

WAVES

→ x

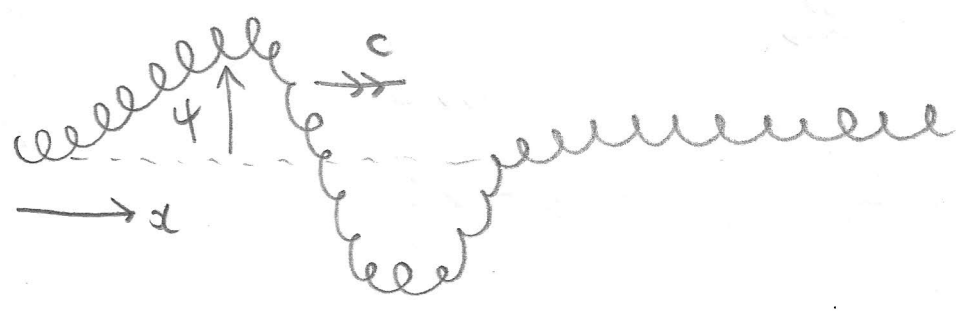
[Snapshot at time t]

c
→

Q1/ (i)



- **Longitudinal wave** on a string
- $\psi(x,t)$ is the compression of the string from the equilibrium separation of the bits.
- The direction of compression is // to the propagation direction of the wave. c is the wave speed.



- **TRANSVERSE** wave on a string
- $\psi(x,t)$ is the \perp displacement to the main axis of the string, and the direction of wave propagation.

(ii) E string: $f = 82.41 \text{ Hz}$. $c = 340 \text{ m/s}$

b) $c = f\lambda$ $\therefore \lambda = \frac{c}{f}$
 $\lambda = \frac{340}{82.41} = \boxed{4.13 \text{ m}}$

a) $T = \frac{1}{f} = \frac{1}{82.41} = \boxed{1.21 \times 10^{-2} \text{ s}}$ (or 12.1 ms)

c) $k = \frac{2\pi}{\lambda} = \frac{2\pi}{(340/82.41)} = \boxed{1.52 \text{ m}^{-1}}$

d) $\omega = 2\pi f = 2\pi \times 82.41 = \boxed{517.8 \text{ rad s}^{-1}}$

check that $\omega = ck$: $\frac{\omega}{k} = \frac{517.8}{1.52} = 340.7 \text{ m/s}$
(involves rounding error!)

(iii) $\psi(x,t) = 3\cos(2.2x - 55t)$ = $A\cos(kx - \omega t)$

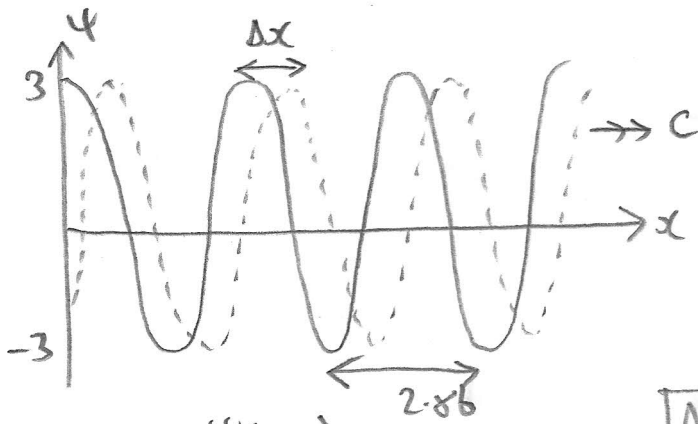
a) Amplitude $A = 3$. $k = 2.2$. $\omega = 55$.

b) $k = \frac{2\pi}{\lambda}$ $\therefore \frac{2\pi}{\lambda} = 2.2 \Rightarrow \lambda = \frac{2\pi}{2.2} = \boxed{2.86}$

c) $\omega = 2\pi f$ $\therefore f = \frac{\omega}{2\pi} = \frac{55}{2\pi} = \boxed{8.75}$

d) $T = \frac{1}{f} = \frac{2\pi}{55} = \boxed{0.11}$

{ No units given but assume wavelength in m frequency in Hz period in s }



— $\psi(x,0)$

--- $\psi(x,0t)$

$\Delta x = c \Delta t$ is translation of $\psi(x,0)$ by Δx .

$\psi(x,t) = 3\cos(2.2x - 55t)$

$\Delta t \ll T$.

(iv) Ultrasound: $\lambda = \frac{c}{f} = \frac{1500}{50 \times 10^3} = \boxed{0.03 \text{ m}}$

Microwaves: $\lambda = \frac{c}{f} = \frac{2.997 \times 10^8}{10 \times 10^9} = \boxed{0.03 \text{ m}}$

ie the same wavelengths. This is why SONAR antennae underwater are \approx the same size as radar antennae (which work at frequencies 1-10 GHz).

(v) $P = \frac{1}{2} Z A^2 \omega^2$ wave power. (Z is "wave impedance")

ie $P \propto A^2 f^2$ since $\omega = 2\pi f$

$\therefore 2 A_2^2 f_2^2 = A_4^2 f_4^2 \quad \therefore \frac{A_2}{A_4} = \frac{f_4}{f_2} \frac{1}{\sqrt{2}} = \frac{10419}{28.1\sqrt{2}} = \boxed{0.842}$

(2) (R4 broadcast at twice the power)

