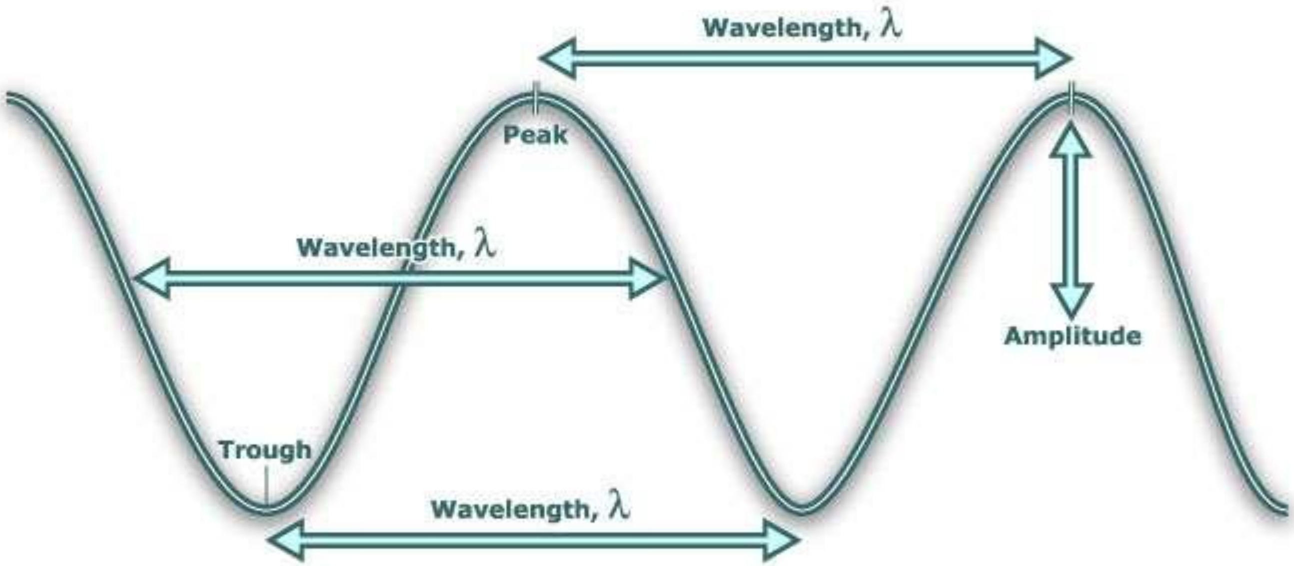
What is a Hormonic wave ?

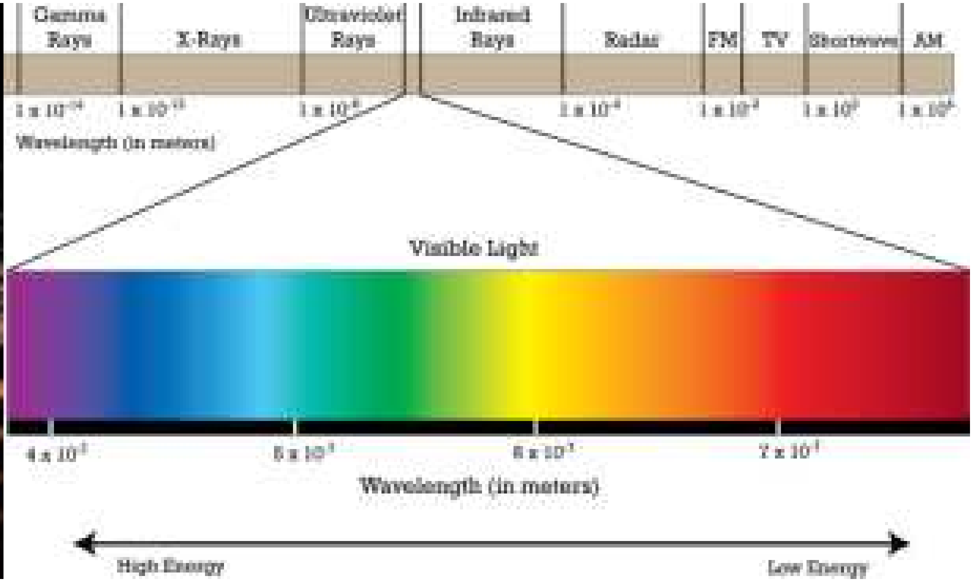
- If a wave is undergoing harmonic motion it is considered a harmonic wave or when a source creates a wave that travels in simple harmonic motion, it is referred as a **harmonic wave.**
- Simple harmonic motion is the type of periodic motion in which the restoring force is directly proportional to the displacement

- It is also known as a sinusoidal wave (a sin graph)
- It has a smooth repetitive oscillation



Difference between Mechanical and Electromagnetic waves

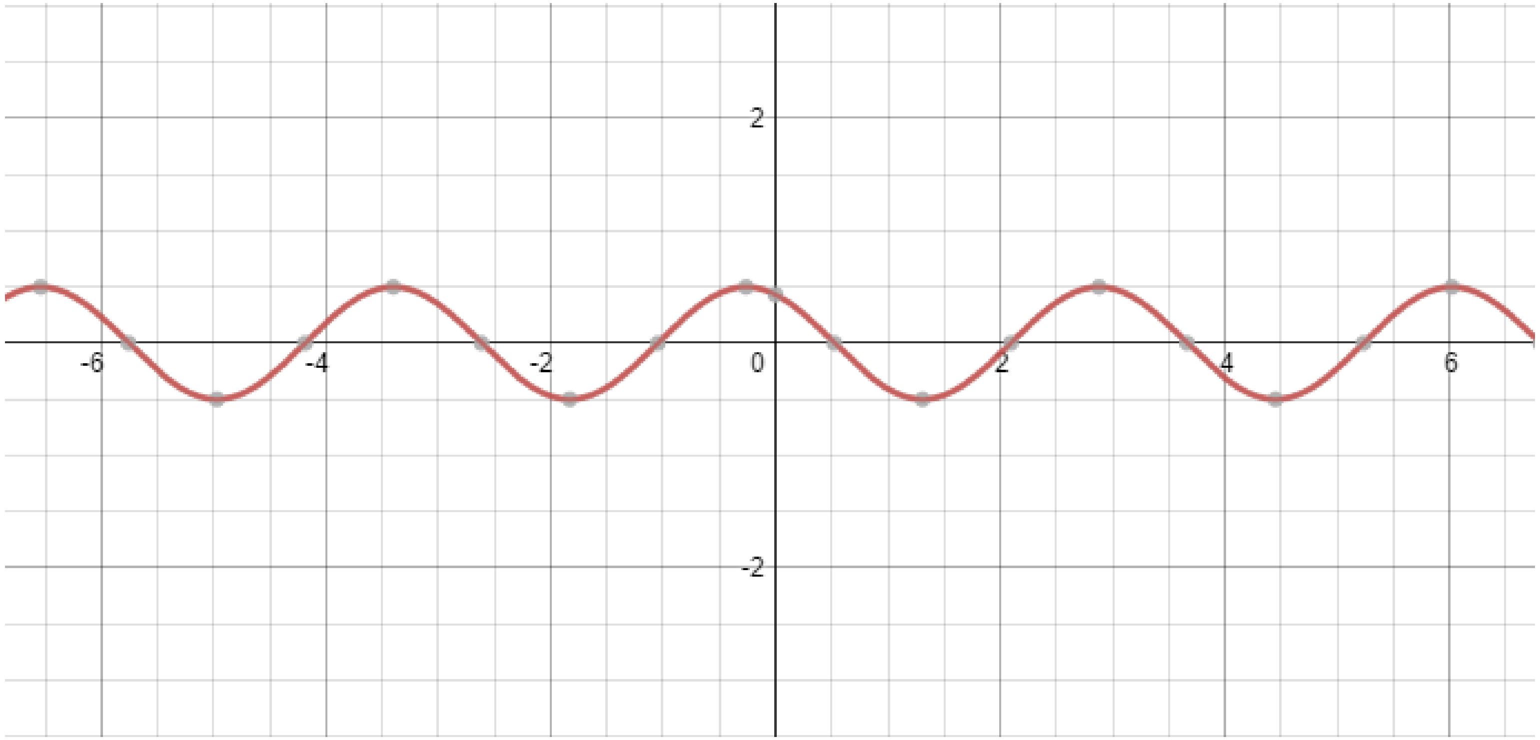
Mechanical wave	Electromagnetic wave
Travels through a medium and wave speed depends on the medium	Generated by charged particles and travels independently of the medium



Characteristics of a Harmonic wave

- **Amplitude:** Corresponds to the maximum displacement from the equilibrium position of any element. Amplitude is always a positive quantity.
- **Wavelength:** The shortest distance over which a wave shape repeats is called the wavelength. Represented by the symbol lambda (λ) or the distance between successive crests or between successive troughs and it is symbolized by lambda, $\boldsymbol{\lambda}$.
- **Wave number:** the reciprocal of the wavelength, $\mathbf{k} = \frac{\mathbf{2\pi}}{\boldsymbol{\lambda}} = \frac{\boldsymbol{\omega}}{\boldsymbol{\vartheta}}$
- **Period:** the time for a particle make one complete cycle T=1/f
- **Frequency:** the number of wave cycles passing a fixed point of the medium in one section
- **Phase shift (ϕ):** a horizontal shift by how many units the "starting point" (0,0) of a standard sine curve, y = sin(x), has moved to the right or left.

What is the amplitude of the graph?



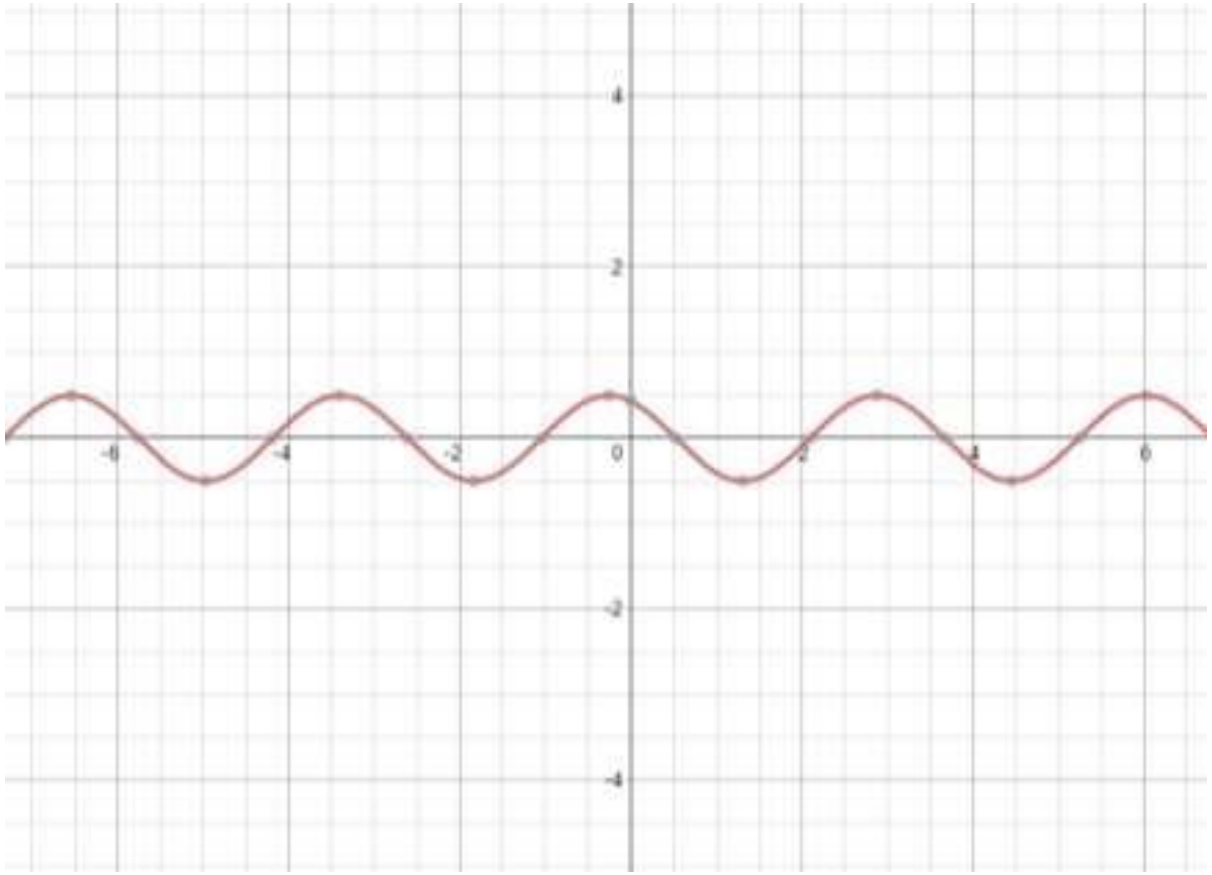
a. -0.5

b. 1

c. 0.5

d. 0.25

What is the wave number of the graph?



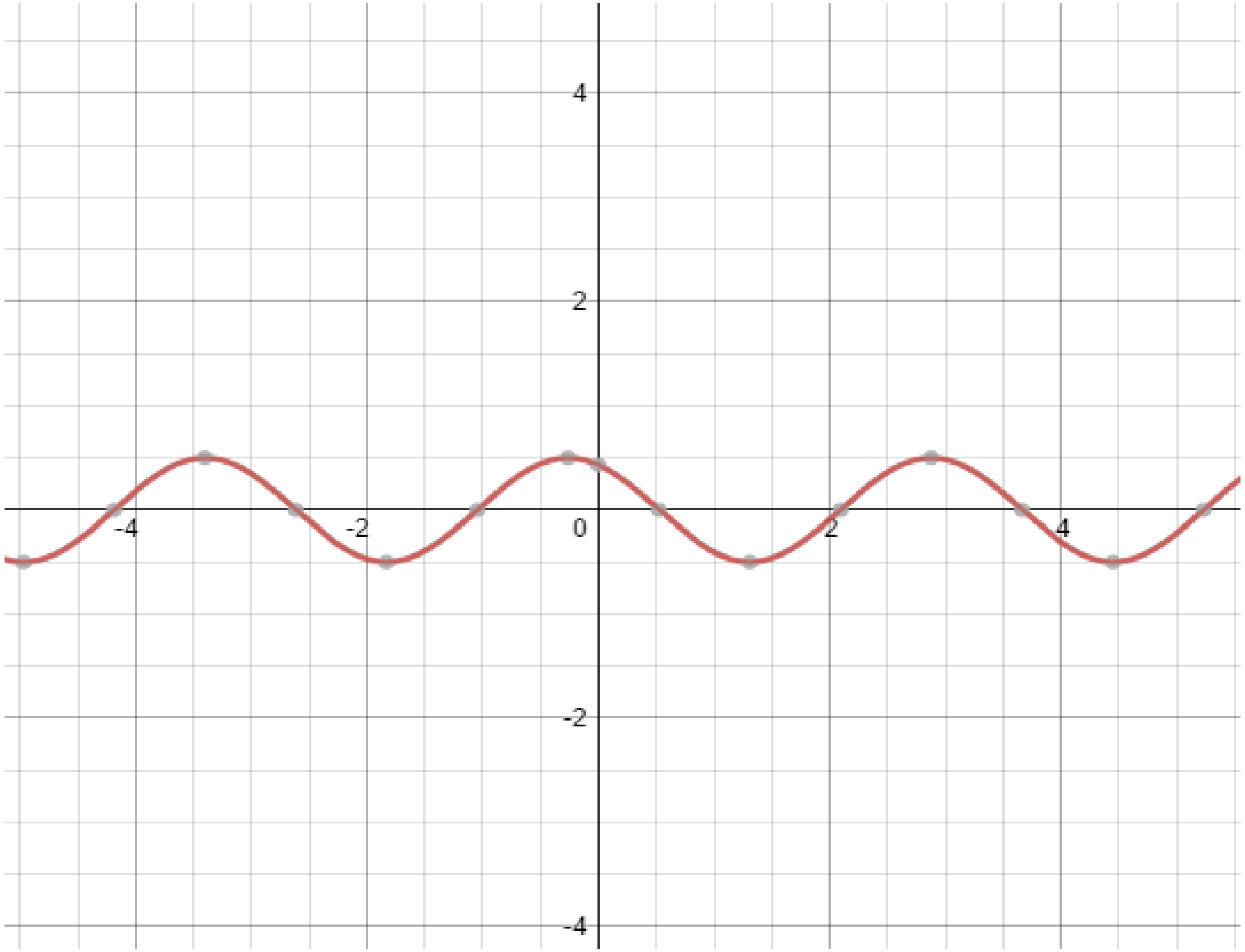
a. π

b. π/2

c. 1/2

d. 2

What is the phase shift?



a. 2π

b. $2\pi/3$

c. $\pi/3$

d. π

Solutions

1. c) 0.5
2. d) 2
3. b)$2\pi/3$

As time changes, the displacement of any element of a medium changes from its equilibrium position.

Therefore, the function for a harmonic wave can be expressed differently depending on whether it is travelling in the direction of increasing x or decreasing x.

Increasing x: $x = (x - vt)$

Therefore,

$$D(x) = A\sin(kx) \qquad (x = (x - vt))$$

$$\Rightarrow D(x,t) = A\sin(k(x - vt)) \qquad (kv = w\text{, so } kvt = wt)$$

$$\Rightarrow D(x,t) = A\sin(kx - wt) \qquad \left(\mathbf{k} = \frac{2\pi}{\lambda} \text{ and } \mathbf{w} = \frac{2\pi}{T}\right)$$

Increasing x: $\mathbf{D(x,t) = A\sin(\frac{2\pi}{\lambda}x - \frac{2\pi}{T}t)}$

Similarly, for decreasing x,

Decreasing x: $\mathbf{D(x,t) = A\sin(\frac{2\pi}{\lambda}x + \frac{2\pi}{T}t)}$

- However, notice how in the above functions when the position is at x=0 and t=0, the displacement is restricted to being zero only.
- Here is when the phase constant is added to the function to account for this restriction. The functions can now be rewritten in terms of wave length and period as well as the phase constant φ:
- Increasing x: $\mathbf{D(x,t) \ = \ A\sin(\frac{2\pi}{\lambda}x - \frac{2\pi}{T}t + \varphi)}$
- Decreasing x: $\mathbf{D(x,t) \ = \ A\sin(\frac{2\pi}{\lambda}x + \frac{2\pi}{T}t + \varphi)}$