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

Thursday 28 January 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 **20** pages. Any blank pages are indicated.

Examiner's Use Only:			
1			
2			
3			
4			
5			
6			
Total			

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, $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$

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

Answer **all** the questions.

1 An AM radio station begins operating each day by switching on the carrier and thus broadcasting silence for a few moments. Then a single-frequency pilot tone is broadcast for a few minutes after which the station broadcasts music. The power spectra of each of these three situations are shown in Fig. 1.1 although they are not in order.

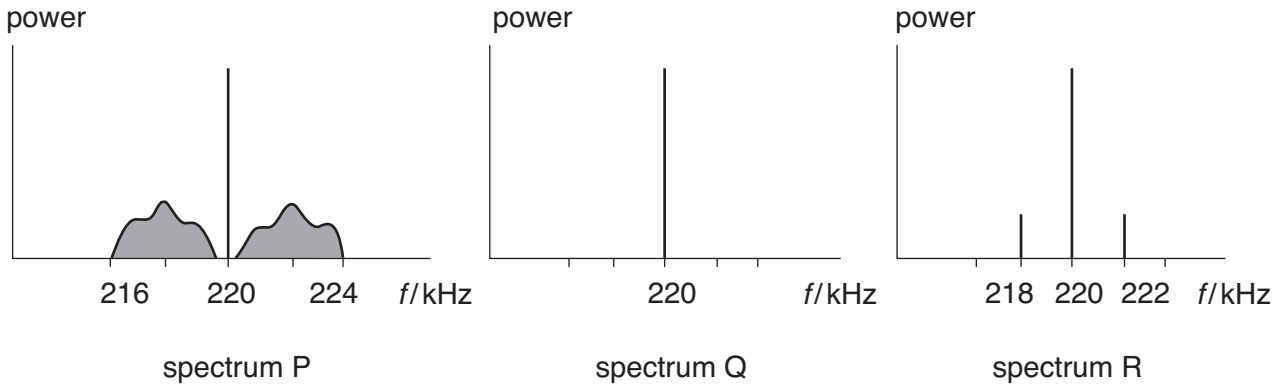

Fig. 1.1

(a) Using Fig. 1.1, state and explain which power spectrum corresponds to

(i) silence

.....

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

(ii) pilot tone

.....

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

(iii) music.

.....

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

(b) Using data from Fig. 1.1, state or calculate,

(i) the transmission frequency of the station

frequency = ...kHz **[1]**

(ii) the frequency of the pilot tone

frequency = ...kHz **[1]**

(iii) the bandwidth of the radio station

bandwidth = ... kHz **[1]**

(iv) the waveband in which the station operates

waveband = ... **[1]**

(v) the maximum number of similar stations which could share this waveband.

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

(c) Explain why the station uses AM rather than FM in this waveband.

.....

.....

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

[Total: 14]

2 **(a)** Fig. 2.1 shows a component used in certain types of electronic circuit.

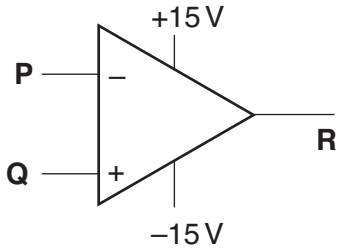

Fig. 2.1

(i) State the name of the component in Fig. 2.1.

..... **[1]**

(ii) Identify the terminals marked **P**, **Q** and **R** as one of the following

output = ... non-inverting input = ... inverting input = ... **[1]**

(iii) By referring to the voltages at the terminals **P**, **Q** and **R**, explain how the component of Fig. 2.1 behaves.

.....

.....

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

(b) Fig. 2.2 shows a circuit built around the component of Fig. 2.1.

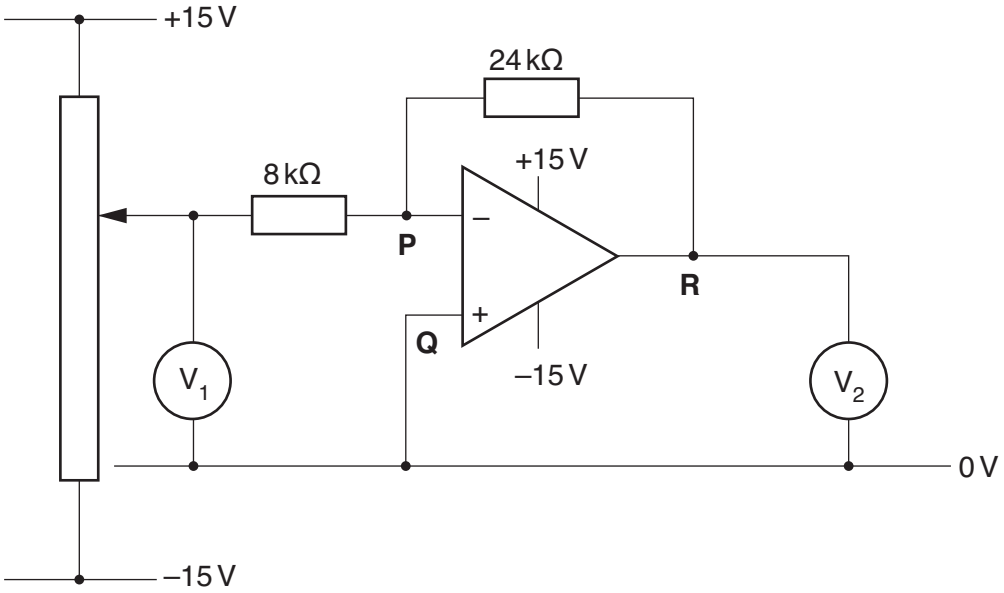

Fig. 2.2

The wiper of the potentiometer is positioned so that the reading on the output voltmeter V_2 is –6.0 V.

(i) Explain why the voltage at **P** is zero volts.

.....

.....

.....

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

(ii) Calculate the current in the 24 kΩ resistor. Show your working.

current = ... A **[2]**

(iii) Calculate the reading on the input voltmeter V_1. Show your working.

V_1 = ... V **[3]**

(c) On the axes of Fig. 2.3, sketch a graph to show how the voltage V_2 varies with the voltage V_1 as the wiper of the potentiometer in Fig. 2.2 is moved from –15 V to +15 V.

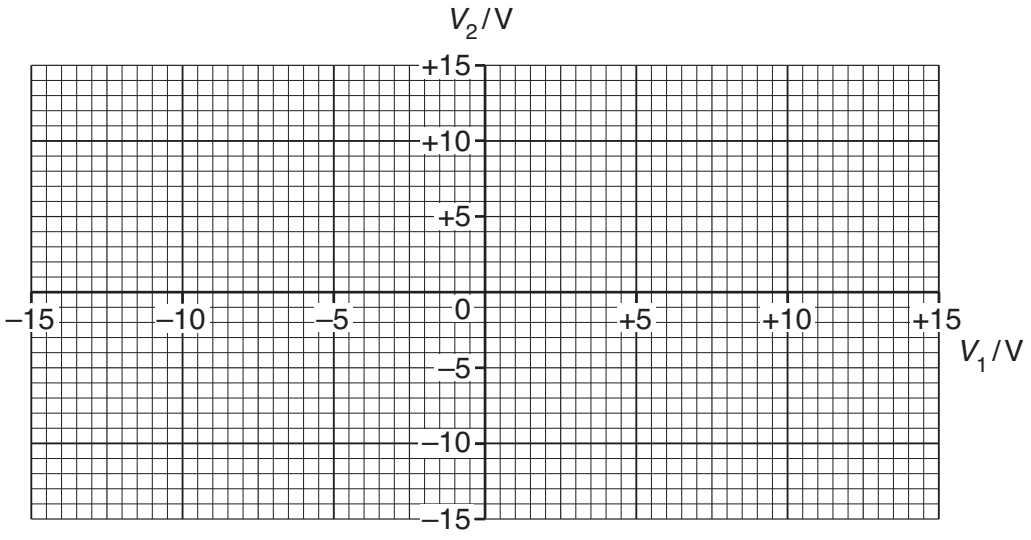

Fig. 2.3

[4]

[Total: 16]

3 Fig. 3.1 shows a diagram of how a telephone call is made between a caller and a listener.

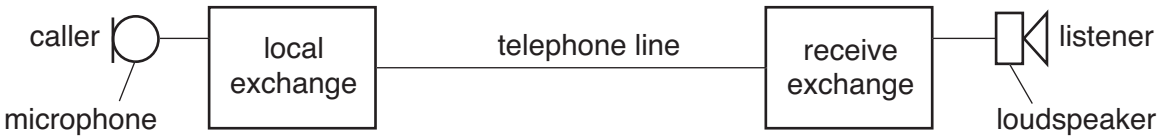

Fig. 3.1

The microphone produces an *analogue* signal which is processed by the local exchange and turned into a *digital* signal. The digital signal is then transmitted along the line to the receive exchange where it is further processed to reproduce the original analogue signal for the listener.

(a) Explain what is meant by an *analogue* signal.

.....

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

(b) Explain what is meant by a *digital* signal.

.....

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

(c) State the name of the modulation process involved in the exchanges and telephone line.

..... **[1]**

(d) Explain how the local exchange processes the analogue signal and how the receive exchange processes the digital signal to allow this system to operate.

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..... **[6]**

(e) Discuss the relative advantages and disadvantages of the process you have described in **(d)**.

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

[Total: 14]

4 Fig. 4.1 shows a simple communication system, which two students are considering setting up between their houses, **A** and **B**, which are 150 m apart.

Fig. 4.1

Their idea is that house **A** should contain a battery and house **B** should contain a lamp. By pressing the push switch in house **A** the lamp in house **B** should light up. The two students intend to devise a lamp on/off code which will allow each letter of the alphabet to be coded uniquely.

The lamp in house **B** is rated at 12 V 36 W.
The copper wire in the cable which is to link the two houses has a cross sectional area of 0.15 mm^2.
The resistivity of copper is $1.8 \times 10^{-8}\,\Omega\,m$.

(a) Calculate

(i) the current required to operate the lamp

current ..... A **[2]**

(ii) the total resistance of the two copper wires which link the two houses

resistance = ... Ω **[3]**

(iii) the battery voltage in house **A** required to make the lamp operate normally

battery voltage = ... V **[2]**

(iv) the attenuation of the system in decibels.

attenuation = ... dB **[3]**

(b) The code for each letter of the alphabet is to be composed of a mixture of short or long light pulses of about 0.5 second and 1 second to represent 0 and 1 respectively.

Estimate the time taken to transmit this sentence which contains seventy two letters.

Explain your working.

time = ...s

.....

.....

.....

..... **[4]**

[Total: 14]

5 Radio waves may propagate from a transmitting aerial to a receiving aerial by **three** different paths. For each of the waves listed below,

- state a waveband in which it is the main means of propagation
- describe the means by which the wave propagates
- quote a typical maximum range for terrestrial transmissions
- state a typical use of the waveband

space waves

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..... **[4]**

surface waves

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..... **[4]**

sky waves

.....

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..... **[4]**

[Total: 12]

6 A householder wants to reduce the amount of mains energy used in his home, in order to combat global warming. He plans to install a device which is powered by a renewable energy source. He considers three options:

A an array of photoelectric cells mounted on his house roof

B a solar panel mounted on the house roof for heating water by solar radiation

C an aerogenerator attached by a short pole to the house chimney.

Option A: Photoelectric cells

Photoelectric cells consist of two layers of different semiconductor materials in contact with each other. When a cell is exposed to solar radiation an e.m.f. is created. See Fig. 6.1. The cells are arranged in an array as shown in Fig. 6.2.

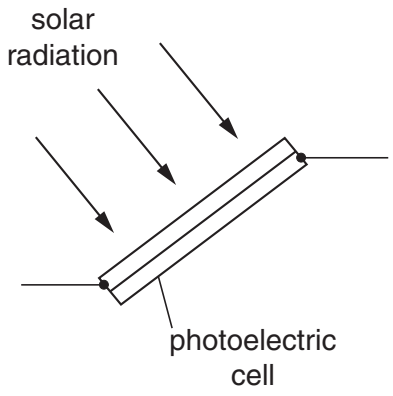

Fig. 6.1

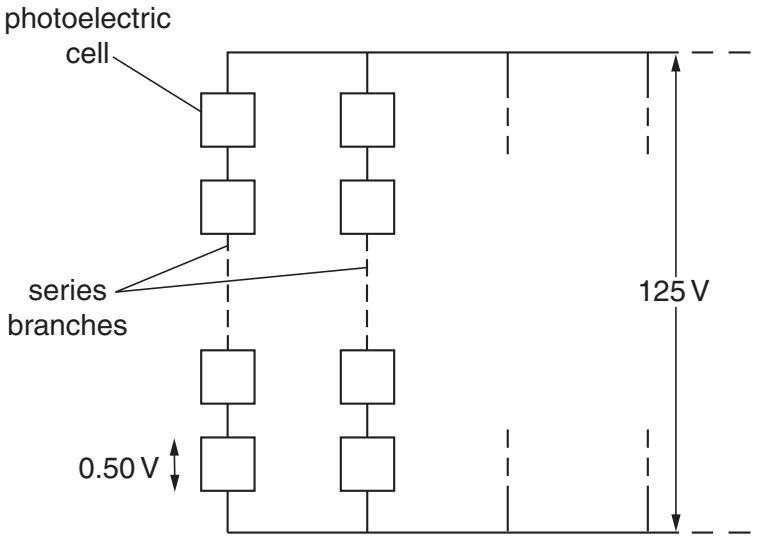

Fig. 6.2

intensity of solar radiation falling on the house	=	800 W m^{-2}
voltage output of each cell for this intensity	=	0.50 V
efficiency of each photoelectric cell	=	10 %
surface area of each photoelectric cell	=	5.0 cm^2
required output from photoelectric cell array	=	125 V

(a) (i) Calculate the total area of photoelectric cells needed to generate 1000 W of electrical power.

area = ... m^2 **[2]**

(ii) Show that the number of photoelectric cells needed is 25 000.

[1]

(iii) The photoelectric cells are arranged as in Fig. 6.2.

1 State the number of cells in **one** series branch. .....

2 State the number of branches in parallel. .....

[2]

(iv) Calculate the current through each photoelectric cell.

current = ... A **[2]**

Option B: Solar Panel

Solar radiation passes through a layer of glass and is absorbed by tubes of water. Cool water flows into the tubes and is heated. Hot water flows out and is led to an insulated storage tank.

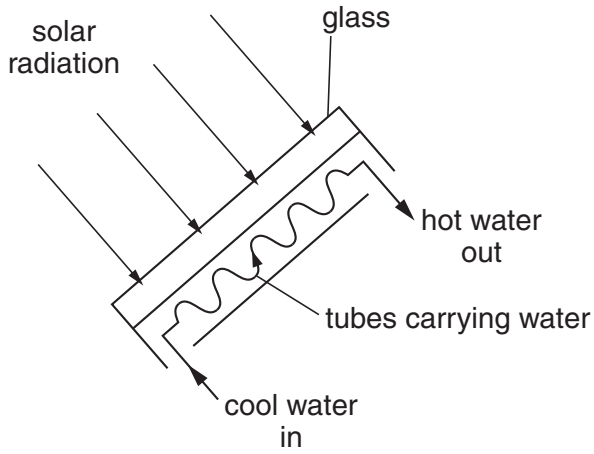

Fig. 6.3

intensity of solar radiation falling on the house	=	800 W m^{-2}
efficiency of solar panel	=	70 %
incoming water temperature	=	20 °C
outgoing water temperature	=	75 °C
specific heat capacity of water	=	4200 J kg^{-1} K^{-1}

(b) (i) Calculate the area of the solar panel needed for the water to gain 1000 J of heat energy per second.

area = ... m^2 **[2]**

(ii) Calculate the rate in kg s^{-1} at which water must flow through the tubes in order to emerge at 75 °C.

rate = ... kg s^{-1} **[3]**

Option C: Aerogenerator

This consists of a fan that rotates in the wind, and an electrical generator.

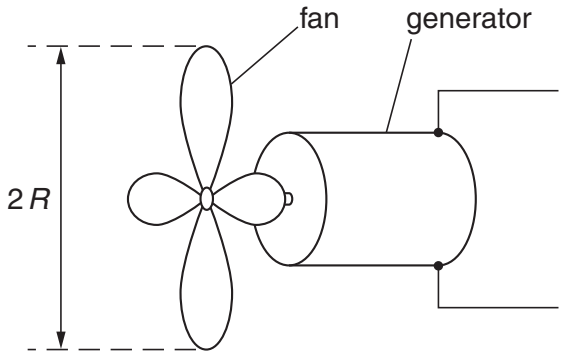

Fig. 6.4

efficiency of aerogenerator	=	40 %
wind speed	=	5.0 m s^{-1}
density of air	=	1.3 kg m^{-3}

(c) The air flowing through the fan in 1 second is a body of air having a cylindrical shape, of diameter $2R$ and length v where v is the speed of the air. See Fig. 6.5.

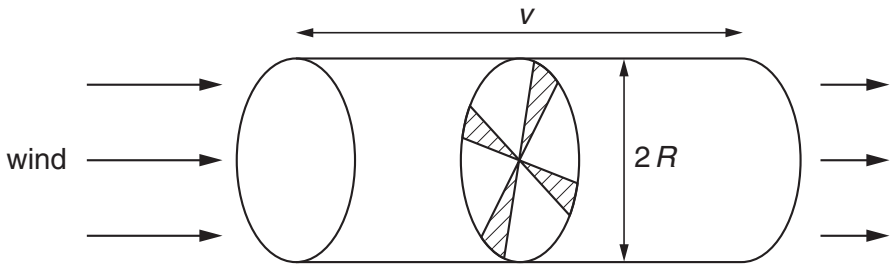

Fig. 6.5

The aerogenerator supplies 1000 J of electrical energy from this air in 1.0 second. This is 40 % of the initial kinetic energy of the air.

(i) Show that the initial kinetic energy of the cylinder of air is 2500 J.

[1]

(ii) Calculate the mass of this cylinder of air.

mass = ... kg **[2]**

(iii) Calculate the radius R of the aerogenerator fan.

R = ... m **[2]**

(d) The householder needs to make a choice.
Comment on the appropriateness or otherwise of **one** of these energy-generating processes for the house.

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

[Total: 20]

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