

Physics Basics

Measurement · Force · Pressure · Energy

This study guide covers:

- Units and systems of measurement (SI units)
- Fundamental and derived units, measuring instruments
- Force — types, Newton's laws of motion
- Pressure — fluid pressure, atmospheric pressure, Pascal's law
- Energy — types, law of conservation of energy, work-energy theorem
- Exam-important points and quick-revision facts

Chapter 1 — Measurement

1.1 What is Measurement?

The process of comparing a physical quantity with a fixed unit is called **measurement**. Every quantity measured in physics must have both a numerical value and a unit. For example, if the length of a table is 2 metres, 2 is the numerical value and metre is the unit.

Types of Physical Quantities

Type	Description	Examples
Fundamental Quantities	Independent quantities that do not depend on other quantities	Length, mass, time, electric current, temperature, luminous intensity, amount of substance
Derived Quantities	Quantities obtained from fundamental quantities	Area, volume, speed, acceleration, force, pressure, energy

1.2 The SI System of Units (International System of Units)

The system of units adopted for universal scientific communication is called the **SI system** (Système International d'Unités). It was established in 1960.

The 7 Fundamental SI Units

No.	Fundamental Quantity	SI Unit	Symbol
1	Length	Metre	m
2	Mass	Kilogram	kg
3	Time	Second	s
4	Electric Current	Ampere	A
5	Temperature	Kelvin	K
6	Amount of Substance	Mole	mol
7	Luminous Intensity	Candela	cd

Exam Tip: "The 7 fundamental units and their symbols" is a frequently asked direct question in TNPSC. Memorize them in order.

Some Important Derived Units

Quantity	Formula	SI Unit
Area	Length $\times$ Breadth	m ²
Volume	Length $\times$ Breadth $\times$ Height	m ³
Density	Mass / Volume	kg/m ³
Speed	Distance / Time	m/s
Acceleration	Change in speed / Time	m/s ²
Force	Mass $\times$ Acceleration	N (Newton)
Pressure	Force / Area	Pa (Pascal)
Work/Energy	Force $\times$ Distance	J (Joule)
Power	Work / Time	W (Watt)

1.3 Measuring Instruments

Instrument	Use
Metre Scale	To measure length to millimetre accuracy
Vernier Callipers	To measure the length/diameter of small objects to 0.01 cm accuracy
Screw Gauge	To measure the diameter of a wire or the thickness of a sheet to 0.001 cm accuracy
Physical Balance	To measure the mass of an object
Stop Watch	To measure time intervals
Thermometer	To measure temperature

Remember: Least Count of a Vernier Callipers = 0.01 cm. Least Count of a Screw Gauge = 0.001 cm (for commonly used models).

1.4 SI Prefixes

Prefix	Symbol	Multiplying Factor
Kilo	k	10 ³ (1000)
Centi	c	10 ⁻² (1/100)
Milli	m	10 ⁻³ (1/1000)

Micro	μ	10^{-6}
Mega	M	10^6
Giga	G	10^9

Chapter 1 — Summary

- The SI system has 7 fundamental units.
- Length (m), mass (kg), time (s) are frequently asked fundamental units.
- Derived units are obtained from fundamental units (e.g. Force = $\text{kg} \cdot \text{m}/\text{s}^2$).
- Vernier callipers and screw gauge are precision length-measuring instruments.

Chapter 2 — Force

2.1 What is Force?

A push or pull that can change or tends to change the state (rest or motion) of an object is called **force**. Force is a vector quantity — it has both magnitude and direction.

$$\text{Force (F)} = \text{Mass (m)} \times \text{Acceleration (a)} \quad | \quad \text{SI Unit: Newton (N)} \quad | \quad 1 \text{ N} = 1 \text{ kg} \cdot \text{m/s}^2$$

2.2 Types of Force

Type	Description	Example
Contact Force	Occurs when objects are in direct contact	Push, pull, friction
Non-Contact Force	Acts from a distance without contact	Gravitational force, magnetic force, electrostatic force
Gravitational Force	The force that pulls objects towards the centre of the Earth	Falling objects
Frictional Force	The force that opposes relative motion between two surfaces	Friction on an object moving on the ground
Magnetic Force	Acts between magnets or on magnetic materials	A magnet attracting iron
Electrostatic Force	Acts between electrically charged objects	A comb attracting bits of paper

2.3 Newton's Laws of Motion

First Law — Law of Inertia

If no external force acts on an object, an object at rest stays at rest, and an object in uniform motion continues to move in the same direction at the same speed. This is the basis of the property called **inertia**.

Example: Passengers lurch forward when a bus stops suddenly — this is an effect of inertia.

Second Law — Force and Acceleration

The rate of change of momentum of an object is directly proportional to the force applied on it, and takes place in the direction of the force.

$$F = m \times a$$

Third Law — Action-Reaction Law

For every action, there is an equal and opposite reaction.

Example: A rocket moves upward as the reaction to expelling burning gases downward. When a rower pushes water backward with an oar, the boat moves forward.

Exam Tip: "Questions combining all three of Newton's laws with their examples" are very common in TNPSC. Memorize at least one everyday example for each law.

2.4 Friction

When two surfaces are in contact, the force that opposes relative motion is called **frictional force**. It varies with the nature of the surfaces.

- **Static Friction:** The friction that acts before an object begins to move
- **Kinetic Friction:** The friction that acts while an object is moving
- **Rolling Friction:** The friction that occurs when objects like wheels roll — this is much smaller

Chapter 2 — Summary

- Force = Mass $\times$ Acceleration ($F = ma$); SI unit Newton (N).
- Newton's 1st law — Inertia; 2nd law — $F=ma$; 3rd law — Action-Reaction.
- Frictional force opposes motion; rolling friction is much smaller.

Chapter 3 — Pressure

3.1 What is Pressure?

The force acting perpendicularly per unit area is called **pressure**. Pressure is a scalar quantity.

$$\text{Pressure (P)} = \text{Force (F)} / \text{Area (A)} \quad | \quad \text{SI Unit: Pascal (Pa)} \quad | \quad 1 \text{ Pa} = 1 \text{ N/m}^2$$

3.2 Fluid Pressure

The pressure at a point in a fluid depends on the depth of that point, the density of the fluid, and the acceleration due to gravity.

$$P = h \times \rho \times g \quad (\text{h} = \text{depth}, \rho = \text{density}, g = \text{acceleration due to gravity})$$

- Fluid pressure increases with depth.
- At the same depth, fluid pressure is equal in all directions.
- Fluid pressure does not depend on the shape of the container; it depends only on depth.

3.3 Pascal's Law

Pascal's law states that when pressure is applied to a confined fluid at any point, that pressure is transmitted equally and undiminished to every part of the fluid.

Applications: Hydraulic lift, hydraulic brake, hydraulic jack.

3.4 Atmospheric Pressure

The pressure exerted by the mass of air surrounding the Earth is called **atmospheric pressure**. Its average value at sea level is:

$$1 \text{ Atmosphere (1 atm)} = 101325 \text{ Pa} \approx 76 \text{ cm of mercury column (76 cm of Hg)}$$

- Atmospheric pressure decreases as altitude increases.
- Instrument used to measure atmospheric pressure: **Barometer**
- Instrument used to measure fluid pressure: **Manometer**
- Atmospheric pressure was first measured by: **Evangelista Torricelli**

Exam Tip: "Who invented the barometer?", "1 atmospheric pressure equals how many cm of mercury column?" — such direct questions are frequently asked in TNPSC.

3.5 Buoyancy — Archimedes' Principle

When an object is fully or partially immersed in a fluid, it experiences an upward thrust equal to the weight of the fluid it displaces.

Application: Ships floating on water; a hydrometer measuring the relative density of liquids.

Chapter 3 — Summary

- Pressure = Force / Area; SI unit Pascal (Pa).
- Pascal's law — pressure applied to a confined fluid transmits equally in all directions.
- 1 atm $\approx$ 76 cm Hg; barometer — measures atmospheric pressure.
- Archimedes' principle — concerns buoyant force.

Chapter 4 — Energy

4.1 What is Energy?

The capacity to do work is called **energy**. The SI unit of energy is the **Joule (J)**. It is a scalar quantity.

$$\text{Work (W)} = \text{Force (F)} \times \text{Displacement (d)} \quad | \quad \text{SI Unit: Joule (J)} \quad | \quad 1 \text{ J} = 1 \text{ N}\cdot\text{m}$$

4.2 Types of Energy

Type of Energy	Description	Example
Kinetic Energy	Energy due to motion	A running car, a flying arrow
Potential Energy	Energy stored due to position or shape	An object placed at a height, a stretched spring
Heat Energy	Associated with a change in temperature	Hot water, solar heat
Light Energy	Energy that travels in the form of light	Sunlight, an electric bulb
Electrical Energy	Energy due to electric current	Household electrical appliances
Chemical Energy	Energy stored in chemical substances	Food, fuel, batteries
Nuclear Energy	Energy released by fission/fusion of atomic nuclei	Nuclear reactor
Sound Energy	Energy that travels through vibrations	Speech, musical instruments

Formulas for Kinetic and Potential Energy

$$\text{Kinetic Energy (KE)} = \frac{1}{2} \times m \times v^2$$

$$\text{Potential Energy (PE)} = m \times g \times h$$

(m = mass, v = velocity, g = acceleration due to gravity, h = height)

4.3 Law of Conservation of Energy

Energy can neither be created nor destroyed; it can only be converted from one form to another. In an isolated system, the total energy always remains constant.

Example: In a hydroelectric power station — the potential energy of water is converted into kinetic energy, and then into electrical energy.

4.4 Work-Energy Theorem

The total work done on an object is equal to the change in its kinetic energy.

$$W = \Delta KE = KE_{\text{final}} - KE_{\text{initial}}$$

4.5 Power

The rate at which work is done is called **power**.

$$\text{Power (P)} = \text{Work (W)} / \text{Time (t)} \quad | \quad \text{SI Unit: Watt (W)} \quad | \quad 1 \text{ W} = 1 \text{ J/s}$$

Commercial unit: The commercial unit of electrical energy is the **kilowatt-hour (kWh)** — this is what is called "one unit" of electricity. $1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$.

Exam Tip: "The law of conservation of energy was first introduced by James Prescott Joule." Questions on converting between kWh and Joule are frequently asked.

Chapter 4 — Summary

- Energy = capacity to do work; SI unit Joule (J).
- $KE = \frac{1}{2}mv^2$; $PE = mgh$.
- Law of conservation of energy — energy can neither be created nor destroyed.
- Power = Work/Time; SI unit Watt (W); commercial unit kWh.

Quick Revision — Key Formulas and Facts

Quantity	Formula	SI Unit
Force	$F = m \times a$	Newton (N)
Pressure	$P = F / A$	Pascal (Pa)
Fluid Pressure	$P = h \times \rho \times g$	Pascal (Pa)
Work	$W = F \times d$	Joule (J)
Kinetic Energy	$KE = \frac{1}{2} m v^2$	Joule (J)
Potential Energy	$PE = m g h$	Joule (J)
Power	$P = W / t$	Watt (W)

Constant	Value
1 Atmospheric pressure (1 atm)	101325 Pa $\approx$ 76 cm Hg
Acceleration due to gravity (g)	9.8 m/s ² (average)
1 kWh	3.6×10^6 J