University of Anbar

College of Science

Department of Applied Geology

First Year

General Physics

جامعة الانبار

كلية العلوم

قسم علوم الجيولجيا التطبيقية

المرحلة الاولى

الفيزياء العامة

Chapter Eight

Waves

الفصل الثامن

الموجات

(Part 2)

Dr. Israa Kamil Ahmed

د . اسراء كامل احمد

Part Two in this Chapter

Wavelength and Frequency **الطول الموجي والتردد**

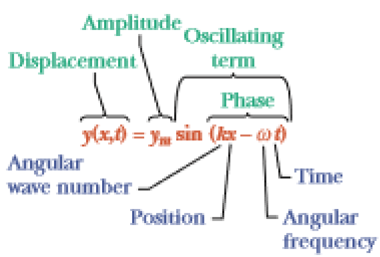
To completely describe a wave (the motion of any element along its length), we need a function that gives the shape of the wave. This means that we need a relation in the form

$$y = h(x,t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

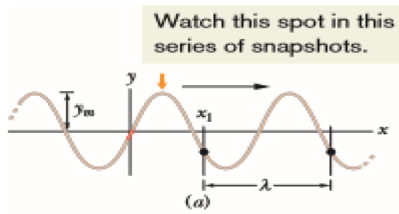
in which y is the transverse displacement of any string element as a function h of the time t and the position x of the element along the string.

In general, a sinusoidal shape like the wave in Fig.1 can be described with h being either a sine or cosine function; both give the same general shape for the wave the elements oscillate parallel to the y axis.at time t the displacement y of the element located at position x is given by

$$y\,(x,t\,) = y_m \sin(kx - wt) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\,(1)$$



The names of the quantities in Eq.1 for a transverse sinusoidal wave.



Wavelength and Angular Wave Number Period, Angular Frequency, and Frequency

الطول الموجي والعدد الموجي الزاوي والتردد الزاوي والتردد

The wavelength **λ** of a wave is the distance (parallel to the direction of the wave's travel) between repetitions of the shape of the wave (or wave shape).A typical wavelength is marked in Fig.2, which is a snapshot of the wave at time t = 0. At that time, gives, for the description of the wave shape,

$\boldsymbol{y\ (x, 0) = y_m \sin kx\ x - wt}$**.........................معادلة الحركة الموجية.....**

$\boldsymbol{k = \frac{2\pi}{\lambda}}$ **(Angular wave number).................العدد الموجي الزاوي...**

We call ***k*** the angular wave number of the wave; its **SI** unit is the radian per meter, or the inverse meter. (Note that the symbol ***k*** here does not represent a spring constant as previously.)

We define the period of oscillation **T** of a wave to be the time any string element takes to move through one full oscillation. A typical period is marked on the graph of Fig. 2.

$\boldsymbol{\omega = \frac{2\pi}{T}}$ ....التردد الزاوي. (Angular frequency)

We call $\boldsymbol{\omega}$ the angular frequency of the wave; its **SI** unit is the radian per second..

The frequency ***f*** of a wave is defined as **1/T** and is related to the angular frequency $\boldsymbol{\omega}$ by

$\boldsymbol{f = \frac{1}{T} = \frac{2\pi}{T}}$ **.................. التردد frequency**

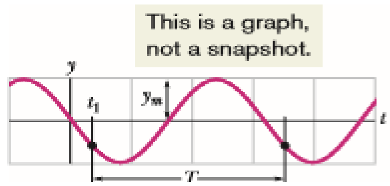


Fig. 2 A graph of the displacement of the string element at x = 0 as a function of time, as the sinusoidal wave of Fig.5-4 passes through the element. The amplitude y_m is indicated. A typical period T measured from an arbitrary time t_1, is also indicated

The Speed of a Traveling Wave

To find the wave speed ***v***

$$v = \frac{\omega}{k}\frac{\frac{2\pi}{T}}{\frac{2\pi}{\lambda}} = \frac{\lambda}{T} = \lambda f$$ **(Wave speed) ………………… سرعة الموجة او السرعة الموجية**

The equation $v = l/T$ tells us that the wave speed is one wavelength per period; the wave moves a distance of one wavelength in one period of oscillation.

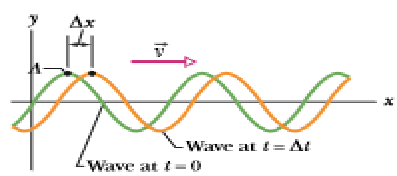


Fig.3, at time t = 0 and then at time t =Δt .As the wave moves to the right at velocity $v^{\rightarrow}$,the entire curve shifts a distance Δx during Δt.Point A "rides" with the wave form,but the string elements move only up and down

$$\frac{dx}{dt} = -\frac{\omega}{k}$$ …………………

The minus sign verifies that the wave is indeed moving in the negative direction of *x* and justifies our switching the sign of the time variable

Consider now a wave of arbitrary shape, given by

$$y\,(x,t) = h(kx \mp \omega t)$$……………………………

Where ***h*** represents any function, the sine function being one possibility.

EXAMPLE:

A wave traveling along a string is described by $y\,(x,t) = 0.00327\sin(72.1x - 2.72t)$

In which the numerical constants are in **SI** units (0.00327 m, 72.1 rad/m, and 2.72 rad/s).

(a) What is the amplitude of this wave? (b) What are the wavelength, period, and frequency of this wave? (c) What is the velocity of this wave? (d) What is the displacement *y* of the string at *x* = 22.5 cm and *t* = 18.9 s?

Transverse wave, amplitude, wavelength, period, velocity

A wave traveling along a string is described by

$$y(x,t) = 0.00327\sin(72.1x - 2.72t),$$

in which the numerical constants are in SI units (0.00327 m, 72.1 rad/m, and 2.72 rad/s).

(a) What is the amplitude of this wave?

KEY IDEA

$$y = y_m \sin(kx - \omega t),$$

so we have a sinusoidal wave. By comparing the two equations, we can find the amplitude.

Calculation: We see that

$$y_m = 0.00327 \text{ m} = 3.27 \text{ mm}. \qquad \text{(Answer)}$$

(b) What are the wavelength, period, and frequency of this wave?

Calculations:

$$k = 72.1 \text{ rad/m} \quad \text{and} \quad \omega = 2.72 \text{ rad/s}.$$

We then relate wavelength λ to k via Eq. 16-5:

$$\lambda = \frac{2\pi}{k} = \frac{2\pi \text{ rad}}{72.1 \text{ rad/m}} = 0.0871 \text{ m} = 8.71 \text{ cm}. \qquad \text{(Answer)}$$

Next, we relate T to ω with Eq. 16-8:

$$T = \frac{2\pi}{\omega} = \frac{2\pi \text{ rad}}{2.72 \text{ rad/s}} = 2.31 \text{ s}, \qquad \text{(Answer)}$$

and from Eq. 16-9 we have

$$f = \frac{1}{T} = \frac{1}{2.31 \text{ s}} = 0.433 \text{ Hz}. \qquad \text{(Answer)}$$

(c) What is the velocity of this wave?

Calculation: The speed of the wave is given by

$$v = \frac{\omega}{k} = \frac{2.72 \text{ rad/s}}{72.1 \text{ rad/m}} = 0.0377 \text{ m/s} = 3.77 \text{ cm/s}. \qquad \text{(Answer)}$$

$$\begin{aligned} y &= 0.00327\sin(72.1 \times 0.225 - 2.72 \times 18.9) \\ &= (0.00327 \text{ m})\sin(-35.1855 \text{ rad}) \\ &= (0.00327 \text{ m})(0.588) \\ &= 0.00192 \text{ m} = 1.92 \text{ mm}. \qquad \text{(Answer)} \end{aligned}$$

REFERENCE

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