THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

PHYSICS A

Telecommunications

2825/05

Candidates answer on the question paper

OCR Supplied Materials:
None

Other Materials Required:
- Electronic calculator

Tuesday 27 January 2009
Morning

Duration: 1 hour 30 minutes

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **90**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- The first five questions concern Telecommunications. The last question concerns general physics.
- This document consists of **16** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**13**	
2	**18**	
3	**16**	
4	**15**	
5	**8**	
6	**20**	
TOTAL	**90**	

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
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 constant,	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
rest 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,	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall,	$g = 9.81\ \mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
refractive index,	$n = \dfrac{1}{\sin C}$
capacitors in series,	$\dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \ldots$
capacitors in parallel,	$C = C_1 + C_2 + \ldots$
capacitor discharge,	$x = x_0 e^{-t/CR}$
pressure of an ideal gas,	$p = \frac{1}{3}\dfrac{Nm}{V}<c^2>$
radioactive decay,	$x = x_0 e^{-\lambda t}$
	$t_{\frac{1}{2}} = \dfrac{0.693}{\lambda}$
critical density of matter in the Universe,	$\rho_0 = \dfrac{3H_0^2}{8\pi G}$
relativity factor,	$= \sqrt{(1 - \dfrac{v^2}{c^2})}$
current,	$I = nAve$
nuclear radius,	$r = r_0 A^{1/3}$
sound intensity level,	$= 10 \lg\left(\dfrac{I}{I_0}\right)$

Answer **all** the questions.

1 Fig. 1.1 shows a noisy FM radio signal being picked up by an aerial.

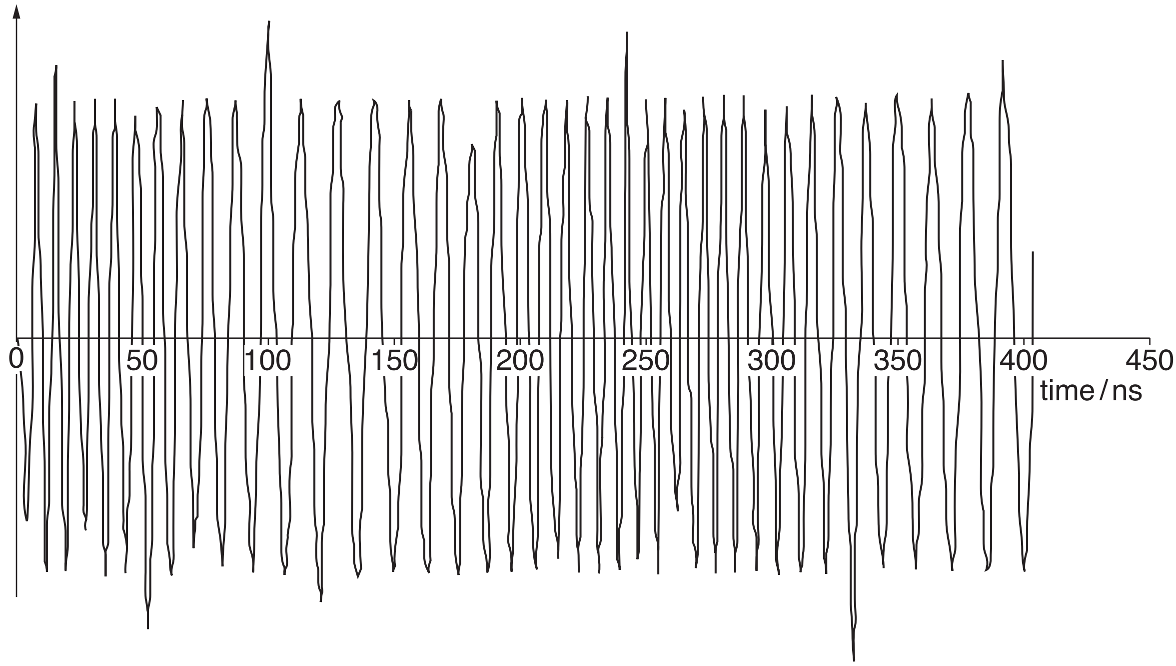

Fig. 1.1

(a) State what is meant by FM and explain how the signal has been formed from its components.

....

....

.... **[2]**

(b) Use information from Fig. 1.1 to estimate

(i) the **carrier** frequency of the signal

carrier frequency = ... MHz **[2]**

(ii) the **modulating** frequency in the transmission.

modulating frequency = ... MHz **[2]**

(c) (i) State what is meant by *noise* in telecommunications.

....

.... **[1]**

(ii) Explain why the signal shown in Fig. 1.1 is referred to as *noisy*.

....

....

.... **[2]**

(d) (i) State and explain **one** advantage of FM over AM in the transmission of radio signals.

....

....

.... **[2]**

(ii) State and explain **one** disadvantage of FM over AM in the transmission of radio signals.

....

....

.... **[2]**

[Total: 13]

2 Fig. 2.1 shows a demonstration set up by a teacher to show parallel transmission. Voltmeters V_1 and V_2 are moving-coil voltmeters.

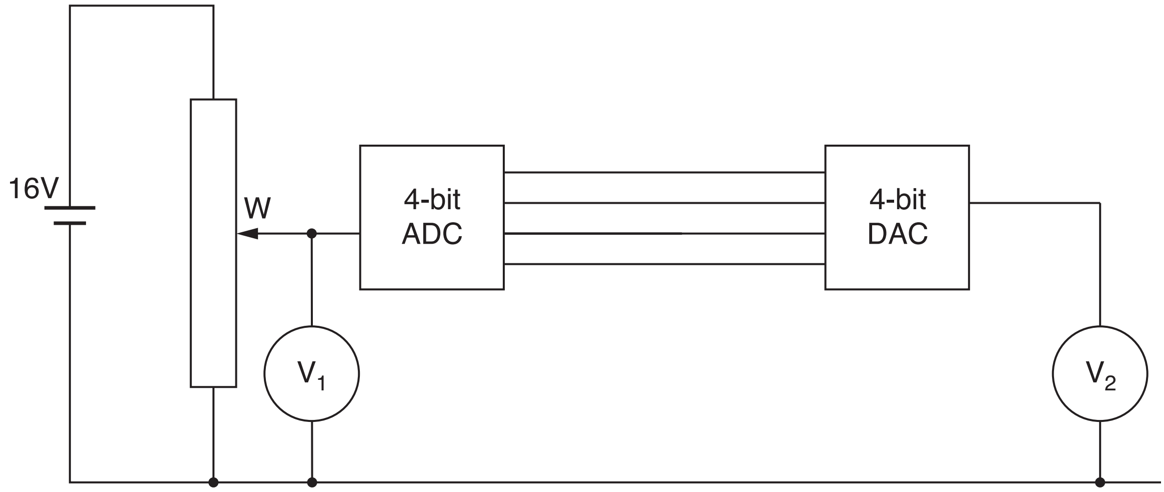

Fig. 2.1

(a) The signal monitored on the voltmeter V_1 is known as an *analogue* signal. State **two** characteristics of an analogue signal.

....

.... **[2]**

(b) Fig. 2.1 shows a 4-bit ADC and a 4-bit DAC. State what is meant by these abbreviations.

ADC ....

DAC .... **[2]**

(c) The teacher moves the wiper W of the potentiometer at a steady speed from its zero output position to its maximum output position over a period of 8 seconds. The wiper is held in the maximum output position for 4 seconds after which time it is steadily returned to zero over a further 8 seconds.

(i) On the axes of Fig. 2.2, draw the variation of the reading V_1 on voltmeter V_1 with time. Label the voltage axis with appropriate values. **[3]**

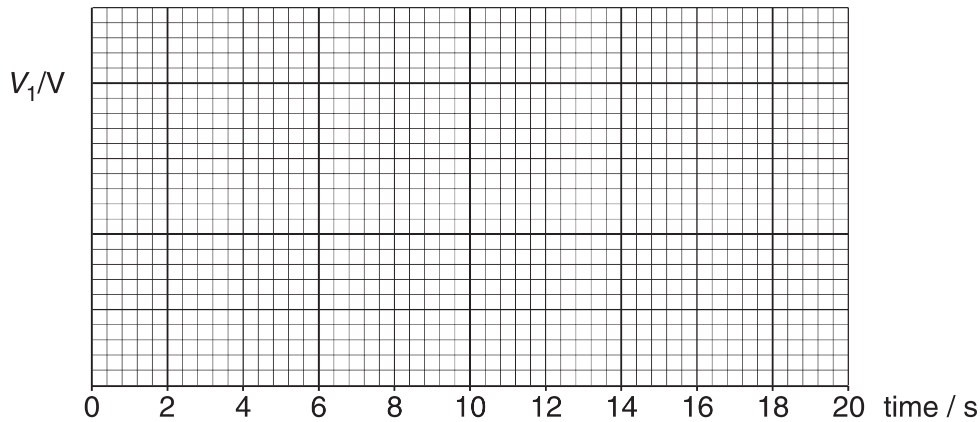

Fig. 2.2

(ii) On the axes of Fig. 2.3, draw the variation V_2 of the reading on voltmeter V_2 with time. Label the voltage axis with appropriate values. **[3]**

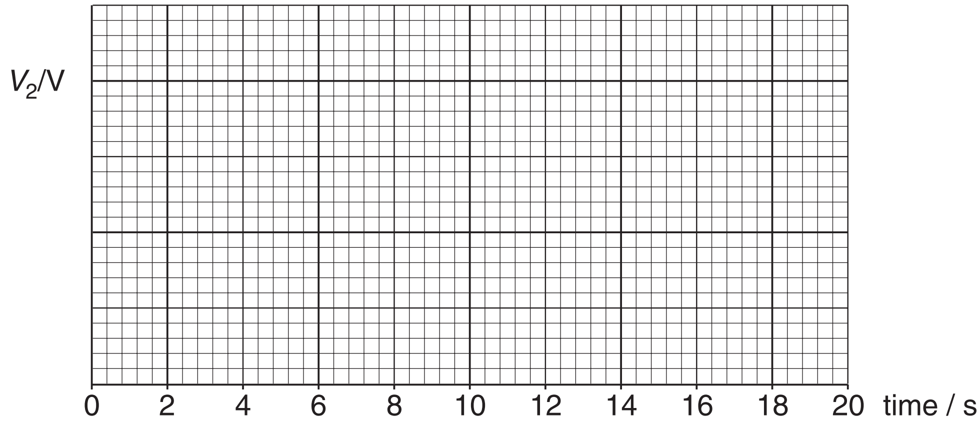

Fig. 2.3

(iii) With reference to the outputs of the ADC and DAC, explain the differences between the graphs in Fig. 2.2 and Fig. 2.3.

....

....

....

....

....

.... **[3]**

(d) (i) The signal from the ADC in Fig. 2.1 is being transmitted in parallel to the DAC. Explain why parallel transmission is only used over relatively **short** distances.

....

....

.... **[2]**

(ii) Outline how the 4-bits would be transmitted over **long** distances.

....

....

....

....

.... **[3]**

[Total: 18]

3 Suppose a telecommunications company is considering laying an undersea optic-fibre cable between Sydney in Australia and San Francisco in the USA.
The distance between these two cities is 12 000 km.
The optic-fibre will be a monomode type with a core diameter of 8.5 μm.
At the transmitting end, a laser will inject a power of 45 mW into the core.
At the receiving amplifier input, the noise power is 0.28 μW.
The signal-to-noise ratio must not fall below 27 dB.

(a) Explain why it is essential to use monomode rather than multimode fibres for such a transmission system.

....

....

....

....

....

.... **[3]**

(b) **(i)** Explain why it is essential to use a laser rather than a LED for the light source.

....

....

.... **[2]**

(ii) The refractive index of the core of the fibre is 1.5.
Calculate the minimum time taken for a signal to travel between the two cities.

time = ... s **[2]**

(c) Assume that there are to be no regenerator amplifiers between the two cities.

(i) Show that the minimum possible signal power to reach the receiver is about 0.14 mW.

[3]

(ii) Calculate the maximum possible attenuation of the entire optic-fibre cable.

attenuation = ... dB **[2]**

(iii) Calculate the attenuation per km for such a cable.

attenuation per kilometre = ... dB km^{-1} **[1]**

(d) The optic-fibre cable cannot be manufactured with the purity required for **(c)(iii)** and it actually has an attenuation per kilometre of 0.17 dB km^{-1}.

(i) State the gain of each regenerator amplifier required.
Assume the same noise figures for the receiving amplifier as in **(c)**.

gain = ... dB **[1]**

(ii) Calculate the number of regenerator amplifiers required in the cable between the two cities.

number = ... **[2]**

[Total: 16]

4 Fig. 4.1 shows a student's circuit featuring a temperature sensor and a low power lamp.

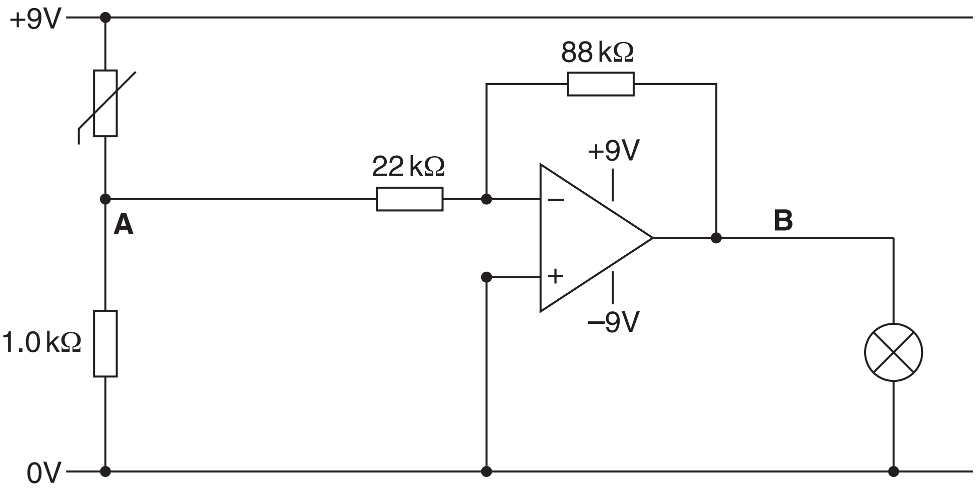

Fig. 4.1

Fig. 4.2 shows how the resistance of the sensor varies with temperature.

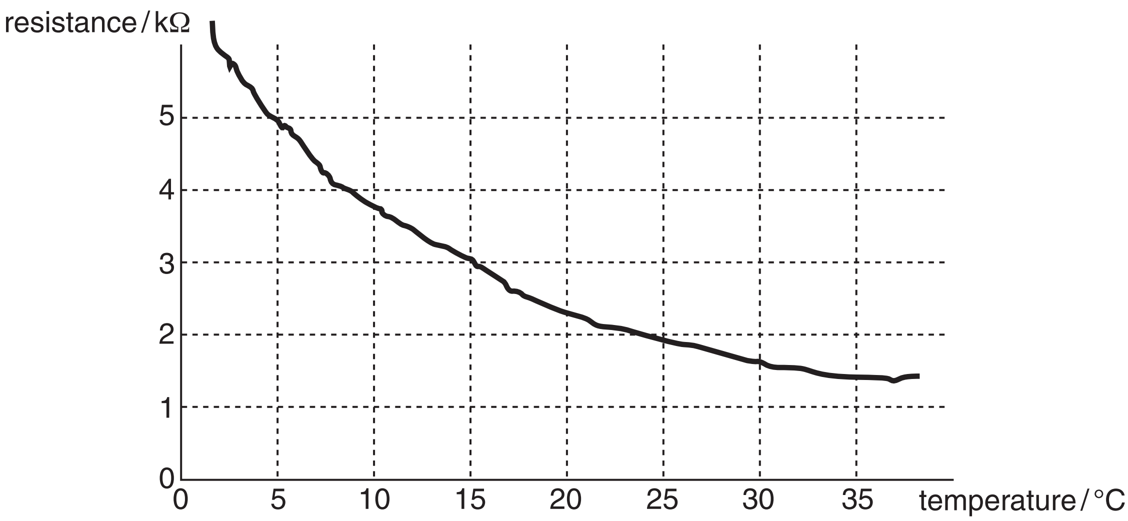

Fig. 4.2

(a) Put a circle around the component which senses temperature. **[1]**

(b) State the name of the component which senses temperature.

.... **[1]**

(c) The sensor is described as a negative temperature coefficient type. Explain what this means.

.... **[1]**

(d) When the temperature is 5 °C, calculate, with your working clearly shown,

(i) the voltage at **A**

voltage at **A** = ... V **[3]**

(ii) the voltage at **B**.

voltage at **B** = ... V **[3]**

(e) When the temperature is 25 °C, calculate the voltage at **B**.

voltage at **B** = ... V **[3]**

(f) Explain how the brightness of the lamp will vary as the temperature of the sensor increases from below 5 °C to above 35 °C.

....

....

....

....

.... **[3]**

[Total: 15]

5 Imagine you are talking to a group of people who are not familiar with the Internet.
They would like you to explain how it works.

(a) Outline, briefly, how information is transferred using the internet.

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.... **[5]**

(b) Briefly describe **three** ways in which society has adapted to the availability of the internet.

1. ....

....

2. ....

....

3. ....

....
[3]

[Total: 8]

6 The speed with which a bullet emerges from the barrel of a gun can be measured by a number of different techniques. This question relates to **two** experiments performed using the same rifle and bullets.

Data:

- mass of rifle 4.3 kg
- mass of bullet 28 g
- length of rifle barrel 72 cm

(a) Fig. 6.1 shows the first experiment where the rifle fires the bullet into a measured distance *D* between two fast optical sensors each of which is connected to a timer.

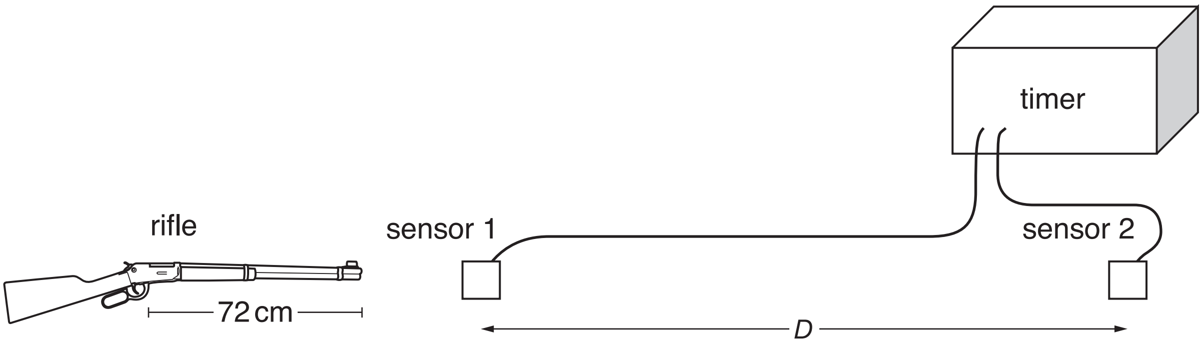

Fig. 6.1

When the bullet reaches sensor 1 the timer starts and when the bullet passes sensor 2 the timer stops.

distance D = 1.28 m
time t = 1.50 ms

(i) Show that the speed of the bullet is about 850 m s^{-1}.

[1]

(ii) The bullet accelerates as it travels along the rifle barrel. Show that the average acceleration in the barrel is about 5×10^5 m s^{-2}.

[2]

(iii) Calculate the average force on the bullet in the barrel.

average force on bullet = ... N **[2]**

(iv) Discuss the effect this force has on the rifle.

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....

....

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.... **[2]**

(b) Fig. 6.2 shows the second experiment where the same rifle fires the bullet horizontally into the middle of a block of lead resting on top of a vertical support.

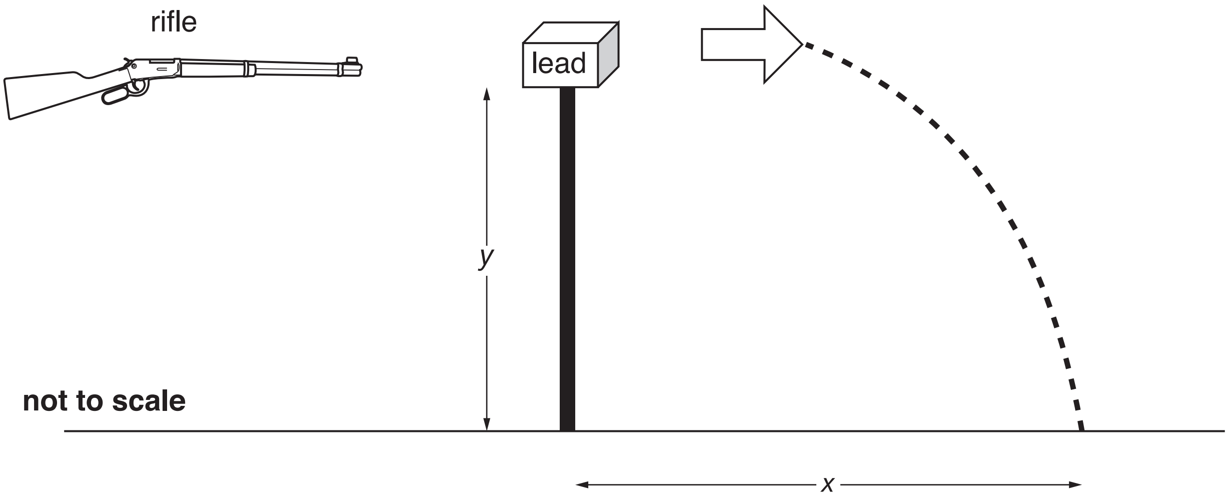

Fig. 6.2

When the bullet reaches the block it becomes embedded in the lead and the block is projected a horizontal distance x and falls a vertical distance y as shown. The following measurements are made;

mass of bullet	28 g
mass of lead block	3.60 kg
vertical distance y	2.41 m
horizontal distance x	4.60 m

(i) Show that the time taken for the block to fall through the vertical distance *y* is about 0.70 s.

[2]

(ii) Show that the horizontal projection speed of the block from the support is about $6.6\,\mathrm{m\,s^{-1}}$.

[1]

(iii) Show that the speed of the bullet given by this collision experiment is also about $850\,\mathrm{m\,s^{-1}}$.

[3]

(c) The initial kinetic energy of the bullet is transferred to the block as kinetic energy and thermal energy.

(i) Estimate the rise in temperature of the lead block. The specific heat capacity of lead is $126\,\mathrm{J\,kg^{-1}\,K^{-1}}$.

rise in temperature = ... K **[5]**

(ii) Explain **two** assumptions you made in this calculation.

....

....

....

....

....

.... **[2]**

[Total: 20]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE