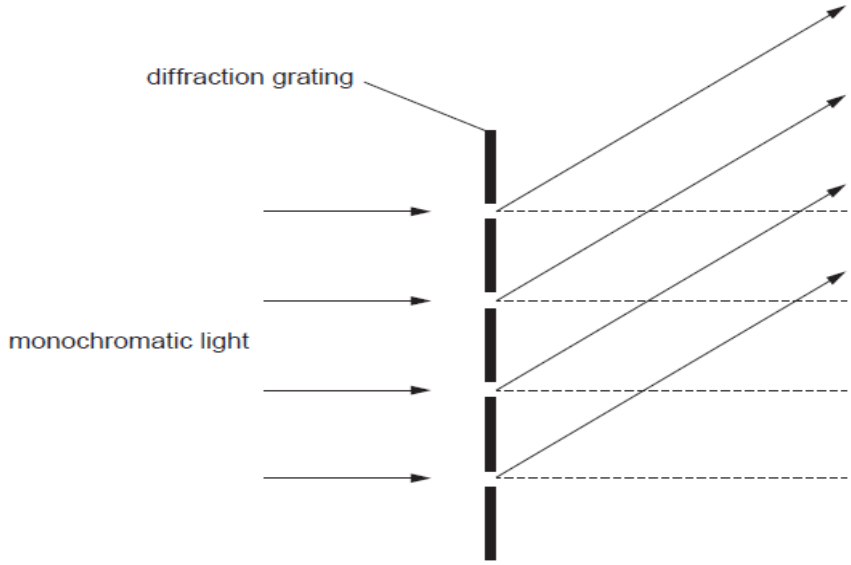
Physics

Question	Maximum Mark	Mark Awarded
#1	9	
#2	9	
#3	9	
#4	9	
#5	10	
#6	11	
#7	11	
#8	11	
#9	15	
#10	16	
#11	20	
Total	130	

#1

(a) Adding to the diagram, derive the equation $n\lambda = d\sin\theta$ for a diffraction grating. [3]



(b) A diffraction grating has 250 lines per mm and light of wavelength 532 nm is incident normally upon it. Calculate the angle between the first and second order light beams. [4]

(c) Another diffraction grating has half the angle between the first and second order light beams when light of wavelength 532 nm is incident upon it. Estimate the number of lines per mm of this second diffraction grating. [2]

Question taken from Eduqas examination paper 842103, June 2017

#2

1. *(a)* State what is meant by two coherent sources. [1]

.....

.....

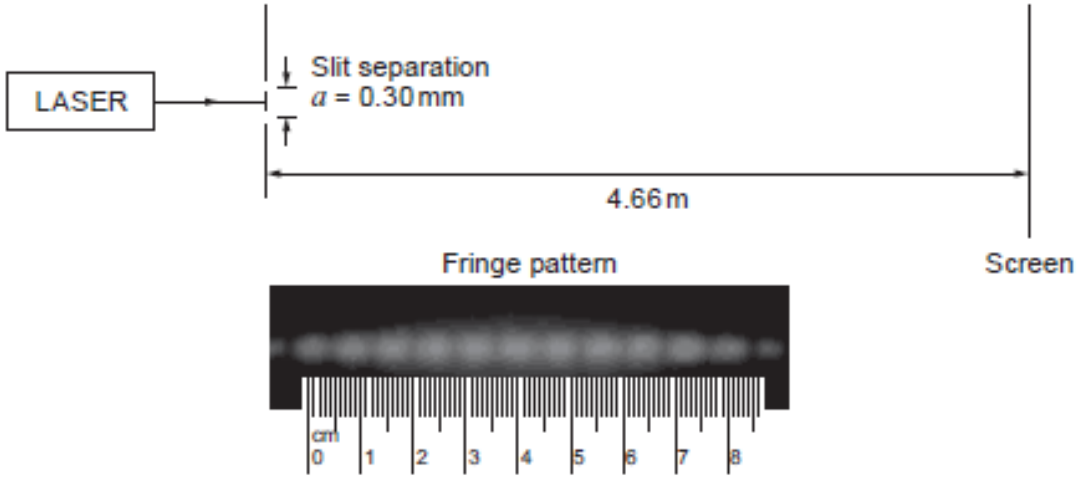
(b) In the 1700s, light was thought to consist of a stream of particles. In the 1800s, it was said to be a wave but since the early 1900s it has been accepted that light behaves both like a wave and like a particle (wave particle duality). Explain briefly the part that Young's double slit experiment played in this history. [2]

.....

.....

.....

(c) Young's double slit experiment is carried out using laser light.



(i) Calculate the fringe separation from the above diagram. [2]

.....

.....

.....

(ii) The distance between the slits and the screen is 4.66 m. Calculate the wavelength of the laser light. [2]

.....

.....

.....

(iii) State one advantage and one disadvantage of using a large slit-to-screen distance. [2]

.....

.....

.....

Question taken from Eduqas examination paper 842103, June 2018

#3

2. *(a)* Explain what properties of light from a laser can be determined using polarisation and interference. Give practical details. [6 QER]

(b) The polarisation of light is used in Liquid Crystal Display TVs. These have been developed from research into new organic materials. Discuss the importance of research and development into new materials, in general, by giving a benefit and an issue that may arise from using new materials. [3]

.....

.....

.....

.....

.....

.....

Question taken from Eduqas examination paper 842002, June 2019

#4

2. *(a)* Single slit diffraction of light is demonstrated by using a red laser and the results are shown below. The two different diffraction patterns are obtained by varying the slit width only.

Figure 2a

Figure 2b

(i) Explain whether Figure 2a or Figure 2b has the wider slit. [2]

.....

.....

.....

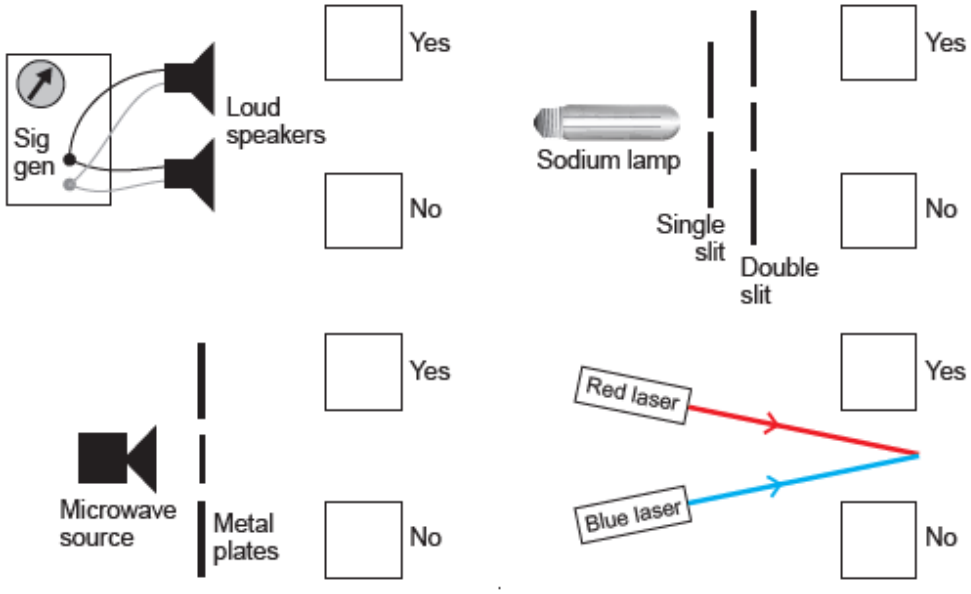
.....

(ii) State what can be done to the single slit to obtain the greatest amount of diffraction. [1]

.....

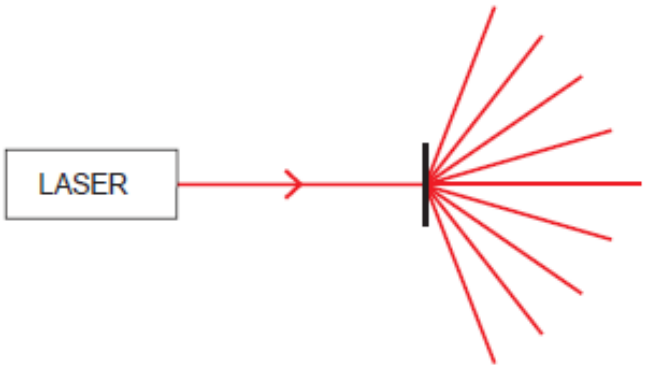
.....

(b) Tick (✓) the appropriate boxes to show which of the following arrangements allow an interference pattern to be observed/heard. [2]



(c) Laser light is shone at a diffraction grating with slit separation 2.4μm and a total of nine bright beams are produced (see below). Determine the maximum and minimum possible wavelengths for the laser light. [4]

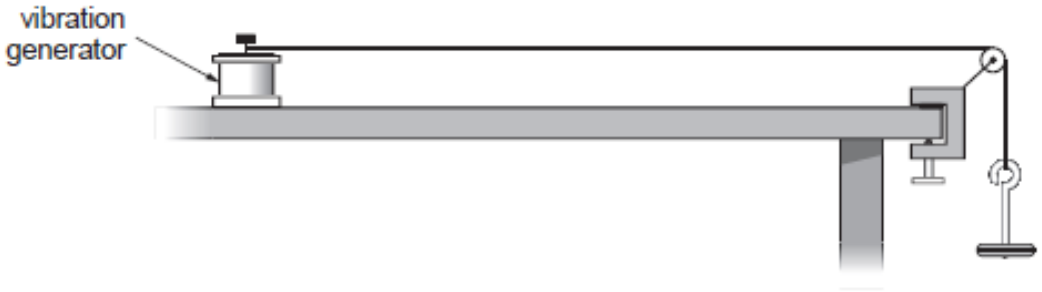
Diagram not to scale



Question taken from Eduqas examination paper 842103, June 2019

#5

1. The apparatus below is used to demonstrate stationary waves on a string. Both the weight, and the distance between the pin and the pulley are kept constant.



The following stationary wave pattern is observed on the string.

(a) Explain why stationary waves are formed at particular frequencies only. [3]

.....

.....

.....

.....

.....

.....

(b) Another stationary wave is formed when the frequency is 450 Hz and the length of each loop is 12.0 cm long.

(i) Calculate the speed of the waves on the string. [3]

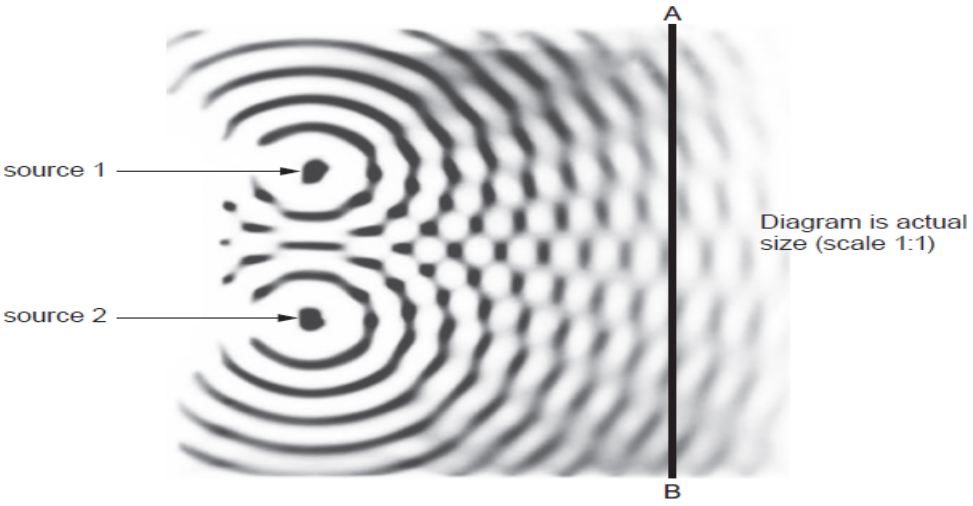
(ii) At a higher frequency there are two more loops formed than at 450 Hz and each is of length 10.0 cm. Determine the number of loops observed at 450 Hz. [4]

Question taken from Eduqas examination paper 842002, June 2019

#6

(a) Explain how two source interference patterns arise. [4]

(b) The diagram shows the two source interference pattern due to two in-phase sources in a ripple/water tank.



(i) **Place an X** on the line AB at any point where there is a path difference of 3 wavelengths between waves from the two sources. [1]

(ii) **Place a Y** on the line AB at any point where there is a path difference of 1.5 wavelengths between waves from the two sources. [1]

(c) (i) The diagram is actual size. Measure the wavelength of the waves accurately by using the distance between wavefronts. [2]

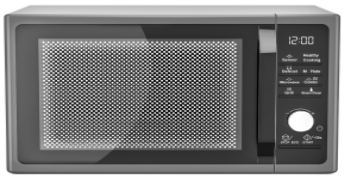
(ii) Hence check whether or not the equation: $\lambda = \frac{a\Delta y}{D}$ is a good approximation for the given diagram. **Show your working.** [3]

Question taken from Eduqas examination paper 842103, June 2017

#7

(a) Bruce throws a lump of coal towards Dani which she catches. Bruce claims that, because chemical energy is being transferred from himself to Dani, the lump of coal is a **wave**. Explain whether or not Bruce is correct. [2]

(b) The door of a microwave oven has a metal grille and this grille has holes in it of diameter 2 mm so that the food can be seen within the oven.

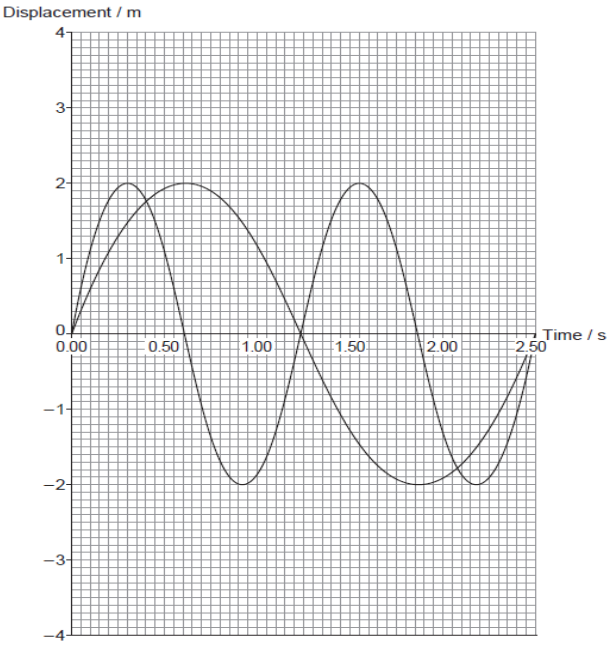


(i) Explain why the food can be seen through the door while the user is safe from dangerous microwaves of wavelength 12 cm. [3]

(ii) State or calculate a typical photon energy of visible light. [1]

(iii) Explain whether or not a microwave photon has a greater or smaller energy than a visible photon. [1]

(c) Two water waves of equal amplitude but different frequencies meet. The variation of the displacements of each wave is shown in the graph at the meeting point of the two waves.

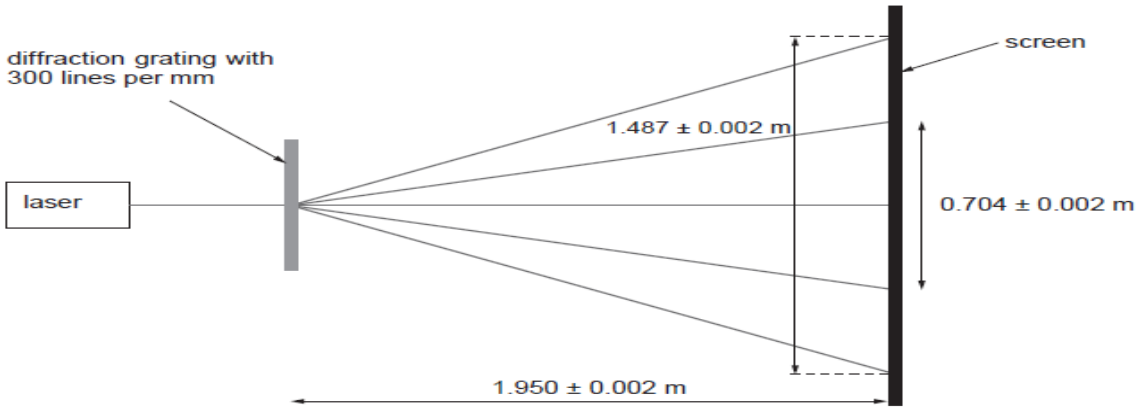


Use the principle of superposition to plot the resultant displacement of the two waves at times 0.00 s, 0.40 s, 1.00 s, 1.25 s, 1.50 s, 2.10 s, 2.50 s **on the same grid** and draw a suitable curve. [4]

Question taken from Eduqas examination paper 842103, November 2020

#8

Rachel carries out an experiment to measure the wavelength of light emitted by a laser. Her measurements and set-up are shown in the diagram below.



(a) (i) **Show clearly** that the measured wavelength of the laser light is 592 nm using the $n = 1$ data in the diagram. [3]

(ii) **Show clearly** that the $n = 1$ data in the diagram leads to an uncertainty in the wavelength of ±2 nm. You may assume that the manufacturer's labelling of 300 lines per mm for the diffraction grating is exact and that $\tan\theta \approx \sin\theta \approx \theta$. [4]

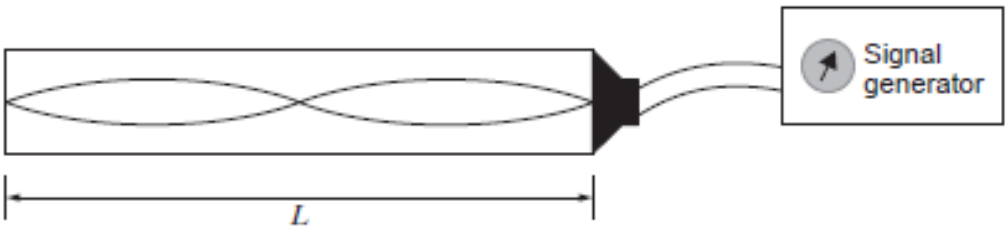
(b) The manufacturer of the laser states that its wavelength is exactly 593.5 nm. The $n = 2$ data in the diagram lead to a measured laser wavelength of 594 ± 1 nm. Explain whether or not these values and the value from part *(a)* are all consistent. [2]

(c) Explain why the $n = 1$ data (592 ± 2 nm) lead to a larger uncertainty than the $n = 2$ data (594 ± 1 nm). [2]

Question taken from Eduqas examination paper 842103, November 2020

#9

5. An experiment is carried out using stationary waves to measure the speed of sound in air. A loudspeaker is placed at one end of a hollow tube so that both ends are closed. The frequency, f, of the signal generator connected to the loudspeaker is varied and those frequencies corresponding to loud noises recorded.



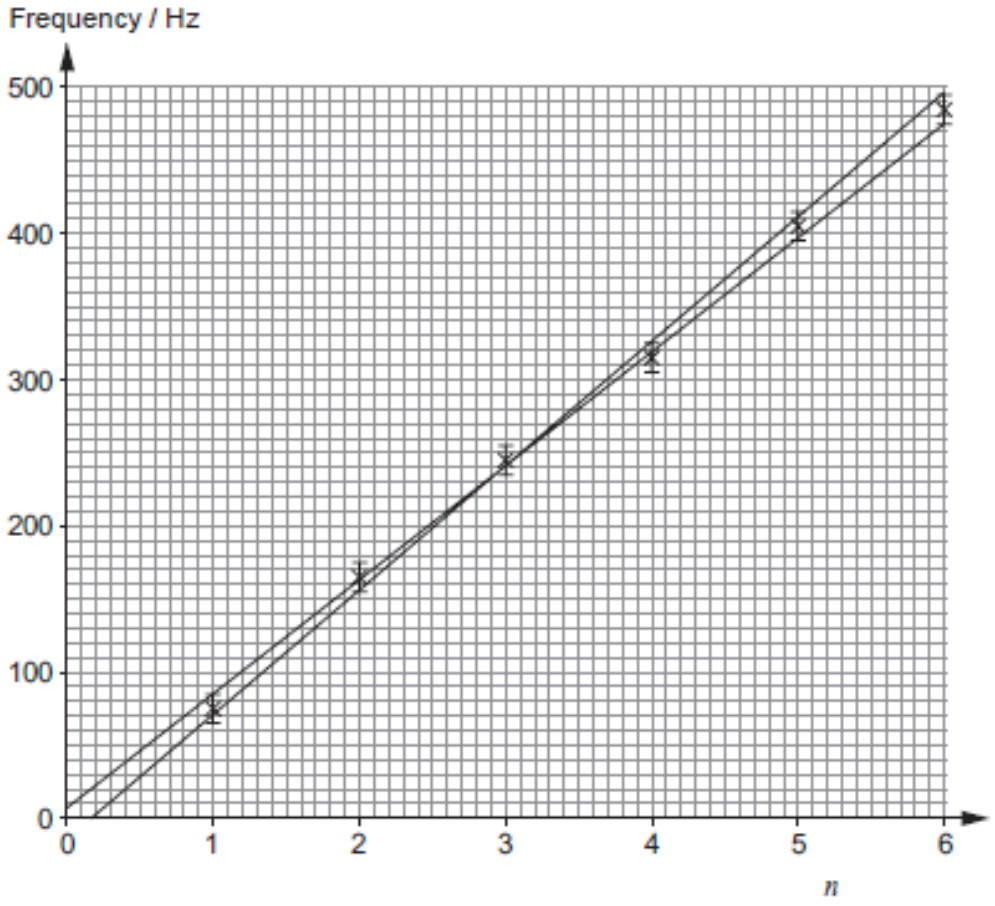
(a) Describe the differences between a stationary wave and a progressive wave in terms of energy, phase and amplitude. [3]

(b) Show that the frequencies corresponding to stationary waves are given by:

$$f = \frac{v}{2L} n$$

where n is any whole number ($n = 2$ in the above diagram). [3]

(c) The data obtained are plotted on the grid below.



Explain to what extent the graph agrees with the equation: [3]

$$f = \frac{v}{2L} n$$

(d) The experiment is repeated with the tube filled with nitrogen dioxide (NO_2), a gas that is 1.5 times denser than air. The speed of sound in a gas is inversely proportional to the square root of the density, ρ:

$$v \propto \frac{1}{\sqrt{\rho}}$$

Explain what effect this will have on the gradient of the graph. [3]

(e) A car company is fined £15 billion for excessive NO_2 emissions of its diesel engines. However, there is little or no reliable evidence that NO_2 produces any detrimental health effects at the concentration levels present in the atmosphere. Discuss whether or not the car company or pedestrians have been treated unfairly. [3]

Question taken from Eduqas examination paper 842103, June 2018

#10

The apparatus shown below is used to produce a visible interference pattern on the screen.

Slits B and C act as *coherent* sources.

(a) (i) Explain what is meant by this statement. [1]

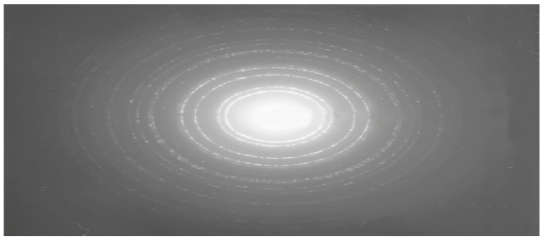
(ii) Explain why destructive interference is observed at certain points on the screen. [3]

(b) (i) The separation of the slits, B and C is 0.090 mm and the perpendicular distance between the slits and the screen is 3.60 m. The slits are illuminated with light of wavelength 4.4×10^{-7} m. A point X on the screen is 52.8 mm away from the central bright fringe at O. Brian states that a bright fringe will be formed at X. Evaluate whether or not he is correct. [4]

(ii) Determine the distance **from** X to the **next dark** fringe formed. [2]

(c) Explain the historical significance of this experiment. [2]

(d) A beam of electrons is fired at a thin sheet of aluminium. A pattern of light and dark circular fringes is observed as shown below.



(i) Explain how this pattern is formed. [2]

(ii) The thin sheet of aluminium is replaced with a foil of copper. The distance between the copper atoms is smaller than in aluminium. Describe how you expect the pattern to change. [2]

Question taken from Eduqas examination paper 842002, June 2017

#11

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

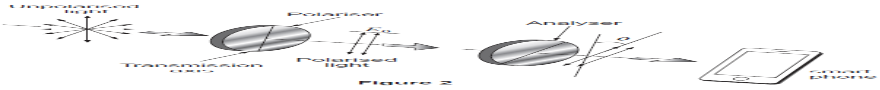


Figure 2

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

These were the results obtained: 5

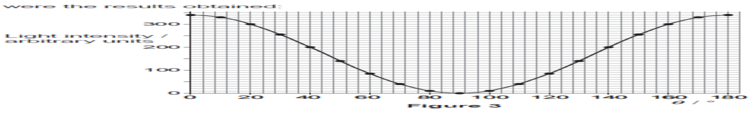


Figure 3

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

$$F = \mu R$$

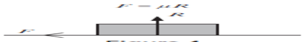


Figure 4

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

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

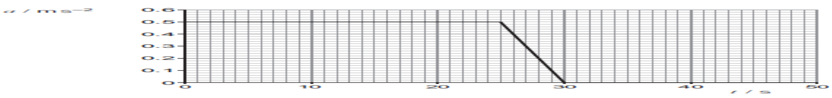


Figure 6

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]

(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]

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

(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]

(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:

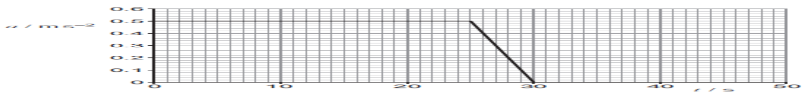
$$B = \frac{K}{r^3} \quad \text{(Paragraph 10)}$$

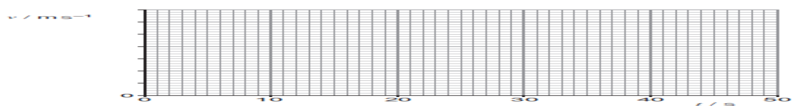
Justify this statement. [2]

(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]

(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]





Question taken from Eduqas examination paper 842101, June 2017