Answer on Question #45661-Physics-Optics

A) A thin film of gasoline floats on a puddle of water. Sun light falls almost perpendicularly on the film and reflects in to your eyes. Although the sun light is white, since it contains all colors the film has a yellow hue because distractive interference has occurred eliminating the color of blue (wave length $\lambda = 4.69 \cdot 10^{-7}\ m$) from the reflected light. If the refractive index of gas and water are 1.4 and 1.33 determine the minimum thickness of the film.

B) A scuba diver $d = 20$ meters beneath the smooth surface of a clear lake looks upward and judges the sun to be $\theta_1 = 40$ degree from directly overhead. At the same time a fisherman is in a boat directly above a diver.

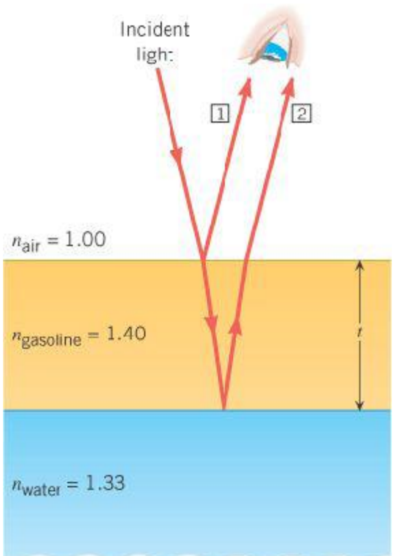
1) At what angle from the vertical would the fisher man measure the sun?

2) If the fisherman looks downward at what depth below the surface would he judge the diver to be?

C) To help keep cool yourself in the summer or sunny day black colored umbrella shades have been used frequently what is your scientific justific.

Solution

A)



Because of reflection and refraction, two light waves enter the eye when light shines on a thin film of gasoline floating on a thick layer of water. Because of the extra distance traveled, there can be interference between the two waves.

$$\lambda_{film} = \frac{\lambda_{vacuum}}{n}.$$

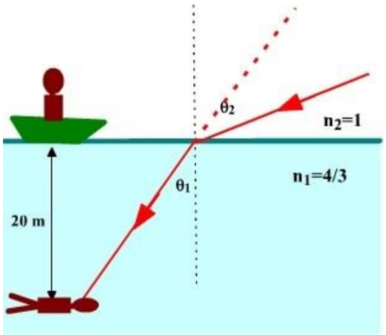
When light travels through a material with a smaller refractive index towards a material with a larger refractive index, reflection at the boundary occurs along with a phase change that is equivalent to one-half of a wavelength in the film. When light travels from a larger towards a smaller refractive index, there is no phase change upon reflection.

$$2t + \frac{1}{2}\lambda_{film} = \frac{1}{2}\lambda_{film}, \frac{3}{2}\lambda_{film}, \frac{5}{2}\lambda_{film}.$$

$$t = \frac{m\lambda_{film}}{2}.$$

$$t = \frac{1 \cdot 469nm/1.40}{2} = 168\ nm.$$

B)



1) Using Snell's law at the water-air boundary

$$n_{air}\sin\theta_2 = n_{water}\sin\theta_1 \rightarrow \sin\theta_2 = \frac{n_{water}}{n_{air}}\sin\theta_1 = \frac{\left(\frac{4}{3}\right)}{1}\sin 40° \rightarrow \theta_2 = 59°.$$

2) $Apparent\ depth\ =\ Actual\ depth \cdot \left(\frac{Index\ of\ Refraction\ of\ Air}{Index\ of\ refraction\ of\ water}\right)$.

$$h = d\frac{n_{air}}{n_{water}} = 20 \cdot \frac{1}{\left(\frac{4}{3}\right)} = 15\ m.$$

C) The statement is wrong.

White light is made up of all the different colors of light, as can be seen when it is separated into these various wavelengths using a prism. The colors that we see are the wavelengths of light that are being reflected off of the objects we are looking at. Objects that are red will reflect only red wavelengths and will absorb the other wavelengths; objects that are blue will reflect only blue wavelengths and will absorb the other wavelengths; etc. Black objects absorb all visible wavelengths of light, which is why black asphalt gets so hot in the sunlight. White objects reflect all wavelengths of light. Therefore, a white umbrella would reflect the largest amount of light. However, this does not necessarily imply that it would be the best color to use for an umbrella because what really matters is how much light is transmitted through the umbrella to reach the shade below. The more light that gets through, the less effective the umbrella is in providing you with shade. Therefore, what really matters is how opaque the umbrella is, rather than what color the umbrella is. The opaqueness will be more characteristic of what material the umbrella is made of than what color it is. The fraction of the light that is transmitted will equal all the light that strikes the umbrella that is neither reflected nor absorbed. Thus, it is best to find an umbrella which combines high reflectivity (*white color, not black*) with high opaqueness (generally a thick material) in order to keep the umbrella from heating up and stop the greatest percentage of the sun's rays from reaching you.