| 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 21 January 2009 – Morning

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.
Some questions must be answered with a cross in a box (☒). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

### 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) Below are three statements about electromagnetic waves. Complete each statement by marking with a cross (☒) next to the correct phrase or word.

(i) As the wavelength increases, the distance between nodes and antinodes in a stationary wave in a given medium

increases ☒

remains constant ☒

decreases ☒

(ii) As the wavelength in a vacuum increases, the number of cycles per second

increases ☒

remains constant ☒

decreases ☒

(iii) As the wavelength in a vacuum increases, the difference between energy levels needed for an atom to absorb the wave

increases ☒

remains constant ☒

decreases ☒

**(3)**

(b) State a property of electromagnetic waves, not mentioned in part (a), which increases as the wavelength is increased.

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**(1)**

(c) Electromagnetic waves differ in how strongly they exhibit particle-like behaviour. State how this depends on their wavelength.

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**(1)**

**Q1**

**(Total 5 marks)**

**2.** Water waves of amplitude 0.080 m are travelling at 1.51 m $s^{-1}$ across the surface of a lake. A leaf X is floating on the surface of the water. As the waves pass, they make the leaf perform simple harmonic motion in the vertical direction. The period of oscillation is 1.20 s.

(a) Show that the wavelength of the waves is approximately 1.8 m.

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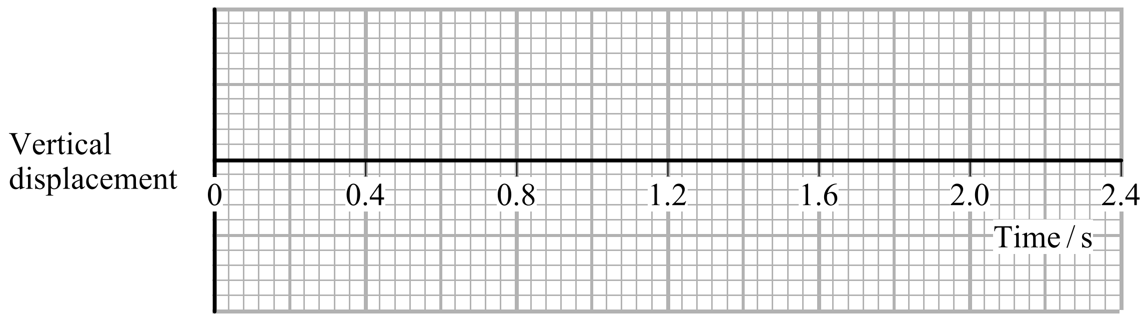
**(2)**

(b) Using the grid below, sketch a graph to show how the vertical displacement of leaf X varies with time over an interval of 2.4 s. Assume that a crest is present at time zero.

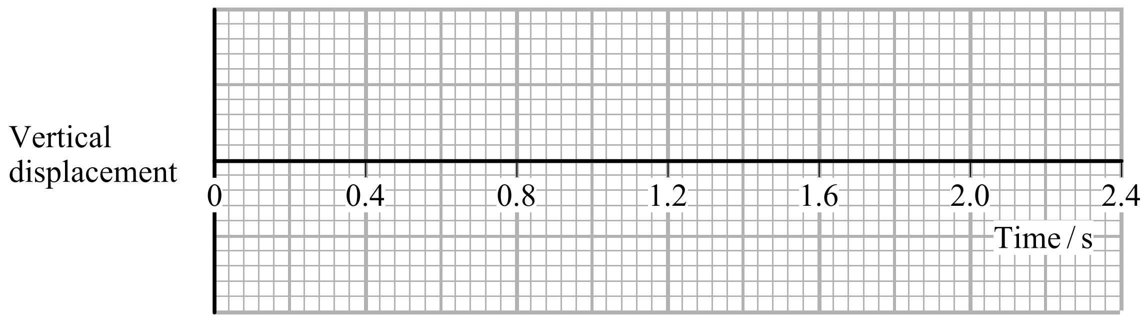
Leaf X




**(2)**

(c) A second leaf Y is floating on the lake 0.45 m away from leaf X in the direction of travel of the waves. Using the grid below, sketch a displacement-time graph for leaf Y over the same time interval.

Leaf Y




**(2)**

**(Total 6 marks)**

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Q2



N 3 1 1 7 3 A 0 3 2 0

**Turn over**

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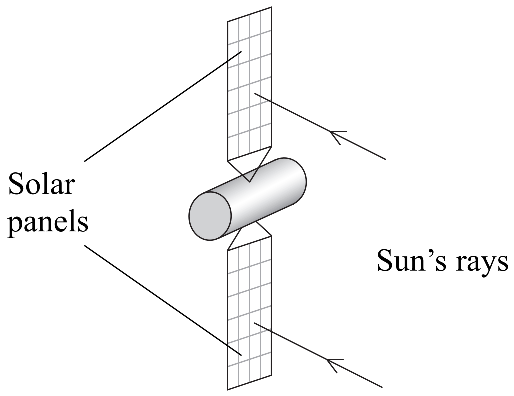
**3.** A satellite orbiting the Earth obtains electrical energy for its instruments from arrays of solar cells. These arrays are perpendicular to the Sun's rays. At this distance from the Sun, the intensity of solar radiation is 1400 W $m^{-2}$.




(a) The total area of the arrays facing the Sun is 27 $m^2$, and they are 19% efficient. Show that the electrical power output is approximately 7 kW.

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**(2)**

(b) (i) Suppose that the same satellite were placed in orbit around Mars, with its arrays still perpendicular to the Sun's rays. Calculate the new electrical power output. Treat the Sun as a point source of radiation.

Distance of Earth from the Sun = $1.5 \times 10^{11}$ m
Distance of Mars from the Sun = $2.3 \times 10^{11}$ m

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Power output = ........................................................

**(3)**



N 3 1 1 7 3 A 0 4 2 0

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(ii) Apart from treating the Sun as a point source, what other assumption have you made in your calculation?

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Explain why this assumption is justified.

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**(2)** **Q3**

**(Total 7 marks)**

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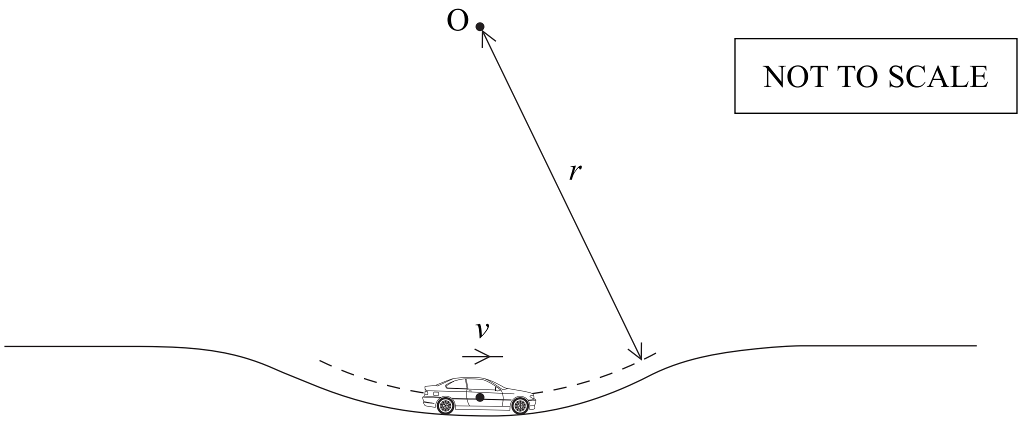
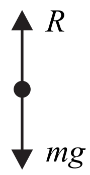
**4.** The diagram shows a car of total mass $m$ moving at constant speed through a dip in a road.




The car is shown at its lowest point. Its centre of gravity is moving at speed $v$ along part of a circle of radius $r$ centred at point O. The free-body force diagram below shows the vertical forces acting on the car at this instant.




(a) Complete the following sentence to describe the upward force $R$.

$R$ is the .............................................................................................. force exerted on

the ................................................ by the ................................................ .

**(2)**

(b) (i) Write down an expression for the acceleration of the car and state its direction.

Acceleration = .......................................... Direction: .........................................

(ii) Explain why the force $R$ is given by:

$$R = mv^2/r + mg$$

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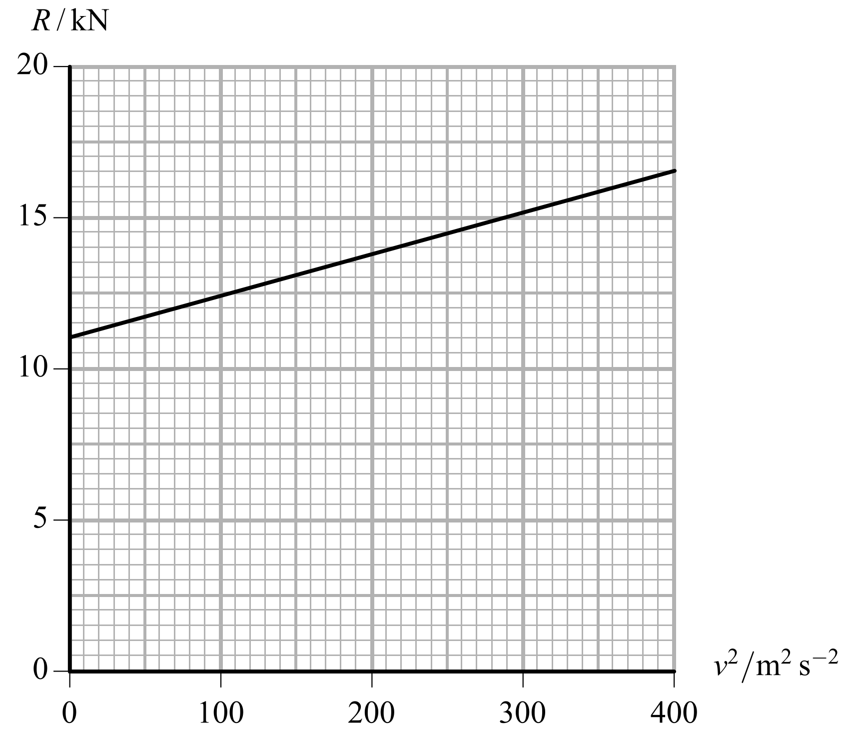
**(4)**

(c) The graph shows how $R$ depends on $v^2$ for a car of mass 1120 kg in one particular dip in the road.




(i) Determine the gradient of the graph.

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Gradient = ...............................................................

**(2)**

(ii) Hence, or otherwise, determine the radius $r$ of the path being followed by the car.

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Radius = ..................................................................

**(2)**

**(Total 10 marks)**

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**Q4**

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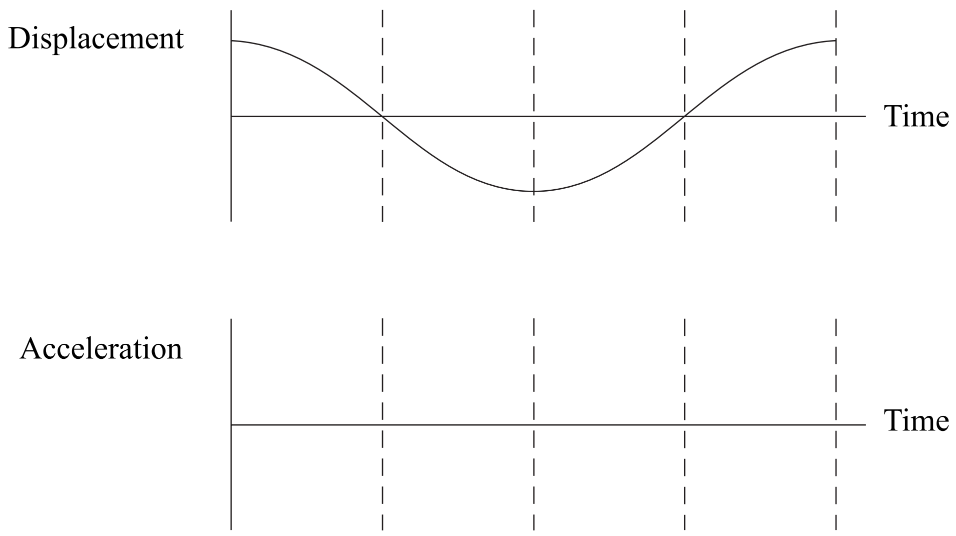
**5.** (a) (i) The diagram shows the displacement-time graph for an object performing simple harmonic motion. Using the axes below the graph, sketch a graph of the object's acceleration against time over the same interval.




**(1)**

(ii) The object has mass $m$. The amplitude of the motion is $x_0$ and its frequency is $f$. Obtain an expression for the maximum resultant force which must act on the object during the motion.

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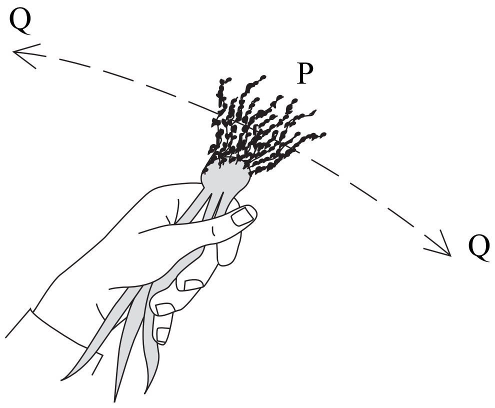
Maximum resultant force = .....................................
**(1)**



N 3 1 1 7 3 A 0 8 2 0

(b) When a plant is pulled out of the ground, soil remains loosely attached to its roots. The soil can be removed by shaking the plant from side to side repeatedly, as shown in the diagram. The motion can be assumed to be simple harmonic.




(i) State whether the soil would be more likely to break free from the roots at the centre of the oscillation P or at its ends Q. Give a reason for your answer.

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**(1)**

(ii) If the soil still remains attached, the plant can be shaken more vigorously. State and explain whether it would be more effective to double the amplitude of the oscillation or to double its frequency.

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**(2)**

**(Total 5 marks)**

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**Q5**



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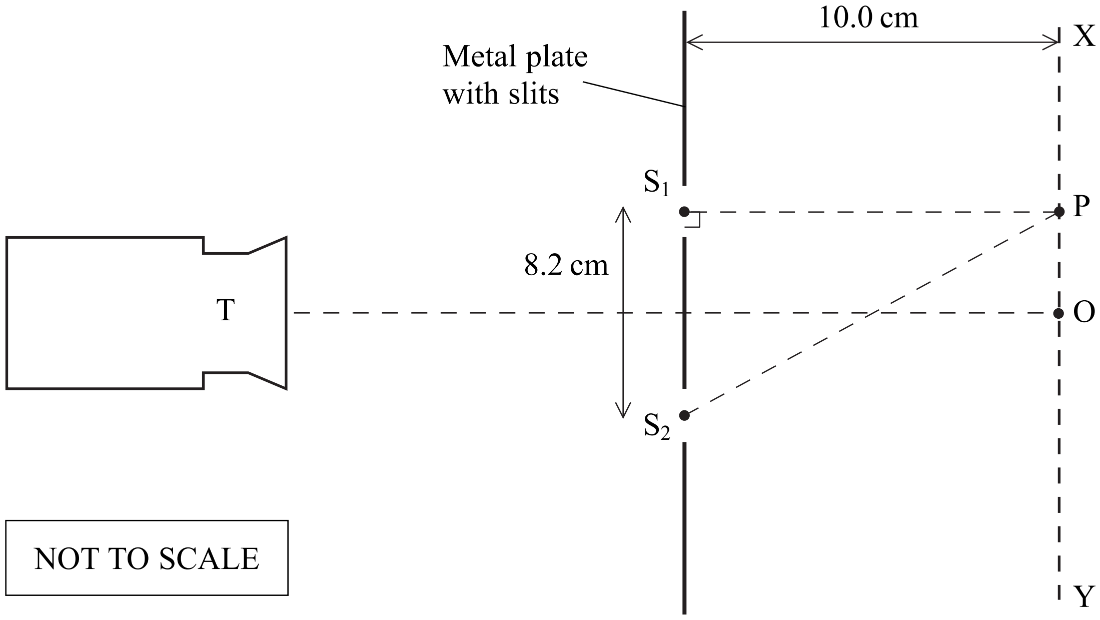
**6.** A student performs an experiment to measure the wavelength of microwaves.




Microwaves from a transmitter T are incident on two slits $S_1$ and $S_2$ which are equidistant from T. The waves are diffracted by the slits and superpose. A small microwave detector is moved along the line XY, which is parallel to the plane of the slits.

(a) The detected intensity has a maximum at O, equidistant from the slits. As the detector is moved from O towards X, the intensity decreases to a minimum before increasing to another maximum.

Explain these observations. You may be awarded a mark for the clarity of your answer.

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**(5)**

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(b) With the apparatus dimensions shown in the diagram, it is found that the first maximum detected after leaving O is at point P, directly ahead of $S_1$.

(i) In this situation, the formula $\lambda = xs/D$ is not valid. However the student does not realise this, and uses the formula to work out the wavelength. Calculate the value he will obtain.

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$\lambda$ = ............................................

**(1)**

(ii) Use the distances marked on the diagram to calculate a more accurate value for $\lambda$. (Note that the diagram is not to scale.)

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$\lambda$ = ............................................

**(3)**

(iii) State **one** condition which must be satisfied by the slit separation $s$ if the formula $\lambda = xs/D$ is to be valid for a two-slit interference experiment.

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**(1)**

**Q6**

**(Total 10 marks)**



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

**Turn over**

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**7.** The maximum kinetic energy $E_{max}$ of a photoelectron is given by the equation

$$E_{max} = hf - \varphi$$

where the other symbols have their usual meanings.

(a) Explain why $E_{max}$ is given by the expression $hf - \varphi$.

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**(3)**

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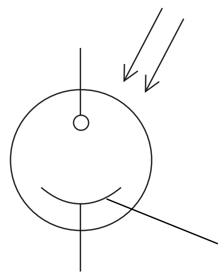
(b) The diagram shows a photocell illuminated with monochromatic light. Photoelectrons are released from its cathode.




Add to the diagram to show the circuit you would need to find the value of $E_{max}$ for these electrons.

Describe how you would use your circuit to determine $E_{max}$.

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**(5)**

(c) Potassium has a work function of $3.6 \times 10^{-19}$ J. Calculate the frequency of radiation needed to eject photoelectrons with a maximum kinetic energy of $2.0 \times 10^{-19}$ J from a potassium surface.

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Frequency = .............................................................

**(2)**

**Q7**

**(Total 10 marks)**

Leave blank

**8.** (a) Evidence for the expansion of the Universe comes from observations of spectral lines in light received from distant galaxies. Describe how the observed wavelength of a given line depends on the distance of the galaxy from Earth.

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**(2)**

(b) A simple model of the Universe predicts that the rate of expansion should be decreasing as time passes.

(i) Explain why one would expect this.

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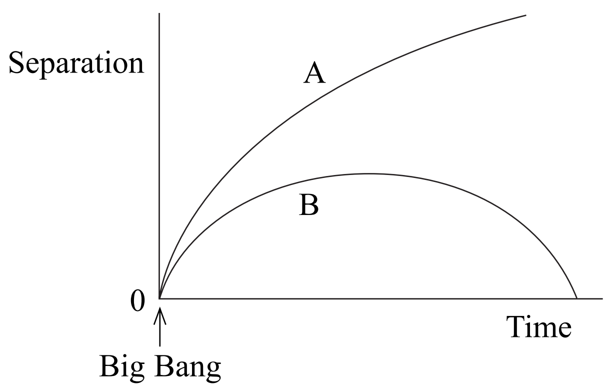
**(1)**

(ii) The model predicts that the separation between two galaxies should vary with time as shown by either graph A or graph B below.




With reference to these graphs, explain the difference between 'open' and 'closed' universes.

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**(2)**

(iii) What condition must be satisfied if the Universe is to follow graph A rather than graph B?

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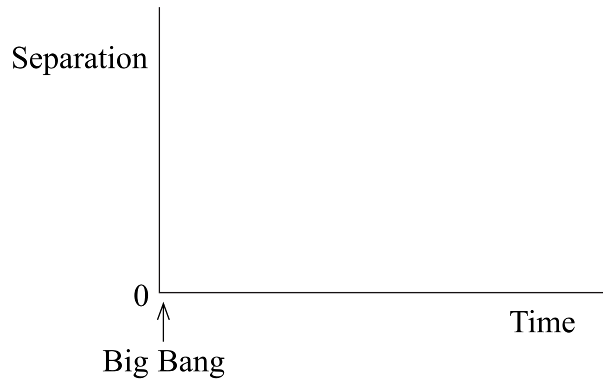
**(1)**

(c) Recent research suggests that, at some time in the past, the rate of expansion stopped decreasing and began to increase. Use the axes below to sketch a graph showing how the separation of two galaxies would change with time if this idea is correct.




**(1)**

**Q8**

**(Total 7 marks)**

**TOTAL FOR PAPER: 60 MARKS**

**END**

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## 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 | $1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$ | |
| 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 | $k = 1/4\pi\varepsilon_0$ <br> $= 8.99 \times 10^{9}\ \mathrm{N\ m^{2}\ C^{-2}}$ | |
| 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 $$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$$

Impulse $$F\Delta t = \Delta p$$

***Mechanical energy***

Power $$P = Fv$$

***Radioactive decay and the nuclear atom***

Activity $$A = \lambda N$$ (Decay constant $\lambda$)

Half-life $$\lambda t_{\frac{1}{2}} = 0.69$$

***Electrical current and potential difference***

Electric current $I = nAQv$

Electric power $P = I^2 R$

***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 $\Delta T$)

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 $\Delta Q$; Work done on body $\Delta W$)

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 $\lambda$; 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 $\varphi$) |
| 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 $\mu_0$) |
| near a long wire | $B = \mu_0 I/2\pi r$ | |
| Magnetic flux | $\Phi = BA$ | |
| E.m.f. induced in a coil | $\varepsilon = -\frac{N\Delta\Phi}{\Delta t}$ | (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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