THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

PHYSICS A

2826/01

Unifying Concepts in Physics

Candidates answer on the Question Paper

OCR Supplied Materials:
None

Other Materials Required:
- Electronic calculator
- Ruler (cm/mm)

Monday 18 January 2010
Afternoon

Duration: 1 hour 15 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 **60**.
- You may use an electronic calculator.
- This document consists of **12** pages. Any blank pages are indicated.

Examiner's Use Only:			
1			
2			
3			
4			
5			
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,	$n = \dfrac{1}{\sin C}$
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 Make estimates of the following quantities. In this question you should show all your assumptions and your working. A wide range of answers will be accepted.

(a) the mass of air in the room you are sitting in

mass = ... kg **[3]**

(b) the speed of a passenger aircraft crossing the Atlantic Ocean

speed = ... $m\,s^{-1}$ **[2]**

(c) the drag force on a car when travelling at its top speed. (The maximum power output of the car is 80 kW.)

force = ... N **[2]**

(d) the magnetic flux from the N-pole of a bar magnet. (The flux density of the Earth's magnetic field in the U.K. is 5×10^{-5} T.)

flux = ... Wb **[2]**

[Total: 9]

2 **(a)** **(i)** Define *energy*.

....

.... **[1]**

(ii) Use your definition in **(i)** and the equation $v^2 = u^2 + 2as$ to show that the kinetic energy of a body of mass m travelling with velocity u is $\frac{1}{2}mu^2$.

[3]

(b) An object has a momentum of 120 N s and a kinetic energy of 480 J. Calculate the mass and the speed of the object.

mass = ... kg

speed = ... $m\,s^{-1}$ **[3]**

(c) A television advert recently stated that a serious injury to a pedestrian is 80% more likely when hit by a car travelling at 40 mph rather than at 30 mph. Show that kinetic energy considerations support this statement.

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....

.... **[3]**

(d) Explain why in an inelastic collision momentum is conserved but kinetic energy is not conserved.

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.... **[2]**

[Total: 12]

3 A cable car in a mountain resort lifts passengers through a total height of 650 m. The total distance travelled is 1200 m, as shown in Fig. 3.1.

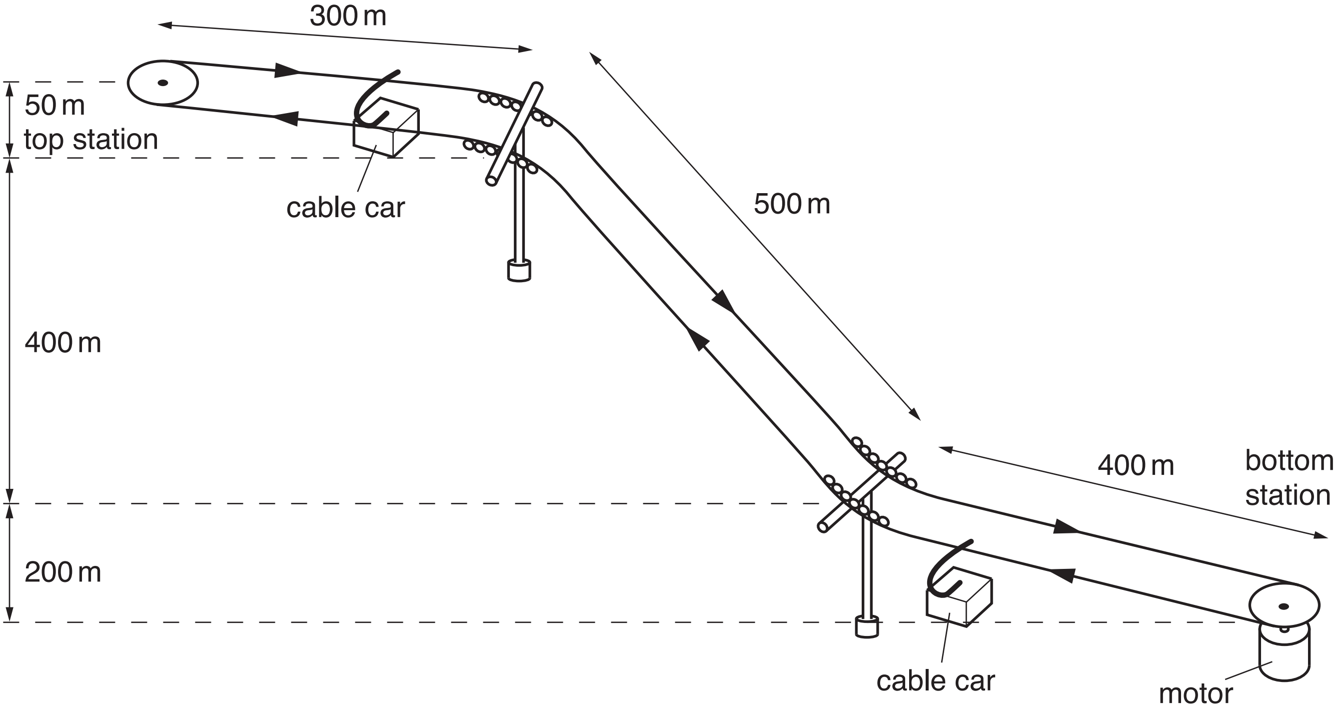

Fig. 3.1

Each car of mass 2800 kg is capable of carrying a maximum additional load of 16 000 kg. The cable shown in Fig. 3.1 is the driving cable. It is a continuous cable of total length 2400 m. Each car also has a support cable that is not shown in Fig. 3.1. The driving cable is driven by an electric motor at the bottom station. The journey from bottom to top takes 500 s.

(a) Calculate

(i) the speed of each car

speed = ... m s^{-1} **[1]**

(ii) the kinetic energy of a fully loaded car at this speed.

kinetic energy = ... J **[2]**

(b) Fig. 3.2 shows a fully loaded car of weight *W* during the steepest part of the ascent when it is travelling with constant velocity. Draw and label arrows on Fig. 3.2 to represent the force *F* that the driving cable exerts on the car and the force *S* that the support cable exerts on the car. In the space at the side of Fig. 3.2 sketch a vector triangle showing *W*, *F* and *S*.

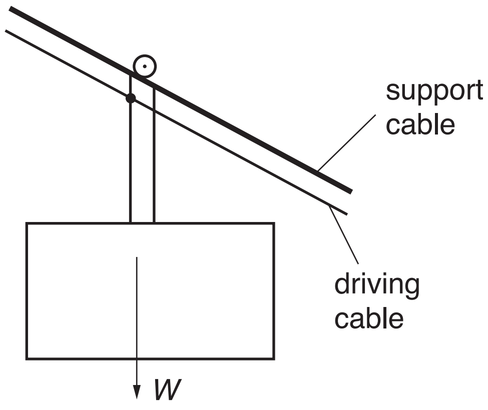

Fig. 3.2

[3]

(c) **(i)** Calculate the rate of gain of potential energy of a fully loaded car during the steepest part of the journey.

rate of gain of potential energy = ... W **[4]**

(ii) As a fully loaded car ascends an empty car descends. Calculate the power the motor needs in order to provide potential energy during the steepest part of the journey.

power of motor = ... W **[3]**

(d) In an actual situation a fully loaded car is ascending during the steepest part of the journey. An empty car is descending. The motor, working from a 2000 V supply, draws a current of 170 A.

(i) Calculate the power supplied to the motor.

power = ... W **[2]**

(ii) Explain two reasons why the power input of the motor must be greater than the value calculated in **(c)(ii)**.

1. ....

....

....

....

2. ....

....

....

.... **[3]**

(iii) Suggest how the motor can vary its power output in order to cope with the different demands on it at different stages of the journey.

....

....

....

.... **[2]**

[Total: 20]

4 **(a)** Explain the difference between electromotive force (e.m.f.) and potential difference (p.d.).

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.... **[2]**

(b) A 12 V battery with negligible internal resistance is connected in parallel with a 15 V battery of internal resistance 2.0 Ω. They are connected to a 5.0 Ω resistor as shown in Fig. 4.1.

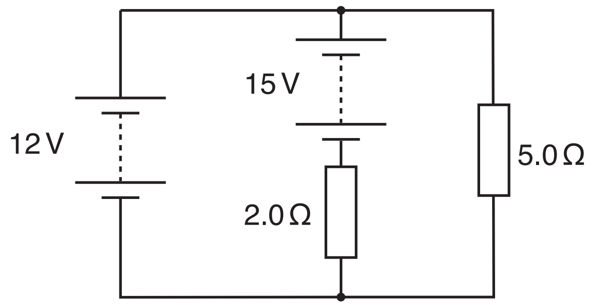

Fig. 4.1

Calculate the power being supplied by the 12 V battery.

power = ... W **[5]**

[Total: 7]

5 A source of sound **S** emits a constant frequency of 480 Hz. The speed of sound in air at a temperature of 0°C is 331 m s^{-1} .

(a) The speed of sound in air is proportional to the square root of the kelvin temperature. Show that the speed of sound at 8.0°C is 336 m s^{-1} to 3 sig. figs.

[2]

(b) Calculate, for the sound of frequency 480 Hz at a temperature of 8.0°C,

(i) its period T

T = ...s **[1]**

(ii) its wavelength λ.

λ = ... m **[1]**

(c) Fig. 5.1 shows the wavefronts of the sound waves spreading out from a fixed point. Fig. 5.2 shows wavefronts spreading out from the same source but in this case the source is moving with a speed of 30 m s^{-1} . The speed of sound in air is the same in both cases. These diagrams are not drawn to scale. You should not make any measurements on them.

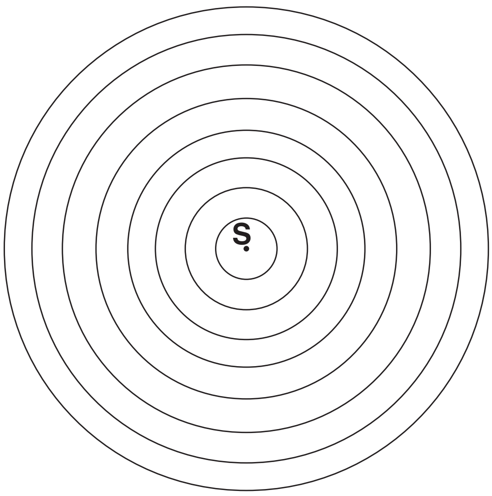

Fig. 5.1

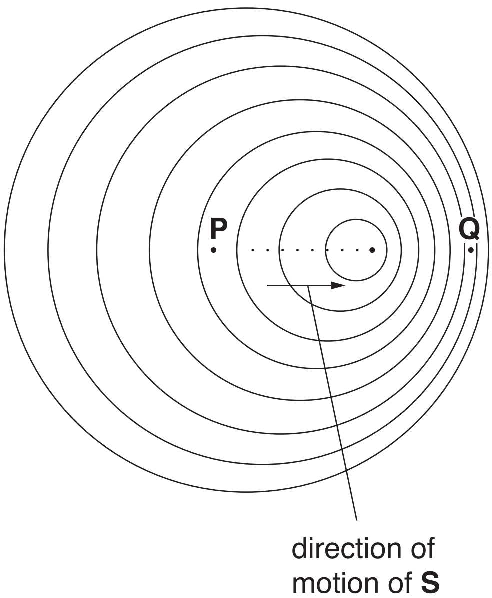

Fig. 5.2

Calculate

(i) using the value from **(b)(i)**, the distance the source moves in time T

distance = ... m **[1]**

(ii) the minimum and the maximum distances between wavefronts in Fig. 5.2.

maximum distance = ...m

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

(iii) the frequency heard by a person standing behind the moving source, at **P**, and the frequency heard by a person standing in front of the source, at **Q**.

frequency at **P** = ... Hz

frequency at **Q** = ...Hz **[3]**

(d) This effect is called the Doppler effect. It happens with light as well as with sound. Describe and explain what difference you would expect to see in light from a distant galaxy that is moving away from the Earth at very high speed, as compared with similar light in a laboratory.

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.... **[2]**

[Total: 12]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE