Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Physics

Advanced

Unit 4: Physics on the Move

Thursday 28 January 2010 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
6PH04/01

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 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- 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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SECTION A

Answer ALL questions.

For questions 1–7, in Section A, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 A particle completes 6.0 revolutions in 4.0 s. The angular velocity, in rad s^{-1}, is

☒ **A** 1.5

☒ **B** 9.4

☒ **C** 24

☒ **D** 150

(Total for Question 1 = 1 mark)

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2 Which of the following is equivalent to the unit for energy?

☒ **A** kg m^2 s^{-2}

☒ **B** kg m s^{-2}

☒ **C** N s^2 kg^{-1}

☒ **D** N^2 s^2

(Total for Question 2 = 1 mark)

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3 A radium nucleus decays by emitting an alpha particle. The speed of the recoiling nucleus is small compared to the speed of the alpha particle. This is because the

☒ **A** force acting on the recoiling nucleus is smaller than the force acting on the alpha particle

☒ **B** momentum is mainly concentrated in the alpha particle

☒ **C** momentum of the recoiling nucleus is smaller than the momentum of the alpha particle

☒ **D** recoiling nucleus has a much larger mass than the alpha particle

(Total for Question 3 = 1 mark)

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4 The potential difference across a capacitor is V. The energy stored on the capacitor is X joules. The potential difference across this capacitor is increased to 3 V. The energy stored, in joules, is increased to

- **A** $3X$
- **B** $6X$
- **C** $9X$
- **D** $27X$

(Total for Question 4 = 1 mark)

5 Figure 1 shows a vertical plane square coil of 50 turns, carrying a current of 3.0 A. The length of each side of the coil is 4.0 cm. Figure 2 shows a view of this coil from above within a horizontal magnetic field of flux density 0.20 T.

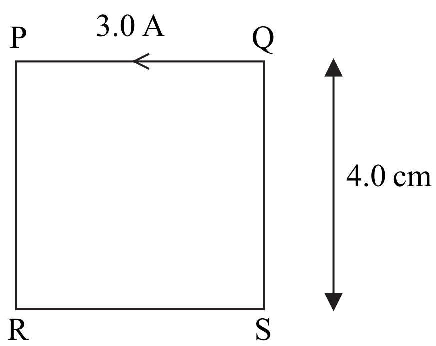


Figure 1

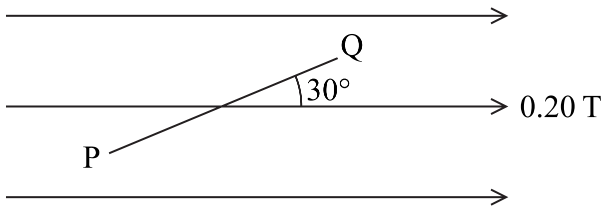


Figure 2

The force on side QS is

- **A** 120 N
- **B** 60 N
- **C** 1.2 N
- **D** 0.60 N

(Total for Question 5 = 1 mark)

6 An electron gun uses a potential difference to accelerate electrons from rest to a speed of 2.00×10^7 m s^{-1}.

(i) The potential difference is

☒ **A** 569 V

☒ **B** 1140 V

☒ **C** 2280 V

☒ **D** 4560 V

(ii) The de Broglie wavelength associated with electrons moving at 2.00×10^7 m s^{-1} is

☒ **A** 3.3×10^{-41} m

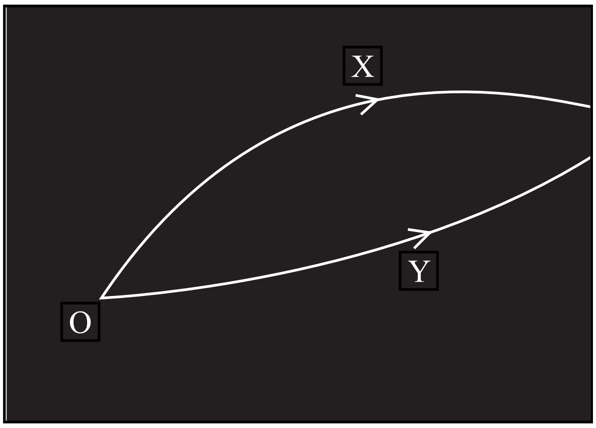
☒ **B** 5.0×10^{-14} m

☒ **C** 3.6×10^{-11} m

☒ **D** 5.0×10^{-8} m

(Total for Question 6 = 2 marks)

7 A particle detector shows tracks produced by two particles X and Y that were created by the decay of a lambda particle at O.



(i) Which of the following is a valid conclusion from these facts?

☒ **A** X is a negatively charged particle.

☒ **B** Y is a positively charged particle.

☒ **C** The lambda particle is neutral.

☒ **D** The magnetic field is acting into the plane of the paper.

(ii) Which of the following is a correct statement about momentum at the decay?

☒ **A** The vector sum of the momenta of X and Y must equal that of the lambda particle.

☒ **B** The momentum of X is equal to that of Y.

☒ **C** The total momentum of this system is zero.

☒ **D** The vector sum of the momenta of X and Y must equal zero.

(iii) Which of the following is a correct statement about energy at the decay?

☒ **A** The energy of X must be greater than that of Y.

☒ **B** The combined energy of X and Y must be more than the energy of the lambda particle.

☒ **C** The mass of the lambda particle must equal the combined energy of X and Y.

☒ **D** The mass energy of the lambda particle must equal the total energy of X and Y.

(Total for Question 7 = 3 marks)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

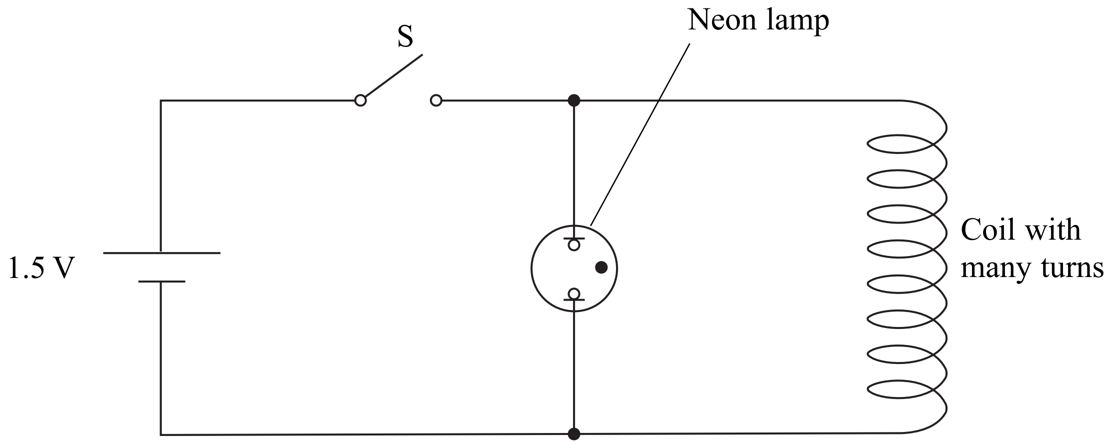
Answer ALL questions in the spaces provided.

***8** Rutherford designed an experiment to see what happened when alpha particles were directed at a piece of gold foil. Summarise the observations and state the conclusions Rutherford reached about the structure of gold atoms.

(5)

(Total for Question 8 = 5 marks)

9 A 1.5 V cell is connected to a switch S, a neon lamp and a coil with many turns as shown. Nothing is observed when the switch is closed but the neon lamp flashes as soon as it is opened.
The neon lamp flashes when the potential difference across it is about 200 V.



Use Faraday's law to explain why the lamp flashes once when the switch S is **opened**.
(4)

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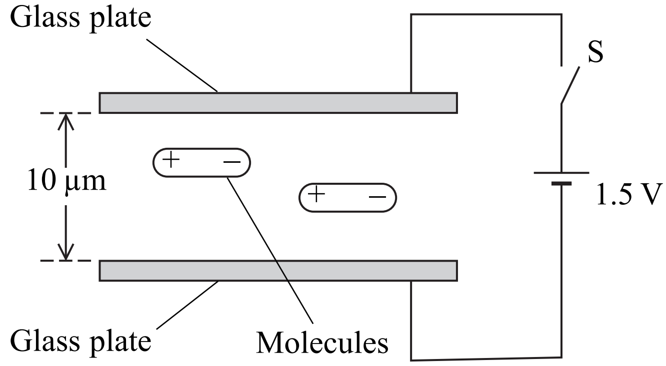
(Total for Question 9 = 4 marks)

10 Liquid crystal displays (LCDs) are made from two parallel glass plates, 10 μm apart, with liquid crystal molecules between them. The glass is coated with a conducting material.



The molecules are positive at one end and negative at the other. They are normally aligned parallel with the glass plates as shown.

The switch S is closed and 1.5 V is applied across the glass plates.

(a) Calculate the electric field strength between the plates. **(2)**

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Electric field strength = ...

(b) Explain what happens to the liquid crystal molecules. **(3)**

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(Total for Question 10 = 5 marks)

11 The diagram represents a proton.

(a) Draw lines to represent its electric field.

(3)

(b) Calculate the electrostatic force on the electron in a hydrogen atom.

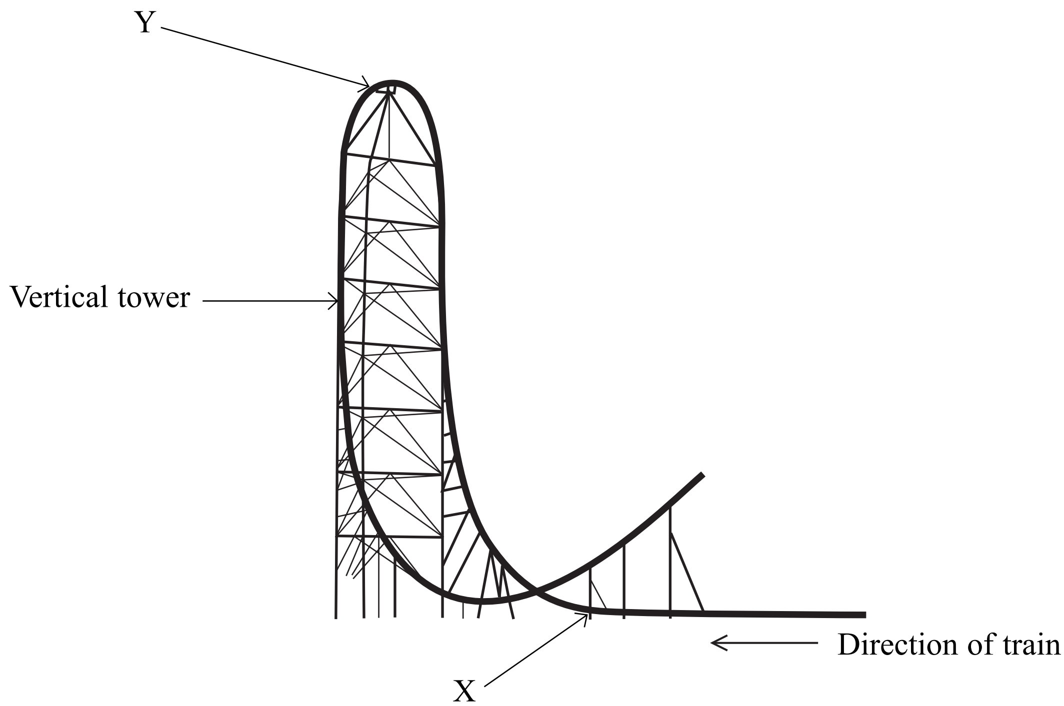
Average distance between proton and electron = 5.4×10^{-11} m

(3)

Force = ...

(Total for Question 11 = 6 marks)

12 Kingda Ka was the highest roller coaster in the world in 2007. A train is initially propelled along a horizontal track by a hydraulic system. It reaches a speed of 57 m s^{-1} from rest in 3.5 s. It then climbs a vertical tower before falling back towards the ground.



(a) Calculate the average force used to accelerate a fully loaded train along the horizontal track.

Total mass of fully loaded train = 12 000 kg

(2)

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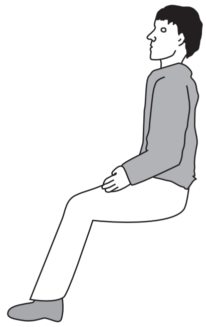
Force = ...

(b) Point X is just before the train leaves the horizontal track and moves into the first bend. Complete the free-body diagram below to show the two forces acting on a rider in the train at this point.

(3)



(c) The mass of the rider is m and g is the acceleration of free fall. Just after point X, the reaction force of the train on the rider is $4mg$ and can be assumed to be vertical. This is referred to as a g-force of $4g$.
Show that the radius of curvature of the track at this point is about 100 m.

(3)

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(d) Show that the speed of the train as it reaches the top of the vertical tower is about 20 m s^{-1}. Assume that resistance forces are negligible.

The height of the vertical tower is 139 m.

(2)

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(e) Riders will feel momentarily weightless if the vertical reaction force becomes zero. The track is designed so that this happens at point Y.

Calculate the radius of the track at point Y.

(2)

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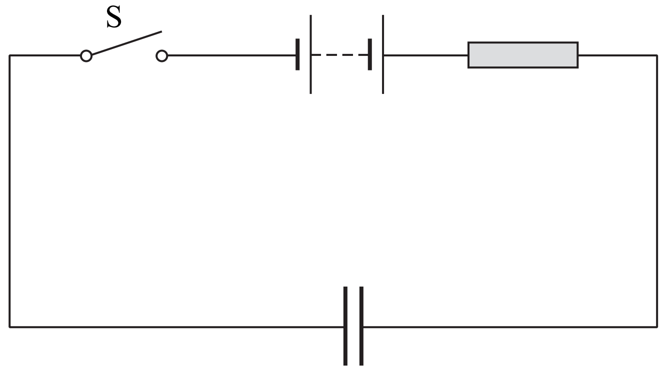
Radius = ...

(Total for Question 12 = 12 marks)

13 An uncharged capacitor is connected into a circuit as shown.



(a) Describe what happens to the capacitor when the switch S is closed.

(2)

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(b) A student models the behaviour of the circuit using a spreadsheet. The student uses a 100 μF capacitor, a 3.00 kΩ resistor and 5.00 V power supply. The switch is closed at time $t = 0$ s.

	A	B	C	D	E
1	t / s	I / mA	ΔQ / μC	Q / μC	p.d. across capacitor / V
2	0	1.67	167	167	1.67
3	0.1	1.11	111	278	2.78
4	0.2	0.74	74	352	3.52
5	0.3	0.49	49	401	4.01
6	0.4	0.33	33	434	4.34
7	0.5	0.22	22	456	4.56
8	0.6	0.15	15	471	4.71
9	0.7	0.10	10	480	4.80
10	0.8	0.07	7	487	4.87

(i) Explain how the value in cell C4 is calculated.

(2)

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(ii) Explain how the value in cell E3 is calculated.

(2)

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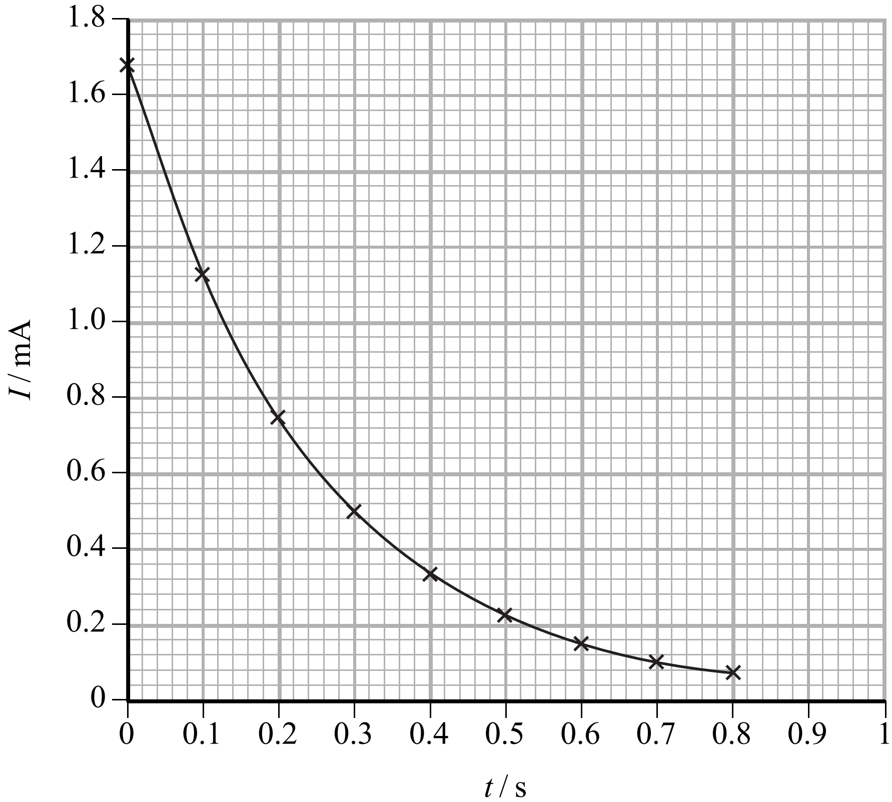
(c) The graph shows how the spreadsheet current varies with time.



(i) Use the graph to show that the time constant is approximately consistent with the component values.

(4)

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(ii) The student thinks that the graph is an exponential curve. How would you use another graph to confirm this?

(3)

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(Total for Question 13 = 13 marks)

***14** Pion radiotherapy is a new form of cancer treatment that has been extensively investigated for tumours of the brain. Pions are short lived sub-atomic particles and belong to a group called mesons.

(a) The following table lists some quarks and their charge.

Quark	Charge / *e*
Up (u)	$+\frac{2}{3}$
Down (d)	$-\frac{1}{3}$
Strange (s)	$-\frac{1}{3}$
Charm (c)	$+\frac{2}{3}$

On the list below circle the combination which could correspond to a π^+ pion.

(1)

uud $\qquad$ $\bar{d}\bar{d}\bar{d}$ $\qquad$ $u\bar{d}$ $\qquad$ $s\bar{c}$

(b) The mass of a pion is 0.14 GeV/c^2 . Calculate the mass of a pion in kg.

(3)

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Mass = ... kg

(c) Pions can be produced by accelerating protons using a cyclotron. Briefly explain the role of electric and magnetic fields within a cyclotron.

(5)

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(d) When pions are used to treat brain tumours they are slowed by the tissue in the brain and cause little damage. When a pion is moving very slowly it may be absorbed by the nucleus of an atom. The atom nucleus then becomes unstable and breaks up into several fragments.

Explain why these fragments shoot out in all directions.

(3)

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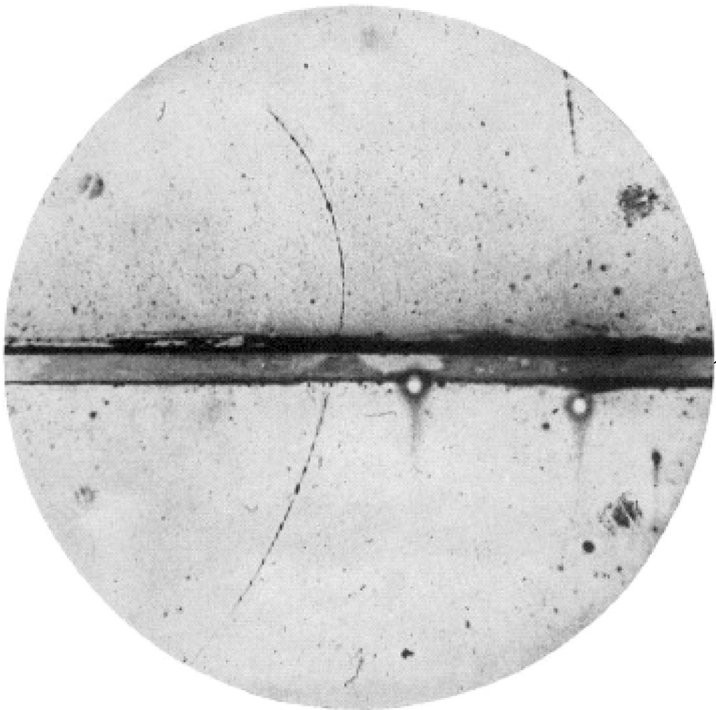
(Total for Question 14 = 12 marks)

15 The photograph shows the track of a positively charged particle either side of a lead plate.



Lead plate

The particle was deflected by a magnetic field of magnetic flux density 1.5 T. The field is perpendicular to the plane of the photograph.

(a) (i) Estimate the actual radius of the track above the lead plate.

The lead plate is 6 mm thick.

(3)

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Radius = ...

N 3 6 1 1 3 A 0 2 0 2 8

(ii) Calculate the momentum of this particle above the lead plate.
Particle charge = 1.6×10^{-19} C

(2)

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Momentum = ...

(b) Explain whether this particle was moving up or down through the lead plate.

(3)

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(c) On the list below circle the correct direction of the magnetic field.

(1)

Into the page   from left to right   down the page   out of the page   up the page

(d) This particle was identified as a positron.

(i) Calculate the speed of the positron while it is moving above the lead plate.

(2)

Speed = ...

(ii) Comment on your answer.

(2)

(Total for Question 15 = 13 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 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	$v = u + at$
	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
Forces	$\Sigma F = ma$
	$g = F/m$
	$W = mg$
Work and energy	$\Delta W = F\Delta s$
	$E_k = \frac{1}{2}mv^2$
	$\Delta E_{grav} = mg\Delta h$

Materials

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

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	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$

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

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

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

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 $k = 1/4\pi\varepsilon_0$
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	$\varepsilon = -d(N\phi)/dt$

Particle physics

Mass-energy	$\Delta E = c^2 \Delta m$
de Broglie wavelength	$\lambda = h/p$