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Waves & Optics

A-level overview

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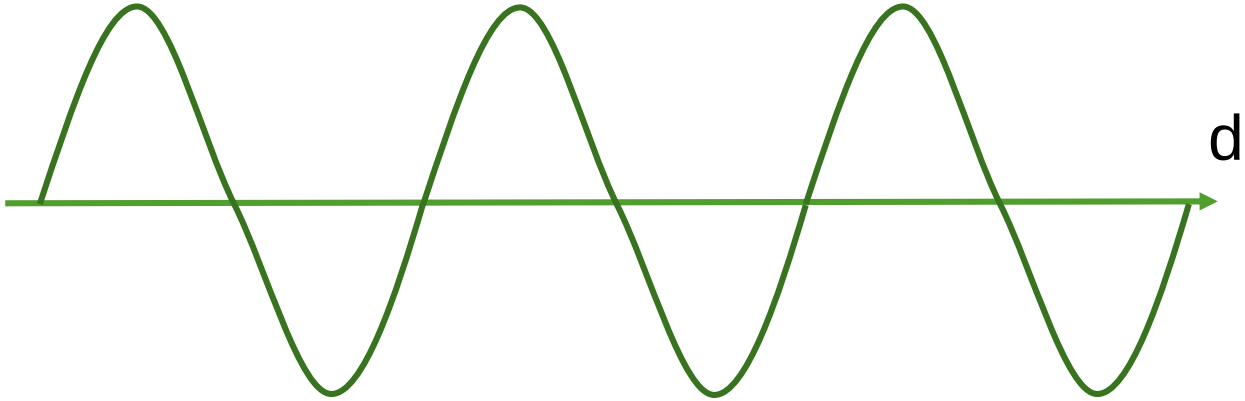
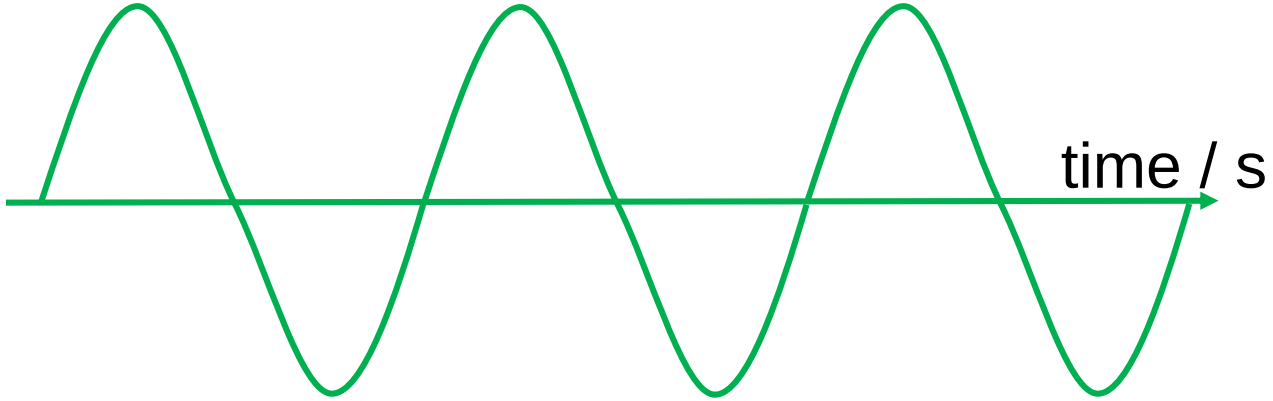
https://isaacphysics.org/pages/remote_learning

Basic wave properties

A transverse wave transmits energy in a direction perpendicular to the oscillations.





Practice with wave formulae

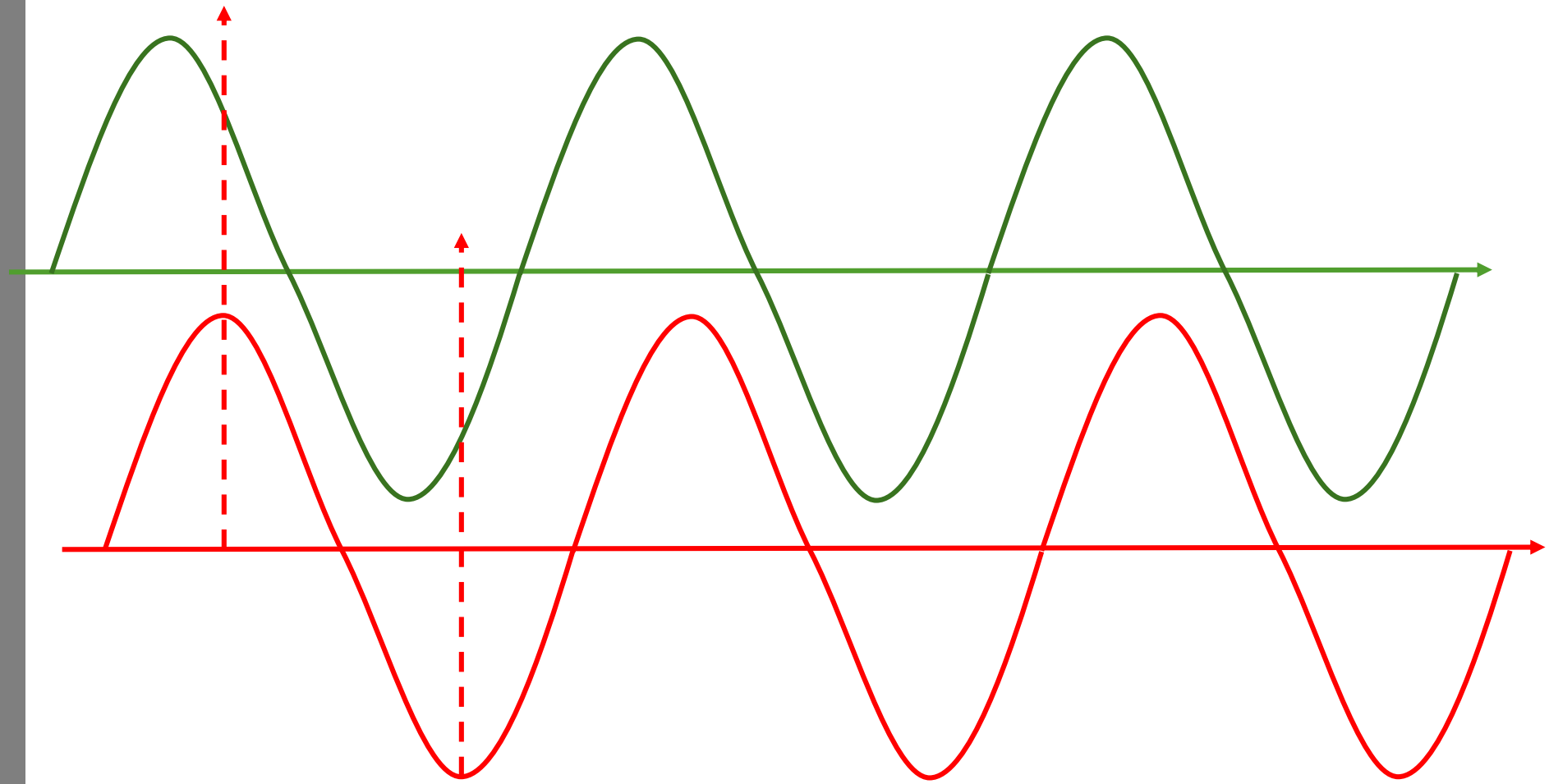
$c = f\lambda$ $f = 1/T$ $c^2 = T / \rho$

1. What is the frequency of light with wavelength 630nm?

2. What is the time period of ‘treble A’ at 440Hz?

3. When the ‘treble A’ is played on a violin string, the wavelength on the string is 0.65m. If $r = 6.5 \times 10^{-4}$ kg/m, what will the tension be?

Phase difference



Phase difference of 0° means constructive interference

Phase difference of 180° means destructive interference

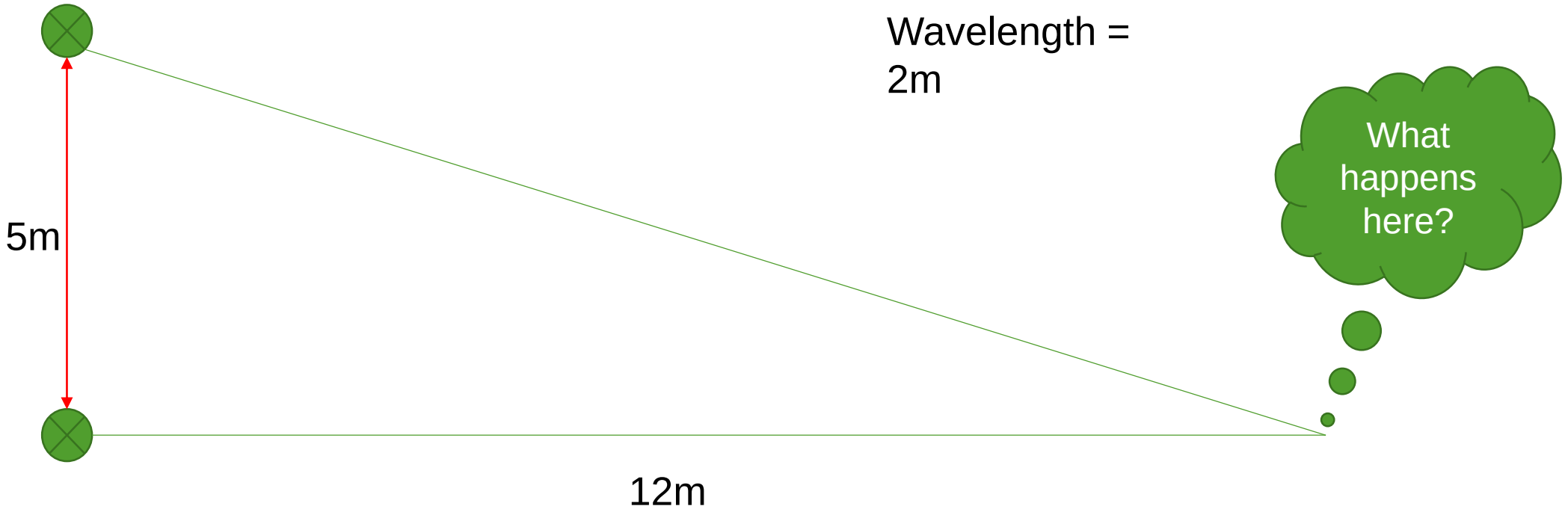
Phase and Path Difference

$$\text{Phase difference} = \frac{\text{Path difference}}{\lambda} \times 360°$$

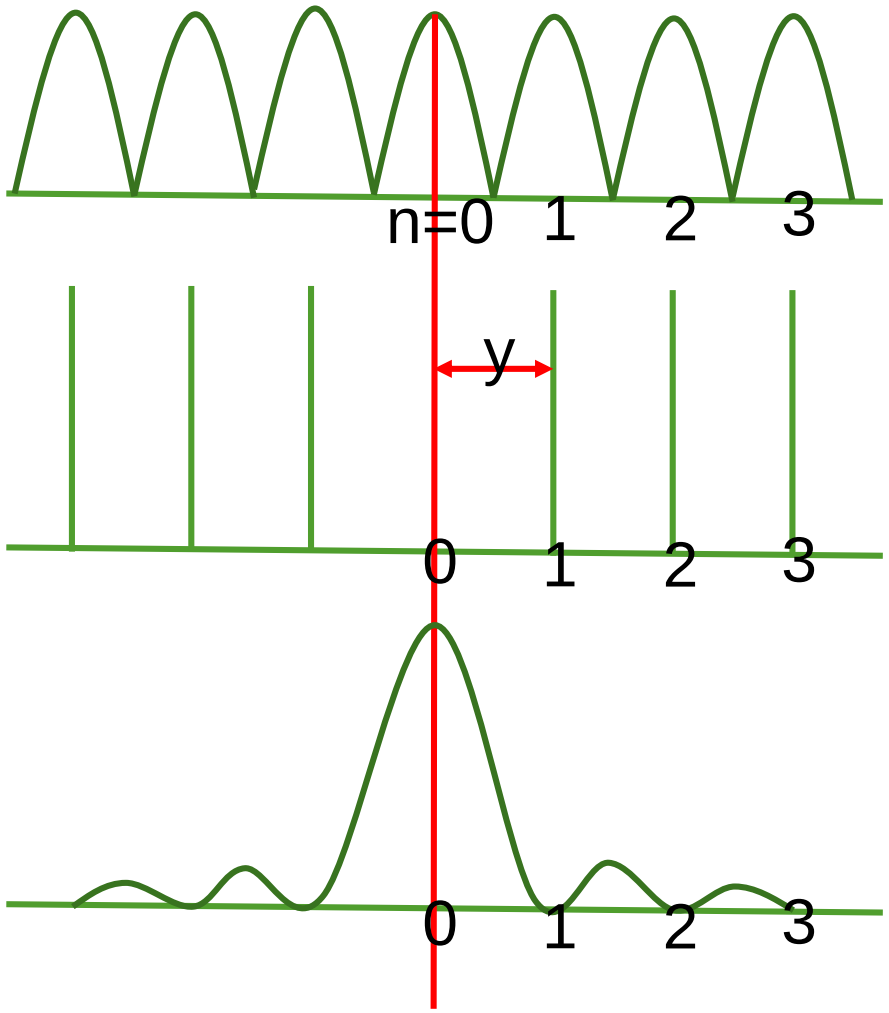
Wavelength	Path difference	Phase difference (give answer between 0° and 360°)
50cm	20cm	
50cm	75cm	
650nm		90°
36m		30°
6.500mm	94.25mm	

Path Difference

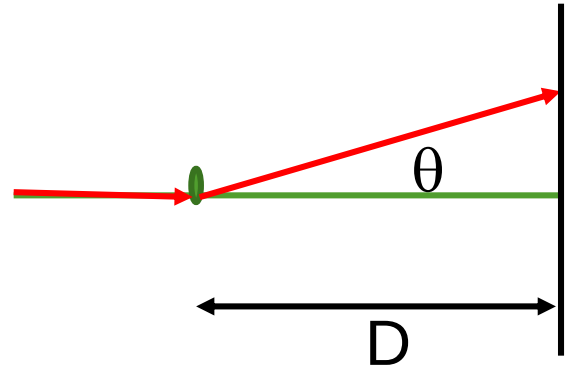
Phase difference of 0° means constructive interference
Phase difference of 180° means destructive interference



Interference formulae



Double slit – spacing s



Grating – spacing of adjacent slits s

Single slit – width s

$y = \lambda D / s$

$n \lambda = s \sin \theta$

Practice with interference formulae

$y = \lambda D / s$

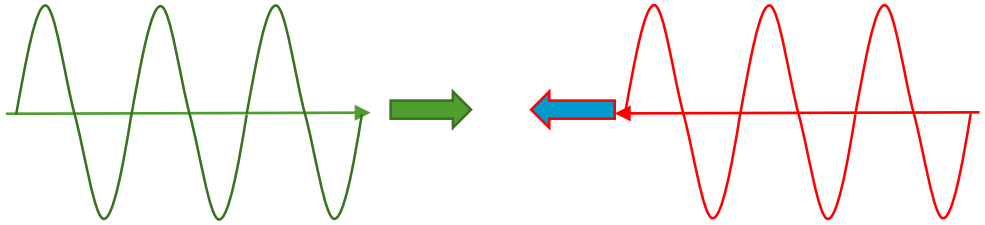
$n \lambda = s \sin \theta$

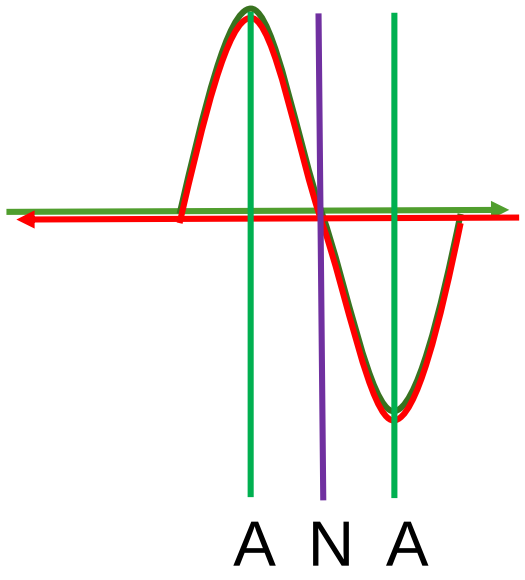
Wavelength λ	Separation of sources s	Distance to screen D	Order of interference n	Fringe Spacing y	Angle to axis θ
480nm	0.020mm	2.50			
650nm		1.50		10cm	
500nm	1.25×10^{-6}m		1		
	1.25×10^{-6}m		2		60°

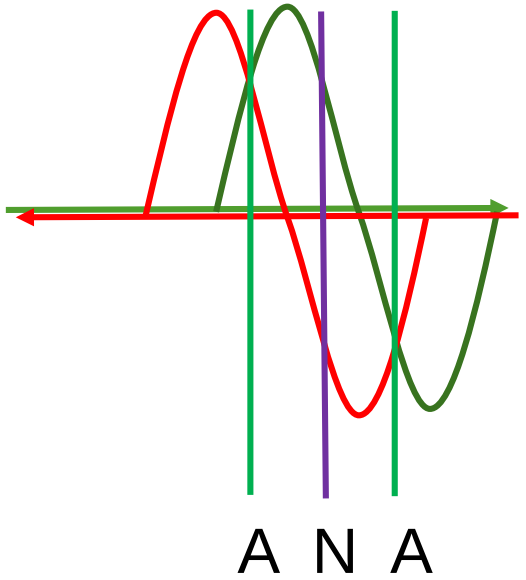
1. What is the separation of sources in a diffraction grating with 600 lines/mm?

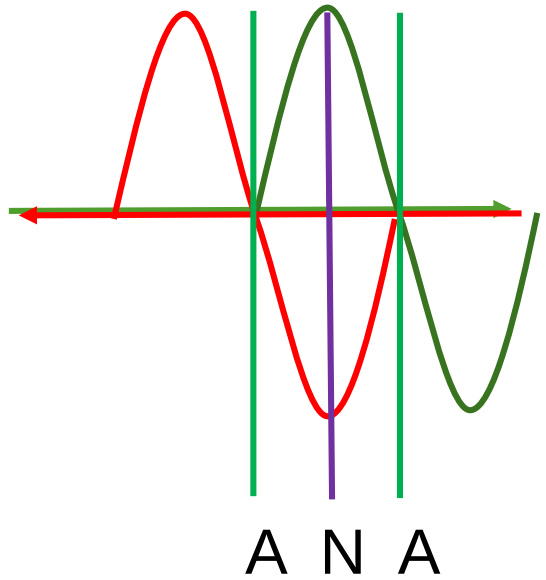
2. How many bright fringes will there be each side of the axis when 660nm light is shone through a grating with 120 lines/mm?

Standing wave









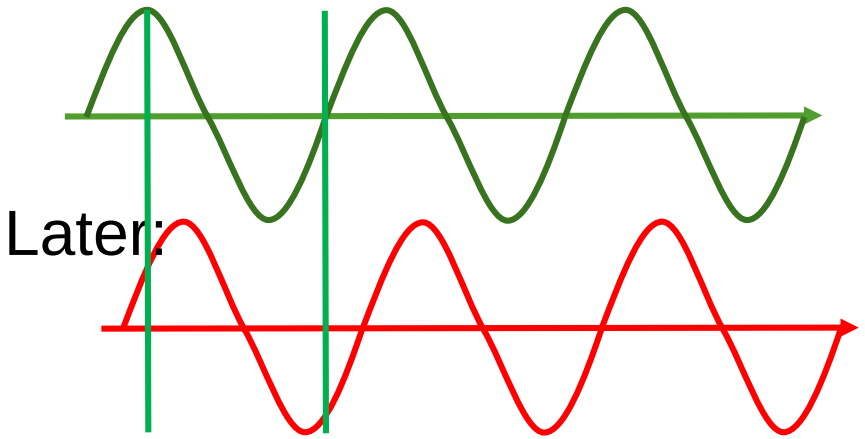
Two travelling waves in opposite directions with the same frequency make a standing wave.

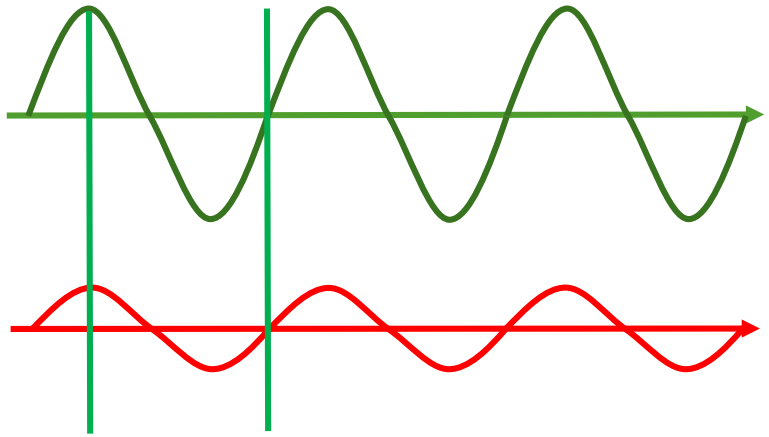
Antinodes A (green line) = bright part are half a wavelength apart

Nodes N (purple line) = dark part are quarter of a wavelength from antinodes

Nodes are not totally ‘dark’ unless the two waves have equal amplitude.

Travelling & Standing waves





All points have same amplitude,
All points (within 1 cycle) have different phase

All points (within half cycle) have same phase,
All points have different amplitudes
Places of max amplitude = Antinodes
Places of zero amplitude = Nodes

Questions on reflected wave interference

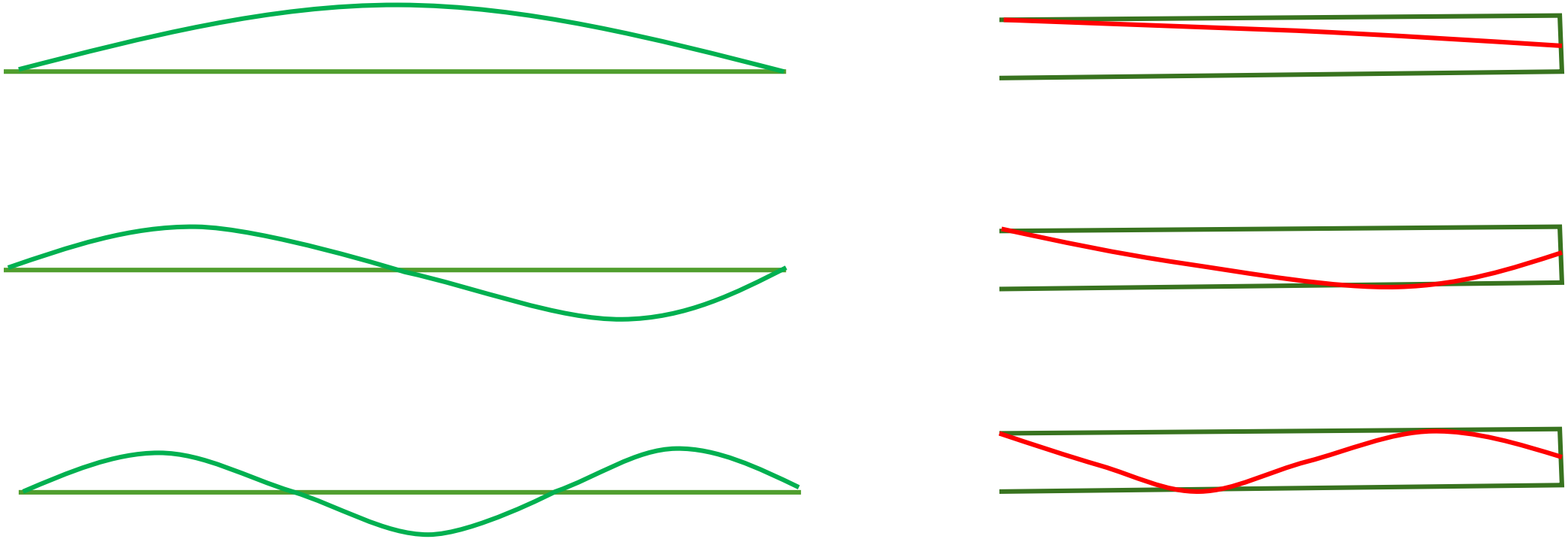
1. What is the spacing between ‘dark’ points when 5.2cm microwaves reflect off a metal surface?

2. Radio waves of frequency 1GHz reflect off a surface. How far apart are the ‘bright’ and ‘dark’ points?

3. Why might the ‘dark’ points not be completely dark?

Modes

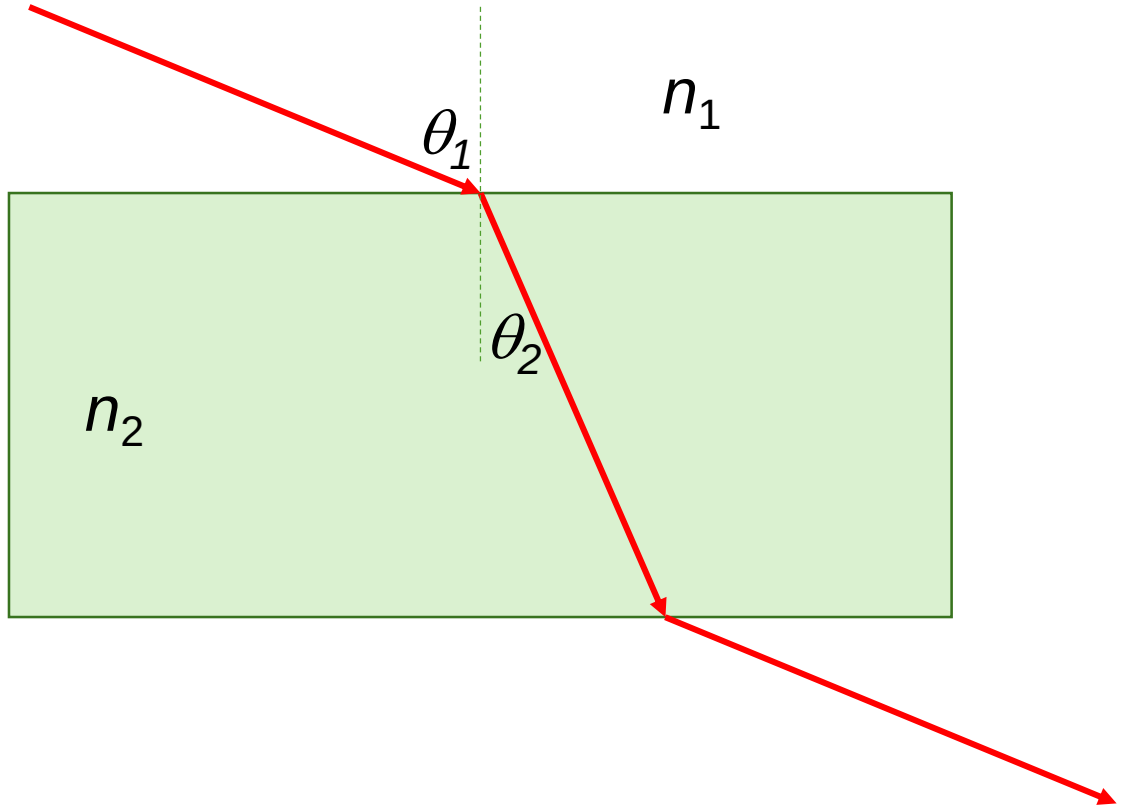
For each, label nodes N and antinodes A,
then write wavelength in terms of length *L*
Then write frequency in terms of length and wave speed *c*



The Fundamental Formula

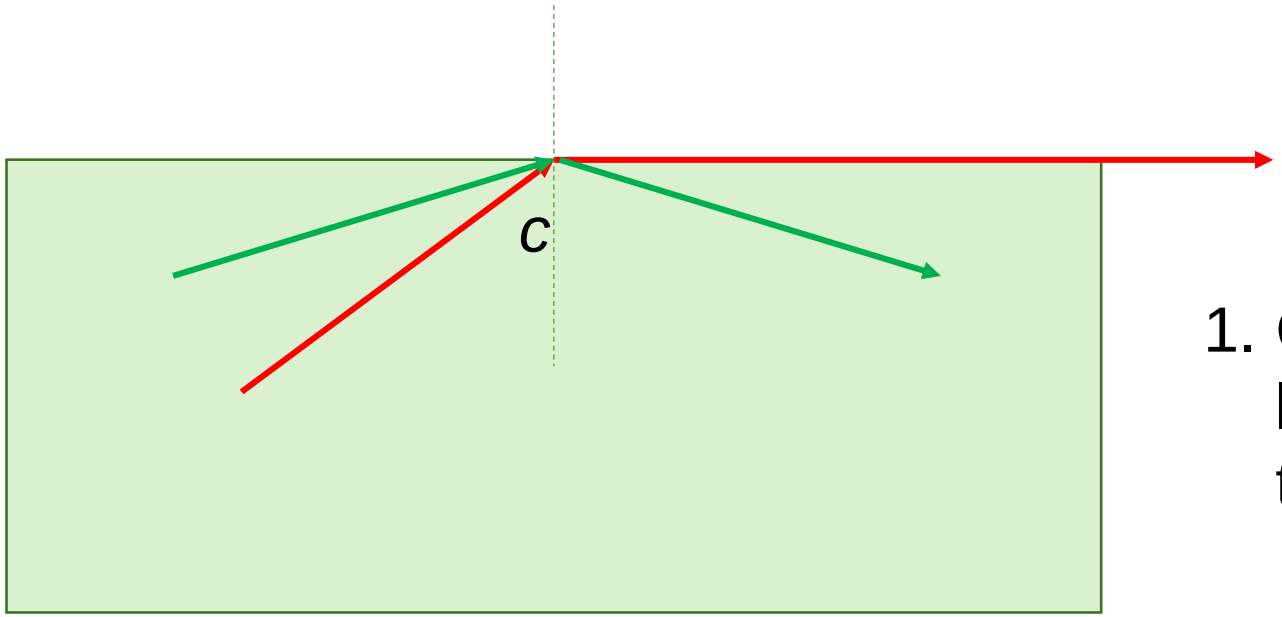
For a wave on a string $c^2 = T/\rho$. Using your result from the previous page where a string fixed at both ends had a longest wavelength of 2L, give a formula for the frequency of the fundamental mode of vibration.

Refraction



Calculate the angle of incidence needed from air to glass (n=1.52) to give an angle of reflection of 22°.

Total Internal Reflection

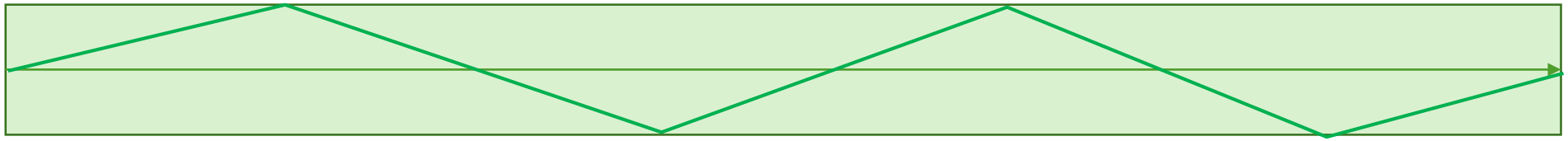


1. Calculate the critical angle for light passing from water (n=1.33) to air.

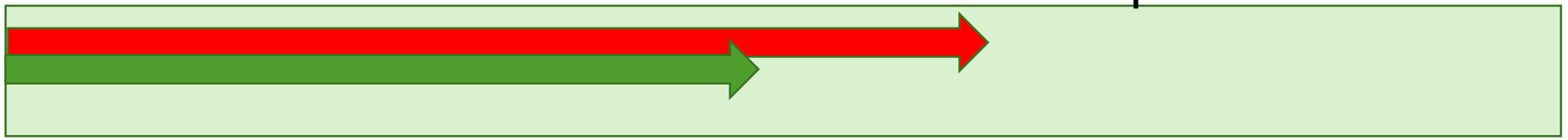
2. Calculate the critical angle for light passing from glass (n=1.52) to water.

Dispersion

Modal dispersion



Material dispersion



Links

A Level Topic Revision

https://isaacphysics.org/pages/a_level_topic_index#a_level_revision

Consolidation Programme

https://isaacphysics.org/pages/summer_programmes_2021