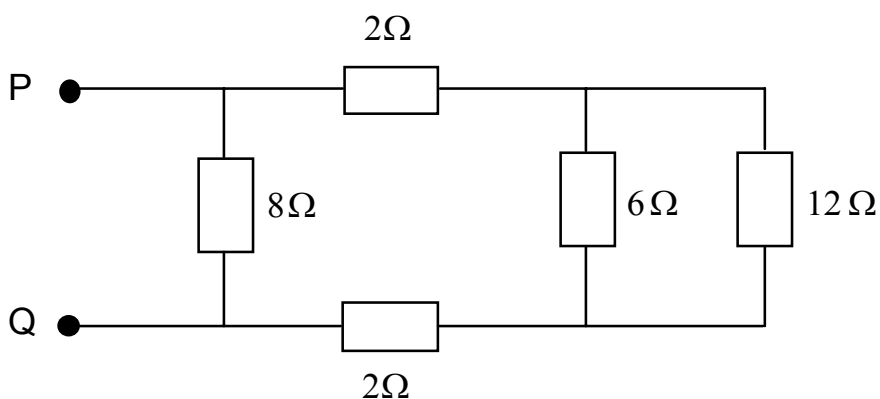


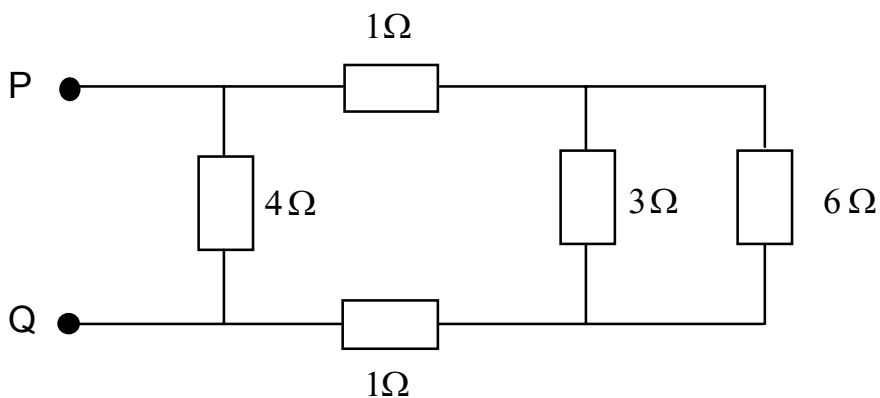
Tutorial 5 (Covering Lectures 9-12)

QUESTIONS:

1. State Ohm's law, and hence define the *ohm*.
2. Write down the connections between the ampere, the coulomb, the volt and the joule.
3. Explain what is meant by the *electrical resistance* of a conductor.
4. What values of resistance can be produced by various interconnections of three $8\ \Omega$ resistors?
5. What values of resistance can be produced by various interconnections of three $12\ \Omega$ resistors?
6. In the resistor network shown below, calculate the effective resistance between terminals P and Q.



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8. Explain what is meant by the *resistivity* of a conductor.
Calculate the resistivity of a wire that has a resistance of $10\ \Omega$, a length of $5\ \text{m}$ and a cross-sectional area of $0.2\ \text{m}^2$.
9. Calculate the resistivity of a wire that has a resistance of $4\ \Omega$, a length of $3\ \text{m}$ and a cross-sectional area of $0.3\ \text{mm}^2$.
10. A length of metal wire has a resistance R .
(i) What would be its resistance if both its diameter and its length are doubled?
(ii) What would be its resistance if both its diameter and its length are halved?
11. For a battery, explain the meaning of the terms *electromotive force* and *potential difference* at the terminals. Why do the two not always have the same magnitude? Derive an equation which relates these two quantities when the battery is connected across a resistor of resistance R .
12. Two $7\ \Omega$ resistors are connected in series across a battery that has an emf of $1.5\ \text{V}$ and an internal resistance of $1\ \Omega$. Calculate the current in, and the voltage across, each of the $7\ \Omega$ resistors.
13. Two resistors have resistances $4\ \Omega$ and $5\ \Omega$ and are connected in series. This combination of resistors is connected to a battery that has an emf of $6\ \text{V}$ and an internal resistance of $1\ \Omega$.
- (i) Calculate the steady current that flows in the circuit.
(ii) What is the potential difference across the $5\ \Omega$ resistor?
(iii) Determine the actual output voltage at the terminals of the battery.
14. A battery has an emf of $5\ \text{V}$ and delivers a current of $0.4\ \text{A}$ when connected to a $12\ \Omega$ resistor.
- (i) Calculate the internal resistance of the battery.
(ii) The resistor is then disconnected and a voltmeter is connected across the battery. Given that the reading on the voltmeter is $4.9\ \text{V}$, calculate the resistance of the voltmeter.

Here, the concept of *power dissipation* and some new formulae are introduced.

15. A potential difference V , applied across a resistor of resistance R , gives rise to a steady current I flowing through the resistor. The amount of electrical energy that is converted to heat per second, i.e. the *power dissipated* P , is given by the equation $P = IV$. Show that the power dissipated is also given by the following two formulae:

$$(i) \quad P = I^2 R, \quad \text{and} \quad (ii) \quad P = \frac{V^2}{R}.$$

Note The standard unit for power (energy per unit time) is the *watt* and 1 watt is written as 1 W. Since the standard units for energy and time are the joule (J) and the second (s), respectively, we have that:

$$\text{Power} = \frac{\text{Energy}}{\text{Time}} \quad \text{and} \quad 1 \text{ W} = \frac{1 \text{ J}}{1 \text{ s}}$$

16. A potential difference of $V = 7 \text{ V}$ gives rise to a current of $I = 3 \text{ A}$ passing through a resistor. What electrical power is dissipated in the resistor?
17. A resistance of 5Ω has a current of 1 A passing through it. Calculate the power dissipated in the resistor. How much energy is dissipated during a time of 3 minutes?
18. A light bulb dissipates 60 W of power. How much energy is dissipated in 1 minute? The light bulb is operated from the 240 V mains supply. Calculate its resistance.

OK ... let's get Festive ☺

19. A 2 kW electric Santa (a present from your favourite aunt) is operated from the 240 V mains supply. Calculate his resistance.
20. A string of Christmas tree lights, consisting of twenty lamps, is connected in series across the 240 V mains supply. The power consumption of the whole string is 24 W .
- (i) Calculate the resistance of each lamp.
- (ii) If one lamp becomes short-circuited, and we assume that the resistance of each of the other lamps is unchanged, what is the total power consumption under these conditions?
- (iii) When one of the lamps is tested by applying only 0.1 V across it, the current passed is 10 mA . Calculate the resistance of this lamp, and explain the difference between your answer and the result found in part (i).

21. A string of Christmas tree lights, consisting of twenty four lamps, is connected in series across the 240 V mains supply. The power consumption of the whole string is 24 W.

(i) Calculate the resistance of each lamp and the current flowing in the string.

(ii) If one lamp becomes short-circuited, and we assume that the resistance of each of the other lamps is unchanged, what is the total power consumption in the string?

(iii) Explain why, when one of the lamps is tested by applying 1 V across it, the current passed is 0.01 A.