Wave Speed

Determining wave speed

- Universal Wave Equation
- valid for all waves and wave types
- frequency (cycles / time) x wavelength (dist./cycles)

$$v = f\lambda$$

USING THE UNIVERSAL WAVE EQUATION (PG. 389)

1. If a wave has a frequency of 230 Hz and a wavelength of 2.3 m, what is its speed? T/I [ans: 530 m/s]

Given:

$f = 230\ Hz$

$= 230\ \frac{1}{s}$

$\lambda = 2.3\ m$

Required:

v = speed

Analysis:

$v = f\lambda$

Steps:

$v = \left(230\ \frac{1}{s}\right)(2.3\ m)$

$v = 530\ m/s$

USING THE UNIVERSAL WAVE EQUATION (PG. 389)

2. If a wave has a speed of 1500 m/s and a frequency of 11 Hz, what is its wavelength? [ans: 140 m]

Given: $v = 1500 \frac{m}{s}$

$f = 11\ Hz$

$= 11 \frac{1}{s}$

Required: λ = wavelength

Analysis: $v = f\lambda$

Steps: $\lambda = \frac{v}{f}$

$\lambda = \frac{1500 \frac{m}{s}}{11 \frac{1}{s}}$

$\lambda = 140\ m$

USING THE UNIVERSAL WAVE EQUATION (PG. 389)

3. If a wave has a speed of 405 m/s and a wavelength of 2.0 m, what is its frequency? T/I
[ans: 2.0×10^2 Hz]

Given: $v = 405$ m/s
$\lambda = 2.0$ m

Required: f = frequency

Analysis: $v = f\lambda$

Steps: $f = \frac{v}{\lambda}$

$f = \frac{405 \text{ m/s}}{2.0 \text{ m}}$

$f = 202 \, (1/s)$

$f = 2.0 \times 10^2$ Hz

Factors that affect wave speed

- More rigid intermolecular forces allow for a faster transfer of energy, and therefore a higher wave speed in a medium

- Waves travel faster in hotter gases than in cooler gases because of the increased molecular motion caused by the higher temperature in a hotter gas

Linear density and tension (strings)

- A string's linear density, (mass per unit distance) determines how much force it will take to make the string vibrate

$$\mu = \frac{m}{L}$$

- m is the mass of the string in kilograms
- L is the length of the string in metres

Linear density and tension

- Another variable affecting wave speed is tension. A loose string will absorb energy, a taut (tight) string will transmit energy very effectively

$$v = \sqrt{\frac{F_T}{\mu}}$$

- F_T is the tension in the string (N)
- μ is the linear density (kg / m)

DETERMINING STRING PROPERTIES (PG. 391)

1. If a 2.5 m long string on the same wave machine has a tension of 240 N, and the wave speed is 300 m/s, what is the mass of the string? T/I [ans: 6.7×10^{-3} kg]

Given: $L = 2.5\,m$

$F_T = 240\,N$

$v = 300\,m/s$

Required: m = mass

Analysis: $\mu = \frac{m}{L}$

$$v = \sqrt{\frac{F_T}{\mu}}$$

① determine μ

② determine m

Steps: $v = \sqrt{\frac{F_T}{\mu}}$

$$v^2 = \frac{F_T}{\mu}$$

$$\mu = \frac{F_T}{v^2}$$

$$\mu = \frac{240\,N}{\left(300\,\frac{m}{s}\right)^2}$$

$$= \frac{240\ kg\frac{m}{s^2}}{90\,000\ \frac{m^2}{s^2}}$$

$$\mu = 2.667\times10^{-3}\ kg/m$$

$$\mu = \frac{m}{L}$$

$$m = \mu L$$

$$= 2.667\times10^{-3}\ kg/m \times 2.5\,m$$

$$m = 6.7\times10^{-3}\ kg.$$

DETERMINING STRING PROPERTIES (PG. 391)

2. If a wave machine string has a linear density of 0.2 kg/m and a wave speed of 200 m/s, what tension is required? T/I [ans: 8×10^3 N]

Given: $\mu = 0.2\ kg/m$

$v = 200\ m/s$

Required: F_T = tension

Analysis: $v = \sqrt{F_T/\mu}$

Steps

$v = \sqrt{F_T/\mu}$

$v^2 = \frac{F_T}{\mu}$

$F_T = v^2 \mu$

$F_T = \left(200\frac{m}{s}\right)^2 0.2\frac{kg}{m}$

$F_T = \left(40000\frac{m^2}{s^2}\right)\left(0.2\frac{kg}{m}\right)$

$F_T = 8000\ \frac{m\ kg}{s^2}$

$F_T = 8 \times 10^3\ N$

Determining String properties (pg. 391)

3. If a string on a wave machine has a linear density of 0.011 kg/m and a tension of 250 N, what is the wave speed? T/I [ans: 1.5×10^2 m/s]

Given: $\mu = 0.011 \frac{kg}{m}$

$F_T = 250\ N$

$= 250 \frac{kg\,m}{s^2}$

Required: v = speed

Analysis: $v = \sqrt{F_T/\mu}$

Steps:

$v = \sqrt{\frac{250\ kg\,m/s^2}{0.011\ \frac{kg}{m}}}$

$\frac{m/s^2}{1/m} = \frac{m}{s^2} \times \frac{m}{1} = \frac{m^2}{s^2}$

$v = \sqrt{22727 \frac{m^2}{s^2}}$

$v = 150\ m/s$

Work

- Pg. 391 #1-3, 4ab, 5-7
- Read 8.5 pgs. 392 - 397