Name: …… ( ) Class: …….

Bukit Batok Secondary School
GCE 'O' LEVEL PRELIMINARY EXAMINATIONS 2021
SECONDARY FOUR EXPRESS

PHYSICS **6091 / 02**

Paper 2 Theory

27 Aug 2021

0800 − 0945 h

1 hour 45 minutes

Candidates answer on the Question Paper

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class, and class register number on all the work you hand in.
Write in dark blue or black ink.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the space provided.

Section B
Answer **all** questions in the space provided. Question 12 has a choice of parts to answer.

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

At the end of examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

FOR EXAMINER'S USE	
Section A	
Section B	
TOTAL	

This Question Paper consists of **21** printed pages.

HABITS OF MIND

Remember to

think flexibly and apply past knowledge to new situations.

Section A

Answer **all** the questions in this section.

1 A man stands at the edge of a vertical cliff and he projects a stone vertically upwards. The stone reached its greatest height, fell past the man and hit the bottom of the cliff.

The motion of the stone is represented by the velocity-time graph shown in Fig. 1.1.

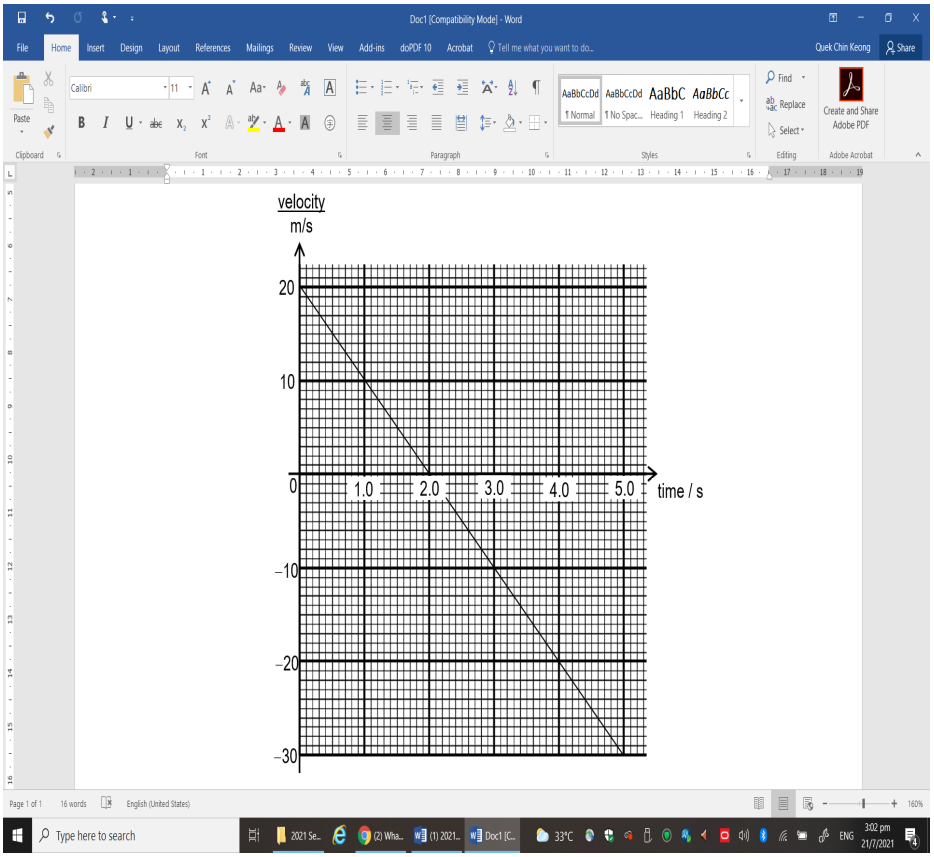

Fig. 1.1

(a) Explain how Fig. 1.1 shows that air resistance has negligible effect on the motion of the stone.

……... [1]

(b) Based on the data shown in Fig. 1.1, determine

(i) the greatest height achieved by the stone,

greatest height = ……. [2]

Question continues on next page...

(ii) the height of the cliff.

height of cliff = ... [2]

2 Fig. 2.1 shows an apparatus that demonstrates how a coin and a piece of paper fall from rest through air.

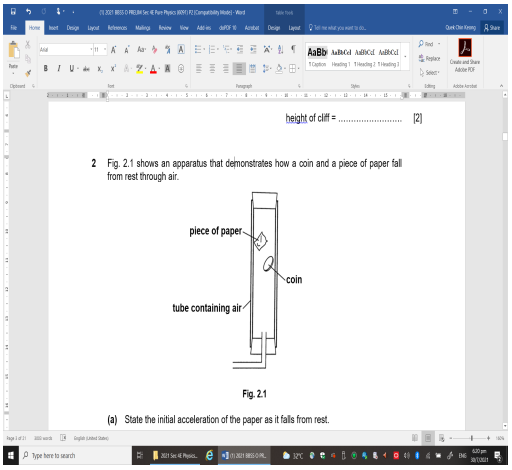

Fig. 2.1

(a) State the initial acceleration of the paper as it falls from rest.

..... [1]

(b) The coin and paper are at the positions shown in Fig. 2.1.
By considering the forces acting on each object, explain why

(i) the paper falls with constant velocity,

.....

..... [1]

(ii) the coin still accelerates.

.....

.....

..... [2]

3 Fig. 3.1 shows a sphere of weight 6.5 N suspended by a wire from point X.
The sphere is pulled to one side by a horizontal force F so that the wire makes an angle of 30° with the vertical.

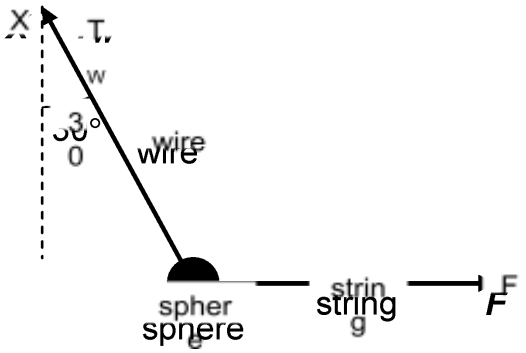

Fig. 3.1

Use a scale of 1.0 cm to represent 0.50 N, draw a scale diagram in the space below to determine the magnitude of

(a) the tension (T_W) in the wire,

(b) the horizontal force F.

magnitude of T_W = …….

magnitude of F = ……. [3]

4 The Qinghai-Tibet Railway is a high-altitude railway that starts at Xining (in Qinghai Province) and ends at Lhasa (in Tibet Autonomous Region) in China. From Xining to Lhasa, the length of the railway is 1956 km and the trip takes 21 hours on average.

Fig. 4.1 shows how the altitude (above sea level in metres) vary as a train travels from Beijing to Lhasa. The train journey from Beijing to Lhasa will take more than a day.

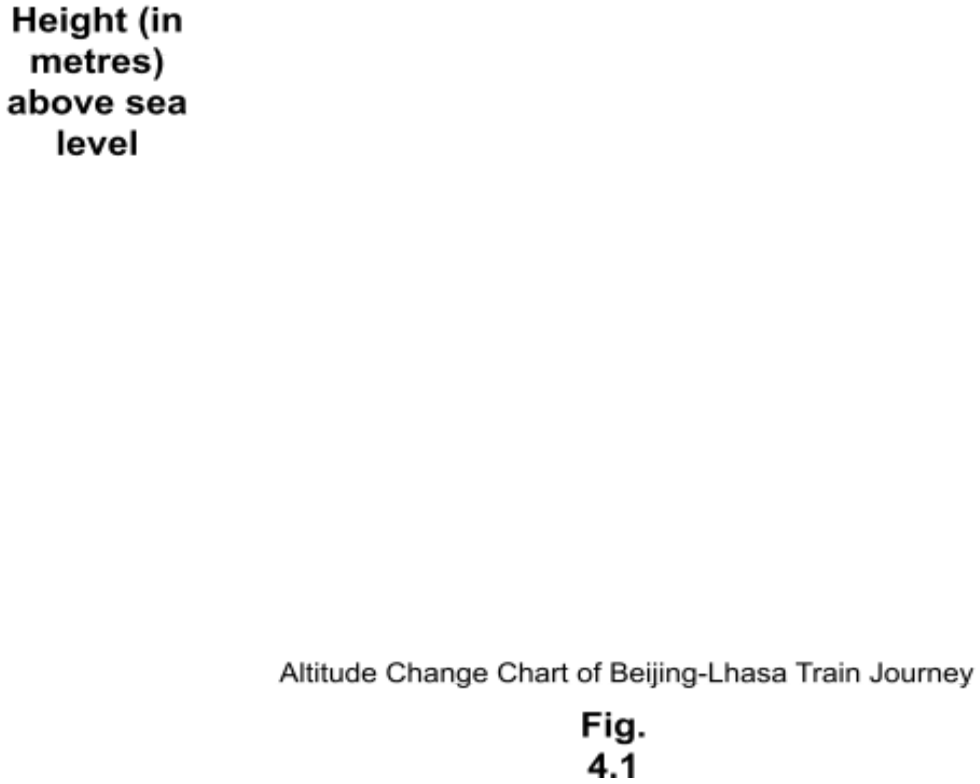

Fig. 4.1

(a) Determine the average speed of a train in metres per second as it travels from Xining to Lhasa.

average speed = …… [3]

(b) Suggest **one** reason why the average velocity of the train is different from the value calculated in part **(a)** above.

[1]

……...

Question continues on next page…

(c) A mercury barometer is brought from Beijing to Lhasa.

(i) Determine the greatest change in altitude during the journey.

greatest change in altitude = …… [1]

(ii) Hence, determine the greatest change in the height of the mercury column in the barometer during the journey.
(density of air = 1.29 kg/m^3; density of mercury = 13600 kg/m^3)

greatest change in height of mercury column = …… [2]

(d) Suggest **one** reason why the value calculated in part **(c)** above may be inaccurate.

……... [1]

5 Fig. 5.1 shows a uniform plank AC of length 3.0 m and weight 100 N held at equilibrium horizontally. End A of the plank is fixed. A box of weight 400 N hangs at end C of the plank. There is a rope tied at end B of the plank. Distance BC is 1.0 m.

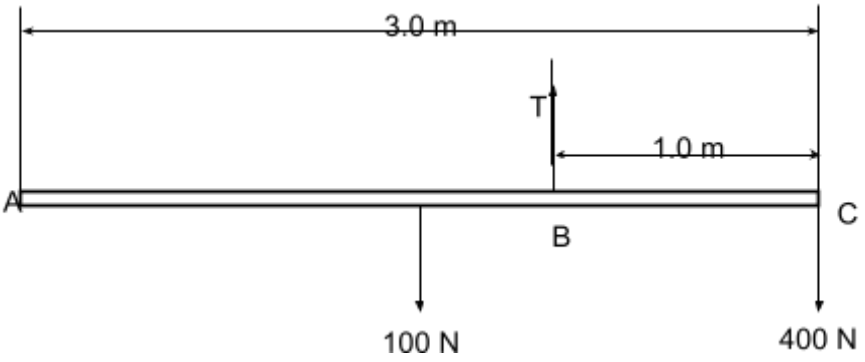

Fig. 5.1

(a) Determine the moment due to the weight of the plank about end A.

moment = …… [2]

(b) Determine the tension T of the rope.

tension T = …… [2]

Question continues on next page…

(c) With the plank still pivoted at end A and the box is still hanging at end C of the plank, the rope exerts an upward force on the plank. At one instant, the plank is held at rest at the position shown in Fig. 5.2.

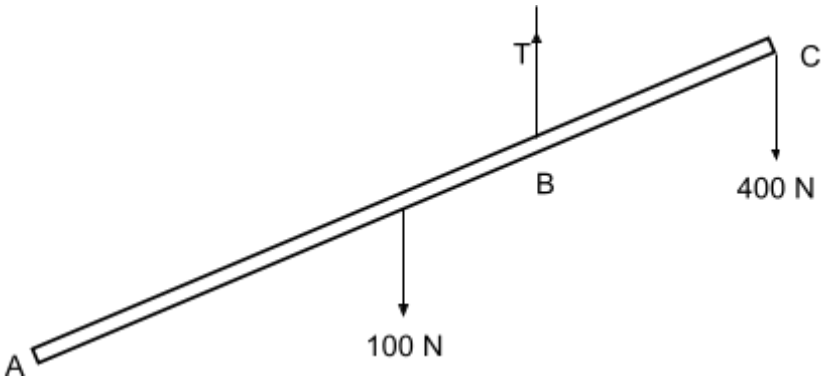

Fig. 5.2

At this instant, is the magnitude of tension T of the rope greater, smaller or the same as the value of T calculated in part **(b)** above?
Explain your answer.

……...

……...

……... [2]

6 **(a)** Define what is meant by

(i) work done, and

……

…… [1]

(ii) power

…… [1]

(b) State the principle of conservation of energy

……...

……...

……... [2]

Question continues on next page…

(c) Fig. 6.1 shows a roller coaster of weight 5000 N and initially at rest at a height of 15.0 m above the ground.
It is then released from rest and it rolls along the track for 50.0 m before it comes to a momentary rest at point X which is 11.0 m above the ground. The track feels warm after the roller coaster rolled past it.

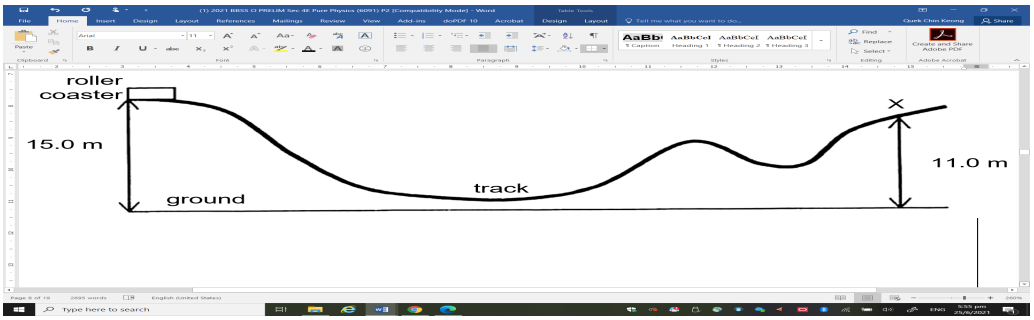

Fig. 6.1

(i) Ignoring loss of energy to the surroundings through other means, determine the work done against friction as it rolls from its initial rest position to point X.

work done against friction = …… [2]

(ii) Determine the frictional force (assumed constant throughout) that acts between the roller coaster and the track.

frictional force = …… [2]

(iii) A motor (not shown in Fig. 6.1) was used to raise the roller coaster from ground level to its initial rest position 15 m above ground level.
Given that the motor takes 30 s to do so, what is the power dissipated by the motor? (Ignore energy lost to the surroundings as heat or sound).

power = …… [2]

7 A student uses a thin converging lens (L) to produce a real, inverted and magnified image (I) of an object O.
Fig. 7.1 shows the incomplete ray diagram drawn by the student.

Fig. 7.1

On Fig. 7.1,

(a) draw a light ray that allows you to confirm the position of lens L, [1]

(b) draw the position of the lens and label it L. [1]

(c) draw another light ray that allows you to determine the focal length of lens L.

State clearly the focal length (f) of lens L in Fig. 7.1 [2]

8 A stone is thrown into a calm lake at point P.
In two seconds, three circular wavefronts are produced on the surface of the water as shown in Fig. 8.1. The distance PQ is 18 cm.

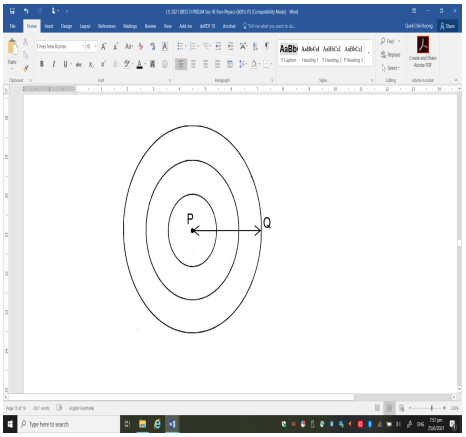

Fig. 8.1

(a) Explain what is meant by

(i) a wave, and

……

…… [1]

(ii) a wavefront.

……

…… [1]

(b) **(i)** Determine the wavelength of the wave.

wavelength = …… [1]

(ii) Hence, determine the speed of the wave.

speed = ... [2]

9 A fine beam of electrons is projected towards the screen and it passes between the poles of an electromagnet as shown in Fig. 9.1. The entire set up is enclosed in vacuum and a bright spot Y is seen when the electron beam hits the screen.

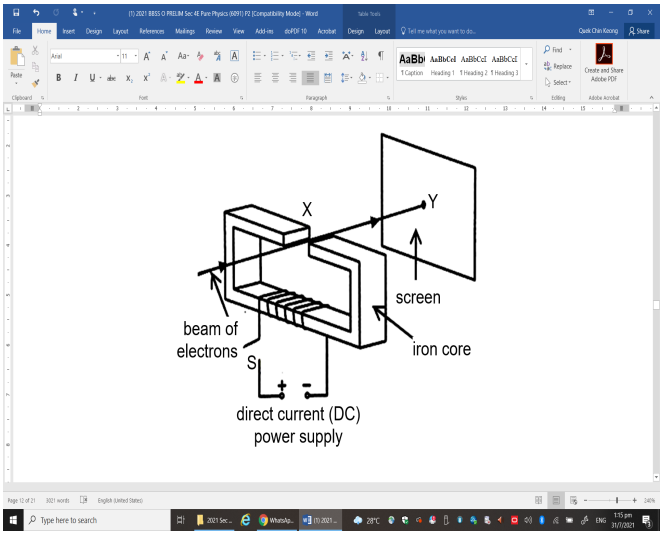

Fig. 9.1

(a) Switch S is then closed.

(i) State the magnetic pole that is produced at part X of the iron core.

..... [1]

(ii) In which direction will spot Y on the screen be deflected?
Explain your choice of answer.

.....

.....

.....

.....

..... [3]

(b) The direct current (DC) power supply in Fig. 9.1 is replaced by an alternating current (AC) power supply.
Predict what would be seen on the screen.

..... [1]

Section B

Answer **all** the questions in this section.
Answer only one of the two alternative questions in **Question 12**.

10 Fig. 10.1 shows a vacuum flask cooker. It comprises of an outer pot and an inner pot.

The inner pot is a single-layered steel container with a shiny and silvery exterior.

The outer pot is a double-layered steel container with vacuum in between the layers.

Both pots come with their own lids. The inner pot can fit into the outer pot.

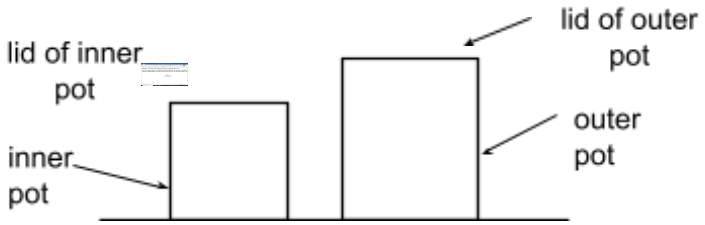

Fig. 10.1

Student A used the vacuum cooker to cook some soup by doing the following:

- The soup was placed into the inner pot over an electric stove.
- The stove is set at high power setting and the soup was cooked for 20 minutes.
- The inner pot, containing the soup, was transferred immediately into the outer pot.
- The outer pot was then covered up with lid and left alone for 3 hours.
- The inner pot containing the soup was taken out of the outer pot and over the electric heater again. The soup was cooked at high power setting for 2 minutes.

Student B is not impressed by student A's way of cooking the soup.

He devised his own way of cooking the same mass of soup by doing the following:

- The soup was placed into the inner pot over an electric stove.
- The stove is set at high power setting and the soup was cooked for 20 minutes.
- The stove is then set at low power setting and the soup was cooked for 100 minutes.

Other details pertaining to the electric stove and the soup are as follows:

power rating of electric stove (high power setting)	2.2 kW
power rating of electric stove (low power setting)	1.1 kW
mass of soup	4.0 kg
specific heat capacity of soup	4400 $Jkg^{-1}°C^{-1}$
temperature of soup (before inner pot is placed inside outer pot)	97.0 °C
temperature of soup	85.0 °C

(after 3 hours)	

Question continues on next page…

(a) Explain what is meant by *the specific heat capacity of the soup is 4400 $Jkg^{-1}°C^{-1}$*.

……...

……...

……... [2]

(b) Determine the rate of heat loss from the soup when it was placed inside the outer pot for 3 hours. Express your answer in SI units.

rate of heat loss = …… [3]

(c) Explain how the inner pot keep the soup warm when it was placed inside the outer pot for 3 hours.

……...

……... [2]

(d) Determine the amount of energy supplied by the stove using student A's method as well as student B's method. Hence, deduce whose method is more energy efficient.

energy supplied (A's method) = ……

energy supplied (B's method) = ……

whose method is more energy efficient: …… [3]

Question continues on next page…

(e) When cooking water-based food, we must exercise caution not to be scalded by steam.
Explain why scalding by steam at 100 °C is more severe than being scalded by the same mass of boiling water at 100 °C.

……...

……... [1]

11 **(a)** Fig. 11.1 shows a ray of light being refracted at a glass surface.
Fig. 11.2 shows the same ray of light being refracted at the same glass surface but at a different angle.

Fig. 11.1 **Fig. 11.2**

(i) Explain why the ray of light bends when it travels from air to glass.

……

……

…… [2]

(ii) Determine the angle of refraction of light in Fig. 11.2.

angle of refraction = …… [2]

Question continues on next page…

(b) Fig. 11.3 shows a ray of light travelling from liquid L to air.
The refracted ray travels along the boundary between air and liquid L.

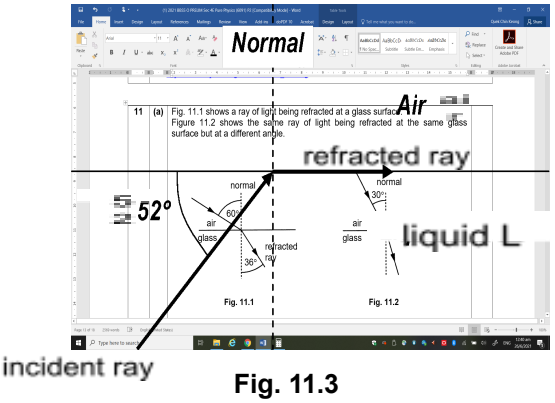

Fig. 11.3

(i) Explain why the refracted ray travels along the boundary.

……

……

…… [2]

(ii) Determine the critical angle of light in liquid L.

critical angle = …… [1]

(iii) Hence, determine the refractive index of liquid L.

refractive index = …… [2]

12 EITHER

Telephone conversations are carried across the oceans of the world as brief pulses of light signals in cables. These cables contain hair-thin fibre optic strands. The core of these strands are made of glass and it is covered by a transparent cladding, as shown in Fig. 12.1. Ideally, total internal reflection occurs and all the light signals is confined to the core.

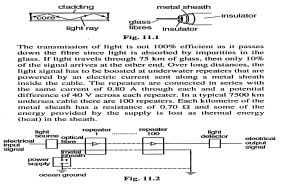

Fig. 12.1

In reality, the transmission of light is not 100% efficient as it passes down the fibre since light is absorbed by impurities in the glass. If light travels through 75 km of glass, then only 10% of the light signal arrives at the other end. Over long distances, the light signal has to be boosted at underwater repeaters that are powered by an electric current sent along a metal sheath inside the cable as shown in Fig. 12.2.

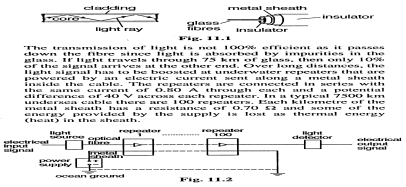

Fig. 12.2

Fig. 12.3 shows a simplified model of a typical 7500 km undersea cable. There are 100 repeaters and they are connected in series. A current through each repeater is 0.80 A and the potential difference across each repeater is 40 V. Each kilometre of the metal sheath has a resistance of 0.70 Ω and some of the energy provided by the supply is lost as thermal energy in the sheath.

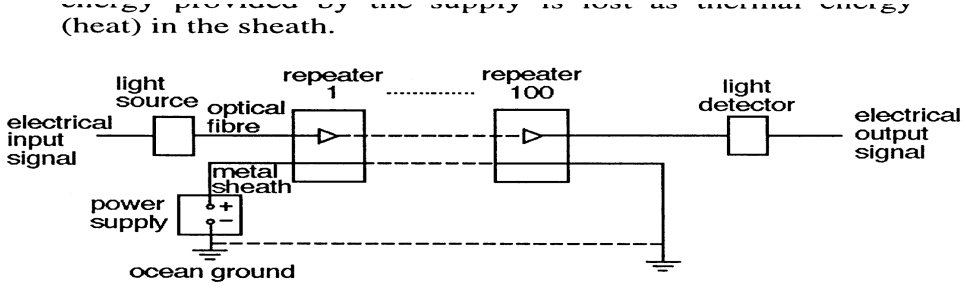

Fig. 12.3

(a) Explain why repeaters are necessary along an undersea cable.

……...

[1]

……...

Question continues on next page…

(b) **(i)** Define what is meant by the refractive index of an optical medium.

……

…… [1]

(ii) Refer to Fig. 12.1, is the speed of light in the core higher, lower or the same as the speed of light in the cladding? Explain your answer.

……

……

…… [2]

(c) Determine, for a 7500 km undersea cable

(i) the potential difference across all the repeaters,

potential difference = …… [1]

(ii) the potential difference across the resistance of the metal sheath,

potential difference = …… [2]

(iii) the potential difference provided by the power supply,

potential difference = …… [1]

(iv) the thermal energy emitted from each kilometre of the metal sheath per second.

thermal energy emitted per second = …… [2]

12 OR

Slightly more than a century ago, scientists like Marie Curie and Henri Becqurel discovered that certain unstable (radioactive) isotopes of some elements (e.g., polonium and radium) emit radiation that could, for example, blacken unused photographic plates. Subsequent works by other scientists showed that these radioactive isotopes emit one or more types of radiation. Currently, there are three types of radiation that are known to man: alpha particles, beta particles and gamma rays. Detectors are necessary in the study of these radiations as they are invisible to the naked eye.

An alpha particle is a positively charged helium nucleus consisting of two protons and two neutrons, a beta particle is a fast moving electron, while gamma rays are high frequency electromagnetic waves. When these three radiations are allowed to pass through an electric field or a magnetic field at right angles, gamma rays is the only radiation that can pass through the field without showing any deflection. Gamma rays are also highly penetrating: they can only be stopped by a few centimetres of thick lead (Pb). It is this highly penetrating nature of gamma rays that makes them useful (in small, controlled doses) in our daily lives.

By “attaching” a small, harmless amount of a gamma ray source (radioactive isotope that emits gamma rays) to a drug and monitoring the radioactivity of the patient at regular time intervals, gamma rays can be used as tracers that allow doctors to monitor how fast the drug is absorbed by the human body.

Gamma rays are also used to detect leaks in underground pipes. A gamma ray source (in liquid form) is first introduced into the underground pipe, and the pipe is then scanned thoroughly by a radioactive detector located above the ground. If the detector picks up an abnormally high activity of gamma rays, then it implies that there is a leak at that section of the pipe. The technicians can then dig up and repair that section of the pipe instead of the entire length of the pipe, avoiding unnecessary inconvenience and costs.

Question continues on next page…

(a) **(i)** Define what is meant by the *inertia* of a body.

……

…… [1]

(ii) Hence, explain which particle, alpha or beta, has larger inertia.

……

…… [2]

(b) Fig. 12.4 shows a beam of gamma rays travelling perpendicularly through a uniform electric field, while a beam of beta particles and a beam of alpha particles are about to travel perpendicularly through the uniform electric field.

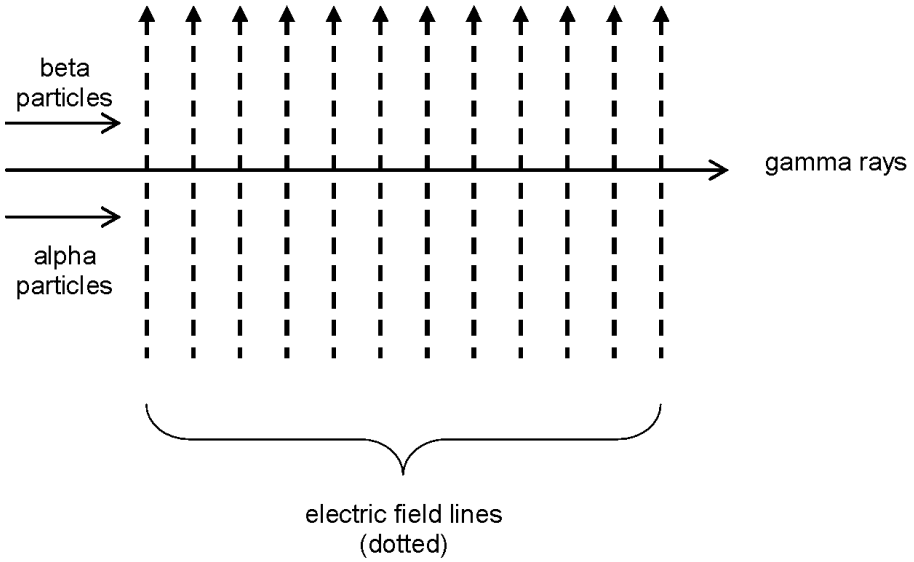

Fig. 12.4

On Fig. 12.4, complete the path of the alpha particles and beta particles as they travel through the electric field. [2]

Question continues on next page…

(c) Fig. 12.5 shows a beam of gamma rays travelling perpendicularly through a uniform magnetic field, while separate beams of alpha particles and beta particles are about to travel perpendicularly through the magnetic field.

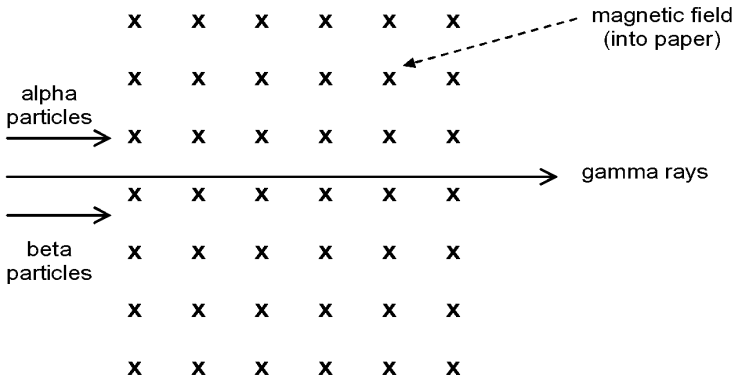

Fig. 12.5

On Fig. 12.5, complete the path of the alpha particles and beta particles as they travel through the magnetic field. [1]

(d) A gamma ray source and a detector were used to check a steel plate for uniform thickness, as shown in Fig. 12.6. The source and the detector were moved along the entire length of the steel plate and a graph of the detector's output against the various parts of the plate was plotted and shown at the lower part of Fig. 12.6.

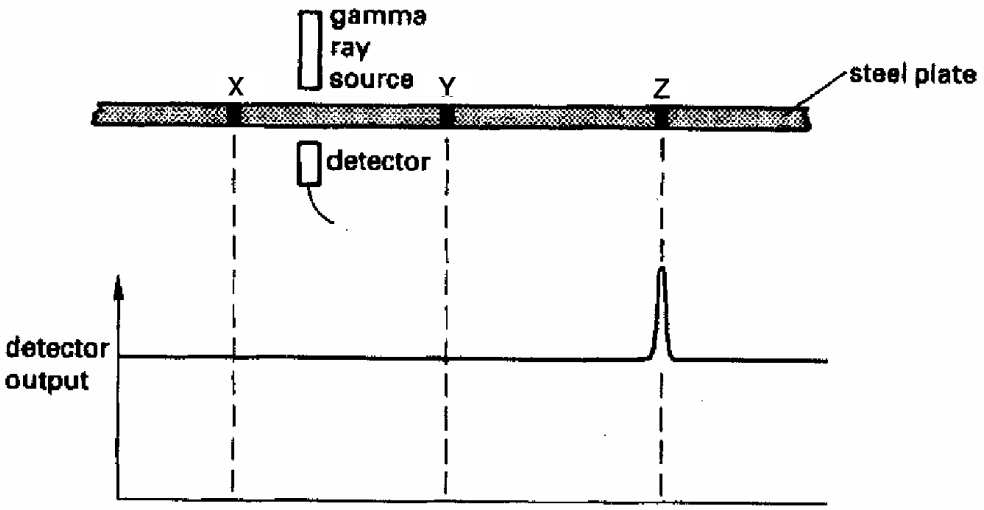

Fig. 12.6

Based on the graph, what can you infer about the thickness of the steel plate at points X, Y and Z? Explain how you arrive at your answer.

……...

……...

……...

……... [4]

*** END OF PAPER ***