hyderabad, Sukkur, Larkana, Mirpurkhas). For the current model paper and official announcements, check your own board's official website before the examination.

About These Notes

These notes cover the full Class 9 Physics course of the Sindh Textbook Board (STBB), following the STBB Physics book for Class 9. The book is in English. Each chapter gives the key concepts, important definitions, the formulas you must know, and the key terms to revise. After the notes, every chapter has original practice questions: 10 multiple choice questions, 5 short questions and 2 long questions. An answer key for all multiple choice questions is given at the end of the book.

How to Use This Book

- Read one chapter's notes first and learn the definitions and formulas by heart.
- Attempt the MCQs without looking at the key, then check your answers and re-read the parts you got wrong.
- Write the short and long questions in your own words; practise the numerical examples with the formulas given.
- Revise the key terms of every chapter before the examination.

Chapters in This Book

1. **Chapter 1:** Physical Quantities and Measurement
2. **Chapter 2:** Kinematics
3. **Chapter 3:** Dynamics
4. **Chapter 4:** Turning Effect of Forces
5. **Chapter 5:** Forces and Matter
6. **Chapter 6:** Gravitation
7. **Chapter 7:** Properties of Matter
8. **Chapter 8:** Energy Sources and Transfer of Energy
9. **Chapter 9:** Thermal Properties of Matter

A Note on the Examination Paper

The Sindh boards set the Class 9 Physics paper from these nine units, with multiple choice questions, short-answer questions and detailed-answer questions, and a separate practical examination. The exact marks split and time allowed differ between boards and between model papers, so no marks figures or paper-pattern figures are printed in these notes. Students should check the current model paper of their own board (Karachi, Hyderabad, Sukkur, Larkana or Mirpurkhas) before the examination.

All practice questions in this book are original and written for these notes. They are not copied from any past paper or guide. Standard textbook values are used, such as g = 10 m/s^2 near the Earth's surface and the density of water = 1000 kg/m^3. In this book, work and energy are covered in Chapter 8 (Energy Sources and Transfer of Energy), as in the STBB book, and not as a separate chapter.

Chapter 1: Physical Quantities and Measurement

Physics begins with measurement. Every physical quantity is measured by comparing it with a standard unit. This chapter introduces physical quantities, the SI system, prefixes, measuring instruments and the errors that can occur while measuring.

Key Concepts

- Physics is the branch of science that studies matter, energy and their interaction. A physical quantity is a quantity that can be measured, for example length, mass, time and temperature.
- Base quantities are the seven quantities of the SI system: length, mass, time, electric current, temperature, amount of substance and luminous intensity. All other quantities are derived quantities, obtained from base quantities.
- The SI unit of length is the metre (m), of mass the kilogram (kg), of time the second (s), of temperature the kelvin (K) and of electric current the ampere (A).
- Prefixes such as kilo (10^3), milli (10^-3), micro (10^-6) and nano (10^-9) are used to express very large or very small quantities in a compact way.
- A measuring instrument has a least count, the smallest value it can measure. The least count of a metre rule is 1 mm and of a stopwatch is usually 0.1 s or 0.01 s.
- Vernier callipers measure small lengths accurately to 0.1 mm (0.01 cm). A screw gauge (micrometer) measures very small lengths to 0.01 mm.
- Zero error occurs when the zero of an instrument does not coincide with the zero of the scale. It must be subtracted from or added to the observed reading as appropriate.
- Random error varies from one reading to another and is reduced by taking the average of several readings. Systematic error is constant and is caused by a faulty instrument or method.
- Significant figures show how precisely a quantity is known. The result of a calculation should not have more significant figures than the least precise measurement used.
- Volume of a regular solid is found from its dimensions; volume of an irregular solid is found by the displacement method using a measuring cylinder.

Important Definitions

Term	Definition
Physical quantity	A quantity that can be measured, such as length, mass, time or temperature.
Base quantity	A quantity that is defined independently, such as length, mass and time.
Derived quantity	A quantity obtained by combining base quantities, such as speed, area and density.
Unit	The standard amount of a physical quantity with which the quantity is compared.
Least count	The smallest value that a measuring instrument can measure.
Zero error	The error shown by an instrument when it should read zero, caused by a misaligned zero mark.
Significant figures	The digits in a measurement that are known reliably plus one uncertain digit.
Precision	How close repeated measurements of the same quantity are to each other.

Accuracy	How close a measurement is to the true value of the quantity.
Density	Mass per unit volume of a substance.

Important Formulas

> Least count of vernier callipers = 1 main scale division - 1 vernier scale division = 0.01 cm
> Least count of screw gauge = pitch / number of divisions on the circular scale = 0.01 mm
> Corrected reading = observed reading - zero error
> Density = mass / volume
> Volume of a cuboid = length x width x height
> Volume of a cylinder = pi x (radius)^2 x height
> Average value = sum of all readings / number of readings
> 1 km = 1000 m; 1 cm = 10 mm; 1 mm = 1000 micrometres

Key Terms to Remember

physical quantity, **base quantity**, **derived quantity**, **SI unit**, **prefix**, **least count**, **zero error**, **vernier callipers**, **screw gauge**, **significant figures**, **precision**, **accuracy**, **random error**, **systematic error**, **density**

Chapter 1: Physical Quantities and Measurement — Practice Questions

Multiple Choice Questions

1. Which of the following is a base quantity?

(a) Speed (b) Force (c) Mass (d) Area

2. The SI unit of electric current is:

(a) Volt (b) Ampere (c) Ohm (d) Watt

3. Which of the following is a derived quantity?

(a) Length (b) Time (c) Density (d) Mass

4. One micrometre is equal to:

(a) 10^-3 m (b) 10^-6 m (c) 10^-9 m (d) 10^-2 m

5. The least count of a metre rule is:

(a) 1 cm (b) 0.1 cm (c) 1 mm (d) 0.01 mm

6. A screw gauge is used to measure:

(a) Long distances (b) Very small lengths (c) Mass of a body (d) Time intervals

7. Which instrument is most suitable for measuring the diameter of a wire?

(a) Metre rule (b) Measuring tape (c) Screw gauge (d) Stopwatch

8. If the zero of a vernier calliper lies below the main scale zero, the zero error is:

(a) Positive (b) Negative (c) Zero (d) Cannot be found

9. The number of significant figures in 0.00450 is:

(a) 2 (b) 3 (c) 4 (d) 5

10. Taking the average of several readings mainly reduces:

(a) Systematic error (b) Zero error (c) Random error (d) Least count

Short Questions

1. Define a physical quantity and give two examples of base and two of derived quantities.
2. State the seven base quantities of the SI system with their units and symbols.
3. Define least count and state the least count of a metre rule and a screw gauge.
4. What is zero error? How is a reading corrected for zero error?
5. Distinguish between precision and accuracy with an example.

Long Questions

1. Describe the construction and working of vernier callipers. Explain how the diameter of a small cylinder is measured with them, including the correction for zero error.
2. Explain random error and systematic error. Describe the methods used to reduce each type of error in a measurement, and explain the rules of significant figures with examples.

Chapter 2: Kinematics

Kinematics is the study of motion without considering the forces that cause it. This chapter explains rest and motion, types of motion, speed, velocity, acceleration and the equations of motion, including the motion of freely falling bodies.

Key Concepts

- Rest and motion are relative: a body at rest in one frame of reference may be in motion in another. A body is in motion when its position changes with time relative to a reference point.
- Motion may be translatory (all parts move together, for example a car moving on a road), rotatory (a body turns about a fixed axis, for example a spinning wheel) or vibratory (a body moves to and fro about a mean position, for example a pendulum).
- Distance is the total length of the path travelled and is a scalar. Displacement is the shortest distance from the initial to the final position in a stated direction and is a vector.
- Speed is distance covered per unit time, a scalar quantity. Velocity is displacement per unit time, a vector quantity, and has both magnitude and direction.
- Average speed is total distance divided by total time. Instantaneous speed is the speed at a particular instant, shown by the speedometer of a vehicle.
- Acceleration is the rate of change of velocity. If velocity increases, acceleration is positive; if it decreases, it is retardation (negative acceleration). Uniform acceleration means velocity changes by equal amounts in equal intervals of time.
- The slope of a distance-time graph gives speed; the slope of a velocity-time graph gives acceleration, and the area under a velocity-time graph gives displacement.
- The three equations of motion for uniformly accelerated motion are: v = u + at; S = ut + (1/2)at^2; and 2aS = v^2 - u^2, where u is initial velocity, v final velocity, a acceleration, t time and S distance.
- A freely falling body moves with the acceleration due to gravity, g, which is about 10 m/s^2 near the surface of the Earth. In free fall the initial velocity is zero and the equations of motion apply with a = g.
- In the absence of air resistance all bodies fall with the same acceleration regardless of their mass; air resistance is what makes a feather fall more slowly than a stone in air.

Important Definitions

Term	Definition
Rest	The state of a body when its position does not change with time relative to a reference point.
Motion	The change in position of a body with time relative to a reference point.
Distance	The total length of the path travelled by a body; a scalar quantity.
Displacement	The shortest distance between the initial and final positions of a body in a specified direction; a vector quantity.
Speed	Distance covered per unit time; a scalar quantity.
Velocity	Displacement per unit time; a vector quantity with magnitude and direction.
Acceleration	The rate of change of velocity with time.
Retardation	Negative acceleration; the rate at which velocity decreases.

Uniform velocity	Velocity that remains constant in magnitude and direction.
Free fall	Motion of a body under the force of gravity alone, with no air resistance.

Important Formulas

> Speed = distance / time
>
> Velocity = displacement / time
>
> Acceleration a = (v - u) / t
>
> v = u + at
>
> S = ut + (1/2) a t^2
>
> 2aS = v^2 - u^2
>
> For free fall: v = gt; h = (1/2) g t^2; v^2 = 2gh (taking g = 10 m/s^2)
>
> Average speed = total distance / total time

Key Terms to Remember

rest, **motion**, **translatory motion**, **rotatory motion**, **vibratory motion**, **distance**, **displacement**, **speed**, **velocity**, **acceleration**, **retardation**, **uniform acceleration**, **free fall**, **acceleration due to gravity**

Chapter 2: Kinematics — Practice Questions

Multiple Choice Questions

1. Which of the following is a vector quantity?

(a) Speed (b) Distance (c) Velocity (d) Time

2. The SI unit of acceleration is:

(a) m/s (b) m/s^2 (c) m^2/s (d) s/m

3. A body moving with uniform velocity has:

(a) Zero acceleration (b) Constant acceleration (c) Increasing acceleration (d) Negative acceleration

4. The slope of a velocity-time graph gives:

(a) Distance (b) Displacement (c) Speed (d) Acceleration

5. The area under a velocity-time graph gives:

(a) Acceleration (b) Speed (c) Displacement (d) Force

6. If a car covers 60 km in 2 hours, its average speed is:

(a) 20 km/h (b) 30 km/h (c) 60 km/h (d) 120 km/h

7. A body starting from rest attains a velocity of 20 m/s in 4 s. Its acceleration is:

(a) 4 m/s^2 (b) 5 m/s^2 (c) 10 m/s^2 (d) 80 m/s^2

8. Which equation gives the distance covered by a body moving with uniform acceleration?

(a) v = u + at (b) S = ut + (1/2)at^2 (c) 2aS = v^2 - u^2 (d) a = (v - u)/t

9. In free fall near the Earth, the acceleration of a body is about:

(a) 1 m/s^2 (b) 5 m/s^2 (c) 10 m/s^2 (d) 20 m/s^2

10. Retardation means:

(a) Increase in velocity (b) Decrease in velocity (c) Constant velocity (d) Zero velocity

Short Questions

1. Distinguish between distance and displacement with one example each.
2. Define speed and velocity. Why is velocity a vector while speed is a scalar?
3. Define acceleration and retardation. State their SI units.
4. What information is obtained from the slope and the area of a velocity-time graph?
5. Define free fall and state the value of g near the surface of the Earth.

Long Questions

1. Derive the three equations of motion for a body moving with uniform acceleration, and use them to solve a numerical problem of your own choice.
2. Explain the graphical analysis of motion: describe the distance-time graph and the velocity-time graph, and show how speed, acceleration and displacement are found from them.

Chapter 3: Dynamics

Dynamics is the study of motion and the forces that cause it. This chapter explains force, inertia, momentum, Newton's laws of motion, friction and the motion of bodies connected by strings.

Key Concepts

- A force is a push or a pull that changes, or tends to change, the state of rest or of uniform motion of a body. Force is a vector quantity and its SI unit is the newton (N).
- Inertia is the property of a body that resists any change in its state of rest or motion. Mass is the measure of inertia: a heavier body has more inertia.
- Momentum is the product of mass and velocity. It is a vector quantity, and its SI unit is kg m/s.
- Newton's first law states that a body remains at rest or in uniform motion unless an unbalanced force acts on it. This law is also called the law of inertia.
- Newton's second law states that the acceleration produced in a body is directly proportional to the applied force and inversely proportional to the mass: F = ma.
- Newton's third law states that to every action there is an equal and opposite reaction. Action and reaction act on different bodies, so they never cancel each other.
- When two bodies are connected by a string over a frictionless pulley, the same tension acts on both, and the system moves with a common acceleration.
- Friction is the force that opposes the relative motion between two surfaces in contact. It acts parallel to the surfaces and opposite to the direction of motion.
- The force of friction depends on the nature of the surfaces and on the normal reaction pressing them together. Smooth surfaces and lubrication reduce friction.
- Mass is the amount of matter in a body and does not change from place to place. Weight is the force with which the Earth attracts a body, W = mg, and it changes with the value of g.

Important Definitions

Term	Definition
Force	A push or a pull that changes or tends to change the state of rest or uniform motion of a body.
Inertia	The property of a body that resists any change in its state of rest or motion.
Momentum	The product of the mass and the velocity of a body.
Newton	The SI unit of force; one newton produces an acceleration of 1 m/s^2 in a mass of 1 kg.
Friction	The force that opposes the relative motion between two surfaces in contact.
Tension	The pulling force transmitted through a string or rope when it is pulled at both ends.
Mass	The amount of matter in a body; a measure of its inertia.
Weight	The force with which the Earth attracts a body towards its centre.
Unbalanced force	A force that is not cancelled by an equal and opposite force and so produces acceleration.
Impulse	The product of force and the time for which it acts; it equals the change in momentum.

Important Formulas

> F = ma
>
> Momentum p = mv
>
> Weight W = mg
>
> Impulse = F x t = change in momentum
>
> Acceleration a = F / m
>
> g = 10 m/s^2 near the surface of the Earth

Key Terms to Remember

force, **inertia**, **momentum**, **Newton's laws**, **friction**, **tension**, **mass**, **weight**, **impulse**, **unbalanced force**, **action and reaction**, **normal reaction**

Chapter 3: Dynamics — Practice Questions

Multiple Choice Questions

1. The SI unit of force is:

(a) Joule (b) Watt (c) Newton (d) Pascal

2. Mass is a measure of:

(a) Weight (b) Inertia (c) Momentum (d) Force

3. Momentum is the product of:

(a) Mass and acceleration (b) Mass and velocity (c) Force and time (d) Weight and velocity

4. Newton's first law is also called the law of:

(a) Action and reaction (b) Inertia (c) Gravitation (d) Conservation of energy

5. If a force of 10 N acts on a mass of 2 kg, the acceleration produced is:

(a) 2 m/s^2 (b) 5 m/s^2 (c) 10 m/s^2 (d) 20 m/s^2

6. According to Newton's third law, action and reaction:

(a) Act on the same body (b) Act on different bodies (c) Cancel each other (d) Are always zero

7. The weight of a body of mass 5 kg on Earth (g = 10 m/s^2) is:

(a) 0.5 N (b) 5 N (c) 15 N (d) 50 N

8. Friction always acts:

(a) In the direction of motion (b) Opposite to the direction of motion (c) At right angles to motion (d) Vertically upward

9. Which of the following reduces friction?

(a) Rough surface (b) Lubrication (c) Greater normal reaction (d) Heavier body

10. Impulse is equal to:

(a) Force x distance (b) Change in momentum (c) Mass x velocity (d) Force / time

Short Questions

1. Define force and state its SI unit.
2. State Newton's three laws of motion in your own words.
3. Distinguish between mass and weight.
4. What is momentum? State its formula and SI unit.
5. Define friction and state two methods of reducing it.

Long Questions

1. State and explain Newton's second law of motion. Derive F = ma and solve a numerical problem with it.
2. Explain the law of conservation of momentum with an example. Describe the motion of two bodies connected by a string over a frictionless pulley, and explain how friction affects motion in daily life.

Chapter 4: Turning Effect of Forces

A force can turn a body about a fixed point as well as move it. This chapter explains torque, the principle of moments, equilibrium, centre of mass and the stability of bodies.

Key Concepts

- Torque is the turning effect of a force about a fixed point. It depends on the magnitude of the force and on the perpendicular distance of its line of action from the pivot.
- A couple is a pair of equal and opposite forces that act along different lines and produce rotation without translation, for example when turning a steering wheel.
- The moment of a force about a point is the product of the force and the perpendicular distance from the point to the line of action of the force. Its SI unit is newton-metre (N m).
- The principle of moments states that when a body is in equilibrium, the sum of the clockwise moments about any point equals the sum of the anticlockwise moments about that point.
- A body is in equilibrium when the resultant force on it is zero and the resultant torque on it is zero. There are two conditions of equilibrium: the vector sum of forces is zero, and the vector sum of torques is zero.
- Stable equilibrium means a body returns to its original position after a small displacement. Unstable equilibrium means it moves away, and neutral equilibrium means it stays in the new position.
- The centre of mass of a body is the point at which its whole mass can be taken to act. For a uniform body it is at its geometrical centre.
- A body is more stable when its centre of mass is low and its base is wide. That is why racing cars are built low and wide, and why a table with a wide base does not topple easily.
- Centre of gravity is the point through which the weight of a body acts. A body topples when the vertical line through its centre of gravity falls outside its base.
- Spanners and door handles work on the principle of moments: the further the force is applied from the pivot, the greater the turning effect for the same force.

Important Definitions

Term	Definition
Torque	The turning effect of a force about a fixed point; the product of force and perpendicular distance from the pivot.
Moment of a force	Force multiplied by the perpendicular distance of its line of action from the pivot point.
Couple	A pair of equal and opposite forces acting along different lines that produce rotation.
Equilibrium	The state of a body when the resultant force and the resultant torque on it are both zero.
Centre of mass	The point of a body at which its whole mass can be taken to act.
Centre of gravity	The point through which the weight of a body acts.
Stable equilibrium	The state in which a body returns to its original position after a small displacement.
Unstable equilibrium	The state in which a body moves further away after a small displacement.

Neutral equilibrium	The state in which a body stays in its new position after a small displacement.
Pivot	The fixed point about which a body turns.

Important Formulas

> Moment of a force = force x perpendicular distance from the pivot
>
> Torque = F x d (SI unit: N m)
>
> Principle of moments: sum of clockwise moments = sum of anticlockwise moments (in equilibrium)
>
> First condition of equilibrium: sum of forces = 0
>
> Second condition of equilibrium: sum of torques = 0

Key Terms to Remember

torque, **moment**, **couple**, **pivot**, **equilibrium**, **centre of mass**, **centre of gravity**, **stable equilibrium**, **unstable equilibrium**, **neutral equilibrium**, **principle of moments**

Chapter 4: Turning Effect of Forces — Practice Questions

Multiple Choice Questions

1. Torque depends on:

(a) Force only (b) Distance only (c) Force and perpendicular distance (d) Mass only

2. The SI unit of torque is:

(a) Joule (b) Newton-metre (c) Watt (d) Pascal

3. A couple is formed by:

(a) Two equal forces in the same direction (b) Two equal and opposite forces on different lines (c) A single force (d) Two forces on the same line

4. The principle of moments applies when a body is in:

(a) Motion only (b) Equilibrium (c) Free fall (d) Rotation only

5. A body is in equilibrium when:

(a) Resultant force is zero only (b) Resultant torque is zero only (c) Both resultant force and torque are zero (d) It is moving fast

6. A body is most stable when its centre of mass is:

(a) High and base narrow (b) Low and base wide (c) High and base wide (d) Low and base narrow

7. The centre of mass of a uniform rod is at its:

(a) One end (b) Geometrical centre (c) Quarter length (d) Surface

8. A body topples when the line through its centre of gravity falls:

(a) Inside its base (b) Outside its base (c) Through its centre (d) Vertically upward

9. Turning a steering wheel is an example of:

(a) A single force (b) A couple (c) Friction (d) Equilibrium

10. A longer spanner is used because it gives:

(a) Less force (b) Greater turning effect (c) Less torque (d) More friction

Short Questions

1. Define torque and state its SI unit.
2. State the principle of moments.
3. State the two conditions of equilibrium.
4. Define centre of mass and centre of gravity.
5. Why is a racing car built low and wide?

Long Questions

1. Explain the principle of moments and describe an experiment to verify it using a metre rule balanced on a knife edge.
2. Define equilibrium and its three types. Explain, with examples, how the position of the centre of mass and the width of the base affect the stability of a body.

Chapter 5: Forces and Matter

Forces change the shape and size of matter. This chapter explains how solids stretch and compress, Hooke's law, stress, strain and Young's modulus, and the elastic and plastic behaviour of materials.

Key Concepts

- When a force is applied to a solid, the solid may change its shape or size. If the change disappears when the force is removed, the deformation is elastic; if it remains, it is plastic.
- Hooke's law states that within the elastic limit, the extension of a spring or wire is directly proportional to the applied force.
- The elastic limit is the greatest force that can be applied to a material without causing permanent deformation. Beyond it, the material does not return to its original shape.
- Stress is the force applied per unit area of cross-section of a material. Its SI unit is the newton per square metre (N/m^2), also called the pascal (Pa).
- Strain is the ratio of the change in length to the original length. It has no unit because it is a ratio of two lengths.
- Young's modulus is the ratio of stress to strain within the elastic limit. It is a property of the material and its SI unit is the pascal.
- Different materials have different stiffness: steel has a large Young's modulus and stretches very little, while rubber has a small Young's modulus and stretches easily.
- A spring stores elastic potential energy when it is stretched or compressed, and this energy is released when the spring returns to its natural length.
- The force constant of a spring is the force needed to produce unit extension. A stiffer spring has a larger force constant.
- Materials such as springs in weighing machines, vehicle suspensions and mattresses are chosen for their elastic properties; brittle materials break without much stretching.

Important Definitions

Term	Definition
Elastic deformation	A change in shape or size that disappears when the applied force is removed.
Plastic deformation	A permanent change in shape or size that remains after the force is removed.
Hooke's law	Within the elastic limit, the extension of a spring is directly proportional to the applied force.
Elastic limit	The greatest force that can be applied without causing permanent deformation.
Stress	Force applied per unit area of cross-section of a material.
Strain	The ratio of the change in length to the original length of a material.
Young's modulus	The ratio of stress to strain within the elastic limit; a measure of stiffness.
Force constant	The force required to produce unit extension in a spring.
Brittle material	A material that breaks without stretching much, such as glass.
Ductile material	A material that can be drawn into wires without breaking, such as copper.

Important Formulas

> Hooke's law: F = k x, where k is the force constant and x is the extension
>
> Stress = force / area
>
> Strain = change in length / original length
>
> Young's modulus E = stress / strain
>
> Elastic potential energy in a spring = (1/2) k x^2

Key Terms to Remember

elastic, **plastic**, **Hooke's law**, **elastic limit**, **stress**, **strain**, **Young's modulus**, **force constant**, **brittle**, **ductile**, **extension**, **compression**

Chapter 5: Forces and Matter — Practice Questions

Multiple Choice Questions

1. Hooke's law is valid:

(a) At all forces (b) Only within the elastic limit (c) Only for liquids (d) Only for gases

2. The SI unit of stress is:

(a) Newton (b) Pascal (c) Joule (d) Watt

3. Strain is:

(a) Force per unit area (b) Change in length per unit original length (c) Mass per unit volume (d) Force per unit length

4. Young's modulus is the ratio of:

(a) Stress to strain (b) Strain to stress (c) Force to mass (d) Extension to force

5. Which material has the larger Young's modulus?

(a) Rubber (b) Steel (c) Sponge (d) Clay

6. If a spring is stretched beyond its elastic limit, it will:

(a) Return to its original length (b) Remain permanently stretched (c) Break at once (d) Become stronger

7. The force constant of a spring is measured in:

(a) N/m (b) N m (c) Joule (d) Pascal

8. Elastic potential energy is stored in a spring when it is:

(a) At rest (b) Stretched or compressed (c) Heated (d) Broken

9. A brittle material is one that:

(a) Stretches a lot before breaking (b) Breaks without much stretching (c) Can be drawn into wires (d) Returns to shape easily

10. For a wire of length L stretched by an amount e, strain is:

(a) e / L (b) L / e (c) e x L (d) L - e

Short Questions

1. State Hooke's law and define the force constant of a spring.
2. Distinguish between elastic and plastic deformation.
3. Define stress and strain. State their units.
4. Define Young's modulus and state what it tells us about a material.
5. Why is steel used in bridges and buildings rather than rubber?

Long Questions

1. State and explain Hooke's law. Describe an experiment to verify it using a spring, and explain the meaning of the elastic limit with a force-extension graph.
2. Define stress, strain and Young's modulus. Derive the relation E = stress / strain and solve a numerical problem to find the extension of a steel wire under a given load.

Chapter 6: Gravitation

Gravitation is the force of attraction between masses. This chapter explains Newton's law of universal gravitation, the mass of the Earth, the variation of g, and the motion of artificial satellites.

Key Concepts

- Newton's law of universal gravitation states that every body in the universe attracts every other body with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.
- The gravitational constant G has the value 6.67 x 10^-11 N m^2/kg^2. It is a universal constant, the same everywhere in the universe.
- The force of gravity between the Earth and a body is the weight of the body. The acceleration due to gravity, g, is about 10 m/s^2 near the surface of the Earth.
- The value of g decreases with height above the surface of the Earth and with depth below the surface. It is also slightly larger at the poles than at the equator.
- The mass of the Earth can be found from the law of gravitation and the measured value of g at the surface: M = g R^2 / G, where R is the radius of the Earth.
- An artificial satellite is an object put into orbit around the Earth. It stays in orbit because the gravitational pull of the Earth provides the centripetal force needed for its circular motion.
- Geostationary satellites orbit above the equator with the same period as the Earth's rotation, so they appear fixed in the sky. They are used for communication and television.
- Communication satellites, weather satellites and navigation satellites are all artificial satellites. The Moon is the Earth's natural satellite.
- Escape velocity is the minimum velocity with which a body must be projected so that it escapes the Earth's gravitational field and never returns.
- Gravitation explains the tides, the motion of the Moon around the Earth and the motion of the planets around the Sun.

Important Definitions

Term	Definition
Gravitation	The force of attraction between any two masses in the universe.
Gravitational constant (G)	The constant of proportionality in Newton's law of gravitation, 6.67 x 10^-11 N m^2/kg^2.
Acceleration due to gravity (g)	The acceleration produced in a freely falling body by the Earth's gravitational pull.
Artificial satellite	A man-made object placed in orbit around the Earth or another planet.
Geostationary satellite	A satellite that orbits above the equator with the same period as the Earth's rotation.
Escape velocity	The minimum velocity needed for a body to escape the Earth's gravitational field.
Centripetal force	The force directed towards the centre of a circular path that keeps a body moving in a circle.
Orbit	The curved path followed by a satellite or planet under the force of gravity.

Weightlessness	The state in which a body feels no weight, as in a freely falling lift or an orbiting satellite.
Tide	The periodic rise and fall of sea level caused mainly by the gravitational pull of the Moon.

Important Formulas

> Newton's law of gravitation: F = G m1 m2 / r^2
>
> Weight W = mg
>
> Mass of the Earth M = g R^2 / G
>
> g = GM / R^2
>
> Orbital velocity of a satellite v = square root of (GM / r)
>
> Escape velocity = square root of (2gR)

Key Terms to Remember

gravitation, **gravitational constant**, **acceleration due to gravity**, **artificial satellite**, **geostationary satellite**, **escape velocity**, **centripetal force**, **orbit**, **weightlessness**, **tide**

Chapter 6: Gravitation — Practice Questions

Multiple Choice Questions

1. The force of gravitation between two masses depends on:

(a) Their masses and the distance between them (b) Their masses only (c) Their distance only (d) Their volumes

2. The value of the gravitational constant G is:

(a) 9.8 N m^2/kg^2 (b) 6.67 x 10^-11 N m^2/kg^2 (c) 10 N m^2/kg^2 (d) 1.6 x 10^-19 N m^2/kg^2

3. The value of g is greatest at the:

(a) Equator (b) Poles (c) Centre of the Earth (d) Top of a mountain

4. As height above the Earth increases, the value of g:

(a) Increases (b) Decreases (c) Stays the same (d) Becomes zero at once

5. The mass of the Earth can be found from:

(a) M = g R^2 / G (b) M = G R^2 / g (c) M = g G / R^2 (d) M = R^2 / gG

6. A geostationary satellite appears fixed because:

(a) It does not move (b) Its period equals the Earth's rotation period (c) It is very far away (d) It is tied to the Earth

7. The centripetal force for a satellite in orbit is provided by:

(a) Friction (b) Gravitation (c) Air pressure (d) Its engine

8. The Moon is:

(a) An artificial satellite (b) The Earth's natural satellite (c) A planet (d) A star

9. Escape velocity from the Earth is about:

(a) 7.9 km/s (b) 11.2 km/s (c) 3 km/s (d) 1 km/s

10. Tides in the sea are mainly caused by the gravitational pull of the:

(a) Sun only (b) Moon (c) Stars (d) Wind

Short Questions

1. State Newton's law of universal gravitation in words and in symbols.
2. Define the gravitational constant G and state its value and unit.
3. Why is the value of g greater at the poles than at the equator?
4. How is the mass of the Earth found from the law of gravitation?
5. What is a geostationary satellite? Give two of its uses.

Long Questions

1. State and explain Newton's law of universal gravitation. Derive the formula for the mass of the Earth and calculate it using g = 10 m/s^2, R = 6.4 x 10^6 m and G = 6.67 x 10^-11 N m^2/kg^2.
2. Explain how an artificial satellite stays in orbit around the Earth. Describe geostationary satellites and their uses, and explain what is meant by escape velocity.

Chapter 7: Properties of Matter

Matter exists as solid, liquid and gas, and its behaviour can be explained by the kinetic molecular model. This chapter explains density, pressure, atmospheric pressure, Pascal's principle and Archimedes' principle.

Key Concepts

- The kinetic molecular model states that matter is made of tiny particles that are in constant motion. The particles of a solid vibrate about fixed positions, those of a liquid slide over each other, and those of a gas move freely in all directions.
- Density is mass per unit volume. The density of water is 1000 kg/m^3. A body floats if its density is less than that of the liquid, and sinks if it is greater.
- Pressure is force per unit area. Its SI unit is the pascal (Pa); one pascal is one newton per square metre.
- Pressure in a liquid increases with depth, because of the weight of the liquid above. It acts equally in all directions at a given depth.
- Atmospheric pressure is the pressure exerted by the air around us. It is about 101,300 Pa at sea level and decreases with height above sea level.
- A barometer measures atmospheric pressure. A mercury barometer supports a column of mercury about 760 mm high at sea level; an aneroid barometer uses a partially evacuated metal box.
- Pascal's principle states that pressure applied to an enclosed liquid is transmitted equally to every part of the liquid. Hydraulic machines such as car lifts and brakes work on this principle.
- Archimedes' principle states that when a body is immersed in a fluid, it experiences an upthrust equal to the weight of the fluid it displaces.
- A body floats when the upthrust on it equals its weight, and sinks when its weight is greater than the upthrust. Ships float because the upthrust on the large volume of water they displace equals their weight.
- Surface tension and viscosity are properties of liquids: surface tension makes the surface of a liquid behave like a stretched skin, and viscosity is the resistance of a liquid to flow.

Important Definitions

Term	Definition
Density	Mass per unit volume of a substance.
Pressure	Force applied per unit area.
Atmospheric pressure	The pressure exerted by the weight of the air in the atmosphere.
Pascal's principle	Pressure applied to an enclosed liquid is transmitted equally to all parts of the liquid.
Archimedes' principle	A body immersed in a fluid experiences an upthrust equal to the weight of the fluid it displaces.
Upthrust	The upward force exerted by a fluid on a body immersed in it.
Barometer	An instrument used to measure atmospheric pressure.
Hydraulic machine	A machine that uses a liquid under pressure to transmit force, for example a hydraulic lift.
Kinetic molecular model	The model that explains matter as tiny particles in constant motion.
Viscosity	The resistance of a liquid to flow.

Important Formulas

> Density = mass / volume
>
> Pressure = force / area
>
> Pressure in a liquid P = density x g x height (P = rho g h)
>
> Atmospheric pressure at sea level = 101,300 Pa (about 760 mm of mercury)
>
> Upthrust = weight of displaced fluid
>
> Hydraulic press: F1 / A1 = F2 / A2

Key Terms to Remember

kinetic molecular model, **density**, **pressure**, **atmospheric pressure**, **barometer**, **Pascal's principle**, **Archimedes' principle**, **upthrust**, **hydraulic machine**, **viscosity**, **surface tension**

Chapter 7: Properties of Matter — Practice Questions

Multiple Choice Questions

1. The density of water is:

(a) 100 kg/m^3 (b) 1000 kg/m^3 (c) 10 kg/m^3 (d) 10,000 kg/m^3

2. The SI unit of pressure is:

(a) Newton (b) Joule (c) Pascal (d) Watt

3. Pressure in a liquid increases with:

(a) Area only (b) Depth (c) Volume only (d) Temperature only

4. Atmospheric pressure at sea level is about:

(a) 101,300 Pa (b) 10,130 Pa (c) 1,013,000 Pa (d) 101 Pa

5. A mercury barometer at sea level supports a column of mercury about:

(a) 76 mm high (b) 760 mm high (c) 7600 mm high (d) 7.6 mm high

6. Pascal's principle is used in:

(a) A thermometer (b) A hydraulic lift (c) A barometer (d) A spring balance

7. According to Archimedes' principle, the upthrust on a body equals the:

(a) Weight of the body (b) Weight of the fluid displaced (c) Volume of the body (d) Density of the body

8. A body floats when:

(a) Its weight is greater than the upthrust (b) The upthrust equals its weight (c) It has no weight (d) The fluid has no density

9. In a hydraulic press, the pressure is:

(a) Greater on the small piston (b) The same at both pistons (c) Greater on the large piston (d) Zero

10. Ice floats on water because the density of ice is:

(a) Greater than water (b) Less than water (c) Equal to water (d) Zero

Short Questions

1. Define density and state the density of water in SI units.
2. Define pressure and state its SI unit.
3. State Pascal's principle and give one application.
4. State Archimedes' principle in your own words.
5. Why does atmospheric pressure decrease with height?

Long Questions

1. Explain the kinetic molecular model of matter and use it to explain the differences between solids, liquids and gases. Derive the formula for pressure in a liquid, P = rho g h.
2. State and explain Pascal's principle and Archimedes' principle. Describe the working of a hydraulic lift and explain why a ship made of steel floats on water.

Chapter 8: Energy Sources and Transfer of Energy

Energy is the ability to do work, and it can be transferred from one form to another but never created or destroyed. This chapter explains work, energy, power and efficiency, and the sources from which we obtain energy.

Key Concepts

- Work is done when a force moves a body through a distance in the direction of the force. Work = force x distance, and its SI unit is the joule (J).
- Energy is the ability to do work. Its SI unit is also the joule. Energy exists in many forms: kinetic, potential, heat, light, sound, chemical and electrical energy.
- Kinetic energy is the energy a body has because of its motion. It depends on the mass of the body and on the square of its velocity.
- Potential energy is the energy a body has because of its position or state. Gravitational potential energy depends on mass, height and the value of g.
- The law of conservation of energy states that energy can neither be created nor destroyed; it can only be changed from one form to another.
- Power is the rate of doing work, or the rate at which energy is transferred. Its SI unit is the watt (W); one watt is one joule per second.
- Efficiency is the ratio of useful energy output to total energy input, usually expressed as a percentage. No machine is 100 percent efficient because some energy is always wasted, usually as heat.
- Energy sources are renewable or non-renewable. Renewable sources, such as the Sun, wind, water and biomass, are replenished naturally; non-renewable sources, such as coal, oil and natural gas, are used up and cannot be replaced quickly.
- Solar energy, wind energy and hydroelectric energy are clean sources that do not pollute the air. Fossil fuels give large amounts of energy but produce smoke and carbon dioxide.
- Energy is transferred by doing work, by heating and by waves. In a power station, chemical or nuclear energy is changed into heat, then into kinetic energy of a turbine, and finally into electrical energy.

Important Definitions

Term	Definition
Work	Force multiplied by the distance moved in the direction of the force.
Energy	The ability to do work.
Kinetic energy	The energy a body has because of its motion.
Potential energy	The energy a body has because of its position or state.
Power	The rate of doing work or of transferring energy.
Efficiency	The ratio of useful energy output to total energy input.
Renewable energy	Energy from a source that is replenished naturally and does not run out.
Non-renewable energy	Energy from a source that is used up and cannot be replaced in a short time.
Joule	The SI unit of work and energy; one joule is the work done by a force of one newton moving a body one metre.
Watt	The SI unit of power; one watt is one joule per second.

Important Formulas

> Work W = F x S
>
> Kinetic energy = (1/2) m v^2
>
> Gravitational potential energy = m g h
>
> Power P = work / time = W / t
>
> Efficiency = (useful energy output / total energy input) x 100%
>
> 1 kW = 1000 W; 1 kWh = 3.6 x 10^6 J

Key Terms to Remember

work, **energy**, **kinetic energy**, **potential energy**, **power**, **efficiency**, **renewable energy**, **non-renewable energy**, **solar energy**, **hydroelectric energy**, **fossil fuel**, **conservation of energy**

Chapter 8: Energy Sources and Transfer of Energy — Practice Questions

Multiple Choice Questions

1. The SI unit of work is:

(a) Watt (b) Joule (c) Newton (d) Pascal

2. Kinetic energy depends on:

(a) Mass and velocity (b) Mass only (c) Height only (d) Time only

3. Gravitational potential energy of a body depends on:

(a) Its speed (b) Its mass and height (c) Its temperature (d) Its volume

4. Power is the rate of:

(a) Doing work (b) Moving a body (c) Applying force (d) Storing energy

5. One watt is equal to:

(a) One joule per second (b) One newton per metre (c) One joule per metre (d) One newton per second

6. Which of the following is a renewable source of energy?

(a) Coal (b) Oil (c) Solar energy (d) Natural gas

7. Efficiency of a machine is always:

(a) 100% (b) More than 100% (c) Less than 100% (d) Zero

8. The energy wasted in most machines appears as:

(a) Light (b) Heat (c) Sound only (d) Motion

9. A body of mass 2 kg moving with velocity 3 m/s has kinetic energy:

(a) 6 J (b) 9 J (c) 12 J (d) 18 J

10. Hydroelectric energy is obtained from:

(a) The Sun (b) Wind (c) Flowing water (d) Coal

Short Questions

1. Define work and state its SI unit and formula.
2. Define kinetic energy and potential energy with one example of each.
3. State the law of conservation of energy.
4. Define power and efficiency. State their units.
5. Give two renewable and two non-renewable sources of energy.

Long Questions

1. Define work, energy and power. Derive the formulas for kinetic energy, (1/2)mv^2, and gravitational potential energy, mgh, and solve a numerical problem with each.
2. Describe the main sources of energy. Compare renewable and non-renewable sources, and explain how energy is transferred in a hydroelectric power station from water to electricity.

Chapter 9: Thermal Properties of Matter

Heat and temperature are closely related but different. This chapter explains temperature, heat, thermal expansion, specific heat capacity, latent heat and the ways in which heat is transferred.

Key Concepts

- Temperature is a measure of how hot or cold a body is. It is measured with a thermometer and its SI unit is the kelvin (K); the Celsius scale is commonly used in daily life.
- Heat is a form of energy that flows from a hotter body to a colder body. Its SI unit is the joule (J).
- When a body is heated, its particles move faster and it expands. Thermal expansion is the increase in the size of a body when its temperature rises. Solids, liquids and gases all expand on heating, and gases expand most.
- A bimetallic strip is made of two different metals joined together. On heating, the metals expand by different amounts, so the strip bends. Bimetallic strips are used in thermostats and fire alarms.
- Specific heat capacity is the amount of heat needed to raise the temperature of 1 kg of a substance by 1 K. Its SI unit is J/(kg K). Water has a high specific heat capacity, which is why it is used in cooling systems.
- The heat absorbed or given out by a body is Q = m c delta T, where m is the mass, c the specific heat capacity and delta T the change in temperature.
- Latent heat is the heat absorbed or given out when a substance changes state without any change in temperature, for example when ice melts or water boils.
- Heat is transferred by conduction, convection and radiation. Conduction is the transfer of heat through a material without the movement of the material itself; metals are good conductors and wood and plastic are poor conductors.
- Convection is the transfer of heat by the movement of a fluid. It causes sea breezes and land breezes and the circulation of water in a heating system.
- Radiation is the transfer of heat by electromagnetic waves and needs no medium. The Sun's heat reaches the Earth by radiation, and dark dull surfaces absorb radiation better than light shiny ones.

Important Definitions

Term	Definition
Temperature	A measure of how hot or cold a body is.
Heat	A form of energy that flows from a hotter body to a colder body.
Thermal expansion	The increase in the size of a body when its temperature rises.
Specific heat capacity	The heat needed to raise the temperature of 1 kg of a substance by 1 K.
Latent heat	The heat absorbed or released during a change of state at constant temperature.
Conduction	Transfer of heat through a material without movement of the material.
Convection	Transfer of heat by the movement of a fluid.
Radiation	Transfer of heat by electromagnetic waves, needing no medium.
Thermostat	A device that keeps temperature steady, often using a bimetallic strip.

Thermal equilibrium	The state in which two bodies in contact reach the same temperature and no heat flows between them.

Important Formulas

> Heat absorbed or given out: Q = m c delta T
>
> Linear expansion: change in length = original length x coefficient of linear expansion x change in temperature
>
> Latent heat: Q = m L, where L is the specific latent heat
>
> 1 K change = 1 degree Celsius change
>
> Boiling point of water = 100 degrees C; melting point of ice = 0 degrees C

Key Terms to Remember

temperature, **heat**, **thermal expansion**, **bimetallic strip**, **specific heat capacity**, **latent heat**, **conduction**, **convection**, **radiation**, **thermostat**, **sea breeze**, **land breeze**

Chapter 9: Thermal Properties of Matter — Practice Questions

Multiple Choice Questions

1. The SI unit of temperature is:

(a) Degree Celsius (b) Kelvin (c) Joule (d) Fahrenheit

2. Heat flows from a body at:

(a) Lower temperature to higher temperature (b) Higher temperature to lower temperature (c) Equal temperature (d) Any direction

3. Which of the following expands most on heating?

(a) Iron (b) Water (c) Air (d) Glass

4. A bimetallic strip bends on heating because:

(a) Both metals expand equally (b) The metals expand by different amounts (c) It melts (d) It contracts

5. Specific heat capacity is measured in:

(a) J/kg (b) J/(kg K) (c) J/K (d) W/K

6. Water has a high specific heat capacity, so it is used in:

(a) Cooling systems (b) Heating coils (c) Thermometers (d) Batteries

7. Latent heat is absorbed during a change of state:

(a) With a rise in temperature (b) With a fall in temperature (c) Without any change in temperature (d) Only in solids

8. Heat transfer by conduction takes place mainly in:

(a) Gases (b) Liquids (c) Solids (d) Vacuum

9. The Sun's heat reaches the Earth by:

(a) Conduction (b) Convection (c) Radiation (d) Evaporation

10. A sea breeze blows during the day from:

(a) Land to sea (b) Sea to land (c) Sky to land (d) Sea to sky

Short Questions

1. Distinguish between heat and temperature.
2. Define specific heat capacity and state its SI unit.
3. What is latent heat? Give one example.
4. Define conduction, convection and radiation with one example of each.
5. Why is water used in the cooling systems of engines?

Long Questions

1. Explain thermal expansion in solids, liquids and gases. Describe the construction and working of a bimetallic strip and its use in a thermostat.
2. Define specific heat capacity and latent heat. Derive Q = m c delta T, explain the three methods of heat transfer with daily-life examples, and explain the formation of sea and land breezes.

MCQ Answer Key

Check your answers below. Each chapter has 10 MCQs, numbered 1 to 10.

Chapter	1	2	3	4	5	6	7	8	9	10
Ch. 1	C	B	C	B	C	B	C	B	B	C
Ch. 2	C	B	A	D	C	B	B	B	C	B
Ch. 3	C	B	B	B	B	B	D	B	B	B
Ch. 4	C	B	B	B	C	B	B	B	B	B
Ch. 5	B	B	B	A	B	B	A	B	B	A
Ch. 6	A	B	B	B	A	B	B	B	B	B
Ch. 7	B	C	B	A	B	B	B	B	B	B
Ch. 8	B	A	B	A	A	C	C	B	B	C
Ch. 9	B	B	C	B	B	A	C	C	C	B

Score guide: count your correct answers out of 90. Re-read the notes for every chapter in which you scored less than 7 out of 10.

Final Revision Checklist

- Can you state all nine chapter titles in order?
- Can you write the three equations of motion and F = ma without looking?
- Can you define torque, stress, strain, pressure, power and specific heat capacity?
- Can you state Newton's laws, Hooke's law, Pascal's principle and Archimedes' principle?
- Have you practised at least one numerical from every chapter?

End of notes. Good luck with your studies — revise regularly, practise the numericals, and check your own board's official website for the current model paper.