H

NATIONAL JUNIOR COLLEGE
Preliminary Examination
Higher 1

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS
Paper 2 Structured Questions

8866/02
01 September 2014
2 hours

Candidate answers on the Question Paper.
No Additional Materials are required.

READ THE INSTRUCTION FIRST
Write your subject class, registration number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **two** questions.
Circle the question number attempted on this cover page.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 6
2	/ 10
3	/ 8
4	/ 7
5	/ 9
6	
7	
8	
Total (80m)	

This document contains 19 printed pages, including this cover page.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ ms^{-1}$
elementary charge,	$e = 1.60 \times 10^{-19}\ C$
the Planck constant,	$h = 6.63 \times 10^{-34}\ Js$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ kg$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ kg$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ kg$
acceleration of free fall,	$g = 9.81\ ms^{-2}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$, $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$

Section A

Answer **all** the questions in this section.

1(a) The travelling microscope may be read to ± 0.1 mm. Discuss whether it would be possible to use this apparatus to detect a variation of 1% in the diameter of the tube between two points 25 mm apart.

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1(b) To reduce random error, we can take the average of several readings of a quantity. Explain why taking average of a few readings can reduce random error.

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1(c) 'Velocity is a vector quantity, and kinetic energy of a body is equal to half its mass times the square of its velocity. Hence, kinetic energy must also be a vector.' Comment on the correctness of this statement.

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2(a) State the conditions necessary for the equations of motion, $v = u + at$ and

$v^2 = u^2 + 2as$, to be applicable.

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2(b) An elevator starts at rest on the ninth floor. At t = 0 s, a passenger pushes a button to go to another floor. **Fig. 2.1** shows the acceleration, a_y, of the elevator as a function of time.

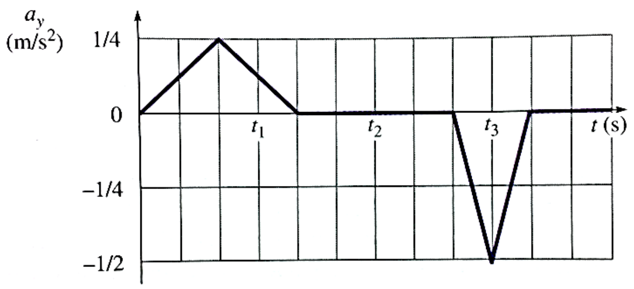

Fig 2.1

2(b) **(i)** State and explain if the passenger has gone to a higher or lower floor.

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....[2]

(ii) Sketch a graph of velocity, v_y, of the elevator with time.

[2]

2(c) When baseball players throw the ball in from the outfield, they usually allow it to take one bounce before it reaches the infield, shown in path 1 in **Fig. 2.2.** The ball's speed is half of what it was before the bounce.

Path 2 is when the ball is thrown such that it does not bounce.

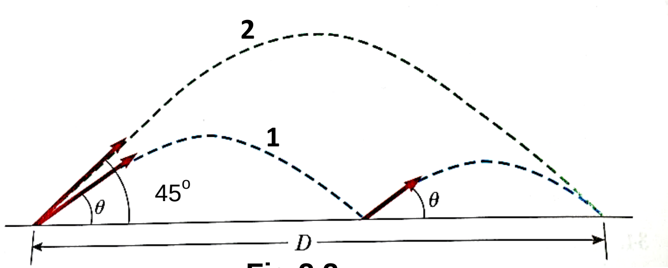

Fig 2.2

(i) Determine the angle θ. You may assume that the player will always throw at the same speed.

angle θ = ...° [2]

(ii) Determine the ratio of the time interval for path 1 to the flight time for path 2.

Ratio = ...[2]

3(a) State the Principle of Conservation of Momentum.

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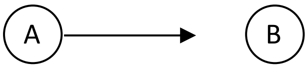
3(b) A billiard ball, ***A*** collides head-on with stationary billiard ball ***B*** of mass 150 g as shown below.



The force exerted on ball ***B*** by ball ***A*** varies with time as shown below.

(i) Calculate the speed of ball ***B*** after the collision.

Speed of ball **B** = ………………………m s^{-1} [2]

(ii) Explain, using Newton's 3rd law of motion, the relationship between the impulse experienced by ***A*** and the impulse experienced by ***B*** during impact.

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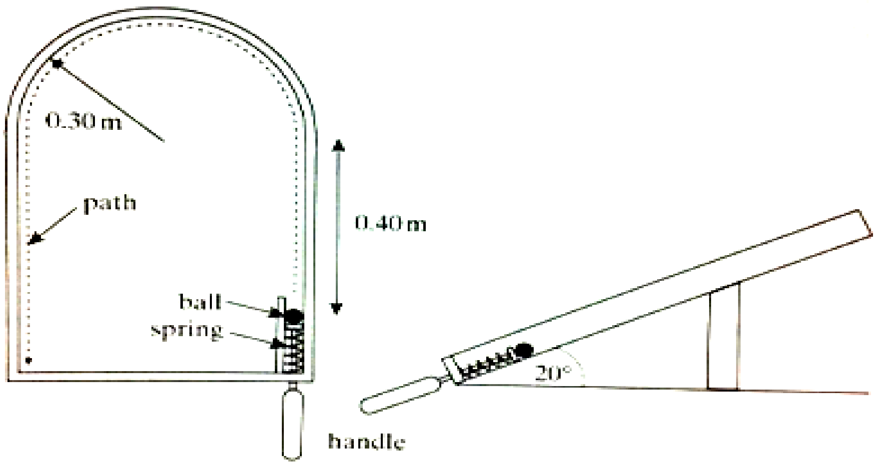
………………………………………………………………………………………………[2]

3(c) Ball ***B*** travelled towards the edge of the table and rolls off the edge with negligible speed. A net is placed 1.0 m below the table to catch the ball. Ball ***B*** lands on the net and is brought to a complete stop in a time of 0.50 s. Calculate the average force exerted on the net by ball ***B***.

Average Force = …………………….N [3]

4 In the bagatelle board shown in the diagram, energy stored in a compressed spring is released to project a ball of mass 50 g along the surface of the board, which has a raised end and is inclined at 20^o to the horizontal.



The diagram shows the ball resting on the relaxed spring. Pulling on the handle with a force of 6.15 N compresses the spring by 50 mm and when the handle is released, the ball follows a path marked by the dashed line. Assume that frictional losses and the kinetic energy of the handle and spring are negligible. Ignore the effect of spin.

4(a) **(i)** Calculate the speed of the ball as it reaches the top of the curve section.

Speed of the ball = ……………………… $m\ s^{-1}$ [2]

4(a) **(ii)** Draw a free body diagram showing all the forces acting on the ball at the instance in **4(a)(i)**.

[2]

4(b) Show that the speed calculated in part 4**(a)(i)** is just sufficient for the ball to complete the path shown, explaining your reasoning.

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5 (a) Electrons can sometimes be assumed to be particles and sometimes it is necessary to consider them having a wavelength.

Describe briefly an example of a situation in which an electron is considered as a particle and another example where it is considered as a wave.

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5(b) A beam of 40 eV electrons traveling in the positive x-direction passes through a slit that is parallel to the y-axis and 5.0 μm wide. The diffraction pattern is recorded on a screen 2.5 m from the slit.

5(b) (i) What is the speed of the electrons?

Speed of electron = ………………………… m s^{-1} [1]

5(b) (ii) In single-slit diffraction, the first minima of the central diffraction pattern occurs at $\sin\theta = \frac{\lambda}{D}$, where *D* is the width of the slit. Based on the angle of diffraction of the first minima of the central diffraction pattern, calculate the maximum y-component of the momentum of an electron just after it has passed through the slit.

P_y = ……………………..N s [2]

5(b) (iii) Hence, estimate the minimum uncertainty in the y-coordinate of an electron just after it has passed through the slit.

Δ y = …………………… m [3]

Section B

Answer **two** of the questions in this section.

6(a) State the conditions for the equilibrium of a body which is acted upon by a number of forces.

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6(b) A landscape gardener wanted to lift a uniform stone paving slab on a step. The gardener inserted the end of a long non-uniform metal bar under the slab and arranged the system as shown in **Fig. 6.1.**

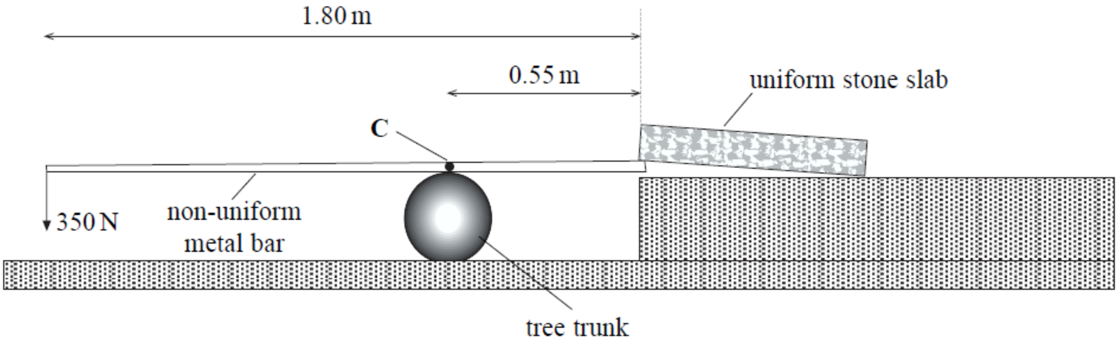

Figure 6.1

The tree trunk was positioned so that the metal bar was pivoted at its centre of mass **C**. The gardener just managed to lift the end of the slab by exerting a downward force of 350 N on the end of the bar.

6(b) **(i)** Show on **Fig. 6.1** all the other forces acting on the metal bar when it just lifted the end of the slab. [2]

6(b) **(ii)** **1.** Calculate the lifting force exerted on the edge of the slab;

Lifting force= ……………………………N [3]

6(b) **(ii)** **2.** Find the weight of the uniform stone stab.

Weight = ……………………….. N [1]

6 (c) Starting with the definition of work, deduce the change in gravitational potential energy of a mass ***m***, when moved a distance ***h*** upwards against a gravitational field of field strength ***g***.

[2]

6(d) **Fig. 6.2** shows the principle of a hydroelectric pumped storage plant. During times when there is a low demand for electricity, the spare capacity of other power stations is used to pump water from the lake into the reservoir. The potential energy of the water is then converted into electricity when needed to satisfy peak demands.

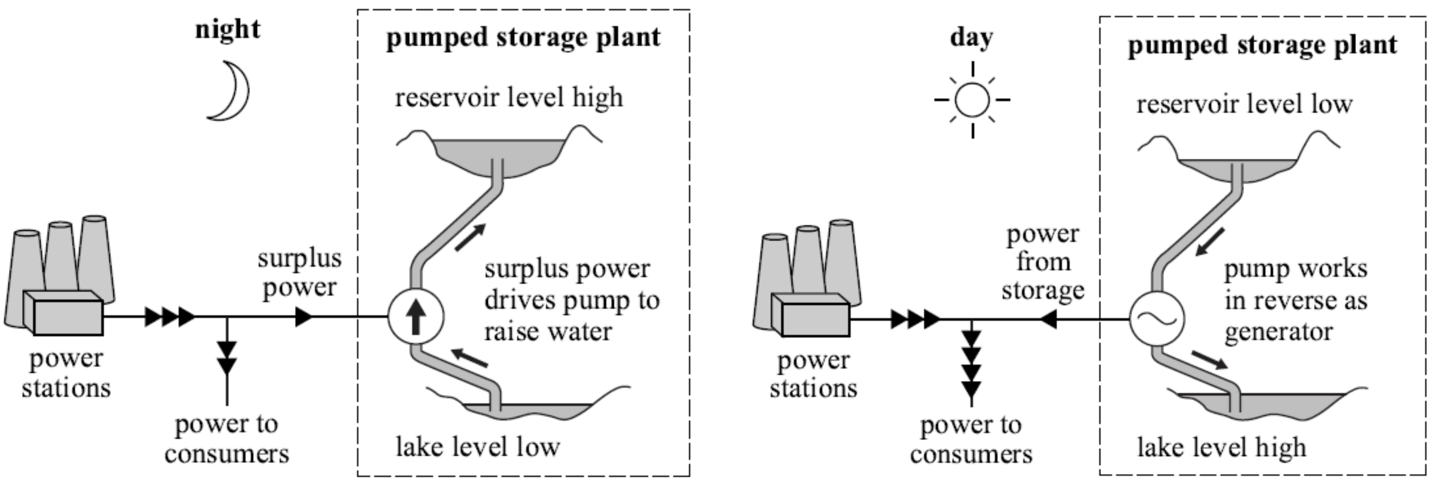

Figure 6.2

For this plant the water falls a mean distance of 370 m between the reservoir and the generator. The mass of water stored in the reservoir when it is full is 1.0×10^{10} kg.

6(d) **(i)** Show that the useful gravitational potential energy stored when the reservoir is full is about 4×10^{13} J.

[2]

6(d) **(ii)** Calculate the speed of the water as it reaches the generator assuming that no energy is lost as the water falls.

Speed of water = …………………………… m s^{-1} [2]

6(d) **(iii)** The pumped storage plant has four 100 MW generators. Calculate the longest time, in hours, for which the stored energy alone could provide power at maximum output. Assume that all the stored gravitational potential energy can be converted into electrical energy.

Time = ………………………….. hours [3]

6(e) In practice not all the stored energy that is put into the system during the night can be retrieved as electrical energy during the day. State and explain how energy is lost in the system.

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7(a) State the *Principle of Superposition*.

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7(b) In order to investigate stationary waves on a stretched steel wire, a student set up the apparatus as shown in **Fig. 7.1.**

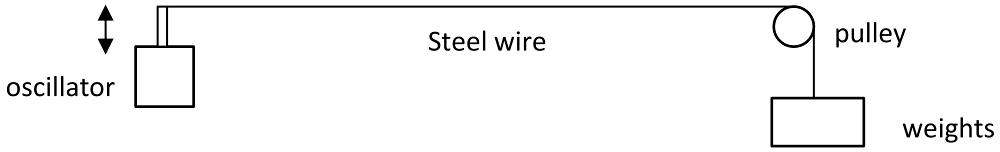

Figure 7.1

7(b) (i) Explain why it is usually necessary to adjust either the vibrating length of the wire or the frequency of the oscillator in order to obtain observable stationary waves on the wire.

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7(b) (ii) What is meant by a node? Explain why a node must exist at the pulley.

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7(b) (iii) The distance between successive nodes on the string is 16.0 cm when the frequency of the oscillator is 75 Hz. Calculate the speed of on the string.

Speed = ………………… m s^{-1} [3]

7(b) **(iv)** Instead of an oscillator, a magnet placed in the middle of the set up can also cause the steel wire to form a stationary wave when an alternating current (current which change direction periodically) is passed through the wire. Explain how the stationary wave is formed.

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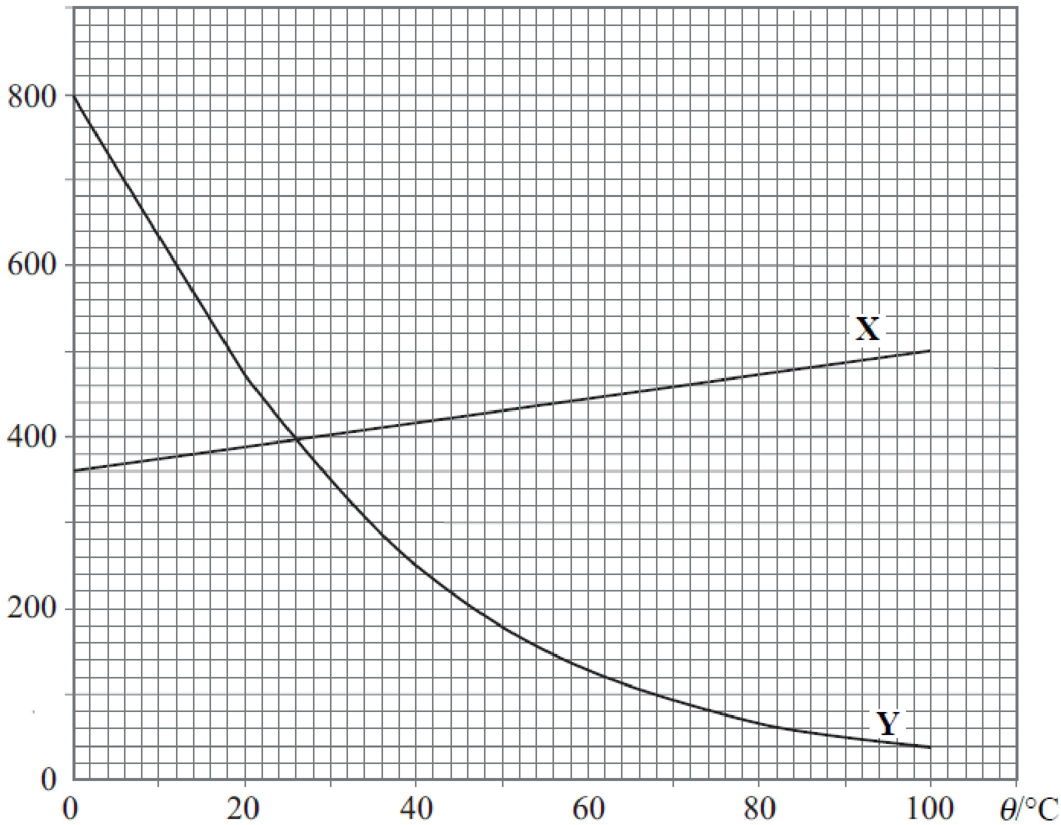
7(c) **Fig 7.2** shows how the resistance ***R*** of two components ***X*** and ***Y*** varies with temperature θ.



7(c) **(i)** **1.** State whether **X** or **Y** is a resistor made of metal wire.

……………………………………………………………………………………………….[1]

2. State the name of the other component.

……………………………………………………………………………………………….[1]

7(c) **(ii)** Explain in terms of the charge carriers why the resistance of component **X** increases when temperature increases whilst that of component **Y** decreases.

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7(c) **(iii)** **1.** In one experiment, the components **X** and **Y** were connected in parallel and were found to carry the same current. State the temperature at which the experiment was performed.

Temperature = ………………………….^{o}C [1]

2. In another experiment the components **X** and **Y** were connected in series to a 4.5 V supply that had negligible internal resistance. The experiment was carried out at a temperature of 70 ^{o}C. Calculate the current in the circuit.

Current = …………………………. A [2]

8(a) Some energy levels of an atom of a gas are shown in **Fig. 8.1**

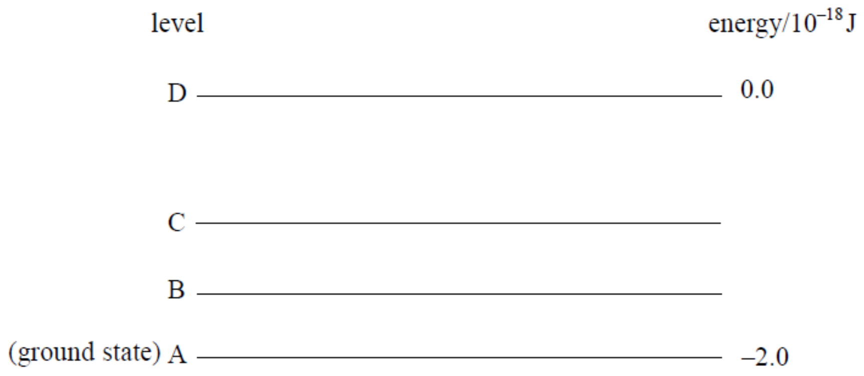

Figure 8.1

When a current is passed through the gas at low pressure, a line spectrum is produced. Two of these lines, which correspond to transitions from levels **B** and **C** respectively to the ground state, are shown in **Fig. 8.2.**

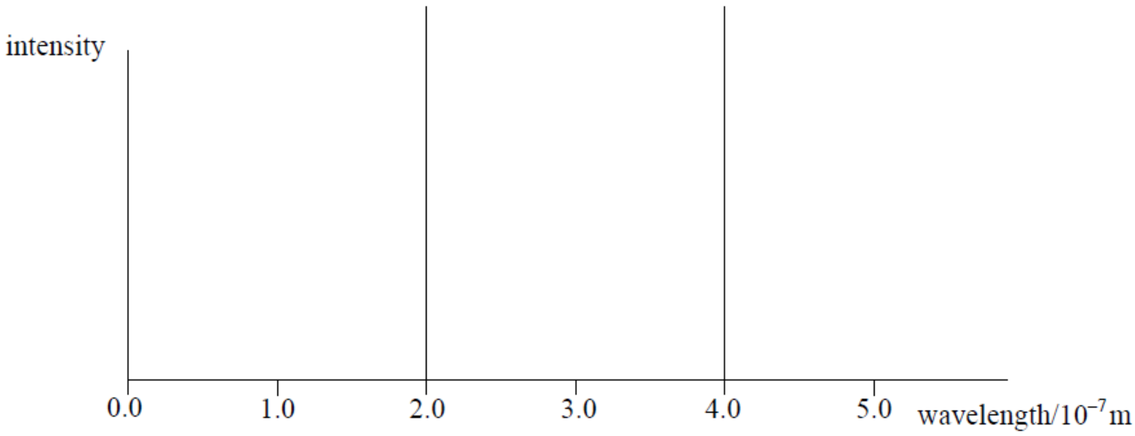

Figure 8.2

8(a) **(i)** Without calculation, describe how the energy levels shown in **Fig. 8.1** can be used to explain the spectrum observed in **Fig. 8.2.**

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....[3]

8(a) **(ii)** Determine the energy of

1. the photons responsible for each of the two lines shown in **Fig. 8.2.**

[3]

2. levels **B** and **C** in **Fig. 8.1**.

Energy of level **B** = ………………J [1]

Energy of level **C** = ………………J [1]

8(a) **(iii)** Instead of using of a low current for the formation of a line spectrum, state and explain another method to produce a line spectrum from the gas.

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…………………………………………………………………………………………………[2]

8(b) **Fig. 8.3** show two circuits **X** and **Y** that were used by a student to test a battery of hree identical cells. In circuit **X** there was no load resistor and in circuit **Y** a load resistor was connected. You can assume that the meters in the circuits were ideal. Their readings are shown on each diagram.

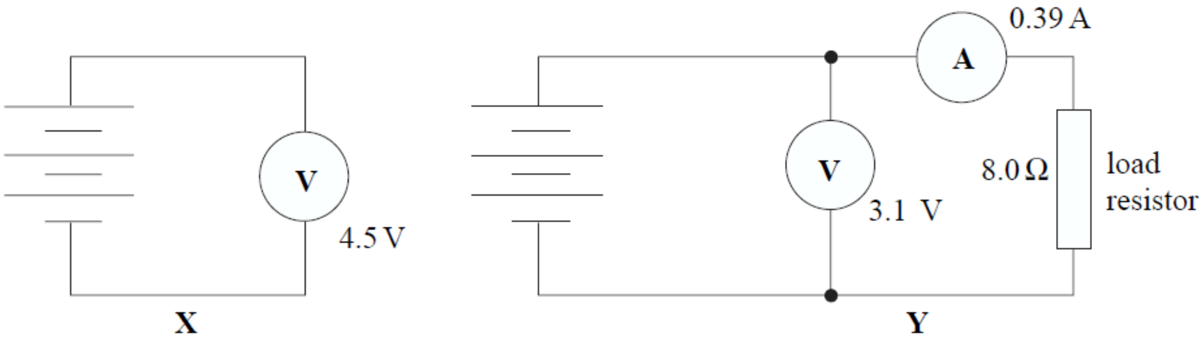

Figure 8.3

8(b) **(i)** Explain what is meant by the *internal resistance* of a battery and why this explains the difference between the voltages recorded in the two circuits.

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....[2]

8(b) **(ii)** Calculate the internal resistance of a single cell.

Internal resistance = ...Ω [3]

8(c) **Fig. 8.4** shows a linear potentiometer that is to be used as a position sensor. The output voltage to a computer interface depends on the position of the rigid bar B.

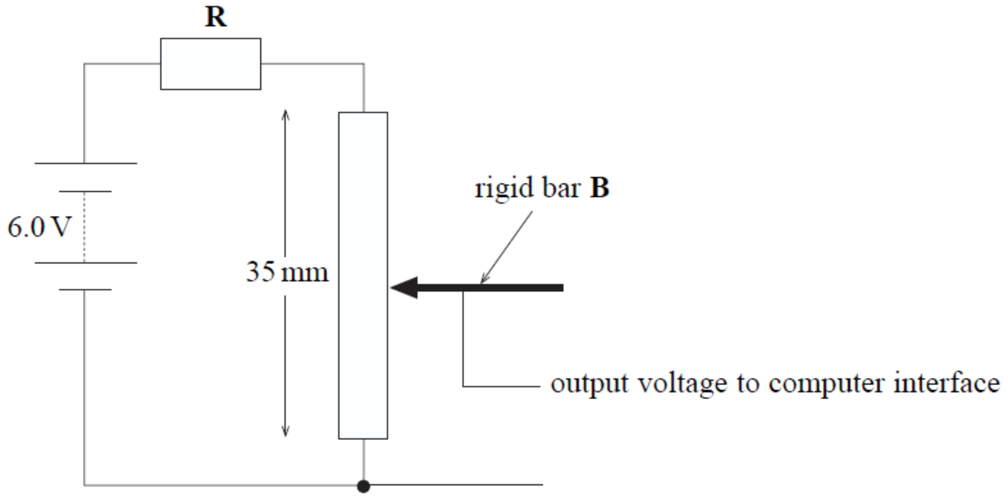

Figure 8.4

The total resistance of the variable resistor is 150 Ω. The circuit designer makes the maximum voltage to the computer interface equal to 4.0 V. The 6.0 V supply has negligible internal resistance.

8(c) (i) Show that the value of the resistor **R** is 75 Ω.

[2]

8(c) (ii) Calculate the total power dissipated in the circuit.

Total power dissipated = ……………………………… W [2]

8(c) (iii) The smallest voltage change that the computer can record is 0.40 V. Calculate the smallest movement of the rigid bar B that can be detected by the computer.

Smallest movement= ……………………………..mm [1]

--**End of Paper**--