Two waves on one string are described by the wave functions

At the end of this section, it will be able to: explain how mechanical waves are reflected and transmitted to the boundaries of a means define the interference terms and overlaps seeks the resulting wave of the two identical sinusoidal waves that differ only from a phase shift up So far, we have studied mechanical waves that propagate continuously through a means, but we have not discussed what happens when the waves meet the outline of the middle or what happens when a wave meets another propagation of the wave through the same means. Waves interact with the borders of the vehicle, and all or part of the wave can be reflected. For example, when you find a certain distance from a rigid rocky wall and scream, you can feel the sound waves are reflected on the rigid surface like an echo. Waves can also interact with other waves that propagate it in the same vehicle. If you throw two rocks in a pond a certain distance from each other, the circular ripples that derive from the two stones seem to go through one another as they propagate out where the stones have entered the water. This phenomenon is known as interference. In this section, we examine what happens to the waves meet a border of a means or another wave propaga in the same vehicle. We will see that their behavior is very different from the behavior of particles and rigid bodies. Later, when studying modern physics, we will see that only at the scale of atoms we see similarities in the properties of waves and particles. When a wave propagates through a means, it reflects when he meets the border of the vehicle. The wave before hitting the border is known as the accident wave. The wave after meeting the border is known as the reflected wave. As the wave is reflected on the border of the vehicle depends on the contour conditions; Waves react differently if the border of the medium is fixed in position or free to move ((figure)). There is a standing contour condition when the vehicle in a border is fixed in a position so that it cannot move. A free border condition exists when the middle on the border is free to move. Figure 16.17 (a) An end of a string is fixed so that it cannot move. A wave propaga on the rope, meeting this condition at the fixed contour, reflects [latex] 180 text {Ã, â °} (\ Text {rad}) [/ latex] out of stage compared to the incident wave . (B) one end of a string is tied to a solid mass on a laboratory ring negligible friction pole, wherein the ring is free to move. A wave propagates on the rope, meeting this free border condition, reflects in phase [latex] 0 text {} Â, Â ° (0, text {} rad) [/ latex] compared to the wave. The part (A), of the (figure) shows a condition at the fixed outline. Here, an end of the rope is fixed to a wall at the end of the string is fixed and the medium (string) to the border cannot move. When the wave is reflected, the amplitude of the reflected mode is exactly the same as the width of the accident wave, but the reflected wave is reflected [latex] 180 text {ã, Â °} (, Text {rad}) [/ latex] out of stage compared to the incident wave. The phase change can be explained with third law NewtonÃ ¢ s: we remind you that NewtonÃ ¢ s third law states that when the object to exercise a force on an object b, then object b exercises equal force and contrary to object A. As the wave incident meets the wall, the string exerts a force upwards on the wall and the walls reacts by exercising an equal force and contrast to the rope. Reflection in a fixed border is inverted. Note that shows the figure a crest of the wave accident reflected by water trough. If the incident wave was a trough, the reflected wave would be a crest. Part (b) shows the figure of a condition at the free outline. Here, an end of the rope is To a negligible mass solid ring on an friction pole, so the end of the string is free to move up and down. As the incident wave meets the border of the vehicle, it is also reflected. In in Case of a free border condition, the reflected wave is compared to the wave of the accident. In this case, the wave meets the free border that applies a force upwards in the ring, accelerating the ring. The ring travels up to the maximum height equal to the width's width and then accelerates towards the balance position due to the voltage in the string. The figure shows the crest of a wave of accident that is reflected in the phase with respect to the wave of the accident as a crest. If the wave of the accident was a trough, the reflected wave would also be a trough. The amplitude of the reflected wave would be equal to the width of the accident wave. In some situations, the border of the vehicle is nor né free né free. Consider (figure) (A), where a string of low linear mass density is connected to a string of a higher linear mass density. In this case, the reflected wave is out of stage compared to the wave of the accident. There is also a broadcast wave that is in phase compared to the wave of the accident. Both the accident and the reflected waves have width less than the wake of the accident wave. If the voltage is the same in both strings, wave speed is higher in string with lower linear mass density. Figure 16.18 Waves traveling along two types of strings: a thick string with a high linear thickness and a thin string with a low linear density. Both strings are under the same voltage, so a wave moves more quickly on the low densitious string than the high density string. a) a wave moving from a low speed to a high speed medium in a reflected wave [latex] 180 text {Ã ¢ Â °} (\ t text {rad}) [/ in Stage latex with respect to the incident impulse (or wave) and a broadcast wave that is in phase with the wave of the accident. (b) When a wave moves from a low speed support to a high-speed vehicle, both the reflected and transmitted wave are steeped by the wave of the accident. Part (b) of the figure shows a string of high linear mass density is connected to a string of a lower linear density. In this case, the reflected wave is compared to the wave of the accident. There is also a broadcast wave that is in phase compared to the wave of the accident. Both the accident and the reflected waves have width less than the wake of the accident wave. Here you may notice that if the voltage is the same in both strings, the wave speed is higher in the string with lower linear mass density. Most waves look very simple. Complex waves are more interesting, even beautiful, but seem formidable. The most interesting mechanical waves consist of a combination of two or more travel waves that propagate it in the same vehicle. The superimposed principle can be used to analyze the combination of waves. It considers two simple pulses of the same amplitude that move to the other in the same means, as shown in (figure). In the end, the waves overlap, producing a wave that has twice the width, and then continue on not influenced by the meeting. It is said that the impulses interferes and this phenomenon is known as interference. Figure 16.19 Two pulses that move towards another interference of experience. The term interference refers to what happens when two waves overlap. To analyze the interference of two or more waves, we use the overlapping principle. For mechanical waves, the superimposed principle states that if two or more travel waves combine in the same point, the resulting position of the mass element of the vehicle, at that point, is the algebraic sum of the position due to the individual Waves. This property is exposed by many waves observed, such as waves on a rope, sound waves and water waves. The waves They also obey the overlapping principle, but the electric and magnetic fields of the combined wave are added instead of moving the vehicle. The waves that obey the overlapping principle are linear waves; Waves that do not obey the at the Principle is said that they are non-linear waves. In this chapter, we deal with linear waves, in particular, sinusoidal waves. The principle of overlap can be understood considering the linear wave equation. In a wave mathematics, we defined a linear wave as a wave whose mathematical representation obeys the linear wave equation. For a cross wave on a string with an elastic recall force, the linear wave equation is [latex] Frac {{partial} ^ {2} y (x, t)} {partial {x } ^ {2}} = frac {1} {{v} ^ {2}}} {2 {partial} ^ {2} y (x, t)} {partial {t} ^ {2 }}. [/ Latex] all wave function [latex] y (x, t) = y (x mp vt), [/ latex] where the topic of the function is linear [latex] (x mp vt) [/ Latex] It is a solution of linear wavequaring and is a linear wave function. If [latex] waveforms {y} _ {1} (x, t) [/ latex] and [latex] {y} _ {2} (x, t) [/ latex] are solutions of equation d 'linear wave, the sum of the two functions [latex] {y} _ {1} (x, t) + {y} _ {2} (x, t) [/ latex] is also a solution of equation d Linear wave. Mechanical waves that obey overlap normally bound to waves with amplitudes that are small compared to their wavelengths. If the amplitude is too large, the medium is distorted beyond the region where the recovery force of the vehicle is linear. Waves can interfere constructively or destroyed. (Figure) shows two identical sinusoidal waves that arrive at the same point exactly in phase. (Figure) (a) and (b) show the two individual waves (figure) (c) shows the resulting wave resulting from the algebraic sum of the two linear waves. The ridges of the two waves are precisely aligned, as well as the troughs. This overlap produces constructive interference. Because disturbances add, constructive interference produces a wave that has twice the amplitude of the individual waves, but has the same wavelength. (Figure) shows two identical waves that come exactly [latex] 180 text {Ã, â °} [/ latex] out of stage, producing destructive interference. (Figure) (a) and (b) show the individual waves, and (figure) (c) shows the overlap of two waves. Because a wave depressions add a wave crest else, the resulting width is zero for destructive interference waves completely cancel. Figure 16.20 Construction interference of two identical waves produces a wave of double width, but the same wavelength. Figure 16.21 Destructive interference of two identical waves, one with a phase shift of [latex] 180 text {ã, â °} (When linear waves interfere, the resulting wave is only the algebraic sum of the individual waves, as indicated in the principle of overlap. (Figure) shows two waves (red and blue) and the resulting wave (black). The resulting wave is the algebraic sum of the two single waves. Figure 16.22 When two linear waves in the same means interfere, the resulting wave height is the sum of the heights of the individual waves, point for point adopted. This shows two waves (red and blue) added together, together with the resulting wave (black). These graphs represent the height of the wave at every point. The waves can be any linear wave, including ripples on a pond, disturbances on a thread, sound, or electromagnetic waves. The overlap of greater waves produces a combination of constructive and destructive interference, and can vary from place to place and from time to time. Sound from a stereo, for example, can be noisy at one point and silent in another. Varying Loudness means that the sound waves add partially constructive and partially destroyed in different places. A stereo has at least two speakers that create sound waves and waves can reflect from the walls. All Waves interfere, and the resulting wave is the overlap of waves. We showed some examples of overlapping waves that are similar. (Figure) shows an example of the overlap of two unlike waves. In this case, disturbances disorders Producing a resulting wave. Figure 16.23ã, the overlapping non-resident waves shows constructive and destructive interference. Sometimes, when two or more mechanical waves interfere, the model produced by the resulting wave can be rich in complexity, some without any easily discernable model. For example, trace the sound wave of your favorite music can seem rather complex and is the overlapping of the individual sound waves of many tools; It's the complex that makes music interesting and worth listening. Other times, the waves can interfere and produce interesting phenomena, which are complex in their appearance and yet beautiful in simplicity of the physical principle of overlap, which formed the resulting wave. An example is the phenomenon known as standing waves, produced by two identical waves that move in different directions. We will seem more closely by this phenomenon in the next section. Many examples in physics consist of two identical sinusoidal waves in width, wave number and angular frequency, but differ from a phase shift: [LATEX] Begin {array} {C} {Y} _ {1} (x, t) = a, text {sin} (kx- omega t + varphi), {y} _ {2} (x, t) = a, text {sin} (kx- omega t). HILL END {array} [/ latex] When these two waves exist in the same vehicle, the resulting wave resulting from the overlap of the two single waves is the sum of the two individual waves: [LATEX] {Y} _ {R } (x, t) = {y} _ {1} (x, t) + {y} _ {2} (x, t) = a, text {sin} (kx- omega t + varfi) + A, text {sin} (kx- omega t). [/ latex] The resulting wave can be better understood using trigonometric identity: [LATEX] text {sin}, u + text {sin}, v = 2, text {sin} (frac {u + v} {2}) text {cos} (frac {uV} {2}), [/ latex] where [latex] u = kx- omega t + varphi [/ lathex] and [latex] v = kx- omega t [/ lathex]. The resulting wave becomes [LATEX] Begin {array} {cc} hill {y} _ {r} (x, t) & = {y} _ {1} (x, t) + {y} _ { 2} (x, t) = a, text {sin} (kx- omega t + varphi) + a, text {sin} (kx omega t) HILL & = 2A , text {sin} (frac {(kx omega t + varphi) + (kx- omega t)} {2}) text {cos} (frac {(kx omega t + warphi) - (kx omega t)} {2}) hill & = 2a, text {sin} (kx- omega t + frac {varphi} {2}) text {cos } (frac {varphi} {2}). HILL END {array} [/ LATEX] This equation is usually written as [latex] {y} _ {r} (x, t) = [2a, text {cos} (frac {varphi} {2})] text {sin} (kx- omega t + frac {varphi} {2}). [/ latex] The resulting wave has the same wavelength and angular frequency, a width of [latex] {A} _ {R} = [2A, text {COS} (frac { Varphi} {2})], [/ LATEX] and a phase shift equal to half of the original phase displacement. Examples of waves that differ only in a phase shift are shown in (figure). The red and blue waves have the same amplitude, the number of the wave and the angular frequency and differ only in a phase shift. Then they have the same period, wavelength and frequency. The green wave is the result of the overlap of the two waves. When the two waves have a phase difference of zero, the waves are in phase and the resulting wave has the same wave number and the same corner frequency and a width equal to twice the single amplitudes (part (a)). This is a constructive interference. If the phase difference is [LATEX] 180 text {Ã ¢ â °}, [/ LATEX] The waves interfere in destructive interference (part (C)). The resulting wave has a width of zero. Any other phase difference translates into a wave with the same wave number and the angular frequency of the two waves of accidents but with a phase shift of [LATEX] VARPHI text {/} 2 [/ LATEX] and A width of [LATEX] 2A, text {COS} (VARPHI text {/} 2). [/ Latex] Examples Shown in parts (b) and (D). Figure 16.24 Superposition of two waves with identical amplitudes, wavelengths and frequency, but which differ in a phase shift. The red wave is defined by the Wave [LATEX] function {Y} _ {1} (x, t) = a, text {sin} (kx- omega t) [/ latex] and the blue wave It is defined by the Wave [LATEX] function {Y} _ {2} (x, t) = a, text {sin} (kx- omega t + varphi) [/ latex]. The black line shows the result of The two waves. The phase difference between the two waves is (a) [latex] 0.00, text {rad}, [/ lathex] (b) [latex] text {/} 2, text {rad, } [/ LATTIC] (c) [latex] text {rad,} [/ lathex] and (d) [latex] 3 more text {/} 2, text {rad} [/ LATEX]. The summary overlay is the combination of two waves in the same position. Constructive interference occurs from the overlap of two identical waves that are in phase. Destructive interference takes place from the overlap of two identical waves [LATEX] 180 text {Ã ¢ â °} (LEXT {radians}) [/ latex] out of stage. The wave resulting from the overlap of two synigant waves that differ only from a phase shift is a wave with a width that depends on the value of the phase difference. A sinusoidal wave of the accident is sent along a string that is fixed to the wall with a velocity of the wave of v. The wave reflects the end of the string. Describe the reflected wave. A string of a length of 2.00 m with a density of linear mass of [latex] MU = 0.006, text {kg / m} [/ in latex] is connected to the end of a string of 2, 00 m with a linear linear density of mass of [LATEX] MU = 0.012, text {kg / m}. [/ latex] The free end of the string of high density is fixed to the wall, and a student contains the free end of the low density string, keeping the voltage constant in both strings. The student sends an impulse along the string. Describe what happens to the interface between the two strings. A long and narrow spring is detained by two students, a student holding every end. Each student finally gives a flip by sending a wave length of a sinusoid wave at the bottom of the spring in opposite directions. When the waves meet in the middle, what does the wave appear? Many of the arguments discussed in this chapter are useful beyond the topics of mechanical waves. It is difficult to conceive a mechanical wave with sharp angles, but you could meet a thus wave shape in the digital electronics class, as shown below. This could be a signal from a device known as an analog digital converter, in which a continuous voltage signal is converted into a discreet signal or a digital sound recording. What is the result of the overlapping of the two signals? A string of a constant linear mass density is kept tense by two students, each holding a end. The voltage in the string is constant. Students each send the waves along the WinGGling string the string. (a) Is it possible that the waves have speeds of different waves? (b) Is the waves have different frequencies? (c) Is it possible that the waves have different wavelengths? Considers two sinusoidal waves traveling along a string, modeled as [latex] {y} _ {1} (x, t) = 0.3, text {m}, text {sin} (4, { text {m}} ^ {- 1} x + 3, {text {}} ^ {- 1} t) [/ latex] and [latex] {y} _ {2} (x, t) = 0.6, text {m}, text {sin} (8, {text {m}}} {- 1}}} {- 1} x-6, {text {s}} ^ {- 1} t). [/ in latex] What is the height of the resulting wave formed by the interference of the two waves in the [LATEX] X = 0.5, text {M} [/ LATEX] at the moment [LATEX] T = 0.2, text {s?} [/ LATEX] Consider two sinusoidal waves of the breast traveling along a string, modeled as [LATEX] {Y} _ {1} (X, T) = 0.3 text {m}, text {sin} (4, {text {m}} ^ {- 1} x + 3, {text {}} ^ {- 1} t + frac { plus} {3}) [/ latex] and [latex] {y} _ {2} (x, t) = 0.6, text {m}, text {sin} (8, {text {m}} ^ {- 1} x -6, {text {s}} ^ {- 1} t). [/ latex] What is the height of the resulting wave formed by the interference of the two waves in the [LATEX] X = 1.0, text {M} [/ LATEX] at the moment [LATEX] T = 3.0 , text {s?} [/ lathex] Consider two sinusoidal waves of the traveling along a string, modeled as [latex] {y} _ {1} (x, t) = 0.3, text {m}, text {sin} (4, {text {m }} ^ {- 1} x-3 ^ {text} ^ {text {s}} ^ {- 1} t) [/ latex] and [latex] {y} _ {2} (x , t) = 0.3, text {m}}, text {sin} (4, {text {m}}} {- 1}} ^ {- 1} x + 3, { text {s}} ^ {- 1} t). [/ LATEX] What is the wave function of the resulting wave? [Tip: use the trig identity [latex] text {sin} (u Â ± v) = text {sin}, u, text {cos}, vÃ ¢ Â ±, text { COS}, text {sin}}}, V [/ LATEX] Two sinusoidal waves are moving through a means in the same direction, both having having of 3.00 cm wavelength of 5.20 m, and a period of 6.52 s, but there is a phase shift of a corner [latex] varphi [/ latex]. What is the phase shift if the resulting wave has a width of 5.00 cm- [Tip: use the trig identity [latex] text {sin}, u + text {sin}, v = 2 text {sin} (frac {u + v} {2}) text {cos} (frac {uV} {2}) [/ latex] Two sinusoidal waves move through a means in the positive X direction , both with amplitudes of 6.00 cm, a wavelength of 4.3 m, and a period of 6.00 s, but you have a phase shift of a corner [latex] varphi = 0.50, text { } rad. [/ Latex] What is the height of the resulting wave at a time [latex] t = 3.15, text {s} [/ latex] and a [latex] x = 0.45, text {m} [/ Latex]? Two sinusoidal waves move through a medium in the positive X direction, both with amplitudes of 7.00 cm a wave number of [latex] k = 3.00, {text {m}} {- 1}, [/ latex] A corner frequency [latex] omega = 2.50, {text {s}} ^ {- 1}, [/ latex] and a period of 6.00 s, but you have a phase shift of a corner [latex] varphi = frac {more} {12}, text {} rad. [/ Latex] What is the height of the resulting wave at a time [latex] t = 2.00, text {s} [/ latex] and a [latex] position x = 0.53, text {m?} [/ latex] Consider two [latex] {y} _ {1} (x, t) [/ latex] and [latex] {y} _ {2} (x, t) [/ latex] which are identical except A multiplication phase shift in the same vehicle. (A) What is the phase shift, in radians, if the wave's width is 1.75 times the amplitude of the individual waves? (B) What is the phase shift in degrees? (C) What is the phase shift as a percentage of the single wavelength? Two sinusoidal waves, which are identical except for a phase shift, travel along in the same direction. The resulting wave's wave equation is [latex] {y} _ {r} (x, t) = 0.70, text {m}, text {sin} (3.00, {text {m}} ^ {- 1} x-6.28, {text {s}} {- 1} T + more {/} 16, text {} rad). [/ Latex] What are the angular frequency, number, amplitude and phase shift of the individual wave waves? Two sinusoidal waves, which are identical except for a phase shift, travel along in the same direction. The resulting wave's wave equation is [latex] {y} _ {r} (x, t) = 0.35, text {cm}, text {sin} (6.28, { text {m}} ^ {- 1} x-1.57, {text {s}} ^ {- 1} t + frac {} {4}). [/ Latex] What are the period, wavelength, amplitude and phase shift of individual waves? Consider two wave functions, [latex] {Y} _ {1} (x, t) = 4.00, text {m}, text {sin} ({{{m}} ^ {-1} x- more {text {s}} ^ {- 1} t) [/ latex] and [latex] {y} _ {2} (x, t) = 4.00, text {m}, text {sin} ({{text {m}} ^ {- 1} x- {{{s}} ^ {- 1} t + frac {more} {3}). [/ LATTIC] (a) Use a sheet, trace the two wave functions and the wave resulting from the overlap of the two wave functions depending on the [latex] position (0.00 x 6.00 text {m}) [/ latex] For the time [latex] t = 0.00, text {s}. [/ Latex] (b) What are the wavelength and the amplitude of the two original waves? (C) What are the wavelength and width of the resulting wave? Consider two wave functions, [latex] {y} _ {2} (x, t) = 2.00, text {m}, text {sin} (frac {} {2} { text {m}} ^ {- 1} x- frac {more} {3} {text {}} ^ {- 1} t) [/ latex] and [latex] {y} _ {2} (x, t) = 2.00, text {m}, text {} sin (frac {} {2} {text {m}} ^ {- 1} x- frac { } {3} {text {s}} ^ {- 1} t + frac {} {6}). [/ Latex] (a) Verify that [latex] {y} _ {r} = 2a, text {cos} (frac {varphi} {2}) text {sin} (kx omega t + Frac {varphi} {2}) [/ LATTIC] is the solution for the wave that results from an overlap of two waves. Make column for x, [latex] {y} _ {1} [/ latex], [latex] {y} _ {2} [/ latex], [latex] {y} _ {1} + {y} _ { 2} [/ latex] and [latex] {y} _ {r} = 2a, text {} so (frac {varphi} {2}) text {sin} (kx omega t + frac {varphi} {2}). [/ Latex] Four wave texture depending on the position in which the X range goes from 0 to 12 m. Consider two wavelengths that differ only for a phase shift, [latex] {y} _ {1} (x, t) = a, text {} so (kx omega t) [/ latex] and [latex] {Y} _ {2} (x, t) = a, text {cos} (kx- omega t + varphi). [/ Latex] Use trigonometric identities [latex] [latex] [/ Latex] and [latex] text {cos} (text {Ã, '} theta) = text {cos} (theta) [/ lathex] to find an wave equation for the wave resulting from the overlap of the two waves. The resulting wave function is a surprise for you? Constructive interference when two waves arrive at the same point exactly in phase; That, the ridges of the two waves are precisely aligned, as well as depressive destructive interference when two identical waves arrive at the same point exactly out of stage; ie, a precisely aligned coat of arms to spread the fixed boundary conditions when the medium at a limit is fixed in a position so that it cannot move the border condition free when the middle of the border is free to move the overlapping of interference two or more waves at the same point at the same point and the phenomenon of overlapping time that occurs when two or more waves arrive at the same point point