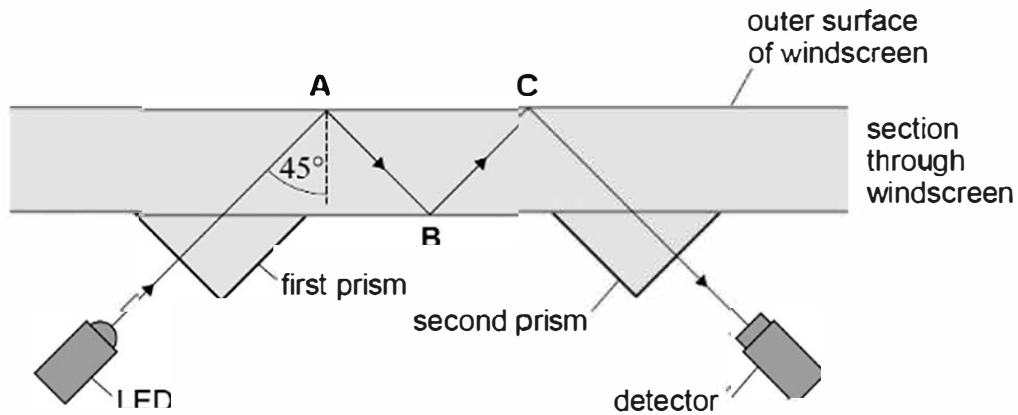


0 2

Some cars are fitted with a water sensor designed to switch on windscreen wipers automatically when it rains. **Figure 1** shows a simplified diagram of the sensor.

Figure 1



A light ray travels from the light-emitting diode (LED) through the first prism and into the windscreen. The ray reflects off the surfaces of the windscreen at **A**, **B** and **C** and then passes through the second prism into the detector.

0 2 . 1

Suggest how the design ensures that there is no deviation of the ray as it enters the first prism.

[1 mark]

0 2 . 2

Suggest **two** features of the design that ensure that there is no deviation of the ray as it leaves the first prism and enters the windscreen glass.

[2 marks]

1 _____

2 _____



0 2 . 3

The refractive index of the windscreen glass is 1.52

Explain why the ray follows the path shown inside the windscreen glass in **Figure 1**.
Support your answer with a suitable calculation.

[2 marks]

Question 2 continues on the next page

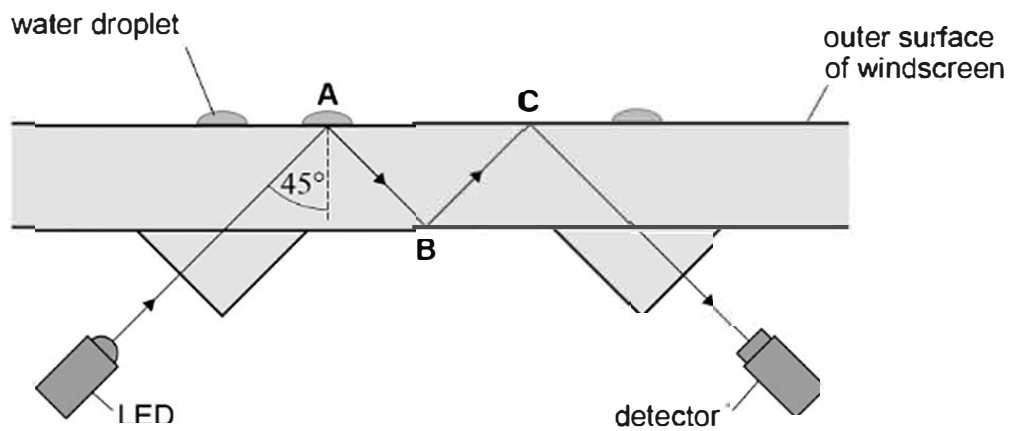
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0 2 . 4

When it starts to rain, water droplets form on the outside of the windscreen as shown in Figure 2.

Figure 2



The refractive index of water is 1.33

Explain why the presence of water at A causes the intensity of the light at the detector to decrease.

Support your answer with a suitable calculation.

[2 marks]



0 2 . 5

The refractive index of the windscreen glass can vary by a few per cent across the thickness of the glass.

Discuss how this variation may affect the path of the ray through the windscreen glass.

[2 marks]

0 2 . 6

A different design has the LED and the detector further apart. The ray undergoes more reflections inside the windscreen glass before reaching the detector.

Discuss **two** ways in which this different design affects the sensitivity of the sensor to the presence of water droplets.

[2 marks]

1 _____

2 _____

11

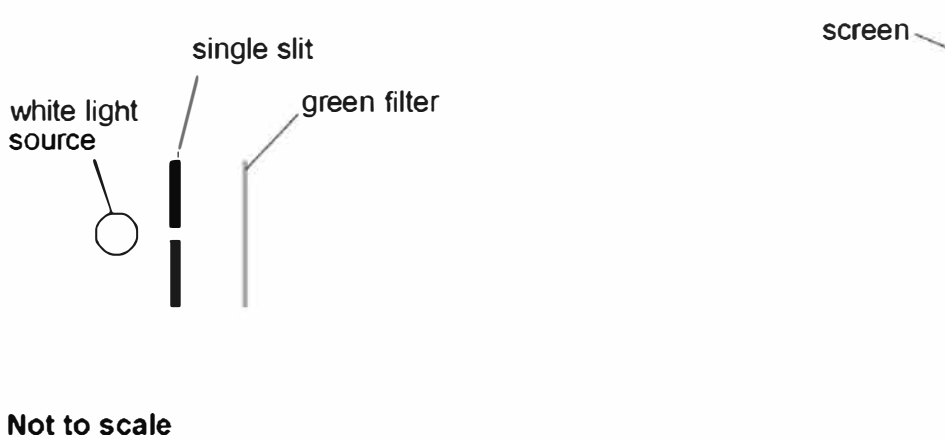
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0 3

Figure 3 shows an arrangement to investigate diffraction. White light is incident on a single slit. After leaving the slit, the diffracted light passes through a green filter to reach the screen.

Figure 3



0 3 . 1

Describe the pattern produced on the screen.

[2 marks]

0 3 . 2

The green filter is replaced with a red filter.

Describe the change in the pattern produced on the screen.

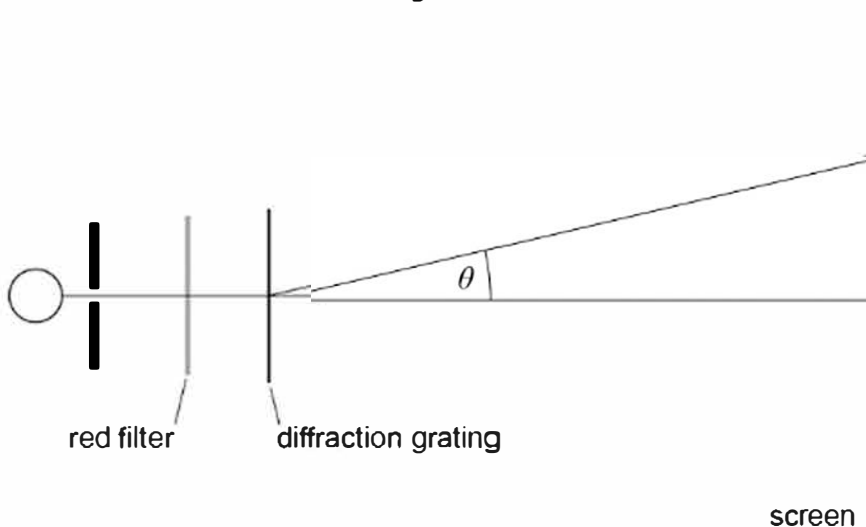
[2 marks]



0 3 . 3

A diffraction grating is placed between the red filter and the screen. The diffraction grating has 500 lines per millimetre. Light is incident normally on the grating. **Figure 4** shows the arrangement.

Figure 4



Not to scale

The wavelength of the red light is 650 nm.

Calculate the angle θ between a first-order maximum and the central maximum.

[2 marks]

$\theta =$ _____ degrees

Question 3 continues on the next page

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0 3 . 4

In practice, the filter transmits red light with wavelengths in the range 600 nm to 700 nm.

Suggest how this affects the appearance of the maxima.

[2 marks]

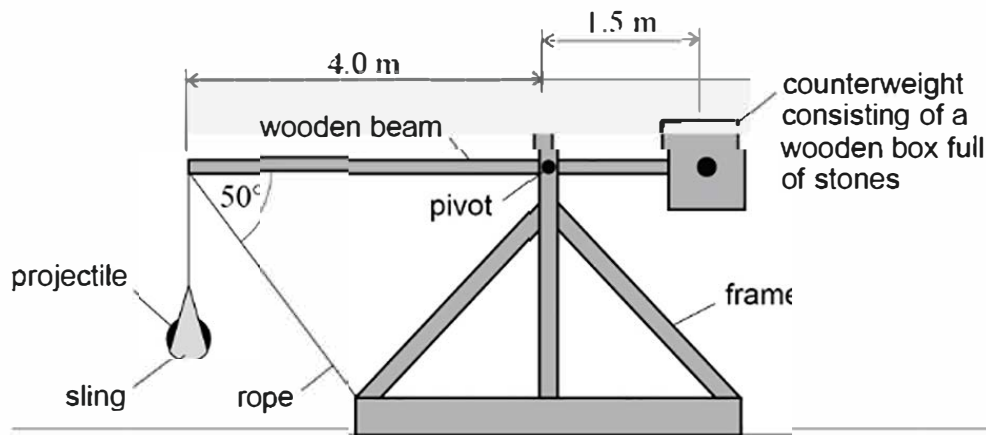
8



0 4

Figure 5 shows a simplified catapult used to hurl projectiles a long way.

Figure 5



The counterweight is a wooden box full of stones attached to one end of the beam. The projectile, usually a large rock, is in a sling hanging vertically from the other end of the beam. The weight of the sling is negligible. The beam is held horizontal by a rope attached to the frame.

0 4 . 1

The catapult is designed so that the weight of the beam and the weight of the **empty** wooden box have no effect on the tension in the rope.

Suggest how the pivot position achieves this.

[2 marks]

Question 4 continues on the next page

Turn over ►

