Students who embark on A-level physics should be able to apply their knowledge from GCSE physics to solve problems in familiar and less familiar contexts. The tasks in this worksheet aim to improve your problem-solving skills in mechanics and electric circuits.

TASK 1 Mechanics

Some assignments have been set for you on **isaacphysics.org**. These problems can be completed online.

1. Create an account on www.isaacphysics.org/register Complete the registration page.
2. Click this link- www.isaacphysics.org/account Enter the school name (West Kirby Grammar School). As you start typing, the school name and address will appear.
3. Click the green "Save" button.

Copy and paste this code- ***93BLDD*** into the box labelled "Enter your code in here".

4. Click the "Apply Code" button.
5. Work through the work set in 'my assignments'

There is a lot more to Isaac Physics than the assignments set for you. There are lots of questions that you can choose from to work on independently. This will help you to develop the skills you'll need to thrive on university courses in Physics, Maths and Engineering etc. On the events page you can find out about free Problem Solving workshops that are run.

TASK 2 Electric Circuits

Work through the following notes and answer the questions on electric circuits.

At AS *Electric current* includes many principles that you learnt at GCSE, and some new ones. This worksheet will help you to revise the concepts from GCSE and to make sure that you are ready to move onto AS.

Learning objectives

After completing the worksheet you should be able to:

- recall the symbols, units, and equations for electrical quantities covered at GCSE
- define and calculate
  - electric current
  - potential difference
  - electromotive force (emf)
  - resistance
  - power
  - energy dissipated.

Background

Electric current, *I*, is the rate of flow of **charge**, *Q*, in a wire or component. Charge is measured in coulombs (C), while current is measured in amperes (A) – usually shortened to 'amps'.

$$\text{current} = \frac{\text{flow of charge}}{\text{time}}$$

$$I = \frac{\Delta Q}{\Delta t}$$

The current flowing through a component is measured by connecting an ammeter in series with the component.

The **potential difference**, V, is the work done (or energy transferred), W, per unit charge, Q. Potential difference is often referred to as pd and is measured in volts (V).

$$\text{potential difference} = \frac{\text{work done}}{\text{charge}}$$

$$V = \frac{W}{Q}$$

Potential difference across a component can be measured by connecting a voltmeter in parallel with the component.

The **electromotive force (emf)** of a battery or cell is the energy provided per unit of charge passing through it, and so it is also measured in volts (V).

The energy transferred (or dissipated), ΔE, in a component is equal to the work done, W and is measured in joules (J).

energy transferred, ΔE = work done, W

= current × time × potential difference

$$W = I\,t\,V$$

Also, energy transferred = power × time

$$\Delta E = P\,t$$

The **power**, P, in watts (W), supplied to a component, is the energy transferred (or dissipated) to that component per second.

$$\text{power} = \frac{\text{energy transferred}}{\text{time}}$$

$$P = \frac{\Delta E}{t} = \frac{W}{t}$$

Or, power = current × potential difference

$$P = I\,V$$

The **resistance**, R, of a component in a circuit is a measure of the difficulty of making current pass through the component. The unit of resistance is the ohm (Ω), which is equal to one volt per ampere.

Resistance is defined as $\frac{\text{potential difference}}{\text{current}}$

$$R = \frac{V}{I}$$

Resistance is caused by the repeated collisions between the charge carriers in the material with each other and with the fixed positive ions of the material.

If you measure the variation of current with pd for a component you can plot a **characteristic graph** of current (on the *y*-axis) against pd (on the *x*-axis). You should know what the characteristic graphs look like for a resistor, a filament lamp, and a diode – you need to make sure that you can remember these. You can see some of these characteristic graphs in Topic 12.4 *Components and their characteristics*.

Task

Before looking at the worked examples, complete the table below. You can then use the completed table when you need a reminder of the symbols, units, and equations.

Quantity	Symbol	Unit	Equation(s) which could be used to find this quantity
Charge			
Current			
Potential difference			
Resistance			
Energy			
Power			

Worked example 1 – resistance

Question

A pd of 15 V is needed to enable a current of 2.5 A to flow through a wire. Calculate the resistance of the wire.

Answer

Step 1

Write down the values given in the question.

$V = 15\ \text{V}$

$I = 2.5\ \text{A}$

$R =$? (*This is the quantity you need to calculate.*)

Step 2

Write down the appropriate equation and substitute the values.

$$R = \frac{V}{I}$$

$$= \frac{15}{2.5}$$

$$= 6.0\ \Omega$$

(*Remember to include units and use the appropriate number of significant figures.*)

Worked example 2 – energy

Question

Calculate the energy dissipated in 1.0 minute by an immersion heater of power 5.0 kW.

Answer

Step 1

Write down the values given in the question and convert them into SI units.

$P = 5.0\,\text{kW} = 5.0 \times 10^3\,\text{W}$

$t = 1.0\,\text{minute} = 60\,\text{s}$

Step 2

Write down the appropriate equation and substitute the values. Give your final answer to an appropriate number of significant figures.

$\Delta E = P\,t$

$= (5 \times 10^3) \times 60$

$= 3.0 \times 10^5\,\text{J}$

Worked example 3 – pd and current

Question

A charge of 25 C flows in 10 s, delivering 200 J of energy to the outside circuit.

a Calculate the pd across the battery.

b Calculate the current flowing from the battery.

Answer

Step 1

Write down the values given in the question.

$\Delta Q = 25\,\text{C}$

$\Delta t = 10\,\text{s}$

$\Delta E = W = 200\,\text{J}$

$V = ?$ (*the pd across the battery*)

$I = ?$ (*the current flowing from the battery*)

a *Step 2*

Write down the appropriate equation, rearrange for pd, and substitute values.

$W = Q\,V$

so

$$V = \frac{W}{Q}$$

$$= \frac{200}{25}$$

$$= 8.0\ \text{V}$$

b *Step 3*

Write down the appropriate equation for current and substitute values.

$$I = \frac{\Delta Q}{\Delta t}$$

$$= \frac{25}{10}$$

$$= 2.5\ \text{A}$$

Worked example 4 – power and resistance

Question

A water heater connected to a 20 V supply, provides 200 J of electrical energy every second to heat the water.

a Calculate the power of the heater.

b Calculate the current passing through the heater.

c Calculate the resistance of the heater element.

Answer

Step 1

Write down the values given in the question.

$V = 20\ \text{V}$

$\Delta E = W = 200\ \text{J}$

$t = 1\ \text{s}$

$P = ?$ (*the power of the heater*)

$II = ?$ (*the current passing through the heater*)

$R = ?$ (*the resistance of the heater element*)

a *Step 2*

Write down the appropriate equation to find power, and substitute in the values.

$$P = \frac{\Delta E}{t} = \frac{200}{1} = 200\,\text{W}$$

b *Step 3*

Write down the appropriate equation, rearrange to make current the subject, and substitute in the values (using your value of *P* from part **a**).

$P = I\,V$

so

$$I = \frac{P}{V}$$

$$= \frac{200}{20}$$

$$= 10\,\text{A}$$

c *Step 4*

Write down the appropriate equation to find resistance, and substitute in the values (using your value for *I* from part **b**).

$$R = \frac{V}{I}$$

$$= \frac{20}{10}$$

$$= 2.0\,\Omega$$

Questions

1 A pd of 15 V is needed to make a current of 2.5 A flow through a wire.

a Calculate the resistance of the wire. (*1 mark*)

b Determine the pd needed to make a current of 2.0 A flow through the wire. (*2 marks*)

2 A current of 200 mA flows through a 4 kΩ resistor. Calculate the pd across the resistor. (*2 marks*)

3 A small water heater is rated at 12 V and 60 W.

a Calculate the current passing through the heater element. (*2 marks*)

b Calculate the resistance of the heater element. (*1 mark*)

4 A current of 4.0 A flows when a light bulb is connected across the terminals of a battery. The pd across the terminals is 12 V.

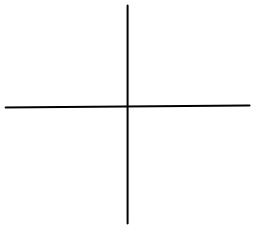
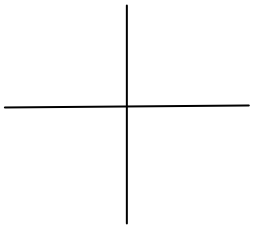
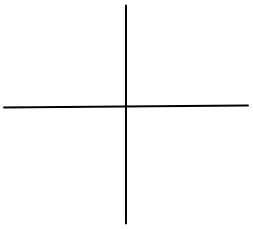
a State the amount of charge flowing past a set point in the circuit every second. (*1 mark*)

b Calculate the electrical energy of each coulomb of charge flowing in the circuit. (*1 mark*)

c Calculate the charge needed to transfer 60 J of energy. (*3 marks*)

d Calculate how long the battery will take to transfer 60 J of energy. (*2 marks*)

5 Draw the *I*–*V* characteristic graphs for a resistor, a filament lamp, and a diode using the axes provided. Below each graph, give a description of the graph and explain the shape of the graph. (*6 marks*)

Resistor	**Filament lamp**	**Diode**
		

6 Draw a labelled circuit diagram of a circuit that you could use to measure the variation of current with pd for a filament lamp. Describe your method. (*3 marks*)