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

Friday 20 January 2006 – 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	
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6	
7	
Total	

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

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. Hubble's law can be represented by the formula $v = Hd$.

(a) State the unit of the Hubble constant H.

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(1)

(b) Show how the age of the Universe can be estimated by using the above formula. State an assumption that has to be made.

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Assumption: .....

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(4)

Q1

(Total 5 marks)

2. (a) What is meant by the principle of superposition of waves?

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(2)

Leave blank

(b) (i) A two-slit interference experiment is used to find the wavelength of light from a monochromatic source. Draw a labelled diagram (not to scale) of the experimental arrangement, giving approximate dimensions.

(3)

(ii) Describe what happens to the interference pattern when the source is replaced by one that emits light of a higher frequency.

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(1)

(iii) Describe what is observed if one of the two slits is covered.

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(3)

Q2

(Total 9 marks)

Leave blank

3. (a) Define simple harmonic motion.

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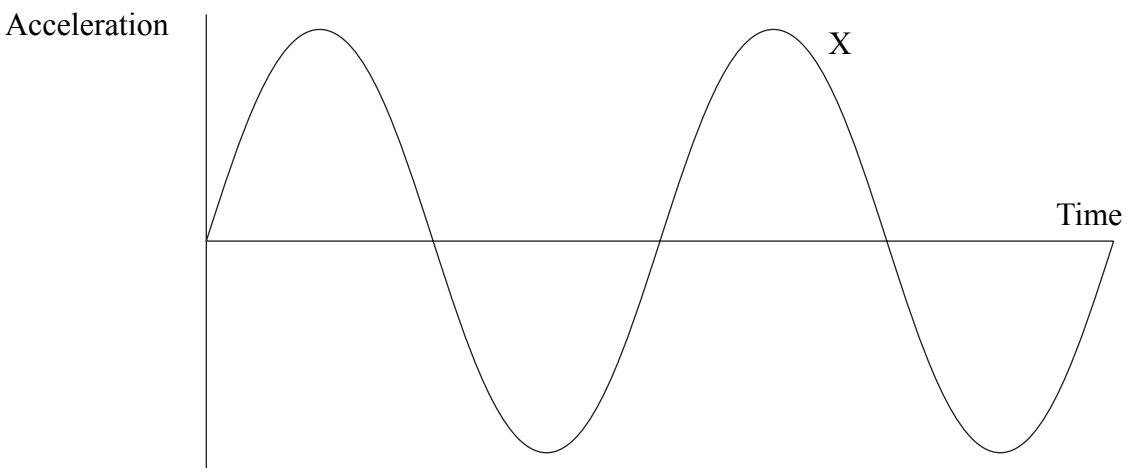
(2)

(b) The curve labelled X shows how the acceleration of a body executing simple harmonic motion varies with time.



Add to the graph

(i) a curve labelled Y showing how the displacement of the same body varies with time over the same time interval,

(ii) a curve labelled Z showing how the velocity of the same body varies with time over the same time interval.

(4)

Leave blank

(c) (i) A mass of 150 g is supported by a spring having a spring constant of 24 N m^{-1}. Show that the frequency of vertical oscillations of the mass is about 2 Hz.

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(3)

(ii) The amplitude of the oscillations is 30 mm. Calculate the maximum speed of the mass.

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Maximum speed = ...

(2)

Q3

(Total 11 marks)

Leave blank

4. A microwave generator produces plane polarised electromagnetic waves of wavelength 29 mm.

(a) (i) Calculate the frequency of this radiation.

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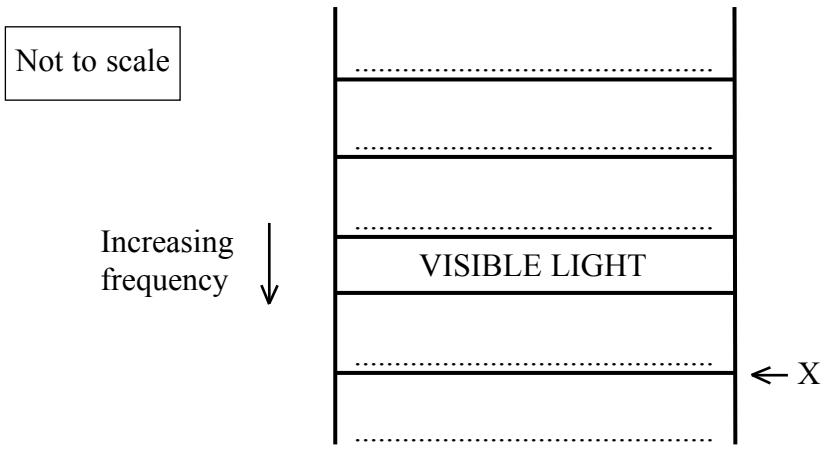
Frequency = ...

(1)

(ii) Complete the diagram of the electromagnetic spectrum below by adding the names of the parts of the electromagnetic spectrum.



(2)

(iii) State a typical value for the wavelength of radiation at boundary X.

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(1)

(b) (i) Explain what is meant by 'plane polarised'.

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(2)

Leave blank

(ii) Describe, with the aid of a diagram, how you would demonstrate that these microwaves were plane polarised.

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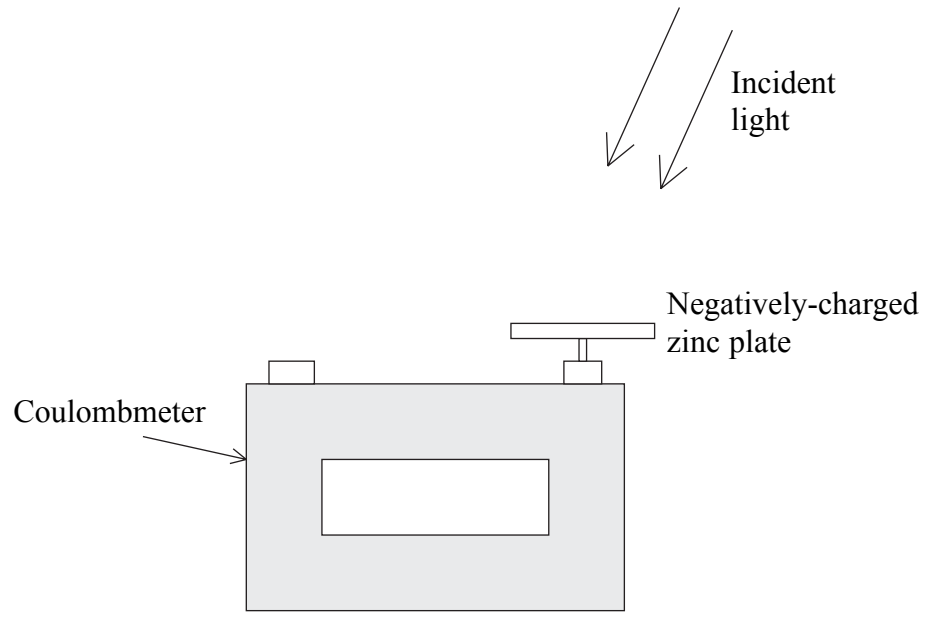
(4)

Q4

(Total 10 marks)

Leave blank

5. The diagram shows a coulombmeter (an instrument for measuring charge) set up to demonstrate the photoelectric effect.



The clean zinc plate is negatively charged. When ultraviolet light is shone onto the zinc plate, the plate discharges. The coulombmeter reading gradually falls to zero. When the experiment is repeated with red light the plate does not discharge.

(a) Explain these effects in terms of the particle theory of light. You may be awarded a mark for the clarity of your answer.

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(4)

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(b) What would happen to the charged plate if

(i) the intensity of the red light were increased

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(ii) the intensity of the ultraviolet light were increased?

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(2)

(c) Zinc has a work function of 3.6 eV. Calculate the maximum kinetic energy of the photoelectrons when the zinc is illuminated with ultraviolet light of wavelength 250 nm.

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Maximum kinetic energy = ...

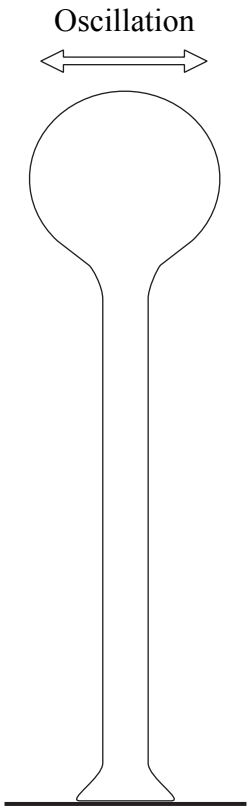
(4)

Q5

(Total 10 marks)

Leave blank

6. A water tower consists of a massive tank of water supported on a vertical column. It oscillates sideways with simple harmonic motion when shaken by longitudinal earthquake waves.



Water tower

(a) What is meant by a **longitudinal wave**?

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(2)

Leave blank

(b) The water tower could collapse when shaken by earthquake waves of a particular frequency. Explain how this could happen.

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(3) **Q6**

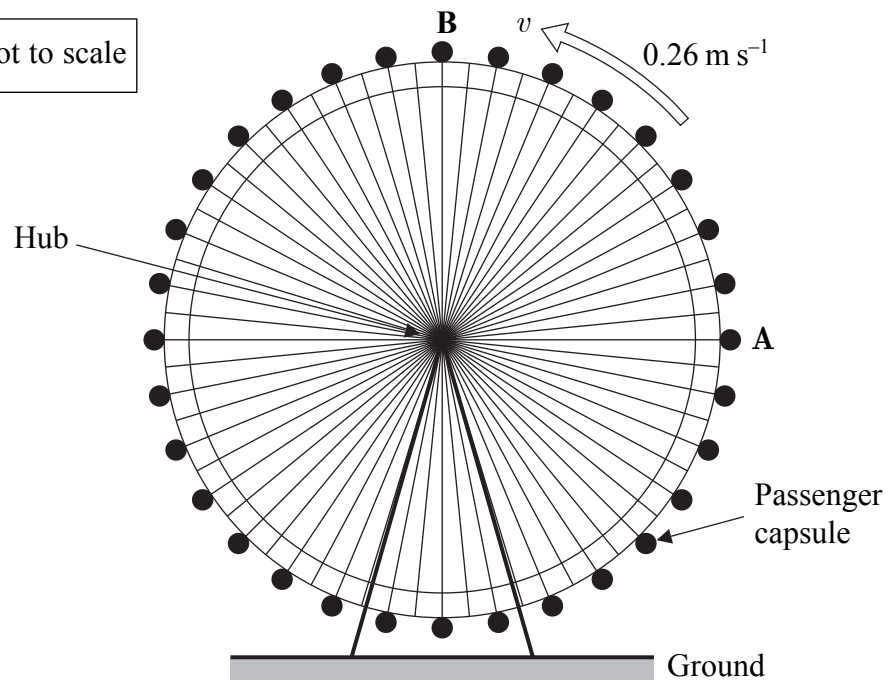
(Total 5 marks)

Leave blank

7. The London Eye is a tourist attraction designed to give passengers a panoramic view over London. The giant wheel completes two revolutions in one hour. Each capsule moves with a constant speed of 0.26 m s^{-1} as it follows a circular path.

Figure 1

Not to scale



(a) Calculate the radius of this circular path.

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Radius = ...

(2)

(b) A man of mass 85 kg follows a circular path of this radius as he rides in a capsule. What is the magnitude and direction of the resultant force acting on the man?

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(3)

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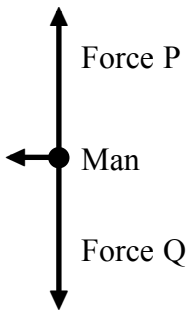
(c) Figure 2 shows the free-body force diagram for the man when the capsule is at position **A** as shown in Figure 1.

Figure 2



(i) Name forces P and Q

Force P: .....

Force Q: .....

(2)

(ii) When the man is at position A there is no resultant **vertical** force acting on him. In this position force P = force Q in magnitude. Explain why the man continues his motion in a circle.

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(2)

(iii) Explain why force Q must be larger than force P when the capsule is at position B.

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(1)

Q7

(Total 10 marks)

TOTAL FOR PAPER: 60 MARKS

END

List of data, formulae and relationships

Data

Speed of light in vacuum	$c = 3.00\times10^{8}\ \text{m s}^{-1}$	
Gravitational constant	$G = 6.67\times10^{-11}\ \text{N m}^{2}\ \text{kg}^{-2}$	
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	$e = 1.60\times10^{-19}\ \text{C}$	
Electronic mass	$m_{\text{e}} = 9.11\times10^{-31}\ \text{kg}$	
Electronvolt	$1\ \text{eV} = 1.60\times10^{-19}\ \text{J}$	
Planck constant	$h = 6.63\times10^{-34}\ \text{J s}$	
Unified atomic mass unit	$\text{u} = 1.66\times10^{-27}\ \text{kg}$	
Molar gas constant	$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$	
Permittivity of free space	$\varepsilon_0 = 8.85\times10^{-12}\ \text{F m}^{-1}$	
Coulomb law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99\times10^{9}\ \text{N m}^{2}\ \text{C}^{-2}$	
Permeability of free space	$\mu_0 = 4\pi\times10^{-7}\ \text{N A}^{-2}$	

Rectilinear motion

For uniformly accelerated motion:

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

Forces and moments

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

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

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

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	$\mathcal{E} = -\frac{N\Delta\Phi}{\Delta t}$	(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	$Q = Q_0 e^{-t/RC}$
	$\frac{t_{\frac{1}{2}}}{RC} = \ln 2$
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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