

Write your name here

Surname

Other names

**Pearson Edexcel**  
**International**  
**Advanced Level**

Centre Number

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Candidate Number

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# Physics

**Advanced**

**Unit 6: Experimental Physics**

Thursday 19 May 2016 – Afternoon

**Time: 1 hour 20 minutes**

Paper Reference

**WPH06/01**

**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.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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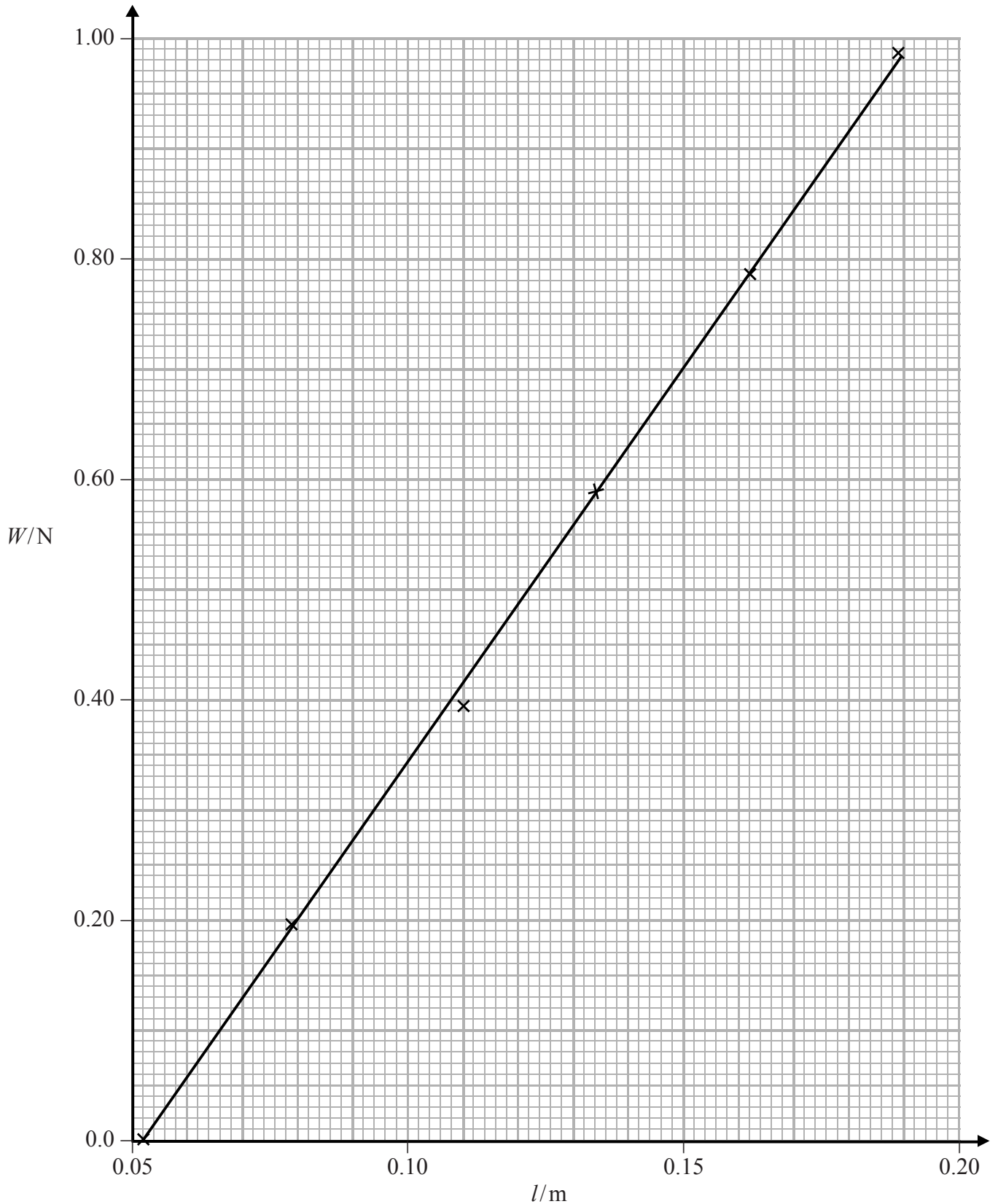


**PEARSON**

Answer ALL questions in the spaces provided.

- 1 A student measured the length  $l_0$  of a spring. She suspended different weights  $W$  from the spring and measured the new length  $l$  each time.

She drew a graph of  $W$  against  $l$ . She measured the gradient of the line of best fit as  $7.14 \text{ Nm}^{-1}$ .



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- (a) She measured  $l_0$  using a metre rule and recorded  $l_0 = 5.2$  cm.  
Explain why a metre rule is a suitable instrument to make this measurement.

(2)

- (b) (i) The student suspended a piece of modelling clay from the spring. She recorded the new length of the spring as  $l = 14.3$  cm.

Determine the weight  $W_1$  of the clay.

(1)

$$W_1 = \dots\dots\dots$$

- (ii) The student estimated the uncertainty in  $l$  as 2 mm. Use this uncertainty and the graph to estimate the uncertainty in your value for  $W_1$ .

(2)

$$\text{Uncertainty} = \dots\dots\dots$$

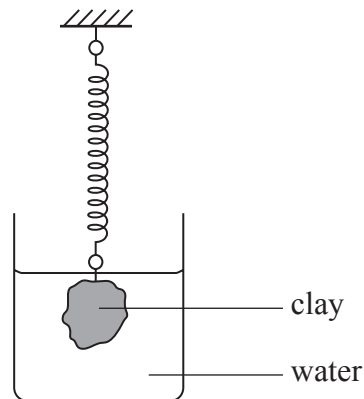
- (iii) Calculate the percentage uncertainty in your value for  $W_1$ .

(1)

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



- (c) The student immersed the clay in water as shown in the diagram. The upthrust of the water on the clay reduced the force of the clay on the spring to a new value  $W_2$  and so  $l$  was also reduced.



- (i) On the diagram draw and label the three forces acting on the clay. (1)

- (ii) When the clay was immersed the student recorded  $l = 9.1$  cm.

Determine  $W_2$ . (1)

$W_2 = \dots\dots\dots$



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(d) The ratio  $\frac{\text{Density of clay}}{\text{Density of water}} = \frac{W_1}{W_1 - W_2}$

density of water = 1000 kg m<sup>-3</sup>

Calculate a value for the density of clay.

(2)

.....

.....

.....

Density of clay = .....

(e) The manufacturer's value for the density of this clay is 1680 kg m<sup>-3</sup>.

Comment on the accuracy of your result.

(3)

.....

.....

.....

.....

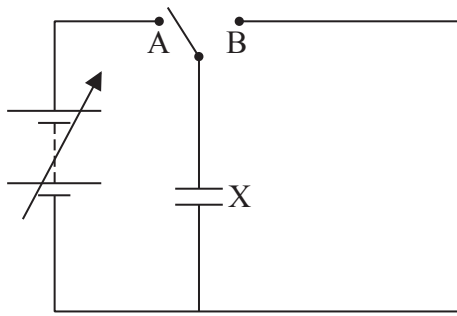
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**(Total for Question 1 = 13 marks)**



2 Part of an electric circuit is shown.



When the switch is connected to terminal A the capacitor X is connected to the variable power supply.

- (a) (i) Add a second capacitor Y to the circuit so that it is connected in parallel with X when the switch is moved to B. (1)
- (ii) Add a voltmeter so that the potential difference (p.d.) across X can be measured when the switch is in either position. (1)
- (b) The capacitance of X is  $C_X$ . If  $C_X$  is known, this circuit can be used to determine the capacitance  $C_Y$  of capacitor Y using the equation

$$V_2 = \frac{C_X}{C_Y} (V_1 - V_2)$$

where

- $V_1$  is the p.d. across X when it is connected to the power supply
- $V_2$  is the p.d. across X when Y is connected in parallel with it.

Write a plan for an experiment using this circuit and a graphical method to determine  $C_Y$ .

Your plan should include

- (i) the readings you would take (2)
- (ii) the graph you would plot and how you would use the graph to determine  $C_Y$  (2)
- (iii) how you would ensure the capacitors would not be damaged during the experiment (1)
- (iv) a precaution you would take to ensure the results are accurate. (1)

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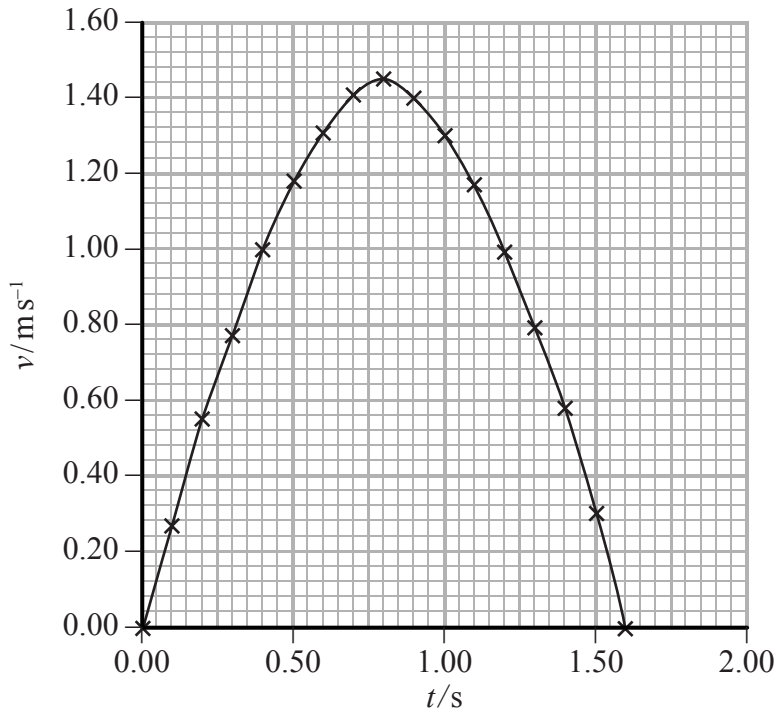
(Total for Question 2 = 8 marks)



- 3 A pendulum is made using a heavy mass suspended on a length of string. The pendulum was suspended from a high ceiling. The pendulum was pulled to one side to a maximum displacement and released.

The velocity  $v$  of the mass and the corresponding time  $t$  were recorded using a sensor and a data logger. Readings were recorded from the instant the pendulum was released.

The readings were plotted on the graph shown.



- (a) (i) Determine the time period  $T$  of the pendulum.

(1)

$T = \dots\dots\dots$

- (ii) State the value for  $t$  when the pendulum is at the centre of the oscillation.

(1)

$t = \dots\dots\dots$

- (iii) Explain why the graph has a horizontal tangent at  $t = 0.80$  s.

(2)

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- (b) (i) Draw a tangent to the graph at  $t = 0.40$  s and use it to calculate the acceleration at this point. (2)

Acceleration = .....

- (ii) State the next time the mass had the same magnitude of acceleration as in (b)(i). (1)

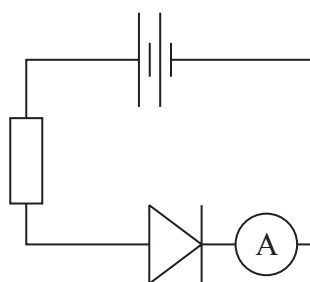
$t =$  .....

- (c) State **one** advantage of using a data logger. (1)

(Total for Question 3 = 8 marks)



- 4 The diode connected in the circuit shown will allow a current to flow.



For a constant potential difference, the current  $I$  and the temperature  $T$  of the diode are related by

$$I = I_0 e^{-\frac{p}{T}}$$

where  $I_0$  and  $p$  are constants and  $T$  is measured in kelvin.

- (a) Explain why a graph of  $\ln I$  against  $1/T$  should produce a straight line.

(2)

- (b) A student carried out an experiment using this circuit. He recorded  $I$  and the temperature  $\theta$  of the diode for different values of  $\theta$  measured in  $^{\circ}\text{C}$ . The results are shown in the table.

$\theta/^{\circ}\text{C}$	$I/\text{mA}$			
0	1.2			
20	3.0			
40	6.0			
60	12.5			
80	22.6			
100	41.7			

- (i) Draw on the grid opposite a graph of  $\ln I$  against  $1/T$ . Use the columns in the table for your processed data.

(4)

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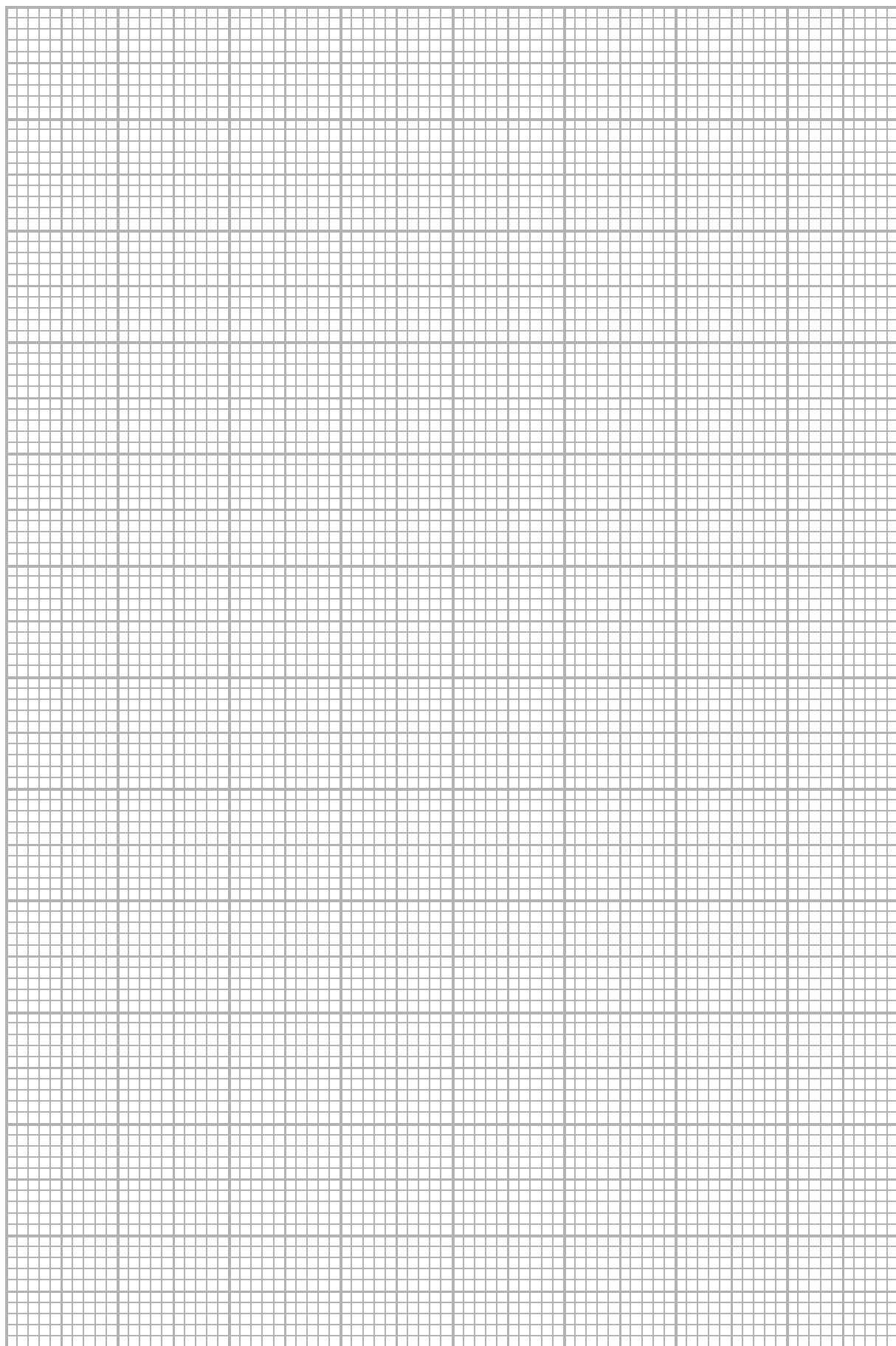
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(ii) Use your graph to determine a value for  $p$ .

(2)

$p =$  .....

(iii) Theory suggests that the electron charge  $e$  is given by  $e = \frac{kp}{V}$

where  $k$  is the Boltzmann constant and  $V = 0.32$  V.

Calculate a value for  $e$ .

(1)

$e =$  .....

(iv) Comment on the accuracy of the result.

(2)

**(Total for Question 4 = 11 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	$F = 6\pi\eta rv$
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

$$P = VI$$

$$P = I^2R$$

$$P = V^2/R$$

$$W = VI t$$

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

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

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

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**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	$F = kQ_1Q_2/r^2$ 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	$\lambda = h/p$

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**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  $v = H_0 d$

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