Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
|---|---|
| | |

**Pearson Edexcel International Advanced Level**

Centre Number | Candidate Number

# Wednesday 22 May 2019

Afternoon (Time: 1 hour 20 minutes) | Paper Reference **WPH06/01**

# Physics

## Advanced
## Unit 6: Experimental Physics

**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 40.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- 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.
- Try to answer every question.
- Check your answers if you have time at the end.

*Turn over* ▶

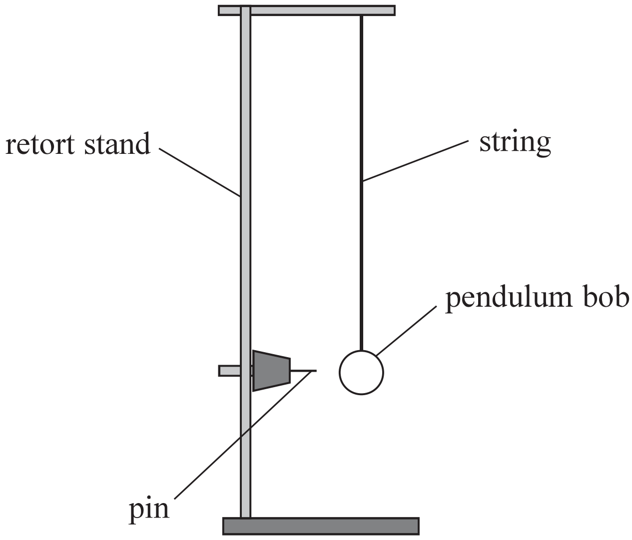




Pearson

**Answer ALL questions. Write your answers in the spaces provided.**

1 A student investigated how the time period $T$ of a simple pendulum varies with the length $l$ of the pendulum, using the apparatus shown.




The pendulum performs simple harmonic motion, hence $T$ is given by the equation

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

The student displaced the pendulum bob by a small distance to set the pendulum oscillating. The student measured the time for 10 complete oscillations.

(a) (i) State the reason for using a small displacement.

**(1)**

........................................................................................................................................................................................................

........................................................................................................................................................................................................

(ii) The student used a pin as a timing marker.

Explain how placing the pin at the centre of oscillation would lead to a more accurate value for $10T$.

**(2)**

........................................................................................................................................................................................................

........................................................................................................................................................................................................

........................................................................................................................................................................................................

........................................................................................................................................................................................................

........................................................................................................................................................................................................

........................................................................................................................................................................................................

(b) The student obtained the following results.

| $10T$/s | $10T$/s | $10T$/s | $10T$/s | $10T$/s | mean $10T$/s | mean $T$/s |
|---|---|---|---|---|---|---|
| 10.15 | 10.32 | 10.20 | 10.28 | 10.24 | | |

(i) Complete the table.

**(2)**

(ii) Calculate the percentage uncertainty in $T$.

**(2)**

........................................................................................................................................

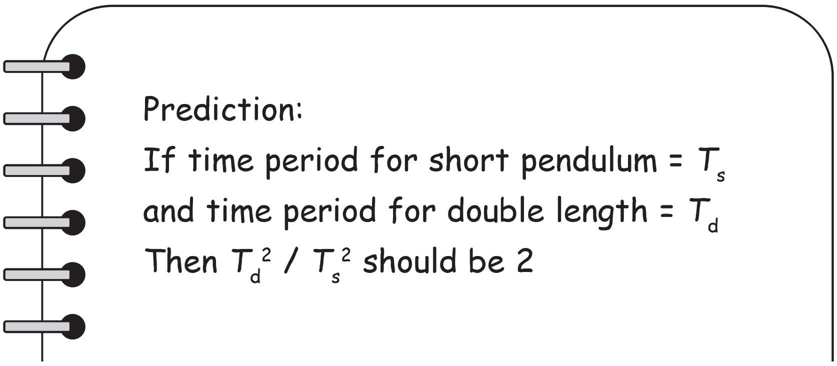
........................................................................................................................................

........................................................................................................................................

........................................................................................................................................

Percentage uncertainty = ..............................................

(c) The student doubled the length of the pendulum. She made the following prediction.




(i) Justify the prediction.

**(2)**

........................................................................................................................................

........................................................................................................................................

........................................................................................................................................

........................................................................................................................................

(ii) The student determines $T$ for the longer pendulum as $1.461 \pm 0.011$ s.

Determine whether her results support her prediction.

**(4)**

.......................................................................................................................................................

.......................................................................................................................................................

.......................................................................................................................................................

.......................................................................................................................................................

.......................................................................................................................................................

.......................................................................................................................................................

.......................................................................................................................................................

.......................................................................................................................................................

**(Total for Question 1 = 13 marks)**

**BLANK PAGE**

**2** An alternating current in a primary coil generates a magnetic field. This induces an e.m.f. across a small secondary coil placed in the magnetic field.

(a) Explain how an e.m.f. is induced across the secondary coil.

**(2)**

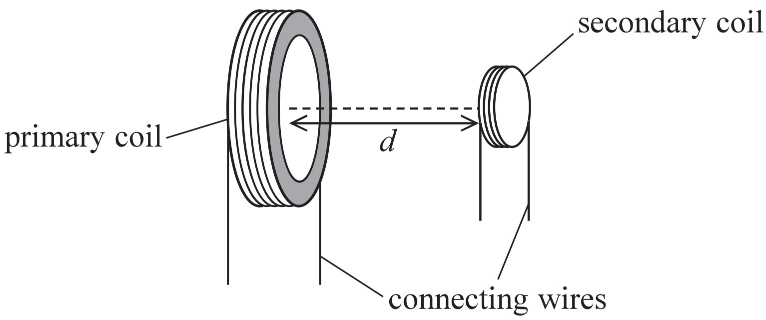
.......................................................................................................................................

.......................................................................................................................................

.......................................................................................................................................

.......................................................................................................................................

(b) A student has the apparatus shown.




The e.m.f. $V$ induced across the secondary coil is given by

$$V = \frac{kNI}{d^3}$$

where

$k$ is a constant,

$N$ is the number of turns on the primary coil,

$I$ is the current in the primary coil,

$d$ is the distance between the centres of the coils as shown.

The student investigates how $V$ varies with $d$.

Write a plan to determine $k$ using a graphical method.

Your plan should include:

(i) a circuit diagram to show how the primary coil should be connected with any additional components required,

**(1)**

(ii) the measurements to be made with any additional apparatus required,

**(3)**

(iii) the graph to be plotted and how it would be used to determine $k$,

**(2)**

(iv) a statement of a significant source of uncertainty.

**(1)**

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

**(Total for Question 2 = 9 marks)**

**BLANK PAGE**

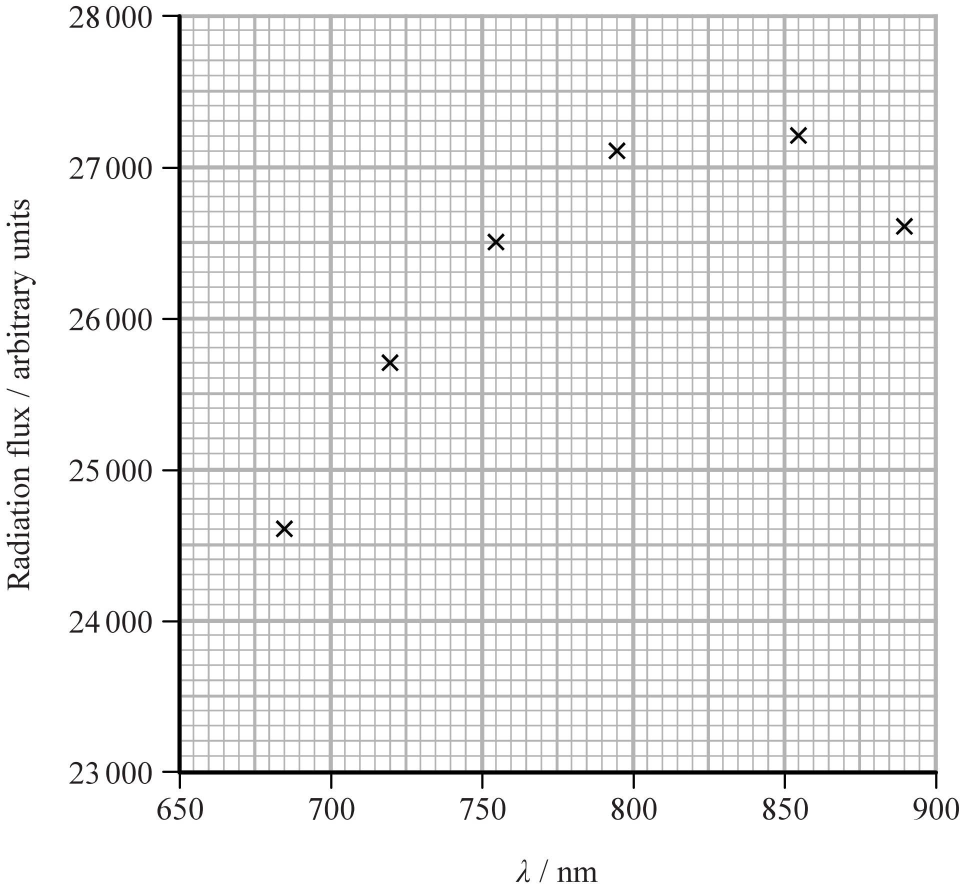
**3** The surface temperature $T$ of a star can be estimated by determining the wavelength $\lambda_{max}$ at which peak power emission occurs from the star.

A student astronomer observed the red giant Betelgeuse.

He measured the radiation flux at six wavelengths and obtained the following results.

| Radiation flux / arbitrary units | $\lambda$ / nm |
|---|---|
| 24 600 | 685 |
| 25 700 | 720 |
| 26 500 | 755 |
| 27 100 | 795 |
| 27 200 | 855 |
| 26 600 | 890 |

The data was plotted as shown.



DO NOT WRITE IN THIS AREA

(a) (i) Draw a line of best fit to show where the radiation flux is a maximum.

**(2)**

(ii) Estimate $\lambda_{max}$.

**(1)**

$\lambda_{max}$ = ..............................

(iii) Calculate a value for $T$.

**(2)**

..............................

..............................

..............................

..............................

$T$ = ..............................

(b) Suggest two reasons why the value of $\lambda_{max}$ might not be accurate.

**(2)**

..............................

..............................

..............................

..............................

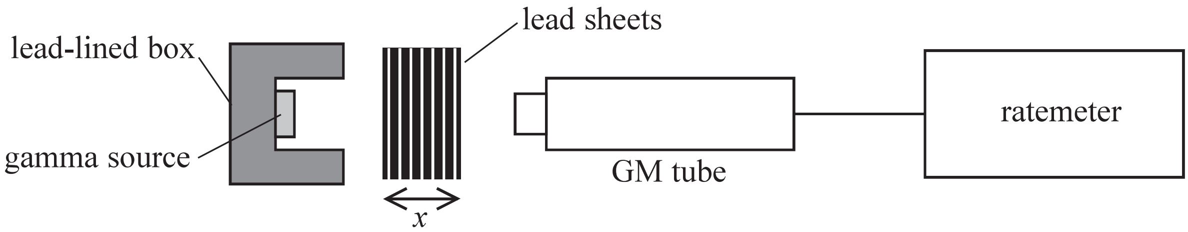
**(Total for Question 3 = 7 marks)**

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

**BLANK PAGE**

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

**4** A student investigated the absorption of gamma radiation by lead, using the apparatus shown.




(a) She recorded and corrected for the background count rate.

Explain why it is possible to correct for background count rate.

**(2)**

.......................................................................................................................................................

.......................................................................................................................................................

.......................................................................................................................................................

.......................................................................................................................................................

(b) The student recorded the corrected count rate $C$ with different thicknesses of lead sheets.

The relationship between $C$ and the total thickness $x$ of the lead sheets is

$$C = C_0 e^{-\mu x}$$

where $C_0$ is the count rate without any lead sheets and $\mu$ is a constant.

Explain why plotting a graph of $\ln C$ against $x$ will produce a straight line.

**(2)**

.......................................................................................................................................................

.......................................................................................................................................................

.......................................................................................................................................................

.......................................................................................................................................................

(c) The student obtained the following results.

| $x$ / mm | $C$ / $s^{-1}$ | |
|---|---|---|
| 1.52 | 132 | |
| 3.89 | 112 | |
| 6.81 | 95 | |
| 9.33 | 86 | |
| 11.48 | 74 | |
| 13.70 | 67 | |

(i) Plot a graph of $\ln C$ against $x$ on the grid provided. Use the additional column in the results table to record your processed data.

**(5)**

(ii) Determine a value for $\mu$.

**(2)**

..............................................................................................................................................

..............................................................................................................................................

..............................................................................................................................................

..............................................................................................................................................

$\mu$ = ..............................................

**(Total for Question 4 = 11 marks)**

**TOTAL FOR PAPER = 40 MARKS**

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

**BLANK PAGE**

## List of data, formulae and relationships

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

***Unit 1***

*Mechanics*

| | |
|---|---|
| Kinematic equations of motion | $v = u + at$<br>$s = ut + \frac{1}{2}at^2$<br>$v^2 = u^2 + 2as$ |
| Forces | $\Sigma F = ma$<br>$g = F/m$<br>$W = mg$ |
| Work and energy | $\Delta W = F\Delta s$<br>$E_k = \frac{1}{2}mv^2$<br>$\Delta E_{grav} = mg\Delta h$ |

*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<br>Stress $\sigma = F/A$<br>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 | $P = VI$<br>$P = I^2R$<br>$P = V^2/R$<br>$W = VIt$ |

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

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

| | |
|---|---|
| Resistivity | $R = \rho l/A$ |
| Current | $I = \Delta Q/\Delta t$<br>$I = nqvA$ |
| 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 | $hf = \phi + \frac{1}{2}mv^2_{max}$ |

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

**Unit 4**

*Mechanics*

| | |
|---|---|
| Momentum | $p = mv$ |
| Kinetic energy of a non-relativistic particle | $E_k = p^2/2m$ |
| Motion in a circle | $v = \omega r$<br>$T = 2\pi/\omega$<br>$F = ma = mv^2/r$<br>$a = v^2/r$<br>$a = r\omega^2$ |

*Fields*

| | |
|---|---|
| Coulomb's law | $F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$ |
| Electric field | $E = F/Q$<br>$E = kQ/r^2$<br>$E = V/d$ |
| Capacitance | $C = Q/V$ |
| Energy stored in capacitor | $W = \frac{1}{2}QV$ |
| Capacitor discharge | $Q = Q_0 e^{-t/RC}$ |
| In a magnetic field | $F = BIl \sin\theta$<br>$F = Bqv \sin\theta$<br>$r = p/BQ$ |
| Faraday's and Lenz's laws | $\varepsilon = -d(N\phi)/dt$ |

*Particle physics*

| | |
|---|---|
| Mass-energy | $\Delta E = c^2 \Delta m$ |
| de Broglie wavelength | $\lambda = h/p$ |

**Unit 5**

*Energy and matter*

| | |
|---|---|
| Heating | $\Delta E = mc\Delta\theta$ |
| Molecular kinetic theory | $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$ |
| Ideal gas equation | $pV = NkT$ |

*Nuclear Physics*

| | |
|---|---|
| Radioactive decay | $\mathrm{d}N/\mathrm{d}t = -\lambda N$ |
| | $\lambda = \ln 2/t_{\frac{1}{2}}$ |
| | $N = N_0 e^{-\lambda t}$ |

*Mechanics*

| | |
|---|---|
| Simple harmonic motion | $a = -\omega^2 x$<br>$a = -A\omega^2 \cos \omega t$<br>$v = -A\omega \sin \omega t$<br>$x = A \cos \omega t$<br>$T = 1/f = 2\pi/\omega$ |
| Gravitational force | $F = Gm_1m_2/r^2$ |

*Observing the universe*

| | |
|---|---|
| Radiant energy flux | $F = L/4\pi d^2$ |
| Stefan-Boltzmann law | $L = \sigma T^4 A$<br>$L = 4\pi r^2 \sigma T^4$ |
| Wien's law | $\lambda_{max} T = 2.898 \times 10^{-3}$ m K |
| Redshift of electromagnetic radiation | $z = \Delta\lambda/\lambda \approx \Delta f/f \approx v/c$ |
| Cosmological expansion | $v = H_0 d$ |