Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number

Candidate Number

Physics

Advanced Subsidiary
Unit 2: Physics at Work

Wednesday 20 January 2016 – Morning
Time: 1 hour 30 minutes

Paper Reference
WPH02/01

You must have:
Ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*****) are ones where the quality of your written communication will be assessed – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

1/1/1/1/1/

PEARSON

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following shows a derived unit expressed in terms of SI base units?

☒ **A** coulomb = ampere × second

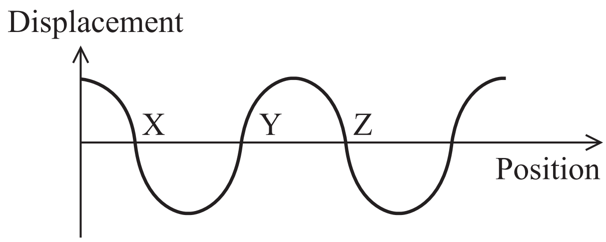
☒ **B** ohm = volt ÷ ampere

☒ **C** volt = joule ÷ coulomb

☒ **D** watt = joule ÷ second

(Total for Question 1 = 1 mark)

2 A sound wave is moving from left to right. The graph shows displacement against position at an instant for the particles in the sound wave. Displacement to the right is considered positive.



Sound waves have compressions and rarefactions.
Which of the following could show the position of these features correctly?

☒ **A** X = compression, Y = compression

☒ **B** X = compression, Z = rarefaction

☒ **C** Y = rarefaction, Z = compression

☒ **D** Y = rarefaction, Z = rarefaction

(Total for Question 2 = 1 mark)

3 Electron diffraction is evidence that

☒ **A** electrons sometimes behave as particles.

☒ **B** photons sometimes behave as particles.

☒ **C** electrons sometimes behave as waves.

☒ **D** photons sometimes behave as waves.

(Total for Question 3 = 1 mark)

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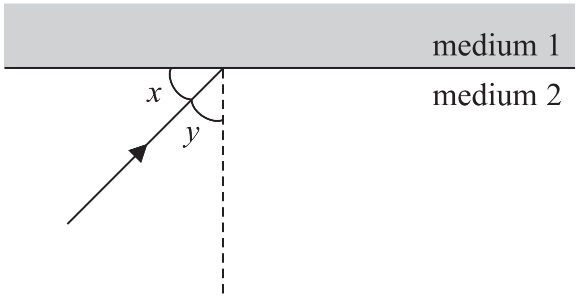
4 The diagram shows a ray of light in medium 2 striking a boundary with medium 1.



The critical angle for light passing from medium 2 to medium 1 is 45°.
The ray in the diagram will be totally internally reflected if

☒ **A** $x = 45°$

☒ **B** $x > 45°$

☒ **C** $y = 45°$

☒ **D** $y > 45°$

(Total for Question 4 = 1 mark)

5 Standing waves are created in an open pipe of length L. There is an antinode at each end.

Which of the following corresponds to the wavelength of the lowest possible frequency standing wave?

☒ **A** L/2

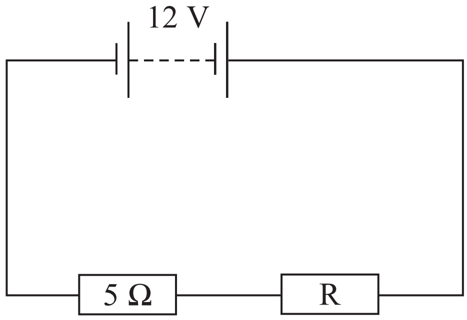
☒ **B** L

☒ **C** 2L

☒ **D** 4L

(Total for Question 5 = 1 mark)

6 The circuit contains a resistor R.



What is the resistance of R if the potential difference across it is 2 V?

☒ **A** 0.83 Ω

☒ **B** 1.0 Ω

☒ **C** 2.0 Ω

☒ **D** 2.4 Ω

(Total for Question 6 = 1 mark)

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7 S is a source of sound of frequency f_S. S is accelerating towards an observer O.

The frequency f_O of the sound heard by O will be

☒ **A** greater than f_S and decreasing.

☒ **B** greater than f_S and increasing.

☒ **C** smaller than f_S and decreasing.

☒ **D** smaller than f_S and increasing.

(Total for Question 7 = 1 mark)

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8 Which of the following types of wave **cannot** be plane polarised?

☒ **A** light

☒ **B** microwaves

☒ **C** ultrasound

☒ **D** ultraviolet

(Total for Question 8 = 1 mark)

9 A circuit contains a battery of four cells in series. Each cell has e.m.f. 1.5 V.

A charge of 3.0 C passes through the battery. What is the energy transferred?

☒ **A** 0.5 J

☒ **B** 2.0 J

☒ **C** 4.5 J

☒ **D** 18 J

(Total for Question 9 = 1 mark)

10 Light passes from one transparent medium to another transparent medium with a higher refractive index.

Which line of the table correctly describes what happens to the frequency and wavelength of the light?

	Frequency	**Wavelength**
☒ **A**	decreased	decreased
☒ **B**	decreased	increased
☒ **C**	unchanged	decreased
☒ **D**	unchanged	increased

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 The Mars Reconnaissance Orbiter has been studying the Martian climate since 2006.

The following passage is about the Orbiter:

> This satellite is powered by two solar panels, each of area 9.5 m^2. The panels have a high efficiency of 26% at converting solar energy into electricity. In orbit around Mars each panel produces about 1500 W of power.

(a) (i) Show that, when in orbit around Mars, the power output of a single panel is about 1500 W.

radiation flux from the Sun at Mars orbit = 590 W m^{-2}

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(ii) The panels are connected together to give a total output potential difference of 32 V. Show that the maximum output current is about 90 A.

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(b) The solar panels are used to charge two batteries of capacity 50 ampere hours (180 kC) each.

(i) Use the current calculated in part (a)(ii) to calculate the minimum time taken to fully charge the batteries.

(2)

Minimum time = ...

(ii) Suggest why the time calculated in (b)(i) is a minimum.

(1)

(Total for Question 11 = 8 marks)

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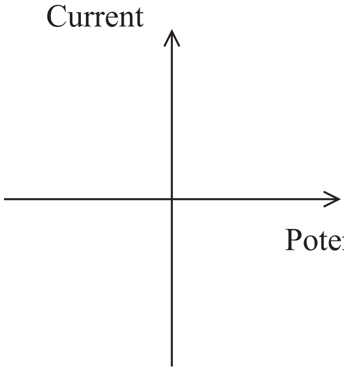
12 Thermistors are semiconductor devices that can be used in control circuits. The resistance of a thermistor depends on its temperature.

(a) Sketch a graph on the axes below to show how current varies with applied potential difference for a negative temperature coefficient thermistor.

(2)



*(b) Explain why the resistance of a negative temperature coefficient thermistor changes as the potential difference is increased.

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(Total for Question 12 = 6 marks)

13 A student carries out an experiment to investigate the photoelectric effect by shining light of different frequencies onto a particular metal.

(a) Describe how the photoelectric effect takes place.

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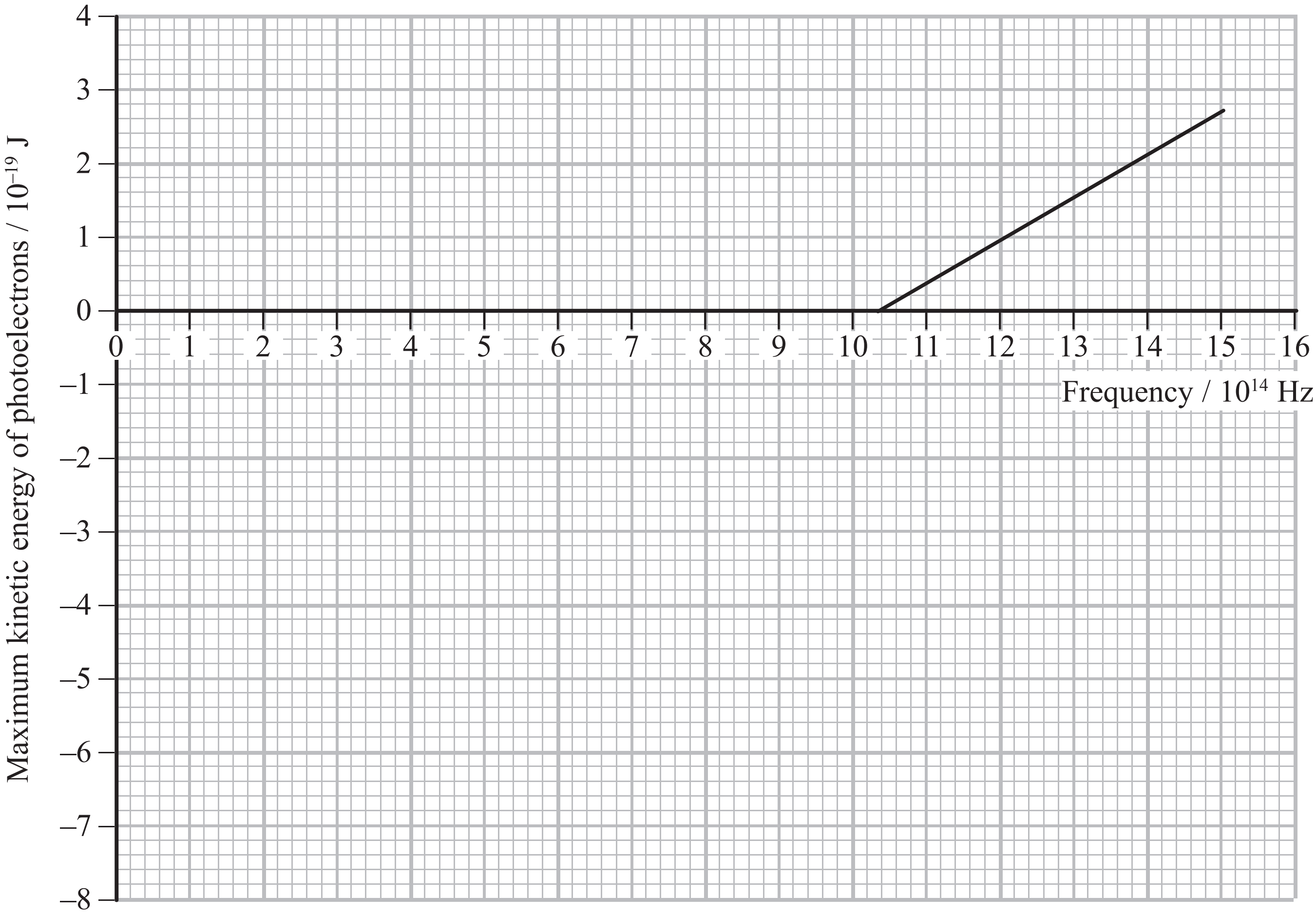
(b) The maximum kinetic energy of the photoelectrons is determined for a range of frequencies of incident light. The results are shown on the graph below.



(i) The list of formulae on this paper gives the expression

$$hf = \phi + \tfrac{1}{2} m v_{max}^2$$

Use this expression and the graph to determine the value of the Planck constant and the work function for the metal in this experiment.

(4)

Planck constant = ...

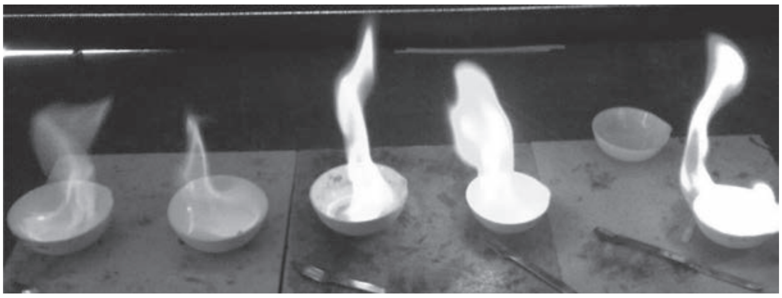
Work function = ...

(ii) Explain why the results of the experiment cannot be explained using the wave theory of light.

(2)

(Total for Question 13 = 8 marks)

14 The photograph shows flame tests being carried out on some chemical compounds.



Flame tests are used to identify the elements present in some chemical compounds. The compounds produce different coloured flames when vaporised. This is because different elements produce spectra containing light with different wavelengths.

Sodium compounds produce a yellow flame because the spectrum of sodium includes light with frequency 5.1×10^{14} Hz.

Before the sodium compound is vaporised the electrons involved in producing the yellow light are in the energy level −5.14 eV.

(a) State what is meant by an energy level.

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(b) (i) Explain why light is emitted when the sodium compound is vaporised.

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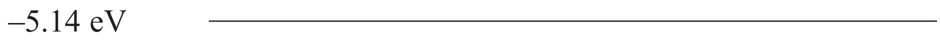
(ii) The diagram represents the −5.14 eV energy level in a sodium atom.



Calculate the energy of the other energy level involved in the emission of the yellow light.
Add this energy level to the diagram and label it with the correct value.

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(c) Explain why different elements produce different spectra.

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(Total for Question 14 = 9 marks)

15 Over 40 years ago, the Apollo astronauts placed reflectors on the surface of the Moon. These are still used by a number of observatories on Earth to monitor the distance to the Moon by reflecting pulses of laser light from them and detecting the reflected signal.

Scientists have determined that the Moon is at a distance of 363 104 km at its closest and 405 696 km at its furthest. It has also been determined that the Moon is getting about 3.8 cm further away from the Earth each year.

(a) Describe how the reflected pulses can be used to determine the distance to the Moon.

(2)

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(b) An observatory sends out pulses of laser light of duration 2.0×10^{-10} s when it is determining the distance to the Moon.

(i) Calculate the pulse length.

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Pulse length = ...

(ii) Discuss whether the levels of precision quoted for the distance to the Moon and its rate of increasing distance from the Earth are justified.

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(iii) The round trip for the light pulses takes about 2.5 seconds. As many as 10 pulses per second may be used.

State why pulses are used rather than a continuous beam.

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(c) Another observatory uses a higher power laser.

(i) This laser produces a pulse of duration 1.0×10^{-10} s. The energy of the pulse is 115 mJ.

Calculate the power of this laser.

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Power = ...

(ii) The wavelength of light produced by this laser is 5.32×10^{-7} m. The light is emitted from an aperture of diameter 75 cm.

Suggest, using the concept of diffraction, why such a large aperture is necessary.

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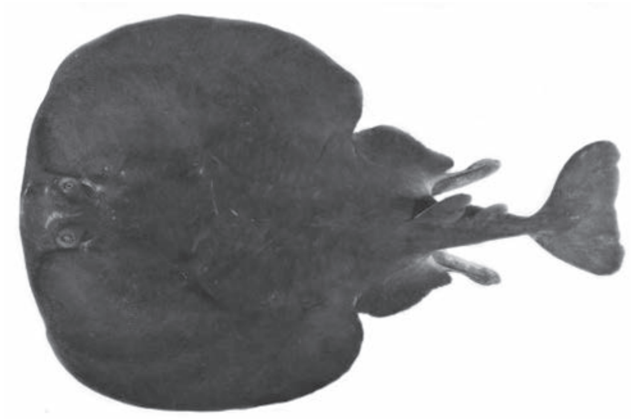
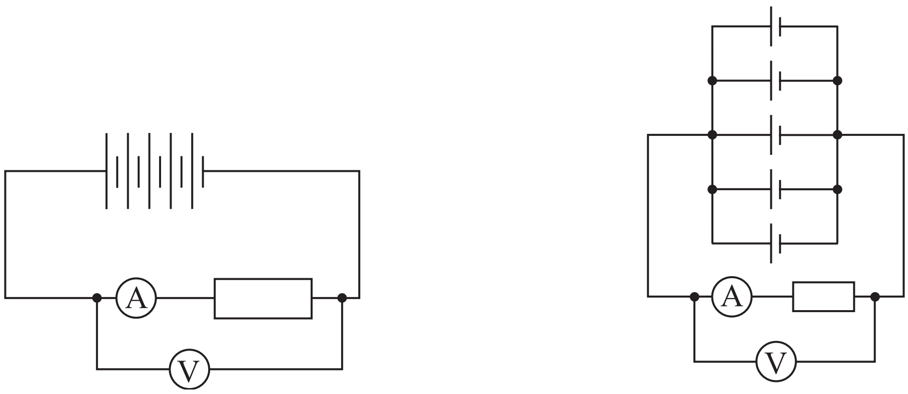
(Total for Question 15 = 12 marks)

16 The photograph shows a type of fish called an electric ray. Electric rays can produce an electric discharge to stun their prey.



Parts of a ray's body act as cells in a battery. In a ray living in fresh water the cells are arranged in series, but for a ray living in salt water the cells are arranged in parallel.

(a) The cell arrangement in rays can be investigated by comparing a circuit containing five cells in series with a circuit containing five cells in parallel. Each arrangement of cells is connected across a range of load resistors and the current and terminal potential difference (p.d.) are measured, as shown in the diagram.



(i) The results for current are shown in the table.

Load resistance / Ω	Current in series arrangement / A	Current in parallel arrangement / A
0.1	2.7	7.2
1	2.0	1.3
10	0.55	0.14

It has been suggested that the cells are in series for a ray living in fresh water because fresh water is a poorer conductor of electricity than salt water.

Discuss whether the results support this suggestion.

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(ii) Calculate the internal resistance of one cell using the following results for five cells in series. The e.m.f. of the five cells together is 6.9 V.

Load resistance / Ω	Terminal p.d. / V	Current / A
2.2	3.3	1.5

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Internal resistance = ...

(iii) Explain why the voltmeter should only be connected directly across the load resistor if the ammeter has negligible resistance.

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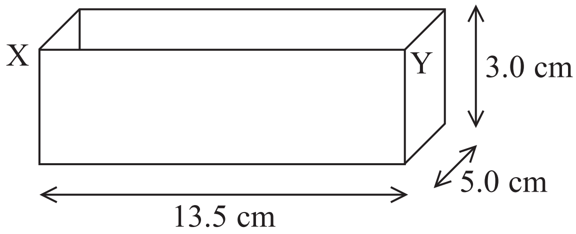
(b) In an experiment to determine the resistivity of salt water, a plastic container is filled with salt water. Pieces of metal foil are placed inside the container, covering the ends X and Y.



A resistance meter is attached to the pieces of metal foil and used to measure the resistance of the salt water between X and Y.

resistance of salt water = 1.2 kΩ

Calculate the resistivity of the salt water.

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Resistivity = ...

(c) When a ray is stunning its prey, it produces a potential difference of 45 V and a current of 0.12 A in a burst of duration 5 ms. There can be up to 400 bursts in an attack.

Calculate the energy transferred by the ray in a 400 burst attack.

(2)

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Energy transferred = ...

(Total for Question 16 = 12 marks)

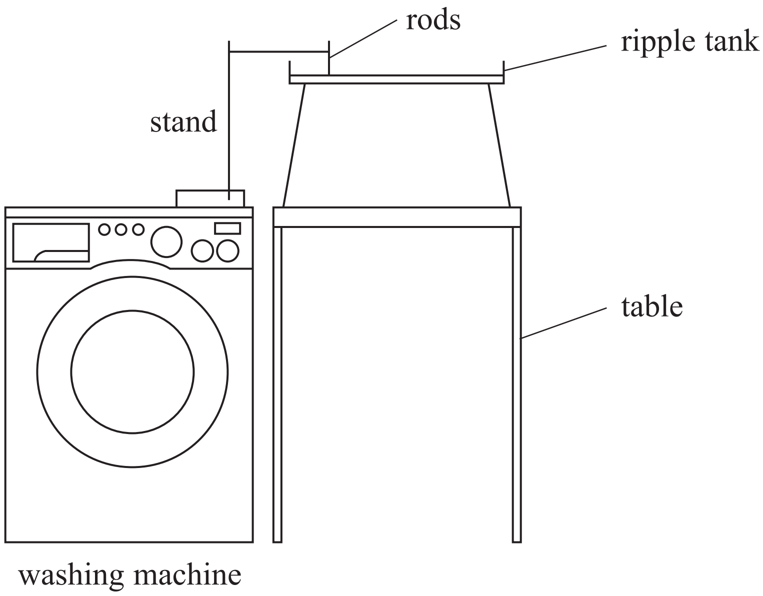
17 A washing machine produces large vibrations during its spin cycle.
A student decides to use the vibrations from the washing machine to produce ripples in a ripple tank and hence determine the frequency at which the washing machine spins.

(a) The student must first determine the speed of a ripple in the tank. She disturbs the surface of the water to produce a single ripple. She uses a stopwatch to measure the time taken for the ripple to travel a distance of 15 cm and records a time of 0.72 s.

Explain an alternative method that she could use to measure the time and why this method would be an improvement.

(4)

(b) A bar is attached to a stand on top of the washing machine so that it vibrates at the same frequency as the machine. Two small rods are attached to the bar so that they just dip into the water in the ripple tank and act as a pair of coherent sources.



Explain why the rods are said to act as coherent sources.

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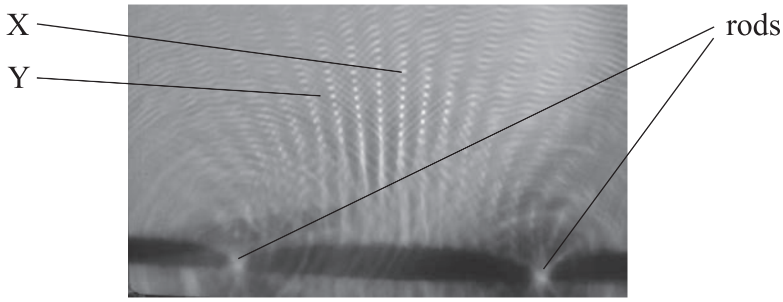
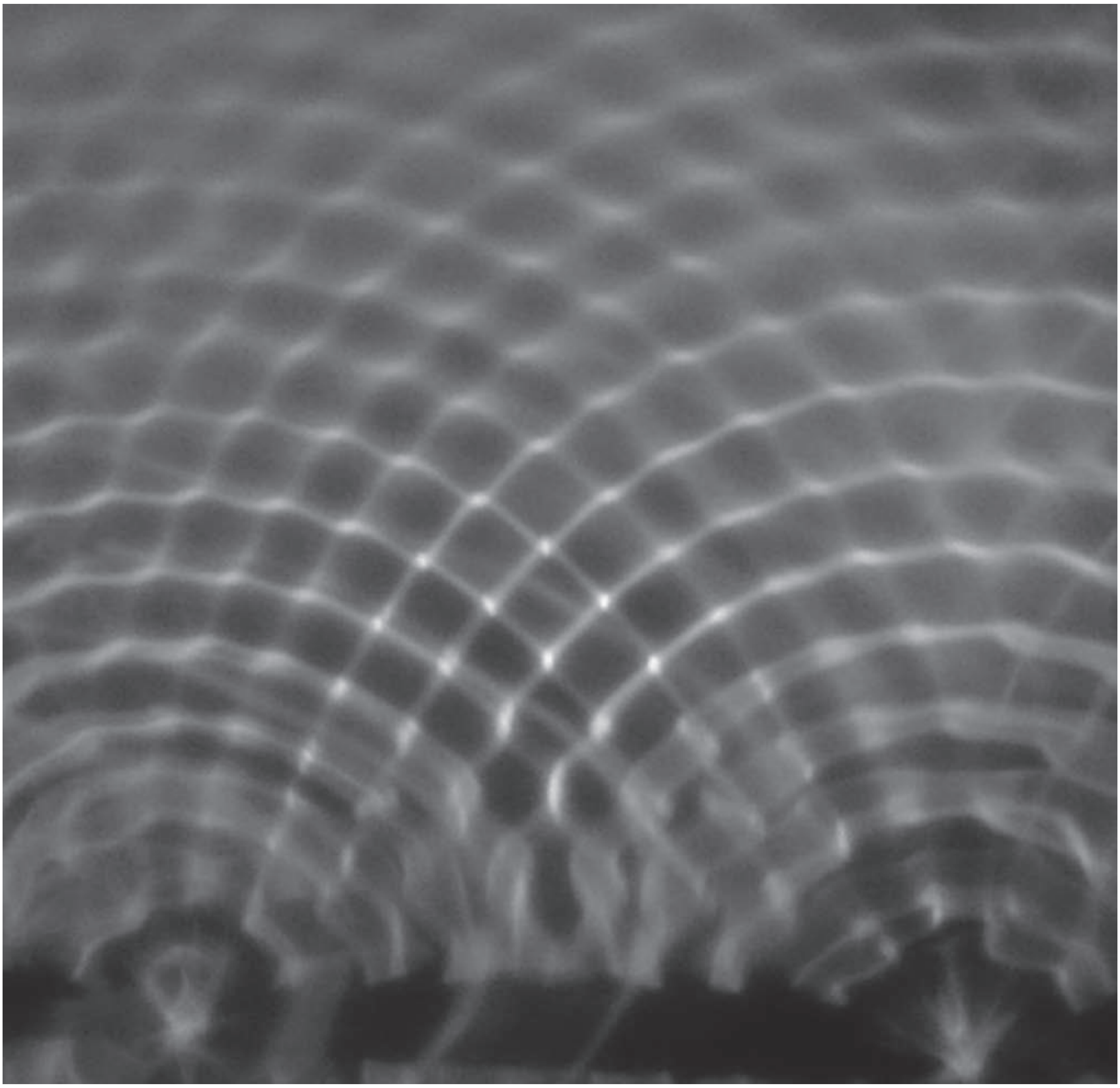
(c) Photograph 1 shows the pattern observed when the washing machine spins.



Photograph 1

X shows a line along which maximum disturbance is seen. Y shows a region in which there is almost no disturbance.

Photograph 2 was taken using a flash to show the individual waves from the two rods at a single instant. Photograph 2 is shown actual size.



Photograph 2

*(i) Explain how the interference pattern in photograph 1 is produced.

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(ii) Use measurements from photograph 2 to determine the frequency of the vibration causing the ripples.

speed of ripples = 25.2 cm s^{-1}

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Frequency of vibration = ...

(Total for Question 17 = 15 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

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List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$	(close to Earth's surface)
Electron charge	$e = -1.60 \times 10^{-19}\ \text{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	
Electronvolt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$	
Gravitational field strength	$g = 9.81\ \text{N kg}^{-1}$	(close to Earth's surface)
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$	

Unit 1

Mechanics

Kinematic equations of motion
$v = u + at$
$s = ut + \frac{1}{2}at^2$
$v^2 = u^2 + 2as$

Forces
$\Sigma F = ma$
$g = F/m$
$W = mg$

Work and energy
$\Delta W = F\Delta s$
$E_k = \frac{1}{2}mv^2$
$\Delta E_{grav} = mg\Delta h$

Materials

Stokes' law $F = 6\pi\eta rv$

Hooke's law $F = k\Delta x$

Density $\rho = m/V$

Pressure $p = F/A$

Young modulus $E = \sigma/\varepsilon$ where
Stress $\sigma = F/A$
Strain $\varepsilon = \Delta x/x$

Elastic strain energy $E_{el} = \frac{1}{2}F\Delta x$

Unit 2

Waves

Wave speed	$v = f\lambda$
Refractive index	${}_1\mu_2 = \sin i/\sin r = v_1/v_2$

Electricity

Potential difference	$V = W/Q$
Resistance	$R = V/I$
Electrical power, energy and efficiency	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$

$$\% \text{ efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100$$

$$\% \text{ efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100$$

Resistivity	$R = \rho l/A$
Current	$I = \Delta Q/\Delta t$ $I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Quantum physics

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{max}$