

Electronics

Typed version of the handwritten O Level Physics class notes (9 to 16 September 2020). The original handwritten pages are on the same page of [megalecture.com](https://www.megalecture.com).

Colour coding of resistors

- 1st strip: digit. 2nd strip: digit. 3rd strip: number of zeros. 4th strip: tolerance (inaccuracy or uncertainty regarding the resistance you have found).
- Start reading from the end away from the tolerance band; the tolerance band is on the extreme right of the resistor, silver or gold in colour: silver = 10%, gold = 5% (meaning the resistance can be 10% or 5% more or less than what you have found).
- Example: green, blue, red, silver = 5, 6, 00 = $5600\ \Omega \pm 10\%$.

Colour	Digit	Colour	Digit
Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet	7
Orange	3	Grey	8
Yellow	4	White	9

The power rating of a resistor is the maximum rate of dissipation of electrical energy as heat before it is damaged (0.25 W to 1 W is normally suitable). If components are operated beyond their power ratings, they will overheat and be damaged.

Potential divider circuit

Two resistors R_1 and R_2 in series across a supply V , with V_1 across R_1 and V_2 across R_2 :

$$V_1 = (R_1 / (R_1 + R_2)) \times V \quad V_2 = (R_2 / (R_1 + R_2)) \times V$$

Q. $R_1 = 3\ \Omega$, $R_2 = 6\ \Omega$, $V = 9\ \text{V}$.

$$V_1 = (3 / (3 + 6)) \times 9 = 3\ \text{V} \quad V_2 = (6 / (3 + 6)) \times 9 = 6\ \text{V}$$

Potentiometer

- A type of variable potential divider.
- An arrangement which is used to get a variable voltage from the e.m.f. of the cell, e.g. the volume control of a CD player.
- A uniform metal wire AB is connected across a 10 V cell. The current is the same for all points, but the resistance is not.

Q. Find the potential difference between any two points on the wire.

$V = IR$, and $R = \rho L/A$, so $V = (I\rho/A) \times L$. Since I , ρ and A are constant, $V \propto L$. This means the potential



difference across the whole length is 10 V, across half the length 5 V, and so on.

A junction is a point in a circuit with a specific energy: two terminals of a voltmeter connected to the same junction give 0 V, because there is no potential difference.

Example with three resistors A, B, C in series across 6 V: $V_A = 0$ V (at the bottom), $V_B = 6$ V (at the top), $V_C = 3$ V (the midpoint), which is the output voltage.

With a sliding contact Y on the wire and a lamp connected between one end X and the contact: as we move Y towards B through the sliding contact, the voltage and the speed increase (moving the contact back and forth changes the voltage and speed; at zero the fan switches off). The intensity is being controlled; a dimmer is used to have this effect. From $R = (\rho/A)L$, the side with the longer length has the greater resistance. The same cell provides a variable voltage.

Relay

- A device which is operated on a small current and is used to automatically switch on and switch off another device which operates on a large current.
- The relay itself is an electromagnet. Its symbol is a coil (a resistor shape) beside a switch.

Circuit A (small current): a 9 V cell, a switch and the relay coil. Circuit B (large current): a 240 V a.c. supply, the relay's switch and an electric bell.

- Since the switch in circuit A is open, no current passes through the relay, so it will not become an electromagnet and will not be able to close the second switch B.
- When the switch is closed, current passes through the relay; it becomes an electromagnet; as a result it closes switch B and the electric bell rings.
- When you press a doorbell you close the switch.

Diode

- A device which allows the current to flow in one direction only is called a diode.
- It converts alternating current to direct current; the process is known as rectification.
- a.c.: the magnitude varies (fluctuates from 0 to 7 A, say). d.c.: the magnitude is the same (7 A throughout).
- Positive half cycle: current from X to Y. Negative half cycle: current from Y to X. The diode conducts only the positive cycles of a.c. and does not allow the negative cycles to pass through it.
- Symbol: a triangle (arrowhead) with a bar. The arrowhead represents the direction of current; the straight line will block current coming from the other end.
- An LED (light-emitting diode) will only blink if a.c. is being provided; it will glow steadily on d.c.
- Rectification: converting a.c. into d.c. Even though a.c. is being provided, current will only be allowed to flow in one direction. The a.c. graph is a full sine wave; the diode graph shows the positive halves only (the negative cycle is blocked).

Q. Are both of them a.c.? The wave that crosses both sides of the axis is a.c. **Has the diode converted a.c. to d.c.?** Yes, but it has only changed the direction, not the magnitude, which is why you cannot draw a straight-line graph this time.

Thermionic emission

- Energy falling on a metal surface: a free electron absorbs the energy to overcome the forces of attraction of the metal, if the energy is enough.
- Since heat is a form of energy, there is a possibility of an electron overcoming the attractive forces if heat is provided to the metal surface. In both cases it is only a possibility, because we are not sure what exact amount of heat or energy we require.
- **Thermionic emission:** a process in which electrons come out of a metal when heat is provided to it. It is the emission of electrons from a metal filament as it is heated by passing a current: since there are a large number of free electrons in metals, when current is passed through the metal filament, a heating effect is produced due to resistance; the free electrons gain energy and are emitted from the filament.
- In a tungsten filament: the filament offers resistance; the current loses (electrical) energy to overcome the resistance; the lost energy converts to heat; the filament produces heat.
- **Cathode ray:** a beam of electrons coming out of a tungsten filament due to heat.

Cathode ray oscilloscope (CRO)

A device which is used to produce a voltage–time trace on a fluorescent screen. Parts: electron gun, deflection system, fluorescent screen.

- Electrons overcome the forces of attraction and come out of the tungsten filament.
- The grid helps to form a fine beam of electrons (through repulsion), and controls the number as well.
- The anode pulls the electrons and accelerates them: a stronger anode means a higher speed.
- The Y-plates are given an alternating voltage, causing the beam of electrons to deflect upwards or downwards (vertical deflection). Depending on where you want the beam to hit, you increase or decrease the voltage of one of the two plates: a higher voltage on the upper plate and the beam hits the top of the screen; higher on the lower plate and it hits the bottom.
- The X-plates are given an alternating voltage, causing the beam of electrons to deflect towards right or left (horizontal deflection).
- The fluorescent screen is a glass screen coated with zinc sulphide; the electron beam glows on reaching the screen.
- A wave forms when both the X and Y plates carry a voltage: the cathode ray oscillates up and down, and right and left.
- If only the Y-plates are given a voltage: a vertical line. If only the X-plates are given a voltage: a horizontal line.
- To move the trace along the X-axis: X-shift button. Along the Y-axis: Y-shift button.
- Voltage gain, e.g. 5 V/cm. Time base, e.g. 10 ms/cm. $\text{voltage} = \text{amplitude} \times \text{Y-gain}$.

The CRO can be used for measuring a.c. voltage, displaying voltage waveforms, and measuring short intervals of time.

- **Voltage sensitivity (Y-gain):** the voltage used by the CRO trace per division, e.g. 5 V/div.
- **Time-base value:** the time used by the CRO trace per division, e.g. 3 ms/div.

The following calculations can be made using the values of voltage sensitivity and time base:

1. Peak voltage = (number of divisions in an amplitude) $\times$ (voltage sensitivity)
2. Time period = (number of divisions in one cycle) $\times$ (time base value)
3. Frequency = $1 / T$

Deflection of an electron beam

By an electric field: when an electron beam passes between two charged plates, it can be observed that the electrons are deflected towards the positive plate. The electrons are attracted by the positive charges on the positive plate and repelled by the negative charges on the negative plate.

By a magnetic field: when an electron beam passes between the two poles of a magnet, it can be observed that the electron beam is deflected. Using the left-hand rule (with the current taken opposite to the electron flow), it is observed that the beam deflects downwards in the sketch.

Checked by Mega Lecture

This typed version follows the handwritten notes. Corrections: the worked potential-divider example gives $V_2 = 6 \text{ V}$ (the notes have $18/5 \text{ V}$, from using 2Ω instead of 6Ω); "if only Y plates are given voltage: horizontal line / only X plates: vertical line" is written the other way round, which is what the earlier lines about vertical and horizontal deflection say; "thermonic immission" is spelt thermionic emission; the resistor colour bands are read from the end away from the tolerance band. The Urdu side notes are given in English. Circuit diagrams are described in words. Spotted a mistake? Tell us on WhatsApp: +92 336 780 1123.