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Short Notes — Applied Physics-I

BTEUP Diploma • 1st Semester (First Year — Common Curriculum, All 41 Branches) •

Short Notes

Session 2026-27

Short Revision Notes — prepared by KAMALDNP Academy from the official BTEUP 2026-27 syllabus. This is NOT a BTEUP board paper or publication.

These **short notes on Applied Physics-I** collect the key points of every unit of the official BTEUP 2026-27 syllabus in one place. Each subtopic starts with the definition and then gives the laws, formulas with units and steps from which a complete **5-mark short answer** can be written in the examination.

Use the notes **with your syllabus PDF and the practice paper**: read one subtopic, close the notes and write the answer from memory, then check the formulas and units again. These are **revision notes only** — they revise the subject quickly before the exam and are not a replacement for your textbook or class notes.

Mechanics

Topics: Laws of motion; force, work, energy and power; friction; circular motion.

Laws of motion

Definition: Mechanics deals with bodies at rest or in motion under forces. Newton's laws are its foundation. **First law (law of inertia):** a body remains at rest or in uniform straight-line motion unless an external force acts on it; inertia is measured by mass. **Second law:** the rate of change of momentum is proportional to the applied force and takes place in the direction of the force, giving $\mathbf{F} = m\mathbf{a}$, where force F is in newton (N), mass m in kg and acceleration a in

m/s^2 . One newton is the force giving 1 kg an acceleration of 1 m/s^2 . **Third law:** to every action there is an equal and opposite reaction, acting on two different bodies.

Momentum and impulse: momentum $p = mv$ ($\text{kg}\cdot\text{m/s}$); impulse $= F \times t = \text{change of momentum}$. Weight is the force of gravity: $W = mg$, with $g = 9.8 \text{ m/s}^2$.

Equations of motion (uniform acceleration):

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Here u is initial velocity, v final velocity, s displacement and t time. For free fall use $a = g$ and $u = 0$; for a body thrown upwards $a = -g$. In a numerical, list the given quantities first, choose the equation containing the unknown, and state the unit.

Force, work, energy and power

Definitions: Force is a push or pull that changes or tries to change the state of rest or motion of a body ($F = ma$, unit newton). **Work** is done when a force moves its point of application: **$W = F \cdot s \cdot \cos \theta$** , where s is the displacement and θ the angle between force and displacement; its unit is the joule (J), $1 \text{ J} = 1 \text{ N} \times 1 \text{ m}$. No work is done when there is no displacement, or when the force is perpendicular to the displacement ($\theta = 90^\circ$). **Energy** is the capacity to do work, measured in joule. **Power** is the rate of doing work: **$P = W/t$** , unit watt (W), $1 \text{ W} = 1 \text{ J/s}$; also $P = F \cdot v$ for a constant velocity.

Forms of mechanical energy:

Kinetic energy $KE = \frac{1}{2}mv^2$

Potential energy $PE = mgh$

Work-energy theorem: the net work done on a body equals the change in its kinetic energy, $W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$. **Law of conservation of energy:** energy can neither be created nor destroyed; it only changes form, so for a freely falling body $KE + PE$ remains constant when friction is neglected. In numericals, convert masses to kg and distances to metres before substituting.

Friction

Definition: Friction is the opposing force that arises at the surface of contact between two bodies when one body moves or tries to move over the other. It always acts opposite to the direction of relative motion (or attempted motion) and parallel to the surfaces in contact.

Laws of friction:

- The frictional force is directly proportional to the normal reaction N between the surfaces: $f = \mu N$.
- It is (approximately) independent of the area of contact and, for kinetic friction, of the sliding speed.

- It depends on the nature and roughness of the surfaces, expressed by the coefficient of friction μ , which has no unit.

Types: static friction acts before motion starts and adjusts itself up to a maximum, the limiting friction $f_s = \mu_s N$; **kinetic (dynamic) friction** acts during motion, $f_k = \mu_k N$. Always μ_s is greater than μ_k , which is why more force is needed to start a body moving than to keep it moving. The **angle of friction** λ satisfies $\tan \lambda = \mu$; the angle of repose of an inclined plane equals the angle of friction.

Uses and reduction: friction makes walking, gripping, braking and belt drives possible, but wastes energy as heat; it is reduced by polishing, lubrication, ball bearings and streamlining.

Circular motion

Definition: Circular motion is the motion of a body along a circular path. In uniform circular motion the speed is constant but the velocity changes continuously because its direction changes, so the body is always accelerated towards the centre of the circle.

Quantities and formulas:

Angular displacement θ , angular velocity $\omega = \theta/t$ (rad/s)

Linear speed $v = \omega r$, where r is the radius

Time period $T = 2\pi/\omega$; frequency $n = 1/T$

Centripetal acceleration $a = v^2/r = \omega^2 r$

Centripetal force $F = mv^2/r = m\omega^2 r$

The **centripetal force** is the force directed towards the centre that keeps the body on the circular path — tension in a string, friction between tyres and road, or gravitational pull for a satellite. It is not a new kind of force; some real force plays this role. **Centrifugal force** is the apparent (pseudo) force felt outwards in the rotating frame.

Applications to quote: a cyclist leans inwards while turning; roads are banked at curves, the ideal banking angle being given by $\tan \theta = v^2/(rg)$; a cream separator and a centrifuge work on the centrifugal principle. In numericals keep ω consistent: if n (revolutions per second) is given, $\omega = 2\pi n$.

Likely question: State Newton's laws of motion and derive $v = u + at$ and $s = ut + \frac{1}{2}at^2$, or solve: a force of 50 N acts on a mass of 10 kg initially at rest — find its velocity and distance covered after 4 s (neglect friction).

Electricity & Magnetism

Topics: Electric charge, current and voltage; Ohm's law; magnetic effects of current.

Electric charge, current and voltage

Definitions: Electric charge is the property of matter due to which it experiences a force in an electric field; its unit is the coulomb (C). Charge is quantised: $Q = \pm ne$, where $e = 1.6 \times 10^{-19}$ C is the charge of one electron. Like charges repel and unlike charges attract, with force given by Coulomb's law, $F = (1/4\pi\epsilon_0) \cdot q_1q_2/r^2$, where $1/4\pi\epsilon_0 = 9 \times 10^9$ N·m²/C² in vacuum.

Electric current is the rate of flow of charge through a conductor: $I = Q/t$, unit ampere (A); 1 A = 1 C/s. In metals the current is a flow of electrons, opposite in direction to the conventional current. **Potential difference (voltage)** between two points is the work done in moving unit charge between them: $V = W/Q$, unit volt (V); 1 V = 1 J/C. Current is measured by an ammeter connected in series, and voltage by a voltmeter connected in parallel.

Conductors and insulators: conductors (copper, aluminium) have many free electrons and allow current easily; insulators (rubber, plastic, glass) have almost none. A cell or battery maintains the potential difference that drives the current around a circuit.

Ohm's law

Definition — Ohm's law: At constant temperature, the current flowing through a conductor is directly proportional to the potential difference across its ends: $V = IR$, where R is the resistance of the conductor in ohm (Ω). The V-I graph of an ohmic conductor is a straight line through the origin, and its slope gives R.

Resistance and resistivity: resistance opposes the flow of current and depends on the conductor as $R = \rho L/A$, where L is the length, A the area of cross-section and ρ the resistivity (specific resistance) of the material, in $\Omega \cdot m$. Resistance increases with length and temperature (for metals) and decreases with thickness; resistivity depends only on the material and temperature, not on dimensions.

Combinations:

Series: $R = R_1 + R_2 + R_3$; current is the same everywhere, voltages divide.

Parallel: $1/R = 1/R_1 + 1/R_2 + 1/R_3$; voltage is the same across each branch, currents divide, and the equivalent is smaller than the smallest resistor.

Electric power and energy: $P = VI = I^2R = V^2/R$ (watt); energy consumed = $P \times t$, measured commercially in kilowatt-hour (unit). State the law's condition — constant temperature — in every answer.

Magnetic effects of current

Definition: A magnetic field is the region around a magnet or a current-carrying conductor in which its magnetic influence is felt. Oersted discovered that a current-carrying conductor deflects a compass needle — current produces magnetism.

Field of a straight conductor: the magnetic field lines are concentric circles around the wire, in a plane perpendicular to it. The direction is given by the **right-hand thumb rule**: hold the conductor with the thumb pointing along the current; the curling fingers give the direction of the field. Field strength increases with current and decreases with distance from

the wire. A current-carrying coil behaves like a bar magnet, and a long coil (solenoid) gives a strong, nearly uniform field inside; inserting a soft-iron core makes an **electromagnet**.

Force on a conductor: a conductor carrying current I , of length L , placed in a magnetic field B experiences a force $\mathbf{F} = BIL \sin \theta$, where θ is the angle between the conductor and the field; the force is greatest (BIL) when the conductor is perpendicular to the field and zero when parallel. Its direction is given by **Fleming's left-hand rule** (thumb = force/motion, first finger = field, middle finger = current). This force on the coil of an electric motor is its working principle. The unit of B is the tesla (T).

Likely question: State and explain Ohm's law, derive the equivalent resistance of three resistors in series and in parallel, and solve a numerical combining both — or describe the magnetic field due to a straight current-carrying conductor with a neat diagram.

Optics & Waves

Topics: Reflection and refraction; lenses; wave motion and sound.

Reflection and refraction

Definitions: Reflection is the bouncing back of light on striking a polished surface such as a mirror. Refraction is the bending of light when it passes from one medium into another, caused by a change in its speed.

Laws of reflection: (1) the angle of incidence equals the angle of reflection, $i = r$, both measured from the normal; (2) the incident ray, reflected ray and normal all lie in the same plane. For a spherical mirror: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$, focal length $f = R/2$, and magnification $m = -v/u$ = height of image/height of object.

Laws of refraction (Snell's law): (1) the incident ray, refracted ray and normal lie in the same plane; (2) $\sin i / \sin r = \text{constant} = \mu$ for the pair of media. The **refractive index** $\mu = \text{speed of light in vacuum} / \text{speed in the medium} = \text{real depth} / \text{apparent depth}$. From a rarer to a denser medium the ray bends towards the normal, and away from it in reverse.

Total internal reflection: when light travels from a denser to a rarer medium at an angle greater than the **critical angle** ($\sin C = 1/\mu$), it is fully reflected inside. Both conditions — denser to rarer, and angle beyond critical — must be stated; uses include optical fibres and a diamond's brilliance.

Lenses

Definition: A lens is a transparent refracting medium (usually glass) bounded by two curved surfaces, or one curved and one plane surface. A **convex (converging) lens** is thicker at the centre and converges a parallel beam to its principal focus; a **concave (diverging) lens** is thinner at the centre and spreads a parallel beam out as if from its focus.

Lens formula (Cartesian sign convention — distances measured from the optical centre, against the incident light negative):

$$1/v - 1/u = 1/f$$

Magnification $m = v/u = \text{height of image/height of object}$

Power of a lens $P = 1/f$, with f in metres; unit dioptre (D); $P = 100/f$ when f is in centimetres

A convex lens has positive focal length and power; a concave lens has negative values. For a camera-like real image the convex lens forms an inverted, real image on the opposite side; a concave lens forms a virtual, erect, diminished image.

Combinations and uses: for lenses in contact, $P = P_1 + P_2$ and $1/F = 1/f_1 + 1/f_2$. Convex lenses are used in cameras, microscopes, telescopes, projectors and to correct long sight (hypermetropia); concave lenses correct short sight (myopia) and are used in door peep-holes. In a numerical, assign signs first and report whether the image is real or virtual from the sign of v .

Wave motion

Definition: A wave is a disturbance that transfers energy from one place to another without the transfer of matter; the particles of the medium only vibrate about their mean positions. In a **transverse wave** (light, waves on a string) the particles vibrate perpendicular to the direction of propagation, forming crests and troughs; in a **longitudinal wave** (sound) they vibrate parallel to it, forming compressions and rarefactions.

Wave quantities:

- **Wavelength λ** — distance between two consecutive crests (or compressions), in metre.
- **Frequency n** — number of complete vibrations per second, in hertz (Hz).
- **Time period T** — time for one complete vibration; $T = 1/n$.
- **Amplitude** — maximum displacement from the mean position; it decides loudness for sound and brightness for light.

Wave relation: distance travelled in one period is one wavelength, so

$$v = n\lambda$$

where v is the wave velocity. This single relation solves most numericals of this unit: given any two of v , n and λ , find the third. Wave velocity depends on the medium, not on the frequency — when a wave enters a new medium its frequency stays constant while v and λ change together.

Sound

Definition: Sound is a form of energy produced by vibrating bodies and carried as a longitudinal wave through a material medium — solid, liquid or gas. It cannot travel through vacuum, which is the standard difference from light, an electromagnetic wave that needs no medium.

Speed of sound: in air the speed is about **332 m/s at 0 °C**, increasing by roughly 0.6 m/s for every 1 °C rise in temperature. Sound travels fastest in solids, slower in liquids and slowest in gases, because the particles are closer and more strongly bound in a solid.

Audible range and beyond: the human ear hears frequencies from **20 Hz to 20,000 Hz**. Below 20 Hz are **infrasonic** waves (earthquakes, elephants); above 20,000 Hz are **ultrasonic** waves, used in SONAR, medical scanning, cleaning delicate instruments and detecting flaws in metals.

Echo: the repetition of sound after reflection from a distant surface such as a wall or hill. For a distinct echo the reflector must be at least about 17 m away (using the persistence of hearing, 0.1 s). Echo distance is found from distance = $(v \times t)/2$, where t is the time for the sound to go and return — the division by 2 is the step most often missed in numericals.

Likely question: State the laws of refraction, define refractive index, and explain total internal reflection with its conditions and one use — or derive the relation $v = n\lambda$ and solve: a sound wave of frequency 500 Hz travels at 332 m/s; find its wavelength.

Modern Physics

Topics: Atomic structure; semiconductors in brief; lasers and their uses.

Atomic structure

Definition: An atom is the smallest particle of an element that retains the chemical identity of the element. It consists of a tiny, dense, positively charged central **nucleus** with electrons revolving around it in fixed orbits (shells) of definite energy.

Fundamental particles:

- **Proton** — in the nucleus, positive charge $+1.6 \times 10^{-19}$ C, mass about 1.67×10^{-27} kg (taken as 1 unit).
- **Neutron** — in the nucleus, no charge, mass nearly equal to the proton.
- **Electron** — revolves around the nucleus, charge -1.6×10^{-19} C, mass about 1/1836 of a proton.

Atomic number and mass number: atomic number Z = number of protons (= number of electrons in a neutral atom); mass number A = protons + neutrons. An atom is written as ${}^A_ZX$. Electrons fill shells K, L, M, N with maximum capacities 2, 8, 18, 32 (by the $2n^2$ rule), and the outermost (valence) electrons decide the chemical behaviour.

Isotopes and Bohr's model: isotopes are atoms of the same element with the same Z but different A , for example hydrogen's protium, deuterium and tritium. In **Bohr's model** electrons move only in certain stable orbits without radiating, and emit or absorb energy only when jumping between orbits — this explains the line spectra of elements in brief.

Semiconductors in brief

Definition: Semiconductors are materials whose electrical conductivity lies between that of conductors and insulators — silicon and germanium are the standard examples. Their conductivity increases with rise in temperature, opposite to metals, because heating frees more charge carriers.

Intrinsic semiconductor: a pure semiconductor. At room temperature some covalent bonds break, producing equal numbers of free electrons and **holes** (vacant bonds that behave as positive carriers); conduction is small.

Extrinsic semiconductor is made by **doping** — adding a tiny controlled impurity:

- **n-type:** a pentavalent impurity such as phosphorus, arsenic or antimony donates extra electrons; electrons are the majority carriers and holes the minority carriers. The impurity is called a donor.
- **p-type:** a trivalent impurity such as boron, gallium or indium creates extra holes; holes are the majority carriers and electrons the minority carriers. The impurity is called an acceptor.

Note clearly that both types are electrically neutral overall — n and p refer to the sign of the majority charge carriers, not to a net charge on the material. A **p-n junction** formed within one crystal is the basis of the diode and, with further doping, of transistors and integrated circuits used in every electronic device.

Lasers and their uses

Definition: LASER stands for Light Amplification by Stimulated Emission of Radiation. A laser produces an intense, narrow beam of light by **stimulated emission**: an incoming photon of exactly the right energy makes an excited atom emit a second photon identical to it in energy, direction and phase, so the light builds up in step. A population inversion (more atoms in the excited state than the lower state), maintained by pumping, is the essential condition.

Properties of laser light:

- **Monochromatic** — light of almost a single wavelength and colour.
- **Coherent** — all waves are in phase, in time and in space.
- **Highly directional** — the beam spreads very little over long distances.
- **Highly intense** — energy is concentrated in a very narrow beam, and can be focused to a tiny spot.

Uses: in medicine for eye and general surgery and for bloodless operations; in industry for cutting, welding, drilling and engraving hard materials; in communication through optical fibres; in barcode scanners, laser printers, CD/DVD reading, surveying and holographic displays. The standard example of a laser device is the ruby laser or the helium-neon (He-Ne) laser — name one in an answer.

Likely question: Describe the structure of the atom with a neat sketch and explain what isotopes are, or differentiate between n-type and p-type semiconductors and state two properties and two uses of lasers.

Quick Revision — One Line Each

- Newton's second law $F = ma$ defines the newton; momentum $p = mv$ and impulse equals the change of momentum.
- Equations of motion: $v = u + at$, $s = ut + \frac{1}{2}at^2$, $v^2 = u^2 + 2as$ — valid only for uniform acceleration.
- Work $W = F \cdot s \cdot \cos \theta$ (joule); kinetic energy $= \frac{1}{2}mv^2$; potential energy $= mgh$; power $P = W/t$ (watt).
- Limiting friction $f = \mu N$; static friction is greater than kinetic friction, and friction opposes relative motion.
- Circular motion: $v = \omega r$, centripetal acceleration $= v^2/r = \omega^2 r$, centripetal force $= mv^2/r$ towards the centre.
- Current $I = Q/t$ (ampere); potential difference $V = W/Q$ (volt); charge of one electron is 1.6×10^{-19} C.
- Ohm's law $V = IR$; resistance $R = \rho L/A$ — resistance rises with length and falls with thickness.
- Series resistances add; in parallel the reciprocal of the equivalent resistance is the sum of reciprocals.
- A current-carrying conductor in a magnetic field experiences force $F = BIL \sin \theta$ (Fleming's left-hand rule).
- Mirror and lens: magnification shows size and sign; power of a lens $P = 1/f$ in metres, measured in dioptre.
- Refractive index $\mu = \text{speed of light in vacuum} / \text{speed in the medium}$; total internal reflection needs travel from denser to rarer medium beyond the critical angle.
- Waves obey $v = n\lambda$; sound in air travels at about 332 m/s at 0 °C and needs a material medium.
- A laser gives monochromatic, coherent, directional light by stimulated emission; a p-type semiconductor has holes and an n-type has electrons as majority carriers.

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