

Please check the examination details below before entering your candidate information

Candidate surname					Other names				
Centre Number					Candidate Number				

Pearson Edexcel International Advanced Level

Monday 22 January 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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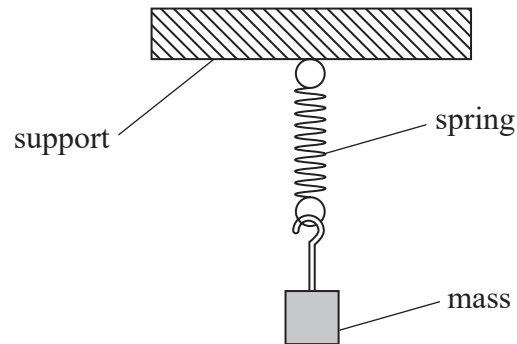
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Answer ALL questions.

- 1 A student investigated the oscillations of a stretched spring using the apparatus shown.

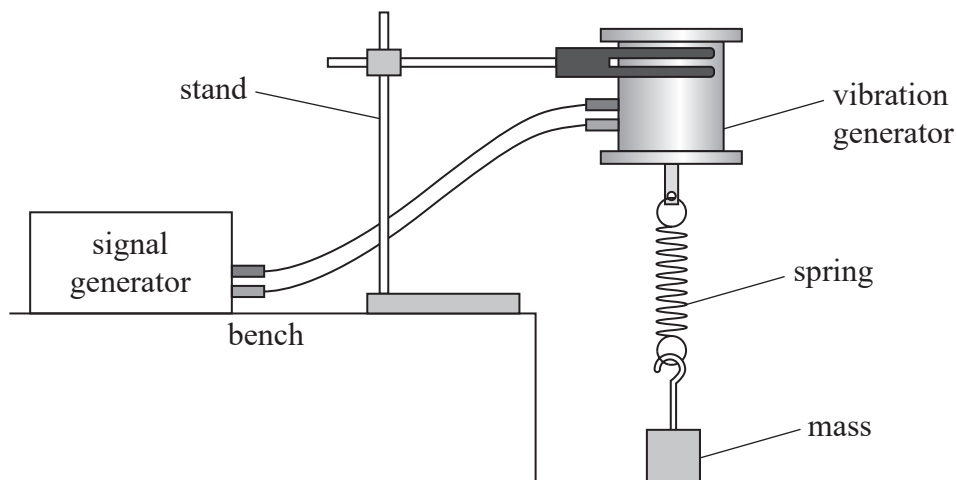


- (a) The student gave the mass a small vertical displacement and released it. She used a stopwatch to determine the time period T of the oscillations.

Describe how the student should determine an accurate value for T .

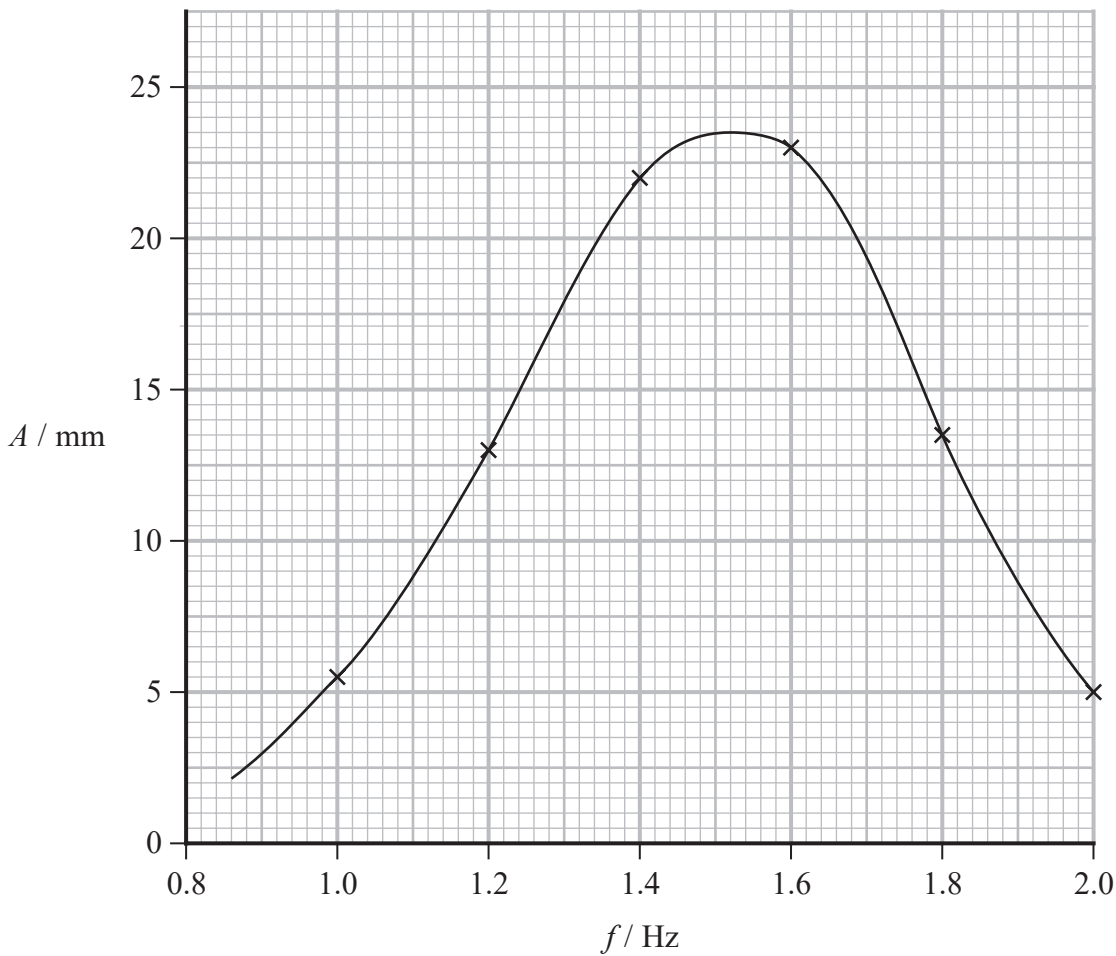
(3)

- (b) The student attached the spring to a vibration generator as shown.



The student used the signal generator to vary the frequency f of the forced oscillations.

The student measured the amplitude A of the oscillations at different values of f , near the resonant frequency f_0 . She plotted a graph of her results as shown.



(i) Determine the value of f_0 from the graph.

(1)

$f_0 = \dots\dots\dots$



(ii) Determine the value of the mass.

$$k = 30 \text{ N m}^{-1}$$

(3)

Mass =

(iii) Explain why your value of f_0 may not be accurate.

(2)

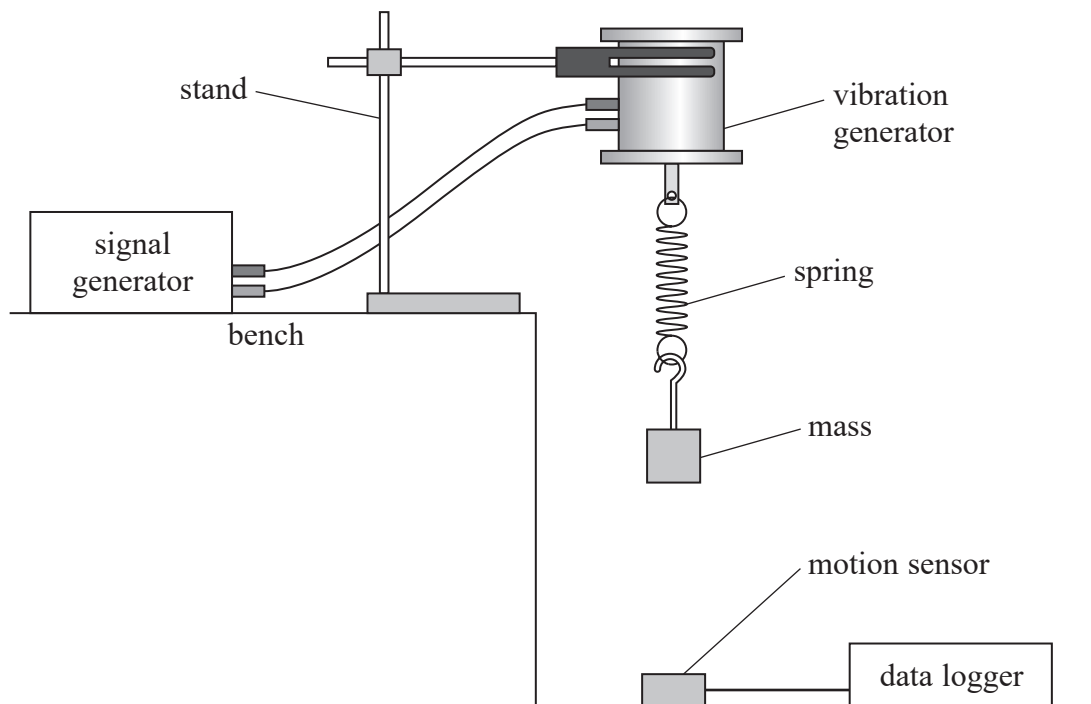
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- (c) The student suggested that a motion sensor and data logger, arranged as shown, would improve the experiment.



Explain how using a motion sensor and data logger would improve the experiment.

(2)

(Total for Question 1 = 11 marks)

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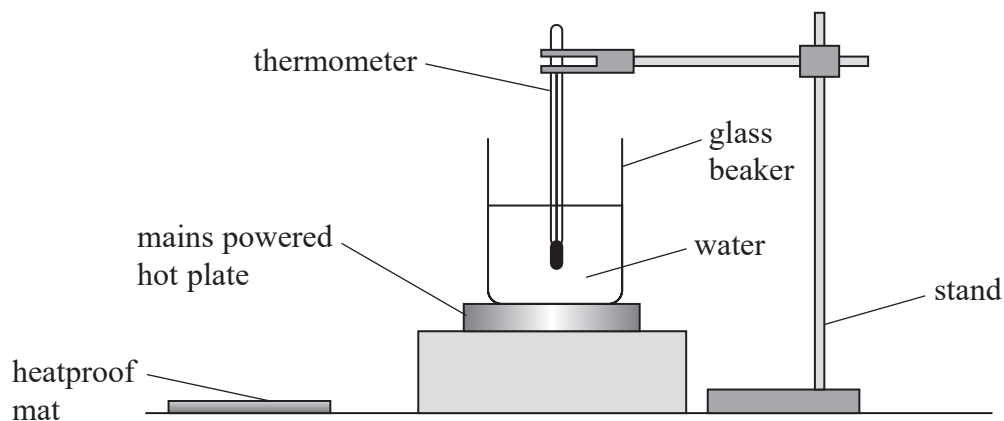
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- 2 A student investigated the cooling of hot water using the apparatus shown.



- (a) The student used the hot plate to heat the water until it boiled.

He moved the glass beaker onto the heatproof mat to allow the water to cool.

Identify **one** safety issue and how it may be dealt with.

(2)

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.....

- (b) The student suggested that the relationship between the temperature θ of the water and time t is

$$\theta = \theta_0 e^{-bt}$$

where θ_0 is the initial temperature of the water and b is a constant.

Devise a method to investigate the validity of this relationship.

Your method should use a suitable graph.

(6)

(Total for Question 2 = 8 marks)



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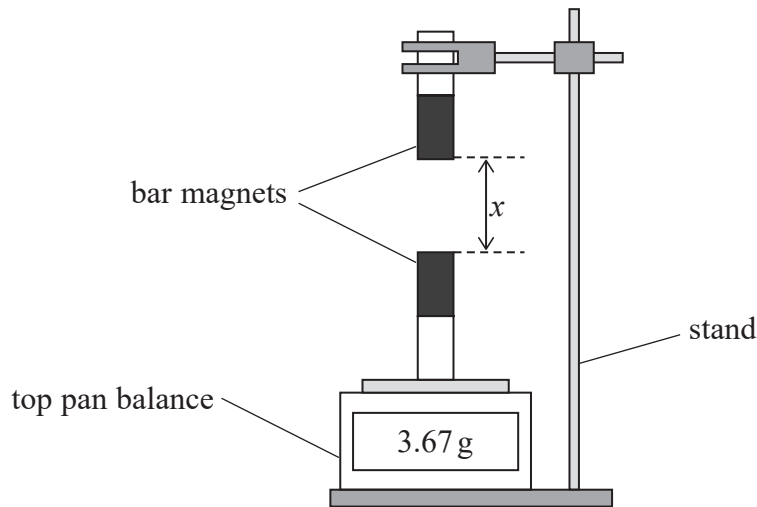
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- 3 A student investigated the force F between two bar magnets, using the apparatus shown. The magnets are separated by a distance x .



- (a) Describe an accurate method to measure a single value of x using a 30 cm ruler.

You should include any additional apparatus.

(3)

- (b) The student predicted that the relationship between F and x was of the form

$$F = kx^p$$

where k and p are constants.

Explain how a graph of $\log F$ against $\log x$ can be used to determine the value of p .

(2)



- (c) The student varied the distance x and determined the corresponding force F . He recorded the following data.

x / mm	F / mN		
102	11.22		
117	7.56		
128	5.25		
145	3.43		
166	2.09		
197	1.18		

- (i) Plot a graph of $\log F$ against $\log x$ on the grid opposite.

Use the additional columns for your processed data.

(6)

- (ii) Determine the gradient of the graph.

(3)

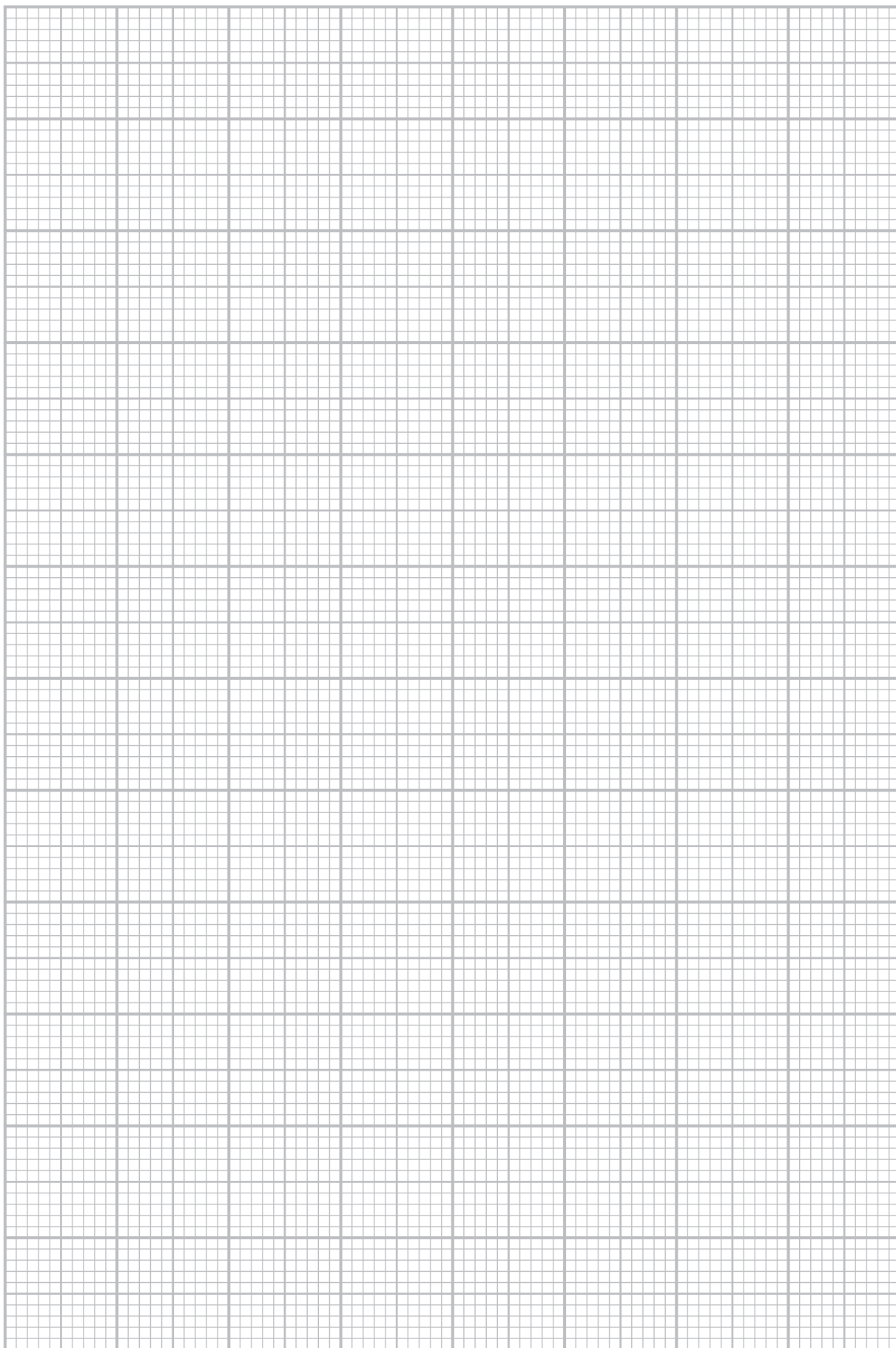
Gradient =



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- (iii) The student suggested that the relationship between F and x is an inverse square relationship.

Explain whether the graph supports this suggestion.

(3)

(Total for Question 3 = 17 marks)

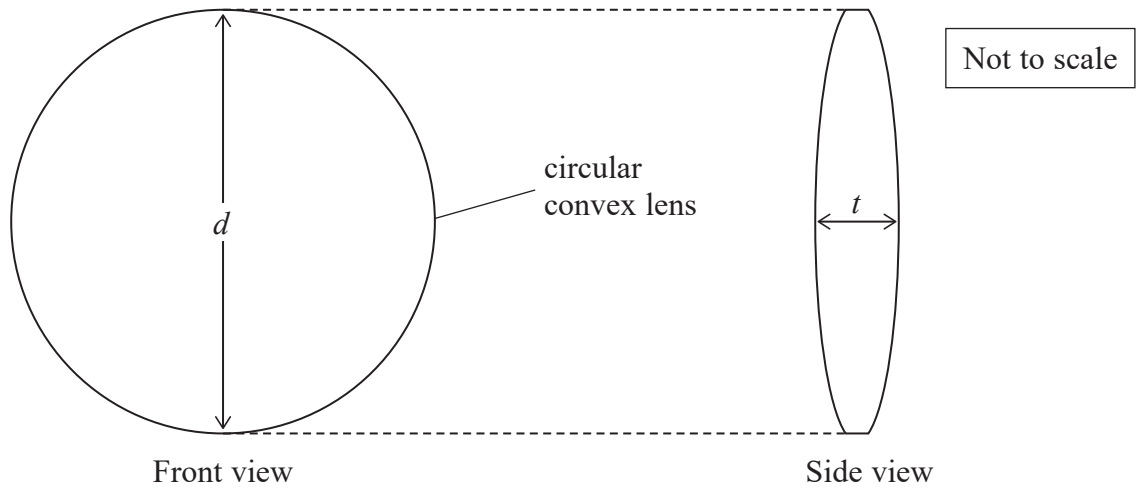
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- 4 A student made measurements of a circular convex lens, as shown.



- (a) (i) The student used vernier calipers to measure the diameter d .

Explain **one** technique she should use to measure d .

(2)

- (ii) The student estimated that the thickness t of the centre of the lens was approximately 5 mm.

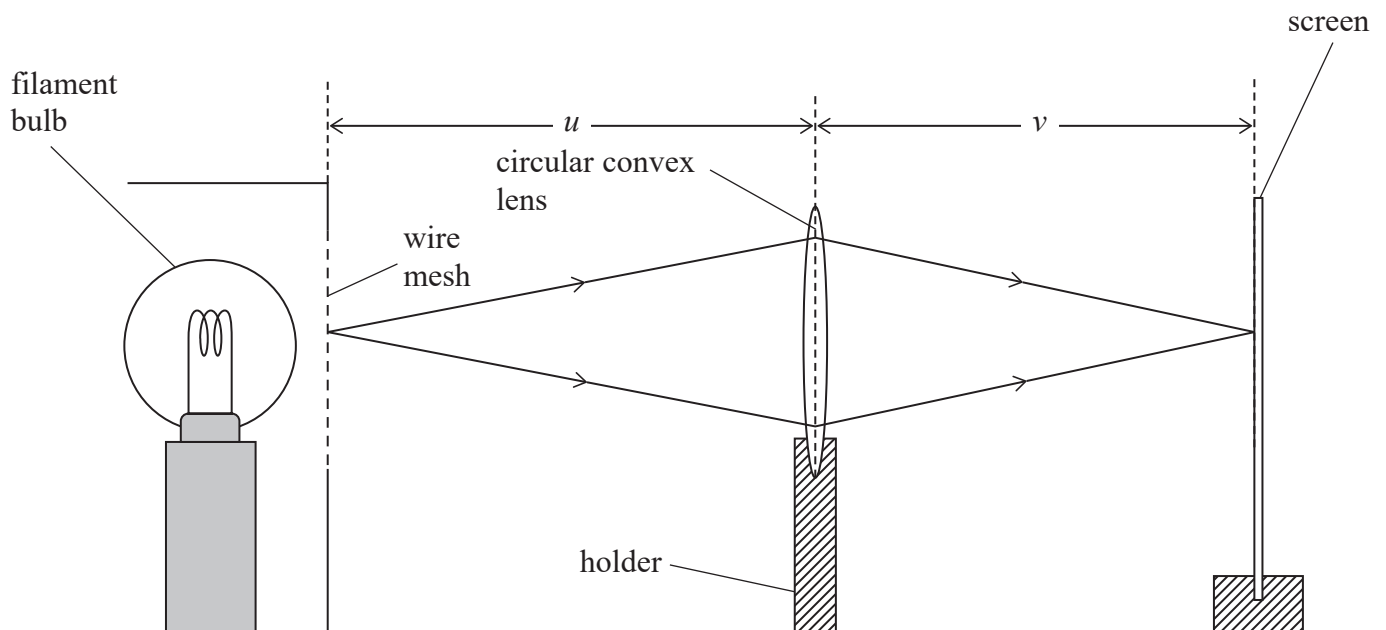
Explain the most appropriate instrument the student should use for a single measurement of t .

Your answer should include a calculation.

(2)



- (b) The student placed the circular convex lens in a holder. She set up the apparatus, as shown.



The student moved the position of the holder until the lens formed a sharp image of the wire mesh on the screen. She measured the distances u and v with a metre rule.

The student determined the focal length f of the lens using the formula

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

Show that the uncertainty in f is about 0.2 cm.

$$u = 29.6 \text{ cm} \pm 0.1 \text{ cm}$$

$$v = 19.2 \text{ cm} \pm 0.1 \text{ cm}$$

$$f = 11.6 \text{ cm}$$

(4)



- (c) The refractive index of the material used to make the lens is determined using the formula

$$n = 1 + \frac{d^2}{8tf}$$

$$d = 5.02 \text{ cm} \pm 0.02 \text{ cm}$$

$$t = 4.28 \text{ mm} \pm 0.01 \text{ mm}$$

$$f = 11.6 \text{ cm} \pm 0.2 \text{ cm}$$

- (i) Determine the value of n .

(2)

$$n = \dots\dots\dots$$

- (ii) Determine the percentage uncertainty in n .

(2)

$$\text{Percentage uncertainty in } n = \dots\dots\dots$$

- (iii) The refractive index of crown glass is 1.52

Deduce whether the lens could be made of crown glass.

(2)

(Total for Question 4 = 14 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	$k = 1/4\pi\epsilon_0$ $= 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$	
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	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$	
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

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

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

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

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

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

Stokes' law

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

Hooke's law

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

Elastic strain energy

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

Young modulus

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

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

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

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Unit 2*Waves*

Wave speed

$$v = f\lambda$$

Speed of a transverse wave
on a string

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

Intensity of radiation

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

Refractive index

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

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

Critical angle

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

Diffraction grating

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

Electricity

Potential difference

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

Resistance

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

Electrical power, energy

$$P = VI$$

$$P = I^2 R$$

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

$$W = VIt$$

Resistivity

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

Current

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

$$I = nqvA$$

Resistors in series

$$R = R_1 + R_2 + R_3$$

Resistors in parallel

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Particle nature of light

Photon model

$$E = hf$$

Einstein's photoelectric
equation

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

de Broglie wavelength

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

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Unit 4*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

$$v = \omega r$$

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

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

$$a = r\omega^2$$

Centripetal force

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

$$F = mr\omega^2$$

Electric and magnetic fields

Electric field

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

Coulomb's law

$$F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}$$

$$E = \frac{Q}{4\pi\epsilon_0 r^2}$$

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

Electrical potential

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

Capacitance

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

Energy stored in capacitor

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

$$W = \frac{1}{2} CV^2$$

$$W = \frac{1}{2} \frac{Q^2}{C}$$

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

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

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

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

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

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

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

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Astrophysics and cosmology

Gravitational field strength $g = \frac{F}{m}$

Gravitational force $F = \frac{Gm_1m_2}{r^2}$

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

Gravitational potential $V_{\text{grav}} = \frac{-Gm}{r}$

Stefan-Boltzmann law $L = \sigma AT^4$

Wien's law $\lambda_{\text{max}}T = 2.898 \times 10^{-3} \text{ m K}$

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

Redshift of electromagnetic radiation $z = \frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$

Cosmological expansion $v = H_0 d$

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