Physics 133 3:30pm, Sp2006; April 20th

Name: KEY

TA: ______________________

This is midterm 1 for Physics 133; write your name on every page of this exam.
Do it NOW....

There are a total of 6 pages, including this cover sheet, and the last page which is an equation sheet. You may detach the equation sheet and refer to it during the exam.

Page 2 has four multiple choice problems. Choose the best single answer.

Pages 3,4,5 each have a single show work problem. All work must be shown in order to receive credit.

GOOD LUCK.

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Multiple choice. Choose the best answer of those provided.
(5 pts each)

1) For a given medium, the frequency of a wave is:
A) Independent of wavelength
B) Proportional to wavelength
(C) Inversely proportional to wavelength (circled)
D) Proportional to the amplitude
E) Inversely proportional to the amplitude

$v = \lambda f$

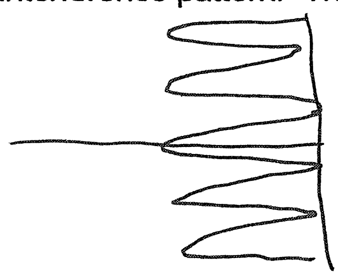
$f = \frac{v}{\lambda}$

2) No fringes are seen in a single-slit diffraction experiment if:
A) The screen is far away
B) The slit width is greater than a wavelength
(C) The slit width is less than a wavelength (circled)
D) The wavelength is less than the distance to the screen
E) None of the above (fringes are always seen)

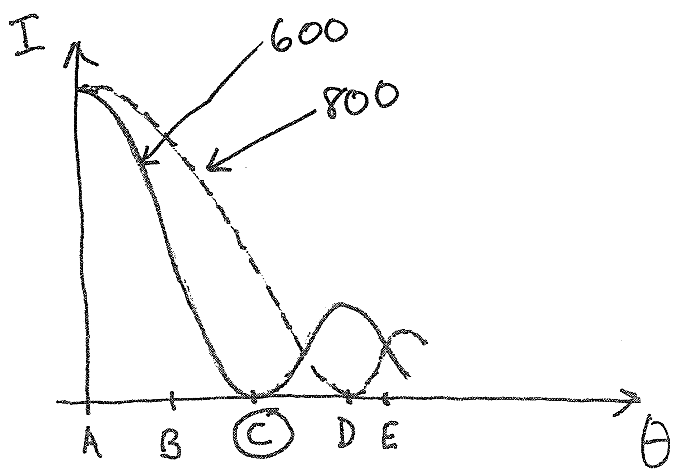
$\sin\theta_p = \frac{p\lambda}{a}$

if $a < \lambda$, $\sin\theta_p > 1$

3) Waves from two slits are in phase at the slits and travel to a distant screen to produce the <u>second</u> side maximum of the interference pattern. The difference in distance traveled by the waves is:
A) Half a wavelength
B) A wavelength
C) Three halves of a wavelength
(D) Two wavelengths (circled)
E) Five halves of a wavelength



4) Two wavelengths, 800nm and 600nm, are used separately in single-slit diffraction experiments. The diagram shows the intensities on a far-away viewing screen as a function of the angle made by the light rays with the straight ahead direction. If both wavelengths are then used simultaneously, at which angle is the light on the screen purely 800nm light? Circle one of A,B,C,D,E on the graph below:



$W = \frac{2\lambda L}{a}$

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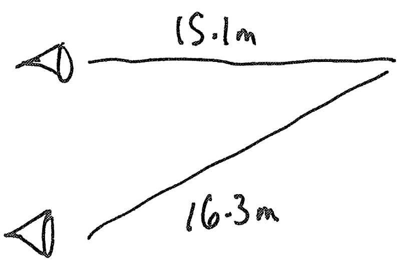
Show work; all work must be shown to receive credit.

1) At a party, two loudspeakers are spaced 3.1m apart, playing the classic song, Lucy in Sky with Diamonds, by William Shatner. You are at this party studying for a physics midterm. You happen to be located 15.1m from one speaker, and 16.3m from the other. You recall that most of the audible range is between 20Hz and 20kHz, and that the speed of sound in air is 340m/s.

A) What is the lowest frequency at which you will hear a minimum signal of this incredible recording, due to fully destructive interference? (15 pts)
B) What is the lowest frequency will you be lucky enough to hear a maximum signal? (10 pts)



$\Delta r = 1.2\text{m}$

A) $\frac{\Delta r}{\lambda} = (m + 1/2)$ set $m = 0$

$$\lambda = \frac{\Delta r}{(m + 1/2)} = \frac{1.2\text{m}}{(1/2)} = 2.4\text{m}$$

$$v = \lambda f$$

$$f = \frac{v}{\lambda} = \frac{340\text{m/s}}{2.4\text{m}} = 141.7\ \text{Hz}$$

B) $\frac{\Delta r}{\lambda} = m$ $m = 0$ is equidistant, so $m = 1$

$$\Delta r = \lambda$$

$$\lambda = 1.2\text{m}$$

$$f = \frac{v}{\lambda} = \frac{340\text{m/s}}{1.2\text{m}} = 283.3\ \text{Hz}$$

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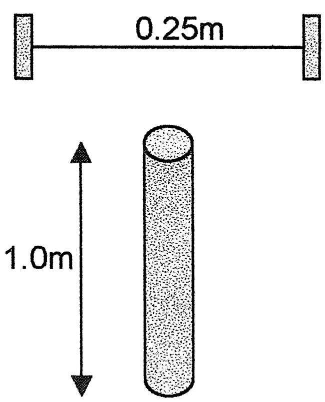
2) A tube 1.0m long is closed at one end, and open to the air at the other. A stretched guitar string of mass 0.010kg is placed near the open end of the tube and plucked. The string is 0.25m long, and oscillates at its fundamental frequency, causing the tube to also oscillate at its fundamental frequency. The speed of sound in air is 340m/s. (Hint: the frequency of oscillation of the string and the tube are the same.)

A) What is the fundamental frequency of the tube? (10 pts)
B) What is the tension in the wire? (20 pts)



A) open/closed

$$\lambda_m = \frac{4L}{m}$$

$$\lambda_1 = \frac{4(1)}{1} = 4.0\,m$$

$$v = \lambda f$$

$$f = \frac{v}{\lambda} = \frac{340\,m/s}{4.0\,m} = 85\,Hz$$

B) string

$$\lambda_m = \frac{2L}{m}$$

$$\lambda_1 = \frac{2(0.25)}{1} = 0.5\,m$$

$$v = \lambda f = (0.5)(85) = 42.5\,m/s$$

$$v = \sqrt{\frac{F_t}{\mu}} \qquad \mu = \frac{0.01\,kg}{0.25} = 0.04\,\frac{kg}{m}$$

$$F_t = \mu v^2 = (0.04)(42.5)^2$$

$$\boxed{F_t = 72.25\,N}$$

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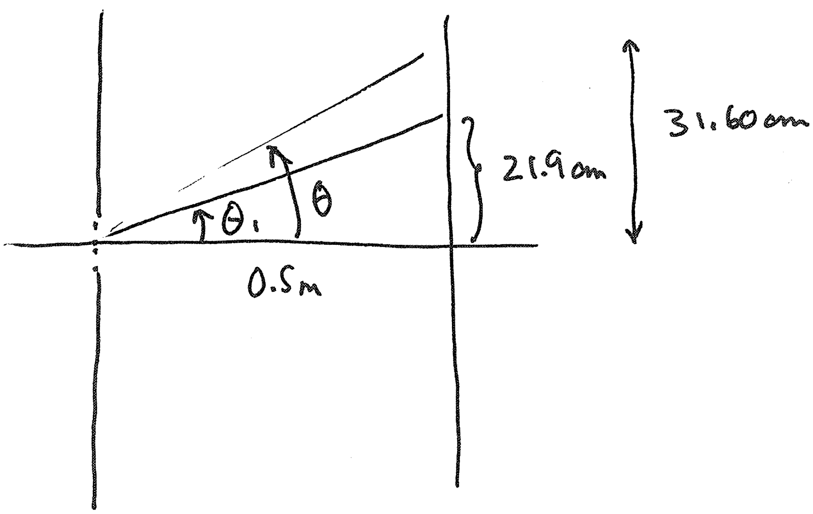
3) Helium atoms emit light at several wavelengths. Light from a helium lamp illuminates a diffraction grating and is observed on a screen 50.0 cm behind the grating. One such wavelength is 501.5nm, and it creates a first order bright fringe 21.90cm from the central maximum.

A) What is the slit spacing of the grating? (15 pts)

B) The first additional bright fringe you notice is at 31.60cm from the central maximum. What is its wavelength? (10 pts)



A) $\tan\theta_1 = \frac{0.219}{0.5} = 0.438$

$\theta_1 = 23.65°$

$d\sin\theta_1 = (1)(501.5nm)$

$d = \frac{501.5nm}{\sin\theta_1} = 1249.99$

$d = 1250nm$

B) $\tan\theta = \frac{0.316}{0.5}$

$\theta = 32.3°$

$d\sin\theta = (1)(\lambda)$

$\lambda = 667.8nm$

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Wave equation: $D(x,t) = A\sin(kx - \omega t + \phi_0)$

$k = 2\pi/\lambda \quad \omega = 2\pi f \quad f = 1/T$

Intensity: $I = P/area = CA^2$

$v = \lambda f \quad v = \sqrt{F_s/\mu}$

$$\sin\alpha + \sin\beta = 2\cos\left[\frac{1}{2}(\alpha - \beta)\right]\sin\left[\frac{1}{2}(\alpha + \beta)\right]$$

Intensity: $I = P/area = CA^2$

Doppler effect:

source approaching: $f_+ = \dfrac{f_0}{1 - v_s/v}$

source receding: $f_- = \dfrac{f_0}{1 + v_s/v}$

observer approaching: $f_+ = (1 + v_0/v)f_0$

observer receding: $f_- = (1 - v_0/v)f_0$

Doppler Effect for light waves:

receding source: $\lambda_{red} = \lambda_0\sqrt{\dfrac{1 + v_s/c}{1 - v_s/c}}$

approaching source: $\lambda_{blue} = \lambda_0\sqrt{\dfrac{1 - v_s/c}{1 + v_s/c}}$

Standing waves: $D(x,t) = 2a\sin(kx)\cos(\omega t)$

fixed strings: $\lambda_m = 2L/m \quad m = 1,2,3,...$

closed/closed tubes: $\lambda_m = 2L/m \quad m = 1,2,3,...$

open/closed tubes: $\lambda_m = 4L/m \quad m = 1,3,5,...$

Beats:

$$D = 2a\cos\left[\frac{1}{2}(\omega_1 - \omega_2)t\right]\sin\left[\frac{1}{2}(\omega_1 + \omega_2)t\right]$$

$f_{beat} = f_1 - f_2$

Interference of two waves:

$$D = \left[2a\cos\left(\frac{\Delta\phi}{2}\right)\right]\sin(kx_{avg} - \omega t + \phi_{0,avg})$$

constructive interference:

$$\Delta\phi = 2\pi\frac{\Delta r}{\lambda} + \Delta\phi_o = 2\pi m \qquad m = 0,1,2,...$$

destructive interference:

$$\Delta\phi = 2\pi\frac{\Delta r}{\lambda} + \Delta\phi_o = 2\pi\left(m + \frac{1}{2}\right) \qquad m = 0,1,2,...$$

Single Slit:

dark fringes: $a\sin\theta_p = p\lambda \quad p = 1,2,3,...$

$y_p = L\tan\theta_p$

$w = 2\lambda L/a$

Michelson Interferometer

standard: $\Delta m = \dfrac{\Delta L_2}{\lambda/2}$

gas-filled cell thickness d: $\Delta m = (n-1)\dfrac{2d}{\lambda_{vac}}$

In material with index of refraction n:

$v_{mat} = c/n$

$\lambda_{mat} = \lambda_{vac}/n$

$f_{mat} = f_{vac}$

Double Slit:

bright fringes: $d\sin\theta_m = m\lambda \quad m = 0,1,2,3,...$

$y_p = L\tan\theta_p$

$\Delta y = \lambda L/d$

$I_{double} = 4I_1\cos^2\left(\dfrac{\pi dy}{\lambda L}\right)$

Diffraction grating:

bright fringes: $d\sin\theta_m = m\lambda \quad m = 0,1,2,3,...$

$y_p = L\tan\theta_p$

width $\propto 1/N$

$I_{max} = N^2 I_1$