



Physics. *You work it out.*

# Waves & Optics

A-level overview

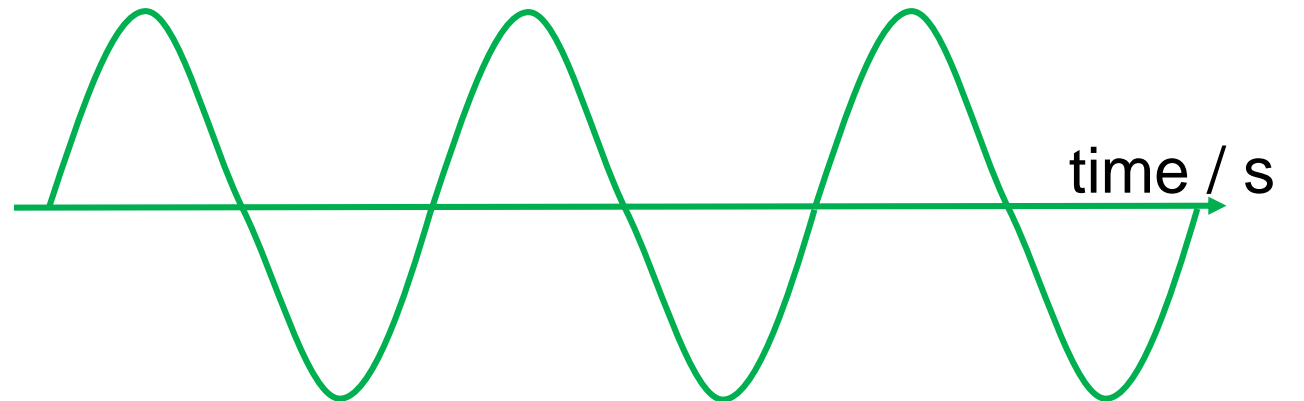
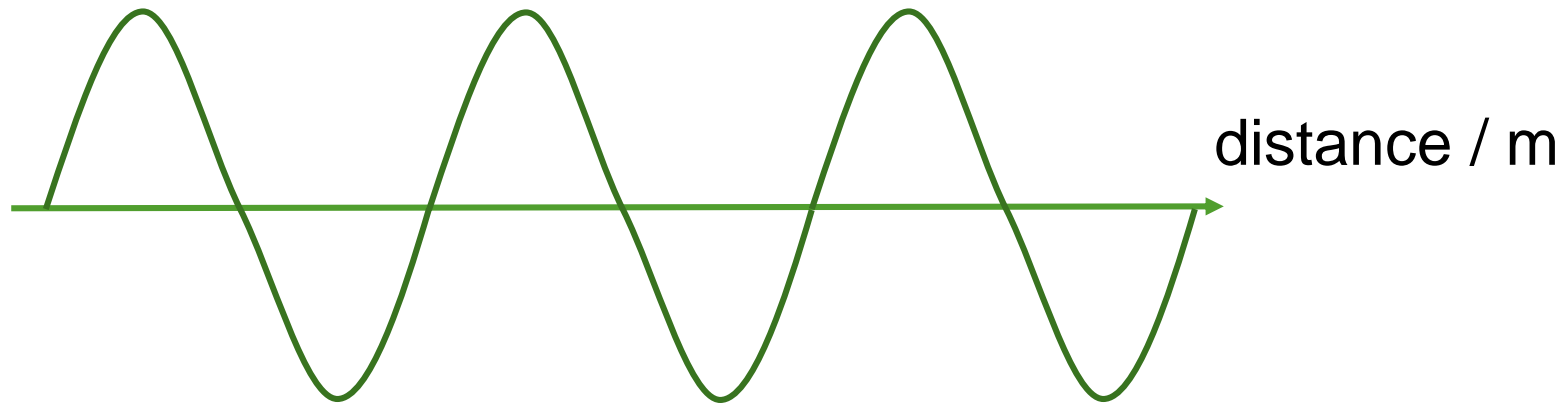
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# Basic wave properties

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





# Practice with wave formulae

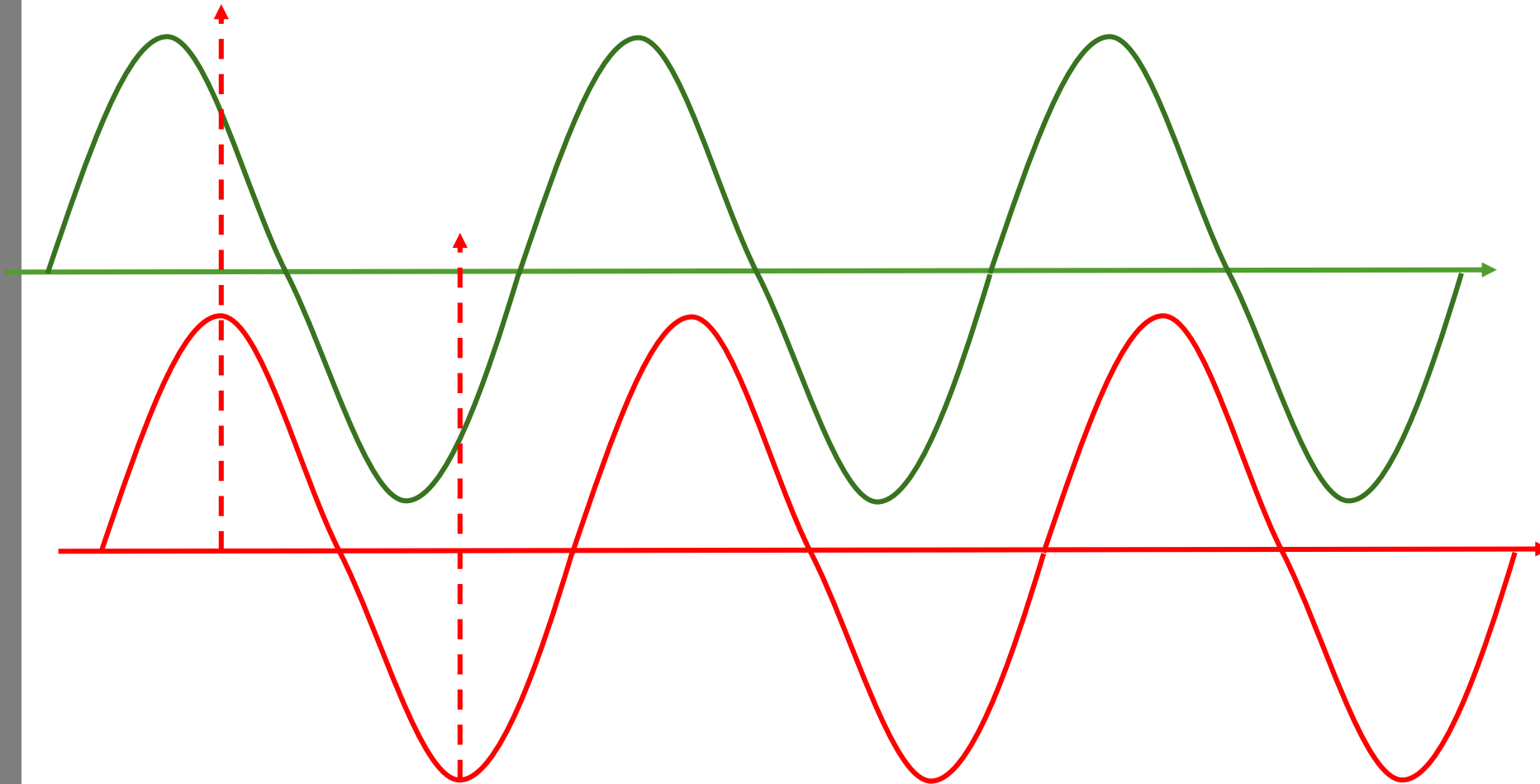
$$c = f \lambda$$

$$f = 1/T$$

$$c^2 = T / \rho$$

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  $\rho = 6.5 \times 10^{-4} \text{ kg/m}$ , what will the tension be?

# Phase difference



Phase difference of  $0^\circ$  means constructive interference  
Phase difference of  $180^\circ$  means destructive interference



# Phase and Path Difference

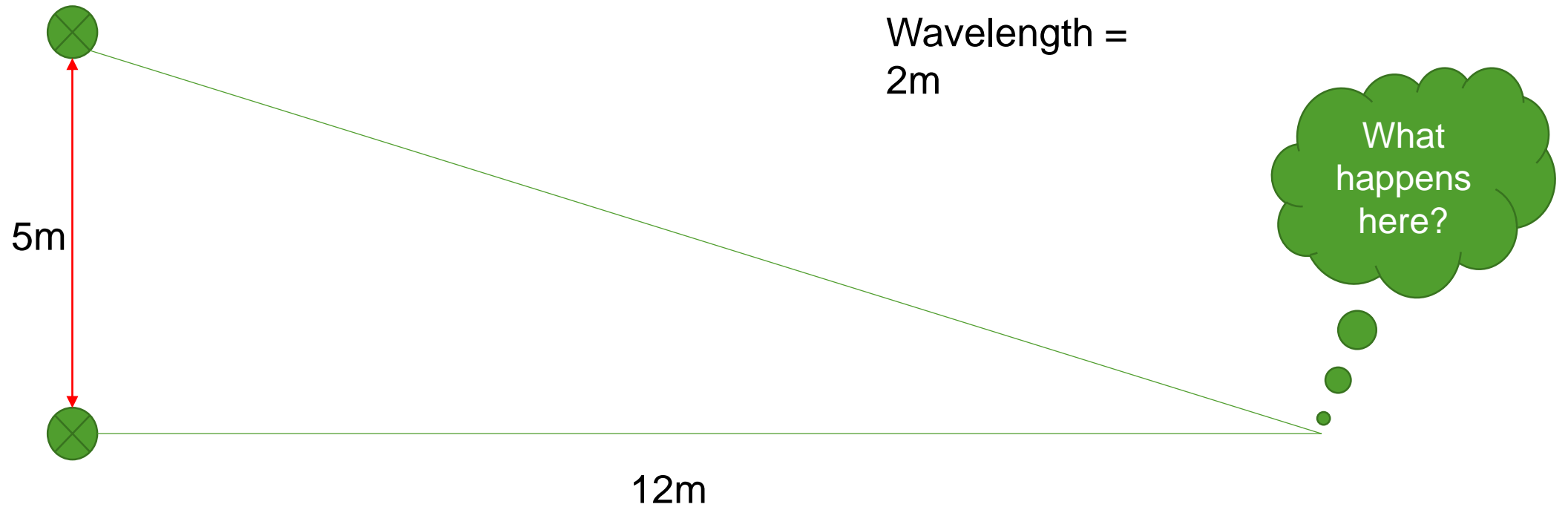
$$\text{Phase difference} = \frac{\text{Path difference}}{\lambda} \times 360^\circ$$

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

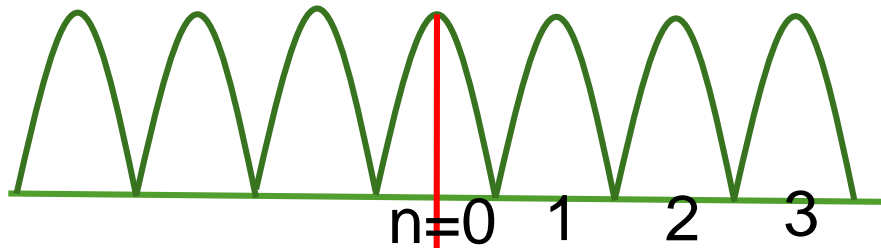


Phase difference of  $0^\circ$  means constructive interference  
Phase difference of  $180^\circ$  means destructive interference

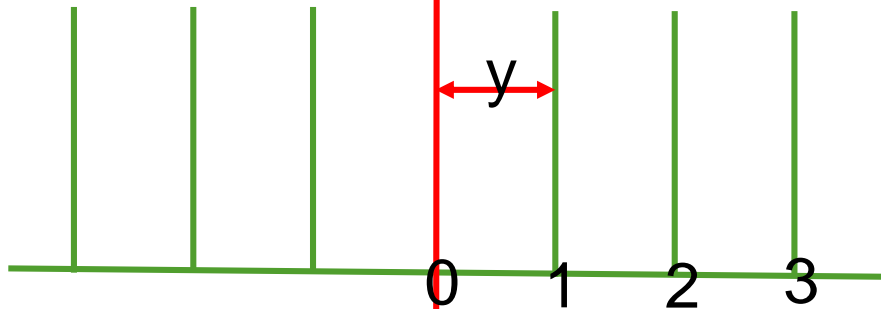
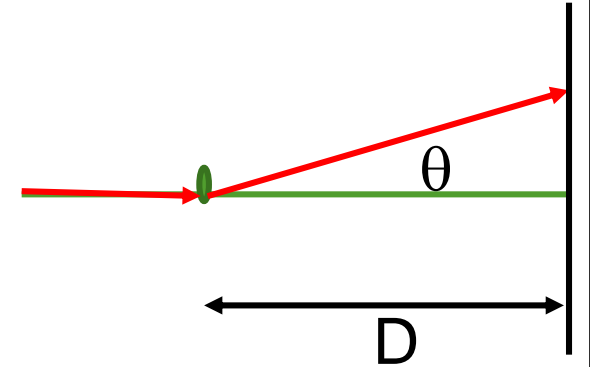
# Path Difference



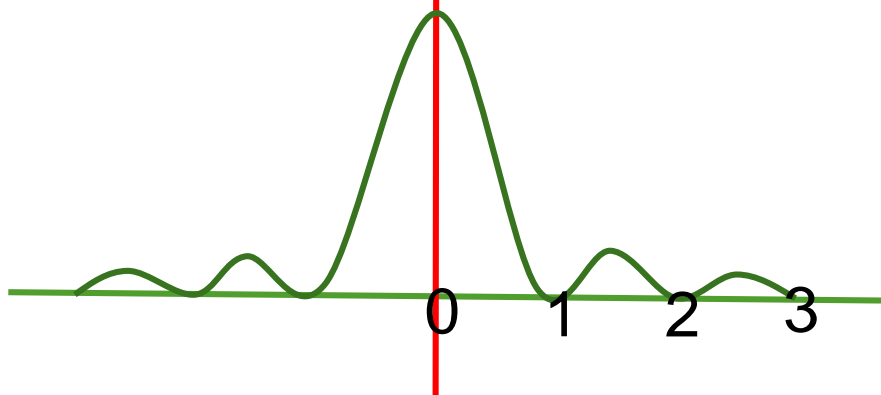
# Interference formulae



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

$$y = \lambda D / s$$

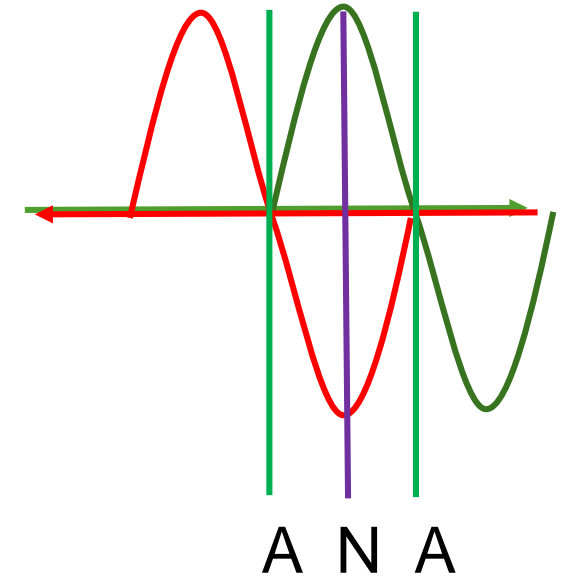
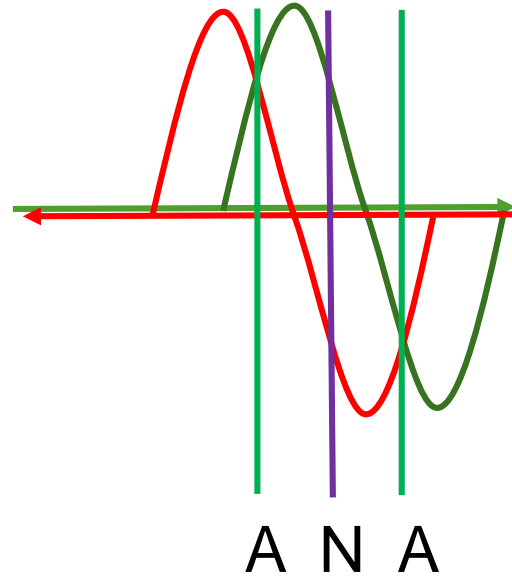
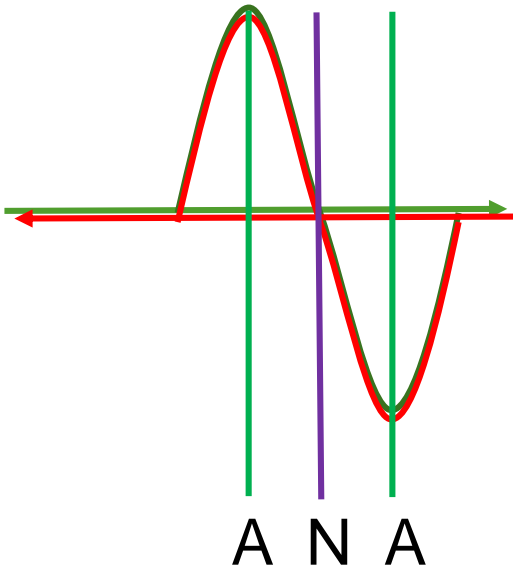
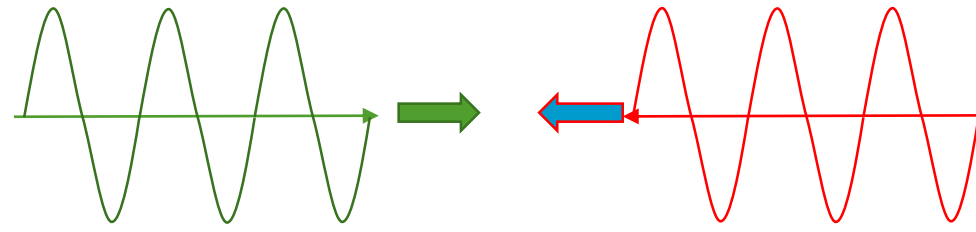
$$n \lambda = s \sin \theta$$

Wavelength $\lambda$	Separation of sources $s$	Distance to screen $D$	Order of interference $n$	Fringe Spacing $y$	Angle to axis $\theta$
480nm	0.020mm	2.50			
650nm		1.50		10cm	
500nm	$1.25 \times 10^{-6} \text{m}$		1		
	$1.25 \times 10^{-6} \text{m}$		2		$60^\circ$

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



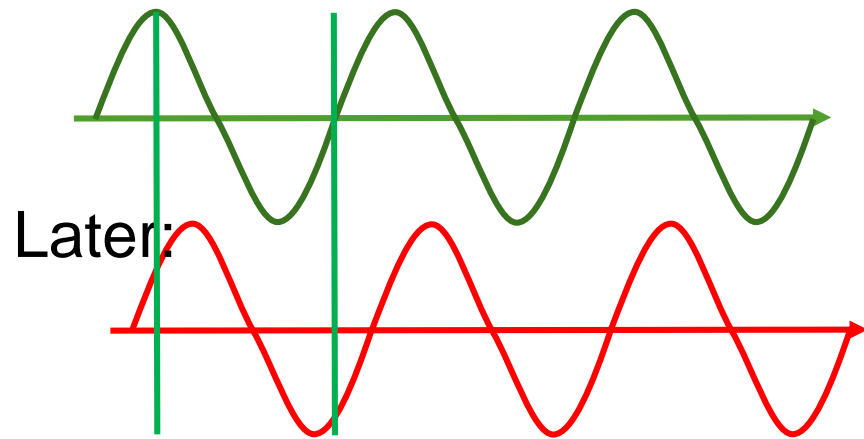
Two travelling waves in opposite directions with the same frequency make a standing wave.

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

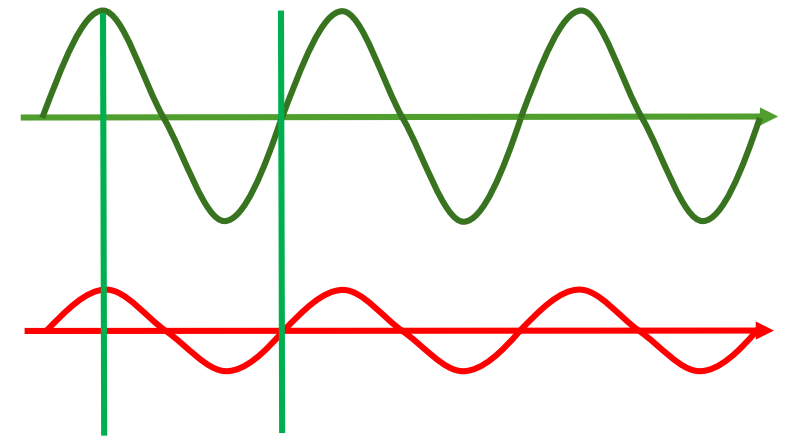
Nodes N (purple line) = dark part are quarter of a wavelength from antinodes

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



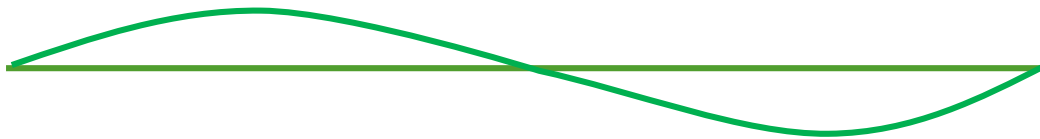
# Questions on reflected wave interference

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  $c$

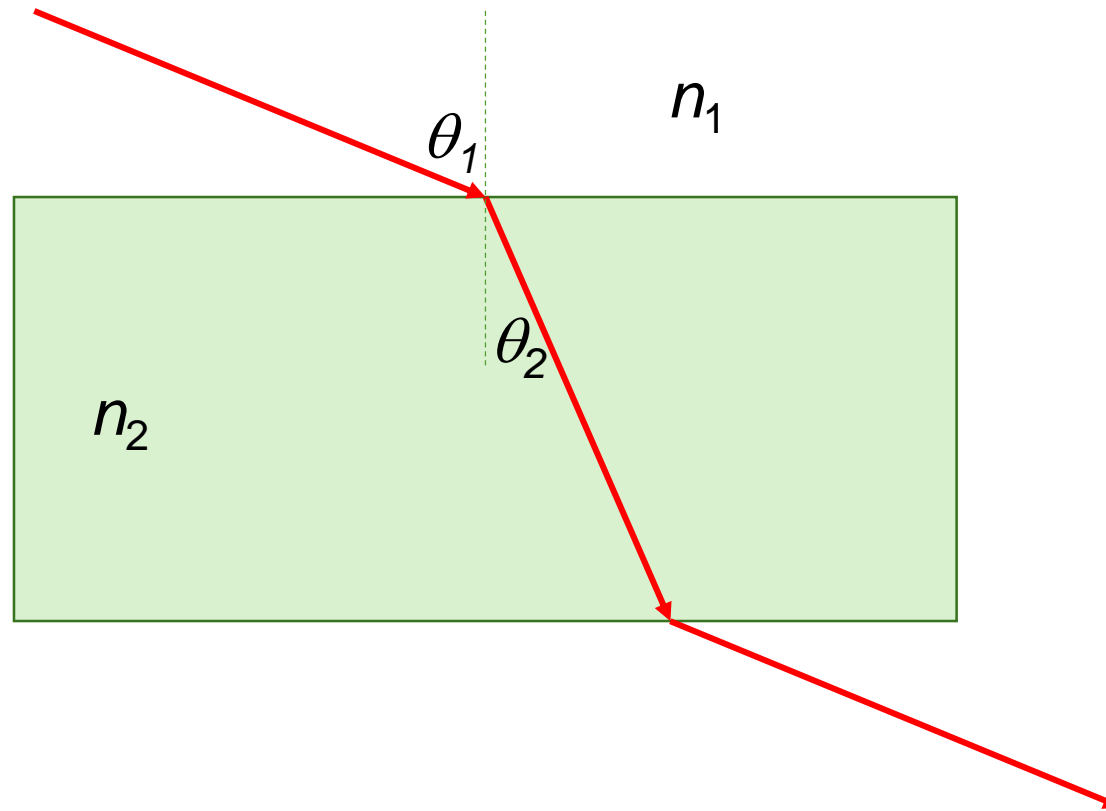




# The Fundamental Formula

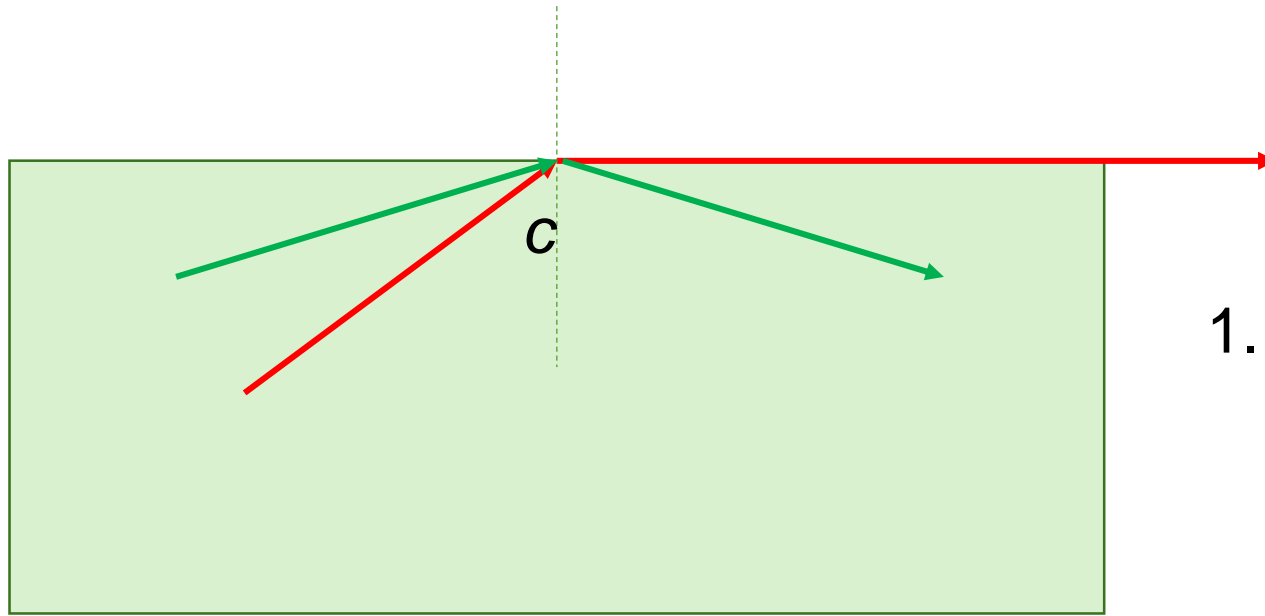
For a wave on a string  $c^2 = T/\rho$ . Using your result from the previous page where a string fixed at both ends had a longest wavelength of  $2L$ , give a formula for the frequency of the fundamental mode of vibration.

# Refraction



Calculate the angle of incidence needed from air to glass ( $n=1.52$ ) to give an angle of refraction of  $22^\circ$ .

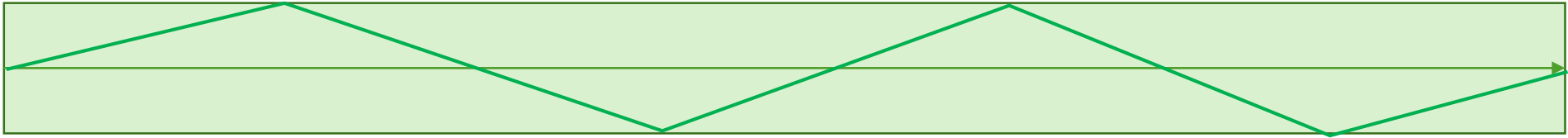
# Total Internal Reflection



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

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