Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education

Centre Number

Candidate Number

Physics

Assessment Unit AS 1
assessing
Forces, Energy and Electricity

SPH11

[SPH11]

Assessment

Assessment Level of Control:
Tick the relevant box (✓)

Controlled Conditions	
Other	

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.

1 (a) State Ohm's law.

____

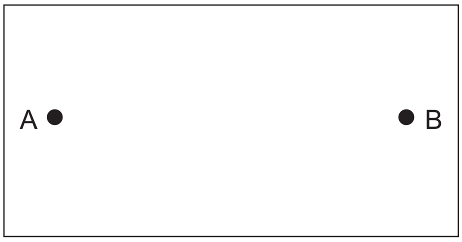
____

____ [2]

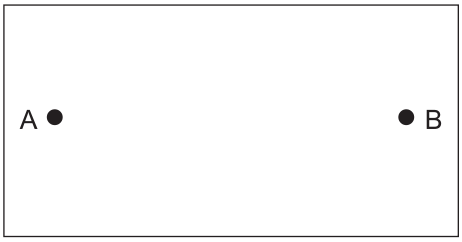
(b) **Three** identical 40 Ω resistors are to be connected between two terminals, A and B, to form a resistor network. There are four possible ways the **three** identical resistors can be arranged to give different values of resistance between A and B.

(i) In the boxes below, sketch the 4 possible arrangements.

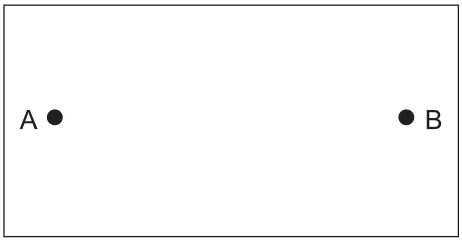
Arrangement 1



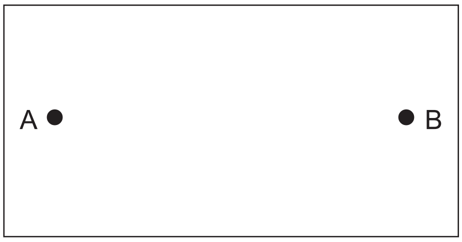
Arrangement 2



Arrangement 3



Arrangement 4



[4]

(ii) 1. Calculate the value of the maximum resistance between A and B.

maximum resistance = ______________ Ω [2]

2. Calculate the value of the minimum resistance between A and B.

minimum resistance = ______________ Ω [2]

2 **(a)** Define the term **work done** in a mechanical system.

____

____ [2]

(b) In February 2013, a 20 m wide asteroid entered the Earth's atmosphere above the town of Chelyabinsk in Russia. Prior to entering the atmosphere, the asteroid had a mass of 1.25×10^7 kg and was moving with a velocity of 1.90×10^4 m s^{-1}.

(i) Calculate the kinetic energy of the asteroid.

Give your answer in terajoules.

Energy = ____________ TJ [3]

(ii) Friction with the atmosphere of the Earth caused a rapid deceleration of the asteroid. While travelling 60 km through the atmosphere, the kinetic energy of the asteroid was reduced to 15% of its original value. Use your answer to part **(b)(i)** to calculate a value for the average frictional force of the atmosphere on the asteroid over this distance.

Average frictional force = ___________ N [3]

(iii) The asteroid exploded at a height of 30 km above the town of Chelyabinsk. This produced an intense flash of light and a sound wave. Many people on the ground saw the flash of light and ran to look out of windows. They were injured by flying glass from broken windows caused by the sound wave.

Calculate the time delay between the arrival of the light and sound from the explosion. Assume the speed of sound was 340 $m\,s^{-1}$.

Time delay = ___________ s [2]

3 Physical quantities may be classified as either a scalar or a vector.

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

____

____ [1]

(b) **Table 3.1** below lists some physical quantities.

Place a tick (✓) beside each scalar quantity.

Table 3.1

Physical Quantity	Scalar (✓)
Force	
Mass	
Acceleration	
Time	
Temperature	
Distance	

[2]

(c) A student makes the following statement:

"Both momentum and kinetic energy of an object are vector quantities as they depend on velocity".

Explain why the statement is incorrect.

____

____ [2]

(d) A boat of total weight 35 000 N is anchored in a harbour as shown in **Fig. 3.1(a)**. To achieve equilibrium, the anchor exerts a force F_A of 6000 N at angle of 25° to the horizontal. This is needed because the water exerts a force F_u due to up-thrust and the current. Consider the boat to be a point mass of weight W. A simplified diagram of the forces acting to achieve equilibrium is shown in **Fig. 3.1(b)**.

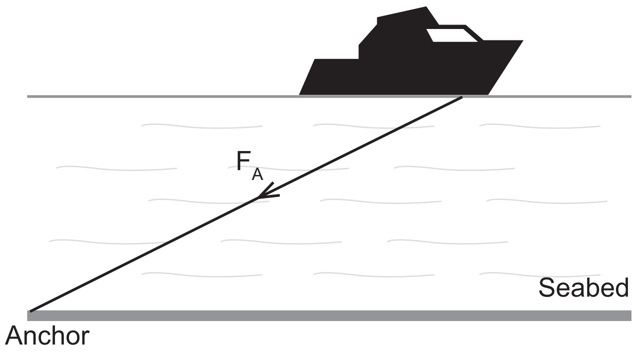


Fig. 3.1(a)

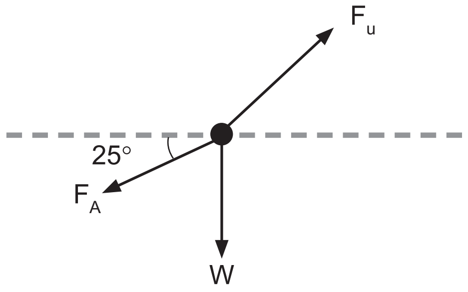


Fig. 3.1(b)

(Not to scale)

Determine the magnitude of F_u, the force exerted on the boat by the water and its direction relative to the horizontal.

Force = _______________ N

Angle to the horizontal = ________ ° [5]

[Turn over

4 In the sport of baseball, a home run is scored if the batter hits the baseball with enough force to enable it to clear the perimeter of the playing area without bouncing.

Treating the air resistance on the ball as negligible, the motion of the ball can be considered to be that of a projectile.

(a) (i) What is the name given to the shape of the curved path that the ball follows through the air?

____ [1]

(ii) Describe projectile motion.

____

____

____ [2]

(b) The ball leaves the bat with an initial velocity u at an angle of 45° relative to the horizontal as shown in **Fig. 4.1**.

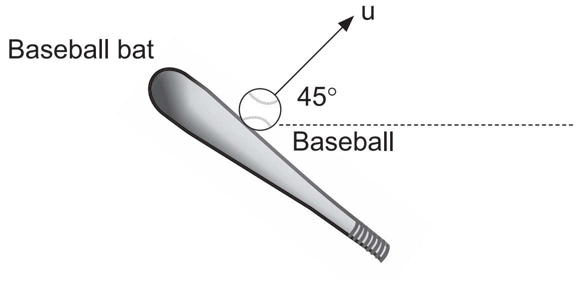


Fig. 4.1

On the axes in **Fig. 4.2**, sketch a graph to show how the horizontal velocity varies from the moment of impact with the bat, t = 0, to the time when it clears the perimeter of the playing area, t = T. Label this line H.

On the same axes, sketch a graph to show how the vertical velocity varies from the moment of impact with the bat, t = 0, to the time when it clears the perimeter of the playing area, t = T. Label this line V.

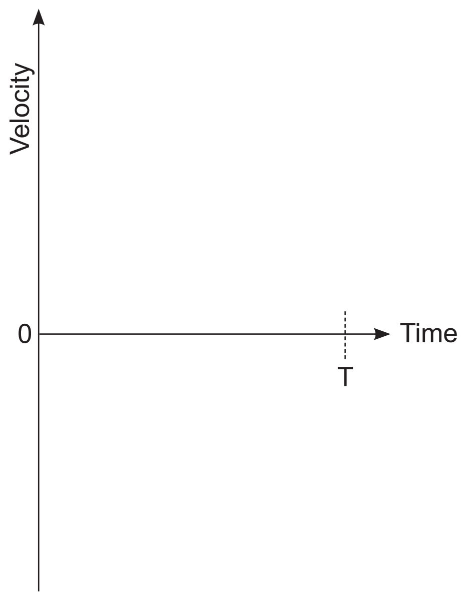


Fig. 4.2

[4]

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

____

____

____ [3]

(b) July 2019 marked the 50th anniversary of the Apollo 11 mission in which humans landed on the moon for the first time.

The Saturn V rocket, shown in **Fig. 5.1**, used in the Apollo program remains the most powerful rocket ever built.

Source: © Getty Images

Fig. 5.1

Prior to lift-off, the mass of the Saturn V rocket was 2.77×10^6 kg.

The engines had to produce enough thrust to accelerate the rocket to 8568 km h^{-1} in 2.5 minutes.

(i) Show that 8568 km h^{-1} is equal to 2400 m s^{-1} when quoted to 2 significant figures.

[2]

12579

(ii) Calculate the magnitude of the thrust required, assuming the mass remained constant throughout the 2.5 minutes.

Thrust = ________________ N [4]

(iii) The engines of the Saturn V rocket only had an efficiency of 12%.

Calculate the magnitude of the theoretical maximum thrust produced by the engines.

Theoretical maximum thrust = ________________ N [2]

(iv) In reality, both the mass and the weight of the rocket will change throughout the 2.5 minutes. Discuss whether you think these quantities would increase or decrease.

Give **two** reasons for your answer.

____

____

____ [3]

6 The magnets used in the Large Hadron Collider (L.H.C.) at CERN need to be superconducting.

(a) Explain the meaning of the term "superconducting".

____

____ [2]

(b) Recently, researchers at CERN built a 40 m long magnesium diboride cable capable of carrying a current of 20 kA.

Magnesium diboride has a critical temperature of –234 °C.

(i) On the axes in **Fig. 6.1** sketch a graph to show how the resistance of magnesium diboride varies with temperature in kelvin from 0 K to 200 K.

Mark clearly the value of the critical temperature in kelvin.

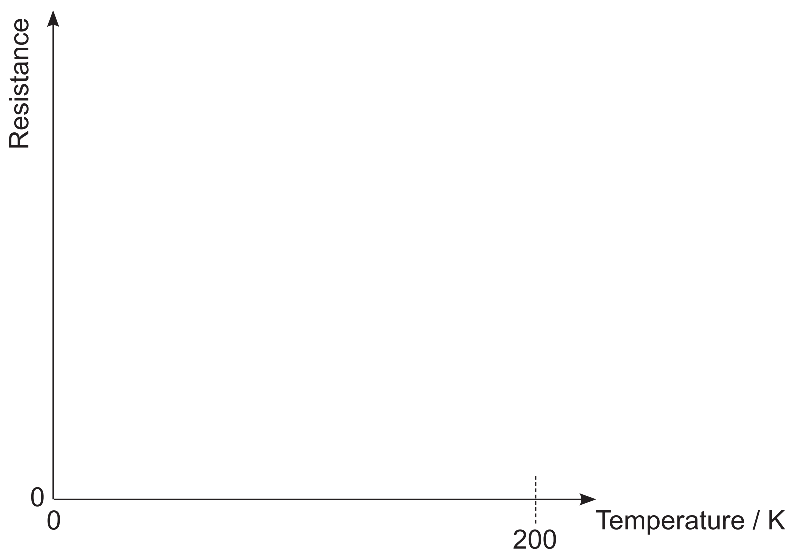


Fig. 6.1

[3]

(ii) Calculate the number of electrons which pass a point within this cable in 2 seconds when the current is 20 kA.

Number of electrons = ______________ [2]

(iii) The number of particles in one mole is called Avogadro's number N_A. It has a value of 6.02×10^{23}. Calculate what percentage of a mole of electrons pass a point every 2 seconds.

Percentage of one mole = ______________ % [2]

(iv) If the cable were to heat up to a temperature above its critical temperature it would have a resistance value of 1.5 μΩ. Calculate the amount of electrical energy which would be dissipated as heat if 15 kA were to flow for 1 minute at this temperature.

Energy = ______________ J [4]

[Turn over

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

____

____ [2]

(b) A lorry can be fitted with a crane to deliver bricks onto a building site, as shown in **Fig. 7.1**.

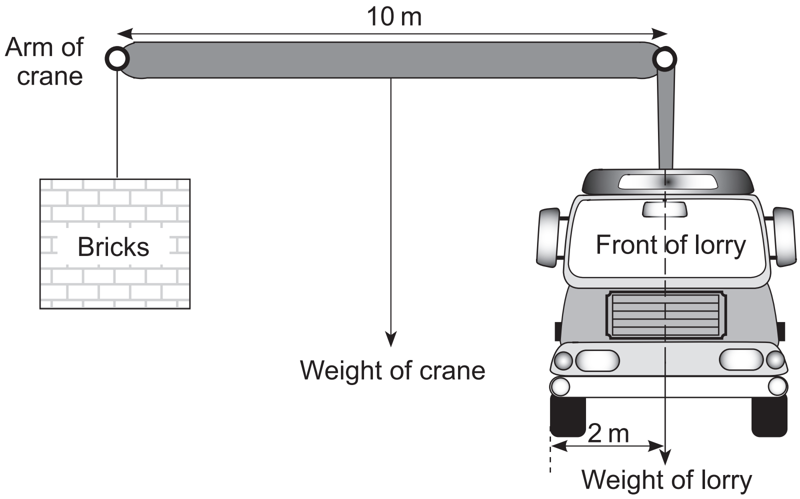


Fig. 7.1

The lorry has a mass of 3500 kg and its centre of gravity is 2 m from the edge of the front wheels as shown. The arm of the crane is a uniform piece of metal of mass 400 kg and length 10 m.

(i) Using the principle of moments, calculate the maximum mass of bricks which can be lifted by this lorry without it tipping.

Maximum mass of bricks = _____________ kg [6]

To enable the lorry to lift a heavier load than that calculated in **(b)(i)**, stabilisers are deployed as shown in **Fig. 7.2**.

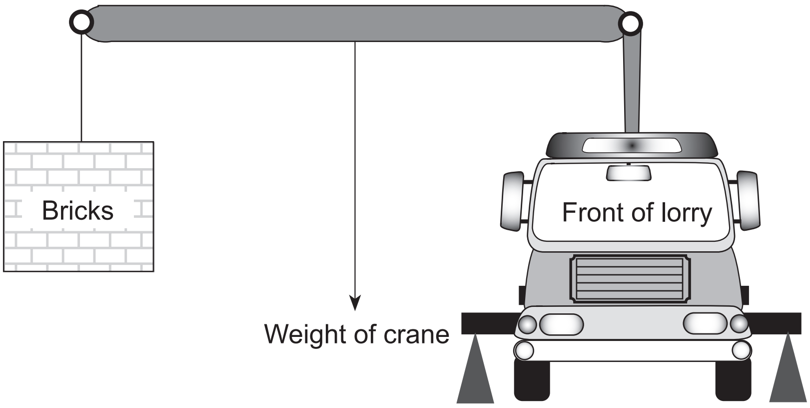


Fig. 7.2

(ii) Explain how these stabilisers function in order to allow the heavier load to be lifted.

____

____

____

____

____ [3]

8 **(a)** A student is provided with a 1.5 m length of constantan resistance wire and asked to determine its resistivity.

(i) In the space below, draw the circuit diagram the student would construct, including an ammeter and voltmeter, to obtain a value for the resistance of the wire.

[2]

(ii) State the additional measurement the student would need to make in order to obtain a value for the resistivity of the wire. Name the piece of apparatus used.

____

____ [2]

(b) The resistivity value of the 1.5 m length the student was provided with was $49.0 \times 10^{-8}\,\Omega$ m and had a resistance value of 12 Ω.

(i) Calculate the diameter of the wire under investigation. Give your answer in millimetres.

Diameter = _____________ mm [6]

The student finds another sample of constantan wire which is twice as long but four times the cross-sectional area.

(ii) Determine the values of resistance and resistivity of this new sample.

Resistivity = _______________ Ω m

Resistance = _______________ Ω [4]

9 **(a)** State the principle of conservation of momentum.

____

____

____ [2]

(b) In a game of pool, a cue ball of mass 95 g is travelling to the left with a speed of 32 cm s^{-1} as shown in **Fig. 9.1**.

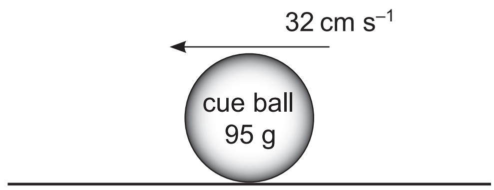


Fig. 9.1

(i) Calculate the momentum of the cue ball, and state its unit.

Momentum = ____________

Unit ________________________ [2]

12579

The cue ball then collides with another ball which has a mass of 125 g travelling in the opposite direction with a speed of 16 cm s^{-1}, as shown in **Fig. 9.2**.

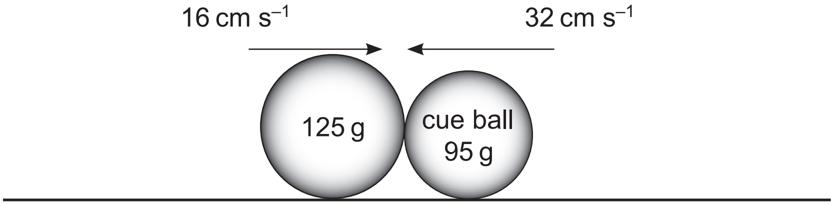


Fig. 9.2

After the collision, the other ball rebounds with a speed of 14 cm s^{-1} to the left, as shown in **Fig. 9.3**.

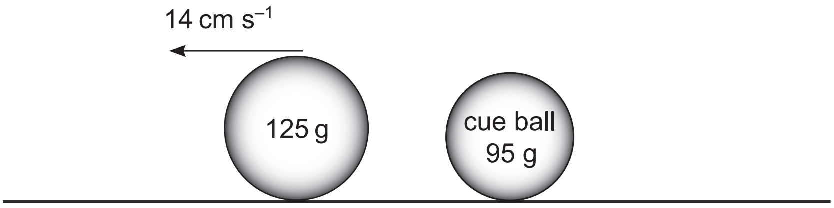


Fig. 9.3

(ii) Calculate the speed and state the direction of the cue ball after the collision.

Speed = ____________ cm s^{-1}

Direction ________________________ [4]

(iii) State whether the collision of the pool balls is considered to be elastic or inelastic. Explain your choice by means of suitable calculations.

____

____

____

____ [3]

THIS IS THE END OF THE QUESTION PAPER

BLANK PAGE

DO NOT WRITE ON THIS PAGE

BLANK PAGE

DO NOT WRITE ON THIS PAGE

12579

BLANK PAGE

DO NOT WRITE ON THIS PAGE

DO NOT WRITE ON THIS PAGE

For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
6	
7	
8	
9	

Total Marks	

Examiner Number