The King's School Canterbury

Sixth Form Entrance 2018

PHYSICS

1 hour

ANSWER ALL THE QUESTIONS ON THE PAPER

You are advised to take note of the information and equations given at the start of each question.

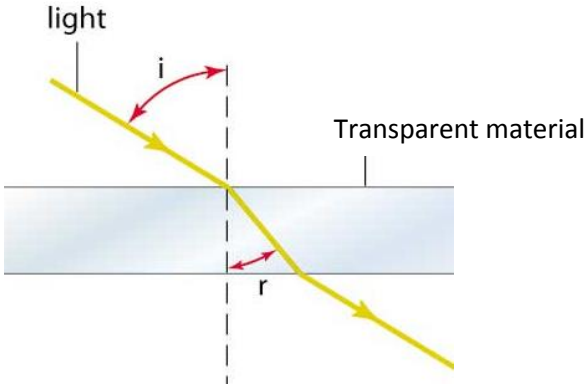
Use of a calculator is permitted.

Name (Capital Letters): .....

Present School: .....

Question 1

Refraction is the bending of light as it travels between different materials, changing speed in the process.



We can determine the amount of refraction by looking at a quantity called the **refractive index** where

$$\textbf{Refractive index} = \frac{\textbf{speed of light in a vacuum (or air)}}{\textbf{speed of light in the material}}$$

A student is studying refraction using a Perspex block.

The pupil is told that the refractive index of this Perspex block is 1.3 and that the speed of light in air can be taken as the same as that in a vacuum i.e. 3×10^8 m/s.

a) Calculate the speed of light in the block. **Quote your answer to 2 significant figures**.

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(2 marks)

Since it is not easy to measure the speed of light in a material, there is another way to find the refractive index using the following equation:

$$\text{Refractive index (or n)} = \frac{\textit{the sine of the angle of incidence}}{\textit{the sine of the angle of refraction}}$$

Or in symbols $\mathbf{n = \frac{\sin i}{\sin r}}$ This is called Snell's Law.

b) Show that this equation gives the correct value of the refractive index for Perspex if the angle of refraction that corresponds to a 20° angle of incidence is 15°.

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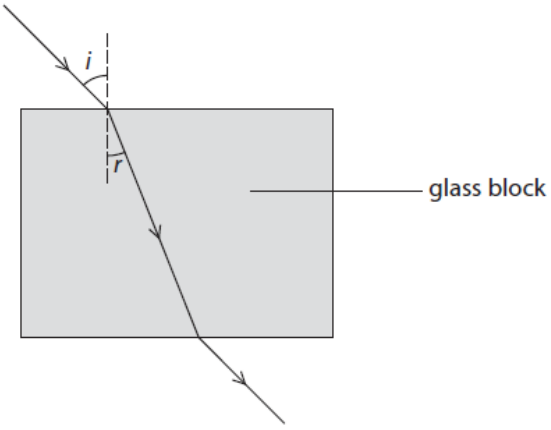
(2 marks)

c) The pupil carries out a different experiment with a glass block and takes a series of measurements of angle i and angle r as shown in the diagram.



i) Suggest a suitable piece of equipment to produce the ray of light.

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(1 mark)

ii) Identify the name of the dotted line drawn perpendicular to the surface.

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(1 mark)

The results she obtained are shown below

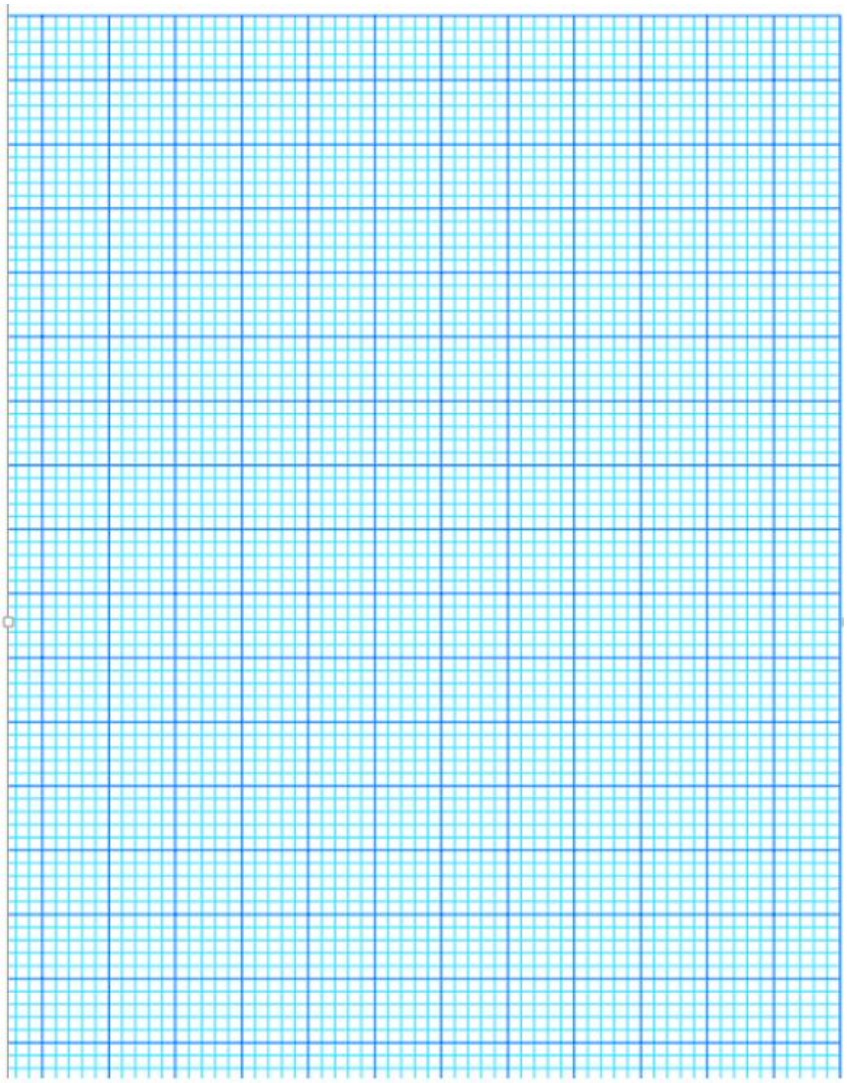
Angle of incidence, *i*	Angle of refraction, *r*	sin *i*	sin *r*
0°	0°	0.00	
15°	10°	0.26	
25°	16°		
35°	22°		
45°	28°		

d) Complete the two columns by finding sin i and sin r for the missing values.

Quote all numbers to 2 decimal places.

(2 marks)

e) Using the grid below, choose suitable scales and plot a graph of **sin i** on the **y axis** and sin r on the x axis. Draw in a line of best fit. (5 marks)



f) Since the refractive index is given by sin i/sin r it can be found by calculating the **gradient** of this graph. Calculate the refractive index of this glass block.

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(2 marks)

g) Suggest a reason why it is better to calculate the refractive index using a graph, rather than just using one pair of values.

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(1 mark)

h) Using either the equation for refractive index or the graph you have just drawn, calculate the angle of refraction you would expect in the glass block for an angle of incidence of 30°.

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(3 marks)

Exam continues on the next page

Question 2

You may find the following information useful for this question.

YOU ARE ADVISED TO READ THIS CAREFULLY AND REFER BACK TO IT AS NEEDED.

Average velocity (in m/s) = distance (in m) / time (in s)	*OR* ***v = d/t***
*Acceleration (in m/s^2) = **change** in velocity (in m/s) / time taken (in s)*	*OR* ***a = (v-u)/t***
Force (in N) = mass (in kg) x acceleration (in m/s^2)	*OR* ***F = ma***

- *Velocity and acceleration are vectors i.e. they have both size and direction.*
- *Gradient of a velocity time graph = acceleration*
- *Area under a velocity time graph = distance travelled*

When an athlete attempts to jump over a horizontal hurdle he pushes down on the ground.

a) Describe the force that causes the athlete to move upwards.

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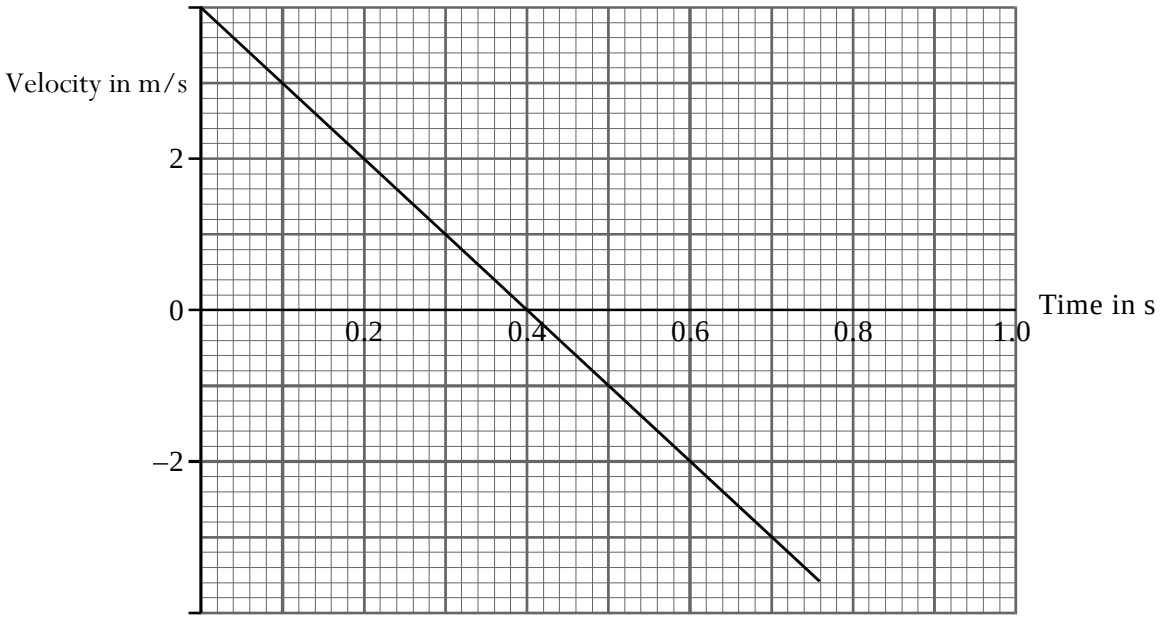
(1 mark)

b) The graph below shows how the upwards velocity of the athlete changes after leaving the ground.



i) After what time does the athlete reach his maximum height?

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(1 mark)

ii) What height does the athlete reach?

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(3 marks)

c) Calculate the acceleration of the athlete.

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(3 marks)

d) What is the direction of the acceleration? Explain how you can tell from the graph.

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(2 marks)

e) The athlete states this his weight is 65kg.

What is wrong with this statement?

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(1 mark)

f) Calculate the size of the force required to cause this acceleration.

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(1 mark)

g) What causes the force that leads to the athlete's acceleration?

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(1 mark)

h) When the athlete finished his race he wrapped himself in a foil blanket.

Explain the purpose of doing this in terms of heat transfer

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Question 3

You may find the following information useful for this question.

YOU ARE ADVISED TO READ THIS CAREFULLY AND REFER BACK TO IT AS NEEDED.

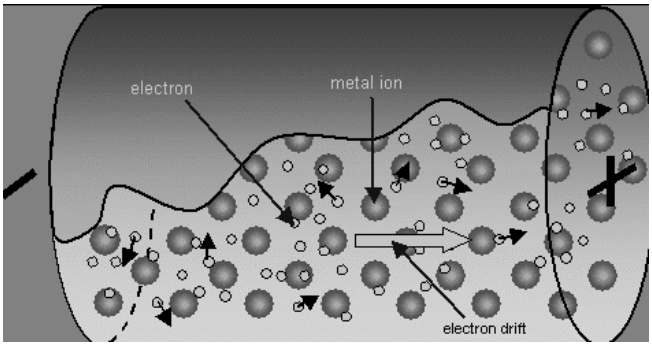
Cross sectional area of a cylinder (e.g. a wire) = πr^2 where r is the radius of the wire.

Volume of a cylinder = $\pi r^2 l$ where l = length

Density (in kg/m^3) = mass (in kg) / volume (in m^3)

Resistance is a measure of how difficult it is for electrical current to flow.

It is caused by the **collisions** between the moving electrons in a conductor and the ions (and other electrons) in its path.



We can calculate resistance using the following equation

$$\textbf{\textit{Resistance (}in }\boldsymbol{\Omega}\textbf{)} = \frac{\textbf{\textit{Voltage (in V)}}}{\textbf{\textit{Current (in A)}}}$$

a) By considering what is happening to the **particles** within a conductor explain the following phenomena:

i) Resistance increases with the length of the conductor.

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(2 marks)

ii) Resistance decreases with the cross-sectional area of the conductor.

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(2 marks)

iii) Resistance of a wire increases as the temperature of the wire increases.

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(2 marks)

iv) Wires made from different metals with the same dimensions have different values for resistance.

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(2 marks)

Since the dimensions of the wire make a difference to the resistance, we define a new quantity called **resistivity** which takes the length and cross-sectional area into account. This can be calculated using:

$$\rho = \frac{R\ A}{l}$$

where

ρ = resistivity
R = resistance in Ω
A = cross sectional area in m^2
l = length of the conductor in m

b) Show that the unit for resistivity is the Ωm

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(1 mark)

c) A student is asked to carry out an experiment to determine the resistivity of tin in the form of a wire.

As a first step, the student takes readings of the current in the wire and the voltage across the wire. The results are shown in the table below.

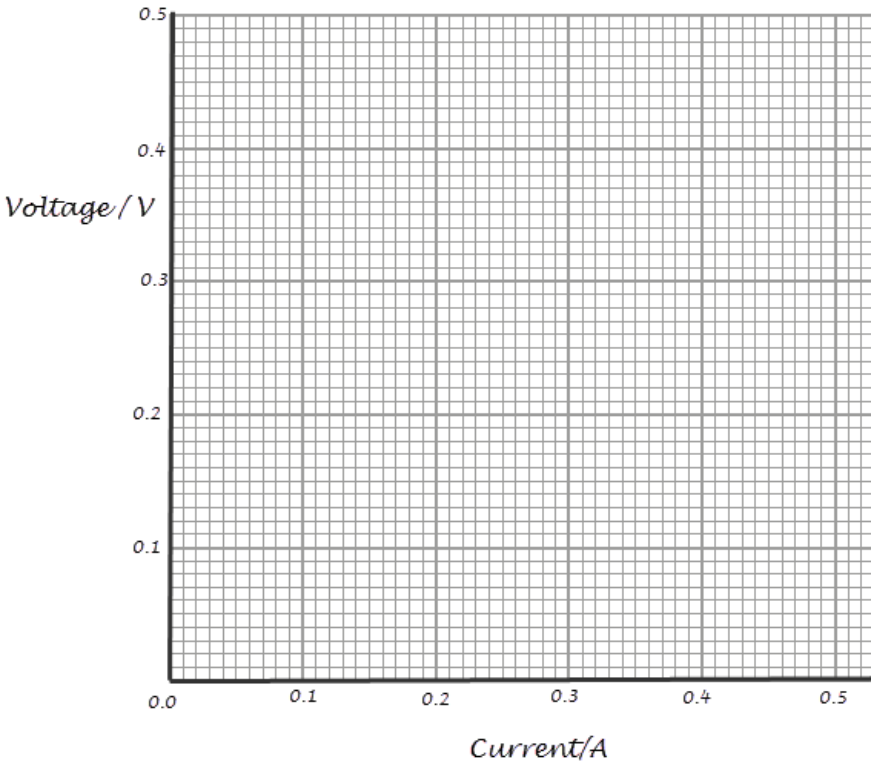
Voltage/V	0.10	0.20	0.30	0.40	0.50
Current/A	0.08	0.16	0.24	0.32	0.40

Draw a circuit diagram of the arrangement that could have been used to obtain the results. You can represent the wire by drawing a resistor.

(3 marks)

Question continues on the next page

d) Plot a graph of voltage against current on the axes below. Include a line of best fit.
(3 marks)



e) Calculate the resistance by finding the **gradient** of this graph.

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(2 marks)

f) The student measured the length of the wire to be 1.45m and the **diameter** to be 4.0×10^{-4}m. Show that the resistivity of tin is approximately $1 \times 10^{-7}\Omega$m.

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g) Draw on the same grid (on previous page) the voltage against current graph for a metal wire of the same length and diameter but with **double** the resistivity of tin.

(2 marks)

h) Calculate the mass of wire used in the experiment given that the density of tin is 7310 kg/m^3.

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(3 marks)

END OF TEST

Total 60 marks