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 Group 1

Monday 19 May 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	Tick box if candidate was unable to connect parallel capacitor correctly	☐
B	First resonant length, l_1	
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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Turn over

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Question 1A

(a) (i) Suspend a total mass of 400 g from one of the springs. Give the mass a small vertical displacement and determine the period T_1 of the subsequent oscillations.

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Put the mass of 400 g on the other spring and determine the period T_2 of vertical oscillations for this spring.

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Calculate the average value T of the periods T_1 and T_2.

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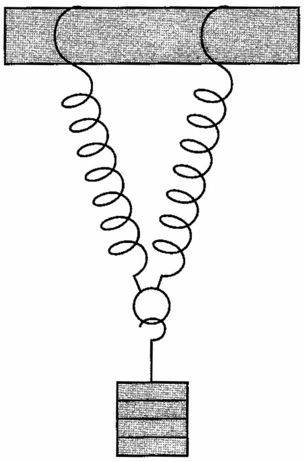
(3)

(ii) Hook the 400 g mass onto the loops of **both** springs as shown in the diagram below.



Determine the period T_p of vertical oscillations for this arrangement of springs.

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Calculate the ratio T_p/T.

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(3)

(iii) Theory predicts that for a parallel arrangement of identical springs $T_p/T = 1/\sqrt{2}$. Discuss the extent to which your results support this prediction.

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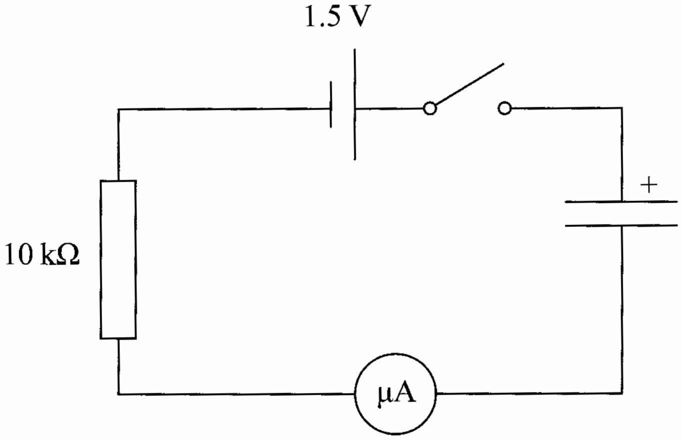
(3)

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



QUESTION 1A CONTINUES ON THE NEXT PAGE

Discharge the capacitor by connecting one of the spare leads across it. Now remove the lead.

Close the switch and determine the time t that it takes for the current in the circuit to fall from 100.0 μA to 36.8 μA. Open the switch when you have done this.

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Describe the procedure you adopted to make this timing as accurate as possible.

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(3)

(ii) Connect the second capacitor **in parallel** with the capacitor in the circuit, making sure that its polarity is correct. When you have done this, you **must** ask the Supervisor to check your circuit before proceeding. If your circuit is not correct, the Supervisor will correct it for you. You will only lose 1 mark for this.

Follow the same procedure as before to determine the time t_p for the current to drop from 100.0 μA to 36.8 μA for the parallel arrangement of capacitors. Open the switch when you have done this.

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Calculate the ratio t_p/t.

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(4)

Q1A

(Total 16 marks)

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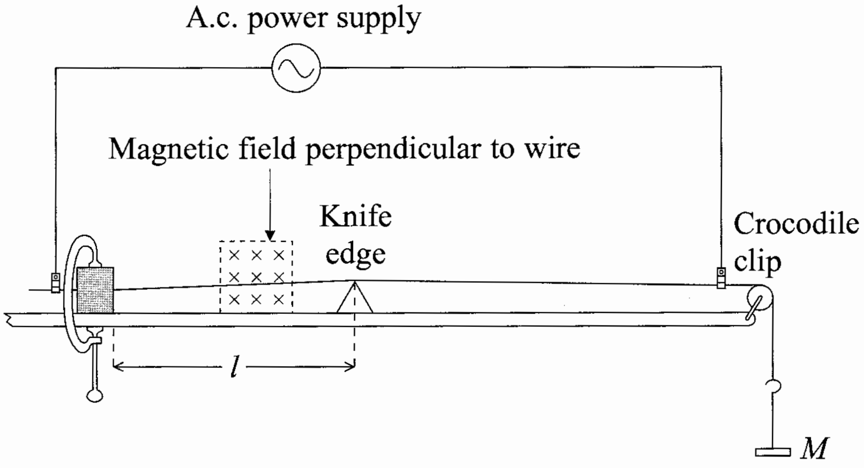
Question 1B

(a) (i) The apparatus has been set up for you as shown in the diagram with $M = 100$ g. For clarity the magnets have not been drawn.



When there is an alternating current in the wire the current passes through the magnetic field. This causes the section of the wire between the wooden blocks and the knife edge to oscillate up and down. Explain why this oscillation occurs.

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(2)

(ii) Switch on the power supply. Increase the length l until you can see that the amplitude of the vibration is at a maximum.

Determine, as accurately as possible, the length l_1 at which this resonance occurs.

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Explain carefully how you ensured that your value for l_1 was as accurate as possible.

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Estimate the percentage uncertainty in your value for l_1.

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Use your value of l_1 to calculate the wavelength λ of the stationary (standing) wave.

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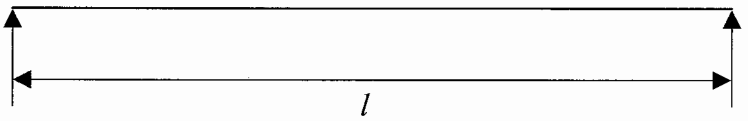
(6)

(b) (i) If l is increased without changing the mass M a stationary wave with two antinodes can be formed. Draw below the shape of this oscillation.



On your sketch mark with an **X** where the magnet may be placed to produce the greatest effect.

(ii) Increase l and adjust the position of the magnet until you can see that the amplitude of this mode of vibration is at a maximum. Determine an accurate value of this length, l_2.

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Hence determine a second value for λ.

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(4)

Switch off the power supply.

QUESTION 1B CONTINUES ON THE NEXT PAGE

(c) Take measurements to determine the diameter d of the wire.

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The density ρ of the material of the wire is given by:

$$\rho = \frac{4Mg}{\pi d^2 f^2 \lambda^2}$$

where f is the frequency of the a.c. supply that is written on the card.

Calculate a value for ρ.

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(4) **Q1B**

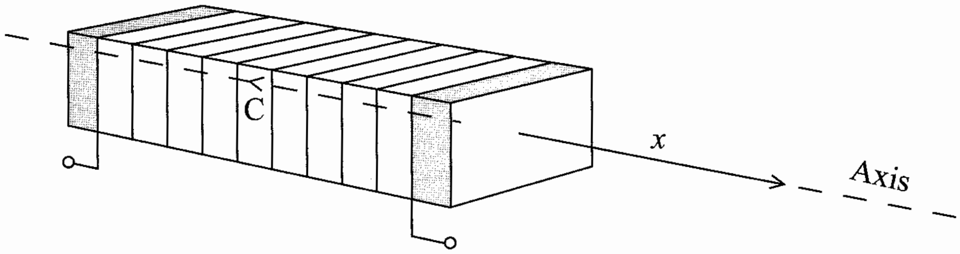
(Total 16 marks)

Leave blank

Question 1C

You are to plan an investigation of how the magnetic field strength varies along the axis of a solenoid. You are then to analyse a set of data from such an experiment.

(a) (i) A solenoid is set up as shown in the diagram below. Add to the diagram the circuit you would connect to the solenoid to set and maintain a known value of current in the solenoid.



(3)

(ii) Draw how you would place a Hall probe to measure the magnetic field strength at a point along the axis a distance x from the centre C of the solenoid. You should draw the Hall probe outside the solenoid and should take care to show the orientation of the chip (sensor) correctly.

(1)

(iii) Describe how you would determine the distance x. You may add to the diagram if you wish.

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(2)

QUESTION 1C CONTINUES ON THE NEXT PAGE

(b) The solenoid has a length of 276 mm and has 337 turns. When the current in the solenoid was adjusted to 500 mA, the calibrated Hall probe indicated that the magnetic field strength at the centre of the solenoid was 0.761 mT.

The magnetic field strength B at the centre of a solenoid having n turns per metre is given by:

$$B = \mu_0 n I$$

when the current in the solenoid is I.

Discuss the extent to which you think that the Hall probe is correctly calibrated.

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(3)

(c) The following data were obtained when the magnetic field strength B was measured along the axis at different distances x from the centre of the solenoid, keeping the current constant at 500 mA.

x / mm	B / mT
0	0.761
40	0.760
80	0.706
120	0.549
140	0.330
150	0.217
160	0.151
180	0.077
200	0.032

Plot a graph of B against x on the grid opposite.

(4)

QUESTION 1C CONTINUES ON THE NEXT PAGE

(d) Theory suggests that the magnetic field strength at the end of a long solenoid is exactly half that at its centre. Discuss the extent to which this experiment supports this suggestion.

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(3)

Q1C

(Total 16 marks)

TOTAL FOR PAPER: 48 MARKS

END

List of data, formulae and relationships

Data

Speed of light in vacuum	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$	
Gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^{2}\ \text{kg}^{-2}$	
Acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$	(close to the Earth)
Gravitational field strength	$g = 9.81\ \text{N kg}^{-1}$	(close to the Earth)
Elementary (proton) charge	$e = 1.60 \times 10^{-19}\ \text{C}$	
Electronic mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	
Electronvolt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$	
Planck constant	$h = 6.62 \times 10^{-34}\ \text{J s}$	
Unified atomic mass unit	$\text{u} = 1.66 \times 10^{-27}\ \text{kg}$	
Molar gas constant	$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$	
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$	
Coulomb law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^{9}\ \text{N m}^{2}\ \text{C}^{-2}$	
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \text{N A}^{-2}$	

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 $P = I^2R$

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 $\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

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 $= \dfrac{\text{Useful output}}{\text{Input}}$

Heat engine maximum efficiency $= \dfrac{T_1 - T_2}{T_1}$

Circular motion and oscillations

Angular speed $\omega = \dfrac{\Delta\theta}{\Delta t} = \dfrac{v}{r}$ (Radius of circular path r)

Centripetal acceleration $a = \dfrac{v^2}{r}$

Period $T = \dfrac{1}{f} = \dfrac{2\pi}{\omega}$ (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 $T = 2\pi\sqrt{\dfrac{l}{g}}$

For a mass on a spring $T = 2\pi\sqrt{\dfrac{m}{k}}$ (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	$\varepsilon = -\dfrac{N\Delta\Phi}{\Delta t}$	(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)
	$\cos\theta \approx 1$	