



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2022

Centre Number

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Candidate Number

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Physics

Assessment Unit AS 1

assessing

Forces, Energy and Electricity



[SPH11]

SPH11

WEDNESDAY 18 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 eight** 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.

13116



24SPH1101

1 (a) Every physical quantity consists of two parts. What are the two parts?

1. _____

2. _____

[2]

(b) The International System of Units consists of seven base units, each exclusive to a fundamental physical quantity. Units for all other quantities are derived. Complete **Table 1.1** by stating the name of the SI unit for each of the quantities listed and place a tick (✓) in the correct column to indicate whether the unit you have stated is base or derived.

Table 1.1

Quantity	Unit	Base	Derived
Time			
Length			
Force			
Kinetic energy			
Amount of substance			
Charge			

[6]



(c) The unit of potential difference is the volt. Express the volt in base units.

Base units = _____

[4]



- 2 (a) A canoeist needs to cross a river from the boathouse on the north side of the river to a jetty on the bank directly opposite. In order to accomplish this, he must maintain a heading at an angle θ to the bank. The canoeist can paddle at 1.8 m s^{-1} in still water. This river is flowing due east at 0.70 m s^{-1} and is 0.50 km wide. This is illustrated in **Fig. 2.1**.

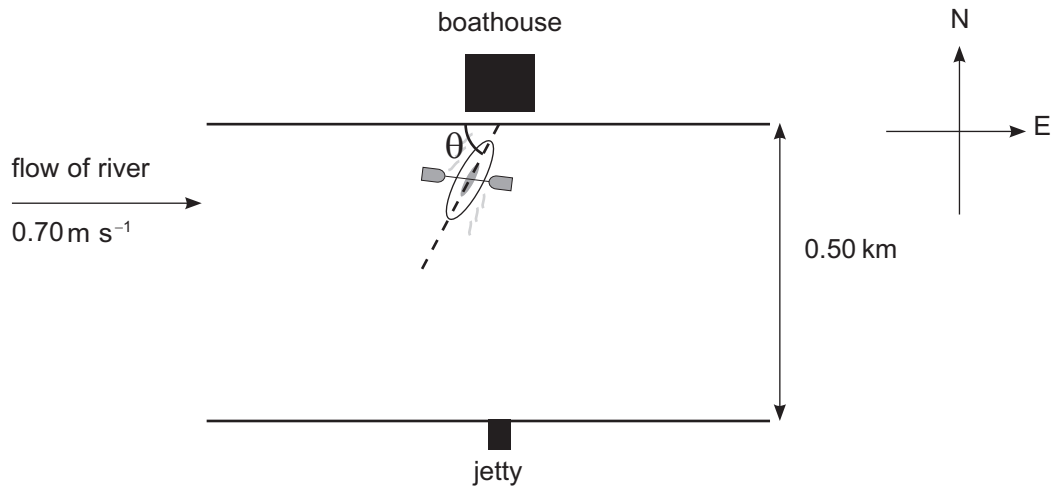


Fig. 2.1

- (i) Draw a labelled vector diagram to represent the velocity of the canoeist \mathbf{v}_c , the velocity of the river \mathbf{v}_r and the resultant velocity \mathbf{V} of the canoeist. Label the angle θ on your diagram.

[3]



(ii) Calculate the angle θ .

$$\theta = \text{_____}^\circ \quad [2]$$

(b) (i) Calculate the time it takes for the canoeist to cross the river and arrive at the jetty.

$$\text{Time} = \text{_____} \text{ s} \quad [3]$$

(ii) Calculate the kinetic energy of the canoeist and his canoe if he has a mass of 73 kg and his canoe has a mass of 20 kg.

$$\text{Kinetic energy} = \text{_____} \text{ J} \quad [3]$$

[Turn over



3 (a) State the principle of moments.

[3]

(b) A child's hanging mobile is shown in Fig. 3.1.

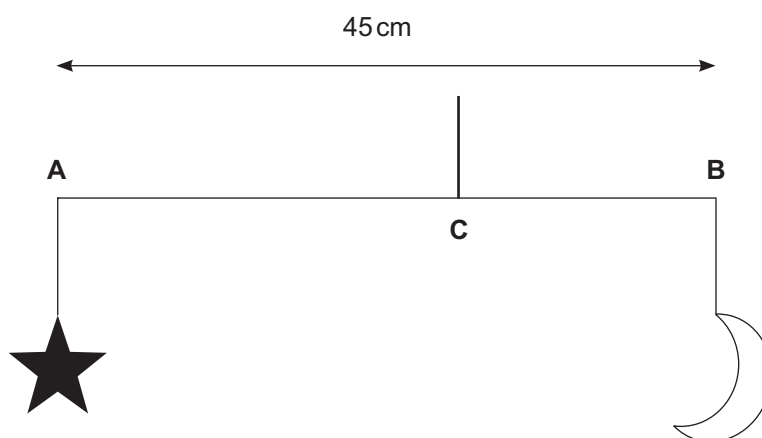


Fig. 3.1

It consists of a uniform plastic rod AB, of length 45 cm and weight 0.50 N, from which plastic shapes can be hung. A star is hung from end A and a crescent moon from end B. The mobile hangs from a string attached at C. The weight of the star shape is 0.20 N and the weight of the crescent moon shape is 0.40 N.



- (i) Determine how far from A the string is attached if the mobile hangs horizontally. Give your answer in centimetres.

Distance from A = _____ cm [4]

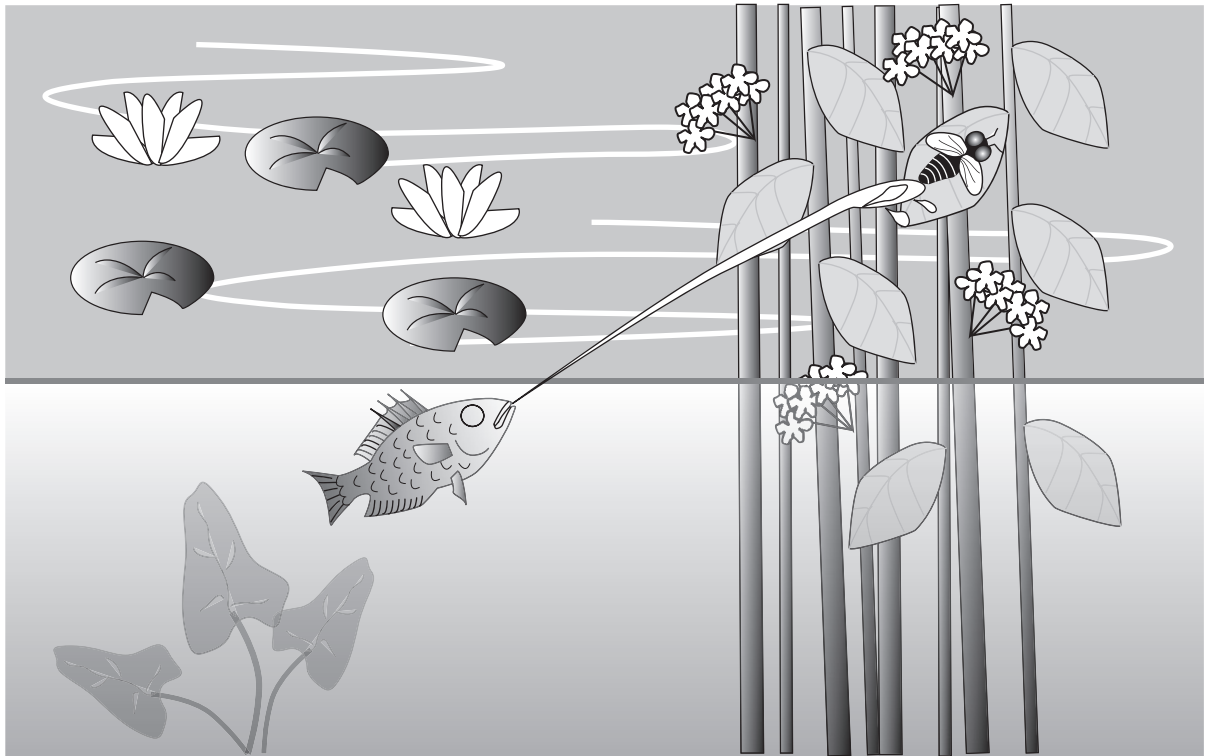
- (ii) Another star is hung from point C. State and explain whether the mobile would remain in a horizontal position or tilt.

 [2]

[Turn over



- 4 Archerfish prey on land-based insects. Their excellent eyesight and ability to compensate for the refraction of light as it passes through an air–water boundary allows them to target their prey successfully. They project water from their mouths and knock insects from branches above the surface of the water. The insects then fall into the water and are eaten by the archerfish. This is illustrated in **Fig. 4.1**.



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Fig. 4.1



- (a) Archerfish typically project water from the surface with a velocity of 2.52 m s^{-1} at an angle of 74° to the horizontal, as indicated in Fig. 4.2.

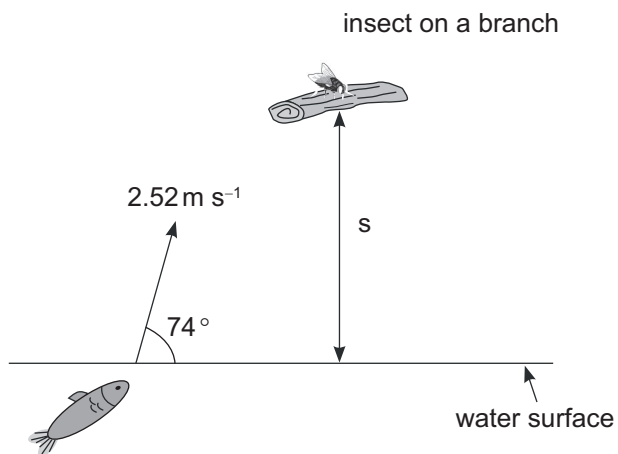


Fig. 4.2

- (i) Calculate the horizontal and vertical components of the initial velocity of the water.

Horizontal component = _____ m s^{-1}

Vertical component = _____ m s^{-1} [2]



- (ii) Calculate the maximum height s of the insect above the surface, that the water from the archerfish will be able to reach.

Maximum height = _____ m [3]

- (iii) Calculate the time it takes for the water to reach the insect at this height.

Time = _____ s [3]



(b) The projected water hits the stationary insect at maximum height **s**. The insect is knocked off the branch with a velocity of 1.25 m s^{-1} in the horizontal direction. The horizontal **impulse** experienced by the insect due to the force from the water is $6.25 \times 10^{-5} \text{ N s}$.

(i) Define **impulse**.

[2]

(ii) Calculate the mass of the insect. Give your answer in milligrams.

Mass = _____ mg [4]

[Turn over



When the insect falls and hits the water, it lands at distance **X** from the point where the water was projected by the archerfish, as shown in **Fig. 4.3**.

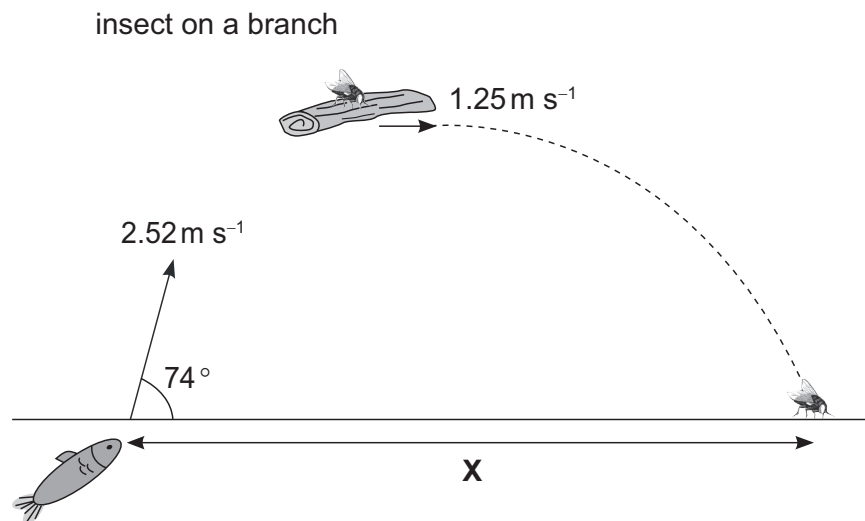


Fig. 4.3

(iii) Calculate the distance **X**. (Assume friction due to air resistance is negligible.)

Distance **X** = _____ m

[4]



(iv) Collisions can be described as **elastic** or **inelastic**. Explain, without calculations, why the collision that occurs when the insect hits the surface of the water is inelastic.

[1]

[Turn over

13116



24SPH1113

5 Pilots of high-speed jet aircraft must learn to land a plane on the flightdeck of aircraft carriers which are much shorter than land-based runways. A successful landing is achieved by snagging a tail hook, attached to the rear of the plane, to a sturdy cable known as an arresting wire. The arresting wire can stop a 24.5×10^3 kg aircraft travelling at 150 miles per hour in 2.85 seconds.

(a) (i) Show that 150 miles per hour is equal to 67.0 m s^{-1} .
(1 mile = 1609 metres)

[2]

(ii) Assume that the jet decelerates **uniformly** during the 2.85 seconds that it takes to land.

Sketch a velocity–time graph on the axes of **Fig. 5.1** for this jet landing. Include a numerical value on each axis.

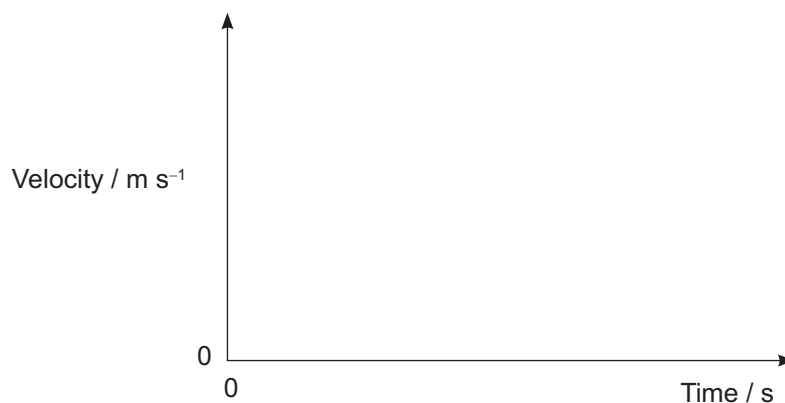


Fig. 5.1

[2]

(iii) State how you would determine the distance travelled by the jet, during its deceleration, from the velocity–time graph you have drawn in **Fig. 5.1**.

[1]



- (iv) There are 4 parallel arresting wires spaced 15 m apart on the flightdeck. Pilots train to snag the third arresting wire as it is the safest option to land. The flightdeck of the aircraft carrier is 150 m long. Use your answer to part (a)(iii) to calculate how far from the end of the flightdeck the jet is, when it comes to a standstill, if the pilot is successful in snagging the third wire. (Assume that the first arresting wire is 15 m in from the start of the flightdeck.)

Distance = _____ m [5]

- (b) Some jets can land vertically on aircraft carriers. They are able to fly slowly, hover and land in tight spaces. Hovering is achieved by directing powerful exhaust streams downwards from the jet engines. State Newtons third law and explain how it applies to a jet which is hovering.

[2]

[Turn over



6 Standard 'twin core and earth' cable, consisting of three copper wires, is used by an electrician to connect a 9.50 kW electric shower to the 230 V mains supply.

(a) (i) Calculate the current drawn from the mains supply when the shower is used at maximum power.

Current = _____ A [3]

(ii) Calculate the electrical energy used by the shower if it is turned on at maximum power for 10 minutes.

Energy = _____ J [3]

(iii) Calculate the number of electrons passing a point in the circuit of the electric shower during these 10 minutes.

Number of electrons = _____ [3]



(b) The electrician uses a 15.0 m length of the 'twin core and earth' cable to connect the shower to the mains supply. Each of the three copper wires has a diameter of 2.76 mm.
The resistivity of copper is $1.72 \times 10^{-8} \Omega \text{ m}$.

(i) Define **resistivity**.

[2]

(ii) Calculate the resistance of **one** of the copper wires used in the cable.

Resistance = _____ Ω [4]

(c) 2.76 mm is the recommended diameter of the wire to be used. Explain fully why it would not be good practice to fit the 9.50 kW shower using a 15.0 m length of cable with a wire of smaller diameter.

[2]

[Turn over



7 A student is asked to perform an experiment to determine the e.m.f. and the internal resistance of a battery from a graph of the results.

(a) In the space below, draw a circuit diagram of the set up that the student would use.

[4]

(b) Describe the procedure that would be carried out to obtain the results.

[3]



(c) Label the axes of **Fig. 7.1** and sketch the graph that would allow both the e.m.f. and internal resistance to be obtained from the results taken.

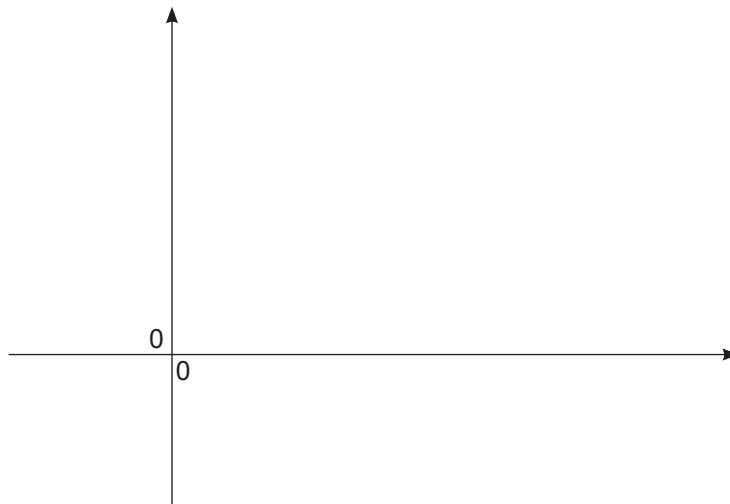


Fig. 7.1

[2]

(d) State how the e.m.f. and internal resistance could be obtained from the graph.

[3]

[Turn over



- 8 A battery with e.m.f. of 12.0V and internal resistance r is connected to a potential divider circuit containing a negative temperature coefficient (n.t.c.) thermistor and a 30.0Ω resistor, as shown in **Fig. 8.1**.
The circuit is operating at room temperature of 18.0°C .
The resistance of the thermistor is 20.0Ω at this temperature and the output voltage V_{out} across the 30.0Ω resistor is 7.12V .

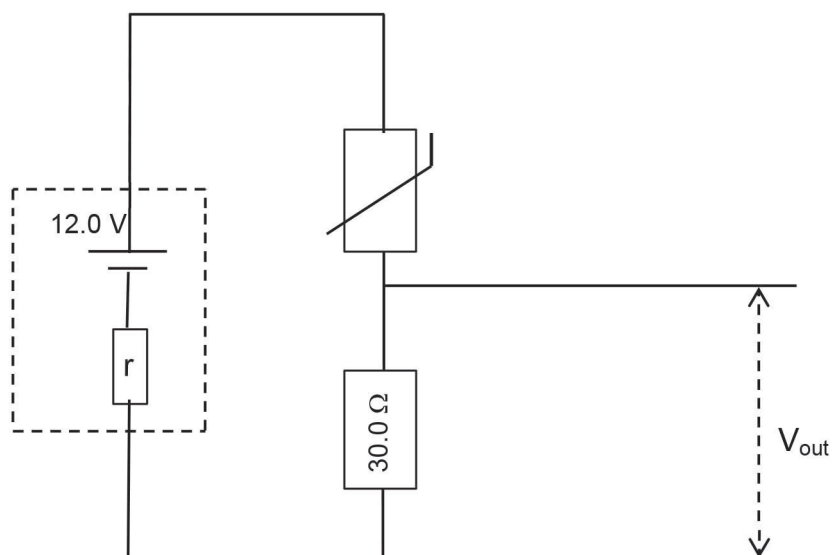


Fig. 8.1

- (a) Determine the internal resistance r of the battery. Quote your answer to three significant figures.

$r =$ _____ Ω

[4]



- (b) The temperature of the room increases to 28.0 °C. Complete **Table 8.1** by ticking the correct option to state how the output voltage across the 30.0 Ω resistor would be affected, if at all, by this change in temperature.

Table 8.1

	V_{out}
Increases	
Decreases	
No change	

Explain your choice.

[3]

- (c) Describe a practical use for this potential divider circuit.

[1]

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24SPH1123

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Question Number	Marks
1	
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24SPH1124



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

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
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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

$$V = E - Ir \text{ (e.m.f., } E; \text{ Internal Resistance, } r)$$

potential divider

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

Particles and photons

Einstein's equation

$$\frac{1}{2} m v_{\text{max}}^2 = hf - hf_0$$

de Broglie equation

$$\lambda = \frac{h}{p}$$

Astronomy

red shift

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

recession speed

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

Hubble's law

$$v = H_0 d$$

