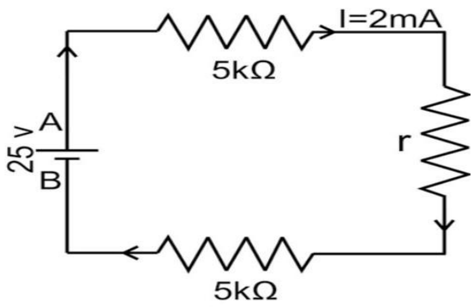
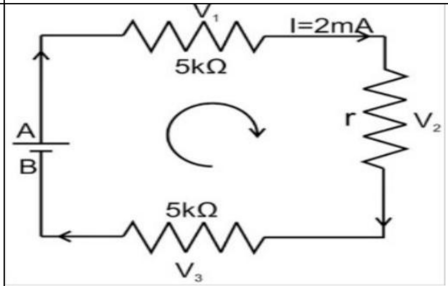
APPLIED PHY~~SICS-II (2ND SEMESTER DIPLOMA ENGG STUDENTS FRO~~M SUMMER 2025 ONWARDS

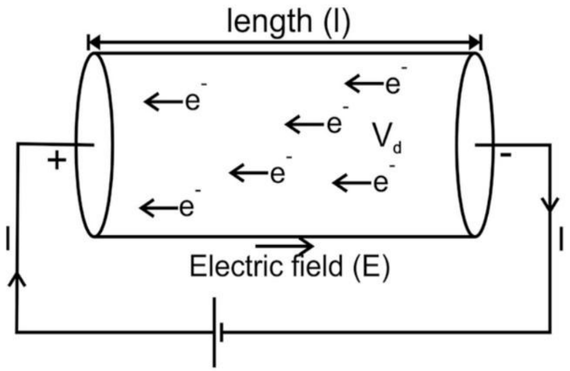
(UNIT - 4: CURRENT ELECTRICITY)

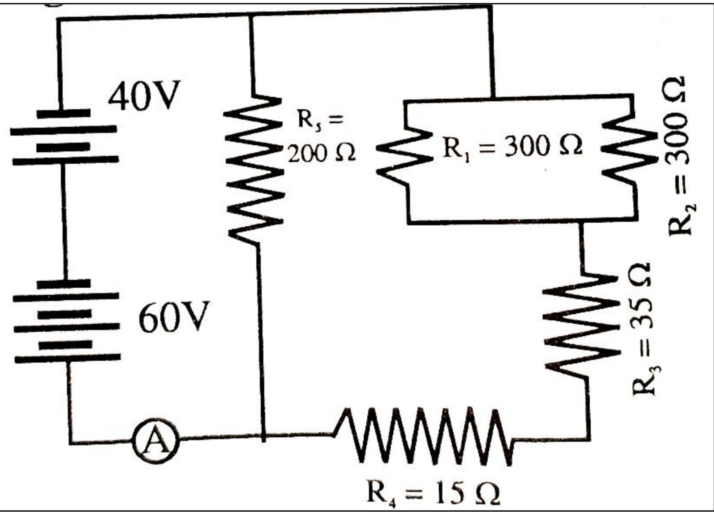
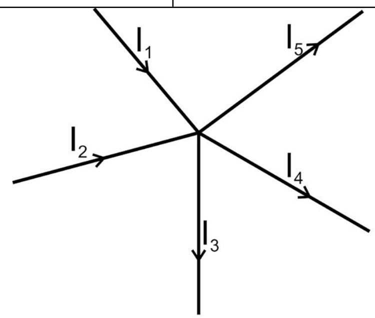
Sl. No.	Question	Taxonomy Level	Mark
1	**Define electric current. Write down its SI unit.**	**Remembering**	**2**
ANS	Electric current is defined as the rate of flow of electric charge (say electrons) through a cross section of a conductor. Mathematically Electric current (I) $= \frac{\text{Total charge flow (q)}}{\text{Time taken (t)}}$ Its SI unit is ampere.		**0.5** **0.5** **1**
2	**Define direct current & alternating current.**	**Remembering**	**2**
ANS	Direct current is defined as the unidirectional flow of electric charge. i.e. even If the magnitude of current changes the direction of current does not change. Alternating current is defined as that current which varies continuously in magnitude & periodically reverses its direction.		**1** **1**
3	**Define resistance. Write down its SI unit.**	**Remembering**	**2**
ANS	Resistance is the property of material by virtue of which it opposes the flow of charge through it. SI unit of resistance is ohm(Ω).		**1** **1**
4	**State Ohm's law.**	**Remembering**	**2**
ANS	The current (I) flowing through a conductor is directly proportional to the potential difference (V) applied across the end of the conductor provided that all the physical conditions and temperature remains constant. $I \propto V \text{ or, } \frac{V}{I} = \text{constant (R)}$ or, $V = IR$ Where the constant of proprertionality R is called resistance of the conductor		**1** **1**
5	**State the factors which affect the resistance of a conductor.**	**Remembering**	**2**
ANS	The following factors affect the resistance of a conductor 1. Length 2. Cross-sectional area 3. Nature of material 4. Temperature of conductor		**0.5** **0.5** **0.5** **0.5**
6	**Name the SI units of conductance & conductivity.**	**Remembering**	**2**
ANS	The SI unit of conductance is siemens (S). The SI unit of conductivity is siemens per meter (S/m)		**1** **1**
7	**Write down the dimensional formula of resistivity & conductance.**	**Remembering**	**2**

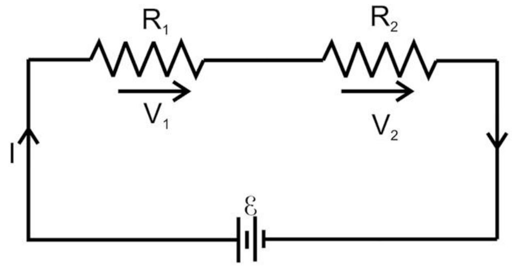
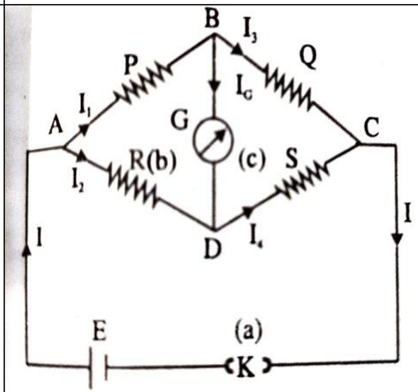
ANS	Dimensional formula of resistivity is $[\rho] = [M^1L^3T^{-3}A^{-2}]$ Dimensional formula of conductance is $[G] = [M^{-1}L^{-2}T^3A^2]$		**1** **1**
8	**Define electric power and write down its SI unit.**	**Remembering**	**2**
ANS	The rate at which an appliance converts electrical energy into other forms of energy is known as electric power. $$\mathrm{P} = \frac{\mathrm{W}}{\mathrm{t}}$$ Si unit of power is watt.		**1** **1**
9	**Convert 1 kWh into joule.**	**Understanding**	**2**
ANS	1 kWh = 1000 watt × 60 × 60 sec = 3600000 watt × sec = 3.6×10^6 J		**1** **1**
10	**Derive a relation between power (P), voltage (V) & resistance (R).**	**Understanding**	**2**
ANS	$\mathrm{P} = \frac{\mathrm{W}}{\mathrm{t}} = \frac{\mathrm{Vq}}{\mathrm{t}} (\because \mathrm{V} = \frac{\mathrm{W}}{\mathrm{q}})$ $\Rightarrow \mathrm{P} = \mathrm{VI} = \mathrm{V}\frac{\mathrm{V}}{\mathrm{R}} (\because \mathrm{I} = \frac{\mathrm{q}}{\mathrm{t}}, \mathrm{V} = \mathrm{IR})$ $\Rightarrow \mathrm{P} = \frac{\mathrm{V}^2}{\mathrm{R}}$		**1** **1**
11	**Evaluate the resistance of a 4-band resistor which has the first band – Green, the second band – Blue, the third band- Orange, the fourth band – Gold.**	**Applying**	**2**
ANS	First band = Green = 5 ohm Second band = Blue = 6 ohm Third band = Orange = 10^3 Fourth band = Gold = $\pm$ 5 % Resistance = 56 × 10^3 $ohm \pm$ 5 %		**2**
12	**A current of 1 ampere flows in a given wire having uniform area of cross section 0.05 cm² along length 50 cm. Determine specific resistance of material of the given wire if the voltage across two ends of wire is 5 volts.**	**Applying**	**2**
ANS	Given A = 0.05 cm^2 = 0.05 × 10^{-4} m^2, l = 50 cm = 0.5 m, I = 1 ampere and V = 5 volts $$\mathrm{R} = \frac{\mathrm{V}}{\mathrm{I}} = \frac{5}{1} = 5\Omega$$		**1** **1**

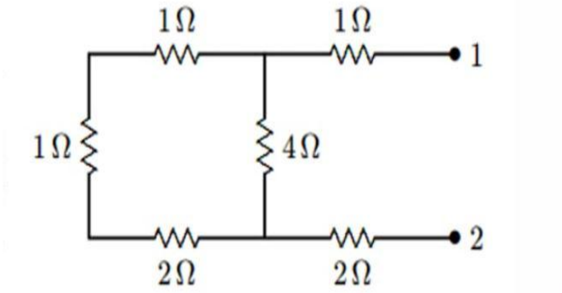
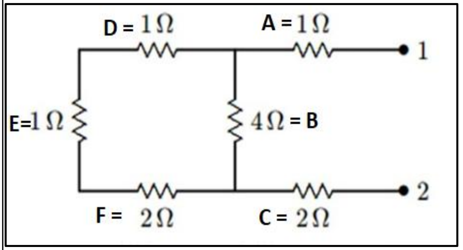
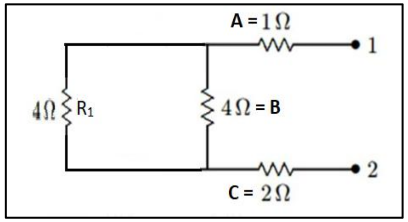
	Specific resistance $\rho = \frac{RA}{l} = \frac{5\times0.05\times10^{-4}}{0.5} = 5\times10^{-5}\Omega m$		
13	**State Joule's law of heating.**	**Remembering**	**2**
ANS	The amount of heat (H) produced in a conductor through which an electric current is maintained is (a) directly proportional to the square of current (I^2) (b) directly proportional to the resistance (R) (c) directly proportional to the time of flow (t) Mathematically $H = I^2Rt$ joules $= \frac{I^2Rt}{4.2}$ calorie		**1** **1**
14	**An electric bulb is marked 100 watt 220 volt. Determine (a) current it draws & (b) its resistance.**	**Applying**	**2**
ANS	Power of the bulb, P = 100 watt, Voltage, V = 220 volt (a) Current, $I = \frac{P}{V} = \frac{100 \text{ watt}}{220 \text{ volt}} = 0.4545$ ampere (b) Resistance, $R = \frac{V^2}{P} = \frac{(220)^2}{100} = 484$ ohm		**1** **1**
15	**The emf of a cell is 2.1 volt & the potential difference between its plates becomes 2 volt when it is connected with an external resistance of 10 ohm. Determine the internal resistance of the cell.**	**Applying**	**2**
ANS	Terminal potential difference = current × external resistance So, $I = \frac{2}{10} = 0.2$ ampere We know internal resistance, $r = \frac{e-V}{I} = \frac{2.1-2}{0.2} = 0.5$ ohm		**1** **1**
16	**A wire has a resistance of 90 Ω and it is cut into three pieces having equal lengths. If these are now connected in parallel, determine the resistance of the combination so formed.**	**Applying**	**2**
ANS	When the wire having resistance of 90 Ω is cut into three equal pieces, each piece will be of resistance = 90/3 = 30Ω If R_p is the resistance of their parallel combination then $\frac{1}{R_p} = \frac{1}{30} + \frac{1}{30} + \frac{1}{30} = \frac{3}{30} = \frac{1}{10}\Omega$ $\Rightarrow R_p = 10\ \Omega$		**1** **0.5** **0.5**
17	**Explain the reason for which resistors are connected in series & parallel.**	**Understanding**	**2**
ANS	Resistors are combined in series and parallel to achieve desired resistance values and control current flow in electric circuits. The resistors are connected in series to increase the resistance of the circuit; while they are connected in parallel, when resistance of the circuit is to be decreased.		**2**

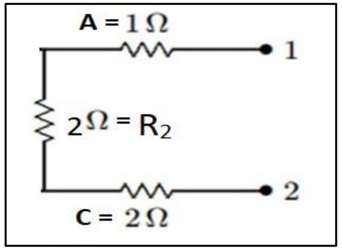
18	**Using Kirchhoff's law, determine the voltage across r in the given circuit. The internal resistance of the voltage source is zero.**  	**Applying**	**5**
	 Let V_2 be the voltage across r in the given circuit. Let us consider loop ABA as follows Using KVL we have $V_1 + V_2 + V_3 - 25V = 0$ $\Rightarrow V_1 + V_2 + V_3 = 25V$ $V_1 = 5k\Omega \times 2mA = 5 \times 10^3\Omega \times 2 \times 10^{-3}A = 10V$ $V_3 = 5k\Omega \times 2mA = 5 \times 10^3\Omega \times 2 \times 10^{-3}A = 10V$ Hence $10V + V_2 + 10V = 25V$ $\Rightarrow V_2 = 25V - 20V = 5V$		**5**
19	**The effective series resistance of two conductors is 7 Ω & their effective parallel resistance is $\frac{12}{7}$ Ω .** **Determine the two resistances.**	**Applying**	**5**
ANS	Let R_1& R_2be the two resistances. R_{series} = R_1 + R_2, $R_{parallel} = \frac{R_1R_2}{R_1+R_2}$ Given $R_1 + R_2 = 7$ & $\frac{R_1R_2}{R_1+R_2}=\frac{12}{7}$ $\Rightarrow \frac{R_1R_2}{7} = \frac{12}{7}$ $\Rightarrow R_1R_2 = 12$ So, $R_1 - R_2 = \sqrt{(R_1 + R_2)^2 - 4R_1R_2}$ $\Rightarrow R_1 - R_2 = \sqrt{7^2 - 4 \times 12}$ $\Rightarrow R_1 - R_2 = \sqrt{49 - 48} = 1$ $R_1 + R_2 = 7$……………(1) $R_1 - R_2 = 1$…………… (2) Adding equation (1) & (2) we have, $2R_1 = 8$ $\Rightarrow R_1 = 8/2 = 4\ \Omega$		**5**

	Putting value of R_1 in equation (1), $4 + R_2 = 7 \Rightarrow R_2 = 7 - 4 = 3\Omega$		
20	**Derive a relation between current & drift velocity.**	**Understanding**	**5**
ANS	Let us consider a conductor of length l & area of cross section A. Hence volume of the conductor = Al Suppose the ends of the conductor are joined to the ends of a battery as shown in the figure below.  It establishes a uniform electric field $\vec{E}$ throughout the conductor. Due to this field the free electrons move with a drift velocity $\vec{v_d}$ in a direction opposite to $\vec{E}$. If n is the density of electrons, then the total no of free electrons is = Aln Since e is the charge of one electron, so the total charge of free electrons, q = Alne Time taken by free electron to travel from one end of the conductor to the other will be $t = \frac{l}{v_d}$ Current, $I = q/t = \frac{Alne}{\frac{l}{v_d}} = Anev_d \Rightarrow v_d = \frac{I}{nAe}$		**5**

21	**Determine the ammeter reading in the circuit.** 	**Applying**	**5**
ANS	As per the given figure both the batteries are in series. So the total emf acting in the circuit = 60 + 40 = 100V Resistors R_1& R_2 are in parallel combination. The equivalent resistance is given by $R_p = \frac{R_1R_2}{R_1+R_2} = \frac{300\times300}{300+300}$ $\Rightarrow R_p = \frac{90000}{600} = 150\ \Omega$ R_p is in series with R_3& R_4. The combined resistance is given by $R_s = R_p + R_3 + R_4 = 150 + 35 + 15 = 200\ \Omega$ R_s is in parallel with R_5. So the effective resistance is given by $R_e = \frac{R_sR_5}{R_s+R_5} = \frac{200\times200}{200+200} = \frac{40000}{400} = 100\ \Omega$ So the current $I = \frac{E}{R_e} = \frac{100\ V}{100\ \Omega} = 1$ ampere Hence the ammeter reading in the circuit is 1 ampere.		**5**
22	**State and Explain Kirchhoff's laws.**	**Understanding**	**5**
ANS	Kirchhoff gave two laws. 1. Kirchhoff's Current Law (KCL) 2. Kirchhoff's Voltage Law (KVL)  **Kirchhoff's Current Law (KCL):** It states that the algebraic sum of currents meeting at any junction in an electrical circuit is zero. Mathematically, $\Sigma I = 0$ Sign Convention: i. The current flowing towards the node or junction is taken as positive ii. The current flowing away from the node or junction is taken as negative. from the above figure, $I_1 + I_2 - I_3 - I_4 - I_5 = 0$ $\Rightarrow I_1 + I_2 = I_3 + I_4 + I_5$ $\Rightarrow I_{in} = I_{out}$		**1** **1.5**

	Current flowing towards the junction = Current going away from the junction. This law is based on the principle of conservation of electric charge. It ensures that charge doesn't gather at a junction. **Kirchhoff's Voltage Law (KVL):** In any closedcircuit, the sum of the emfs is equal to the sum of the product of current and resistance of each part of the circuit. Mathematically, $\Sigma IR = \Sigma\varepsilon$ Sign Convention: i. **<u>Resistance Rule</u>**: For a move through a resistance in the direction of the current the change in the potential is -IR& in the opposite direction it is +IR. ii. **<u>emf Rule:</u>**For a move through an ideal emf device from negative electrode to positive electrode through battery, the emf is +ve (+ε)& in the opposite direction it is -ve($-\varepsilon$).  From the above figure , $-IR_1 - IR_2 + \varepsilon = 0$ $\Rightarrow \varepsilon = IR_1 + IR_2 = V_1 + V_2 \Rightarrow \Sigma\varepsilon = \Sigma IR$		**1** **1.5**
23	**Determine the balanced condition of a Wheatstone's bridge using Kirchhoff's laws.**	**Understanding**	**5**
ANS	 The Kirchhoff's laws can be applied to solve complicated networks such as Wheatstone's bridge. It is an electrical arrangement which forms the basis of most of the instruments to determine an unknown resistance. It consists of 4 resistancesP, Q, R & S connected in the four arms of a square ABCD. A source of emf E is connected between A & Cthrough a key (K). A sensitive Galvanometer of resistance G is connected between B & D. After closing the key (K) the resistances P, Q, R & S are so adjusted that the galvanometer shows no deflection. In this position the bridge is said to be balanced. Applying KVL to the mesh ABD we have, $-I_1P - I_gG + I_2R = 0 \cdots\cdots\cdots\cdots (1)$ In the mesh BCD $-I_3Q + I_4S + I_gG = 0 \cdots\cdots\cdots\cdots (2)$ Applying KCL we get at A, $I = I_1 + I_2 \Rightarrow I_2 = I - I_1 \cdots\cdots\cdots\cdots (3)$ at B, $I_1 = I_3 + I_g \Rightarrow I_3 = I_1 - I_g \cdots\cdots\cdots\cdots(4)$ at C, $I_3 + I_4 = I \Rightarrow I = I_1 - I_g + I_4$ (putting value of $I_3$from eqn 4) $\Rightarrow I_4 = I - I_1 + I_g \cdots\cdots\cdots\cdots (5)$		**5**

	Putting the value of I_2 in equ^n (1) & I_3& I_4 in equ^n (2) we have, $$-I_1P - I_gG + (I - I_1)R = 0 \Rightarrow I_1P + I_gG = (I - I_1)R \cdots\cdots\cdots\cdots (6)$$ $$-(I_1 - I_g)Q + (I - I_1 + I_g)S + I_gG = 0 \Rightarrow (I_1 - I_g)Q - (I - I_1 + I_g)S - I_gG = 0 \cdots\cdots\cdots (7)$$ When the bridge is balanced, no current flows through the galvanometer. i.e. $I_g = 0$ Hence equ^n (6) & (7) becomes $I_1P = (I - I_1)R \cdots\cdots\cdots\cdots (8)$ $$I_1Q - (I - I_1)S = 0 \Rightarrow I_1Q = (I - I_1)S \cdots\cdots\cdots (9)$$ Dividing equ^n (8) by (9) we have $\frac{I_1P}{I_1Q} = \frac{(I-I_1)R}{(I-I_1)S} \Rightarrow \mathbf{\frac{P}{Q} = \frac{R}{S}}$ This is the condition of balanced Wheatstone's Bridge.		
24	**Determine the equivalent resistance between points 1 and 2 of the circuit given**  **below.**	**Applying**	**5**
ANS	 (Fig. 1) Given that A = 1 Ω, B = 4 Ω, C = 2 Ω, D = 1 Ω, E = 1 Ω, F = 2 Ω From Fig.1 resistances D, E and F are connected in series. Let the equivalent resistance of these 3 resistors is R_1. ∴ $R_1 = D + E + F = 1 + 1 + 2 = 4\ \Omega$………………………. (1) R_1 and B are connected in parallel (Fig.2) Hence, $\frac{1}{R_2} = \frac{1}{R_1} + \frac{1}{B}$ $\Rightarrow \frac{1}{R_2} = \frac{1}{4} + \frac{1}{4} = \frac{1+1}{4} = \frac{1}{2}$ $\Rightarrow R_2 = 2\ \Omega$  (Fig.2)		**5**

	Again A, R_2, and C are connected in series (Fig.3) So equivalent resistanceR = A+ R_2 + C R = 1+ 2 + 2 = 5 Ω Hence the equivalent resistance between point 1 and 2 is 5 Ω.  (Fig.3)		
25	**Differentiate between Alternating Current and Direct Current.**	**Understanding**	5
ANS	**Alternating Current (AC)** 1. Alternating current is defined as that current which varies continuously in magnitude & periodically reverses its direction. 2. In AC voltage alternates between positive and negative values. 3. Waveform is usually sinusoidal (can be triangular or square). 4. AC is primarily used in power distribution systems, home appliances, and industrial equipment. 5. AC is generated by power plants, alternators & inverters. 6. AC can be transmitted over long distances with minimal energy loss using transformers.	**Direct Current (DC)** 1. Direct current is defined as the unidirectional flow of electric charge. 2. In DC voltage remains constant over time. 3. Waveform is constant (a straight line). 4. DC is commonly used in batteries, electronic devices, and circuits that require constant voltage. 5. DC is produced by sources like batteries, solar panels & DC generators. 6. DC cannot be transmitted over long distance as it loses more energy. But it is efficient for short range applications.	5
26	**Two resistances of 3 ohm and 2 ohm are in parallel connection and a potential difference of 12 V is applied across them. Determine** **(a) the equivalent resistance of the parallel combination** **(b) the circuit current** **(c) the branch currents**	**Applying**	5

ANS	Given that R_1 = 3 ohm R_2 = 2 ohm (a) Resistance R of the parallel combination is given by, $$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$ $$\Rightarrow \frac{1}{R} = \frac{1}{3} + \frac{1}{2} = \frac{2+3}{6} = \frac{5}{6}$$ $$\Rightarrow R = \frac{6}{5} = 1.2 \text{ ohm}$$ (b) Let I be the current, then $$I = \frac{\text{Potential difference}}{\text{total resistance}} = \frac{12}{1.2} = 10 \text{ A}$$ (c) Let I_1 and I_2 be the currents flowing through the resistances R_1 and R_2. $$I_1 = I \times \frac{R_2}{R_1 + R_2} = 10 \times \frac{2}{3+2} = 4 \text{ A},\ I_2 = I \times \frac{R_1}{R_1 + R_2} = 10 \times \frac{3}{3+2} = 6 \text{ A}$$	1 1 1 1+1