DPP – 2 (Waves)

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Q 1. The speed of a wave on a string is 150 m/s when the tension is 120 N. The percentage increase in the tension in order to raise the wave speed by 20% is
(a) 44% (b) 40%
(c) 20% (d) 10%

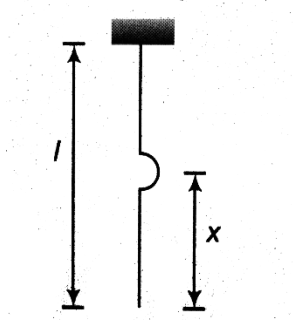
Q 2. If tension of a wire is increased to four times, how is the wave speed changed?
(a) Become 4 times (b) Become 2 times
(c) Become $\frac{1}{2}$ times (d) Become $\frac{1}{4}$ times

Q 3. Speed of transverse wave in a string of density 100 kg/m^3 and area of cross-section 10 mm^2 under a tension of 10^3 N is
(a) 100 m/s (b) 1000 m/s
(c) 200 m/s (d) 2000 m/s

Q 4. Transverse waves travel with a speed of 20.0m/s in a string under a tension of 6.00 N. what tension is required for a wave speed of 30.0m/s in the same string?
(a) 12 N (b) 11.5 N
(c) 4.5 N (d) 13.5 N

Q 5. What is the speed of a transverse wave in a rope of length 10 m and mass 80 gm under a tension of 80 N?
(a) 100 m/s (b) 200 m/s
(c) 300 m/s (d) 50 m/s

Q 6. A uniform rope of mass 0.1kg and length 2.45m hangs from a ceiling.
(a) Find the speed of transverse wave in the rope at a point 0.5m distant from the lower end.
(b) Calculate the time taken by a transverse wave to travel the full length of the rope.



(a) 1.11 m/s, 1 sec (b) 1.22 m/s, 2 sec

(c) 2.22 m/s, 1 sec (d) 3.11 m/s, 2 sec

Q 7. Along a stretched wire a transverse wave passes with speed 3000 m/s. If the tension in the wire increased four times, then the velocity of the wave is
(a) 1500 m/s (b) 3000 m/s
(c) 6000 m/s (d) 9000 m/s

Q 8. A uniform rope of length 12m and mass 6kg hangs vertically from a rigid support. A block of mass 2kg is attached to the free end of the rope. A transverse pulse of wavelengths 0.06m is produced at the lower end of the rope. What is the wavelength of the pulse when it reaches the top of the rope?
(a) 0.06 m (b) 0.12 m
(c) 0.24 m (d) 0.36 m

Q 9. A certain 120 Hz wave on a string has an amplitude of 0.160 mm. The amount of energy exists in an 80 g length of the string is 58×10^{-x} mJ. Find x
(a) 1 (b) 2
(c) 4 (d) 6

Q 10. If the frequency and amplitude of a transverse wave on a string are both doubled, then the amount of energy transmitted through the string is
(a) doubled (b) becomes 4 time
(c) Becomes 16 times (d) becomes 32 times

Q 11. A 200Hz wave with amplitude 1mm travels on a long string of linear mass density 6g/m keep under a tension of 60N.
(a) Find the average power transmitted across a given point on the string.
(b) Find the total energy associated with the wave in a 2.0m long portion of the string.
(a) 0.79 W, 3.9 mJ (b) 1.41 W, 1.9 mJ
(c) 0.12 W, 4.1 mJ (d) 0.47 W, 9.4 mJ

Q 12. The average power transmitted through a given point on a string supporting a sine wave is 0.20 W when the amplitude of the wave is 2.0 mm. What power will be transmitted through this point if the amplitude is increased to 3.0 mm.
(a) 0.45 W (b) 0.65 W
(c) 1.45 W (d) 1.65 W

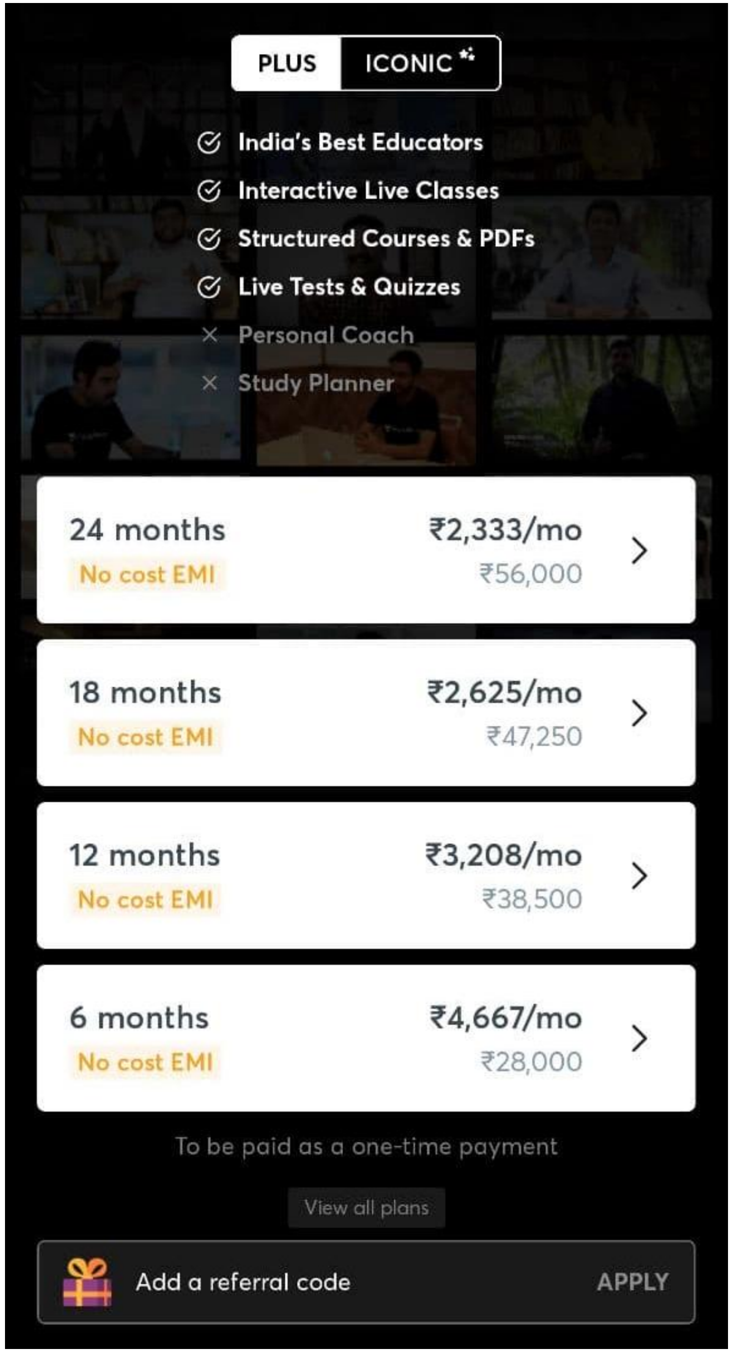
Q 13. A transverse wave of amplitude 0.50mm and frequency 100Hz is produced on a wire stretched to a tension of 100N. If the wave speed is 100m/s. What average power is the source transmitting to the wire?
(a) 45 mJ (b) 49 mJ
(c) 24 mJ (d) 37 mJ

Q 14. The time taken by a transverse wave going on a wire having mass 5 g, form one end to another end of wire is 0.5 s. The area of cross-section of wire is 1 mm^2 and Young's modulus of elasticity is 16×10^{11} N/m^2. The speed of wave is 80 m/s. The strain in wire is
(a) 2×10^{-7} (b) 5×10^{-7}

(c) 4×10^{-6} (d) 3×10^{-6}

Answer Key

Q.1 a	Q.2 b	Q.3 b	Q.4 d	Q.5 a
Q.6 c	Q.7 c	Q.8 b	Q.9 b	Q.10 c
Q.11 d	Q.12 a	Q.13 b	Q.14 b	



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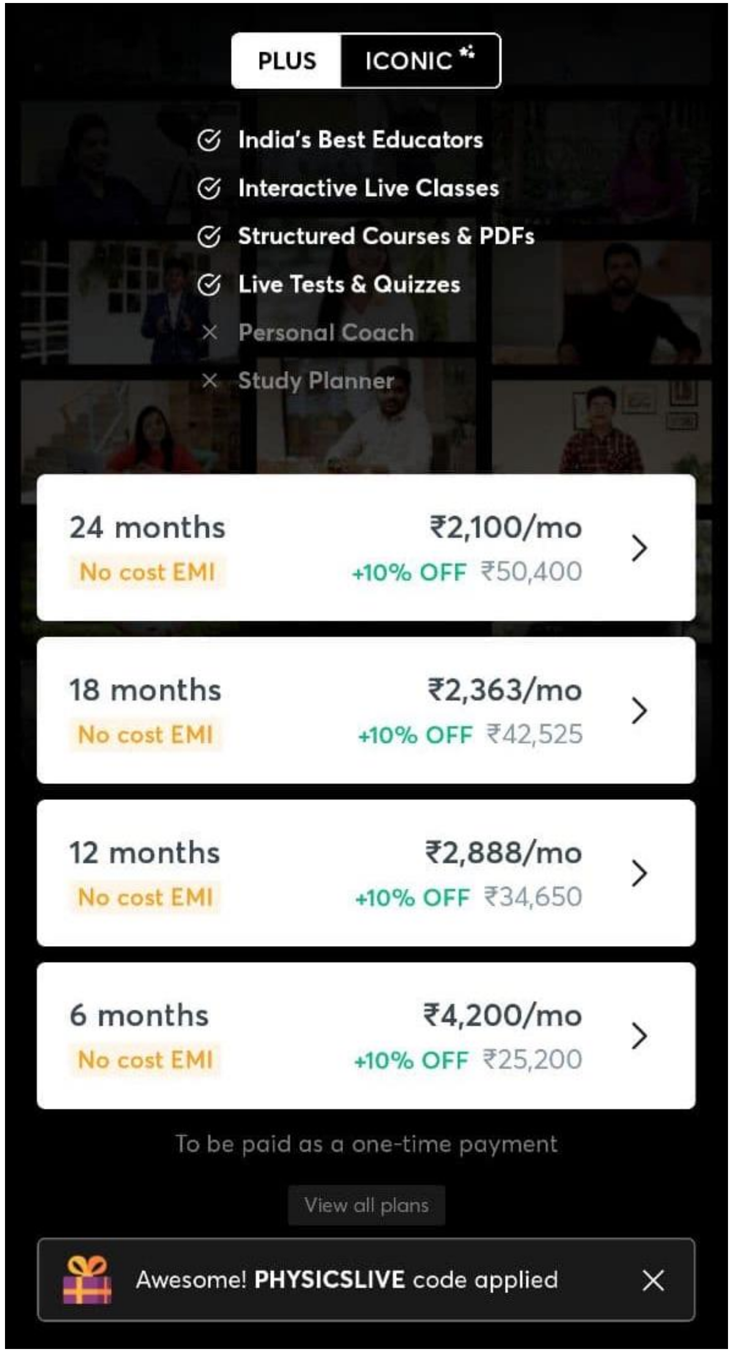


Written Solution

DPP-2 Waves: Waves on String & Energy related to Travelling wave

By Physicsaholics Team

Solution 1:

$v_1 = 150$ m/s ; $T_1 = 120$ N

$v_2 = v_1 + (20\%)v_1$

$= 1.2 v_1 = 150 \times 1.2$

$v_2 = 180$ m/s.

$v \propto \sqrt{T}$

then; $\frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$

$\frac{150}{180} = \sqrt{\frac{T_1}{T_2}}$

$\frac{5}{6} = \sqrt{\frac{T_1}{T_2}}$

$\left(\frac{5}{6}\right)^2 = \frac{120}{T_2}$

$T_2 = \left(\frac{6}{5}\right)^2 \times 120 = \frac{36}{25} \times 120$

$T_2 = 172.8$ N

% change $= \frac{T_2 - T_1}{T_1} \times 100$

so; $\frac{T_2 - T_1}{T_1} \times 100 = \frac{172.8 - 120}{120} \times 100$

$\frac{\Delta T}{T_1}\% = \frac{52.8}{120} \times 100$

$\frac{\Delta T}{T_1} = 44\%$ Ans.

Ans. a

Solution 2:

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

$$v \propto \sqrt{T}$$

$$\frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$$

when; $T_2 = 4T_1$

$$\frac{v_1}{v_2} = \sqrt{\frac{T_1}{4T_1}} = \frac{1}{2}$$

$$\boxed{v_2 = 2v_1}$$ Ans.

Ans. b

Solution 3:

$\rho = 100\ kg/m^3$

$A = 10\ mm^2 = 10^{-5}\ m^2$

μ = mass per unit length [kg/m]

$= \rho A = \left[100\ \frac{kg}{m^3}\right] \times \left[10^{-5}\ m^2\right]$

$\boxed{\mu = 10^{-3}\ kg/m}$

$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{10^3}{10^{-3}}} = 10^3$

$\boxed{v = 1000\ m/s}$ Ans

Ans. b

Solution 4:

$T_1 = 6N$; $v_1 = 20$ m/s.

$T_2 = ?$; $v_2 = 30$ m/s

$v \propto \sqrt{T}$

$\frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$

$\frac{20}{30} = \sqrt{\frac{6}{T_2}}$

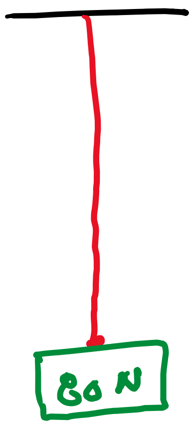
$\left(\frac{2}{3}\right)^2 = \frac{6}{T_2}$

$T_2 = \frac{9}{4} \times 6 = 9 \times 1.5$

$T_2 = 13.5\ N$ Ans

Ans. d

Solution 5:



$$\mu = \frac{80\,gm}{10\,m} = \frac{80\times10^{-3}\,kg}{10\,m}$$

$$\mu = 8\times10^{-3}\,kg/m$$

∵ self wt i.e. 80 gm is negligible w.r.t. Tension 80 N

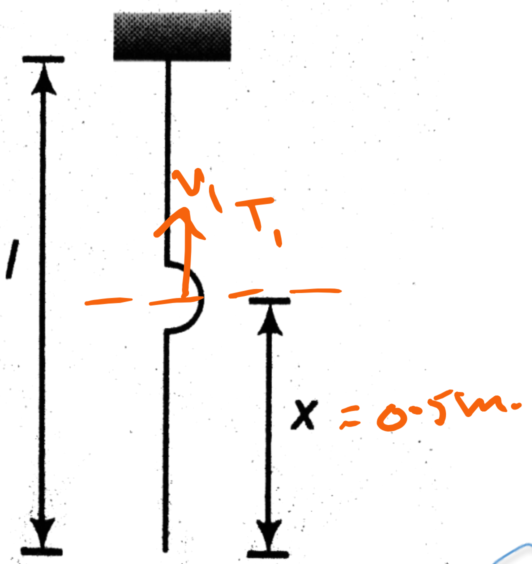
so; $T = 80\,N$ = uniform in complete string

so; $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{80}{8\times10^{-3}}} = \sqrt{10^4}$

$\boxed{V = 100\,m/s}$ Ans

Ans. a

Solution 6:



$\mu = \frac{0.1}{2.45} = \frac{1}{24.5}$ kg/m

mass in 0.5m length

$m_1 = \mu \times 0.5 = \frac{1}{24.5} \times 0.5$

$m_1 = \frac{5}{245} = \frac{1}{49}$ kg.

(a) so; at $x = 0.5m$

Tension in string

$T_1 = m_1 g = \frac{1}{49} \times 9.8$

$T_1 = \frac{98}{49} \times 10^{-1}$

$\boxed{T_1 = 0.2\,N}$

so; $v_1 = \sqrt{\frac{T_1}{\mu}} = \sqrt{\frac{0.2}{1/24.5}}$

$v_1 = \sqrt{0.2 \times 24.5}$

$v_1 = \sqrt{4.9}$ m/s

$\boxed{v_1 \simeq 2.22 \text{ m/s}}$

(b) $t = 2\sqrt{\frac{L}{g}}$

$t = 2\sqrt{\frac{2.45}{9.8}}$

$t = 2\sqrt{0.25}$

$t = 2 \times 0.5$

$\boxed{t = 1 \text{ sec}}$

Ans. c

Solution 7:

$v_1 = 3000$ m/s

$T_1 = T$

when; $T_2 = 4T$

$v_2 = ?$

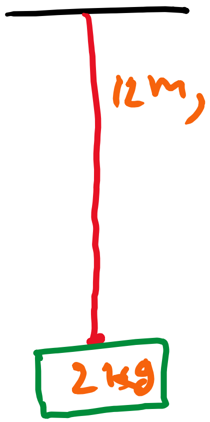
so; $\frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$

$\frac{3000}{v_2} = \sqrt{\frac{T}{4T}} = \frac{1}{2}$

$v_2 = 6000$ m/s Ans

Ans. c

Solution 8:



12m, 6kg

$\mu = \frac{6}{12} = 0.5$ kg/m

at bottom point

$T_1 = 2g = 20N$

$v_1 = \sqrt{\frac{T_1}{\mu}}$

$V = f\lambda$

$f =$ same

so; $v \propto \lambda$

so; $v \propto \lambda$ and $v \propto \sqrt{T_1}$

so; $\lambda \propto \sqrt{T_1}$

at upper end; $T_2 = (2+6)g = 8g$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\Rightarrow \frac{0.06}{\lambda_2} = \sqrt{\frac{2g}{8g}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$$

$\lambda_2 = 0.12$ m Ans

Ans. b

Solution 9:

$$E = \frac{1}{2}(\mu L)\omega^2 A^2$$

$$= \frac{1}{2} m \omega^2 A^2$$

$$= \frac{1}{2}(80\times10^{-3}) \times (2\pi\times120)^2 \times (0.160\times10^{-3})^2$$

$$= 40\times10^{-3} \times (240\pi)^2 \times 0.0256\times10^{-6}$$

$$= 58.1\times10^{4}\times10^{-9}\ J$$

$$\simeq 58\times10^{-5}\ J$$

$$\boxed{E = 58\times10^{-2}\ mJ}$$

So; $\boxed{x = 2}$

Ans. b

Solution 10:

$f \to 2f$

$A \to 2A$

$E \propto \omega^2 A^2$

$\because \omega \propto f$

So, $E \propto f^2 A^2$

$$\frac{E_1}{E_2} = \frac{(f_1 A_1)^2}{(2f_1 \cdot 2A_1)^2}$$

$$\frac{E_1}{E_2} = \frac{1}{4^2} = \frac{1}{16}$$

$\boxed{E_2 = 16E_1}$ Ans

Ans. c

Solution 11:

$f = 200\ Hz$; $A = 1\ mm = 10^{-3}\ m$

$\mu = 6\ g/m = 6\times10^{-3}\ kg/m$

$T = 60\ N$

$P_{avg} = \frac{1}{2}\mu v A^2\omega^2$

$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{60}{6\times10^{-3}}} = \sqrt{10^4}$

$\boxed{v = 100\ m/s}$

so, $P_{avg} = \frac{1}{2}(6\times10^{-3})\times(100)\times(10^{-3})^2\times(2\pi\times200)^2$

$= 3\times10^{-3}\times10^2\times10^{-6}\times4\pi^2\times4\times10^4$

$= 3\times16\pi^2\times10^{-3}$

$\boxed{P_{avg} = 0.47\ W}$

(b) time to travel 2 m

$t = \frac{x}{v} = \frac{2}{100} = 0.02\ sec$

$E = P\times t$

$E = 0.47\times0.02$

$\boxed{E = 9.4\ mJ}$

Ans. d

Solution 12:

$P_{avg} = 0.20\ W$

$A = 2\ mm$

$\because P_{avg} \propto A^2$

so;

$$\frac{(P_{avg})_1}{(P_{avg})_2} = \left(\frac{A_1}{A_2}\right)^2$$

$$\frac{0.20}{(P_{avg})_2} = \left(\frac{2\ mm}{3\ mm}\right)^2 = \frac{4}{9}$$

$$(P_{avg})_2 = \frac{9}{4} \times 0.2$$

$$\boxed{(P_{avg})_2 = 0.45\ W}$$

Ans. a

Solution 13:

$A = 0.5\ mm$

$f = 100\ Hz$

$\omega = 200\pi\ rad/s$

$T = 100\ N$

$v = 100\ m/s$

$P_{avg} = \frac{1}{2}\mu v A^2\omega^2$

$\because v = \sqrt{\frac{T}{\mu}} \Rightarrow \mu = \frac{T}{v^2}$

$\Rightarrow P_{avg} = \frac{1}{2}\frac{T}{v^2} v A^2\omega^2$

$= \frac{1}{2}\frac{T}{v}A^2\omega^2$

$= \frac{1}{2}\times\frac{100}{100}\times(5\times10^{-4})^2\times(200\pi)^2$

$P_{avg} = \frac{1}{2}\times 25\times10^{-8}\times 4\pi^2\times10^4$

$= 50\pi^2\times10^{-4}$

$= 493.4\times10^{-4}$

$= 49.34\times10^{-3}\ J$

$\boxed{P_{avg} \simeq 49\ mJ}$ Ans

Ans. b

Solution 14:

$m = 5\ gm$

$t = 0.5\ sec$

$A = 1\ mm^2 = 10^{-6}\ m^2$

$Y = 16 \times 10^{11}\ N/m^2$

$V = 80\ m/s$

$Y = \frac{stress}{strain} = \frac{\sigma}{\epsilon}$

$\epsilon = \frac{\sigma}{Y} = \frac{T/A}{Y}$

$\epsilon = \frac{T}{AY}$

$\&\ v = \sqrt{\frac{T}{\mu}} \rightarrow T = \mu v^2$

length of wire $= l = vt$

$= 80 \times 0.5$

$= 40\ m$

so; $\mu = \frac{5}{40}\ g/m = \frac{1}{8}\ g/m = \frac{10^{-3}}{8}\ kg/m$

so; $T = \mu V^2 = \frac{10^{-3}}{8} \times (80)^2 = 10^{-1} \times 8$

$\boxed{T = 0.8\ N}$

so; $\epsilon = \frac{0.8}{10^{-6} \times 16 \times 10^{11}} = \frac{0.8}{16 \times 10^5}$

$\epsilon = \frac{8}{16} \times 10^{-6} = \frac{1}{2} \times 10^{-6}$

$\boxed{\epsilon = 5 \times 10^{-7}}$ Ans

Ans. b

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Chalo Niklo