Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2025

Centre Number

Candidate Number

Physics

Assessment Unit AS 1
assessing
Forces, Energy and Electricity

SPH11

[SPH11]
WEDNESDAY 14 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 and use a dark HB pencil for drawings and graphs.
Do not write with a gel pen.
Answer **all ten** 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 a scientific calculator.

1 (a) (i) Explain the difference between a scalar and a vector quantity.

_____

_____ [1]

(ii) Categorise the quantities in **Table 1.1** as either scalar or vector, by placing a tick (✓) in the appropriate column for each quantity.

Table 1.1

Quantity	Scalar	Vector
Energy		
Momentum		
Density		
Time		

[2]

(b) Three weights, W_1, W_2 and W_3, are suspended on light inextensible strings over frictionless pulleys as shown in **Fig. 1.1**. The system is in equilibrium.

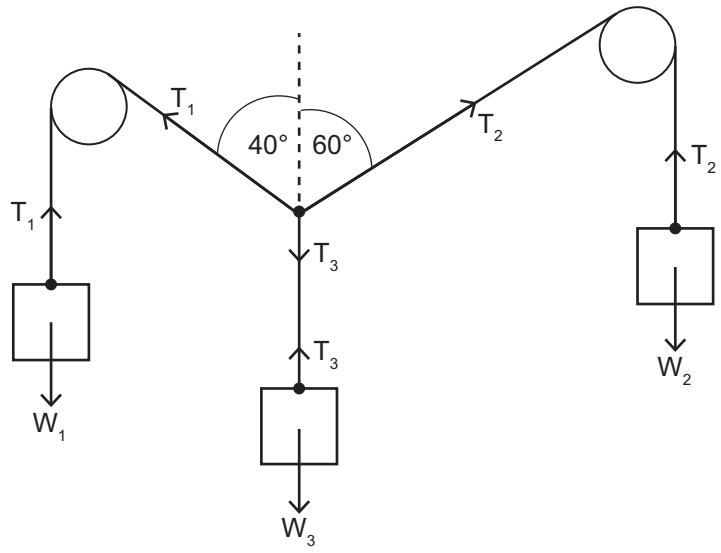


Fig. 1.1

(i) Weight W_1 is 3.92 N. Show that weight W_2 is approximately 2.9 N.

[3]

(ii) Calculate the weight W_3.

W_3 = _____ N [2]

[Turn over

2 A cyclist starts from rest and moves forward for 60 seconds. A graph of acceleration against time for the motion is shown in **Fig. 2.1**.

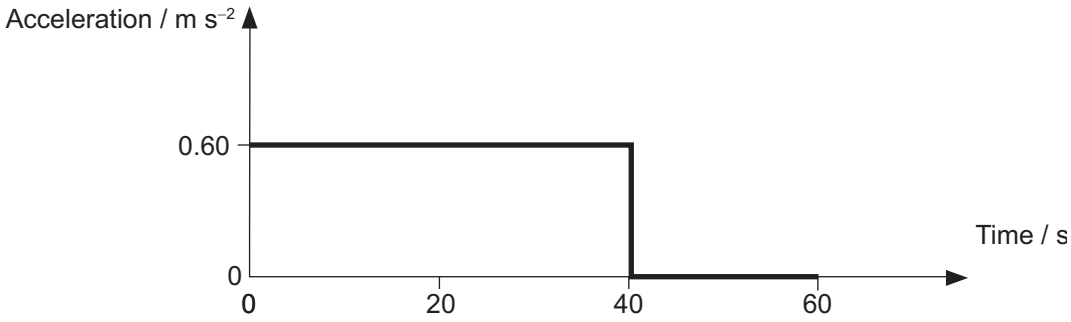


Fig. 2.1

(a) Sketch a velocity–time graph for the motion on the axes of **Fig. 2.2** and use it to calculate the displacement of the cyclist from the starting position after 60 seconds.

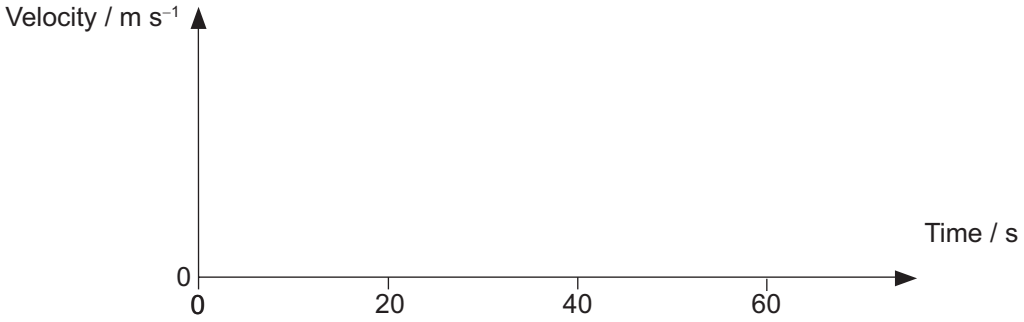


Fig. 2.2

Displacement = _____ m [7]

(b) Calculate the work done by the cyclist against an average frictional force of 36 N over the time period from 40 to 60 seconds.

Work done = _____ J [3]

[Turn over

3 A car of mass 800 kg travelling at 21 m s^{-1} collides with a barrier. The collision causes damage to the car in the form of dents in the metal.

(a) State Newton's second law in terms of momentum.

[3]

(b) **(i)** Distinguish between an elastic and an inelastic collision.

[1]

(ii) The collision between the car and the barrier is inelastic. How can this be deduced from the description of the collision?

[1]

(c) After colliding with the barrier, the car rebounds in the opposite direction with a speed of 11 m s^{-1}.
Calculate the change of momentum experienced by the car.

Change of momentum = _____ kg m s^{-1} [4]

(d) The duration of the impact was 0.45 seconds. Calculate the force exerted by the barrier on the car in that time.

Give your answer to two significant figures.

Force = _____ N [4]

[Turn over

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

_____

_____ [2]

A bridge crane has a horizontal uniform steel gantry supported by two uniform, vertical steel pillars S_1 and S_2 as shown in **Fig. 4.1**. The weight of the gantry is 21 kN. On the gantry is a moveable hoist from which a load is suspended. The hoist can be moved horizontally between the pillars, which are 20 m apart. The weight of the hoist is 4.5 kN.

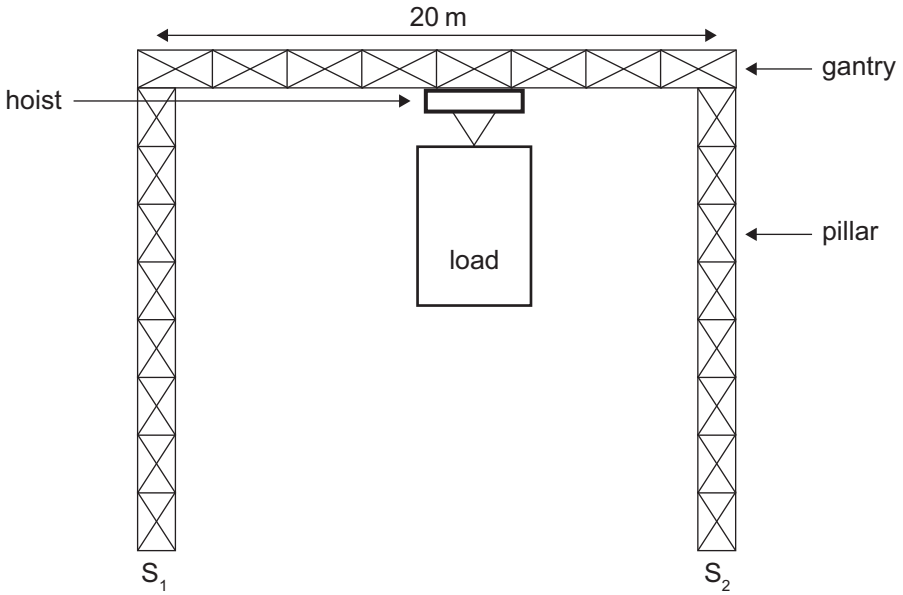


Fig. 4.1

(b) A load of 58 kN is suspended from the hoist, at a horizontal distance of 11 m from S_1. Calculate the upward supporting force provided by each of the pillars, S_1 and S_2.

Force at S_1 = _____ kN

Force at S_2 = _____ kN [7]

[Turn over

5 A golfer pitches a ball, at an angle of 48° to the horizontal, directly into a hole. The hole is a horizontal distance of 12 m away, as shown in **Fig. 5.1**.

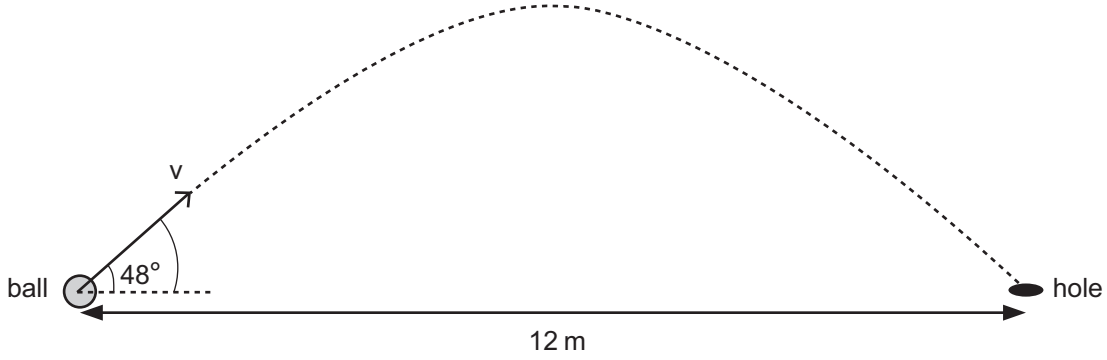


Fig. 5.1

(a) Write expressions for the vertical and horizontal components of the ball's velocity at the instant the club strikes it.

Vertical component: v_V = _____

Horizontal component: v_H = _____ [2]

(b) The total time of flight of the ball is 1.65 s.

(i) Calculate the magnitude of the velocity v with which the ball was struck.

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

(ii) Calculate the maximum height reached by the ball.

Height = _____ m [4]

[Turn over

6 Two graphs have been sketched on the axes in **Fig. 6.1**. Graph S represents the variation in resistance of a superconducting material. The other graph M represents a non-superconducting metal.

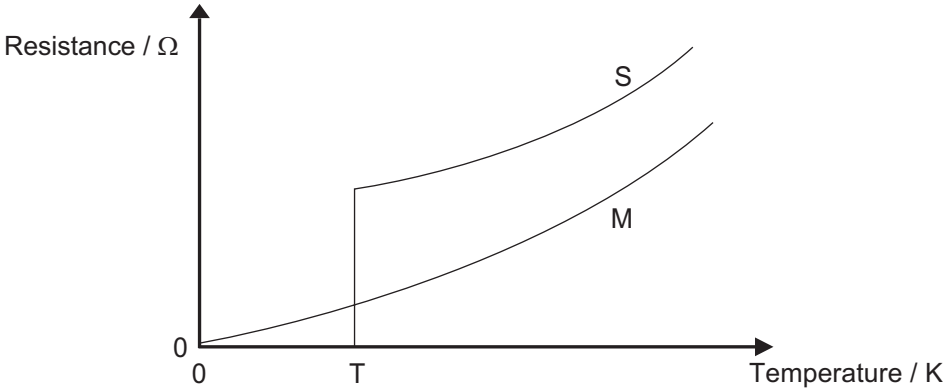


Fig. 6.1

(a) (i) What name is given to the temperature T labelled in **Fig. 6.1**?

_____ [1]

(ii) Above the temperature T, the two graphs show a close similarity in shape. Explain the cause in the variation of resistance as the temperature increases from T, making reference to the particles involved.

_____

_____

_____

_____ [3]

(b) (i) Give an example of where a superconductor is used rather than a non-superconducting metal.

_____ [1]

(ii) Explain why it is beneficial to use a superconductor rather than a non-superconducting metal.

_____

_____

_____

_____

_____ [3]

[Turn over

7 A current of 155 mA flows through the power supply of the circuit shown in **Fig. 7.1**.

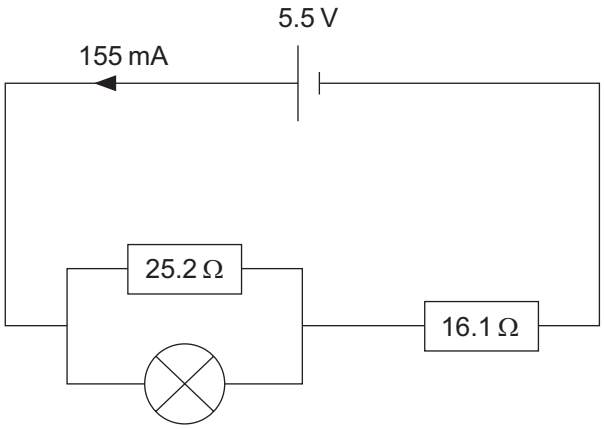


Fig. 7.1

(a) Calculate the number of electrons that pass through the power supply in one hour.

Number of electrons = _____ [5]

(b) Show that the potential difference across the bulb is 3.0 V.

[3]

(c) Calculate the power dissipated by the bulb.

Power = _____ W [4]

(d) A metal wire of length 1.75 m is used to make the 25.2 Ω resistor. The resistivity of the metal is 1.10×10^{-6} Ω m. Calculate the radius of the wire.

Radius = _____ m [5]

[Turn over

8 **(a)** Explain the difference between the terms electromotive force and potential difference.

_____

_____

_____

_____ [2]

(b) The circuit shown in **Fig. 8.1** shows a battery with internal resistance 1.5 Ω connected to an unknown resistor R and a switch S_1.

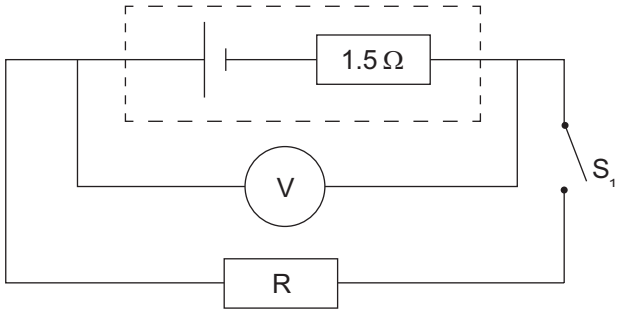


Fig. 8.1

When S_1 is open, the voltmeter reads 6.3 V.
When S_1 is closed, the voltmeter reads 5.9 V.

Calculate the resistance of R.

Resistance = _____ Ω [3]

9 A potential divider is used to supply a variable potential difference from a fixed power supply.

(a) Label the circuit diagram in **Fig. 9.1** with the quantities V_{in}, V_{out}, R_1 and R_2 which are found in the potential divider equation on your Data and Formula Sheet. [2]

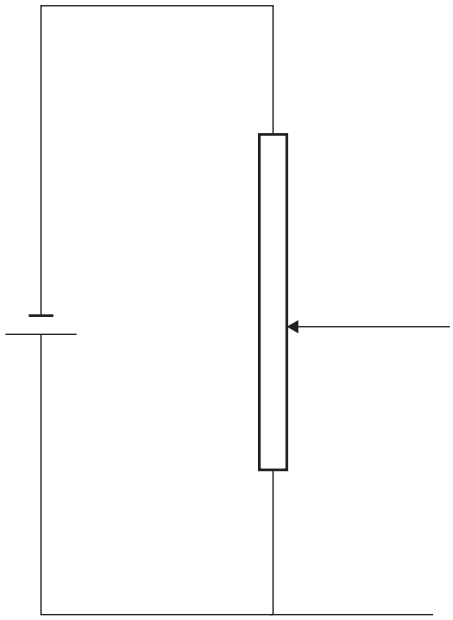


Fig. 9.1

(b) Explain how the circuit shown in **Fig. 9.1** is used to obtain a range of potential differences from a minimum 0 V to the maximum value.

_____

_____

_____

_____ [2]

[Turn over

(c) The resistance of a light-dependent resistor (LDR) decreases as the light intensity across it increases. **Fig. 9.2** shows a fixed resistor in series with a LDR.

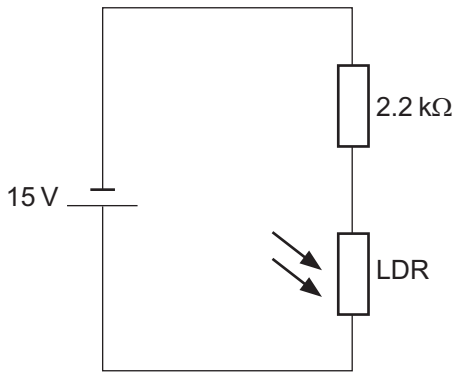


Fig. 9.2

(i) Calculate the resistance of the LDR when the potential difference across it is 8.5 V.

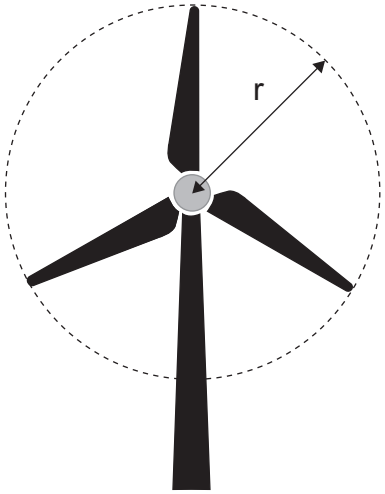
Resistance = _____ kΩ [3]

(ii) A bulb is placed across the LDR and lights with normal brightness. What will happen to the brightness of the bulb if the light intensity on the LDR increases?

_____

_____ [1]

10 Wind farms are widely used as part of the electricity supply network. An image of a wind turbine is shown in **Fig. 10.1**. The length of one turbine blade r is shown.



Source: © Getty images

Fig. 10.1

(a) Each wind turbine can generate electrical current when there is air moving at an appropriate velocity across its blades, causing the blades to rotate. For one turbine design, the range of appropriate velocities is 12–16 m s^{-1}. The maximum value is a safety limit, above which the turbine will shut down.

Suggest why there is a minimum air velocity of 12 m s^{-1}, below which the turbine will not generate electric current.

_____

_____ [1]

[Turn over

(b) The volume of air passing a turbine in one second can be considered as a cylinder, see **Fig. 10.2**. The circular face of the cylinder is the area A swept out by the blades, where the blade length is the radius r of the circle. The length of the cylinder is the distance d travelled by the air in one second.

The volume V of the cylinder is calculated using **Equation 10.1**.

$V = \pi r^2 d$ **Equation 10.1**

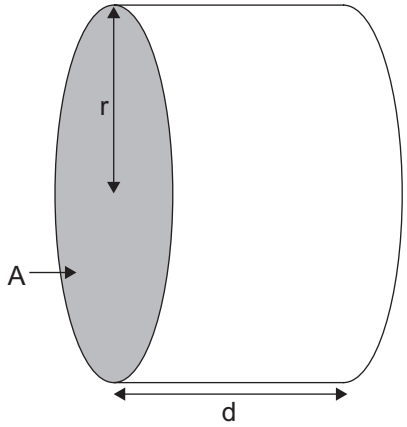


Fig. 10.2

(i) When the blade length is 65 m and the air velocity is 14 m s^{-1}, calculate the total kinetic energy of the air incident on the turbine every second.

The density of the air is 1.4 kg m^{-3}.

Give your answer in megajoules.

Total kinetic energy = _____ MJ [7]

(ii) A wind farm is required to produce an output power of 500 MW when the average air velocity is 14 m s^{-1}.

If the efficiency of each turbine is 39%, calculate the minimum number of wind turbines needed to meet this demand.

Minimum number of wind turbines = _____ [5]

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For Examiner's use only	
Question Number	**Marks**
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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 $v = H_0 d$