Centre No.						Paper Reference	Surname	Initial(s)
Candidate No.						6 7 3 6 / 0 1	Signature	

Paper Reference(s)

6736/01

Edexcel GCE

Physics

Advanced Level

Unit Test PHY6

Friday 25 January 2008 – Morning

Time: 2 hours

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
3	
4	
Total	

Materials required for examination	**Items included with question papers**
Nil	Insert

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your signature, your surname and initials.
Answer **ALL** questions in the spaces provided in this question paper.
In calculations you should show all the steps in your working, giving your answer at each stage.
Calculators may be used.
Include diagrams in your answers where these are helpful.

Information for Candidates

This question paper is designed to give you the opportunity to make connections between different areas of physics and to use skills and ideas developed throughout the course in new contexts. You should include in your answers relevant information from the whole of your course, where appropriate.
You should have an insert that is the passage for use with Section I.
The marks for individual questions and the parts of questions are shown in round brackets.
There are four questions in this paper. The total mark for this paper is 80.
The list of data, formulae and relationships is printed at the end of this booklet.

Advice to Candidates

You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, taking account of your use of grammar, punctuation and spelling.

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SECTION I

Read the passage on the separate insert and then answer the Section I questions.

1. (a) State **two** different uses to which ultrasonic waves have been put by people.

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(2)

(b) Show that the maximum wavelength of ultrasonic waves in air will be less than 20 mm (paragraph 1).

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(3)

(c) Explain what is meant by the following phrases used in paragraph 1 of the passage:

(i) waves do not disperse,

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(ii) attenuation of the wave,

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(iii) mechanical longitudinal wave.

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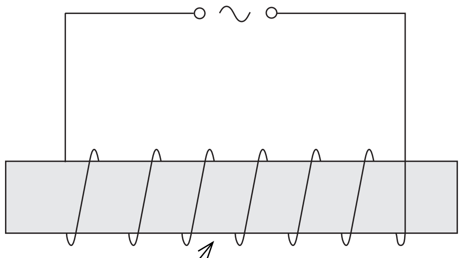
(d) Longitudinal stationary waves are set up on a 30 mm long nickel rod in a solenoid to make an ultrasonic transducer. Each end of the rod oscillates with an amplitude of 0.010 mm when the frequency of the alternating current in the solenoid is 80 kHz.



(i) Add to the diagram to show the shape of the magnetic field when the current in the solenoid is at a maximum.

(2)

(ii) Calculate the maximum acceleration of the ends of the nickel rod during their oscillations.

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(2)

(iii) Explain what is meant by a stationary wave.

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(iv) Calculate the speed of ultrasonic waves in the nickel rod, explaining how you decide your value for the wavelength λ of these waves.

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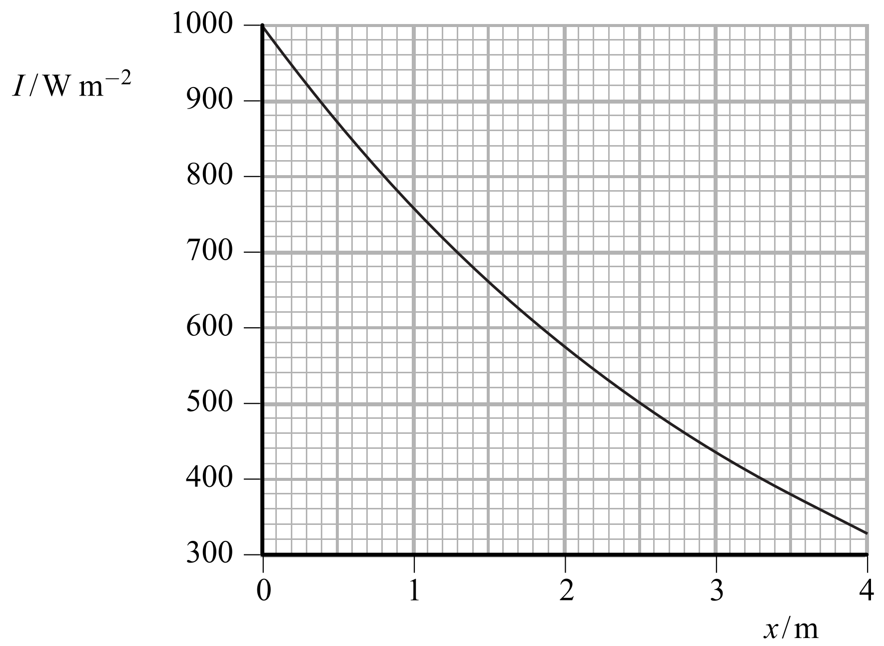
(e) (i) The graph shows how the intensity I of a parallel beam of ultrasonic waves decreases as the beam propagates a distance x in air.



Use the graph to confirm that the intensity of the beam is decreasing exponentially.

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(ii) The intensity I of an ultrasonic wave in air depends on the squares of the particle's amplitude x_0 and frequency f (paragraph 4), i.e.

$$I = kx_0^2 f^2 \qquad \text{where } k \text{ is a constant.}$$

1. Show that the constant k has base SI units kg m^{-2} s^{-1}.

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2. It can be shown that k depends directly on the density of the air. By considering the base units of k, suggest what other factor k depends on.

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(4)

(f) Describe an experiment to show that small wavelength waves diffract less than long wavelength waves. You may refer to waves of any kind.

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(g) Explain how measurements of Doppler shifts of electromagnetic waves have enabled us to estimate the age of our Universe.

You may be awarded a mark for the clarity of your answer.

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(5) **Q1**

(Total 32 marks)

TOTAL FOR SECTION I: 32 MARKS

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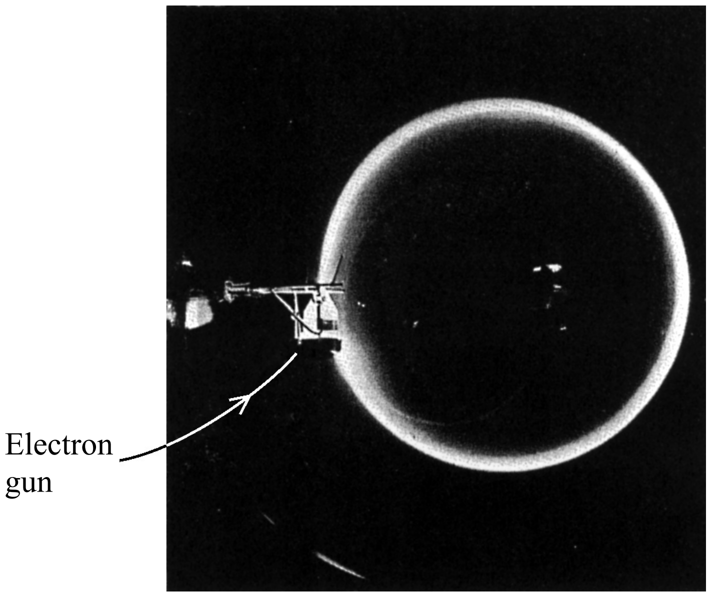
SECTION II

(Answer ALL questions)

2. (a) An electron gun fires a beam of electrons upwards from the centre left of a tube in which there is a very small amount of helium gas. The photograph shows the resulting circular glow. A uniform magnetic field of flux density B acts perpendicular to the plane of the circle in which the electrons are moving at a uniform speed v.



(i) Explain how you can deduce that the magnetic field is directed into the plane of the circle.

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(2)

(ii) Prove that the circle has a radius $r = mv/Be$ where e is the charge on the electron and m is the electron mass. Hence prove that the time T taken for the electrons to complete one circle is independent of the speed v at which they were fired.

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(3)

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(iii) The electrons are fired by accelerating them from rest across a potential difference of 160 V.

Calculate the speed with which they are fired.

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(2)

(iv) Some of the electrons ionise the helium atoms in the tube and as the ionised atoms return to excited states and then to the ground state they emit visible photons.

Draw a labelled diagram to illustrate this statement.

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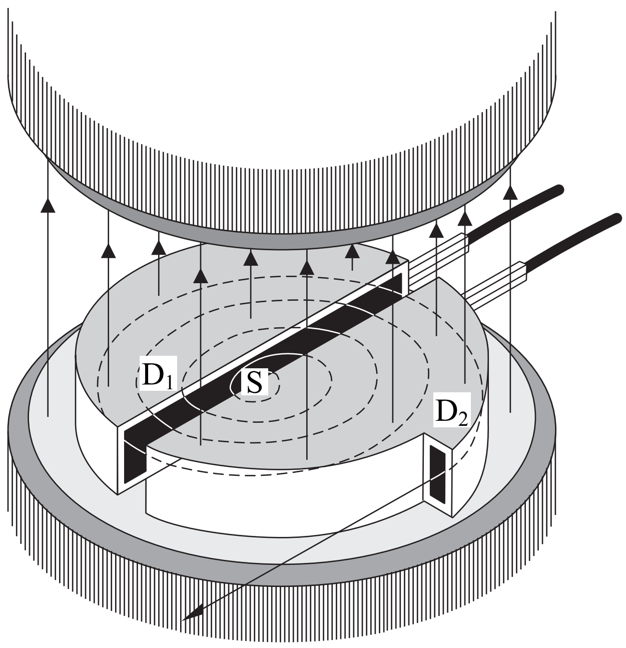
(b) Protons from a source S can be accelerated to high energies by a cyclotron. The protons travel in a vacuum inside two Dee-shaped metal boxes D_1 and D_2 shown in the diagram of a cyclotron below.



(i) Add labels to the diagram to identify the other key components of a cyclotron.

(3)

(ii) Each proton emerging from a cyclotron has a kinetic energy of 9.4 MeV.

Express this energy gain as an increase in the mass of each proton and comment on how this relates to its rest mass.

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(4) **Q2**

(Total 17 marks)

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3. (a) The first supersonic jet airliner, Concorde, had a typical take-off mass of 170 000 kg, of which nearly 50% was fuel, and a take-off speed of 380 km h^{-1}.

(i) Show that the average acceleration of such a Concorde during a runway take-off of length 1.7 km was about 3 m s^{-2}.

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(ii) Hence, calculate the average forward push of a seat on a passenger of mass 85 kg during such an acceleration.

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(iii) Explain why, using the same engines as at take-off, but in reverse thrust, the deceleration of a Concorde on landing after a long flight was much greater than 3 m s^{-2}.

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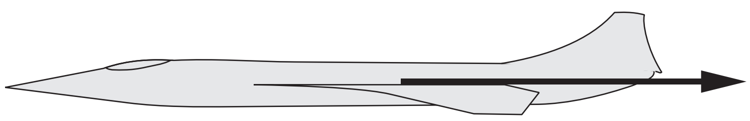
(b) The diagram shows Concorde flying at a steady cruising speed high in the atmosphere with an air drag (the air resistance force) on it of 210 kN.



(i) Add arrows to the diagram to show any other forces acting on Concorde, giving their sizes where possible.

(ii) Explain how any force that acts to drive Concorde through the air is produced.

You may be given a mark for the clarity of your answer.

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(c) The air pressure and temperature at Concorde's cruising height are 8.0 kPa and −50 °C; very low compared to the average values at take-off, which are 101 kPa and 25 °C.

Deduce the ratio of the density of air at take-off to that at cruising height. Explain how you made your deduction and state any assumptions you made.

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(5)

Q3

(Total 16 marks)

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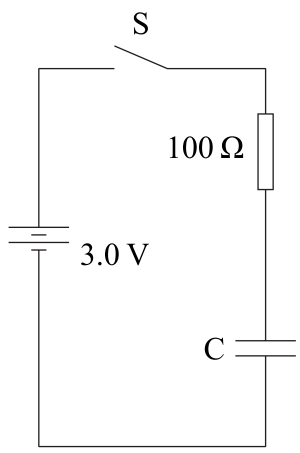
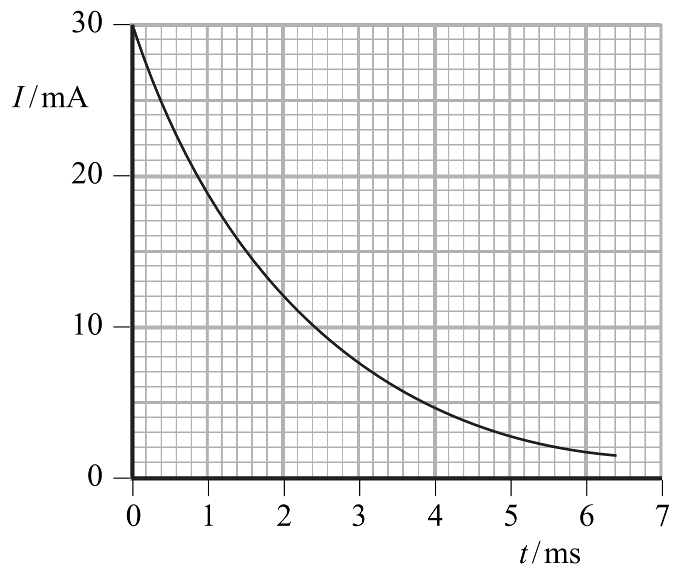
4. (a) When the switch S in the circuit below is closed the initially uncharged capacitor charges through the 100 Ω resistor. The current I in the circuit varies with time t as shown on the accompanying graph.





(i) By estimating the charge which flows, deduce the capacitance C of the capacitor.

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(4)

(ii) Explain why the initial current is 30 mA.

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(2)

(iii) Complete the table to show the potential difference V_R across the 100 Ω resistor at various times during the charging process.

t/ms	0	2	4	6
V_R/V				

(2)

N 2 6 6 9 9 A 0 1 6 2 4

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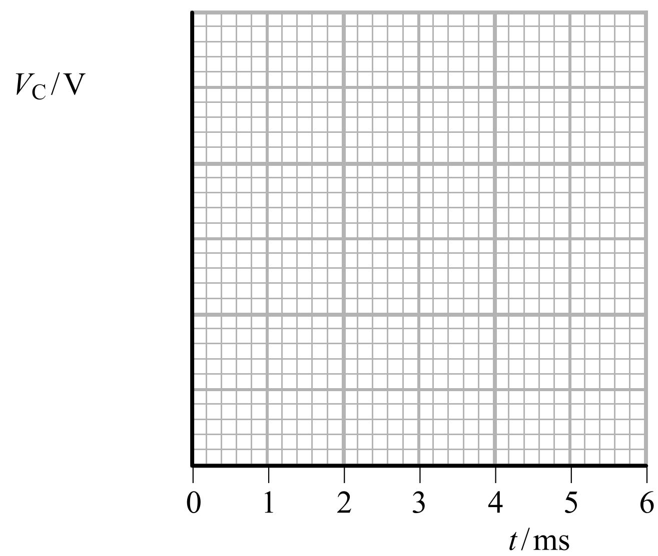
(iv) Add to the axes below a graph to show how the potential difference V_C across the capacitor varies during the first 6 ms of the charging process. Label the p.d. axis with appropriate values.



(3)

(b) The circuit shown in part (a), with a different value of C and a resistor of resistance R in place of the 100 Ω, can be used to act as a delay switch. For example when switching on a house alarm system by closing switch S, the occupant needs a delay while he or she leaves the house before the alarm is activated.

(i) State how the alarm circuit should be connected to the circuit in part (a).

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(ii) Suggest a suitable time delay and hence suggest values for C and R for use in such a system.

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(4)

Q4

(Total 15 marks)

TOTAL FOR PAPER: 80 MARKS

END

List of data, formulae and relationships

Data

Speed of light in vacuum	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$	
Gravitational constant	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$	
Acceleration of free fall	$g = 9.81\ \mathrm{m\,s^{-2}}$	(close to the Earth)
Gravitational field strength	$g = 9.81\ \mathrm{N\,kg^{-1}}$	(close to the Earth)
Elementary (proton) charge	$e = 1.60 \times 10^{-19}\ \mathrm{C}$	
Electronic mass	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$	
Electronvolt	$1\,\mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$	
Unified atomic mass unit	$\mathrm{u} = 1.66 \times 10^{-27}\ \mathrm{kg}$	
Molar gas constant	$R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$	
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$	
Coulomb law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^{9}\ \mathrm{N\,m^{2}\,C^{-2}}$	
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{N\,A^{-2}}$	

Rectilinear motion

For uniformly accelerated motion:

$$v = u + at$$

$$x = ut + \tfrac{1}{2}at^2$$

$$v^2 = u^2 + 2ax$$

Forces and moments

Moment of F about O = $F \times$ (Perpendicular distance from F to O)

Sum of clockwise moments about any point in a plane = Sum of anticlockwise moments about that point

Dynamics

Force $F = m\dfrac{\Delta v}{\Delta t} = \dfrac{\Delta p}{\Delta t}$

Impulse $F\Delta t = \Delta p$

Mechanical energy

Power $P = Fv$

Radioactive decay and the nuclear atom

Activity $A = \lambda N$ (Decay constant λ)

Half-life $\lambda t_{\frac{1}{2}} = 0.69$

Electrical current and potential difference

Electric current	$I = nAQv$	
Electric power	$P = I^2 R$	

Electrical circuits

Terminal potential difference	$V = \mathcal{E} - Ir$	(E.m.f. $\mathcal{E}$; Internal resistance r)
Circuit e.m.f.	$\Sigma\mathcal{E} = \Sigma IR$	
Resistors in series	$R = R_1 + R_2 + R_3$	
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$	

Heating matter

Change of state:	energy transfer $= l\Delta m$	(Specific latent heat or specific enthalpy change l)
Heating and cooling:	energy transfer $= mc\Delta T$	(Specific heat capacity c; Temperature change ΔT)
Celsius temperature	$\theta/°\mathrm{C} = T/\mathrm{K} - 273$	

Kinetic theory of matter

Temperature and energy	$T \propto$ Average kinetic energy of molecules
Kinetic theory	$p = \frac{1}{3}\rho\langle c^2\rangle$

Conservation of energy

Change of internal energy	$\Delta U = \Delta Q + \Delta W$	(Energy transferred thermally ΔQ; Work done on body ΔW)
Efficiency of energy transfer	$= \frac{\text{Useful output}}{\text{Input}}$	
Heat engine maximum efficiency	$= \frac{T_1 - T_2}{T_1}$	

Circular motion and oscillations

Angular speed	$\omega = \frac{\Delta\theta}{\Delta t} = \frac{v}{r}$	(Radius of circular path r)
Centripetal acceleration	$a = \frac{v^2}{r}$	
Period	$T = \frac{1}{f} = \frac{2\pi}{\omega}$	(Frequency f)

Simple harmonic motion:

displacement $x = x_0 \cos 2\pi ft$

maximum speed $= 2\pi f x_0$

acceleration $a = -(2\pi f)^2 x$

For a simple pendulum	$T = 2\pi\sqrt{\frac{l}{g}}$	
For a mass on a spring	$T = 2\pi\sqrt{\frac{m}{k}}$	(Spring constant k)

Waves

Intensity	$I = \dfrac{P}{4\pi r^2}$	(Distance from point source r; Power of source P)

Superposition of waves

Two slit interference	$\lambda = \dfrac{xs}{D}$	(Wavelength λ; Slit separation s; Fringe width x; Slits to screen distance D)

Quantum phenomena

Photon model	$E = hf$	(Planck constant h)
Maximum energy of photoelectrons	$= hf - \varphi$	(Work function φ)
Energy levels	$hf = E_1 - E_2$	
de Broglie wavelength	$\lambda = \dfrac{h}{p}$	

Observing the Universe

Doppler shift	$\dfrac{\Delta f}{f} = \dfrac{\Delta\lambda}{\lambda} \approx \dfrac{v}{c}$	
Hubble law	$v = Hd$	(Hubble constant H)

Gravitational fields

Gravitational field strength	$g = F/m$	
for radial field	$g = Gm/r^2$, numerically	(Gravitational constant G)

Electric fields

Electric field strength	$E = F/Q$	
for radial field	$E = kQ/r^2$	(Coulomb law constant k)
for uniform field	$E = V/d$	
For an electron in a vacuum tube	$e\Delta V = \Delta(\frac{1}{2}m_e v^2)$	

Capacitance

Energy stored	$W = \frac{1}{2}CV^2$	
Capacitors in parallel	$C = C_1 + C_2 + C_3$	
Capacitors in series	$\dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3}$	
Time constant for capacitor discharge	$= RC$	

Magnetic fields

Force on a wire	$F = BIl$	
Magnetic flux density (Magnetic field strength)		
in a long solenoid	$B = \mu_0 nI$	(Permeability of free space μ_0)
near a long wire	$B = \mu_0 I/2\pi r$	
Magnetic flux	$\Phi = BA$	
E.m.f. induced in a coil	$\mathcal{E} = -\dfrac{N\Delta\Phi}{\Delta t}$	(Number of turns N)

Accelerators

Mass-energy	$\Delta E = c^2\Delta m$
Force on a moving charge	$F = BQv$

Analogies in physics

Capacitor discharge	$Q = Q_0 e^{-t/RC}$
	$\dfrac{t_{\frac{1}{2}}}{RC} = \ln 2$
Radioactive decay	$N = N_0 e^{-\lambda t}$
	$\lambda t_{\frac{1}{2}} = \ln 2$

Experimental physics

$$\text{Percentage uncertainty} = \frac{\text{Estimated uncertainty} \times 100\%}{\text{Average value}}$$

Mathematics

$$\sin(90° - \theta) = \cos\theta$$

$$\ln(x^n) = n\ln x$$

$$\ln(e^{kx}) = kx$$

Equation of a straight line	$y = mx + c$	
Surface area	cylinder $= 2\pi rh + 2\pi r^2$	
	sphere $= 4\pi r^2$	
Volume	cylinder $= \pi r^2 h$	
	sphere $= \frac{4}{3}\pi r^3$	
For small angles:	$\sin\theta \approx \tan\theta \approx \theta$	(in radians)
	$\cos\theta \approx 1$	

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