FUKIEN SECONDARY SCHOOL

S5 First Term Examination (2020–2021)

Physics

(1 hour 30 minutes)

Date: 4th January 2021 Name: _____

Time: 10:30 a.m. – 12:00 noon Class: _____ No.:_____

Instructions to students:

1. Write your name, class and class number on both the question paper and the answer sheets.
2. Answer ALL questions.
3. Write down all the answers on the answer sheets.
4. Hand in the question paper and the answer sheets at the end of the examination.
5. The total mark of the paper is 90.
6. The paper consists of two sections: Section A Multiple Choice Questions (30 marks) and Section B Structured Questions (60 marks).
7. The numerical answers should be either exact or correct to 3 significant figures.
8. You may use the following formula and data.

Data

speed of light in vacuum $c = 3.00 \times 10^8$ m s^{-1}

Formula

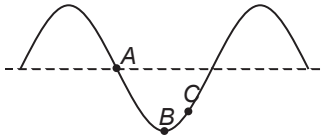
C1. $\Delta y = \dfrac{\lambda D}{a}$ fringe width in double-slit interference

C2. $d \sin\theta = n\lambda$ diffraction grating equation

C3. $\dfrac{1}{u} + \dfrac{1}{v} = \dfrac{1}{f}$ equation for a single lens

Section A: Multiple Choice Questions (30 marks)

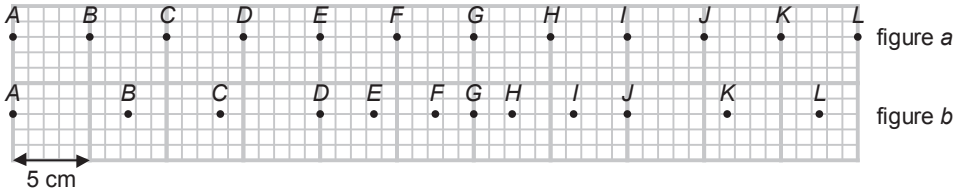
1. The figure below shows a transverse wave travelling along a string. At the instant as shown below, particle *C* is moving downwards.



Which of the following statements is correct?

A. The wave is travelling from right to left.
B. Particle *A* is moving downwards at this instant.
C. Particle *B* is always at rest.
D. Particles *A* and *B* vibrate with same amplitudes.

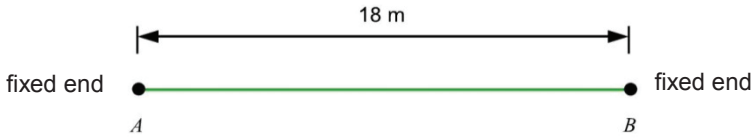
2. A longitudinal wave is travelling from left to right in a medium. Figure *a* shows the equilibrium positions of some particles *A* to *L* in the medium. Figure *b* shows the positions of the particles at a certain time when the wave is passing through them.



At the instant shown, which of the following particles is moving to the left?

A. Particle *A*
B. Particle *D*
C. Particle *G*
D. Particle *K*

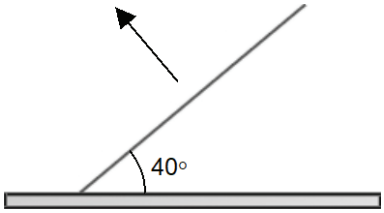
3. As shown in the figure below, a stationary wave produced on a string *AB* has a wave speed of 3 m s^{-1} and frequency of 3 Hz. The string is 18 m long.



How many antinodes are there?

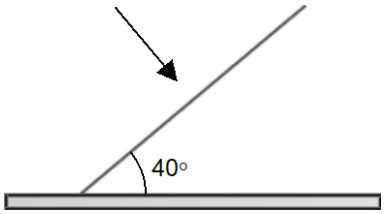
A. 9
B. 18
C. 27
D. 36

4.

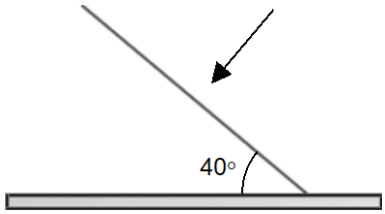


Which of the following can produce the above reflected pulse?

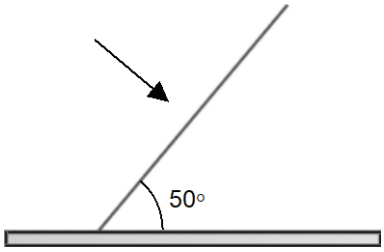
A.



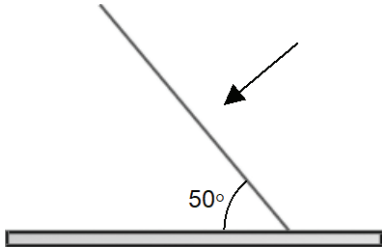
B.



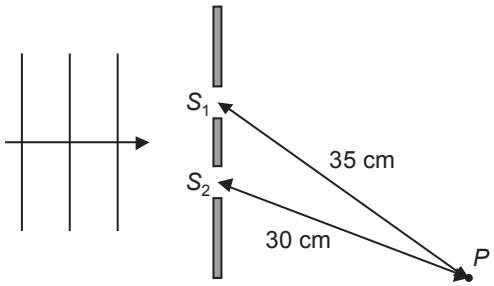
C.



D.



5.

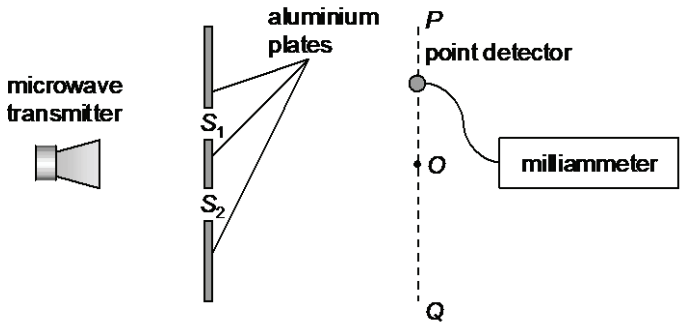


As shown in the figure above, a train of straight water waves travels towards a straight barrier with two openings. Two sets of circular waves are produced on the other side of the barrier. The distance of a point P from S_1 and S_2 are 35 cm and 30 cm respectively. Suppose destructive interference occurs at P. What is the possible wavelength of the wave?

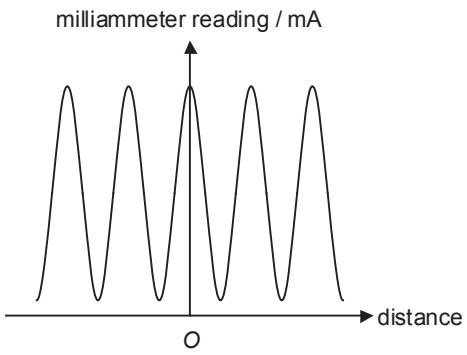
A. 1 cm
B. 2 cm
C. 3 cm
D. 5 cm

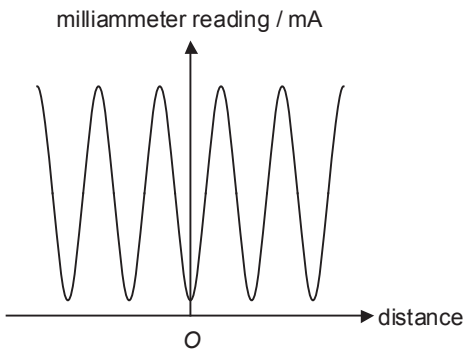
6. Which of the following statements concerning visible light and microwaves is/are correct?
   (1) Visible light is electromagnetic wave while microwaves are not.
   (2) Visible light and microwaves travel with the same speed in air.
   (3) Visible light can be diffracted while microwaves cannot.
   A. (1) only
   B. (2) only
   C. (2) and (3) only
   D. (1), (2) and (3)

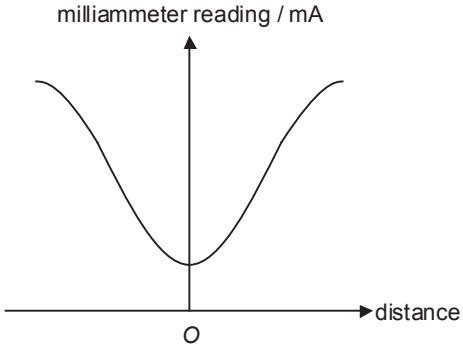
7.

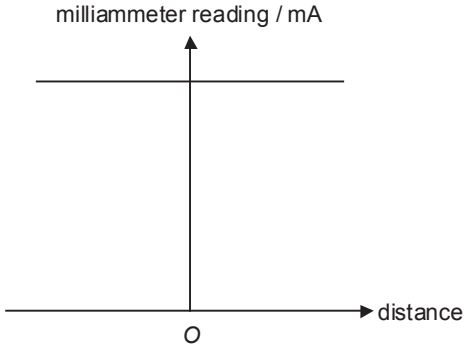


A student directs a beam of microwaves towards three aluminium plates as shown in the figure above. O is a point on PQ such that $S_1O = S_2O$. Which of the following graphs best shows the reading of the milliammeter when the point detector is moved along PQ?

A.


B.


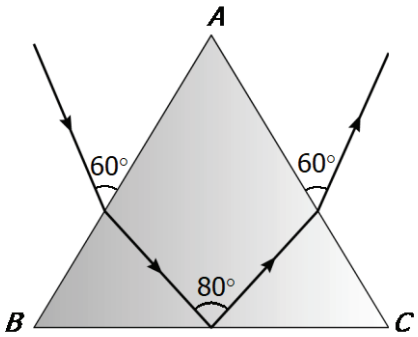
C.


D.


8. A monochromatic laser is incident normally on a transmission grating. At a point X on the screen, a bright fringe is formed due to a path difference of 2×10^{-6} m. If the wavelength of the laser is 5×10^{-7} m, what is the order of the bright fringe at X?
   A. first
   B. second
   C. third
   D. fourth

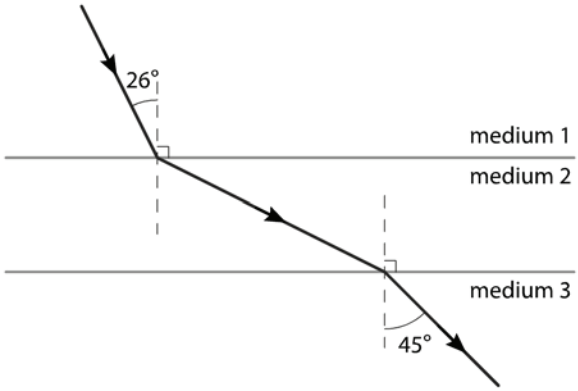
9. In a Young's double slit experiment, the second-order and third-order dark fringes are separated by a distance of 0.02 m. If the slit separation is 0.03 mm and the screen is 90 cm away from the double-slit, find the wavelength of the light source.
   A. 1.67×10^{-7} m
   B. 6×10^{-7} m
   C. 6.67×10^{-7} m
   D. 6×10^{-6} m

10. As shown in the figure below, a ray of light travelling in air is incident on the side AB of a triangular prism made of material X. The ray of light is totally reflected on the side BC and leaves the prism through the side AC.



   What is the minimum possible refractive index of material X?
   A. 1.02
   B. 1.15
   C. 1.56
   D. 2

11. A light ray travels from medium 1 to medium 3 as shown in the figure below. The three media are separated by parallel boundaries.



If the wavelength of the light in medium 1 is λ_1, find the wavelength of the light in medium 3.

A. $1.61\ \lambda_1$
B. $1.27\ \lambda_1$
C. $0.620\ \lambda_1$
D. Answer cannot be found as the angle of refraction in medium 2 is not known.

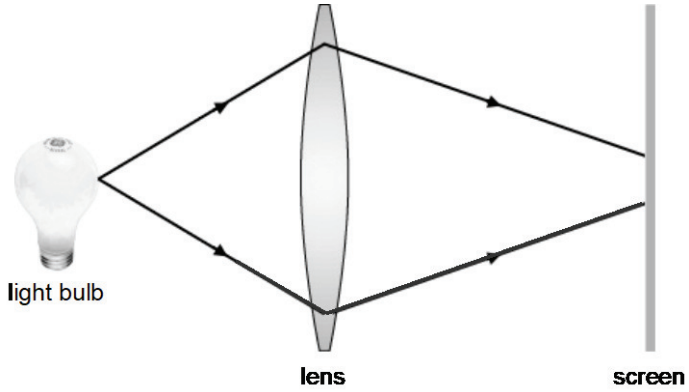
12.

A student observes the word "PHYSICS" on a piece of paper as shown in the figure above. Which of the following statements about the image formed by lens are INCORRECT?

(1) The image formed is virtual.
(2) The object distance is equal to the focal length of the lens.
(3) When the lens is moved towards the print slightly, the print would be further magnified.

A. (1) and (2) only
B. (1) and (3) only
C. (2) and (3) only
D. (1), (2) and (3)

13. A light bulb is placed in front of a convex lens as shown in the figure below.

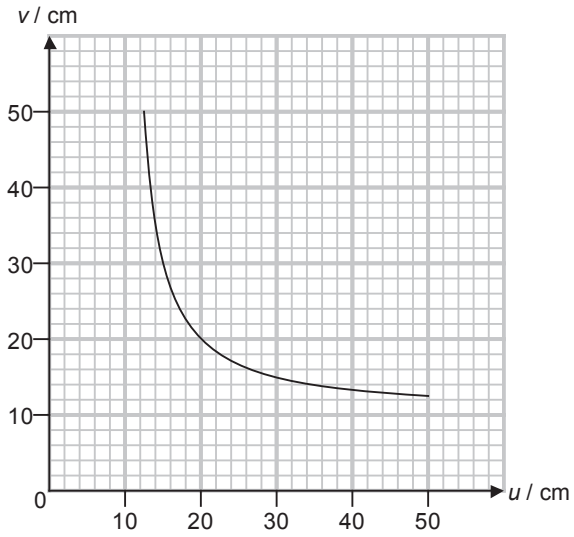


A sharp image of the light bulb can be formed by

(1) replacing the lens with a converging lens of a longer focal length.
(2) placing a convex lens between the light bulb and the lens.
(3) moving the light bulb farther away from the lens.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

14.



An object is placed in front of a convex lens and an image is formed behind the lens. The graph above shows the relationship between the object distance *u* and the image distance *v*. What is the focal length of the lens?

A. 10 cm
B. 20 cm
C. 30 cm
D. 40 cm

15. A real image of a linear magnification of 0.5 is formed by a convex lens. What is the linear magnification of the image when the object distance is halved?

A. 0.25
B. 0.5
C. 1
D. 2

End of Section A

Section B: Structured Questions (60 marks)

1. A stationary wave is produced on an elastic string which is fixed with one end to a vibrator and the other to a stand. The frequency of the vibrator is set at 50 Hz. The distance between the vibrator and the stand is 1 m. Figure 1a shows the positions of particles *X* and *Y* at the instant when they are furthest from their equilibrium positions.

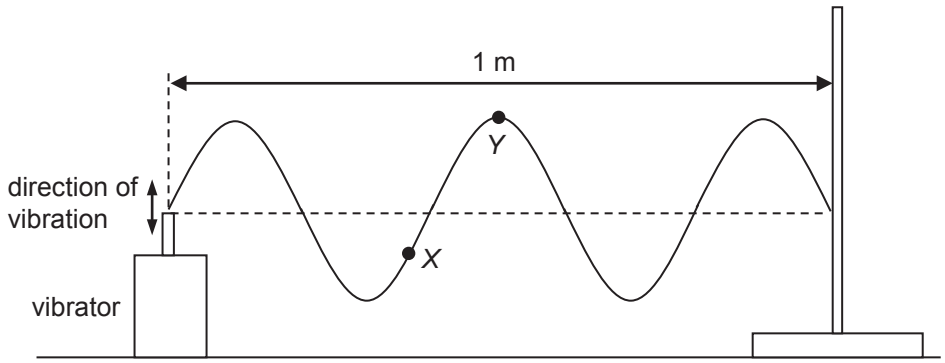


Figure 1a

(a) Find the wavelength and the wave speed of the stationary wave. (3 marks)

(b) Describe the motion of particles *X* and *Y* at the instant shown in Figure 1a. (2 marks)

(c) Figure 1b on the answer sheet shows the displacement–time graph of particle *X*. Sketch the displacement–time graph of particle *Y* in the same figure. (2 marks)

(d) Describe how you can produce another stationary wave with fewer antinodes compared with the one shown in Figure 1a. (1 mark)

2. Loudspeaker L_1 produces a sound wave. Figure 2a shows the positions of the air particles at different instants as the sound wave travels. Take the displacement to the right as positive.

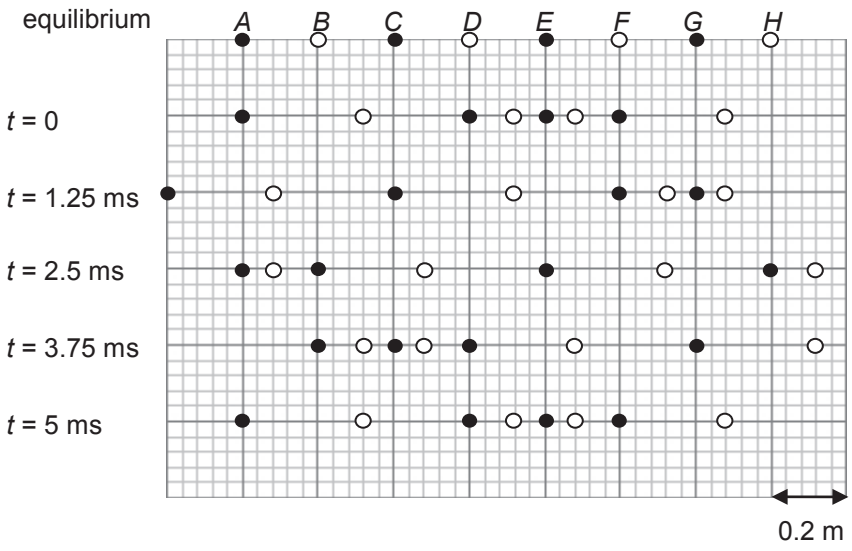


Figure 2a

(a) In Figure 2b on the answer sheet, draw the displacement–time graph for particle C from t = 0 to t = 5 ms. (3 marks)

(b) Hence, determine the amplitude and the frequency of the wave. (2 marks)

(c) Find the wavelength of the wave. (2 marks)

(d) In Figure 2c, another loudspeaker L_2 is placed face-to-face with L_1. The two loudspeakers are connected to the same signal generator. The distance between L_1 and L_2 is 5.5λ. O is at the mid-point between them. Describe the sound wave detected at O. Explain your answer briefly. (3 marks)

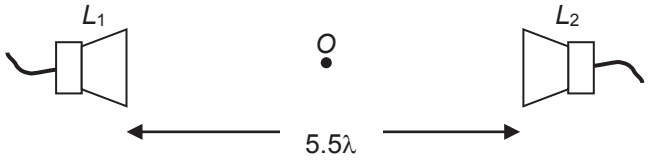


Figure 2c

3. Peter lives in a house A on one side of a hill. A transmitting station T_1 is located at site P on the other side of the hill. (See Figure 3) The station transmits radio waves of frequency 600 kHz and TV waves of frequency 500 MHz. (1 MHz = 10^6 Hz)

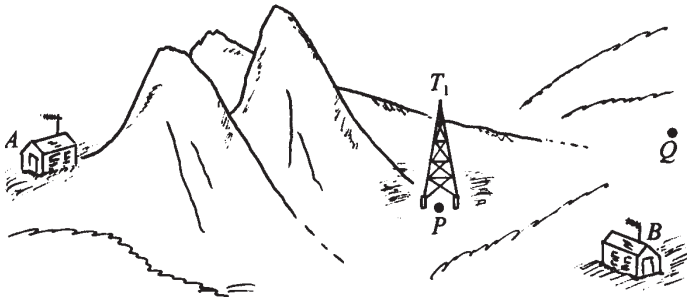


Figure 3

(a) Find the wavelengths of the radio waves and TV waves. (3 marks)

(b) Name the wave phenomenon which enables the waves transmitted by T_1 to reach Peter's house. (1 mark)

(c) Peter finds that the radio reception is better than the TV reception. Explain this phenomenon. (2 marks)

(d) Peter is watching TV in his house. He finds that the reception is affected when an aeroplane flies overhead. Explain this phenomenon. (2 marks)

(e) Another transmitting station will be built at site *Q*. (See Figure 3.) Mary lives in a house *B* such that *BP* = 3.95 km and *BQ* = 3.20 km.

(i) Find the path difference at *B* from *P* and *Q*. (1 mark)

(ii) Mary listens to the radio in her house. How will the reception be affected if both stations transmit identical radio waves at 600 kHz? Explain your answer. (Neglect the reflection of waves from the hill.) (3 marks)

4. A student uses the set-up shown in Figure 4a to find the wavelength of a laser beam.

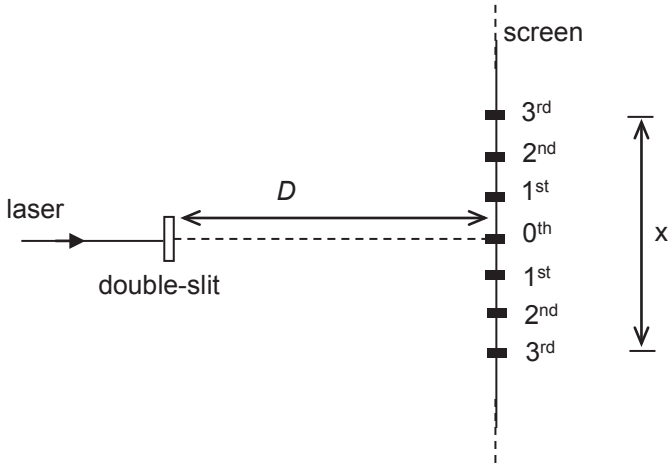


Figure 4a

He placed a screen at a distance *D* from a double-slit of slit separation 0.2 mm. Then, he measures the separation *x* between the bright fringes of the third order. By setting *D* to different values, the following results are obtained.

D / m	0.5	1.0	1.5	2.0	2.5
x / cm	1.1	1.9	3.1	3.9	5.1

(a) State one safety precaution of the experiment. (1 mark)

(b) (i) Plot a graph of x against D on Figure 4b on the answer sheet. (3 marks)

(ii) Express the slope of the graph in (b)(i) in terms of λ. (2 marks)

(iii) Estimate the wavelength λ of the laser. (2 marks)

(c) Comment on the following statement:

'Using a double-slit of wider slit separation will improve the accuracy of the result.' (3 marks)

5. A ray of light travelling in air enters a rectangular glass block $ABCD$ at point P as shown in Figure 5. The ray is incident at an angle of 40° and refracted at 25°. Then, the ray travels along PQ inside the glass block. It meets the glass-air boundary at point Q with an angle of incidence θ. (Given $AQ > DQ$)

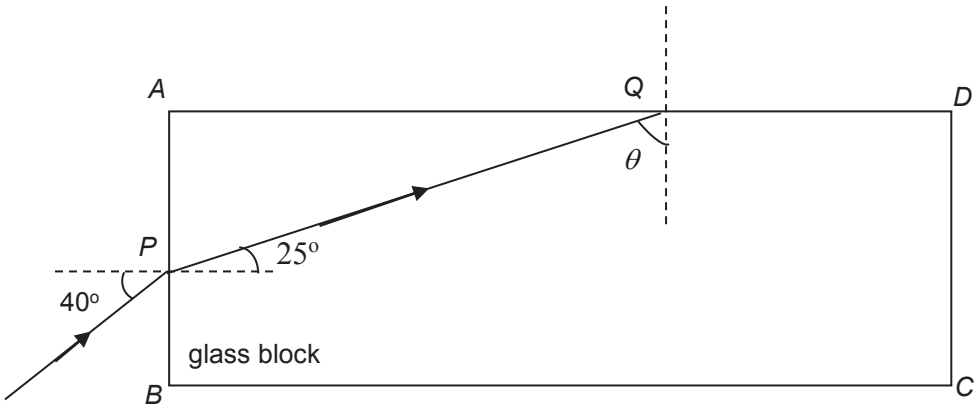


Figure 5

(a) (i) Find the refractive index of the glass. (2 marks)

(ii) Find the critical angle of the glass. (2 marks)

(b) (i) Describe and explain what happens when the light ray hits point Q. (2 marks)

(ii) Complete the path of the light ray in the figure on the answer sheet until it finally emerges from the glass block to the air. (2 marks)

(c) A layer of water (refractive index = 1.33) is applied on the side AQD of the block. Explain whether the light ray will enter the water at point Q. (4 marks)

6. Ronald designs a device which can project the screen of a phone onto a wall. He fixes his phone inside a box and cuts a hole on a surface of the box. A lens is then fixed at the hole and produces the image of the screen on a wall as shown in Figure 6a.

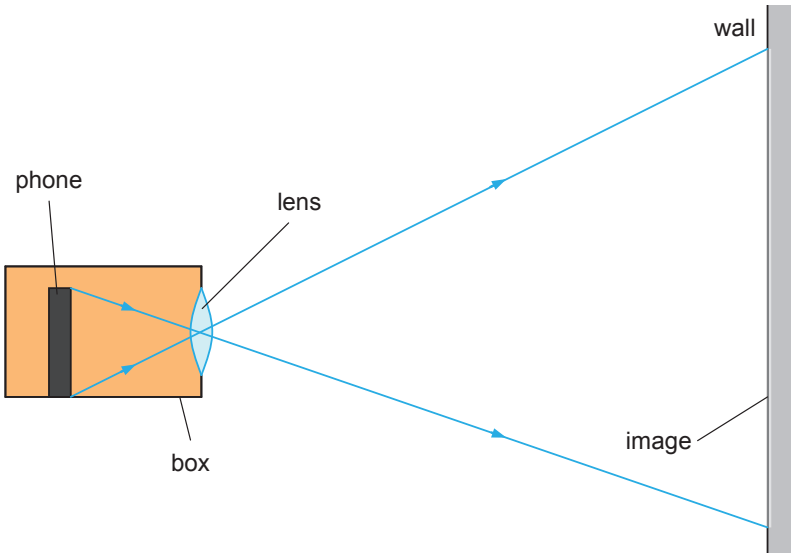


Figure 6a

(a) State the kind of lens used in the device. (1 mark)

(b) When the screen of the phone is 10 cm away from the lens, a clear image is formed on a wall 90 cm away from the lens.

(i) State the linear magnification of the image. (1 mark)

(ii) By drawing a suitable ray diagram on Figure 6b on the answer sheet, determine the focal length of the lens. (3 marks)

(c) Ronald projects a clear image of the screen onto a wall 2 m away from the lens. Find the distance between the screen and the lens using the lens formula and the answer of (b)(ii). (2 marks)

End of Section B

End of Paper