Write your name here

Surname

Other names

Pearson Edexcel
Level 3 GCE

Centre Number

Candidate Number

Physics
Advanced
Paper 3: General and Practical Principles
in Physics

Thursday 14 June 2018 – Morning
Time: 2 hours 30 minutes

Paper Reference
9PH0/03

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 120.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You may use a scientific calculator.
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- You are advised to show your working in calculations, including units where appropriate.

Turn over ▶

P 5 2 3 6 3 A 0 1 4 0

Pearson

BLANK PAGE

P52363A0240

P 5 2 3 6 3 A 0 2 4 0

Answer ALL questions in the spaces provided.

1   A practical physics textbook states that "measurements may give a precise value for the quantity being determined but this may not necessarily be an accurate value".

(a) Describe what physicists mean by the terms accuracy and precision.

(2)

....

....

....

....

....

....

(b) The temperature of the air in a room is measured using a mercury-in-glass thermometer.

Describe how the value for the temperature may be precise but not accurate.

(2)

....

....

....

....

....

....

(Total for Question 1 = 4 marks)

2 A student is investigating how the internal resistance of a dry cell varies over time.
She sets up the circuit shown to draw current from the cell.
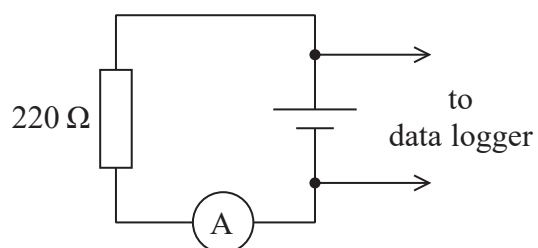
The student proposes to use a data logger to monitor the terminal potential difference (p.d.)
of the cell over a period of time.

(a) State why a data logger would be suitable to collect data in this investigation.

(1)

....

....

(b) The graph shows how the terminal p.d. varies as the chemical energy store in the cell
is depleted.
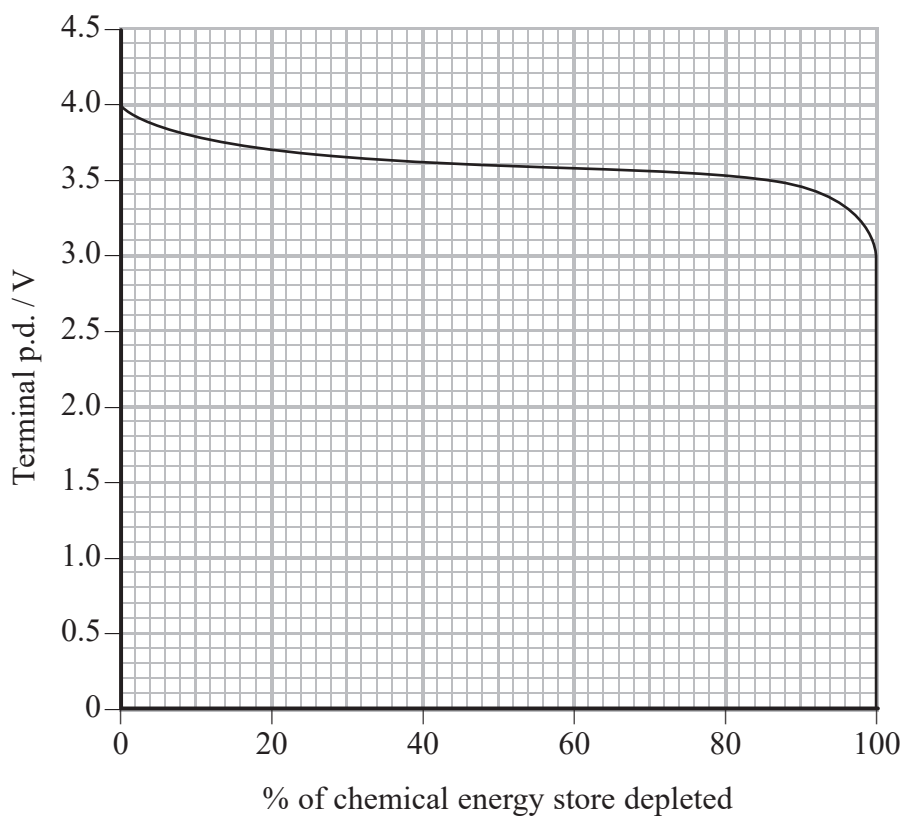
(i) Explain, using the graph, why the current drawn from the cell decreases as the chemical energy store in the cell is depleted.

(2)

....

....

....

....

....

(ii) Determine the internal resistance of the cell when its chemical energy store is 80% depleted. Assume that the e.m.f. of the cell remains constant at 4.0 V.

(3)

....

....

....

....

....

....

....

....

....

Internal resistance = ...
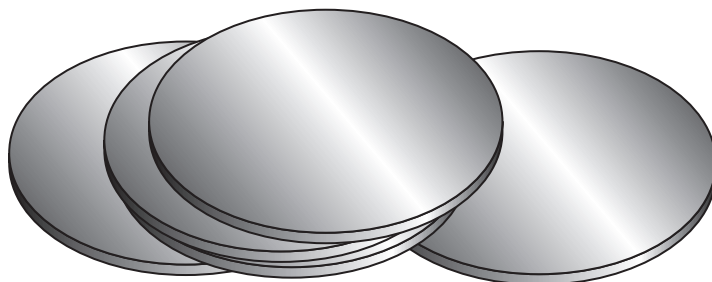
(Total for Question 2 = 6 marks)

3 A student is investigating the properties of steel. He has fifty steel discs available.

Each disc has a diameter $d \approx 1.3$ cm and a thickness $t \approx 2$ mm.

(a) State a suitable measuring instrument that could be used with a single disc to measure t.

(1)

....

....

(b) A balance which can measure mass with a resolution of 0.2 g is available.

Determine the minimum number of discs that should be placed on the balance together if the percentage uncertainty in the measurement of the mass is to be less than 0.5%.

(4)

density of steel = 7900 kg m⁻³

....

....

....

....

....

....

....

....

....

....

Minimum number of discs = ...

(c) The measured uncertainty in d is ±0.1 mm and the measured uncertainty for t is ±0.05 mm.

Determine the percentage uncertainty in the calculated volume of the disc.

(3)

....

....

....

....

....

....

....

Percentage uncertainty in volume = ...

(Total for Question 3 = 8 marks)

P 5 2 3 6 3 A 0 7 4 0

4 A student set up the circuit shown and measured the current I through the filament lamp for a range of values of potential difference (p.d.) V.
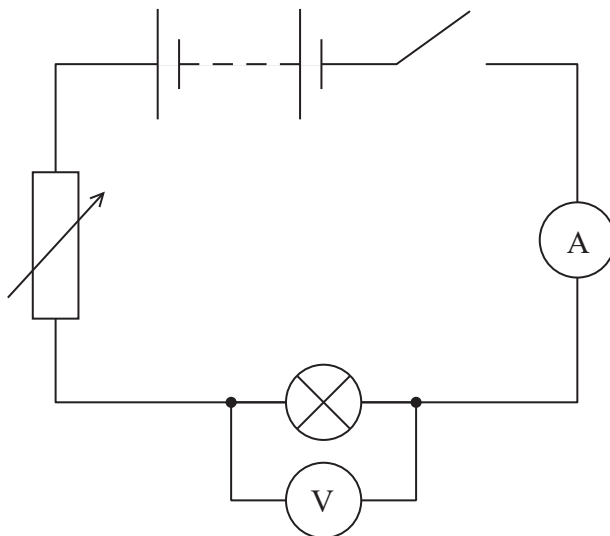
The student's data is shown in the table.

V / V	I / A
3.0	0.6
4.0	0.75
6.0	1.00
8.0	1.20
10.0	1.35
12.0	1.5

(a) Criticise the student's recording of the data.

(1)

....

....

(b) The student drew a graph of how current varies with p.d. She drew a straight line on the graph and claimed that the data demonstrates that the filament lamp obeys Ohm's law because the graph is linear.

Assess the validity of the student's statement.

(4)

....

....

....

....

....

....

....

....

....

....

(c) Using the circuit shown the student was unable to obtain data for p.d.s less than 2.5 V.

Draw a diagram of a circuit the student could have used to enable a full range of p.d.s from 0 to 12 V to be investigated.
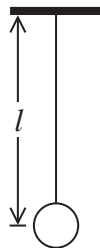
(2)

(Total for Question 4 = 7 marks)

BLANK PAGE

P 5 2 3 6 3 A 0 1 1 4 0

5 A student is using a simple pendulum to determine a value for the acceleration of free fall g.

(a) She measures the length l of the pendulum four times with a metre rule and records the following values.

l / cm			
l_1	l_2	l_3	l_4
85.5	86.0	87.5	85.5

She calculates the mean length l_m of the pendulum using the following method:

$$l_m = \frac{85.5 + 86.0 + 87.5 + 85.5}{4} = 86.1 \text{ cm}$$

(i) Calculate a more accurate value for l_m.

(2)

....

....

....

....

$l_m = $ ....

(ii) Determine the time period of the oscillations of this pendulum, using your calculated value for l_m.

(2)

....

....

....

Time period of oscillations = ...

(b) She sets the pendulum into oscillations with small amplitude and uses a stopwatch to determine the time period.
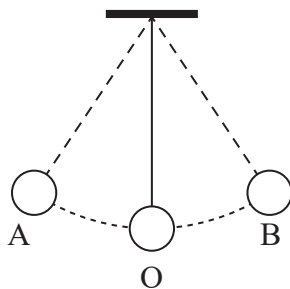
The student releases the pendulum at A and simultaneously starts the stopwatch. She measures the time taken for 5 oscillations and divides the value by 5. She repeats the procedure twice and calculates a mean time period.

Explain two modifications to the student's method that would improve the value obtained for the time period.

(4)

....

....

....

....

....

....

....

....

....

(Total for Question 5 = 8 marks)

6 A student is experimenting with different combinations of springs and recalls that in physics it is often possible to model different physical situations in similar ways.

The student suggests that a parallel combination of springs could be a model for a parallel combination of resistors in a circuit.
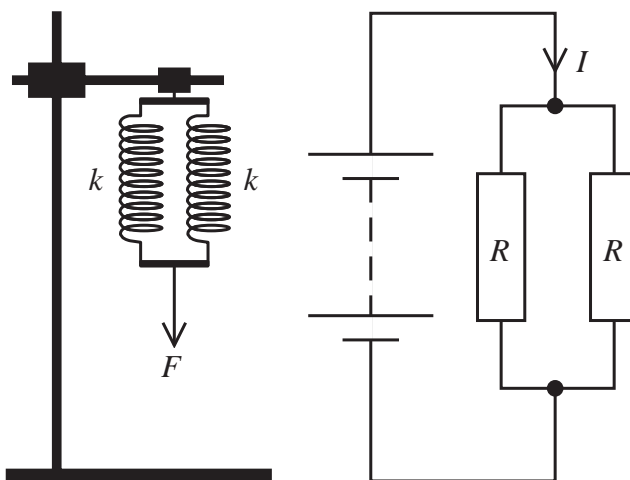
(a) Derive an expression for the effective resistance R_{eff} of two resistors R_1 and R_2 connected in parallel in a circuit.

(3)

....

....

....

....

....

....

(b) Assess the validity of the student's suggestion by considering the effective stiffness of two identical springs in parallel.

(6)

....

....

....

....

....

....

....

....

....

....

....

....

(Total for Question 6 = 9 marks)

P 5 2 3 6 3 A 0 1 5 4 0

7 A student carried out an experiment to determine the specific latent heat of vaporisation of water using the apparatus shown.
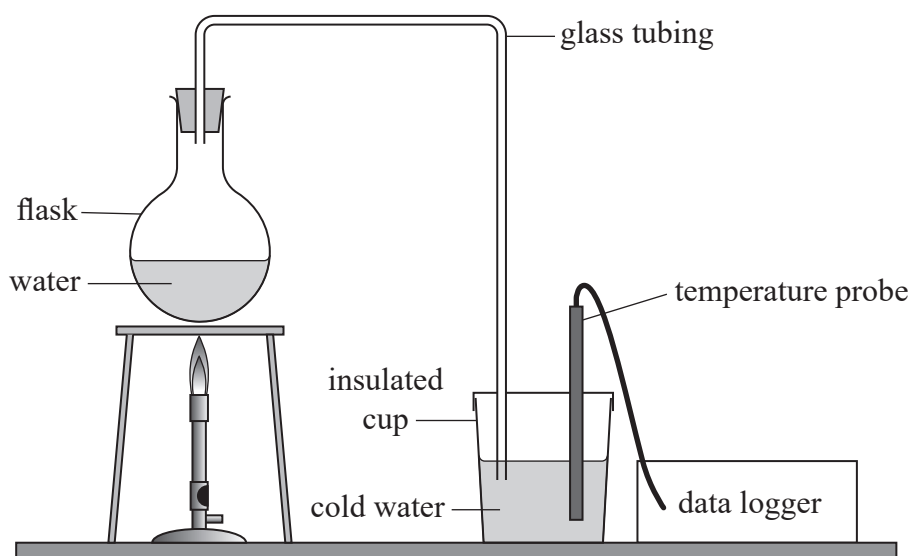
The water in the flask was heated and steam was forced out of the flask and through the glass tubing into the cold water in the insulated cup. The steam condensed as it passed into the cold water.

(a) The initial temperature of the cold water was 18.5 °C and the mass of water in the cup was 255.0 g. After steam had been passed through the water for some time the temperature had risen to 26.0 °C and the mass of the water in the cup was 258.3 g.

Calculate the specific latent heat of vaporisation of water.

(3)

specific heat capacity of water = 4190 J kg^{-1} K^{-1}

....

....

....

....

....

....

....

Specific latent heat of vaporisation of water = ...

(b) (i) Explain why the water was heated to boiling point and left boiling for a few minutes before the insulated cup of cold water was put in place.

(2)

....

....

....

....

....

(ii) Identify a significant source of error in this experiment and the steps that should be taken to minimise its effect on the calculated value of the specific latent heat of vaporisation of water.

(2)

....

....

....

....

....

....

....

(Total for Question 7 = 7 marks)

8 A converging lens can be used to produce a real image on a screen.

(a) A converging lens of focal length 15.0 cm is used to project an image of an illuminated object onto a screen. The object is a circle of diameter 4.0 mm and the image must be as large as possible on a screen of size 0.75 m by 1.25 m.

Calculate the distance between the lens and the screen for this image to be displayed.

(3)

....

....

....

....

....

....

....

....

....

Distance between lens and screen = ...

(b) A magazine article includes the statement:

> If the distance from the lens to the screen is doubled, the brightness of the image is halved.

Assess the validity of this statement.

(2)

....

....

....

....

....

....

....

....

(Total for Question 8 = 5 marks)

9 A student has been learning about the photoelectric effect.

(a) The student was asked by his teacher to explain the photoelectric effect. He gave the following explanation:

> Light above a certain threshold is able to free electrons from a metal, because the light gives energy to electrons in the metal.
> Some of this energy is used to release the electrons from the metal and the rest becomes kinetic energy of the freed electron.

Discuss whether the student's answer fully explains the photoelectric effect.

(4)

....

....

....

....

....

....

....

....

....

....

....

....

....

....
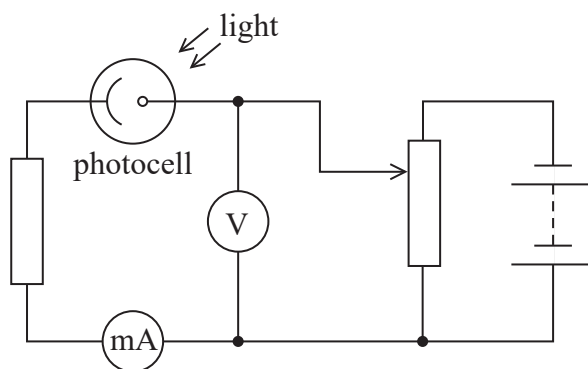
P 5 2 3 6 3 A 0 1 9 4 0

(b) The student sets up a circuit to investigate the photoelectric effect.

The student illuminates the photocell with light of known frequency f. A current is produced in the circuit due to the emitted electrons. He adjusts the potential difference, using a potential divider, until the reading on the milliammeter is zero and records the corresponding reading V_s on the voltmeter. He repeats this procedure for other frequencies of light.

When the reading on the milliammeter is zero the maximum kinetic energy of the emitted electrons is given by eV_s.

Explain how the student can use his results to determine a value for the Planck constant h using a graphical method.

(5)

....

....

....

....

....

....

....

....

....

....

....

....

....

....

(c) This experiment demonstrates the particle nature of light.

Explain what is meant by the particle nature of light.

(2)

....

....

....

....

....

(Total for Question 9 = 11 marks)

10 The Shanghai Maglev Train is the first commercially operated high-speed magnetic levitation train in the world, connecting the airport and central Shanghai.

(a) The total distance travelled is 29.9 km and the total journey time is 440 s. The train starts from rest and reaches a speed of 97 m s^{-1} in 120 s.

(i) Calculate the average acceleration of the train during the first 120 s.

(2)

....

....

....

Average acceleration of train = ...

(ii) Calculate the average speed of the train for the period following the 120 s acceleration.

(3)

....

....

....

....

....

....

Average speed of train = ...

(b) Electromagnetic forces enable the train to levitate above a steel rail.

Explain why magnetic levitation is an advantage for a high-speed transport system.

(2)

....

....

....

....

*(c) A linear induction motor provides the force to accelerate the train forwards. A current flows in sequence through coils of wire mounted in the track. The train is dragged along as the magnetic field progresses along the coils of wire in the track. This is similar to moving a permanent magnetic field away from a conductor.

A teacher demonstrates this effect by quickly removing one end of a bar magnet from a suspended aluminum ring.

aluminium ring

N   S   direction of movement

magnet

When the magnet is removed from the ring, the ring moves in the same direction as the magnet.

Explain, using the laws of electromagnetic induction, why the ring moves in the direction of the magnet.

(6)

....

....

....

....

....

....

....

....

....

....

....

....

(Total for Question 10 = 13 marks)

11 The International Space Station (ISS) is in a low Earth orbit. Astronauts in ISS have an apparent weight of zero. In order to determine their mass, the astronauts must secure themselves to a platform which is set into oscillation and moves with simple harmonic motion.

(a) Explain why the astronauts in the ISS have an apparent weight of zero.

(2)

....

....

....

....

(b) State what is meant by simple harmonic motion.

(2)

....

....

....

....

....

(c) Describe how, using a stopwatch and a ruler, the following quantities could be determined for the oscillating platform:

(i) the frequency of oscillation

(2)

....

....

....

....

(ii) the maximum speed of the platform.

(2)

....

....

....

....

(d) The platform continues to move with simple harmonic motion at the same frequency, but its amplitude is doubled.

Explain how the maximum kinetic energy of the platform will change.

(2)

....

....

....

....

(Total for Question 11 = 10 marks)

P 5 2 3 6 3 A 0 2 5 4 0

12 Our understanding of the atom has developed over time, from early models in which atoms were considered to be hard incompressible spheres, through to the nuclear model of the atom and the ladder model in which electrons exist in a discrete number of allowed energy states.

*(a) The model of atoms as hard incompressible spheres, moving rapidly and randomly, can be used to explain why gases exert a pressure.

Explain, using ideas of momentum, why the pressure exerted by a gas increases as the temperature of the gas increases.

(6)

....

....

....

....

....

....

....

....

....

....

....

....

(b) The nuclear model of the atom was established following a series of experiments in which alpha particles were directed at thin gold foil.

(i) An alpha particle approaching a gold nucleus, $^{197}_{79}$Au, head-on will be brought to rest and returned along its original path.

Calculate the minimum distance between the alpha particle and the nucleus for alpha particles of energy of 5.5 MeV.

(4)

....

....

....

....

....

....

....

Minimum distance = ...

(ii) It is observed that electrons, with energy of 5.5 keV, are diffracted as they pass through the thin gold foil.

Explain a conclusion about the electrons that can be made from this observation.

(3)

....

....

....

....

....

....

P 5 2 3 6 3 A 0 2 7 4 0

(c) In the energy ladder model of the atom, electrons exist in a discrete number of allowed energy states. The collision of electrons with gold atoms may lead to the production of high frequency electromagnetic radiation.

Explain how high frequency electromagnetic radiation may be produced when electrons collide with atoms in a metal.

(4)

....

....

....

....

....

....

....

....

(Total for Question 12 = 17 marks)

13 A method to determine the wavelength of light using a converging lens was first proposed by Sir Isaac Newton.

A converging lens is placed on a plane glass plate. The lens is illuminated from above with a parallel beam of monochromatic light, as shown.

Some of the light is reflected from the upper surface of the lower glass plate and some from the lower surface of the lens. Interference between these two reflected waves produces circular fringes. The pattern is viewed through a microscope.

microscope

monochromatic
light source

glass plate

converging lens

glass plate

Side view of apparatus
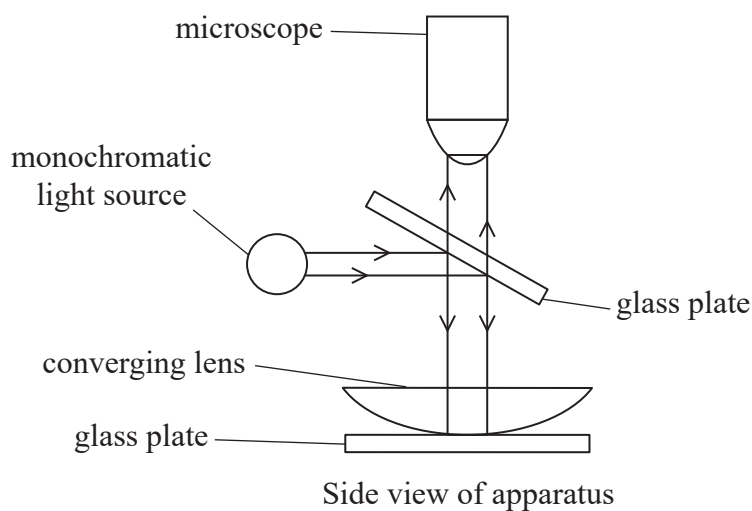
Pattern seen through
microscope

The diameter D of each circular fringe, numbered N from the centre, is measured using the microscope. The data obtained from such an experiment is shown.

N	D / mm		
1	5.13		
2	7.08		
3	8.71		
4	10.23		
5	11.48		

(a) The relationship between N and D is of the form $D = pN^q$ where p and q are constants.

Determine p and q for this data using a graphical method. Use the additional columns for your processed data.

(8)

....

....

....

....

....

....

....

....

....

....

$p = $ ....

$q = $ ....

P 5 2 3 6 3 A 0 3 1 4 0
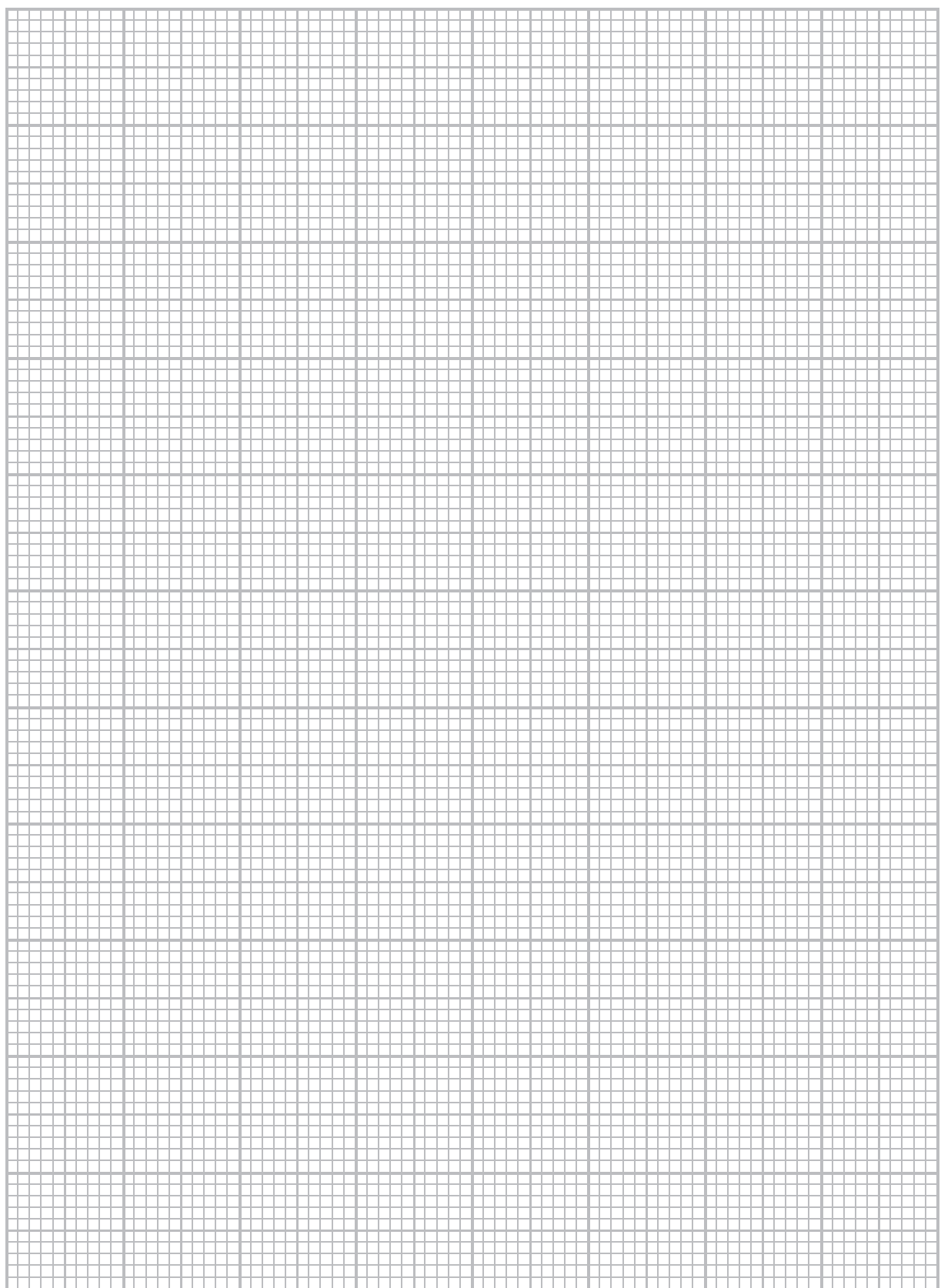
(b) The table below shows the readings from which the diameter of the first dark circle was calculated.

Position of left-hand side of circle / mm	Position of right-hand side of circle / mm	Diameter / mm
54.79	49.66	5.13

(i) Use these readings to estimate the percentage uncertainty in the diameter due to the resolution of the instrument.

(2)

....

....

....

....

Percentage uncertainty = ...

(ii) State why the actual percentage uncertainty would have been greater than the value calculated in (b)(i).

(1)

....

....

....

(c) When considering the principles of this experiment, a student suggests that interference fringes would only be produced with monochromatic light. This is because interference requires coherent light waves.

Discuss the validity of the student's suggestion.

(4)

....

....

....

....

....

....

....

....

....

....

(Total for Question 13 = 15 marks)

TOTAL FOR PAPER = 120 MARKS

BLANK PAGE

BLANK PAGE

P 5 2 3 6 3 A 0 3 5 4 0

BLANK PAGE

P52363A03640
P 5 2 3 6 3 A 0 3 6 4 0

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81$ m s^{-2}	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}	
Coulomb law constant	$k = \dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9$ N m^2 C^{-2}	
Electron charge	$e = -1.60 \times 10^{-19}$ C	
Electron mass	$m_e = 9.11 \times 10^{-31}$ kg	
Electronvolt	1 eV $= 1.60 \times 10^{-19}$ J	
Gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}	
Gravitational field strength	$g = 9.81$ N kg^{-1}	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}	
Planck constant	$h = 6.63 \times 10^{-34}$ J s	
Proton mass	$m_p = 1.67 \times 10^{-27}$ kg	
Speed of light in a vacuum	$c = 3.00 \times 10^8$ m s^{-1}	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}$ kg	

Mechanics

Kinematic equations of motion

$$s = \frac{(u + v)t}{2}$$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Forces

$$\sum F = ma$$

$$g = \frac{F}{m}$$

$$W = mg$$

$$\text{moment of force} = Fx$$

Momentum

$$p = mv$$

Work, energy and power

$$\Delta W = F\Delta s$$

$$E_k = \frac{1}{2}mv^2$$

$$\Delta E_{grav} = mg\Delta h$$

$$P = \frac{E}{t}$$

$$P = \frac{W}{t}$$

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

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

Electric circuits

Potential difference

$$V = \frac{W}{Q}$$

Resistance

$$R = \frac{V}{I}$$

Electrical power and energy

$$P = VI$$

$$P = I^2R$$

$$P = \frac{V^2}{R}$$

$$W = VIt$$

Resistivity

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

Current

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nqvA$$

Materials

Density

$$\rho = \frac{m}{V}$$

Stokes' law

$$F = 6\pi\eta rv$$

Hooke's law

$$\Delta F = k\Delta x$$

Young modulus

$$\text{Stress } \sigma = \frac{F}{A}$$

$$\text{Strain } \varepsilon = \frac{\Delta x}{x}$$

$$E = \frac{\sigma}{\varepsilon}$$

Elastic strain energy

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

Waves and Particle Nature of Light

Wave speed

$$v = f\lambda$$

Speed of a transverse wave on a string

$$v = \sqrt{\frac{T}{\mu}}$$

Intensity of radiation

$$I = \frac{P}{A}$$

Power of a lens

$$P = \frac{1}{f}$$

$$P = P_1 + P_2 + P_3 + \dots$$

Thin lens equation

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

Magnification for a lens

$$m = \frac{\text{image height}}{\text{object height}} = \frac{v}{u}$$

Diffraction grating

$$n\lambda = d \sin \theta$$

Refractive index

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$n = \frac{c}{v}$$

Critical angle

$$\sin C = \frac{1}{n}$$

Photon model

$$E = hf$$

Einstein's photoelectric equation

$$hf = \phi + \frac{1}{2}mv^2_{max}$$

de Broglie wavelength

$$\lambda = \frac{h}{p}$$

Further mechanics

Impulse

$$F\Delta t = \Delta p$$

Kinetic energy of a non-relativistic particle

$$E_k = \frac{p^2}{2m}$$

Motion in a circle

$$v = \omega r$$

$$T = \frac{2\pi}{\omega}$$

$$F = ma = \frac{mv^2}{r}$$

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

$$a = r\omega^2$$

Centripetal force

$$F = \frac{mv^2}{r}$$

$$F = mr\omega^2$$

Fields

Coulomb's law

$$F = k\frac{Q_1 Q_2}{r^2}$$

$$\text{where } k = \frac{1}{4\pi\varepsilon_0}$$

Electric field strength

$$E = \frac{F}{Q}$$

$$E = k\frac{Q}{r^2}$$

$$E = \frac{V}{d}$$

Electric potential

$$V = k\frac{Q}{r}$$

Capacitance

$$C = \frac{Q}{V}$$

Energy stored in a capacitor

$$W = \frac{1}{2}QV$$

Capacitor discharge

$$Q = Q_0 e^{-t/RC}$$

Resistor – capacitor discharge

$$I = I_0 e^{-t/RC}$$

$$V = V_0 e^{-t/RC}$$

In a magnetic field

$$F = BIl \sin \theta$$

$$F = Bqv \sin \theta$$

Faraday's and Lenz's laws

$$\varepsilon = \frac{-d(N\phi)}{dt}$$

Root-mean-square values

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

P5 2 3 6 3 A 0 3 9 4 0

Nuclear and particle physics

In a magnetic field

$$r = \frac{p}{BQ}$$

Thermodynamics

Heating

$$\Delta E = mc\Delta\theta$$

$$\Delta E = L\Delta m$$

Molecular kinetic theory

$$\frac{1}{2}m\langle c^2 \rangle = \frac{3}{2}kT$$

$$pV = \frac{1}{3}Nm\langle c^2 \rangle$$

Ideal gas equation

$$pV = NkT$$

Stefan-Boltzmann law

$$L = \sigma AT^4$$

$$L = \sigma 4\pi r^2 T^4$$

Wien's law

$$\lambda_{max}T = 2.898 \times 10^{-3} \text{ m K}$$

Space

Intensity

$$I = \frac{L}{4\pi d^2}$$

Redshift of electromagnetic radiation

$$z = \frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$$

Cosmological expansion

$$v = H_0 d$$

Nuclear radiation

Mass-energy

$$\Delta E = c^2 \Delta m$$

Radioactive decay

$$A = \lambda N$$

$$\frac{dN}{dt} = -\lambda N$$

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$

$$N = N_0\, e^{-\lambda t}$$

$$A = A_0\, e^{-\lambda t}$$

Gravitational fields

Gravitational force

$$F = \frac{Gm_1 m_2}{r^2}$$

Gravitational field strength

$$g = \frac{Gm}{r^2}$$

Gravitational potential

$$V_{grav} = \frac{-Gm}{r}$$

Oscillations

Simple harmonic motion

$$F = -kx$$

$$a = -\omega^2 x$$

$$x = A \cos \omega t$$

$$v = -A\omega \sin \omega t$$

$$a = -A\omega^2 \cos \omega t$$

$$T = \frac{1}{f} = \frac{2\pi}{\omega}$$

$$\omega = 2\pi f$$

Simple harmonic oscillator

$$T = 2\pi \sqrt{\frac{m}{k}}$$

$$T = 2\pi \sqrt{\frac{l}{g}}$$