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 PHY 4

Wednesday 10 June 2009 – Afternoon

Time: 1 hour 20 minutes

Examiner's use only

Team Leader's use only

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

Materials required for examination	**Items included with question papers**
Nil	Nil

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 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. Each of the statements below is true provided that a certain condition is met. Complete each statement by adding the appropriate condition.

(a) The wavelength of a wave is inversely proportional to its frequency provided that

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....

(b) Two sound waves of the same frequency will interfere destructively provided that

....

....

(c) An atom can absorb electromagnetic radiation of a given frequency provided that

....

....

(d) An electron will have a shorter de Broglie wavelength than a neutron provided that

....

.... **Q1**

(Total 4 marks)

Leave blank

2. (a) For an object of mass m to move at a steady speed v round a circular path of radius r, a resultant force F must act on it.

(i) Using only these quantities, write down a formula for the force and state its direction.

Formula: ....

Direction: ....

(1)

(ii) Show that the force can also be expressed in the form

$$F = mr\omega^2$$

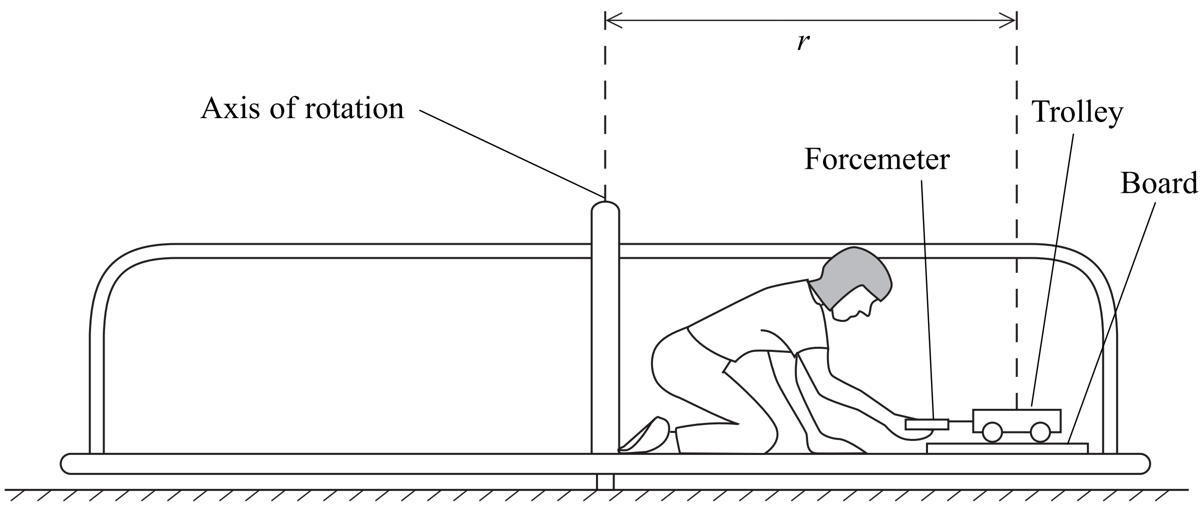
where ω is the angular speed.

....

....

(1)

(b) Some students use a playground roundabout to test the formula $F = mr\omega^2$.



One student gets on to the roundabout and places a trolley on a board. The trolley wheels are parallel to a radius of the roundabout and the centre of the trolley is at a distance r from the axis of rotation. One end of the trolley is attached to a forcemeter which the student holds in her hand to keep r constant. She reads the forcemeter whilst a second student turns the roundabout at a steady speed. A third student times the rotations with a stopwatch.

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(i) State one condition which must be satisfied if the forcemeter reading is to equal the resultant force on the trolley.

....

....

(1)

(ii) The mass of the trolley is 0.95 kg. In one test, the distance r is 1.50 m and the roundabout takes 28 s to complete 5 revolutions. Calculate the expected reading on the forcemeter.

....

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....

....

Force = ...

(3)

(iii) Describe how the students could use the apparatus to test the relationship between F and ω. You may be awarded a mark for the clarity of your answer.

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(5)

Q2

(Total 11 marks)

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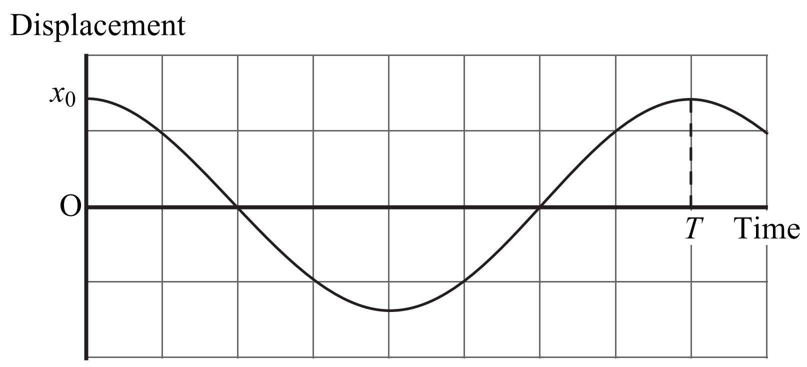
3. The graph shows how the displacement of an object performing simple harmonic motion varies with time.



(a) Add an X to the graph to label each point at which the kinetic energy is a maximum.
(1)

(b) The mass of the object is m. Show that its maximum kinetic energy E is given by

$$E = \frac{2\pi^2 m x_0^{\,2}}{T^2}$$

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(2)

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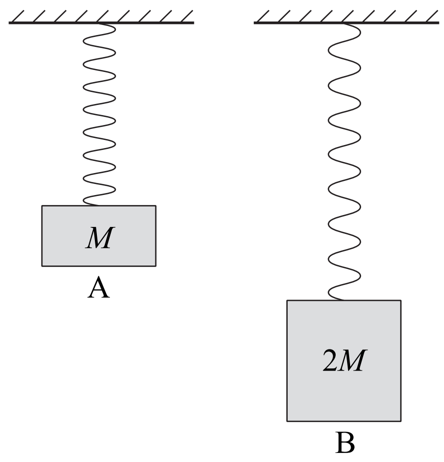
(c) Two objects A and B, of mass M and $2M$ respectively, are suspended from identical springs.



The objects are given identical vertical displacements from their equilibrium positions and then released. Air resistance may be neglected.

Determine the value of the ratio

$$\frac{\text{Maximum kinetic energy of B}}{\text{Maximum kinetic energy of A}}$$

Explain your answer.

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....

Ratio = ...

(3) **Q3**

(Total 6 marks)

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4. Under certain conditions the intensity of radiation at a distance r from a source of power P is given by

$$I = \frac{P}{4\pi r^2}$$

(a) State two conditions which must be satisfied if this formula is to be valid.

1 ....

....

2 ....

....

(2)

(b) Explain with the aid of a diagram how the formula follows from the definition of intensity.

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(3)

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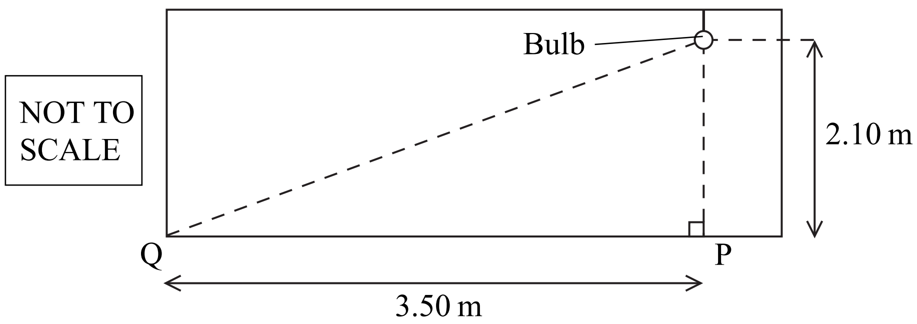
(c) A room is illuminated by a single light bulb suspended from the ceiling near one end.



(i) The intensity of light from the bulb at point P is 2.7 W m^{-2}. Calculate a value for the intensity at Q.

....

....

....

....

....

....

Intensity = ...

(3)

(ii) In practice, the illumination in this room is likely to be more uniform than your calculation predicts. Suggest why.

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(1)

Q4

(Total 9 marks)

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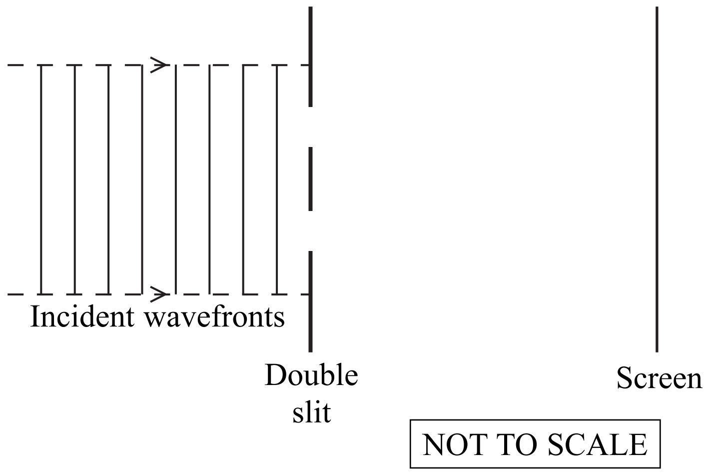
5. The diagram shows the principle of an experiment to measure the wavelength of light from a laser.



When wavefronts from the laser are incident on the double slit, interference fringes are seen on the screen.

(a) Explain how diffraction leads to the formation of the fringe pattern. You should add to the diagram above to illustrate your answer.

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....
(3)

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(b) The experimenter wishes to increase the fringe width.

(i) State one change in the dimensions of the apparatus which would have this effect.

....

....

(ii) Explain one disadvantage of making this change.

....

....

(2)

(c) However large the fringe width, there is a problem in measuring it accurately. Explain the problem and state how the measurement can be made more accurate.

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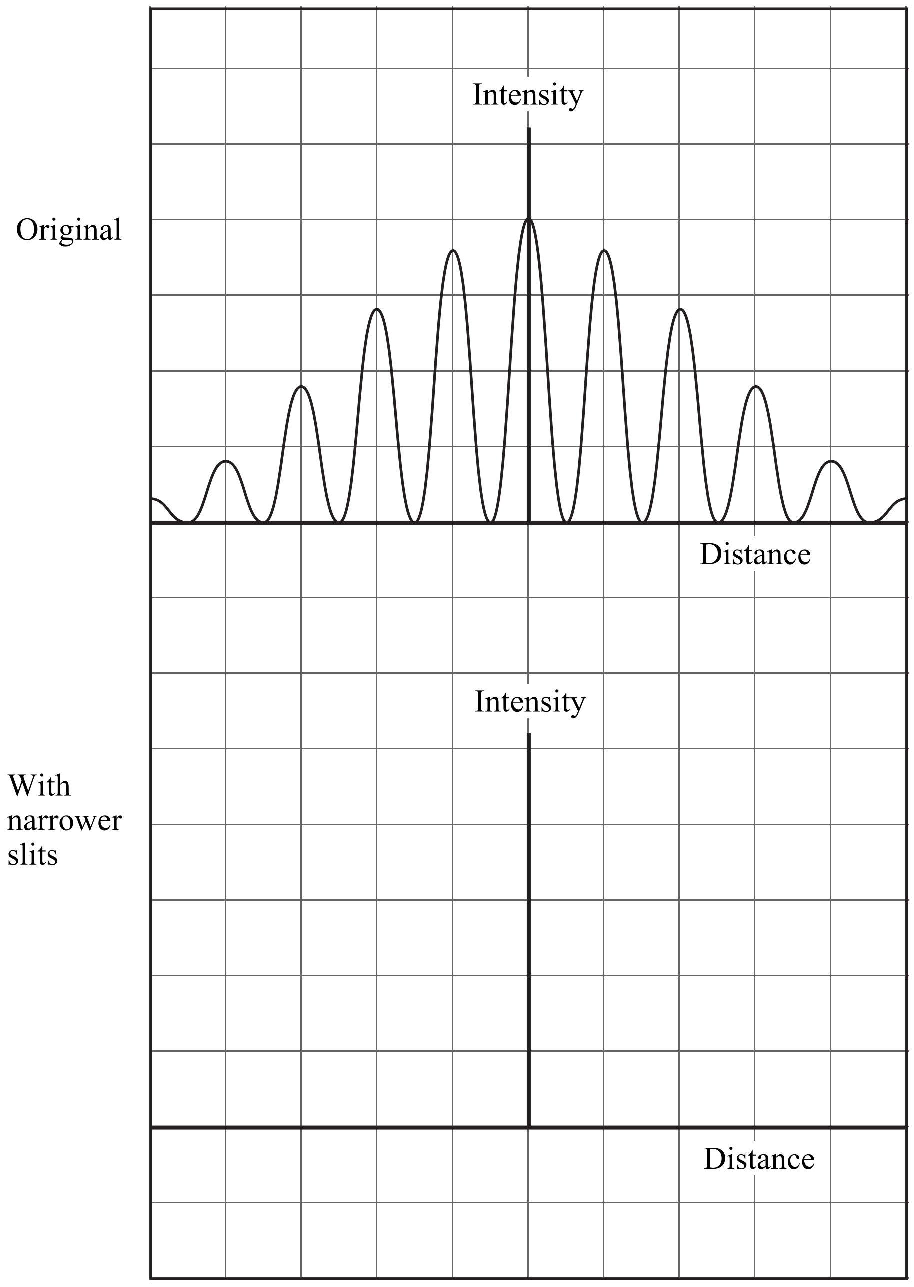
....

(2)

(d) The graph shows how the intensity of the fringe pattern in one experiment varies with distance across the screen. Using the axes below, sketch a second graph to show how the intensity would vary with distance if the slits were made narrower. All other dimensions of the apparatus, including the slit separation, remain the same.



(3) **Q5**

(Total 10 marks)

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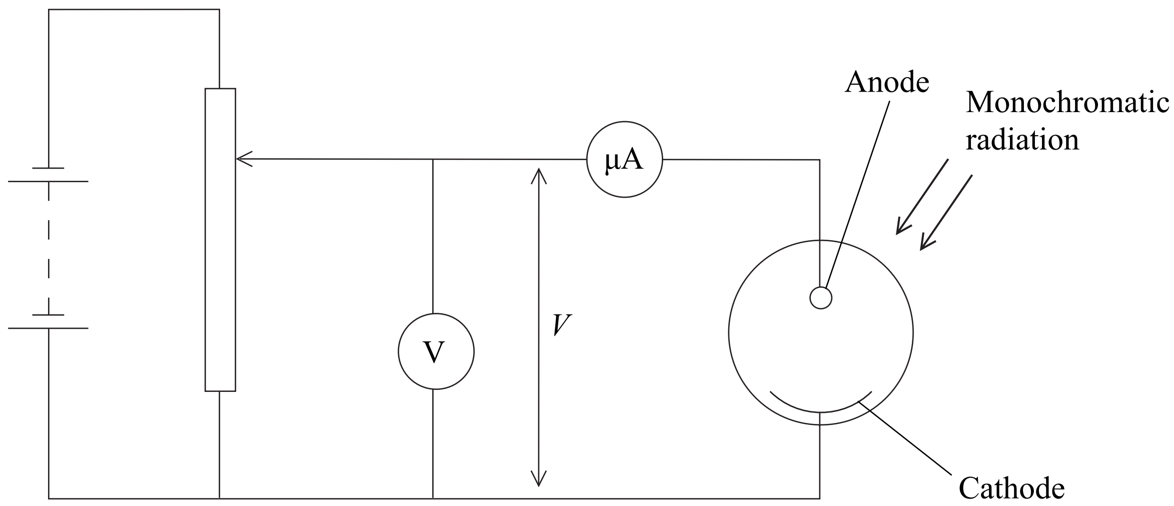
6. Monochromatic radiation falls on the cathode of a photocell. The photocell is connected in the circuit shown, which allows a variable reverse potential difference to be applied between the anode and cathode.



(a) When the potential difference V is set to zero, the microammeter indicates a small current. Explain how this current arises.

....

....

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....
(2)

(b) The radiation has a frequency of 7.5×10^{14} Hz. Show that each photon has an energy of approximately 5×10^{-19} J.

....

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....
(2)

N 3 0 4 1 3 A 0 1 4 2 4

(c) The cathode is made of sodium, which has a work function of 3.7×10^{-19} J. Show that the stopping potential, for radiation of frequency 7.5×10^{14} Hz, is approximately 0.8 V.

....

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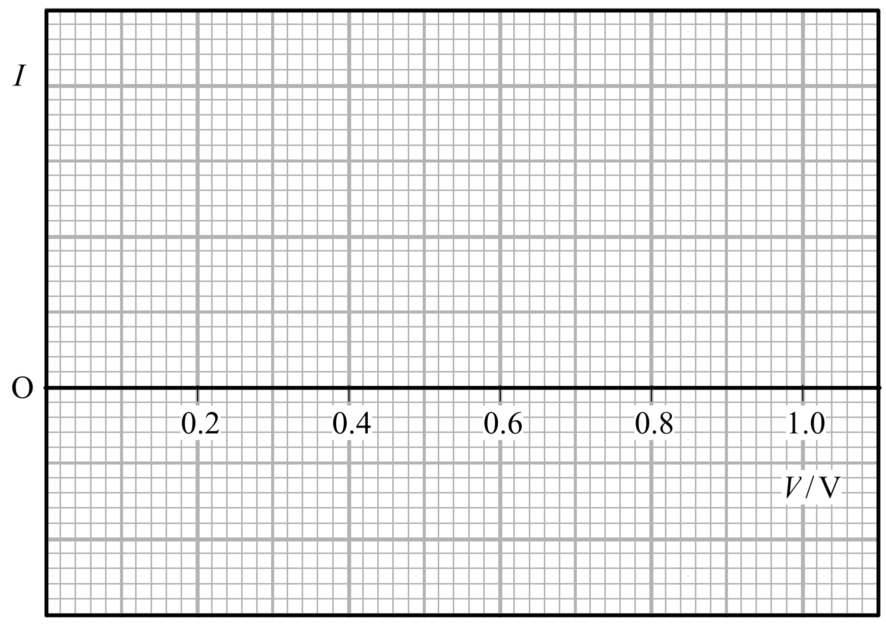
(2)

(d) Using the axes below, sketch a graph to show how the current I would change as the reverse potential difference V is increased from zero to 1.0 V. No scale is required on the current axis.



(3)

(Total 9 marks)

Leave blank

Q6

N 3 0 4 1 3 A 0 1 5 2 4

Turn over

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7. Digital information is often encrypted (expressed in code) before transmission. For this to work, both sender and receiver must know the "key" to the code. Quantum cryptography is a technique for sending the key to the code securely. The key is a long binary number and, in quantum cryptography, each bit of this number is transmitted by a single photon.

(a) The value of the bit (0 or 1) can be represented by the state of polarization of the electromagnetic wave associated with the photon.

(i) Explain what is meant by a plane polarized wave.

....

....

....

(ii) Suggest how the type of polarization could be used to represent the value of the bit.

....

....

....

(2)

(b) One way to generate the single photons is to produce laser pulses so weak that each contains on average just one photon. In a typical system the wavelength used is 1.55×10^{-6} m and 3.0×10^{4} pulses are sent per second.

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

....

(1)

(ii) Calculate the mean power of the signal.

....

....

....

....

Power = ...

(3)

Q7

(Total 6 marks)

Leave blank

8. (a) Outline how astronomers measure the velocities with which galaxies are receding from the Earth.

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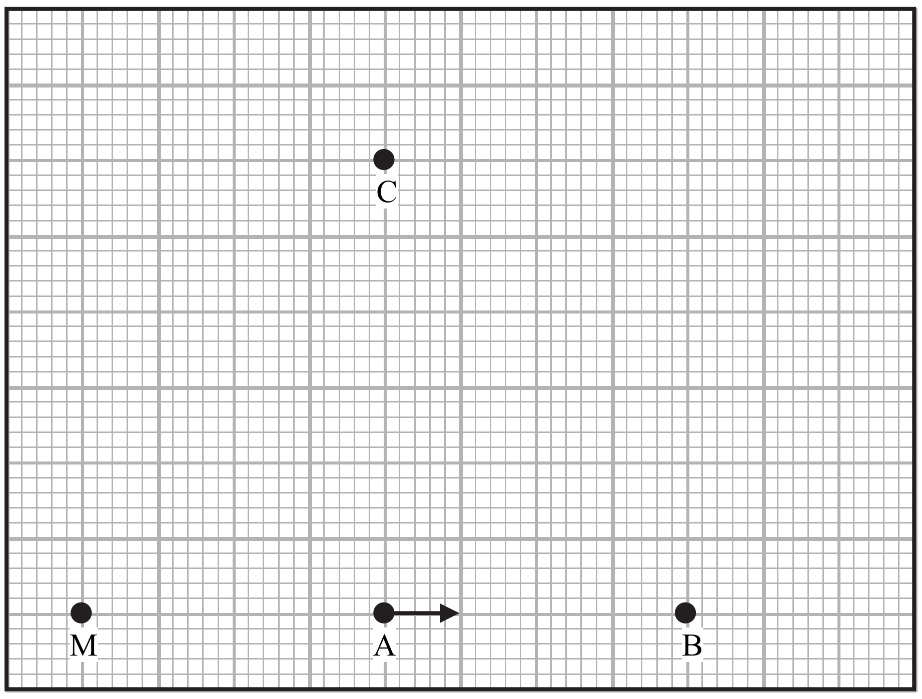
(3)

(b) The diagram shows the relative positions of four widely separated galaxies: our own Milky Way galaxy, M, and three other galaxies A, B and C.



The arrow represents, in magnitude and direction, the velocity of galaxy A relative to us. Add similar arrows to the diagram to represent, in magnitude and direction, the velocities of galaxies B and C. If you need to do any calculation, use the space below the diagram.

(2) **Q8**

(Total 5 marks)

TOTAL FOR PAPER: 60 MARKS

END

N 3 0 4 1 3 A 0 1 7 2 4

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	$m_{\mathrm{e}} = 9.11 \times 10^{-31}\ \mathrm{kg}$	
Electronvolt	$1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$	
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	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{N\,A^{-2}}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$	

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	$T = 2\pi\sqrt{\frac{l}{g}}$	(Pendulum length l)
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	$\varepsilon = -\dfrac{N\Delta\Phi}{\Delta t}$	(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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