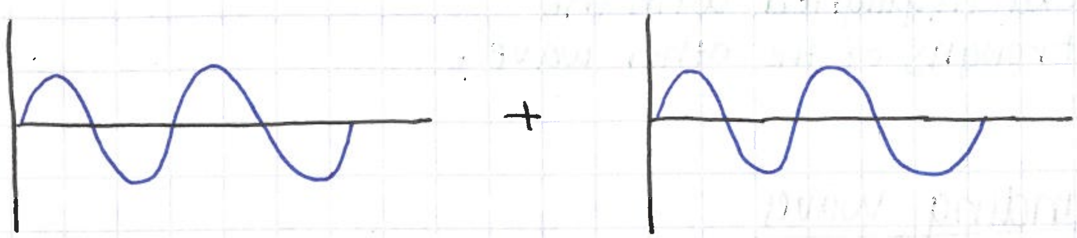
||CH17: SUPERPOSITION||

May 15, 2019

→ when two waves exist at the same place simultaneously, they interfere with each other

Principle of superposition → when 2 or more waves exist at the same place simultaneously, the resultant disturbance is the sum of the individual disturbances.

→ Overlapping waves add algebraically to produce a resultant wave.



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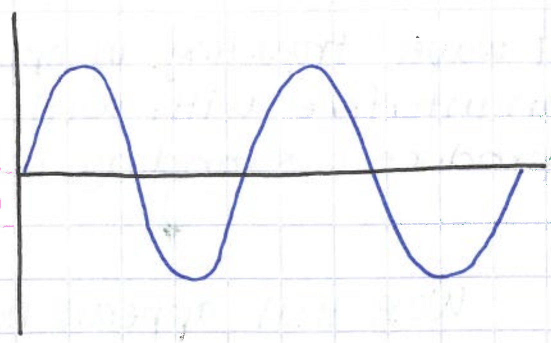
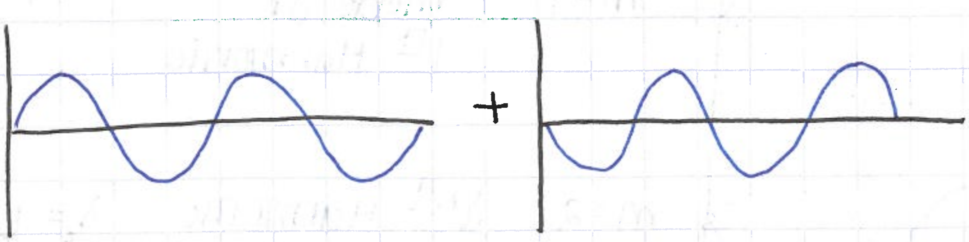
Fully Constructive Interference



→ Resultant amplitude will be twice the amplitude of either wave.

Exactly in phase → peaks & troughs are exactly aligned with each other.



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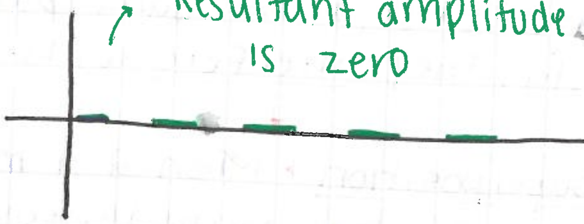


Resultant amplitude is zero

Fully descructive Interference

OR

Maximally destructive Interference

Exactly out of phase

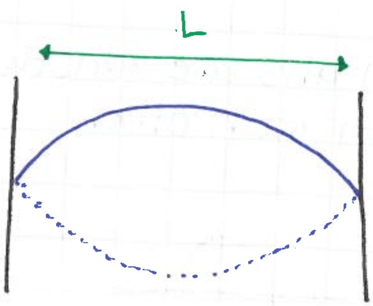
↳ The peaks of one wave are exactly aligned with the troughs of the other wave

Standing waves

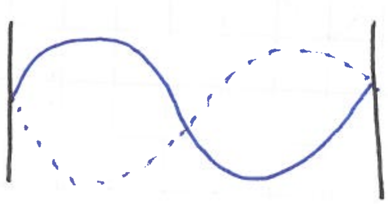
→ Two identical waves traveling in opposite direction can interfere with with each other & produce a standing wave

↓

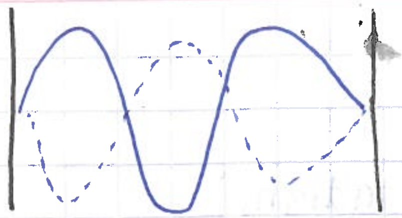
Wave that appears not to be traveling



$m=1$ Fundamental mode or 1st Harmonic $\lambda_1 = 2L$



$m=2$ 2nd Harmonic $\lambda_2 = L$



$m=3$ 3rd Harmonic $\lambda_3 = 2L/3$

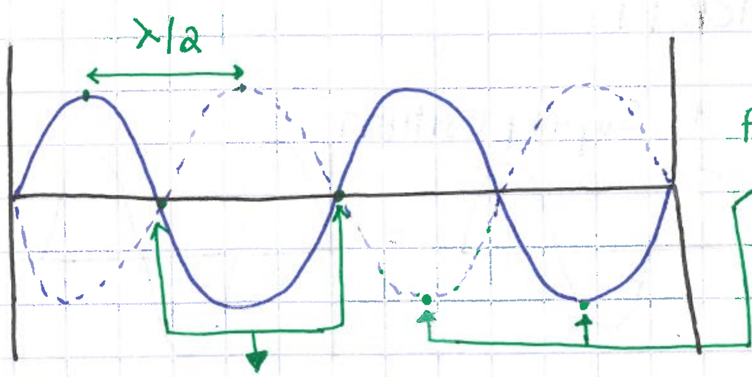
$$\boxed{\lambda_m = \frac{2L}{m} \quad m=1,2,3,\dots}$$

$m \rightarrow$ mode or harmonic #

$$\lambda f = v \longrightarrow f_m = v/\lambda_m \longrightarrow f_m = \frac{v}{\left(\frac{2L}{m}\right)}$$

$$\boxed{f_m = \frac{mv}{2L} \quad m=1,2,3,\dots} \longrightarrow \boxed{f_m = m f_1} \quad m=2,3,4\dots$$

fundamental frequency $\boxed{f_1 = \frac{v}{2L}}$



Antinodes (amplitudes is a maximum because of fully constructive interference)

Nodes (amplitude is zero because of fully destructive interference)

RECAP

May 16, 2019

$$\boxed{D(x,t) = A\sin(\underbrace{kx - \omega t + \phi_0}_{\text{Phase (angle in radians)}})}$$

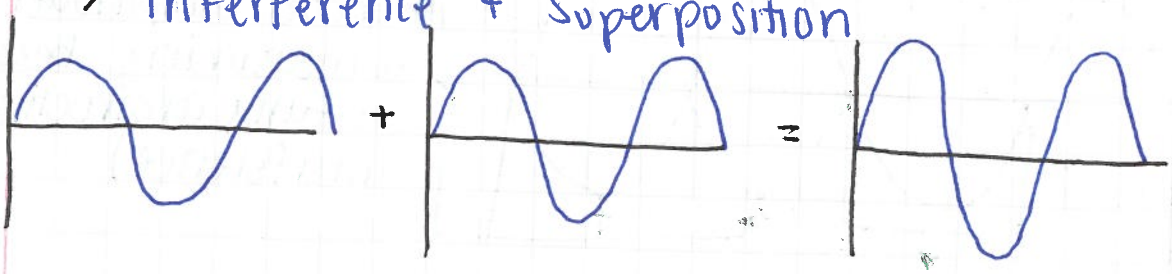
$$\boxed{\omega = 2\pi f = \frac{2\pi}{T}} \qquad \boxed{k = \frac{2\pi}{\lambda}} \qquad \boxed{v = \frac{\omega}{k} \quad v = \lambda f}$$

for waves on a stretched string:

$$\boxed{v = \sqrt{\frac{T_s}{\mu}} \quad \boxed{\mu = \frac{m}{L}}}$$

CHAPTER 17

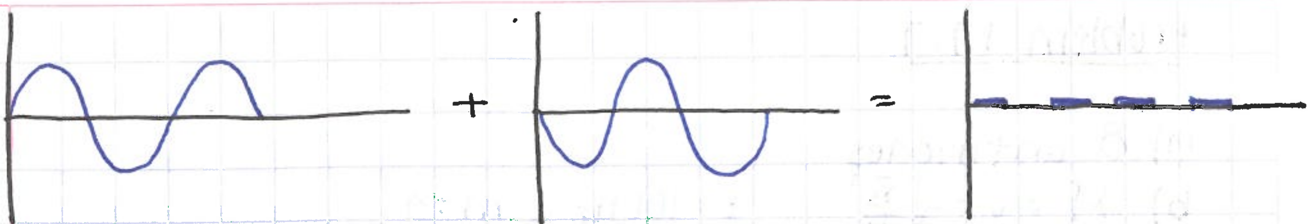
→ Interference + Superposition



In phase = $\Delta\phi = 0, \pm 2\pi, \pm 4\pi, \ldots$

→ fully constructive interference, maximally constructive.

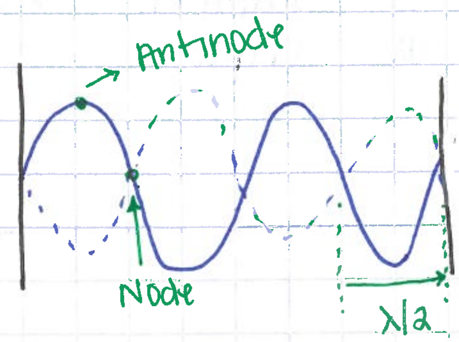
RECAP CH7 May 16, 2019



Out of phase : $\Delta\phi = \pm\pi, \pm 3\pi, \pm 5\pi, \ldots$

→ fully destructive interference, maximally destructive.

Standing waves



$m=4$
4th Harmonic

wavelength

$\boxed{\lambda_m = \frac{2L}{m} \quad m=1,2,\ldots}$

$\boxed{f_m = \frac{mv}{2L} \quad m=1,2,3\ldots}$

$\boxed{f_1 = \frac{v}{2L}}$ $\boxed{f_m = mf_1}$

↑ fundamental frequency

For a standing wave on a string : $\boxed{v = \sqrt{\frac{T_s}{\mu}} \quad \boxed{\mu = \frac{m}{L}}}$

Problem 16.B

$D(x,t) = A\sin(kx - \omega t + \phi_0)$

$k = 20m^{-1}$. $\omega = 600s^{-1}$

$v = \frac{\omega}{k} = \frac{600s^{-1}}{20m^{-1}} \rightarrow \underline{v = 30\ m/s}$

$v = \sqrt{\frac{T_s}{\mu}} \rightarrow v^2 = \frac{T_s}{\mu} \rightarrow \mu = \frac{T_s}{v^2} \rightarrow \mu = \left(\frac{15.0N}{(30m/s)^2}\right) = 1.67\times10^{-2}\frac{kg}{m}$

$\frac{1.67\times10^{-2}kg}{m} \cdot \frac{10^3 g}{1\ kg} = \boxed{16.7\frac{g}{m}}$

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Problem 17.7

a) 8 antinodes

b) $\lambda f = v = \sqrt{\frac{T_s}{\mu}}$ $f = 100Hz$, $m=4$

$f_m = \frac{mv}{2L}$

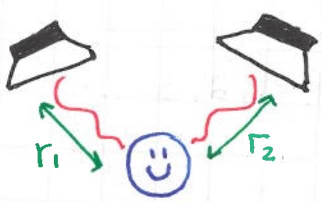
Note: $v = 100m/s$ T_s μ double μ Triple T_s

$v = \sqrt{\frac{T_s}{\mu}} = 100m/s$

$\downarrow$

$\sqrt{\frac{3T_s}{2\mu}} \rightarrow \sqrt{\frac{3}{2}}\underbrace{\sqrt{\frac{T_s}{\mu}}}_{}$ $= 100m/s$

Interference



Two sources of identical waves that are initially in phase.

↳ Even though they are initially in phase, they can arrive out of phase if they different distances.

Path length difference $\Delta r = |r_2 - r_1|$

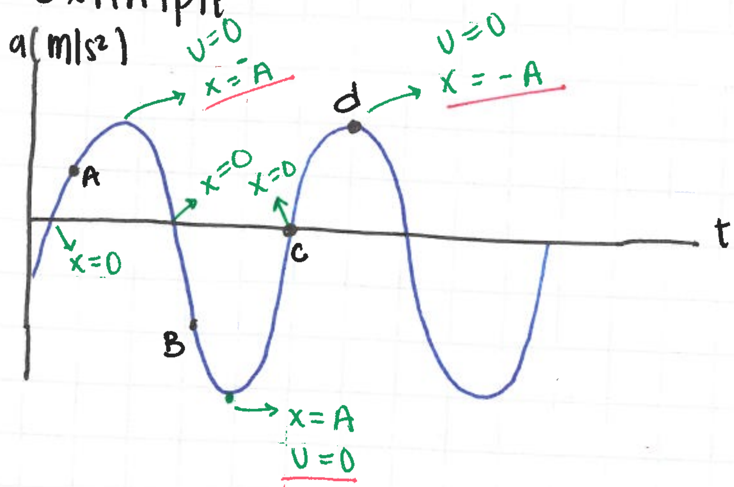
If $\Delta r = 0, \lambda, 2\lambda, 3\lambda, \ldots$ fully constructive interference

if $\Delta r = \lambda/2, 3\lambda/2, 5\lambda/2 \ldots$ fully destructive interference

REVIEW

May 16, 2019

EXAMPLE



$a(t) = -w^2 x(t)$

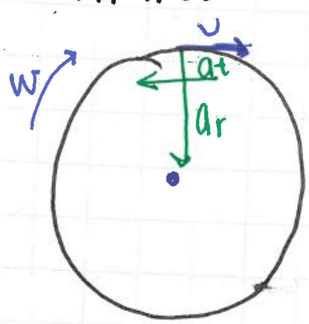
$v = \pm v_{max}$ at $x = 0$

$v = 0$ at $x = \pm A$

at $x = A$, $a = -a_{max}$

$x = -A$, a_{max}

EXAMPLE



& slowing down

$a_t = \frac{dv}{dt} \rightarrow r\alpha$

$a_r = \frac{v^2}{r} = rw^2$

$a_{total} = \sqrt{a_t^2 + a_r^2}$

neg (at) & neg (ar) = 3rd quadrant.