Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel International Advanced Level

Centre Number

Candidate Number

Monday 29 October 2018

Morning (Time: 1 hour 35 minutes) | Paper Reference **WPH04/01**

Physics

Advanced
Unit 4: Physics on the Move

You do not need any other materials.

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.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over

Pearson

SECTION A

Answer ALL questions.

For questions 1–10, 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 Which of the following is a lepton?

☒ **A** pion

☒ **B** photon

☒ **C** neutron

☒ **D** electron

(Total for Question 1 = 1 mark)

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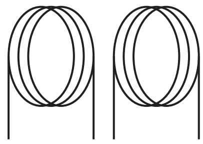
2 Two coils, L and M, are placed next to each other as shown.



There is an alternating current in coil L. An alternating potential difference is produced across coil M.

Which of the following changes will **not** increase the maximum potential difference across M?

☒ **A** Increasing the frequency of the alternating current.

☒ **B** Increasing the magnitude of the current in coil L.

☒ **C** Increasing the number of turns on coil M.

☒ **D** Increasing the separation of L and M.

(Total for Question 2 = 1 mark)

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3 At an airport, suitcases of mass 22 kg are placed onto a conveyor belt moving at a speed of $0.75\,\text{m}\,\text{s}^{-1}$. 12 cases are placed onto the belt every minute.

Which of the following gives the average horizontal force F_H exerted by the belt, in newtons?

☒ **A** $F_H = 22 \times 12 \times 9.81$

☒ **B** $F_H = 22 \times 0.75 \times 12$

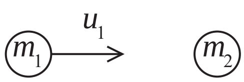
☒ **C** $F_H = \dfrac{22 \times 0.75 \times 12}{60}$

☒ **D** $F_H = \dfrac{22 \times 0.75 \times 60}{12}$

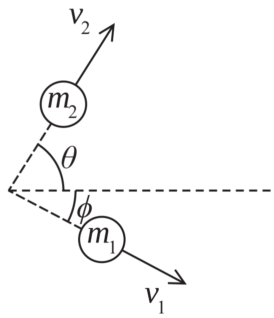
(Total for Question 3 = 1 mark)

Questions 4 and 5 refer to an elastic collision between two spheres.

A sphere of mass m_1 moving with velocity u_1 collides elastically with a stationary sphere of mass m_2. The spheres then move apart at different velocities as shown.



Before collision



After collision

4 Which of the following equations applies in the direction of u_1?

☒ **A** $m_1u_1 = m_1v_1\cos\varphi + m_2v_2\cos\theta$

☒ **B** $m_1u_1 = m_1v_1\cos\theta + m_2v_2\cos\varphi$

☒ **C** $m_1u_1 = m_1v_1\sin\varphi + m_2v_2\sin\theta$

☒ **D** $m_1u_1 = m_1v_1\sin\theta + m_2v_2\sin\varphi$

(Total for Question 4 = 1 mark)

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5 Which of the following equations applies if the collision is elastic?

☒ **A** $\frac{1}{2}m_1u_1^{\ 2} = \frac{1}{2}m_1(v_1\sin\varphi)^2 + \frac{1}{2}m_2(v_2\sin\theta)^2$

☒ **B** $\frac{1}{2}m_1u_1^{\ 2} = \frac{1}{2}m_1(v_1\cos\varphi)^2 + \frac{1}{2}m_2(v_2\cos\theta)^2$

☒ **C** $\frac{1}{2}m_1u_1^{\ 2} = \frac{1}{2}m_1v_1^{\ 2} + \frac{1}{2}m_2v_2^{\ 2}$

☒ **D** $\frac{1}{2}m_1u_1^{\ 2} = \frac{1}{2}(m_1 + m_2)(v_1 + v_2)^2$

(Total for Question 5 = 1 mark)

Turn over ▶

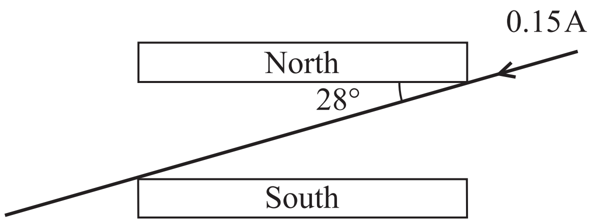
6 In the early 20th century, Rutherford carried out investigations into the scattering of alpha particles by thin gold foil.

Which of the following conclusions could **not** be made from the results of these investigations?

- ☒ **A** Most of the mass of the atom is concentrated in one place.
- ☒ **B** The atom is mostly empty space.
- ☒ **C** The nucleus contains positively charged protons.
- ☒ **D** There is a concentration of charge at one place in the atom.

(Total for Question 6 = 1 mark)

7 The diagram shows a current-carrying wire passing between north and south magnetic poles.



The magnetic flux density between the poles is 0.09 T. The length of wire within the magnetic field is 4.5 cm.

Which of the following gives the force F on the wire in newtons?

- ☒ **A** $F = 0.09 \times 0.15 \times 0.045$ into the page
- ☒ **B** $F = 0.09 \times 0.15 \times 0.045 \times \sin 62°$ into the page
- ☒ **C** $F = 0.09 \times 0.15 \times 0.045$ out of the page
- ☒ **D** $F = 0.09 \times 0.15 \times 0.045 \times \sin 62°$ out of the page

(Total for Question 7 = 1 mark)

8 A particle has mass 4.8 MeV/c^2.

What is the mass of the particle in kilograms?

- ☒ **A** 8.5×10^{-36}
- ☒ **B** 8.5×10^{-30}
- ☒ **C** 2.6×10^{-21}
- ☒ **D** 5.3×10^{-11}

(Total for Question 8 = 1 mark)

9 $^{14}_{6}C$ is an isotope of carbon. It is formed in the Earth's atmosphere when a nucleus of element X absorbs a neutron and emits a proton.

Which row of the table correctly shows the proton number and nucleon number of this nucleus of element X?

	Proton number	Nucleon number
☒ **A**	5	13
☒ **B**	6	15
☒ **C**	7	14
☒ **D**	7	15

(Total for Question 9 = 1 mark)

10 The Λ^0 particle is a baryon.

Which of the following products could **not** be produced by the decay of a Λ^0 particle?

☒ **A** $p + \pi^0$

☒ **B** $n + \pi^0$

☒ **C** $p + e^- + \bar{\nu}_e$

☒ **D** $p + \mu^- + \bar{\nu}_\mu$

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 While studying cosmic rays in the 1940s, Clifford Charles Butler discovered two new classes of heavy particles. These classes were named hyperons and mesons.

(a) Baryons are combinations of quarks or of antiquarks. Hyperons are baryons that contain at least one strange quark but no charm, bottom or top quarks.

Explain why there are six possible quark combinations for hyperons.

(2)

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(b) Charm, bottom and top quarks were all proposed by theoretical physicists before being identified by experimental physicists. The existence of the charm quark was confirmed experimentally in 1974, the bottom quark in 1977 and the top quark in 1995.

Explain how the standard model led to the prediction of the bottom and top quarks.

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(Total for Question 11 = 4 marks)

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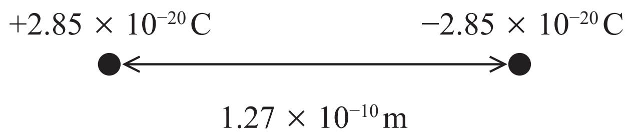
12 Hydrogen chloride is a ‘polar molecule’. This polar molecule can be modelled as a point charge of $+2.85 \times 10^{-20}$ C and a point charge of -2.85×10^{-20} C, separated by a distance of 1.27×10^{-10} m.



(a) Determine the magnitude of the electrostatic force between the charges.

(2)

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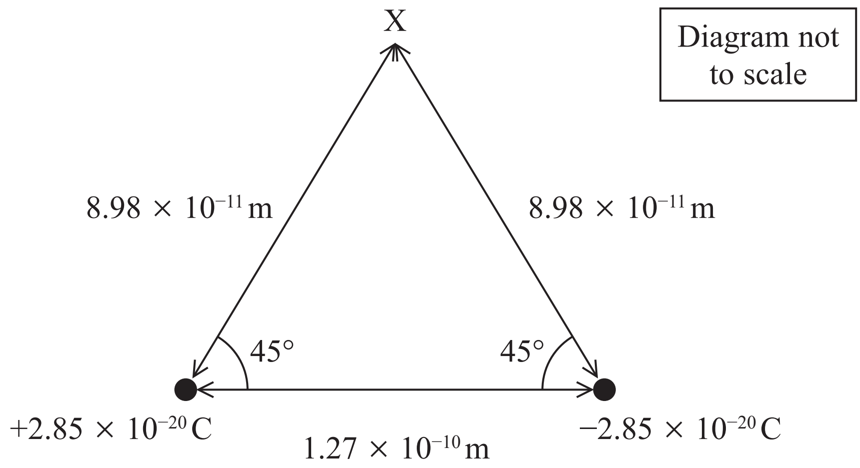
Force = ...

(b) Polar molecules have their own electric fields that can interact with external electric fields.

Point X is 8.98×10^{-11} m from each charge, as shown.



Determine the magnitude of the resultant electric field strength at point X due to the polar molecule.

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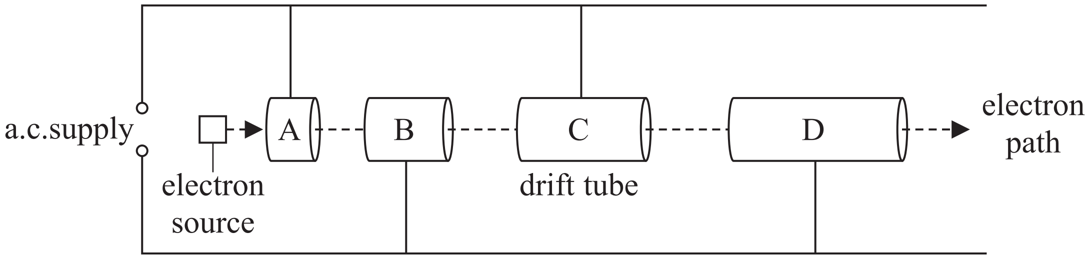
Magnitude of resultant electric field strength = ...

(Total for Question 12 = 6 marks)

13 The Linear Collider Collaboration is a multinational group planning to build the next generation of linear accelerators. These will achieve higher energies than exisiting linear accelerators.

*(a) The diagram represents the first section of a linear accelerator (linac) being used to accelerate electrons.



At the start of the linac the drift tubes steadily increase in length along the path of the electrons.

Explain why the drift tubes have a constant length at the other end of the linac.

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*(b) Many linacs collide beams of particles with stationary targets.

The Linear Collider Collaboration would use two linacs aligned in opposite directions so that the beams of accelerated particles collide with each other.

Explain why this would allow the creation of a greater range of particles.

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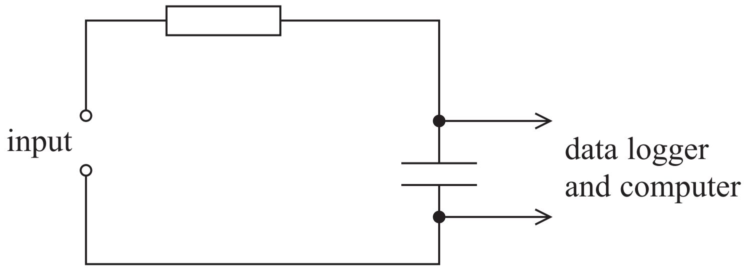
(Total for Question 13 = 7 marks)

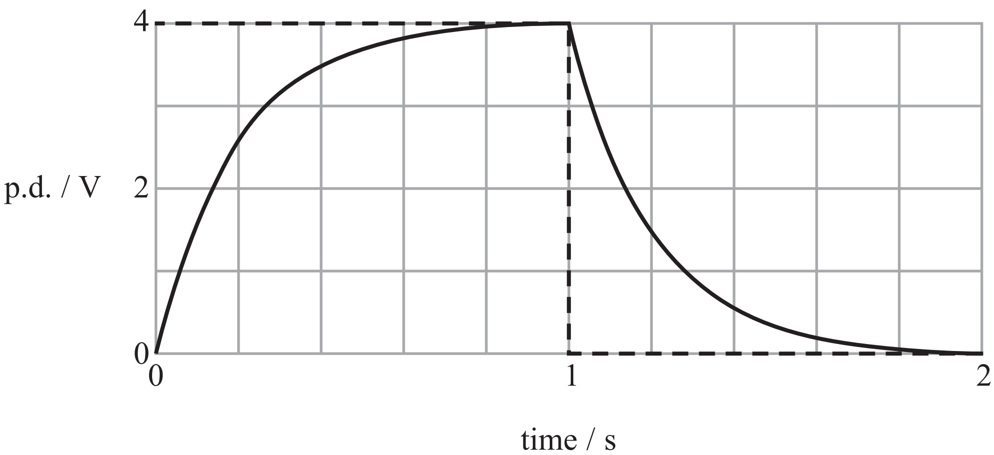
14 A student investigated the properties of capacitors. The diagram shows the circuit used by the student.



A potential difference (p.d.) alternating between zero and 4.0 V was applied to the input.

The variation of p.d. across the capacitor with time was displayed on the computer as shown below.

The input is shown by the dashed line.



(a) Explain the shape of the graph.

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(b) (i) Show that the capacitance of the capacitor was about 1×10^{-5} F.

resistance of resistor = 15 kΩ

(3)

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(ii) Determine the maximum energy stored in the capacitor.

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Maximum energy = ...

*(c) Explain why this graph could not have been obtained using a voltmeter and stopwatch.

(3)

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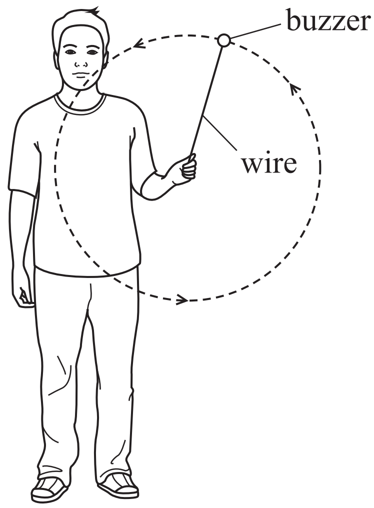
(Total for Question 14 = 11 marks)

15 A student wondered whether a small buzzer could be powered using the Earth's magnetic field.

The student attached a buzzer to one end of a wire. He held the other end of the wire and whirled the buzzer in a vertical circle as shown.



front view

(a) Explain how an e.m.f. was produced between the ends of the wire.

(2)

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(b) The radius of the vertical circle was 85 cm. The buzzer completed 27 revolutions in 15 s. Assume that the speed of the buzzer was constant.

(i) Calculate the centripetal force acting on the buzzer.

mass of buzzer = 150 g

(3)

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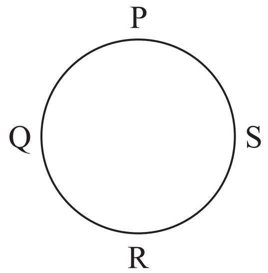
Centripetal force = ...

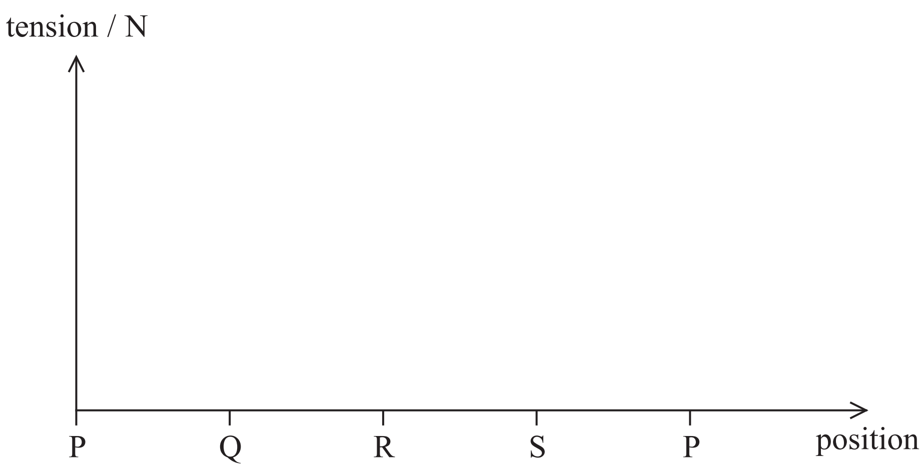
(ii) The tension in the wire varied as the buzzer moved around the circle.

Sketch a graph to show the variation in the magnitude of the tension during one full revolution.



You should calculate the maximum and minimum values of tension and add them to your sketch.

(4)



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(iii) Determine the size of the e.m.f. produced.

The magnitude of the horizontal component of the magnetic flux density of the Earth's magnetic field was 2.2×10^{-5} T.

(4)

e.m.f. = ...

(c) The student used a second wire to complete the circuit to the buzzer and whirled the buzzer around in a vertical circle.

Explain why there was no current in the circuit.

(2)

(Total for Question 15 = 15 marks)

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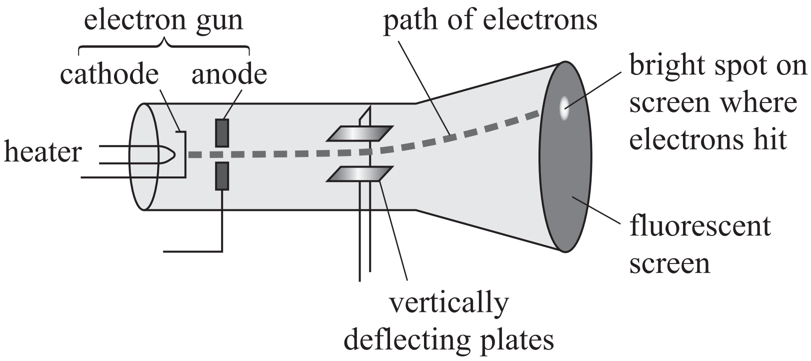
16 The diagram shows a simplified representation of a cathode ray tube in an oscilloscope.



(a) The electron gun produces electrons that are accelerated by the anode.

Explain how the cathode produces electrons.

(2)

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(b) The beam passes between deflecting plates then hits the fluorescent screen, causing a bright spot. The beam is deflected when a potential difference (p.d.) is applied across the plates. The amount of deflection is determined by the magnitude of the p.d.

The electrons leave the anode with a speed of $1.90 \times 10^{7}\,\mathrm{m\,s^{-1}}$.

(i) Calculate the p.d. required between the cathode and the anode for the electrons to reach this speed.

(3)

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p.d. required = ...

(ii) The electron beam leaves the plates at an angle to the horizontal of 21°.
Show that the vertical component of the velocity of the electrons is about $7 \times 10^6\,\mathrm{m\,s^{-1}}$.

(2)

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(iii) Calculate the p.d. *V* that must be applied across the deflecting plates so that the electron beam leaves the plates at an angle to the horizontal of 21°.
The deflecting plates are 1.2 cm long and 4.6 mm apart.

(6)

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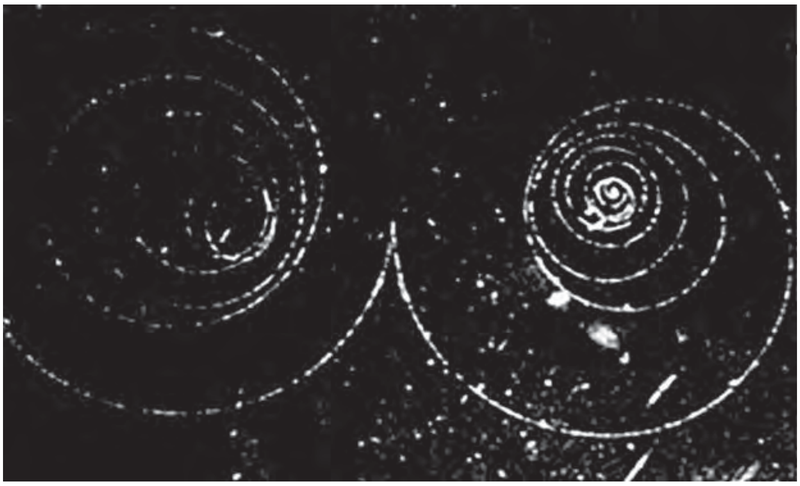
V = ...

(Total for Question 16 = 13 marks)

17 The photograph shows the particle detector track for the process of pair production. In this process, a gamma photon becomes an electron and its antiparticle, a positron.



(a) (i) State why the gamma photon has no track.

(1)

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(ii) Explain why the electron and positron tracks in the photograph show a decreasing radius.

(2)

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(b) Calculate the minimum frequency of the gamma photon for pair production to be possible.

(4)

Minimum frequency = ...

(c) Photons do not have mass but they have momentum.

(i) Show that the energy and momentum of a photon are related by the formula

$$E = pc$$

(2)

(ii) Pair production occurs as a result of an interaction of a photon with another particle. It cannot occur for a photon in a vacuum because it is impossible to satisfy all the necessary conservation laws.

A photon has an energy of 1.64×10^{-13} J. An electron and positron produced in a vacuum by this photon would each have kinetic energy 2.22×10^{-16} J.

Show that these particles could not satisfy the conservation of momentum.

(5)

(Total for Question 17 = 14 marks)

TOTAL FOR SECTION B = 70 MARKS
TOTAL FOR PAPER = 80 MARKS

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List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \mathrm{m\ s^{-2}}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \mathrm{J\ K^{-1}}$	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^{9}\ \mathrm{N\ m^2\ C^{-2}}$	
Electron charge	$e = -1.60 \times 10^{-19}\ \mathrm{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$	
Electronvolt	$1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$	
Gravitational constant	$G = 6.67 \times 10^{-11}\ \mathrm{N\ m^2\ kg^{-2}}$	
Gravitational field strength	$g = 9.81\ \mathrm{N\ kg^{-1}}$	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\ m^{-1}}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\ s}$	
Proton mass	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \mathrm{m\ s^{-1}}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \mathrm{W\ m^{-2}\ K^{-4}}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$	

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

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

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

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

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	$\lambda = h/p$