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

Pearson

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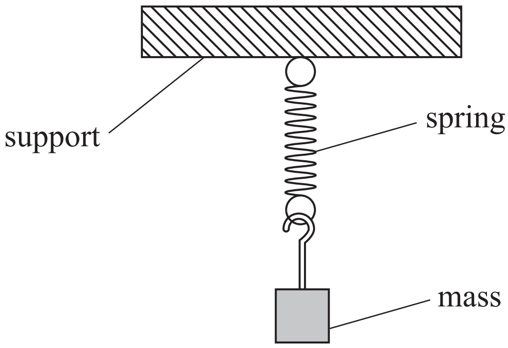
Answer ALL questions.

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.

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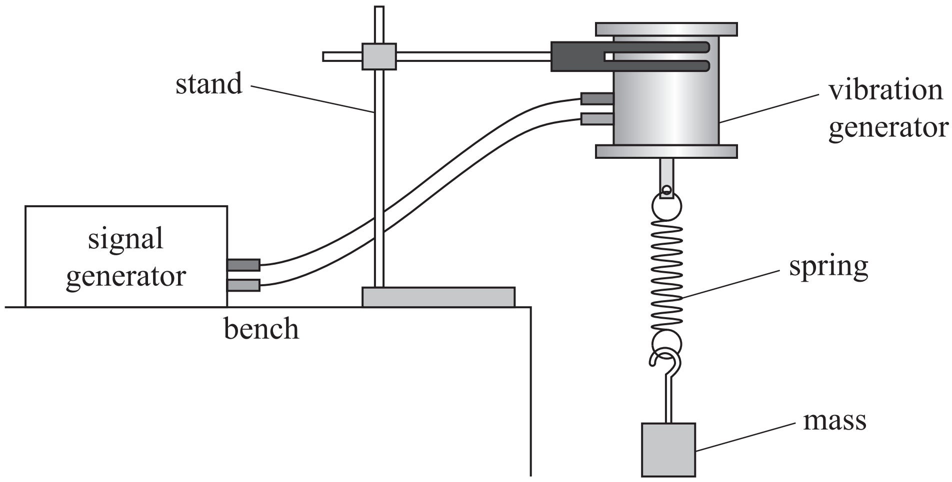
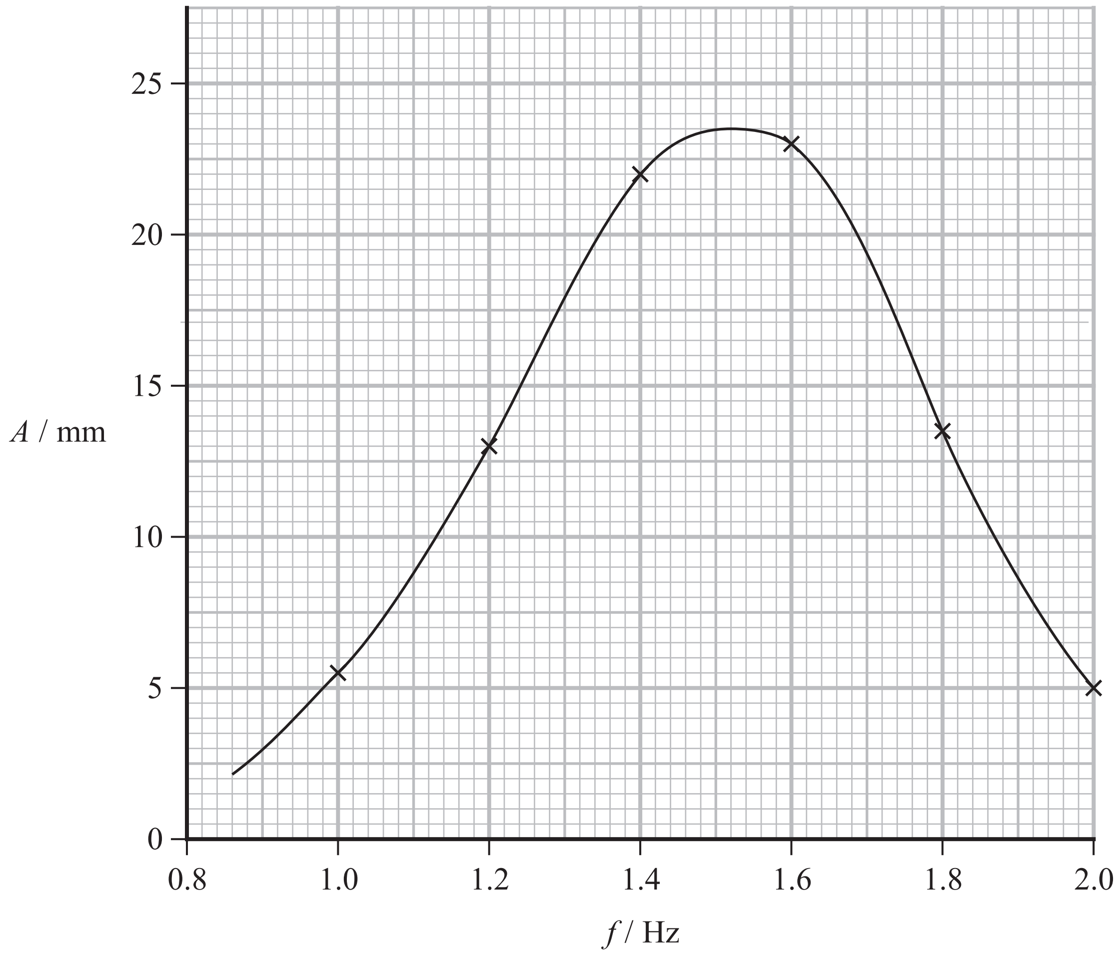
(b) The student attached the spring to a vibration generator as shown.



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 = ...

(ii) Determine the value of the mass.

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

(3)

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Mass = ...

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

(2)

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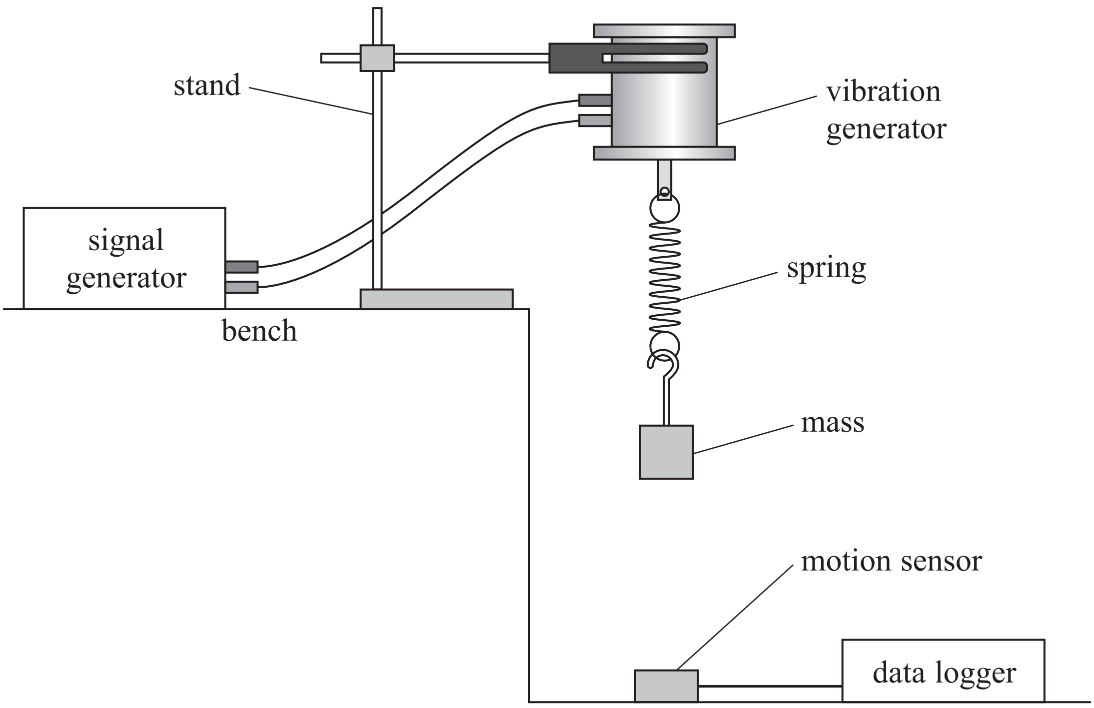
(c) The student suggested that a motion sensor and data logger, arranged as shown, would improve the experiment.



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

(2)

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(Total for Question 1 = 11 marks)

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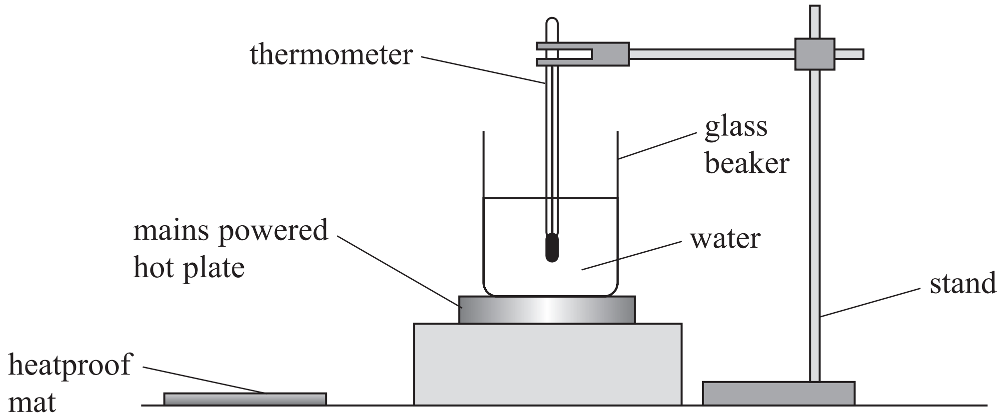
2 A student investigated the cooling of hot water using the apparatus shown.



(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)

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(Total for Question 2 = 8 marks)

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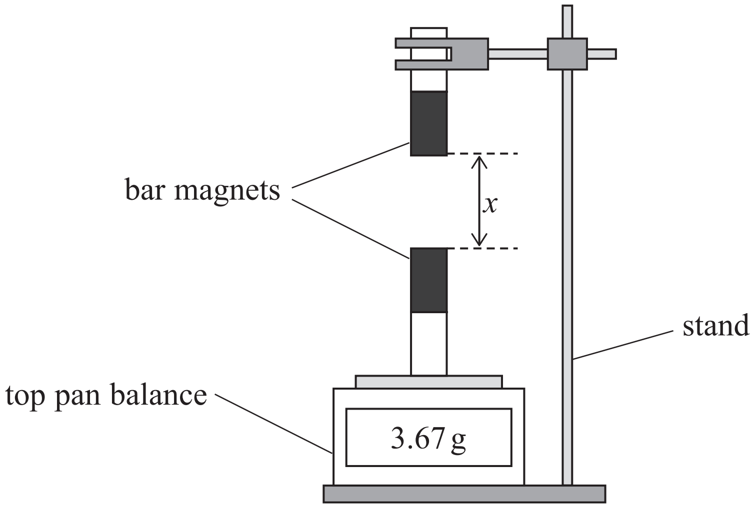
3 A student investigated the force F between two bar magnets, using the apparatus shown. The magnets are separated by a distance x.



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

You should include any additional apparatus.

(3)

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(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)

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(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)

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Gradient = ...

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

Explain whether the graph supports this suggestion.

(3)

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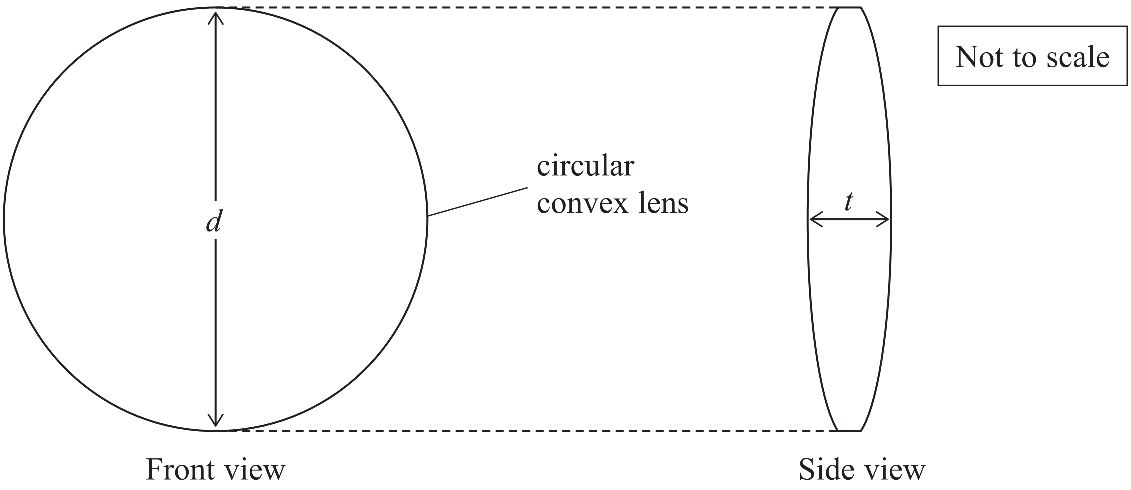
(Total for Question 3 = 17 marks)

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)

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(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)

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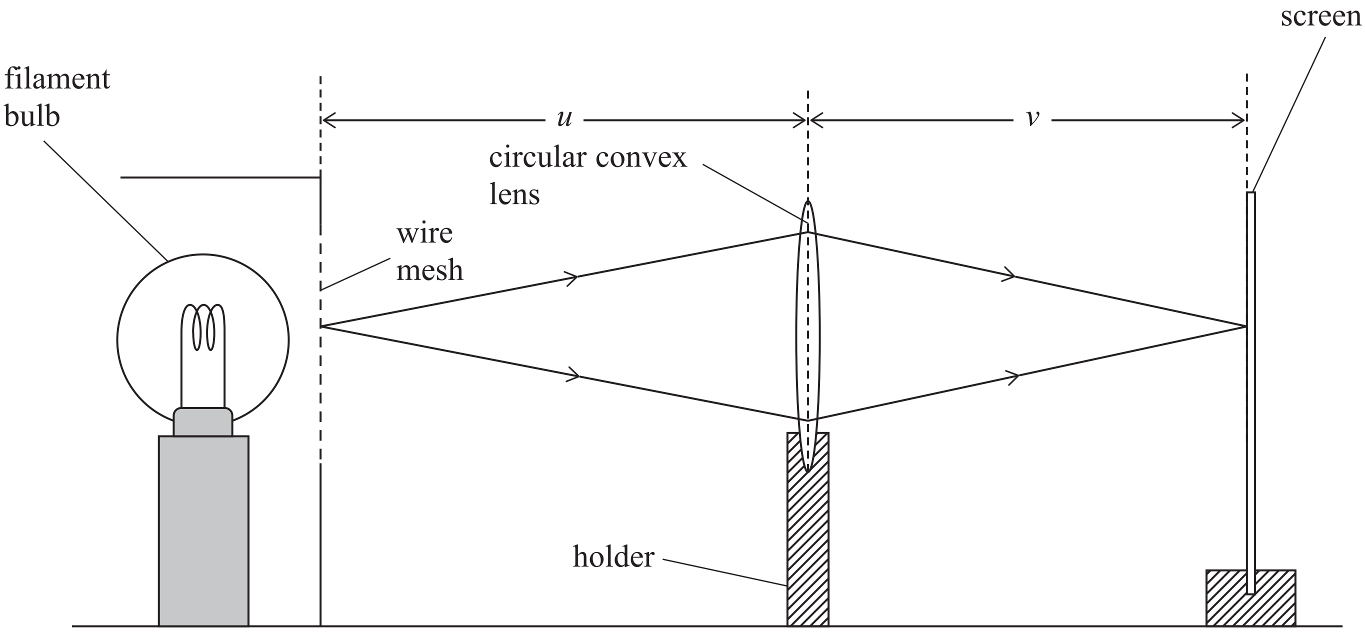
(b) The student placed the circular convex lens in a holder. She set up the apparatus, as shown.



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 cm ± 0.1 cm
v = 19.2 cm ± 0.1 cm
f = 11.6 cm

(4)

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(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)

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n = ...

(ii) Determine the percentage uncertainty in n.

(2)

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Percentage uncertainty in n = ...

(iii) The refractive index of crown glass is 1.52

Deduce whether the lens could be made of crown glass.

(2)

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(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	$k = 1/4\pi\varepsilon_0$	
	$= 8.99 \times 10^{9}\ \text{N m}^2\ \text{C}^{-2}$	
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

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

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

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 $F = 6\pi\eta r v$

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

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

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

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

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	$P = VI$
	$P = I^2R$
	$P = \frac{V^2}{R}$
	$W = VIt$
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	$hf = \phi + \frac{1}{2}mv^2_{max}$
de Broglie wavelength	$\lambda = \frac{h}{p}$

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	$F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{V}{d}$
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	$Q = Q_0 e^{-t/RC}$

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	$g = \frac{F}{m}$
Gravitational force	$F = \frac{Gm_1m_2}{r^2}$
Gravitational field	$g = \frac{Gm}{r^2}$
Gravitational potential	$V_{grav} = \frac{-Gm}{r}$
Stefan-Boltzmann law	$L = \sigma AT^4$
Wien's law	$\lambda_{max}T = 2.898 \times 10^{-3}\,\mathrm{m\,K}$
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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