OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE **2825/05**

PHYSICS A

Telecommunications

FRIDAY 25 JANUARY 2008 Morning

Time: 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials: Electronic calculator

CUP/T36534

Candidate Forename

Candidate Surname

Centre Number

Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or 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.
- Do **not** write outside the box bordering each page.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question 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 six questions concern Telecommunications. The last question concerns general physics.

FOR EXAMINER'S USE

Qu.	Max.	Mark
1	9	
2	10	
3	13	
4	17	
5	11	
6	10	
7	20	
TOTAL	90	

This document consists of **16** printed pages.

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, $n = \frac{1}{\sin C}$

capacitors in series, $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$

capacitors in parallel, $C = C_1 + C_2 + \ldots$

capacitor discharge, $x = x_0 e^{-t/CR}$

pressure of an ideal gas, $p = \frac{1}{3}\frac{Nm}{V}<c^2>$

radioactive decay, $x = x_0 e^{-\lambda t}$

$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$

critical density of matter in the Universe, $\rho_0 = \frac{3H_0^2}{8\pi G}$

relativity factor, $= \sqrt{(1 - \frac{v^2}{c^2})}$

current, $I = nAve$

nuclear radius, $r = r_0 A^{1/3}$

sound intensity level, $= 10 \lg \left(\frac{I}{I_0}\right)$

[Turn over

Answer **all** the questions.

1 Many people around the world possess a licence to operate their own transmitting and receiving equipment. Such people are called radio hams. Fig. 1.1 shows a cross-section of the Earth with a radio ham at **A** communicating with another radio ham at **B**.

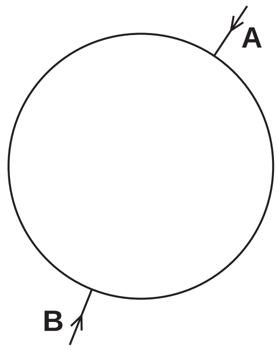


Fig. 1.1

(a) State the name and quote the frequency range of the waveband the two radio hams are allowed to use.

name .... [1]

frequency range .... to .... [2]

(b) **(i)** On Fig. 1.1, draw a typical path taken by the radio waves in travelling from **A** to **B**. You should label any important features you have to draw. [2]

(ii) Explain why the radio waves follow this path.

....

.... [1]

(c) Draw the diagram of a dipole aerial which could be used in this waveband. Calculate a typical length for this aerial and explain your calculations.

length of aerial = ... m [3]

[Total: 9]

2 In the early days of the telephone system, signals to be transmitted over long distances were carried by copper wires hanging from telegraph poles. Later, this system was replaced by underground coaxial cables.

(a) State and explain **one** reason why coaxial cable is preferable to free copper wires.

....

....

....

.... [2]

(b) In the modern telephone system, more and more of the coaxial cable has been replaced by optic fibre for the long distance transmission of telephone and internet signals.
State and explain **four** reasons why optic fibre is preferable to coaxial cable.

1. ....

....

....

2. ....

....

....

3. ....

....

....

4. ....

....

.... [8]

[Total: 10]

3 Fig. 3.1 shows a microphone picking up a steady sound source and passing the resulting signal into an amplifier. The input and output of the amplifier are being monitored on a dual-trace oscilloscope.

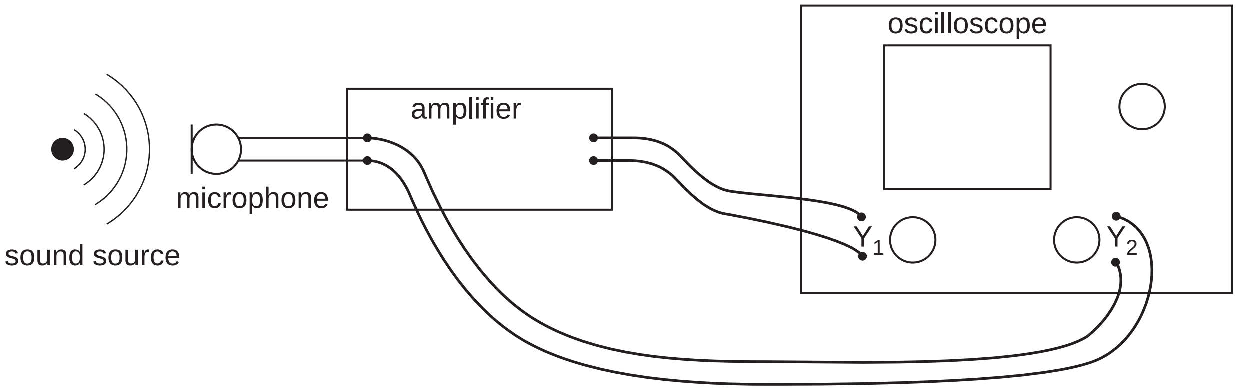


Fig. 3.1

Fig. 3.2 shows the screen and settings on the dual-trace oscilloscope. The top trace is the amplifier output signal Y_1 and the bottom trace is the amplifier input signal Y_2.

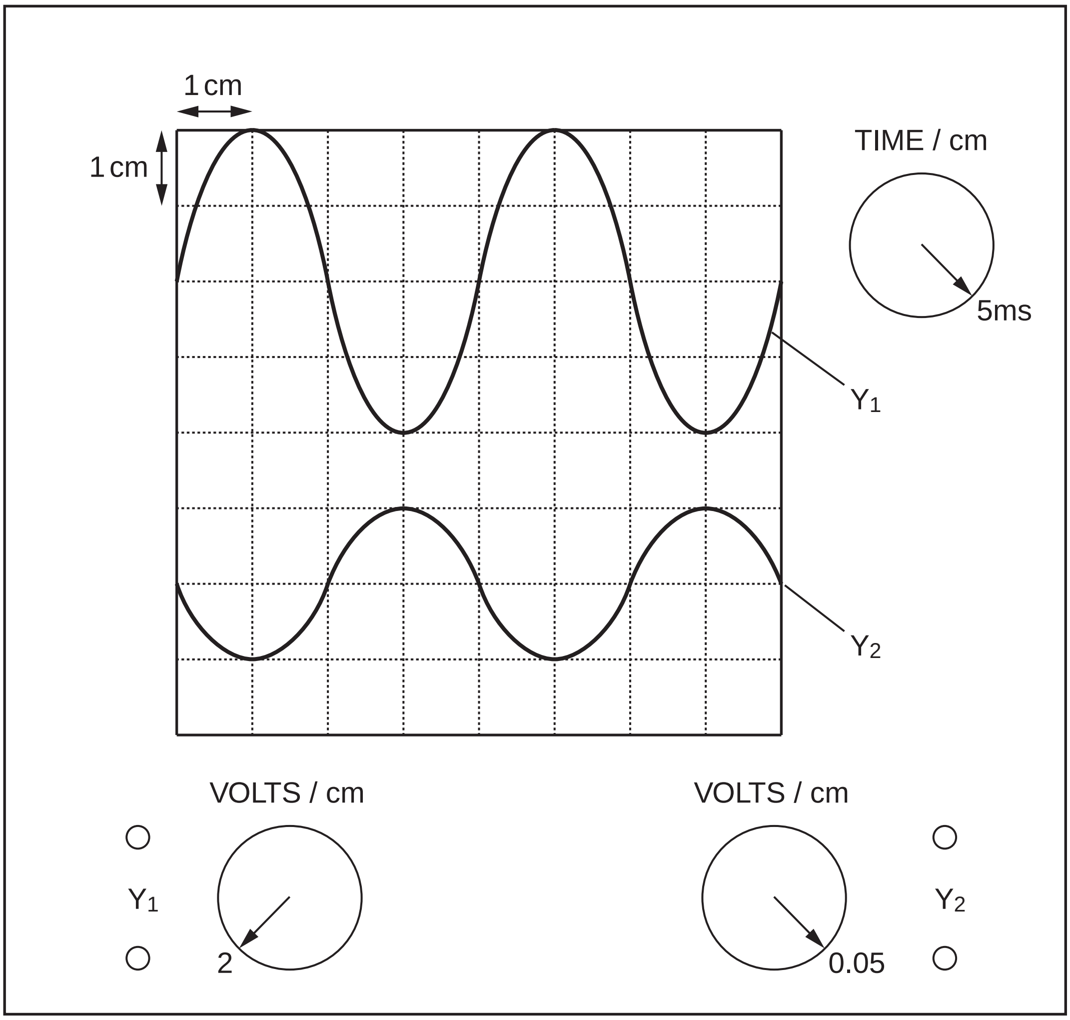


Fig. 3.2

(a) From an observation of the oscilloscope trace in Fig. 3.2, calculate

(i) the peak voltage of the output signal Y_1

peak output = ... V [1]

(ii) the peak voltage of the input signal Y_2

peak input = ... V [1]

(iii) the voltage gain of the amplifier

voltage gain = ... [2]

(iv) the frequency of the sound source.

frequency = ... Hz [2]

(b) How can you tell that the amplifier is an inverting amplifier?

....

.... [1]

(c) In the space below, draw a circuit diagram for an amplifier, based around an op-amp, which has the same voltage gain as the amplifier in Fig. 3.1. Label your resistors with appropriate values and mark the positions of the input and output signals.

[6]

[Total: 13]

4 Fig. 4.1 shows a transmission system where a transmitting station TX sends signals to a receiving station RX along a copper cable.

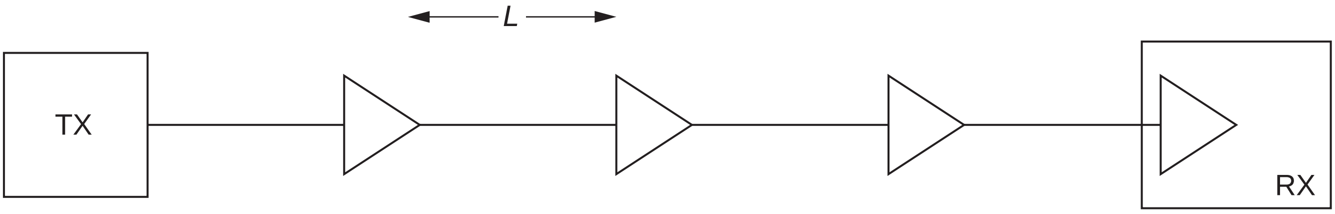


Fig. 4.1

The cable has been cut into four sections of equal length *L* and there are three amplifiers placed in the cable as shown with a fourth amplifier in the receiving station.

(a) **(i)** Explain what is meant by *attenuation* in general and how it can arise in a copper cable.

....

....

.... [2]

(ii) Explain what is meant by *noise* in telecommunications.

....

.... [1]

(iii) Explain why the signal from TX must be repeatedly amplified in the manner shown in Fig. 4.1 rather than transmitting through an uninterrupted distance of 4*L* and then amplifying it.

....

....

....

.... [3]

(b) The cable has an attenuation of 5.6 dB km^{-1} and each amplifier has an amplification of 42 dB.

The signal after the final amplifier in the receiving station should have the same power as that from the transmitting station. Calculate the separation *L* of the amplifiers which would achieve this. Explain your working.

L = ... km

.... [2]

(c) The actual characteristics of the transmission system are as follows:

- The amplifiers are separated by 8.5 km
- The cable has an attenuation of 5.6 dB km^{-1}
- Each amplifier has an amplification of 42 dB
- The transmitter outputs a signal of power 86 W into the cable
- The noise power in the cable is 31.2 μW

Calculate

(i) the total attenuation in the four sections of cable

total attenuation = ... dB [1]

(ii) the total amplification of the four amplifiers

total amplification = ... dB [1]

(iii) the power output of the amplifier in the receiving station

power output = ... W [3]

(iv) the signal-to-noise ratio at the **input to the amplifier** in the receiving station.

signal-to-noise ratio = ... dB [3]

(d) Comment on the implications of your answer to **(c)(iv)**.

....

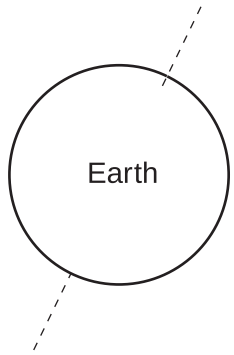
.... [1]

[Total: 17]

5 You are to give a brief talk on the use of Earth-orbiting satellites to a group of students who are not studying Physics. You should concentrate on just two types, the polar orbiting satellite and the geostationary satellite.

- For each type of satellite, describe the orbit in detail, illustrating your answer with a suitably labelled sketch.
- State **two** uses for each type of satellite.
- Explain how the special features of the orbit are essential in the satellite's task.

Polar orbiting satellites



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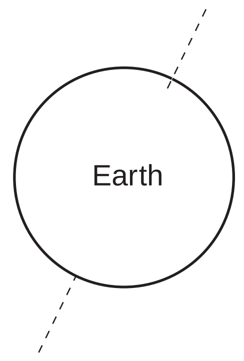
.... [5]

Geostationary satellites



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.... [6]

[Total: 11]

6 **(a)** **(i)** On the axes of Fig. 6.1 draw a sketch graph of an AM signal. [1]

Fig. 6.1

(ii) Explain, making reference to the relative magnitudes of any frequencies involved, how the AM signal has been formed from its components.

....

....

.... [3]

(b) **(i)** On the axes of Fig. 6.2 draw a sketch graph of an FM signal. [1]

Fig. 6.2

(ii) Explain, making reference to the relative magnitudes of any frequencies involved, how the FM signal has been formed from its components.

....

....

.... [1]

(c) State and explain **one** way in which FM is superior to AM and **one** way in which AM is superior to FM in the transmission and reception of radio signals.

....

....

....

....

....

....

.... [4]

[Total: 10]

7 The normal temperature of a healthy human body is 37 °C. When an adult person at this temperature is at rest, energy from food is required to maintain normal internal body activity (the basal metabolic rate). On average this energy is supplied to the body at the rate of 75 W. When involved in physical activity, extra energy from food is used. 20% of this extra energy is needed to do mechanical work; the remaining 80% heats the body and has to be dissipated. The energy available from 1 g of food in the form of carbohydrate is about 1.7×10^4 J.

(a) A meal provides a person with 250 g of carbohydrate.

(i) Estimate the period of rest in hours which is provided for by this intake of food.

period of rest = ... hour [2]

(ii) Suggest why the temperature of the person's body remains steady during this period.

....

....

....[2]

(b) A mountaineer of mass 70 kg climbs a mountain to a vertical height of 800 m above the starting point in 1.5 hours. Calculate

(i) the gain in potential energy of the mountaineer

potential energy gain = ... J [2]

(ii) the mass of carbohydrate used to provide this gain in potential energy

mass = ... g [1]

(iii) the minimum total mass of carbohydrate used by the mountaineer.

mass = ... g [3]

(c) A marathon runner, of mass 65 kg, competes on a day when the temperature of the environment is 40 °C. The rate of heating of the runner's body is 900 W.

(i) Calculate the rate of temperature rise of the runner's body. Assume that the body has a specific heat capacity of $4200\,\text{J}\,\text{kg}^{-1}\,\text{K}^{-1}$.

rate of temperature rise = ... $\text{K}\,\text{s}^{-1}$ [2]

(ii) Explain why the runner's body cannot lose heat to the surrounding air by the processes of conduction, convection and radiation.

....

....

....[2]

(iii) The runner maintains normal body temperature by using heat from the body to evaporate water (sweat) from the surface of the skin. The heat required to vaporise 1 kg of water is 2.4×10^{6} J. Calculate the mass of water evaporated from the skin in 2.5 hours of running.

mass = ... kg [2]

(iv) To minimise harm to the body **during the race**, state and explain **two** precautions the runner should take.

1. ....

....

....

2. ....

....

....[4]

[Total: 20]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE