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ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2009

Centre Number

71	

Candidate Number

Physics

Assessment Unit AS 1

Module 1: Forces, Energy and Electricity

[AY111]

AY111

TUESDAY 27 JANUARY, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 75.
Quality of written communication will be assessed in question 4.
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.

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

Total Marks	

If you need the values of physical constants to answer any questions in this paper, they may be found in the Data and Formulae Sheet.

Examiner Only	
Marks	Remark

Answer **all eight** questions.

1 **(a)** The list below gives a number of physical quantities and units. For those which are **base** quantities or **base** units, place a tick (✔) in the appropriate box.

Coulomb ☐

Force ☐

Length ☐

Mole ☐

Newton ☐

Temperature ☐ [2]

(b) What are the base units of kinetic energy?

____ [1]

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

____

____

____

____ [2]

(ii) A student states that kinetic energy is a vector quantity, because it involves velocity, and velocity is certainly a vector. However, another student says that kinetic energy is a scalar. The second student is correct. Explain why.

____

____ [1]

(d) **Fig. 1.1** shows two vectors **P** and **Q**.

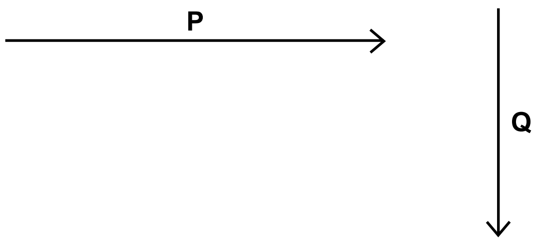

Fig. 1.1

In the space below, **sketch** the constructions necessary to obtain the vectors **A** and **B**, where **A** = **P** + **Q** and **B** = **P** – **Q**. (Drawings to scale are **not** required.)

A = **P** + **Q**

B = **P** – **Q**

[3]

Examiner Only	
Marks	Remark

2 **(a)** **(i)** **Fig. 2.1** shows the velocity–time graph for a car travelling in a straight line along a level road.

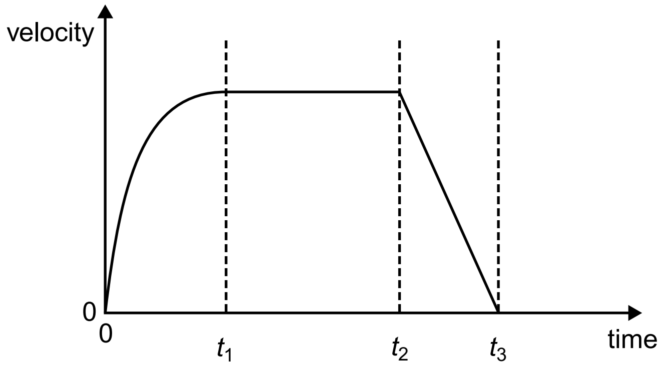

Fig. 2.1

Using the terms **uniform**, **non-uniform**, **zero**, with the words **acceleration** and/or **deceleration**, as appropriate, describe the acceleration or deceleration of the car in the time intervals indicated below.

1. $0 - t_1$ ____________________________

2. $t_1 - t_2$ ____________________________

3. $t_2 - t_3$ ____________________________ [3]

(ii) The car has a mass of 1800 kg. At time t_2 the speed of the car is 16.7 m s^{-1}. The driver applies a constant braking force of 1200 N at this instant. Calculate the time interval between the application of the brakes and the car coming to rest.

Time interval = ___________ s [4]

Examiner Only

Marks	Remark

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(Questions continue overleaf)

(b) **Fig. 2.2** shows a player in a darts competition.

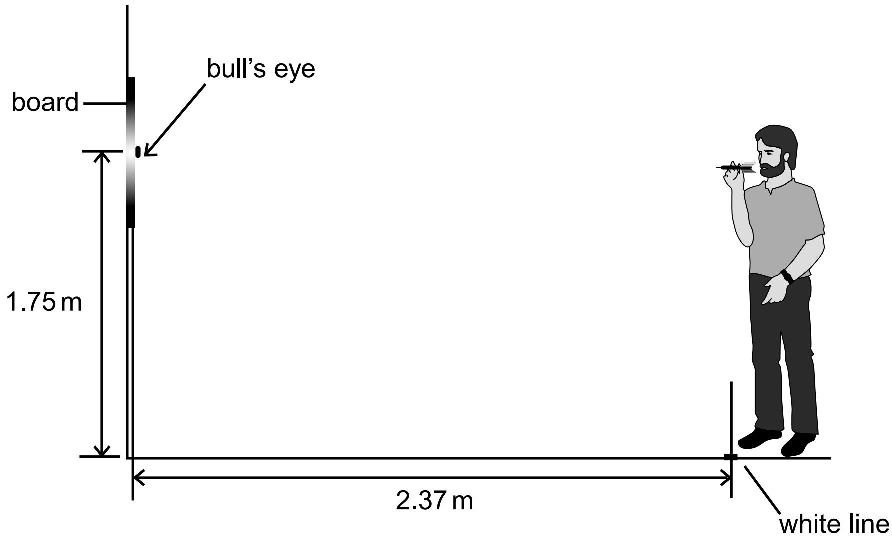

Fig. 2.2 (not to scale)

The player stands at a white line on the floor, 2.37 m from the board. The bull's eye on the board is 1.75 m above the floor. **Fig. 2.3** shows the bottom segment of the board. Depending on the region of this segment into which the dart sticks, it scores 3 points or multiples of 3 points.

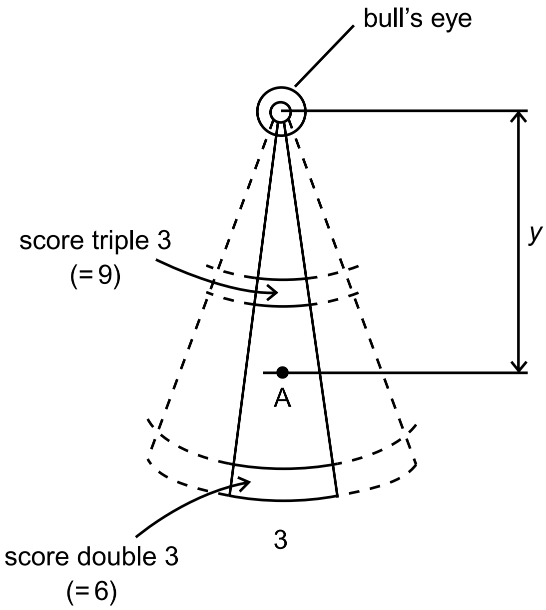

Fig. 2.3 (not to scale)

Examiner Only	
Marks	Remark

Standing at the white line directly in front of the board, the player throws a dart horizontally, from a point 1.75 m above the floor (at the same level as the bull's eye), with a speed of 14.0 m s^{-1}.

(i) Calculate the time taken for the dart to travel between the player's hand and the dart board. Ignore air resistance.

Time = ________________ s [2]

(ii) The dart sticks into the board at the point marked A on **Fig. 2.3**. Calculate the vertical distance *y* of the point A below the centre of the bull's eye.

Vertical distance *y* = ____________ m [3]

(iii) The player now needs a double-3 (see **Fig. 2.3**) to win the game. Without further calculation, indicate by placing a tick (✔) in the appropriate box how the projection speed should be adjusted to achieve this result. The dart is to be thrown horizontally towards the bull's eye, as before. Explain your answer.

The speed of the dart should be **increased** ☐

The speed of the dart should be **decreased** ☐

Explanation:

____

____

____

____ [3]

Examiner Only	
Marks	Remark

(c) The player changes the type of dart used to one which has a greater mass, and throws it in the same direction, and with the same speed, as the dart which hit point A. Describe how the position at which the dart strikes the board will change, if at all, as a consequence of the change of mass of the dart. Explain your answer.

The dart strikes the board **above** point A ☐

The dart strikes the board **at** point A ☐

The dart strikes the board **below** point A ☐

Explanation:

____

____

____ [2]

Examiner Only	
Marks	Remark

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(Questions continue overleaf)

3 A man pushes a wheelbarrow on level ground at a constant speed of $1.5\,\mathrm{m\,s^{-1}}$, as shown in **Fig. 3.1**. The wheelbarrow contains soil. The combined mass of wheelbarrow and soil is 22 kg.

Examiner Only	
Marks	Remark

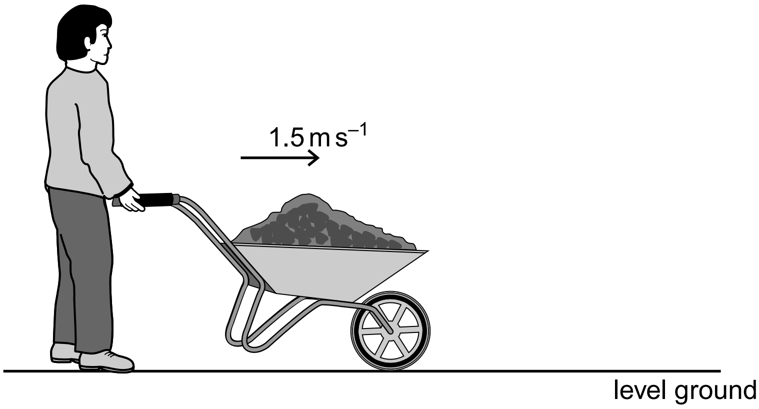


Fig. 3.1

(a) The total frictional force acting is 12 N. State the force exerted by the man on the wheelbarrow. Explain your answer.

Force = ____________ N

Explanation:

____

____

____ [2]

(b) The man now approaches a slope inclined at 5.0° to the horizontal, as shown in **Fig. 3.2**.

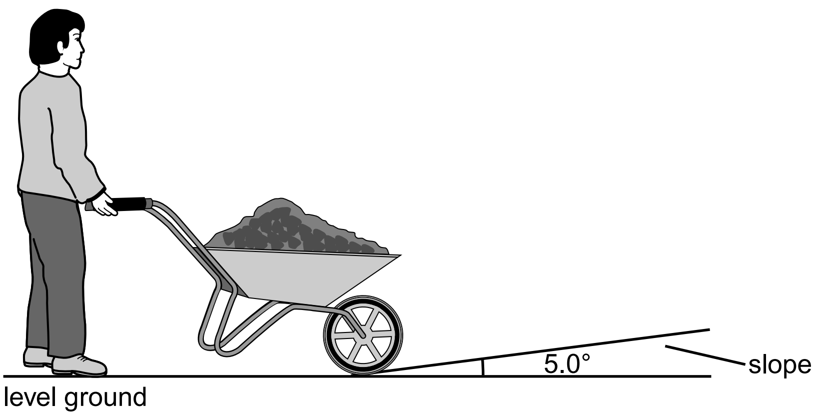


Fig. 3.2

Examiner Only	
Marks	Remark

(i) The man pushes the wheelbarrow up the slope, maintaining the same constant force that he applied in **(a)**. The frictional force has the same constant value as in **(a)**. The distance the wheelbarrow moves up the slope before it stops is x, where x is measured in metres.

(1) Calculate the change in kinetic energy of the wheelbarrow from the bottom of the slope to the point where it stops.

Change in kinetic energy = ____________ J [1]

(2) Obtain an expression, in terms of x, for the change in gravitational potential energy of the wheelbarrow from the bottom of the slope to the point where it stops.

Change in gravitational potential energy = _____________ [2]

(3) Use the principle of conservation of energy to find the distance x.

x = ____________ m [1]

(ii) Calculate the **total** force the man must exert on the wheelbarrow and its contents to move it up the slope at the original constant speed of $1.5\,\mathrm{m\,s^{-1}}$. The frictional force is constant at 12 N.

Total force = ____________ N [3]

Where appropriate in this question you should answer in continuous prose. You will be assessed on the quality of your written communication.

Examiner Only	
Marks	Remark

4 A soft squashy ball is dropped from rest from a height onto a hard surface. The graph in **Fig. 4.1** shows how the height of the top of the ball above the surface varies with time.

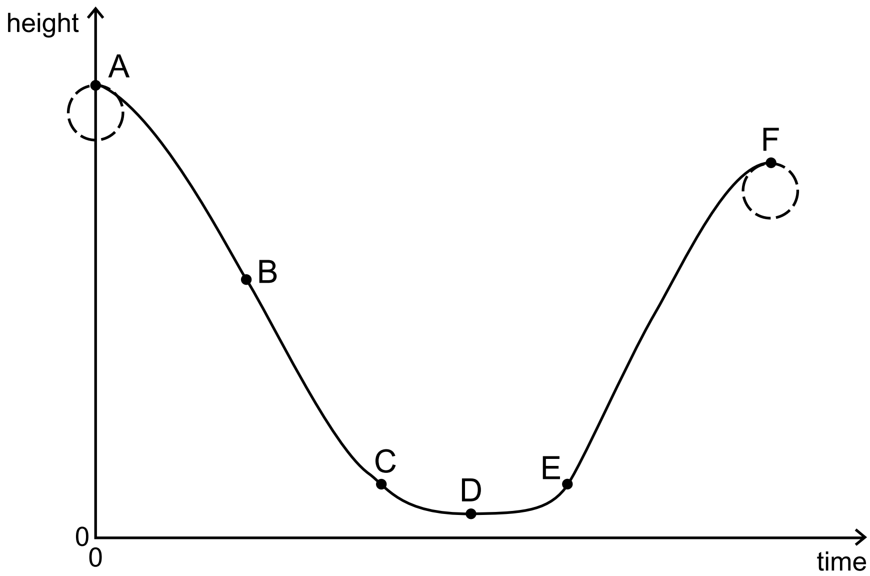
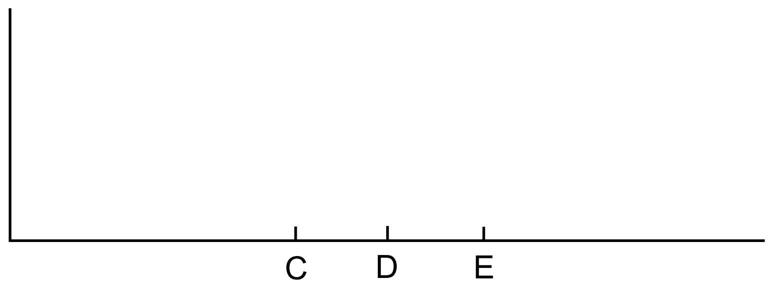


Fig. 4.1

Points in the motion of the ball have been labelled A, B, C, D, E and F. The ball first makes contact with the surface at the time corresponding to C. It leaves the surface again at the time corresponding to E.

(a) On **Fig. 4.2**, sketch the shape of the ball at the times corresponding to C, D and E.



[2]

Fig. 4.2

(b) State the type or types of energy possessed by the ball at the times corresponding to the following points.

(i) Point A: ____

(ii) Point B: ____

(iii) Point C: ____ [3]

(c) After rebounding from the surface, the ball rises to a height represented by point F. The fact that F is at a lower height than point A might suggest that the principle of conservation of energy has been broken. Explain why the principle has not, in fact, been broken.

____

____

____

____ [2]

Quality of written communication [1]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

5 **(a)** Define electric current.

____

____ [1]

(b) 5.0×10^{20} electrons pass normally through a cross-section of a wire in 25 s.
Find the current in the wire.

Current = ___________ A [1]

(c) A number of electrons travel between two electrodes in an evacuated tube. This flow of electrons may be considered to be an electron beam current. The mean speed of the electrons is $8.0 \times 10^6\,m\,s^{-1}$ and the distance between the two electrodes is 0.45 m. The electron beam current is 1.85 mA.

(i) Calculate the time taken for an electron to travel between the two electrodes at this speed.

Time = ___________ s [1]

(ii) Hence calculate the number of electrons in the beam at any instant.

Number = ___________ [2]

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(Questions continue overleaf)

Examiner Only	
Marks	Remark

6 **(a)** A wire has resistance R and is made of metal of resistivity ρ.
Write down the equation relating R to ρ. State the meaning of any other terms in your equation.

____

____

____ [1]

(b) A copper wire is 2.0 m long and has a radius of 0.56 mm. When the current in the wire is 3.5 A, the potential difference between the ends of the wire is 0.12 V.
Calculate the resistivity of copper.

Resistivity = ____________________ Ω m [4]

(c) This copper wire (wire A) is now replaced with a different copper wire (wire B) of length 2.0 m (the **same** as before) but of radius 0.28 mm (**half** the previous value). State how the resistance and resistivity of wire B compare with the values of the corresponding quantities for wire A. In each case, explain your reasoning.

Resistance of wire B compared with resistance of wire A:

____

Reasoning: ______________________________________

____ [2]

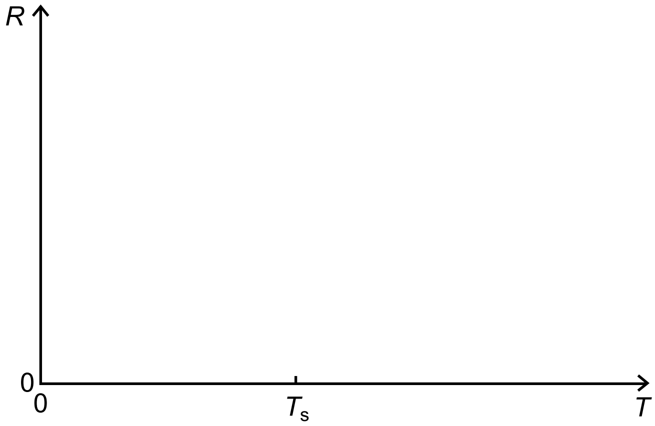
Resistivity of wire B compared with resistivity of wire A:

____

Reasoning: ______________________________________

____ [2]

(d) On the axes of **Fig. 6.1**, sketch a graph to show the variation with temperature T of the resistance R of a wire made of a superconducting material below and above the superconducting transition temperature T_s.



[2]

Fig. 6.1

Examiner Only	
Marks	Remark

7 The circuit of **Fig. 7.1** contains five 10 Ω resistors connected to a 6 V battery as shown.

Examiner Only	
Marks	Remark

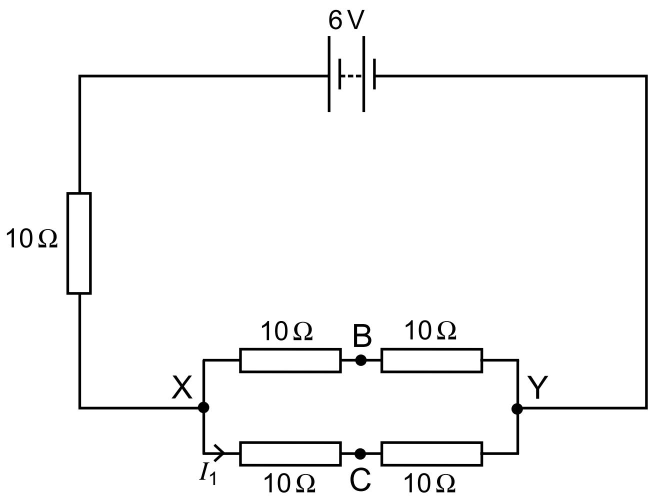


Fig. 7.1

(a) (i) Calculate the total resistance of the network between the points X and Y.

Resistance = ____________ Ω [2]

(ii) (1) Use your answer to **(a)(i)** to calculate the total current drawn from the battery.

Current = ___________ A [1]

(2) Hence determine the current I_1 in **Fig. 7.1**.

I_1 = ___________ A [1]

(b) (i) Explain why the potential difference between points B and C is zero.

____

____ [1]

(ii) A wire of negligible resistance is now placed to connect the points B and C of the circuit of **Fig. 7.1**. The potential difference between points B and C **remains zero**.

How does the current now drawn from the battery compare with that in **(a)(ii)(1)** (i.e. before the wire is connected between B and C)? Indicate your answer by placing a tick (✔) in the appropriate box.

The current is greater than before ☐

The current is the same as before ☐

The current is less than before ☐

Explain your answer.

____ [1]

(iii) The wire in **(b)(ii)** is removed from B and C and now placed to connect the points X and Y of the circuit of **Fig. 7.1**. Calculate the current now drawn from the 6 V battery.

Current ______________ A [2]

Examiner Only	
Marks	Remark

8

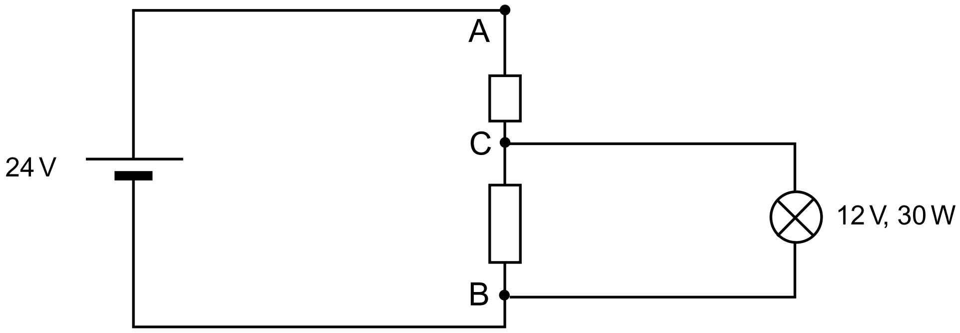


Fig. 8.1

In **Fig. 8.1**, AC is a resistor of resistance R and BC is a resistor of resistance $3R$. The cell has an e.m.f. of 24 V and negligible internal resistance. A lamp rated 12 V, 30 W is connected as shown. When the circuit is switched on, the lamp operates under the rated conditions (i.e. normally).

(a) Calculate the resistance of the lamp when it is operated at its rated conditions.

Resistance = _____________ Ω [3]

(b) What must be the potential difference across the resistance BC if the lamp is to operate normally?

p.d. = _____________ V [1]

(c) Hence determine the p.d. across the resistance AC when the lamp is operating normally.

p.d. = _____________ V [1]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(d) Hence determine, in terms of R, the necessary combined resistance of the lamp and the resistor BC when the lamp operates normally.

Resistance = ______________ [1]

(e) Hence calculate the magnitude of R.

R = ______________ Ω [2]

THIS IS THE END OF THE QUESTION PAPER

GCE Physics

Data and Formulae Sheet

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 e$V = 1.60 \times 10^{-19}$ J

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

Hooke's Law $F = kx$ (spring constant k)

Sound

Sound intensity level/dB $= 10 \lg_{10} \frac{I}{I_0}$

Waves

Two-source interference $\lambda = \frac{ay}{d}$

Light

Lens formula $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

Magnification $m = \frac{v}{u}$

Electricity

Terminal potential difference $V = \varepsilon - Ir$ (E.m.f. ε; Internal Resistance r)

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

Particles and photons

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

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