AS
PHYSICS
(7407/1)

Paper 1

Specimen 2014 Morning Time allowed: 1 hour 30 minutes

Materials
For this paper you must have:
- a pencil
- a ruler
- a calculator
- a data and formulae booklet.

Instructions
- Answer **all** questions.
- Show all your working.

Information
- The maximum mark for this paper is 70.

Please write clearly, in block capitals, to allow character computer recognition.

Centre number ☐☐☐☐☐ Candidate number ☐☐☐☐

Surname

Forename(s)

Candidate signature ____________________

Answer **all** questions.

0 1 . 1 Complete **Table 1** comparing some of the properties of the positive pion, π^+, and the proton.

[5 marks]

Table 1

Name	π^+	**Proton**
Relative charge	+1	
Baryon number		
Quark composition		

0 1 . 2 When a positive pion interacts with a proton, a kaon can be produced, along with another strange particle, as shown in this equation

$$\pi^+ + p \rightarrow K^+ + X$$

Circle the type of interaction shown in this equation.

[1 mark]

Electromagnetic   Gravitational   Strong Nuclear   Weak Nuclear

0 1 . 3 Deduce the relative charge, baryon number and strangeness of particle X.

[3 marks]

0 1 . 4 Particle X can decay to produce a neutron and positive pion as shown in this equation

$$X \rightarrow n + \pi^{+}$$

Circle the type of interaction shown in this equation.

[1 mark]

Electromagnetic Gravitational Strong Nuclear Weak Nuclear

0 1 . 5 Explain your answer.

[2 marks]

0 1 . 6 The neutron and positive pion will then decay. The positive pion can decay into a positron and an electron neutrino.

Write down the equation for the decay of the neutron.

[2 marks]

0 1 . 7 Explain why no further decays occur.

[2 marks]

0 2 The photoelectric effect can be demonstrated by illuminating a negatively charged plate, made from certain metals, with ultraviolet (UV) light and showing that the plate loses its charge.

0 2 . 1 Explain why, when ultraviolet light is shone on a **positively** charged plate, no charge is lost by the plate.

[2 marks]

0 2 . 2 Threshold frequency and work function are important ideas in the study of the photoelectric effect.

Tables 2 and **3** summarise the work functions of three metals and photon energies of three UV light sources.

Table 2

Metal	Work function/ eV
Zinc	4.3
Iron	4.5
Copper	4.7

Table 3

Light source	Photon energy/ eV
1	4.0
2	4.4
3	5.0

Discuss the combinations of metal and UV light source that could best be used to demonstrate the idea of threshold frequency and the idea of work function.

[6 marks]

0 2 . 3 Calculate the maximum kinetic energy, in J, of the electrons emitted from a zinc plate when illuminated with ultraviolet light.

work function of zinc = 4.3 eV
frequency of ultraviolet light = 1.2×10^{15} Hz

[3 marks]

maximum kinetic energy ______________ J

0 2 . 4 Explain why your answer is a maximum.

[1 mark]

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Turn to page 8 for the next question

Turn over for the next question

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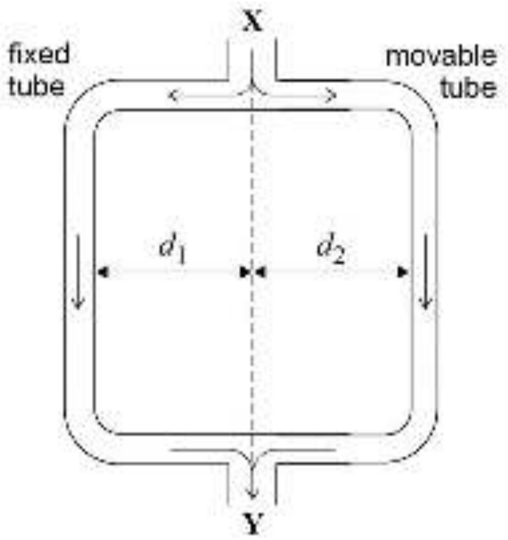
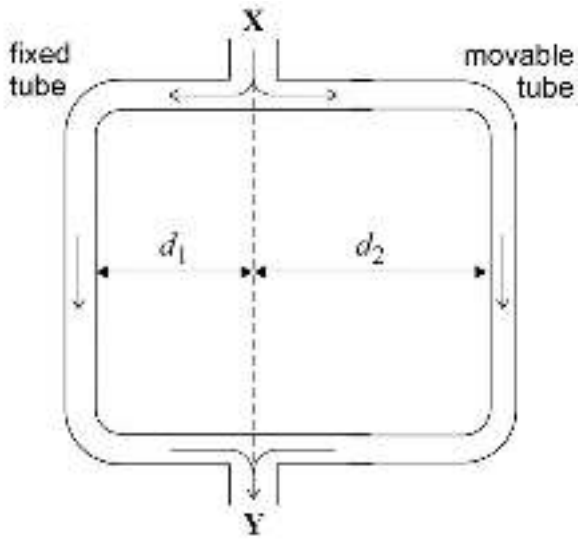
ANSWER IN THE SPACES PROVIDED

0 3 **Figure 1** and **Figure 2** show a version of Quincke's tube, which is used to demonstrate interference of sound waves.





A loudspeaker at **X** produces sound waves of one frequency. The sound waves enter the tube and the sound energy is divided equally before travelling along the fixed and movable tubes. The two waves superpose and are detected by a microphone at **Y**.

0 3 . 1 The movable tube is adjusted so that $d_1 = d_2$ and the waves travel the same distance from **X** to **Y**, as shown in **Figure 1**. As the movable tube is slowly pulled out as shown in **Figure 2**, the sound detected at **Y** gets quieter and then louder.

Explain the variation in the loudness of the sound at **Y** as the movable tube is slowly pulled out.

[4 marks]

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0 3 . 2 The tube starts in the position shown in **Figure 1**.

Calculate the minimum distance moved by the movable tube for the sound detected at **Y** to be at its quietest.

frequency of sound from loud speaker = 800 Hz

speed of sound in air = 340 $\mathrm{m\,s^{-1}}$

[3 marks]

minimum distance moved = ____________________ m

0 3 . 3 Quincke's tube can be used to determine the speed of sound.

State and explain the measurements you would make to obtain a value for the speed of sound using Quincke's tube and a sound source of known frequency.

[4 marks]

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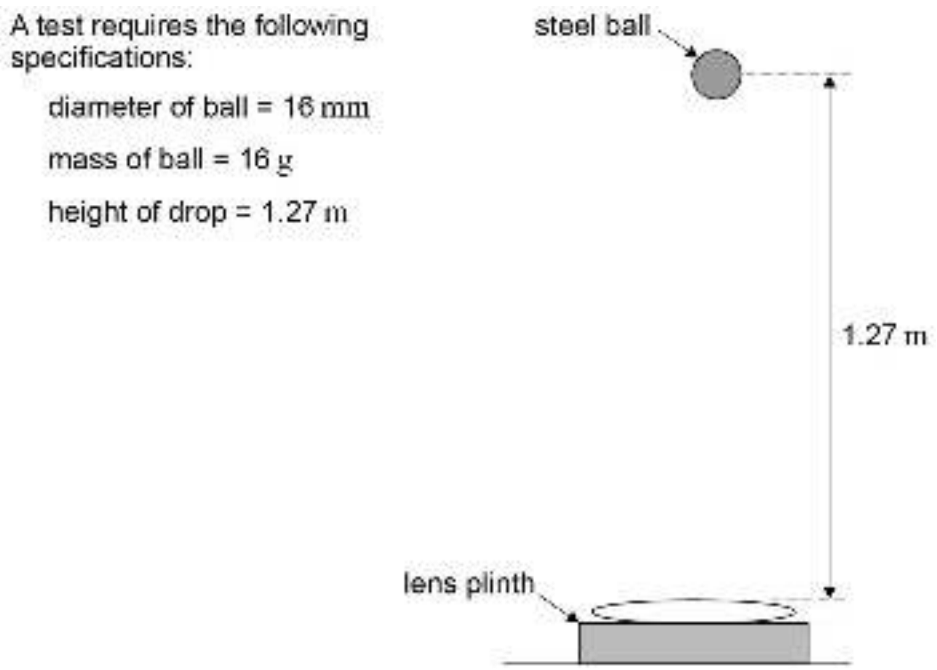
0 4 Spectacle lenses can be tested by dropping a small steel ball onto the lens, as shown in **Figure 3**, and then checking the lens for damage.

Figure 3



0 4 . 1 Calculate the density of the steel used for the ball.

[3 marks]

density = ____________________ kg m^{-3}

0 4 . 2 In a test the ball bounced back to a height of 0.85 m.

Calculate the speed of the ball just before impact.

[2 marks]

speed = ____________________ m s^{-1}

0 4 . 3 Calculate the speed of the ball just after impact.

[2 marks]

speed = ____________________ $m\ s^{-1}$

0 4 . 4 Calculate the change in momentum of the ball due to the impact.

[2 marks]

momentum = ________________ $kg\ m\ s^{-1}$

0 4 . 5 The time of contact was 40 ms. Calculate the average force of the ball on the lens during the impact.

[2 marks]

average force = ___________________ N

0 4 . 6 Explain, with reference to momentum, why the test should also specify the material of the plinth the lens sits on.

[2 marks]

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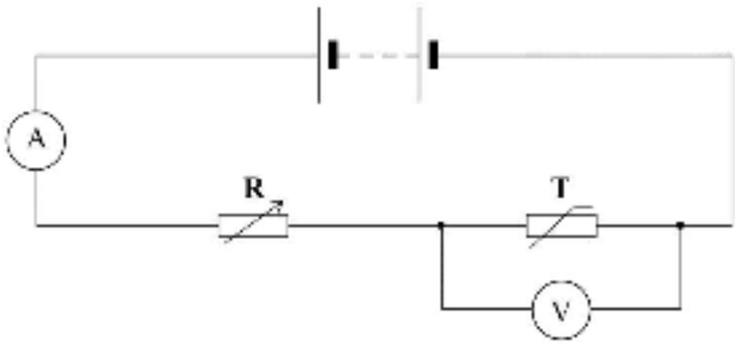
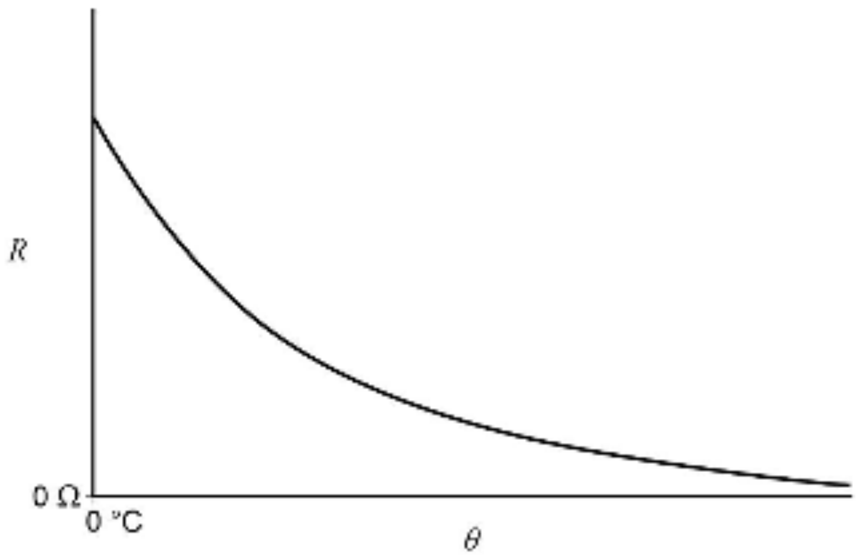
0 5 **Figure 4** shows a circuit including a thermistor **T** in series with a variable resistor **R**. The battery has negligible internal resistance.

Figure 4



The resistance–temperature (R-θ) characteristic for **T** is shown in **Figure 5**.

Figure 5



0 5 . 1 The resistor and thermistor in **Figure 4** make up a potential divider.

Explain what is meant by a potential divider.

[1 mark]

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0 5 . 2 State and explain what happens to the voltmeter reading when the resistance of **R** is increased while the temperature is kept constant.

[3 marks]

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0 5 . 3 State and explain what happens to the ammeter reading when the temperature of the thermistor increases.

[2 marks]

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0 5 . 4 The battery has an emf of 12.0 V. At a temperature of 0 °C the resistance of the thermistor is $2.5 \times 10^3\ \Omega$.

The voltmeter is replaced by an alarm that sounds when the voltage across it exceeds 3.0 V.

Calculate the resistance of R that would cause the alarm to sound when the temperature of the thermistor is lowered to 0 °C.

[2 marks]

resistance = ____________________ Ω

0 5 . 5 State **one** change that you would make to the circuit so that instead of the alarm coming on when the temperature falls, it comes on when the temperature rises above a certain value.

[1 mark]

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0 6 If lengths of rail track are laid down in cold weather, they may deform as they expand when the weather becomes warmer. Therefore, when rails are laid in cold weather they are stretched and fixed into place while still stretched. This is called pre-straining.

The following data is typical for a length of steel rail:

Young modulus of steel =	2.0×10^{11} Pa
cross sectional area of a length of rail =	7.5×10^{-3} m^2
amount of pre-strain =	2.5×10^{-5} for each kelvin rise in temperature the rail is expected to experience.

A steel rail is laid when the temperature is 8 °C and the engineer decides to use a pre-strain of 3.0×10^{-4}.

0 6 . 1 Calculate the tensile force required to produce the pre-strain in the rail required by the engineer.

[3 marks]

tensile force = ____________________ N

0 6 . 2 Calculate the elastic strain energy stored in a rail of unstressed length 45 m when pre-strained as in part 6.1.

[2 marks]

elastic strain energy = ____________________ J

Question 6 continues on the next page

0 6 . 3 Calculate the temperature at which the steel rail becomes unstressed.

[2 marks]

temperature = ____________________ °C

0 6 . 4 Explain why the engineer does not use the highest observed temperature at the location of the railway track to determine the amount of pre-strain to use.

[2 marks]

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END OF QUESTIONS

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