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Targets:

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Study Tips - The following summary covers the knowledge and understanding part of the Measuring Electricity unit. You need to know this material thoroughly - you will be tested on it in the Prelim and Final SQA Exam and this material is your basic starting point for tackling problem solving questions.

Notes - In order to study effectively, it is best to **make your own notes** in some form that allows for self-testing.

How? - Use a Note-taking System

Your objective is to capture on paper the **main facts** and **ideas** so that you can study them thoroughly. Divide an A4 page into a narrow (5 cm) left hand "recall" column and a wide right hand "notes" column. You may also want to leave a margin at the bottom of the page where you can write a one or two sentence summary of all the information contained on that page. The wide column on the right is where you write the notes. Don't crowd them - leave plenty of white space. After completing your notes, read them over and make sure you clearly understand each fact and idea, then, in the narrow column on the left, write a brief, meaningful question (or note down key terms, concepts or formulae).

An alternative is to use a spider diagram (or "Mind Map") as notes or to use "flash cards" with questions on one side and answers and examples on the other. Flash cards are very portable so they are

especially useful for testing yourself during spare moments on a bus etc.

It is important to use a method that gets **you** to ask **questions**. The process of asking questions helps you focus on the essential material and helps you understand things more clearly.

How do I remember it all? - Recitation is the most powerful method known for embedding facts and ideas into your memory. E.g. if you have written notes as suggested: Cover the notes in the wide column exposing only the questions in the narrow column. Recite the answers in your own words. Recite over and over again until you get the right answer

What else can I do? - Practice!

A critical component of physics is solving problems. Work at as many problems as possible, especially exam style questions.

Attempt all the questions in this booklet.

Section 1 Alternating and Direct Current



Calculating charge, current or time.

$$Q = I t$$

where Q is charge measured in coulombs (C),

I is current measured in amps (A),

t is time measured in seconds (s).

Example: A current of 3 A flows for 12 s in a circuit containing a lamp. How much charge has passed through the lamp in that time?

Answer: $Q = I t = 3 \times 12 = 36 \text{ C}$

The **voltage** of a supply is a measure of the energy given to the charges in a circuit.

Circuit symbols.

Component	Circuit Symbol	Description
Battery		Supplies electrical energy.
Lamp		Converts electrical energy to light energy.
Switch		Open: breaks a circuit Closed: completes a circuit.
Heater		Converts electrical energy into heat energy.
Resistor		Opposes current, it converts electrical energy into heat energy.
Variable resistor		A resistor whose resistance can be changed.
Motor		Converts electrical energy into kinetic energy.
Ammeter		Used to measure electric current - always connected in series.
Voltmeter		Used to measure voltage - always connected in parallel.
Ohmmeter		Measures resistance directly - use when component is not connected.
Fuse		A protection device. It melts when the current gets too high.

1. What are the two types of charge?
2. Name a source of direct current (d.c.).
3. What is the frequency of the mains voltage in the UK?
4. What is the size of the mains voltage in the UK?
5. What do we mean when we talk about electric current?
6. In alternating current what do we mean when we talk about peak voltage?
7. Draw the symbol for a variable resistor, a fuse and a lamp.
8. Try to find out the symbol for a capacitor and a diode.
9. What is the unit that we use to measure electric charge?
10. What is the equation that links time, charge and current?
11. Draw the pattern you would see on an oscilloscope when it is displaying an alternating current pattern.
12. What do we mean by voltage in a circuit?

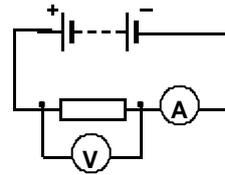
Section 2 Resistance.

Positions of ammeter and voltmeter in a circuit:
 The **ammeter** in **series**, the **voltmeter** in **parallel**.
 An increase in **resistance** of a circuit leads to a decrease in the current in that circuit.

Calculating resistance, current, voltage.

$$V = I R$$

V is voltage measured in volts (V),
 I is current measured in amps (A),
 R is resistance measured in ohms (Ω).



Example: A current of 4 A flows through a 20 ohm resistor.
 Calculate the voltage across the resistor.

Answer: $V = I R = 4 \times 20 = 80 \text{ V}$

The ratio V/I for a resistor remains approximately constant for different currents.

Variable resistors can change the current in a circuit. They have many uses, including: volume controls on radios or televisions; controlling the speed of electric motors in toy cars.

When there is an electric current in a wire, there is an energy transformation. For example, electrical energy is transformed into heat in an electric fire.

The energy transformation occurs in the resistance wire (element). In a lamp, electrical energy is transformed into heat and light. The energy transformation in an electric lamp occurs in resistance wire (filament lamp) or gas (discharge tube). A discharge tube lamp is more efficient than a filament lamp (i.e. more of the energy is transformed into light and less into heat).

Calculations involving energy, power and time.

$$E = P t$$



E is energy measured in joules (J)
 P is power measured in watts (W)
 t is time measured in seconds (s)

Example: A 100 W lamp is switched on for 550 s. Calculate the energy produced.

Answer: $E = P t = 100 \times 550 = 55\,000 \text{ J}$

Calculating power, current and voltage.

$$P = I V$$



P is power measured in watts (W)
 I is current measured in amps (A),
 V is voltage measured in volts (V).

Example: A current of 12 A flows through an appliance. If the voltage across the appliance is 230 V, calculate the power.

Answer: $P = I V = 12 \times 230 = 2\,760 \text{ W}$

Calculations involving power, current and resistance.

$$P = I^2 R$$



(This equation combines $V = IR$ with $P = IV$)

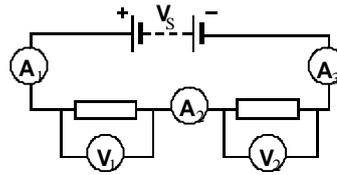
Example: A current of 0.5 A flows through a lamp of resistance 20 Ω . Calculate the power of the lamp.

Answer: $P = I^2 R = 0.52 \times 20 = 0.25 \times 20 = 5 \text{ W}$

1. What happens to the current in a circuit when we increase the resistance?
2. What is the unit we use to measure resistance?
3. Draw a diagram to show a circuit with two bulbs - show where you would connect a voltmeter to measure the voltage across one of the bulbs.
4. State one use for a variable resistor.
5. What is the formula that links current, voltage and resistance?
6. Which has a higher resistance a long thin wire or a long thick one?
7. What is the unit that we use to measure power?
8. What is the missing word: power = x current.
9. What is the unit that we use to measure energy?
10. Which is more efficient a filament lamp or a gas discharge tube lamp?
11. What is the equation that links power, energy and time?

Section 3 Useful Circuits

Series circuits



1. In a series circuit, the current is the same at all points.

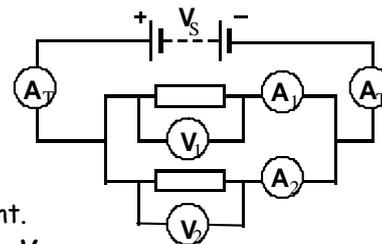
reading on A_1 = reading on A_2 = reading on A_3

2. The sum of the voltages across components in series is equal to the voltage of the supply.

reading on V_1 + reading on V_2 = V_s

3. **Series switches.** When switches are connected in series, any one of the switches can switch off the appliance. Most household appliances have to be switched on at the socket before they can be switched on at the appliance itself.

Parallel circuits



1. The **voltage** across components in parallel is the same for each component.

reading on V_1 = reading on V_2 = reading on V_s

2. The sum of the currents in parallel branches is equal to the current drawn from the supply.

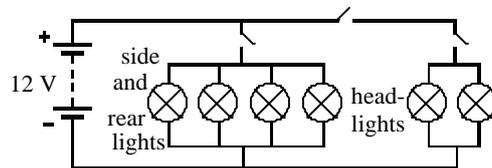
reading on A_1 + reading on A_2 = reading on A_T

3. Connecting too many appliances to one socket is dangerous because a large current could be drawn from the supply (equal to the sum of the currents for each appliance). This could cause the socket to overheat.

Continuity tester. Connect test object or circuit between these two wires. If the lamp lights there is a continuous circuit.

Fault finding. The continuity tester can be used in fault finding as shown above. An ohmmeter can also be used. A high reading (very large resistance) indicates an open circuit (e.g. a broken wire). A very low reading indicates a short circuit.

Car lighting. All lamps are in parallel with the 12 V car battery. This means that each lamp has 12 V across it. The current drawn from the battery will increase as more lamps are switched on.



Calculations involving resistors in series: $R_T = R_1 + R_2 + \dots$

Example: Find the total resistance of the combination of resistors shown here.

Answer: $R_T = R_1 + R_2 = 22 + 36 = 58 \Omega$

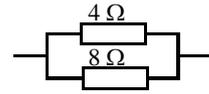


Calculations involving resistors in parallel:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$$

Example:

Find the total resistance of the combination of resistors shown here.



Answer:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots \quad \left(\frac{1}{4} + \frac{1}{8} \right)$$

$$= 0.25 + 0.125 = 0.375$$

$$\frac{1}{R_T} = 0.37 = 2.67 \Omega$$

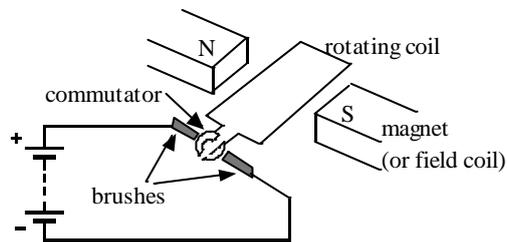
1. What is the missing word: Current is the same at all points in a circuit.
2. In a parallel circuit what happens to the voltage in each of the branches?
3. What is the formula for adding resistors in parallel?
4. Describe how you could test a circuit to see if there is a break in it?
5. A pupil wires up a circuit with a bulb in it and is surprised to see that the bulb doesn't light. His teacher tells him that the problem is a short circuit. What does he mean by this?
6. If you have too many branches in a parallel circuit what can happen to the supply current?
7. A bulb and two resistors are connected in series in a circuit with a 6V supply. When the voltage across the first resistor is measured it is found to be 3V. The voltage across the bulb is 1.4V. What will the voltage across the second resistor be?

8. Why are the lights in a car connected in parallel?
9. What is the missing word: The total resistance of a circuit is if additional parallel branches are added.
10. Three resistors are connected in series; 5Ω , 3Ω and 2Ω . What is the total resistance of the circuit?

Section 4 Movement from Electricity.

When a wire carries current, there is a **magnetic field** around it. It experiences a force when it is placed in a magnetic field. The direction of this force depends upon the direction of current and of the magnetic field. If either is reversed, the direction of the force is reversed. When the field and the current are at right angles to each other, the force is at right angles to both. Electromagnets, electric bells and relays make use of the magnetic effect of a current.

Electric motor. This is a simple diagram of an electric motor. Note the positions of the rotating coil, field coil (magnet), brushes and commutator.



The d.c. electric motor. When the rotating coil carries a current there is a magnetic field around it. It will experience a force since it is in a magnetic field. This makes the coil rotate. The **commutator** allows the coil to keep on rotating. The **commutator** is a ring which has been split into two. It reverses the direction of the current in the coil so that the turning force is always acting in the same direction. The **brushes** connect the commutator to the electrical supply so that current can flow through the coil but still allow the commutator and coil to turn.

Commercial motors. The **brushes** in a commercial motor are made of **carbon** (graphite) because it is soft enough to wear away as it slides over the commutator, without causing wear and damage to the commutator itself. The brushes are held against the commutator by springs so they always make good contact.

A **multi-section commutator** is used in a commercial motor. This is to make the rotation of the coil much smoother. (The turning force is always greatest when a coil is at right angles to the magnetic field. A combination of several coils at different angles means that one of the coils is always at right angles to the magnetic field.) The magnetic field in a commercial motor is provided by field coils rather than permanent magnets. Field coils are fixed coils which carry current and become electromagnets. This is a more compact and cheaper way of providing a magnetic field.

1. What is an electromagnet?
2. Give two examples of where electromagnets can be used.
3. What happens to a wire carrying a current when it is placed in a magnetic field?
4. What is field coil and where would you find one?

5. What does the commutator in an electric motor do?
6. Draw a diagram to show the magnetic field pattern round a bar magnet.
7. Why is carbon used to make brushes for an electric motor?
8. Why are multi-section commutators used in commercial motors?
9. Describe briefly how an electric motor operates.
10. What do the brushes do in an electric motor?
11. Identify on the diagram of the electric motor, the rotating coil, field coil (magnet), brushes and commutator.

