FOR OFFICIAL USE

AH

National
Qualifications
2026

Mark

X857/77/01

Physics

THURSDAY, 21 MAY

9:00 AM – 12:00 NOON

X857701

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day Month Year

Scottish candidate number

Total marks — 155

Attempt ALL questions.

Reference may be made to the Physics relationships sheet X857/77/11 and the data sheet on *page 02*.

Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. You should score through your rough work when you have written your final copy.

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

Use **blue** or **black** ink.

Do not remove any exam materials. You must leave this booklet on your desk; if you do not, you could lose all the marks for this paper.

Qualifications Scotland
Teisteanasan Alba

X85770101

A/PB

DATA SHEET

COMMON PHYSICAL QUANTITIES

Quantity	Symbol	Value	Quantity	Symbol	Value
Gravitational acceleration on Earth	g	$9.8\ m\,s^{-2}$	Mass of electron	m_e	9.11×10^{-31} kg
Radius of Earth	R_E	6.4×10^6 m	Charge on electron	e	-1.60×10^{-19} C
Mass of Earth	M_E	6.0×10^{24} kg	Mass of neutron	m_n	1.675×10^{-27} kg
Mass of Jupiter	M_J	1.90×10^{27} kg	Mass of proton	m_p	1.673×10^{-27} kg
Radius of Jupiter	R_J	7.15×10^7 m	Mass of alpha particle	m_α	6.645×10^{-27} kg
Mean Radius of Jupiter Orbit		7.79×10^{11} m	Charge on alpha particle		3.20×10^{-19} C
Solar radius		6.955×10^8 m	Planck's constant	h	6.63×10^{-34} J s
Mass of Sun		2.0×10^{30} kg	Permittivity of free space	ε_0	$8.85 \times 10^{-12}\ F\,m^{-1}$
1 AU		1.5×10^{11} m	Permeability of free space	μ_0	$4\pi \times 10^{-7}\ H\,m^{-1}$
Stefan-Boltzmann constant	σ	$5.67 \times 10^{-8}\ W\,m^{-2}\,K^{-4}$	Speed of light in vacuum	c	$3.00 \times 10^8\ m\,s^{-1}$
Universal constant of gravitation	G	$6.67 \times 10^{-11}\ m^3\,kg^{-1}\,s^{-2}$	Speed of sound in air	v	$3.4 \times 10^2\ m\,s^{-1}$

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	Magnesium fluoride	1.38

SPECTRAL LINES

Element	Wavelength (nm)	Colour	Element	Wavelength (nm)	Colour
Hydrogen	656	Red	Cadmium	644	Red
	486	Blue-green		509	Green
	434	Blue-violet		480	Blue
	410	Violet	**Lasers**		
	397	Ultraviolet	**Element**	**Wavelength (nm)**	**Colour**
	389	Ultraviolet	Carbon dioxide	9550 } 10 590 }	Infrared
Sodium	589	Yellow	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	2.70×10^3	933	2623	9.02×10^2	3.95×10^5	....
Copper	8.96×10^3	1357	2853	3.86×10^2	2.05×10^5	....
Glass	2.60×10^3	1400	....	6.70×10^2	....	....
Ice	9.20×10^2	273	....	2.10×10^3	3.34×10^5	....
Glycerol	1.26×10^3	291	563	2.43×10^3	1.81×10^5	8.30×10^5
Methanol	7.91×10^2	175	338	2.52×10^3	9.9×10^4	1.12×10^6
Sea Water	1.02×10^3	264	377	3.93×10^3	....	....
Water	1.00×10^3	273	373	4.18×10^3	3.34×10^5	2.26×10^6
Air	1.29	....	....	....	....	....
Hydrogen	9.0×10^{-2}	14	20	1.43×10^4	....	4.50×10^5
Nitrogen	1.25	63	77	1.04×10^3	....	2.00×10^5
Oxygen	1.43	55	90	9.18×10^2	....	2.40×10^4

The gas densities refer to a temperature of 273 K and a pressure of 1.01×10^5 Pa.

* X 8 5 7 7 7 0 1 0 2 *

Total marks — 155 marks

Attempt ALL questions

1. The vehicle *Mythen* set a new world record for the acceleration of an electric vehicle, from rest.

During the first 1.05 seconds of a test run, the horizontal velocity v of the vehicle is given by the relationship

$$v = 8.13t^2 + 15.4t$$

where v is measured in $m\,s^{-1}$ and t is measured in s.

Using calculus methods:

(a) determine the displacement of the vehicle at $t = 1.05$ s **3**

Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

1. (continued)

(b) determine the acceleration of the vehicle at $t = 1.05$ s. 3

Space for working and answer

(c) **Figure 1A** shows three lines that could represent the motion of the vehicle during the first 1.05 s of the test run.

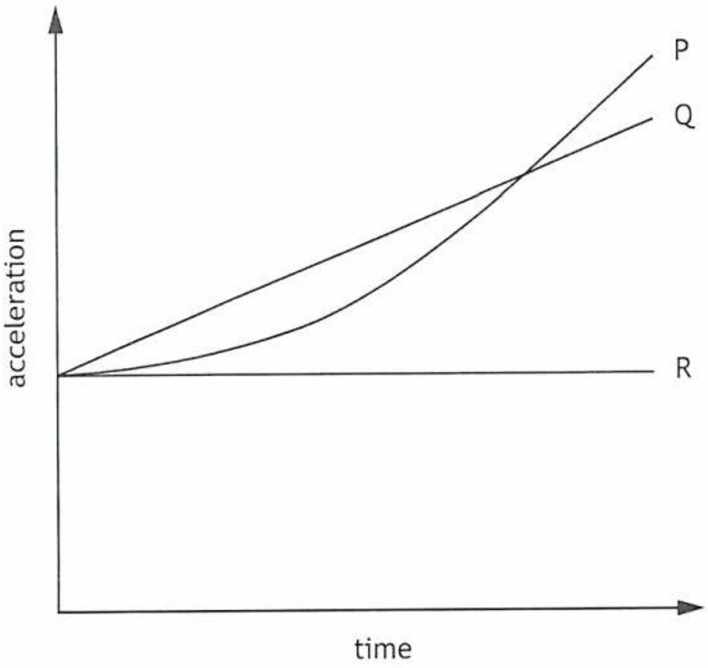


Figure 1A

State which line, P, Q, or R, represents the variation of acceleration of the vehicle with time for the first 1.05 s of the test run. 1

* X 8 5 7 7 7 0 1 0 5 *

MARKS DO NOT WRITE IN THIS MARGIN

2. A student conducts an experiment using a rope to swing a bucket of water in a vertical circular path, as shown in **Figure 2A**.

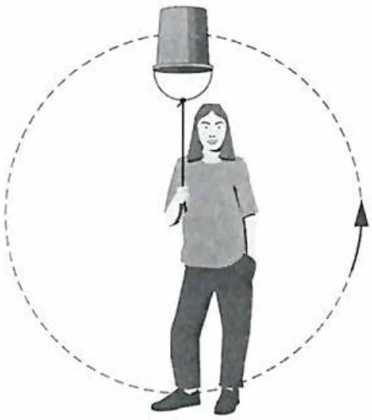


Figure 2A

The distance from the point of rotation to the surface of the water is 1.05 m.

The mass of the water is 2.58 kg.

(a) (i) At the maximum height, the tension in the rope is 0 N.

By considering the forces acting on the water, show that the minimum constant angular velocity required for all of the water to remain in the bucket at its maximum height is $3.06\ \text{rad s}^{-1}$. 3

Space for working and answer

(ii) Determine the minimum number of **complete** rotations per minute required to ensure all of the water remains in the bucket at its maximum height. 4

Space for working and answer

* X 8 5 7 7 7 0 1 0 6 *

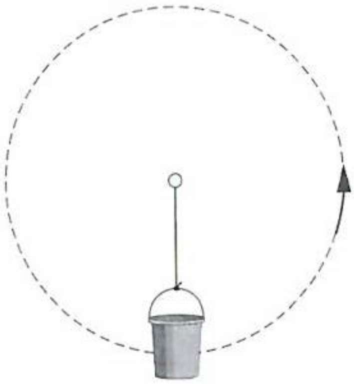
2. (continued)

(b) (i) On **Figure 2B**, show the forces acting vertically on the bucket when it is at the lowest point in its circular path.

You must name these forces and show their directions. 2

(An additional diagram, if required, can be found on *page 48*.)

Figure 2B



(ii) The mass of the bucket and water is 2.88 kg.

The angular velocity is now increased to 3.61 rad s^{-1}.

Determine the tension in the rope at the lowest point in the circular path. 3

Space for working and answer

2. (b) (continued)

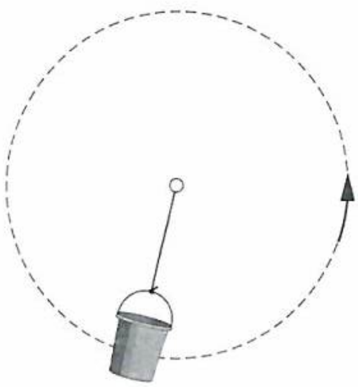
(iii) The angular velocity is increased again.

The rope snaps when the bucket is at the position shown in **Figure 2C**.

On **Figure 2C**, show the direction of the initial velocity of the bucket immediately after the rope snaps. 1

(An additional diagram, if required, can be found on *page 48*.)

Figure 2C



* X 8 5 7 7 7 0 1 0 8 *

MARKS | DO NOT WRITE IN THIS MARGIN

2. (b) (continued)

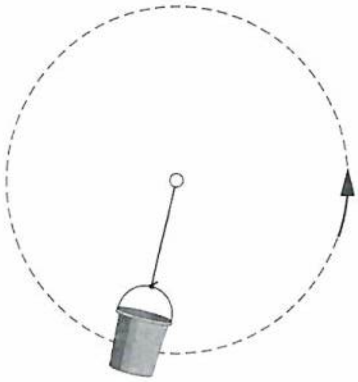
(iii) The angular velocity is increased again.

The rope snaps when the bucket is at the position shown in **Figure 2C**.

On **Figure 2C**, show the direction of the initial velocity of the bucket immediately after the rope snaps. 1

(An additional diagram, if required, can be found on *page 48*.)

Figure 2C



* X 8 5 7 7 7 0 1 0 8 *

MARKS | DO NOT WRITE IN THIS MARGIN

3. A gardener is using a lawnmower to cut grass.

The lawnmower cutting unit consists of a rectangular metal blade and a circular plastic disc, as represented in **Figure 3A**.

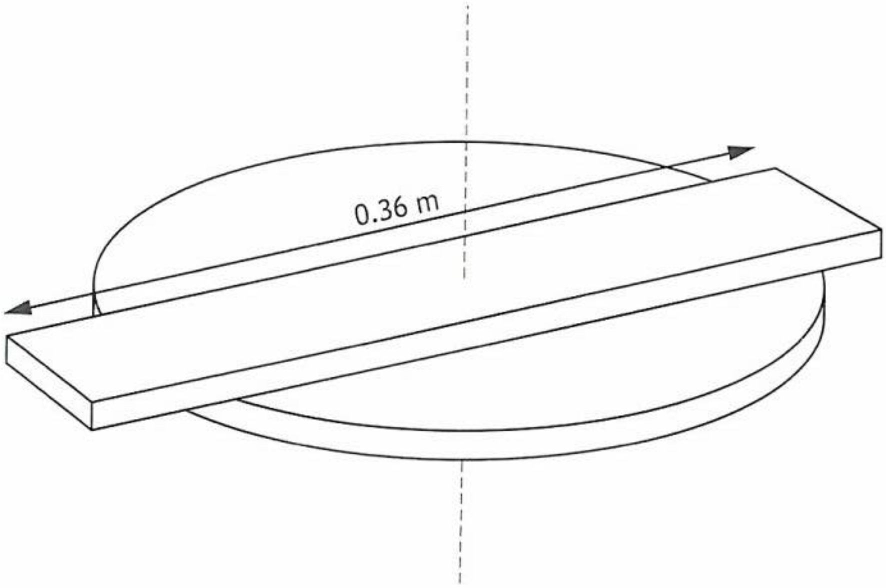


Figure 3A

The blade can be modelled as a uniform rod of length 0.36 m and mass 0.32 kg, rotating about its centre.

The moment of inertia of the plastic disc is 4.7×10^{-3} kg m^2.

(a) Determine the total moment of inertia of the lawnmower cutting unit. 3

Space for working and answer

* X 8 5 7 7 7 0 1 1 0 *

MARKS DO NOT WRITE IN THIS MARGIN

3. (continued)

(b) (i) When switched on, the lawnmower cutting unit rotates about the axis of rotation. The cutting unit takes 1.4 s to reach its maximum angular velocity of 31 rad s^{-1}.

Calculate the average angular acceleration of the lawnmower cutting unit during this time. 3

Space for working and answer

(ii) Calculate the average unbalanced torque acting on the lawnmower cutting unit to produce this angular acceleration. 3

Space for working and answer

(c) The metal blade is now replaced with a plastic blade of smaller mass. The plastic blade has the same dimensions as the metal blade.

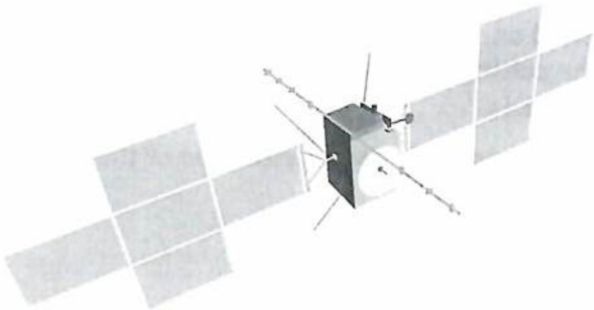
State whether the unbalanced torque required to produce the angular acceleration in (b) (i) is greater than, equal to, or less than that calculated in (b) (ii).

Justify your answer. 2

* X 8 5 7 7 7 0 1 1 1 *

MARKS DO NOT WRITE IN THIS MARGIN

4. The European Space Agency mission Juice was launched in 2023 to explore Jupiter and three of its icy moons: Callisto, Ganymede, and Europa.



Data for the three moons are shown in the table below.

	Mean radius of orbit ($\times 10^9$ m)	Orbital period (days)
Callisto	1.89	16.7
Ganymede	1.07	7.16
Europa		3.55

(a) (i) By considering the force acting between Europa and Jupiter, show that the relationship between the mean radius of orbit and orbital period is

$$T^2 = 3.12 \times 10^{-16} \times r^3$$

where T is the orbital period in seconds and r is the mean radius of orbit. 2

Space for working and answer

(ii) Calculate the mean radius of orbit of Europa. 2

Space for working and answer

* X 8 5 7 7 7 0 1 1 2 *

4. (continued)

(b) (i) State what is meant by *gravitational potential of a point in space.* 1

(ii) When Juice reaches Callisto, it will have a mass of 5980 kg.

The gravitational potential with respect to Jupiter at the orbital radius of Callisto is $-6.71 \times 10^{7}\ \mathrm{J\,kg^{-1}}$.

Juice will then travel from Callisto to Ganymede.

Determine the change in potential energy of Juice with respect to Jupiter when it travels from Callisto to Ganymede. 5

Space for working and answer

(c) Juice will then travel from Ganymede to Europa before returning to Callisto.

State the change in potential energy of Juice, with respect to Jupiter, for this part of the journey. 1

MARKS DO NOT WRITE IN THIS MARGIN

5. The equivalence principle is a fundamental part of Einstein's theory of general relativity.

(a) State what is meant by the *equivalence principle*. 1

(b) A spacecraft is travelling through deep space. It is accelerating in the direction shown in **Figure 5A**.

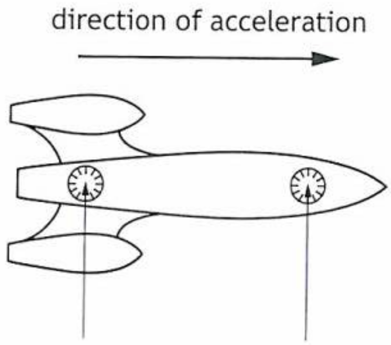


Figure 5A

An astronaut inside the spacecraft is beside clock P and can also observe clock Q. The astronaut observes the rate at which the clocks run is not the same.

State which of the two clocks is observed to run more slowly.

Justify your answer. 2

* X 8 5 7 7 7 0 1 1 4 *

5. **(continued)**

(c) General relativity predicts the existence of black holes.

The black hole Gaia BH3 has recently been discovered. It was discovered when astronomers observed the motion of a star orbiting Gaia BH3.

The mass of Gaia BH3 has been determined to be 6.54×10^{31} kg.

(i) Calculate the Schwarzschild radius of Gaia BH3. 3

Space for working and answer

(ii) Explain how astronomers know that the orbit of the observed star is greater than the Schwarzschild radius of Gaia BH3. 2

[Turn over

6. The absolute magnitude M of a star is a measure of its luminosity L.

The luminosity of a star can be calculated using the relationship

$$\frac{L}{L_{Sun}} = 10^{0.4(M_{Sun} - M)}$$

Proxima Centauri is the closest star to Earth outside the Solar System.

Proxima Centauri has an absolute magnitude of +11.75.

The absolute magnitude of the Sun is +4.74.

The luminosity of the Sun is 3.83×10^{26} W.

(a) (i) Show that the luminosity of Proxima Centauri is 6.01×10^{23} W. 1

Space for working and answer

(ii) The apparent brightness of Proxima Centauri is 2.96×10^{-11} W m^{-2}.

Determine the distance, in light-years, of Proxima Centauri from Earth. 4

Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

6. **(continued)**

(b) Stars are classified depending on their position on the H-R diagram.

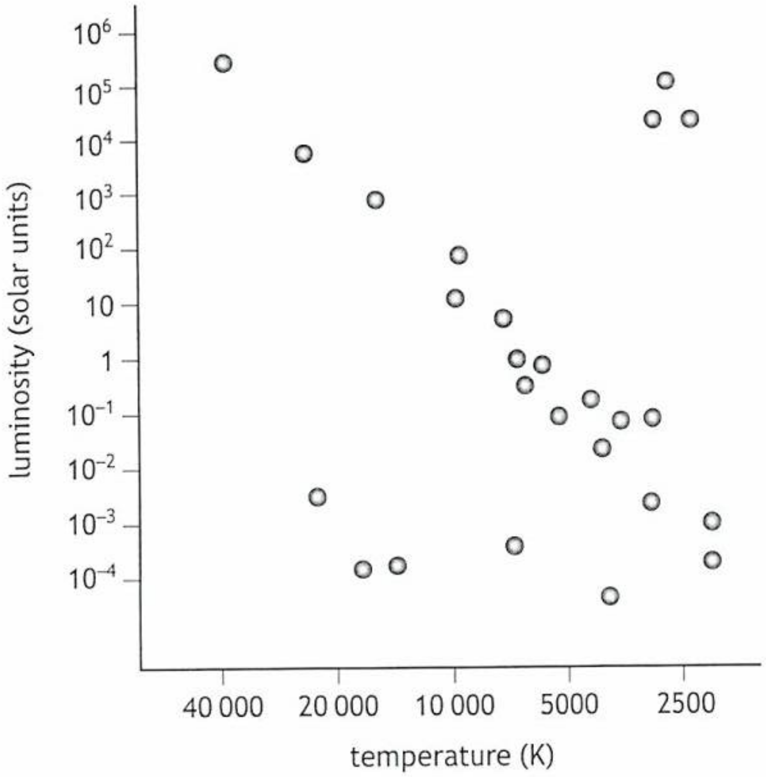


Figure 6A

The surface temperature of Proxima Centauri is 2990 K.

(i) On the H-R diagram shown in **Figure 6A**, circle the star at the position of Proxima Centauri. 1

(An additional diagram, if required, can be found on *page 49*.)

(ii) At present both the Sun and Proxima Centauri are main sequence stars.

The Sun will ultimately become a white dwarf.

The mass of Proxima Centauri is approximately one order of magnitude less than the Sun.

State the type of star Proxima Centauri will ultimately become. 1

[Turn over

MARKS DO NOT WRITE IN THIS MARGIN

7. In the Bohr model of the hydrogen atom the electron can occupy only fixed orbits. Some of these orbits are represented in **Figure 7A**.

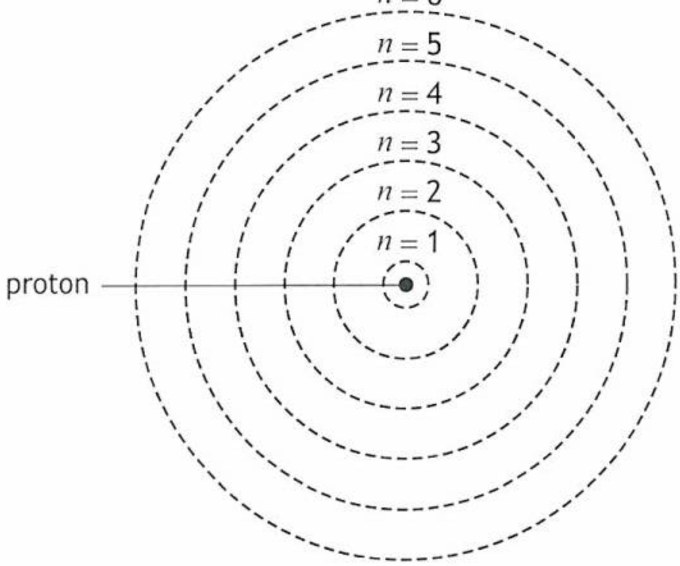


Figure 7A

(a) (i) By considering quantisation of angular momentum and the de Broglie wavelength, show that

$$2\pi r = n\lambda$$

where the symbols have their usual meaning. 2

Space for working and answer

(ii) In terms of the circumference of electron orbits, state the implication of the relationship

$$2\pi r = n\lambda$$

1

X857770118

MARKS DO NOT WRITE IN THIS MARGIN

7. (a) (continued)

(iii) The de Broglie wavelength of an electron in the third electron orbit is 9.97×10^{-10} m.

Calculate the radius of the $n = 3$ electron orbit. **2**

Space for working and answer

(b) (i) The total energy of an electron in a hydrogen atom is given by the relationship

$$E_t = -\frac{hcR}{n^2}$$

where R is the Rydberg constant $= 1.10 \times 10^7$ m^{-1} and the other symbols have their usual meaning.

Calculate the total energy of an electron in the $n = 2$ orbit. **2**

Space for working and answer

(ii) A student states that the total energy of an electron in the $n = 3$ orbit is greater than the total energy of an electron in the $n = 2$ orbit.

State why the student is correct. **1**

* X 8 5 7 7 7 0 1 1 9 *

8. Electrons can be accelerated in a uniform electric field.

(a) The momentum of an electron accelerated in an electric field is given by the relationship

$$p = \sqrt{2meV}$$

where the symbols have their usual meaning.

(i) Show that the de Broglie wavelength for an electron accelerated in an electric field is given by the relationship

$$\lambda = \frac{1.228 \times 10^{-9}}{\sqrt{V}}$$ 2

Space for working and answer

(ii) Electrons are accelerated in an electric field produced by a potential difference of 150 V. This creates an electron beam.

The beam is directed at a lattice structure with a spacing of 230 pm.

The electrons exhibit wave-like behaviour as they pass through the lattice structure.

Explain, using a calculation, why these electrons exhibit wave-like behaviour. 3

Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

8. (continued)

(b) Light can exhibit both wave-like and particle-like behaviour.

State one piece of experimental evidence for particle-like behaviour of light. 1

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

9. Bridge bungee jumping involves a person jumping from a high bridge while attached to an elastic cord.

A bungee jumper is shown in **Figure 9A**.

Figure 9A

(a) At a later time in the jump, the motion of the bungee jumper can be modelled as simple harmonic motion (SHM).

(i) State what is meant by *simple harmonic motion (SHM)*. **1**

(ii) The vertical displacement y of the bungee jumper from the equilibrium position at time t during the first cycle of SHM is represented by the relationship

$$y = 7.8\sin(1.7t)$$

Determine the velocity of the bungee jumper at $t = 0.72$ s. **3**

Space for working and answer

* X 8 5 7 7 7 0 1 2 2 *

MARKS | DO NOT WRITE IN THIS MARGIN

9. (a) (continued)

(iii) State whether the velocity determined in a (ii) is less than or equal to the maximum velocity of the bungee jumper during SHM.

You must justify your answer. **2**

(b) (i) The mass of the bungee jumper is 65 kg.

Calculate the maximum potential energy in the bungee cord. **3**

Space for working and answer

(ii) Sketch a graph showing the variation of potential energy in the bungee cord with displacement of the jumper from the equilibrium position, for the first half cycle of SHM.

You must show numerical values on both axes. **3**

(An additional diagram, if required, can be found on *page 49*.)

* X 8 5 7 7 7 0 1 2 3 *

10. A student conducts an experiment to determine a value for the thickness of a human hair.

The student uses two microscope slides separated by the hair at one end.

This is shown in **Figure 10A**.

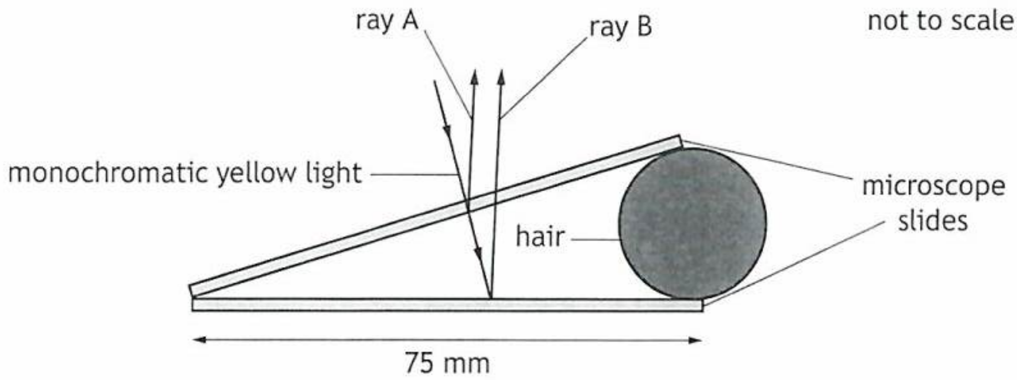


Figure 10A

The monochromatic yellow light is produced by a sodium lamp.

An interference pattern is produced and is viewed through a travelling microscope.

The student measures the distance across 19 fringe separations to be 5.83 mm.

The interference pattern is shown in **Figure 10B**.

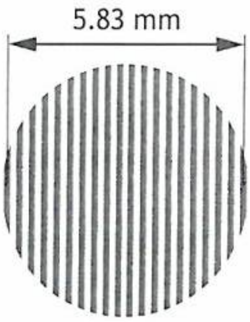


Figure 10B

(a) (i) State whether this interference pattern is produced by division of amplitude or by division of wavefront. 1

10. (a) (continued)

(ii) With reference to ray A and ray B on **Figure 10A**, explain how a bright fringe in the observed interference pattern is produced. 2

(iii) Determine the thickness of the hair. 4

Space for working and answer

(iv) Explain why the student measured the distance across 19 fringe separations rather than just a single fringe separation. 1

(b) The student now replaces the human hair with a dog hair, which is thicker than the human hair.

State whether the fringe separation is less than, the same as, or greater than with the human hair.

Justify your answer. 2

MARKS DO NOT WRITE IN THIS MARGIN

11. As part of their Advanced Higher Project about thin film interference, a student draws the diagram in **Figure 11A** to show why different colours of light are observed when white light is incident on a soap bubble.

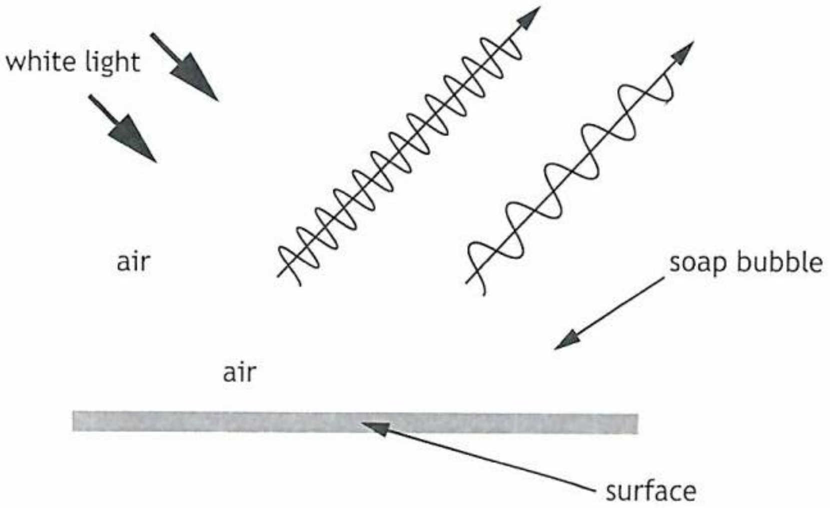


Figure 11A

Using your knowledge of physics, comment on the ideas represented in the student's diagram. 3

* X 8 5 7 7 7 0 1 2 6 *

MARKS | DO NOT WRITE IN THIS MARGIN

12. Some water skiers wear polarising sunglasses while water skiing.

(a) (i) State what is meant by *plane-polarised light*. 1

(ii) A water skier has two pairs of sunglasses. One pair of sunglasses contains polarising lenses and the other does not.

Describe an experiment that could be carried out to determine which pair contains polarising lenses. 2

* X 8 5 7 7 7 0 1 2 8 *

12. (continued)

(b) Sunlight is reflected from the sea water to a water skier wearing polarising sunglasses.

This is shown in **Figure 12A**.

not to scale

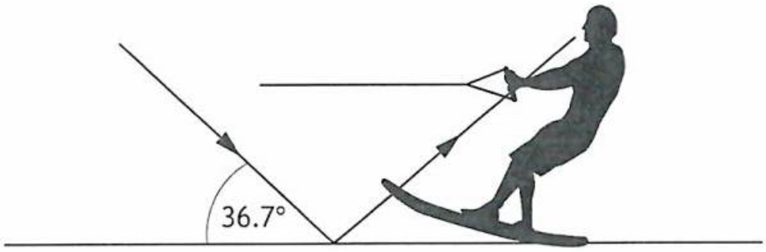


Figure 12A

The refractive index of sea water is 1.34.

(i) Calculate Brewster's angle for sea water. 3

Space for working and answer

(ii) State if the reflected rays in **Figure 12A** are 100% plane polarised.

You must justify your answer. 2

MARKS DO NOT WRITE IN THIS MARGIN

13. In the Bohr model of the hydrogen atom the electron can occupy only fixed orbits.

The electrical potential at each specific orbit is different.

The electron can only make transitions between these orbits.

(a) State what is meant by *electrical potential at a point*. 1

(b) (i) Show that the electrical potential energy for an electron at an orbital radius of 4.76×10^{-10} m is -4.84×10^{-19} J. 3

Space for working and answer

(ii) (A) The electron makes a transition to a lower orbital radius, emitting a photon.

The electrical potential energy of the electron at the new radius is -10.9×10^{-19} J.

Assuming that the change in energy of the electron is equal to the change in its potential energy, determine the wavelength of the emitted photon. 3

Space for working and answer

* X 8 5 7 7 7 0 1 3 0 *

13. (b) (ii) (continued)

(B) The determination of the wavelength of the photon emitted should also consider the kinetic energy of the electron.

The total energy of the electron at the higher orbital radius is -2.42×10^{-19} J.

The total energy of the electron at the lower orbital radius is -5.44×10^{-19} J.

Determine whether the electron has greater kinetic energy in the higher or lower orbital radius.

Justify your answer by calculation. 2

Space for working and answer

(c) The actual wavelength of the photon emitted is 656 nm.

The emitted photon can be represented by the travelling wave equation

$$y = A\sin 2\pi\left(Mt - Nx\right)$$

Determine the values of M and N. 3

Space for working and answer

14. Millikan's oil drop experiment is a method to determine the magnitude of the charge on an electron. The experiment involves observing a charged oil drop in an electric field between two parallel plates.

A simplified diagram of the apparatus is shown in **Figure 14A**.

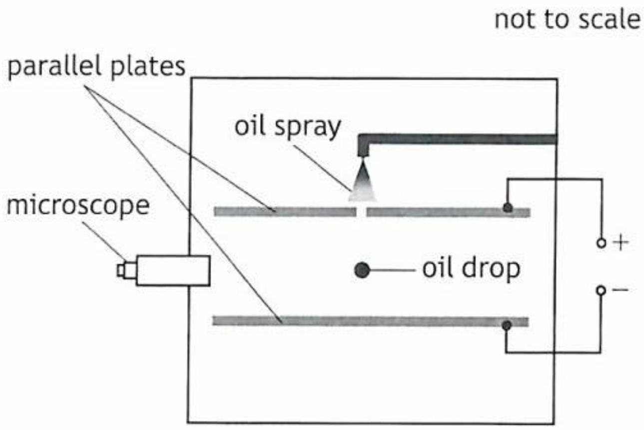


Figure 14A

The first stage of the experiment involves determining the terminal velocity v_t of the oil drop passing through the microscope field of view.

When the oil drop falls at terminal velocity, a digital stopwatch is used to measure the time for the drop to travel a set distance.

The procedure is repeated and the times recorded are

15.12 s, 13.48 s, 14.69 s, 14.63 s, 16.58 s

(a) (i) Calculate the approximate random uncertainty in the mean value of time. **1**

Space for working and answer

14. (a) (continued)

(ii) The distance travelled by the oil drop is $(3.00 \pm 0.05) \times 10^{-3}$ m.

The terminal velocity v_t of the oil drop was determined to be 2.01×10^{-4} m s^{-1}.

Determine the absolute uncertainty in the terminal velocity. 3

Space for working and answer

(iii) Suggest an improvement to the experimental procedure that could reduce the absolute uncertainty in the value for the terminal velocity. 1

[Turn over

14. (continued)

(b) The second stage of the experiment involves altering the potential difference between the plates until the drop is held stationary.

The drop has a mass of 9.58×10^{-16} kg and is held stationary when the potential difference between the plates is 322 V.

This is shown in **Figure 14B**.

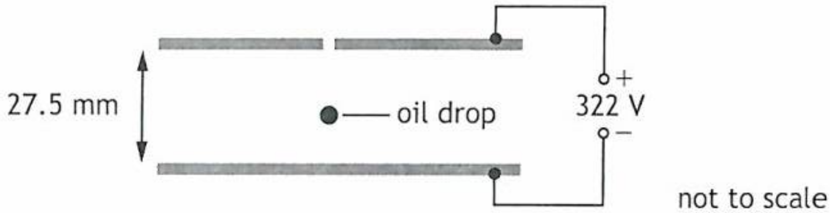


Figure 14B

(i) Calculate the electric field strength between the plates. 3

Space for working and answer

(ii) By considering the forces acting on the drop, determine the magnitude of the charge on the drop. 3

Space for working and answer

(iii) Determine the number of excess electrons on the drop. 1

Space for working and answer

15. A model electric motor consists of a rotor, which is free to rotate about an axis perpendicular to a uniform magnetic field, as shown in **Figure 15A**.

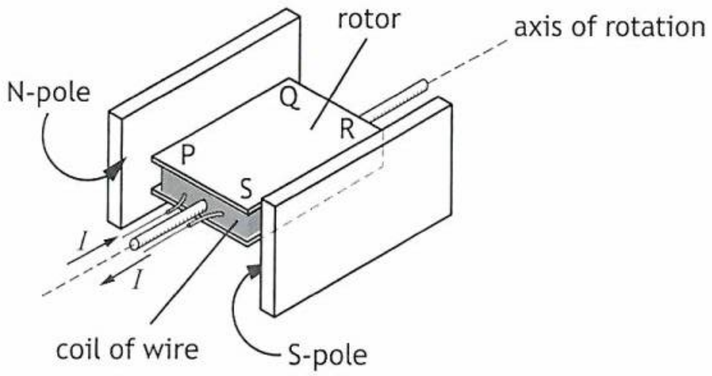


Figure 15A

The length of the wire along the side PQ is 45 mm.

The magnetic induction between the poles of the magnets is 44 mT.

The current in the coil of wire is 0.56 A.

(a) (i) Calculate the magnitude of the force experienced by one wire of the coil on the rotor side PQ. 3

Space for working and answer

15. (a) (continued)

(ii) The length of the wire along the side QR is 25 mm.

The coil in the rotor consists of 16 turns.

Determine the torque on the rotor when it is in the position shown in **Figure 15A**. 4

Space for working and answer

(iii) Explain why no force acts on the rotor side QR. 1

[Turn over

MARKS DO NOT WRITE IN THIS MARGIN

15. (continued)

(b) The rotor now rotates 90° clockwise to the position shown in **Figure 15B**.

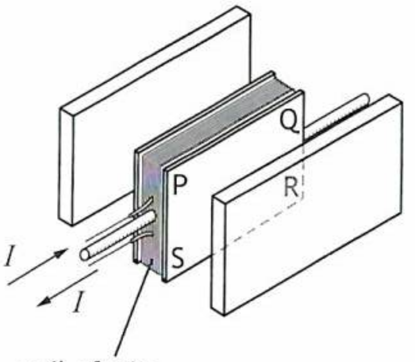


Figure 15B

(i) On **Figure 15C**, show the direction of the forces acting on sides PQ and RS of the rotor. 1

(An additional diagram, if required, can be found on *page 50*.)

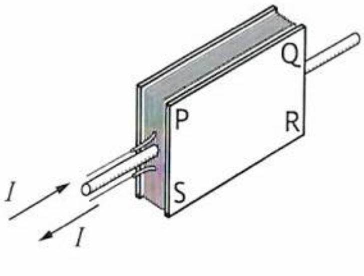


Figure 15C

(ii) Explain why the rotor cannot start to rotate from the position shown in **Figure 15B**. 1

MARKS | DO NOT WRITE IN THIS MARGIN

15. (continued)

(c) The rotor is modified so that there are now two perpendicular coils of wire, as shown in **Figure 15D**.

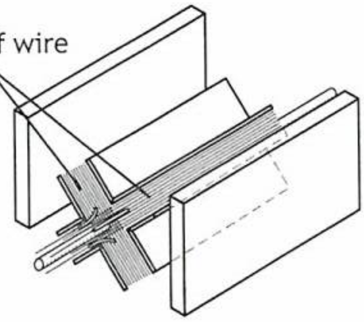


Figure 15D

Explain why this modification improves the operation of the model electric motor. **1**

[Turn over

* X 8 5 7 7 7 0 1 3 9 *

16. Some traffic light systems consist of traffic lights linked to induction coils. The induction coils are embedded in the road as shown in **Figure 16A**.

MARKS | DO NOT WRITE IN THIS MARGIN

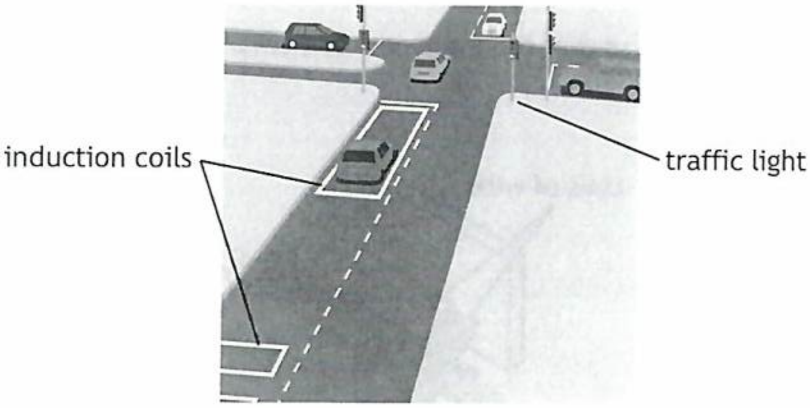


Figure 16A

The timing of the traffic light sequence can be controlled using an RC circuit.

A test circuit is set up to investigate the timing of the traffic light sequence.

Part of this circuit is shown in **Figure 16B**.

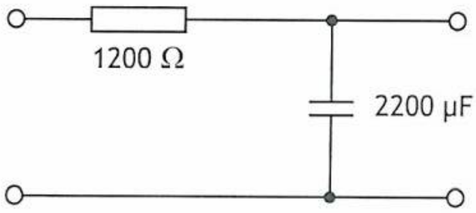


Figure 16B

(a) (i) The capacitor is initially uncharged.

Determine the time required for the capacitor to become **fully** charged. 4

Space for working and answer

X857770140

16. (a) (continued)

(ii) State one alteration to the circuit that would increase the time for the capacitor to become fully charged. 1

(b) The bodywork of a car includes materials containing iron.

The induction coils embedded in the road are used to trigger a timer when a car passes over the coils.

State the effect of the car on the inductance of the induction coils. 1

[Turn over

16. (continued)

(c) A second test circuit is set up to investigate the induction coils.

Part of the circuit is shown in **Figure 16C**.

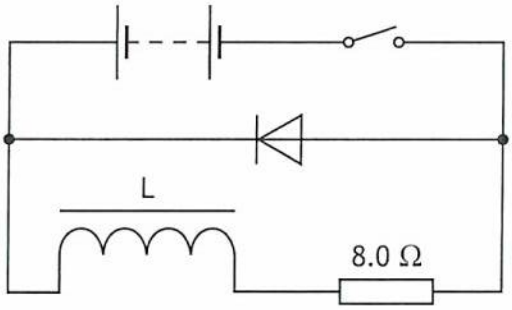


Figure 16C

In this test circuit, the inductor has an inductance of 64 mH.

The steady state current in the inductor is 750 mA.

(i) Calculate the energy stored in the inductor. 3

Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

16. (c) (continued)

(ii) The power supply in the test circuit fails, causing the current to reduce to zero. The initial rate of change of current is $-1800\ A\,s^{-1}$.

(A) Calculate the back EMF generated in the circuit. 3

Space for working and answer

(B) Explain the role of the diode in protecting the circuit. 1

[Turn over

* X 8 5 7 7 7 0 1 4 3 *

17. A group of students carried out an experiment to investigate the reactance of a capacitor.

A signal generator with an analogue frequency scale was used to produce AC signals.

The students varied the frequency of the AC signal and determined the corresponding reactance of the capacitor.

A table and corresponding graph of the results are shown in **Figure 17A**.

f (Hz)	X_c (Ω)
100	0.300
200	0.100
400	0.110
500	0.076
800	0.071
900	0.067
1000	0.043

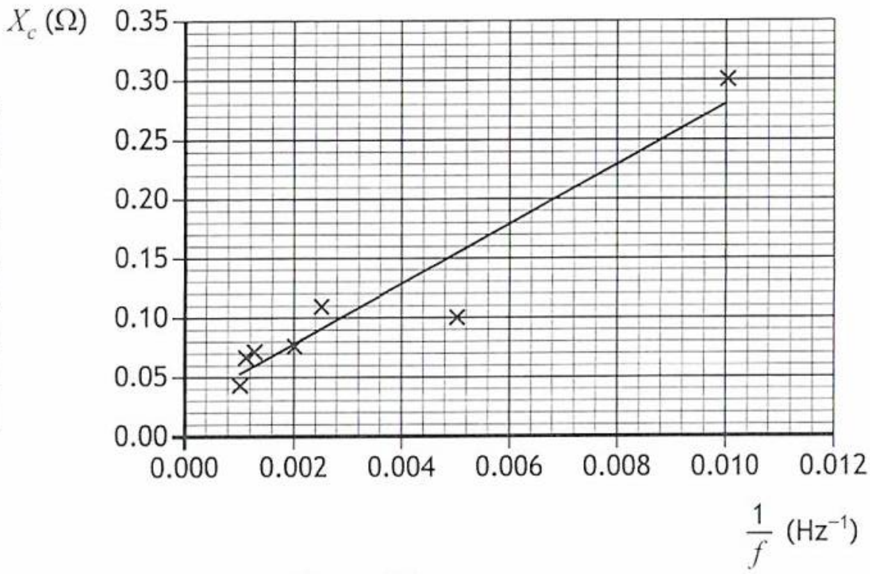


Figure 17A

The students discuss the experiment:

Student 1 'I don't think we chose a good set of frequencies.'

Student 2 'But it produces a straight line that passes close to the origin.'

Student 3 'I think there is a problem with accuracy here, rather than precision.'

Student 4 'Well the dial on the old signal generator was loose. We should have used a digital one.'

Using your knowledge of physics, discuss how the student conversation could lead to better experimental technique and analysis of results. 3