Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Physics
Advanced
Unit 4: Physics on the Move

Tuesday 24 January 2012 – 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 ▶

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 The momentum of a particle is p. The kinetic energy of the particle is doubled.

The momentum is now

☐ **A** $\sqrt{2}p$

☐ **B** $2p$

☐ **C** $4p$

☐ **D** $8p$

(Total for Question 1 = 1 mark)

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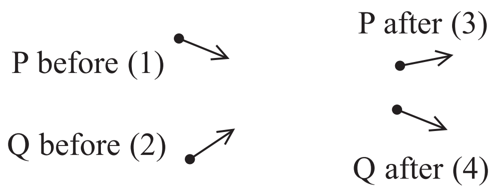
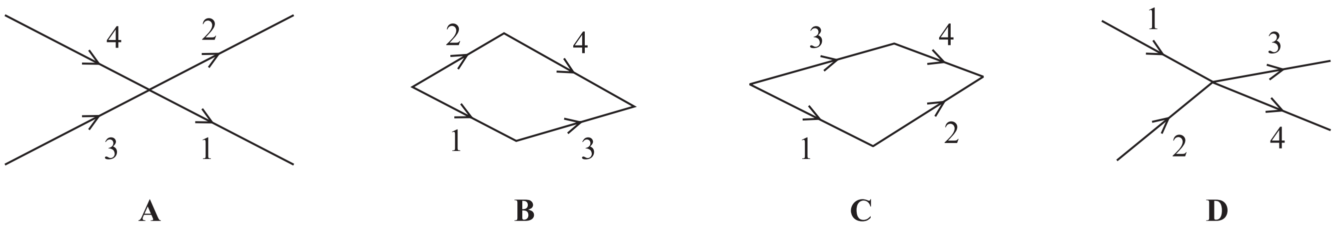
2 The diagram represents the collision between two sub-atomic particles P and Q moving with momenta 1 and 2 respectively. After the collision they have momenta 3 and 4 respectively.



Which vector diagram best shows the correct relationship for the momenta of P and Q?



☐ **A**

☐ **B**

☐ **C**

☐ **D**

(Total for Question 2 = 1 mark)

3 A student is sitting on the right-hand side in a bus, facing the direction of travel. The bus goes round a bend to the left. The student remains in the same position within the bus.

The student experiences

☒ **A** a force to the left and a force to the right.

☒ **B** a resultant force to the left.

☒ **C** a resultant force to the right.

☒ **D** no resultant force.

(Total for Question 3 = 1 mark)

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4 The unit of flux linkage is

☒ **A** T

☒ **B** T m^{-2}

☒ **C** Wb

☒ **D** Wb m^{-2}

(Total for Question 4 = 1 mark)

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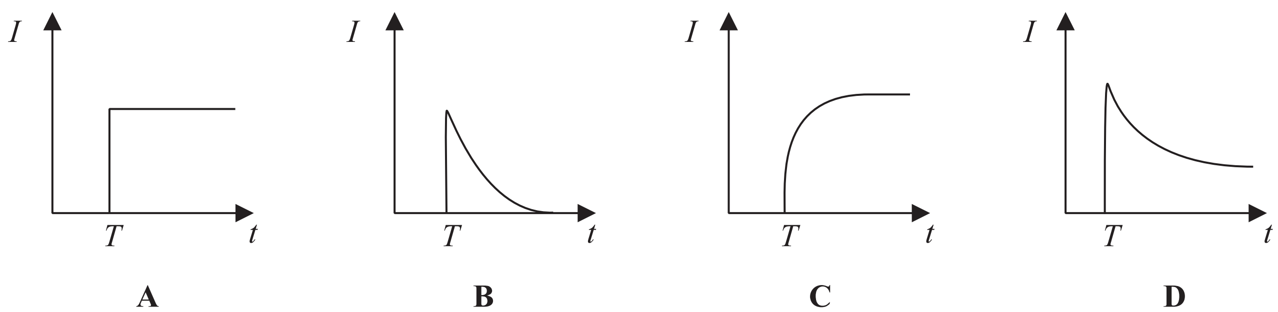
5 An electric motor is connected via a switch to a battery. A graph is plotted to show the variation of current *I* with time *t*. The switch is closed at time *T*.

Which of the following graphs is correct?



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 5 = 1 mark)

6 Deuterium ^2_1H is an isotope of hydrogen.

An atom of deuterium has

		protons	**neutrons**	**electrons**
☒	**A**	1	2	2
☒	**B**	1	1	1
☒	**C**	2	1	2
☒	**D**	1	0	1

(Total for Question 6 = 1 mark)

7 The rest mass of a proton is 1.67×10^{-27} kg. This mass, in MeV/c^2 is approximately

☒ **A** 2.4×10^{-20}

☒ **B** 3.1×10^{-6}

☒ **C** 1.0

☒ **D** 940

(Total for Question 7 = 1 mark)

8 A positive kaon (K^+) is a meson which includes a strange quark. Its structure could be

☒ **A** $u\overline{s}$

☒ **B** us

☒ **C** $\overline{s}\overline{d}\overline{d}$

☒ **D** usd

(Total for Question 8 = 1 mark)

9 The K^+ is likely to decay to

☒ **A** $\pi^+ + \mu^- + \overline{\nu}_\mu$

☒ **B** $\pi^+ + \pi^0$

☒ **C** $\pi^+ + \pi^-$

☒ **D** $\pi^0 + \mu^- + \overline{\nu}_\mu$

(Total for Question 9 = 1 mark)

10 The de Broglie wavelength of a moving tennis ball is calculated as 1×10^{-33} m. This means that the moving tennis ball

☒ **A** diffracts through a narrow slit.

☒ **B** does not behave as a particle.

☒ **C** does not display wave properties.

☒ **D** is travelling at the speed of light.

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 (a) Explain what is meant by a uniform electric field.

(2)

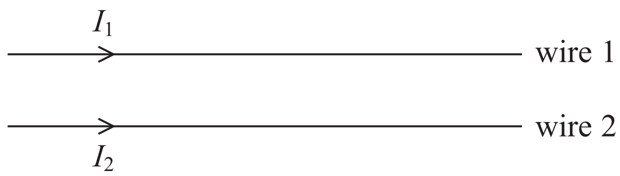
(b) Describe how a uniform electric field can be demonstrated in a laboratory.

(3)

(Total for Question 11 = 5 marks)

***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)

***13** At the beginning of the last century, experiments were performed using alpha particles and gold foil. The alpha particles were directed at the gold foil and a detector was used to see if and where they were scattered.

Summarise the results from these experiments and the conclusions that were drawn from them.

(5)

(Total for Question 13 = 5 marks)

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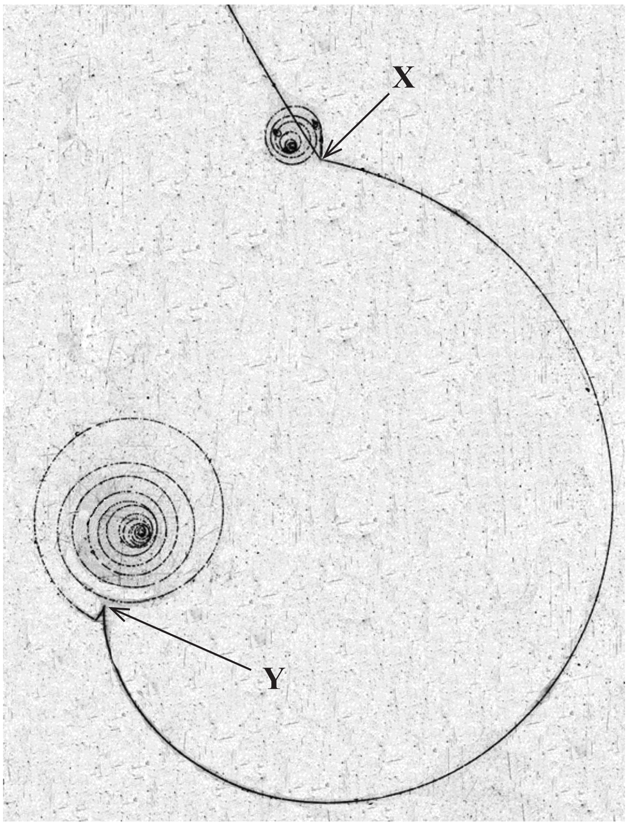
14 The photograph shows tracks in a particle detector.



(a) Explain the role of a magnetic field in a particle detector.

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(b) Explain how you can tell that track XY was produced by a particle moving from X to Y rather than from Y to X.

(2)

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(c) The particle that produced track XY was a π^+. Deduce the direction of the magnetic field in the photograph.

(1)

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(d) At Y, the π^+ decayed into a positively charged muon (μ^+) and a muon neutrino. The μ^+ has a very short range before decaying into various particles, including a positron which produced the final spiral.

(i) Give **two** reasons why you can deduce that the muon neutrino is neutral.

(2)

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(ii) Explain the evidence from the photograph for the production of the muon neutrino at Y.

(3)

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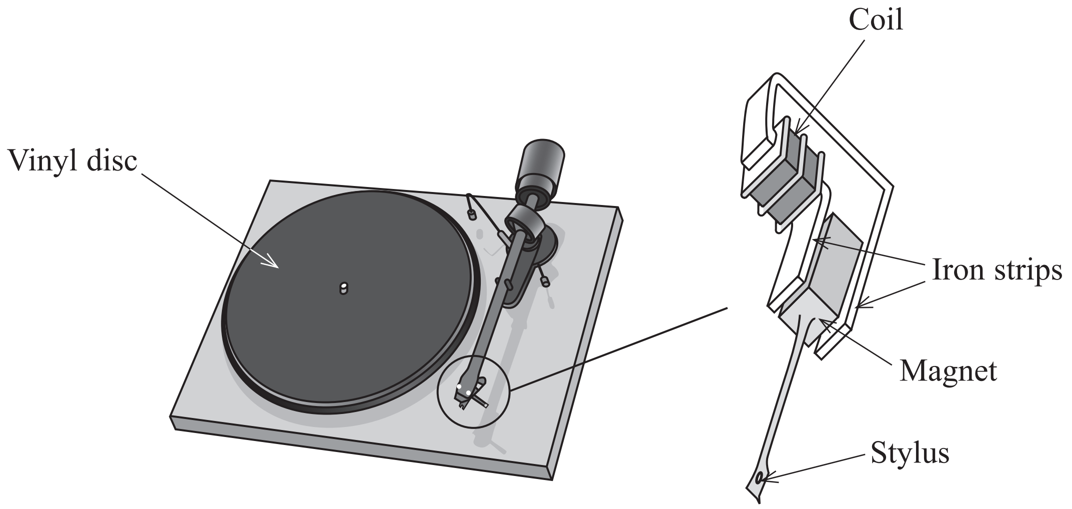
(Total for Question 14 = 10 marks)

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)

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(b) The potential difference is then amplified and sent to a loudspeaker. Long-playing vinyl discs (LPs) have to be rotated at 33 rpm (revolutions per minute) so that the encoded bumps in the groove lead to the correct sound frequencies.

(i) Calculate the angular velocity of an LP.

(2)

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Angular velocity = ...

(ii) As the stylus moves towards the centre of the LP the encoded bumps must be fitted into a shorter length of groove.

Explain why the encoding of bumps in the groove becomes more compressed as the stylus moves towards the centre.

(3)

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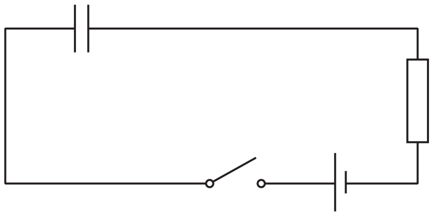
(Total for Question 15 = 9 marks)

16 The diagram shows a circuit that includes a capacitor.



(a) (i) Explain what happens to the capacitor when the switch is closed.

(2)

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(ii) The potential difference (p.d.) across the resistor rises to a maximum as the switch is closed.

Explain why this p.d. subsequently decreases to zero.

(2)

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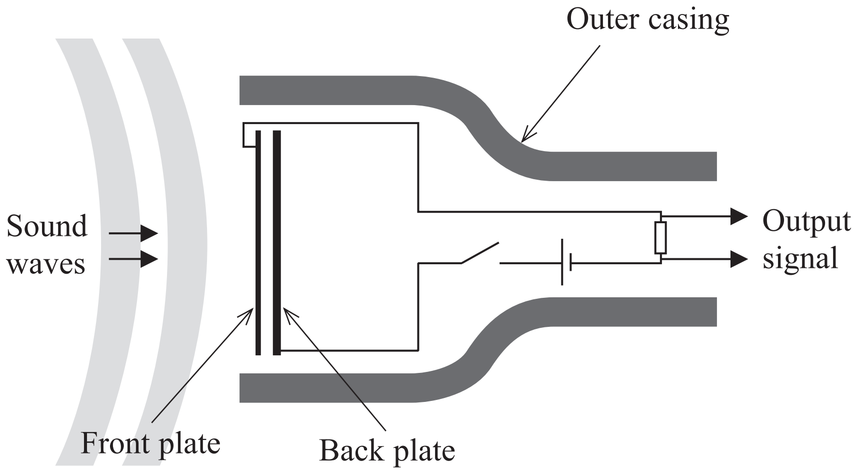
*(b) One type of microphone uses a capacitor. The capacitor consists of a flexible front plate (diaphragm) and a fixed back plate. The output signal is the potential difference across the resistor.



The sound waves cause the flexible front plate to vibrate and change the capacitance. Moving the plates closer together increases the capacitance. Moving the plates further apart decreases the capacitance.

Explain how the sound wave produces an alternating output signal.

(4)

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(c) A microphone has a capacitor of capacitance 500 pF and resistor of resistance 10 MΩ.

Explain why these values are suitable even for sounds of the lowest audible frequency of about 20 Hz.

(4)

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(Total for Question 16 = 12 marks)

17 Anti-hydrogen atoms have been created at CERN. An anti-hydrogen atom consists of an anti-proton and a positron.

(a) Compare the properties of an anti-hydrogen atom with a hydrogen atom.

(2)

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(b) Calculate the electrostatic force of attraction between the positron and the anti-proton.

Assume that the radius of the anti-hydrogen atom is 5.3×10^{-11} m.

(3)

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Force = ...

(c) Scientists want to find out if anti-hydrogen atoms emit the same spectra as hydrogen atoms. Anti-protons are relatively easy to contain, however, it is very difficult to contain anti-hydrogen atoms for any period of time.

Explain why it is difficult to contain anti-hydrogen atoms compared with anti-protons.

(2)

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(d) The technology suggested in the science fiction series, Star Trek, for powering the Starship Enterprise relied on antimatter. When an anti-hydrogen atom meets a hydrogen atom, they annihilate and produce energy.

(i) How much energy, in joules, would be produced by the annihilation of just 1 milligram of anti-hydrogen atoms?

(3)

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Energy = ... J

(ii) Anti-protons are required to produce anti-hydrogen atoms. The total production of anti-protons on Earth over the past 25 years adds up to only a few nanograms.

Suggest why so little anti-matter has been created.

(1)

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(Total for Question 17 = 11 marks)

18 James Chadwick is credited with "discovering" the neutron in 1932.

Beryllium was bombarded with alpha particles, knocking neutrons out of the beryllium atoms. Chadwick placed various targets between the beryllium and a detector. Hydrogen and nitrogen atoms were knocked out of the targets by the neutrons and the kinetic energies of these atoms were measured by the detector.

(a) The maximum energy of a nitrogen atom was found to be 1.2 MeV.

Show that the maximum velocity of the atom is about 4×10^6 m s^{-1}.

mass of nitrogen atom = 14u, where $u = 1.66 \times 10^{-27}$ kg

(3)

(b) The mass of a neutron is Nu (where N is the relative mass of the neutron) and its initial velocity is x. The nitrogen atom, mass 14u, is initially stationary and is then knocked out of the target with a velocity, y, by a collision with a neutron.

(i) Show that the velocity, z, of the neutron after the collision can be written as

$$z = \frac{Nx - 14y}{N}$$

(3)

P 3 9 8 4 9 A 0 1 9 2 4

Turn over ▶

(ii) The collision between this neutron and the nitrogen atom is elastic. What is meant by an elastic collision?

(1)

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(iii) Explain why the kinetic energy E_k of the nitrogen atom is given by

$$E_k = \frac{Nu(x^2 - z^2)}{2}$$

(2)

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(c) The two equations in (b) can be combined and z can be eliminated to give

$$y = \frac{2Nx}{N + 14}$$

(i) The maximum velocity of hydrogen atoms knocked out by neutrons in the same experiment was 30×10^7 m s^{-1}. The mass of a hydrogen atom is $1u$.

Show that the relative mass N of the neutron is 1.

(3)

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(ii) This equation can **not** be applied to all collisions in this experiment.

Suggest why.

(1)

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(Total for Question 18 = 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 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	$\lambda = h/p$