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

Thursday 15 June 2006 – Morning

Time: 1 hour 20 minutes

Materials required for examination	Items included with question papers
Nil	Nil

Examiner's use only

Team Leader's use only

Question Number	Leave Blank
1	
2	
3	
4	
5	
6	
7	
8	
Total	

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname, initials 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 eight 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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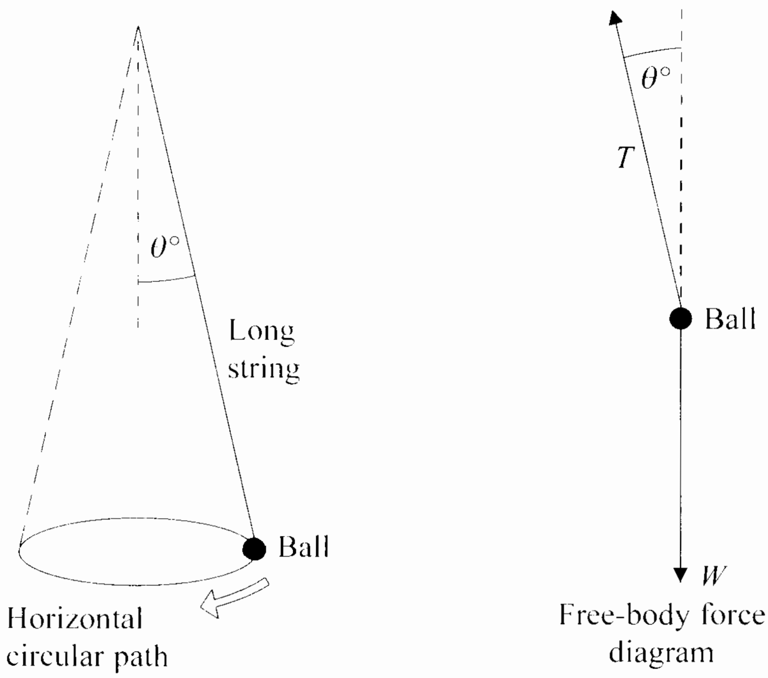
1. A ball attached to the end of a long string is made to rotate in a horizontal circular path at a constant speed. The forces acting on the ball are its weight, W, and the tension, T, in the string.



With reference to the free-body force diagram, explain how it is possible for the ball to move with constant speed and yet still be accelerating.

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.... Q1

(Total 4 marks)

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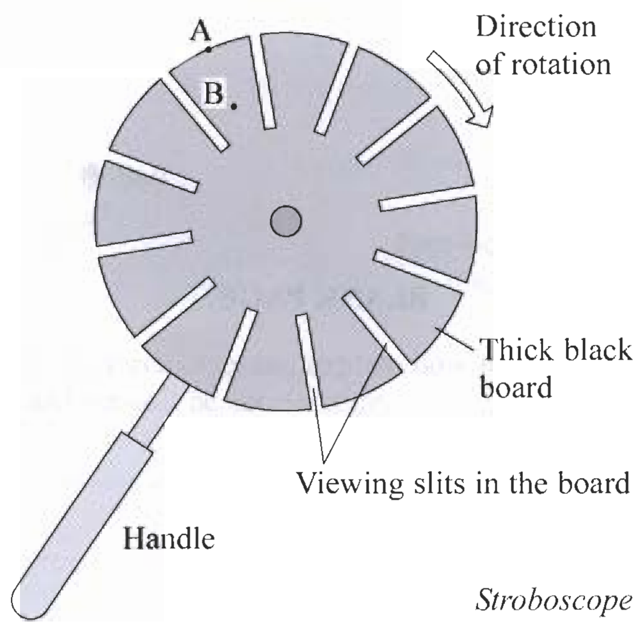
2. (a) Plane progressive wavefronts are produced in a ripple tank. The frequency of the vibrator producing the waves is 50 Hz. Calculate the time interval between successive wavefronts.

....

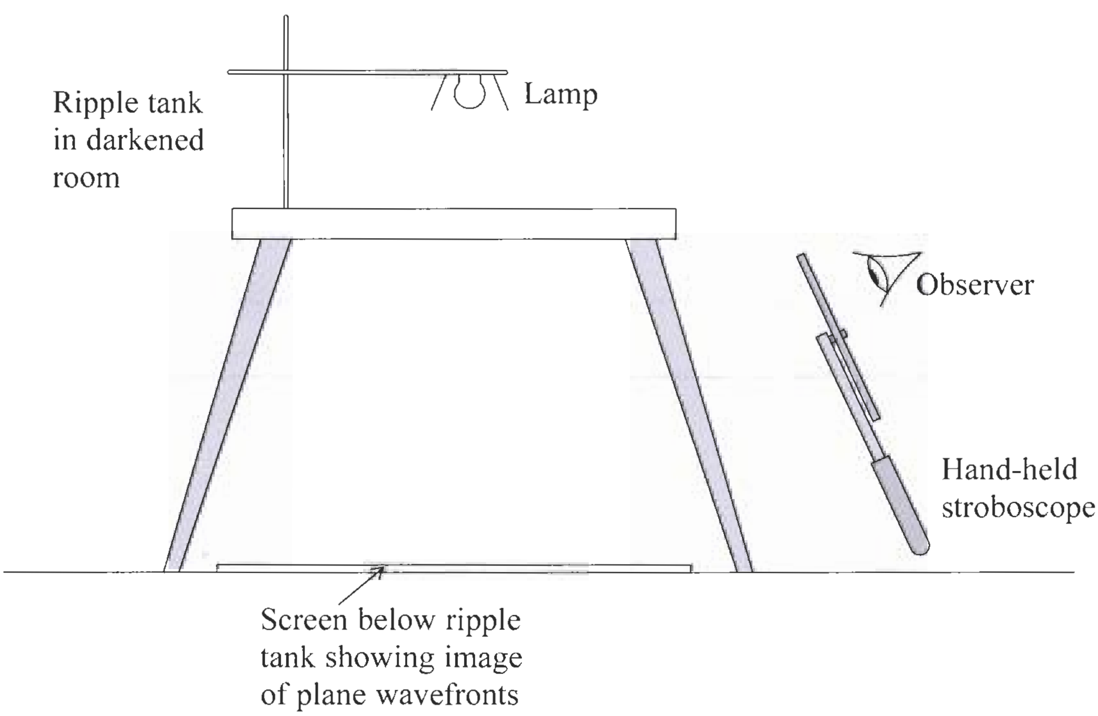
Time interval = ...

(1)

(b) The wavefronts are projected onto a white screen directly below the ripple tank. They are viewed through the slits in a stroboscope that is rotated by hand. Diagrams of the stroboscope and the arrangement are shown below.



Stroboscope



N 2 2 3 7 0 A 0 4 2 0

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(i) The angular speed of the stroboscope is gradually increased to the fastest speed at which the wavefronts appear stationary. State the time interval between successive slits at this instant.

....

(1)

(ii) Show that the angular speed, ω_A, of a point A on the rim of the stroboscope at this same instant is approximately 26 rad s^{-1}.

....

....

....

(2)

(iii) The radius of the stroboscope is 15 cm. Calculate the velocity, v_A, of A.

....

....

Velocity = ...

(2)

(iv) Point B is 10 cm from the centre of the stroboscope and 5.0 cm from A. State the value of the following ratios.

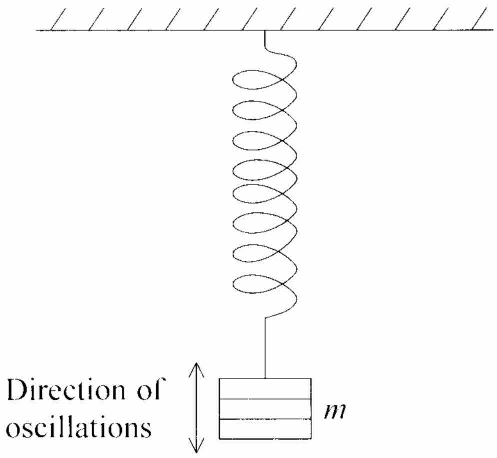
$\omega_A : \omega_B$ = ...

$v_A : v_B$ = ...

(2) **Q2**

(Total 8 marks)

3. A spring of negligible mass and spring constant, k, has a load of mass, m, suspended from it. A student displaces the mass and releases it so that it oscillates vertically.



(a) The student investigates the variation of the time period, T, of the vertical oscillations with m.

Describe how he could verify experimentally that $T \propto \sqrt{m}$. Include any precautions the student should take to make his measurements as accurate as possible. You may be awarded a mark for the clarity of your answer.

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(5)

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(b) The student calculates the natural frequency of his mass-spring system. Show that for a mass of 400 g and a spring constant of 230 N m^{-1} this frequency is approximately 4 Hz.

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(3)

(c) The student connects the mass-spring system to a vibrator and signal generator to demonstrate resonance. Explain fully, with respect to this system, what is meant by the terms **natural frequency** and **resonance**.

Natural frequency: ....

....

....

....

....

Resonance: ....

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(4) **Q3**

(Total 12 marks)

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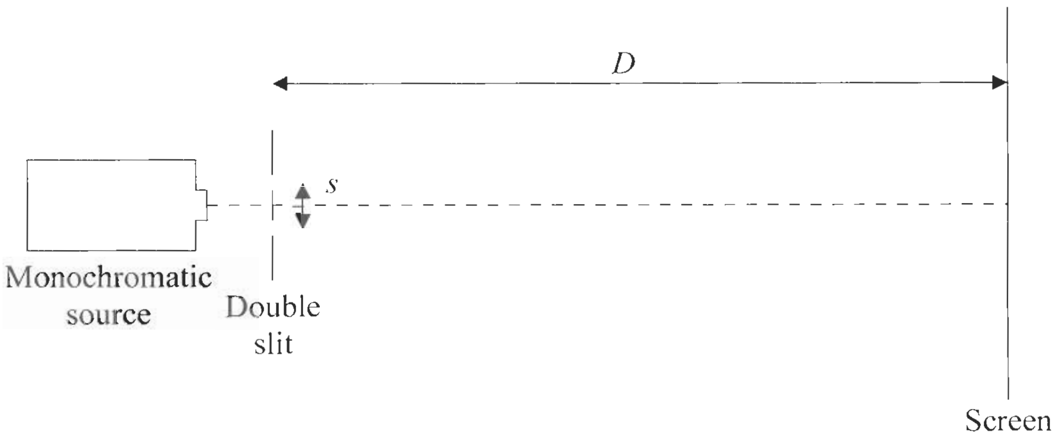
4. (a) Monochromatic red light of wavelength 720 nm is used to produce a two slit interference pattern on a screen.



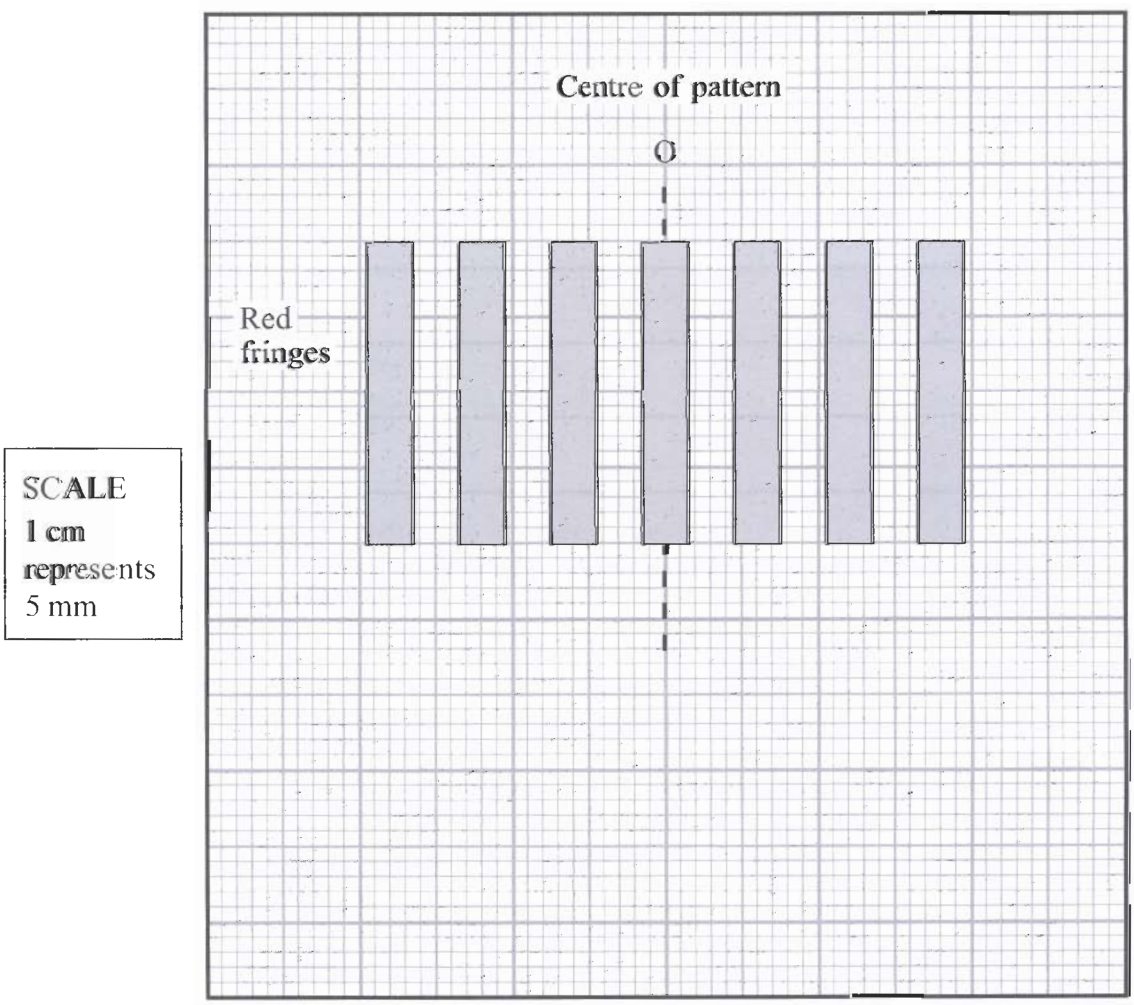
(i) Give typical values for the slit separation s and the distance D between the double slit and screen.

s ....

D ....

(2)

(ii) A drawing of the central section of the interference pattern is shown on the grid below. The centre of the pattern is at O.



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Determine a value for the separation of the red fringes. Show your working.

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....

....

Fringe separation = ...

(3)

(b) The red source is replaced by a monochromatic blue source of wavelength 480 nm to produce a second interference pattern. The practical arrangement remains unchanged.

Use the lower part of the grid to draw the five central blue fringes. Use the lines below for any calculation you make.

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(3)

(c) Describe the appearance of the central fringe formed at O when a white light source is used.

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(2)

Q4

(Total 10 marks)

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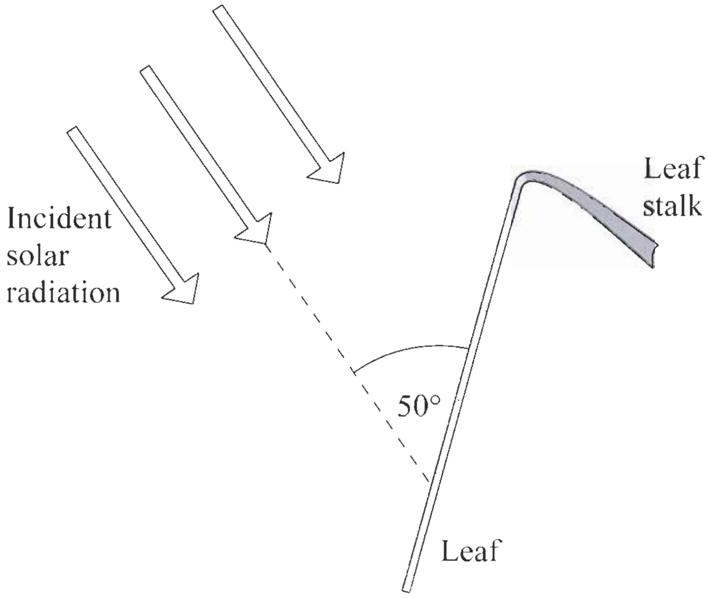
5. A leaf of a plant tilts towards the Sun to receive solar radiation of intensity 1.1 kW m^{-2}, which is incident at 50° to the surface of the leaf.



(a) The leaf is almost circular with an average radius of 29 mm. Show that the power of the radiation perpendicular to the leaf is approximately 2 W.

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(3)

(b) Calculate an approximate value for the amount of solar energy received by the leaf during 2.5 hours of sunlight.

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Energy = ...

(2)

Q5

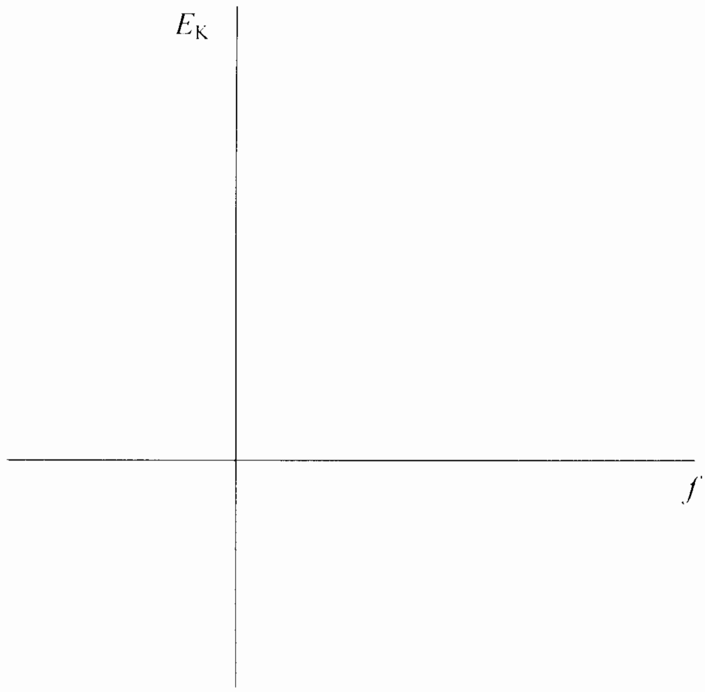
(Total 5 marks)

N 2 2 3 7 0 A 0 1 0 2 0

Leave blank

6. Photoelectrons are emitted from the surface of a metal when radiation above a certain frequency, f_0, is incident upon it. The maximum kinetic energy of the emitted electrons is E_K.

(a) On the axes below sketch a graph to show how E_K varies with frequency f.



(2)

(b) State how the work function, ϕ, of the metal can be obtained from the graph.

....

....

(1)

(c) Explain why this graph always has the same gradient irrespective of the metal used.

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(1) **Q6**

(Total 4 marks)

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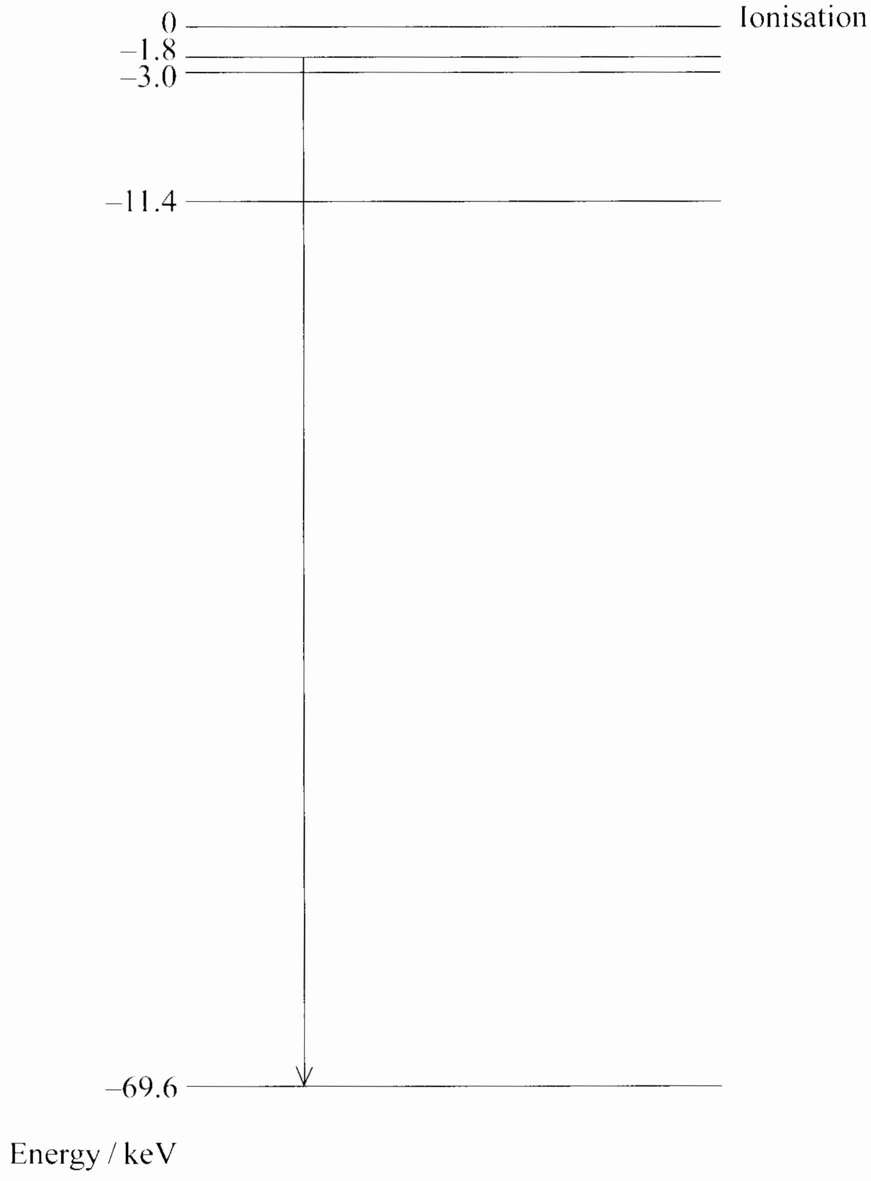
7. The diagram shows some of the energy levels of a tungsten atom.



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(a) An excited electron falls from the –1.8 keV level to the –69.6 keV level. Show that the wavelength of the emitted radiation is approximately 0.02 nm.

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(4)

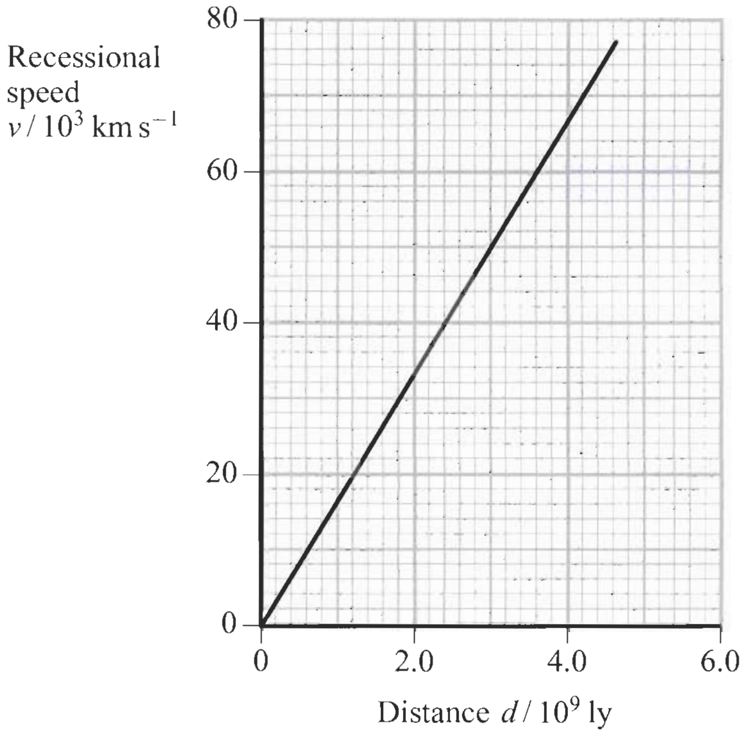
(b) To which part of the electromagnetic spectrum does this radiation belong?

....

(1) **Q7**

(Total 5 marks)

8. (a) Edwin Hubble examined the relationship between the recessional speed of galaxies, v, and their distance, d, from Earth. The graph shows the best-fit line for his results.



(i) Use the graph to determine a value for the Hubble constant, H, in s^{-1}. Show your working.

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Hubble constant = ...s^{-1}

(4)

(ii) What is the main source of uncertainty in the value of H?

....

(1)

Leave blank

(b) Explain how the Hubble constant provides us with an estimate for the age of the Universe, t.

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(2)

(c) Ionised calcium has a line spectrum which includes a spectral line of wavelength 393 nm. The observed wavelength of this calcium line in the radiation from a distant galaxy is 469 nm. Calculate the galaxy's recessional speed.

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Recessional speed = ...

(3)

(d) Briefly explain how the value of the average mass-energy density of the Universe will determine whether the Universe is open or closed.

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....

(2) **Q8**

(Total 12 marks)

TOTAL FOR PAPER: 60 MARKS

END

List of data, formulae and relationships

Data

Speed of light in vacuum	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$	
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	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$	
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	$\mu_0 = 4\pi \times 10^{-7}\ \text{N A}^{-2}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$	

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	$I = \frac{P}{4\pi r^2}$	(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)
	$\cos\theta \approx 1$	

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