Wave and Motion : Waves in Strings –

Subjective Questions (Typical)

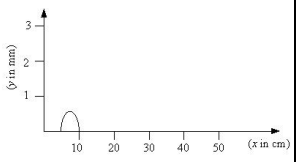
No of Questions:60 **Time Allotted: 9 Hours**

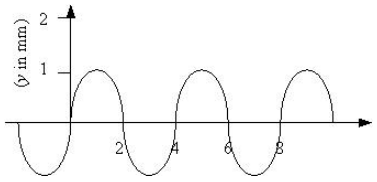
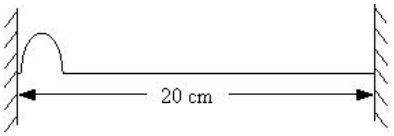
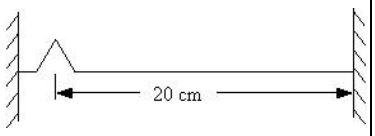
All questions are compulsory

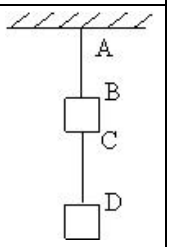
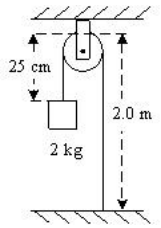
[Note: a. Figures are conceptual only and not to the scale**]**

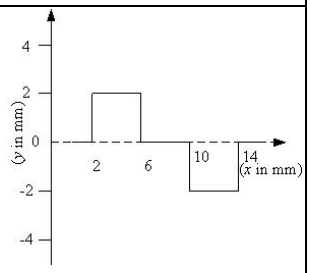
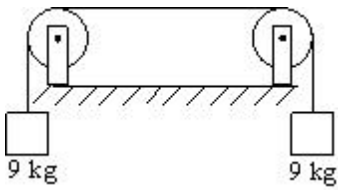
[b. Solutions may be taken up in Two parts as, Part I: 1 to 20, Part II: 21 to 40 and Part III: 41 to 60**]**

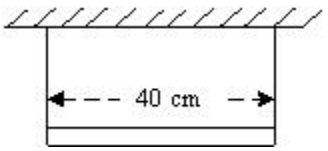
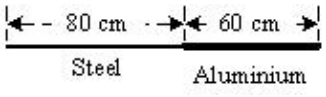
[c. It is advised to attempt question under examination conditions**]**

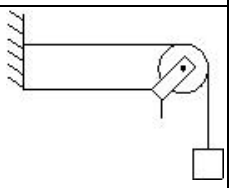
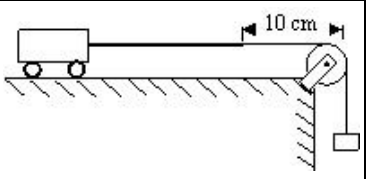
Q-01	A wave pulse passing on a string with a speed of 40 cm/s in the negative x-direction has its maximum at x = 0 at t = 0. Where will the maximum be located at t = 5 s?
Q-02	The equation of a wave travelling on a string stretched along the X-axis is given by $y = Ae^{-\left(\frac{x}{a}+\frac{t}{T}\right)^2}$. (a) Write dimension of A, a and T. (b) Find the wave speed (c) In which direction is the wave travelling? (d) Where is the maximum of the pulse located at $t = T$? And at $t = 2T$?
Q-03	Figure shows a wave pulse at $t = 0$. The pulse moves to the right with a speed of 10 cm/s. Sketch the shape of the string at t = 1s, 2s and 3s. 
Q-04	A pulse travelling on a string is represented by the function $y = \frac{a^2}{(x-vt)^2+a^2}$, where a = 5 mm and v = 20 cm/s. Sketch the shape of the string at t = 0, 1s and 2s. Take x = 0 in the middle of the string.
Q-05	The displacement of the particle at $x = 0$ of a stretched string carrying a wave in the positive x-direction as given by $f(t) = A\sin\left(\frac{t}{T}\right)$. The wave speed is v. Write the wave equation.
Q-06	A wave pulse is travelling on a string with a speed v towards the positive X-axis. The shape of the string at $t = 0$ is given by $g(x) = A\sin\left(\frac{x}{a}\right)$, where A and a are constants. (a) What are the dimensions of A and a? (b) Write the equation of the wave for a general time t, if the wave speed is v.
Q-07	A wave propagates on a string in the positive x-direction at a velocity v. The shape of the string at $t = t_0$ is given $g(x, t_0) = A\sin\left(\frac{x}{a}\right)$. Write the wave equation for a general time t.
Q-08	The equation of a wave travelling on a string is $y = (0.10\text{mm})\sin[(31.4\text{m}^{-1})x + (314\text{s}^{-1})t]$. (a) In which direction does the wave travel? (b) Find the wave speed, wavelength and frequency of the wave. (c) What is the maximum displacement and the maximum speed of a portion of the string?
Q-09	A wave travels along the positive x-direction with a speed 20 m/s. The amplitude of the wave is 0.20 cm and the wavelength 2.0 cm.

	(a) Write a suitable wave equation, which describes this wave. (b) What is the displacement and velocity of the particle at x=2.0 cm at time t=0 according to the wave equation written? (c) Can you get different values of this quantity if the wave equation is written in a different fashion?
Q-10	A wave is described by the equation $= (1.00\text{ mm})\sin\pi\left[\frac{x}{2.0\text{ cm}} - \frac{t}{0.01\text{ s}}\right]$. (a) Find the time period and the wavelength. (b) Write the equation for the velocity of the particles. Find the speed of the particle at $x = 1.0$ cm at time $t = 0.01$ s. (c) What are the speeds of the particle at $x = 3.0$ cm, 5.0 cm and 7.0 cm at t=0.01 s? (d) What are the speeds of the particle at $x = 1.0$ cm at t = 0.011 s, 0.012 s and 0.013s?
Q-11	A particle on a stretched string supporting a travelling wave, takes 5.0 ms to move from its mean position to the extreme position. The distance between two consecutive particles, which are at their mean positions, is 2.0 cm. Find the frequency, the wavelength and the wave speed?
Q-12	Figure shows a plot of the transverse displacement of the particles of a string at $t = 0$ through which a travelling wave is passing in the positive x-direction. The wave speed is 20 cm/s. Find (a) amplitude (b) wavelength (c) wave number (d) Frequency of the wave 
Q-13	A wave travelling on a string at a speed of 10 m/s causes each particle of the string to oscillate with a time period of 20 ms. (a) What is the wavelength of the wave? (b) If displacement of a particle is 1.5 cm at a certain instant, what will be the displacement of a particle 10 cm away from it at the same instant?
Q-14	A steel wire of length 64 cm weighs 5 g. If it is stretched by a force of 8N, what will be the speed of a transverse wave passing on it?
Q-15	A string of length 20 cm and a linear mass density 0.40 g/cm is fixed at both ends and is kept under a tension of 16 N. A wave pulse is produced at $t = 0$ near an end as shown in figure which travels towards the other end.  (a) When will the string have the shape shown in the figure again? (b) Sketch the shape of the string at a time half of that found in part (a)?
Q-16	A string of linear mass density 0.5 g/cm and a total length 30 cm is tied to a fixed wall at one end to a frictionless ring at the other end as shown in the figure. The ring can move on a vertical rod. A wave pulse is produced on the string which moves towards the ring at a speed of 20 cm/s. The pulse is symmetric about its maximum which is located at a distance of 20 cm from the end joined to the ring.  (a) Assuming that the wave is reflected from the ends without loss of energy, find the time taken by the string to regain its shape. (b) The shape of the string changes periodically with time. Find the time period. (c) What is the tension in the string?
Q-17	Two wires of different densities but same area of cross-section are soldered together at one end and are stretched to a tension T. The velocity of a transverse wave in the first wire is double of that in the second wire. Find ratio of the density of the first wire top that of the second wire.
Q-18	A transverse wave is described by $y = (0.02\text{ m})\sin[(1.0\text{ m}^{-1})x + (30\text{s}^{-1})t]$ propagates on a stretched string having a linear mass density 1.2×10^{-4} kg/m. Find the tension in the string.

Q-19	A travelling wave is produced on a long horizontal string by vibrating an end up and down sinsusoidally. The amplitude of vibration is a 1.0 cm and displacement becomes zero 200 times per second. The linear mass density of the string is 0.10 kg/m and it is kept under tension of 90 N. (a) Find the speed and the wavelength of the wave. (b) Assume that the wave moves in the positive x-direction and at t=0, the end x=0 is at its positive extreme position. Write the wave equation. (c) Find the velocity and acceleration of the particle at x=50 cm at time t = 10 ms.
Q-20	A string of length 40 cm and weighing 10 g is attached to a spring at one end and to fixed wall at the other end. The spring has a spring constant of 160 N/m and is stretched by 1 cm. If wave pulse is produced on the string near the wall, how much time will it take to reach the spring?
Q-21	Two blocks each having a mass of 3.2 kg are connected by a wire CD and the system is suspended from the ceiling by another wire AB as shown in the figure. The linear mass density of the wire AB is 10 g/m and that of CD is 8 g/m. Find the speed of a transverse wave pulse produced in AB and in CD. 
Q-22	In the arrangement shown in the figure, the string has a mass of 4.5 g. How much time will it take for a transverse disturbance produced at the floor to reach the pulley? Take g = 10 m/s^2. 
Q-23	A 4.0 kg block is suspended from the ceiling of an elevator through a string having a linear mass density of 19.2×10^3 kg/m. Find the speed (with respect to the string) with which a wave pulse can proceed on the string if the elevator accelerates up at the rate of 2.0 m/s^2. Take g = 10 m/s^2.
Q-24	A heavy ball is suspended from the ceiling of a motor car through a light spring. A transverse pulse travels at a speed of 60 cm/s on the string when the car is at rest and 62 cm/s when the car accelerates on a horizontal road. Find the acceleration of the car. Take g = 10 m/s^2.
Q-25	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?
Q-26	A heavy but uniform rope of length L is suspended from a ceiling. (a) Write velocity of a transverse wave travelling on the string as a function of the the distance from the lower end. (b) If the rope is given a sudden sideways jerk at the bottom, how long will it take for the pulse to reach the ceiling? (c) A particle is dropped from the ceiling at the instant the bottom end is given the jerk. Where will the particle meet the pulse?
Q-27	Two long strings A and B. each having linear mass density 1.2×10^{-2} kg/m are stretched by different tensions 4.8 N and 7.5 N respectively and are kept parallel to each other with their left ends at x = 0. Wave pulses are produced on the strings at the left ends at t = 0 on string A and t = 20 ms on string B. When and where will the pulse on string B overtakes on A?
Q-28	A transverse wave of amplitude 0.50 mm and frequency 100 Hz is produced on a wire stretched to a tension of 100 N. If the wave speed is 100 m/s, what average power is the source transmitting to the wire?

Q-29	A 200 Hz wave with amplitude 1 mm travels on a long string of linear mass density 6 g/m kept under a tension of 60 N. (a) Find the average power transmitted across a given point on the string. (b) Find the total energy associated with the wave in a 2.0 m long portion of the string.
Q-30	A tuning fork of frequency 440 Hz is attached to a long string of linear mass density 0.01 kg/m kept under a tension of 49 N. The fork produces transverse waves of amplitude 0.50 mm on the string. (a) Find the wave speed and the wavelength of the waves. (b) Find the maximum speed and acceleration of a particle of the string (c) At what average rate is the tuning fork transmitting energy to the string?
Q-31	Two waves, travelling in the same direction through the same region, have equal frequencies, wavelengths and amplitudes. If the amplitude of each wave is 4 mm and the phase difference between the waves is 90^0, what is the resultant amplitude?
Q-32	Figure shows two waves pulses at t = 0 travelling on a string in opposite directions with the same wave speed 50 cm/s. Sketch the shape of the string at t = 4 ms, 8 ms and 12 ms. 
Q-33	Two waves, each having a frequency of 100 Hz and a wavelength of 2.0 cm, are travelling in the same direction on a string. What is the phase difference between the waves (a) If the second wave was produced 0.015 s later than the first one at the same place? (b) If the two waves were produced at the same instant but the first one was produced at a distance 4.0 cm behind the second one? (c) If each of the wave has an amplitude of 2.0 mm, what would be the amplitude of the resultant wave in part (a) and (b)?
Q-34	If speed of a transverse wave on a stretched string of length 1 m is 60 m/s, what is the fundamental frequency of vibration?
Q-35	A wire of length 2.00 m is stretched to a tension of 160 N. If the fundamental frequency of vibration is 100 Hz, find its linear mass density?
Q-36	A steel wire of mass 4.0 g and length 80 cm is fixed at two ends. The tension in the wire is 50 N. Find the frequency and wavelength of the fourth harmonic of the fundamental.
Q-37	A piano wire weighing 6.00 g and having a length of 90.0 cm emits a fundamental frequency corresponding to "middle C" ($\upsilon = 261.63$ Hz). Find the tension in the wire.
Q-38	A sonometer wire having a length of 1.50 m between the bridges vibrates in its second harmonic resonance with a tuning fork of frequency 256 Hz. What is the speed of the transverse wave on the wire?
Q-39	The length of the wire shown in the figure between the pulleys is 1.5 m and its mass 12.0 g. Find the frequency of vibration with which the wire vibrates in two loops leaving the middle point of the wire between the two pulleys at rest. 

Q-40	A one meter long stretched string having a mass of 40 g is attached to a tuning fork. The fork vibrates at 128 Hz in a direction perpendicular to the string. What should be the tension in the string if it is to vibrate in four loops?
Q-41	A wire, fixed at both ends, is seen to vibrate at a resonant frequency of 240 Hz and also 320 Hz. (a) What could be the maximum value of the fundamental frequency? (b) Of transverse waves can travel on this string at a speed of 40 m/s, what is its length?
Q-42	A string, fixed at both ends, vibrates in a resonant mode with a separation of 2.0 cm between the consecutive nodes. For the next higher resonant frequency, this separation is reduced to 1.6 cm. Find the length of the string.
Q-43	A 660 Hz tuning fork sets up vibration in a string clamped at both ends. The wave speed for a transverse wave on this string is 220 m/s and the string vibrates in three loops. (a) Find the length of the string. (b) If maximum amplitude of a particle is 0.5 cm, write a suitable equation describing the motion.
Q-44	A particular guitar wire is 30.0 cm long and vibrates at a frequency of 196 Hz when no finger is placed on it. The next higher notes on the scale are 220 Hz, 247 Hz, 262 Hz and 294 Hz. How far from the end of the string must the finger be placed to play these notes?
Q-45	A steel wire fixed at both ends has a fundamental frequency of 200 Hz. A person can hear sound of maximum frequency 14 kHz. What is the highest harmonic that can be played on this string which is audible to the person?
Q-46	Three resonant frequencies of a string are 90, 150 and 210 Hz. (a) Find the highest possible fundamental frequency of vibration of this string? (b) Which harmonics of the fundamental are the given frequencies? (c) Which overtones are these frequencies? (d) If the length of the string is 80 cm, what would be the speed of a transverse wave on this string?
Q-47	Two wires are kept tight between the same pair of supports. The tensions in the wires are in the ratio 2:1, the radii are in ration 3:1 and the densities are in the ratio 1:2. Find the ratio of their fundamental frequencies.
Q-48	A uniform horizontal rod of length 40 cm and mass 1.2 kg is supported by two identical wires as shown in the figure. Where should a mass of 4.8 kg be placed on the rod so that the same tuning fork may excite the wire on the right into its fundamental vibrations and that on left into its first overtone? Take g = 10 m/s^2. 
Q-49	Figure shows an aluminium wire of length 60 cm joined to a steel wire of length 80 cm and stretched between two fixed supports. The tension produced is 40 N. The cross-sectional area of the steel wire is 1.0 mm^2 and that of aluminium wire is 3.0 mm^2. What could be the minimum frequency of a tuning fork which can produces standing wave in the system with the joint as a node? The density of the aluminium is 2.6 g/cm^3 and that of steel is 7.8 g/cm^3. 
Q-50	A string of length L fixed at both ends vibrates in its fundamental mode at a frequency v and a maximum amplitude A. (a) Find the wavelength and the wave number k, (b) Take the origin at one end of the string and the X-axis along the string. Take Y-axis along the direction of the displacement. Take $t = 0$ at the instant when middle point of the string passes through its mean position and is going towards positive y-direction. Write the equation describing

	the standing wave.
Q-51	A 2 m long string fixed at both ends is set into vibration in its first overtone. The wave speed on the string is 200 m/s and the amplitude is 0,5 cm. (a) Find the wavelength and the frequency. (b) Write the equation giving the displacement of different points as a function of time. Choose X-axis along the string with origin at one end and $t = 0$ at the instant when the point $x = 50$ cm has reached its maximum displacement.
Q-52	The equation for the vibration of a string, fixed at ends vibrating in its third harmonic is given by $y = (0.4\text{ cm})\sin[(0.314\text{cm}^{-1})x]\cos[(600\pi\text{s}^{-1})t]$. (a) What is the frequency of vibration? (b) What are the positions of nodes? (c) What is the length of the string? (d) What is the wavelength and the speed of two travelling waves that can interfere to give this vibration.
Q-53	The equation of a standing wave, produced on a string fixed at both ends, is – $y = (0.4\text{ cm})\sin[(0.314\text{cm}^{-1})x]\cos[(600\pi\text{s}^{-1})t]$ What could be smallest length of the string.
Q-54	A 40 cm wire having a mass 3.2 g is stretched between two fixed supports 40.05 cm apart. In its fundamental mode, the wire vibrates at 220 Hz. If the area of cross-section of the wire is 1.00 mm^2, find its Young's modulus.
Q-55	Figure shows a string stretched by a block going over a pulley. The string vibrates in its tenth harmonic in unison with a particular tuning fork. When a beaker containing water is brought under the block so that block is completely dipped into the beaker the string vibrates in eleventh harmonic. Find density of the material of the block. 
Q-56	A 2.00 m long rope, having a mass 80 g is fixed at one end and is tied to a light string at the other end. The tension in the string is 256 N. (a) Find the frequencies of the fundamental and the first two overtones. (b) Find the wavelength in the fundamental and the first two overtones.
Q-57	A heavy string is tied at one end to a movable support and a light thread at the other end as shown in the figure. The thread goes over a fixed pulley and supports a weight to produce a tension. The lowest frequency with which the heavy string resonates is 120 Hz. If the movable support is pushed to the right by 10 cm so that the joint is placed on the pulley, what will be the minimum frequency at which the heavy string can resonate? 
Q-58	When two progressive waves $y_1 = 4\sin(2x - 6t)$ and $y_2 = 3\sin\left(2x - 6t - \frac{\pi}{2}\right)$ are superimposed, the amplitude of the resultant wave is?
Q-59	A 20 cm long string, having a mass of 1.0 g, is fixed at both the ends. The tension in the string is 0.5 N. The string is set into vibrations using an external vibrator of frequency 100 Hz. Find separation (in cm) between the successive nodes of the string.
Q-60	A transverse harmonic disturbance is produced in a string. The maximum transverse velocity is 3 m/s and maximum transverse acceleration is 90 m/s^2. If the wave velocity is 20 m/s then find the waveform.