Rewarding Learning

Centre Number

Candidate Number

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2023

Physics

Assessment Unit AS 1
assessing
Forces, Energy and Electricity

SPH11

[SPH11]
WEDNESDAY 17 MAY, MORNING

TIME

1 hour 45 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
You must answer the questions in the spaces provided.
Do not write outside the boxed area on each page or on blank pages.
Complete in black ink only. **Do not write with a gel pen.**
Answer **all nine** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.

13526

1 **(a)** At the heart of the International System of Units (SI units) is a set of seven **base units**.

All other recognised SI units are referred to as **derived units**.

Explain the difference between **base units** and **derived units**.

_____

_____

_____

_____ [2]

(b) A metal sphere of radius r, moving with a velocity v through a fluid, will experience a resistive force F, given by **Equation 1.1**

$$F = 6\pi r\eta v \qquad \textbf{Equation 1.1}$$

where η is a constant.

Use **Equation 1.1** to determine the base units of the constant η.

Base units of η = _____ [4]

(c) (i) A small sphere of radius, r, 3 mm is made of stainless steel. Calculate the mass of the sphere if the density of stainless steel is 7850 kg m^{-3}.

The volume of a sphere $V = \frac{4}{3}\pi r^3$

Mass of the sphere = _____ kg [4]

(ii) The mole is the SI base unit of "amount of substance". The number of atoms in a mole is 6.02×10^{23}, the Avogadro number.

If 52% of the sphere in part **(c)(i)** is iron, calculate the number of iron atoms in the sphere.
One mole of iron atoms has a mass of 0.056 kg.

Number of iron atoms = _____ [3]

[Turn over

2 **(a)** A student incorrectly states the principle of conservation of momentum as follows:

"In a system of interacting bodies, the total momentum is conserved."

Identify the error / omission in this statement.

_____

_____ [1]

(b) A stationary object of mass 4.2 kg explodes and splits into two pieces.

(i) One piece has a mass of 2.5 kg and a kinetic energy of 281 J. Calculate the velocity of this piece.

Velocity = _____ m s^{-1} [3]

(ii) Use the principle of conservation of momentum to determine the magnitude of the velocity of the other piece.

Magnitude of the velocity = _____ m s^{-1} [3]

(c) Collisions can be classified as either elastic or inelastic. Complete **Table 2.1** by placing a ✔ to indicate whether momentum, total energy and kinetic energy are conserved in each type of collision. If the quantity is not conserved, enter an **X**.

Table 2.1

	Momentum	**Total energy**	**Kinetic energy**
Elastic			
Inelastic			

[2]

[Turn over

3 **(a)** Define the moment of a force about a point.

_____

_____

_____ [2]

(b) State the SI unit of the moment of a force.

_____ [1]

(c) A hanging basket is suspended by a non-uniform bracket. The bracket consists of three sections; a horizontal section of length 45 cm, a vertical section of length 25 cm and a diagonal section.

A diagram of the bracket is represented by **Fig. 3.1**.

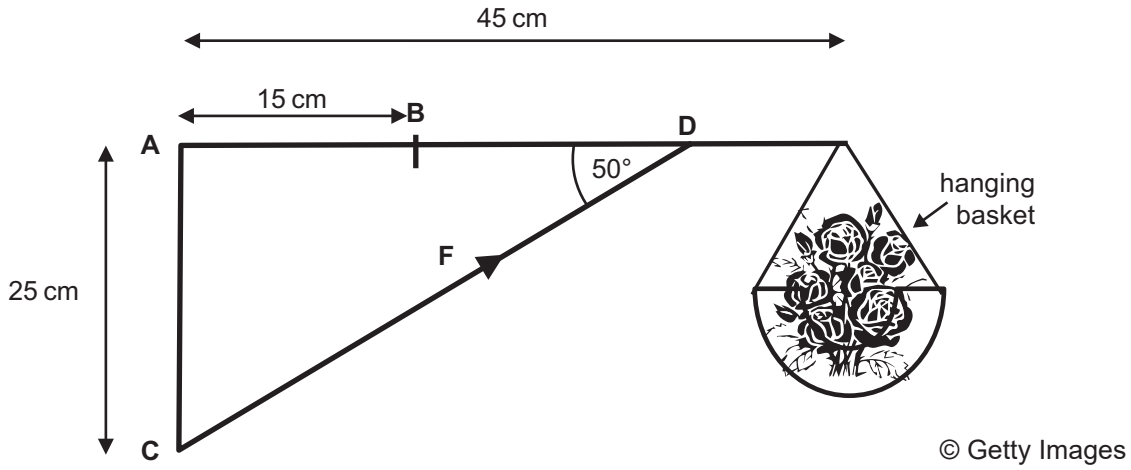

Fig. 3.1

The mass of the bracket is 0.9 kg and the centre of gravity of the bracket is at point **B**. The mass of the hanging basket is 8 kg.

By taking moments about point **A**, calculate the force **F** in section **CD** of the bracket.

Force = _____ N [7]

(d) A gardener stands on a stool to water the basket. After he jumps off the stool, he bends his knees on landing to reduce the risk of injury. In terms of impulse and momentum, explain why he does this, rather than keeping his legs straight on impact with the ground.

_____

_____

_____

_____

_____

_____

_____ [3]

[Turn over

4 The Virgin Hyperloop is a futuristic form of transport that involves a pod travelling along a track at high speed inside a vacuum tube.

On 8th November 2020, in the desert of Nevada, Virgin Hyperloop trialled its first journey with passengers. The pod accelerated uniformly from rest, along a straight 500 m test track, reaching a maximum speed of 47.8 m s^{-1}. It travelled at this maximum speed before decelerating uniformly, at the same rate as it accelerated, to rest.

(a) Sketch a velocity–time graph on the axes in **Fig. 4.1** for the pod during this journey.

Fig. 4.1

[2]

(b) Calculate the acceleration of the pod if it took 6.25 s to reach the maximum speed.

Acceleration = _____ m s^{-2} [3]

(c) The pod stopped 80 m from the end of the test track. Determine the distance travelled by the pod at the maximum speed.

Distance travelled at maximum speed = _____ m [5]

(d) Calculate the total time that the pod was moving during the trial.

Total time = _____ s [2]

[Turn over

5 **(a)** State Newton's second law of motion.

_____

_____

_____ [3]

(b) A person of mass m stands on a set of scales in a lift. The scales are calibrated to measure weight in newtons.

(i) The lift ascends with an acceleration of 0.8 m s^{-2}. Calculate the mass of the person if the reading on the scales is 650 N during this ascent.

Mass of person m = _____ kg [3]

(ii) Determine the reading on the scales if the lift moves at constant speed.

Reading on the scales = _____ N [2]

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[Turn over

6 A pilot plans to fly a small aircraft from Enniskillen to Beragh.
On the day of the flight there is a crosswind blowing at 90° to the displacement vector from Enniskillen to Beragh, as shown in **Fig. 6.1**.

As a consequence of the wind, to reach Beragh the pilot needs to head the aircraft at an angle of 50° East of North. Some information about the flight is shown in **Table 6.1**.

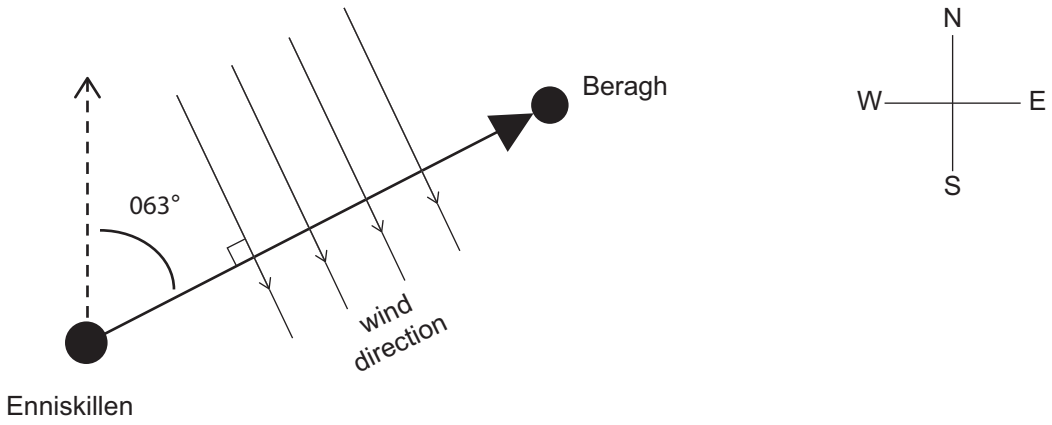


Fig. 6.1

Table 6.1

Bearing of Beragh from Enniskillen	063°
Aircraft heading	050°
Wind speed	12 m s^{-1}
Time taken to fly from Enniskillen to Beragh	11.2 minutes
Altitude	305 m

(a) (i) Draw a labelled vector diagram to show the velocity of the wind V_w, the velocity of the aircraft in still air V_a, and the resultant velocity of the aircraft V_r. Include a value for the angle between V_a and V_r.

[3]

(ii) Calculate the velocity of the aircraft in still air.

Velocity of aircraft in still air = _____ m s^{-1} [2]

(iii) Determine the resultant velocity of the aircraft between Enniskillen and Beragh.

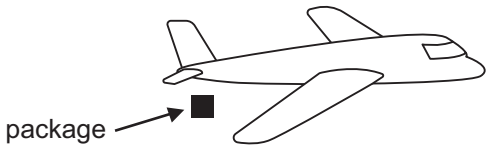
Resultant velocity of aircraft = _____ m s^{-1} [2]

[Turn over

(iv) Determine how far Beragh is from Enniskillen. Give your answer in kilometres.

Distance = _____ km [4]

(b) A package is released from rest at the back of the aircraft during the journey from Enniskillen to Beragh. On **Fig. 2.2** sketch the path that the package takes as it falls towards the ground.



Ground

Fig. 2.2

[2]

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[Turn over

7 **Fig. 7.1** shows three identical cells, each of e.m.f. 2.0 V and internal resistance r, connected in series with a resistor of resistance 10 Ω.

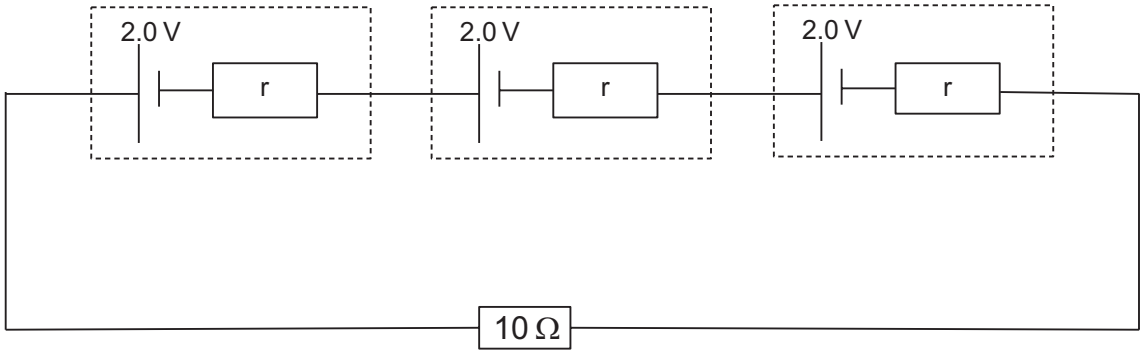

Fig. 7.1

(a) A charge of 28.8 C flows through the resistor in 60 seconds.
Calculate the current in the circuit.

Current = _____ A [3]

(b) Determine the internal resistance r of each cell.

Internal resistance = _____ Ω [3]

[Turn over

8 A circuit containing a box, with an unknown component inside, is connected to a 6.0 V power supply and a bulb as shown in **Fig. 8.1**. The bulb has a resistance of 5.33 Ω and the power dissipated by it is 3.0 W.

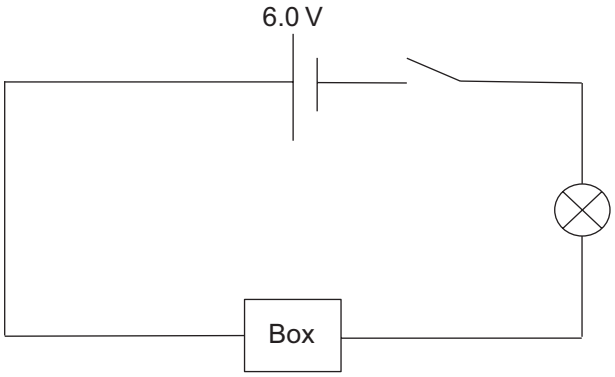

Fig. 8.1

(a) (i) Calculate the current that flows through the bulb when the switch is closed.

Current = _____ A [3]

(ii) Calculate the potential difference across the unknown component in the box.

Potential difference = _____ V [4]

(b) (i) Sketch the current–voltage characteristic for the metal filament in the bulb on the axes in **Fig. 8.2**.

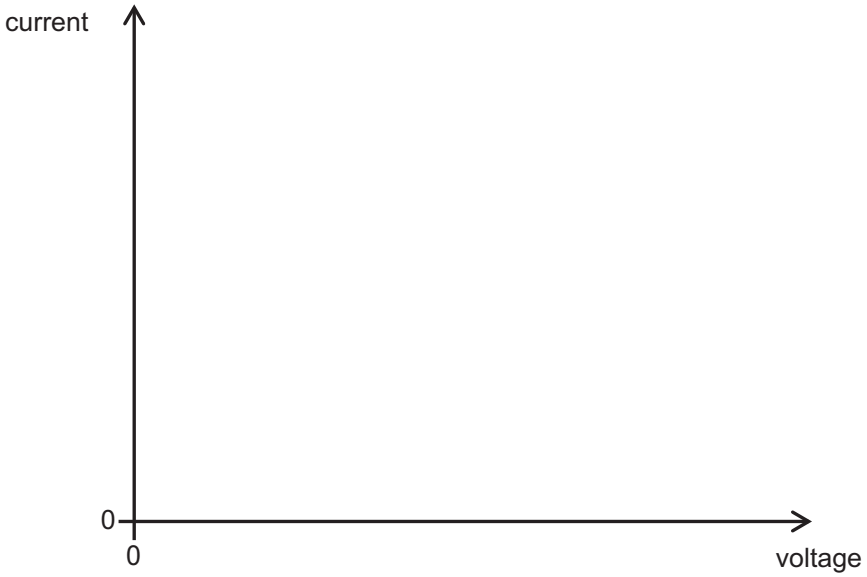

Fig. 8.2

[2]

(ii) Describe how the resistance of the metal filament in the bulb changes as the current through it increases. Explain why the change happens.

[4]

(c) The current–voltage characteristic for the component in the box is shown on the axes in **Fig. 8.3**.

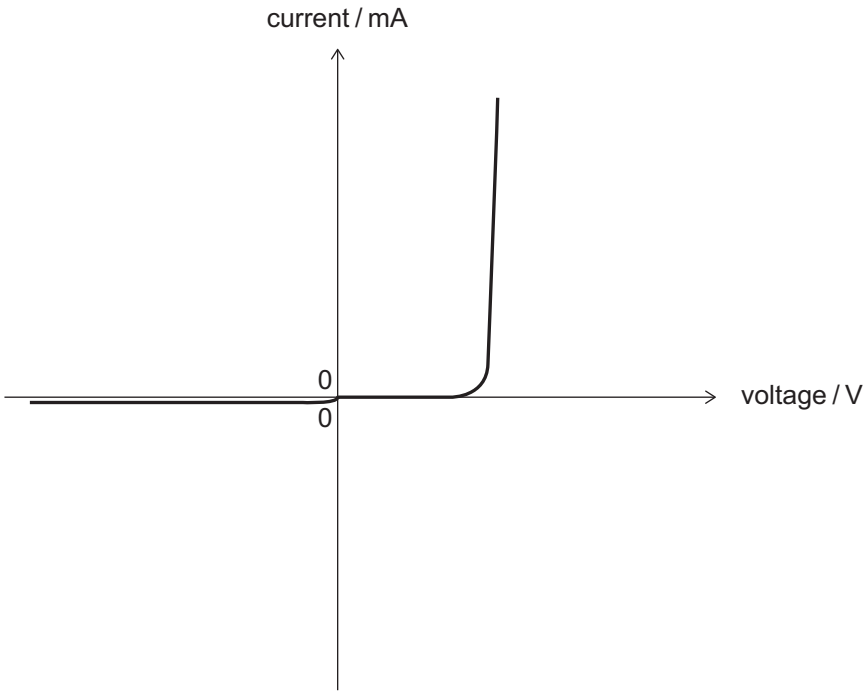

Fig. 8.3

(i) Name the component in the box. _____ [1]

(ii) The power supply in the circuit is reversed and the switch is again closed. State whether the bulb would be on or off and explain your choice.

_____

_____

_____ [2]

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[Turn over

9 A strain gauge consists of a thin metal wire, as shown in **Fig. 9.1**. It is a sensing device that can be used to measure deformations in structures. The resistance of the wire can be measured using an ohmmeter. When the structure deforms, a tensile force causes the resistance of the wire to increase.

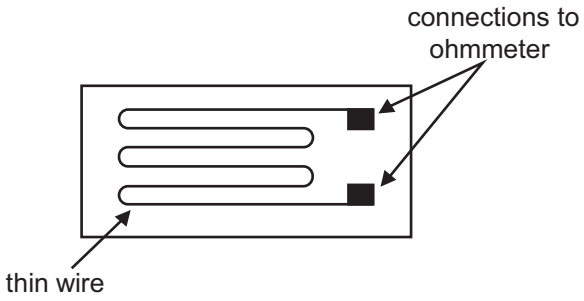

Fig. 9.1

(a) (i) Explain why the resistance of the wire increases when the tensile force is applied.

_____

_____ [2]

(ii) The wire used in the gauge has a diameter of 2.0×10^{-5} m and total length of 0.06 m. It is made of metal of resistivity $6.5 \times 10^{-7}\,\Omega$ m. Calculate the resistance of the wire used in the gauge.

Resistance of wire = _____ Ω [4]

(b) **Fig. 9.2** shows a sensing circuit that can be used to monitor the change in resistance of the strain gauge and hence deformation of the structure. The buzzer has a resistance of 78 Ω and will sound when the potential difference across it is 4 V. Calculate the minimum resistance of the strain gauge for the buzzer to sound.

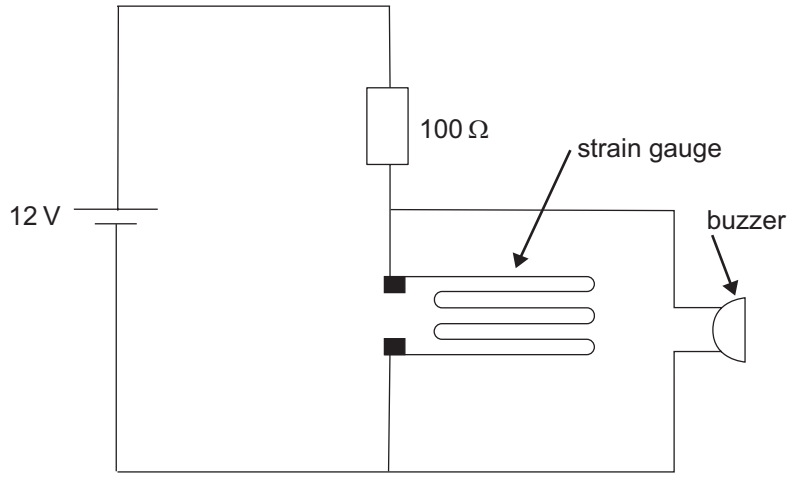

Fig. 9.2

Minimum resistance of strain gauge = _____ Ω [4]

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For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
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8	
9	
Total Marks	

Examiner Number

Rewarding Learning

ADVANCED SUBSIDIARY
General Certificate of Education

Physics

Assessment Units AS 1 and AS 2

[SPH11/SPH21]

DATA AND FORMULAE SHEET

Data and Formulae Sheet for AS 1 and AS 2

Values of constants

speed of light in a vacuum	$c = 3.00 \times 10^{8}$ m s^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
acceleration of free fall on the Earth's surface	$g = 9.81$ m s^{-2}
electron volt	1 eV $= 1.60 \times 10^{-19}$ J
the Hubble constant	$H_0 \approx 2.4 \times 10^{-18}$ s^{-1}

Useful formulae

The following equations may be useful in answering some of the questions in the examination:

Mechanics

conservation of energy	$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Fs$ for a constant force

Waves

two-source interference	$\lambda = \frac{ay}{d}$
diffraction grating	$d \sin\theta = n\lambda$

Light

lens equation $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

Electricity

terminal potential difference $V = E - Ir$ (e.m.f., E; Internal Resistance, r)

potential divider $V_{out} = \frac{R_1 V_{in}}{R_1 + R_2}$

Particles and photons

Einstein's equation $\frac{1}{2} m v_{max}^2 = hf - hf_0$

de Broglie equation $\lambda = \frac{h}{p}$

Astronomy

red shift $z = \frac{\Delta\lambda}{\lambda}$

recession speed $z = \frac{v}{c}$

Hubble's law $v = H_0 d$