Assignment-1

EE:1205 Signals and Systems
Indian Institute of Technology, Hyderabad

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I. Question 12.15.1

A string of mass 2.50 kg is under a tension of 200 N. The length of the stretched string is 20.0 m. If the transverse jerk is struck at one end of the string, how long does he disturbance take to reach the other end ?

II. Solution

We know

No.	Variable	Value
1	M	2.5 kg
2	T	200 N
3	l	20 m

TABLE 1
Values

Mass per unit length

$$\mu = \frac{M}{l} = \frac{2.5}{20} = 0.125\ kgm^{-1} \tag{1}$$

The velocity (v) of the transverse wave in the string is given by the relation

$$v = \sqrt{\frac{T}{\mu}} \tag{2}$$

$$= \sqrt{\frac{200}{0.125}} \tag{3}$$

$$= 40\ m/s \tag{4}$$

Calculating the time taken,

$$t = \frac{l}{v} = \frac{20}{40} = 0.5\ s \tag{5}$$

We can calculate the equation of the wave by using

$$y = Asin[kx + \omega t] \tag{6}$$

We know

$$\nu = \frac{1}{t} = 2\ Hz \tag{7}$$

$$\therefore \omega = 2\pi\nu = 4\pi \tag{8}$$

Wavelength,

$$v = \lambda\nu \tag{9}$$

$$40 = 2\lambda \tag{10}$$

$$\therefore \lambda = 20m \tag{11}$$

from this, we get the value of k

$$k = \frac{2\pi}{\lambda} = \frac{\pi}{10} \tag{12}$$

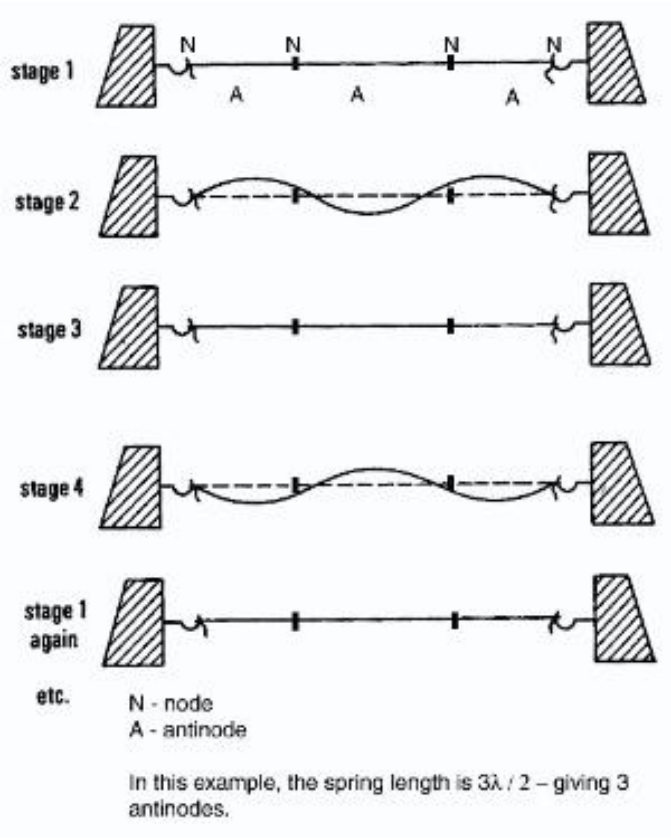
Hence, the wave equation is given by

$$y = Asin[\frac{\pi x}{10} + 4\pi t] \tag{13}$$

Differentiating this displacement equation and putting the values, we can get the wave velocity equation

$$V_y = 8\pi Acos[\frac{\pi x}{10} + 4\pi t] \tag{14}$$

and the time taken to reach the other end of the string is 0.5 s


stage 1
N
N
N
N
A
A
A
stage 2
stage 3
stage 4
stage 1
again
etc.
N - node
A - antinode
In this example, the spring length is 3λ / 2 – giving 3 antinodes.