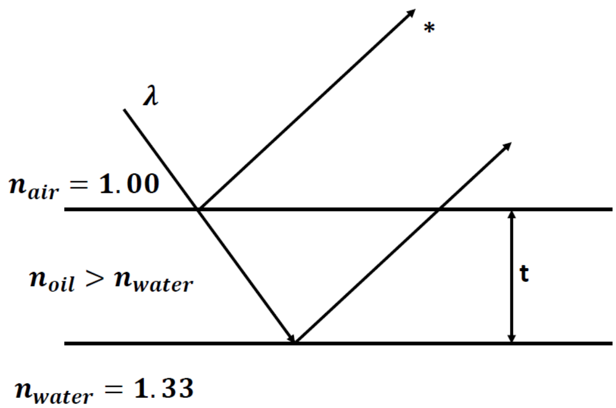
9. A film of oil lies on wet pavement. The refractive index of the oil exceeds that of the water. The film has the minimum nonzero thickness such that it appears dark due to destructive interference when viewed in red light (wavelength = 640.0 nm in vacuum). Assuming that the visible spectrum extends from 380 to 750 nm, for which visible wavelength(s) in vacuum will the film appear bright due to constructive interference?



$$Total\ Phase\ Diff = Optical\ Path\ Diff + Phase\ Shifts = \left(m + \frac{1}{2}\right)\lambda$$

This is for destructive interference which is what we have for the red light. So we are told we have the smallest thickness so with 1 phase shift we get

$$2n_{oil}t + \frac{\lambda}{2} = \left(m + \frac{1}{2}\right)\lambda$$

$$2n_{oil}t = m\lambda$$

So the minimum thickness would be m= 1. That means the thickness of the film is given by

$$t = \frac{\lambda_{red}}{2n_{oil}}$$

Now we need to consider constructive interference, so our phase equation is now

$$Total\ Phase\ Diff = Optical\ Path\ Diff + Phase\ Shifts = m\lambda$$

$$2n_{oil}t + \frac{\lambda}{2} = m\lambda$$

$$2n_{oil}t = \left(m + \frac{1}{2}\right)\lambda$$

This is the condition for constructive interference. We do not use (m-1/2), because we do not want negative signs showing up. Now substitute what we found for thickness

$$2n_{oil}t = 2n_{oil}\left(\frac{\lambda_{red}}{2n_{oil}}\right) = \lambda_{red} = \left(m + \frac{1}{2}\right)\lambda$$

So the possible wavelengths are

$$\lambda = \frac{\lambda_{red}}{\left(m + \frac{1}{2}\right)} = \frac{640.0\ nm}{\left(m + \frac{1}{2}\right)}$$

So now we just put in m's and see what we get for a wavelength. We only count wavelengths between 380 nm and 750 nm

$m = 0$

$$\lambda = \frac{640.0\ nm}{\left(m + \frac{1}{2}\right)} = \frac{640.0\ nm}{0.5} = 1280\ nm > 750\ nm$$

$m = 1$

$$\lambda = \frac{640.0\ nm}{\left(m + \frac{1}{2}\right)} = \frac{640.0\ nm}{1.5} = 426.7\ nm\ \ This\ is\ good!$$

$m = 2$

$$\lambda = \frac{640.0\ nm}{\left(m + \frac{1}{2}\right)} = \frac{640.0\ nm}{2.5} = 256.0\ \ nm\ < 380\ nm$$

Only visible light is

$$\boxed{\lambda = 427\ nm}$$

Please send any comments or questions about this page to ddonovan@nmu.edu

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