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[BCT-A] 019

Assignment - 2 [Wave motion]

DATE

1) The speed of transverse wave on string is 170 m/s when string tension 120 N. To what value must the tension be changed to raise the wave speed to 180 m/s.

=> Soln,

$V_1 = 170$ m/s $\quad V_2 = 180$ m/s

$T_1 = 120$ N $\quad T_2 = ?$

Now,

$$\frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\frac{170}{180} = \sqrt{\frac{120}{T_2}}$$

$$T_2 = \frac{120}{0.89}$$

$$\therefore T_2 = 134.53 \text{ N.}$$

2) A rod vibrating at 12 Hz generates harmonic waves with amplitude of 1.5 mm in a string of linear mass density 2gm/m. If the tension on string is 15 N. What is the average power supplied by source.

=> given.

$f = 12 H_z$

$a = 1.5$ mm $= 1.5 \times 10^{-3}$ m.

$\mu = 2$ gm/m $\longrightarrow 0.002$ kg/m

$T = 15$ N

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We have

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{15}{0.002}} = 86.60 \text{ m/s}$$

Now,

$$P = 2\pi^2 \rho f^2 a^2 A.v.$$
$$= 2\pi^2 \frac{m}{Al} f^2 a^2 A.v.$$
$$= 2\pi^2 \mu f^2 a^2 A.v$$
$$= 2 \times (3.14)^2 \times 0.002 \times 12^2 \times (1.5 \times 10^{-3})^2 \times 86.60$$
$$= 1.107 \times 10^{-3} \omega \#$$

(3) A string has linear density of 625 gm/m & is stretch with tension of 50N. A wave, whose of requeired & amplidtude are 160 Hz & 10mm resp. is travelling along the string. Find the power.

⇒ Given

$\mu = 625$ gm/m $= 0.625$ kg/m

$T = 50$ N

$a = 10$ mm $= 1 \times 10^{-2}$ m

$f = 160$ Hz

We have,

$$v = \sqrt{\frac{T}{\mu}} = 8.95 \text{ m/s}$$

Now,

$$P = 2\pi^2 \rho a^2 f^2 A.v.$$
$$= 2\pi^2 \frac{m}{Al} a^2 f^2 A.v.$$
$$= 2\pi^2 \times 0.625 \times (1 \times 10^{-2})^2 \times (160)^2 \times 8.95$$
$$= 282.67 \omega \#$$

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4) The elastic limit of steel forming a piece of wire is equal to 2.7×10^8 Pa. What is the max^m speed at which transverse wave pulse can propagate along this wire without exceeding this stress?

⇒ Soln.

$$(\text{stress})_{max} = \frac{T}{A} = 2.7 \times 10^3 \text{ Pa}$$

Now,

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

$$= \sqrt{\frac{T}{m} \times l}$$

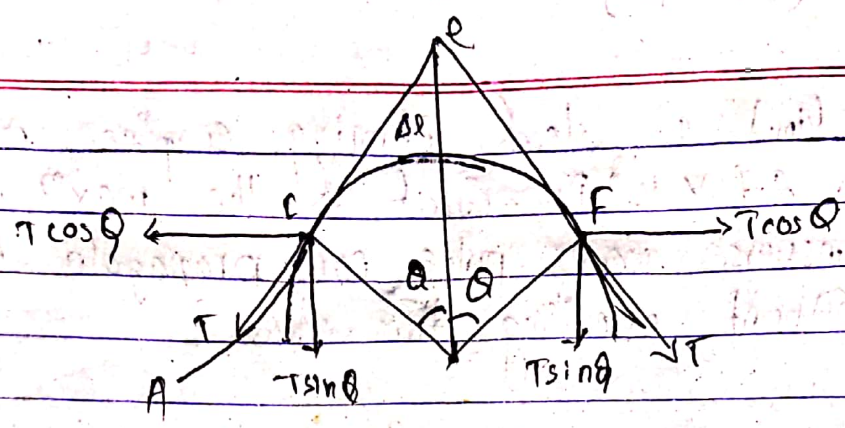
$$= \sqrt{\frac{T}{\rho . A . l} . l}$$

$$= \sqrt{\frac{\text{stress}}{\rho}}$$

$$= \sqrt{\frac{2.7 \times 10^8}{7.89 \times 10^3}}$$

$$= 184.98 \text{ m/s}$$ //

5) Derive a relation for speed of transverse wave in a stretched string & show that the average rate of energy transfer is $\frac{1}{2} \mu v \omega^2 A^2$, where the symbols are having usual meaning.



let us consider a string AEFB is stretch & hence, a transverse wave from left to right with velocity (v) found. A force with magnitude equal to string pulls tangentially on this element at each end so,

$$F = T\sin\theta + T\sin\theta$$

for small θ,

$$\sin\theta \approx \theta$$

so, $F = 2T\theta$

Here,

$$2\theta = \frac{\Delta l}{R}$$

$$F = \frac{\Delta l\, T}{R}$$

μ is the linear mass density & Δm is the mass of small element then,

$$\Delta m = \mu \Delta l$$

The element has cen. pr. acceleration

$$a = \frac{v^2}{R}$$

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So,

$F = ma$

$$T \times \frac{\Delta l}{R} = \mu \Delta l \times \frac{v^2}{R}$$

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

Now,

$$TE = \frac{1}{2} \rho \omega^2 a^2$$

$$= \frac{1}{2} \rho \, 4\pi^2 f^2 a^2$$

$$= \frac{1}{2} 4\pi^2 \rho f^2 a^2$$

$$= 2\pi^2 \rho f^2 a^2$$

Now,

TE for unit vol. $= 2\pi^2 \rho f^2 a^2 A v t$

Now,

$$\text{Power} = \frac{TE}{t}$$

$$= 2\pi^2 \rho f^2 a^2 A \cdot v$$

$$= 2\pi^2 \mu f^2 a^2 v$$

$$= 2\pi^2 \cdot \mu \frac{\omega^2}{4\pi^2} a^2 v$$

$$= \frac{1}{2} \mu \omega^2 a^2 v$$ #

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