Physical Science – Paper 1

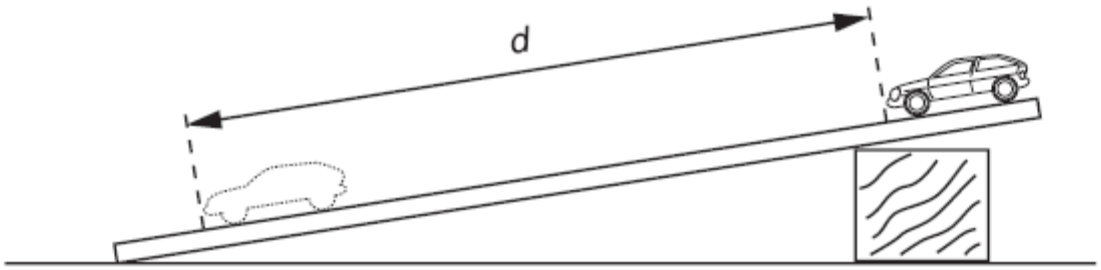
Time: 3 hours **Marks: 150**

Instructions:

1) This paper contains 16 printed pages. Check and make sure that you have all of the pages.
2) An answer sheet is included in the 16 pages. Remember to hand it in.
2) A data sheet is included at the end of the question paper.
3) Start each question on a new page.

Question 1

A student has been asked to determine the linear acceleration of a toy car as it moves down a slope. He sets up the apparatus as shown in the diagram below.



The time *t* to move from rest through a distance *d* is found for different values of *d*.

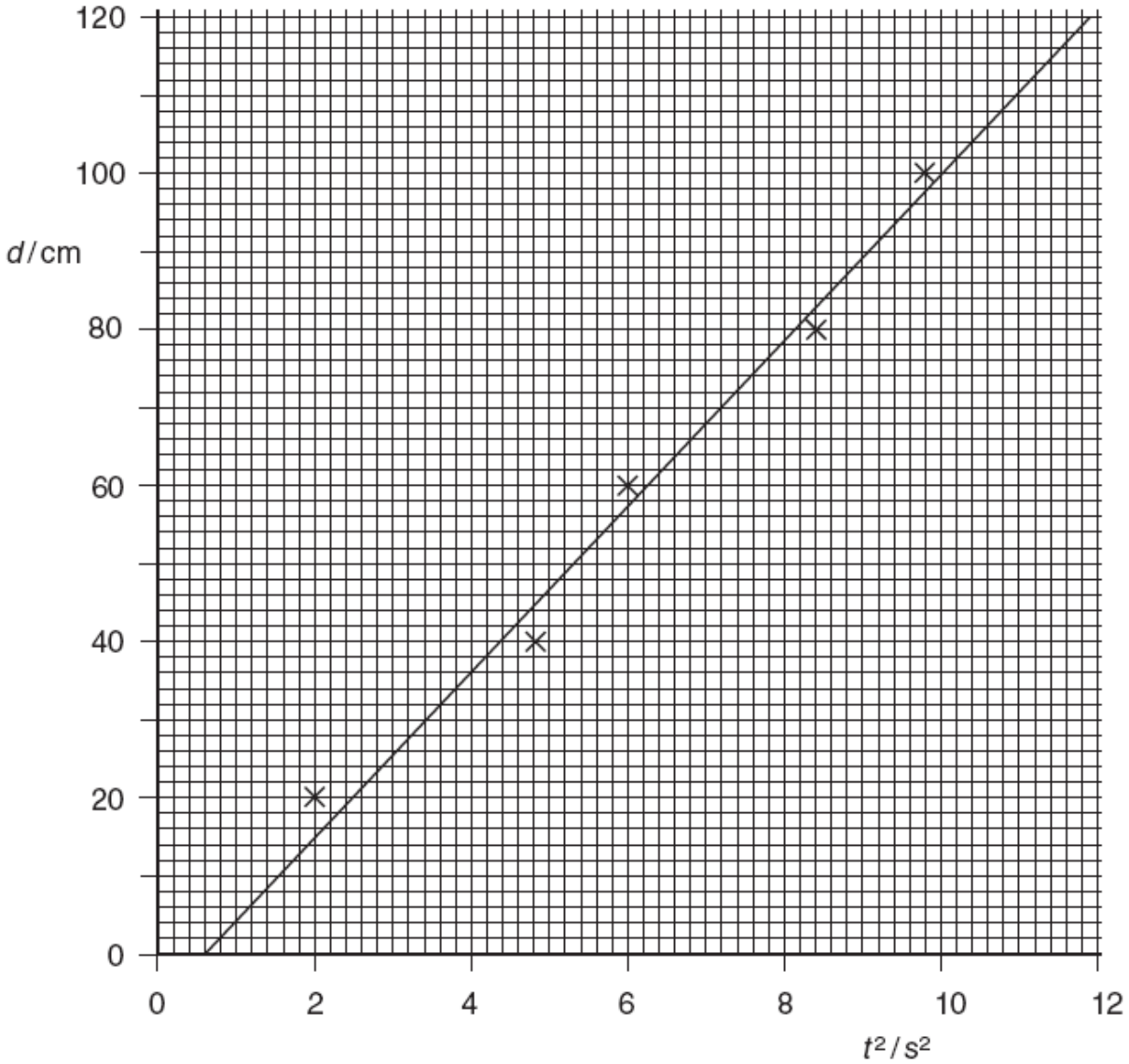
1.1 Which is the independent variable? (1)

1.2 Which is the dependent variable? (1)

1.3 Make a rough sketch of the graph you would expect to obtain from plotting d (x axis) against t (y axis) (1)

1.4 The student who did the experiment, decided to plot a graph of *d* (*y*-axis) against t^2 (*x*-axis) as shown. Why did the student decide to plot these quantities? (1)

1.5 Use the graph plotted by the student to determine the acceleration of the toy car. Explain your working by considering an equation of motion. (4)



1.6 There are many ways that the student could have determined the acceleration of the toy car. Describe a **different** method that you would have used, if you had been asked to do an experiment. Your answer must be brief and in point form. Include details on what you would measure, how you would measure it and how you would determine the acceleration. (4)

Question 2

A cricketer throws a ball vertically upwards so that the ball leaves his hands at a speed of 25 $m.s^{-1}$. Air resistance can be neglected.

2.1 Calculate the maximum height reached by the ball (3)

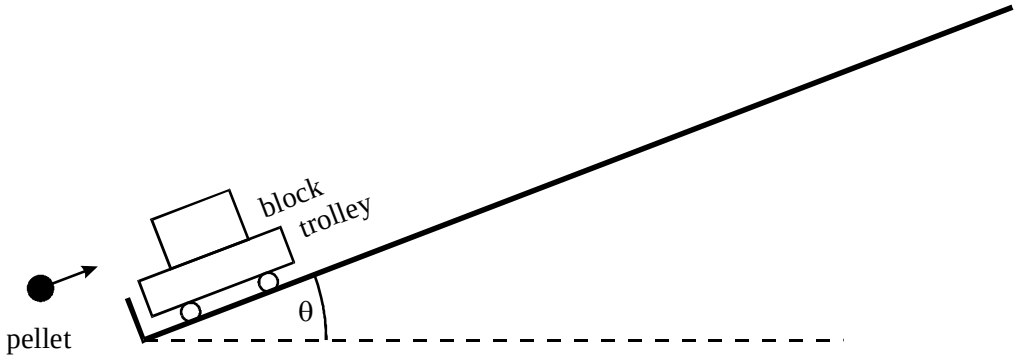
2.2 Calculate the time taken to reach maximum height (2)

2.3 If air resistance cannot be ignored, comment on the acceleration of the cricket ball while moving up and while moving down compared to the case where there is no air resistance. Draw force diagrams to assist you in your explanation. (4)

2.4 When catching the ball, the cricketer moves his hands for a short distance in the direction of travel of the ball as it makes contact with his hands. Explain, using scientific concepts, why this technique is used to reduce painful hands. (2)

Question 3

The diagram represents part of an experiment that is being used to estimate the speed of an air gun pellet.



The pellet which is moving parallel to the track, strikes the block, embedding itself. The trolley and the block then move along the track, rising a vertical height, *h*.

The following data is collected from the experiment

mass of trolley, block and pellet	0.50 kg
mass of pellet	0.002 kg
speed of trolley and block immediately after impact	0.48 m s^{-1}

3.1 Using energy considerations explain how the speed of the trolley and block immediately after it has been struck by the pellet, may be determined from measurements of *h.* Assume frictional forces are negligible. (3)

3.2 State the Law of Conservation of Momentum (2)

3.3 Calculate the momentum of the system immediately **after** impact (2)

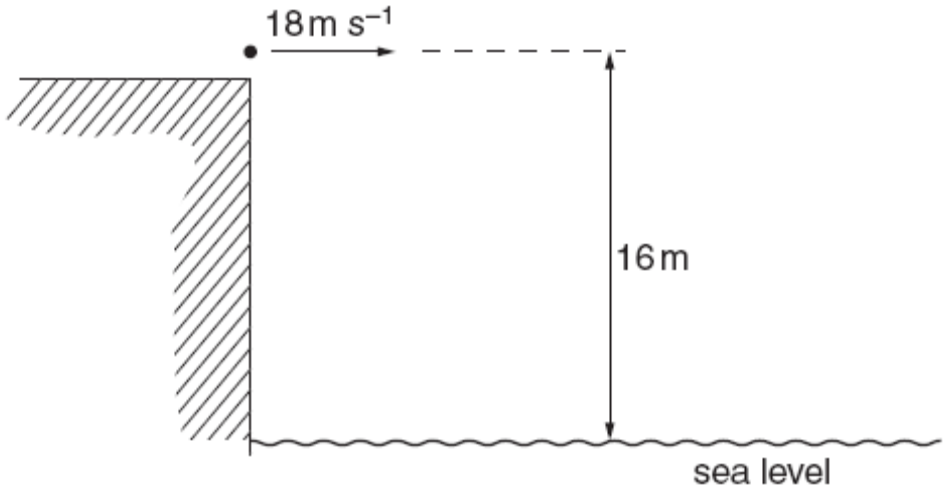
3.4 Calculate the speed of the pellet just before impact (3)

3.5 Prove, by calculation, that the collision between the pellet and block is inelastic. (3)

3.6 Pellet guns are dangerous weapons. Comment on this statement with reference to your answer from question 3.4 and that the minimum kinetic energy to pierce skin is 2 J. (2)

Question 4

A stone of mass 56 g is thrown horizontally from the top of a cliff with a speed of 18 m.s^{-1}, as illustrated.



The initial height of the stone above the level of the sea is 16 m. Air resistance may be neglected.

4.1 Calculate the change in gravitational potential energy of the stone as a result of falling through 16 m. (2)

4.2 State the horizontal velocity of the stone as it hits the water. (1)

4.3 Calculate the **total** kinetic energy of the stone as it reaches the sea. (3)

4.4 Use your answer in 4.3 to show that the speed of the stone as it hits the water is 25.4 m.s^{-1}. (2)

4.5 Draw a vector diagram to represent the horizontal velocity, the vertical velocity and the resultant velocity of the stone as it hits the water. (2)

4.6 Use your vector diagram to determine the angle with the horizontal at which the stone hits the water. (2)

4.7 If air resistance had been taken into account, the stone would have hit the water with a speed of 22 m.s^{-1}. Calculate the work done against air resistance. (2)

Question 5

5.1 Consider the following continuous spectrum:

Colour	Violet	Indigo	Blue	Green	Yellow	Orange	Red
Wavelength (nm)	400		500		600		700

Calculate the wavelength, in nm, of light which has a frequency of $6{,}5\times10^{14}$ Hz and identify which colour it should represent. (3)

5.2 A ray of white light is passed through a green filter and then shone onto a piece of white paper with blue writing on it.

5.2.1 What colour will the white paper appear under this light?
Explain your answer. (2)

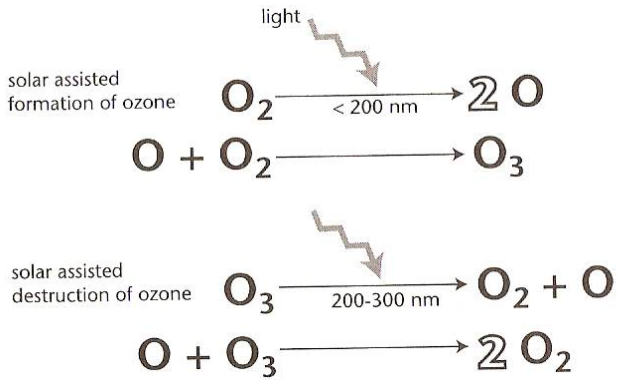
5.2.2 What colour will the writing appear under this light?
Explain your answer. (2)

5.3 A famous white statue is on display in a museum. The curator used a beam of red and a beam of blue light to illuminate the statue. What colour would the white statue appear to have in this lighting? (2)

5.4 Read the following article:

Solar radiation and ozone

The ability of the atmospheric O2 and O3 to absorb ultraviolet light has important consequences for the atmosphere and life on Earth. These molecules ensure that the harmful ultraviolet rays of the sun are intercepted before they reach the troposphere, which all forms of life inhabit. The formation and destruction of ozone can be represented by the following cycle.



When an oxygen molecule absorbs a photon of light with a wavelength shorter then 200 nm, the energy splits the molecule into two oxygen atoms. One of these atoms can react with another oxygen molecule to form an ozone molecule.

Up to 98% of the sun's high-energy ultraviolet light is absorbed by the destruction and formation of atmospheric ozone.

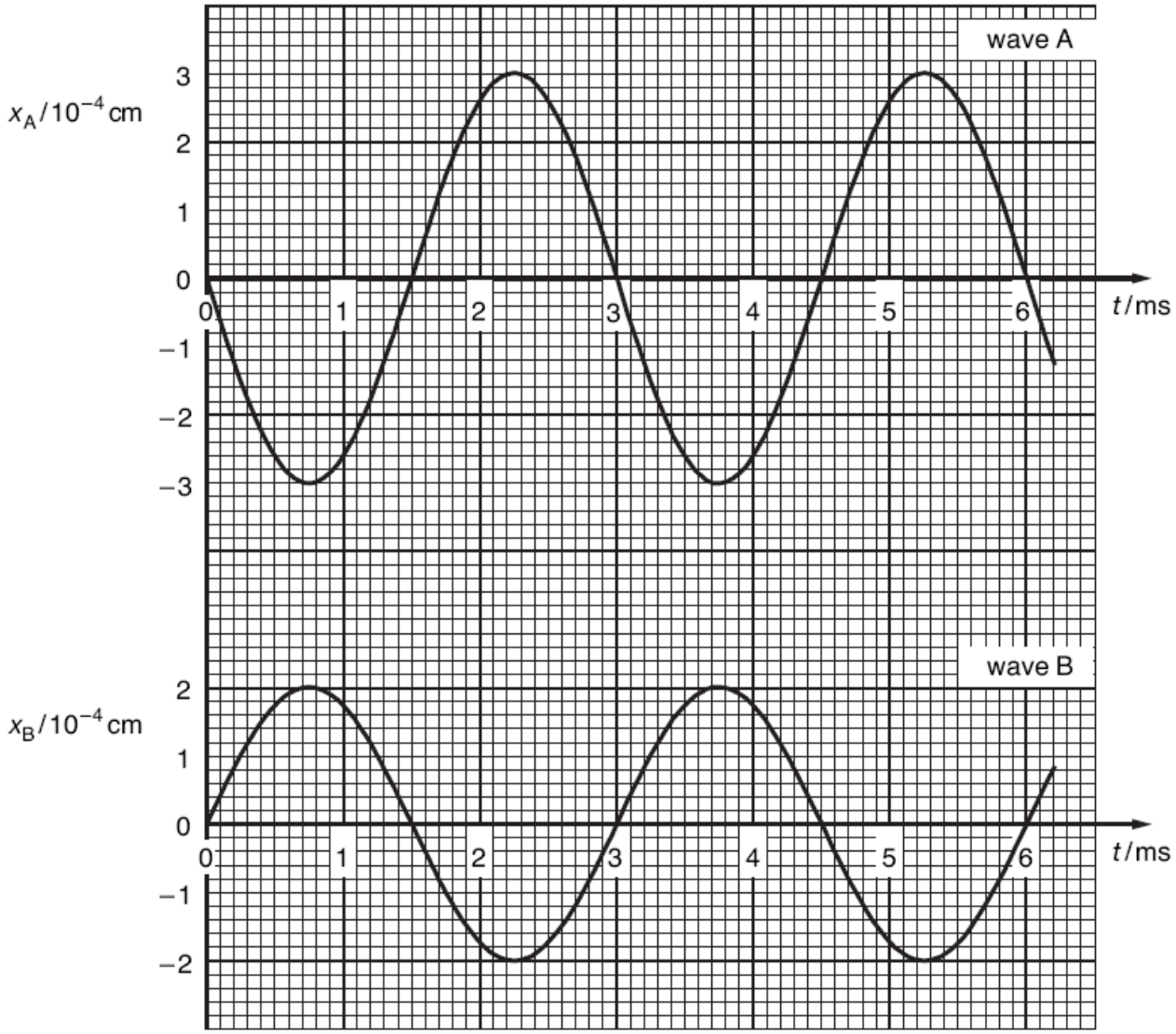
(taken and adapted from Study and Master Physical Science Learner's book Gr 12 published by Cambridge University Press (2007) pg 181

5.4.1 Using information from the above article analyse and explain why the article says this "has important consequences for … life on Earth". (3)

5.4.2 What will happen if the hole in the ozone layer gets bigger? (1)

Question 6

6.1 The diagram below shows the variation with time t of the displacements x_A and x_B at a point P of two sound waves A and B.



6.1.1 What type of wave is a sound wave? (1)

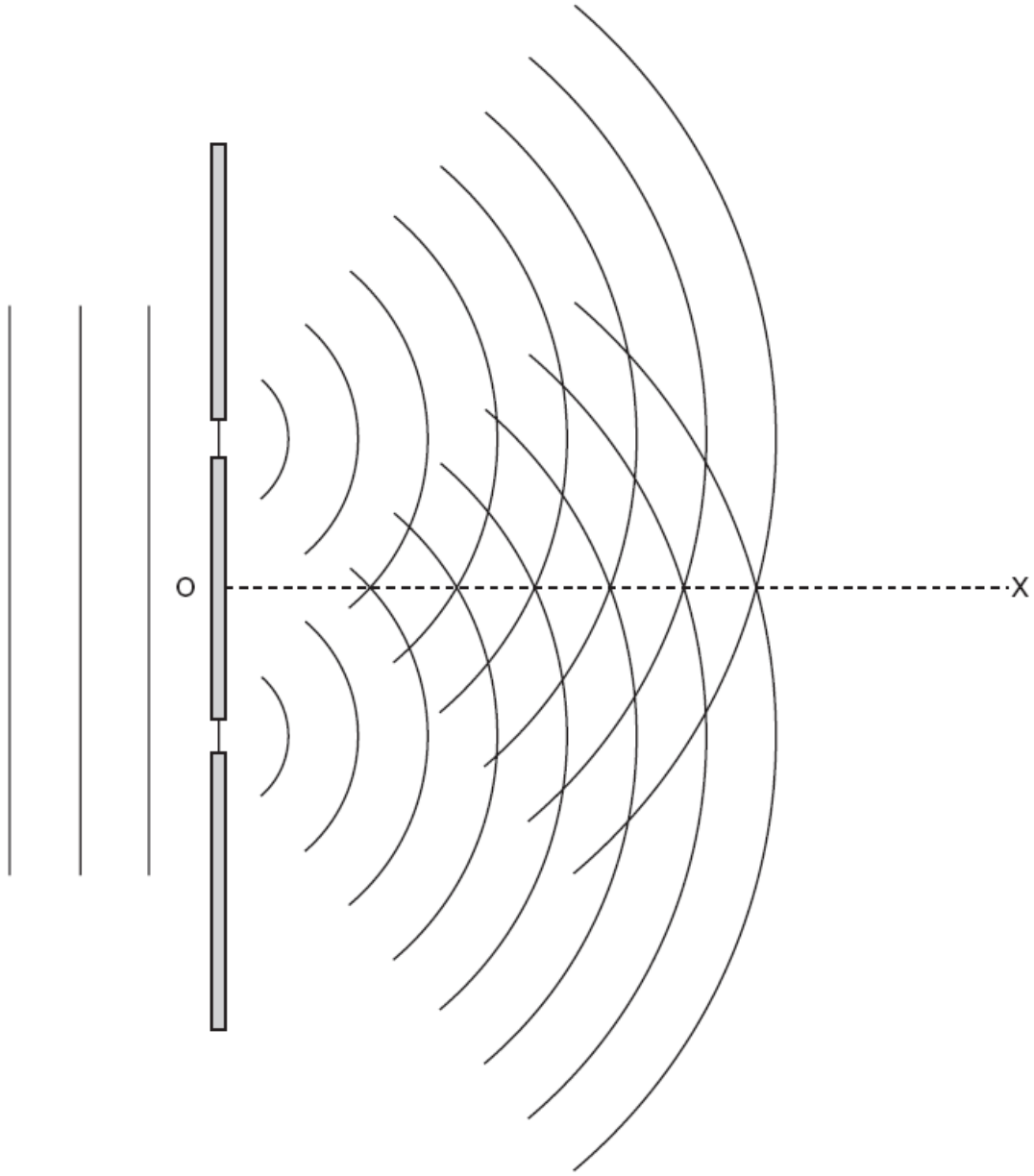
6.1.2 State one similarity and one difference between these two waves. (2)

6.1.3 Determine the resultant displacement for the two waves at point P

(i) at time t = 3.0ms,

(ii) at time t = 4.0ms. (3)

6.2 The diagram below (and **on the answer sheet**) shows wavefronts of red light incident on, and emerging from, a double slit arrangement.



The wavefronts represent successive crests of the wave. The line OX shows one direction along which constructive interference may be observed.

6.2.1 On the figure reproduced **on the answer sheet**, draw lines to show
- (i) a second direction along which constructive interference may be observed (label this line CC),
- (ii) a direction along which destructive interference may be observed (label this line DD). (2)

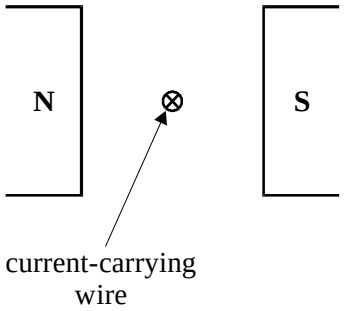
6.2.2 If a screen were placed at X perpendicular to the line OX, describe what would be seen on the screen. (1)

6.2.3 If blue light were used instead of red light, how would the pattern differ? (1)

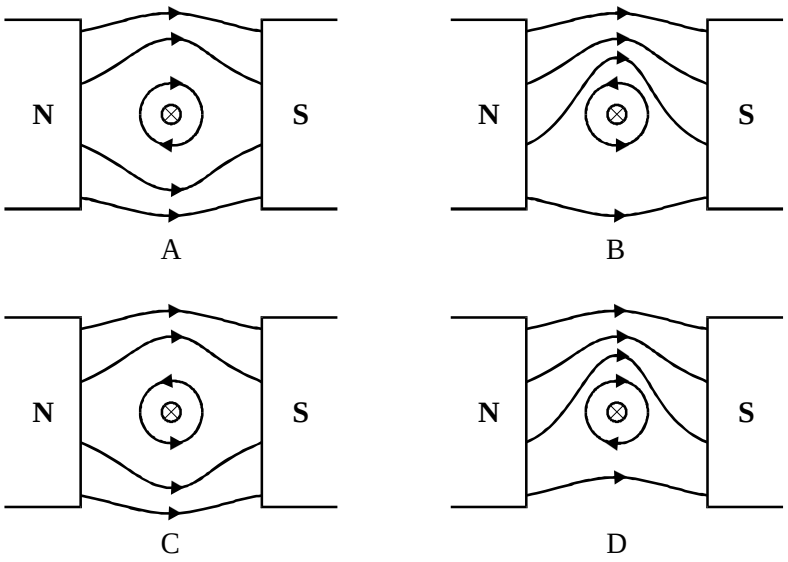
6.2.4 Suggest a wavelength of light that could be used to produce this effect. (1)

Question 7

The diagram below shows a wire carrying a large electric current between the poles of a magnet so that the current flows vertically into the paper.



7.1 Which one of the following gives the best representation of the magnetic flux pattern in the region between the poles of the magnet?



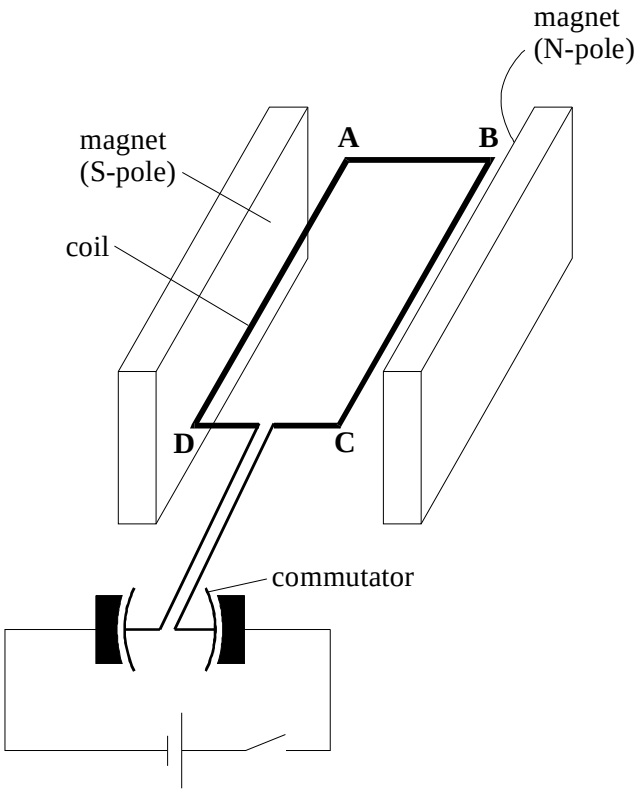
(2)

7.2 In which direction does the current carrying wire experience a force? (2)

7.3 Explain why the current carrying wire experiences a force in the direction given in 7.2. (2)

Question 8

The figure below shows a simple d.c. electric motor.



8.1 Explain the operation of the simple d.c. electric motor. (4)

8.2 State and explain the position of the coil when it experiences the minimum value of force causing rotation. (2)

8.3 An electric motor has many uses, all of which rely on energy conversion. State what type of energy conversion happens in a motor. (2)

8.4 For a practical electric motor, identify **two** sources of energy wastage. For each, specify the location and the nature of the energy transformations that occur. (2)

Question 9

In **Figure 1** the magnet forms the bob of a simple pendulum. The magnet oscillates with a small amplitude along the axis of a 240 turn coil that has a cross-sectional area of 2.5×10^{-4} m^2.

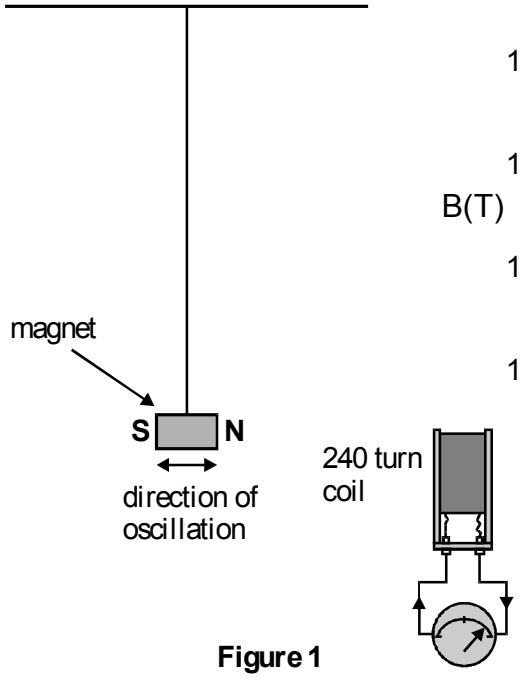


Figure 1

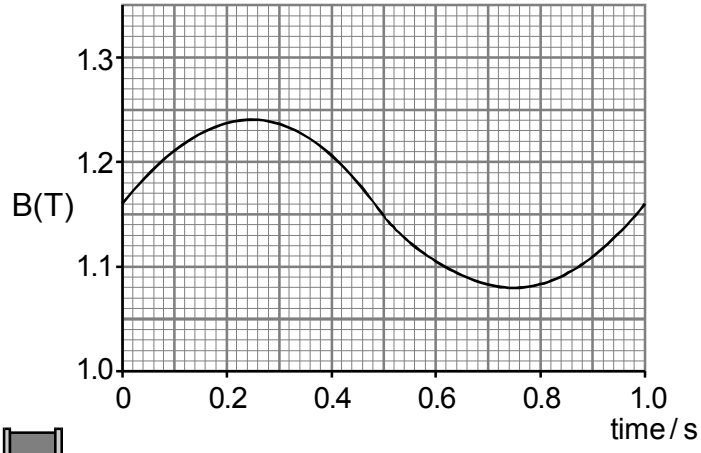


Figure 2

Figure 2 shows how the magnetic flux density, *B*, through the coil varies with time, *t*, for one complete oscillation of the magnet. The magnetic flux density through the coil can be assumed to be uniform.

9.1 State Faraday's Law. (2)

9.2 Calculate the maximum emf induced in the coil. (3)

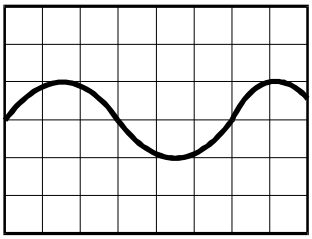
9.3 Sketch on **figure 3 (on answer sheet)** a graph to show how the induced emf in the coil varies during the same time interval. (2)

9.4 State **three** ways of increasing the maximum induced emf. (3)

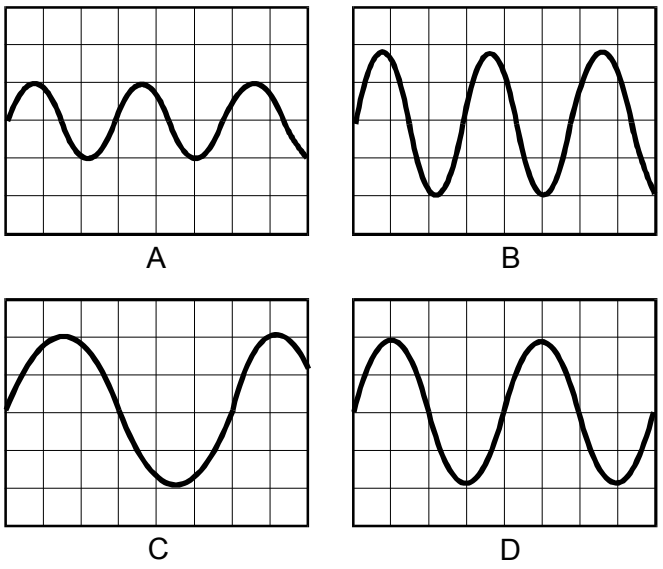
Question 10

In view of the current electricity crisis in South Africa, some of the electrical devices in your home are run off an a.c. generator when required.

10.1 The diagram below shows the waveform obtained when the output of the generator is connected to a cathode ray oscilloscope (a fancy voltmeter that allows you to see the emf produced. The amplitude is proportional to the voltage).



Which one of the following best represents the output when the speed of rotation of the generator is doubled and no adjustment is made to the oscilloscope?



(2)

10.2 Often, d.c. current is needed. How would a.c. and d.c generators differ in design. (without the use of diodes) (2)

10.3 On the diagram, **on the answer sheet**, sketch the emf that would be produced by a d.c. generator. (2)

10.4 Often, emf is supplied at voltages higher than required. Explain, in terms of electromagnetic induction, how a transformer may be used to step down voltage. (4)

10.5 A minidisc player is provided with a mains adapter. The adapter uses a transformer with a turns ratio of 15:1 to step down the mains voltage from 230V.

(i) Calculate the output voltage of the transformer. (3)

(ii) State **two** reasons why the transformer may be less than 100% efficient. (2)

Question 11

11.1 In a helium-neon laser, the electrons in the neon atoms drop down from their excited state at -4.026 eV to -5.990 eV. What is the frequency of the light emitted? (4)

11.2 Explain briefly how scientists can use emission line spectra? (2)

Question 12

A metal plate is illuminated with an ultra violet radiation of frequency 1.67×10^{15} Hz. The maximum kinetic energy of the liberated electrons is 3.0×10^{-19} J.

12.1 Calculate the energy of one photon. (2)

12.2 Calculate the work function of the metal. What does this number mean? (3)

12.3 The radiation is maintained at the same frequency, but the intensity is doubled. State and explain what changes, if any, occur to the number of electrons released per second and the maximum kinetic energy of these electrons. (4)

Question 13

In an experiment, light of different wavelengths was shone onto a metal surface. The kinetic energy of the emitted electrons was determined and recorded in a table:

λ (nm)	**E_K (× 10^{-19} J)**	**1/λ (× 10^{6} m^{-1})**
200	6.72	5.00
300	3.30	3.33
400	1.68	2.50
500	0.66	2.00
600	0.05	1.67

13.1 Plot a graph of 1/λ (x axis) against E_K (y axis). (7)

13.2 The photoelectric equation is

$$\frac{hc}{\lambda} = W_f + E_K$$

Rearrange this equation into a straight line form (appropriate for your graph), and use your graph to determine

(i) The work function, W_f

(ii) Planck's constant, h (5)

13.3 On the same set of axes, sketch a graph you would expect to obtain if the experiment were repeated with a metal having a larger work function. Label this graph 13.3 (2)

Question 14

Describe the structure of an LED and explain why it requires a minimum potential difference to emit light, and why the light is of a particular frequency. (4)

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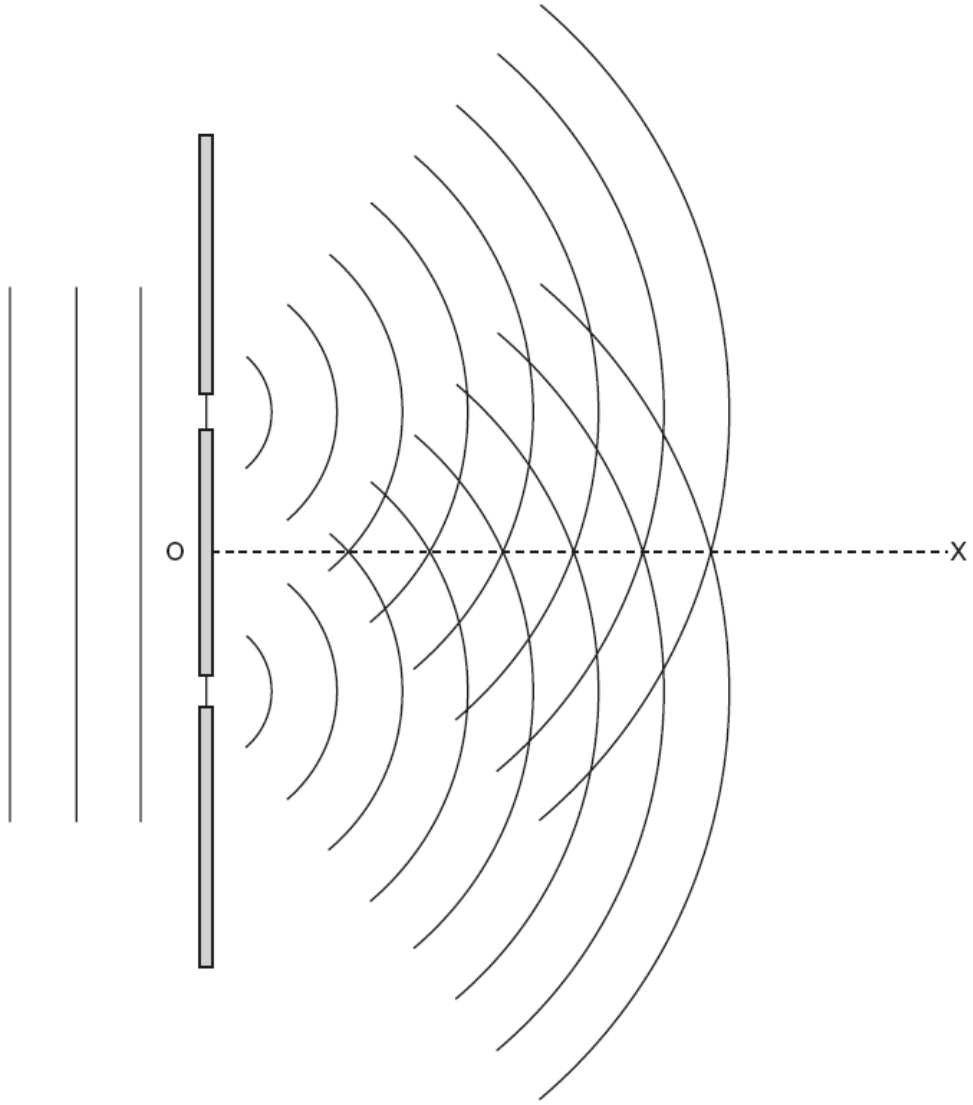
ANSWER SHEET

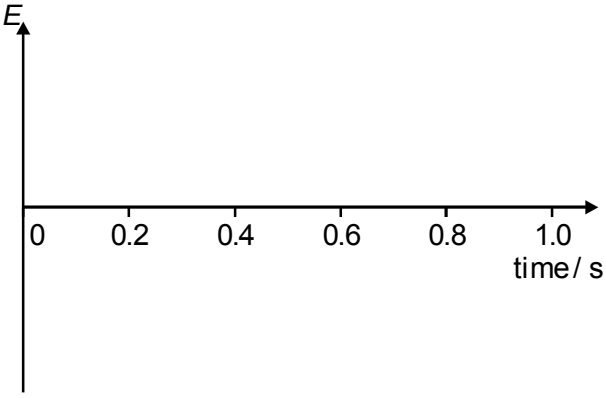
NAME: _____

Question 6.2



(2)

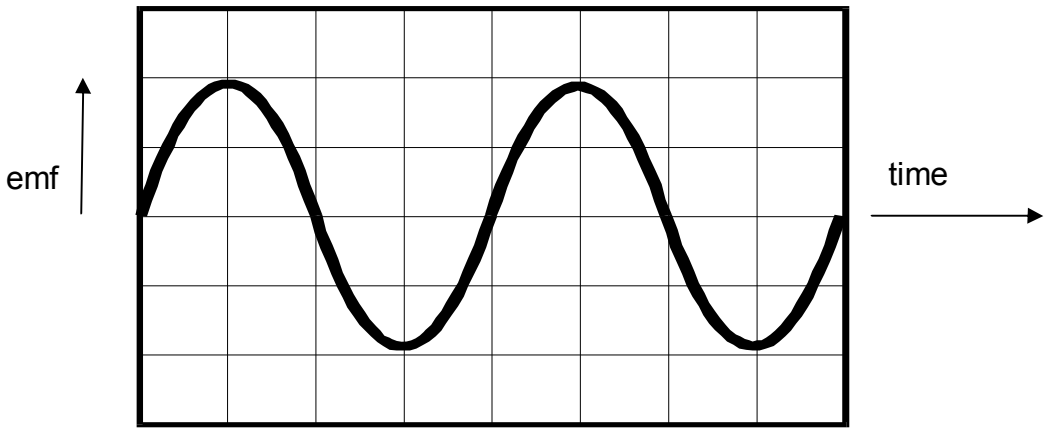
Question 9.3



(2)

Figure 3

Question 10.3
This diagram represents an emf produced by an a.c. generator. On the same diagram, sketch the emf that would be produced by a d.c. generator.



(2)

Question 13 – Graph (7)