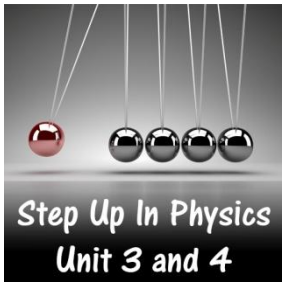
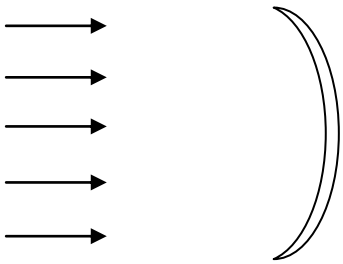
Light as a Wave

Problems Worksheet



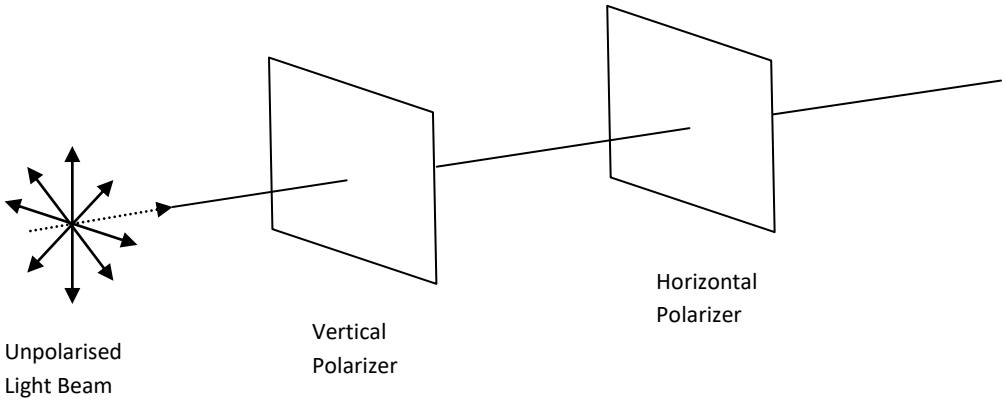
1. Complete the ray diagram showing the reflection of the microwave that is incident on the antenna dish.



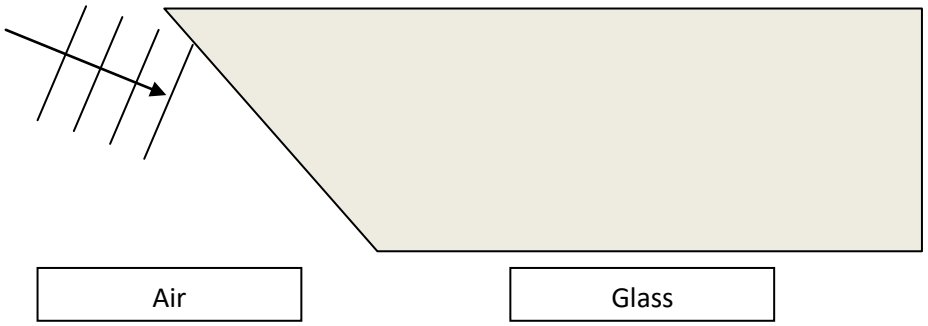
2. Apollo missions placed reflector arrays on the surface of the Moon which allows for observers on Earth to shine beams of light at the Moon's surface which are reflected back to Earth.
    a. Calculate the altitude of the Moon if the time it takes for the reflected light to be received is 2.50 s after the initial transmission.

    b. Long term experiments reveal the Earth-Moon distance is increasing at a rate of 3.80 cm per year. How many years will it take for the time of the reflected light to increase to 2.60 s?

3. A vertical polarizer is placed in the path of an unpolarised light beam. A horizontal polarizer is also in the direction of the light beam, placed after the vertical polarizer. Clearly draw and label how the light beam behaves as it interacts with each polarizer.

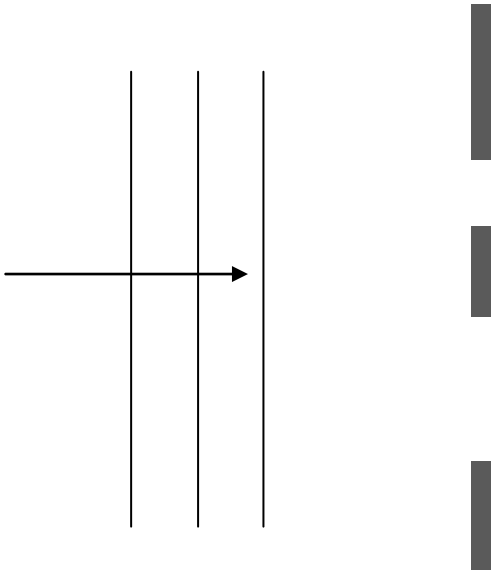


4. A beam of 545 nm light is passing from air to glass.
    a. Complete the diagram showing the behaviour of the light as it enters the glass.



    b. State which properties of the wave will change as the wave moves from air to glass and state whether these properties will increase or decrease.

5. A 20.0 cm radiowave is approaching an obstacle with gaps in it as shown below.



   a. Complete the diagram showing the behaviour of the radiowave as it passes through the gaps in the obstacle.

   b. Describe how the behaviour of the wave would change through each gap if the radiowave had double the wavelength shown in the diagram.

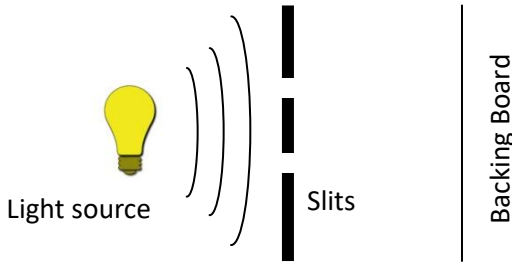
6. Radar is used by the military and civilian airports to detect aircraft. Radiowaves at a specific frequency are transmitted in all directions by the transmit radar. A receiving antenna located nearby is tuned in to pick up any radiowaves with that same frequency.
   a. Describe using physical principles how the transmit radar could be manipulated to produce the desired frequency of radiowave.

   b. Describe how the radar system can use radiowaves to determine the distance and direction of aircraft.

c. How far away is an aircraft if the receiving antenna picks up a radiowave 3.47×10^{-5} s after transmission?

d. A defence contractor offers the military a radar system based on a 10 MHz signal or a 150 MHz signal. Justify which is the better choice for the military's radar.

7. Simone sets up an experiment where monochromatic yellow light is shone through two thin slits with a plain backing board behind it as shown in the diagram below.

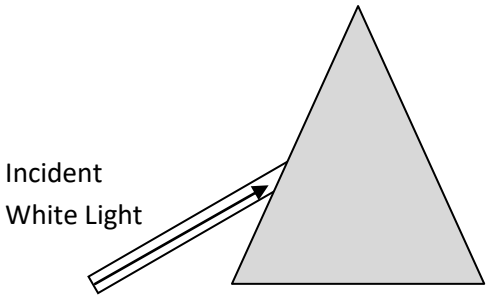


a. What observation would Simone make when looking at the backing board?

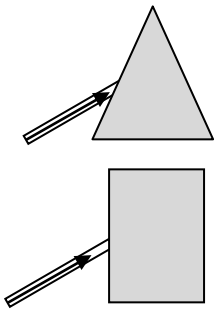
b. Explain this observation with reference to the wave model of light.

8. A glass triangular prism can be used to observe all the colours that make up white light.
    a. Explain how the glass triangular prism achieves this.

    b. Complete the diagram to show how the incident beam of white light behaves when directed towards the triangular prism. Label your diagram clearly.



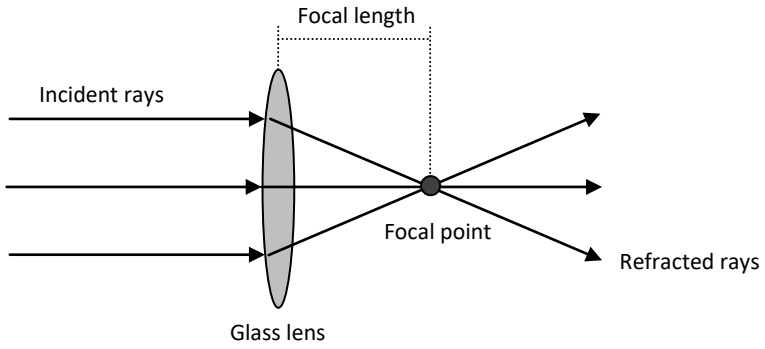
    c. The same effect cannot be observed as easily using a glass rectangular prism. Explain why not.



9. Sun light that reflects off shiny horizontal surfaces such as wet roads and white sand has a tendency to be horizontally polarised. Polaroid sunglasses take advantage of this tendency and can significantly reduce the glare from the reflections off of these surfaces.
    a. Describe the meaning of the term "horizontally polarised".

b. Explain how Polaroid sunglasses reduce the glare from the reflections off of these surfaces.

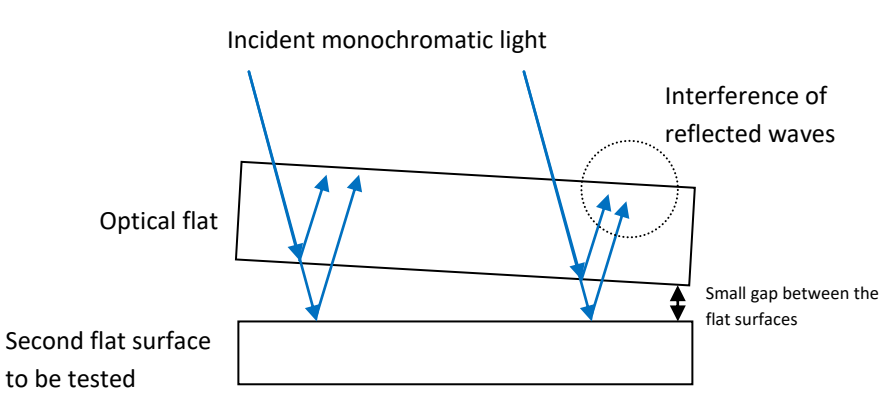
10. Lenses are transmissive devices that make use of the refractive properties of electromagnetic waves to affect the focus of incident electromagnetic waves. A convex lens is used in magnifying glasses. A simplified ray diagram showing the refraction of light towards a single focal point using a convex lens is shown below. One of the issues with forming a magnified image using refraction through a lens is that different colours have different focal lengths. This negative side effect is called chromatic aberration and causes distortions in the image.



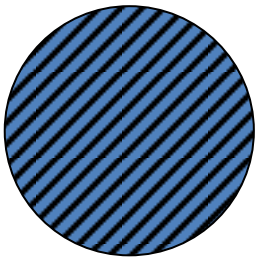
a. Explain why different colours have different focal lengths.

b. Which colour would have the greatest focal length? Justify your answer.

11. An optical flat is a highly polished flat piece of glass that is used to determine how flat other surfaces are. The optical flat is placed on the second flat surface to be tested. No surface is ever perfectly flat, so there are still very small gaps between the optical flat and the second surface. When monochromatic light is shone through the top of the optical flat, the light reflects off both the underside of the optical flat and the second surface. These reflected waves have travelled different distances before they interfere at the top of the optical flat.



Top down view of optical flat with light and dark bands



The two reflected waves cause an alternating pattern of light and dark banding to be seen on the top surface of the optical flat. The spacing between repeating light and dark bands gives an indication of the relative flatness.

a. Describe why regions of dark and light bands show up on the optical flat, despite being illuminated by a uniform light source.

b. In one small region the distance between the optical flat and the second flat surface is half the wavelength of the incident light. Would this region show as a bright or dark band? Justify your answer.

c. Why is it important that white light is not used with the optical flat to test the relative flatness between the two surfaces?

d. An optical flat and monochromatic light was used to test the flatness of two different surfaces. The appearance of the optical flat for each surface is shown below.

Surface A test

Surface B test

Which surface (A or B) is the flatter of the two tested surfaces? Justify your answer.