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PRAYAS

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Lecture - 04

Physics

Waves

By- Saleem Ahmed Sir

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Topics *to be covered*

1. Qus Practice
2.
3.
4.

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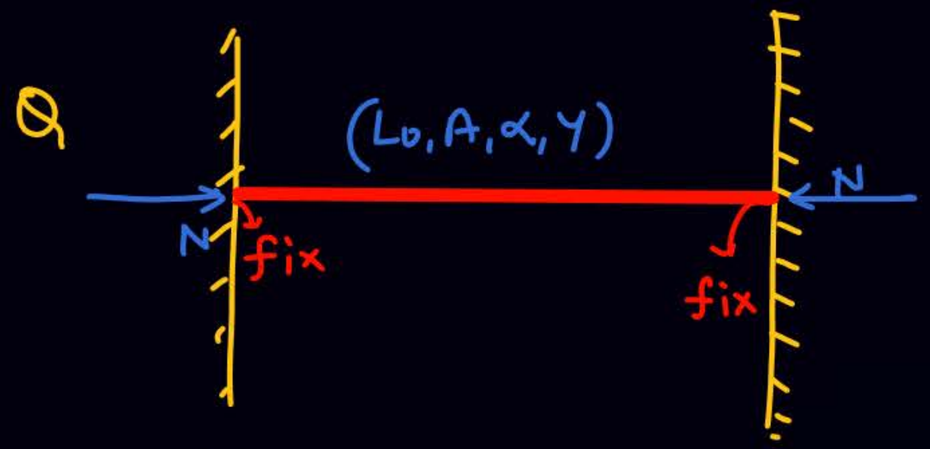
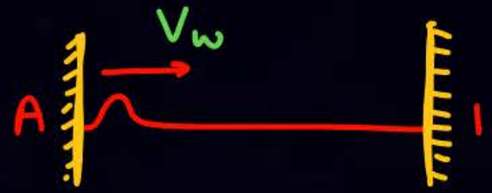


If temp of rod is decrease by $\Delta\theta$

$$N_{wall} = AY\alpha\Delta\theta$$



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$$\frac{F}{A} = Y\frac{\Delta l}{l}$$

$$\frac{N_{wall}}{A} = Y\alpha\Delta\theta$$

$$V_w = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{N_{wall}}{\mu}}$$

$$V_w = \sqrt{\frac{AY\alpha\Delta\theta}{M/L}}$$

$$t = \frac{AB}{V_w}$$

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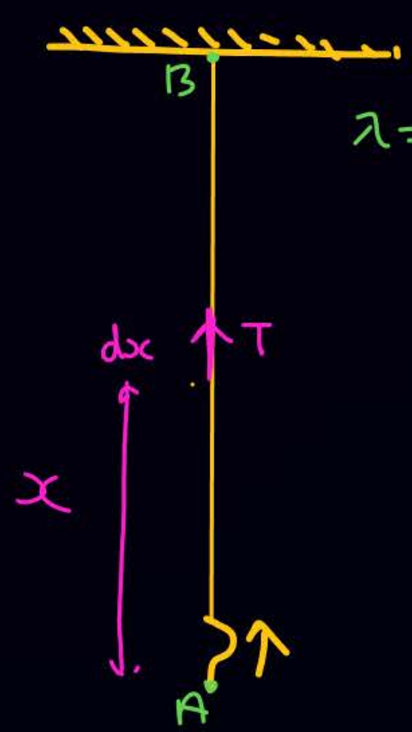

→ Distance from Lower point A

$\lambda = \lambda_0 x$ mass per unit length $\equiv \lambda$

find time taken by pulse to move from A ⟶ B.

$T = m_x g$

$m_x = \int \lambda\, dx = \int_0^x \lambda_0 x \cdot dx = \frac{\lambda_0 x^2}{2}$

$V_w = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{\frac{\lambda_0 x^2}{2} \cdot g}{\lambda_0 x}} = \sqrt{\frac{xg}{2}} = \frac{dx}{dt}$

$\int_0^L \frac{dx}{\sqrt{x}} = \int_0^{t_0} \sqrt{\frac{g}{2}}\, dt$

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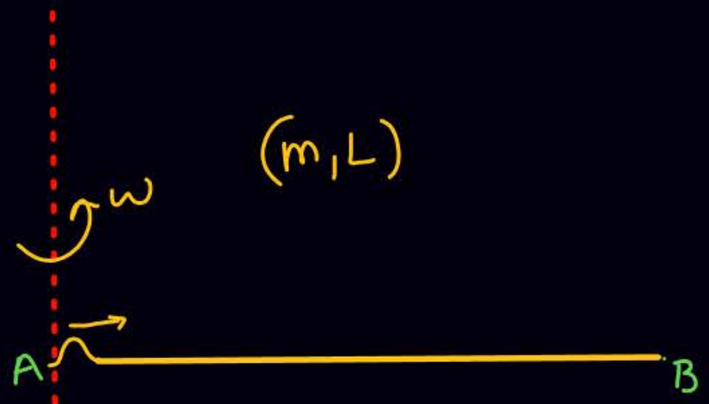

$$T = m' r_{com} \omega^2$$

$$T = \frac{m}{L}(L-x)\left(x + \frac{L-x}{2}\right)\omega^2$$

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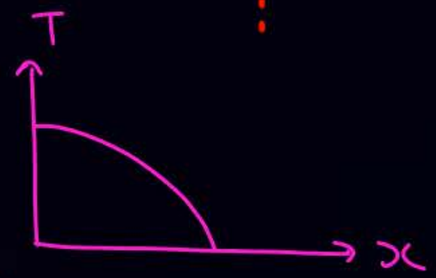
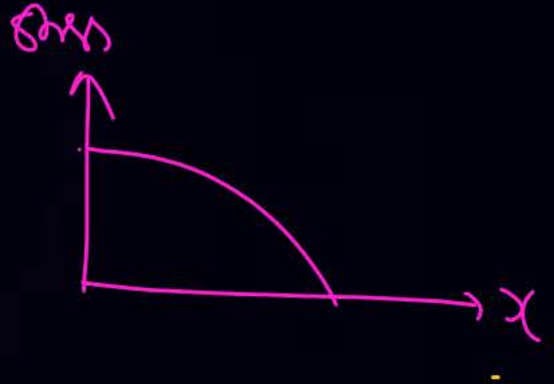
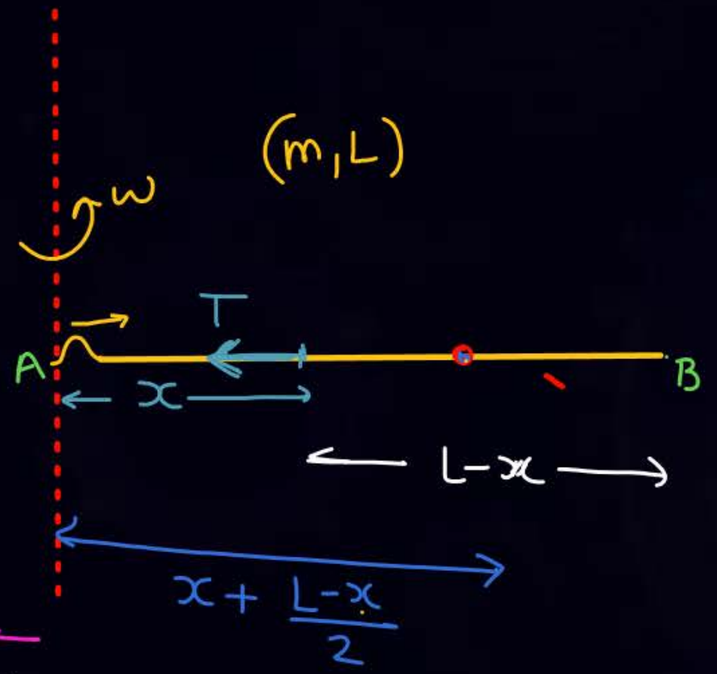
$$T = \frac{m}{2L}(L^2 - x^2)\omega^2$$

Elasticity







$$V_w = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{\frac{m}{2L}(L^2 - x^2)\omega^2}{m/L}} = \frac{dx}{dt}$$

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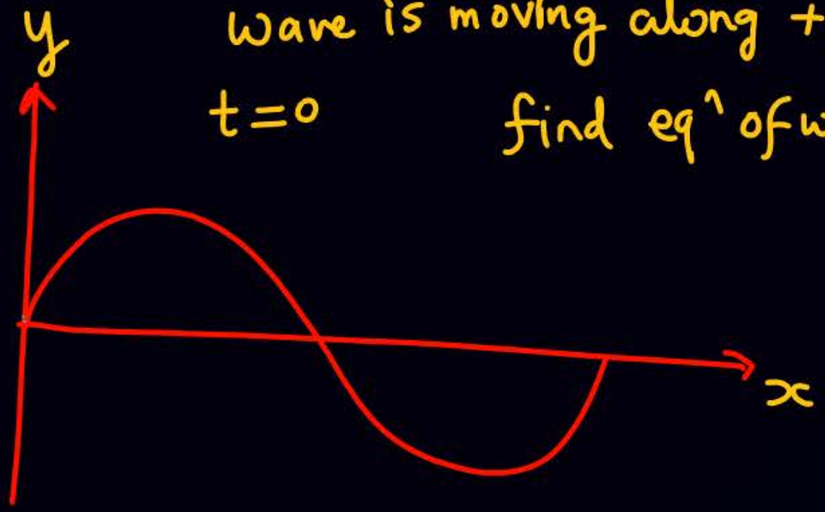
Q wave is moving along $+x$ axis



$t = 0$ find eq^n of wave

(M-1)

$$y = A\sin k(x - vt)$$
$$= A\sin(kx - \omega t)$$

$$V_p = -V_w(\text{slope})$$

$x = 0$ वाला particle $\Rightarrow V_p = - + + \Rightarrow V_p < 0$

$$V_p = \frac{\partial y}{dt} = A\omega\cos(\omega t - kx + \phi)$$

$$y = A\sin(\omega t - kx + \phi)$$

put $x = 0,\ t = 0,\ y = 0$

$$0 = A\sin(0 - 0 + \phi)$$

$$\sin\phi = 0$$

$\phi \rightarrow 0$, π

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$t = 0,\ x = 0,\ V_p < 0$

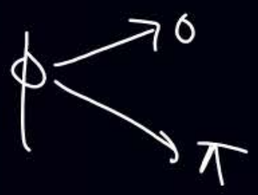
$$V_p = A\omega\cos(0 - 0 + \phi) < 0$$

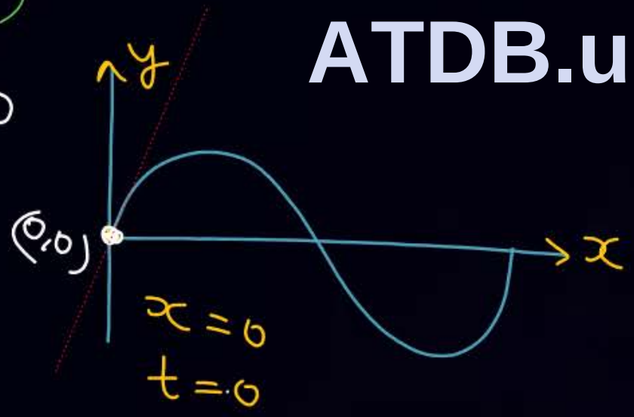
$$\cos\phi < 0$$

$$\boxed{\phi = \pi}$$

$$y = A\sin(\omega t - kx + \pi) = -A\sin(\omega t - kx)$$

$$A\sin(kx - \omega t)$$
$$\parallel$$





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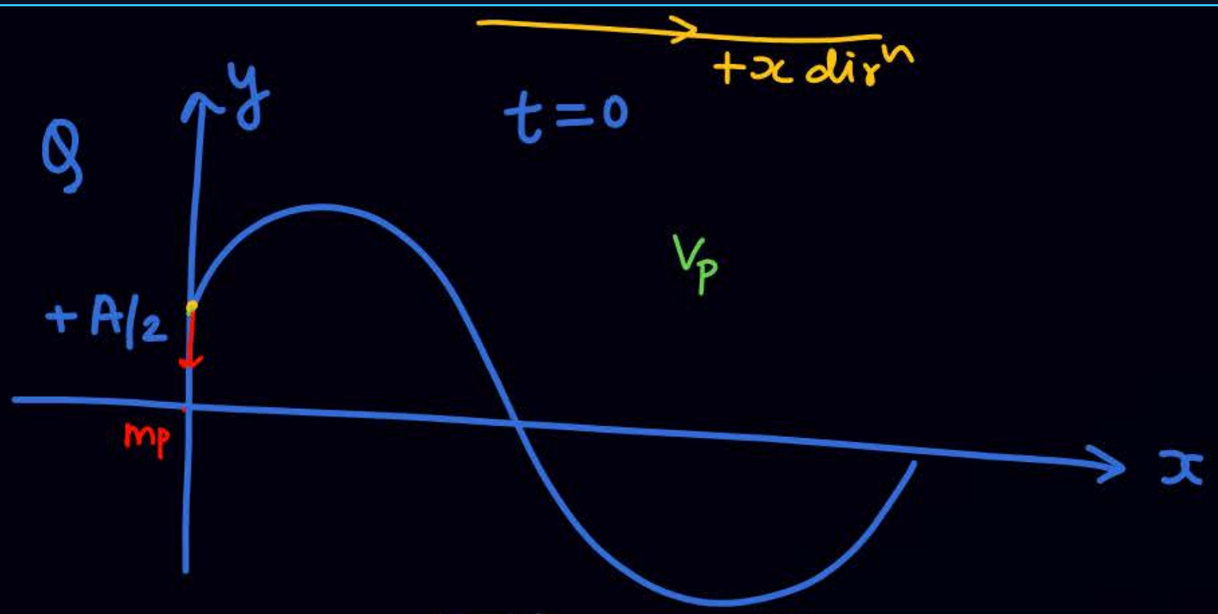
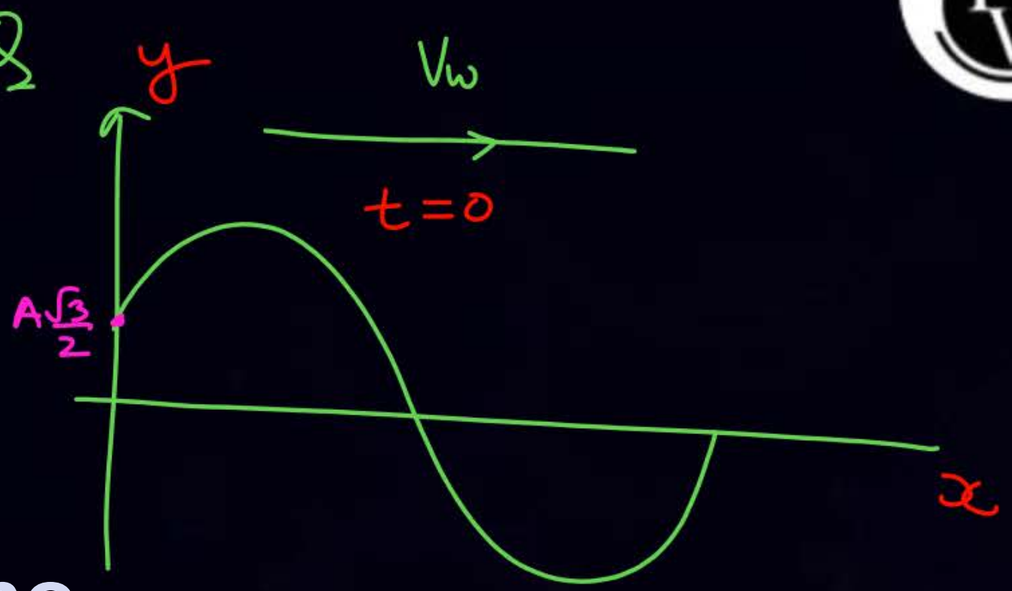
$V_p = - + +$





$V_p < 0$

$y = A\sin(\omega t - kx + 150)$

$y = A\sin(\omega t - kx + 120)$

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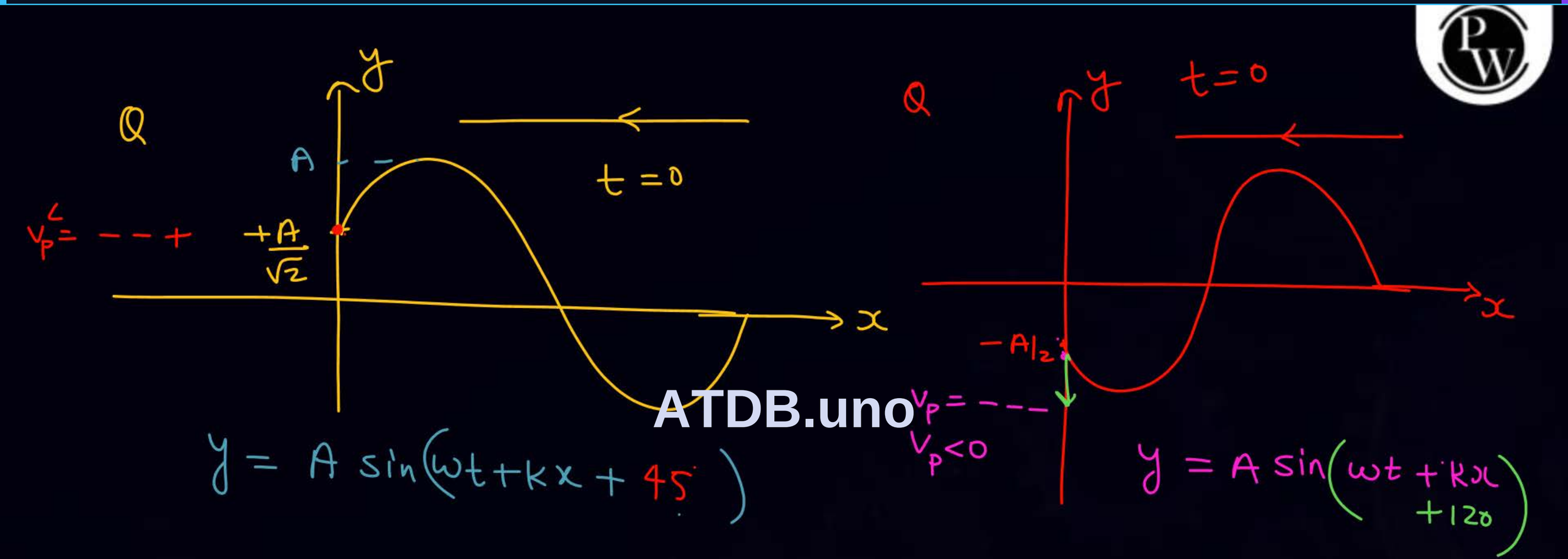

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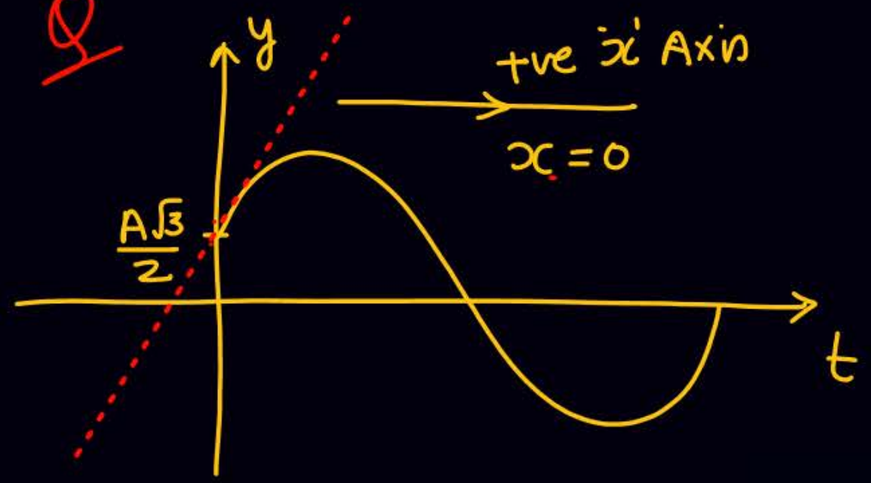
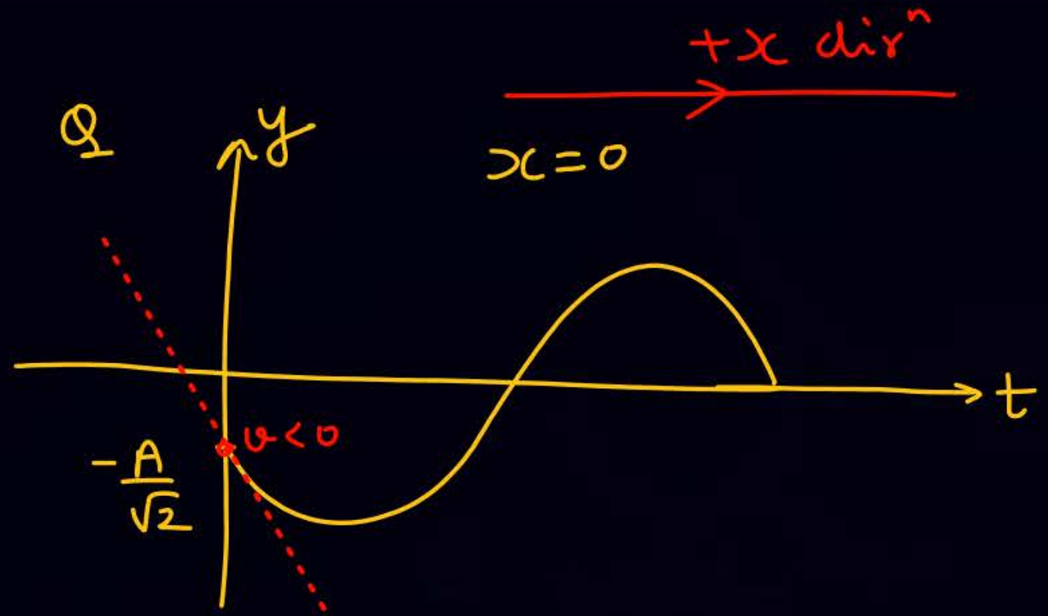
Q



$y = A\sin(\omega t - kx + 60^\circ)$

Q



$y = A\sin(\omega t - kx + 225)$

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Ex.3 $Y(x,t) = 0.05 / [(4x + 2t)^2 + 5]$ represents a moving wave pulse, where x and y are in meters and t is in seconds. Then which statement(s) are **CORRECT**:

(A) Pulse is moving in – x direction

(B) Wave speed is 0.5 m/s

(C) Maximum particle displacement is 1 cm

(D) It is a symmetric pulse

समीकरण $Y(x,t) = 0.05 / [(4x + 2t)^2 + 5]$ एक गतिशील तरंग स्पन्द को व्यक्त करती है। यहां x तथा y मीटर में तथा t सेकण्ड में है। सही कथन(कथनों) को चुनिये।

(A) स्पन्द – x दिशा में गतिशील है।

(B) तरंग चाल 0.5 m/s है।

(C) अधिकतम कणीय विस्थापन 1 cm है।

(D) यह एक सममित स्पन्द है।

Ans. **(A,B,C,D)**

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$y = \frac{.05}{(4x+2t)^2+5}$ → max

$V_w = \frac{2}{4} = \frac{1}{2}$ (–x में)

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4. A long uniform string of mass density 0.1 kg/m is stretched with a force of 40 N. One end of the string ($x = 0$) is oscillated transversely (sinusoidally) with an amplitude of 0.02 m and a period of 0.1 sec, so that travelling waves in the +x direction are set up.

(a) What is the velocity of the waves?

(b) What is their wavelength?

(c) If at the driving end ($x = 0$) the displacement (y) at $t = 0$ is 0.01 m with dy/dt negative, what is the equation of the travelling waves?

एक लम्बी समरूप रस्सी का द्रव्यमान घनत्व 0.1 kg/m है। इसे 40 N के एक बल द्वारा खींचा जाता है। इस रस्सी का एक सिरा ($x = 0$), 0.02 m आयाम व 0.1 sec आवर्तकाल से ज्यावक्रीय दोलन करता है ताकि +x दिशा में प्रगामी तरंगें उत्पन्न हो जाये।

(a) तरंगों का वेग क्या है?

(b) उनकी तरंगदैर्ध्य क्या है?

(c) यदि $x = 0$ सिरे पर $t = 0$ पर विस्थापन (y) का मान 0.01 m हो तथा dy/dt = ऋणात्मक हो तो प्रगामी तरंगों की समीकरण क्या होगी?

Ans. (a) 20 m/s; (b) 2 m; (c) $y(x,t) = 0.02\sin(\pi x - 20\pi t + \pi/6)$]

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3. The figure shows a snap photograph of a vibrating string at $t = 0$. The particle P is observed moving up with velocity 20π cm/s. The angle made by string with x-axis at P is 6°.

(a) Find the direction in which the wave is moving

(b) the equation of the wave

(c) the total energy carried by the wave per cycle of the string, assuming that μ, the mass per unit length of the string = 50 gm/m.

चित्र में $t = 0$ पर एक कम्पनशील रस्सी को प्रदर्शित किया गया है। कण P, 20π cm/s के वेग से ऊपर की ओर गति करता हुआ प्रेक्षित होता है। P पर रस्सी द्वारा x अक्ष के साथ बनाया गया कोण 6° है, ज्ञात कीजिए

(a) वह दिशा जिसमें तरंग गति कर रही है।

(b) तरंग की समीकरण

(c) रस्सी के प्रति चक्र तरंग द्वारा ले जायी गयी कुल ऊर्जा (मान लीजिए: रस्सी की प्रति एकांक लम्बाई का द्रव्यमान $\mu = 50$ g/m)

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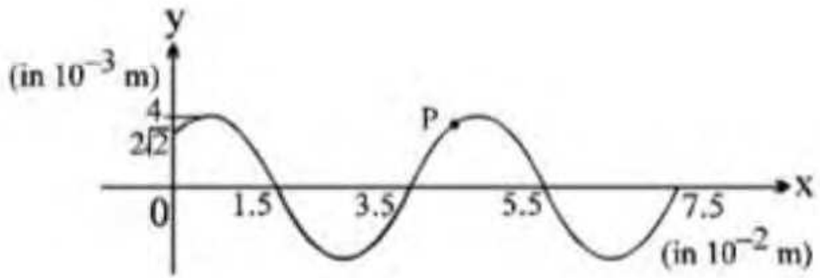

Ans. (a) negative x ; (b) $y = 4\times10^{-3} \sin 100\pi\left(3t + 0.5x + \frac{1}{\quad}\right)$ (x , y in meter) ; (c) $144\pi^2 \times 10^{-5}$ J

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6. The extension in a string, obeying Hooke's law is x. The speed of wave in the stretched string is v. If the extension in the string is increased to 1.5 x find the new speed of wave.

हुक के नियम का पालन कर रही एक रस्सी में विस्तार x है। खिंची हुई रस्सी में तरंग की चाल v है। यदि रस्सी में विस्तार को 1.5 x तक बढ़ा देते हैं तो तरंग की नई चाल ज्ञात कीजिए।

Ans. 1.22 v

$$V_w = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{Kx}{\mu}}$$

$$V_{\text{नई}} = \sqrt{\frac{K(1.5x)}{\mu}}$$

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7. A uniform rope of length L and mass m is held at one end and whirled in a horizontal circle with angular velocity ω. Ignore gravity. Find the time required for a transverse wave to travel from one end of the rope to the other.

एक L लम्बाई तथा द्रव्यमान m वाली एकसमान रस्सी के एक सिरे को पकड़कर इसे कोणीय वेग ω से क्षैतिज वृत्त में घुमाते हैं। गुरूत्व को नगण्य मानिये। रस्सी के एक सिरे से दूसरे सिरे तक जाने में अनुप्रस्थ तरंग को लगा समय ज्ञात करें।

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8. A copper wire is held at the two ends by rigid supports. At 30°C, the wire is just taut, with negligible
Find the speed of transverse waves in this wire at 10°C.
Given : Young modulus of copper = 1.3×10^{11} N/m^2.
Coefficient of linear expansion of copper = 1.7×10^{-5} °C^{-1}.
Density of copper = 9×10^3 kg/m^3.

Ans 70 m/s

$$\frac{T}{A} = Y \alpha \Delta\theta$$

$$\begin{array}{r} 34 \\ 13 \\ \hline 442 \end{array} \quad (5)$$

$$V_w = \sqrt{\frac{T}{\rho A}} = \sqrt{\frac{AY\alpha\Delta\theta}{\rho A}} = \sqrt{\frac{Y\alpha\Delta\theta}{\rho}} = \sqrt{\frac{1.3\times10^{11}\times1.7\times10^{-5}\times20}{9\times10^3}}$$

$$= \sqrt{\frac{13\times17\times200}{9}} = \frac{10}{3}\sqrt{442}$$

$$= 70$$

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1. A long string under tension of 100 N has one end at $x = 0$. A sinusoidal wave is generated at $x = 0$ whose equation is given by $y = (0.01\ \text{cm}) \sin\left[\left(\frac{\pi x}{10}\ \text{m}\right) - 50\pi t\,(\text{sec})\right]$

(i) Sketch the shape of the string at $t = \frac{1}{50}$ sec.

(ii) Find the average power transmitted by the wave.

(iii) Draw velocity time graph of particle at $x = 5$ m.

एक लम्बी रस्सी में तनाव 100 N है तथा इसका एक सिरा $x = 0$ पर है। $x = 0$ पर एक ज्यावक्रीय तरंग उत्पन्न होती है जिसकी समीकरण $y = (0.01\ \text{cm}) \sin\left[\left(\frac{\pi x}{10}\ \text{m}\right) - 50\pi t\,(\text{sec})\right]$ है।

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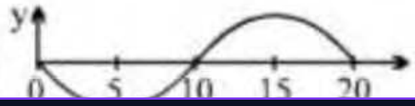
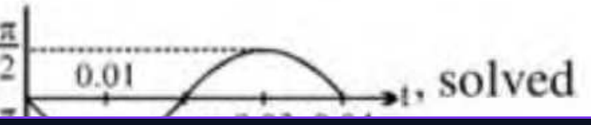
(i) $t = \frac{1}{50}$ sec पर रस्सी की आकृति बनाइये।

(ii) तरंग द्वारा सम्प्रेषित औसत शक्ति ज्ञात कीजिए।

(iii) $x = 5$ m पर कण का वेग-समय ग्राफ बनाइये।

Ans. (i) 

(ii) 25×10^{-6} W (iii) 

, solved

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2. At $x = 0$ particle oscillate by law $y = \frac{3}{2t^2+1}$. If wave is propagating along –ve x axis with velocity 2m/s. Find equation of wave

$t \longrightarrow t + \frac{x}{2}$

$x = 0$ पर एक कण $y = \frac{3}{2t^2+1}$ नियम द्वारा दोलन करता है। यदि तरंग ऋणात्मक x–अक्ष की दिशा में 2 m/s के वेग से संचरित हो तो तरंग का समीकरण ज्ञात कीजिए।

(A) $y = \frac{3}{2\left(t-\frac{x}{2}\right)^2+1}$ (B) $y = \frac{3}{2\left(t+\frac{x}{2}\right)^2+1}$ (C) $y = \frac{3}{2\left(t-\frac{z}{2}\right)^2+1}$ (D) $y = \frac{3}{2\left(t+\frac{z}{2}\right)^2+1}$

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Ans. (B)

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string at an instant of time. This picture is superimposed on a coordinate system to help you make any necessary measurements. The second picture is a graph of the vertical displacement of *one* point along the string as a function of time. How far does this wave travel along the string in one second?

एक अनुप्रस्थ तरंग क्षैतिज रस्सी में गतिशील है। प्रथम चित्र किसी क्षण रस्सी की आकृति को दर्शाता है। किसी भी प्रकार के आवश्यक प्रेक्षण के लिए इस चित्र को एक निर्देशांक निकाय पर उकेरा जाता है। द्वितीय चित्र रस्सी पर एक बिन्दु के ऊर्ध्वाधर विस्थापन को समय के फलन के रूप में दर्शाता है। यह तरंग इस रस्सी पर एक सेकण्ड में कितनी दूरी तय करेगी ?

$V_w = \frac{\omega}{k} = \frac{\lambda}{T}$

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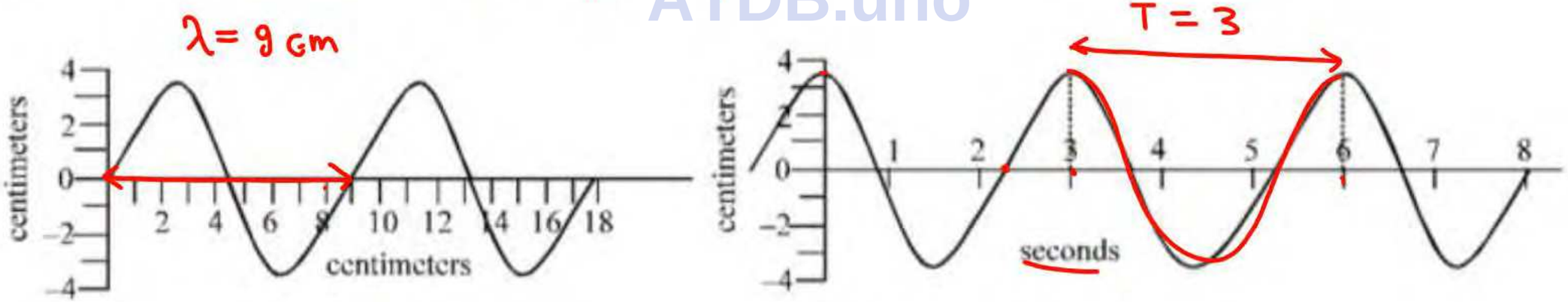

(A) 0.3 cm (B) 3.0 cm (C) 9.0 cm (D) 27 cm

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8. A sinusoidal wave travelling in the positive direction of x on a stretched string has amplitude 2.0 cm, wavelength 1 m and wave velocity 5.0 m/s. At x = 0 and t = 0, it is given that displacement y = 0 and $\frac{\partial y}{\partial t} < 0$. Express the wave function correctly in the form y = f(x, t) :-

एक ज्यावक्रीय तरंग एक खिंची हुई रस्सी पर धनात्मक x दिशा में 2 cm आयाम, 1 m तरंगदैर्ध्य व 5.0 m/s तरंग वेग से गतिशील है। x = 0 तथा t=0 पर इसका विस्थापन y = 0 है तथा $\frac{\partial y}{\partial t} < 0$ है। इस तरंग फलन को y = f(x, t) के रूप में लिखा जायेगा

(A) $y = (0.02\ m) \sin 2\pi (x-5t)$

(B) $y = (0.02\ cm) \cos 2\pi(x-5t)$

(C) $y = (0.02\ m) \sin 2\pi \left(x - 5t + \frac{1}{4}\right)$

(D) $y = (0.02\ cm) \cos 2\pi \left(x - 5t + \frac{1}{4}\right)$

Ans. (A)

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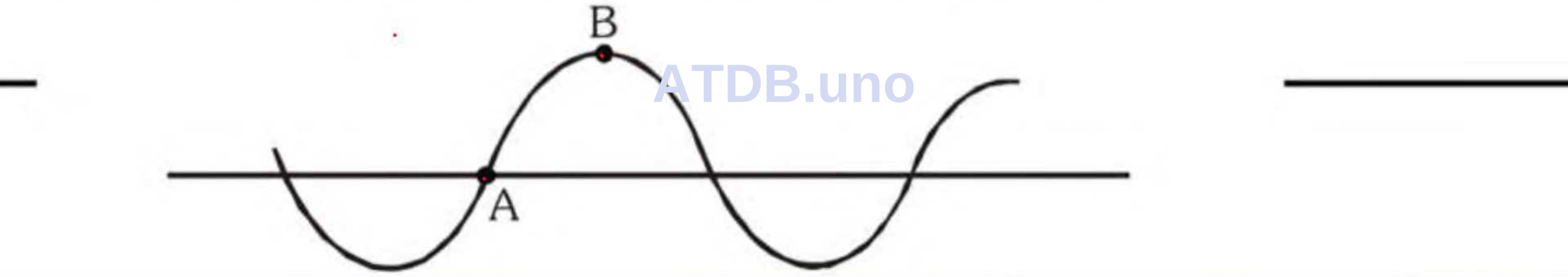
A progressive wave is travelling in a string as shown. Then which of the following statement about KE and potential energy of the elements A and B is true?

(A) For point A : kinetic energy is maximum and potential energy is min.

(B) For point B : kinetic energy is minimum and potential energy is min.

(C) For point A : kinetic energy is minimum and potential energy is max.

(D) For point B : kinetic energy is minimum and potential energy is max.



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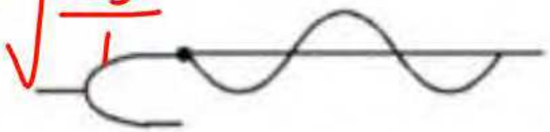
tension 25N. The maximum velocity of the prong is 1 cm/s, then the average power needed to drive the prong is:

किसी विद्युत चालित स्वरित्र की भुजा को एक ऐसी लम्बी रस्सी के साथ जोड़ दिया जाता है जिसके लिए $\mu = 1$ kg/m तथा तनाव 25 N है। यदि भुजा का अधिकतम वेग 1 cm/s हो तो इसे चलाने के लिए आवश्यक औसत शक्ति होगी :-

$\frac{1}{2}\mu A^2\omega^2 V_\omega = \frac{1}{2} \times 1 \times (10^{-2})^2 \sqrt{\frac{25}{1}}$



(A) 5×10^{-4} W (B) 2.5×10^{-4} W (C) 1×10^{-4} W (D) 10^{-3} W

Ans. (B)

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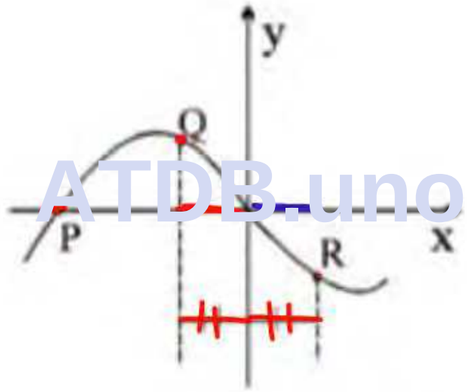
3. At a certain moment, the photograph of a string on which a harmonic wave is travelling to the right is shown. Then, which of the following is true regarding the velocities of the points P, Q and R on the string.

किसी क्षण रस्सी पर दांयी ओर संचरित हो रही सन्नादी तरंग को दर्शाया गया है। रस्सी पर बिन्दुओं P, Q तथा R के वेगों के सम्बन्ध में निम्न में से कौनसा कथन सत्य है?

$v_P = -v_w$ slope



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(A) v_P is upwards (B) $v_Q = -v_R$ (C) $|v_P| > |v_Q| = |v_R|$ (D) $v_Q = v_R$

Ans. (C,D)

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2. The equation of a wave on a string of linear mass density 0.04 kg m^{-1} is given by

$$y = 0.02(\text{m}) \sin\left[2\pi\left(\frac{t}{0.04(\text{s})} - \frac{x}{0.50(\text{m})}\right)\right]$$. The tension in the string is : **[AIEEE - 2010]**

रैखिक द्रव्यमान घनत्व 0.04 kg m^{-1} वाली एक डोरी पर एक तरंग का समीकरण

$$v_\omega = \frac{\omega}{k} = \sqrt{\frac{T}{\mu}}$$

$$y = 0.02(\text{m}) \sin\left[2\pi\left(\frac{t}{0.04(\text{s})} - \frac{x}{0.50(\text{m})}\right)\right]$$ से दिया जाता है, डोरी में तनाव है :

(1) 6.25 N (2) 4.0 N (3) 12.5 N (4) 0.5 N

Ans. (1)

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5. The transverse displacement y(x, t) of a wave on a string is given by $y(x,t) = e$. This represents a :- [AIEEE - 2011]

(1) standing wave of frequency $\sqrt{b}$

(2) standing wave of frequency $\frac{1}{\sqrt{b}}$

(3) wave moving in +x directionwith speed $\sqrt{\frac{a}{b}}$

(4) wave moving in –x direction with speed $\sqrt{\frac{b}{a}}$

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1. A wave travelling along the x-axis is described by the equation $y(x, t) = 0.005 \cos(\alpha x - \beta t)$. If the wavelength and the time period of the wave in 0.08m and 2.0 s respectively then α and β in appropriate units are **[AIEEE - 2008]**

x-अक्ष के अनुदिश गति कर रही एक तरंग का समीकरण $y(x, t) = 0.005 \cos(\alpha x - \beta t)$ द्वारा प्रदर्शित किया गया है। यदि तरंग की तरंगदैर्ध्य तथा आवर्तकाल क्रमश: 0.08m तथा 2.0 s हो तो α तथा β के मान होगें

(1) $\alpha = 25.00\pi, \beta = \pi$

(2) $\alpha = \frac{0.08}{\pi}, \beta = \frac{2.0}{\pi}$

(3) $\alpha = \frac{0.04}{\pi}, \beta = \frac{1.0}{\pi}$

(4) $\alpha = 12.50\pi, \beta = \frac{\pi}{2.0}$

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Ans. (1)

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7. A uniform string of length 20m is suspended from a rigid support. A short wave pulse is introduced at its lowest end. It starts moving up the string. The time taken to reach the support is :-
(take $g = 10\ ms^{-2}$)

20m लम्बाई की एकसमान डोरी को एक दृढ़ आधार से लटकाया गया है। इसके निचले सिरे से एक सूक्ष्म तरंग-स्पंद चालित होता है। ऊपर आधार तक पहुँचने में लगने वाला समय है :- **[JEE-Main-2016]**

($g = 10\ ms^{-2}$ लें)

(1) $\sqrt{2}\,s$ (2) $2\pi\sqrt{2}\,s$ (3) $2s$ (4) $2\sqrt{2}\,s$

Ans. (4)

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the following equation

$$y = 0.05 \sin(420t - 21.0 x)$$

where x and y are in metres and t is in seconds.

The tension in the string is equal to :

एक आवर्ती अनुप्रस्थ तरंग एक डोरी जिसका रेखीय द्रव्यमान घनत्व 0.200 kg/m है, पर निम्न समीकरण द्वारा व्यक्त की जाती है :

$$y = 0.05 \sin(420t - 21.0 x)$$

जहाँ x व y मीटर में है एवं t सैकण्ड में है। डोरी में तनाव है :

(A) 32 N (B) 42 N (C) 66 N (D) 80 N

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Ans. (D)

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generated by plucking one end of the taut (tight) wire. The pulse makes four trips back and forth along the cord in 0.8 sec. The tension is the cord will be :-

एक 4 m लम्बे तार का द्रव्यमान 0.2 kg है। तार को क्षैतिजत: रखा जाता है। तने हुये तार के एक सिरे को झटका देकर एक अनुप्रस्थ स्पंद उत्पन्न किया जाता है। यह स्पंद तार के अनुदिश 0.8 sec में चार बार आगे-पीछे गति करता है। तार में तनाव होगा:-

(A) 80 N (B) 160 N (C) 240 N (D) 320 N

Ans. (A)

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$y_1 = 5 \sin 2\pi (10t - 0.1x); y_2 = 10 \sin 2\pi (20t - 0.2x)$

Check

Ratio of intensities $\frac{I_2}{I_1}$ will be :

$I \propto A^2\omega^2$

दो तरंगों को निम्न समीकरणों के द्वारा दर्शाया जाता है :

$y_1 = 5 \sin 2\pi (10t - 0.1x); y_2 = 10 \sin 2\pi (20t - 0.2x)$

तब तीव्रताओं का अनुपात $\frac{I_2}{I_1}$ होगा :

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(A) 1 (B) 2 (C) 4 (D) 16

Ans. (C)

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area of cross-section of the wire is 1.0 mm^2 and its young's modulus is 16×10^{11} N/m^2. Find the extension of the wire over its natural length.

एक 50 cm लम्बाई एवं 5.0 kg द्रव्यमान के तार में अनुप्रस्थ तरंग की चाल 80 m/s है। तार के अनुप्रस्थ काट का क्षेत्रफल 1.0 mm^2 है एवं इसका यंग प्रत्यास्थता गुणांक 16×10^{11} N/m^2 है। तार का अपनी प्राकृतिक लम्बाई के सापेक्ष विस्तार ज्ञात करे।

Ans. 20 mm

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x is the distance from one end of the wire and k is a constant.

(a) Show that $M = kL^2/2$

(b) Show that the time required for a pulse generated at one end of the wire to travel to the other end is given by $t = \sqrt{8ML/9F}$ where F (constant)is the tension in the wire.

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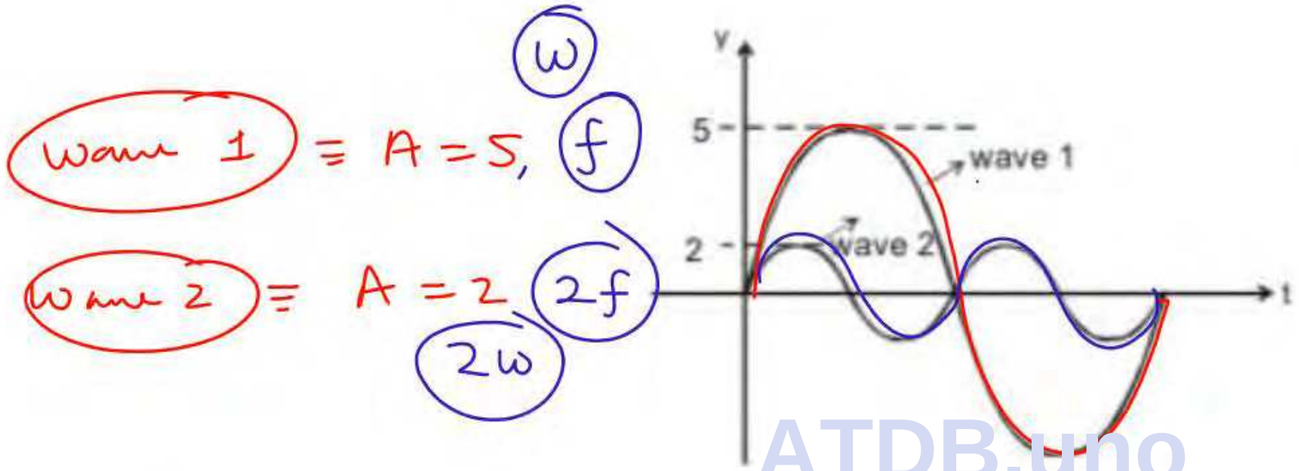
average intensities?

समान माध्यम में दो तरंगो को y-t वक्र द्वारा प्रदर्शित किया गया है। इनकी औसत तीव्रता का अनुपात ज्ञात करे।



wave 1 ≡ A = 5, f, ω

wave 2 ≡ A = 2, 2f, 2ω

$I \propto A^2\omega^2$

$$\frac{25 \times \omega^2}{(2)^2 \times (2\omega)^2} = \frac{25}{16}$$

Ans. $\frac{25}{16}$

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tension of 100 N. If the wave speed is 100 m/s, what average power is the source transmitting to the wire?

एक 0.50 mm आयाम एवं 100 Hz आवृति की अनुप्रस्थ तरंग को तनाव 100 N तक तनित एक तार में उत्पन्न किया जाता है। यदि तरंग की चाल 100 m/s है तब स्त्रोत तार में कितनी औसत शक्ति संचरित कर रहा है?

Ans. 49 mW

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When the car is at rest, the speed of transverse waves in the string is 60 ms^{-1}. When the car has acceleration a, the wave-speed increases to 60.5 ms^{-1}. The value of a, in terms of gravitational acceleration g, is closest to :

द्रव्यमान M वाली एक भारी गेंद को कार की छत से द्रव्यमान m (m << M) वाली एक हल्की रस्सी से लटकाया जाता है। जब कार विराम में होती है तो रस्सी में उत्पन्न अनुप्रस्थ तरंगों की चाल 60 ms^{-1} होती है। जब कार का त्वरण a होता है तब तरंग चाल 60.5 ms^{-1} तक बढ़ जाती है तो गुरूत्वीय त्वरण g के पदों में a का निकटतम मान होगा :-

[JEE-Main-2019_Jan]

(1) $\frac{g}{5}$ (2) $\frac{g}{20}$ (3) $\frac{g}{10}$ (4) $\frac{g}{30}$

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Ans. (1)

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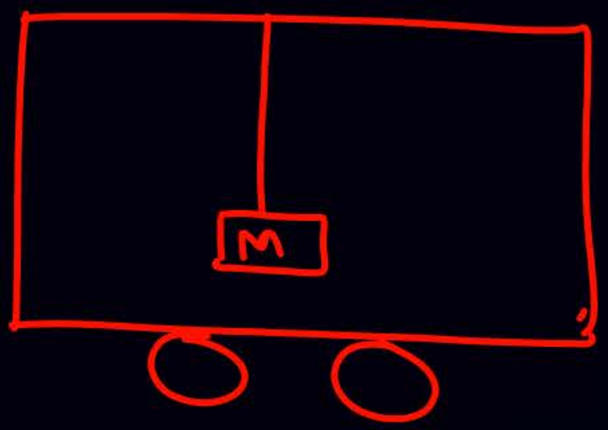

$$g_{eff} = \sqrt{g^2 + a^2}$$

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$$T = Mg$$

$$v_w = \sqrt{\frac{Mg}{\mu}} = 60$$

$$v_w = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{M\sqrt{g^2+a^2}}{\mu}} = 60.5$$

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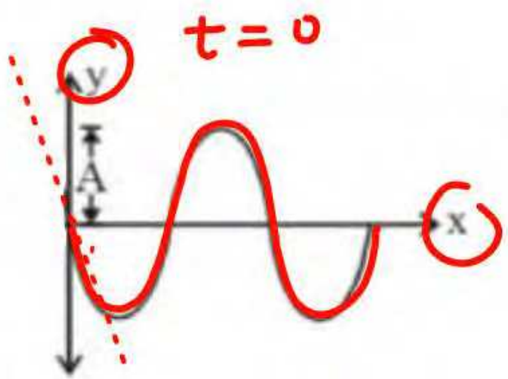
$(kx - \omega t + \phi)$. Its snapshot at $t = 0$ is given in the figure:

धनात्मक x-दिशा में गमन करती हुई किसी प्रगामी तरंग को $y(x, t) = A \sin(kx - \omega t + \phi)$, से निरूपित किया जाता है।

$t = 0$ पर खींचा गया आशु चित्र निम्न से दिया जाता है :

$V_p = - + -$

$V_p > 0$



$y = A\sin(\omega t - kx + 0)$

$y = -A\sin(kx - \omega t)$

$y = A\sin(kx - \omega t + 180)$

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For this wave, the phase ϕ is :

इस तरंग के लिए, कला ϕ का मान होगा :

[JEE-Main-2019_April]

(1) 0 (2) $-\frac{\pi}{2}$ (3) π (4) $\frac{\pi}{2}$

Ans. (3)

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7. A transverse wave travels on a taut steel wire with a velocity of v when tension in it is 2.06×10^4 N. When the tension is changed to T, the velocity changed to v/2. The value of T is close to :

जब एक तने हुए स्टील के तार में तनाव 2.06×10^4 N हो तो इस पर चलने वाली एक अनुप्रस्थ तरंग की गति v है। यदि तनाव का मान बदलकर T कर दिया जाये तो तरंग की गति बदलकर v/2 हो जाती है। T का मान निम्न में से किसके निकटतम है ?

[JEE-Main-2020_Jan]

(1) 10.2×10^2 N (2) 5.15×10^3 N (3) 2.50×10^4 N (4) 30.5×10^4 N

Ans. (2)

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Each point of the wave moves to and fro through a total distance of 6 cm. What will be the mathematical expression of this travelling wave ?

$\omega = 2\pi f$ $\quad V_\omega = \frac{\omega}{k}$

245 Hz आवृत्ति की कोई ध्वनि तरंग धनात्मक x-अक्ष के अनुदिश 300 ms^{-1} की चाल से गमन कर रही है। इस तरंग का प्रत्येक कण 6 cm की कुल दूरी का दोलन करता है। इस प्रगामी तरंग के लिए गणितीय व्यंजक क्या होगा ?

[JEE-Main-2021_March]

(1) $Y(x,t) = 0.03\,[\sin 5.1\,x - (0.2 \times 10^3)t]$

(2) $Y(x,t) = 0.06\,[\sin 5.1\,x - (1.5 \times 10^3)t]$

(3) $Y(x,t) = 0.06\,[\sin 0.8\,x - (0.5 \times 10^3)t]$

(4) $Y(x,t) = 0.03\,[\sin 5.1\,x - (1.5 \times 10^3)t]$

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ns. (4)

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which the wave velocity becomes equal to the maximum particle velocity, will be:

एक अनुप्रस्थ तरंग समीकरण $y = 2\sin(\omega t - kx)$ cm द्वारा प्रदर्शित है। उस तरंगदैर्ध्य का मान (cm में) ज्ञात कीजिए, जिस पर तरंग वेग, कण के अधिकतम वेग के बराबर होगा। **[JEE-Main-2022_July]**

(A) 4π (B) 2π (C) π (D) 2

Ans. (A)

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The area of cross-section of the wire is 2.0 mm^2 and its Young's modulus is 1.2×10^{11} Nm^{-2}. The extension of the wire over its natural length due to its tension will be $x \times 10^{-5}$ m. The value of x is_____.

एक 50 cm लम्बी एवं 10 g द्रव्यमान की रस्सी पर चलने वाली अनुप्रस्थ तरंग की चाल 60 ms^{-1} है। तार का अनुप्रस्थ क्षेत्राफल 2.0 mm^2 और इसका यंग गुणांक 1.2×10^{11} Nm^{-2} है। तन्यता के कारण इसकी वास्तविक लम्बाई में हुई वृद्धि $x \times 10^{-5}$ m है। x का मान है _____.

[JEE-Main-2022 July]

Ans. (15)

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top end of the rope is attached to a fixed rigid support at O. A transverse wave pulse (Pulse 1) of wavelength λ_0 is produced at point O on the rope. The pulse takes time T_{OA} to reach point A. If the wave pulse of wavelength λ_0 is produced at point A (Pulse 2) without disturbing the position of M it takes time T_{AO} to reach point O. Which of the following options is/are **correct** ?

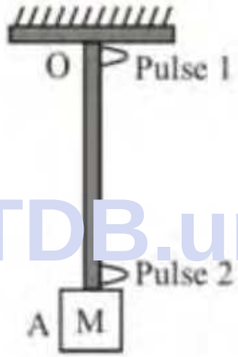
[JEE-Advance-2017]

(A) The time $T_{AO} = T_{OA}$

(B) The velocities of the two pulses (Pulse 1 and Pulse 2) are the same at the midpoint of rope

(C) The wavelength of Pulse 1 becomes longer when it reaches point A

(D) The velocity of any pulse along the rope is independent of its frequency and wavelength.



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एक समान रैखिक घनता वाले (uniform mass per unit length) उर्ध्वाधर डोर के निचले सिरे पर एक गुटका M लटका हुआ हैं। डोर का दूसरा सिरा दृढ़ आधार (बिंदु O) से संलग्न है। तरंग-दैर्ध्य λ_0 की अनुप्रस्थ तरंग स्पंद (स्पंद 1, pulse 1) बिंदु O पर उत्पन्न की गई हैं। ये तरंग स्पंद बिंदु O से बिंदु A तक T_{OA} समय में पहुँचती हैं। गुटके M को बिना विक्षोभित किये हुए बिंदु A पर निर्माण की गई तरंग-दैर्ध्य λ_0 की अनुप्रस्थ तरंग स्पंद (स्पंद 2, Pulse 2) बिंदु A से बिंदु O तक T_{AO} समय में पहुँचती हैं। निम्न में से कौन सा(से) कथन सही है/हैं ?

[JEE-Advance-2017]

(A) समय $T_{AO} = T_{OA}$

(B) डोर के मध्य बिंदु पर स्पंद 1(Pulse 1) एवं स्पंद 2 (Pulse 2) का वेग समान है।

(C) स्पंद 1 (Pulse 1) की तरंग-दैर्ध्य बिंदु A तक पहुंचने में लम्बी हो जाएगी।

(D) डोर के अनुदिश प्रेषित किसी भी स्पंद का वेग उसकी आवृत्ति एवं तरंग-दैर्ध्य पर निर्भर नहीं हैं

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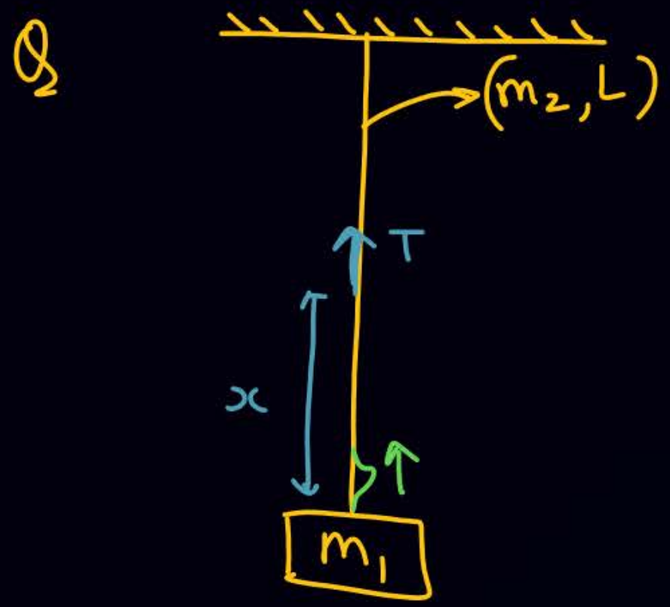
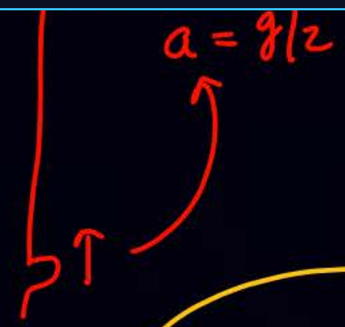


$$T = \left(\frac{m_2}{L}x + m_1\right)g$$

$$v_w = \sqrt{\frac{\left(\frac{m_2 x}{L} + m_1\right)g}{\frac{m}{L}}}$$



$$a_{cc} = g/2$$

$$= \sqrt{xg + \frac{m_1 L}{m_2}g} = V_w$$

$$xg + \frac{m_1}{m_2}Lg = V^2$$

$$g + 0 = 2V\frac{dV}{dx}$$

$$a = g/2$$

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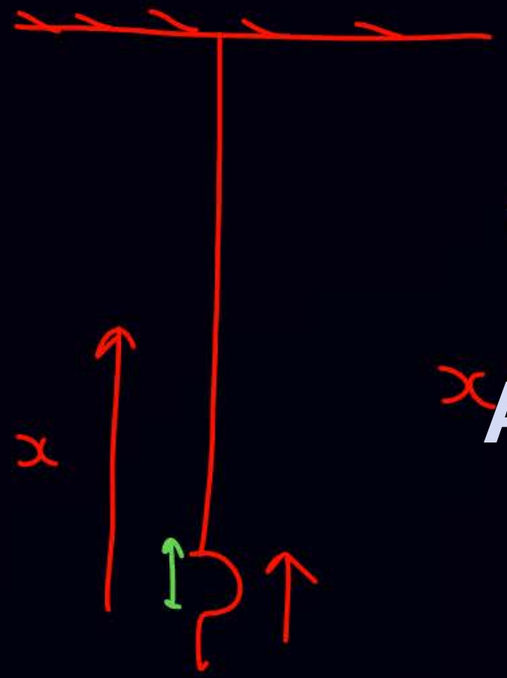
$$v = \sqrt{xg}$$



$$v = f\lambda$$

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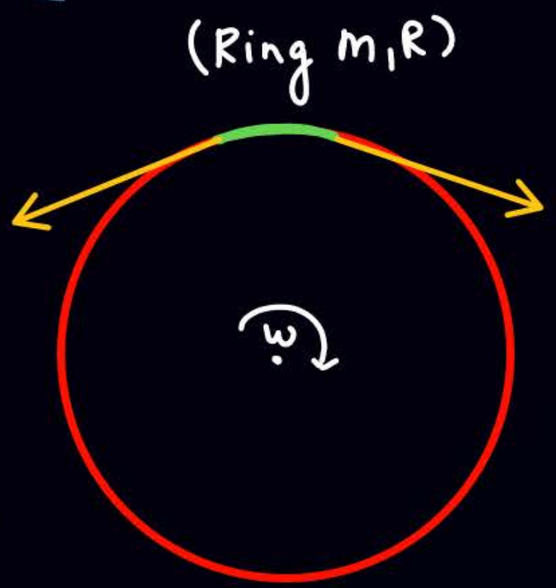
(Ground $\mu = 0$)

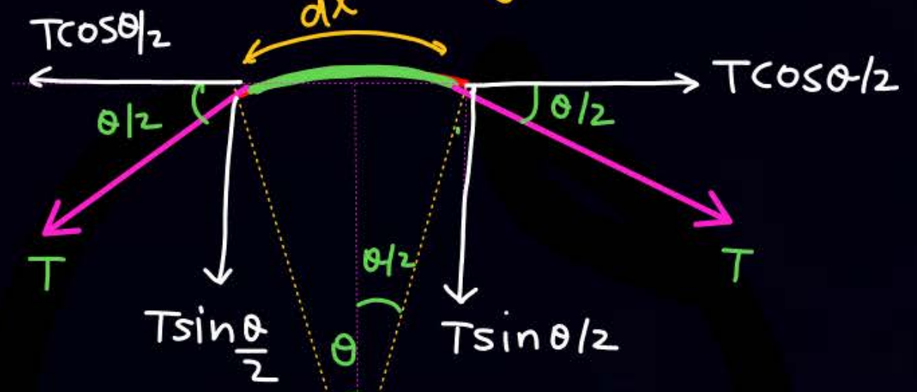
Q



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

$$V_w = \sqrt{\frac{\mu R^2 \omega^2}{\mu}} = R\omega$$

① T in the ring



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$$2T\sin\frac{\theta}{2} = (dm)R\omega^2$$

$$2 \cdot T \cdot \frac{\theta}{2} = T\theta = T\frac{dl}{R} = dm \cdot R\omega^2$$

$$T = \left(\frac{dm}{dl}\right) R^2\omega^2$$

$$T = \lambda R^2\omega^2$$

$$T = \mu R^2\omega^2$$

μ → mass per unit length.

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1. One end of a long string is attached to an oscillator moving in transverse direction at a frequency of 20 Hz. The string has a cross-sectional area of 0.80 mm^2 and a density of 12.5 g cm^{-3}. It is subjected to a tension of 64 N along the x axis. At $t = 0$, the source is at a maximum displacement of $y = 1.0$ cm.

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(i) Find the speed of the wave travelling on the string.

(ii) Write the equation for the wave.

(iii) What is the displacement of the particle of the string at $x = 50$ cm at time $t = 0.05$ s?

(iv) What is the velocity of this particle at this instant?

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Solved Ex.

14. One end of a string of length L is tied to the ceiling of a lift accelerating upwards with an acceleration $2g$. The other end of the string is free. The linear mass density of the string varies linearly from 0 to λ from bottom to top.

(*a*) The velocity of the wave in the string will be zero.

(*b*) The acceleration of the wave on the string will be $3g/4$ every where.

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(*c*) The time taken by a pulse to reach from bottom to top will be $\sqrt{8L/3g}$

(*d*) The time taken by a pulse to reach from bottom to top will be $\sqrt{4L/3g}$

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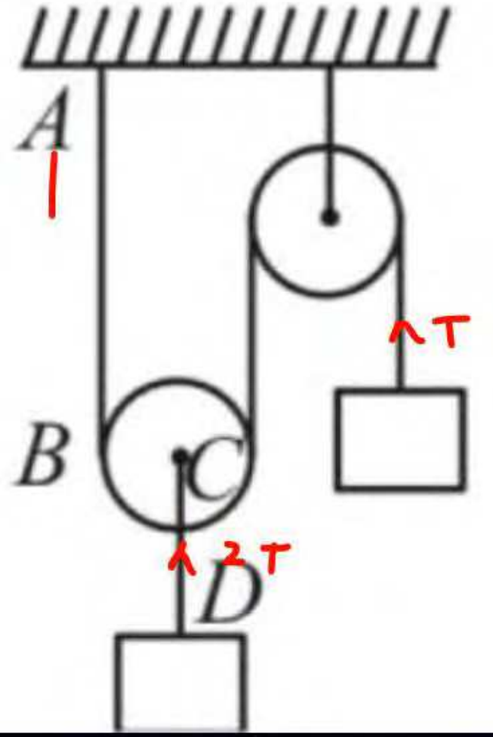
15. Both the strings, shown in figure are made of same material and diameter of CD is double that of AB. The pulleys are light. The speed of a transverse wave in the string AB is v_1 and in CD it is v_2, then $\frac{v_1}{v_2}$ is $\sqrt{x}$. Find x.



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19. The ratio $\frac{P_2}{P_1}$ of power transmitted by two travelling waves on the same string shown in *y-x* graph below is ____16____.

Ans

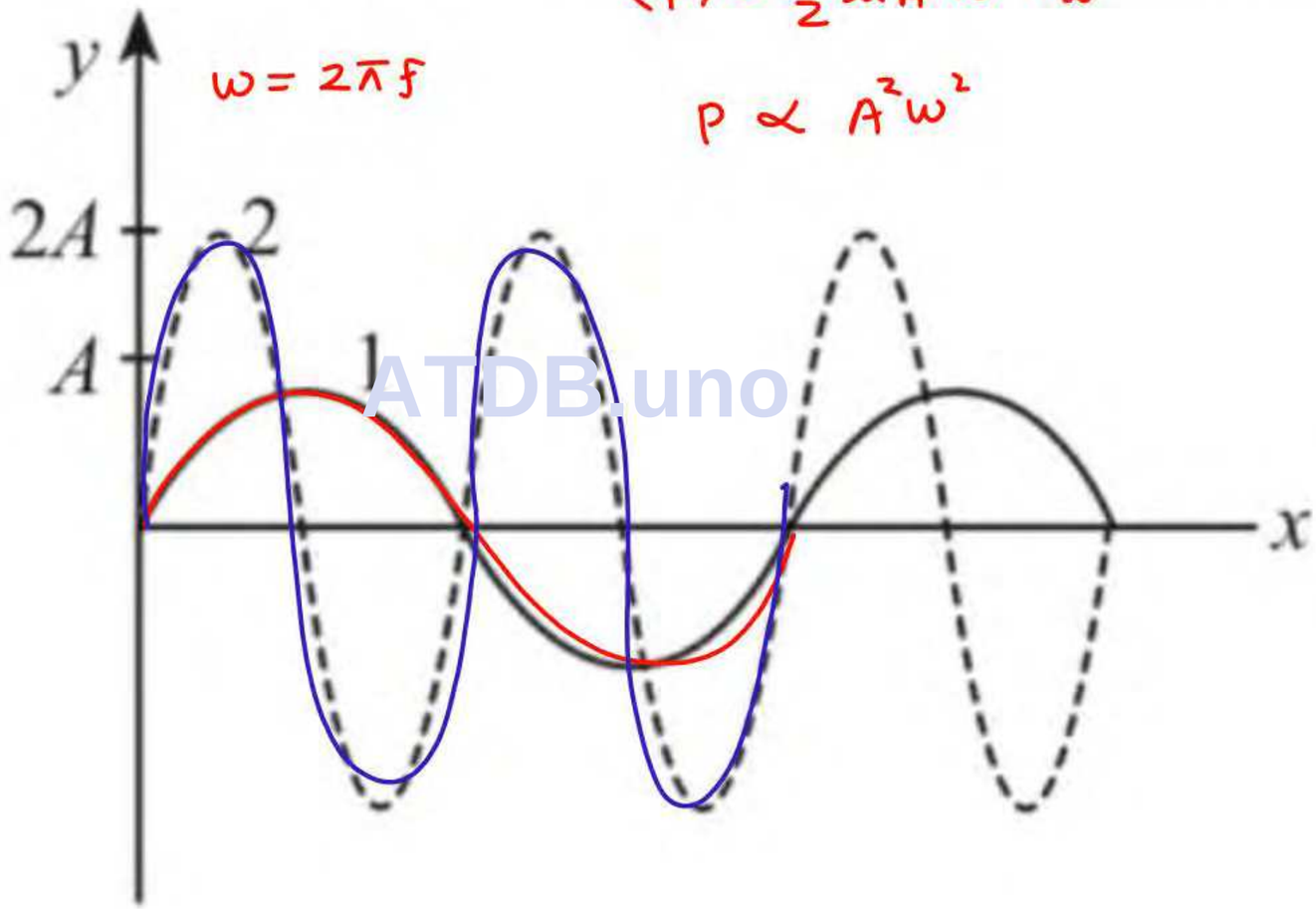
$\langle P \rangle = \frac{1}{2}\mu A^2 \omega^2 V_w$

① ≡ A, f, ω

② ≡ 2A, 2f, 2ω

$\omega = 2\pi f$

$P \propto A^2\omega^2$



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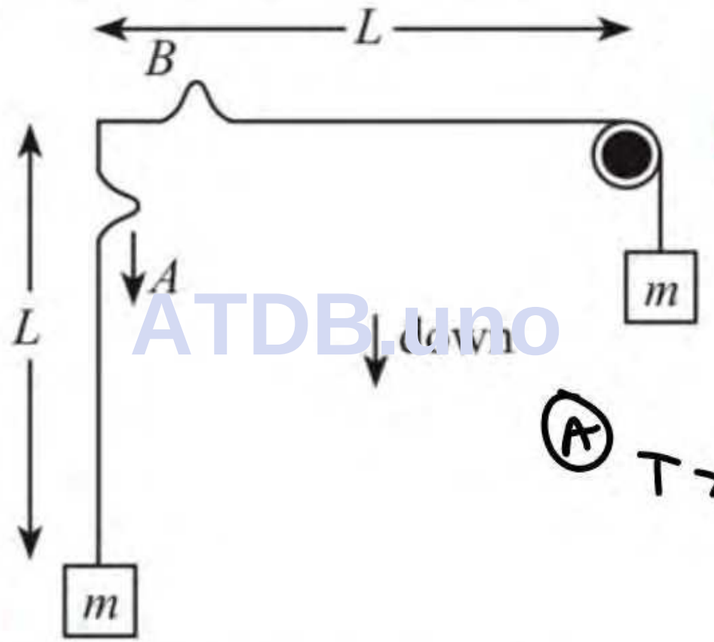
below. Both are stretched by means of an identical weight of mass m hanging on each string as shown. At time $t = 0$ an identical wave pulse is flipped onto each string, where it travels to the end, reflects off of the mass or the pulley as the case may be, and returns. Which of the following is true?



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(a) The pulse on string A returns first

(b) The pulse on string B returns first

(c) The pulse on string A returns at the same time as the pulse on string B

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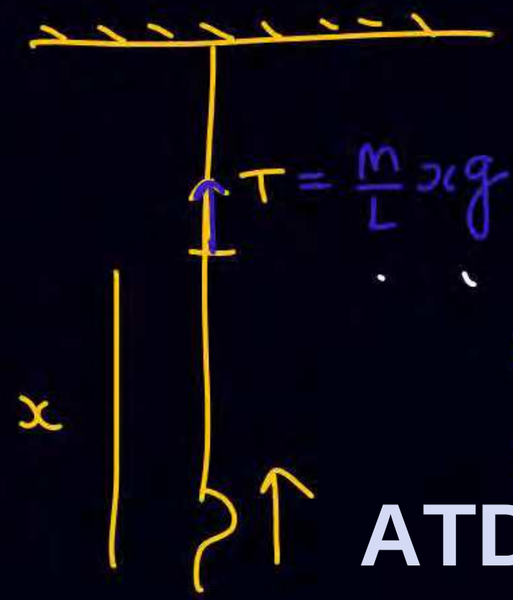

$$v_w = \sqrt{\frac{\frac{M}{K}xg}{\frac{M}{K}}} = \sqrt{xg}$$

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QUESTION

A wire of density 8×10^3 kg m^{-3} is stretched between two clamps 0.5 m apart. The extension developed in the wire is 3.2×10^{-4} m. If $Y = 8 \times 10^{10}$ Nm^{-2}, the fundamental frequency of vibration in the wire will be _____ Hz.

[11 April 2023 - Shift 2]

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Ans : (80)

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QUESTION

A transverse harmonic wave on a string is given by $y(x, t) = 5\sin(6t + 0.003x)$ where x and y are in cm and t in sec. The wave velocity is _____ ms^{-1}

[10 April 2023 - Shift 1]

$$\frac{6}{.003}$$

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Ans : (20)

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QUESTION

A steel wire with mass per unit length 7.0×10^{-3} kg m^{-1} is under tension of 70 N. The speed of transverse waves in the wire will be: [01 February 2023 - Shift 1]

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

(1) 200π m/s

(2) 100 m/s

(3) 10 m/s

(4) 50 m/s

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Ans : (2)

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QUESTION

A transverse wave is represented by $y = 2\sin(\omega t - kx)$ cm. The value of wavelength (in cm) for which the wave velocity becomes equal to the maximum particle velocity, will be:

[JEE Mains 2022]

$\frac{\omega}{k} = A\omega$

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$\frac{\lambda}{2\pi} = 2$

1. 4π
2. 2π
3. π
4. 2

Ans : (1)

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QUESTION

The mass per unit length of a uniform wire is 0.135 g/cm. A transverse wave of the form $y = -0.21 \sin(x + 30t)$ is produced in it, where x is in meter and t is in second. Then, the expected value of tension in the wire is $x \times 10^{-2}$ N. Value of x is.
(Round-off to the nearest integer).

[JEE Mains 2021]

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Ans : 1215

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A string with linear mass density $\lambda = 5.00 \times 10^{-4}$ kg/m is under a tension of 80.0 N. How much power must be supplied to the string to generate sinusoidal waves at a frequency of 60.0 Hz and an amplitude of 6.00 cm?

Ans 512

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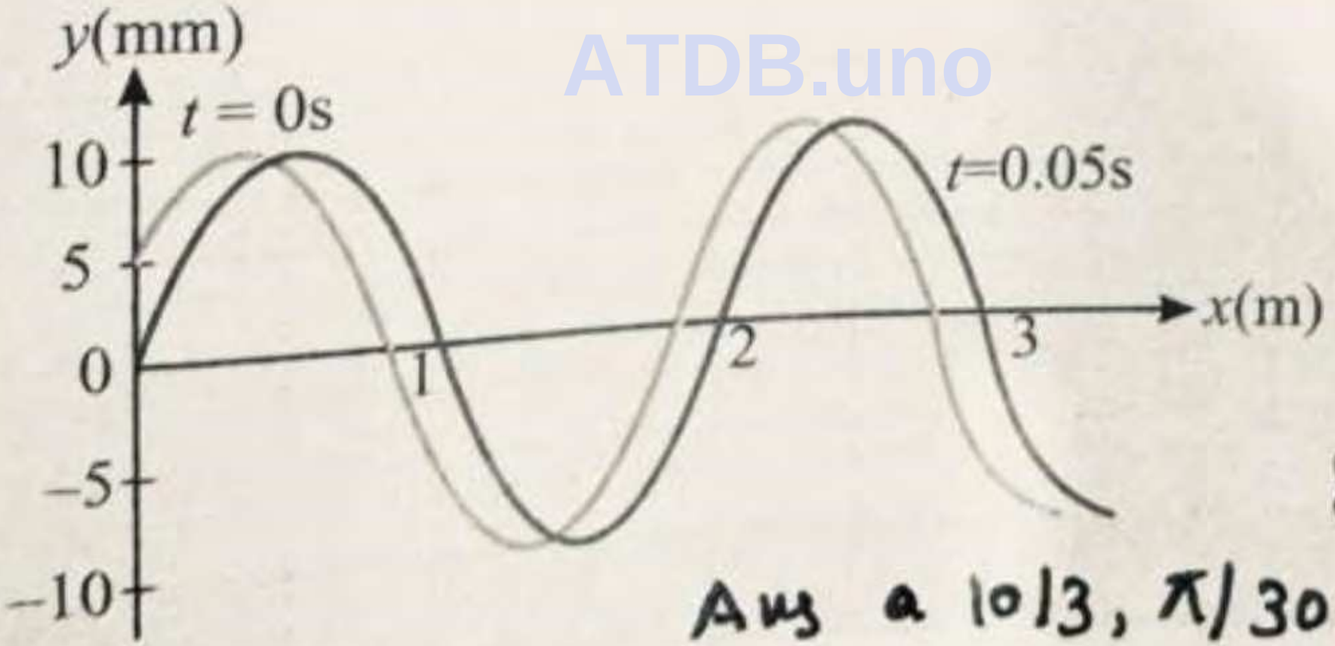
Figure represents two snaps of a travelling wave on a string of mass per unit length $\mu = 0.25$ kg/m. The first snap is taken at $t = 0$ and the second is taken at $t = 0.05$ s. Determine **(a)** the speed of the wave, **(b)** the wavelength and frequency of the wave, **(c)** the maximum speed of the particle, **(d)** the tension in the string **(e)** the equation of the wave.



$y = 10 \sin(\pi x$

Ans a 10/3, π/30, 25/3 . (−π10/3 t + π/6)

the
Sol
loop
draw
force

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A circular loop of string rotates about its axis on a frictionless horizontal plane at a uniform rate so that the tangential speed of any particle of the string is v. If a small transverse disturbance is produced at a point of the loop, with what speed (relative to the string) will this disturbance travel on the string?

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4. A travelling wave pulse is given by $y = \dfrac{}{5+(x+2t)^2}$

In which direction and with what velocity is the pulse propagating? What is the amplitude of the pulse? (-2, 2)

5. A travelling wave pulse is given by

$$y = \frac{0.8}{(3x^2 + 12xt + 12t^2 + 4)}$$

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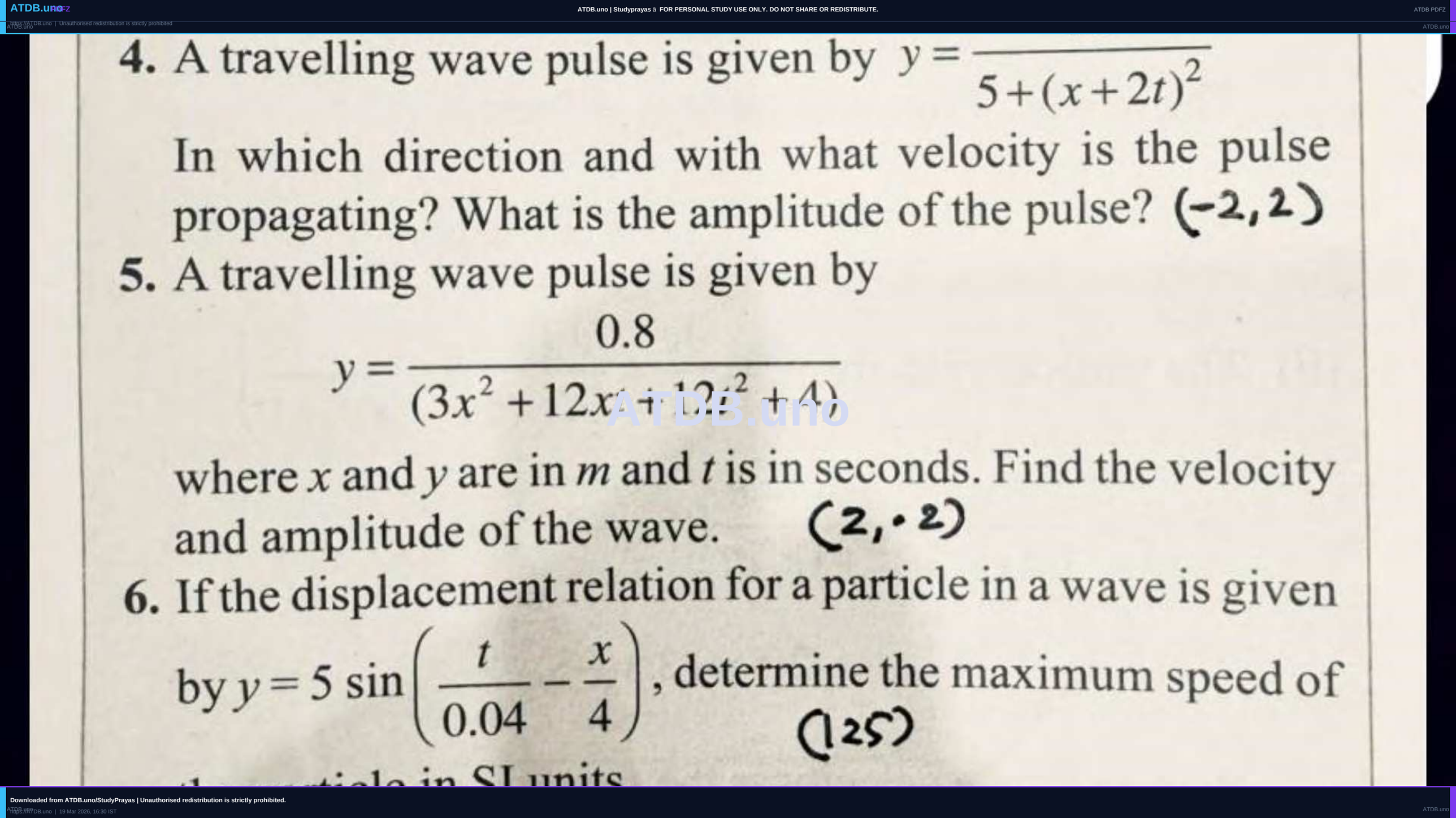
where x and y are in m and t is in seconds. Find the velocity and amplitude of the wave. (2, .2)

6. If the displacement relation for a particle in a wave is given by $y = 5 \sin\left(\dfrac{t}{0.04} - \dfrac{x}{4}\right)$, determine the maximum speed of (125)



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A wave pulse is traveling along $+x$ direction on a string at 2 m/s. Displacement y (in cm) of the particle at $x = 0$ at any time t is given by $2/(t^2 + 1)$. Find

(a) Expression of the function $y = (x, t)$, i.e., displacement of a particle at position x and time t.

$$y = \frac{2}{t^2+1} \rightarrow \frac{2}{\left(t-\frac{x}{2}\right)^2+1}$$

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Homework

- Ques are attached
- HCV → solved ex. pge 319 ⇒ (1–6)
  objective I ⇒ 4, 7, 8,
  Exercise ⇒ (1–13)
- Module → Parikshit (JA) ⇒ 4, 15, 19, 28,

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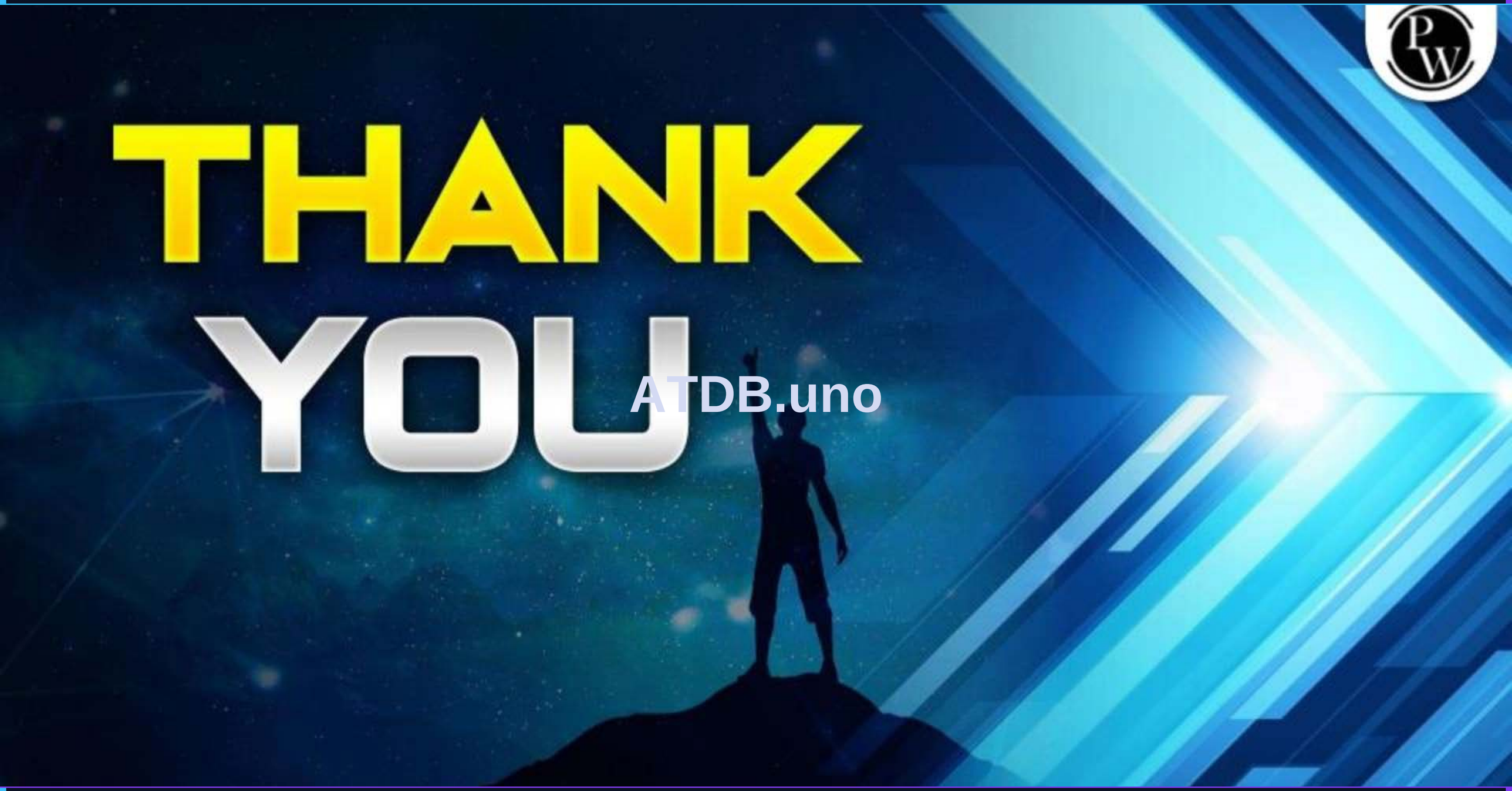

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