Centre No.						Paper Reference	Surname	Initial(s)
Candidate No.						6 7 3 4 / 0 1	Signature	

Paper Reference(s)

6734/01

Edexcel GCE

Physics

Advanced Level

Unit Test PHY4

Monday 22 January 2007 – Morning

Time: 1 hour 20 minutes

Materials required for examination
Nil

Items included with question papers
Nil

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
3	
4	
5	
6	
7	
Total	

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initial(s) and signature.
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

The marks for individual questions and the parts of questions are shown in round brackets.
There are seven questions in this paper. The total mark for this paper is 60.
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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1. (a) Explain with the aid of a diagram why transverse waves can be plane polarised but longitudinal waves cannot be plane polarised.

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(3)

(b) (i) A filament lamp is observed directly and then through a sheet of Polaroid. Describe and explain the effect of the sheet of Polaroid on the intensity of the light seen.

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(2)

(ii) The sheet of Polaroid is now rotated in a plane perpendicular to the direction of travel of the light. What effect, if any, will this have on the intensity of the light seen?

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(1)

Q1

(Total 6 marks)

Leave blank

2. A communication satellite is in orbit above the Earth's surface.

(a) The satellite's electrical system is powered by 20 000 photovoltaic cells, each of area 10 cm^2. The intensity of the sunlight falling on the cells is 1.4 kW m^{-2}. The cells produce 5.0 kW of electrical power. Calculate the efficiency of the cells in transferring solar energy to electrical energy.

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Efficiency = ...

(3)

(b) (i) The satellite generates a signal of power 5.0 kW and orbits at a height of 3.6×10^4 km above the Earth's surface. Calculate the intensity which is detected at the Earth's surface if the satellite transmits uniformly in all directions. Assume there is no absorption of the signal along its path.

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....

Intensity = ...

(2)

(ii) In practice, reflectors on the satellite focus all the 5.0 kW of transmitted power onto a small area of the Earth's surface. If this area is a circle of diameter 1000 km, calculate the intensity that would be detected there. Assume there is no absorption of the signal along its path.

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Intensity = ...

(2)

Q2

(Total 7 marks)

Leave blank

3. (a) Define simple harmonic motion.

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(2)

(b) (i) A 120 g mass performs simple harmonic motion when suspended from a spring that has a spring constant of $3.9\ \text{N m}^{-1}$. Calculate the period T.

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....

T = ...

(2)

(ii) The simple harmonic motion is started by displacing the mass 15 cm from its equilibrium position and then releasing it. Calculate the maximum speed of the mass.

....

....

Maximum speed = ...

(2)

(iii) Calculate the maximum acceleration of the mass.

....

....

Maximum acceleration = ...

(2)

(iv) The 120 g mass is replaced by a wooden block. When the block performs simple harmonic motion the period is 1.4 s. Calculate the mass of the block.

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....

Mass of block = ...

(2)

Q3

(Total 10 marks)

Leave blank

4. The cello is a stringed musical instrument that may be played either by stroking the strings with a bow or by plucking the strings with the fingers.

QUESTION 4 CONTINUES ON THE NEXT PAGE

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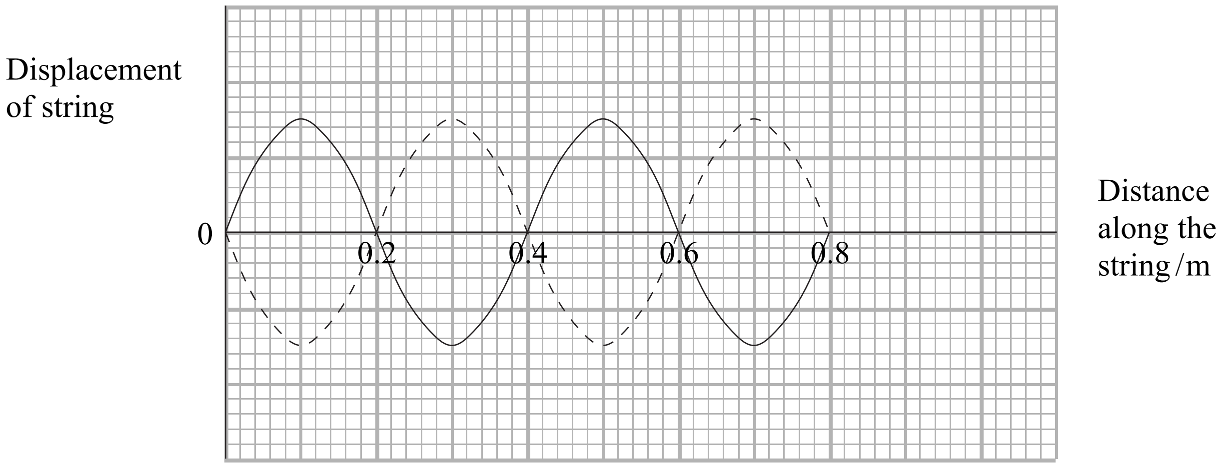
(a) One of the attached strings on the cello has a vibrating length of 0.80 m. The string is made to oscillate as a stationary wave by means of a bow and the following pattern of oscillations is seen. The position of the string at two different times is shown.



(i) Explain how the movement of the bow causes this wave pattern.

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(3)

(ii) Using the diagram calculate the wavelength of the wave.

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Wavelength = ...

(2)

(iii) State two differences between the wave on the string and the sound wave it produces.

1 ....

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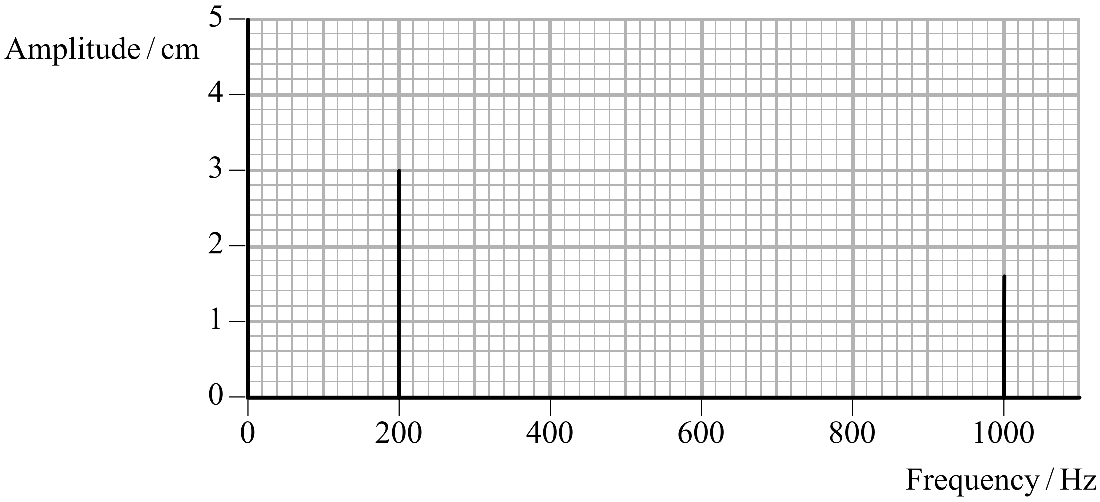
2 ....

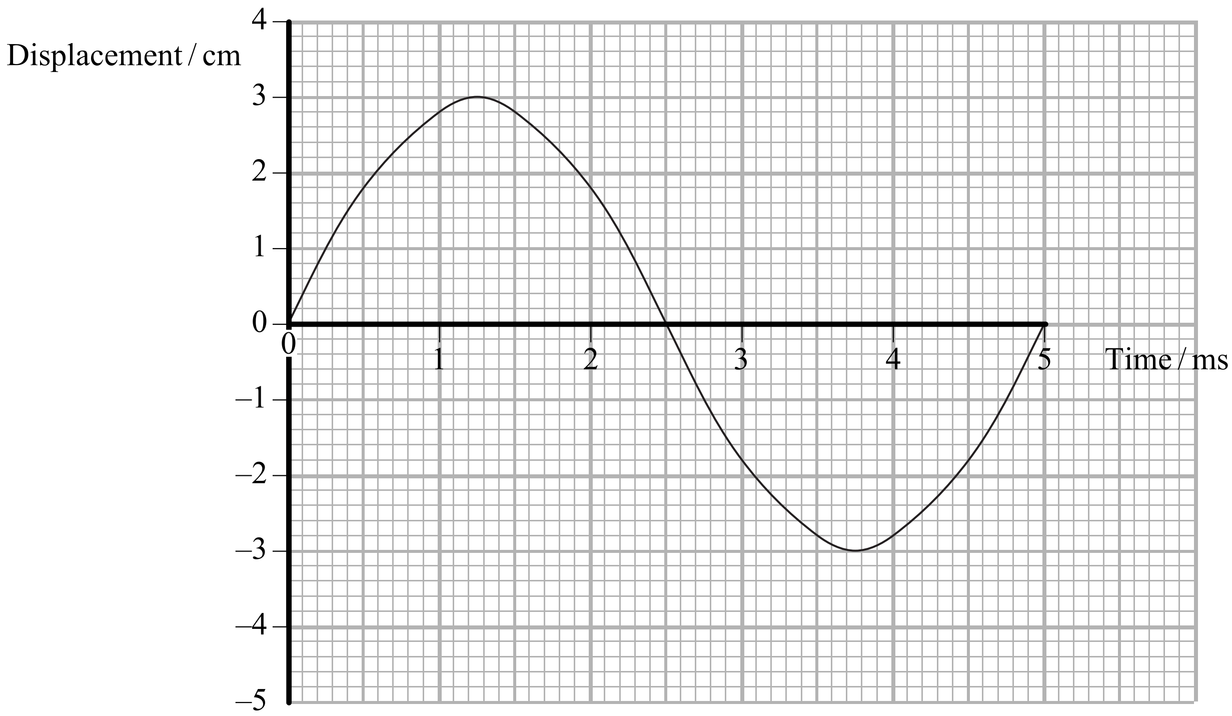
....

(2)

(b) The cello string is then plucked and the waveform of the resulting sound is analysed by an oscilloscope. It is found to consist of two frequencies of different amplitudes. The frequency spectrum is shown below.



The waveform of the 200 Hz wave has been drawn on the axes below. On the same axes sketch the waveform of the 1000 Hz wave.



(2)

Q4

(Total 9 marks)

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5. (a) State three conditions which must be satisfied if two waves are to produce an observable interference pattern.

1 ....

2 ....

3 ....

(3)

Leave blank

(b) (i) Describe an experiment using microwaves to produce and detect a two slit interference pattern. You may find it useful to draw a diagram.

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(3)

(ii) The dimensions of a microwave experiment are such that the equation $\lambda = xs/D$ is not valid. Explain how you would find a value for the wavelength of the microwaves from your experiment.

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(3)

Q5

(Total 9 marks)

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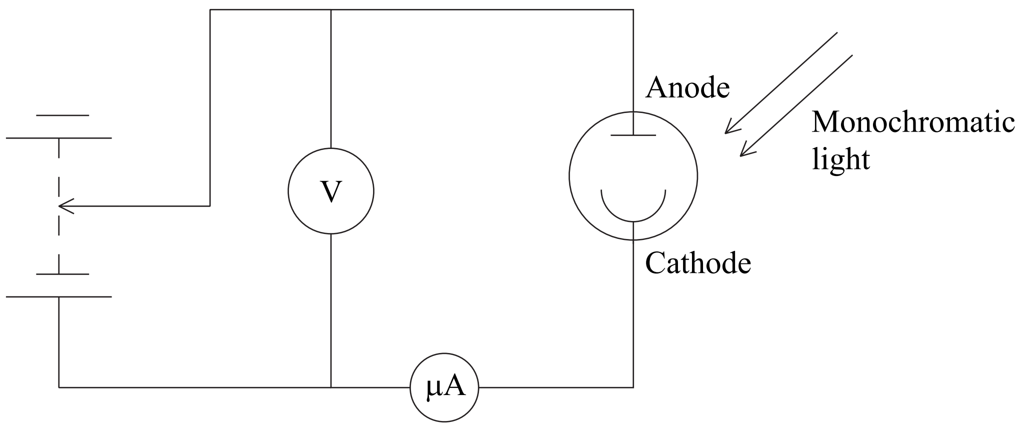
6. The diagram shows monochromatic light falling on a photocell.



The photocell is connected so that there is a reverse potential difference across the cathode and the anode.

(a) Explain the following observations.

(i) Initially there is a current which is measured by the microammeter. As the reverse potential difference is increased the current reading on the microammeter decreases.

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(ii) When the potential difference reaches a certain value V_s, the stopping potential, the current is zero.

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(5)

N 2 3 5 9 8 A 0 1 0 1 6

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(b) What would be the effect on the value of the stopping potential V_s of

(i) increasing the intensity of the incident radiation whilst keeping its frequency constant

....

....

(ii) increasing the frequency of the incident radiation whilst keeping its intensity constant?

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(2)

Q6

(Total 7 marks)

Leave blank

7. (a) (i) Electrons are often used to study crystal structure. A suitable electron has a kinetic energy of 2.46×10^{-18} J. Show that the de Broglie wavelength for this electron is about 3×10^{-10} m.

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....

(5)

(ii) Which part of the electromagnetic spectrum would have a wavelength similar to the electron in (i)?

....

(1)

(iii) Explain why such an electron is suitable for studying crystal structures.

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(2)

(b) What is meant by wave-particle duality? Illustrate your answer with reference to the behaviour of electrons.
You may be awarded a mark for the clarity of your answer.

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(4) **Q7**

(Total 12 marks)

TOTAL FOR PAPER: 60 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 $\quad F = m\dfrac{\Delta v}{\Delta t} = \dfrac{\Delta p}{\Delta t}$

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	$\theta/°\text{C} = T/\text{K} - 273$	

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

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	$\dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3}$	
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)

$\cos\theta \approx 1$