Class	AdmNo

Candidate Name: ______________________________

H

millennia institute

2015 Preliminary Exam 2
Pre-university 2

H1 PHYSICS **8866 / 02**

Thursday **17 September 2015**

2 hours

Additional Materials: Nil

READ THESE INSTRUCTIONS FIRST

Do not turn over this page until you are told to do so.

Write your full name, class and index number in the spaces at the top of this page and 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 or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer all questions. Write your answers in the spaces provided on the question paper.

Sections B
Answer **TWO** questions. Write your answers in the spaces provided on the question paper. **Circle the 2 questions attempted on this cover page.**

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

The use of a calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

FOR EXAMINER'S USE	
Section A (40 marks)	
1	**/ 6**
2	**/ 9**
3	**/ 8**
4	**/ 10**
5	**/ 7**
Section B (40 marks)	
6	**/ 20**
7	**/ 20**
8	**/ 20**
TOTAL	**/ 80**

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
acceleration of free fall,	g	=	9.81 m s^{-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	=	$\rho g h$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots$

For Examiner's Use

Section A (40 marks)

Answer all the questions in this section.

1 Fig. 1.1 shows the displacement-time graph of a moving object from a point P.

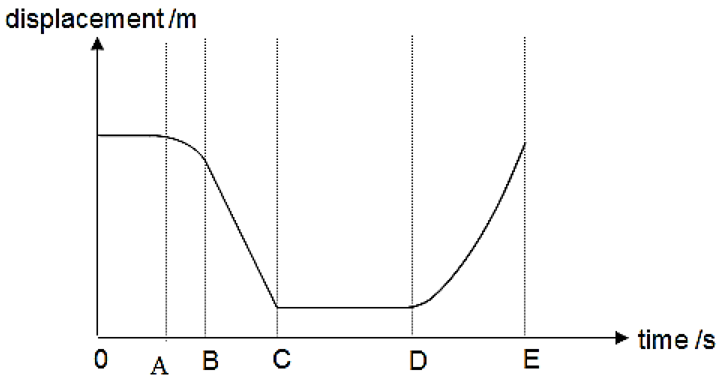

Fig. 1.1

A student describes the state of motion of the object for time interval A to B as follows:
"The object is moving away from point P. It is slowing down and is decelerating towards P."

(a) Comment and explain the validity of the student's description.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[3]

(b) Define velocity.

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

(c) Sketch the corresponding velocity-time graph of the object for the whole journey in Fig 1.2**.** [2]

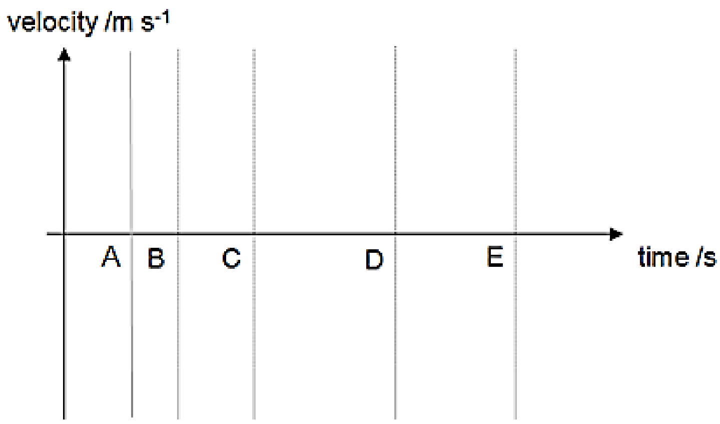

Fig. 1.2

2 One section of a motorway bridge is supported by 8 equally spaced cables that pass through a central supporting pillar, as shown in Fig. 2.1.

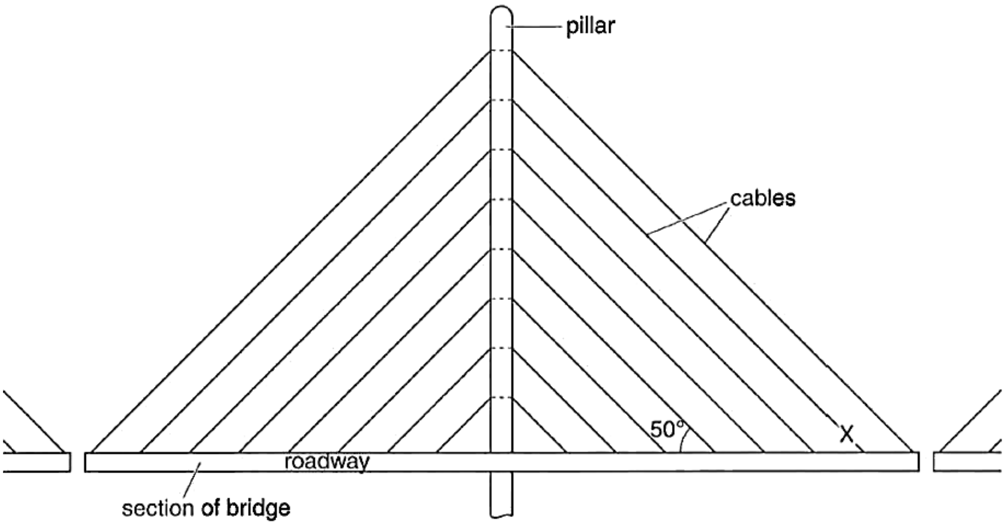

Fig 2.1

The cables are at an angle of 50° (not to scale) to the horizontal and the maximum tension allowed in each cable is 7.8×10^5 N.

(a) The mass of the roadway in this section is 350 tonnes (1 tonne = 1000 kg). Calculate the maximum mass of traffic that is allowed on this section of the roadway.

mass of traffic = …………………………….tonne [3]

(b) The force per unit extension for the cable marked X on Fig. 2.1 is 7.0×10^6 N m^{-1}. Calculate the increase in the extension of the cable when the tension in it increases by 5.2×10^5 N.

increase in extension = …………………………….. m [2]

For Examiner's Use

(c) Suggest a reason why

(i) the maximum tension allowed in each cable is well below the breaking tension,

....

....

.... [1]

(ii) there needs to be a flexible attachment between separate sections of the bridge,

....

....

.... [1]

(iii) in heavy traffic lorries are only allowed on to the bridge when there are cars in between them,

....

....

.... [1]

(iv) high-sided lorries, but not cars, are banned from the bridge when the wind is strong.

....

....

.... [1]

For Examiner's Use

3 **(a)** State the principle of superposition of waves.

....

....

....

....

....[1]

(b) A wave of amplitude X and intensity Y is incident with a second wave of amplitude $\sqrt{5}$X and intensity 5Y. Both waves have the same frequency.

Find the resultant amplitude and intensity in terms of X and Y when the two waves superpose with a phase difference of π radians.

Amplitude = ... [1]

Intensity = ... [1]

(c) In an experiment on superposition, light of wavelength 530 nm from a laser is incident normally on a double slits, and the interference pattern is observed on a screen situated at a distance D away from the slits.
The fringe separation x is measured for a number of different values of D, and a graph of D against x is plotted as shown in Fig. 3

For Examiner's Use

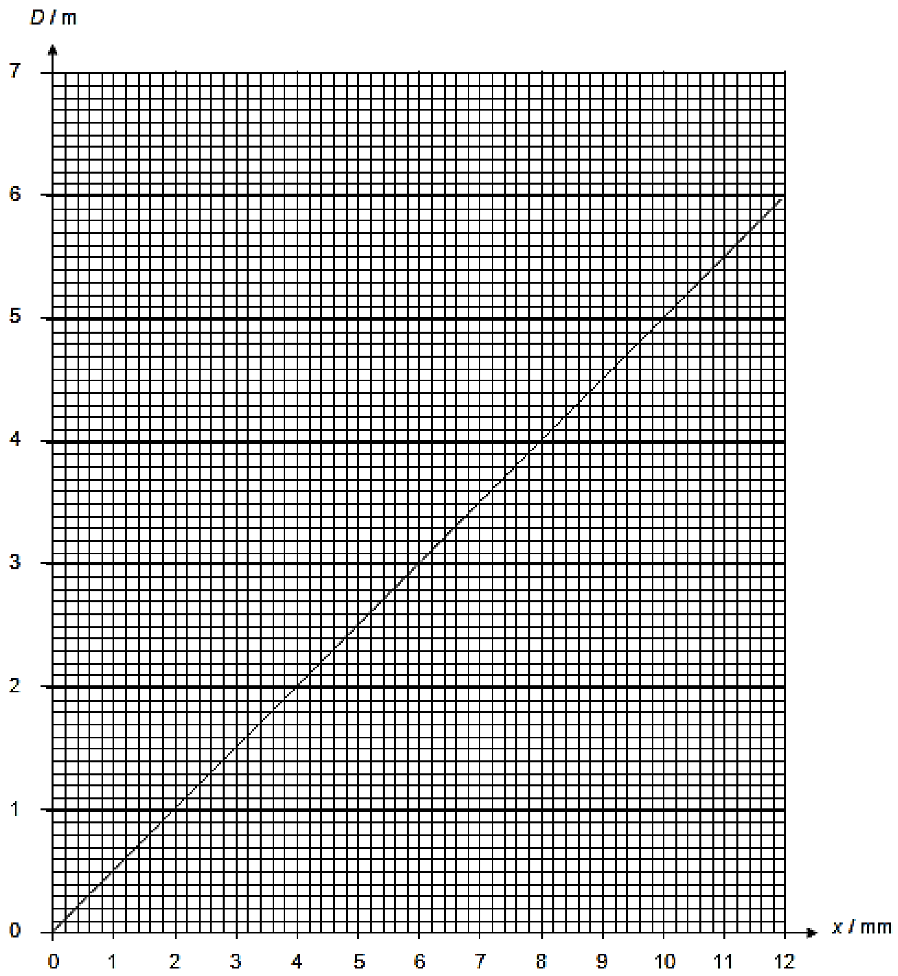

Fig 3

(i) Use the result from the graph to find a value for the separation between the double slits.

Separation between slits = ………………………. m [3]

(ii) The experiment in (c) is repeated with the slits separation reduced by halved.
Draw a new line Z on Fig 3 to represent the changes to relationship between D and x.
Describe the changes to the interference pattern when the slit separation is halved.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

[Turn over

4 The current-potential difference relationship for two electrical components P and Q is shown in Fig. 4.1.

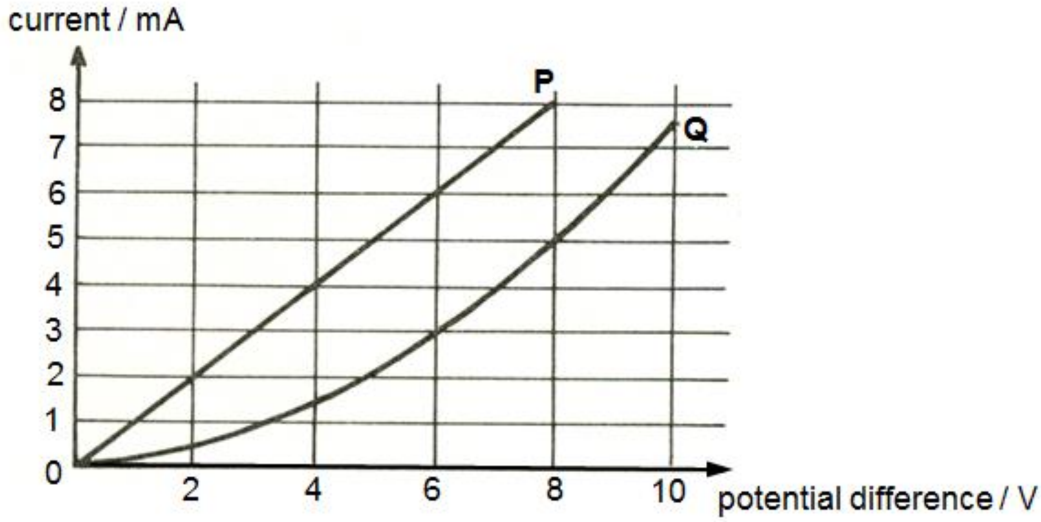

Fig 4.1

(a) Identify

(i) component P.

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

(ii) component Q.

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

(b) P and Q are connected in parallel. The current flowing through P is 6 mA.

(i) State the potential difference across Q.

potential difference across Q = …………V [1]

(ii) State the current flowing in Q.

current flowing in Q = ………….... mA [1]

For Examiner's Use

(iii) Determine the effective resistance if P and Q are considered as a single component.

effective resistance = …………………Ω [3]

(c) P and Q are now connected in series with a battery of internal resistance of 2 Ω.
The current flowing through P is 3 mA.

(i) Calculate the terminal potential difference across the battery.

terminal potential difference across the battery = …………V [2]

(ii) Calculate the rate of heat dissipated in the battery.

rate of heat dissipated by the battery = …………W [1]

For Examiner's Use

5 The graph in Fig. 5.1 shows how the acceleration of freefall g changes with distance from the centre of the Earth.
The distance from the centre of the Earth x is given in terms of the radius r of the Earth. At the centre of the Earth the value of the acceleration is zero and the value increases to the value of 9.8 m s^{-2} at the Earth's surface. From the surface of the Earth the value decreases as shown.

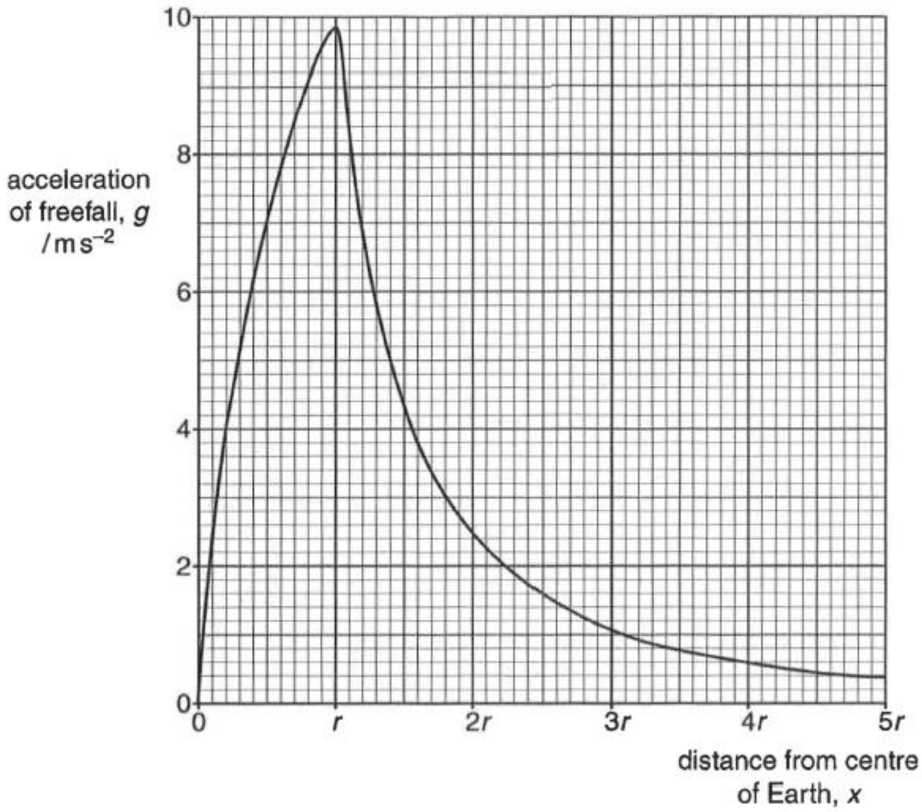

Fig 5.1

(a) Show, by taking readings from the graph, that g is inversely proportional to x^2, for distances beyond the Earth's surface. [3]

For Examiner's Use

(b) The centre of the Moon is at a distance of 60r from the centre of the Earth. Deduce the value of g at this distance.

g at the Moon's distance = ……………………… m s^{-2} [2]

(c) The International Space Station is at a height h above the Earth's surface. The value of g at this height is 8.81 m s^{-2}. Calculate h.
The radius of the Earth is 6370 km.

height of Station = ……………………… km [2]

Section B (40 marks)

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

6 The following data concern a tennis ball at a given instant just before it is struck by a tennis racket:

horizontal momentum of tennis ball = 2.4 N s,
kinetic energy of tennis ball = 45 J.

(a) Why is it correct to give direction of the momentum but not of the kinetic energy?

....

....[1]

(b) Write down in terms of the mass m and the velocity v of a body, expressions for

(i) the momentum,

....[1]

(ii) the kinetic energy.

....[1]

(c) Use your answer in **(b)** to help you to calculate the mass and velocity of the tennis ball.

mass = ... kg [1]

velocity = ... m s^{-1} [1]

(d) When the racket hits the ball it exerts an average force of 200 N in a direction opposite to its momentum, bringing the ball to rest momentarily. Calculate

(i) the time the tennis ball takes to stop,

time = ... s [2]

(ii) the distance the tennis ball travels before stopping.

distance = ... m [2]

For Examiner's Use

(e) A different average force of 160 N then continue to act on the tennis ball for a further 0.025 s. Calculate

(i) the new momentum of the ball,

momentum = ………………….. kg m s^{-1} [2]

(ii) the new velocity of the ball.

velocity = ………………….. m s^{-1} [1]

(f) Calculate the increase in kinetic energy of the ball for the whole time that a force is applied to it and hence deduce the mean power being delivered to the ball while it is in contact with the racket.

mean power = ………………………… W [3]

(g) Using Hooke's Law, suggest why, in practice, it is impossible for a constant force to be applied to the ball to decelerate it to zero velocity.

....

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

(h) As the tennis ball travels to the other end of the court, it hits and bounces off the rough ground. The arrow below gives the direction of the velocity of the ball just before contact. At the point where the ball is in contact with the ground, draw a free body diagram to show the forces acting on the ball, together with the action reaction pair for each force on the ball that is drawn.
Label all forces carefully in Fig 6.

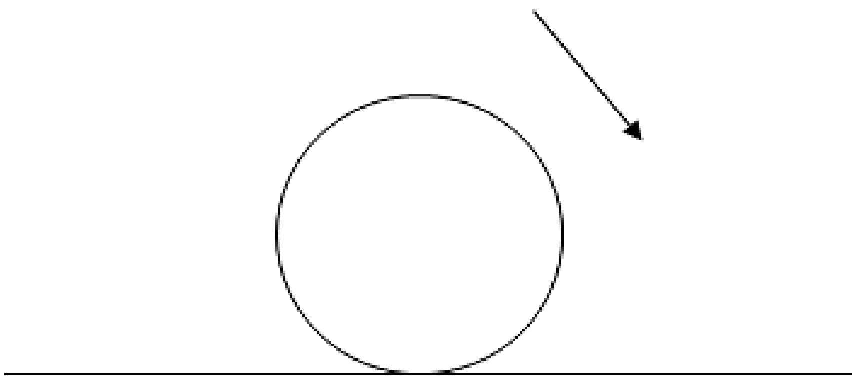

Fig 6 [3]

7 **(a)** Electromagnetic radiation is, in some circumstances, regarded as having a particulate nature and, in other circumstances, regarded as having a wave nature

(i) Describe and explain a phenomenon which provides evidence for the particulate nature of electromagnetic radiation.

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.... [4]

(ii) Describe and explain a phenomenon which provides evidence for the wave nature of electromagnetic radiation.

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.... [3]

For Examiner's Use

(b) Electrons can, in some circumstances, be considered to have a wave nature. Calculate the de Broglie wavelength of an electron travelling with a speed of 8.37×10^{6} m s^{-1}.

wavelength = ………………………… m [3]

(c) A hydrogen atom can be thought of as an electron in orbit around a proton. The orbiting electron can only have certain values of energy. These energy levels are numbered and the energy for each level is given in both joules and electron-volts in the table of Fig. 7.1 (a).

energy level *n*	energy / 10^{-19} J	energy / eV
1	−21.7	−13.6
2	−5.43	−3.40
3	−2.41	−1.51
4	−1.36	−0.85
5	−0.87	−0.54
6	−0.61	−0.38
7	−0.45	−0.28
∞	0	0

Fig. 7.1(a)

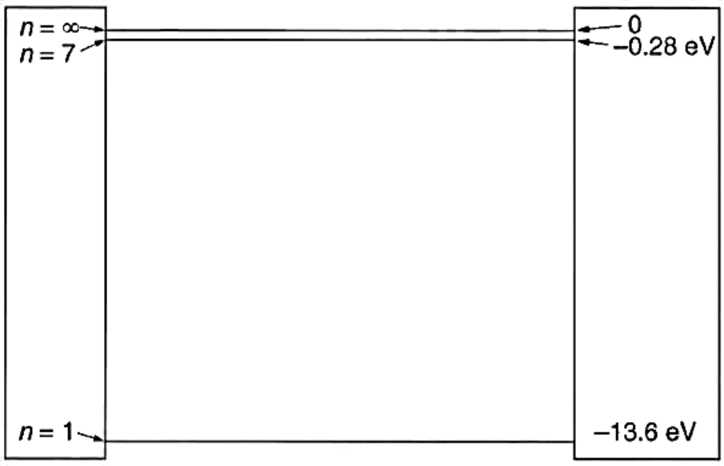

Fig. 7.1(b)

(i) Without making any precise measurements, give an indication of the relative separations between energy levels by completing Fig. 7.1 (b) for the other five values in the table. [2]

(ii) On Fig. 7.1 (b), draw six arrows to show energy released when an electron moves to level 1 from each of the levels *n* = 2,3,4,5,6 and 7. [1]

(iii) Calculate the wavelength of radiation emitted when an electron moves from energy level 4 to energy level 2.

wavelength = …………………… m [3]

(iv) State the type of electromagnetic radiation that corresponds to your answer in (iii).

radiation is ……………………… [1]

(v) State the type of electromagnetic radiation released when any electron moves to level 1.

radiation is ……………………… [1]

(d) The theory that originally gave rise to all the values quoted in the table, Fig. 7.1(a), is very successful in predicting the energy levels for atomic hydrogen, which has just one orbiting electron. Suggest why it is far less successful in predicting the energy levels in any other atom.

………………………………………………………………………………………..

………………………………………………………………………………………..

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……………………………………………………………………………………… [2]

8 **(a)** A coil of 1500 turns of insulated wire is tightly wound on a non-magnetic tube to make a solenoid of mean radius 22 mm, as shown in Fig. 8.1. The wire itself has radius 0.86 mm and is made of a material of resistivity 1.7×10^{-8} Ω m. The coil is connected to a supply of e.m.f. 12 V and negligible internal resistance.

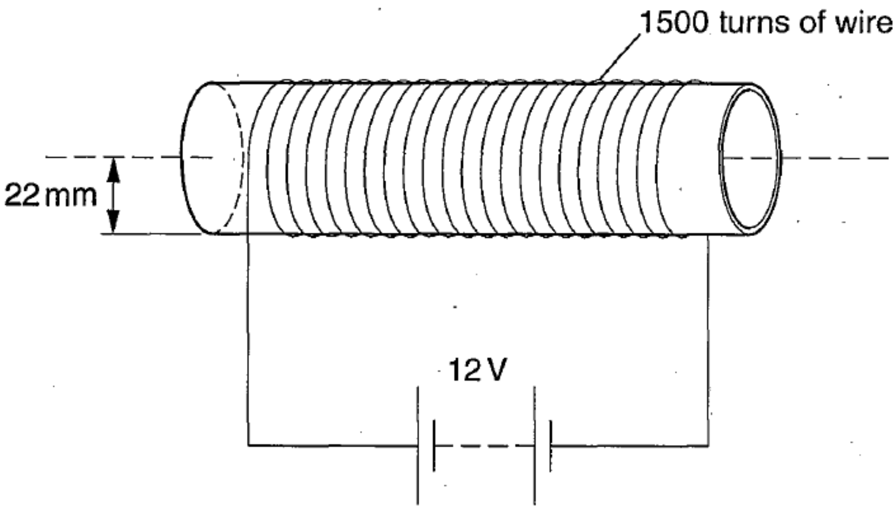

Fig 8.1

Calculate

(i) the total length of wire in the coil,

length = …………………… m [2]

(ii) the total resistance of the coil,

resistance = …………………… Ω [3]

(iii) the current in the coil.

current = …………………… A [2]

(b) On Fig. 8.1, draw the pattern of the magnetic field within and around the solenoid. Use arrows to show the direction of the field inside the solenoid. [3]

For Examiner's Use

(c) The magnetic flux density in the solenoid is measured using a current balance. The current balance is a U-shaped piece of stiff wire ABCDEF pivoted at BE, as shown in Fig. 8.2.

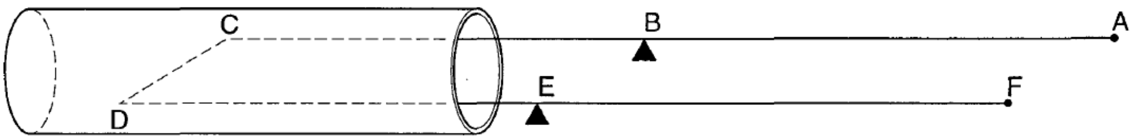

Fig 8.2

When in use, there is a turning force on the stiff wire caused by a current in CD.

(i) Explain why the current in CD causes a turning effect.

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....

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....

....

.... [3]

(ii) Explain why currents in CB and DE do not contribute to the turning force.

....

....

....

.... [1]

For Examiner's Use

(iii) CD has length 25 mm, CB and DE each has length 106 mm.

The stiff wire is first balanced when there is no current in it. A current of 4.9 A is then passed through CD and, in order to rebalance the stiff wire, a force of 5.7 x 10^{-4} N is applied at a distance of 77 mm from the pivot, as shown in the side view of the balance, Fig. 8.3.

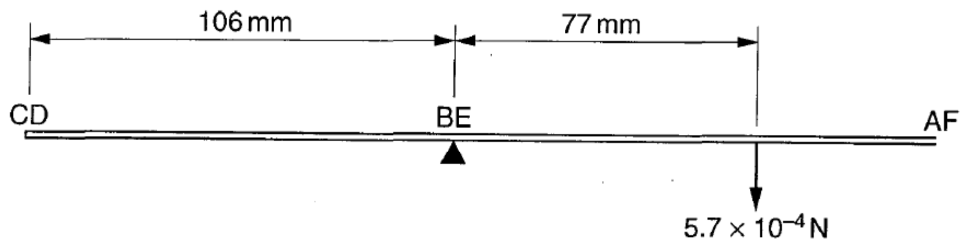

Fig 8.3 (side view)

1. What is the direction of the current in CD?

direction = ... [1]

2. Calculate the magnetic flux density in the solenoid. Give the full name of the unit for magnetic flux density.

magnetic flux density = ...

full name of unit ....

[5]

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