PHYSICS-2112 Spring 2018 **Exam 2** **March 6, 2018**

Last Name (print)__________________________ First Name (print)__________________________

Signature _________________________________ LSUID No. _______________________________

DEPARTMENTAL POLICY STATES THAT ANY AND ALL NONAPPROVED ELECTRONIC DEVICES MUST BE TURNED OFF AND IN YOUR BAG AT THE FRONT OF THE ROOM. NO STUDENT MAY LEAVE THE ROOM DURING THE EXAM FOR ANY REASON – ONCE A STUDENT EXITS THE ROOM HIS/HER EXAM IS OVER.

<u>Circle one:</u>

N. Zuniga-Hansen	(Sec. 2; MWF 11:30 am)
D. Mesa	(Sec. 3; MWF 1:30 pm)
C. Deibel	(Sec. 4; TTh 10:30 am)

Have your LSU ID ready when you turn in your paper.

You may only use an ordinary scientific or graphing calculator. *You may not use a cell phone, smart phone, or tablet application as your calculator.*

Examine your paper to be sure it is complete and legible. There should be 12 multiple choice questions and 2 free-response problems, totaling 100 points. There are 7 pages, including the cover sheet.

A formula sheet is attached to this exam.

<u>For the multiple choice questions</u>, bubble in the correct answer on your scantron for each question. There is room on the exam for scratch work or calculations, but that work will not be checked or graded. Partial credit may be awarded on multiple choice questions, but this partial credit will be based on the answers that you have bubbled in on the scantron and NOT on your scratch work on the exam itself.

<u>For the free-response problems, show all relevant work in the space provided.</u> Without supporting work, even a correct answer will receive little or no credit. Partial credit will be awarded as warranted.

If your work for a problem is somewhere other than the space provided for that part of the problem, <u>you must indicate where your work is located</u>. *E.g.*, if you need more room for your solution, then you may write on the back of the page. Be sure to add a note to this effect; otherwise, anything on the back of the paper will be regarded as scratch work and will not be checked or graded.

Be sure that numerical answers appear with appropriate **<u>SI units</u>**. Points will be deducted for missing, incorrect, or "silly" units. If the final answer is, in fact, a dimensionless quantity, please write the numerical result followed by the word <u>dimensionless</u>.

You will have 55 minutes to complete this examination.

Question #1 (no points)

Bubble in the answer choice corresponding to your class section number.

(a) Sec. 2; MWF 11:30 am
(b) Sec. 3; MWF 1:30 pm
(c) Sec. 4; TTh 10:30 am

Question #2 (no points)

Your version of the test is A. Bubble in answer **A** on your scantron.

Question # 3 (5 points)

Which of the following relationships between the force F on a particle and the particle's position x gives Simple Harmonic Motion?

(a) $F = -5x$
(b) $F = -400x^2$
(c) $F = 10x$
(d) $F = 3x^2$
(e) None of the above

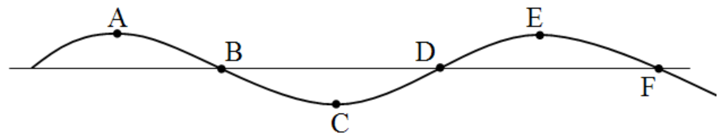
Question # 4 (5 points)

Jimmy and Jenny are floating on a quiet river using giant doughnut-shaped tubes. At one point, they are 5.0 m apart when a speed boat passes. After the boat passes, they begin bobbing up and down at a frequency of 0.25 Hz. Just as Jenny reaches her highest level, Jimmy is at his lowest level. As it happens, Jenny and Jimmy are always within one wavelength. What is the speed of the wave?

(a) 1.3 m/s
(b) 2.5 m/s
(c) 3.8 m/s
(d) 5.0 m/s
(e) 7.5 m/s

Question # 5 (5 points)

The drawing shows the vertical position of points along a string versus distance as a wave travels along the string. Six points on the wave are labeled A, B, C, D, E, and F. Between which two points is the length of the segment equal to one wavelength?



(a) A to E
(b) B to D
(c) A to C
(d) A to F
(e) C to F

Question # 6 (5 points)

The equation for a certain wave is $y = 4.0 \sin [2\pi(0.14x + 2.5t)]$ where y and x are measured in meters and t is measured in seconds. What is the magnitude and direction of the velocity of this wave?

(a) 1.8 m/s in the $+x$ direction
(b) 1.8 m/s in the $-x$ direction
(c) 18 m/s in the $-x$ direction
(d) 18 m/s in the $+x$ direction
(e) 0.35 m/s in the $-x$ direction

Question # 7 (5 points)

Ethanol has a density of 659 kg/m^3. If the speed of sound in ethanol is 1162 m/s, what is its adiabatic bulk modulus?

(a) 1.7×10^8 N/m^2
(b) 2.2×10^8 N/m^2
(c) 7.7×10^8 N/m^2
(d) 8.9×10^8 N/m^2
(e) 6.1×10^9 N/m^2

Question # 8 (5 points)

Two pulses of identical shape travel toward each other in opposite directions on a string, as shown in the figure. Which one of the following statements concerning this situation is true?

(a) The pulses will pass through each other and produce beats.
(b) As the pulses pass through each other, they will interfere destructively.
(c) The pulses will interfere to produce a standing wave.
(d) The pulses will reflect from each other.
(e) The pulses will diffract from each other

Question # 9 (5 points)

Three physical pendulums, with masses m_1, $m_2 = 2m_1$, and $m_3 = 3m_1$ have the same shape and size and are suspended at the same point. Rank them according to their periods, from shortest to longest.

(a) 1, 2, 3
(b) 3, 2, 1
(c) 2, 3, 1
(d) 2, 1, 3
(e) all three are the same

Question # 10 (5 points)

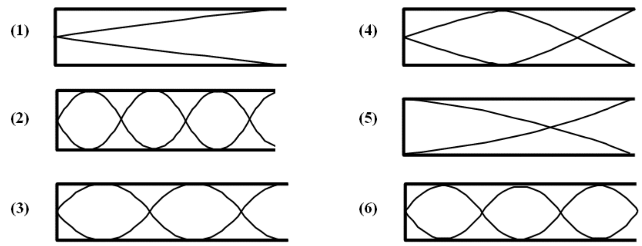
Two waves, A and B, are superposed. For which one of the following circumstances will beats result?

(a) A and B are identical waves traveling in the same direction.
(b) A and B are traveling with differing speeds.
(c) A and B are identical waves traveling in the opposite directions.
(d) A and B are waves with slightly differing frequencies, but otherwise identical.
(e) A and B are waves with slightly differing amplitudes, but otherwise identical.

Question # 11 (5 points)

The drawings show standing waves of sound in six organ pipes of the same length. Each pipe has one end open and the other end closed. Some of the drawings show situations that are not possible. Which one of these tubes emits a sound with the smallest frequency?

(a) 1
(b) 2
(c) 3
(d) 4
(e) 6



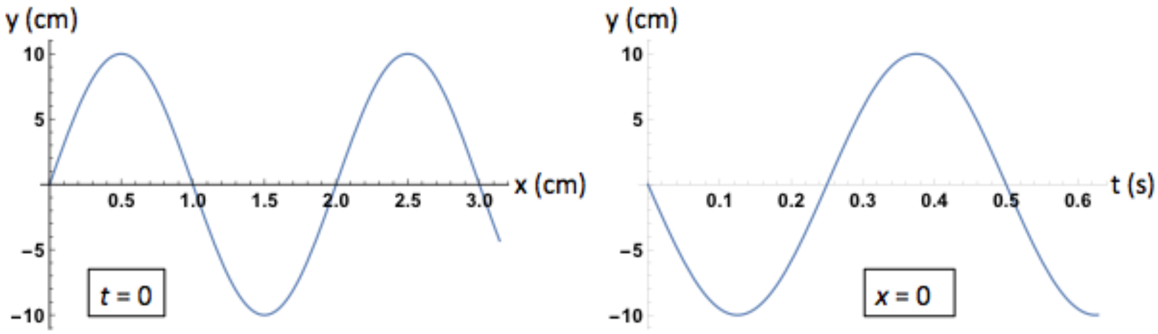
Question # 12 (5 points)

The maximum pressure amplitude Δp_m that the human ear can tolerate in loud sounds is about 28 Pa (which is very much less than the normal air pressure of 10^5 Pa). What is the displacement amplitude s_m for such a sound in air of density ρ =1.21 kg/m^3, at a frequency of 1000 Hz and a speed of 343 m/s?

(a) 1.1×10^{-5}m
(b) 1.21×10^{-3}m
(c) 3.43×10^{-5}m
(d) 2.8×10^{-5}m
(e) 1.0×10^{-3}m

Problem #1 (30 points) – Show your work!

A transverse wave propagates along a string of linear mass density 500 g/m. The displacement of the string at $t = 0$ s and $x = 0$ cm is shown in the figures below (note the units on the axes!). Determine the following quantities.



a) (6 points) From simply looking at the graphs, what is the period (T), wavelength (λ), and amplitude (y_m) of the wave?

b) (5 points) What is the wave number (k) of the wave?

c) (5 points) What is the angular frequency (ω) of the wave?

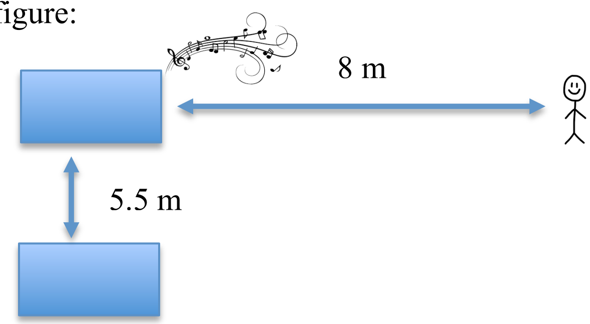
d) (4 points) What is the wave speed?

e) (5 points) What is the average power transmitted by the wave?

f) (5 points) What is the maximum transverse speed of the string?

Problem #2 (20 points) – Show your work!

In the Mardi Gras parade, two carnival chariots are parked parallel to each other and play music of frequency 330 Hz. Bob is standing in front of one of the chariots as indicated in the figure:



a) (5 points) What is the angular frequency of the sound waves emitted by the chariots?

b) (5 points) Calculate the phase difference between the waves that reach Bob where he is standing.

c) (5 points) The displacement amplitude of the waves emitted by the chariots is 9×10^{-7} m. What is the displacement amplitude of the resultant wave that Bob hears?

d) (5 points) The chariots start to move toward Bob. Both travel at constant speed of 0.6 m/s. Bob begins to walk away at a speed of 1.02 m/s. What is the frequency in Hertz that Bob perceives as he walks away from the chariots?

Formula Sheet for LSU Physics 2112, EXAM 2, Spring 2017

Units:

$1\,\mathrm{m} = 39.4\,\mathrm{in} = 3.28\,\mathrm{ft}$ $\quad 1\,\mathrm{mi} = 5280\,\mathrm{ft}$ $\quad 1\,\mathrm{min} = 60\,\mathrm{s}$, $\quad 1\,\mathrm{day} = 24\,\mathrm{h}$ $\quad 1\,\mathrm{rev} = 360° = 2\pi\,\mathrm{rad}$

$1\,\mathrm{atm} = 1.013\times10^5\,\mathrm{Pa} = 760\ \mathrm{torr} = 14.7\ \mathrm{psi}$ $\quad T = \left(\frac{1\,K}{1°\mathrm{C}}\right)T_{\mathrm{C}} + 273.15\,\mathrm{K}$ $\quad T_{\mathrm{F}} = \left(\frac{9\,°\mathrm{F}}{5°\mathrm{C}}\right)T_{\mathrm{C}} + 32°\mathrm{F}$

$1\ \mathrm{V} = \mathrm{J/C}$ $\quad 1\ \mathrm{eV}{=}1.602\times10^{-19}\ \mathrm{J}$

Constants:

$\mathrm{g} = 9.8\,\mathrm{m/s^2}$ $\quad m_e = 9.109\times10^{-31}\,\mathrm{kg}$ $\quad m_p = 1.673\times10^{-27}\,\mathrm{kg}$

$m_ec^2 = 511\,\mathrm{keV}$ $\quad m_pc^2 = 938\,\mathrm{MeV}$

$\mathrm{e} = 1.602\times10^{-19}\,\mathrm{C}$ $\quad \epsilon_0 = 8.854\times10^{-12}\,\mathrm{C^2/(N\ m^2)}$ $\quad hc = 1239.8\ \mathrm{eV\cdot nm}$

$k = 1.38\times10^{-23}\,\mathrm{J/K}$ $\quad R = 8.31\,\mathrm{J/(mol\cdot K)}$ $\quad$ Avogadro's # $= 6.02\times10^{23}$ particles/mol

$h = 6.626\times10^{-34}\ \mathrm{J\cdot s} = 4.136\times10^{-15}\ \mathrm{eV\cdot s}$ $\quad \hbar = 1.054\times10^{-34}\ \mathrm{J\cdot s} = 6.582\times10^{-16}\ \mathrm{eV\cdot s}$

Properties of H_2O:

Density:	$\rho_{\mathrm{water}} = 1000\ \mathrm{kg/m^3}$	
Specific heat:	$c_{\mathrm{water}} = 4187\ \mathrm{J/(kg\ K)}$	$c_{\mathrm{ice}} = 2220\ \mathrm{J/(kg\ K)}$
Heats of transformation:	$L_{\mathrm{vaporization}} = 2.256\times10^6\ \mathrm{J/kg}$	$L_{\mathrm{fusion}} = 3.33\times10^5\ \mathrm{J/kg}$

Simple Harmonic Motion (SHM): $T = \frac{1}{f} = \frac{2\pi}{\omega}$

Linear:
$$x(t) = x_m\cos(\omega t + \phi)$$
$$v(t) = -x_m\omega\sin(\omega t + \phi)$$
$$a(t) = -x_m\omega^2\cos(\omega t + \phi) = -\omega^2 x(t)$$

Angular:
$$\theta(t) = \theta_m\cos(\omega t + \phi)$$
$$\Omega(t) = -\theta_m\omega\sin(\omega t + \phi)$$
$$\alpha(t) = -\theta_m\omega^2\cos(\omega t + \phi) = -\omega^2\theta(t)$$

Linear Oscillator: Spring-Block: $\omega = \sqrt{\frac{k}{m}}$ $\quad$ Horizontal Spring-Block: $E_{\mathrm{mec}} = \frac{1}{2}kx_m^2$

Hooke's Law: $F = -kx$

Pendulums: Torsion: $\omega = \sqrt{\frac{\kappa}{I}}$ $\quad$ Simple: $\omega = \sqrt{\frac{g}{L}}$ $\quad$ Physical: $\omega = \sqrt{\frac{mgh}{I}}$

Torsion torque: $\tau = -\kappa\theta$

Waves:

$$y(x,t) = y_m\sin(kx \mp \omega t + \phi)$$

Angular Frequency: $\omega = \frac{2\pi}{T}$ $\quad$ Wave Number: $k = \frac{2\pi}{\lambda}$

Speed: $v = \frac{\omega}{k} = \lambda f$

Stretched String Speed: $v = \sqrt{\frac{\tau}{\mu}}$ $\quad$ Linear Density: $\mu = \frac{m}{L}$

Power: $P_{avg} = \frac{1}{2}\mu v\omega^2 y_m^2$

Transverse speed: $u = \frac{\partial y}{\partial t} = -\omega y_m cos(kx - \omega t)$

Interference of Waves: $y'(x,t) = \left[2y_m\cos\frac{\phi}{2}\right]\sin\left(kx - \omega t + \frac{\phi}{2}\right)$

Standing Waves: $y'(x,t) = [2y_m\sin(kx)]\ \cos(\omega t)$ $\quad$ Resonance: $f_n = \frac{v}{\lambda_n} = n\frac{v}{2L}$

Sound Waves:

$s(x,t) = s_m \cos(kx \mp \omega t)$ $\Delta p(x,t) = \Delta p_m \sin(kx \mp \omega t)$ $\Delta p_m = (v\rho\omega)s_m$

Sound Speed: $v = \sqrt{\frac{B}{\rho}}$ Angular Frequency: $\omega = \frac{2\pi}{T}$ Wave Number: $k = \frac{2\pi}{\lambda}$

Speed: $v = \frac{\omega}{k} = \lambda f$ **Power:** $P_{avg} = \frac{1}{2}\rho A v \omega^2 s_m^2$ Intensity: $I = \frac{P}{A} = \frac{P_s}{4\pi r^2}$

Interference of Waves: $s'(x,t) = \left[2s_m \cos\frac{\phi}{2}\right] \cos\left(kx - \omega t + \frac{\phi}{2}\right)$ $\phi = 2\pi\frac{\Delta L}{\lambda} +$ "other shifts"

Constructive int.: $\phi = 2m\pi \quad m = 1, 2, 3, ...$
Destructive int.: $\phi = (2m+1)\pi \quad m = 1, 2, 3, ...$

Resonant Frequencies in Pipes,

Both Ends Open: $f = \frac{v}{\lambda} = \frac{nv}{2L} \quad n = 1, 2, 3, ...$

One End Open, One Closed: $f = \frac{v}{\lambda} = \frac{nv}{4L} \quad n = 1, 3, 5, ...$

Sound Level: $\beta = (10\text{dB}) \log \frac{I}{I_0}$ $I_0 = 10^{-12}\text{W/m}^2$

Beats:

$s(t) = s_m \cos\omega_1 t + s_m \cos\omega_2 t$ $= 2s_m[\cos\omega' t]\cos\omega t$ $\omega' = \frac{1}{2}(\omega_1 - \omega_2)$
$f_{beats} = |f_1 - f_2|$

Doppler Effect:

Source Moving: $f' = f\frac{v}{v \mp v_S}$ Detector Moving: $f' = f\frac{v \pm v_D}{v}$ Combined: $f' = f\frac{v \pm v_D}{v \mp v_S}$