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

Edexcel GCE

Physics

Advanced Level

Unit Test PHY5 Practical Test Group 2

Wednesday 21 May 2008 – Morning

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 series capacitor correctly	
B	Resonant length for $M = 100$ g 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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Question 2A

(a) (i) Suspend a total mass of 300 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 300 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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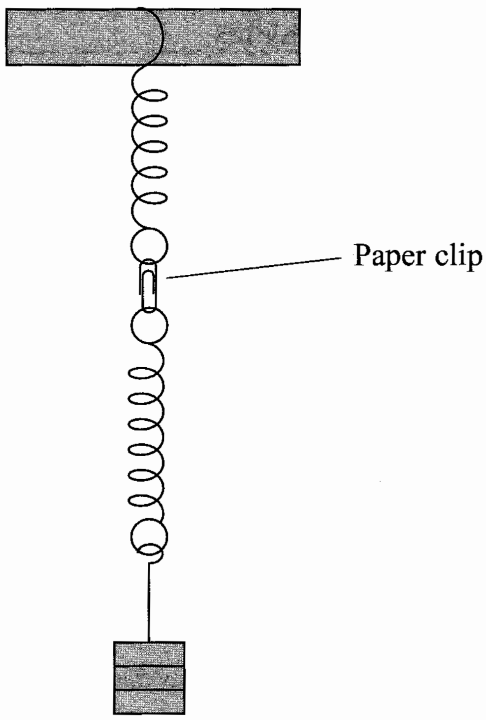
(3)

(ii) Remove one of the springs from the rod. Connect it to the other spring using the paper clip to give a series arrangement of springs as shown in the diagram below.



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(ii) Connect the second capacitor **in series** 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_s for the current to drop from 100.0 μA to 36.8 μA for the series arrangement of capacitors. Open the switch when you have done this.

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Calculate the ratio t_s / t.

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(4)

(iii) For this circuit, the time t is proportional to the capacitance C of the circuit. Discuss whether your results suggest that the two capacitors have the same capacitance when taking into account a manufacturing tolerance of 20%.

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(3)

Q2A

(Total 16 marks)

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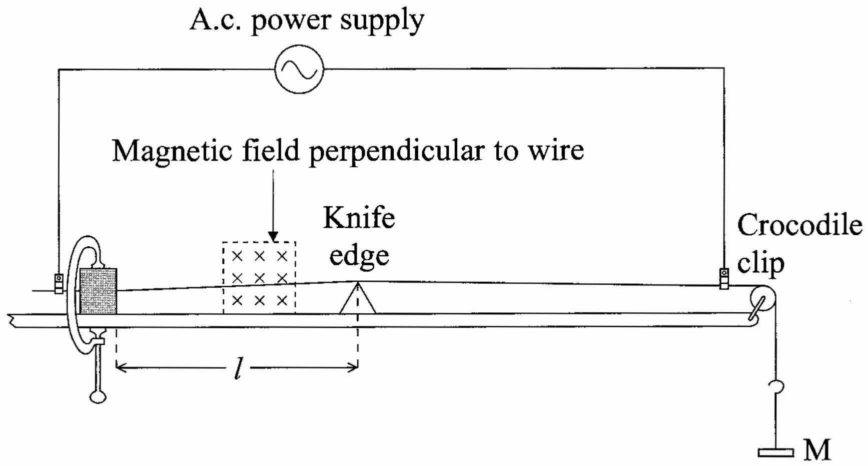
Question 2B

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



The fundamental mode of a stationary (standing) wave can be formed on a length l of the wire. Draw on the diagram the shape you would see. State the relationship between the wavelength λ of the wave and the length l.

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(2)

(b) (i) Switch on the power supply. Increase l until you can see that the amplitude of vibration of the wire 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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N 3 1 1 9 7 A 0 6 1 6

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The frequency f of the supply is as stated on the card. Use this value and your value for l_1 to determine a value for the speed c of the wave along the wire.

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(5)

(ii) Add 300 g to the mass hanger to make $M = 400$ g. For standing waves on a wire the tension T in the wire and the resonant length l are related by the equation:

$$T = k\, l^2$$

You are to determine the new resonant length, l_2.

Explain whether you would expect the new length to be longer or shorter than l_1.

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Suggest where the magnet should be placed to obtain the largest possible vibration.

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Adjust the position of the knife edge and magnet until you can see that the amplitude of vibration of the wire is at its maximum value for the fundamental mode. Determine an accurate value of this length, l_2.

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Estimate the percentage uncertainty in your value for l_2.

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(5)

QUESTION 2B CONTINUES ON THE NEXT PAGE

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(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:

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

Use $M = 0.100\,\text{kg}$ and your value for the speed c from (b)(i) to calculate a value for ρ.

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(4)

Q2B

(Total 16 marks)

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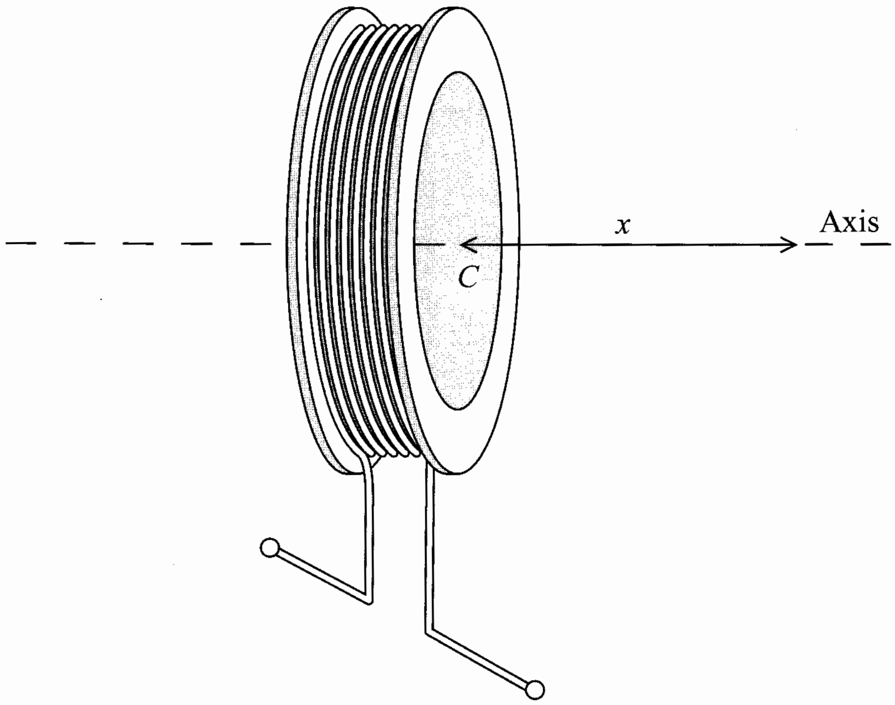
Question 2C

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

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



(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 coil. You should be careful to show the orientation of the Hall chip (sensor) correctly.

(1)

(iii) Describe how you would determine the average diameter of the coil. You may add to the diagram if you wish.

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(2)

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(b) The coil has a diameter of 124 mm and has 70 turns. When the current in the coil was adjusted to 500 mA, the calibrated Hall probe indicated that the magnetic field strength at the centre of the coil was 0.350 mT.

The magnetic field strength B at the centre of a coil having a radius r and N turns is given by

$$B = \frac{\mu_0 NI}{2r}$$

when the current in the coil 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 coil, keeping the current constant at 500 mA.

x / mm	B / mT
0	0.350
20	0.304
40	0.219
50	0.163
60	0.120
80	0.071
100	0.039
120	0.024

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

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(4)

QUESTION 2C CONTINUES ON THE NEXT PAGE

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(d) Theory suggests that when $x = r$, the radius of the coil, the magnetic field strength is $1/\sqrt{8}$ of the field strength at the centre of the coil. Discuss the extent to which this experiment supports this suggestion.

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(3) **Q2C**

(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 × (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 $\quad \lambda t_{\frac{1}{2}} = 0.69$

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Electrical current and potential difference

Electric current $I = nAQv$

Electric power $P = I^2R$

Electrical circuits

Terminal potential difference $V = \varepsilon - Ir$ (E.m.f. ε; Internal resistance r)

Circuit e.m.f. $\Sigma\varepsilon = \Sigma IR$

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 $\theta/°C = T/K - 273$

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)
	$\cos\theta \approx 1$	