THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

PHYSICS A

Health Physics

2825/02

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 seven questions concern Health Physics. The last question concerns general physics.
- This document consists of **20** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**12**	
2	**7**	
3	**8**	
4	**9**	
5	**16**	
6	**12**	
7	**6**	
8	**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, $n = \frac{1}{\sin C}$

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 A student has an eye with a near point of 45.0 cm and a far point at infinity.

(a) Explain the term *near point.*

.....

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

(b) The power of the student's eye is 59.0 D when focusing on an object at infinity.

(i) Show that the focal length of the refracting system of this eye is about 17 mm.

[2]

(ii) State the distance of the retina from the cornea. Assume that all of the refraction in the eye occurs at the front edge of the cornea.

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

(iii) Use the lens equation to calculate the power of the student's eye when focusing on an object at its near point of 45 cm.

power = ... D **[3]**

(c) The near point of a **normal** eye is situated at a distance of 25 cm from the eye. Calculate the power of the refracting system of a normal eye of the same linear dimensions as the eye in **(b)**, when it is focusing on an object at 25 cm.

power = ... D **[1]**

(d) **(i)** Calculate the power of the corrective lens needed for the student's eye in **(b)** to view an object comfortably at a distance from the eye of 25 cm.

power = ... D **[2]**

(ii) State the shape of the corrective lens for this eye.

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

(iii) State the defect from which this eye suffers.

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

[Total: 12]

2 Explain the eye defect *astigmatism*. Discuss how an appropriate spectacle lens may be employed to correct the defect. Your answer should include

- a possible reason for the defect
- a description of the vision experienced by someone with astigmatism
- an explanation of the shape of the corrective lens.

Reference must be made in your written response to any relevant diagrams drawn in the space below.

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..... **[7]**

[Total: 7]

3 Describe the use of X-rays in imaging internal body structures. Your answer should include

- how an X-ray beam is used to produce an image of a bone
- an explanation of the use of a contrast medium such as barium
- examples of the types of structure that can be imaged by using a contrast medium.

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..... **[8]**

[Total: 8]

4 Fig. 4.1 shows a simple model to demonstrate the forces exerted by back muscles for a person bending over at an angle of θ to the vertical.

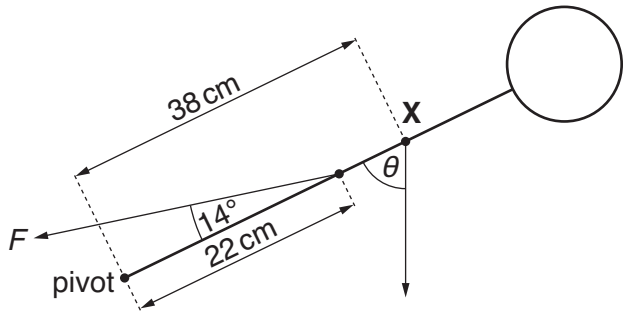

Fig. 4.1

The back muscles may be considered to act as a single force *F* through a point on the back situated 22 cm from the pivot and making a **constant** angle of 14° with the back. The weight *W* of the upper body acts through a point **X**, situated a distance of 38 cm from the pivot.

(a) Calculate for an upper body weight *W* of 450 N, the size of the force *F* needed by the back muscles to keep the back at an angle of

(i) $\theta = 60°$

F = ... N **[4]**

(ii) $\theta = 30°$.

F = ... N **[1]**

(b) Explain in detail, including reference to your answers to **(a)**, the body position which should be adopted when lifting heavy loads from the ground.

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

[Total: 9]

5 An argon-ion laser produces laser light of wavelengths 488 nm (blue) and 515 nm (green). Light from this type of laser is used to treat red birthmarks on skin as well as to perform eye surgery on detached retinas.

(a) (i) Calculate the intensity of the laser beam for a beam diameter of 0.24 mm if the output power from the laser is 5.2 W. Give an appropriate unit for your answer.

intensity = ……. unit ……. **[4]**

(ii) The laser described in **(i)** is used for surgery on a detached retina. The intensity at the retina is higher than that calculated in **(i)**. Explain why.

.....

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

(b) The laser light is passed through a **green** filter.

(i) Calculate the energy of a single photon of laser light which emerges from the green filter.

energy = …… J **[3]**

(ii) Calculate the number of photons per second from the green filter if the output power of the light emerging from the green filter is 2.6 W.

number per second = ... **[2]**

(iii) Suggest why an argon-ion laser is more suitable than a helium-neon (red light) laser for treating red birthmarks.

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

(c) State and explain **two** advantages of laser surgery compared with conventional surgery.

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

[Total: 16]

6 The maximum sensitivity of the hearing of a young person with normal hearing occurs at a frequency of about 2 kHz.

(a) On Fig. 6.1 draw a sketch graph to show the variation of the threshold of hearing for a young person with normal hearing across the audible frequency range. Label each axis with appropriate values. **[4]**

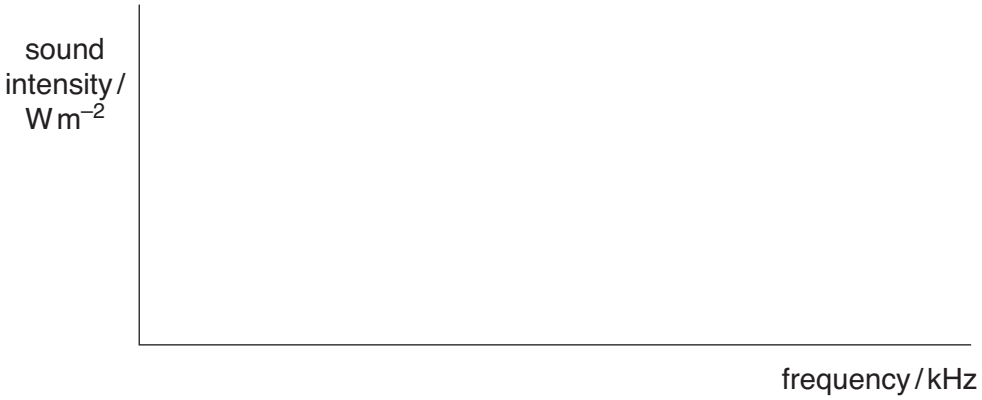

Fig. 6.1

(b) A student measures the intensity level 1 m from a ticking clock and records a value of 25 dB. When an alarm bell from the clock sounds, the intensity level is recorded as 75 dB. The student concludes that the alarm bell is 3 times louder than the clock tick.

(i) Calculate the factor by which the intensity changes when the alarm bell sounds.

$$\text{factor} = \frac{\text{intensity of alarm bell from clock}}{\text{intensity of ticking clock}}$$

factor = ... **[4]**

(ii) By making reference to the difference between *loudness* and *intensity*, explain giving reasons why the student's conclusion is unrealistic.

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

[Total: 12]

7 **(a)** Define the term *exposure*.

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

(b) Exposure is related to absorbed dose by a factor *f*. This factor for an X-ray photograph of a broken bone is $85\,J\,C^{-1}$. The exposure received during this X-ray is

$$2.8 \times 10^{-5}\,C\,kg^{-1}.$$

(i) Calculate the absorbed dose. Give an appropriate unit for your answer.

absorbed dose = …….. unit …… **[2]**

(ii) The quality factor *Q* for these X-rays is 1.2. Explain what is meant by this statement.

.....

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

(iii) Calculate the dose equivalent for the absorbed dose calculated in **(i)**.

dose equivalent = ……. Sv **[2]**

[Total: 6]

8 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. 8.1). Brakes can be applied to the lower pulley wheel to control the speed of the carriages.

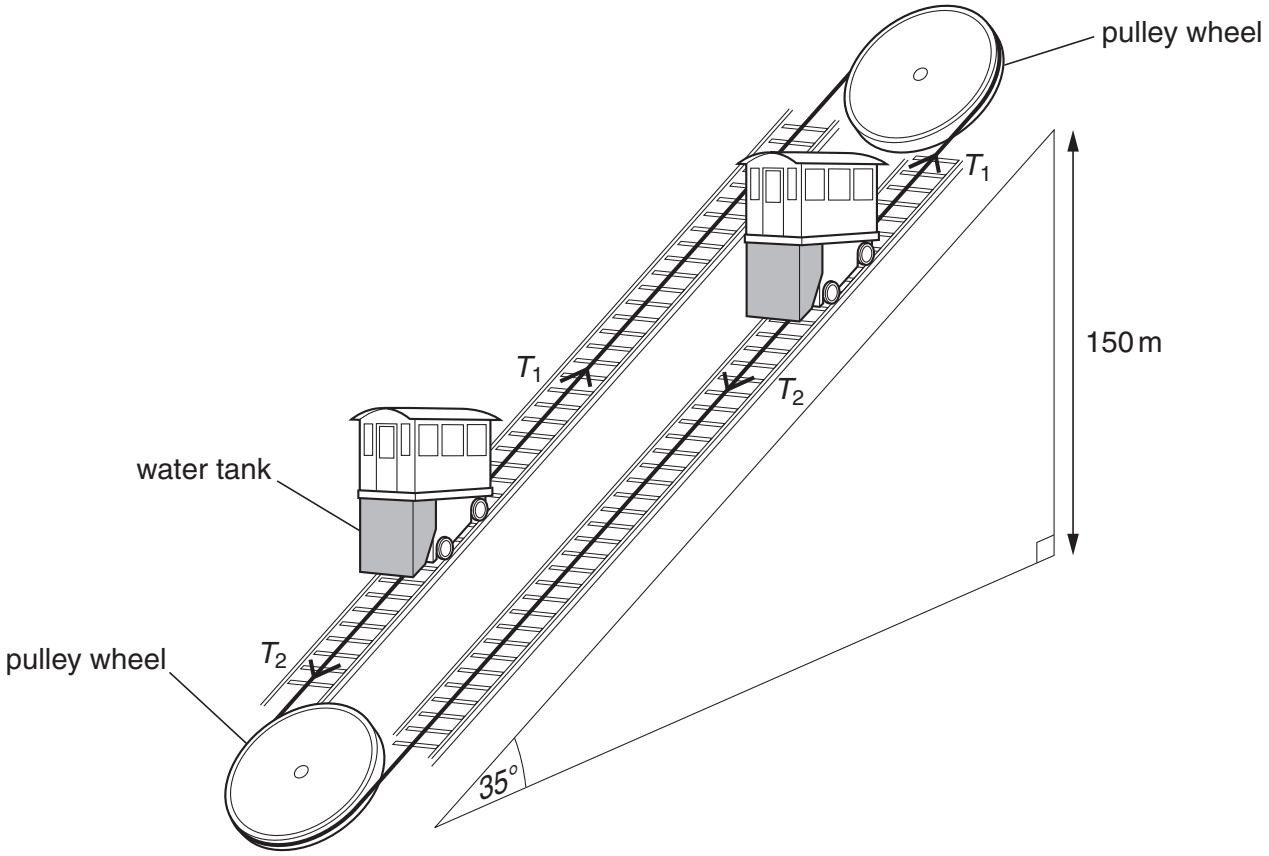

Fig. 8.1

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.

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.....

..... **[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 $1.5\,m\,s^{-2}$ and there is a resultant force of 8.7×10^3N parallel to the track acting on the lower carriage.

(i) Calculate the volume of water which has been released when there is a resultant force of 8.7×10^3 N parallel to the track acting on 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 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]

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 $4.7 \times 10^2\,J\,kg^{-1}\,K^{-1}$.

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.

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

[Total: 20]

END OF QUESTION PAPER

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