Surname	Centre Number	Candidate Number
Other Names		2

GCE A LEVEL – NEW

A420U10-1

S17-A420U10-1

PHYSICS – A level component 1
Newtonian Physics

THURSDAY, 15 JUNE 2017 – MORNING

2 hours 15 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1.**	**8**	
	2.	**16**	
	3.	**12**	
	4.	**12**	
	5.	**12**	
	6.	**20**	
Section B	**7.**	**20**	
	Total	**100**	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Answer **all** questions.

Write your name, centre number and candidate number in the spaces at the top of this page.

Write your answers in the spaces provided in this booklet. If you run out of space, use the continuation page at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

This paper is in 2 sections, **A** and **B.**

Section **A**: 80 marks. Answer **all** questions. You are advised to spend about 1 hour 35 minutes on this section.

Section **B**: 20 marks. Comprehension. You are advised to spend about 40 minutes on this section.

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **5***(a)*.

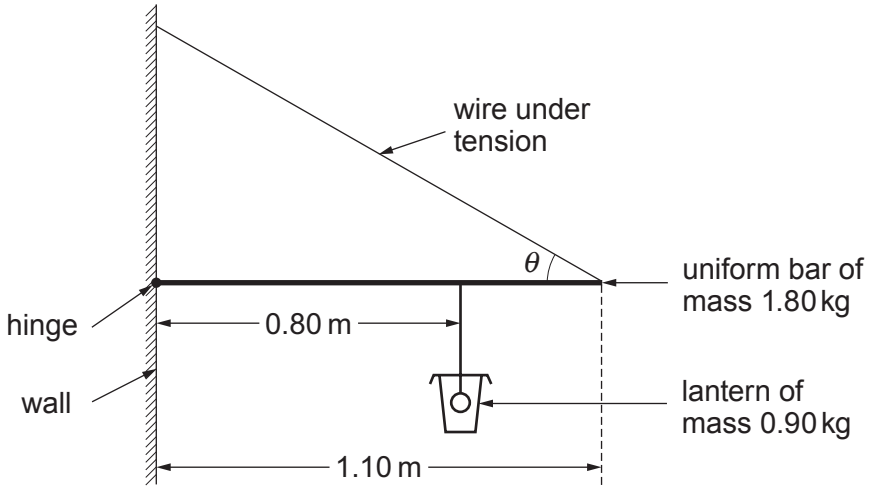
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SECTION A

Answer **all** *questions.*

1. A lantern is suspended from a hinged horizontal metal bar, as shown in the diagram.



(a) (i) Calculate the sum of the clockwise moments about the hinge of the forces acting on the bar. [3]

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(ii) For an angle, θ, of 35°, calculate the tension in the wire. [2]

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(iii) Discuss the effect, if any, on the tension of making the angle θ smaller (by using a shorter wire and attaching it to a lower point on the wall). [2]

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(b) A physics student, Sundeep, calculates that if the wire breaks, then, 0.10 s after it breaks, the angular velocity of the bar about the hinge would be 1.3 rad s^{-1}. Calculate the speed of the tip of the bar (right hand end) when it has this angular velocity. [1]

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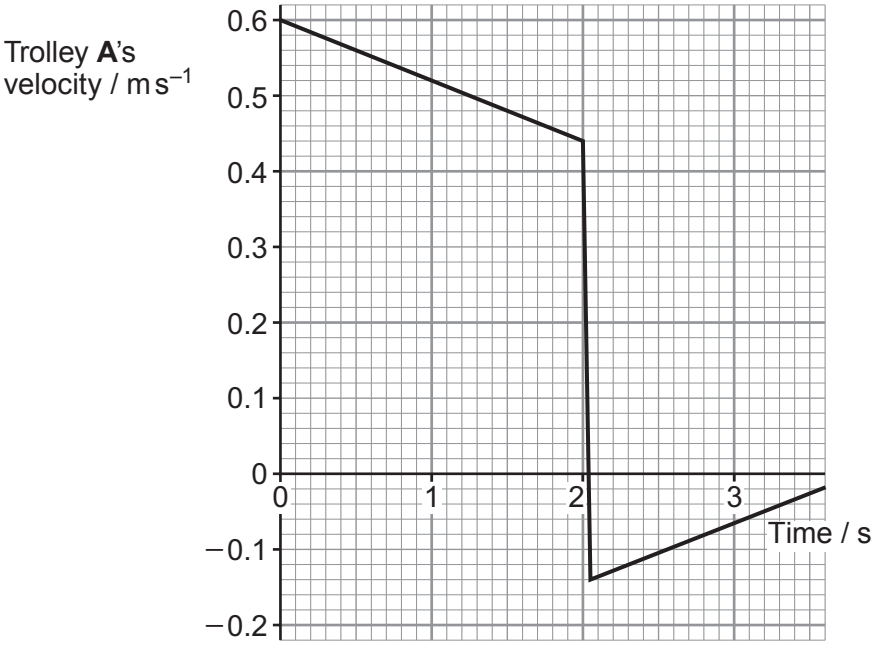
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2. *(a)* A trolley, **A**, is initially moving on a flat surface towards a stationary trolley, **B**, as in the diagram.



A datalogger is used to produce a velocity-time graph for **A**, starting before the collision and continuing after the collision.



(i) Calculate the resistive force on trolley **A** before the collision. [3]

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(ii) Calculate the work done by this resistive force between time t = 0 and time t = 2.0 s. [3]

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(iii) Determine the velocity of trolley **B** immediately after the collision. *[Ignore the effects of resistive forces during the collision.]* [4]

(iv) Jasmine suggests that this is an elastic collision. Determine whether or not she is right, showing your working clearly. [3]

(b) It is suggested that cars should be made of thicker metal. Discuss whether this is a good suggestion. You may discuss environmental as well as safety issues. [3]

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3. *(a)* The magnitude of the acceleration of a body travelling at speed v in a circle of radius r is given by:

$$a = \frac{v^2}{r}$$

(i) Show clearly that this equation is homogeneous in terms of units. [2]

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(ii) A teacher claims that the equation gives a 'sensible' value for the centripetal acceleration as r becomes extremely large. Justify her claim. [2]

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(b) A car of mass 1 150 kg moving at constant speed takes 52 s to complete a lap of a flat circular track of radius 200 m.

(i) Show that the magnitude of the centripetal force on the car is approximately 3 400 N. [3]

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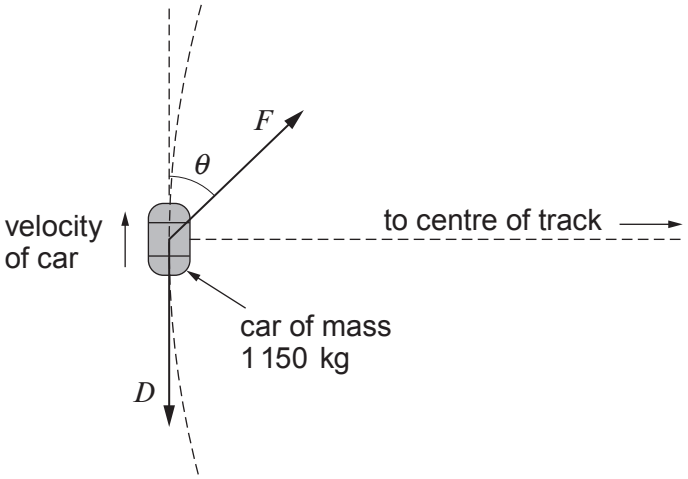
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(ii) The diagram shows the car at one point on its journey (clockwise) around the track. D is the force of air resistance on the car, and F is the horizontal component of the force on the car's tyres from the road. F = 5 500 N.

VIEW FROM ABOVE



I. Calculate the angle, θ, at which F must act in order to provide the centripetal force calculated in *(b)*(i). [2]

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II. Calculate D, giving your reasoning. [3]

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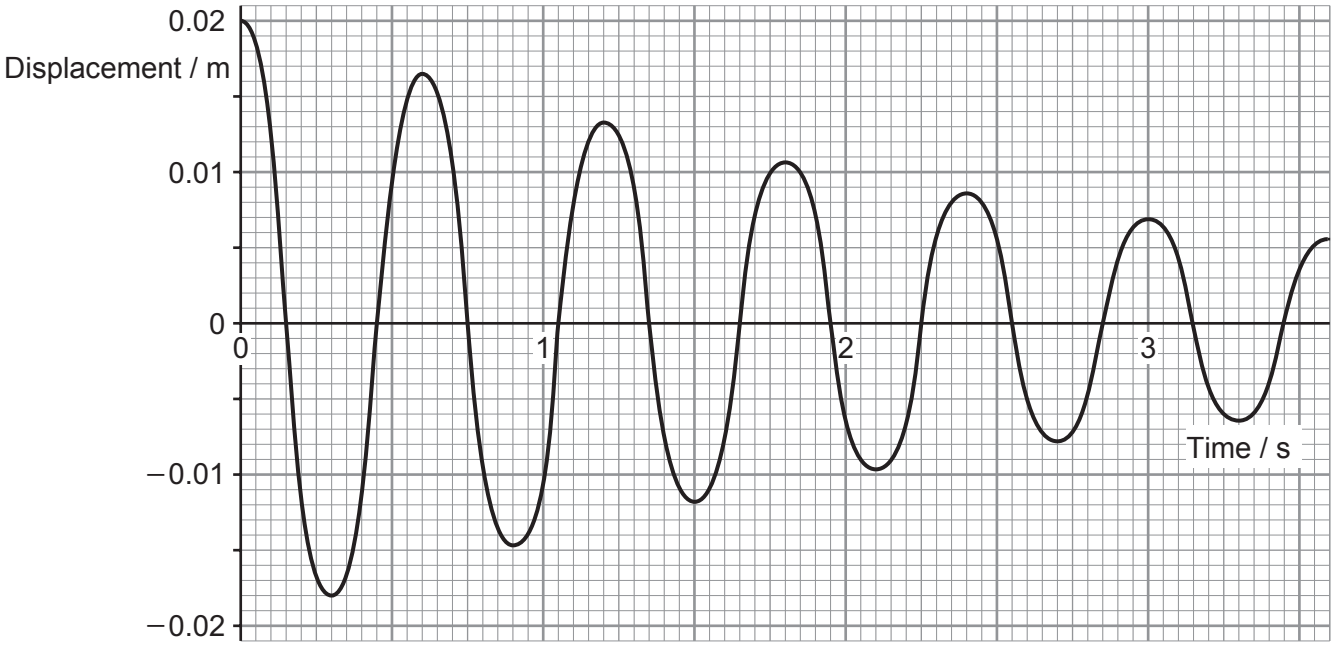
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Turn over.

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4. A metal sphere of mass 0.200 kg, hanging from a light spring of stiffness k = 22.0 N m^{-1}, is set oscillating up and down about its equilibrium position. A datalogger records the sphere's position and plots the graph shown below.



(a) State what feature of the graph shows that the sphere's oscillations are damped and identify the force responsible for this feature. [2]

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(b) Evaluate whether or not ordinary simple harmonic motion theory predicts the actual periodic time as shown on the graph convincingly. [4]

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(c) **Mark with a small circle** the point on the graph where the sphere's speed is the greatest. Use shm theory to calculate a value for this speed **and** explain whether this value is likely to be too high or too low. [4]

(d) The amplitude, A, (in m) of the oscillations at time t is given by the equation:

$$A = 0.020\, e^{-\lambda t}$$

Determine the value of λ. [2]

12

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5. *(a)* Explain, in terms of molecules, how a gas exerts a pressure on the walls of its container, and why this pressure increases with temperature. [6 QER]

(b) A cylinder of volume 0.020 m^3 contains 0.091 kg of nitrogen gas (relative molecular mass = 28) at a pressure of 3.9×10^5 Pa. Calculate:

(i) the rms speed of the molecules; [3]

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(ii) the temperature of the gas. [3]

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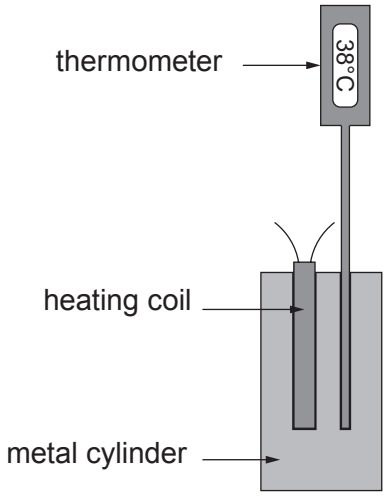
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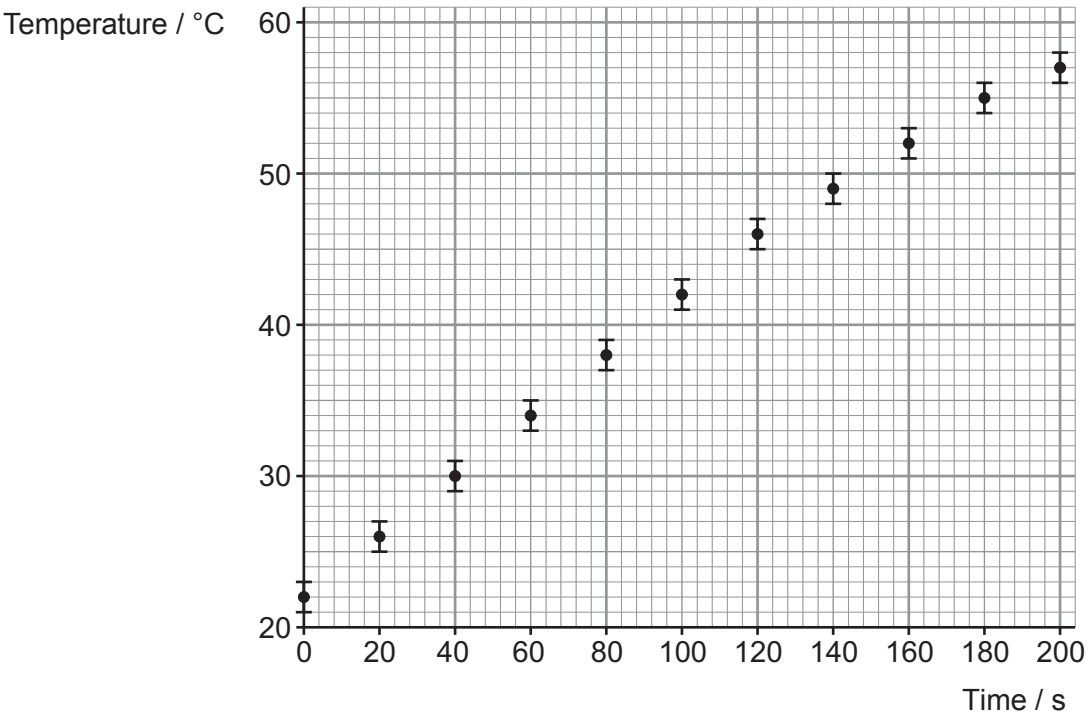
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Turn over.

6. *(a)* Alice performs an experiment to determine the specific heat capacity, c, of a metal in the form of a cylinder with holes drilled in it for a heating coil and a thermometer. She determines the mass, m, of the cylinder using a digital balance. Alice sets up a circuit to provide constant power to the heating coil and to enable the pd, V, across it and current, I, through it to be measured. The graph of temperature against time for the cylinder, as well as her other measurements, are given below.

m = 0.570 kg, V = 12.20 V, I = 3.81 A





Examiner only

(i) Draw a circuit diagram of the circuit required. [Show the heating coil as a resistor.] [2]

(ii) Suggest why the points for the highest temperatures show significant deviations from the trend of the points at lower temperatures, and what could have been done to reduce the deviation. [2]

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(iii) **Using an appropriate portion of the graph**, determine the maximum gradient and the minimum gradient. [4]

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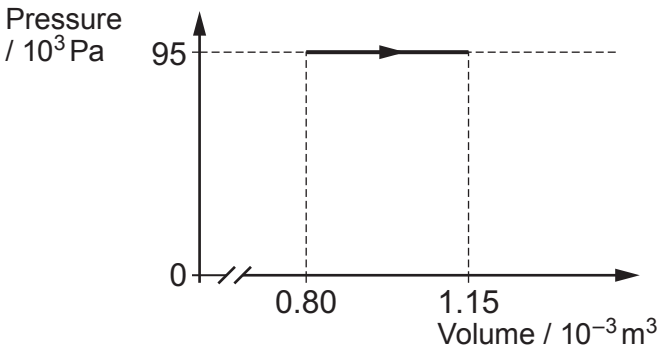
(iv) Show clearly that the graph gradient should be:

$$\text{gradient} = \frac{VI}{mc}$$ [2]

(v) Hence determine a value for the specific heat capacity of the metal of the cylinder, together with its **absolute uncertainty**. Assume that the percentage uncertainties in m, V and I are negligible. [5]

Examiner only

(b) In another experiment, 0.031 mol of helium (a monatomic gas) is heated so that it expands at constant pressure (see diagram). Its temperature rises from 295 K to 424 K.



(i) Calculate the heat flow into the gas during this change. [3]

(ii) Discuss whether or not this amount of heat would be needed in all circumstances to raise the temperature of 0.031 mol of helium from 295 K to 424 K. [2]

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SECTION B

7. Read through the following article carefully.

Cool Physics for Smart Phones
by Justino Luis Moreno

Paragraph

Some meters can be expensive to buy but if you've got a smart phone it's surprising just how many meters it can be employed as, if you get hold of the right apps. Right now on my iphone I've got a seismometer, magnetometer, accelerometer, tiltometer, protractor, light meter, ruler, decibel meter, oscilloscope and frequency meter. In the hands of a physicist your smart phone is transformed into a whole lot of experimental fun. 1

Experiment 1 - Measuring the speed of sound

All you need is a hollow cardboard tube of length between 1 and 3 metres. You'll also need a frequency meter app (mine's part of a free guitar tuner) and somebody who can make didgeridoo noises into the cardboard tube. Anyone can make these noises after a bit of practice and you should even be able to play the two lowest notes. The cardboard tube didgeridoo can be classed as a pipe that is closed at one end. There is a node of air displacement at the closed end, and an antinode at the open end. The second lowest note is called the third harmonic because it has a frequency of 3 times the lowest (or 'fundamental' or 'first harmonic'). When carrying out this experiment with a hollow tube of length 1.800 m, the fundamental note had a frequency of 47 Hz. This gave a value of the speed of sound of around 340 m s^{-1} which is not bad with a piece of throw-away cardboard and a free guitar tuning app. 2



Figure 1

Experiment 2 - Investigating polarisation of light

Unfortunately, light meter software tends to use a unit called 'lux,' but as long as we don't change light source mid-experiment the lux is proportional to the intensity. We shall concentrate on an experiment to do with polarisation - the variation of transmitted intensity through a polaroid with angle of the polaroid relative to the polarised light. The set-up is shown below. 3

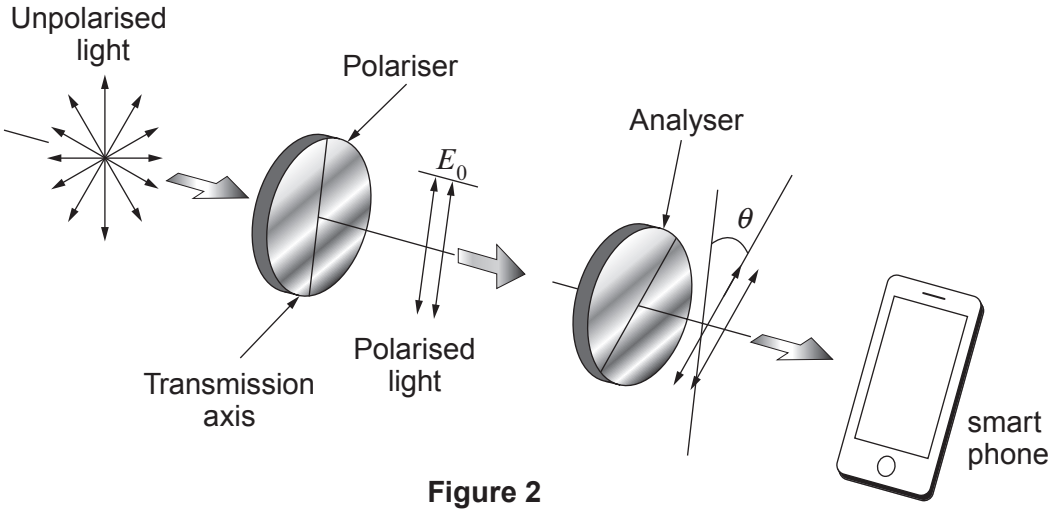


Figure 2

The polariser provides the polarised light, the analyser is rotated in steps through 180° and the intensity of light is recorded using the smart phone. You can measure the angle (θ) with a plastic protractor but there is a smarter way. You can tape the analyser over the smart phone camera and have 2 apps running simultaneously – a light meter to measure the light intensity and a tiltometer to measure the angle of the analyser. 4

Paragraph

These were the results obtained: 5

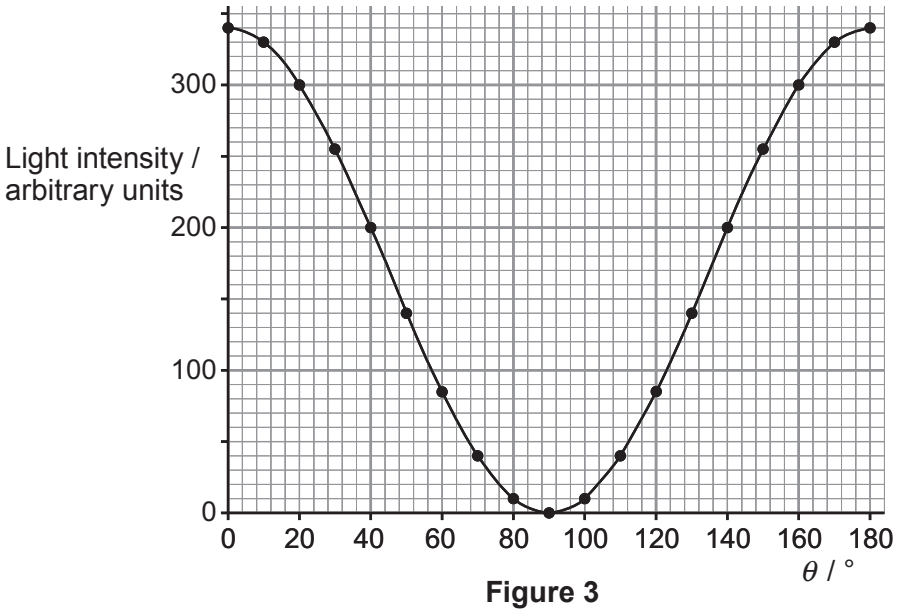


Figure 3

These results are in excellent agreement with Malus's Law – that the intensity, I, of light is given by:

$$I = I_0 \cos^2 \theta$$

where θ is the angle of the analyser relative to the polariser.

Experiment 3 - Measuring the coefficient of friction

There is a simple rule of friction that states: 6

$$F = \mu R$$

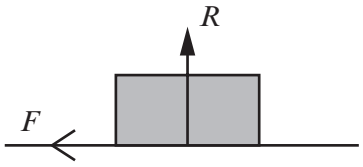


Figure 4

where F is the maximum frictional force, R is the normal contact force and μ is the coefficient of friction. Basically, μ is a dimensionless constant that tells you how slippery the contact is between two smooth surfaces. The greater the value of μ the greater the frictional force (for a given value of R).

One of the easiest methods of obtaining values of the coefficient of friction is to place a block on a slope and tilt the slope until the block slips. When the block slips it's easy to show that the coefficient of friction is given by: $\mu = \tan\theta$ 7

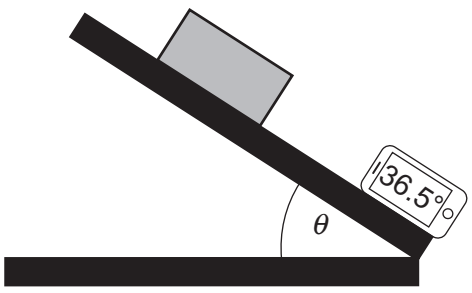


Figure 5

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Paragraph

The angle can be measured easily with an uncertainty of less than 1° using a smart phone with a tiltometer placed on the slope. Here are some results obtained for rubber on tarmac. 8

Surface	Mean slide angle (degrees)	Mean coefficient of friction
smooth rubber on tarmac	44.4	0.98
rubber with treads on tarmac	40.4	0.85

Table 1

Experiment 4 - Investigating magnetic field strengths

The phone was used as a magnetometer to take readings of the magnetic field strength, B, at two distances, r, from the centre of a small bar magnet (with the magnet end-on to the magnetometer). The results are shown in Table 2. 9

r / cm	B / mT
8.0	9.8
12.0	2.9

Table 2

These results suggest that B depends on r according to an inverse cube law, that is a law of the form: 10

$$B = \frac{K}{r^3}$$

where K is a constant.

Experiment 5 - Investigating the acceleration of a car

All sorts of investigations can be done with a mobile phone used as an accelerometer. Oscillations particularly lend themselves to this method. As an even simpler case, though, here is a (tidied up) acceleration-time graph, based on accelerometer readings for a car **starting from rest** at time t = 0 and going along a straight road. 11

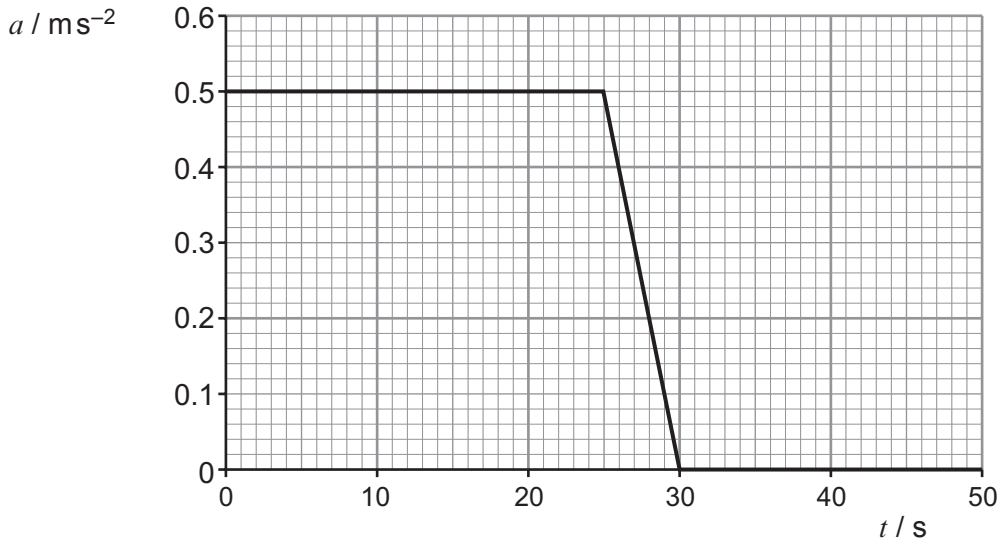


Figure 6

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Answer **all** *questions.*

Answer the following questions in your own words. Direct quotes from the original article will not be awarded marks.

(a) **Experiment 1** - Draw diagrams showing the stationary wave patterns for the lowest frequency (first harmonic) and the next lowest frequency (third harmonic) in the hollow cardboard tube (Paragraph 2). [2]

(b) **Experiment 1** - Calculate the frequency and wavelength for the third harmonic in the 1.800 m tube (Paragraph 2). [2]

(c) **Experiment 2** - Explain qualitatively why the variation in light intensity detected by the smart phone is as shown in Figure 3 (see Paragraphs 4 & 5 and Figure 2 also). Do not refer to Malus's law or the $\cos^2 \theta$ dependency. [4]

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(d) **Experiment 2** - In paragraph 5 it is claimed that the results plotted in Figure 3 are in excellent agreement with the law $I = I_0 \cos^2\theta$.

(i) Show clearly that for these results, using the arbitrary units of the graph scale, I_0 = 340. [1]

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(ii) Check whether or not the point plotted in Figure 3 for θ = 140° is in agreement with the law $I = I_0 \cos^2\theta$. Show all steps in your working. [2]

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(e) **Experiment 3** - Some textbooks claim that "rubber tyres have patterns of grooves or tread: these patterns increase the roughness and give better grip." Evaluate whether the data in Table 1 (Paragraph 8) disproves this theory or whether this result is due to experimental uncertainty. [3]

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(f) **Experiment 4** - According to the writer, the results in Table 2 (Paragraph 9) suggest that B depends on r according to an inverse cube law, that is a law of the form:

$$B = \frac{K}{r^3} \qquad \text{(Paragraph 10)}$$

Justify this statement. [2]

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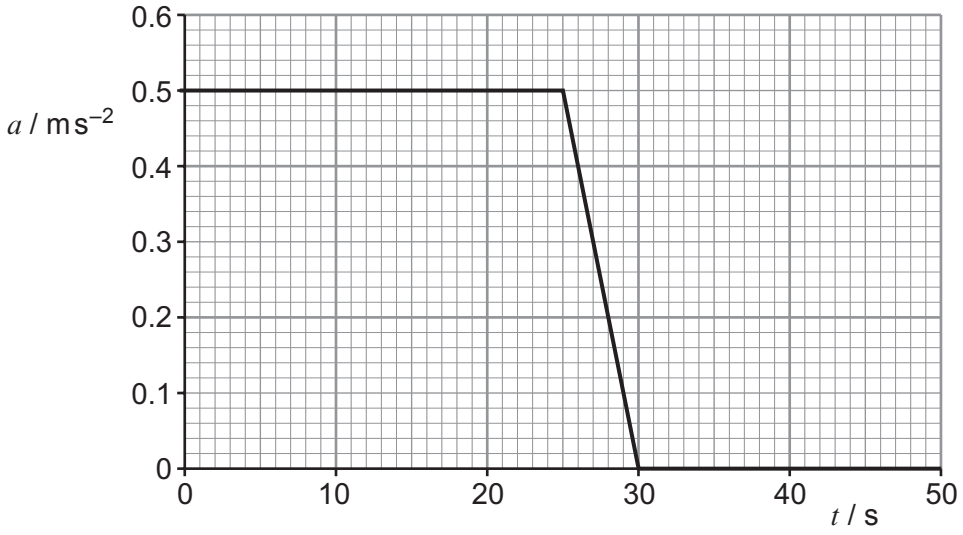
(g) **Experiment 5**

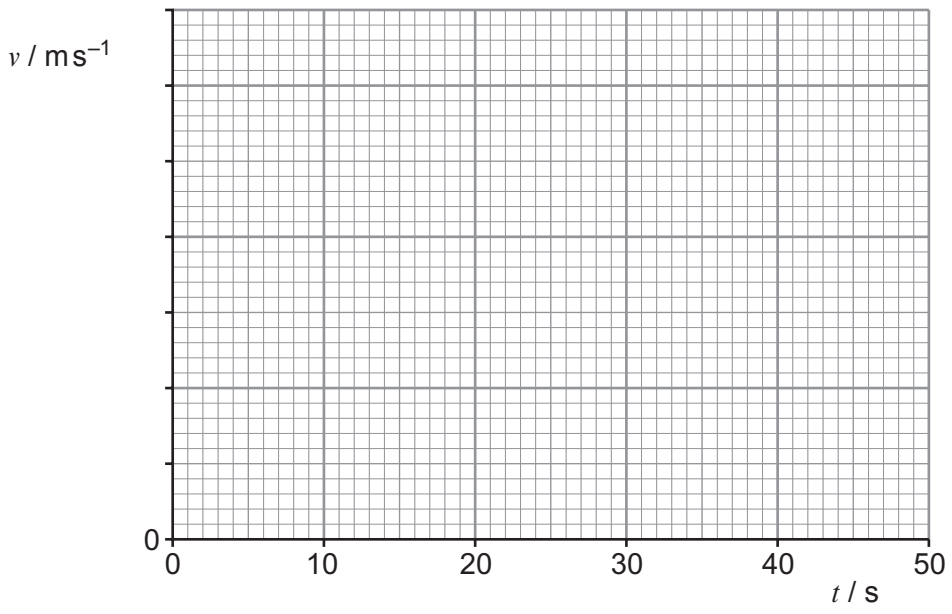
(i) For the car, starting from rest, whose acceleration-time graph is given in Figure 6, calculate the velocity at t = 25 s. [1]

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(ii) Sketch a velocity-time graph for the car, on the blank grid below. Put a scale on the vertical axis. (A copy of Figure 6 is provided so that you can refer to it easily.) [3]





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