Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number | Candidate Number

Physics

Advanced

Unit 4: Physics on the Move

Wednesday 11 June 2014 – Afternoon
Time: 1 hour 35 minutes

Paper Reference **6PH04/01**

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.
- 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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1/1/1/1/

P 4 3 1 2 0 A 0 1 2 4

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 A footballer kicks a football from the penalty spot. A graph of force on the ball against time is drawn.

The area under the force-time graph represents

☐ **A** acceleration

☐ **B** change in kinetic energy

☐ **C** change in momentum

☐ **D** displacement

(Total for Question 1 = 1 mark)

2 Select the row of the table which correctly identifies the quantities conserved in an inelastic collision.

	Momentum	Kinetic energy	Total energy
☐ **A**	conserved	conserved	conserved
☐ **B**	conserved	not conserved	conserved
☐ **C**	conserved	not conserved	not conserved
☐ **D**	not conserved	not conserved	not conserved

(Total for Question 2 = 1 mark)

3 Which variables are linked in the de Broglie equation?

☐ **A** frequency and wavelength of a photon

☐ **B** wavelength and momentum of a moving electron

☐ **C** energy and frequency of a photon

☐ **D** work function and threshold frequency of a metal

(Total for Question 3 = 1 mark)

P 4 3 1 2 0 A 0 2 2 4

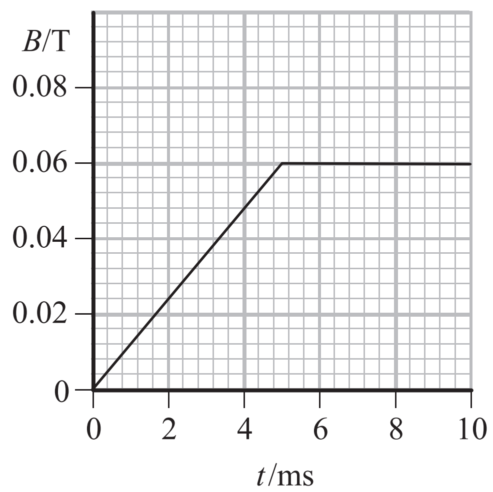
4 A radioactive isotope of aluminium is $^{25}_{13}Al$

Select the row in the table that correctly identifies a neutral atom of this isotope.

	Neutrons	Protons	Electrons
☒ **A**	12	13	12
☒ **B**	13	12	13
☒ **C**	13	12	12
☒ **D**	12	13	13

(Total for Question 4 = 1 mark)

5 A coil of 300 turns each of area 1.5×10^{-4} m² is placed in a magnetic field with its plane at right angles to the field. The graph shows how the magnetic flux density *B* of the field varies with time *t*.



The e.m.f. induced in the coil during the first 5 ms is

☒ **A** 5.4×10^{-1} V

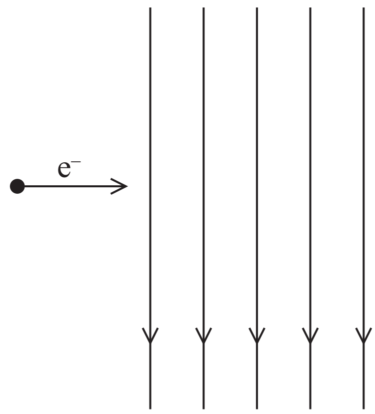
☒ **B** 4.5×10^{-2} V

☒ **C** 1.8×10^{-3} V

☒ **D** 5.4×10^{-4} V

(Total for Question 5 = 1 mark)

6 An electron travelling horizontally enters a uniform electric field which acts vertically downwards as shown in the diagram.



Which of the following statements is **incorrect**?

☒ **A** The electron follows a parabolic path.

☒ **B** The electron accelerates while in the field.

☒ **C** The electric force on the electron acts downwards.

☒ **D** The speed of the electron increases.

(Total for Question 6 = 1 mark)

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7 A current of 1.50 A flows in a straight wire of length 0.450 m. The wire is placed in a uniform magnetic field of flux density 2.00×10^{-3} T which acts perpendicular to the wire. Under these conditions the magnetic force balances the weight of the wire.

Calculate the mass of the wire.

☒ **A** 1.32×10^{-2} kg

☒ **B** 1.35×10^{-3} kg

☒ **C** 1.38×10^{-4} kg

☒ **D** 1.35×10^{-4} kg

(Total for Question 7 = 1 mark)

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8 An alpha particle moves at right angles to a uniform magnetic field and experiences a force F. A beta particle moves at right angles to a magnetic field of half the magnetic flux density but at ten times the velocity of the alpha particle.
The magnitude of the force on the beta particle will be

☒ **A** 0.25 F

☒ **B** 0.40 F

☒ **C** 2.5 F

☒ **D** 5.0 F

(Total for Question 8 = 1 mark)

9 Which of the following is a possible unit for rate of change of momentum?

☒ **A** kg m s^{-1}

☒ **B** kg m s^{-2}

☒ **C** N s

☒ **D** N s^{-1}

(Total for Question 9 = 1 mark)

10 The photograph shows cars driving around a roundabout at a constant speed.

The resultant force F on a car causes it to follow a circular path.

Which of the following statements about F is **incorrect**?

☒ **A** F is equal to the product of the mass and angular velocity of the car.

☒ **B** F is equal to the product of the momentum and angular velocity of the car.

☒ **C** F is in the same direction as the acceleration of the car.

☒ **D** F is perpendicular to the momentum of the car.

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

***11** A stationary radium nucleus decays by emitting an alpha particle. The speed of the recoiling nucleus is small compared to the speed of the alpha particle.

Explain why the nucleus recoils and why its speed is small compared to that of the alpha particle.

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(Total for Question 11 = 4 marks)

12 The Starflyer is a fairground ride which operates 60 m above the ground. As it begins to spin, the chairs in which the riders sit move outwards.

Consider the chair and rider as a single object. By drawing a free-body force diagram and considering the forces acting, explain the following observations.

The angle to the vertical of the supporting ropes depends on the speed of rotation, but does not depend on the mass of the rider.

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(Total for Question 12 = 5 marks)

13 An electron is accelerated from rest through a potential difference of 700 V in a vacuum.

(a) Show that the final momentum of the electron is about 1×10^{-23} N s.

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(b) Calculate the wavelength associated with this electron.

(2)

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Wavelength = ...

(c) Suggest why such electrons would be useful for investigating the atomic structure of materials.

(1)

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(Total for Question 13 = 6 marks)

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14 The photograph is an image of the paths of particles obtained from an early particle detector, the cloud chamber.

Modern particle detectors such as the ones at CERN still work on the basic principle that charged particles cause ionisation of the material through which they pass. These ionisations can be tracked and recorded. Magnetic fields are used to deflect the particles so that their properties can be investigated.

(a) State what is meant by ionisation in this context.

(1)

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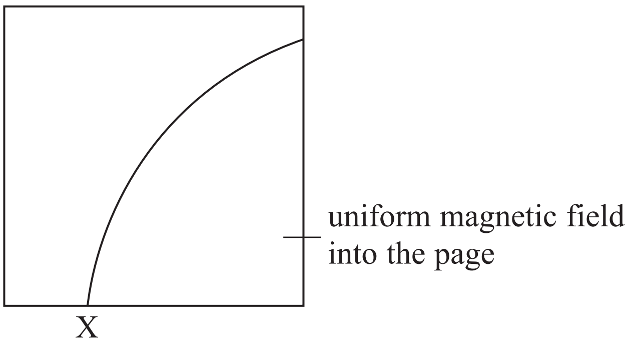
(b) The diagram below shows the ionisation path of a particle when it is in the region of a uniform magnetic field. The particle enters the field at X.



State how we know that the particle is negatively charged.

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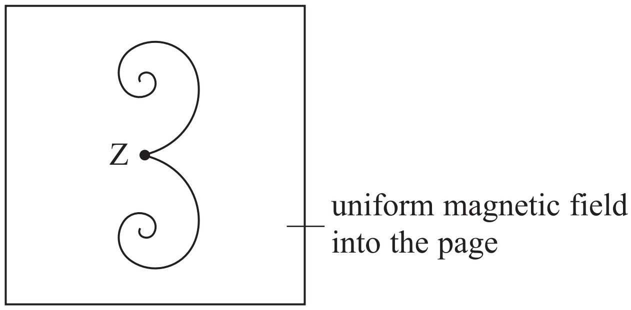
P 4 3 1 2 0 A 0 1 0 2 4

(c) The diagram below shows an event occurring in the same magnetic field.



Point Z is where a high energy photon interaction occurs which causes two particles to be formed.

Describe, with reasons, what can be deduced about the photon and the two particles that are formed in this interaction.

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(Total for Question 14 = 7 marks)

15 (a) A magnetic field can be measured with a device called a Hall probe. The probe is connected to a voltmeter. When the probe is placed at right angles to a magnetic field, a potential difference is recorded on the voltmeter. The potential difference increases with increasing magnetic flux density.

A wire carries a constant current. A Hall probe is used to investigate how the magnetic flux density produced by the wire varies with distance from the wire.

The potential difference V was recorded for a range of distances r.

r/cm	V/V
1.0	0.725
1.5	0.483
2.0	0.363
2.5	0.29
3.0	0.242
3.5	0.21

(i) Criticise these results.

(2)

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(ii) It is suggested that V and r are related by the equation

$$V = \frac{k}{r}$$

where k is a constant.

(1) Determine by calculation whether this suggestion is valid.

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(2) A graph of $\frac{1}{V}$ is plotted against r.

State how the graph would indicate that the equation is correct.

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(b) The Hall probe can be replaced with a small coil of wire which is connected to a sensitive voltmeter. The plane of the coil is at right angles to the magnetic field produced by the current-carrying wire.

(i) Explain, with reference to Faraday's law, why the voltmeter reading would be zero.

(2)

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(ii) State **three** different ways in which an e.m.f. could be induced in this coil.

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(Total for Question 15 = 10 marks)

16 (a) Explain what is meant by the term electric field strength.

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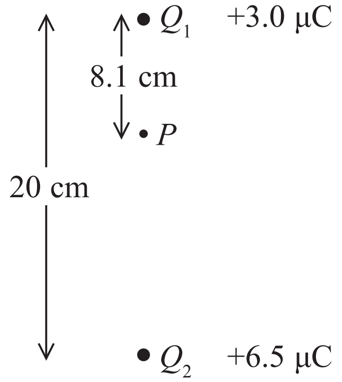
(b) (i) Two point charges Q_1 and Q_2 are placed 20 cm apart. Q_1 has a charge of +3.0 µC and Q_2 has a charge of +6.5 µC.



At point P, a distance 8.1 cm from Q_1, the electric field strength is approximately zero.

Demonstrate by calculation that this statement is correct.

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(ii) A charge of +4.5 μC is placed at point P.
State the magnitude of the force acting on this charge.

(1)

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(iii) The + 4.5 μC charge is moved from point P to a point half way between Q_1 and Q_2.

Explain qualitatively why energy would be needed for this movement.

(2)

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(Total for Question 16 = 8 marks)

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17 In recent years there has been a development of ultracapacitors which have much higher capacitance than traditional capacitors. Capacitors store energy due to charge in an electric field whereas batteries store energy due to a chemical reaction. There are several applications where ultracapacitors have an advantage over batteries; for example storing energy from rapidly fluctuating supplies or delivering charge very quickly.

(a) A typical ultracapacitor has a capacitance of 1500 F and a maximum operating potential difference of 2.6 V.

(i) Show that the charge on this capacitor when fully charged is about 4000 C.

(2)

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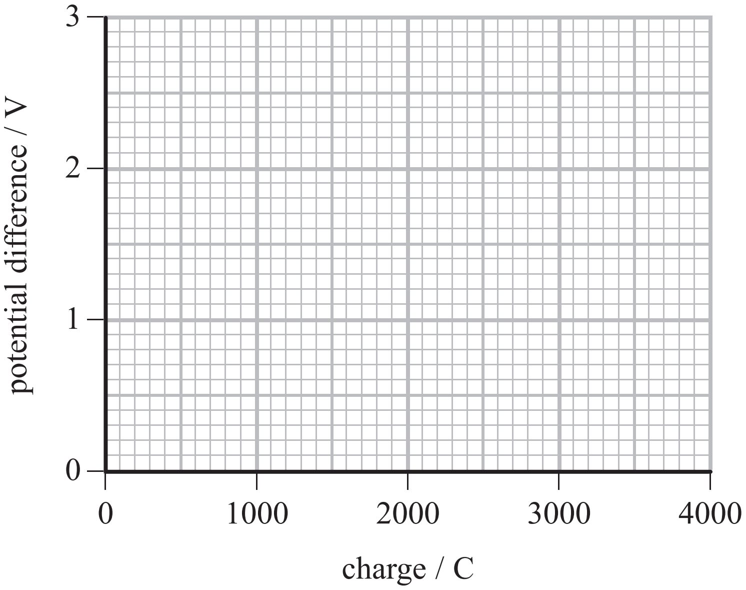
(ii) Complete the graph on the axes below to show how the potential difference varies with charge for this capacitor.

(2)



(iii) Calculate the energy stored in this capacitor when fully charged.

(2)

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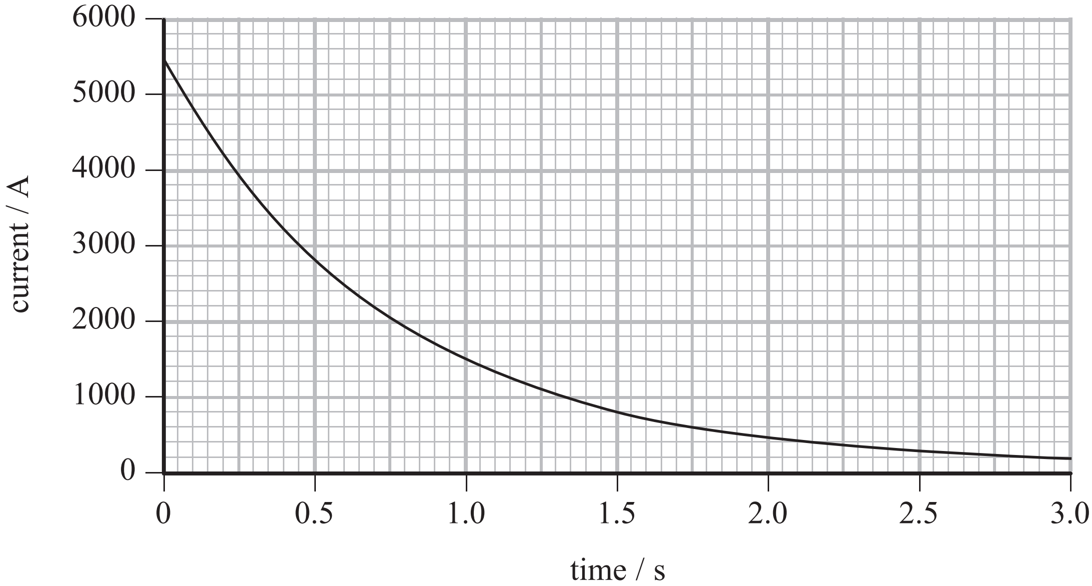
Energy = ...

(b) The graph below shows how the current varies with time as the capacitor is discharged through a circuit.



(i) Describe and explain the shape of the graph.

(2)

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(ii) Calculate the resistance of the circuit.

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Resistance = ...

(c) There is a limit to the amount of charge an ultracapacitor can hold but it can deliver the charge very quickly. A battery can deliver much more charge but only at a slower rate. For electric powered vehicles it is suggested that using a combination of batteries and ultracapacitors would give the best performance.

Suggest, with reasons, which stages of a journey would be more suited to ultracapacitors and which would be more suited to batteries.

(3)

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(Total for Question 17 = 15 marks)

18 Subatomic particles such as pions are produced after collisions between protons that have been accelerated in a cyclotron.

*(a) Explain briefly the role of electric and magnetic fields in the cyclotron.

(5)

(b) The mass of a pion is 2.5×10^{-28} kg.

Calculate the mass of a pion in GeV/c^2.

(3)

Mass = ... GeV/c^2

(c) The table shows the charge of some quarks.

Type of quark	**Charge/*e***
u	+2/3
d	−1/3
s	−1/3

Explain what is meant by a charge of +2/3

(1)

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(d) The omega (Ω) minus particle consists of three strange quarks and is produced by the following interaction.

$$K^- + p \rightarrow K^+ + K^0 + \Omega^-$$

Kaons are mesons and consist of a strange quark and either an up or a down quark.

(i) Complete the table to show a possible quark combination for each kaon.

(3)

Particle	Quark combination
K^-	
K^+	
K^0	

(ii) The total mass of the particles produced in this interaction is greater than the total mass of the two particles that collided.
Explain this increase in mass.

(3)

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(Total for Question 18 = 15 marks)

TOTAL FOR SECTION B = 70 MARKS

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

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	$\lambda = h/p$