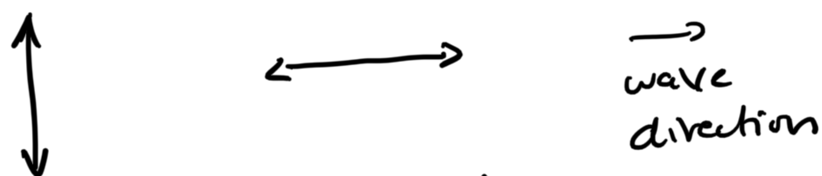
Waves

→ normal waves are disturbances of a medium (the material in which the wave travels)

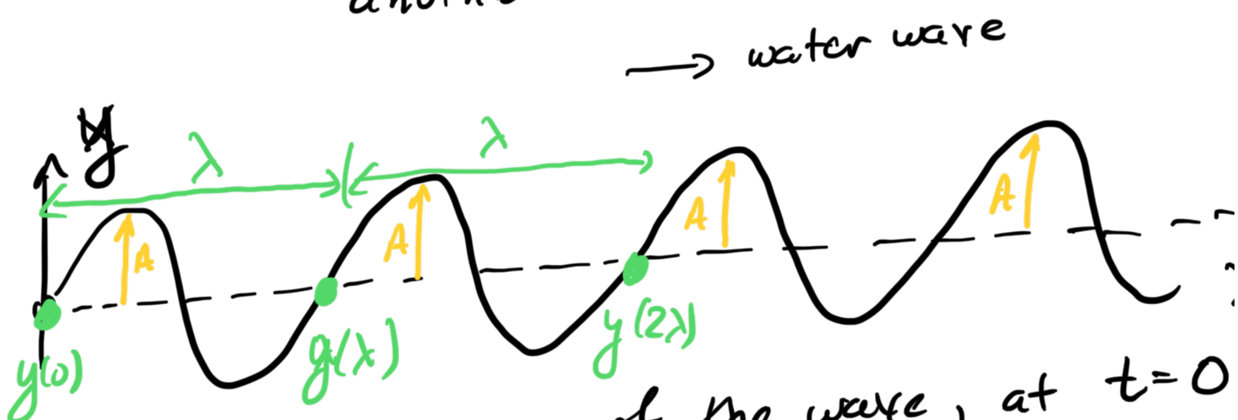
→ the molecules of the material are actually moving.



transverse (e.g. water waves)

longitudinal (e.g. sound waves)

→ energy travels from one place to another.



→ take a picture of the wave, at $t=0$

$$y = \underset{\text{Amplitude}}{A} \sin(\underset{\text{wave number}}{k}x + \underset{\text{phase}}{\phi})$$

(i) the sin function goes between +1 and -1 ∴
y goes between +A and -A.

(ii) the sin function repeats every 360°, or
every 2π radians.

$$y(0) = A \sin(\phi)$$

$$y(\lambda) = A \sin(k\lambda + \phi) = y(0)$$

$$\therefore \quad k\lambda = 2\pi$$

$$k = 2\pi/\lambda$$

$$y = A \sin\left(\frac{2\pi x}{\underset{\text{wavelength.}}{\lambda}} + \phi\right)$$

Now, image sitting at $x=0$, and allowi[ng]
time to pass.

$$y_0(t) = A\sin(\omega t + \phi)$$

Again, the sin function repeats every
2π radians, or every T seconds.

$$\therefore \quad \omega = \frac{2\pi}{T}$$

$$\boxed{y_0(t) = A\sin\left(\frac{2\pi t}{T} + \phi\right)}$$

Putting these two things together, we
can write:

amplitude

pha[se]

$$y(x,t) = A\sin\left(\frac{2\pi x}{\lambda} - \frac{2\pi t}{T} + \phi\right)$$

wavelength period

Recall: distance = speed × time.

$\therefore$ speed = $\dfrac{\text{distance}}{\text{time}}$

$$v_{wave} = \frac{\lambda}{T}$$

Define $\boxed{\text{frequency} \equiv \frac{1}{T}}$

$\therefore$ $\boxed{v_{wave} = f \cdot \lambda}$

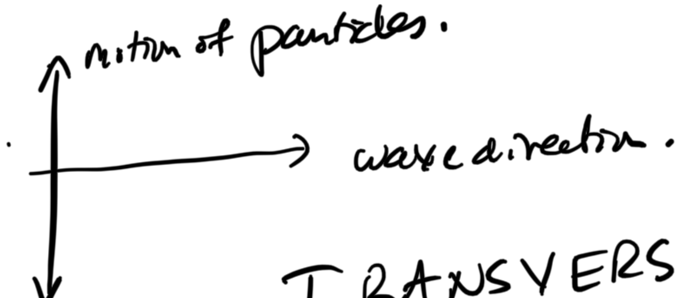
a constant for a given medium at a given pressure, temperature.

① A wave is traveling in a constant medium.

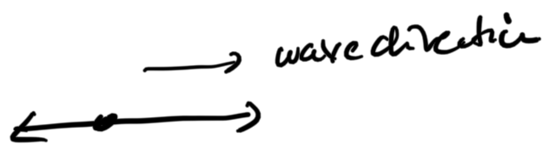
∴ the wave is going to travel at a constant speed.

② amplitude, (A) wavelength, (λ) phase, (ϕ)

frequency, (f) period, (T) medium ↑ the material

④ 

TRANSVERSE wave

⑤ 

LONGITUDINAL WAVE

(6) $f = 80\ Hz$

$= \frac{1}{s} = s^{-1}$

$f = \frac{1}{T}$ $\therefore$ $T = \frac{1}{f}$

$= \frac{1}{80\ Hz}$

$= 0.0125\ s$

(9) What type of "waves" do not have a physical medium?

LIGHT WAVES!

(Electromagnetic waves/radiation)

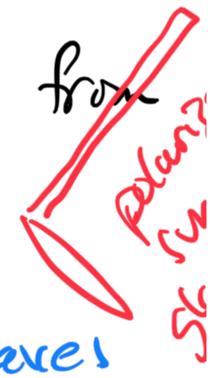
(3) Light waves can be polarized.

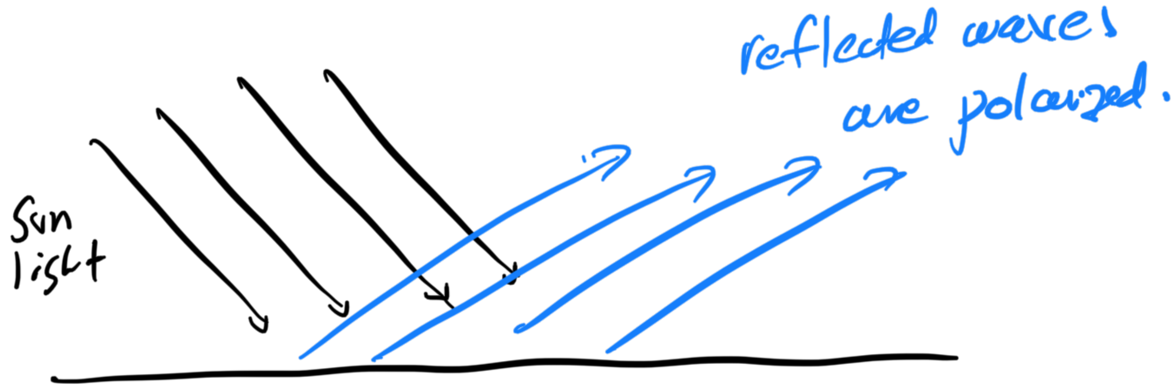
In normal light, the direction of "oscillation" is random (unpolarized)

" oscillation.

For polarized light, the oscillation direction is not random. It is aligned with some axis.

e.g. Light waves reflected from water.





The only questions we have left are 7 + 8.

Two waves

$$y_1 = A_1 \sin(2\pi f_1 t)$$

$$y_2 = A_2 \sin(2\pi f_2 t)$$

$$y_{total} = y_1 + y_2$$

$$= A_1 \sin(2\pi f_1 t) + A_2 \sin(2\pi f_2 t)$$

$$\Big\downarrow \text{math}$$

$$= (A_1 + A_2) \sin\left(2\pi\left(\frac{f_1+f_2}{2}\right)t\right) \times \cos\left(2\pi\left(\frac{f_1-f_2}{2}\right)t\right)$$

Beat frequency

$$= |f_1 - f_2|$$

$$= |81\text{ Hz} - 50\text{ Hz}| = 31\text{ Hz}$$

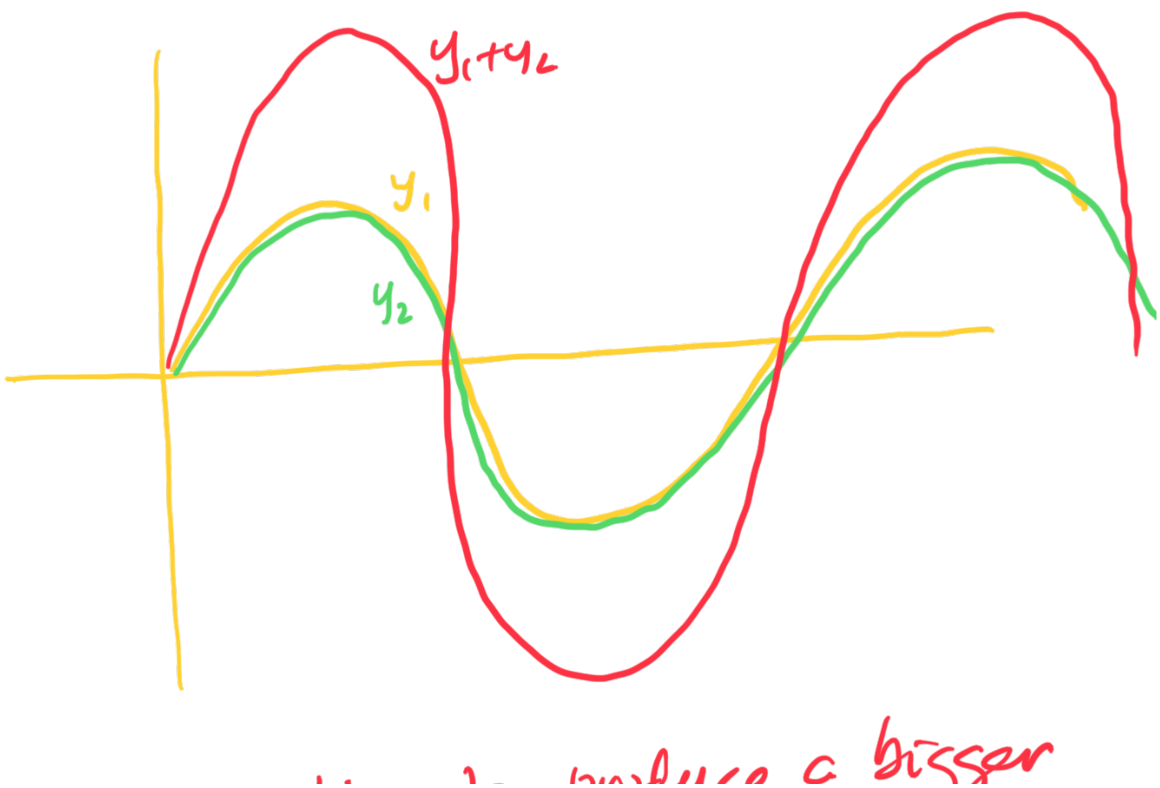
Combining two waves of the <u>same</u> frequency:

$$y_1 = A\sin(2\pi f t + \phi_1)$$

$$y_2 = A\sin(2\pi f t + \phi_2)$$

$$y = y_1 + y_2$$

<u>Case 1</u> $\phi_1 = \phi_2 = 0°$

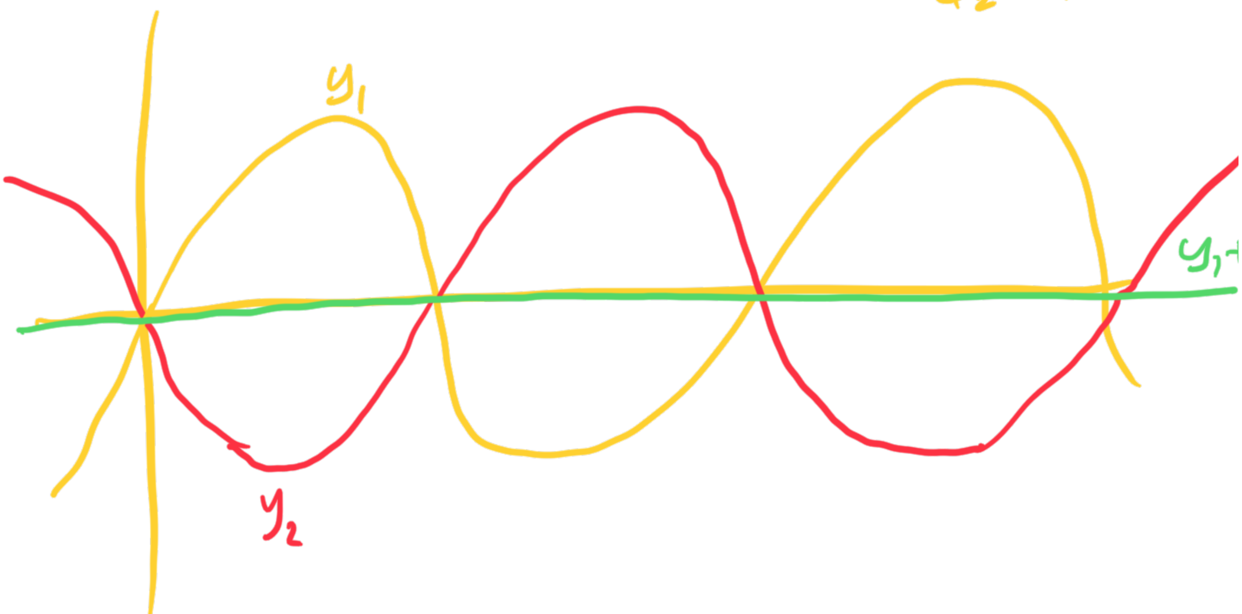


produce a bigger

- waves combine to produce ...
wave.

CONSTRUCTIVE interference

Case 2: $\Phi_1 = 0°$
$\Phi_2 = 180°$



→ waves combine and cancel each other out!

DESTRUCTIVE interference!