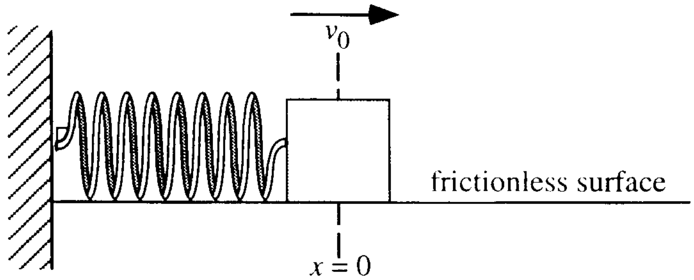
Name SOLUTION Total Points ________

Last First

1. A block of mass $m = 300$ g is attached to a horizontal spring of spring constant $k = 20$ N/m. At $t = 0$ the spring is at its equilibrium length and the block is given a velocity $v_0 = 80$ cm/s to the right. The subsequent motion of the block can be described by $x = x_{max} \cos(\omega t + \phi)$.



A. [11 pts] Determine the following quantities:

i. the angular frequency ω

$$\omega = \sqrt{\frac{k}{m}} = 8.16 \frac{rad}{s}$$

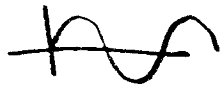
ii. the amplitude x_{max}

CONSERVE E : $E_i = E_F$ and $KE_i = PE_f$ and $\frac{1}{2} m v_0^2 = \frac{1}{2} k x^2$

so $x_m = \sqrt{\frac{m}{k} v_0^2} = .1\,m$

iii. the phase constant ϕ

At $t = 0$ $x = 0$ $\therefore$ $0 = \cos\phi$ $\therefore$

$\phi = -\pi/2$. x vs t looks like 

B. [5 pts] At $t = 0.5$ s, determine:

i. the displacement x of the block (about its equilibrium position.)

$$x = .1\,m \cos\left(8.16 \frac{rad}{s}(.5s) - \frac{\pi}{2}\right) = -.08\,m$$

ii. the speed v of the block.

$$v = \dot{x} = (.1\,m)\left(8.16 \frac{rad}{s}\right) \sin\left(8.16 \frac{rad}{s}(.5s) - \frac{\pi}{2}\right) = -.48 \frac{m}{s}$$

C. [9 pts] As described above, at $t = 0$ the block is at its equilibrium position ($x = 0$) and is moving to the right. At $t = T/4$ (where T is the period of the motion) the block has reached its maximum displacement ($x = x_{max}$).

i. At $t = T/8$, is the block *to the right of, to the left of,* or *at* $x = x_{max}/2$? Explain.

since the block has a greater average velocity from $t=0$ to $t = T/8$ than from $T/8$ to $T/4$ and the time interval is the same the block must have travelled a greater distance from $t=0$ to $T/8$.

ii. Is the change in velocity of the block (Δv_1) between $t = 0$ and $t = T/8$ *greater than, less than,* or *equal to* the change in velocity between $t = T/8$ and $t = T/4$ (Δv_2)? Explain.

As the spring stretches, the force on the block increases until $T/4$ $\therefore$ the average acceleration from $T/8$ to $T/4$ is bigger and since the Δt's are equal we have $\Delta V = a \Delta t$ so ΔV from $T/8$ to $T/4$ must be bigger.

Name (please print): ____ total points:______
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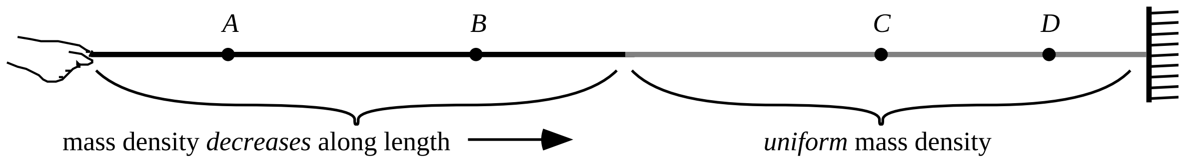
2. [25 pts] A fishing line consists of two sections. The first has a linear mass density that decreases smoothly from left to right along its length; the second has uniform linear mass density. At the boundary, the linear mass densities of the two sections are equal.

The *left* end of the fishing line is given two quick, identical shakes, causing two pulses to propagate from left to right along the line. *(For this problem, ignore reflections.)*



A. [8 pts] The speed of the first pulse is measured when it passes point *A* (v_A), point *B* (v_B), point *C* (v_C), and point *D* (v_D). Rank v_A, v_B, v_C, and v_D in order from smallest to largest. Explain.

$v_A < v_B < v_C = v_D$ The tension is the same everywhere in the two sections of the line, so the speed of the pulse varies only with the linear mass density of the line on which it propagates. The speed will be smaller at point *A* than point *B*, because the mass density is greater at *A* than *B*. The mass densities at *C* and *D,* and thus the pulse speeds, will be equal, because that section of the line has uniform density. The speed at *B* is less than that at *C* because the mass density of the two sections are matched at the boundary.

B. [6 pts] Does the width of the first pulse *increase, decrease,* or *remain the same* as it moves from point *A* to point *B*? Explain.

Increase. The first pulse speeds up as it moves along the line from point *A* to point *B.* The leading edge of the pulse always moves with greater speed than the trailing edge. This implies that the edges become farther apart, and the width of the pulse increases.

C. [6 pts] An observer measures the time that elapses between the crests of the two pulses passing point *B* (Δt_B). Another observer measures the time that elapses between the crests of the two pulses passing point *C* (Δt_C).

Is Δt_B *greater than, less than,* or *equal to* Δt_C? Explain.

Equal to. The time between the two crests passing any fixed point on the line is determined by how much time is taken between shakes of the left end of the line, and is independent of the medium along which the pulses propagate.

D. [5 pts] During the time interval when the first pulse has passed the boundary but the second pulse has not yet reached it, does the distance between the crests of the two pulses *increase, decrease,* or *remain the same?* Explain.

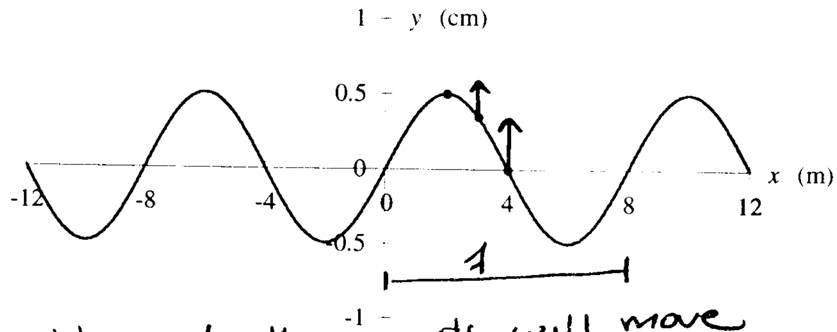
Increase. During this interval, the first pulse moves with greater speed than the second pulse. Thus it will have a greater displacement along the line than the second pulse, and the distance between the two pulses will increase. Once the second pulse moves onto the right hand section of the line, the distance between the pulses will remain constant.

Name SOLUTION

Last First

Total Points ________

3. A wave travels to the right on a string with tension $T = 320$ N and linear mass density $\mu = 0.2$ kg/m. A portion of the string at $t = 0$ is shown in the figure.



A. [6 pts] At each of the three points marked on the figure, sketch a vector showing the direction of the velocity of that part of the string at the instant shown. Explain your reasoning.

since the wave moves right and the points will move in the y direction with the string two will move up But the one at the top will have an inst. velocity of zero.

B. [8 pts] Write an expression that describes the shape of the string at all positions x for all times t. Give numerical values for all constants.

$y = A\sin(kx - \omega t)$ and $k = \frac{2\pi}{\lambda}$ where $\lambda = 8m$ and $\omega = 2\pi f$ since $v = \sqrt{T/\mu} = 40 m/s$ and $v = \lambda f$ we get $\omega = 31.4 \frac{rad}{s}$ and $k = .79 m^{-1}$ so $y = .5cm(.79m^{-1}x - 31.4 \frac{rad}{s} t)$

C. [11 pts] A second wave of the same wavelength and amplitude travels on the same string in the same direction as the wave above. The phase difference between the two waves is $\Delta\phi = 0.2\pi$ rad.

i. Write an expression for the *transverse velocity* of the string as a function of x and t.

$y_T = y_1 + y_2 = A\sin(kx - \omega t) + A\sin(kx - \omega t + .2\pi)$ so

$\dot{y}_T = -[\omega A\cos(kx - \omega t) + \omega A\cos(kx - \omega t + .2\pi)]$

using $\cos A + \cos B = 2\cos\frac{1}{2}(A+B)\cos\frac{1}{2}(A-B)$ we get $-2\omega A\cos(kx - \omega t + .1\pi)\cos(.1\pi)$

ii. Find the transverse velocity of a marker attached to the string at $x = 3.6$ m at $t = 3$ s.

Plugin in #'s we have:

$$\dot{y}_T = -2\omega A\cos .1\pi \cos((.79m^{-1})(3.6m) - (31.4\frac{rad}{s})(3s))$$
$$= -.31 m/s\,[.95]\cos[2.84 - 94.2] = .28 m/s$$

iii. Find the maximum transverse *acceleration* of the marker attached to the string.

max transverse acceleration is when $\cos[kx\ldots]$ goes to 1 $\therefore$ $a_{max} = |\ddot{y}_T| = 2\omega^2 A\cos(.1\pi)$

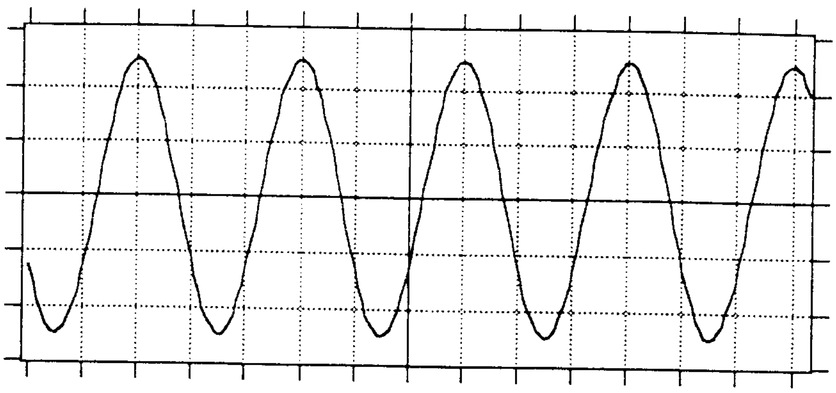
$$= 9.36 m/s^2$$

LAB PROBLEM SOLUTIONS

Physics 123, Spring 2000, Exam 1 Name ____________________ Total Pts.______

(last), (first)

Question 4 (25 points)



a. 6 pts) A signal from a microphone is shown in the above scope trace. Assuming a time setting of 0.5 ms/division and a voltage sensitivity of 20 mV/ division, state the period, frequency and amplitude (peak-to-peak) of the observed signal. (Include all units.)

$T = 1.5\,ms \qquad f = \frac{1}{T} = 666.7\,Hz \qquad V = 100\,mV$

b. 6 pts) Assume that the above oscilloscope trace is generated by a signal source driving a speaker. If the microphone is moved away from the speaker and the scope is triggered by the microphone what do you expect to happen to the trace? What if the scope is triggered by the signal generator driving the speaker?

when triggered by the microphone the trace will not change or shift in time, but the amplitude will be reduced.

when triggered relative to the signal generator, the trace will shift/change in time and the amplitude will be reduced.

c. 7 pts) For a 700 Hz signal, one displaces the microphone 40 cm from its original position, and observes that the first maximum moves by 0.6 ms. What is the wavelength of this signal and what is the speed of sound. Is this velocity consistent with the speed of sound in air?

$T = \frac{1}{f} = 1.429\,ms$, $\lambda = (\text{position change}) \times \left(\frac{T}{\text{time change}}\right) =$

$\boxed{\lambda = 40\,cm \cdot \left(\frac{1.429\,ms}{.6\,ms}\right) = 95.2\,cm}$

$V = \lambda f = (95.2\,cm) \times (700\,Hz)$

$\boxed{V_{ss} = 666.4\,m/s}$ No V_{ss} in air is $331\,m/s$

d. 6 pts) If the lab temperature increased would you expect the speed of sound to decrease or increase? Assuming room temperature of 20 C, what % change would one observe in the speed of sound if the laboratory temperature rose to 50 C?

$V_{ss} \propto \sqrt{T}$ where T is in kelvin $\Rightarrow$ $V_{ss} \uparrow$ if $T \uparrow$

$\frac{V_{50^\circ}}{V_{20^\circ}} = \frac{\sqrt{323}}{\sqrt{293}} = 1.05 \Rightarrow$ 5% increase in speed of sound.