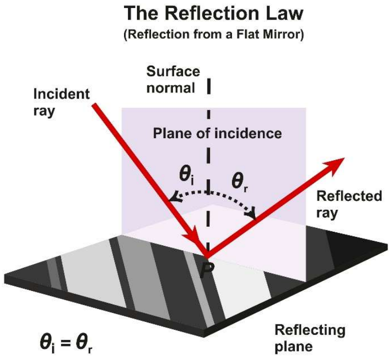
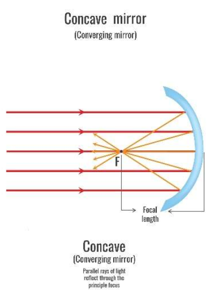
1. **Reflection from Mirror 2:** The angle of incidence on Mirror 2 (i_2) is $90° - 70° = 20°$. The ray is reflected at an angle of $r_2 = 20°$ to the normal (or $70°$ to the mirror surface). (2 marks)



2. When a positively charged rod is placed in contact with an uncharged rod: **Electrons** from the uncharged rod will flow to the positively charged rod. As a result, the uncharged rod will acquire a **net positive charge**.
3. Copper is an excellent conductor, and the wire is made thick to give it very **low resistance**. The low resistance ensures that the very large current from a lightning strike is conducted safely to the ground **without excessive heat generation** , which would prevent the wire from melting.
4. V1; It is connected across the terminals of the cells, measuring the total e.m.f. (electromotive force) of the circuit. The other voltmeters (V2 and V3) measure the potential difference (p.d.) across external components, and their sum is usually less than the e.m.f. due to the internal resistance of the cells
5. **Like magnetic poles repel each other**.
6.



7. **Insulated copper wire** (to form the coil).
   A **source of D.C. (e.g., cell/battery)** (to provide the current).
8. **Manganese Dioxide:** Acts as a **depolariser**. It oxidises the hydrogen gas produced at the carbon electrode, preventing bubbles from insulating the electrode and stopping the cell's operation.
   Powdered Carbon: Increases the **electrical conductivity** of the electrolyte paste.
9. Generate straight waves using a vibrator and project the pattern onto a screen below the tank. Use a metre rule to measure the **total distance (D)** covered by a large number (N) of consecutive bright bands (crests).

   Calculate the wavelength using the relationship: $\lambda = \frac{D}{N}$.
10. ound travels faster on warm nights because the **speed of sound increases with the temperature** of the air. On a warm night, the air molecules move faster, allowing sound energy to be transmitted more quickly than on a cold night.
11. .

$n_{\text{perspex}} = \frac{3}{2}$, $n_{\text{water}} = \frac{4}{3}$. We want $n_{\text{water with respect to perspex}}$:

$$n_{\text{perspex}\to\text{water}} = \frac{n_{\text{water}}}{n_{\text{perspex}}} = \frac{4/3}{3/2}$$

$$n_{\text{perspex}\to\text{water}} = \frac{4}{3} \times \frac{2}{3} = \frac{8}{9}$$

The refractive index is $\frac{8}{9}$ (or 0.889).

12. A diode is a semiconductor device that allows current to flow easily in only **one direction** (forward bias). In a rectification circuit, when connected to A.C., the diode blocks the current during the **negative half-cycle** (reverse bias). This converts the alternating current into a unidirectional, pulsating direct current, a process called **half-wave rectification**.
13. **Optical Fibres** (for high-speed data transmission)
14. Thermometer.
15. (a) Place the magnet in an **East-West direction**. **Heat the magnet** to a red-hot temperature (to increase molecular disorder). **Strike the magnet vigorously and repeatedly** with a hammer. The mechanical shock and heating will scramble the aligned magnetic domains, causing the magnet to lose its magnetism.
    (b) (i) As the wire moves out of the magnetic field , the needle of the centre zero galvanometer **deflects momentarily** in **one direction**.
    (ii) The movement of the wire cutting the magnetic field lines causes a **change in magnetic flux linkage**. This change induces an **e.m.f.** (electromotive force) and consequently, an induced current in the circuit (according to **Faraday's Law of Induction**), which the galvanometer detects.
    (iii) An increased speed of motion of the wire will cause a **larger momentary deflection** on the galvanometer. **Explanation:** This is because a higher speed leads to a **greater rate of change of magnetic flux linkage**. Since the magnitude of the induced e.m.f. is directly proportional to the rate of change of flux (Faraday's Law), a faster motion produces a larger induced current.

(c) Hysteresis losses (energy wasted in magnetising and demagnetising the core) can be minimized by using a **soft magnetic material** for the transformer core. This material, such as **soft iron** or **silicon steel**, has a **narrow hysteresis loop**, meaning less energy is required to reverse the direction of magnetisation repeatedly.

16. **(a) (i)The voltage is stepped down:** This is done **to make the electricity safe for use** by consumers.
(ii) Transmission cables used are thick: The cables are made thick to reduce their electrical resistance (R). This minimizes the power loss (P_{loss} = I_2R) along the transmission lines.
(b)

- **Electrocution Hazard: High voltage poses a serious risk of severe electrical shock or death to people or animals upon contact.**
- **High Insulation Costs: High voltage requires more expensive, thicker, and stronger insulation for safety and to prevent arcing.**

(c)

- **Use more efficient bulbs: Replace less efficient bulbs (like incandescent) with LEDs or CFLs of the same lumen output.**
- **Switch off lights when not needed: Ensure lights are switched off when classrooms are empty or when sufficient natural light is available.**

(d)

(i) **Current drawn by each bulb (I):** Using $P = VI$:

$$I = \frac{P}{V} = \frac{60\ \text{W}}{240\ \text{V}} = 0.25\ \text{A}$$

(ii) **Energy consumed (E) if used for 10 hours:** Total power $(P_{\text{total}}) = 10 \times 60\ \text{W} = 600\ \text{W} = 0.6\ \text{kW}$. Time $(t) = 10\ \text{h}$. Using $E = P \times t$:

$$E = 0.6\ \text{kW} \times 10\ \text{h} = 6.0\ \text{kWh}$$

17. (a)

- **Determining the frequency** and period of an A.C. signal.
- **Studying and measuring the waveform** (shape) of an electrical signal.

(b)

$$f = \frac{v}{\lambda} = \frac{3.0 \times 10^8\ \text{m/s}}{0.02\ \text{m}}$$

$$f = 1.5 \times 10^{10}\ \text{Hz}$$

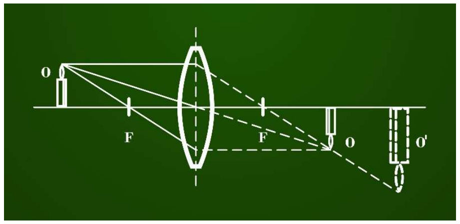
(c) (i) The intensity is increased by **making the grid potential less negative (more positive)**. The grid controls the number of electrons reaching the screen; a less negative grid allows **more electrons** to pass through and strike the screen, making the spot brighter.

(ii) **Time Base ON:** The beam is deflected horizontally at a constant speed, producing a **horizontal trace** (a straight line). If an input is applied, the waveform of the input signal is displayed.

Time Base OFF: The horizontal sweep stops, and the spot only moves vertically according to the input signal applied to the Y-plates. If an A.C. signal is applied, a **vertical straight line** is observed.

18. (a)

- Set up the lens and the screen some distance apart, pointing towards a **very distant object** (e.g., a distant tree)
- Adjust the position of the **screen** until a **sharp, inverted, and diminished image** of the distant object is formed on it
- Measure the distance between the **optical centre of the lens** and the **screen** using the metre rule
- This measured distance is the **estimated focal length (f)** of the lens.



(b) (i) Sketch for a Conductor: For a conductor, the conductivity decreases as temperature increases.
(ii)
The conductivity of a conductor decreases because an increase in temperature causes the fixed metal ions in the lattice to vibrate with greater amplitude. This increased vibration leads to more frequent collisions between the moving free electrons and the vibrating ions, which increases the resistance and thus reduces the conductivity.

(c) (i)

- The bulb goes on and off because the diode acts as a rectifier.
- In one half-cycle, the A.C. source **forward-biases** the diode, allowing current to flow to the bulb, so the bulb lights up.
- In the next half-cycle, the A.C. source **reverse-biases** the diode, blocking the current flow, so the bulb goes off. The high frequency of the A.C. source causes the rapid on/off cycling, making the bulb appear to flicker or glow continuously (if the frequency is high enough).

(ii) The output voltage is a **half-wave rectified** signal, meaning only the positive (or negative, depending on the diode's orientation) half-cycles pass through.

19. (a) The photoelectric effect is the phenomenon where **electrons (photoelectrons) are emitted** from a metal surface when electromagnetic radiation (like light) of **sufficient frequency** is incident upon it.
(b) (i) **Missing component:** To demonstrate the photoelectric effect, the zinc plate needs to be charged, so the missing component is a **Gold-leaf Electroscope**.
(ii)

- **Charge the Electroscope:** Place the zinc plate on the cap of the electroscope and charge it **negatively** (e.g., by induction) so the gold leaves diverge.
- **Illumination:** Shine the **UV radiation** onto the surface of the negatively charged zinc plate.
- **Observation:** The **gold leaves will be observed to gradually collapse** (fall), indicating a loss of charge.
- **Conclusion:** The UV radiation supplies energy greater than the work function, causing **photoelectrons to be ejected** from the negatively charged plate, hence the charge leaks away and the leaves fall.

(c) Photoelectric Calculations

Given: Work function $\phi = 4.8 \text{ eV}$, $\lambda = 1.6 \times 10^{-7} \text{ m}$.

(i) **Work function in Joules (ϕ):** Using $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$:

$$\phi = 4.8 \text{ eV} \times 1.6 \times 10^{-19} \text{ J/eV} = 7.68 \times 10^{-19} \text{ J}$$

The work function is $7.68 \times 10^{-19} \text{ J}$. (1 mark)

(ii) **Energy of the radiation (E):** Using $E = \frac{hc}{\lambda}$, with $h = 6.63 \times 10^{-34} \text{ J} \cdot \text{s}$ and $c = 3.0 \times 10^8 \text{ m/s}$:

$$E = \frac{(6.63 \times 10^{-34} \text{ J} \cdot \text{s}) \times (3.0 \times 10^8 \text{ m/s})}{1.6 \times 10^{-7} \text{ m}}$$

$$E = 1.243 \times 10^{-18} \text{ J}$$

(iii) **Yes**, the radiation will eject photoelectrons.

Reason: The energy of the incident radiation ($E \approx 1.24 \times 10^{-18}$ J) is **greater than** the work function ($\phi = 7.68 \times 10^{-19}$ J). For photoemission to occur, $E \geq \phi$, which is satisfied here.