Name of the Student:_____
Max. Marks : 21 Marks **Time : 21 Minutes**

Q1.

Einstein developed his theory of special relativity from two postulates. One postulate states that physical laws have the same form in all inertial frames.

(a) State the other postulate and explain how it is consistent with the equation:

$$c = \sqrt{\frac{1}{\mu_0 \varepsilon_0}}$$

_____

_____

_____

_____

(2)

A proton leaves a particle accelerator at point **X** and moves at a constant speed towards a target at point **Y**.
The speed of the proton is 2.5×10^8 m s^{-1} in the frame of reference of the target.

The distance **XY** in the frame of reference of the proton is 38 m.

(b) Calculate the distance **XY** in the frame of reference of the target.

distance **XY** in the frame of reference of the target = _____ m

(2)

(c) Show that the kinetic energy E_k of the proton is about 1.2×10^{-10} J.

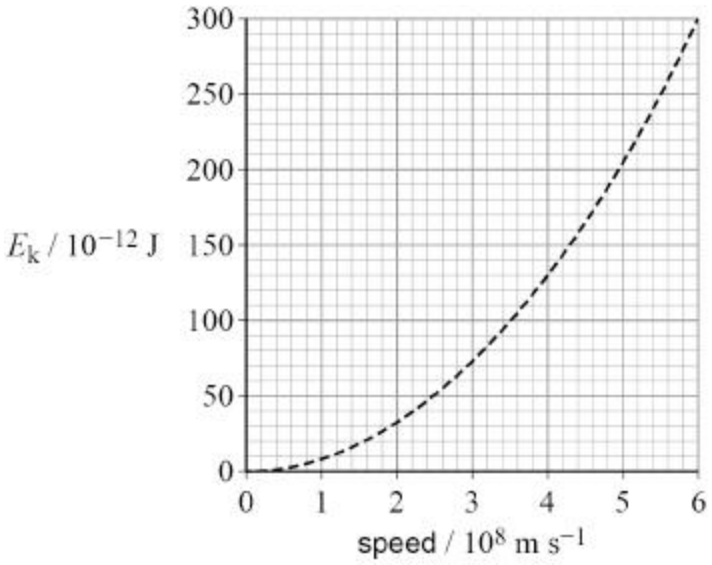
(3)

(d) Sketch on the figure below the variation of E_k with speed v for a proton.

To help you, the dashed line represents

$$E_k = \frac{1}{2} m_0 v^2$$

where m_0 is equal to the mass of a proton at rest.



(3)

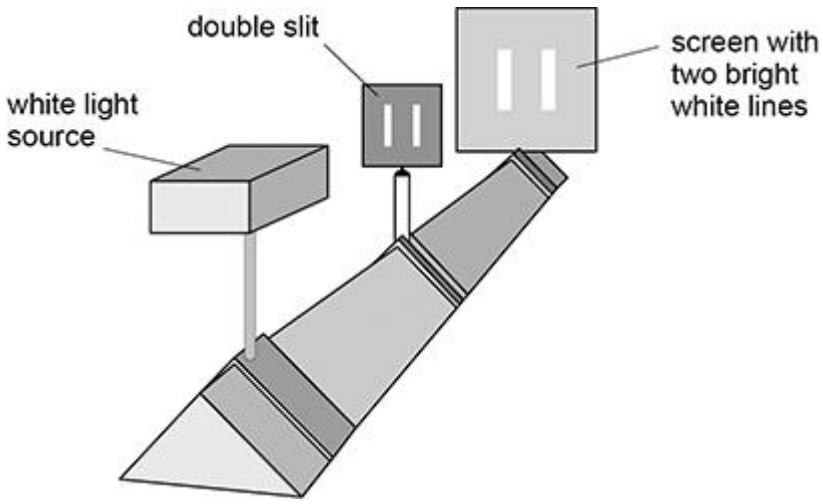
(Total 10 marks)

Q2.

In the 17th century, Isaac Newton proposed a theory to explain some of the properties of light. An alternative theory of light was proposed by Christiaan Huygens at about the same time.

A student uses the arrangement in **Figure 1** to investigate the two theories.

Figure 1



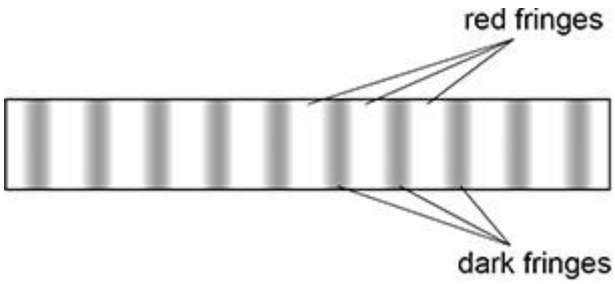
(a) The student observes two bright white lines on the screen.

Explain how this observation supports Newton's theory of light.

(2)

(b) The student makes alterations to the apparatus in **Figure 1**.
Figure 2 shows the red and dark fringes that the student now observes on the screen.

Figure 2



Identify the alterations made by the student and explain how the observations in **Figure 2** support Huygens' theory of light.

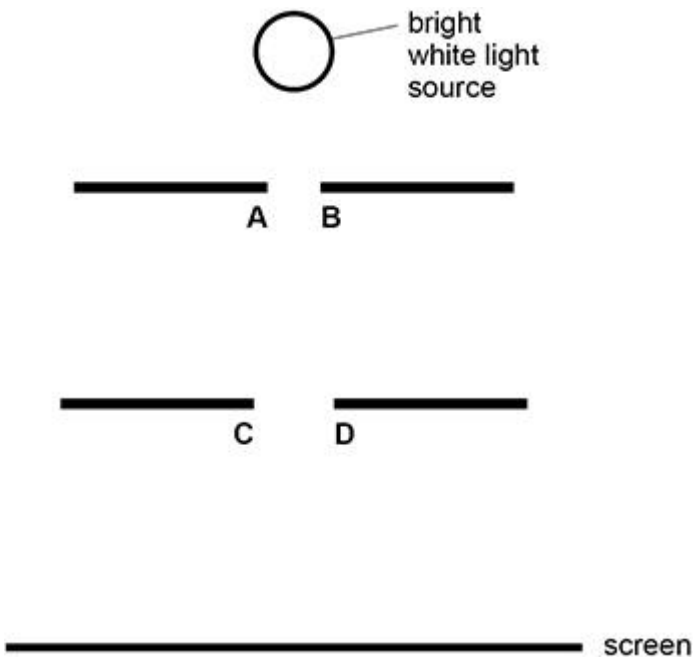
In your answer you should:

- identify alterations made to the apparatus in **Figure 1**
- outline the key features of Huygens' theory
- explain how the result of this experiment supports Huygens' theory.

(6)

(c) Shortly before the work of Newton and Huygens, Francesco Grimaldi carried out an experiment into the behaviour of light. **Figure 3** shows Grimaldi's arrangement.

Figure 3



A bright white light source is used to illuminate a small circular aperture, **AB**.
The light from this aperture illuminates a second, slightly larger circular aperture, **CD**.

The light passing through both apertures arrives at a screen.

Newton's theory and Huygens' theory make different predictions about the appearance of the light on the screen.

Discuss these differences in appearance.

(3)
(Total 11 marks)