Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Thursday 31 October 2024

Morning (Time: 1 hour 20 minutes)

Paper reference **WPH16/01**

Physics

International Advanced Level
UNIT 6: Practical Skills in Physics II

You must have:
Scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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.*
- **Show all your working out** in calculations and **include units** where appropriate.

Information

- The total mark for this paper is 50.
- 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.

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 ▶

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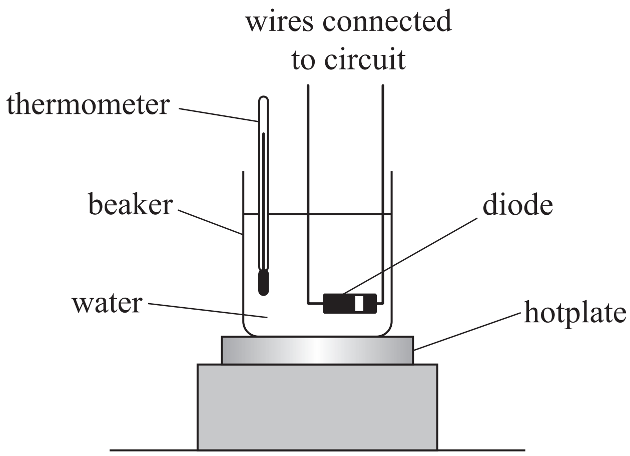
Pearson

Answer ALL questions.

1 A student investigated how the current in a diode varied with the temperature of the diode.

(a) The student varied the temperature of the diode from room temperature to 100 °C using the apparatus shown.



Identify one health and safety issue and how it should be dealt with.

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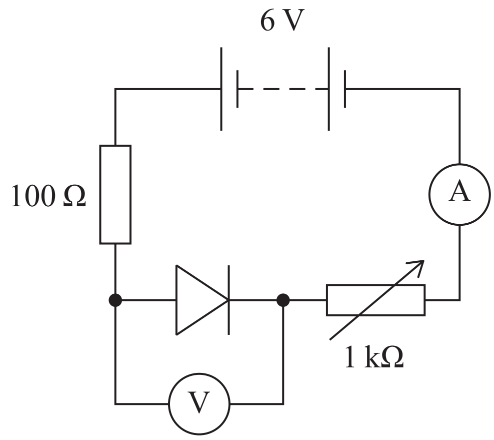
(b) The student connected the diode in the circuit shown.



He used the ammeter to measure the current as he varied the temperature of the diode.

Explain why the student was correct to include a variable resistor in the circuit.

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(c) The student predicted that the variation of current with temperature would be linear from 0 °C to 100 °C.

He recorded the following data to plot a graph of current against temperature.

Temperature / °C	**Current / A**
29.5	4.3
41	6.34
50	9

(i) Explain whether the unit for current in the table is correct for this data.

You should include a suitable calculation.

(3)

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(ii) Give two reasons why this data cannot be used to test the student's prediction.

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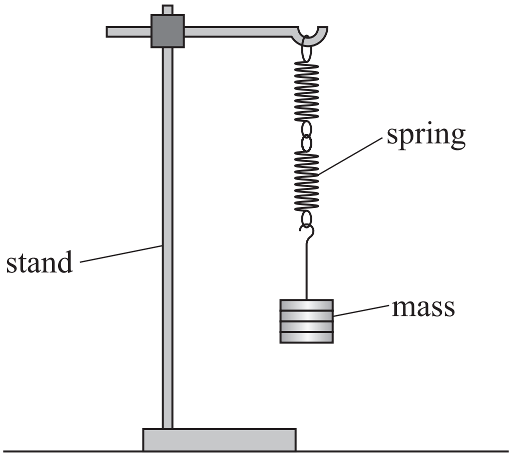
(Total for Question 1 = 9 marks)

2 A student investigated the free oscillations of a mass-spring system using the apparatus shown.



The student displaced the mass downwards and allowed the mass to oscillate.

She used a stopwatch to determine the time taken for the mass to complete 5 oscillations.

(a) The student recorded the following measurements.

5*T* / s	7.69	7.58	7.43	7.51

(i) Determine the mean value of the period T.

(2)

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Mean value of T = ...

(ii) Determine the percentage uncertainty in the mean value of T.

(2)

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Percentage uncertainty = ...

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(iii) The student measured the time for multiple oscillations and calculated the mean.

Describe three other techniques she should use to obtain an accurate value for T.

(3)

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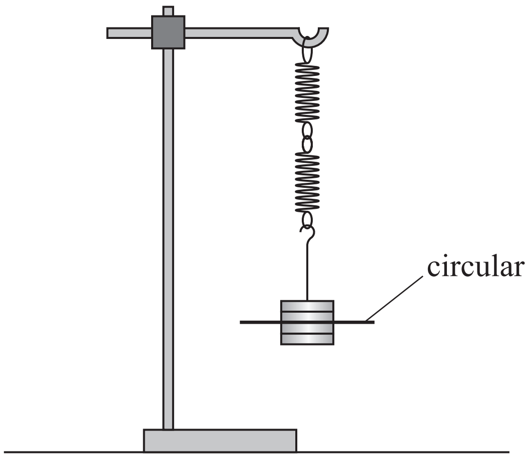
(b) The student modified the apparatus to investigate damped oscillations of the mass-spring system.

She placed a circular piece of card between the masses to act as a damper, as shown.



The amplitude A of the damped oscillations varies with the number n of oscillations as

$$A = A_0 e^{-\lambda n}$$

where A_0 is the initial amplitude and λ is a constant.

Devise a method to determine the time taken for A to decrease to half its initial value.

Your method should include the use of a suitable graph.

(6)

(Total for Question 2 = 13 marks)

3 The luminosity L of a main sequence star varies with the mass M of the star.

The relationship between L and M is given by

$$L = L_{\odot}\left(\frac{M}{M_{\odot}}\right)^{r}$$

where
$L_{\odot}$ is the luminosity of the Sun
$M_{\odot}$ is the mass of the Sun
r is a constant.

(a) Explain how a graph of $\log L$ against $\log \dfrac{M}{M_{\odot}}$ can be used to determine the value of r.

(2)

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(b) The data for six main sequence stars is given in the table.

$\dfrac{M}{M_{\odot}}$	L / 10^{35} W		
6.5	31 200		
3.2	3040		
1.7	235		
0.93	30.4		
0.78	16.2		
0.47	2.43		

(i) Plot a graph of $\log L$ against $\log \dfrac{M}{M_{\odot}}$ on the grid opposite.

Use the additional columns for your processed data.

Do **not** convert the values of L from 10^{35} W to W.

(6)

(ii) Determine the value of r from the graph.

(3)

$r =$ ....

(iii) Determine the value of $L_\odot$ from the graph.

(3)

$L_\odot =$ ....

(iv) A particular main sequence star has a mass of $33\,M_\odot$.

Determine the luminosity L of this star.

(2)

$L =$ ....

(Total for Question 3 = 16 marks)

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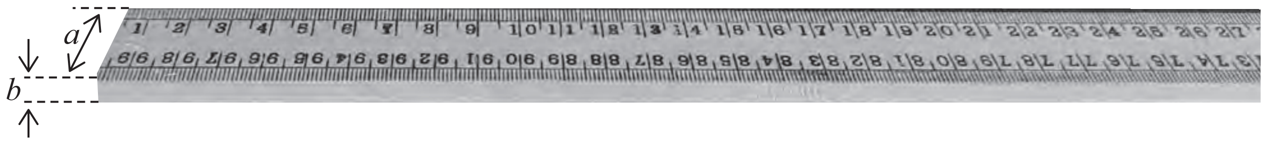
4 A student made measurements of a wooden metre rule. The width of the metre rule was a and the thickness of the metre rule was b, as shown.



(a) The student used digital calipers to measure a.

Explain one technique she should use to measure a.

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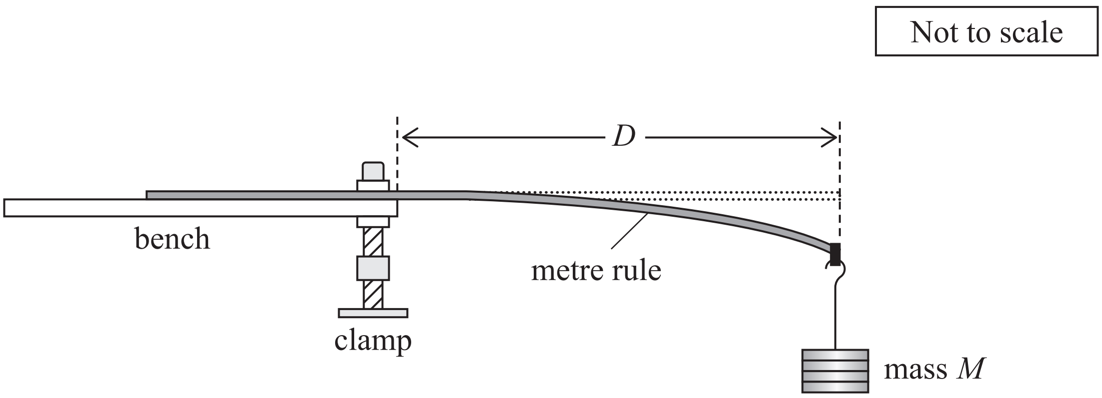
(b) The student clamped the metre rule to a bench. She attached a mass M at a distance D from the clamp, as shown below.



The student displaced the mass vertically and allowed it to oscillate.

She measured the time taken for 20 oscillations, $20T$, where T is the time for 1 oscillation. She repeated this measurement several times.

The metre rule is made from wood. The Young modulus E of the wood is given by the formula

$$E = \frac{16\pi^2 MD^3}{ab^3T^2}$$

(i) The student increased D and measured $20T$ several times again.

Explain how increasing D affects the percentage uncertainty in the measurement of $20T$.

(3)

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(ii) The student recorded the following data.

$M = 400\,\text{g}$
$D = 0.800\,\text{m} \pm 0.001\,\text{m}$
$a = 25.02\,\text{mm} \pm 0.05\,\text{mm}$
$b = 6.17\,\text{mm} \pm 0.02\,\text{mm}$
$T = 0.62\,\text{s} \pm 0.01\,\text{s}$

Show that E is about 14 GPa.

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(iii) Show that the percentage uncertainty in E is about 5%.

(3)

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(iv) The value of E for beech wood is 11.9 GPa.

Deduce whether the metre rule could be made from beech wood.

(2)

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(Total for Question 4 = 12 marks)

TOTAL FOR PAPER = 50 MARKS

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

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

$$v = u + at$$

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

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

Forces

$$\Sigma F = ma$$

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

$$W = mg$$

Momentum

$$p = mv$$

Moment of force

$$\text{moment} = Fx$$

Work and energy

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

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

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

Power

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

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

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Efficiency

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

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

Materials

Density $\rho = \dfrac{m}{V}$

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

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

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

Young modulus $E = \dfrac{\sigma}{\varepsilon}$ where

Stress $\sigma = \dfrac{F}{A}$

Strain $\varepsilon = \dfrac{\Delta x}{x}$

Unit 2

Waves

Wave speed $v = f\lambda$

Speed of a transverse wave on a string $v = \sqrt{\dfrac{T}{\mu}}$

Intensity of radiation $I = \dfrac{P}{A}$

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

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

Critical angle $\sin C = \dfrac{1}{n}$

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

Electricity

Potential difference $V = \dfrac{W}{Q}$

Resistance $R = \dfrac{V}{I}$

Electrical power, energy $P = VI$

$P = I^2R$

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

$W = VIt$

Resistivity $R = \dfrac{\rho l}{A}$

Current $I = \dfrac{\Delta Q}{\Delta t}$

$I = nqvA$

Resistors in series $R = R_1 + R_2 + R_3$

Resistors in parallel $\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Particle nature of light

Photon model $E = hf$

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

de Broglie wavelength $\lambda = \dfrac{h}{p}$

Unit 4

Further mechanics

Impulse	$F\Delta t = \Delta p$
Kinetic energy of a non-relativistic particle	$E_k = \dfrac{p^2}{2m}$
Motion in a circle	$v = \omega r$
	$T = \dfrac{2\pi}{\omega}$
	$a = \dfrac{v^2}{r}$
	$a = r\omega^2$
Centripetal force	$F = ma = \dfrac{mv^2}{r}$
	$F = mr\omega^2$

Electric and magnetic fields

Electric field	$E = \dfrac{F}{Q}$
Coulomb's law	$F = \dfrac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{V}{d}$
Electrical potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
Capacitance	$C = \dfrac{Q}{V}$
Energy stored in capacitor	$W = \dfrac{1}{2}QV$
	$W = \dfrac{1}{2}CV^2$
	$W = \dfrac{1}{2}\dfrac{Q^2}{C}$
Capacitor discharge	$Q = Q_0 e^{-t/RC}$

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Resistor-capacitor discharge	$I = I_0 e^{-t/RC}$
	$V = V_0 e^{-t/RC}$
	$\ln Q = \ln Q_0 - \frac{t}{RC}$
	$\ln I = \ln I_0 - \frac{t}{RC}$
	$\ln V = \ln V_0 - \frac{t}{RC}$
In a magnetic field	$F = Bqv \sin \theta$
	$F = BIl \sin \theta$
Faraday's and Lenz's laws	$\mathscr{E} = \frac{-\mathrm{d}(N\phi)}{\mathrm{d}t}$

Nuclear and particle physics

In a magnetic field	$r = \frac{p}{BQ}$
Mass-energy	$\Delta E = c^2 \Delta m$

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Unit 5

Thermodynamics

Heating	$\Delta E = mc\Delta\theta$
	$\Delta E = L\Delta m$
Ideal gas equation	$pV = NkT$
Molecular kinetic theory	$\frac{1}{2}m<c^2> = \frac{3}{2}kT$

Nuclear decay

Mass-energy	$\Delta E = c^2\Delta m$
Radioactive decay	$A = \lambda N$
	$\frac{dN}{dt} = -\lambda N$
	$\lambda = \frac{\ln 2}{t_{1/2}}$
	$N = N_0 e^{-\lambda t}$
	$A = A_0 e^{-\lambda t}$

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

Astrophysics and cosmology

Gravitational field strength	$g = \dfrac{F}{m}$
Gravitational force	$F = \dfrac{Gm_1m_2}{r^2}$
Gravitational field	$g = \dfrac{Gm}{r^2}$
Gravitational potential	$V_{\mathrm{grav}} = \dfrac{-Gm}{r}$
Stefan-Boltzmann law	$L = \sigma A T^4$
Wien's law	$\lambda_{\mathrm{max}} T = 2.898 \times 10^{-3}\,\mathrm{m\,K}$
Intensity of radiation	$I = \dfrac{L}{4\pi d^2}$
Redshift of electromagnetic radiation	$z = \dfrac{\Delta\lambda}{\lambda} \approx \dfrac{\Delta f}{f} \approx \dfrac{v}{c}$
Cosmological expansion	$v = H_0 d$

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