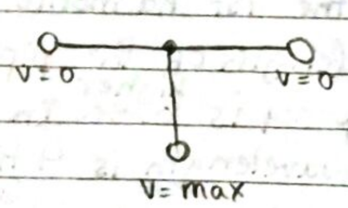
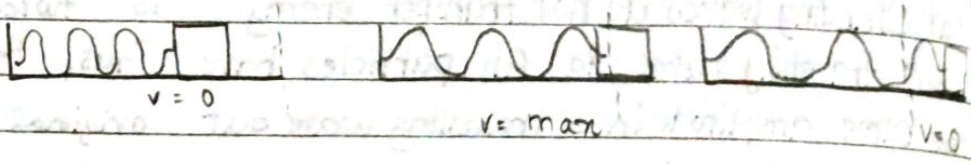
Presentation notes

4. Waves

4.1 Oscillations

1) Oscillations are vibrations which repeat themselves.
2) In all oscillations, $v = 0$ at the extremes and $v = max$ at the middle of the motion.





3) Maximum displacement = Amplitude, x_0. Zero displacement = equilibrium position

Displacement x is measured from equilibrium.

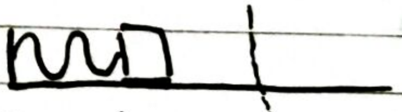
4) Period T - time taken for one oscillation or cycle.

5) Frequency Hz or cycles/s - Number of cycles per second.

6) $$\boxed{f = \frac{1}{T}, \quad T = \frac{1}{f}}$$

7) Phase difference

We can leave a mass from the right or left. T & f remain unchange

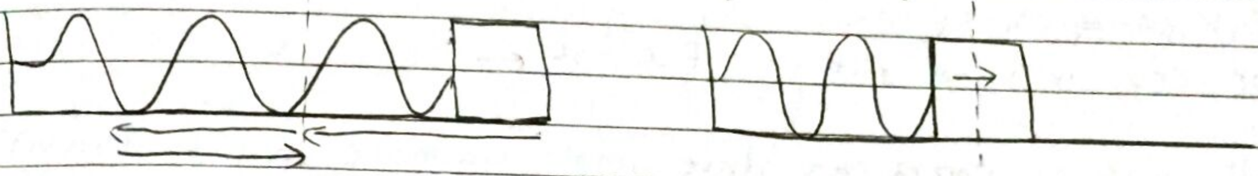


But, there is a phase difference of half a cycle.

- How much a particle or wave is in front of behind another particle or wave.

Calculated in radians or degrees.

Phase difference = $\frac{1}{4}$ of a cycle



Phase difference = $\frac{3}{4}$ of a cycle

8) $F = -kx$

$F = ma$

$ma = -kx$

$a = -\frac{k}{m}x$

$\boxed{a \propto -x}$

Example

A spring having a spring constant of $125\ Nm^{-1}$ is attached to a 5.0 kg mass, stretched ~~4.0 m~~ -2.0 m as shown, and then released from rest.

a) Find acceleration.

$ma = -kx$

$a = -\frac{k}{m}x$

$a = -\left(\frac{125}{5}\right)(-2)$

$a = +50\ ms^{-2}$

b) Find displacement of the mass when $a = -42ms^{-2}$?

$-42 = -\frac{k}{m} \times x$

$-42 = -\frac{125}{5} \times x$

$\frac{-42}{-25} = x = +1.7\ m$

9) Simple Harmonic Motion

In SHM, $\boxed{a \propto -x}$ $\boxed{\text{Definition of SHM}}$

Show that a mass oscillating on a spring executes SHM?

$f = -kx = ma$

$a = -\left(\frac{k}{m}\right)x$

$a \propto -x$

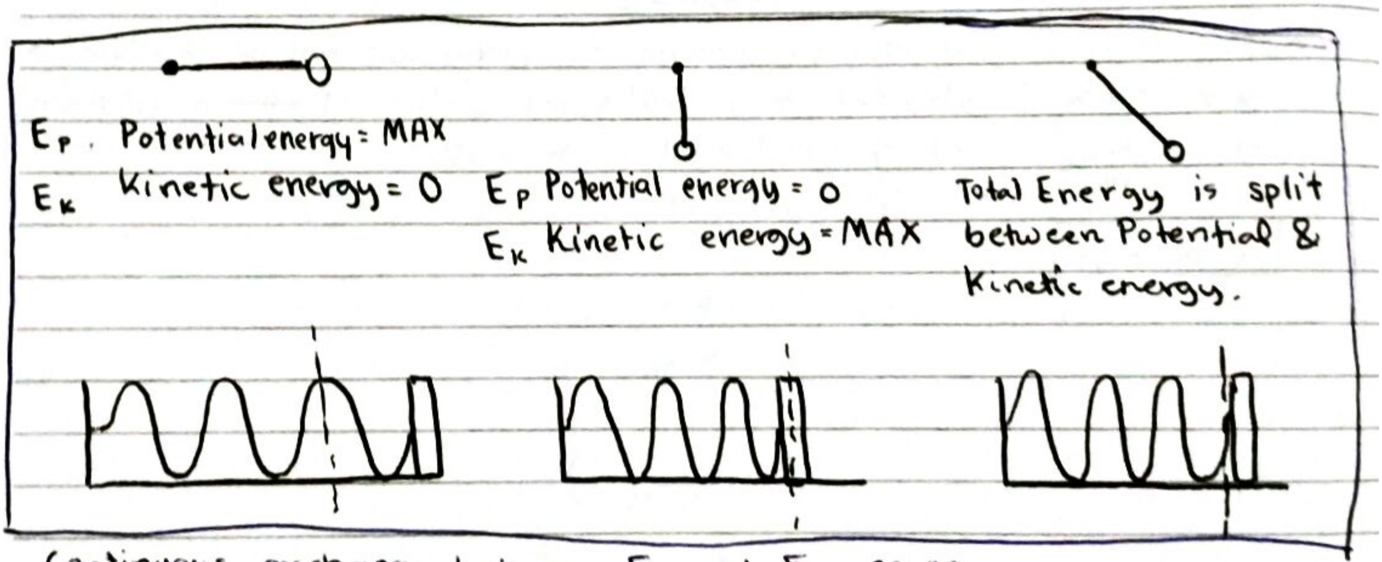
If displacement is positive, acceleration & spring force are negative and vice versa

Any force that is ~~opposite~~ proportional to the opposite of a displacement is called a <u>restoring force</u>.

For any restoring force $F \propto -x$.

All restoring forces can drive simple harmonic motion (SHM).

10) Energy changes during one cycle of an oscillation.



E_P. Potential energy = MAX
E_K Kinetic energy = 0

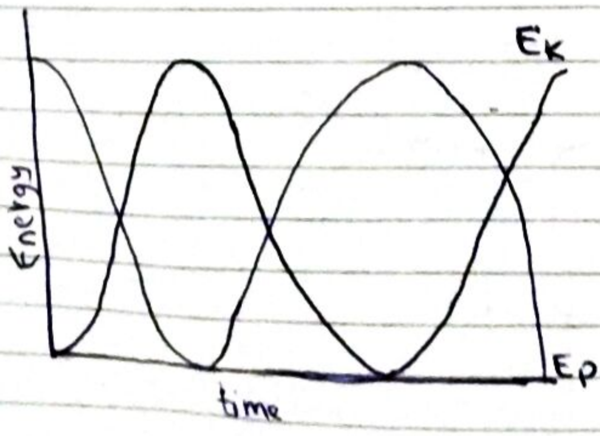
E_P Potential energy = 0
E_K Kinetic energy = MAX

Total Energy is split between Potential & Kinetic energy.

Continuous exchange between E_K and E_P occurs.

$\boxed{E_K + E_P = \text{Constant} = E_T}$ Relation between E_K & E_P

FYI If friction & drag are both zero E_T = CONSTANT



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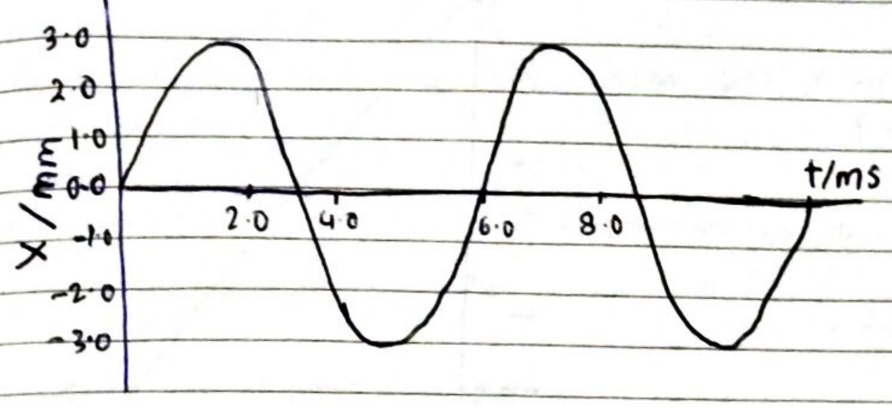
11) Sketching & interpreting SHM graphs

E.g.



x vs t graph for a 2.5 kg mass spring $k = 4.0 N m^{-1}$

a) Period & Frequency

Period = 6 milli seconds

= 6×10^{-3} seconds

frequency = $\frac{1}{6 \times 10^{-3}}$ = 170 Hz

b) Amplitude : 3.0 mm

: 0.003 m

= 3×10^{-3} m

c) Sketch graph where amplitude is cut in half

Amplitude = 1.5 mm, Period unchanged

Period is independent of Amplitude.

E.g.

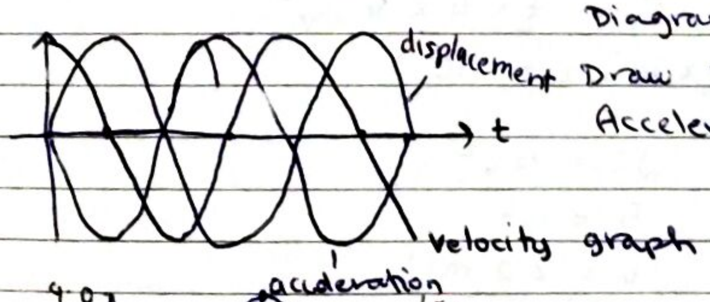


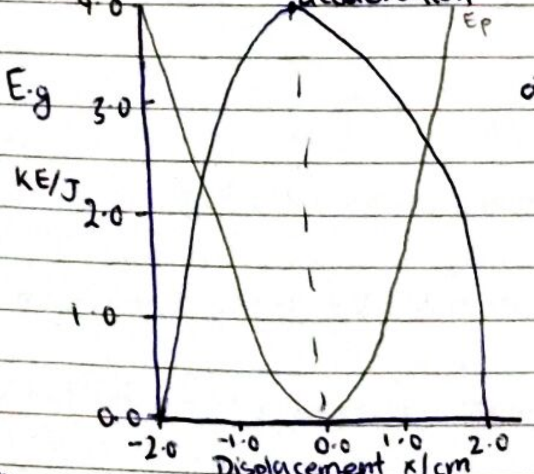
Diagram show x vs time t.

Draw velocity graph.

Acceleration graph $a \propto -x$, reflection

Slope determines ~~the velocity graph~~ the sign of V_{max}. + or −.

E.g



a) Determine the max. velocity of the mass.

$KE = \frac{1}{2}mv^2$

$4.0 = \frac{1}{2} \times 0.125 \times v^2$

$64 = v^2$

$v = 8 ms^{-1}$

b) Sketch Ep and determine total energy.

Total energy = 4 J

c) Determine spring constant k of the spring.

~~$8 = \frac{1}{2}k(0)^2 \quad 0 + \frac{1}{2}(0.125)(8)^2$~~

~~$4 = 0 + \frac{1}{2}k(2)^2$~~ $4 = \frac{1}{2}k(0.02)^2$

~~$k = 2 N m^{-1}$~~ $\frac{4}{0.0002} = 20000 N m^{-1}$

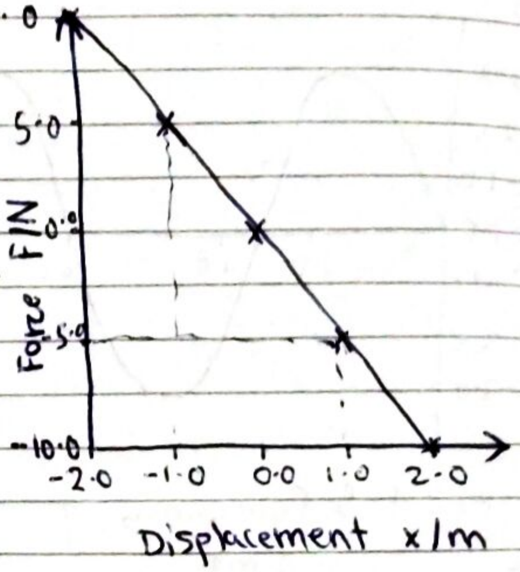
d) $F = -kx_{0.0}$

$= -20000 \times 1 = -200$

$a = \frac{-200}{0.125} = -1600 = -1.6 \times 10^3 ms^{-2}$

Example

A 4.0 kg mass is placed on a spring's end and displaced 2.0 m to the right.



a) How do you know that the mass is undergoing SHM?

F and negative displacement are proportional.

Spring constant

b) $F = -kx$

$10 = -k \times -2.0$

$10 = k \times 2.0$

$5.0 = k$

$k = 5.0\ N m^{-1}$

c) $E = \frac{1}{2}(5)(2)^2$ - Total Energy

$E = 10\ J$

Ex.

4.0 kg mass placed on a spring's end and displaced 2.0 m to the right.

Same graph as above.

d) Find max. speed of the mass.

$E_T = \frac{1}{2} \times 4 \times V_{max}^2$

$\frac{1}{2} \times 10 \times 2 = 10\ J$

$20 = 4v^2$

$5 = v^2$

$v = 2.2\ m s^{-1}$

e) Speed of mass when x is 1.0 m.

$E_T = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$

$E_T = \frac{1}{2}(4)v^2 + \frac{1}{2}(k)(1)$

$10 = 2v^2 + 2.5$

$7.5 = 2v^2$

$3.75 = v^2$

$v = 1.9\ m s^{-1}$

4.2 Travelling waves

1) Medium - material through which a wave propagates. Rope, spring, steel

2) Transverse wave - waves with oscillations that are perpendicular to the direction of propagation of energy.

3) Longitudinal wave - waves with oscillations that are parallel to the direction of propagation.

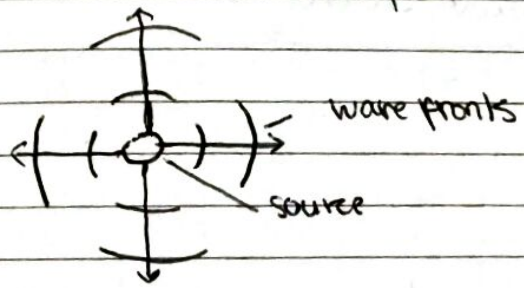
4) The nature of sound waves

- Consider a speaker, vibrating due to electrical input in form of music.

As the cone pushes outward, the squishes air molecules together
- compression

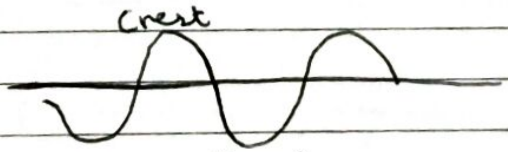
As the cone retracts, it separates the air molecules in a process called rarefaction.

Since vibrations are parallel to wave velocity, - longitudinal wave.

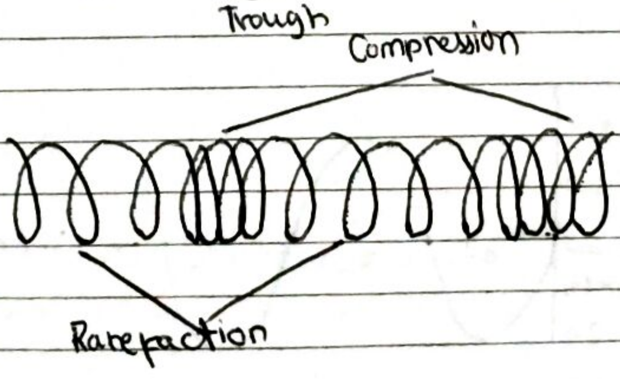


The wavefronts are located at the compressions.

5) Rays & wavefronts are perpendicular to each other.

6) 

Transverse wave



Longitudinal wave.

7) In ~~travelling waves~~ SHM
- Each particle has the same period T
- Each particle is slightly out of phase

8) ~~Si~~ Distance from equilibrium position - displacement
Amplitude - maximum displacement
Wavelength - λ, distance from crest to crest (or trough to trough)
Period T - time taken for 1 wave crest to travel 1 wavelength. Same for all particles of the medium.

9) wave speed = λ / T | Relation between v, λ & T

$v = \lambda / T$

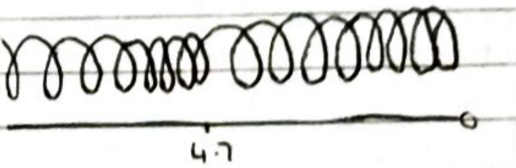
Frequency - how many wave crests per ~~second~~ unit time pass a given point. Hz

$f = \frac{1}{T}$ | Relation between f and T

Example

spring following SHM.

1 cycle in 0.25s.



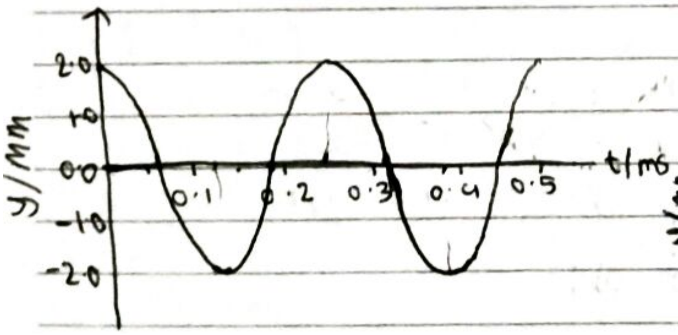
a) wavelength

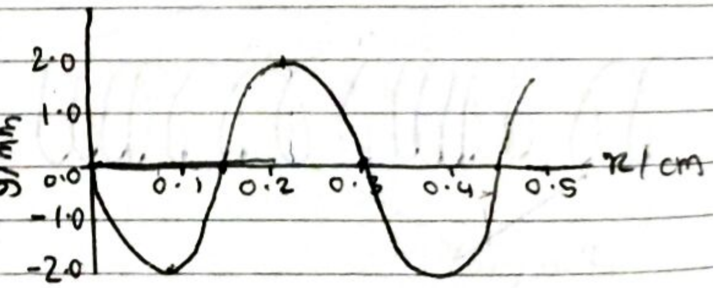
$\frac{4.7}{100} = 0.047m$

b) Period = 0.25s

c) Wave speed = $c = \frac{\lambda}{T} = \frac{0.047}{0.25} = 0.19 ms^{-1}$

Example





a) Amplitude = 2.0 mm = 0.0020m

Wavelength = 0.3 cm = 0.0030m

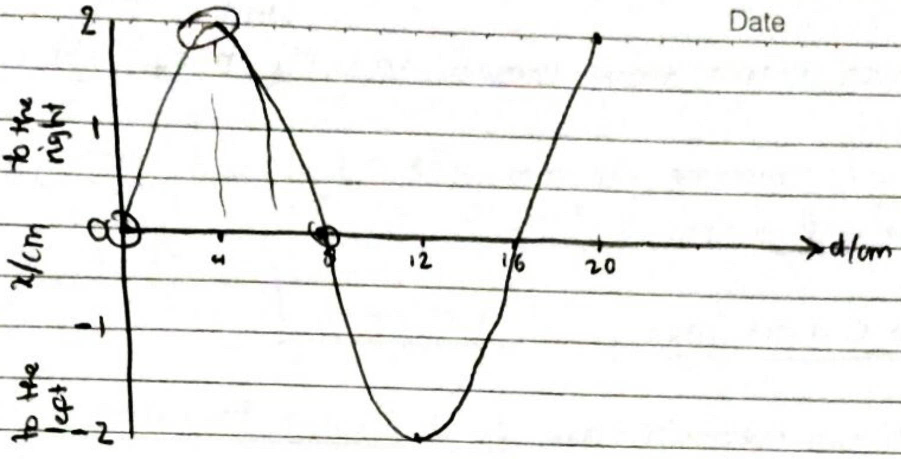
b) Period = 0.25 mseconds, 0.00025 seconds

Frequency = ~~4 Hz~~ 4000 Hz

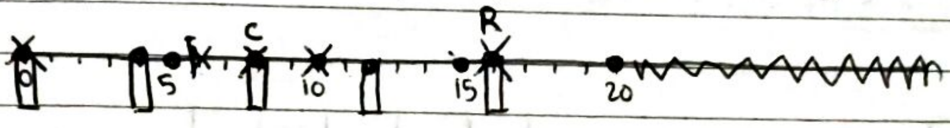
c) Wave speed = $c = 4000 \times 0.0030$

$= 12 ms^{-1}$

Example



Question Equilibrium positions of 6 particles is shown. Using x, indicate actual position.

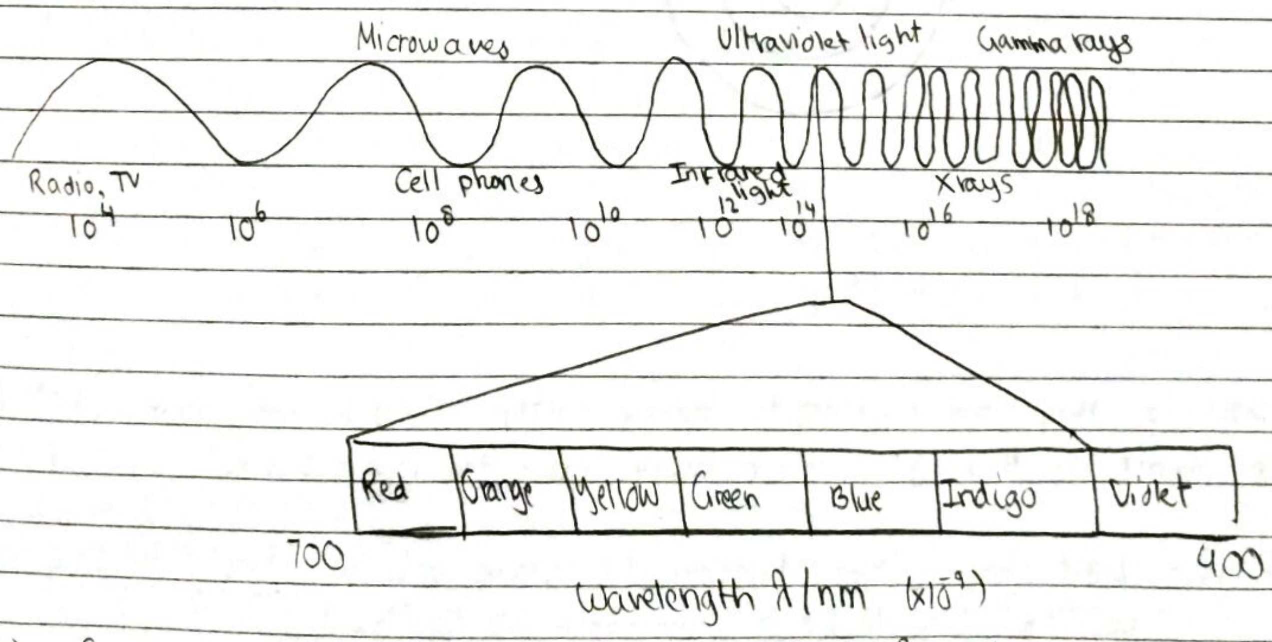


Label center of compression and rarefaction

10) $v = f\lambda$

$c = f\lambda$ | relation between v, λ and f

11) Electromagnetic spectrum



12) Speed of Electromagnetic waves = $3.0 \times 10^8\ ms^{-1}$

If wavelength is 475 nm. Frequency?

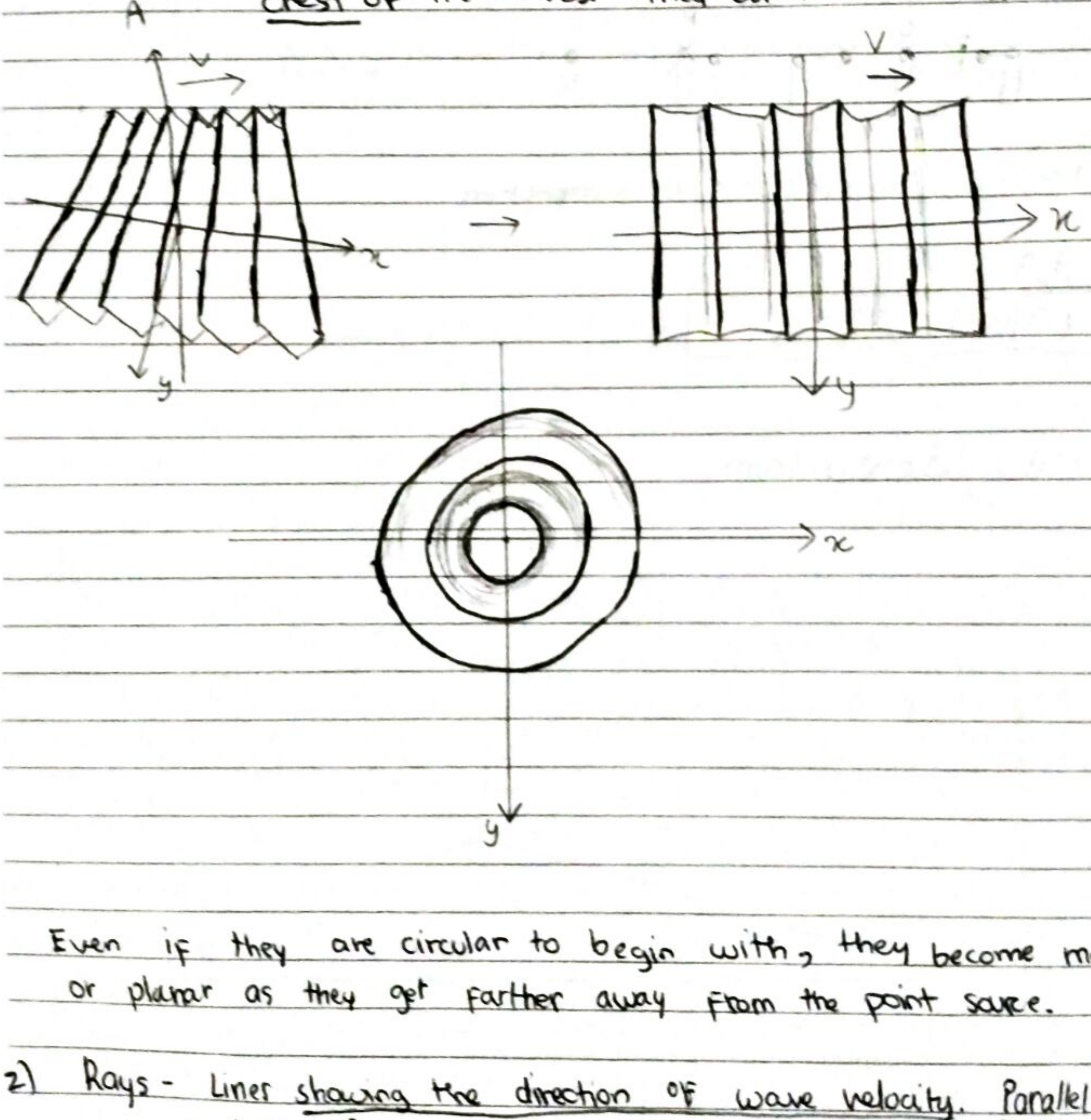
$3.0 \times 10^8 = f \times 475 \times 10^{-9}$, $f = 6.3 \times 10^{14}$ Hz

13) Sound waves cannot travel through vacuum, but ~~but~~ light can.

light can because vacuum has a light-wave carrying medium called the luminiferous ether.

4.3 - Wave Characteristics

1) Wavefronts - wavefronts are perpendicular to wave velocity. It is a surface that travels with a wave. Located at the crest of the waves. They don't have to be straight.



Even if they are circular to begin with, they become more "flat" or planar as they get farther away from the point source.

2) Rays - Lines showing the direction of wave velocity. Parallel to wave velocity. Perpendicular to ~~wave velo~~ wavefronts.

3) Longitudinal waves also have rays & wavefronts. Compressions are wavefronts.

Date

4) Amplitude and Intensity

Intensity - Rate of energy being transmitted per unit area (Wm^{-2})

Intensity = $\frac{\text{Power}}{\text{Area}}$	Definition of intensity I

E.g. A 200W speaker transmits sound in a spherical wave. Find the intensity at

a) 1.0 m

$$I = \frac{200}{4\pi(1)^2}$$

$$= \frac{63.7}{4} Wm^{-2}$$

$$= 16 Wm^{-2}$$

b) 2.0 m

$$I = \frac{200}{4\pi(2)^2}$$

$$= 3.98$$

$$= 4.0 Wm^{-2}$$

Doubling distance reduces intensity by 75%!

For spherical waves: $I = \frac{\text{Power}}{4\pi r^2}$	$I \propto \frac{1}{x^2}$	Intensity I vs. distance x

Recall that $E_T = \frac{1}{2}kx_{max}^2$ where x_{max} = amplitude

Since $P = E_T/\text{time}$, clearly $P \propto E_T$ so that $P \propto A^2$ (Amplitude, not area!)

$I = \frac{\text{Power}}{\text{Area}}$ so,

$I \propto A^2$ (amplitude)	Intensity I vs. amplitude A

Example

At a distance of 18.5m from a sound source the intensity is $2.00 \times 10^{-1} Wm^{-2}$.

a) Find I at 26.5m.

$I_1 = \frac{k}{18.5^2}$, $0.2 \times 18.5^2 = k = 68.45$

$I = \frac{68.45}{26.5^2} = 0.097 Wm^{-2}. = 9.75 \times 10^{-2} Wm^{-2}.$

b) Compare amplitudes at 18.5m & 26.5m.

~~$18.5 = k(A_1)^2$~~

~~$265 = k(A_2)^2$~~

~~$\frac{A_1}{A_2} = 0.836$~~

~~$\frac{18.5}{26.5} = \left(\frac{A_1}{A_2}\right)^2$~~

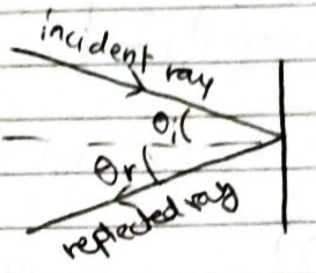
$\frac{0.2}{0.0975} = \left(\frac{A_1}{A_2}\right)^2$, $\frac{A_1}{A_2} = 1.43$

A_1 is 1.43 times A_2.

5) Wave reflection

~~Reflected~~ Reflection occurs when a wave meets a boundary, object or a change in medium, and is at least partially diverted backwards.

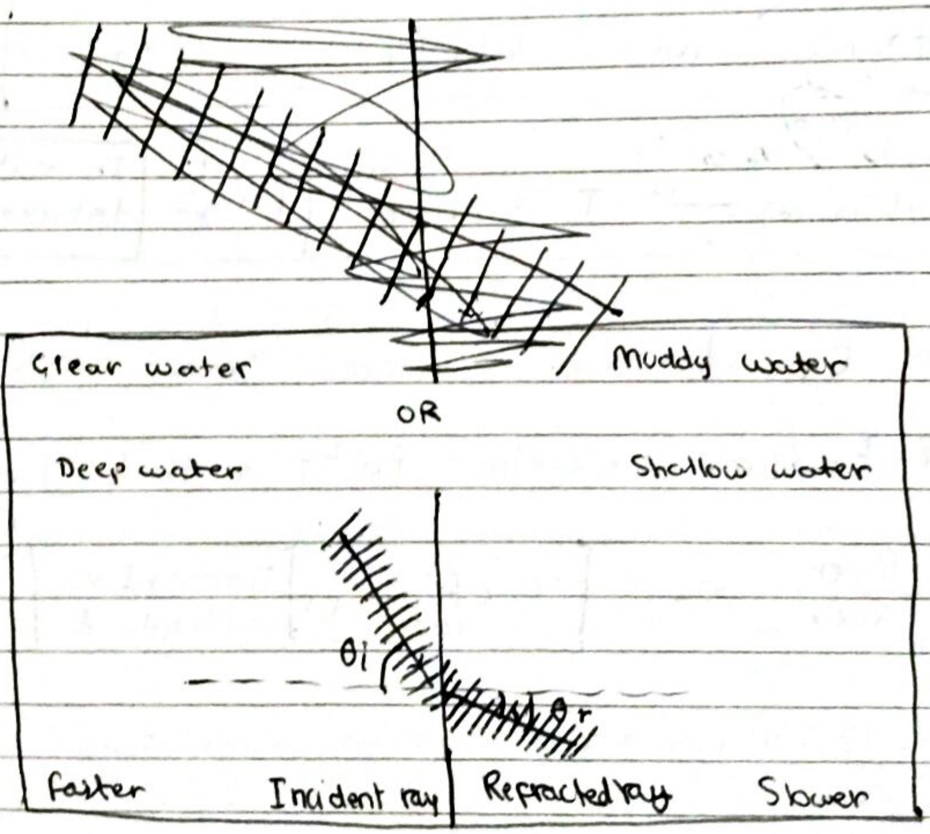
$\theta_{incident} = \theta_{reflection}$



Frequency & wavelength do not change.

6) Refraction

when a wave is partially allowed through the boundary of another medium.



Period & frequency do not change.
Speed & wavelength change

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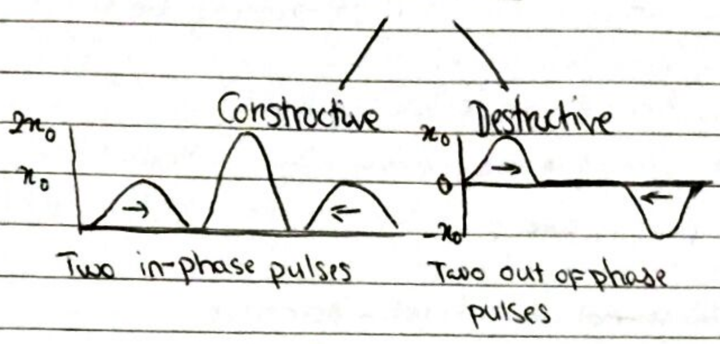
6) Superposition

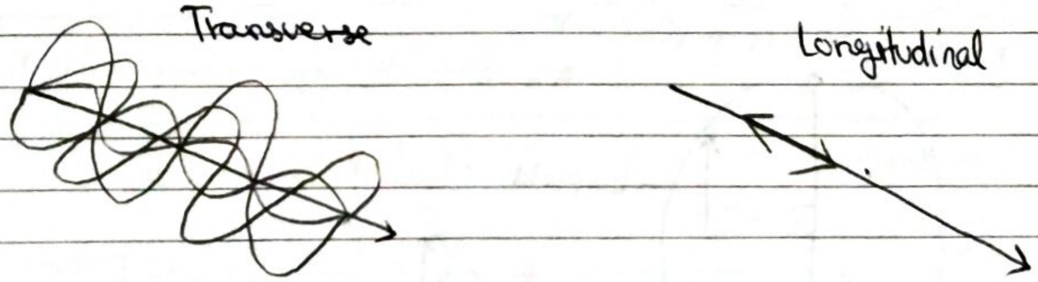
Addition of 2 or more waves passing each other. Interference



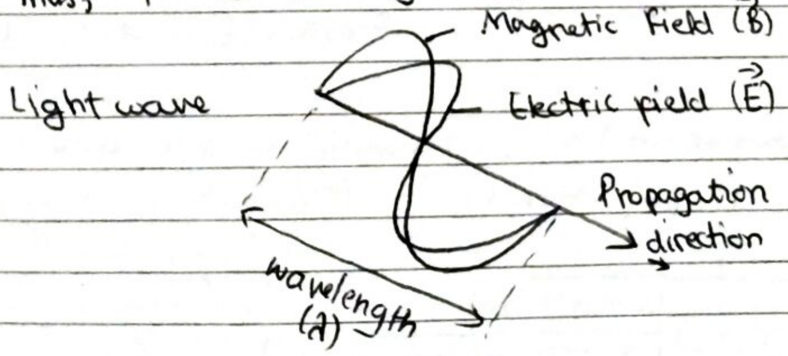
7) Polarization

In transverse waves the oscillations are perpendicular to the propagation of the wave. But, oscillations are parallel to the propagation in longitudinal waves.

Transverse waves can have infinite modes of oscillation, each of which is perpendicular to the propagation, but longitudinal only has one mode.



Thus, polarization only applies to transverse waves.



This topic only considers polarization of electric fields.

For a light source, the charges can oscillate in any direction, thus producing random and continuous orientations of the electric field.

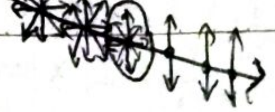
Unpolarized light - random orientations of electric fields in a light source.

Polaroid absorbs unpolarized light except those whose electric fields are oriented in a certain line. (Those that are perpendicular to the "slots")

Polarized light - Light with E-fields oriented in one direction.

Light may be polarized or partially polarized by reflecting off surfaces too.

Polarizer - object that polarizes ~~light~~ unpolarized light.

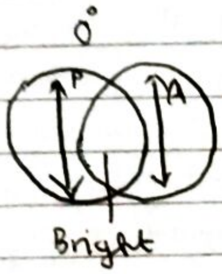


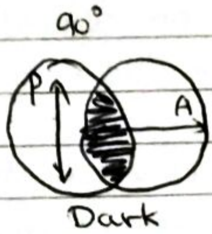
Linear-polarized aka plane-polarized

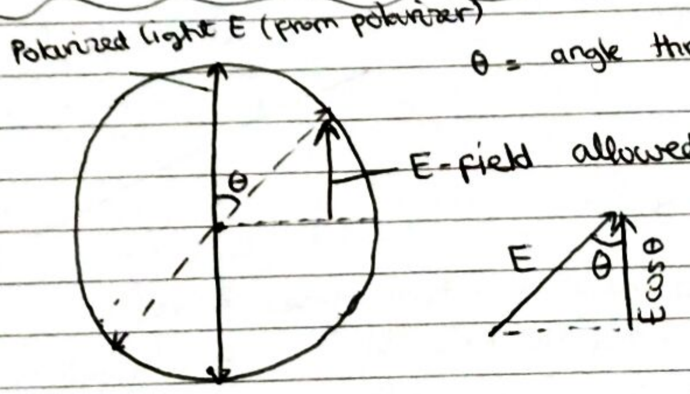
Two polaroid films in a beam of unpolarized light. Why, if second filter is rotated 90°, will the intensity of light passing be 0?

- First plane polarizes light.
- Second plane, originally allowed the light, but now since the electric fields are parallel to its 'slots', it blocks the polarized beam.

~~first polari~~ First - polarizer
Second - Analyzer







θ = angle through analyzer is turned

$$\cos\theta = \frac{\text{E-field allowed}}{E}$$

$\therefore E\cos\theta$ = E-field allowed

Since, Intensity $\propto$ square of amplitude, Intensity of light that comes out of analyzer is proportional to $(E\cos\theta)^2$

$$I = I_0 \cos^2\theta$$	**Malus's law** I_0 = original intensity of the light and θ is angle of analyzer

Example, Initially, two sheets of Polaroid are parallel.

a) Calculate the angle one sheet needs to be turned in order to reduce the amplitude of the observed E-field to half its original value.

$I_1 \propto A^2$
$I_2 \propto (\frac{1}{2}A)^2$
$I_2 \propto \frac{1}{4}A$

$I_1 = I_0 \cos^2\theta$

$\frac{I_1}{4} = I_0 \times \cos\theta \times \cos\theta$

$\cos\theta = \frac{1}{2}$ $\theta = 60°$

b) Calculate effect of the rotation on intensity.

$I = \frac{I_0}{4}$

c) Calculate rotation angle needed to halve the intensity to its original value.

$I = \frac{I_0}{2}$

$\frac{I_0}{2} = I_0 \times \cos^2\theta$

$\frac{1}{2} = \cos^2\theta$

$\sqrt{\frac{1}{2}} = \cos\theta$

$\frac{1}{\sqrt{2}} = \cos\theta$

$\theta = 45^\circ$

Polarized light has its E-field oriented in one direction.

E.g. Polarized light is incident on analyzer, I_0. Transmission axis makes an angle θ with direction of electric field.

i) Calculate intensity if $\theta = 60^\circ$

$I = I_0 \cos^2(60)$

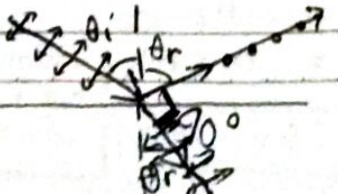
$I = I_0 \times \frac{1}{4}$

$= \frac{I_0}{4}$

Application - Sunglasses only allow light with e-fields oriented in one direction to reduce glare from a reflecting surface.

7 You can also partially polarize light by reflecting it off a surface where both reflection & refraction occurs.

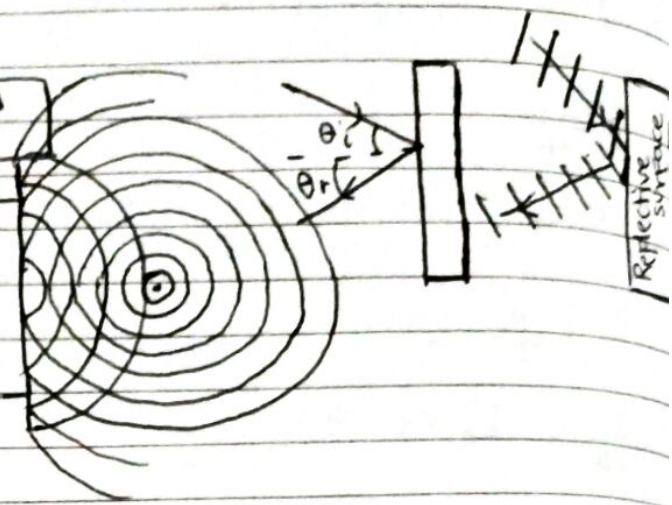
<u>Brewster's law</u> - If the reflected & refracted ray make a 90° angle, the reflected ray will be totally linearly polarized,
$\theta_{refl} + \theta_{refr} = 90^\circ$, this angle i is called Brewster's angle.



4.4 Wave Behaviour

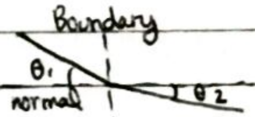
1) Reflection

- $\boxed{\theta_{incident} = \theta_{reflect}}$ Reflected waves



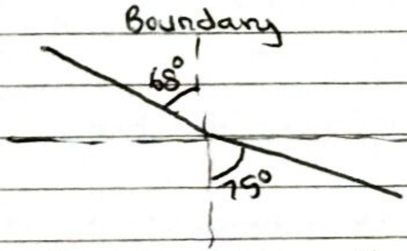
2) Refraction

Snell's law



$$\boxed{\frac{v_2}{v_1} = \frac{\sin\theta_2}{\sin\theta_1}}$$ Snell's law for refracted waves

E.g.



Wave traveling at 50 ms^{-1} strikes a boundary as shown. Part of it is refracted.

a) Angle of reflection?

22°

b) Speed of transmitted wave?

$$\frac{x}{50} = \frac{\sin 15}{\sin 22}$$

$$x = 34.5\ ms^{-1}$$
$$= 35\ ms^{-1}$$

Eg. Wave travelling at 20 ms^{-1} hits a medium at 28° relative to normal, and refracted at 32°. What is the speed in the new medium?

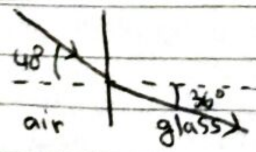
Solution $\frac{x}{20} = \frac{\sin 32}{\sin 28}$

$$x = \frac{20\sin 32}{\sin 28} = 22.6$$
$$= 23\ ms^{-1}$$

A refractive index n_m is used when dealing with light waves. Defined to be the ratio of the speed of light in vacuum c to the speed in medium v_m.

$$\boxed{n_m = \frac{c}{v_m}}$$ Index of refraction

E.g.



a) Index of refraction of glass sample?

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$
$$(1)\sin 40 = n_2 \sin 36$$
$$n_2 = 1.09 = 1.1 \text{ (unitless)}$$

b) Speed of light in glass? It is 3.0×10^8 in air.

$$\frac{3\times10^8}{x} = 1.1$$

$$x = 2.7 \times 10^8\ ms^{-1}$$

$n_m = \frac{c}{v_m}$, so $v_{m_1} = \frac{c}{n_{m_1}}$ & $v_{m_2} = \frac{c}{n_{m_2}}$

$$\frac{v_2}{v_1} = \frac{\sin\theta_2}{\sin\theta_1} = \frac{\frac{c}{n_2}}{\frac{c}{n_1}}$$

$$\frac{\sin\theta_2}{\sin\theta_1} = \frac{n_1}{n_2}$$

$$\boxed{n_2 \sin\theta_2 = n_1 \sin\theta_1}$$ Relationship between two mediums

(n = 1 of air & free space) Index of refraction

$\frac{n_1}{n_2} = \boxed{\frac{\sin\theta_2}{\sin\theta_1}}$, $\frac{v_2}{v_1} = \boxed{\frac{\sin\theta_2}{\sin\theta_1}}$

$\frac{n_1}{n_2} = \frac{v_2}{v_1} = \frac{\sin\theta_2}{\sin\theta_1}$ where $n = 1$ for air & free space	Snell's law for refracting waves

Eg. Index of refraction for a glass is 1·65. What is the speed of light in it?

$$\frac{n_1}{n_2} = \frac{v_2}{v_1}$$

$$\frac{1}{1{\cdot}65} = \frac{v_2}{3{\cdot}0 \times 10^8}$$

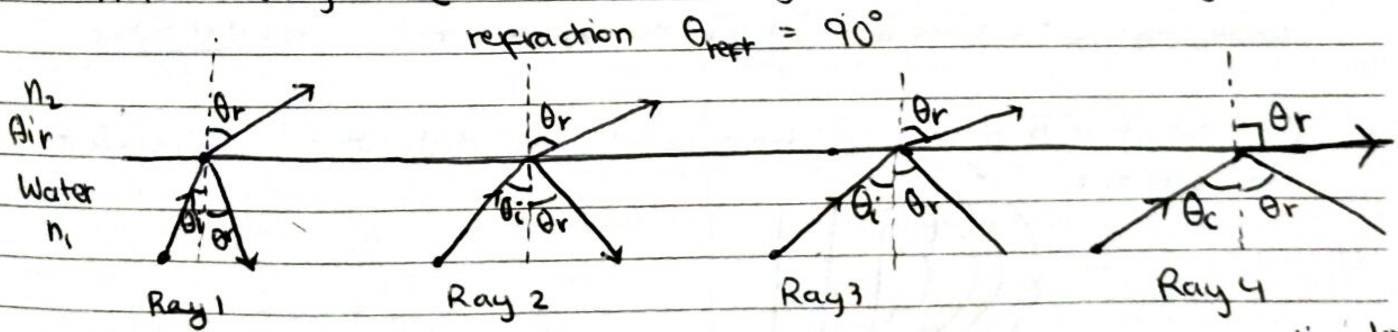
$$\frac{3{\cdot}0 \times 10^8}{1{\cdot}65} = v_2$$

$$v_2 = 1{\cdot}8 \times 10^8 \, ms^{-1}$$

3) Total internal reflection

When a wave moves from an optically denser medium to an optically less dense medium, it is possible for all of the light to be reflected - trapping it inside. This is the principal behind fiber optics.

- Critical angle θ_c - incident angle at which the angle of refraction $\theta_{refr} = 90°$



$n_1 \sin c = n_2 \sin 90° = n_2 (1)$

$n_1 \sin c = 1$ ← less dense medium

$\sin c = \frac{n_2}{n_1}$	Snell's law for critical angle

↑ denser medium

In this case, n_2 is refractive index of air. So,

$n_2 = 1$

$\sin c = \frac{1}{n_1}$	when n_2 is air.

Date

Example

A ray of light is trapped in piece of crown glass. n = 1.52

a) Critical angle if glass is in air?

$\frac{n_2}{n_1} = \sin c$

$\frac{1}{1.52} = \sin c$

$c = 41.1°$

b) Critical angle if glass in water? water, n = 1.33

$\frac{1.33}{1.52} = \sin c$

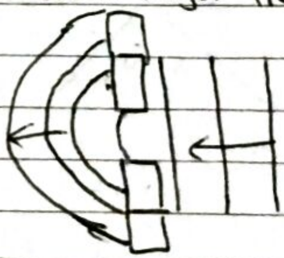
$c = 61.0°$

Since sine of something is <u>always</u> ≤ 1, you can always tell whether a critical angle exists. E.g. $\frac{1.33}{1.52} < 1$, EXISTS! $\frac{1.52}{1.33} > 1$ DOES NOT EXIST!

4) Diffraction

If a wave meets a hole in a wall that is of comparable size to its wavelength, the wave will be bent through a process called diffraction

If aperture is much larger than wavelength, diffraction is minimal to non-existent.



FYI Diffraction is caused by objects in a medium that interact with a wave. Not caused by 2 mediums' boundary.

(KIKY)

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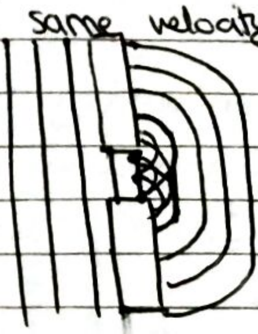
5) Huygen's law

" Every point on a wavefront emits a spherical wavelet of the same velocity and wavelength as the original wave. "



Smaller the aperture, better the diffraction effect.

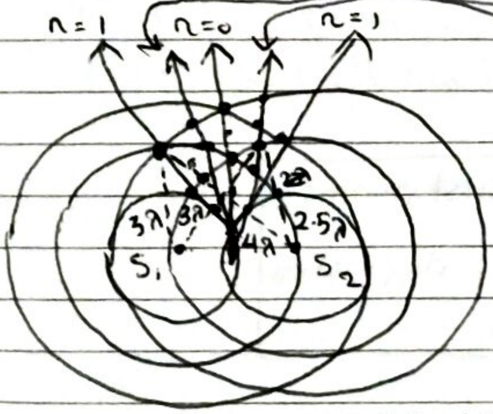
6) Coherent waves

Waves that are in-phase and have the same frequency.

7) Path difference

Path difference = $n\lambda$ n is an integer	condition for constructive interference

Path difference = $(n+\frac{1}{2})\lambda$ n is an integer	condition for destructive interference



Destructive interference

n = 0

Distance from S_1 = 3λ

Distance from S_2 = ~~2λ~~ 2.5λ

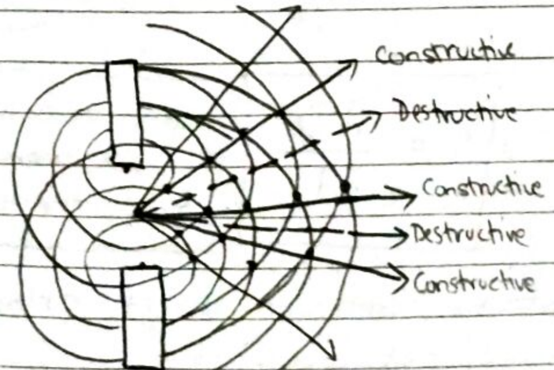
Path difference = $3\lambda - 2.5\lambda = 0.5\lambda$

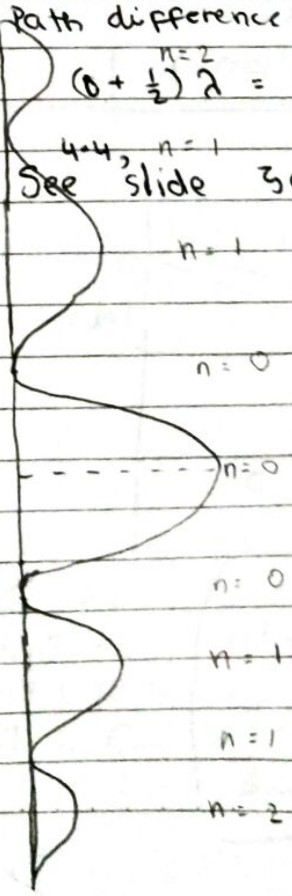
$(0 + \frac{1}{2})\lambda = \frac{1}{2}\lambda$

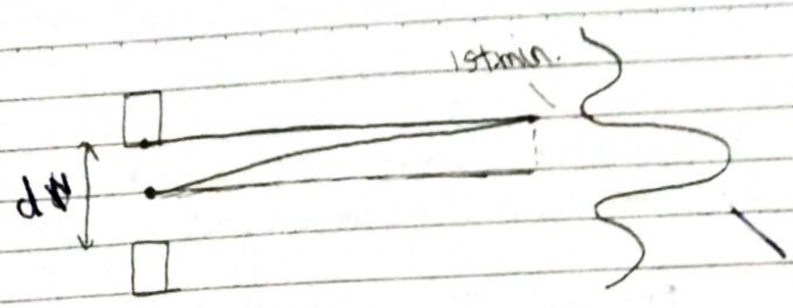
See slide 30 for an example

Path difference = $4\lambda - 3\lambda = 1\lambda$

n = 1 $\quad$ $1 \times \lambda = \lambda$
= path difference

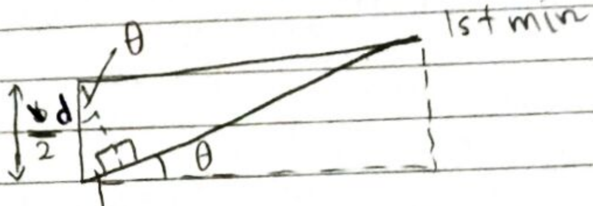






The path difference must be $\frac{\lambda}{2}$ because destructive interference

Intensity distribution is caused by path difference along d.



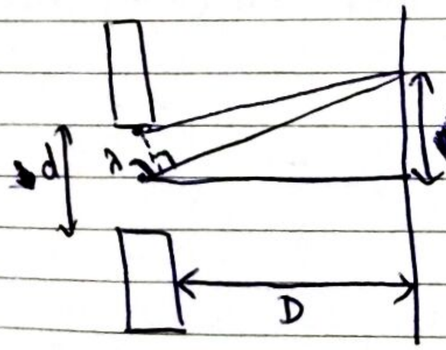
$\frac{\lambda}{2}$ because destructive interference

$$\sin\theta = \frac{\frac{\lambda}{2}}{\frac{d}{2}} = \frac{\lambda}{d}$$

Recall that if θ is very small (and in radians), then
$\sin\theta \approx \theta$ (in radians)

Sooooo...

$\theta = \frac{\lambda}{d}$ (θ in radians)	Location of first minimum in single slit diffraction



~~$d = \frac{\lambda D}{b}$ or (in book, $\frac{\lambda D}{d}$)~~

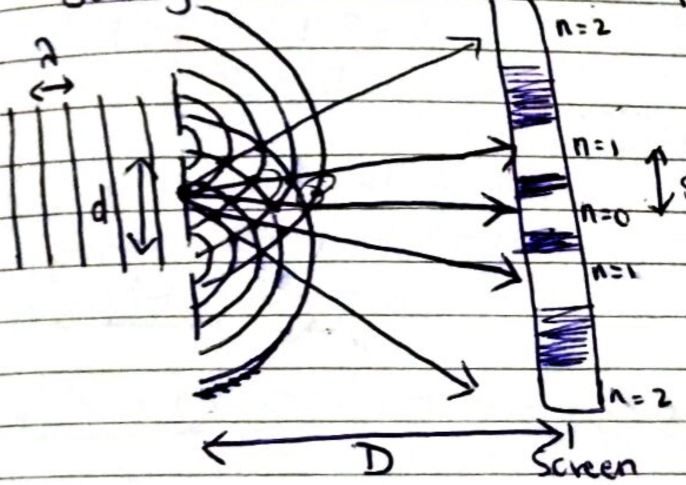
$s = \frac{\lambda D}{d}$	Length between max ma ~~or minima~~ & center maxim

This formula is not going to work in case of single slit! Just go to next page

s = Distance between bright fringes
d = Distance between slits
D = Distance between slits and screen
λ = Path difference

when interference is crest - crest = max high
trough - trough = max low
crest - trough = minimum displacement

8) Young's Double-slit experiment



$s = \frac{\lambda D}{d}$ | Young's double-slit experiment

[illegible]

E.g Coherent light having $\lambda = 675$ nm is incident on two vertical slits separated by 1.25mm. A screen is located 4.50 m away from the card. Find distance between central & first maximum?

$$s = \frac{\lambda D}{d} = \frac{(675 \times 10^{-9})(4.5)}{0.00125} = 0.00243 \text{ m}$$

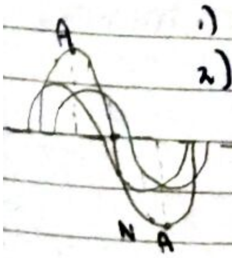
$$s = 2.43 \times 10^{-3} \text{ m}$$

4.5 Standing waves

1) Essential idea: When travelling waves meet they can superpose to form standing waves in which energy may not be transferred.

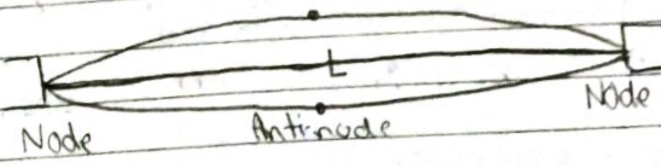
Properties

1) They do not travel
2) Its "lobes" grow and shrink & reverse, but do not go left or right.



Node (N) - point with 0 displacement.
Anti-node - lobes that grow & shrink & reverse.

Guitar string



$$\frac{1}{2}\lambda = L$$

$$\lambda = 2L$$

$$v = \lambda f = 2Lf$$

$$f_1 = \frac{v}{2L}$$

Fixed ends have nodes.
Open ends have anti-nodes.

This is the lowest frequency possible from this string, known as <u>fundamental frequency f_1</u>.

Fundamental frequency of any system is the <u>first harmonic</u>.

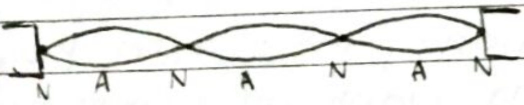
$$\lambda = L$$

$$v = \lambda f = Lf$$

$$f_2 = \frac{v}{L}$$

<u>Second harmonic</u>.

A HARMONIC IS NAMED BY THE RATIO OF ITS FREQUENCY TO THAT OF THE FIRST HARMONIC.



$$\lambda = \frac{2}{3}L$$

$$f_3 = \frac{v}{\frac{2}{3}L} = \frac{3v}{2L} = f_3$$

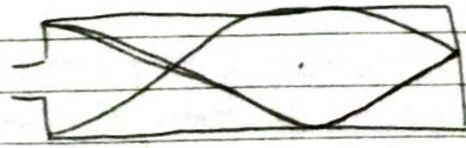
3rd Harmonic.

In pipes, longitudinal waves are created instead of transverse.
These waves are reflected from the ends of the pipe.
Consider and open-end & close-end pipe.

$\frac{1}{4}\lambda = L_1$

$f_1 = \frac{v}{4L}$

1st Harmonic



$\frac{3}{4}\lambda = L_2$

$f_2 = \frac{3v}{4L}$

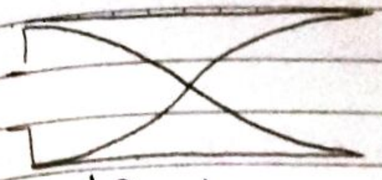
3rd Harmonic

$\frac{5}{4}\lambda = L$

$f_3 = \frac{5v}{4L}$

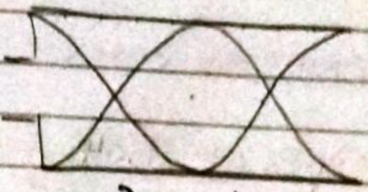
5th Harmonic

Date



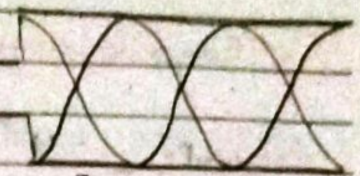
$\frac{1}{2}\lambda = L$

$f_1 = \frac{v}{2L}$



$\lambda = L$

$f_2 = \frac{v}{L}$



$\frac{3}{2}\lambda = L$

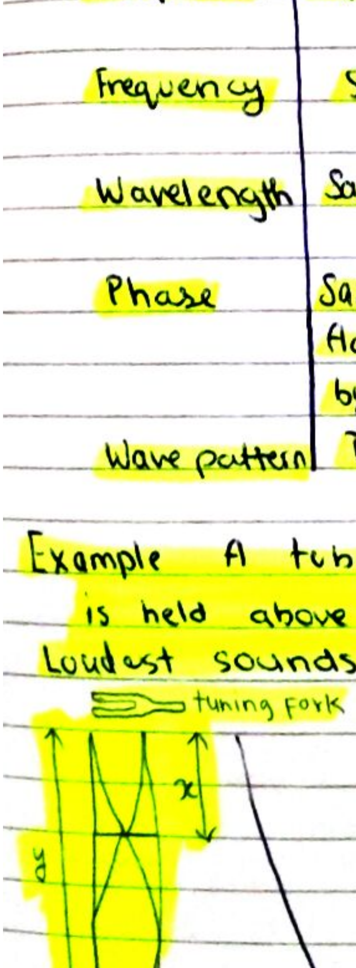
$f_3 = \frac{3v}{2L}$

IB expects you to make this sketches and find wavelengths and frequencies.

2) Distinguishing between standing & travelling waves

	Standing wave	Traveling wave
Energy	Not transferred. Although, antinode have it-ε	Transferred
Amplitude	Different amplitude for all points	Same amplitude for all points
Frequency	SHM & same frequency	SHM & same frequency
Wavelength	Same as component waves	Distance between crests
Phase	Same for each point in a lobe. Adjacent points are phase shifted by 180°	Different for each point along a single wavelength
Wave pattern	Does not move	moves

Example A tube is filled with water and a vibrating tuning fork is held above the open end. Water runs out slowly from tap. Loudest sounds at x distance & y distance from the top. What is λ?



Antinode at tuning fork!

Water allows no oscillation. Node!

At x, $\lambda = 4x$

At y, $\lambda = \frac{4}{3}y$

$\frac{1}{4}\lambda = x$

$\frac{3}{4}\lambda = y$

$y - x = \frac{1}{2}\lambda$

$2(y - x) = \lambda$

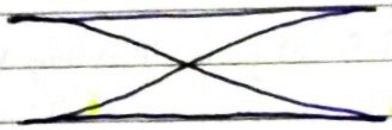
Option D - $\lambda = 2(y - x)$ ✓

($y + x$ is also correct but not in options.)

- Edges of a drum-head are nodes.

Example A pipe, open at both ends, has length L. Speed of sound in air in the pipe is v. Frequency is fundamental. Find frequency.

[✓ A] $\frac{v}{2L}$ B $\frac{L}{2v}$ C $\frac{4v}{L}$ D $\frac{L}{4v}$



$$2L = \lambda$$
$$v = f\lambda$$
$$v = 2fL$$
$$\frac{v}{2L} = f$$

4) Standing waves ~~is~~ in an open pipe comes about as a result of

A) Superposition and diffraction

B) Replection and diffraction

[✓ C)] Reflection and superposition

D) Replection and repraction

5) All particles between two nodes have

1) Same frequency
2) Different amplitudes
3) Different energy

Date

6) i) What is meant by a <u>continuous traveling</u> wave?

- Energy transfer via a vibrating medium without interruption.
- Medium itself does not travel with the wave disturbance.

ii) § What is meant by the speed of a travelling wave?

- Speed at which wave disturbance propagates.
- Speed at which wave front travels.
- Speed at which energy is transferred.

Make sure that :

Frequency = oscillations per <u>unit time</u> not SECONDS!!!

wavelength = Distance travelled in one oscillation.

7) In transverse waves, displacement is up & down. light
In longitudinal waves, displacement is sideways. Sound

8) Point T is moving downwards. How about point U.
Standing wave.