Note that there are **two** definitions of the sinc function in common use:

$$\boxed{\frac{\sin(\pi x)}{\pi x} \equiv \operatorname{sinc}(x)}$$

This definition is used in this course and has zeros at 0 and $x=n$ where n is an integer.

It has the convenient normalization $\int_{-\infty}^{\infty} \operatorname{sinc}(x)\, dx = 1$

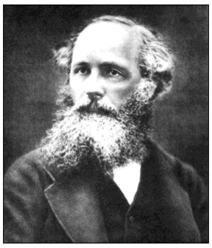
The alternative definition, which has zeros at 0 and $n\pi$ is:

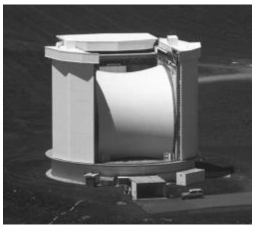
$$\boxed{\frac{\sin(x)}{x} \equiv \operatorname{sinc}(x)} \quad \text{so} \quad \int_{-\infty}^{\infty} \operatorname{sinc}(x)\, dx = \pi$$

PHY2208 Lecture 16

Introduce **polarization** phenomena
Review basics of EM radiation
Describe linear and circular polarization in terms of EM theory

Y&F section 34-6
Pedrotti & Pedrotti 8-7, Ch.14 (intro & sec 1)





In the 19th century James Clerk Maxwell unified electricity and magnetism. His equations clearly predicted the existence of electromagnetic (EM) radiation comprising coupled time- and space-varying electric and magnetic fields. EM waves have the following properties:

EM waves are transverse i.e ***E*** and ***B*** are orthogonal to the wave propagation direction.

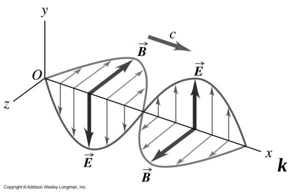
E and ***B*** are mutually orthogonal i.e. $\mathbf{E} \bullet \mathbf{B} = 0$

Since ***E*** and ***B*** each satisfy a wave equation we can find plane wave solutions of the form:

$$\mathbf{E} = E_0 \cos(\mathbf{k}\cdot\mathbf{r} - \omega t)\hat{\mathbf{e}} \quad \text{(ditto for } \mathbf{B}\text{)}$$

E and ***B*** are always in phase (in vacuo)

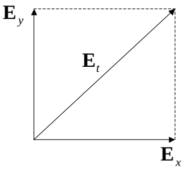
$|\mathbf{E}| / |\mathbf{B}| = c$ so $|\mathbf{B}| << |\mathbf{E}|$



E can clearly have any orientation within a place perpendicular to ***k*** (ditto for ***B***)

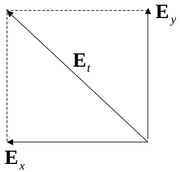
Polarization effects arise because E can point in different directions (all perpendicular to ***k***).

Consider the interference of two EM waves whose E-vectors are in orthogonal polarization states. The magnitude of the E-field must be calculated as the **vector sum** of the individual fields.



in-phase case

$$|\mathbf{E}_t| = \sqrt{E_x^2 + E_y^2}$$



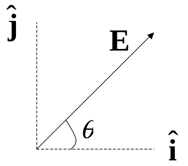
anti-phase case

$$|\mathbf{E}_t| = \sqrt{E_x^2 + E_y^2}$$

Magnitude of E_t is the same regardless of whether the two waves are in-phase or in antiphase: Orthogonally polarized light waves **cannot** produce destructive interference.

Since ***E*** is a vector, we can resolve it into two orthogonal components i.e.

$$\mathbf{E} = E_x\hat{\mathbf{i}} + E_y\hat{\mathbf{j}}$$



$$E_x = |\mathbf{E}|\cos\theta$$
$$E_y = |\mathbf{E}|\sin\theta$$

The E component of any general EM wave can be decomposed into two orthogonally polarized EM waves.

For a harmonic plane wave consider the phase relationship between E_x and E_y. Must they vary in phase? No!

But first let's consider the case where E_x does vary in phase with E_y.

When E_x and E_y vary in phase and so the direction of ***E*** at any point ***r*** remains constant the light is **linearly polarized**.

Now let's consider that (somehow) the phase of E_y is retarded by π with respect to E_x

The effect of retarding one component of linearly polarized light by π is to flip the direction of polarization into its mirror image.

Finally let's consider retarding one component by a phase of π/2

The direction of the E-vector rotates with angular frequency ω. This is **circularly polarized** (or, more generally **elliptically** polarized).