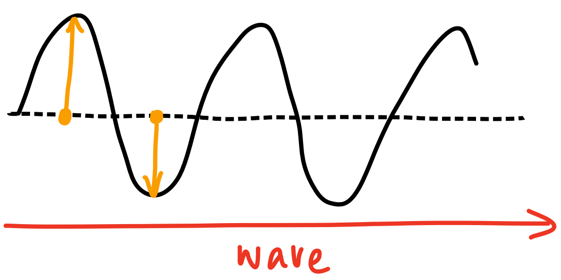
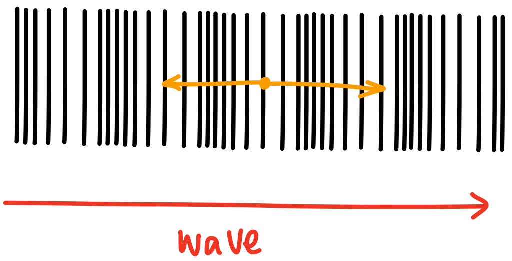
Transverse Wave



Particles oscillate perpendicular to direction of wave

e.g. Electromagnetic waves, water waves.

Longitudinal Wave



Particles oscillate parallel to direction of wave

e.g. Sound.

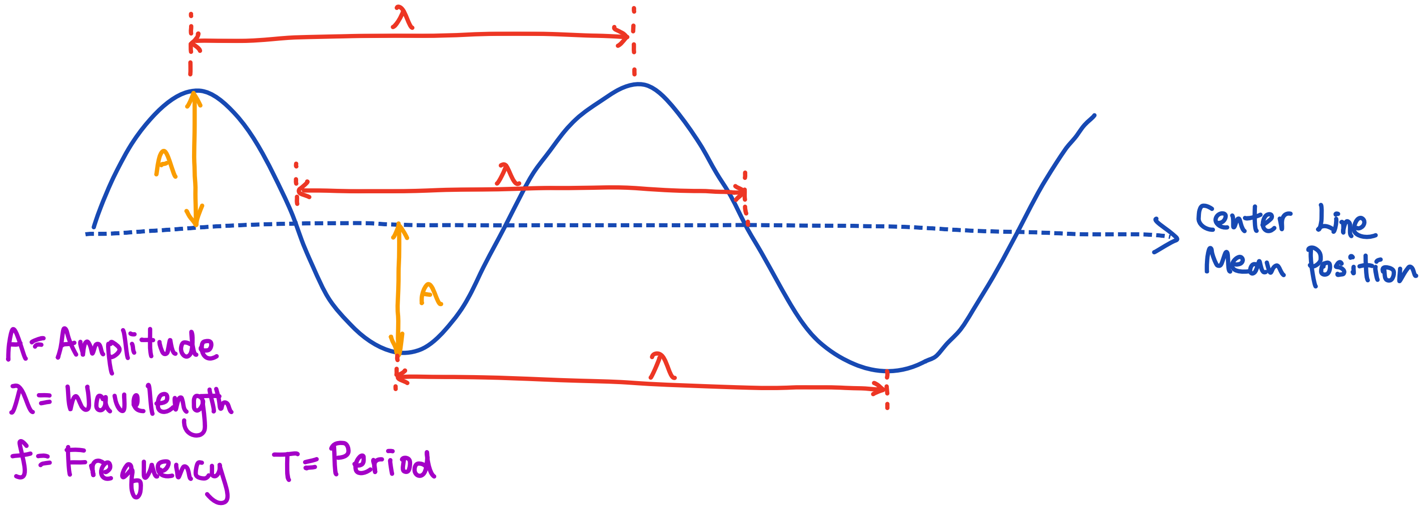
Progressing Wave : A wave that is <u>moving</u> through a material

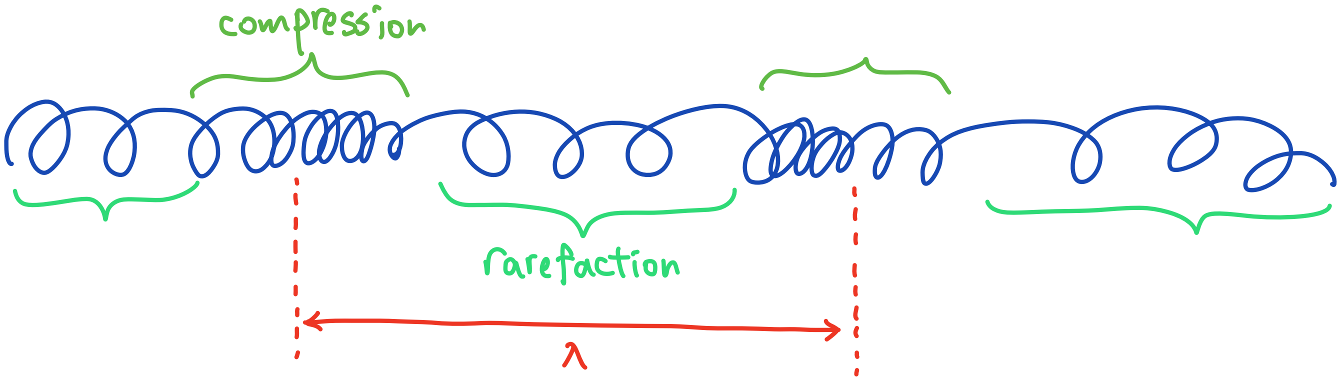
Mechanical Wave: A wave that requires a physical medium/material

↳ Requires a force to create oscillation of matter.

Electromagnetic Waves (EM Waves) do not need a physical medium

A wave transfers energy.





Wavelength: Distance from one point to the same point on the next wave
[m] Distance between 2 adjacent points in phase on a progressive wave

Amplitude: The maximum displacement of a particle from its mean position
[m]

Frequency: Number of waves / oscillations per unit time
[Hz]

Time period: Time taken per wave/oscillation
[s] Time taken for one complete wave to pass a point

$v = f\lambda$ $\quad f = \frac{1}{T}$

$v = \frac{\lambda}{T}$

$[ms^{-1}] = \frac{[m]}{[s]}$

For em waves:

$c = f\lambda$

speed of light

The EM Wave Spectrum

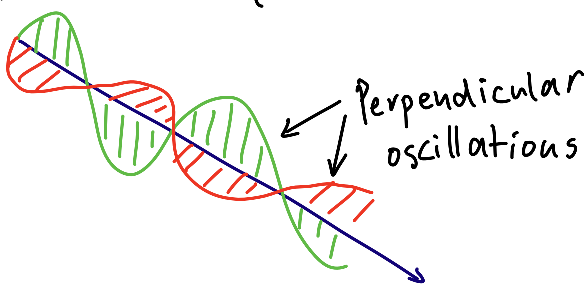
Large Wavelength — Short Wavelength

Radio, Microwave, Infrared, Red (700nm) … Violet (400nm), Ultraviolet, X-Ray, Gamma

$\underbrace{\text{Red} \quad \text{Violet}}_{\text{Visible Light}}$

Low frequency & energy — High frequency & energy

Polarisation (We'll talk more about this later)



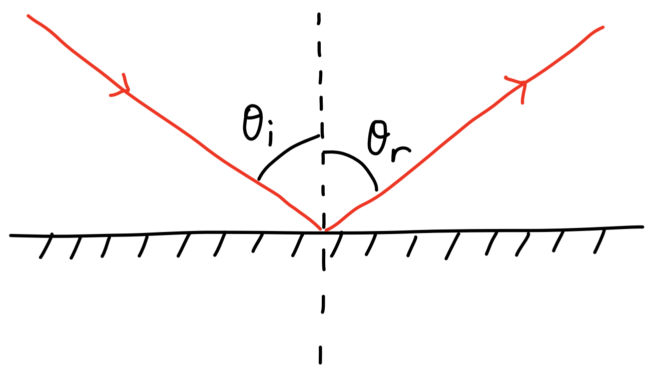
When considering EM waves,

use $\underline{c} = f\lambda$!

speed is constant!

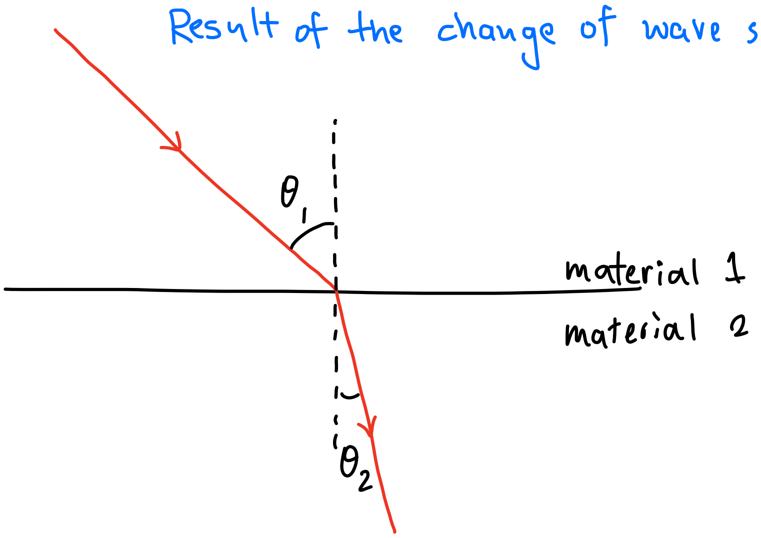
Reflections

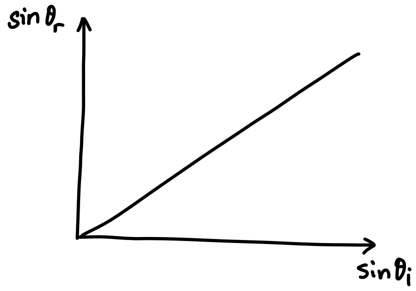
Angle of reflection = Angle of incidence



Refractions

Result of the change of wave speed





During refraction, $\sin\theta_r \propto \sin\theta_i$ ⚠ The constant is different for each wavelength of light

Snell's law: $n_1 \sin\theta_i = n_2 \sin\theta_r$

where n = refractive index of material

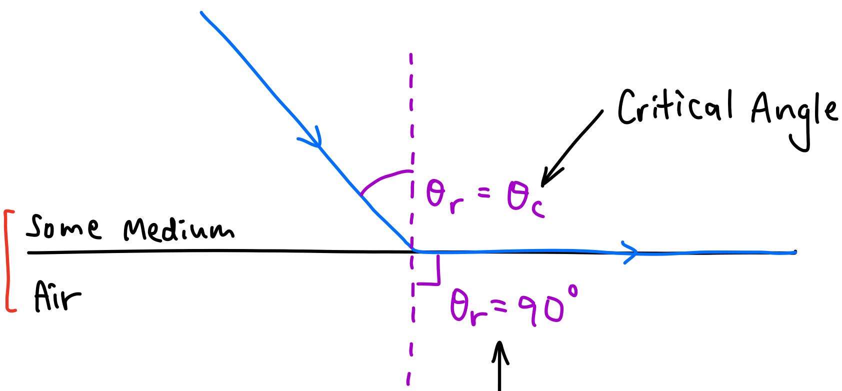
$$n = \frac{c}{v} = \frac{\text{speed of light in vacuum}}{\text{speed of light in medium}}$$

(Vacuum has n of 1)

(Air has n of ≈ 1)

Critical Angle and Total Internal Reflection

From a medium into air
(NOT AIR → MEDIUM)



The refracted ray travels tangent to the surface.

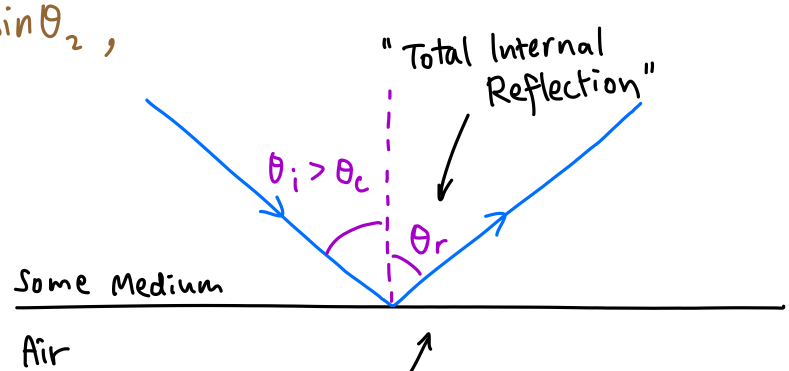
To find θ_c,

use $n_1 \sin\theta_1 = n_2 \sin\theta_2$,

and substitute

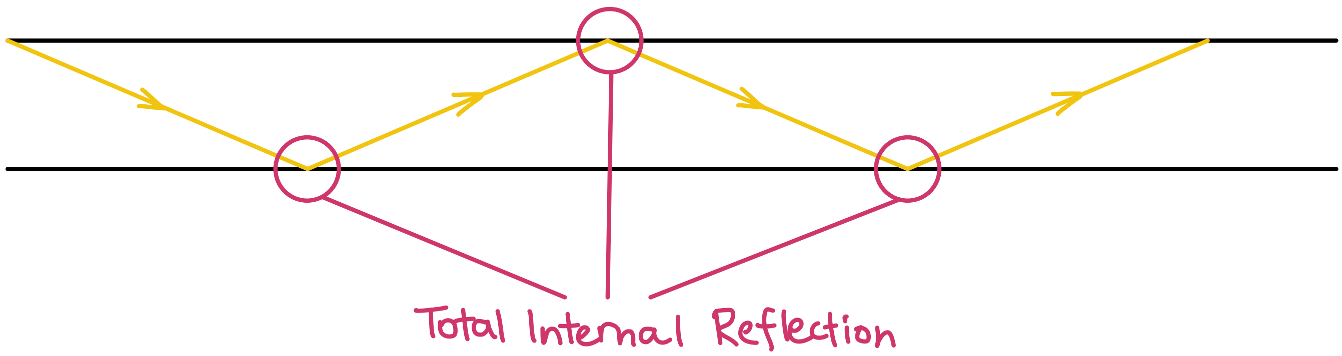
θ_1 or $\theta_2 = 90°$

Not 0° since θ is measured from the normal



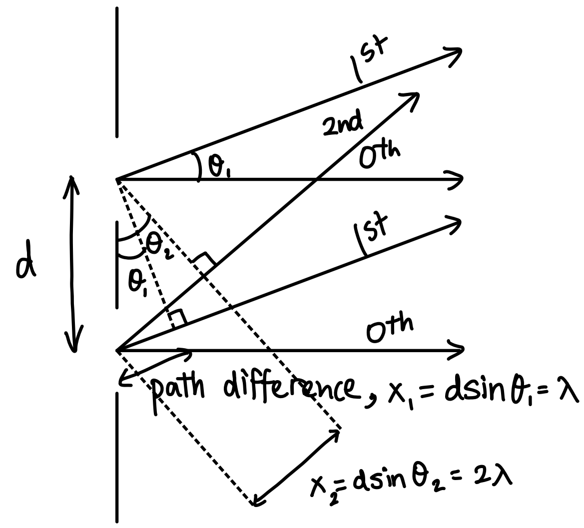
No refraction whatsoever

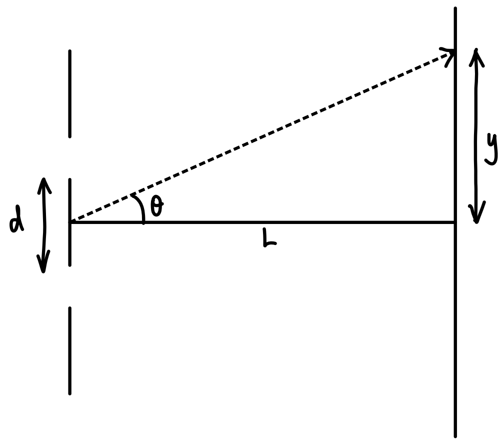
OPTICAL FIBRES



Difffffffffrrrrrraction Grating

Double slit experiment:





Only if $L >> d$
And light is coherent

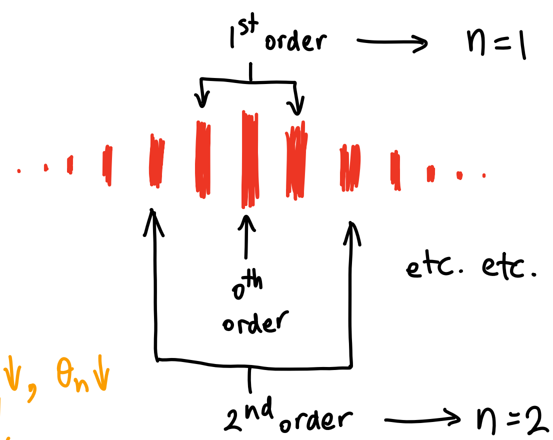
constructive interference

at $d\sin\theta_n = n\lambda$ where n is an integer
($n = 0, \pm1, \pm2 \ldots$)

destructive interference

at $d\sin\theta = (n + \frac{1}{2})\lambda$

Result on screen:

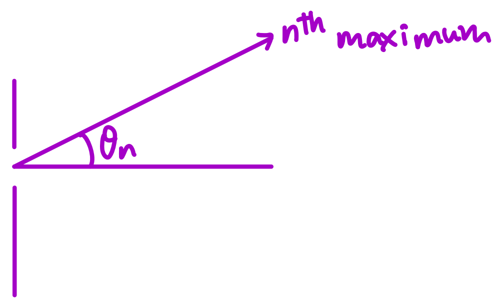


If diffracting white light, a spectrum appears.

when $\lambda\downarrow$, $\theta_n\downarrow$

$$d\sin\theta_n = n\lambda$$

DO NOT FORGET



d: slit separation

θ_n: angle from center line to nth maximum

n: the order of the maximum in question

λ: wavelength of light

Example!

Violet light (400 nm) through 300 slits/mm

a) angle to the 3rd order maximum (θ_3)

b) how many maxima will be visible?

a) $d\sin\theta_n = n\lambda$ $\quad$ $400\text{nm} = 400\times10^{-9}\text{ m}$

$300 \text{ slits/mm} = 300 \text{ slits}/0.001\text{ m}$

Slit separation $= 0.001\text{m}/300 \text{ slits} = \frac{1}{300000}\text{ m}$

$$\frac{1}{300000}\sin\theta_3 = 3(400\times10^{-9})$$

$$\theta_3 = \sin^{-1}(900000\times400\times10^{-9}) = 21.1^\circ$$

b) Maximum when $\theta_n = 90^\circ$ $\quad$ $\sin 90^\circ = 1$

$d\sin\theta_n = n\lambda$

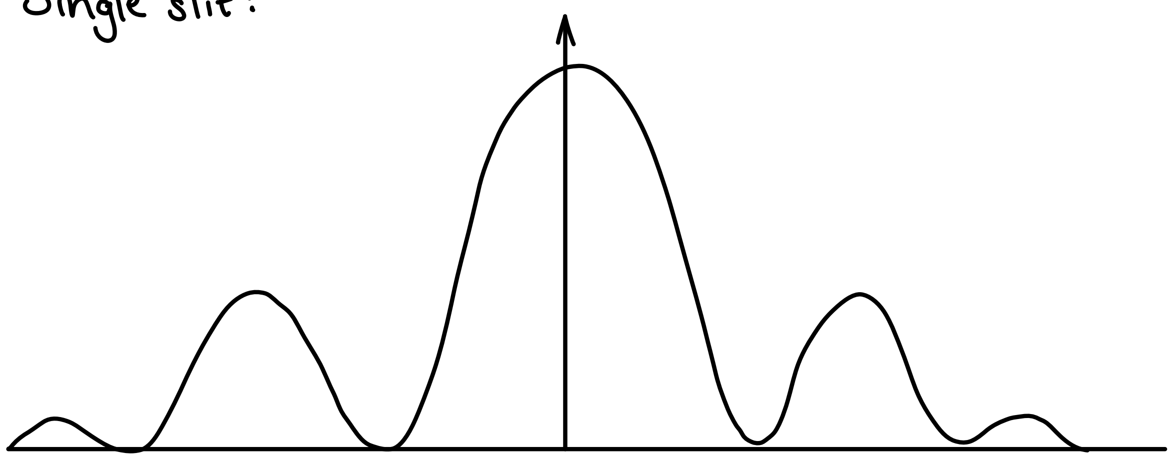
$$n = \frac{d}{\lambda}\sin\theta_n = \frac{1}{300000} \div 400\times10^{-9} = \frac{25}{3} = 8.33 \approx 8$$

greatest order

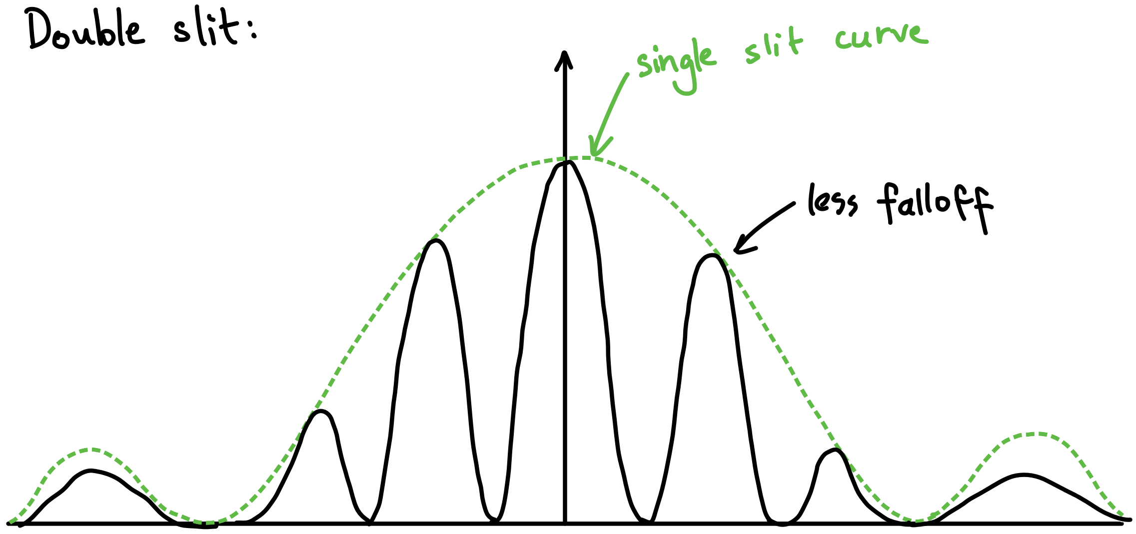
$8\times2+1 = 17$ maxima

Experiment graphs

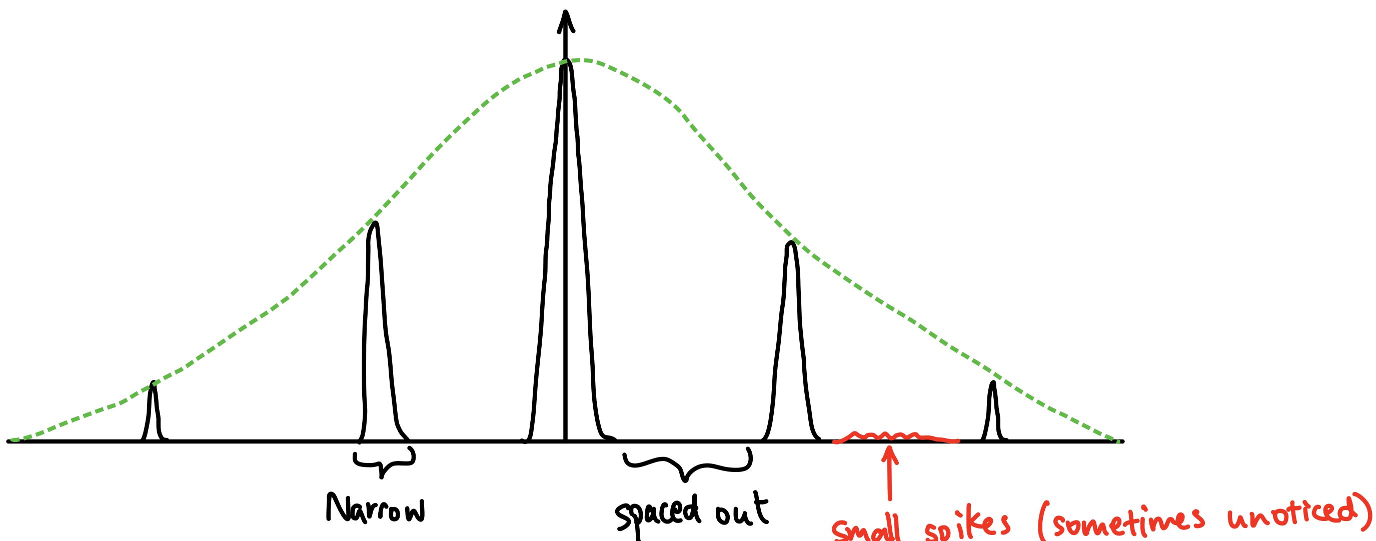
Single slit:



Double slit:



Diffraction grating:



Application

Find wavelength of light / electrons