Equations	
$I = \frac{P}{A}$	$irradiance = \frac{power}{area}$
$I_1 d_1 = I_2 d_2$	$irradiance_1 \times (distance_1)^2 = irradiance_2 \times (distance_2)^2$
$I = \frac{k}{d^2}$	$irradiance(Wm^{-2}) \times distance^2(m^2) = constant\ value\ (W)$
$n_2 = \frac{sin\theta_1}{sin\theta_2} = \frac{\lambda_1}{\lambda_2} = \frac{v_1}{v_2}$	$refractive\ index = \frac{sin\theta_1}{sin\theta_2} = \frac{wavelength_1}{wavelength_2} = \frac{velocity_1}{velocity_2}$
$n_m = \frac{sin\theta_a}{sin\theta_m}$	$refractive\ index\ of\ a\ material = \frac{sin\theta_{air}}{sin\theta_{material}}$
$sin\theta_c = \frac{1}{n}$	$sin\theta_{critical\ angle} = \frac{1}{refractive\ index}$
$E = hf$	$Energy\ of\ incident\ photon = Planck's\ constant \times frequency$
$E = hf_0$	$Work\ function = Planck's\ constant \times threshold\ frequency$
$E_k = hf - hf_0$	$Kinetic\ energy\ of\ photoelectron = energy\ of\ incident\ photo - Work\ function$
$v = f\lambda$	$speed = frequency \times wavelength$
$E_2 - E_1 = hf$	$most\ excited\ energy - least\ excited\ energy = Planck's\ Constant \times frequency$
$path\ difference = m\lambda\ or\ \left(m + \frac{1}{2}\right)\ where\ m = 0, 1, 2, , ...$ $m\lambda\ gives\ constructive\ interference\ and\ \left(m + \frac{1}{2}\right)\ give\ destructive\ interference$	
$d \sin\theta = m\lambda$	$Slit\ separation \times sin\ of\ angle\ from\ centre\ to\ the\ spot = m \times a\ whole\ number\ of\ wavelengths$ NB This equation is for constructive interference

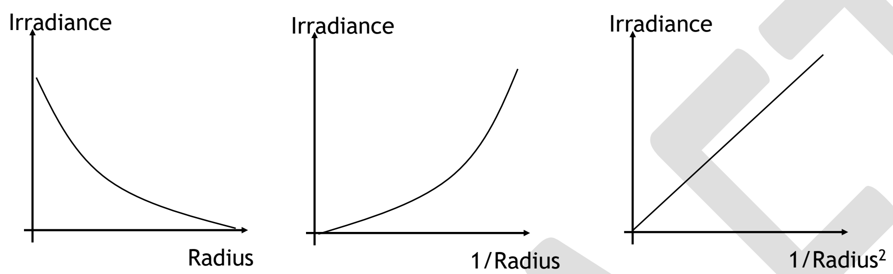
Key Number	Meaning
6.63×10^{-34} J s	Planck's Constant

Key Words	Meaning
Irradiance	the power per unit area incident on a surface.
Inverse Square Law	irradiance is inversely proportional to the square of the distance from a point source. as distance increases by a factor of 2,irradiance decreases by a factor of 4.
Absolute Refractive Index (n)	Tells us how refractive a material is, the greater the *n*, the smaller the angle of refraction in the material, the greater is the reduction in *v* and λ.
Definition of n	The absolute refractive index of a material is the ratio speed of light in a vacuum to the speed of light in the material.
Critical Angle	critical angle as the angle of incidence which produces an angle of refraction of 90˚.
Coherent Source	A coherent source has a constant phase relationship. This means they will have the same frequency, wavelength, speed and be generated in phase.
Interference	Interference can occur when the waves from 2 or more coherent sources meet.
Constructive interference	This will occur when the waves meet in phase, this will cause the amplitude to increase.
Destructive interference	This will occur when the waves meet out of phase, this will cause the amplitude to decrease.
Maxima	maxima are produced when the path difference between waves is a whole number of wavelengths. Crest meets crest, constructive interference causes the amplitude to double to the sum of the two coherent sources at that point.
Minima	minima are produced when the path difference between waves is an odd number of half-wavelengths. Crest meets trough The point where destructive interference causes the amplitude to be 0, the sum of the two coherent sources at that point.
Path Difference	The different in the path travelled by each wave until the point of interference. This can be calculated by subtracting the length travelled by wave 2 from wave 1.
Diffraction Grating	A material that has serval gaps and blocks in a short space. They are used to demonstrate interference of light. They typically have 100s of lines in every mm.
Spectra	visible light split up into its component frequency's, can be absorption, continuous, emission or line emission.

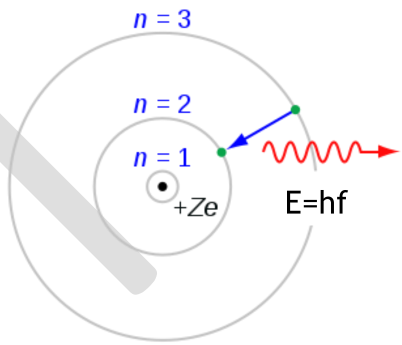
Key Words	Meaning
Energy Levels	Electrons in an atom can be at discreet energy levels. They cannot exist in the spaces between these energy levels. Electrons can move between the levels by gaining or emitting energy.
ionisation energy,	The E_I, is the energy required to remove an electron from an atom in its ground state to a free state in which it has no E_K i.e. its total energy is zero.
Excitation energy	is the energy required to promote an electron from one energy level to a higher energy state.
Ground state	The ground state is the lowest energy level where an electron can be found.
Ionisation	process in which an electron is given enough energy to break away from an atom when the electron is just ionised it has zero potential energy.
Fraunhofer lines	The lines missing when looking at the emission spectrum from the sun. this is because gases in the atmosphere of the sun absorb certain frequencies of light.

Diagrams

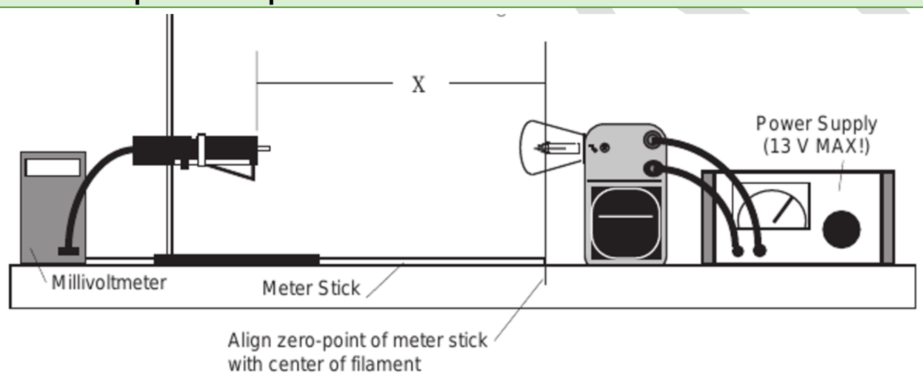
Inverse Square Law [i]



Bohr Model of the Atom[ii]

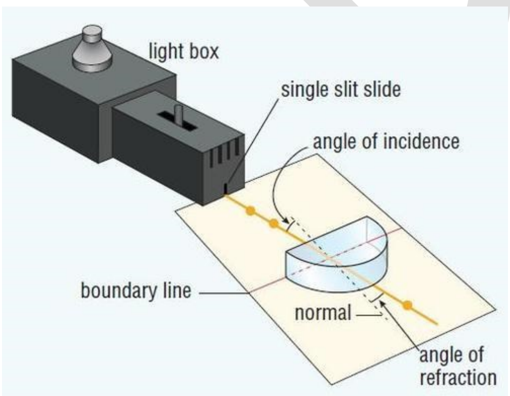


Inverse square law practical[iii]

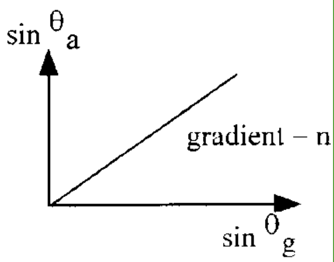


Good practice: Point source light bulb -so light spreads out from a central point. Bulb connected to power supply. Light level meter connected to a display, Black paper to reduce reflections, Take background reading or complete experiment in the dark with only light source the bulb. Beware of shadows created when leaning over to take a measurement.

Verifying SNELL'S LAW



It is better to take angles from either side of the normal to reduce any likelihood of systematic uncertainty arising if the block is not placed correctly and the marked normal is not at 90 degrees to the boundary.

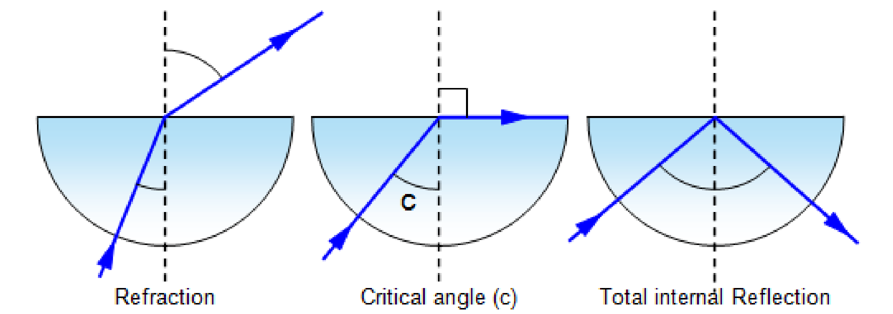


Refractive index is wavelength specific

Critical **Angle**[iv]

Total internal reflection occurs **in the material** when the angle of incidence is greater than the critical angle.

Less than the critical angle	at the critical angle	greater than the critical angle...	

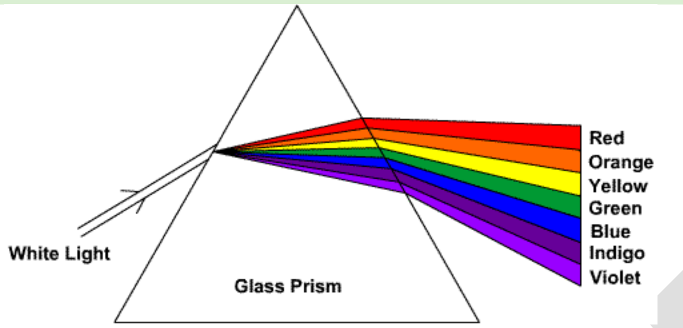


At the critical angle, $\theta_m = \theta_c$ and $\theta_a = 90°$

$$n = \frac{\sin\theta_a}{\sin\theta_m} = \frac{\sin 90}{\sin\theta_c}$$

$$n = \frac{1}{\sin\theta_c}$$

Prism[v]



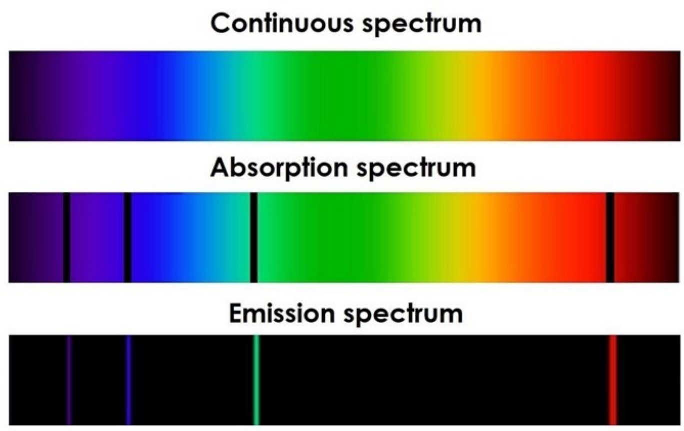
Blue refracts most, red least. Remember *n* is wavelength specific.

RED light has a wavelength ≈ 690nm

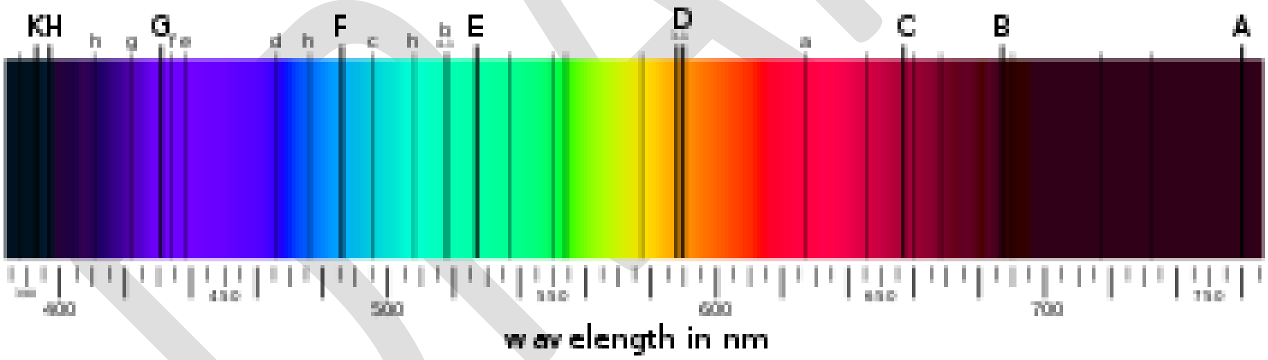
GREEN light has a wavelength ≈ 540nm

BLUE light has a wavelength ≈ 440nm

Spectra[vi]



Fraunhofer lines[vii]

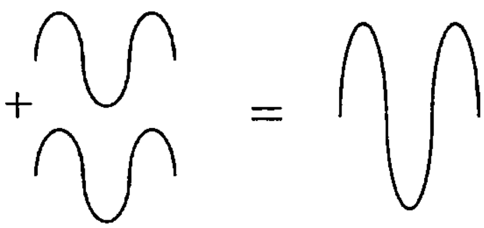


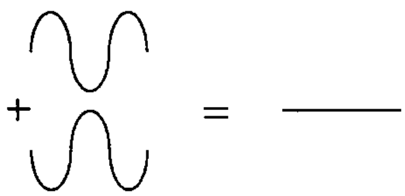
the absorption lines (Fraunhofer lines) in the spectrum of sunlight provide evidence for the composition of the Sun's outer atmosphere

Interference

interference is evidence for the wave model of light coherent waves have a constant phase relationship.

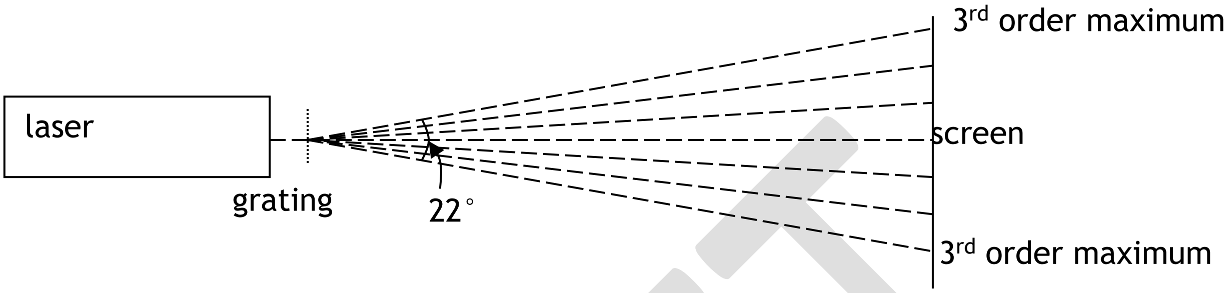
maxima are produced when the path difference between waves is a whole number of wavelengths





minima are produced when the path difference between waves is an odd number of half-wavelengths respectively.

CONSTRUCTIVE	DESTRUCTIVE
path difference $= m\lambda$	path difference $= (m + {}^{1}/_{2})\lambda$
$S_2P - S_1P = (m)\lambda$	$S_2P - S_1P = (m + {}^{1}/_{2})\lambda$
$\frac{xd}{D} = m\lambda$	$\frac{xd}{D} = (m + {}^{1}/_{2})\lambda$
$\lambda = \frac{xd}{mD}$	$\lambda = \frac{xd}{(m + {}^{1}/_{2})D}$
$d\sin\theta = m\lambda$ where m is an integer.	$d\sin\theta = (m + {}^{1}/_{2})\lambda$



e.g. Monochromatic light from a laser is directed through a grating and on to a screen as shown. The grating has 100 lines per millimetre.
Calculate the wavelength of the laser light.
Solution:

$m = 3$

$\theta = \frac{22}{2} = 11°$ n = 100 lines per millimetre = 100 000 lines per metre,

$$d = \frac{1}{100\,000} = 1\cdot00 \times 10^{-5}\ m$$

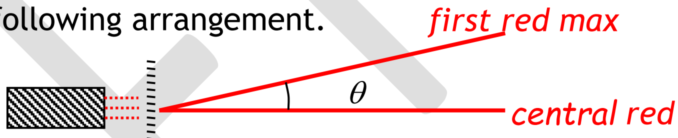
$$m\lambda = d\sin\theta$$

$$3 \times \lambda = 1\cdot00 \times 10^{-5} \times \sin 11°$$

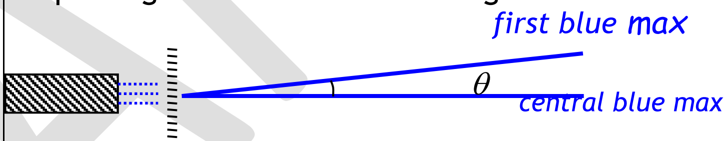
$$\lambda = \frac{1\cdot00 \times 10^{-5} \times \sin 11°}{3} = 6\cdot36 \times 10^{-7}\ \mathrm{m}$$

$\underline{\lambda = 6\cdot36 \times 10^{-7}\ \mathrm{m}}$

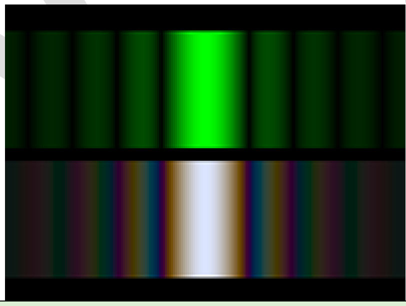
Using the red source arrangement gives us the following arrangement.



Replacing the red with the blue gives:

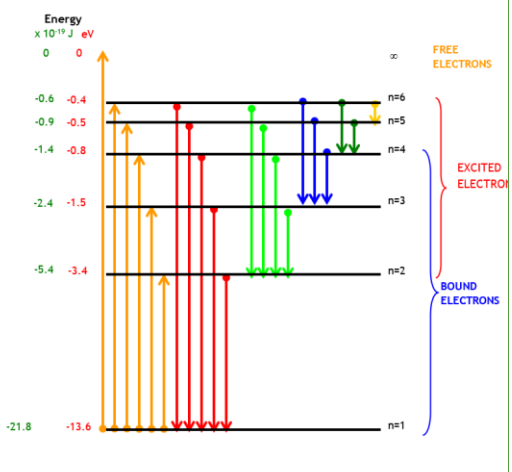


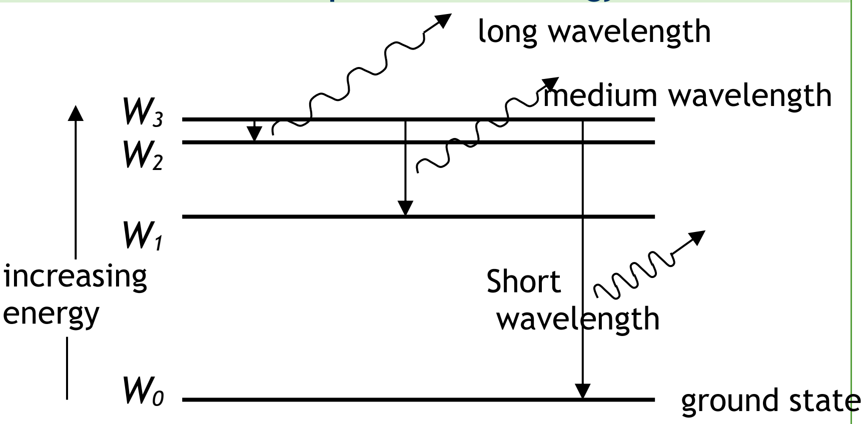
When white light is passed through a grating the 2nd and 3rd orders are likely to overlap



Red light diffracts more than blue light

The energy in the bound electrons is QUANTISED, or comes in specific quantities (QUANTA). This means that the electrons of an atom can have certain quantities of energy and no other.





Sorry I need to tidy up the image references!

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[i] Particles and Waves Part 2 By J A Hargreaves
[ii] https://en.wikipedia.org/wiki/Bohr_model

iii iii manuals, P. and SYSTEM, T., 2022. *PASCO TD-8555 THERMAL RADIATION SYSTEM - Manual (Page 13)*. [online] manualsdir.com. Available at: <https://www.manualsdir.com/manuals/340664/pasco-td-8555-thermal-radiation-system-td-8554a-thermal-radiation-system-td-8553-thermal-radiation-system-td-8555-radiation-sensor-td-8554a-radiation-sensor-td-8553-radiation-sensor.html?page=13&original=1>

[iv] https://www.schoolphysics.co.uk/age11-14/Light/text/Total_internal_reflection/index.html
[v] https://physics.stackexchange.com/questions/65812/why-do-prisms-work-why-is-refraction-frequency-dependent
[vi] https://www.pinterest.co.uk/pin/764486105473144689/
[vii] https://en.wikipedia.org/wiki/Fraunhofer_lines

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