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 29 June 2010
Afternoon

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	15	
2	14	
3	15	
4	17	
5	9	
6	20	
TOTAL	**90**	

Turn over

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,	$\mathrm{u} = 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron,	$m_\mathrm{e} = 9.11 \times 10^{-31}\ \mathrm{kg}$
rest mass of proton,	$m_\mathrm{p} = 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant,	$R = 8.31\ \mathrm{J K^{-1}\ mol^{-1}}$
the Avogadro constant,	$N_\mathrm{A} = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
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,	$\dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dots$
capacitors in parallel,	$C = C_1 + C_2 + \dots$
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 portable radio receiver approximately equidistant from three different radio stations, **A**, **B** and **C**, each broadcasting different programmes on the AM medium wave network.

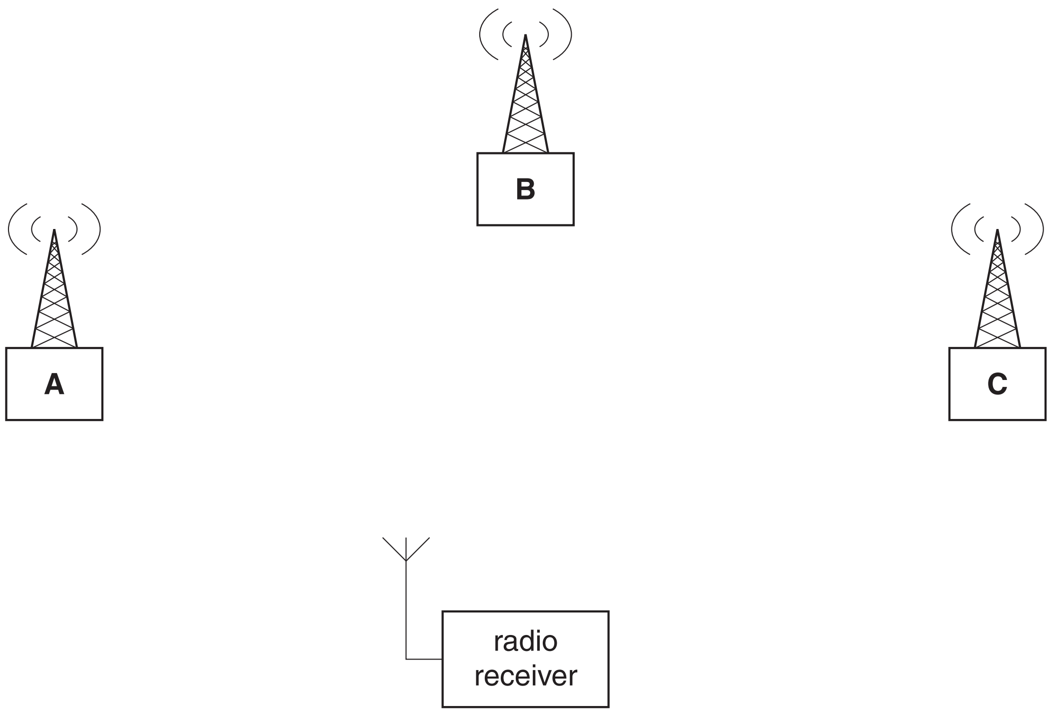

Fig. 1.1

(a) State a typical carrier frequency any one of the MW transmitters could use.

.... **[1]**

(b) Show by means of a suitable calculation that it is impractical for the portable radio to use a dipole aerial.

[2]

(c) State **two** reasons why the aerial of the receiver cannot simply be connected directly to a moving coil loudspeaker.

....

....

....

.... **[2]**

(d) Fig. 1.2 shows the block diagram of an AM radio receiver.

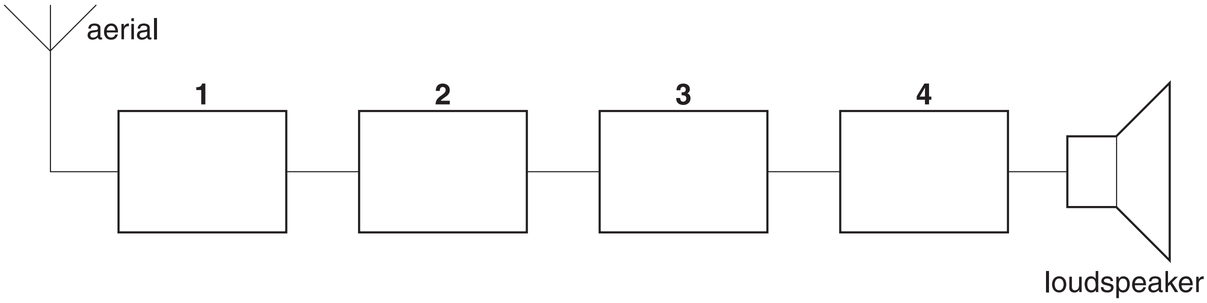

Fig. 1.2

(i) Label the blocks numbered **1** to **4**. **[4]**

(ii) Explain the function of each part of this receiver.

aerial ....

....

block **1** ....

....

block **2** ....

....

block **3** ....

....

block **4** ....

....

loudspeaker ....

.... **[6]**

[Total: 15]

2 Fig. 2.1 shows how the attenuation per kilometre in a cable varies with the frequency of the input signal.

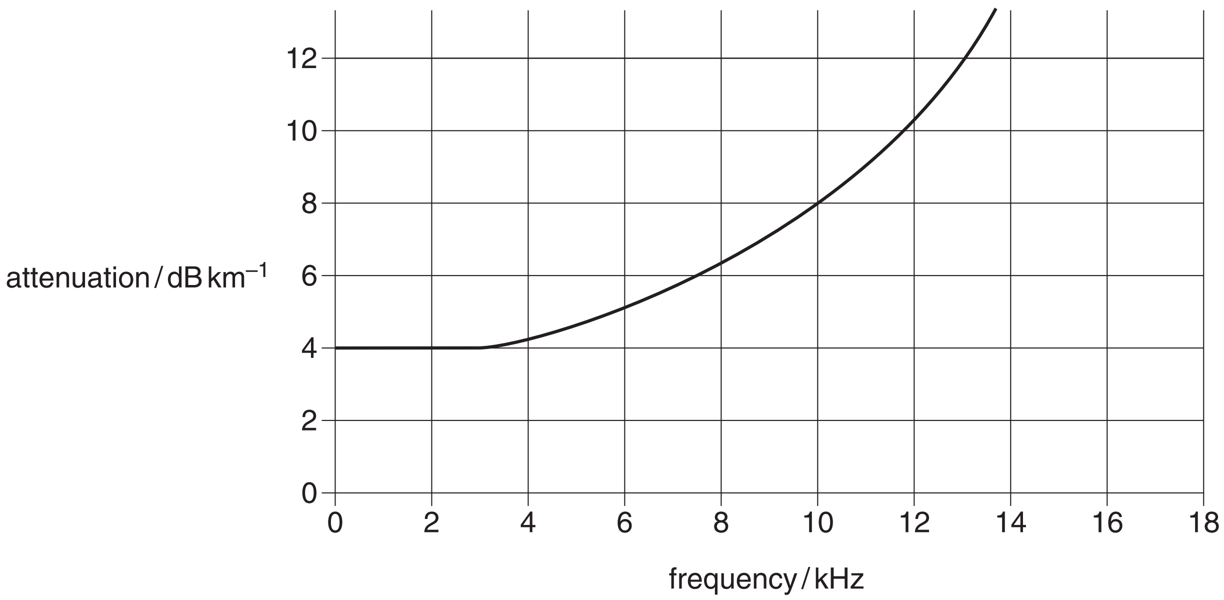

Fig. 2.1

(a) State what is meant by *attenuation*.

.... **[1]**

(b) This cable is to be used to transmit an audio signal through several kilometres.

Use Fig. 2.1 to explain what will be heard at the receiving end when the input signal is

(i) music with the full range of audio frequencies

....

....

.... **[2]**

(ii) speech restricted to a maximum frequency of 3 kHz.

....

....

.... **[2]**

(c) The cable of Fig. 2.1 is used to transmit speech restricted to frequencies below 3 kHz.

The input power to the cable is 2.7 W.
The noise power in the cable is a constant 8.6 μW.
The signal-to-noise ratio must not fall below 25 dB.

(i) Calculate the lowest acceptable signal power in the cable.

lowest power = ... W **[3]**

(ii) Calculate the total attenuation of the signal at the point of lowest acceptable signal power.

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

(iii) Calculate the maximum uninterrupted length of cable which can be used.

length = ... km **[1]**

(iv) Explain quantitatively what must be done to allow the signal to be transmitted through a distance of 30 km and arrive at the other end with the same 2.7 W power as at the input to the cable.

....

....

....

....

....

.... **[3]**

[Total: 14]

3 Fig. 3.1 shows a light dependent resistor (LDR) and a light-emitting diode (LED) in a circuit using an op-amp operating from ±15V power supplies.

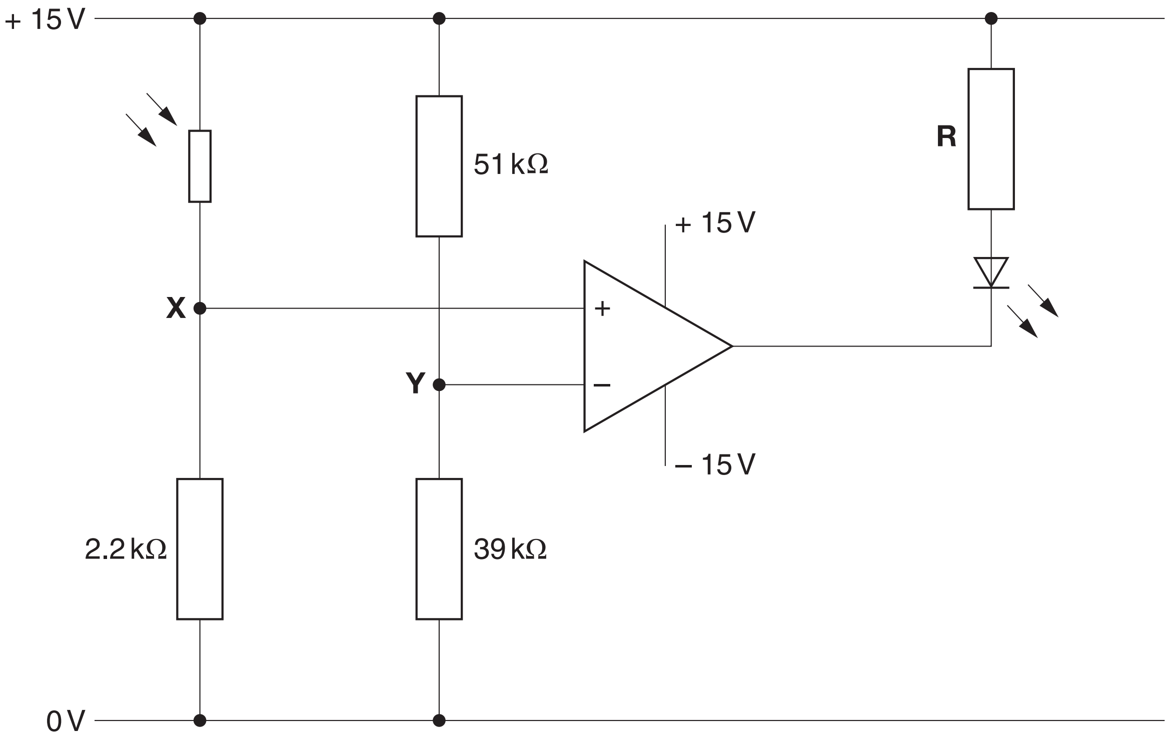

Fig. 3.1

(a) Label the light dependent resistor with **LDR** and the light-emitting diode with **LED**. **[1]**

(b) The op-amp in this circuit is being used to compare the fixed voltage V_Y at **Y**, with the variable voltage V_X at **X**. Explain how the output of the op-amp changes as V_X changes.

....

....

....

.... **[3]**

(c) Calculate the voltage at **Y**.

V_Y = ... V **[2]**

(d) In a certain light condition, the LDR has a resistance of 2.9 kΩ.

Calculate the output voltage of the op-amp and write down the state of the LED.

op-amp output = ... V

LED .... **[3]**

(e) Explain how the output brightness of the LED changes as the lighting conditions change from darkness (LDR resistance ≈ 1 MΩ) to daylight (LDR resistance ≈ 100 Ω).

....

....

....

.... **[3]**

(f) Calculate a suitable value for the resistor **R** to limit the LED current to a maximum value of 5 mA.

resistance = ... Ω **[3]**

[Total: 15]

4 Fig. 4.1 shows a geostationary satellite in orbit around the Earth. The satellite is broadcasting TV signals into a footprint of diameter 1200 km.

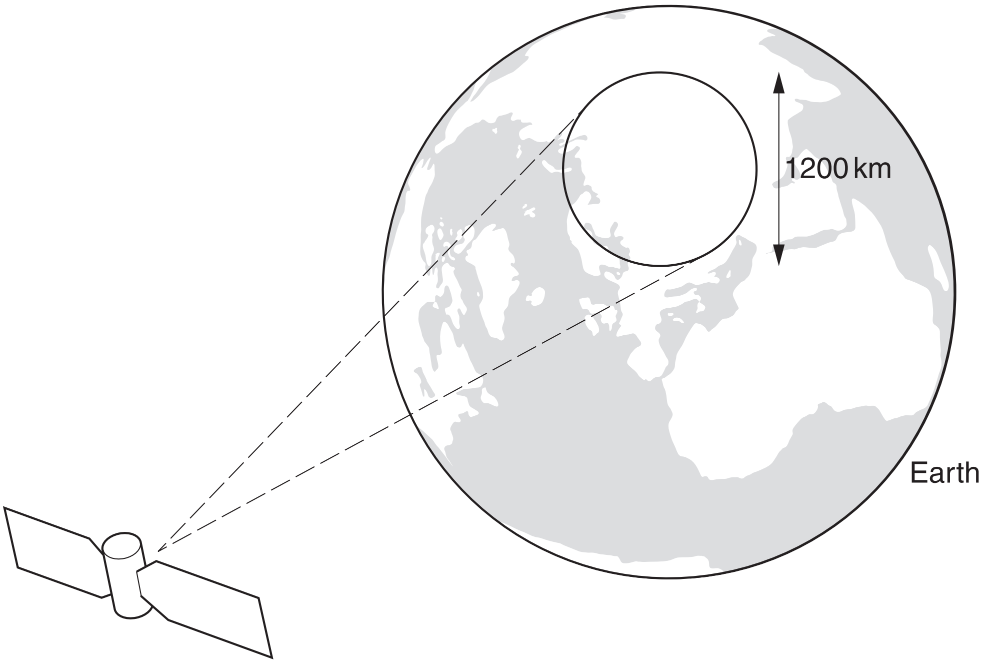

Fig. 4.1

(a) State **three** conditions which have to be met for a satellite to remain in geostationary orbit.

....

....

.... **[3]**

(b) Explain why it is necessary for the satellite to carry both batteries and solar panels.

....

....

.... **[2]**

(c) The area of the solar panels exposed to the Sun is $3.5\,m^2$. They produce a maximum output power of 1120 W when the intensity of sunlight is $1.6\,kW\,m^{-2}$.

Calculate the efficiency of the solar panels in converting sunlight to electricity.

efficiency = ... % **[3]**

(d) The satellite transmits a power of 650 W back to the Earth. 90% of this power is concentrated in the footprint of diameter 1200 km. Calculate the maximum power which can be received on Earth by a circular satellite dish of diameter 0.85 m.

Assume power is uniformly distributed within the footprint.

power = ... W **[4]**

(e) Explain, quoting typical frequencies in your answer, how the TV signal gets from the TV transmitting station on Earth to the satellite dish of the viewer.

....

....

....

....

....

....

.... **[3]**

(f) Explain the advantage of broadcasting TV signals by satellite instead of by terrestrial transmissions from dipole aerials.

....

....

....

.... **[2]**

[Total: 17]

5 Nowadays almost all A-level students in the UK own a mobile phone yet very few have any idea of how the mobile phone network operates. Imagine you are to give a talk on the subject to a group of Physics students who are not studying this module. In the space below, set out the main features you would bring out in your talk to explain the principles of operation of the mobile telephone network. In particular you should explain, making reference to the frequencies involved,

- why the aerial on a mobile handset is very small
- why the power transmitted from a handset must be small
- how the system operates to allow users to call home from almost anywhere in the UK.

.... [9]

[Total: 9]

6 This question is about a cliff railway that is entirely powered by water. The rail line links a town at the top of a hill with another town at the bottom of the hill. The railway has two carriages running on parallel tracks. They are connected by a continuous cable running around two pulley wheels mounted at the top and bottom of the track bed (see Fig. 6.1). Brakes can be applied to the lower pulley wheel to control the speed of the carriages.

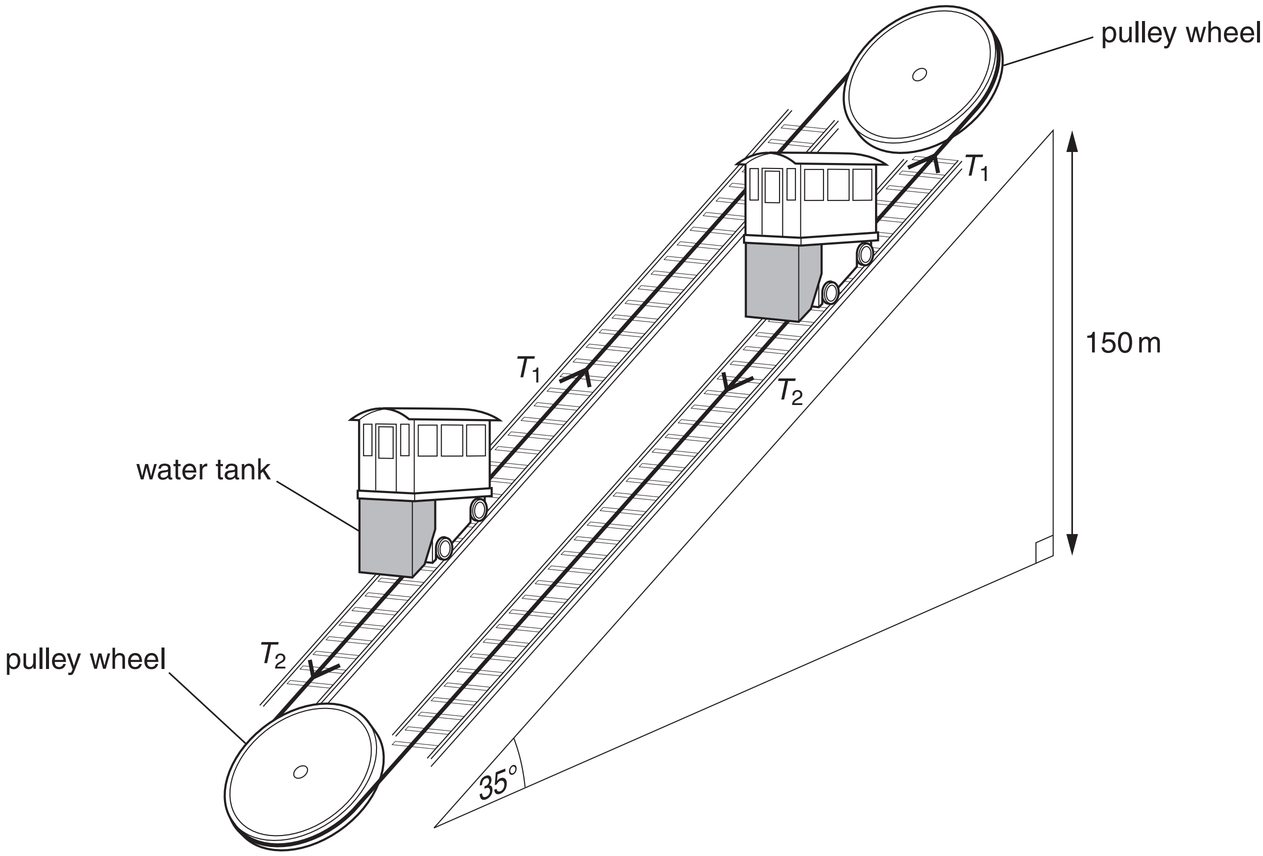

Fig. 6.1

Each carriage has a tank beneath the passenger compartment which can hold 5.0 m^3 of water. Before the start of each journey both tanks are full of water. When the passengers are aboard, water is released from the lower carriage until the weight of the lower carriage is less than that of the upper carriage. The brakes on the pulley wheel are released and the carriages accelerate toward the other station. When the speed of the carriages reaches 6.6 m s^{-1}, the brakes are partially applied to maintain a constant speed.

When the carriages reach the stations the brakes are fully applied and the carriages slow down and stop. While the passengers leave, the water tank beneath the carriage at the top station is refilled with water from a river. Passengers board both lower and upper carriages and the whole process is repeated.

Data: mass of each carriage fully loaded (including a full tank of water) = 10 000 kg
volume of water tank = 5.0 m^3
length of rails = 260 m
vertical height from lower station to the top station = 150 m
angle of inclination of rails = 35°
density of water = 1000 kg m^{-3}
mass of each brake block = 25 kg

(a) Describe the energy changes that occur when the lower carriage is lifted to the upper station while the upper carriage moves to the lower station.

....

....

....

.... **[3]**

(b) Just before the water tank in the lower carriage begins to drain, both carriages are carrying their full load and the tension T_2 in the lower cable is small enough to be ignored.

Show that the tension T_1 in the upper cable is about 5.5×10^4 N when both carriages are fully loaded.

[2]

(c) When the brakes are released, the acceleration of both cars is $1.5\,\text{m}\,\text{s}^{-2}$ and there is a resultant force of 8.7×10^3 N parallel to the track acting on the lower carriage.

(i) Calculate the volume of water which has been released from the lower carriage.

volume = ... m^3 **[4]**

(ii) Calculate the time taken from the moment the lower carriage leaves the station to the point when it reaches its maximum speed of $6.6\,\mathrm{m\,s^{-1}}$. Assume the acceleration remains constant.

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

(iii) Calculate the distance travelled during this time.

distance = ... m **[2]**

(d) At the start of one particular journey both carriages are fully loaded. 3800 kg of water is released from the lower carriage.

(i) Show that the net change in potential energy of the system is about 5.5 MJ.

[2]

QUESTION 6 CONTINUES OVER THE PAGE

Six iron brake blocks, each of mass 25 kg, apply a force against the lower pulley wheel. This maintains the constant speed during the journey and then, following an increase in this force, brings the carriages to a halt.

(ii) Calculate the rise in temperature of the brake blocks in this journey if the brake blocks absorb all of the potential energy change calculated in **(i)**.

The specific heat capacity of iron is $4.7 \times 10^2\,\mathrm{J\,kg^{-1}\,K^{-1}}$.

rise in temperature = ... K **[3]**

(iii) In practice the rise in temperature of the brake blocks is much less than the value calculated in **(ii)**. Discuss reasons why.

....

....

....

.... **[2]**

[Total: 20]

END OF QUESTION PAPER