Rewarding Learning

Centre Number

| 71 | |
|---|---|

Candidate Number

| |
|---|

**ADVANCED SUBSIDIARY (AS)**
**General Certificate of Education**
**January 2009**

# Physics

## Assessment Unit AS 1

*assessing*

## Module 1: Forces and Electricity

**[ASY11]**

ASY11

**TUESDAY 27 JANUARY, MORNING**

**TIME**

1 hour.

**INSTRUCTIONS TO CANDIDATES**

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

**INFORMATION FOR CANDIDATES**

The total mark for this paper is 60.
Quality of written communication will be assessed in question **4(c)**.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
Your attention is drawn to the Data and Formula Sheet which is inside this question paper.
You may use an electronic calculator.
You will need a ruler and protractor.

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

| **Total Marks** | |
|---|---|

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



Answer **all seven** 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**.

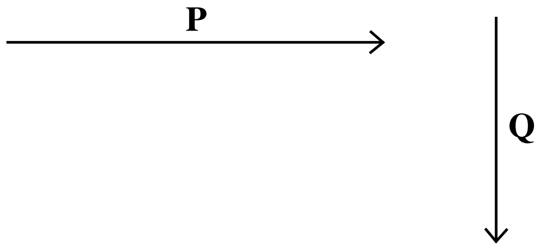



**Fig. 1.1**

In the spaces 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** **Fig. 2.1** shows a player in a darts competition.

| Examiner Only | |
|---|---|
| Marks | Remark |

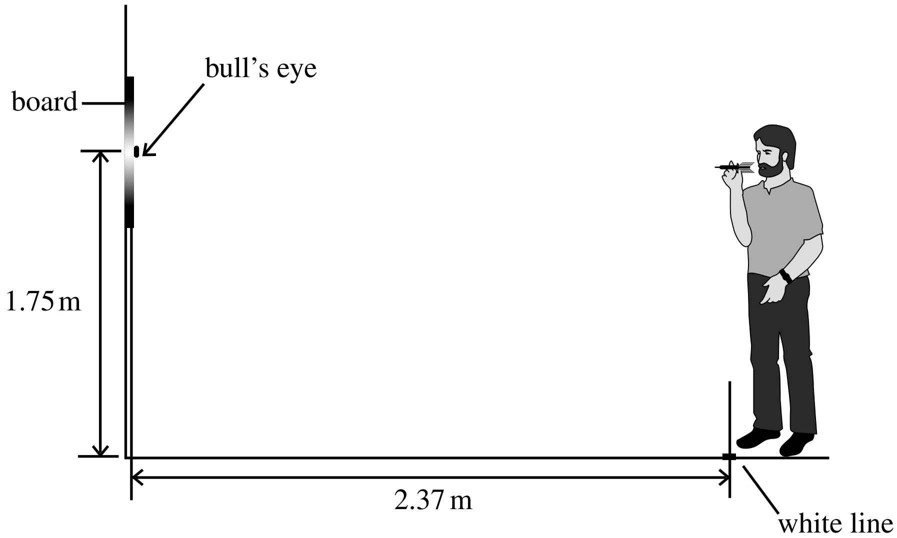



**Fig. 2.1 (not to scale)**

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. 2.2** 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.

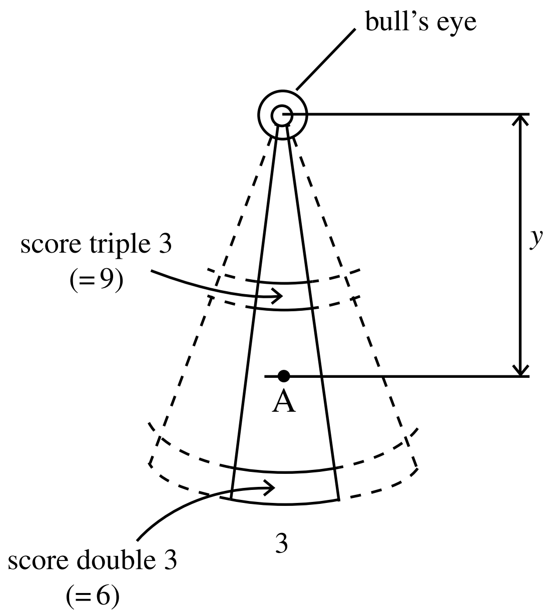



**Fig. 2.2 (not to scale)**

| Examiner Only | |
|---|---|
| Marks | Remark |

**(a)** 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 $14.0\,\text{m}\,\text{s}^{-1}$.

**(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. 2.2**. 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. 2.2**) 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 |

**(b)** 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]

**BLANK PAGE**

**(Questions continue overleaf)**

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

| Examiner Only | |
|---|---|
| Marks | Remark |

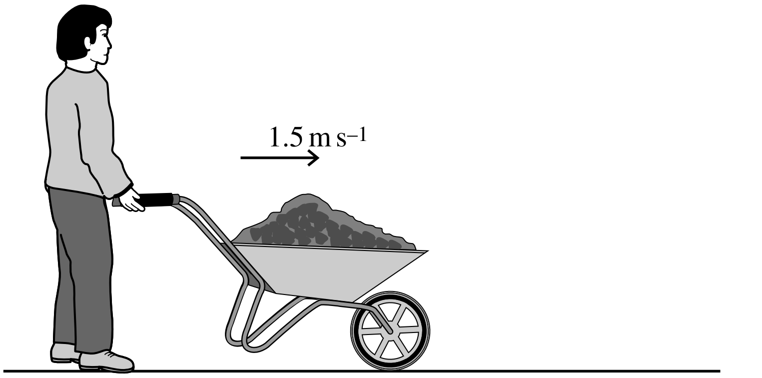



**Fig. 3.1**

**(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**.

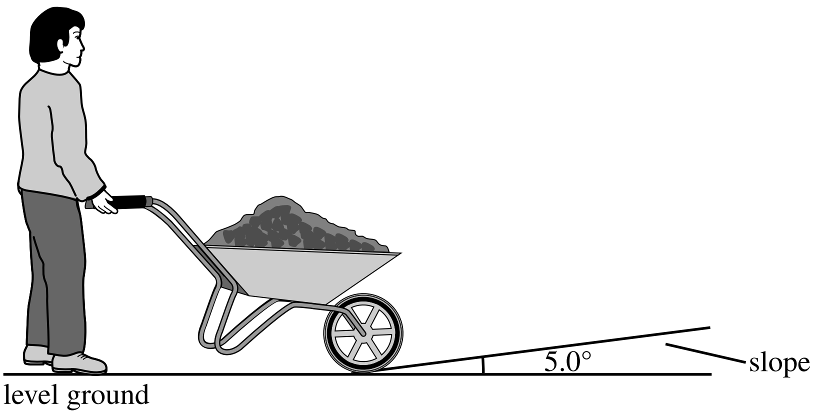



**Fig. 3.2**

| 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 of 12 N. Calculate the distance up the slope the wheelbarrow moves before it stops.

Distance = _____________ m [4]

**(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 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.

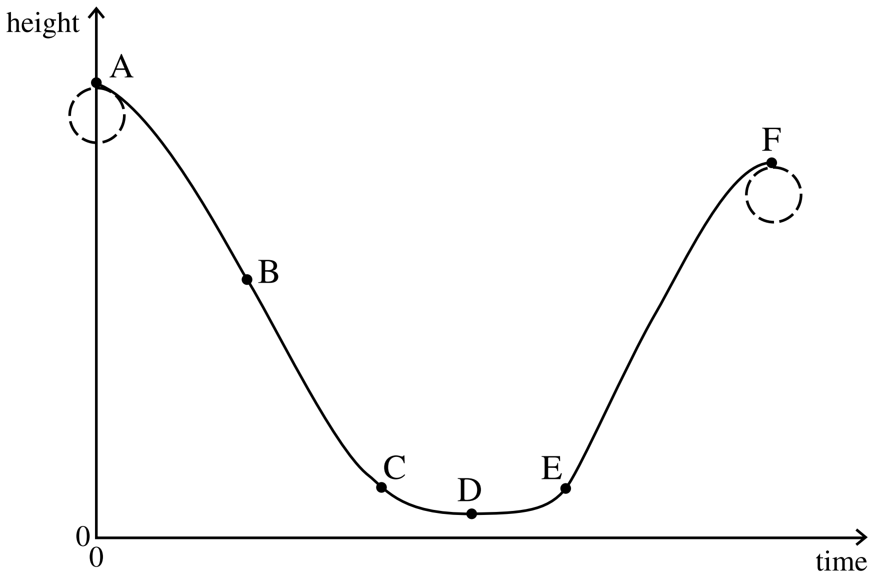
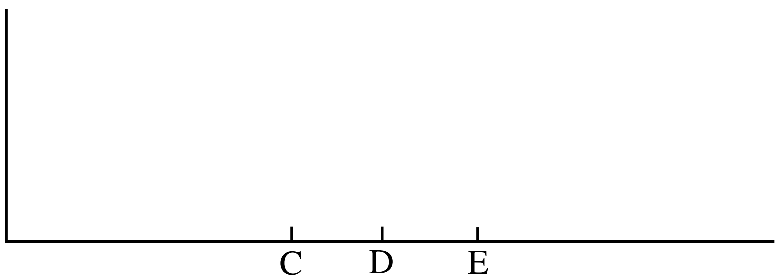



**Fig. 4.1**

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**

| Examiner Only | |
|---|---|
| Marks | Remark |

**(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]

**5** **Fig. 5.1** shows a solid metal cylinder of cross-sectional area $A$. The cylinder carries a conventional current $I$ in the direction from left to right.

| Examiner Only | |
|---|---|
| Marks | Remark |

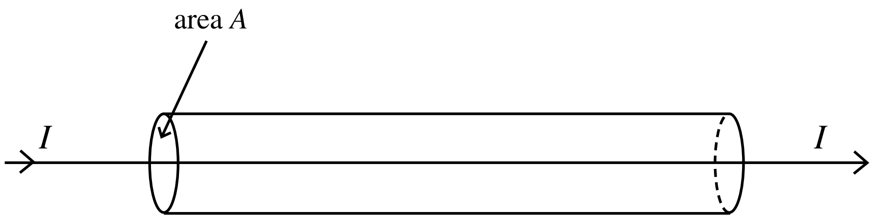



**Fig. 5.1**

The number density of charge carriers in the metal is $n$.

**(a)** Explain what is meant by **the direction of a conventional current**.

________________________________________________

______________________________________________ [1]

**(b)** Derive the relationship

$$I = nAve$$ **Equation 5.1**

between the current, the drift speed $v$ of the charge carriers and the charge $e$ of a carrier.

[4]

Examiner Only

Marks | Remark

**(c)** A copper wire is 2.8 m long and has diameter 1.2 mm.

**(i)** This length of wire contains $2.7 \times 10^{23}$ charge carriers. Show that the number density of charge carriers in the wire is $8.5 \times 10^{28}\,\mathrm{m^{-3}}$.

[2]

**(ii)** The wire carries a current of 3.5A. Calculate the drift speed of charge carriers in the wire.

Drift speed = ___________________ $\mathrm{m\,s^{-1}}$ [2]

**(d)** The number density of charge carriers is an important quantity in determining the electrical properties of a metal. Because the number density appears in the relatively simple **Equation 5.1**, it might be thought that it would be easy to measure experimentally. However, it is not practicable to use **Equation 5.1** to obtain $n$ directly. Suggest why this is the case.

______________________________________________________________

______________________________________________________________

____________________________________________________________ [1]

| Examiner Only | |
|---|---|
| Marks | Remark |

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

______________________________________________

______________________________________________

______________________________________________ [1]

**(b)** **(i)** An aluminium wire is 1.5 m long and has a radius of 0.56 mm. When the current in the wire is 0.32 A, the potential difference between the ends of the wire is 0.013 V. Calculate the resistivity of aluminium.

Resistivity = ______________ $\Omega$ m [4]

| Examiner Only | |
|---|---|
| Marks | Remark |

**(ii)** This aluminium wire (wire A) is now replaced with a different aluminium wire (wire B), of length 1.5 m (the **same** as before) but of radius 0.28 mm (**half** the previous value). State how the resistance and the 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:

_______________________________________________

_______________________________________________

**Resistivity** of wire B compared with resistivity of wire A:

_______________________________________________

Reasoning:

_______________________________________________

_______________________________________________ [4]

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

| Examiner Only | |
|---|---|
| Marks | Remark |

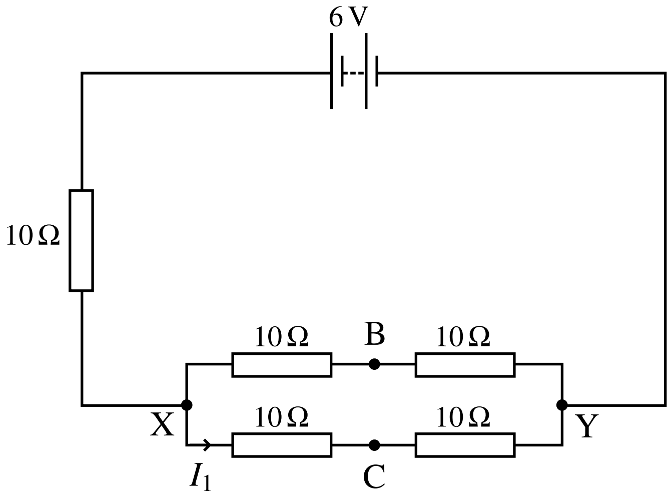



**Fig. 7.1**

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

Resistance = ______________ Ω [2]

**(ii)** Hence determine the current $I_1$.

Current = ______________ A [2]

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

______________________________________________________________________

______________________________________________________________________ [1]

| Examiner Only | |
|---|---|
| Marks | Remark |
| | |

**THIS IS THE END OF THE QUESTION PAPER**

# GCE Physics (Advanced Subsidiary and Advanced)

## Data and Formulae Sheet

*Values of constants*

| | |
|---|---|
| speed of light in a vacuum | $c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$ |
| permeability of a vacuum | $\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$ |
| permittivity of a vacuum | $\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$ <br> $\left(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\ \mathrm{F^{-1}\,m}\right)$ |
| elementary charge | $e = 1.60 \times 10^{-19}\ \mathrm{C}$ |
| the Planck constant | $h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$ |
| unified atomic mass unit | $1\ \mathrm{u} = 1.66 \times 10^{-27}\ \mathrm{kg}$ |
| mass of electron | $m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$ |
| mass of proton | $m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$ |
| molar gas constant | $R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$ |
| the Avogadro constant | $N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$ |
| the Boltzmann constant | $k = 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$ |
| gravitational constant | $G = 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$ |
| acceleration of free fall on the Earth's surface | $g = 9.81\ \mathrm{m\,s^{-2}}$ |
| electron volt | $1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$ |

ASY11INS

# USEFUL FORMULAE

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

## Mechanics

| | |
|---|---|
| Momentum-impulse relation | $mv - mu = Ft$ for a constant force |
| Power | $P = Fv$ |
| Conservation of energy | $\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Fs$ for a constant force |

## Simple harmonic motion

| | |
|---|---|
| Displacement | $x = x_0 \cos \omega t$ or $x = x_0 \sin \omega t$ |
| Velocity | $v = \pm\omega\sqrt{x_0{}^2 - x^2}$ |
| Simple pendulum | $T = 2\pi\sqrt{l/g}$ |
| Loaded helical spring | $T = 2\pi\sqrt{m/k}$ |

## Medical physics

| | |
|---|---|
| Sound intensity level/dB | $= 10 \lg_{10}(I/I_0)$ |
| Sound intensity difference/dB | $= 10 \lg_{10}(I_2/I_1)$ |
| Resolving power | $\sin \theta = \lambda/D$ |

## Waves

| | |
|---|---|
| Two-slit interference | $\lambda = ay/d$ |
| Diffraction grating | $d \sin \theta = n\lambda$ |

## Light

| | |
|---|---|
| Lens formula | $1/u + 1/v = 1/f$ |

## Stress and Strain

| | |
|---|---|
| Hooke's law | $F = kx$ |
| Strain energy | $E = <F> x$ $(= \frac{1}{2}Fx = \frac{1}{2}kx^2$ if Hooke's law is obeyed) |

## Electricity

| | |
|---|---|
| Potential divider | $V_{out} = R_1V_{in}/(R_1 + R_2)$ |

## Thermal physics

| | |
|---|---|
| Average kinetic energy of a molecule | $\frac{1}{2}m<c^2> = \frac{3}{2}kT$ |
| Kinetic theory | $pV = \frac{1}{3}Nm<c^2>$ |

## Capacitors

| | |
|---|---|
| Capacitors in series | $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ |
| Capacitors in parallel | $C = C_1 + C_2 + C_3$ |
| Time constant | $\tau = RC$ |

## Electromagnetism

Magnetic flux density due to current in

| | |
|---|---|
| (i) long straight solenoid | $B = \frac{\mu_0 NI}{l}$ |
| (ii) long straight conductor | $B = \frac{\mu_0 I}{2\pi a}$ |

## Alternating currents

| | |
|---|---|
| A.c. generator | $E = E_0 \sin \omega t$ $= BAN\omega \sin \omega t$ |

## Particles and photons

| | |
|---|---|
| Radioactive decay | $A = \lambda N$ $A = A_0 e^{-\lambda t}$ |
| Half life | $t_{\frac{1}{2}} = 0.693/\lambda$ |
| Photoelectric effect | $\frac{1}{2}mv^2_{max} = hf - hf_0$ |
| de Broglie equation | $\lambda = h/p$ |

## Particle Physics

| | |
|---|---|
| Nuclear radius | $r = r_0 A^{\frac{1}{3}}$ |