

Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Pearson Edexcel International Advanced Level		Centre Number <div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; width: 20px; height: 20px;"></div> <div style="border: 1px solid black; width: 20px; height: 20px;"></div> <div style="border: 1px solid black; width: 20px; height: 20px;"></div> <div style="border: 1px solid black; width: 20px; height: 20px;"></div> <div style="border: 1px solid black; width: 20px; height: 20px;"></div> </div>	Candidate Number <div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; width: 20px; height: 20px;"></div> <div style="border: 1px solid black; width: 20px; height: 20px;"></div> <div style="border: 1px solid black; width: 20px; height: 20px;"></div> <div style="border: 1px solid black; width: 20px; height: 20px;"></div> </div>
Wednesday 23 January 2019			
Morning (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 ►

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

1 (a) A student measured the diameter d of a tennis ball using vernier calipers.

- (i) She closed the jaws of the calipers to check for a zero error. A zero error is a systematic error.

State what is meant by a systematic error.

(1)

- (ii) Comment on whether repeat measurements are appropriate for the measurement of diameter.

(2)

- (iii) The student obtained the following results.

d/cm	6.61	6.56	6.59	6.55
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The mean value of d was calculated as 6.58 cm.

Calculate the percentage uncertainty in the mean value of d .

(2)

Percentage uncertainty =



(iv) The volume V of the tennis ball is given by the equation

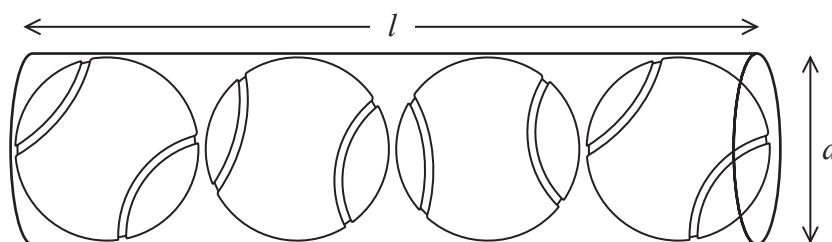
$$V = \frac{4}{3}\pi r^3$$

Calculate V and its uncertainty.

(3)

$$V = \dots \pm \dots$$

(b) The student bought a set of four of these tennis balls. The tennis balls were packed into a cylindrical tube of length l and internal diameter d as shown.



The packing fraction is defined as the ratio $\frac{\text{total volume of tennis balls}}{\text{volume of tube}}$.

(i) Show that the packing fraction for this arrangement is $2/3$

(3)



(ii) The volume of the tube is $1020 \pm 30 \text{ cm}^3$.

Determine whether the student's measurements confirm that the packing fraction is $\frac{2}{3}$
(4)

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(Total for Question 1 = 15 marks)

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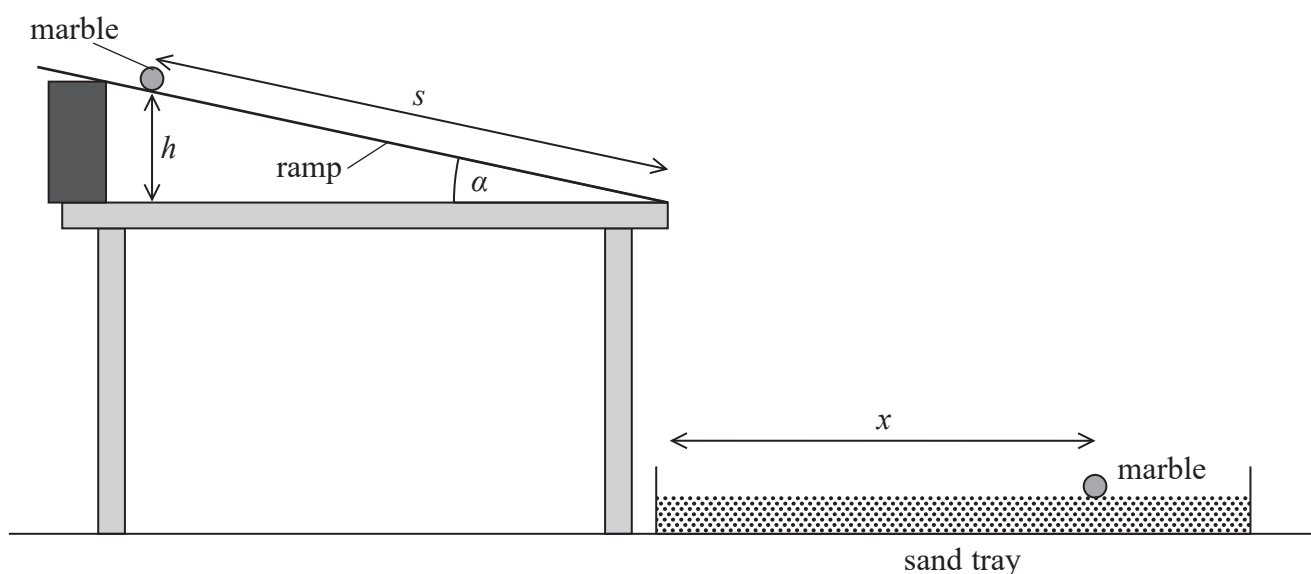
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- 2 The projectile motion of a marble can be investigated using the apparatus shown.



Some students investigate how the horizontal distance x the marble travels between the end of the ramp and where it lands in the sand tray is related to the angle of the ramp α .

- (a) The angle α is adjusted so that a marble at the top of the ramp just begins to roll.

Student A measures α with a protractor and records a value of 5° .

Student B measures the distances s and h with a metre rule and records s as 1.000 m and h as 8.7 cm. He calculates α from these measurements.

Explain whether student A or student B will obtain a more accurate value for α .

(4)



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(b) Describe how x should be measured. You may add to the diagram if you wish.

(2)

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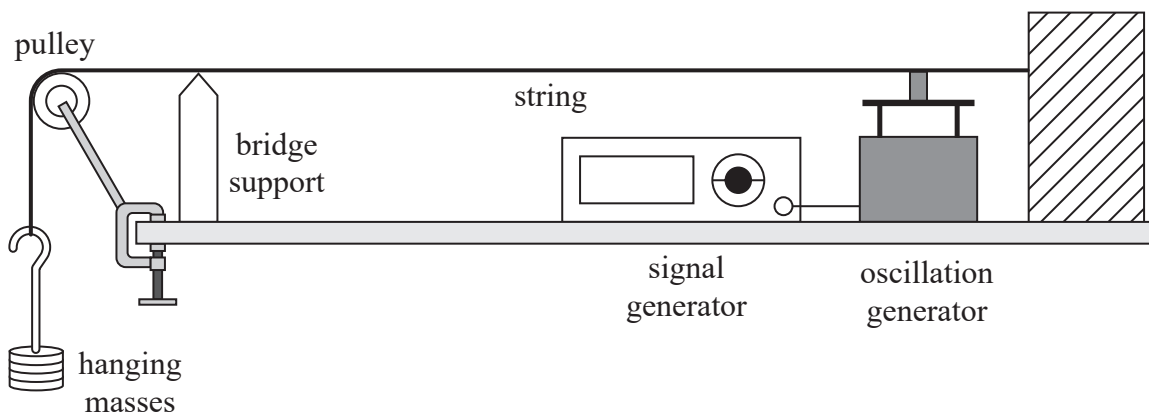
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(Total for Question 2 = 6 marks)



- 3 A student investigated the resonance of a string using the apparatus shown.



When the signal generator was switched on the string oscillated. The signal generator was adjusted until the string resonated.

- (a) State what is meant by resonance.

(2)

- (b) The student measured the resonant frequency f with different hanging masses.

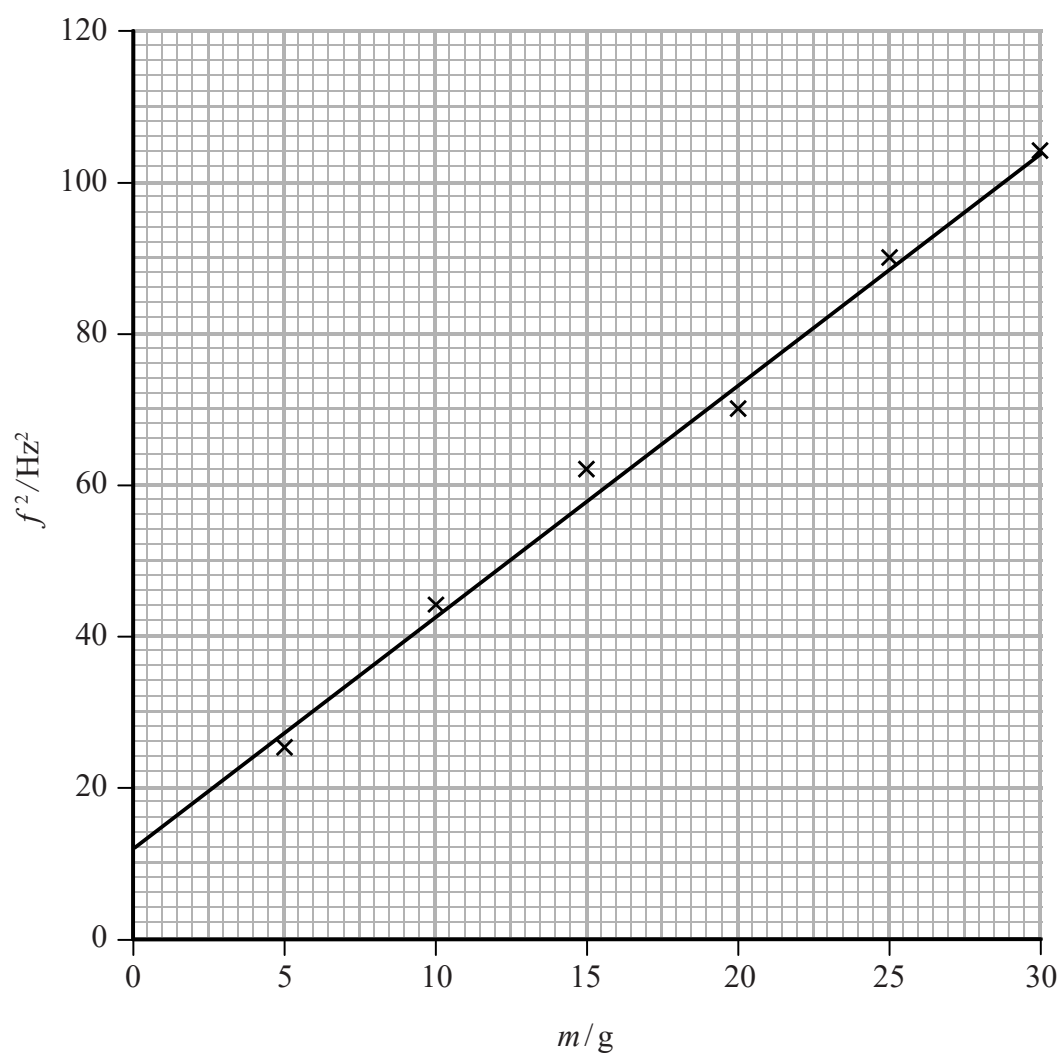
He predicted that f would vary as

$$f = k\sqrt{m}$$

where m is the mass of the hanging masses and k is a constant.

He plotted the following graph.





Discuss whether the graph supports the student's prediction.

(4)

(Total for Question 3 = 6 marks)



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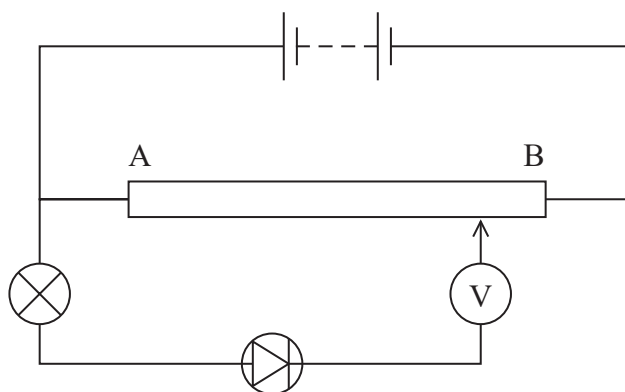
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- 4 A student investigated how the current I through a diode varies with the potential difference V across it. She set up the following circuit using a lamp to monitor the current.



- (a) Although the components were not faulty, when the slider was moved from A to B and the voltmeter reading changed from 0 V to 3 V, the lamp did not light.

(i) Explain this observation.

(3)

(ii) State how the circuit should be modified so that the lamp will light.

(1)

- (b) In the modified circuit, the student replaced the lamp with an ammeter and a resistor.

The relationship between I and V is

$$I = ae^{bV}$$

where a and b are constants.



Explain why plotting a graph of $\ln I$ against V will produce a straight line.

(2)

(c) The student obtained the following results.

V/V	I/mA	
0.641	20	
0.662	40	
0.673	60	
0.682	80	
0.690	100	
0.695	120	

(i) Plot a graph of $\ln I$ against V on the grid provided. Use the additional column to record your processed data.

(5)

(ii) Determine a value for b .

(2)

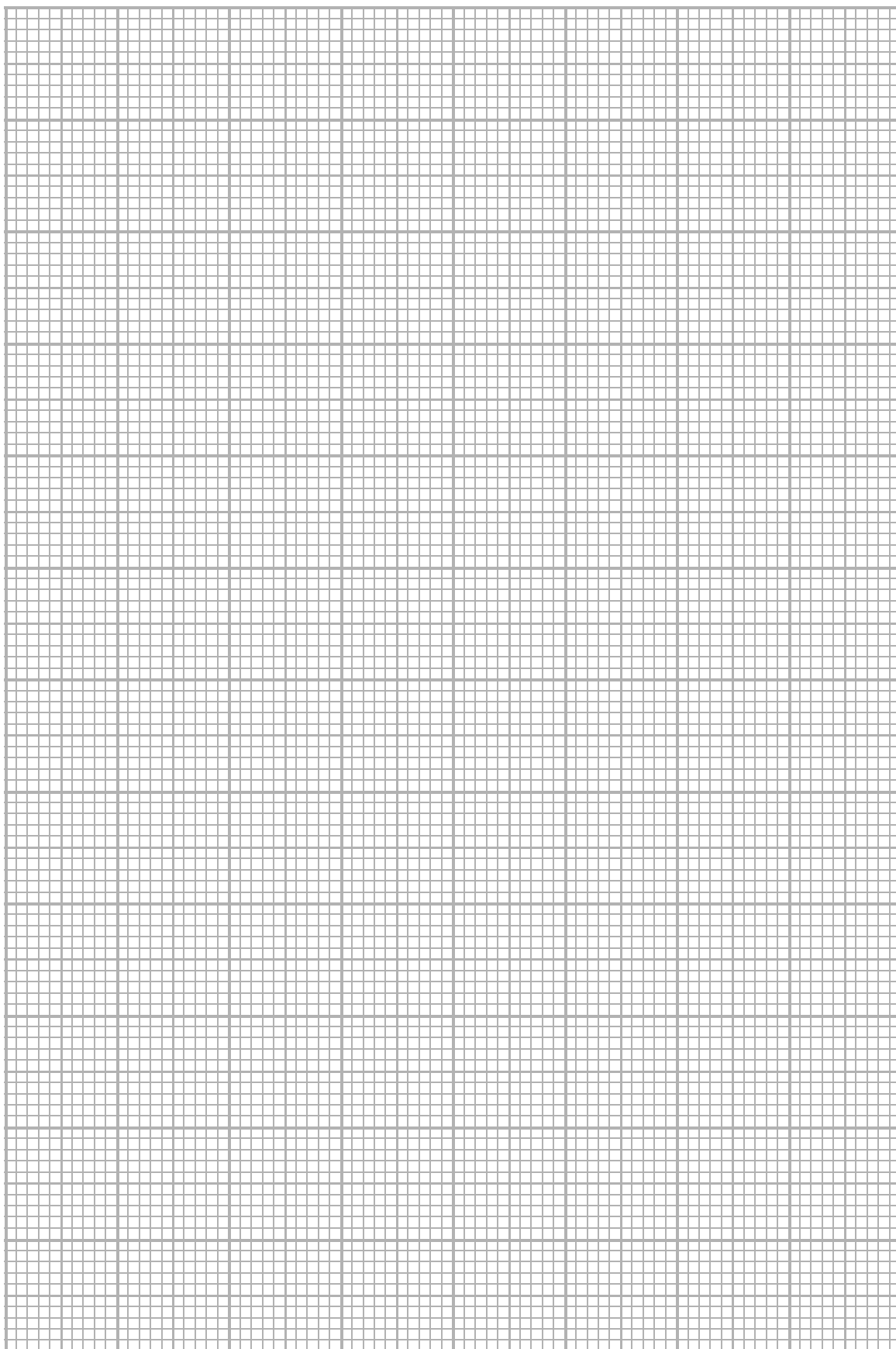
$b =$



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(Total for Question 4 = 13 marks)

TOTAL FOR PAPER = 40 MARKS



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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	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
Forces	$\Sigma F = ma$ $g = F/m$ $W = mg$
Work and energy	$\Delta W = F\Delta s$ $E_k = \frac{1}{2}mv^2$ $\Delta E_{\text{grav}} = mg\Delta h$

Materials

Stokes' law	$F = 6\pi\eta r v$
Hooke's law	$F = k\Delta x$
Density	$\rho = m/V$
Pressure	$p = F/A$
Young modulus	$E = \sigma/\epsilon$ where Stress $\sigma = F/A$ Strain $\epsilon = \Delta x/x$
Elastic strain energy	$E_{\text{el}} = \frac{1}{2}F\Delta x$



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

$$P = VI$$

$$P = I^2R$$

$$P = V^2/R$$

$$W = VIt$$

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

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

Resistivity

$$R = \rho l/A$$

Current

$$I = \Delta Q / \Delta t$$

$$I = nqvA$$

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

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



Unit 4*Mechanics*

Momentum

$$p = mv$$

Kinetic energy of a
non-relativistic particle

$$E_k = p^2/2m$$

Motion in a circle

$$v = \omega r$$

$$T = 2\pi/\omega$$

$$F = ma = mv^2/r$$

$$a = v^2/r$$

$$a = r\omega^2$$

Fields

Coulomb's law

$$F = kQ_1Q_2/r^2 \text{ where } k = 1/4\pi\epsilon_0$$

Electric field

$$E = F/Q$$

$$E = kQ/r^2$$

$$E = V/d$$

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

$$F = BIl \sin \theta$$

$$F = Bqv \sin \theta$$

$$r = p/BQ$$

Faraday's and Lenz's laws

$$\epsilon = -d(N\phi)/dt$$

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	$dN/dt = -\lambda N$
	$\lambda = \ln 2/t_{1/2}$
	$N = N_0 e^{-\lambda t}$

Mechanics

Simple harmonic motion	$a = -\omega^2 x$ $a = -A\omega^2 \cos \omega t$ $v = -A\omega \sin \omega t$ $x = A \cos \omega t$ $T = 1/f = 2\pi/\omega$
Gravitational force	$F = Gm_1 m_2 / r^2$

Observing the universe

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

