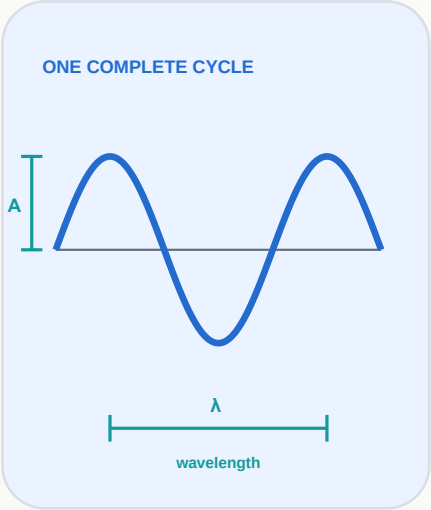
PEARSON EDEXCEL IAL PHYSICS | UNIT 2

LESSON 2.1.1

Wave Speed, Frequency, Wavelength and Phase

A wave repeats in space and time. Wavelength describes the spatial cycle, period describes the time cycle, and wave speed connects them.



THE CORE RELATIONSHIPS

WAVE EQUATION

$v = f\lambda$

m/s = Hz × m

PERIOD AND FREQUENCY

$f = 1/T$

T in seconds

PHASE FROM PATH

phase fraction = $\Delta x/\lambda$

one cycle = 360 degrees

FIVE QUANTITIES TO DISTINGUISH

AMPLITUDE, A

Maximum displacement from equilibrium. It is not the crest-to-trough height.

WAVELENGTH, lambda

Shortest distance between two points in phase, such as crest to next crest.

PERIOD, T

Time for one complete cycle; unit s.

FREQUENCY, f

Cycles passing a point each second; unit Hz.

WAVE SPEED, v

Distance travelled by the wave per second; unit m/s.

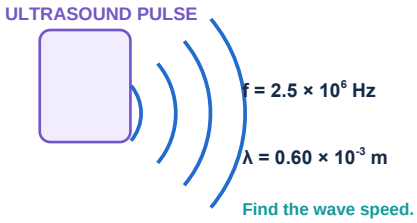
READ THE AXIS FIRST

A displacement-distance graph shows wavelength. A displacement-time graph shows period. The same wave shape can represent two different measurements.

1 Using the wave equation

Convert prefixes before substituting. Frequency and wavelength must describe the same wave in the same medium.

WORKED EXAMPLE: ULTRASOUND



PREFIX CHECK

1 MHz = 10^6 Hz

1 mm = 10^{-3} m

CALCULATE IN THREE STEPS

1 CONVERT

2.5 MHz = 2.5×10^6 Hz

0.60 mm = 0.60×10^{-3} m

2 SUBSTITUTE

$v = f\lambda$

$= 2.5 \times 10^6 \times 0.60 \times 10^{-3}$

3 ANSWER

$v = 1.5 \times 10^3$ m s^{-1}

= 1500 m/s

PERIOD TO FREQUENCY

$T = 4.0$ ms $= 4.0 \times 10^{-3}$ s $f = 1/T = 1/(4.0 \times 10^{-3}) = 250$ Hz

Higher frequency means a shorter period.

REARRANGE WITH UNITS

FIND SPEED

Use v = f times wavelength; Hz times m gives m/s.

FIND FREQUENCY

Use f = v/wavelength; m/s divided by m gives Hz.

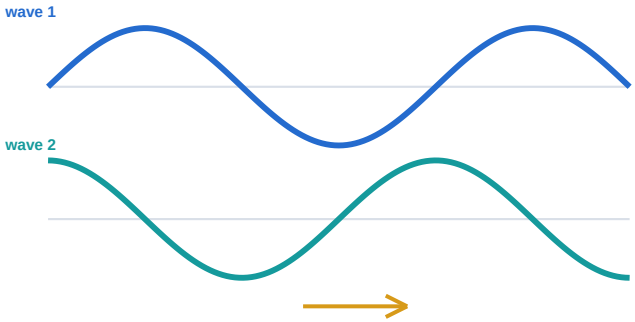
FIND WAVELENGTH

Use wavelength = v/f; m/s divided by Hz gives m.

2 Phase difference and path difference

Phase tells where a point is within a cycle. Convert a path or time separation into a fraction of one complete cycle.

ONE CYCLE, THREE EQUIVALENT VIEWS



PHASE RELATIONSHIP

$$\text{phase fraction} = \frac{\Delta x}{\lambda}$$

also equals $\Delta t / T$

multiply by 360 degrees or 2 pi radians

LANDMARK PHASE DIFFERENCES

IN PHASE

0 or 360 degrees; separated by a whole number of wavelengths.

QUARTER CYCLE

90 degrees; separated by one-quarter of a wavelength.

ANTIPHASE

180 degrees; separated by half a wavelength.

WORKED PHASE EXAMPLE

$\Delta x = 0.30$ m, $\lambda = 0.80$ m phase $= 360 \times 0.30/0.80 = 135° = 3\pi/4$ rad

A phase difference has an angle, not a unit of metres.

DIRECTION MATTERS

State whether one point leads or lags when the direction of travel is known. A phase angle alone gives the size of the offset, not its direction.