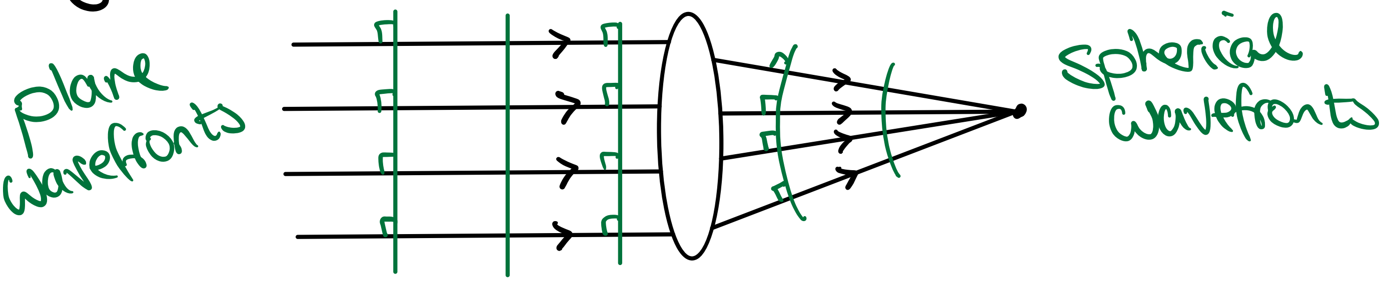
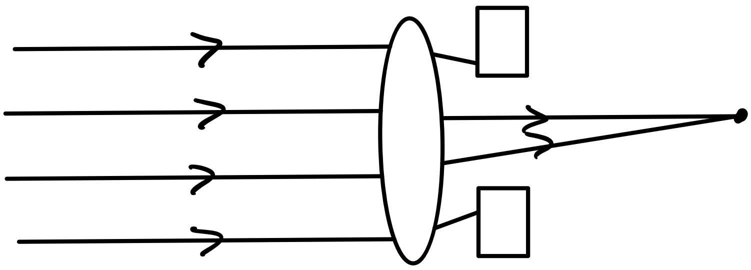
Ray Optics

Rays are <u>normal</u> to wavefronts.



In ray optics, wavefronts are contours of equal optical path length. $OPL = n \cdot L$ (n - refractive index, L - length).

In ray optics there is <u>no diffraction or interference</u>. Rays that hit the aperture are blocked and rays do not change direction ($\therefore$ no diffraction).



Ideas such as Snell's law & Fermat's principle work at all angles. <u>Paraxial Ray Optics</u> is when we assume small angles. $\sin\phi = \tan\phi = \phi$. This can allow us to find analytical equations (eg. thin lens formula).

Wave Optics

Interference & Diffraction. We need to know λ to calculate the phase of the light (unlike ray).

$$\underbrace{E_0}_{\text{amplitude}} e^{i\overbrace{(kz-\omega t)}^{}}$$

$$E(z,t) = \underbrace{E_0}_{\text{amplitude}}\, e^{i\underbrace{(kz-\omega t)}_{\text{phase}}}$$

Plane Wave

We can use of definition of wavenumber ($k = \frac{2\pi}{\lambda}$) to get

$$E(z,t) = E_0 e^{i(kz-\omega t)} = E_0 e^{i(\frac{2\pi}{\lambda_n}z-\omega t)}$$

In a medium, the wavelength of light is given by

$$\lambda_n = \frac{\lambda}{n}$$

∴ the phase change $\Delta\phi$ over a distance z is given by

$$\Delta\phi = \frac{2\pi}{\lambda/n} z = \frac{2\pi}{\lambda}(nz) = k_0 \cdot (OPL)$$

$= \frac{2\pi}{\lambda}$

optical path length

We can split wave optics into two types: <u>Scalar wave optics</u> (little EM theory) and <u>vector wave optics</u> ($\underline{E}$ is a vector, Maxwell's Eq^{n}s).

Quantum Optics

Often looking at a single photon using QM. We look at the probability wavefunction ψ.