

Basic wave

perceptual { ray
wave front

rational

(wave types)

longitudinal - transverse

EM - mechanical

progressive - standing

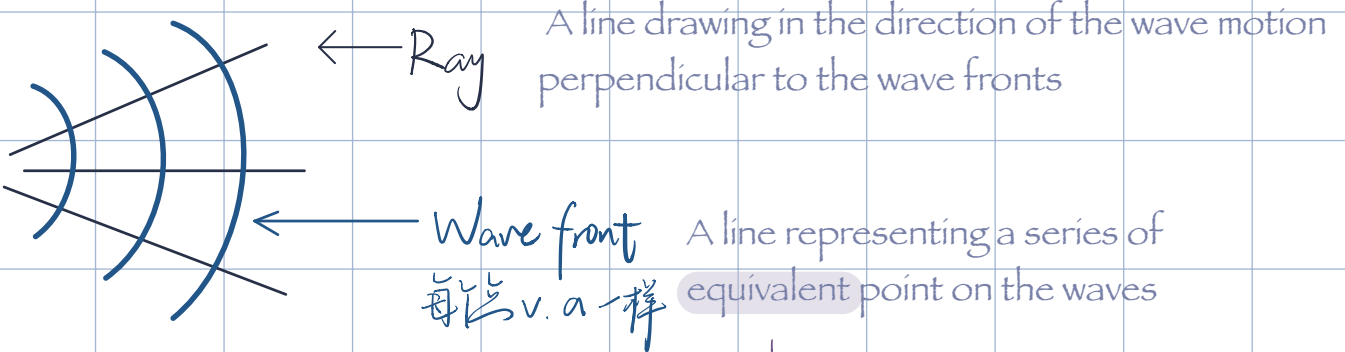
propagation { PE detection
(V3) $\frac{2\pi}{\lambda}$ v

oscillation

phase relationship

Wave basics

● 呈现形式

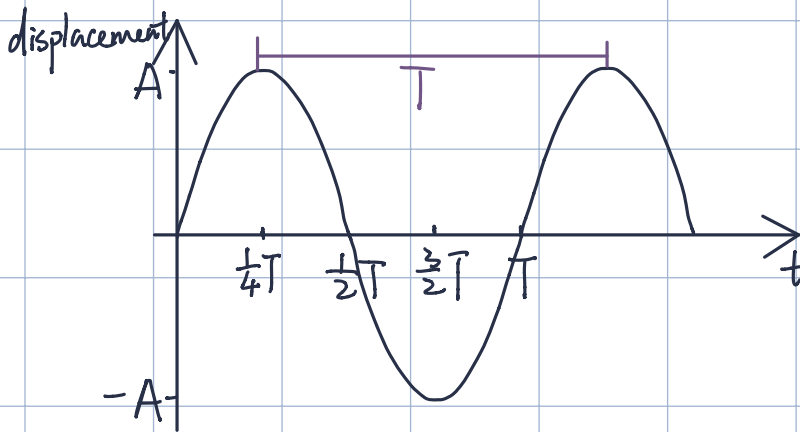


看运动模式
(displacement. v. a)

● 运动模式

1. oscillation 振荡 { of source
of medium

振荡一个周期，
波传播一个波长。



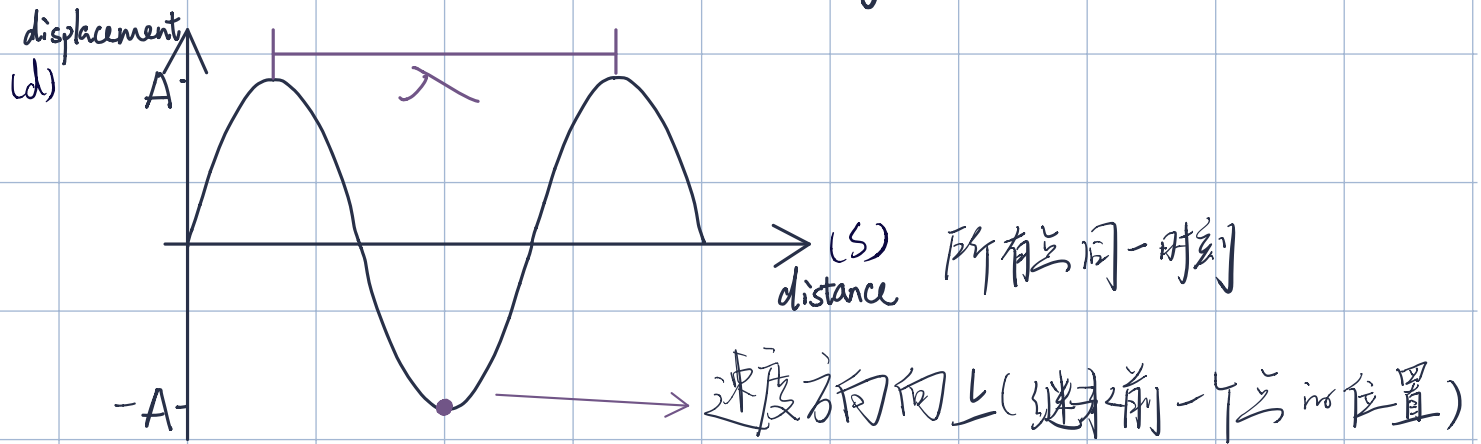
一点不同时刻

• amplitude (A) 振幅 The maximum displacement from equilibrium point

! • frequency (f) = $\frac{1}{T}$ The number of a complete cycle per second

• period (T) 周期 Time required to complete a cycle

2. propagation 传播 { of motion of energy



- period The time taken for one wave to pass through a point
- frequency (source)

The number of complete waves pass through a point in a second

- wave speed (v) = λf (介质决定) $v = \frac{\lambda}{T} = \lambda f$

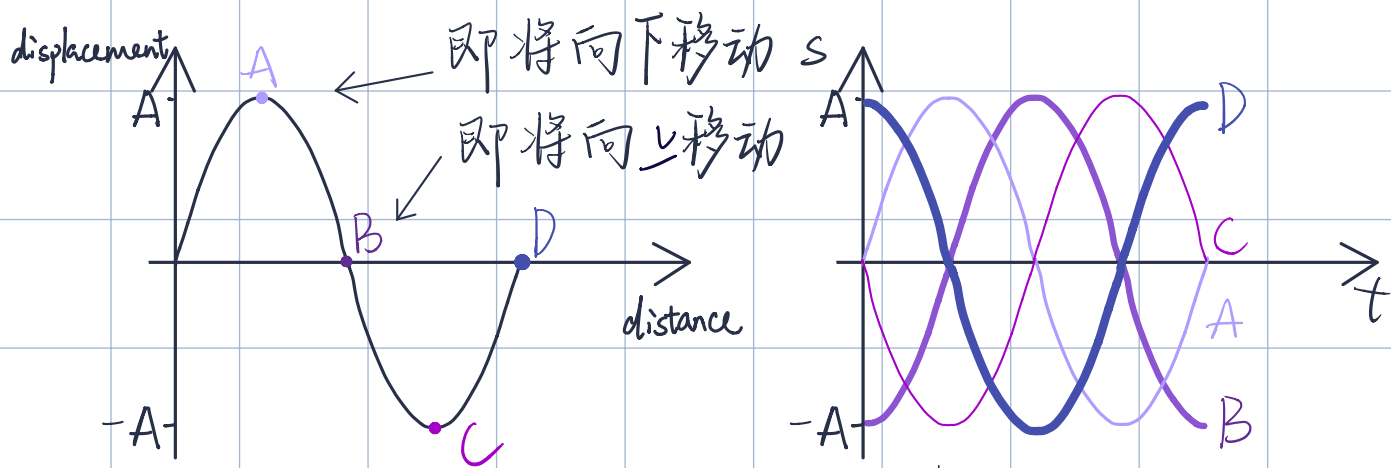
The velocity at which where waves move

速度受介质种类影响

- wave length (λ) (source & medium 一起决定)

The shortest distance between two adjacent points that are in phase

* motion graph



可以先确定点

线上每点的 amplitude 和 period 保持一致

{ out of phase (ep. A & C) 两个粒子完全运动相反
in phase 运动方式完全相同. (波完全重叠)

分析 motion 的角度

- ① 宏观 oscillation
- ② 微观 propagation
- ③ phase relation ← 看分值回答
- ④ 总结 (create compression & rarefaction)

Wave phase

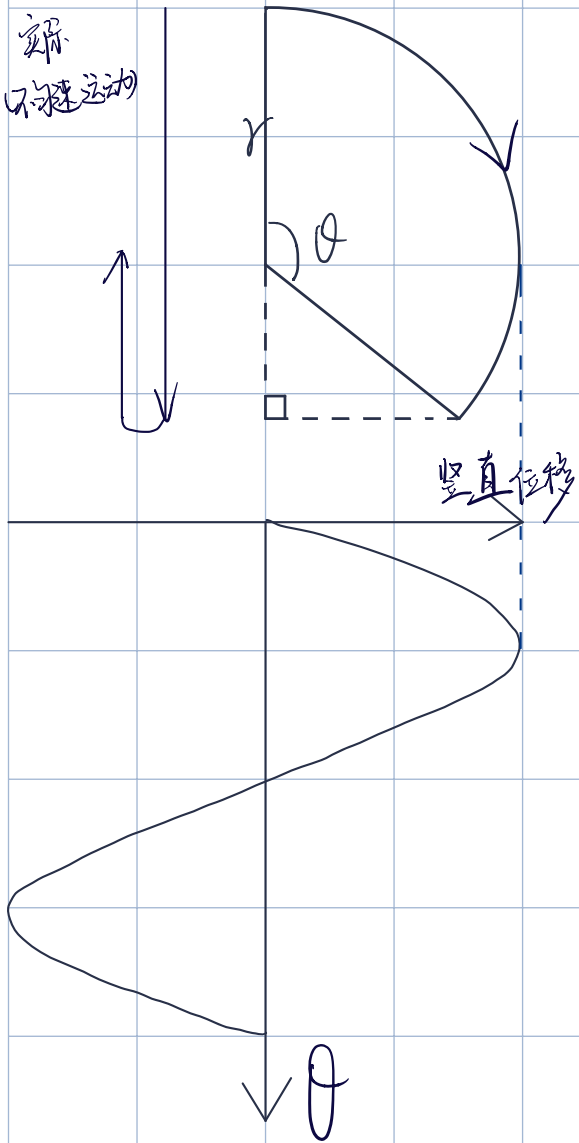
● def.

The position within a cycle that particle occupies relative to the onset of the cycle

相位空间里的水平位移与振荡同步

($0 \sim 2\pi$) 可用相位空间里的水平位移来替换匀速圆周运动的角度变化

↳ 匀变速



已知 $\angle \theta$, 求竖直位移

$r = \text{amplitude}$

$\theta = \cos T$

$S_y = A \cos(\pi - \theta)$



path difference = phase difference
 \searrow 2π

phase = θ = 角速度 \times t
角速度相同时, 粒子在相位空间里做匀速圆周运动

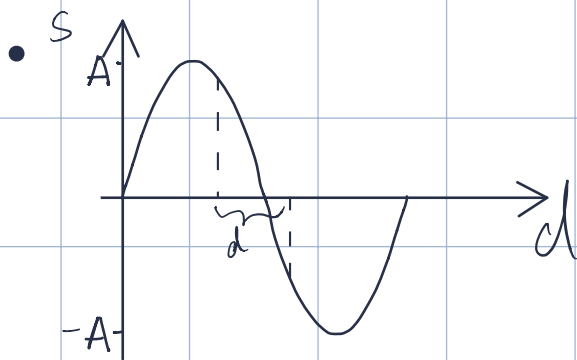
Phase difference

← 测量角度的单位

- 两个特殊情况的 phase difference

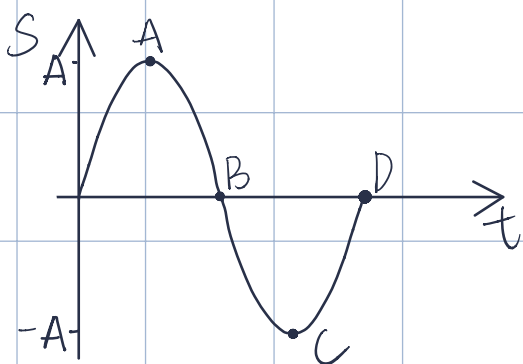
in phase: 两个粒子的 PD = $n\lambda$

anti phase: 两个粒子的 PD = $(\frac{1}{2} + n)\lambda$



已知 distance

$$\frac{pd}{2\pi} = \frac{d}{\lambda}$$



已知 time difference

$$\frac{pd}{2\pi} = \frac{\Delta t}{T}$$

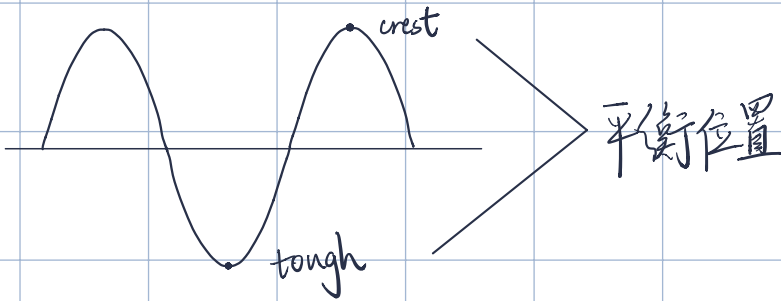
| | | | |
|------------------|--------------|------|----------------------------|
| path difference | = $n\lambda$ | cons | $(n + \frac{1}{2})\lambda$ |
| phase difference | = 0 | | π |

Wave types

1. transverse wave 横波

def. 振荡方向 \perp 传播方向 ep. water wave & light

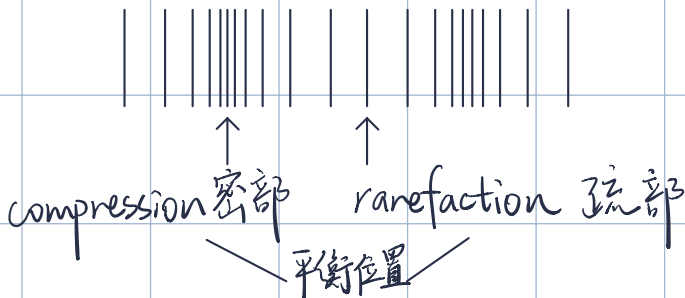
oscillation occur right angle to the direction of travel of wave



longitudinal wave 纵波

def. 振荡方向 \parallel 传播方向 ep. sound

oscillation occur parallel to the direction of travel of wave





displacement:
粒子到平衡位置上的距离

2. EM wave

mechanical wave

不要介质
要介质

3. progressive wave standing wave

| | 驻波  stationary \sim | 行波  progressive \sim |
|------------|---|--|
| E transfer | storing | transfer |
| Amplitude | 0 ~ A_{max} | constant |
| Phase | in phase | 不同 |

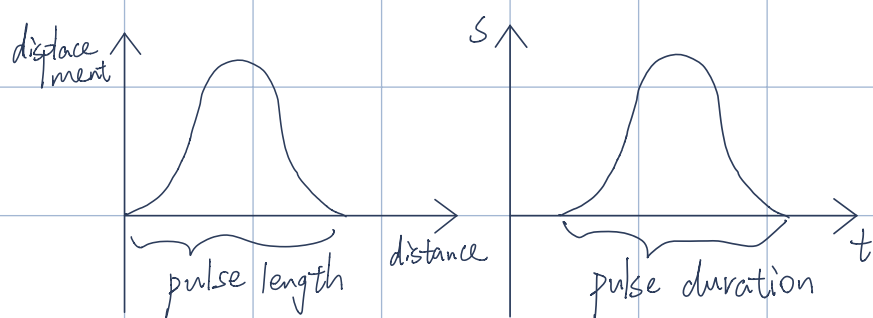
Pulse-echo detection 脉冲回波检测

● What

Pulse: short wave (波长短)

Echo: reflected pulse

Detection: the distance of the object



● How 得到方法

测一次 pulse 的时间 (Δt)

$$\text{distance} = \frac{\Delta t v}{2}$$

● Notice 不用 continuous wave 的原因:

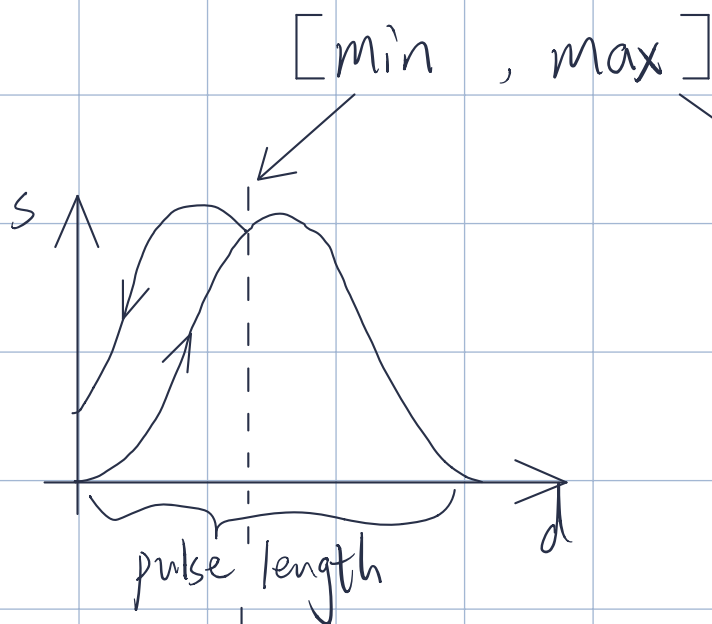
① 干涉, 只需要求一个波来回的时间

② 很难确定一个连续波上的观察点

We need pulse to come back before next pulse emitted.

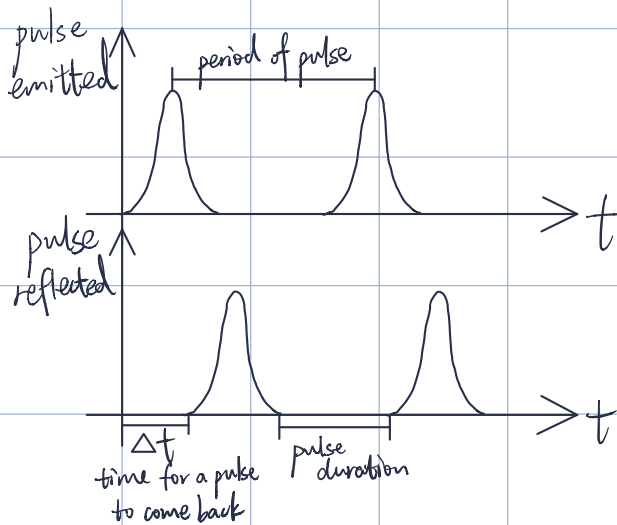
So we can tell which reflected pulse originated with which emitted pulse.

● Range



$$d \geq \frac{1}{2} \text{ pulse length}$$

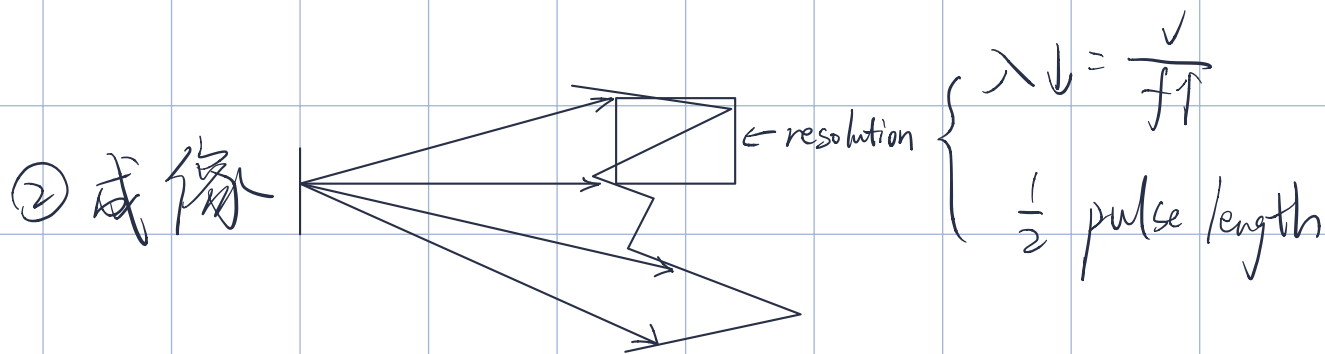
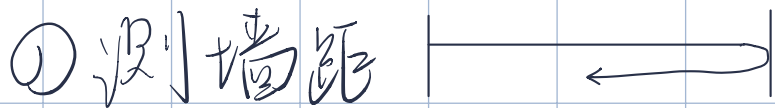
↓
pulse duration $\times v$



$$\Delta t < T$$

↓
↳ the period of the pause to come back

● 题目



● 图像

① 如何根据 PE detection 得出图像 ep. B超

· 变多

Probe moved to different positions to get many distances of these positions

不同方位测量得到B超图像

· density

Echo bring not only distance but also density information of boundary

B超图像会有深浅变化

→ reflection & penetration 反射和折射的能量分布

Reflection occurs when there is a change in density

Δ density \uparrow energy reflected \uparrow

② medical imaging { ^{超声波}ultrasound — reflection
X ray — penetration

· different waves

① 声波: infrasound, sound (20-20000Hz), ultrasound

② 电磁波: 长

| | | | |
|--|---------------|------------------------------|--------------------------|
| | radio wave | ← 频率小, 波长大, 能量小 | |
| | micro wave | | |
| | infrared 红外 | | } non-ionizing radiation |
| | visible light | | |
| | ultraviolet | | |
| | X-ray | } ionizing radiation 电离辐射 | |
| | gamma | | |

↓
短

• 好处 & 坏处

① damage to DNA

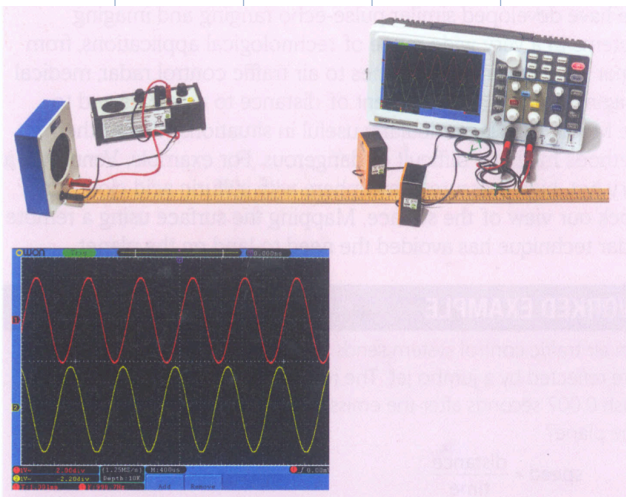
② resolution 最小精度

$$= \frac{1}{2} \text{ pulse} = \frac{1}{2} \text{ pulse duration} \times v = \text{wavelength}$$

def. the smallest the detail that can be distinguish

减小 resolution: ① $\lambda \downarrow$ ② pulse length/pulse duration \downarrow

● 测声速实验



① 2个 microphone 与 loudspeaker
同样距离, 示波器与两个波 in phase

② 移动其中一个 microphone,
使示波器与两个波 out of phase

③ f : 从 signal generator
入: 两个 microphone 的张音

④ $v = f\lambda$