[C069/SQP190]

NATIONAL QUALIFICATIONS

Time: 2 hours 30 minutes

PHYSICS
ADVANCED HIGHER
Specimen Question Paper

Answer **all** questions.

Any necessary data may be found on the Data Sheet on *page two*.

Care should be taken to give an appropriate number of significant figures in the final answers to calculations.

Square-ruled paper (if used) should be placed inside the front cover of the answer book for return to the Scottish Qualifications Authority.

DATA SHEET

COMMON PHYSICAL QUANTITIES

Quantity	*Symbol*	*Value*	*Quantity*	*Symbol*	*Value*
Gravitational acceleration	g	$9{\cdot}8\ \text{m s}^{-2}$	Mass of electron	m_e	$9{\cdot}11 \times 10^{-31}$ kg
Radius of Earth	R_E	$6{\cdot}4 \times 10^{6}$ m	Magnitude of the charge on an electron	e	$1{\cdot}60 \times 10^{-19}$ C
Mass of Earth	M_E	$6{\cdot}0 \times 10^{24}$ kg	Mass of neutron	m_n	$1{\cdot}675 \times 10^{-27}$ kg
Mass of Moon	M_M	$7{\cdot}3 \times 10^{22}$ kg	Mass of proton	m_p	$1{\cdot}673 \times 10^{-27}$ kg
Mean Radius of Moon Orbit		$3{\cdot}84 \times 10^{8}$m	Planck's constant	h	$6{\cdot}63 \times 10^{-34}$ J s
Universal constant of gravitation	G	$6{\cdot}67 \times 10^{-11}\ \text{m}^3\ \text{kg}^{-1}\ \text{s}^{-2}$	Permittivity of free space	ε_0	$8{\cdot}85 \times 10^{-12}\ \text{F m}^{-1}$
Speed of light in vacuum	c	$3{\cdot}0 \times 10^{8}\ \text{m s}^{-1}$	Permeability of free space	μ_0	$4\pi \times 10^{-7}\ \text{H m}^{-1}$
Speed of sound in air	v	$3{\cdot}4 \times 10^{2}\ \text{m s}^{-1}$			

REFRACTIVE INDICES

The refractive indices refer to sodium light of wavelength 589 nm and to substances at a temperature of 273 K.

Substance	*Refractive index*	*Substance*	*Refractive index*
Diamond	2·42	Glycerol	1·47
Glass	1·51	Water	1·33
Ice	1·31	Air	1·00
Perspex	1·49		

SPECTRAL LINES

Element	*Wavelength*/nm	*Colour*
Hydrogen	656	Red
	486	Blue-green
	434	Blue-violet
	410	Violet
	397	Ultraviolet
	389	Ultraviolet
Sodium	589	Yellow

Element	*Wavelength*/nm	*Colour*
Cadmium	644	Red
	509	Green
	480	Blue

Lasers

Element	*Wavelength*/nm	*Colour*
Carbon dioxide	9550 } 10590 }	Infra red
Helium-neon	633	Red

PROPERTIES OF SELECTED MATERIALS

Substance	*Density*/ kg m^{-3}	*Melting Point*/ K	*Boiling Point*/ K	*Specific Heat Capacity*/ J kg^{-1} K^{-1}	*Specific Latent Heat of Fusion*/ J kg^{-1}	*Specific Latent Heat of Vaporisation*/ J kg^{-1}
Aluminium	$2{\cdot}70 \times 10^3$	933	2623	$9{\cdot}02 \times 10^2$	$3{\cdot}95 \times 10^5$	....
Copper	$8{\cdot}96 \times 10^3$	1357	2853	$3{\cdot}86 \times 10^2$	$2{\cdot}05 \times 10^5$	....
Glass	$2{\cdot}60 \times 10^3$	1400	....	$6{\cdot}70 \times 10^2$	....	....
Ice	$9{\cdot}20 \times 10^2$	273	....	$2{\cdot}10 \times 10^3$	$3{\cdot}34 \times 10^5$	....
Glycerol	$1{\cdot}26 \times 10^3$	291	563	$2{\cdot}43 \times 10^3$	$1{\cdot}81 \times 10^5$	$8{\cdot}30 \times 10^5$
Methanol	$7{\cdot}91 \times 10^2$	175	338	$2{\cdot}52 \times 10^3$	$9{\cdot}9 \times 10^4$	$1{\cdot}12 \times 10^6$
Sea Water	$1{\cdot}02 \times 10^3$	264	377	$3{\cdot}93 \times 10^3$	....	....
Water	$1{\cdot}00 \times 10^3$	273	373	$4{\cdot}19 \times 10^3$	$3{\cdot}34 \times 10^5$	$2{\cdot}26 \times 10^6$
Air	1·29	....	....	....	....	....
Hydrogen	$9{\cdot}0 \times 10^{-2}$	14	20	$1{\cdot}43 \times 10^4$	....	$4{\cdot}50 \times 10^5$
Nitrogen	1·25	63	77	$1{\cdot}04 \times 10^3$	....	$2{\cdot}00 \times 10^5$
Oxygen	1·43	55	90	$9{\cdot}18 \times 10^2$	....	$2{\cdot}40 \times 10^5$

The gas densities refer to a temperature of 273 K and a pressure of $1{\cdot}01 \times 10^5$ Pa.

Answer ALL questions

Marks

1. (*a*) The acceleration a of an object is given by the following expression

$$a = \frac{d^2s}{dt^2}$$

where the symbols have their usual meanings.

Starting with this expression for the acceleration, show that, for an object moving with constant acceleration, the velocity v of the object at time t is given by

$$v = u + at$$

where u is the velocity at time $t = 0$. **2**

(*b*) A test vehicle moves in a straight line along a track. Its displacement, in metres, as a function of time is given by

$$s = 24t - 2t^2.$$

Find

(i) the time when the vehicle momentarily comes to rest;

(ii) the vehicle's displacement at this time;

(iii) the vehicle's acceleration. **4**

(*c*) The test vehicle was timed as it travelled a measured distance of (1·000 ± 0·005) m along the track. The times recorded for this distance were

1·21 s; 1·23 s; 1·24 s; 1·20 s; 1·22 s.

Calculate

(i) the average speed of the vehicle;

(ii) the absolute uncertainty in this speed. **4**

(10)

Marks

2. (*a*) A playground roundabout consists of a uniform disc and eight handrails in the form of arcs as shown in Figure 1. The uniform disc has a radius of 2·0 m and a moment of inertia, about the axis of rotation, of 500 kg m^2. The handrails each have a mass of 15 kg. The inner handrails are 1·0 m from the centre.

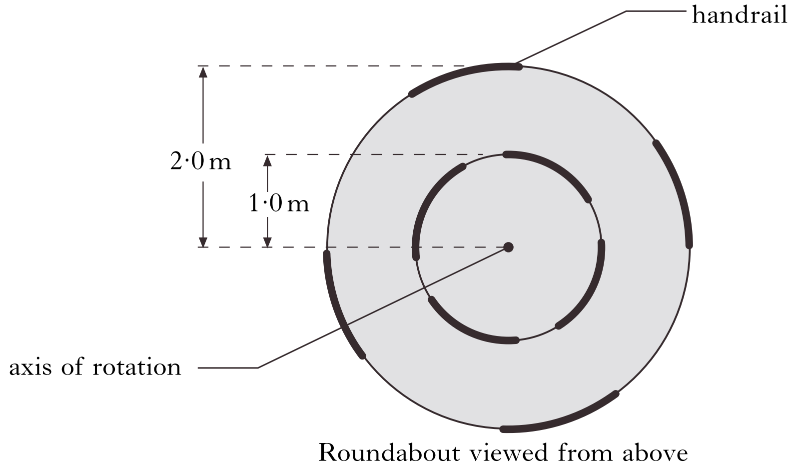


Figure 1

Show that the moment of inertia of the roundabout about the axis of rotation is 800 kg m^2. **2**

(*b*) A boy of mass 40 kg stands in a vertical position on the rim of the roundabout as shown in Figure 2. The roundabout is rotating about its axis of rotation with constant angular velocity. The roundabout takes 3·0 s to make one complete revolution. The effect of friction at the axis of rotation can be neglected.

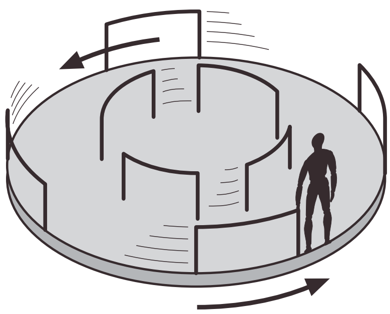


Figure 2

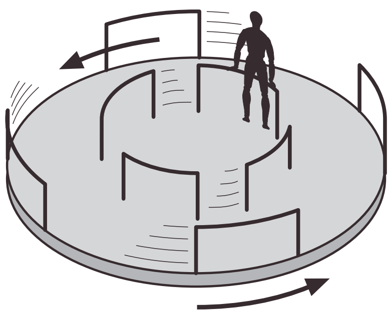


Figure 3

Calculate the angular velocity, in radians per second, of the roundabout. **1**

(*c*) The boy now moves to a position 1·0 m from the axis of rotation as shown in Figure 3. He holds the handrail to steady himself and maintain his body in a vertical position.

(i) Explain why the angular velocity of the roundabout changes. Assume that the boy's mass does not alter and that no external torque is applied.

(ii) Hence, or otherwise, calculate the new angular velocity of the roundabout after the boy moves inwards. **5**

(*d*) (i) Show by calculation that the kinetic energy of the system has not been conserved.

(ii) Account for this change in kinetic energy. **4**

(12)

Marks

3. (*a*) The displacement y of a particle at time t may be given by

$$y = A\cos \omega t$$

where A and ω are constants.

Show that this relationship is a solution of the equation for simple harmonic motion. **3**

(*b*) The acceleration a of a simple pendulum can be represented by

$$a = -\frac{g}{l}y$$

where g is the gravitational field strength, l is the length of the pendulum and y is a small horizontal displacement from O as shown in Figure 4.

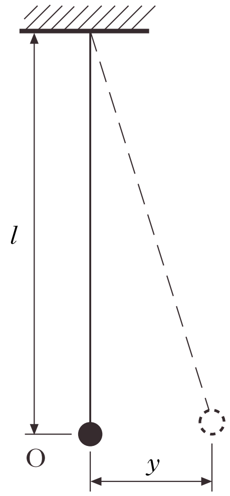


Figure 4

Derive an expression for the period T of the pendulum. **3**

3. (continued)

(*c*) In an experiment to measure the acceleration due to gravity g, the length of a simple pendulum is varied. The period of the pendulum is measured for a number of different lengths. The results are used to draw the graph of (period)^2 against length as shown in Figure 5.

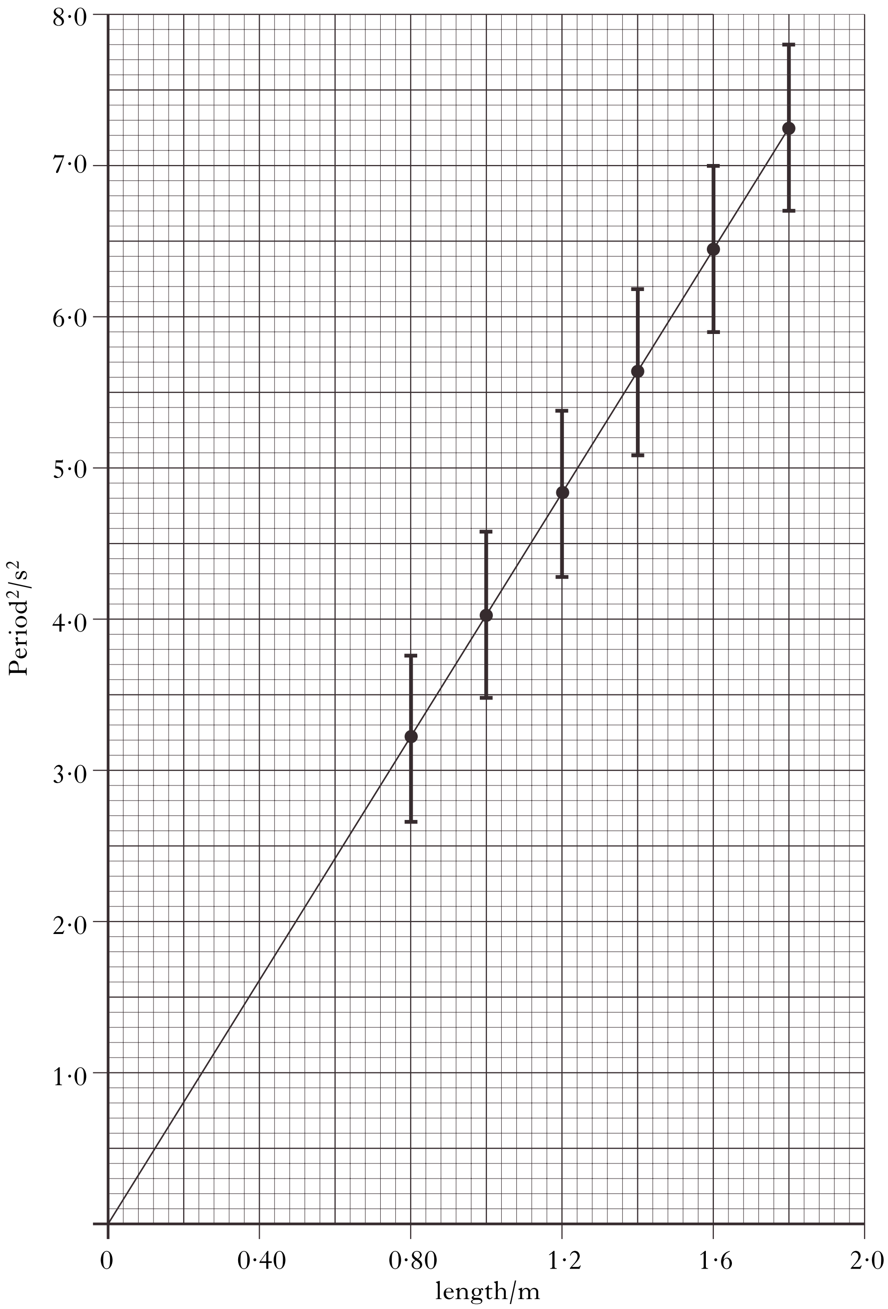


Figure 5

Calculate the gradient of the graph and hence find a value for g. **3**

(*d*) Describe how uncertainties could be minimised in the measurement of the period. **1**

(10)

Marks

4. (*a*) Bohr's model of the hydrogen atom includes assumptions about the orbiting electron. One of these is that the electron moves in a circular orbit centred on the nucleus.

(i) State briefly one of the other assumptions.

(ii) By considering the electron as a point mass m travelling around the nucleus, show that the radii of the allowed orbits r_n are given by

$$r_n = \frac{nh}{2\pi mv}$$

where the remaining symbols have their usual meanings.

(iii) Calculate the speed of an electron in the first allowed orbit of radius $5{\cdot}3 \times 10^{-11}$ m. **5**

(*b*) Planck and Einstein suggested that electromagnetic radiation exhibits a wave-particle duality. De Broglie extended this idea to matter.

(i) Write down an expression for the wavelength λ associated with a particle that has a momentum of magnitude p.

(ii) (A) A woman of mass 50 kg walks through a doorway at a speed of $1{\cdot}5\,\mathrm{m\,s^{-1}}$. Calculate her de Broglie wavelength.

(B) Explain why the effect of diffraction is negligible when the woman passes through the doorway. **4**

(9)

5. (*a*) Two spherical conductors A and B of the same radius are shown in Figure 6.

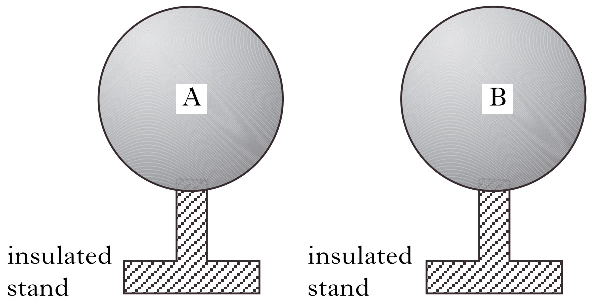


Figure 6

These spheres are to be given charges that are equal in magnitude but opposite in sign.

Explain how this charge distribution can be achieved. **4**

(*b*) A negative pion consists of a down quark and an up antiquark. The electric charge on the down quark is $-5{\cdot}33 \times 10^{-20}$ C and that on the up antiquark is $-1{\cdot}07 \times 10^{-19}$ C.

(i) The distance between the quark-antiquark pair is $1{\cdot}00 \times 10^{-15}$ m. Calculate the electrostatic force between them.

(ii) Name the force which holds this quark-antiquark pair together. **3**

(7)

6. The apparatus shown in Figure 7 allows protons of a selected speed to emerge from the exit aperture. The protons travel in a vacuum.

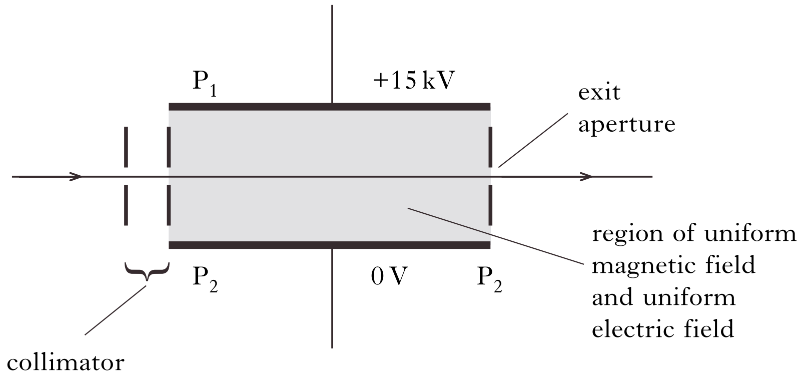


Figure 7

Protons moving with different speeds pass through the collimator. They then enter a region where there is a uniform magnetic field and a uniform electric field.

The magnetic induction of the magnetic field is 0·060 T. The plates P_1 and P_2 are 5·0 mm apart and there is a potential difference of 15 kV between the plates.

(*a*) Sketch the electric field pattern between the plates P_1 and P_2. **1**

(*b*) Calculate the magnitude of the electric field strength between the plates P_1 and P_2. **2**

(*c*) State the direction of the magnetic field in this region. **1**

(*d*) (i) Show that the velocity of the protons passing through the exit aperture is $5{\cdot}0 \times 10^7\,\text{m s}^{-1}$.

(ii) Relativistic mass is given by the equation

$$m = \frac{m_0}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}$$

where the symbols have their usual meanings.

Calculate the relativistic energy of a proton travelling at $5{\cdot}0 \times 10^7\,\text{m s}^{-1}$. **5**

(9)

Marks

7. (*a*) Figure 8 shows a long, current carrying conductor, PQ. At a perpendicular distance of 0·050 m from PQ, the magnetic induction, due to the current, is $2{\cdot}0 \times 10^{-5}$ T.

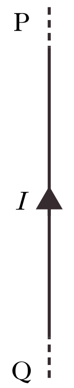


Figure 8

Calculate the current I in the conductor PQ. **2**

(*b*) A second long conductor RS is placed 0·050 m from PQ as shown in Figure 9. PQ is parallel to RS. RS carries a current of 4·0 A in the opposite direction to the current in PQ.

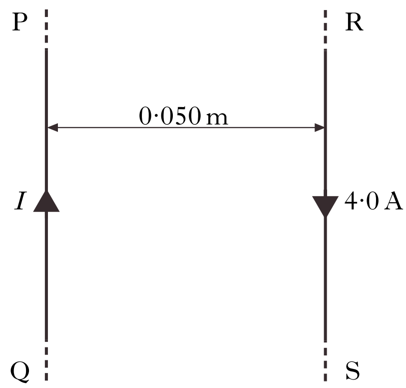


Figure 9

(i) (A) Calculate the magnitude of the force on each metre of RS.

(B) State the direction of this force.

(ii) The distance between the conductors is doubled.

What effect does this have on the size of the force on each metre of RS? **4**

7. (continued)

(*c*) Conductor RS is now placed between the poles of a magnet at right angles to the direction of the magnetic field as shown in Figure 10. There is a uniform magnetic field between the poles of the magnet and end effects can be ignored.

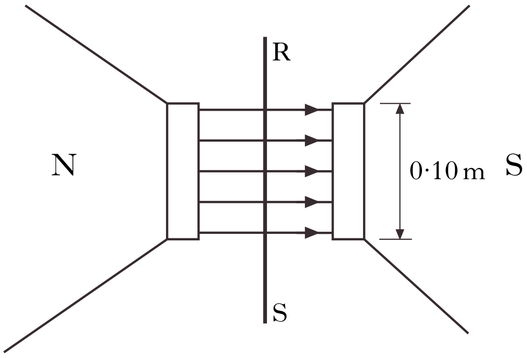


Figure 10

(i) When the current in conductor RS is 4·0 A, the force acting on RS is $8{\cdot}0 \times 10^{-3}$ N. Calculate the magnetic induction.

(ii) Conductor RS is now turned so that it makes an angle θ with the direction of the magnetic field as shown in Figure 11.

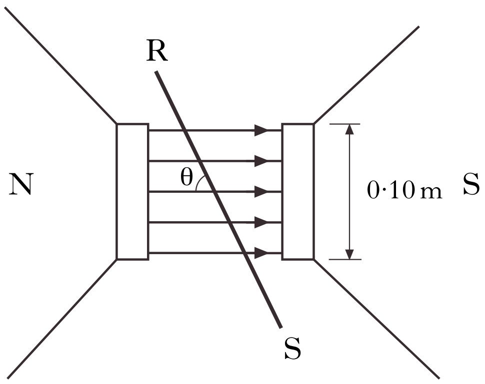


Figure 11

Explain why the force on the conductor is the same as in (*c*)(i). **3**

(9)

Marks

8. (*a*) A particle of charge q and mass m moves in a uniform magnetic field of induction B. The particle travels in a circular orbit with constant speed v as shown in Figure 12.

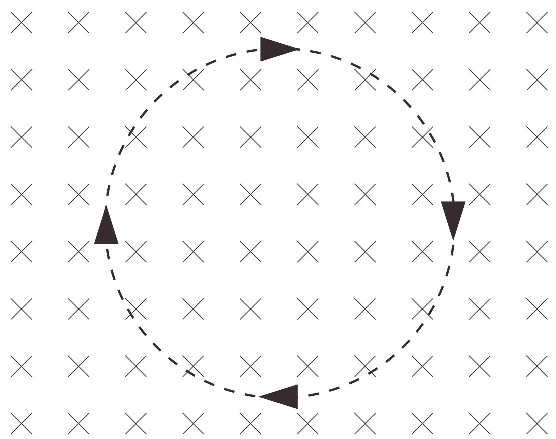


Figure 12

Show that the radius of r of the orbit is given by

$$r = \frac{mv}{qB}.$$ **2**

(*b*) In Figure 13, the continuous lines show the direction of the Earth's magnetic field.

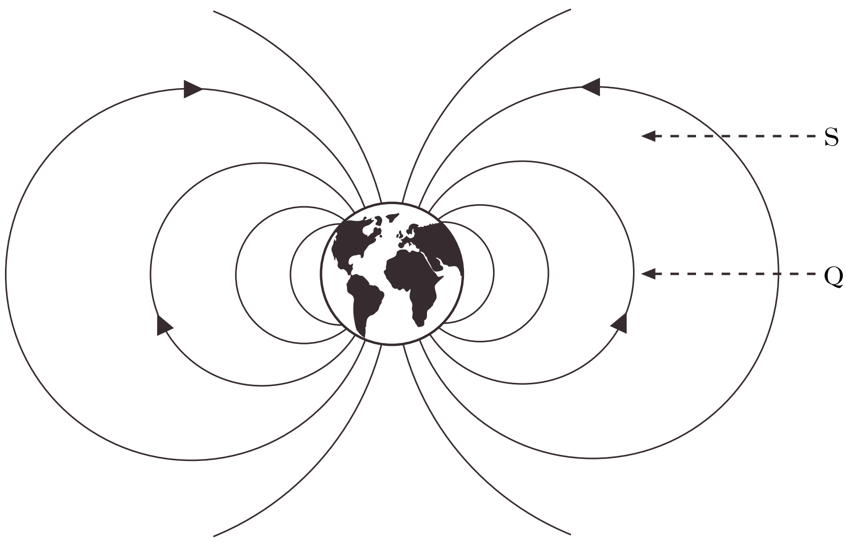


Figure 13

(i) Describe the paths that would be followed by protons initially approaching the Earth along paths Q and S.

Path Q is perpendicular to the direction of the Earth's magnetic field lines.

(ii) A proton approaches the Earth along path Q. The speed of the proton is $2{\cdot}0 \times 10^6\,\text{m s}^{-1}$. The magnetic induction at a point on the path of the proton is $1{\cdot}3 \times 10^{-5}\,\text{T}$. Calculate the radius of curvature of the path of the proton at this point. **4**

(*c*) State and explain the conditions under which a charged particle, moving in a uniform magnetic field, describes a helical path. **2**

(8)

Marks

9. Figure 14 shows a circuit containing an ideal inductor in series with a 4·0 Ω resistor. The battery has negligible internal resistance.

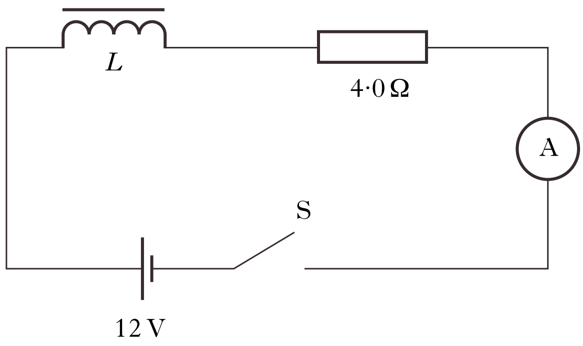


Figure 14

(*a*) Define the henry. **1**

(*b*) (i) The switch S is now closed. The initial rate of change of current is 2·0 A s^{-1}.
Calculate the self-inductance L of the coil.

(ii) Sketch a graph to show how the current in the inductor varies with time from the moment the switch is closed.

A scale must be shown on the current axis.

(iii) Calculate the maximum energy stored in the inductor. **6**

(7)

10. A travelling wave is represented by the expression

$$y = 0{\cdot}0050 \sin 10\left(5t - \frac{x}{3}\right)$$

where y and x are measured in metres, and t in seconds.

(*a*) Find, for this wave

(i) the frequency;

(ii) the wavelength;

(iii) the speed. **3**

(*b*) Calculate the phase difference in radians between two points at a distance of 0·20 m and 1·10 m respectively from the origin. **2**

(*c*) Another wave is travelling at the same speed but in the opposite direction. This wave has five times the amplitude and twice the frequency of the original wave.
State the expression that represents this travelling wave. **3**

(*d*) (i) State what is meant by the Doppler effect.

(ii) The spectral lines of hydrogen atoms from a distant galaxy are observed to have a lower frequency than the equivalent lines produced from hydrogen atoms in a laboratory on Earth. Explain this observation. **2**

(10)

11. (*a*) (i) State the condition for two light sources to be coherent.

(ii) Describe, with the aid of a diagram, how two coherent light sources can be produced in practice. **3**

(*b*) The thickness of a very thin cylindrical optical fibre may be checked using "thin wedge fringes". Figure 15 shows two optically flat glass plates. The upper plate is resting on two cylindrical optical fibres A and B, 0·120 m apart. The diameter of fibre A is 0·20 mm.

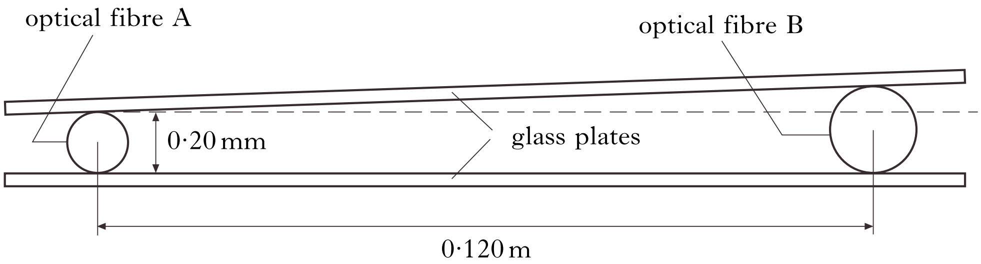


Figure not to scale

Figure 15

This apparatus is illuminated, from above, by light of wavelength 590 nm. Thin wedge fringes of separation 4·4 mm are observed.

(i) Calculate the difference in diameter between fibre A and fibre B.

(ii) The manufacturer of the fibre claims a tolerance of ±5% in the diameter.

Does fibre B meet with the manufacturer's specification?

You must justify your answer by calculation. **6**

(9)

[*END OF QUESTION PAPER*]

NATIONAL
QUALIFICATIONS

PHYSICS
ADVANCED HIGHER
Specimen Marking Instructions
and Analysis Grid

Marks

1. (*a*) $a = \frac{d^2s}{dt^2} = \frac{d}{dt}\left(\frac{ds}{dt}\right) = \frac{dv}{dt}$ {½}

$\int dv = \int a.dt$ {½}

$v = at + c$ {½} but $v = u$ when $t = 0$ {½}

$\therefore v = u + at$ **[2]**

(*b*) (i) $\left(\frac{ds}{dt}\right) = v$ {½} $= 24 - 4t$ {½}

when $v = 0$ $t = 6s$ **{1}** [½ for value ½ for unit]

(ii) $s = 24 \times 6 - 2 \times 6^2 (= 144 - 72)$

$= 72\,\text{m}$ **{1}** [½ for value ½ for unit]

(iii) $a = \frac{d^2s}{dt^2} = \frac{dv}{dt} = -4\,\text{m s}^{-2}$ **{1}** [½ for value ½ for unit] **[4]**

(*c*) (i) Mean time $= \frac{1\cdot21 + 1\cdot23 + 1\cdot24 + 1\cdot20 + 1\cdot22}{5} = 1\cdot22\,\text{s}$ {½}

Average speed $= \frac{1\cdot000}{1\cdot22} = 0\cdot820\,\text{m s}^{-1}$ {½}

(ii) Random uncertainty in time $= \frac{1\cdot24 - 1\cdot20}{5} = 0\cdot008\text{s}$ {½}

% uncertainty in time $= \frac{0\cdot008}{1\cdot22} \times 100\% = 0\cdot66\%$ {½}

% uncertainty in length $= \frac{0\cdot005}{1\cdot000} \times 100\% = 0\cdot50\%$ {½}

% uncertainty in speed $= \sqrt{(0\cdot66\%)^2 + (0\cdot50\%)^2} = 0\cdot83\%$ {½}

Absolute uncertainty in speed $= 0\cdot007\,\text{m s}^{-1}$ **{1}** **[4]**

(10)

2. (*a*) $I_{\text{roundabout}} = I_{\text{disc}} + 4mr_1^2 + 4mr_2^2$ {½}

$= 500$ {½} $+ 4 \times 15 \times 1^2$ {½} $+ 4 \times 15 \times 2^2$ {½}

$= 800\ \text{kg m}^2$ **[2]**

(*b*) $\theta = \dfrac{2\pi}{T}$ {½} $= \dfrac{2\pi}{3} = 2 \cdot 1 (\text{rad s}^{-1})$ {½}

[Accept $\dfrac{2\pi}{3}$ (rad s^{-1})] **[1]**

(*c*) (i) $I_{(\text{roundabout+boy})}$ decreases as a result of boy moving towards centre. **{1}**

(conservation of angular momentum) the product $I\omega$ does not change so ω must increase. **{1}**

(ii)

$I_1\omega_1 = I_2\omega_2$ {½}

$960 \times 2 \cdot 1 = 840\,\omega_2$ {½}

$\omega_2 = \dfrac{960 \times 2 \cdot 1}{840}$

$\omega_2 = 2 \cdot 4\ \text{rad s}^{-1}$ **{1}**

[½ for value ½ for unit]

$I_1 = I_{\text{roundabout}} + I_{\text{boy at 2 m}}$

$= 800 + 40 \times 2^2 = 960\ (\text{kg m}^2)$ {½}

$I_2 = I_{\text{roundabout}} + I_{\text{boy at 1 m}}$

$= 800 + 40 \times 1^2 = 840\ (\text{kg m}^2)$ {½}

[5]

(*d*) (i) $E_{k\ before} = \dfrac{1}{2} I\omega^2$ {½} $= \dfrac{1}{2} \times 960 \times (2 \cdot 1)^2$ {½} $= 2100\ \text{J}$ **{1}**

$E_{k\ after} = \dfrac{1}{2} \times 840 \times (2 \cdot 4)^2 = 2400\ \text{J}$ **{1}**

(ii) Work done by boy in pulling himself towards centre of roundabout. **{1}** **[4]**

(12)

Marks

3. (*a*) $y = A\cos\omega t$

$v = \dfrac{dy}{dt}$ {½} $= -$ {½} $A\omega \sin \omega t$ {½}

$a = \dfrac{dv}{dt}$ {½} $= -\omega^2 A\cos\omega t$ {½} $= -\omega^2 y$ {½} **[3]**

(*b*) $\omega^2 = \dfrac{g}{l}$ **{1}** and $\omega = \dfrac{2\pi}{T}$ {½}

$\dfrac{4\pi^2}{T^2} = \dfrac{g}{l}$ {½} $\therefore T = 2\pi\sqrt{\dfrac{l}{g}}$ **{1}** **[3]**

(*c*) gradient $= \dfrac{3\cdot 2 - 0}{0\cdot 80 - 0}$ {½} (or any corresponding points)

$= 4\cdot 0$ {½}

$T^2 = \dfrac{4\pi^2 l}{g} \therefore$ gradient $= \dfrac{T^2}{l} = \dfrac{4\pi^2}{g}$ **{1}**

$4\cdot 0 = \dfrac{4\pi^2}{g}$

$g = 9\cdot 9\ \text{m s}^{-2}$ **{1}** [Accept $9\cdot 8 - 10\ \text{m s}^{-2}$] **[3]**

(*d*) Measure the time taken for a number of swings of the pendulum and divide by the number of swings **{1}**

$$\text{eg Period} = \frac{\text{Time for 5 swings}}{5}$$

OR Repeat readings to reduce the random error. **[1]**

(10)

Marks

4. (*a*) (i) Electron's orbital angular momentum is quantised **{1}**

OR electron does not radiate energy

OR total energy in each orbit is constant

OR when electron makes a transition from an orbit to a lower energy orbit a single quantum of electromagnetic radiation is emitted.

(ii) mvr_n **{1}** $= \frac{nh}{2\pi}$ **{1}** **OR** $2\pi r_n = n\lambda$ **{1}**

$2\pi r_n = \frac{nh}{mv}$ **{1}**

$r_n = \frac{nh}{2\pi mv}$ $\qquad r_n = \frac{nh}{2\pi mv}$

(iii) $v = \frac{1 \times (6 \cdot 63 \times 10^{-34})}{2\pi \times 9 \cdot 11 \times 10^{-31} \times 5 \cdot 3 \times 10^{-11}}$ {½} for $n = 1$ {½} for substitution of values

$= 2 \cdot 2 \times 10^{6}\ \mathrm{m\,s^{-1}}$ **{1}** [½ for value ½ for unit] **[5]**

(*b*) (i) $\lambda = \frac{h}{p}$ **{1}**

(ii) (A) $\lambda = \frac{h}{mv} = \frac{6 \cdot 63 \times 10^{-34}}{50 \times 1 \cdot 5}$ **{1}** $= 8 \cdot 8 \times 10^{-36}$ m **{1}**

(B) λ is very small compared with width of doorway. **{1}** **[4]**

(9)

5. (*a*) Place spheres together so they are touching. **{1}**
Bring charged rod up close to one of the spheres on opposite side to other sphere. **{1}**
Separate spheres, touching only insulated base (in presence of charged rod). **{1}**
Remove rod. **{1}**
Spheres have equal but opposite charges. **[4]**

(*b*) (i) $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$ {½}

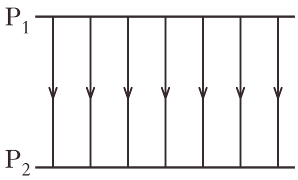
$= \frac{(-5 \cdot 33 \times 10^{-20}) \times (-1 \cdot 07 \times 10^{-19})}{4\pi \times 8 \cdot 85 \times 10^{-12} \times (1 \cdot 00 \times 10^{-15})^2}$ {½}

$= 51 \cdot 3$ N **{1}** [½ for value ½ for unit]

(ii) Strong (nuclear) **{1}** **[3]**

(7)

6. (*a*)



{½} for direction
{½} for uniform field **[1]**

(*b*) $E = \frac{V}{d}$ {½} $= \frac{15\,000}{5 \cdot 0 \times 10^{-3}}$ {½} $= 3 \cdot 0 \times 10^6 \text{ V m}^{-1}$ **{1}** [½ for value ½ for unit] **[2]**

(*c*) Into page **{1}** **[1]**

(*d*) (i) $qvB = qE$ {½}

$v = \frac{E}{B}$ {½} $= \frac{3 \cdot 0 \times 10^6}{0 \cdot 060}$ **{1}** $= 5 \cdot 0 \times 10^7 \text{ m s}^{-1}$

(ii) $m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{1 \cdot 673 \times 10^{-27}}{\sqrt{1 - \frac{(5 \cdot 0 \times 10^7)^2}{(3 \cdot 0 \times 10^8)^2}}}$

$m = 1 \cdot 7 \times 10^{-27}$ (kg) **{1}**

$E = mc^2$ {½}

$= 1 \cdot 7 \times 10^{-27} \times (3 \cdot 0 \times 10^8)^2$ {½}

$= 1 \cdot 5 \times 10^{-10}$ J **{1}** [½ for value ½ for unit] **[5]**

(9)

Marks

7. (*a*) $B = \frac{\mu_0 I}{2\pi r}$ {½}

$I = \frac{2\pi r B}{\mu_0} = \frac{2\pi \times 0\cdot05 \times 2\cdot0 \times 10^{-5}}{4\pi \times 10^{-7}}$ {½}

$= 5\cdot0$ A **{1}** [½ for value ½ for unit] **[2]**

(*b*) (i) (A) $\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi r}$ {½} $= \frac{4\pi \times 10^{-7} \times 5 \times 4}{2\pi \times 0\cdot05}$ {½}

$= 8\cdot0 \times 10^{-5}$ N m^{-1} **{1}** [½ for value ½ for unit]

OR $\frac{F}{l} = IB$ {½} $= 4 \times 2 \times 10^{-5}$ {½}

$= 8 \times 10^{-5}$ N m^{-1} **{1}**

(B) Away from PQ {½} and at right angles to RS. {½}

(ii) Force is halved. **{1}** **[4]**

(*c*) (i) $F = IlB$ {½}

$B = \frac{F}{Il} = \frac{8\cdot0 \times 10^{-3}}{4\cdot0 \times 0\cdot10}$ {½}

$= 2\cdot0 \times 10^{-2}$ T **{1}** [½ for value ½ for unit]

(ii) $F = IlB \sin\theta$ {½} and $l \sin\theta = 0\cdot10$ {½}

OR same perpendicular length **{1}** (of conductor in magnetic field) **[3]**

(9)

Marks

8. (*a*) $F_c = F_m$ **{1}**

$\frac{mv^2}{r}$ {½} $= qvB$ {½}

$r = \frac{mv}{qB}$ **[2]**

(*b*) (i) Q: circular **{1}**

S: helical **{1}**

(ii) $r = \frac{mv}{qB} = \frac{1\cdot673 \times 10^{-27} \times 2\cdot0 \times 10^{6}}{1\cdot6 \times 10^{-19} \times 1\cdot3 \times 10^{-5}}$ {½} {½}

$r = 1\cdot6 \times 10^{3}$ m **{1}** [½ for value ½ for unit] **[4]**

(*c*) Motion not perpendicular to field {½}

Component of motion perpendicular to B causes a circular path {½}

Component of motion parallel to B causes (steady) motion parallel to field. **{1}** **[2]**

(8)

9. (*a*) Inductance of 1 H if an e.m.f. of 1 V is induced when *I* changes at 1 A s^{-1} **{1}** **[1]**

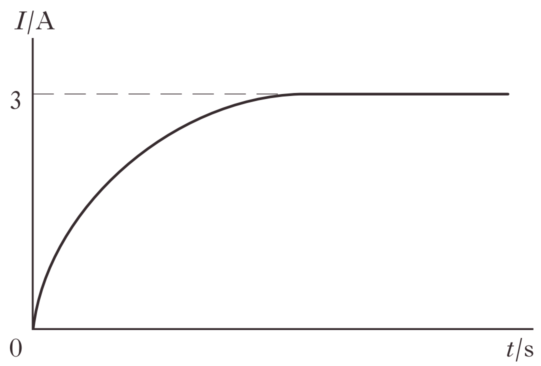
(*b*) (i) Since ideal inductor, self-induced e.m.f. e = –e.m.f. of cell.

$e = -L\frac{dI}{dt}$ {½}

$-12 = -L \times 2\cdot0$ {½}

$L = 6\cdot0$ H **{1}**

(ii)



{1} for shape

{1} for 3 A

(iii) Energy $= \frac{1}{2}LI^2$ {½} $= \frac{1}{2} \times 6 \times 3^2$ {½} $= 27$ J **{1}** [½ for value ½ for unit] **[6]**

(7)

Marks

10. (*a*) (i) $2\pi f = 50$ {½} $f = 8 \cdot 0$ Hz {½}

(ii) $\frac{2\pi}{\lambda} = \frac{10}{3}$ {½} $\lambda = 1 \cdot 9$ m {½}

(iii) $v = f\lambda$ {½} $= 15 \text{ m s}^{-1}$ {½} **[3]**

(*b*) $1 \cdot 10 - 0 \cdot 20 = 0 \cdot 90$ (m) {½}

$\lambda \equiv 2\pi$ radians {½}

Phase difference $= \frac{0 \cdot 90}{1 \cdot 9} \times 2\pi$ {½} $= 3 \cdot 0$ (rad) {½} **[2]**

{1} for positive sign

(*c*) $y = 0 \cdot 0250 \sin 2\pi \left(16t + \frac{x}{0 \cdot 94}\right)$ **[3]**

{1} {½} {½}

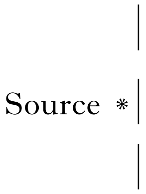
(*d*) (i) The change in frequency observed when a source of sound waves is moving relative to an observer. **{1}**

(ii) Galaxy is moving away (from Earth). **{1}** **[2]**

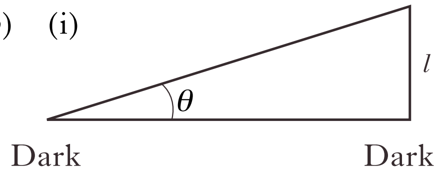
(10)

Marks

11. (*a*) (i) Sources have constant phase relationship. **{1}**

(ii) 

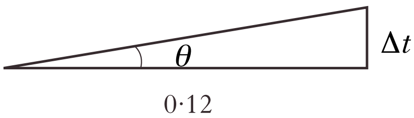
{1} Single light source with double slit {½}. Width of slits must be comparable with wavelength of light. {½} **[3]**

(*b*) (i) 

$l = \frac{\lambda}{2}$ **{1}**

$$\tan\theta = \frac{\frac{\lambda}{2}}{4\cdot4 \times 10^{-3}}$$

$$\therefore \theta = \tan^{-1}\left(\frac{590 \times 10^{-9}}{2 \times 4\cdot4 \times 10^{-3}}\right) \quad \{½\} \quad = 0\cdot004° \quad \{½\}$$



$\therefore \Delta t = \tan 0\cdot004 \times 0\cdot12$ **{1}**

$= 8 \times 10^{-6}$ m **{1}** [½ for value ½ for unit]

$(= 8 \times 10^{-3}$ mm$)$

(ii) Change in diameter $= \frac{8 \times 10^{-3}}{0\cdot20} \times 100\%$ {½}

$= 4\%$ **{1}**

Yes {½} (fibre meets the specification) **[6]**

(9)

[*END OF MARKING INSTRUCTIONS*]

Advanced Higher Physics

Specimen Question Paper Analysis Grid

Questions relating to Mechanics

	Outcome 1				Outcomes 2 and 3					Grade A Type
Question Number	a	b	c	d	2a	2b 3d	2c 3f	2d 3b 3g	3e	
1(*a*)		2								
1(*b*) (i)						2				
1(*b*) (ii)						1				
1(*b*)(iii)						1				4
1(*c*) (i)						1				
1(*c*) (ii)									3	3
2(*a*)						2				
2(*b*)						1				
2(*c*) (i)			2							
2(*c*) (ii)						3				3
2(*d*) (i)		3								
2(*d*) (ii)							1			1
3(*a*)		3								
3(*b*)					3					3
3(*c*)					3					
3(*d*)								1		
4(*a*) (i)				1						
4(*a*) (ii)						2				
4(*a*)(iii)		2								
4(*b*) (i)	1									
4(*b*) (ii) (A)		2								
4(*b*) (ii) (B)							1			1
Total	1	12	2	1	6	13	2	1	3	15
41 marks	16				25					

Questions relating to Electrical Phenomena

	Outcome 1				Outcomes 2 and 3					Grade A Type
Question Number	a	b	c	d	2a	2b 3d	2c 3f	2d 3b 3g	3e	
5(*a*)								4		
5(*b*) (i)		2								
5(*b*) (ii)				1						
6(*a*)					1					
6(*b*)		2								
6(*c*)							1			
6(*d*) (i)						2				
6(*d*) (ii)						3				3
7(*a*)						2				
7(*b*) (i) (A)		2								
7(*b*) (i) (B)			1							
7(*b*) (ii)							1			
7(*c*) (i)		2								
7(*c*) (ii)							1			1
8(*a*)					2					2
8(*b*) (i)							2			
8(*b*) (ii)						2				
8(*c*)			2							
9(*a*)	1									
9(*b*) (i)						2				
9(*b*) (ii)					2					
9(*b*)(iii)		2								
Total	1	10	3	1	5	11	5	4	0	6
40 marks	15				25					

Questions relating to Wave Phenomena

	Outcome 1				Outcomes 2 and 3					Grade A Type
Question Number	a	b	c	d	2a	2b 3d	2c 3f	2d 3b 3g	3e	
10(*a*) (i)		1								
10(*a*) (ii)		1								
10(*a*)(iii)		1								
10(*b*)						2				2
10(*c*)					3					3
10(*d*) (i)			1							
10(*d*) (ii)			1							
11(*a*) (i)				1						
11(*a*) (ii)								2		
11(*b*) (i)						4				4
11(*b*) (ii)							2			
Total	0	3	2	1	3	6	2	2	0	9
19 marks	6				13					

Outcome coverage for all three units

	Outcome 1		Outcomes 2 and 3		Grade A Type
	Marks	Recommended	Marks	Recommended	Marks
Mechanics	16	16 ± 3	25	24 ± 4	15
Electrical Phenomena	15	16 ± 3	25	24 ± 4	6
Wave Phenomena	6	8 ± 2	13	12 ± 3	9
Total	37	40 ± 4	63	60 ± 4	30

[*END OF ANALYSIS GRID*]