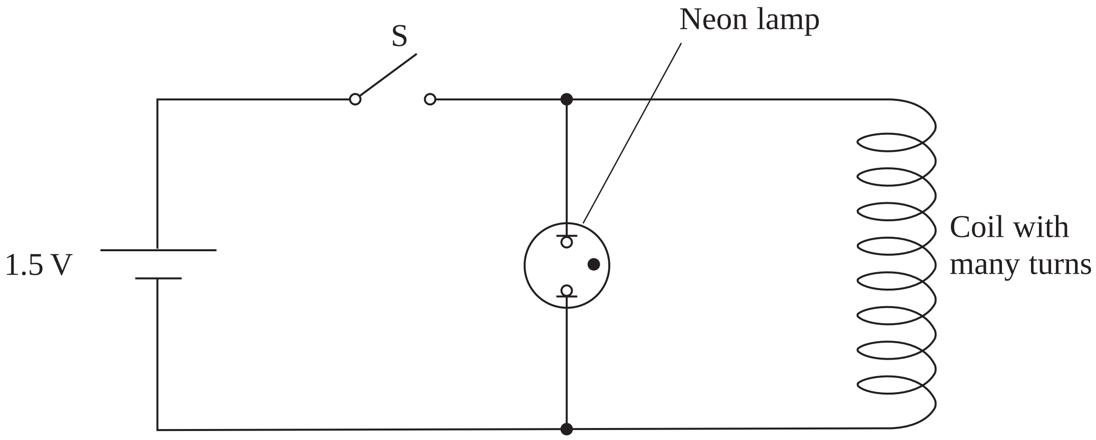
Edexcel Physics Unit 4

Topic Questions from Papers

Electromagnetism

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)

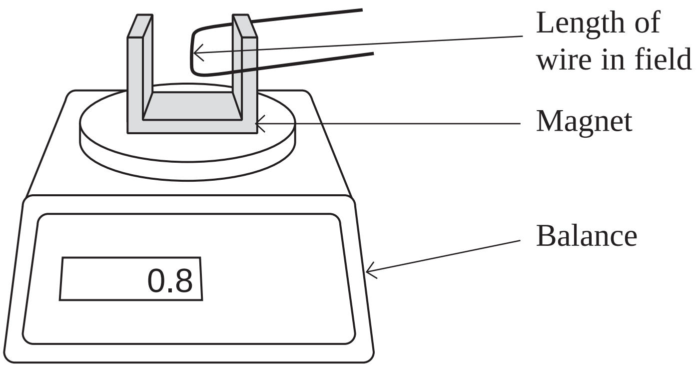
(Total for Question 9 = 4 marks)

Turn over

SECTION B

Answer ALL questions in the spaces provided.

11 The diagram shows a horizontal wire which is at right angles to a magnetic field. The magnetic field is produced by a horseshoe magnet which is on a balance adjusted to read zero when the current in the wire is zero.



When the current is 4 A, the reading on the balance is 0.8 gram.

The length of wire in the magnetic field is 0.05 m.

Calculate the average magnetic flux density along the length of the wire.

(3)

Magnetic flux density = ...

(Total for Question 11 = 3 marks)

***12** Faraday's and Lenz's laws are summarised in the list of formulae as

$$\varepsilon = -\frac{\mathrm{d}(N\phi)}{\mathrm{d}t}$$

(a) State the meaning of the term $N\phi$.

(2)

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(b) Explain the significance of the minus sign.

(3)

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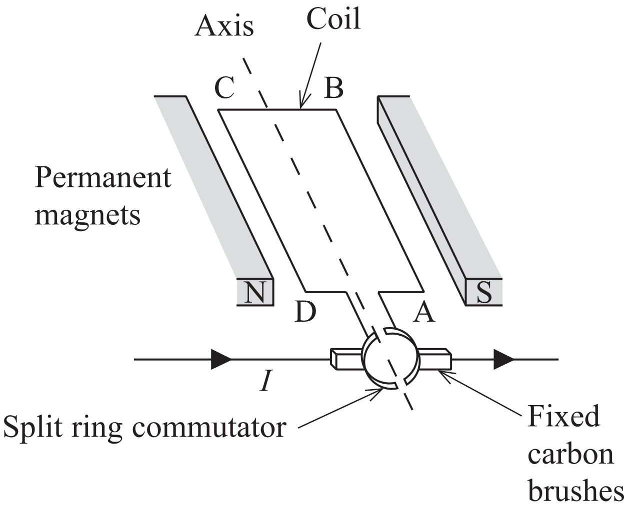
(Total for Question 12 = 5 marks)

13 The simplified diagram shows a d.c. electric motor. The split ring commutator consists of two copper semicircular sections attached to either end of a coil. Fixed carbon brushes rub against, and make electrical connections to, the split ring commutator.

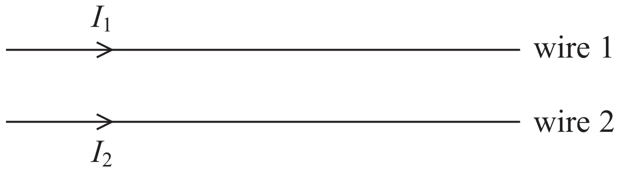


(a) Explain why the coil turns and why it continues to rotate. Add to the diagram to help your explanation.

(4)

***12** In 1820 Hans Oersted did an experiment with an electric current in a wire. He noticed that whenever the current was on, it affected a compass needle lying near the wire.

A few years later, André Ampere observed that two parallel wires attract each other if they are carrying current in the same direction.



Explain André Ampere's observation. You may wish to add to the diagram.

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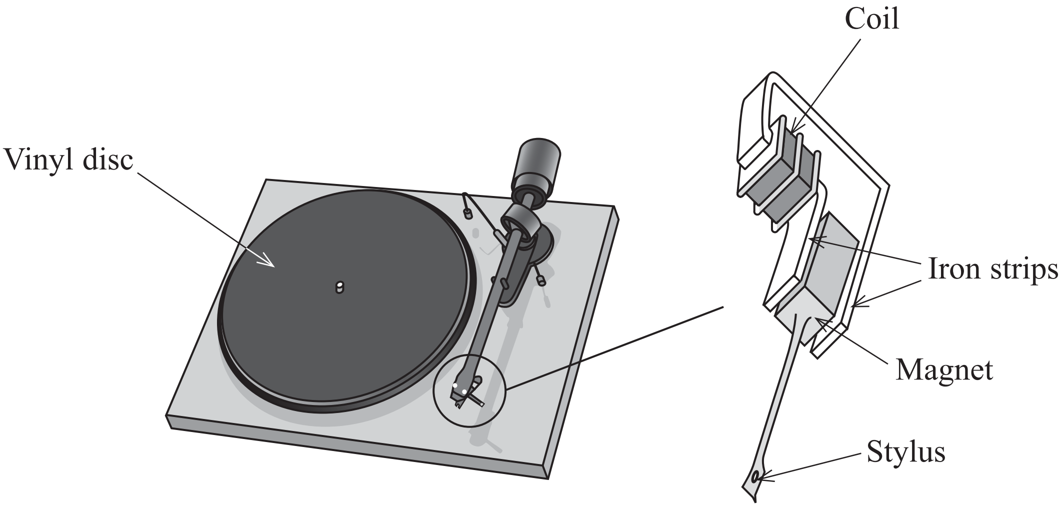
(Total for Question 12 = 5 marks)

15 A vinyl disc is used to store music. When the disc is played, a stylus (needle) moves along in a groove in the disc. The disc rotates and bumps in the groove cause the stylus to vibrate.



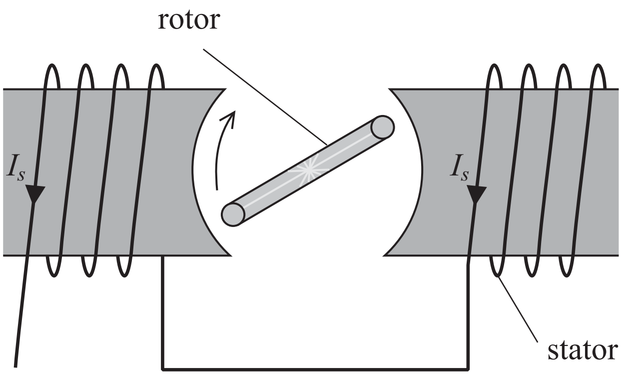
The stylus is attached to a small magnet which is near to a coil of wire. When the stylus vibrates, there is a potential difference across the terminals of the coil.

(a) Explain the origin of this potential difference.

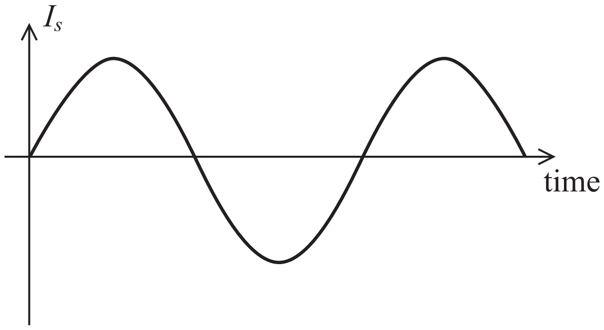
(4)

15 The diagram represents a simple induction motor. An alternating current I_s is supplied to a stationary coil (stator). This coil is wrapped around an iron core.

A rotating coil (rotor) is shown end on in the diagram.



(a) The graph shows the variation of the alternating current I_s with time.



*(i) Explain how current is induced in the rotor coil.

(4)

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(ii) Explain why the rotor turns.

(2)

(iii) State **two** ways of making the rotor turn faster.

(2)

1

2

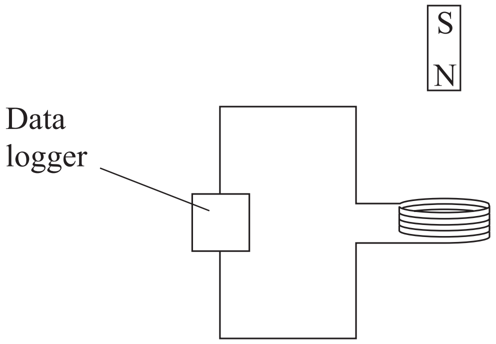
(b) An induction motor is used to rotate the turntable in a record deck. Long-play records require the turntable to rotate at 33 revolutions per minute.

(i) Calculate the angular velocity of the turntable.

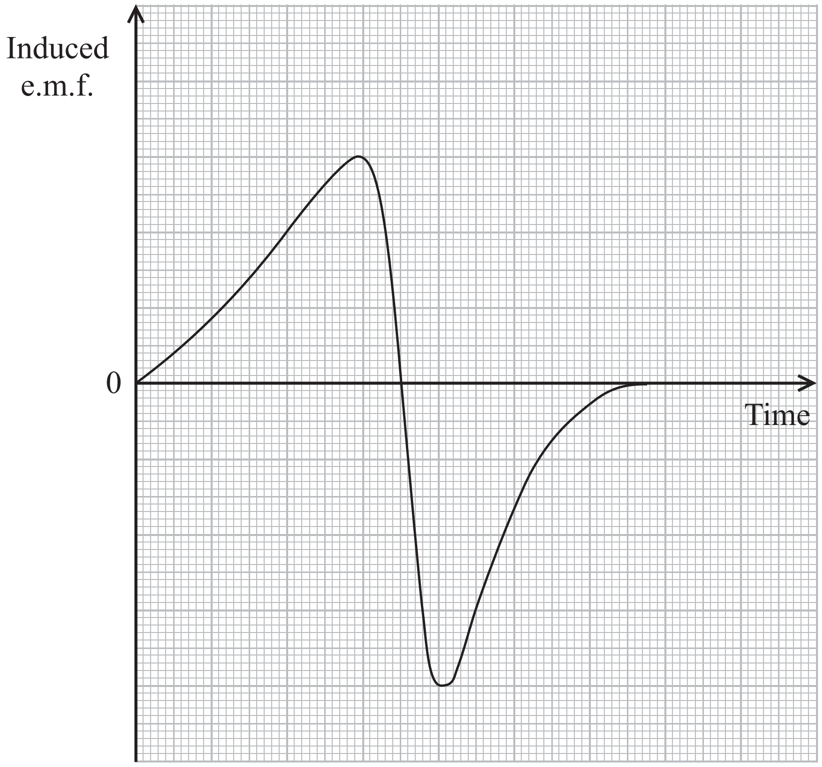
(3)

Angular velocity = ...

16 A teacher demonstrates electromagnetic induction by dropping a bar magnet through a flat coil of wire connected to a data logger.



The data from the data logger is used to produce a graph of induced e.m.f. across the coil against time.



*(a) Explain the shape of the graph and the relative values on both axes.

(6)

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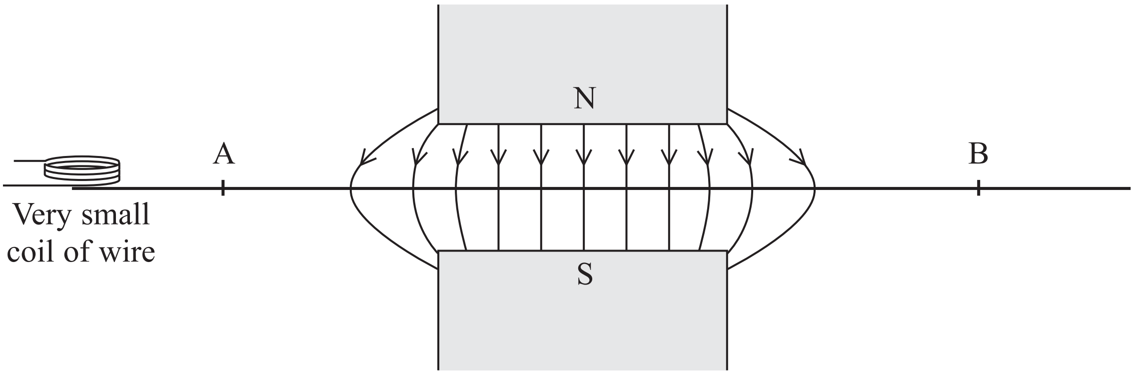
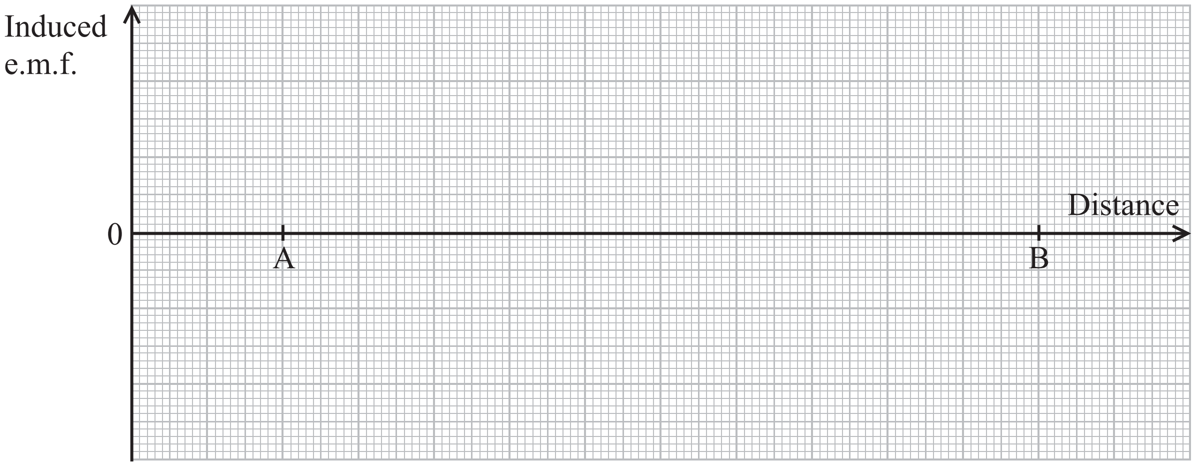
(b) The teacher then sets up another demonstration using a large U-shaped magnet and a very small coil of wire which is again connected to a data logger.

The north pole is vertically above the south pole and the coil is moved along the line AB which is midway between the poles. The magnetic field due to the U-shaped magnet has been drawn. The plane of the coil is horizontal.



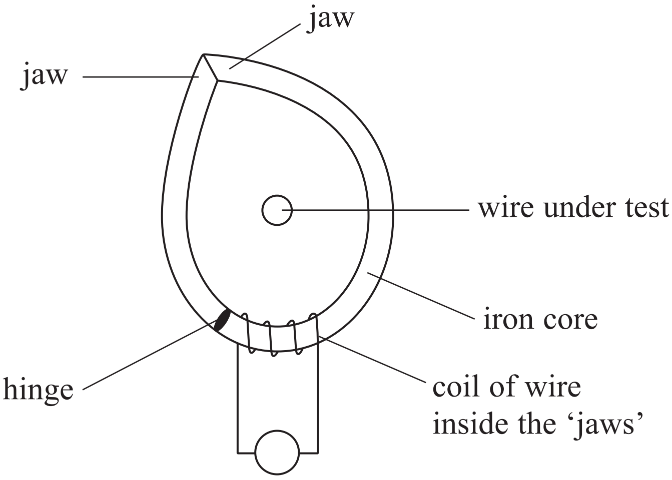
Sketch a graph to show how the e.m.f. induced across the coil varies as the coil moves from A to B at a constant speed.

(4)



(Total for Question 16 = 10 marks)

16 The photograph shows a digital clamp meter or ‘amp-clamp’. This can be used to measure the current in the live wire coming from the mains supply without breaking the circuit.



The ‘jaws’ of the clamp are opened, placed around the wire carrying the current and then closed. Inside the ‘jaws’ is an iron core with a coil of wire wrapped around it.

*(a) Explain how an e.m.f. would be produced in the coil of wire inside the amp-clamp when the ‘jaws’ are placed around a wire carrying an alternating current.

(4)

(b) State why the amp-clamp cannot be used with a steady direct current.

(1)

(c) The amp-clamp cannot be used with a cable that is used to plug a domestic appliance like a lamp into the mains supply.

Explain why not.

(2)

(d) (i) Explain why the amp-clamp can be used to determine the magnitude of different alternating currents with the same frequency.

(2)

(ii) The amp-clamp may **not** be reliable when comparing alternating currents of different frequencies.

Suggest why not.

(2)

(Total for Question 16 = 11 marks)

13 The magnetic force F that acts on a current-carrying conductor in a magnetic field is given by the equation

$$F = BIl.$$

(a) State the condition under which this equation applies.

(1)

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(b) The unit for magnetic flux density B is the tesla.

Express the tesla in base units.

(2)

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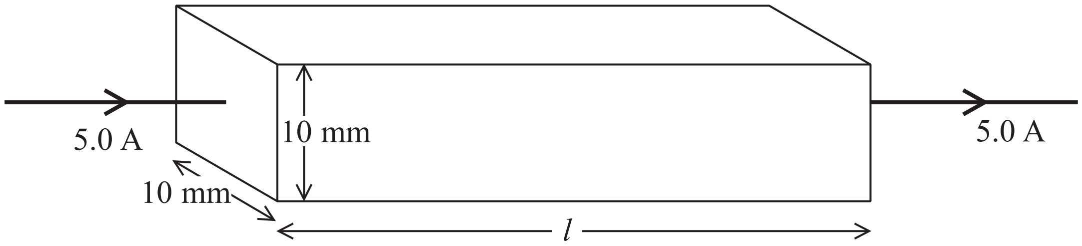
(c) The diagram shows a rectangular bar of aluminium which has a current of 5.0 A through it.



The bar is placed in a magnetic field so that its weight is supported by the magnetic field.

Calculate the minimum value of the magnetic flux density B needed for this to occur.

density of aluminium = 2.7×10^3 kg m^{-3}

(3)

Minimum B = ...

(d) State the direction of the magnetic field.

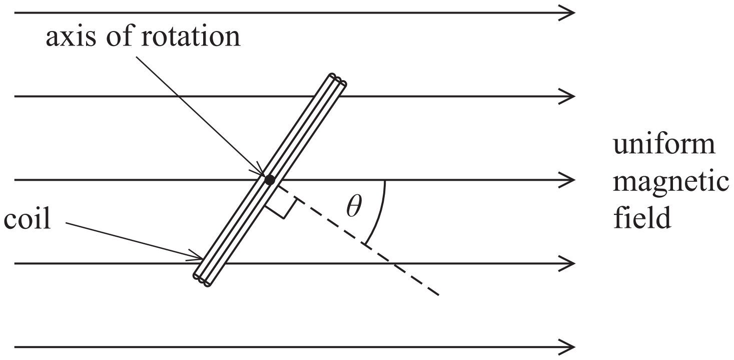
(1)

....

(Total for Question 13 = 7 marks)

Turn over ▶

18 The diagram shows an end view of a simple electrical generator. A rectangular coil of wire is rotated in a uniform magnetic field of magnetic flux density 3.0×10^{-2} T. The axis of rotation is at right angles to the field direction.



(a) The coil has 200 turns and an area of 2.0×10^{-4} m^2.

Calculate the magnetic flux linkage for the coil when $\theta = 0°$.

(2)

Flux linkage = ...

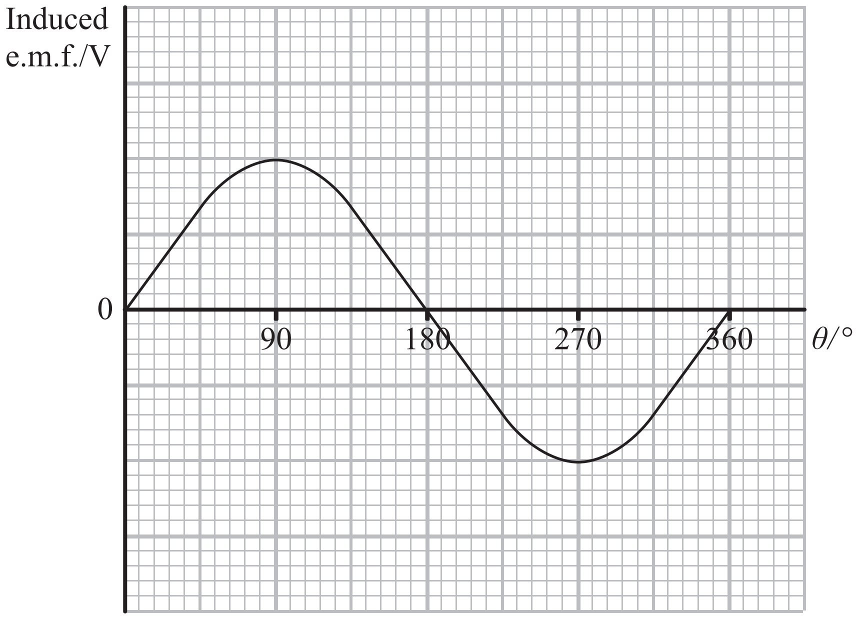
(b) The coil is rotated at a constant rate of 2 revolutions per second.

(i) Calculate the average e.m.f. induced in the time taken for the coil to rotate from $\theta = 0°$ to $\theta = 90°$.

(3)

Average e.m.f. = ...

(ii) The graph shows how the induced e.m.f. varies over one cycle of rotation of the coil.



Explain why the magnitude of the e.m.f. is smallest and greatest at the values of θ shown in the graph.

(3)

(iii) State and explain how the graph would differ if the coil rotated at a slower rate.

(2)

(c) Vehicles such as electric cars are driven by electric motors. These vehicles use regenerative braking to reduce the speed of the vehicle. The motor is operated as a generator during braking and the output from the generator is used to recharge the batteries of the car.

(i) Explain how using the motor as a generator slows the car down.

(2)

(ii) In practice, these vehicles also use friction braking as well as regenerative braking. This is because regenerative braking on its own will not fully stop a car. Suggest why.

(2)

(Total for Question 18 = 14 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \mathrm{m\ s^{-2}}$	(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	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$ $\% \text{ efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$ $\% \text{ efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$
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	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Quantum physics

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{\text{max}}$

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	$Q = Q_0\mathrm{e}^{-t/RC}$
In a magnetic field	$F = BIl \sin\theta$ $F = Bqv \sin\theta$ $r = p/BQ$
Faraday's and Lenz's Laws	$\varepsilon = -\mathrm{d}(N\phi)/\mathrm{d}t$

Particle physics

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