Tutorial 6 (Covering Lectures 11-14)

Topics:
- **A. The Wheatstone Bridge,**
- **B. Kirchhoff's Laws,**
- **C. Metre Bridges and Variation of Resistance with Temperature**

QUESTIONS:

1. Consider a **Wheatstone Bridge** circuit ABDC in which P and Q are the resistances in branch ABD, and R and X are the resistances in branch ACD. The galvanometer is connected between junctions B and C, and a battery is connected to junctions A and D.

   (a) Draw a complete diagram of the bridge circuit and derive the balance condition equation in terms of the resistances P, Q, R and X.

   (b) In two particular experiments, in which X represents the resistance of a light bulb, the following values are obtained for the balanced bridge:

	P	Q	R	X
(i)	1000 Ω	0.5 Ω	1000 Ω	?
(ii)	1000 Ω	1000 Ω	5 Ω	?

   Calculate the resistance X in both cases. In only one of these experiments, the light bulb is glowing brightly. Identify whether this is case (i) or (ii), and justify your answer.

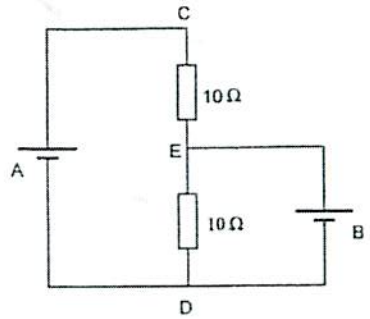
   (c) In two other experiments, in which X represents the resistance of a light bulb, the following values are obtained for the balanced bridge:

	P	Q	R	X
(i)	100 Ω	1 Ω	100 Ω	?
(ii)	100 Ω	100 Ω	10 Ω	?

   Calculate the resistance X in both of these cases.

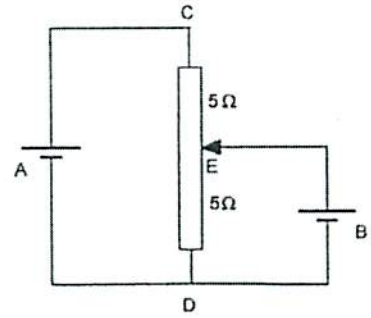
2. State ***Kirchhoff's laws*** for circuit networks.

3. In the circuit drawn below, battery A has an emf of 12 V and an internal resistance of 2 Ω; battery B has an emf of 3 V and an internal resistance of 1 Ω.



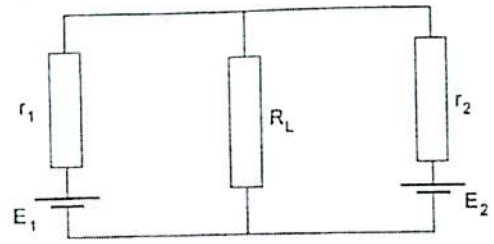
   (a) Calculate the current through battery A and that through battery B. What is the current through ED?
   (b) Calculate the power dissipated in the resistor between E and D. If the circuit is switched on for 5 minutes, calculate the energy dissipated in the resistor between C and E.

4. In the circuit drawn below, battery A has an emf of 10 V and an internal resistance of 2 Ω; battery B has an emf of 3 V and an internal resistance of 3 Ω.



   (a) Calculate the current through batteries A and B. What is the current through ED?
   (b) Calculate the power dissipated in the resistance between C and E. If the circuit is switched on for 3 minutes, calculate the energy dissipated between C and E.
   (c) If the contact E is moved along CD, find the value of the resistance between D and E for which there is no current flow through battery B.

5. In the circuit drawn below, two batteries with emf's E_1 and E_2 and internal resistances of r_1 and r_2, respectively, are connected to a load resistor R_L. $E_1 = 12$ V, $E_2 = 8$ V, $r_1 = 6\ \Omega$, $r_2 = 4\ \Omega$ and $R_L = 16\ \Omega$.



Calculate:

i) the currents supplied by each of the batteries and the current flowing in the load resistor. Comment on the directions of these currents;

ii) the power dissipation in r_1, r_2 and R_L, respectively;

iii) the output voltage of each of the batteries. Compare these values with emf's of the batteries and explain the difference.

6. Draw the circuit of, and derive the balance equation of, a ***metre bridge***.

7. Give an expression for the relationship between resistance R and temperature T.
Define the **temperature coefficient of resistance**, α.

8. A metre bridge is used in an experiment to investigate the variation of electrical resistance of a nickel wire with temperature.

A nickel wire and a $10\ \Omega$ standard resistor are connected in the gaps of the metre bridge. When the wire is kept at a temperature of $0\ ^\circ C$, the balance point is found to be 50 cm from the end of the bridge nearest to the nickel wire. When it is at a temperature of $100\ ^\circ C$, the balance point occurs at 60 cm from the same end of the bridge.

(a) Calculate the temperature of the nickel wire when the balance point occurs at 54 cm from the end of the bridge nearest the nickel wire.

(b) Calculate the resistivity of nickel, at this new temperature, if the wire is 300 cm long and has a cross-sectional area of $5\times10^{-4}\ cm^2$.

(c) Explain the advantage of using a $10\ \Omega$ standard resistor in preference to a $100\ \Omega$ standard resistor in this experiment.

9. A metre bridge is used in an experiment to investigate the variation of electrical resistance of a nickel wire with temperature.

A nickel wire and a $10\ \Omega$ standard resistor are connected in the gaps of the metre bridge. When the wire is kept at a temperature of $0\ ^\circ C$, the balance point is found to be 40 cm from the end of the bridge nearest to the nickel wire. When it is at a temperature of $100\ ^\circ C$, the balance point occurs at 50 cm.

(a) Calculate the temperature of the nickel wire when the balance point occurs at 44 cm from the end of the bridge nearest the nickel wire.

(b) Calculate the resistivity of nickel at this temperature if the wire is 150 cm long and has a cross-sectional area of $2.5\times10^{-4}\ cm^2$.