

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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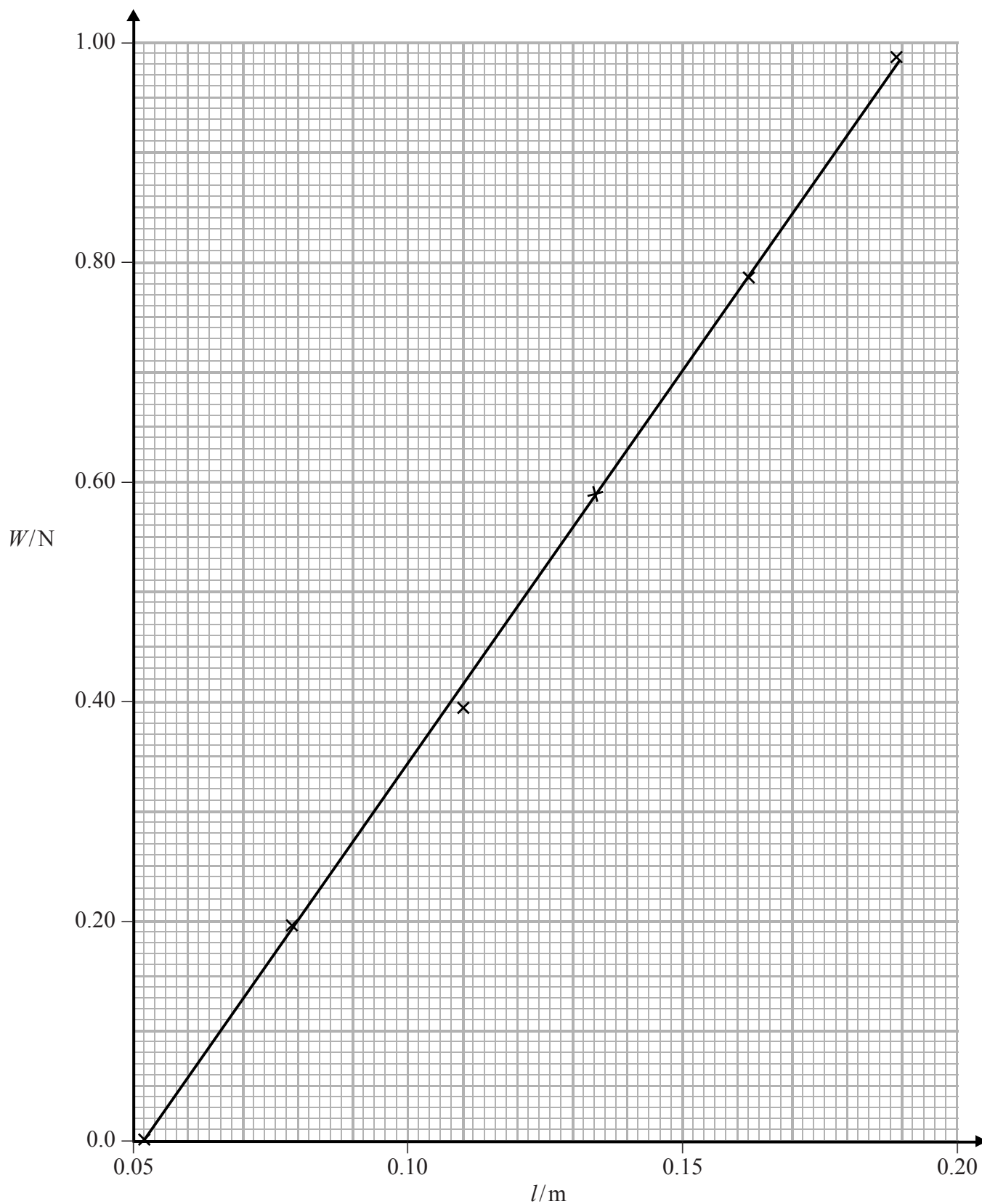


**PEARSON**

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)

 $W_1 =$  .....

- (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)

Uncertainty = .....

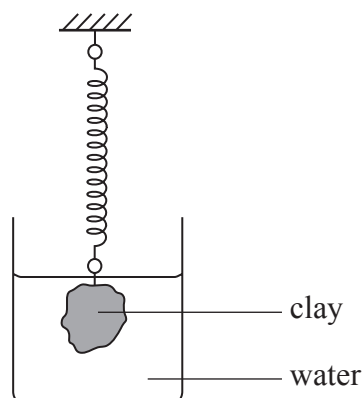
- (iii) Calculate the percentage uncertainty in your value for  $W_1$ .

(1)

Percentage uncertainty = .....



- (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)

$W_2 =$  .....



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

density of water =  $1000 \text{ kg m}^{-3}$

Calculate a value for the density of clay.

(2)

Density of clay = .....

(e) The manufacturer's value for the density of this clay is  $1680 \text{ kg m}^{-3}$ .

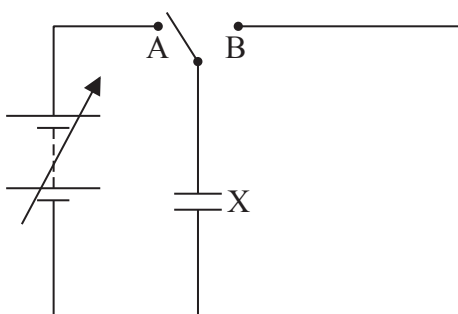
Comment on the accuracy of your result.

(3)

(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)

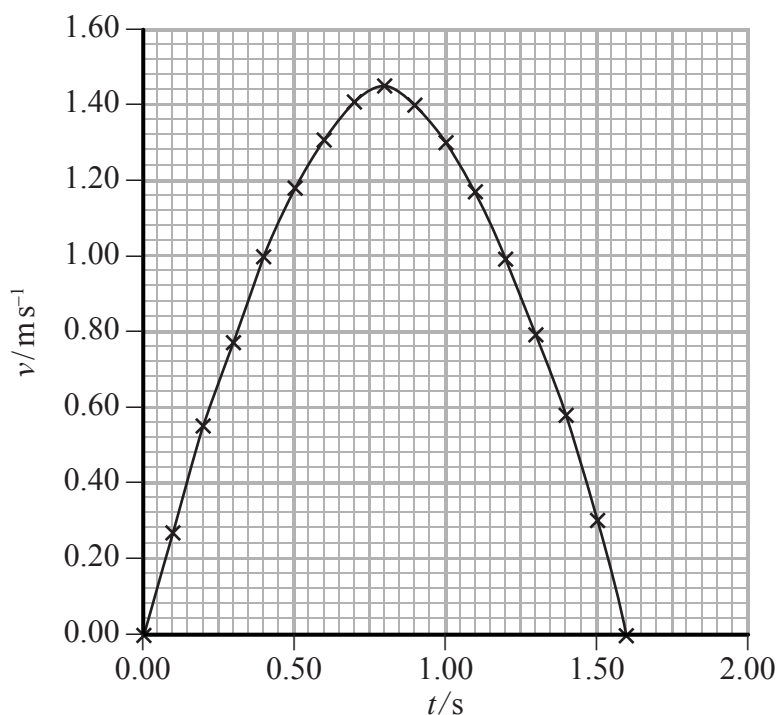


P 4 6 6 5 5 A 0 7 1 6

- 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)

$T =$  .....

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

(1)

$t =$  .....

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

(2)



- (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)

$t =$  .....

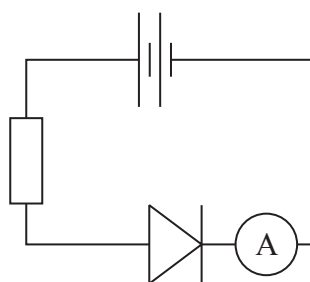
- (c) State **one** advantage of using a data logger.

(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.

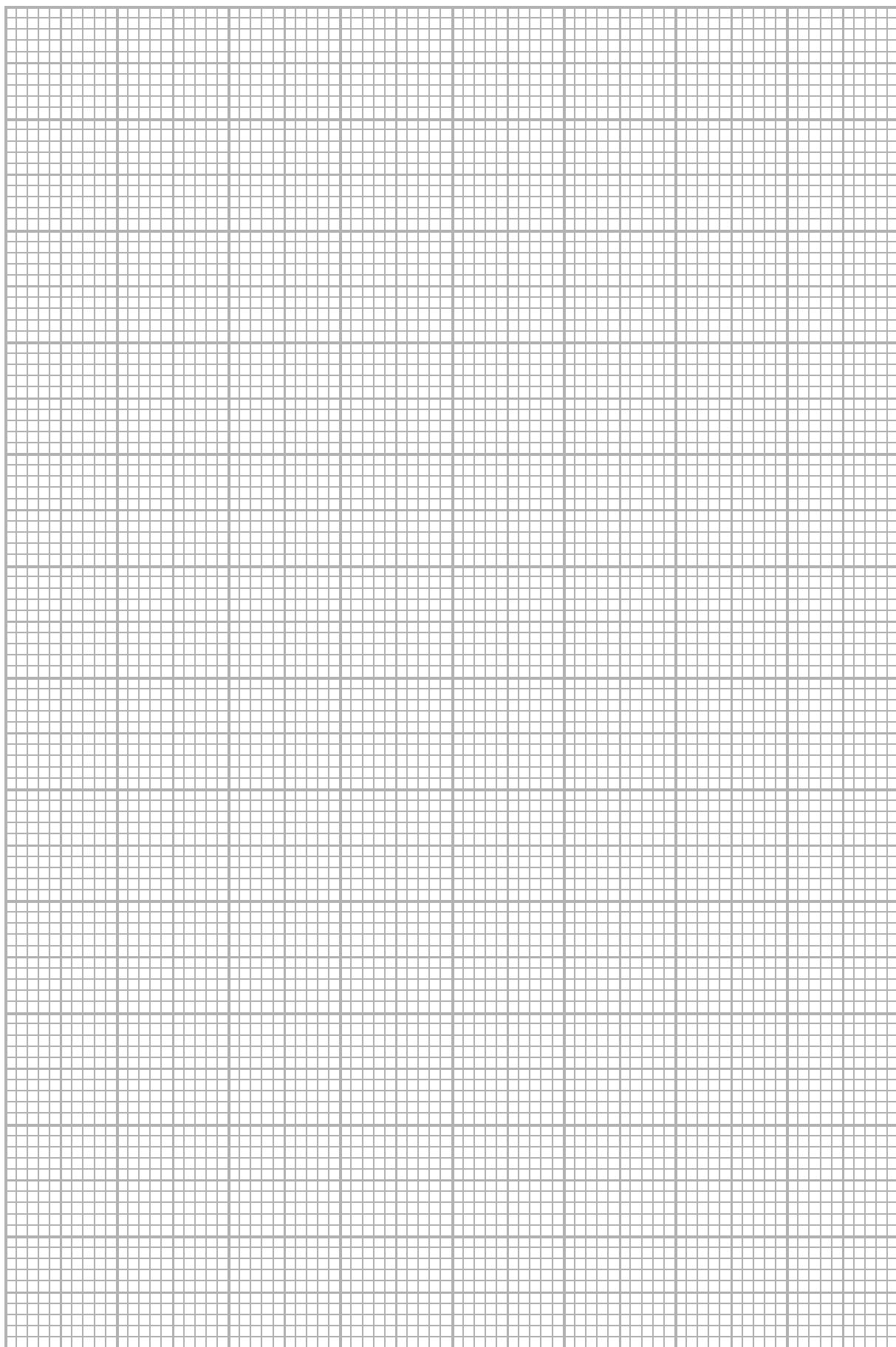
(4)



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(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**



### 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       | $k = 1/4\pi\epsilon_0$<br>$= 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$ |                            |
| 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 | $v = u + at$<br>$s = ut + \frac{1}{2}at^2$<br>$v^2 = u^2 + 2as$                            |
| Forces                        | $\Sigma F = ma$<br>$g = F/m$<br>$W = mg$                                                   |
| Work and energy               | $\Delta W = F\Delta s$<br>$E_k = \frac{1}{2}mv^2$<br>$\Delta E_{\text{grav}} = mg\Delta h$ |

#### 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<br>Stress $\sigma = F/A$<br>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                | $v = H_0 d$                                                |

