Preparing for

A-Level Physics

Workbook

PART A - Key maths skills for A level Physics

Task 1 - Standard form

1. Write in standard form
   (a) 379.4
   (b) 0.0712

2. Write as ordinary numbers (use the data sheet on the last page of this booklet):
   (a) The speed of light
   (b) The charge on an electron

3. Write one quarter of a million in standard form.

4. Write these constants in ascending order (ignoring units):
   permeability of free space; the Avogadro constant; proton rest mass; acceleration due to gravity; mass of the Sun.

5. Work out the value of the following.
   Give your answer in standard form.
   The mass of an electron/the mass of the Earth (use the data sheet).

6. Solve $(2.4 \times 10^{7})x = 1.44 \times 10^{9}$
   Give your answer in standard form.

Answers to Task 1 – Standard form

1. a. 3.794×10^{2} b. 7.12×10^{-2}
2. a. $300\ 000\ 000\ ms^{-1}$ b. 0.000 000 000 000 000 000 16 C
3. 2.5×10^{5}
4. Correct ascending order: proton rest mass permeability of free space acceleration due to gravity the Avogadro constant mass of the Sun.

5.

1.52×10^{-55}

6.

6.0×10^{1}

Task 2 - Decimal places, significant figures and rounding

1. How many rockets would be needed to deliver 30 tonnes of material to a space station, if every rocket could hold 7 tonnes?

2. A power station has an output of 3.5 MW. The coal used had a potential output of 9.8 MW.

   Work out the efficiency of the power station.

   Give your answer as a percentage to one decimal place.

3. A radioactive source produces 17 804 beta particles in 1 hour.

   Calculate the mean number of beta particles produced in 1 minute.

   Give your answer to one significant figure.

Answers to Task 2 – Decimal places, significant figures and rounding

1. 5 rockets
2. 3.5/9.8 * 100% = 35.7% (1 d.p.)
3. 300 (1 sig. fig.)

Task 3 - Fractions, ratios and percentages

1. The ratio of turns of wire on a transformer is 350 : 7000 (input : output)

   What fraction of the turns are on the input side?

2. A bag of electrical components contains resistors, capacitors and diodes.

   $\frac{2}{5}$ of the components are resistors.

   The ratio of capacitors to diodes in a bag is 1 : 5. There are 100 components in total.

   How many components are diodes?

3. The number of coins in two piles are in the ratio 5 : 3. The coins in the first pile are all 50p coins. The coins in the second pile are all £1 coins.

   Which pile has the most money?

4. A rectangle measures 3.2 cm by 6.8 cm. It is cut into four equal sized smaller rectangles.

   Work out the area of a small rectangle.

5. Small cubes of edge length 1 cm are put into a box. The box is a cuboid of length 5 cm, width 4 cm and height 2 cm.

   How many cubes are in the box if it is half full?

6. In a circuit there are 600 resistors and 50 capacitors. 1.5% of the resistors are faulty. 2% of the capacitors are faulty.

   How many faulty components are there altogether?

7. How far would you have to drill in order to drill down 2% of the radius of the Earth?

8. Power station A was online 94% of the 7500 days it worked for.

   Power station B was online $\frac{8}{9}$ of the 9720 days it worked for.

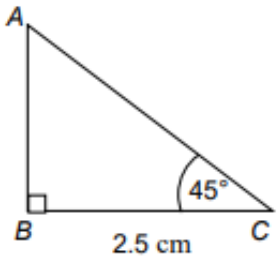
   Which power station was offline for longer?

Answers to Task 3 - Fractions, ratios and percentages

1. 1/20
2. 50 diodes
3. The second pile (250 : 300)
4. 5.44 cm^2
5. 20 cubes
6. 10 faulty components altogether (9 resistors and 1 capacitor)
7. 127 400 metres or 127.4 km
8. Power Station B was offline for longer. Power station A = online 7050 days, offline 450 days. Power station B = online 8640 days, offline 1080 days

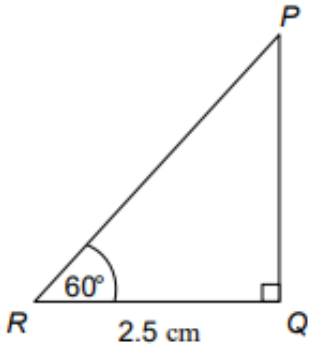
Task 4 - Using sine, cosine and tangent

1 (a) Work out the length of *AB*.



(Not drawn accurately)

(b) Work out the length of *PR*.



(Not drawn accurately)

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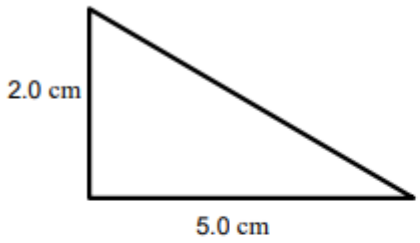
Answers to Task 4 - Using sine, cosine and tangent

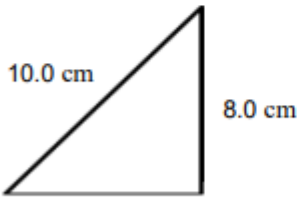
1(a) 2.5 cm

1(b) 5.0 cm

Task 5 - Pythagoras's theorem

Work out the lengths of the unlabelled sides.





Task 6 - Arithmetic means

1. The mean weight of 9 people is 79 kg

   A 10th person is such that the mean weight increases by 1 kg

   How heavy is the 10th person?

2. A pendulum completes 12 swings in 150 s.

   Work out the mean swing time.

Answers to Task 5 - Pythagoras's theorem

1. 5.4 cm ($x^2 = 5^2 + 2^2$)
2. 6.0 cm ($10^2 = x^2 + 8^2$)

Answers to Task 6 - Arithmetic means

1. 89 kg If the mean increases by 1kg when the 10th person is added then the total mass of 10 people would be 10 × 80 = 800 kg. 9 people have a mean mass of 79kg so their total mass would be 9 × 79 = 711 kg. Therefore the 10th person must have a mass of 800 – 711 = 89 kg.
2. $\frac{150}{12}$ = 13 seconds

Task 7 - Rerranging formulas

1. Rearrange $y = 2x + 3$ to make x the subject.

2. Rearrange $C = 2\pi r$ to make r the subject.

3. Rearrange $E = \frac{1}{2}mv^2$ to make v the subject.

4. Rearrange $s = ut + \frac{1}{2}at^2$ to make u the subject.

5. Rearrange $s = ut + \frac{1}{2}at^2$ to make a the subject.

6. Rearrange $\omega = \frac{v}{r}$ to make r the subject.

7. Rearrange $T = 2\pi\sqrt{\frac{v}{r}}$ to make r the subject.

8. Rearrange $v = \omega\sqrt{A^2 - x^2}$ to make x the subject.

Note: in science, subscripts are often used to label quantities. So in the following two examples, there are two masses, m_1 and m_2. The 1 and 2 are part of the quantity and should be kept with the m.

9. Rearrange $F = \frac{Gm_1m_2}{r^2}$ to make m_2 the subject.

10. Rearrange $F = \frac{Gm_1m_2}{r^2}$ to make r the subject.

Answers to Task 7 - Rerranging formulas

1. Rearrange $y = 2x + 3$ to make x the subject. $x = \frac{y-3}{2}$

2. Rearrange $C = 2\pi r$ to make r the subject. $r = \frac{C}{2\pi}$

3. Rearrange $E = \frac{1}{2}mv^2$ to make v the subject. $v = \sqrt{\frac{2E}{m}}$

4. Rearrange $s = ut + \frac{1}{2}at^2$ to make u the subject. $2s = 2ut + at^2$ $u = \frac{2s - at^2}{2t}$

5. Rearrange $s = ut + \frac{1}{2}at^2$ to make a the subject. $a = \frac{2(s-ut)}{t^2}$

6. Rearrange $\omega = \frac{v}{r}$ to make r the subject. $r = \frac{v}{\omega}$

7. Rearrange $T = 2\pi\sqrt{\frac{r}{v}}$ to make r the subject. $T^2 = \frac{4\pi^2 r}{v}$ $r = \frac{4\pi^2 v}{T^2}$

8. Rearrange $v = \omega\sqrt{A^2 - x^2}$ to make x the subject. $v^2 = \omega^2(A^2 - x^2)$ $x = \sqrt{A^2 - \frac{v^2}{\omega^2}}$

Note: in science, subscripts are often used to label quantities. So in the following two examples, there are two masses, m_1 and m_2. The 1 and 2 are part of the quantity and should be kept with the m.

9. Rearrange $F = \frac{Gm_1m_2}{r^2}$ to make m_2 the subject. $m_2 = \frac{Fr^2}{Gm_1}$

10. Rearrange $F = \frac{Gm_1m_2}{r^2}$ to make r the subject. $r = \sqrt{\frac{Gm_1m_2}{F}}$

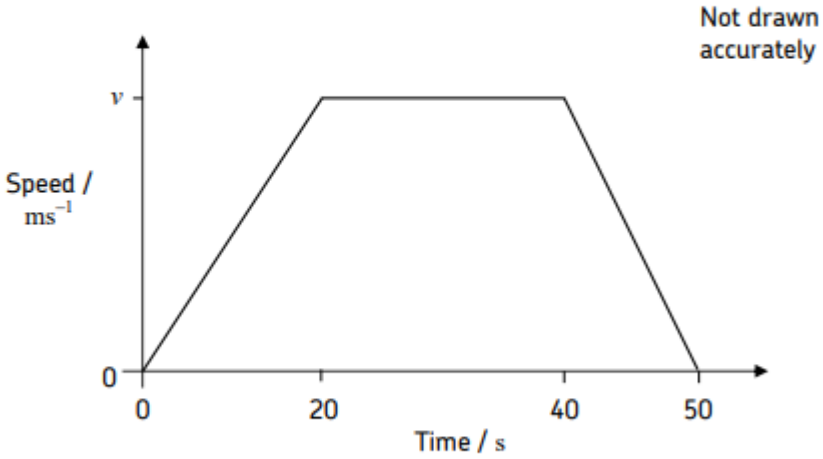
Task 8 – Graph gradients and areas

1. The graph shows the speed of a car between two sets of traffic lights.

   It achieves a maximum speed of v metres per second.

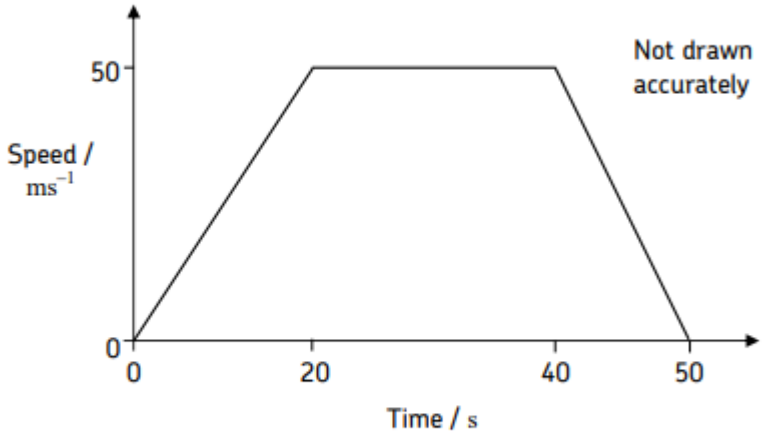
   It travels for 50 seconds.

   The distance between the traffic lights is 625 metres.



   Calculate the value of v

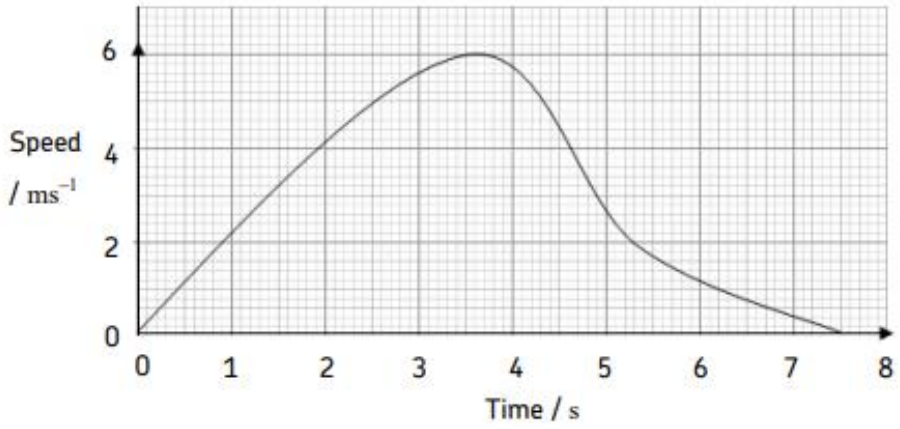
2. The graph shows the speed of a train between two stations.



   Calculate the distance between the stations.

Non-linear graphs

3 The graph shows the speed-time graph of a car.



Use the graph to work out:

a. The maximum speed of the car.

b. The total distance travelled.

c. The average speed for the journey.

Answers to Task 8 – Graphs, gradients and areas

1.

Applying the formula for the area of a trapezoid:

$$\text{Area} = \frac{a + b}{2} h$$

From the graph, a = 20, b = 50 and h represents the unknown value v, so:

$$625 = \frac{20 + 50}{2} v$$

Rearranging to find v:

$$v = \frac{625 \times 2}{70}$$

$$= 17.9 \text{ ms}^{-1}$$

Alternatively you could calculate the area using the left triangle, the middle square and the right triangle, ie

$$\text{Area} = \frac{20\,v}{2} + 20v + \frac{10v}{2}$$

$$625 = 10v + 20v + 5v$$

Rearranging to find v:

$$v = \frac{625}{35}$$

$$= 17.9 \text{ ms}^{-1}$$

2.

Here you need to calculate the area of the trapezoid, which will give you the distance:

$$\text{Area} = \frac{20 + 50}{2} \times 50$$

$$= 1750 \text{ m}$$

Again, alternatively you could calculate the area using the left triangle, the middle square and the right triangle.

3.

a. 6.0 ms^{-1}
b. Answer between 21 and 24 m (count the number of squares under the line).
c. Use your answer from part b:

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

For example,

$$\frac{21}{15} = 2.8\ ms^{-1}$$

Or

$$\frac{24}{7.5} = 3.2\ ms^{-1}$$

PART B - Exam questions

Task 9 - Motion questions (GCSE recap)

1 A car is travelling along a level road.

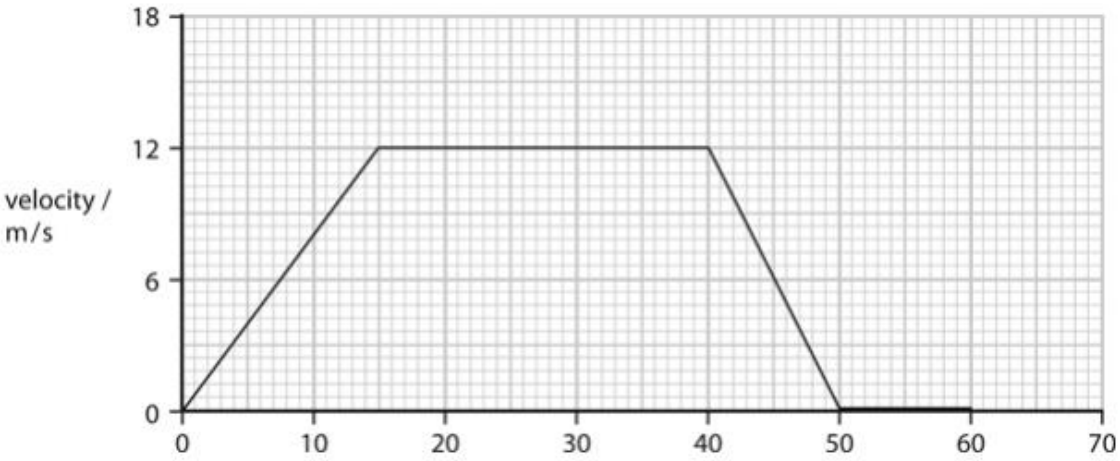
a The car travels at constant velocity. It covers 250 m in 40 s. Calculate the average velocity during this time.

(2 marks)

b The car now accelerates in a straight line.
Its average acceleration is 12 m/s^2.
Calculate the increase in velocity of the car in 4.0 s.

(3 marks)

2 The graph shows a velocity-time graph for a cyclist over a time of 60 s.



a **i** When is the cyclist travelling with greatest velocity?
Place a cross (☒) in the box next to your answer.

A for the first 15 seconds ☐
B between 15 and 40 seconds ☐
C between 40 and 50 seconds ☐
D for the last 10 seconds ☐

(1 mark)

ii Calculate how long the cyclist is stationary for in seconds.

(1 mark)

iii Calculate how far the cyclist travels in metres during the first 40 seconds.

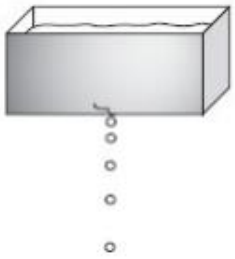
(1 mark)

b A different cyclist accelerates for 8 s. During this time they accelerate from 3 m/s to 14.2 m/s.

Calculate the acceleration during this time.

(3 marks)

3 A water tank drips water.



a Scientists could use four quantities to describe the movement of the water drops.

Three of these quantities are vectors.

The other quantity is a scalar.

acceleration	force	mass	velocity

i Complete the sentence by putting a cross (☒) in the box next to your answer.

The scalar quantity is...

A acceleration ☐

B force ☐

C mass ☐

D velocity ☐

(1 mark)

ii State any vector quantity **not** listed above.

(1 mark)

iii Complete the following sentence using one of the quantities from the word box above.

In a vacuum, all bodies falling towards the Earth's surface have the same

_____.

(1 mark)

b The mass of one water drop is 0.00008 kg.
Calculate its weight in Newtons.
(Gravitational field strength is 10 N/kg)

(2 marks)

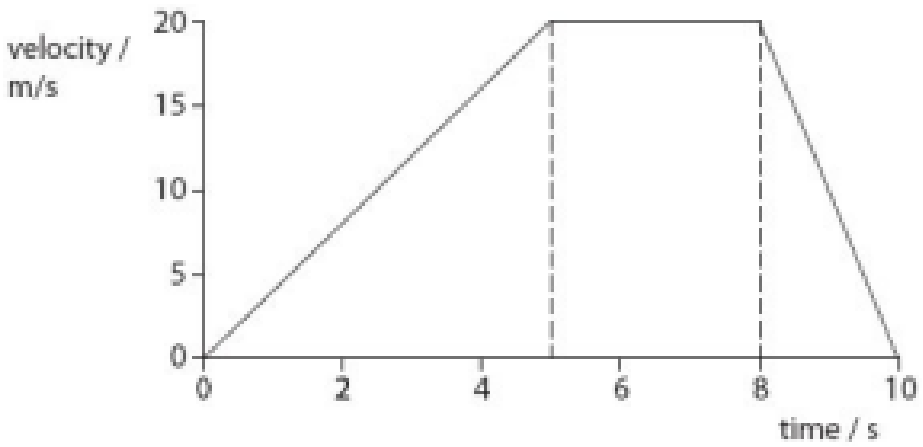
c The water drop falls to the ground, 13 m below, in 1.7 s.
Calculate the average speed in m/s of the drop while it is falling.

(2 marks)

d Assuming the droplet starts at rest calculate the velocity just before it hits the ground. Ignore air resistance.
($g = 10 m/s^2$)

(3 marks)

4 The graph shows how the velocity of a small car changes with time.



a Use the graph to estimate the velocity of the car at three seconds.

(1 mark)

b Calculate the acceleration in m/s^2 of the car when it is speeding up.

(2 marks)

c Explain why the units of acceleration are m/s^2.

(2 marks)

d Show that the car travels further at a constant velocity than it does when it is slowing down.

(3 marks)

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Answers to Task 9 - Motion questions

1

a The car travels at constant velocity. It covers 250 m in 40 s. Calculate the average velocity during this time.

$$V = \frac{s}{t} = \frac{250}{40} = 6.25 \text{ m/s}$$

2 marks

b The car now accelerates in a straight line.
Its average acceleration is 12 m/s².
Calculate the increase in velocity of the car in 4.0 s.

Use $a = \frac{\Delta v}{\Delta t}$

$\Delta v = a \Delta t$

$= 12 \times 4.0 = 48 \text{ m/s}$

3 marks

2a i

When is the cyclist travelling with greatest velocity?
Place a cross (☒) in the box next to your answer.

A for the first 15 seconds	☐
B between 15 and 40 seconds	☒
C between 40 and 50 seconds	☐
D for the last 10 seconds	☐

ii Calculate how long the cyclist is stationary for in seconds.

$60 - 50 = 10 \text{ s}$

(1 mark)

iii Calculate how far the cyclist travels in metres during the first 40 seconds.

$\left(\frac{12 \times 15}{2}\right) + (12 \times 25)$

$90 + 300 = 390 \text{ m}$

(1 mark)

b A different cyclist accelerates for 8 s. During this time they accelerate from 3 m/s to 14.2 m/s.

Calculate the acceleration during this time.

Use $a = \frac{\Delta v}{\Delta t}$

$\frac{14.2 - 3}{8} = 1.4 \text{ m/s}^2$

(3 marks)

3a.

i Complete the sentence by putting a cross (☒) in the box next to your answer.

The scalar quantity is...

A acceleration	☐
B force	☐
C mass	☑
D velocity	☐

(1 mark)

ii State any vector quantity **not** listed above.

Eg. displacement
momentum
NOT 'weight' which is a force

(1 mark)

iii Complete the following sentence using one of the quantities from the word box above.

In a vacuum, all bodies falling towards the Earth's surface have the same acceleration.

b A different cyclist accelerates for 8 s. During this time they accelerate from 3 m/s to 14.2 m/s.

Calculate the acceleration during this time.

Use $a = \frac{\Delta v}{\Delta t}$

$\frac{14.2 - 3}{8} = 1.4 \text{ m/s}^2$

(3 marks)

c The water drop falls to the ground, 13 m below, in 1.7 s.

Calculate the average speed in m/s of the drop while it is falling.

$v = \frac{s}{t} = \frac{13}{1.7} = 7.6 \text{ m/s}$

(2 marks)

d Assuming the droplet starts at rest calculate the velocity just before it hits the ground. Ignore air resistance.

($g = 10 \text{m/s}^2$)

$a = \frac{\Delta v}{\Delta t} = \frac{v - u}{t}$

$u = 0$, so $a = \frac{v}{t}$

$v = at = gt = 10 \times 1.7 = 17 \text{ m/s}$

(3 marks)

4.

a Use the graph to estimate the velocity of the car at three seconds.

12 m/s. (Draw line on graph).

(1 mark)

b Calculate the acceleration in m/s^2 of the car when it is speeding up.

$a = \frac{\Delta v}{\Delta t} = \frac{v - u}{t} = \frac{20 - 0}{5} = 4 m/s^2$

(2 marks)

c Explain why the units of acceleration are m/s^2.

metres per second per second

$(m/s)/s = m/s^2$

(2 marks)

d Show that the car travels further at a constant velocity than it does when it is slowing down.

Area under graph method.

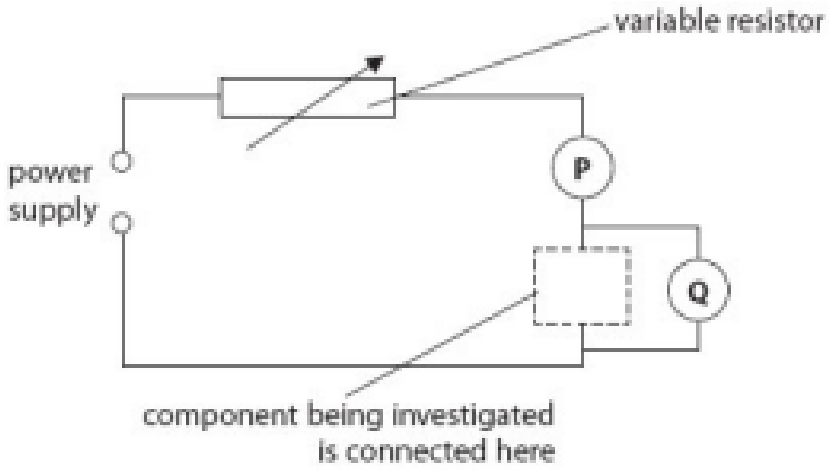
At constant v : $d = 20 \times 3 = 60 m$.

Slowing down : $d = \frac{20 \times 2}{2} = 20 m$

(3 marks)

Task 10 - Electric circuits questions (GCSE recap)

1 Some students investigate the electrical resistance of different components using this circuit.



a Which row of the table is correct for both meters P and Q?
Place a cross (☒) in the box next to your answer.

		meter P is	meter Q is
A	☒	an ammeter	an ammeter
B	☒	an ammeter	a voltmeter
C	☒	a voltmeter	a voltmeter
D	☒	a voltmeter	an ammeter

(1 mark)

b One of the components being investigated is a 12 ohm resistor.
When it is in the circuit, the ammeter reading is 0.50 A.
Calculate the voltmeter reading.

(2 marks)

c The students reduce the resistance of the variable resistor.

State what happens to the readings on each of the meters P and Q. Explain what happens to P.

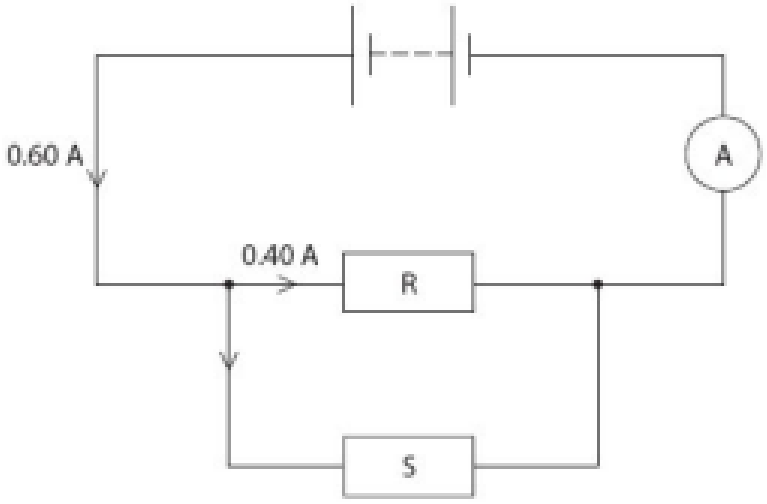
(2 marks)

d The students then reduce the voltage of the power supply.

State what happens to the current in the circuit.

(1 mark)

2 **a** The diagram shows an electric circuit with two resistors, R and S.



i R has a resistance of 11 ohms.

Calculate the potential difference across R.

(2 marks)

ii Use information from the diagram to calculate the current in S.

(1 mark)

iii Calculate the resistance of S.

(2 marks)

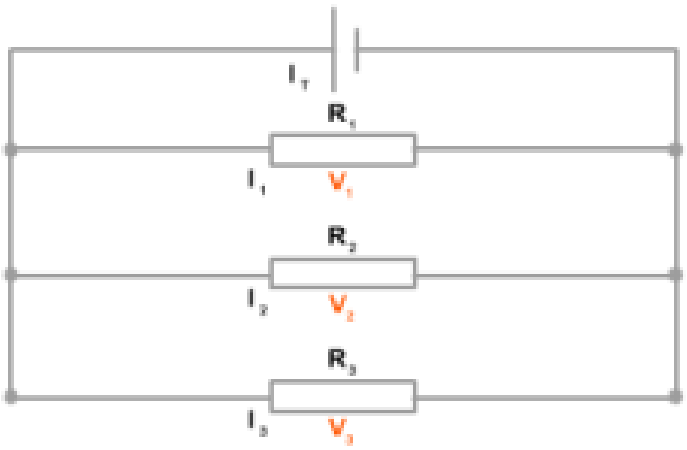
b Complete the sentence by putting a cross (☒) in the box next to your answer.

A student wants to measure the battery voltage with a voltmeter.
The voltmeter should be placed...

- **A** in series with the battery ☐
- **B** in parallel with the battery ☐
- **C** in parallel with the ammeter ☐
- **D** in series with either resistor R or S ☐

(1 mark)

3 The diagram shows an electric circuit with three resistors, R_1, R_2 and R_3.



a **i** R_1 has a resistance of 5 ohms. The current flowing in it is 2A.
Calculate the potential difference across R_1.

(2 marks)

ii State the voltage provided by the battery

(1 mark)

b **i** The resistance of R_2 is 10 ohms and R_3 is 4 ohms. Calculate the combined resistance of R_1, R_2 and R_3 in this arrangement.

(4 marks)

ii Calculate the current being produced by the battery.

(2 marks)

c Calculate the current flowing in:

i R_2

ii R_3

(3 marks for **i** and **ii** combined)

Answers to Task 10 - Electric Circuits questions

1.

a Which row of the table is correct for both meters P and Q?
Place a cross (☒) in the box next to your answer.

		meter P is	meter Q is
A	☐	an ammeter	an ammeter
B	☑	an ammeter	a voltmeter
C	☐	a voltmeter	a voltmeter
D	☐	a voltmeter	an ammeter

(1 mark)

b One of the components being investigated is a 12 ohm resistor.
When it is in the circuit, the ammeter reading is 0.50 A.
Calculate the voltmeter reading.

Use $V = I \times R$

$0.50 \times 12 = 6.0\ V$

(2 marks)

c The students reduce the resistance of the variable resistor.
State what happens to the readings on each of the meters P and Q. Explain what happens to P.

Reading on ammeter P increases
Total circuit resistance decreases, increasing current flow

Reading on voltmeter Q increases

(2 marks)

d The students then reduce the voltage of the power supply.
State what happens to the current in the circuit.

It reduces

(1 mark)

2a.

i R has a resistance of 11 ohms.
Calculate the potential difference across R.

$V = I \times R$

$= 0.40 \times 11 = 4.4\,V$

(2 marks)

ii Use information from the diagram to calculate the current in S.

$I_S = 0.60 - 0.40$

$= 0.20\ A$

(1 mark)

iii Calculate the resistance of S.

V across $S = 4.4\,V$ (from 2a i)

$R = \frac{V}{I} = \frac{4.4}{0.2} = 22\ \Omega$

(2 marks)

b.

A in series with the battery ☐

B in parallel with the battery ☑

C in parallel with the ammeter ☐

D in series with either resistor R or S ☐

3

a i R_1 has a resistance of 5 ohms. The current flowing in it is 2A. Calculate the potential difference across R_1.

$V = I \times R = 2 \times 5 = 10\,V$

(2 marks)

ii State the voltage provided by the battery

10 V

(1 mark)

b i The resistance of R_2 is 10 ohms and R_3 is 4 ohms. Calculate the combined resistance of R_1, R_2 and R_3 in this arrangement.

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ (look this up if not met before).

$\frac{1}{5} + \frac{1}{10} + \frac{1}{4}$

$\frac{1}{R_T} = 0.2 + 0.1 + 0.25 = 0.55$

$R_T = \frac{1}{0.55} = 1.8\,\Omega$

(4 marks)

ii Calculate the current being produced by the battery.

$$I = \frac{V}{R} = \frac{10V}{1.8\,\Omega} = 5.5\,A$$

(2 marks)

c Calculate the current flowing in:

i R_2 $I_2 = \frac{V}{R_2} = \frac{10}{10} = 1\,A$

ii R_3 $I_3 = \frac{V}{R_3} = \frac{10}{4} = 2.5\,A.$

(3 marks for **i** and **ii** combined)

Data sheet

Quantity	Symbol	Value	Units
speed of light in vacuo	c	3.00×10^{8}	$m\ s^{-1}$
permeability of free space	μ_0	$4\pi \times 10^{-7}$	$H\ m^{-1}$
permittivity of free space	ε_0	8.85×10^{-12}	$F\ m^{-1}$
magnitude of the charge of electron	e	1.60×10^{-19}	C
the Planck constant	h	6.63×10^{-34}	J s
gravitational constant	G	6.67×10^{-11}	$N\ m^2\ kg^{-2}$
the Avogadro constant	N_A	6.02×10^{23}	mol^{-1}
electron rest mass	m_e	9.11×10^{-31}	kg
proton rest mass	m_p	$1.67(3) \times 10^{-27}$	kg
neutron rest mass	m_n	$1.67(5) \times 10^{-27}$	kg
gravitational field strength	g	9.81	$N\ kg^{-1}$
acceleration due to gravity	g	9.81	$m\ s^{-2}$
atomic mass unit	u	1.661×10^{-27}	kg
mass of the Sun		1.99×10^{30}	kg
mean radius of the Sun		6.96×10^{8}	m
mass of the Earth		5.98×10^{24}	kg
mean radius of the Earth		6.37×10^{6}	m

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