FINAL MARK SCHEME

Centre No.						Paper Reference							Surname	Other names
Candidate No.						6	7	3	5	/	2	A	Signature	

Edexcel GCE

Physics

Advanced Level

Unit Test PHY5 Practical Test

Friday 18 January 2008 – Afternoon

Time: 1 hour 30 minutes

For Examiner's use only

For Team Leader's use only

Question numbers	Leave blank
A	
B	
C	
Total	

Supervisor's Data and Comments		
A	Width a	
	Thickness b	
	Mass M	
Comments		

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, other names and signature.

PHY5 consists of questions A, B and C. Each question is allowed 20 minutes plus 5 minutes writing-up time. There is a further 15 minutes for writing-up at the end. The Supervisor will tell you which experiment to attempt first.

Write all your results, calculations and answers in the spaces provided in this question booklet.

In calculations you should show all the steps in your working, giving your answer at each stage.

Information for Candidates

The marks for individual questions and the parts of questions are shown in round brackets.

The total mark for this paper is 48.

The list of data, formulae and relationships is printed at the end of this booklet.

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Question A

(a) (i) Take measurements to determine as accurately as possible values for the width a and thickness b of the half-metre rule.

a/cm: 2.81, 2.82, 2.83

$\bar{a}$ = 2.82 cm

$a \pm 0.04$ cm of Supervisor (1)

b/cm: 0.60, 0.62, 0.61

$\bar{b}$ = 0.61 cm

$b \pm 0.04$ cm of Supervisor (1)

$\boxed{\text{Readings must be to 0.01 cm precision or better}}$

Calculate the volume V of the rule.

$V = 50 \times 2.82 \times 0.61\ \text{cm}^3$

$= 86.0\ \text{cm}^3$

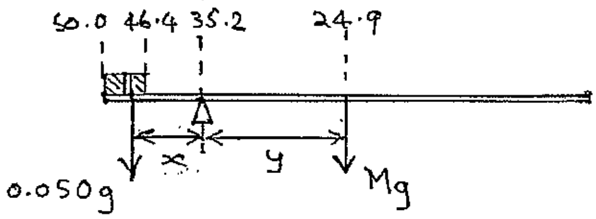
Both repeated & mean calculated (1)

(3) 3

(ii) Balance the rule on the knife edge and record the position of its centre of mass.

Scale reading at centre of mass 24.9 cm

Place the 50 g mass close to one end of the rule and move the knife-edge under the rule until the rule balances. Draw a diagram of the arrangement in the space below.



Correct diagram showing measurements to centres of mass (1)

Technique for centre of 50 g mass or repeated. (1)

Both lengths ≥ 8 cm and mm precision (1)

On your diagram show the position of the centre of mass of the rule and the measurements necessary to determine the mass of the rule using the principle of moments.

$x = \left(\frac{50.0 + 46.4}{2}\right) - 35.2\ \text{cm}$

$= 13.0\ \text{cm}$

$y = 35.2 - 24.9\ \text{cm}$

$= 10.3\ \text{cm}$

N 2 5 1 8 7 A 0 2 1 6

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Determine the mass M of the rule. Show all your working and calculations below.

$M \cancel{g} y = 0.050 \cancel{g} x$	Correct calculation of M, with unit (1)
$M = \frac{0.050 \times 13.0}{10.3}$	Value ± 2g of
$= \underline{0.0631\ kg}$	Supervisor (1)
$(= 63.1\ g)$	(0.002 kg)

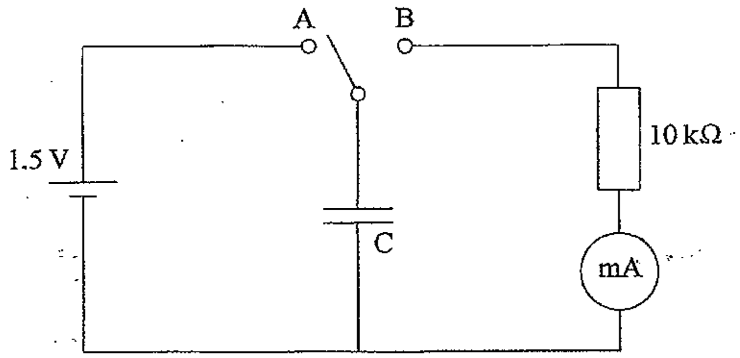
(5) 5

(iii) Use your values of V and M to calculate a value for the density of the rule.

Density $= \frac{M}{V} = \frac{63.1\,g}{86.0\ cm^3}$	Correct calculation of density from correct V
$= \underline{0.73\ g\ cm^{-3}}$	(ecf on M), with unit and 2/3 sf. (1)

(1) 1

(b) The circuit shown below has been set up ready for you to use.



The capacitor C can be charged by connecting the switch to contact A and then discharged through the 10 kΩ resistor by switching to B.

Leave blank

(i) Charge the capacitor and then discharge it through the resistor. Record the initial current I_0 in the circuit at the instant contact is made at B.

I_0 = 0.145 mA

Calculate the value of $0.368\, I_0$ = 0.053 mA

I_0 (0.12 – 0.17) mA and 0.368 I_0 correctly calculated with unit (1)

(1)

1

(ii) Determine an accurate value for the time t that it takes for the current to decrease from I_0 to $0.368\, I_0$.

t/s : 22.99, 22.69, 23.16

$\bar{t}$ = 22.9 s

≥ 3 readings (2)
[2 readings gets (1)]
[No unit (–1)]

Calculate a value for the capacitance C of the capacitor using the relationship

$$C = \frac{t}{R}$$

where $R = 10\ \text{k}\Omega$.

$C = \frac{t}{R} = \frac{22.9\ \text{s}}{10\ \text{k}\Omega}$

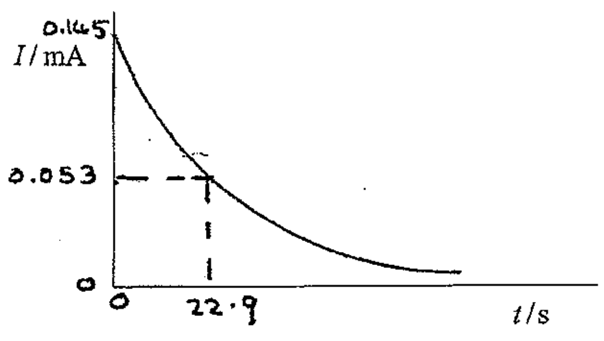
= 2300 μF

Correct calculation of C, with unit (F, mF or μF NOT $\text{s}\Omega^{-1}$) (1)
in range 1750 – 2650 μF and 2/3 s.f.

(3)

3

(iii) Sketch a graph of the discharge of the capacitor on the axes below. You should include relevant values on the axes.



Correct shaped curve starting at t = 0 and not cutting t axis (1)
Zero on t axis, t value shown (1)
I_0 and $0.368 I_0$ shown (1)
[Allow omission of numbers provided in correct position (just below half way)]

(3)

3

(Total 16 marks)

QA 16

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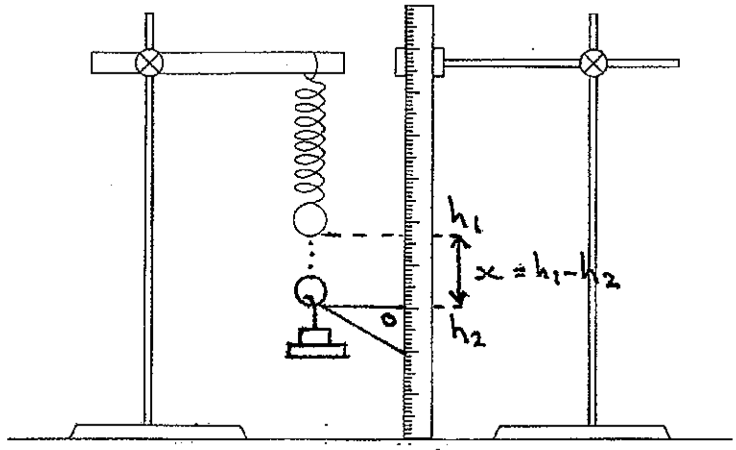
Question B

A spring has been set up ready for you to use.



(a) Hook the 100 g mass hanger onto the spring and add a further mass of 50 g so that the total suspended mass m is 150 g. You will be required to determine the extension x of the spring from its original unstretched length and the time period T of small vertical oscillations of the spring for five different values of $m \geq 150$ g.

Describe how you intend to measure x. You may add to the diagram if you wish.

Correct use of set square, either as shown or to ensure rule vertical (1)

x found from difference of two heights SHOWN or x repeated (1)

(2)

2

(b) Tabulate your readings in the space below. Add values of T^2 to your table.

m/g	h/mm	x/mm	20T/s	20T/s	T^2/s^2
0	463	0	—	—	—
150	391	72	11.14	11.19	0.312
200	367	96	12.86	12.77	0.411
250	340	123	14.24	14.26	0.508
300	314	149	15.65	15.70	0.614
350	289	174	16.94	17.01	0.720

Table for m, x, T, T^2 with units (1)

~~Total of~~ $\geq 30T$ (2)

[$\geq 20T \rightarrow (1)$]

5 good values (3)

[$4 \rightarrow (2)$
$3 \rightarrow (1)$]

["Good" = $0.01\ s^2$ from AE's ~~best fit~~ line]

(6)

6

[Systematic error (−2) eg. ≠T, whole seconds or whole cm]

N 2 5 1 8 7 A 0 6 1 6

(c) Plot a graph of T^2 against x on the grid below.

Sensible scale (allowing at least ½ grid in both directions, avoiding awkward scales, e.g. 3's) (1)

Plots accurate to ½ square & good straight line (1)

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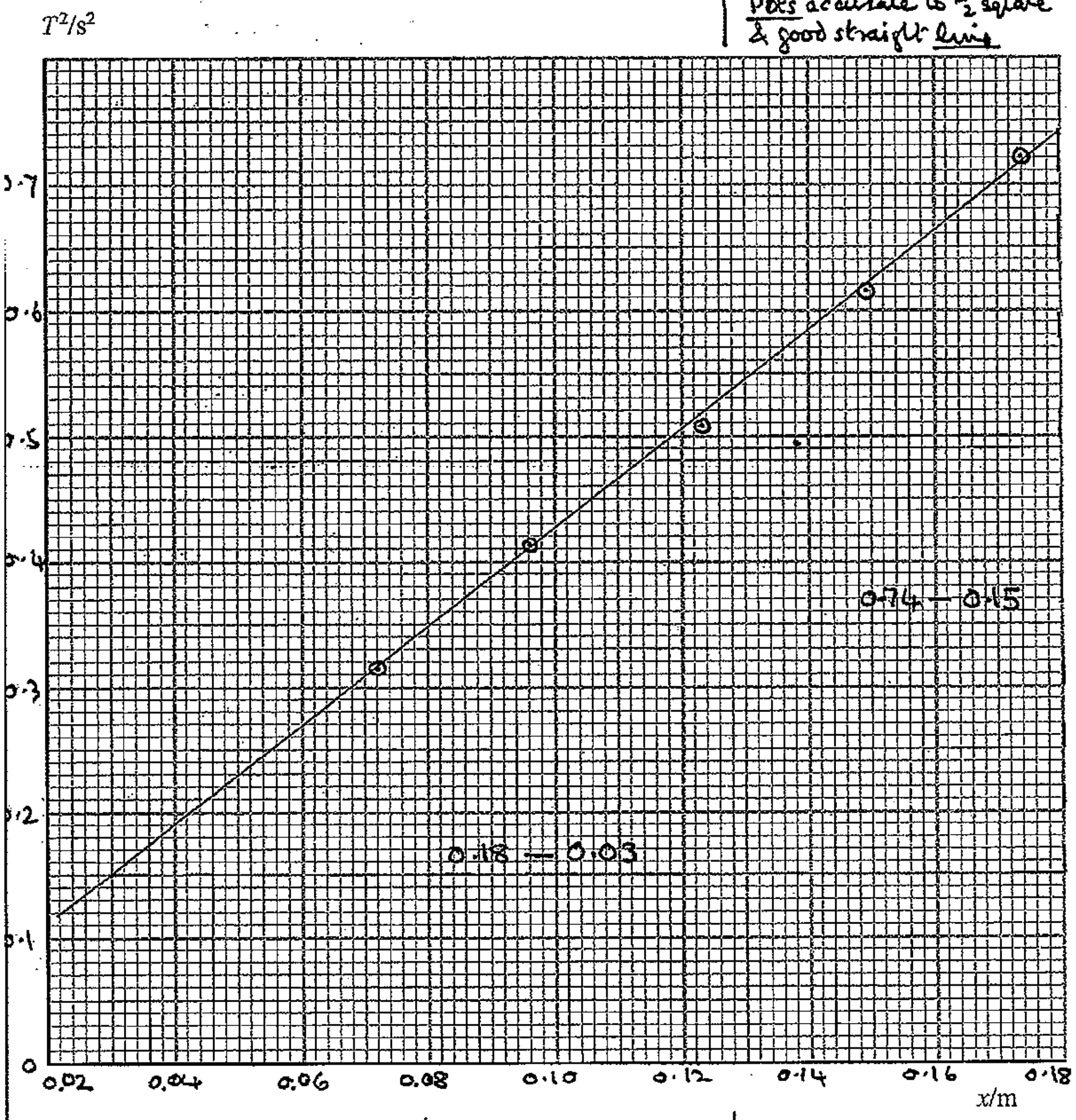

Determine the gradient S of your graph.

$S = \dfrac{0.74 - 0.15}{0.18 - 0.03}$

$= \underline{3.93\ (s^2\ m^{-1})}$

Large Δ (base ≥ 10 cm) (1)

Correct calculation of S (ignore units) ≥ 2 sf (1)

(4)

4

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(d) Calculate a value for the gravitational field strength g using the relationship

$$g = \frac{4\pi^2}{S}$$

$g = \dfrac{4\pi^2}{3.93 \text{ s}^2\text{m}^{-1}}$

$= \underline{10.0 \text{ ms}^{-2}}$

Correct calculation of g, with value between 9.3 and 10.3 ms^{-2} and unit and 1 d.p. (1)

Calculate the percentage difference between your value and the accepted value for g. Comment on this percentage difference in terms of the experimental uncertainty of your measurements.

% difference $= \dfrac{10.0 - 9.8}{9.8} \times 100\%$

$= \underline{2\%}$

Correct % difference with 9.8(1) as denominator (1)

Typically $x = \pm 2$ mm and $20T = \pm 0.1$s, giving about 2% uncertainty in x and 1% in T (2% in T^2). Thus 2% is within experimental uncertainty

Sensible comment related to % difference (1)

Quantified by at least one example (1)

4

(4)

(Total 16 marks)

QB 16

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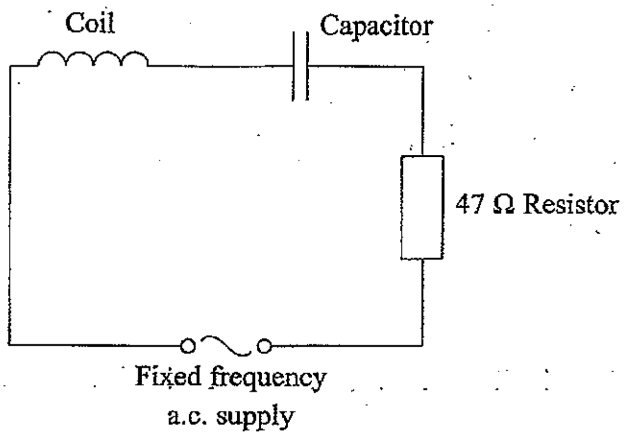
Question C

This question is about using capacitors to produce resonance in an electrical circuit.

(a) A teacher sets up the following circuit to demonstrate electrical resonance.

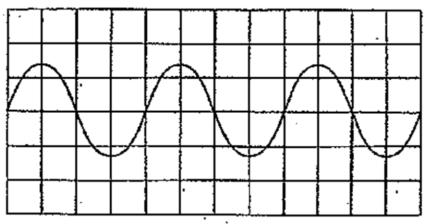


(i) Explain how an oscilloscope could be used to determine the current in the circuit.

Connect CRO across 47Ω resistor and measure p.d., V. | ----- (1)

Divide V by 47Ω to find the current I in the circuit [Consequent mark] | ---- (1)

With the time base set at 5 ms/div and the voltage sensitivity at 0.5 V/div, the following trace is obtained on the oscilloscope screen.



(ii) Calculate the frequency of the signal.

$1\lambda \equiv 4$ div $= 4 \times 5$ ms | Correct data for T = 20ms (1)

$T = 20\,ms^{-1} \Rightarrow f = 1/20ms = 50Hz$ | f + unit (1) [ecf on T]

(iii) Determine the peak voltage of the signal.

$V = 1{\cdot}4$ div $\times$ 0.5 V/div = 0·70V | 0.65 – 0.75 V with unit (1)

(5) 5

N 2 5 1 8 7 A 0 9 1 6

Turn over

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(b) The teacher has three capacitors, having values of 100 μF, 220 μF and 470 μF. Using these capacitors singly and in different combinations the teacher determines the currents shown in the table.

Explain how the capacitors could be used to get the capacitance values shown.

Use capacitors singly or in parallel combinations, eg 100 μF in parallel with 220 μF gives 320 μF

Parallel (1)
Example quoted (1)
[Consequent mark]

Capacitance C / μF	Current I / mA
100	11.8
220	20.2
320	35.9
470	55.0
570	41.5
690	32.7

(2)

2

(c) Plot a graph of the current I against the capacitance C on the grid opposite.

(5)

(d) (i) Use your graph to estimate the capacitance that would cause resonance in the circuit.

Resonance at 445 μF

Between 420 – 465 μF with unit (1)

(ii) Between which values of capacitance in the table would it be useful to take an extra measurement?

Between 320 μF & 470 μF (1)

Graph

Scale : using ≥ ½ axes in both directions and avoiding awkward scales, e.g. 3's .... (1)

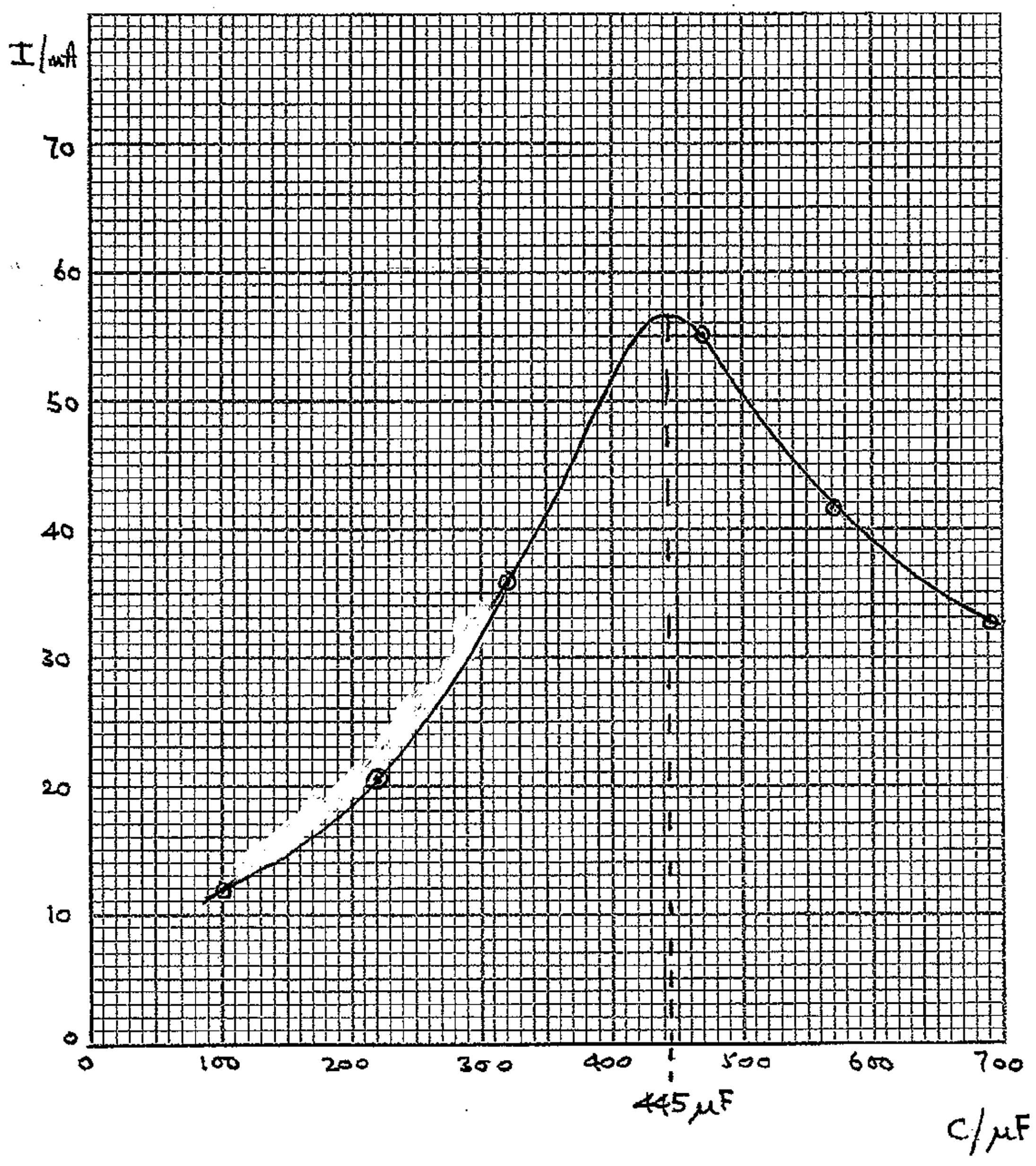
Axes : labelled, with units .... (1)

Plots : accurate to 0.5 square .... (1)

Line : smooth curve, with peak < 470 μF (2)

[smooth curve with peak at 470 μF → (1)]

5



QUESTION C CONTINUES OVERLEAF

N 2 5 1 8 7 A 0 1 1 1 6

(iii) No capacitors in this range are available, but the teacher does have a 4700 μF capacitor. Explain how this could be used in conjunction with the 470 μF capacitor to get a suitable value and calculate the capacitance of the resulting combination.

Connect in series

$\frac{1}{C} = \frac{1}{470} + \frac{1}{4700}$

$C = 427\ \mu F$

series (1)

427 μF (1)

(4)

4

QC 1 6

(Total 16 marks)

TOTAL FOR PAPER: 48 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	$1 \, \mathrm{eV} = 1.60 \times 10^{-19} \, \mathrm{J}$	
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 $\quad F = m\dfrac{\Delta v}{\Delta t} = \dfrac{\Delta p}{\Delta t}$

Impulse $\quad F\Delta t = \Delta p$

Mechanical energy

Power $\quad P = Fv$

Radioactive decay and the nuclear atom

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

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

Electrical current and potential difference

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

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

Superposition of waves

Two slit interference $\lambda = \frac{xs}{D}$ (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 $\lambda = \frac{h}{p}$

Observing the Universe

Doppler shift $\frac{\Delta f}{f} = \frac{\Delta\lambda}{\lambda} \approx \frac{v}{c}$

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

Electrical 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 $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

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)
	$\cos\theta \approx 1$	