DS 10:
Electromagnetic Waves

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April 1, 2022

1 Laws of Reflection and Refraction

(a) Consider an interface between two dielectric media along the $xy-$plane. Imagine an electromagnetic plane wave incident on the interface, travelling along some angle θ_I to the $z-$axis. Write out the electric and magnetic fields for this incident wave.

(b) Such a system will have a reflected and transmitted wave. Write out their electric and magnetic fields as well.

(c) Now, consider the behaviour of these waves at the interface ($z = 0$) and show that

(i) $(k_I)_x = (k_R)_x = (k_T)_x$, and

(ii) $(k_I)_y = (k_R)_y = (k_T)_y$.

(d) Using the above results, show that:

(i) The incident, reflected, and transmitted wave vectors lie in the same plane (called the **plane of incidence**), which also includes the normal to the surface (in this case, the $z-$axis.

(ii) The angle of incidence is equal to the angle of reflection, i.e.

$$\theta_I = \theta_R. \tag{1}$$

(iii) The angles of incidence and transmission are related through Snell's Law:

$$n_1 \sin\theta_I = n_2 \sin\theta_T \tag{2}$$

(iv) Now, imagine we were working with sound waves instead of electromagnetic waves. Which of the above results would need to be changed?