

波動現象 Phenomena of wave motion

波動學第二課

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連續機械行波的能量分佈 Distribution of energies in continuous waves

考慮某一瞬間各質點的能量／單一質點隨時間推移的能量：

- 質點的總機械能 Total mechanical energy of a particle = 動能 KE + 勢能 PE
 - ▶ 總機械能：跟振幅相關。 $(\propto A^2)$
Total mechanical energy: related to amplitude. $(\propto A^2)$
 - ▶ 勢能：跟位移相關。 $(\propto y^2)$
Potential energy: related to displacement of a particle. $(\propto y^2)$
 - ▶ 動能：跟質點的移動速率相關。 $(\propto v^2)$
Kinetic energy: related to speed of a particle. $(\propto v^2)$
- 若沒有能量損耗，總機械能不變。
When there is no energy loss, total mechanical energy remains the same.

連續機械行波的能量分佈 Distribution of energies in continuous waves

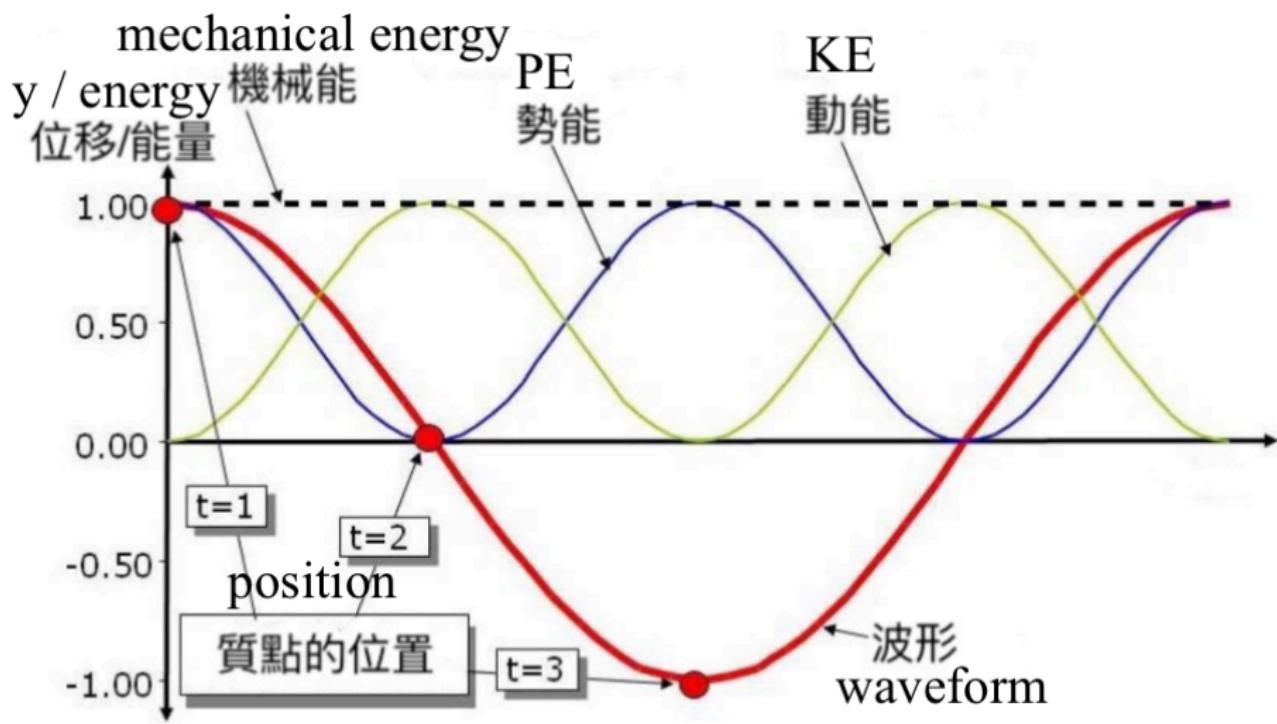
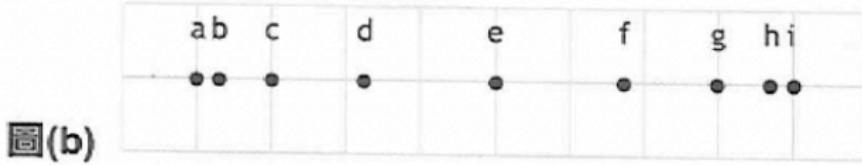
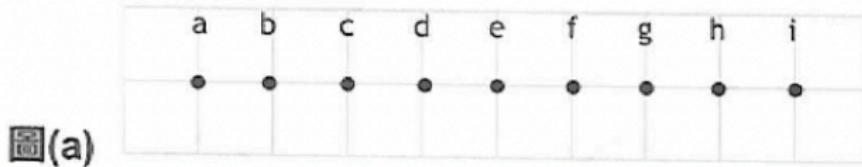


圖 (a) 顯示九個均勻分佈的質點。圖 (b) 顯示一縱波各質點的位置。在此時此刻，下列哪線圖正確地顯示各點的勢能 PE 隨位置 x 的變化？

Figure (a) shows nine uniformly distributed particles. Figure (b) displays the positions of the particles in a longitudinal wave. At this moment, which of the following graphs accurately represents the variation of potential energy (PE) with respect to the position (x) of each point?

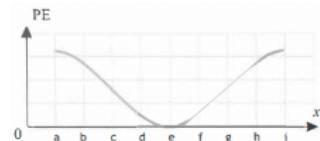


例題 Example

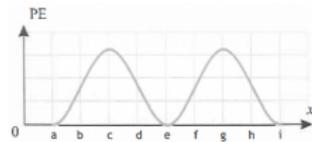
A.



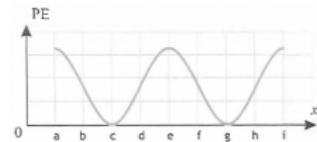
B.



C.



D.



水波槽 ripple tank

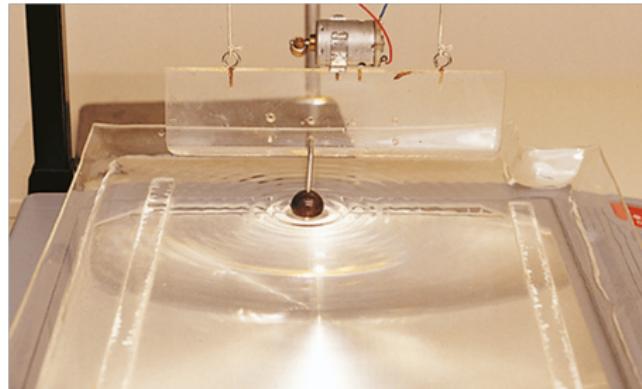
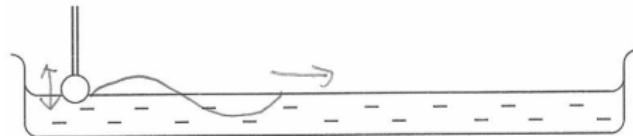


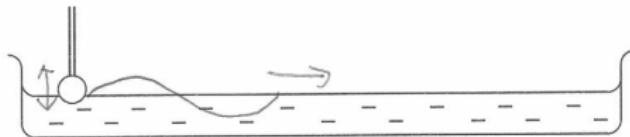
Figure: 水波槽可以用來產生水波 ripple tanks can be used to produce water wave

水波的傳播 Propagation of water wave

- 當點振源移動一次上下一個完整的周期時，會產生一個完整的水波波長。

When point source completes one full oscillation, one wavelength of wave is produced.

- ▶ 點振源的頻率 = 水波的頻率。
frequency of point source = frequency of water wave.
- ▶ 點振源無法控制水波的速率。
point source cannot control speed of water wave.
- ▶ $\because v = f \lambda$ ，頻率越大，波長越短。
 $\because v = f \lambda$, wavelength decreases as frequency increases.



製造水波 Generating water wave

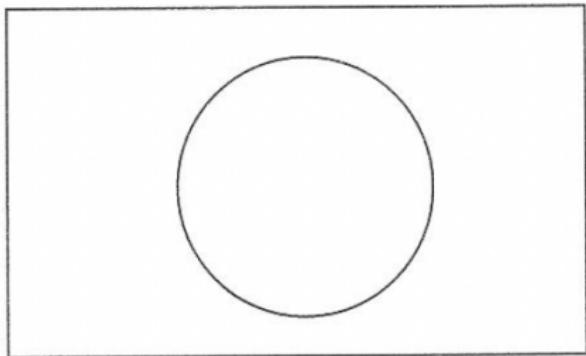


Figure: 脈衝水波 a pulse of water wave

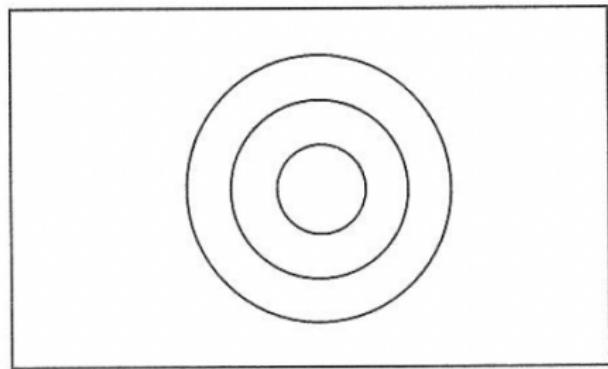
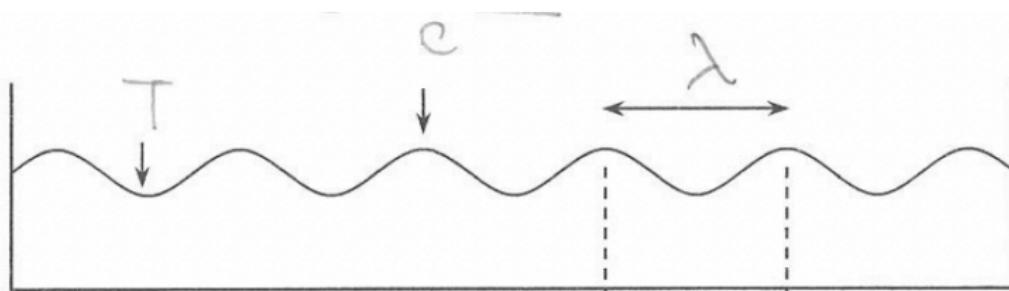
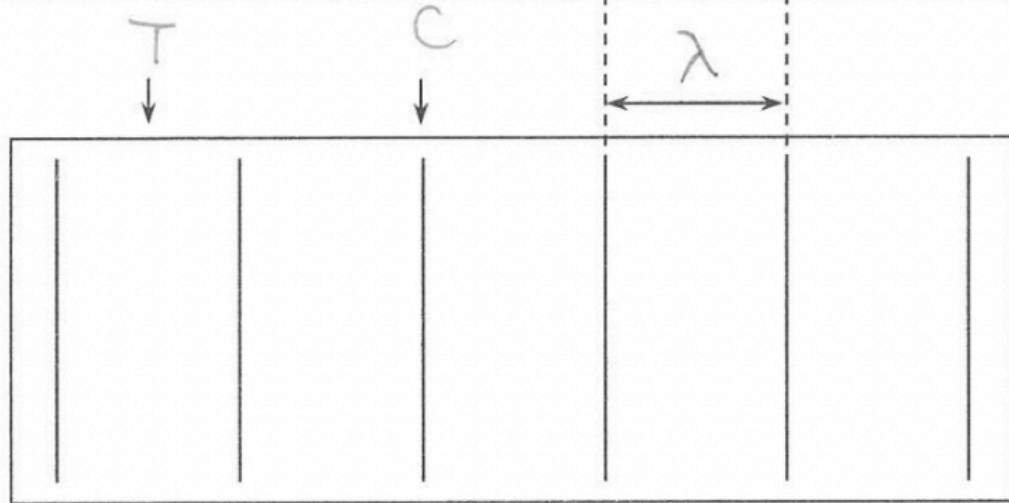


Figure: 連續水波 continuous water wave

以不同角度觀察水波 observe water waves

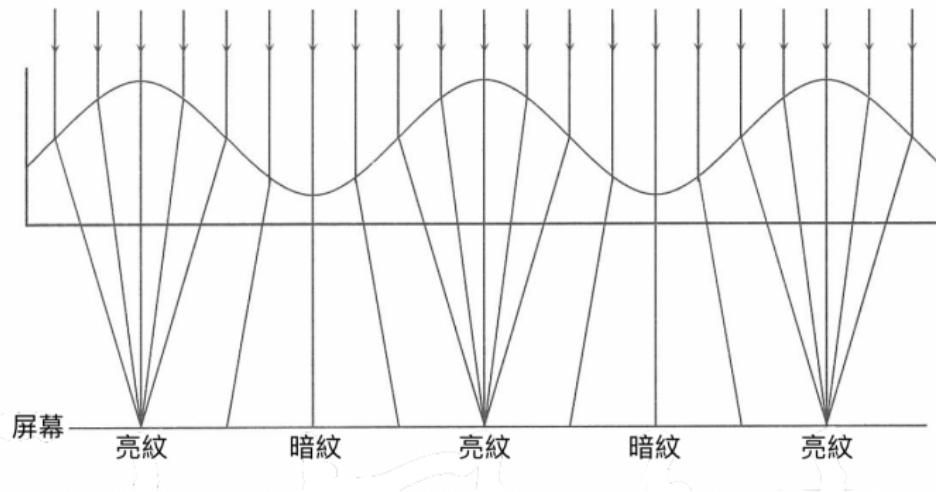


側面圖



俯瞰圖

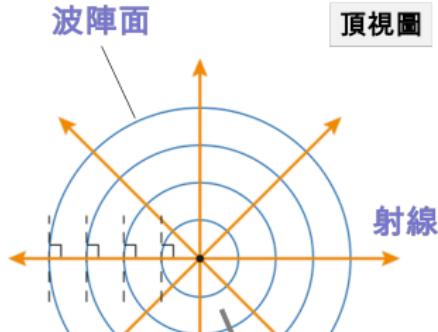
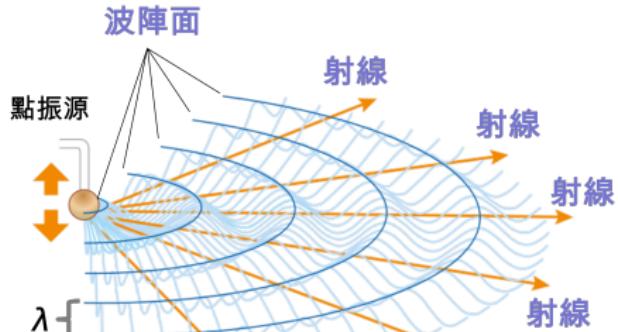
在屏幕上形成的條紋 water wave formed on a screen



- 波峰聚焦光線形成光紋。
Crests converge light rays and form bright fringes.
- 波谷發散光線形成暗紋。
Troughs diverge light rays and form dark fringes.

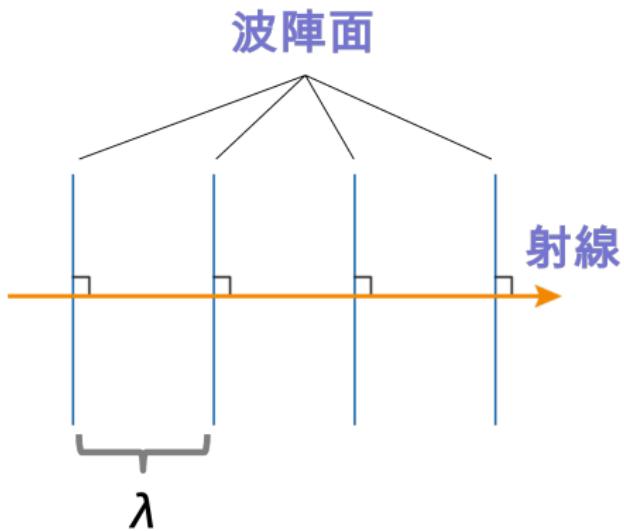
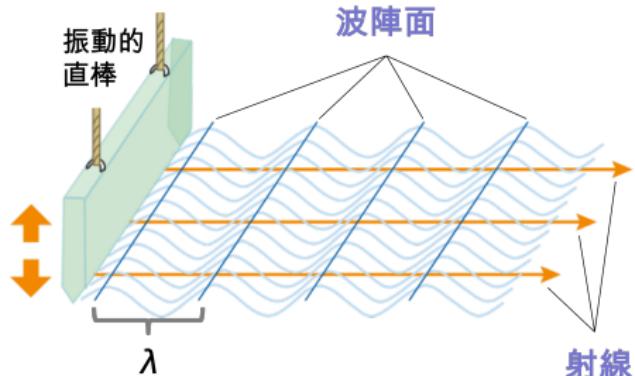
波陣面和射線 Wavefront and rays

- 波峰連接的線稱為波陣面。
Wavefront: line connecting neighboring crests particles particles.
- 在同一波陣面上，所有質點都以同相振動。
On the same wavefront, all particles vibrate in-phase.
- 射線：表示波的傳播方向的線
Ray: lines showing direction of travel of waves.
- 波陣面必定垂直於射線。
Wavefront must be perpendicular to rays.



波陣面和射線 Wavefront and rays

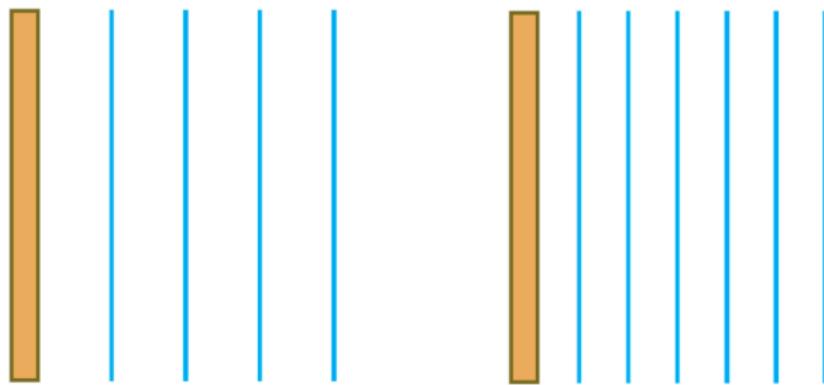
頂視圖



例題 Example

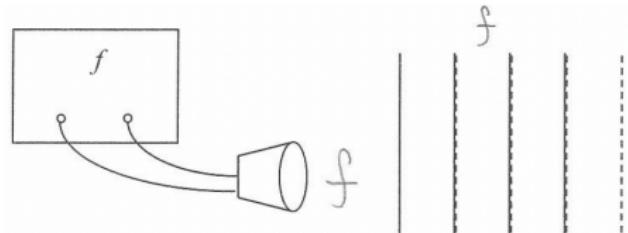
左圖和右圖分別是兩個直線水波 P 和 Q。其中 P 的水比較淺。比較兩波的 λ, v, f 。

The left and right figures respectively depict two straight water waves, labeled as P and Q. Wave P is shallower. Compare λ, v, f of the two waves.



量度水波的頻率 Measuring frequency of water wave

- 在黑暗的環境下，調整頻閃觀察器的頻率直至波形看起來靜止不動。
In dim environment, adjust a stroboscope so that a frozen wave pattern is observed.
- 這時頻閃觀察器的頻率 = 波的頻率。
Frequency of stroboscope = frequency of wave.



量度水波的波長 Measuring wavelength

- 調整頻閃觀察器的頻率直至波形看起來靜止不動。

In dim environment, adjust a stroboscope so that a frozen wave pattern is observed.

- 使用米尺量度幾個連續水波的波長。

Use a ruler to measure wavelength of water wave.

