A-Level Physics

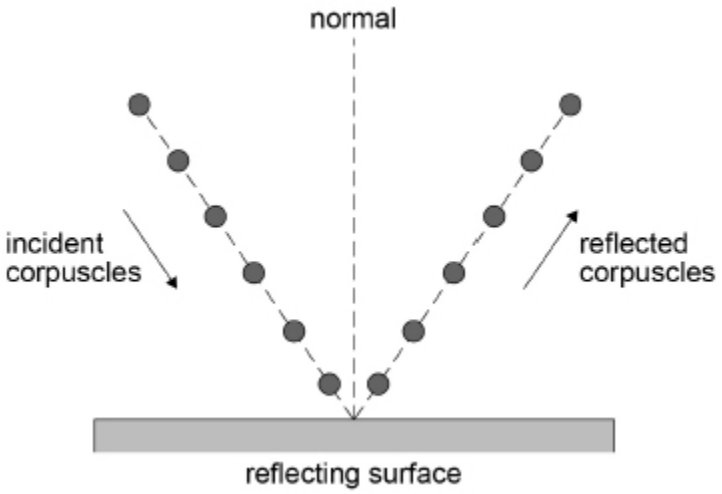
Newton's Corpuscular Theory of Light

Question Paper

Time available: 52 minutes
Marks available: 38 marks

1. Newton used a corpuscular theory of light to explain reflection.

The diagram shows how corpuscles would reflect from a horizontal surface.



(a) What happens to the horizontal and vertical components of the velocity of the corpuscles, according to the theory, when they are reflected?

Tick (✓) **one** box.

Horizontal component of velocity	Vertical component of velocity	Tick the correct box
Unchanged	Changed	
Changed	Unchanged	
Unchanged	Unchanged	
Changed	Changed	

(1)

(b) Newton used the corpuscular theory to explain the refraction of light at an interface between air and water.

Huygens used the wave theory to explain the refraction of light at the interface.

Discuss the evidence that led to the rejection of Newton's corpuscular theory.

In your answer you should include

- how each theory explains refraction
- how experimental evidence led to the acceptance of the wave theory.

(6)

(c) Light is now known to behave as an electromagnetic wave.

Describe a plane-polarised electromagnetic wave travelling through a vacuum.
You may wish to draw a labelled diagram.

(3)

(Total 10 marks)

2. (a) (i) Describe how Newton used the corpuscular theory to explain the refraction of light as it passes from one substance into a substance of higher optical density.

(3)

(ii) Huygens used a wave theory to explain refraction.

Explain why the corpuscular theory was rejected in favour of a wave theory to explain refraction.

(2)

(iii) Describe and explain the difference in the appearance of the fringes in Young's double-slit experiment that are predicted by the corpuscular theory and by the wave theory for light.

(2)

(b) Electromagnetic waves and matter are now known to exhibit both particle and wave behaviour. The photons for a particular X-ray wavelength have energy 5.0 keV.

Calculate the potential difference through which an electron has to be accelerated so that its de Broglie wavelength is the same as that of this X-ray.

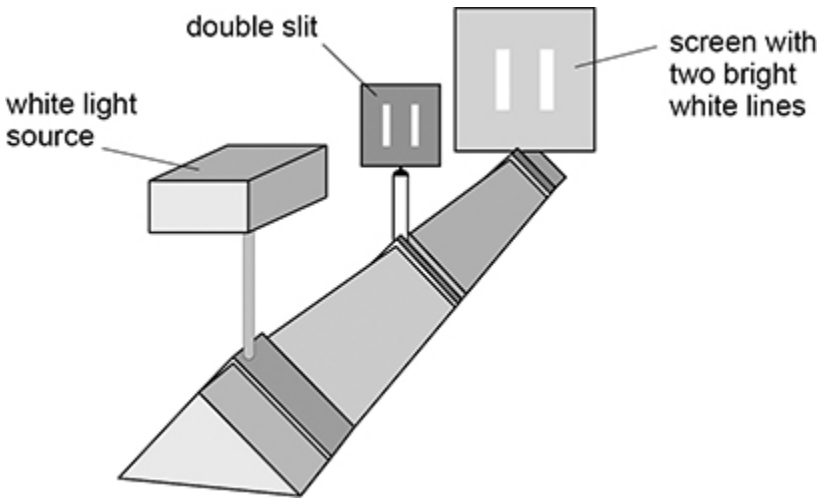
(4)

(Total 11 marks)

3. 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.

_____

_____

_____

_____

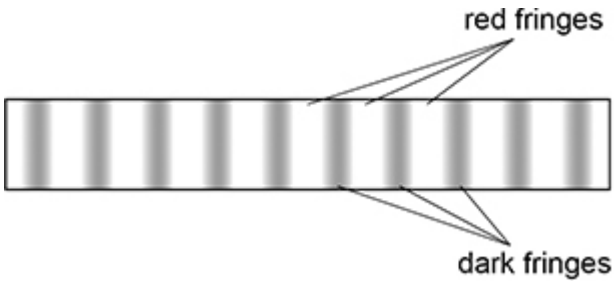
_____

_____

(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.

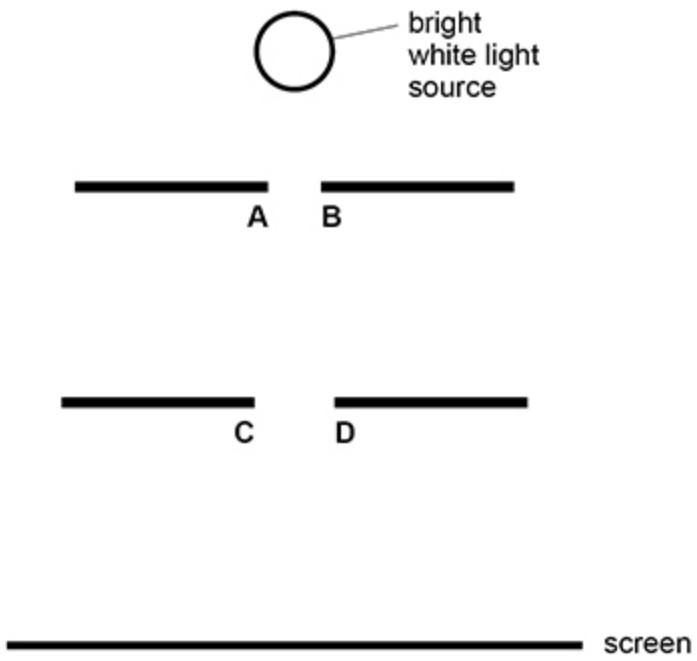
In your answer you should:

- 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.

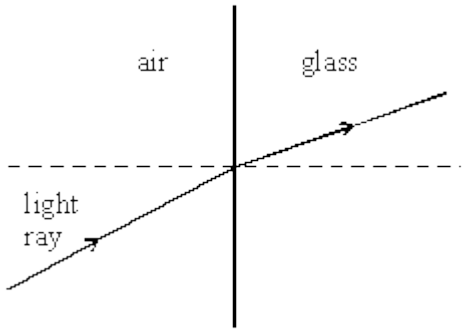
Newton's theory and Huygens' theory make different predictions about the appearance of the light on the screen.

Discuss these differences in appearance.

(3)

(Total 11 marks)

4. (a) The diagram below shows the path followed by a light ray travelling from air into glass.



Use Newton's theory of light to explain the refraction of the light ray at the air/glass boundary.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(b) Newton's theory of light was eventually abandoned in favour of Huygens' wave theory which correctly predicted the speed of light in glass in comparison with the speed of light in air.

(i) What did each theory predict about the speed of light in glass in comparison with the speed of light in air?

_____

_____

_____

(ii) Describe **one** further piece of evidence that supports Huygens' wave theory.

_____

_____

_____

_____

_____

(3)

(Total 6 marks)