Centre Number	Index Number	Name	Class
S3016			

RAFFLES INSTITUTION
2022 Preliminary Examination

PHYSICS **9749/03**
Higher 2

21 September 2022
Paper 3 Longer Structured Questions **2 hours**

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your index number, name and class in the spaces at the top of this page.
Write in dark blue or black pen in the spaces provided in this booklet.
You may use pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only and **circle the question number** on the cover page.

You are advised to spend one and half hours on Section A and half an hour on Section B.
The number of marks is given in brackets [ ] at the end of each question or part question.

***This booklet only contains Section B.**

For Examiner's Use		
Section B (circle 1 question)	7	/ 20
	8	/ 20
Deduction		

This document consists of **8** printed pages.

Section B

Answer **one** question from this Section in the spaces provided.

7 **(a)** Fig. 7.1 shows a stretched string connected to an oscillator at one end and a load over a smooth pulley at the other end. The length of the string between the oscillator and the pulley is L.

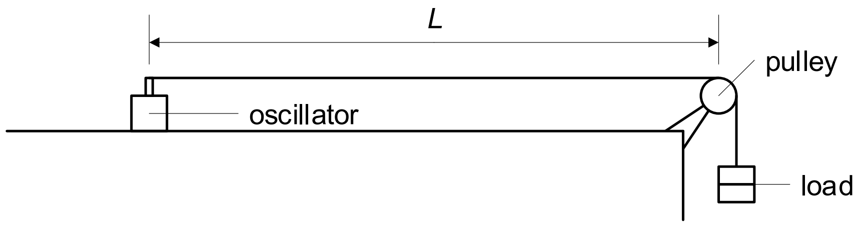

Fig. 7.1

(i) Explain why observable stationary waves are seen on the string when the oscillator is vibrating vertically at certain discrete frequencies.

....

....

....

....

....

....

.... [3]

(ii) Show that the discrete frequencies in **(a)(i)** are integer multiples of $\frac{v}{2L}$ where v is the speed of the wave on the string.

[1]

(iii) When the frequency of the oscillator is 40.0 Hz, a stationary wave with 5 nodes is seen for $L = 0.600$ m.

Calculate v.

v = ... m s^{-1} [2]

(iv) The speed v of the wave on the string is related to the tension T in the string by

$$v = k\sqrt{T}$$

where k is a constant.

Determine the new frequency of the oscillator such that a stationary wave with 5 nodes is still seen on the string if the tension is decreased by 2%.

new frequency = ... Hz [2]

(b) (i) Fig. 7.2 shows a point source positioned a distance D from a single slit of width 0.30 mm. The point source emits monochromatic light of wavelength 600 nm.

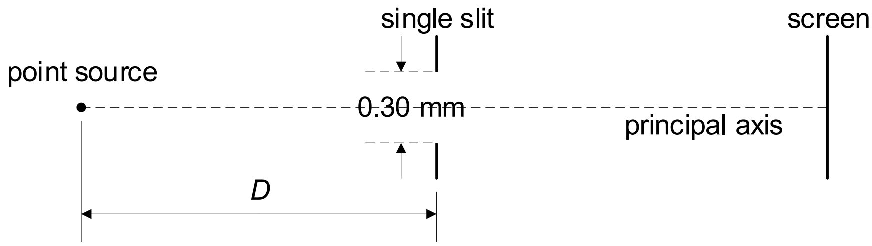

Fig. 7.2 (not to scale)

1. Show that the angle of the first minimum of the diffraction pattern from the principal axis is 2.0×10^{-3} rad.

[1]

2. Sketch on Fig. 7.3, the diffraction pattern of the light after passing through the single slit. The maximum intensity of the central bright fringe is I_0.

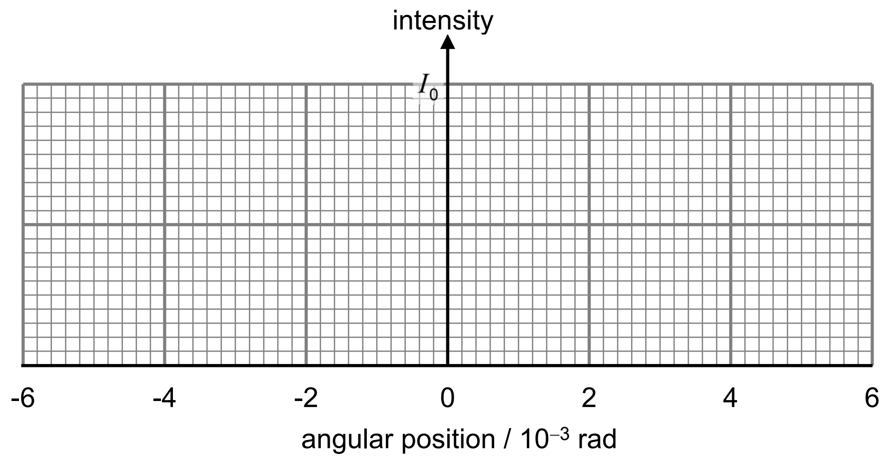

Fig. 7.3

[2]

3. A second identical point source is placed 0.50 m beside the original point source at the same distance D from the single slit.

Determine D where the two point sources are just resolved.

D = ... m [2]

(ii) The second point source is now removed. An opaque film with a width of 0.10 mm is positioned at the centre of the single slit such that a double slit is formed as shown Fig. 7.4.

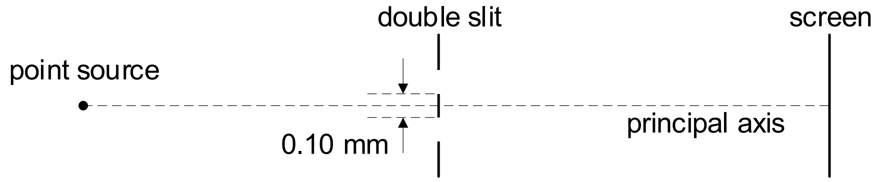

Fig. 7.4 (not to scale)

1. Determine the separation between the two slits.

separation = ... mm [1]

2. Besides a change in intensity, state, with numerical values, the other changes to the diffraction pattern observed in Fig. 7.3.

....

....

....

....

.... [3]

3. Determine, in terms of I_0, the maximum intensity of the pattern after the film is applied.

maximum intensity = ... [3]

8 A uranium-238 (U) nucleus, originally at rest in a cloud chamber, undergoes spontaneous decay by emitting an α-particle to form a thorium (Th) nucleus.

(a) State what is meant by the number *238*.

....

.... [1]

(b) Complete the nuclear equation below for the decay.

$$^{238}_{\boxed{}}\text{U} \rightarrow {}^{\boxed{}}_{90}\text{Th} + {}^{4}_{\boxed{}}\text{He}$$

[2]

(c) The α-particle travels 40.0 mm in the cloud chamber to produce a track of ion-pairs which causes the α-particle's path to be visible due to condensation taking place on the ions produced.

On average, an α-particle produces 5.90×10^{3} ion-pairs per mm of track in the cloud chamber and the energy required to produce an ion-pair is 2.70×10^{-18} J.

(i) Show that the kinetic energy of the α-particle is 6.37×10^{-13} J.

[1]

(ii) Determine the momentum of the thorium nucleus.

momentum = ... N s [2]

(iii) Determine the total kinetic energy of the α-particle and the thorium nucleus.

total kinetic energy = ... MeV [3]

(iv) State an assumption you made in your calculations in **(c)(ii)** and **(c)(iii)**.

....

.... [1]

(d) Fig. 8.1 shows the variation with nucleon number A of the nuclear binding energy per nucleon B_E.

The nuclear binding energy per nucleon of uranium-238 nucleus is 7.57 MeV and that of the α-particle is 7.08 MeV.

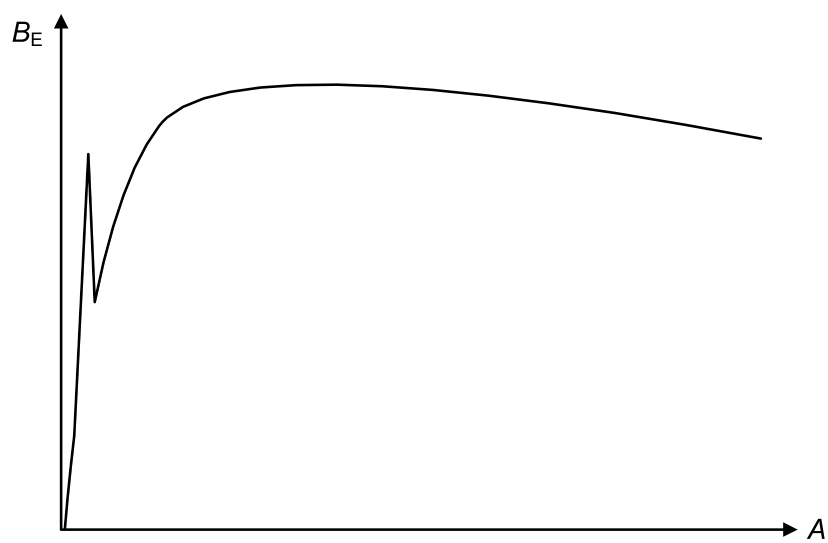

Fig. 8.1

(i) Explain the term *nuclear binding energy*.

....

....

.... [1]

(ii) State the nuclide with the highest B_E and its B_E to 2 significant figures.

nuclide : ....

B_E : .... MeV [2]

(iii) Determine the nuclear binding energy per nucleon of the thorium nucleus.

binding energy per nucleon = ... MeV [3]

(iv) On the curve in Fig. 8.1, mark the approximate positions of the nuclei of

1. uranium-238 (label the position U),

2. thorium (label the position Th),

3. α-particle (label the position α). [2]

(v) Nuclear fusion is a nuclear reaction that releases energy.

1. Explain the term *nuclear fusion*.

....

.... [1]

2. One such type of nuclear fusion reaction is $A + B \rightarrow C$.

On Fig. 8.1, mark the approximate positions of the nuclei of A, B and C. [1]

End of Paper 3 Section B