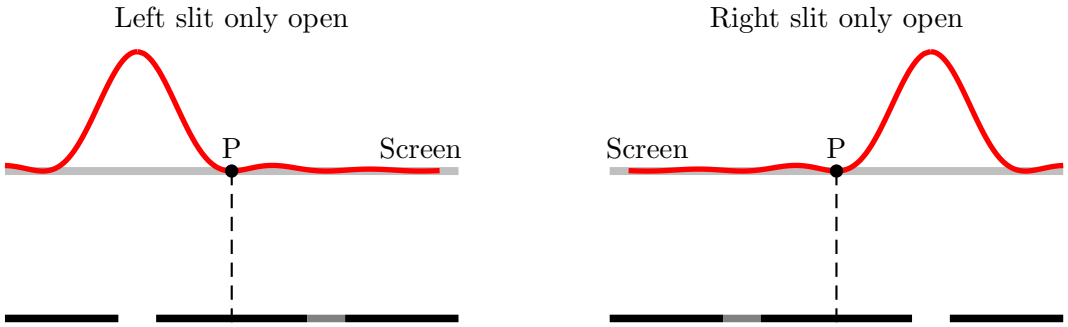
Concepts of Physics: Homework 9

Due: 11 November 2022

1 Hobson, *Physics, Concepts and Connections, 5ed*, Ch. 12 Conceptual Exercise 10, page 292.

2 Photon interference experiments

Light is fired toward various barriers containing slits. The light travels upwards directly toward the barrier. The intensity of the light that arrives on the screen is graphed in the diagram.

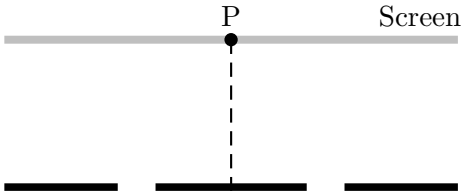


a) Suppose that only the left slit is open. Indicate the location on the screen where any photon is most likely to arrive. According to the information given above, is it possible for any photon to arrive at point P?

b) Suppose that only the right slit is open. Indicate the location on the screen where any photon is most likely to arrive. According to the information given above, is it possible for any photon to arrive at point P?

c) Suppose that both slits are open. Using the wave picture of light (Ch 9) indicate the intensity profile of the light on the screen. Use the diagram below.

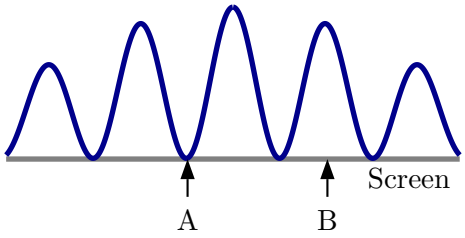
Both slits open



d) Is it possible for any photon to arrive at point P when both slits are open? Does your answer agree with those for when only the left slit and only the right slit are each open? Explain your answer.

3 Double slit interference: photon arrival

Photons are fired, one at a time toward a barrier that contains two slits. The diagram illustrates that probability with which they arrive at various locations on a screen. The arrows indicate two locations, A and B, on the screen. A photon is fired toward the screen and it hits location B. The next photon is then fired toward the screen. Which of the following is true about the next photon to arrive on the screen? Explain your answer.



i) The photon will definitely not arrive at A and will definitely not arrive at B.

ii) The photon will definitely not arrive at A and will definitely arrive at B.

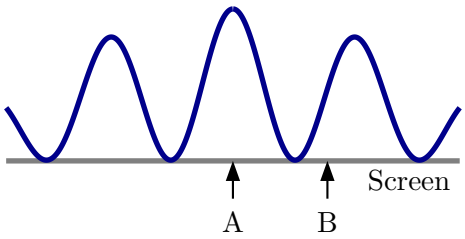
iii) The photon will definitely not arrive at A and might arrive at B.

iv) The photon will definitely not arrive at B and will definitely arrive at A.

v) The photon will definitely not arrive at B and might arrive at A.

4 Double slit interference: photon counts

Light with one wavelength is incident on a double slit barrier. The diagram illustrates the intensity of the light at various locations on a screen. The arrows indicate two locations, A and B, on the screen.



a) Consider the statement: "A photon that arrives at A has more energy that a photon that arrives at B." Is this statement true or false? Explain your answer.

b) Suppose that in a short period of time 8000 photons arrive at A. Approximately how many will arrive at B during the same period of time?

5 Photons and light intensity

A red LED emits light with exactly one frequency. The light subsequently passes though a tinted lens without changing its frequency but reducing its intensity.

a) Is the energy of each photon that passes through the lens the same as, smaller than or larger than the energy of each photon that leaves the LED? Explain your answer.

b) Is the number of photons that pass through the lens per second the same as, smaller than or larger than the number that leave the LED per second? Explain your answer.

6 Photons produced by laser light

A typical low powered laboratory laser has a power of 5 mW (i.e. produces 0.005 J per second). Suppose that such a laser produces a pulse of light of duration 0.025 s (this is quite normal).

a) If the wavelength of the light is 632 nm (6.32×10^{-7} m), determine the frequency of the light and the energy of each photon.

b) Determine the total number of photons contained in the pulse.

7 Visible light versus ultraviolet light

Red light typically has a frequency of 4.5×10^{14} Hz while particular ultraviolet light has a frequency of 2.0×10^{15} Hz.

a) Determine the energy of a single photon of each type of light.

b) Explain why ultraviolet light is more likely (than red light) to cause damage to the molecules within skin cells.

8 Reading exercise: wave nature of particles

Read section 12.4 (pages 282-287). The following exercises are intended to give you an understanding of the concepts presented in the text.

a) Describe one experiment (that is described by the text) which shows evidence for the fact that electrons can behave as waves.

b) Consider the locations of the electrons in the experiments described in the text. When an individual electron strikes the screen does it do so at one small location or does it's wave nature make it spread out over a large area?

c) Do Concept Check 6 on page 287. After you have done it check the answer at the end of the text.

d) Do Conceptual Exercise 18 on page 292.