SOLUTIONS

PHYSICS-2112 Fall 2019 **Exam 2** **October 22, 2019**

Last Name (print)________________________ *First* Name (print)________________________

Signature ______________________________ LSU ID 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.

Circle one:

C. Deibel	(Sec. 1; MWF 9:30 am)
M. Wilde	(Sec. 2; MWF 12:30 pm)
P. Sprunger	(Sec. 3; TTh 9:00 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 6 pages, including the cover sheet.

For the multiple choice questions, 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.

For the free-response problems, show all relevant work in the space provided. 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, you must indicate where your work is located. *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 **SI units**. 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 dimensionless.

You will have 60 minutes to complete this examination.

A

Question #1 (no points)

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

A. Sec. 1; MWF 9:30 am (Deibel)
B. Sec. 2; MWF 12:30 pm (Wilde)
C. Sec. 3; TTh 9:00 am (Sprunger)

Question #2 (no points)

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

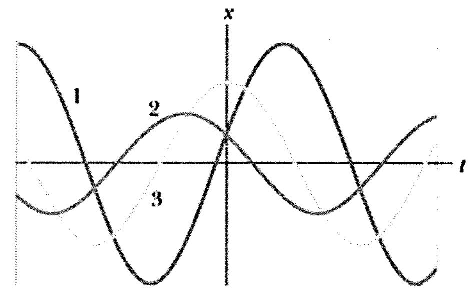
Question #3 (5 points)

The figure shows the $x(t)$ curves for three different experiments involving the same spring–box system oscillating in simple harmonic motion. Rank the curves according to the box's potential energy at $t = 0$ greatest first.

A. 3 > 2 > 1
B. 1 > 2 > 3
C. 3 > 1 = 2
D. 1 > 3 > 2
E. 1 = 2 > 3

$PE = \frac{1}{2}kx^2$

function of x @ $t=0$



Question #4 (5 points)

Suppose that a simple pendulum consists of a small 7 g bob at the end of a cord of negligible mass. What is the pendulum's length L, if the angle θ between the cord and the vertical is given by

$$\theta = \underbrace{(0.1 \text{ rad})}_{\theta_m} \cos[\underbrace{(7.0 \text{ rad/s})}_{\omega}\, t + \varphi] \ ?$$

A. $L = 0.1$ m
B. $L = 5$ m
C. $L = 0.2$ m
D. $L = 1.4$ m
E. $L = 1.6$ m

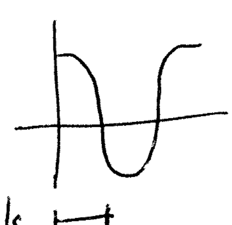
$\omega = \sqrt{\frac{g}{L}}$

$\Rightarrow \quad L = \frac{g}{\omega^2} = \frac{9.8 \text{ m/s}^2}{(7 \text{ rad/s})^2} =$

Question #5 (5 points)

A sinusoidal wave travels along a string. The time for a particular point to move from maximum displacement to zero is 0.3 s. What is the period T? The wavelength is 2.5 m; what is the wave speed v?

A. $T = 0.6$ s, $v = 1.5$ m / s
B. $T = 1.2$ s, $v = 3.0$ m / s
C. $T = 0.6$ s, $v = 4.167$ m / s
D. $T = 1.2$ s, $v = 2.083$ m / s
E. $T = 0.3$ s, $v = 8.333$ m / s



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

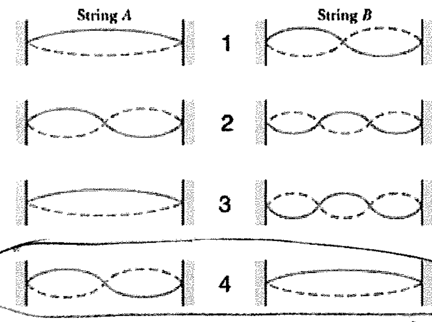
$\Rightarrow v = \frac{2.5 \text{ m}}{1.2 \text{ s}} = 2.083 \text{ m/s}$

maximum to zero is 1/4 of period T

$\Rightarrow \quad T = 4 \cdot 0.3 \text{ s} = 1.2 \text{ s}$

Question #6 (5 points)

Strings *A* and *B* have identical lengths and linear densities, but string *B* is under greater tension than string *A*. The figure shows four situations, labeled (1) through (4), in which standing wave patterns exist on the two strings. In which situation is there the possibility that strings *A* and *B* are oscillating at the same resonant frequency?



A. Situation 4
B. Situation 2
C. Situation 3
D. Situation 1
E. none

$\tau_B > \tau_A$

$\Rightarrow v_B > v_A$ from $v = \sqrt{\frac{\tau}{\mu}}$

resonance $\frac{nv}{2L} = f_n = \frac{v}{\lambda_n}$ require $\lambda_A < \lambda_B$ to have $v_A/\lambda_A = v_B/\lambda_B$

Question #7 (5 points)

A string fixed at both ends is 7.1 m long and has a mass of 0.16 kg. It is subjected to a tension of 50 N and set oscillating. (a) What is the speed *v* of the waves on the string? (b) What is the longest possible wavelength λ for a standing wave?

A. $v = 17.68$ m/s, $\lambda = 14.2$ m
B. $v = 17.68$ m/s, $\lambda = 7.1$ m
C. $v = 47.1$ m/s, $\lambda = 7.1$ m
D. $v = 2218.8.1$ m/s $\lambda = 14.2$ m
E. $v = 47.1$ m/s, $\lambda = 14.2$ m

$v = \sqrt{\frac{\tau}{\mu}}$ $\mu = \frac{0.16\text{ kg}}{7.1\text{ m}}$

$\Rightarrow v = \sqrt{\frac{50\text{ N}}{.16\text{ kg}/7.1\text{ m}}} = 47.1\text{ m/s}$

longest possible is $\lambda = 2L = 14.2$ m

Question #8 (5 points)

The source of a sound wave has a power of 8 mW. If it is a point source, what is the intensity *I* at a 3 m distance?

A. 0.889 mW / m^2
B. 0.0707 mW / m^2
C. 2.67 mW / m^2
D. 0.375 mW / m^2
E. 0.283 mW / m^2

$I = \frac{P}{A} = \frac{8\text{ mW}}{4\pi r^2} = \frac{8\text{ mW}}{4\pi \cdot (3\text{ m})^2}$

$= 0.0707\text{ mW/m}^2$

Question #9 (5 points)

The A string of a violin is too tightly stretched and thus out of tune. Beats at 4.00 per second are heard when the string is sounded together with a tuning fork that is oscillating accurately at concert A (440 Hz). What is the **period** of the violin string oscillation?

A. 2.25 ms
B. 2.23 ms
C. 444 ms
D. 448 ms
E. 2.27 ms

$f_{beat} = f_1 - f_2$

$4\text{ Hz} = f_1 - 440\text{ Hz}$

$\Rightarrow f_1 = 444\text{ Hz}$

$\Rightarrow T_1 = \frac{1}{444} = 0.00225\text{ s}$

$= 2.25\text{ ms}$

Question #10 (5 points)

Organ pipe A, with both ends open, has a fundamental frequency of 300 Hz. The third harmonic ($n_B = 3$) of organ pipe B, with only one end open, has the same frequency as the second harmonic ($n_A = 2$) of pipe A. How long are pipe A and pipe B? (Take the speed of sound to be 343 m/s.)

A. A length = 1.14 m, B length = 0.858 m
B. A length = 0.572 m, B length = 0.429 m
C. A length = 0.572 m, B length = 0.763 m
D. A length = 1.14 m, B length = 1.52 m
E. A length = 0.286 m, B length = 0.214 m

$f_{1,A} = 300Hz$

$f_{2,A} = 2 \cdot f_{1,A} = 600Hz$

$f_{3,B} = 600Hz$

$f_{2,A} = \frac{2 \cdot v}{2L_A} \Rightarrow \frac{343m/s}{600Hz} = 0,572m$

$f_{3,B} = \frac{3v}{4L_B} \Rightarrow L_B = \frac{3}{4} \cdot \frac{34}{60} = .429$

Question #11 (5 points)

The following four waves are sent along strings with the same linear densities (x is in meters and t is in seconds). Rank the waves according to the tension in the strings along which they travel, greatest first:

(1) $y1 = (3mm) \sin(x - 3t)$,
(2) $y2 = (6mm) \sin(2x - 2t)$,
(3) $y3 = (1mm) \sin(4x - t)$,
(4) $y4 = (2mm) \sin(x - 2t)$.

A. 2 > 1 > 4 > 3
B. 3 > 2 > 4 > 1
C. 1 > 4 > 2 > 3
D. 3 > 4 > 1 > 2
E. 1 = 2 = 3 = 4

$y_m \sin(kx - \omega t)$

$v = \frac{\omega}{k}$

$v = \sqrt{\frac{\tau}{\mu}}$

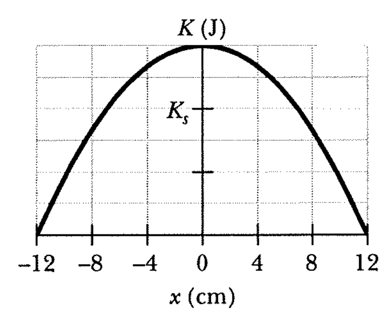
$\Rightarrow v_1 = 3$, $v_2 = 1$, $v_3 = 1/4$, $v_4 = 2$

$\Rightarrow v_1 > v_4 > v_2 > v_3$

$\Rightarrow \tau_1 > \tau_4 > \tau_2 > \tau_3$

Question #12 (5 points)

The figure shows the kinetic energy K of a simple harmonic oscillator versus its position x. The vertical axis scale is set by $K_s = 4.0$ J. What is the spring constant?



A. 208 N/m
B. 278 N/m
C. 0.056 N/m
D. 556 N/m
E. 833 N/m

$K_s = 4,0 J$

$\Rightarrow K_{max} = 6 J$

$K_{max} = PE_{max} = 6 J$

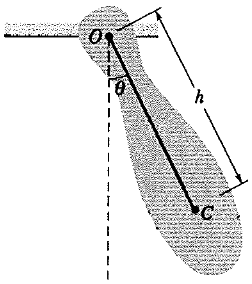
$PE_{max} = \frac{1}{2} k x_{max}^2$

$x_{max} = 12 cm = .12 m$

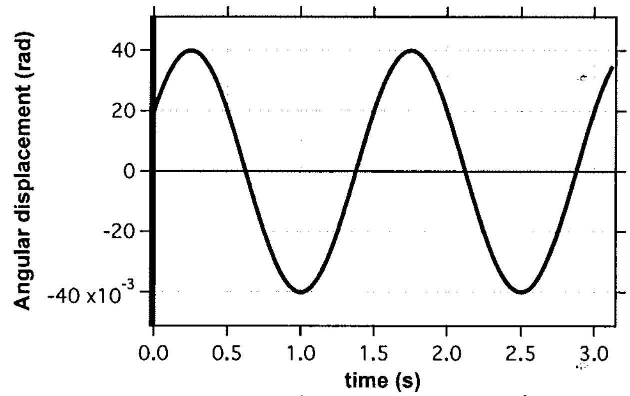
$\Rightarrow k = 2 \cdot 6J / (.12m)^2 = 833 N/m$

4

Problem #1 (25 points) - Show your work! **(Circle your answers)**



A physical pendulum, with momement of inertia mass $\underline{I = 1.2\ kg{\bullet}m^2}$, swings freely in the vertical plane about an axis located at ***O***. The center of mass of the object is located at ***C***, a distance $\underline{h = 0.65\ m}$ from the pivot. At $t = 0$, the pendulum is pulled to the right an angle $\theta(0) = 20\ mrad$ and given a small positive (upward) initial velocity. The graph gives the angular displacement ($\theta(t)$), measured from vertical, of the physical pendulum oscillating in simple harmonic motion (SHM). Use values (with correct units) from the graph, along with ***I*** and ***h*** *(if needed)*, to answer the following.



a) (4 points) From the graph, what is the period T of oscillation?

$T = 1.5\,s$

b) (4 points) From the graph, what is the amplitude θ_m of oscillation?

$\theta_m = 40\ mrad\ (= 40 \times 10^{-3}\ \text{radians})$

c) (6 points) Write an equation of the SHM angular displacement [e.g. $\theta(t) = \theta_m \cos(\omega t + \phi)$] with appropriate values (and units) indicated.

$\omega = \frac{2\pi}{T} = \frac{2\pi}{1.5\,s} = 4.189\ rad/s$

$\theta(0) = 20\ mrad = 40\,mrad \cos(\phi)$

$\Rightarrow \frac{1}{2} = \cos(\phi) \Rightarrow \phi = \pm\pi/3$, but $-\pi/3$

$\Rightarrow \theta(t) = 40\,mrad \times \cos\left(\left(4.189\,\frac{rad}{s}\right)t - \pi/3\right)$

↑ minus

d) (6 points) What is the magnitude of the maximum angular velocity of the pendulum?

$\theta_m \cdot \omega = 40\ mrad \cdot 4.189\ \frac{rad}{s}$

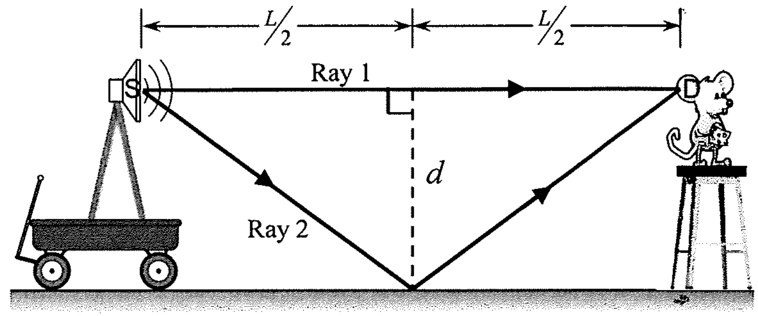
$= 0.168$

e) (5 points) Based on the values given, what is the mass (m) of the physical pendulum?

$\omega = \sqrt{\frac{mgh}{I}}$

$\Rightarrow \frac{I\omega^2}{gh} = m = \frac{1.2\,kg \cdot m^2 \cdot \left(4.189\,\frac{rad}{s}\right)^2}{9.8\,m/s^2 \cdot .65\,m} = 3.31\ kg$

Problem #2 (25 points) – Show your work!
(Circle your answers)



As shown in the figure, a large mouse on a stool is listening to a speaker in a room with a nice smooth marble floor at distance $d = 1.80$ **m** from the ground. The stationary speaker (source **S**) isotropically emits sound of frequency $f = 860$ **Hz**. Sound ray 1 extends directly to the mouse's ear (Detector **D**), at a horizontal distance $L =$ **6.00 m**. Sound ray 2 extends to D via a floor reflection, which occurs on a perpendicular bisector to the SD line. Assume that the reflection at the floor does ***NOT*** change the phase and the speed of sound in air is $v_{sound,\text{air}} = 343$ m/s.

a) (5 points) What is the wavelength (λ) of the sound waves emitted by the speaker (S) in air?

$v = \frac{\lambda}{T} = \lambda f \Rightarrow \frac{343\,m/s}{860\,Hz} = 0.399\ m$

b) (5 points) Calculate the path length difference (ΔL) between sound ray 1 and ray 2 going from the speaker (S) to the mouse's ear (D)?

$L_1 = 6\,m$

$\frac{L_2}{2} = \sqrt{(L/2)^2 + d^2} = \sqrt{(3m)^2 + (1.8m)^2} = 3.5m$

$\Rightarrow L_2 = 7m$

$\Delta L = |L_2 - L_1| = 1\,m \Leftarrow$

c) (5 points) Calculate the phase difference (ϕ) between the two waves (Ray 1 and Ray 2) that reach the mouse's ear (D).

$\phi = 2\pi \frac{\Delta L}{\lambda} = \frac{2\pi \cdot 1m}{0.399m} = 15.75\ rad$

d) (5 points) What is the resulting type of interference that the mouse experiences: *Fully Constructive*, *Fully Destructive*, or *Intermediate*? (Support your answer!)

$\cos\left(\frac{15.75}{2}\right) = -0.021$

intermediate

destructive also acceptable since ≈ 0

e) (5 points) The wagon on which the emitting speaker is mounted begins to be pulled <u>away</u> from the mouse at constant speed of 10.3 m/s (23 mph), what is the frequency (in Hertz) that the mouse now perceives from the speaker along sound ray 1?

$f' = \frac{v}{v + v_s} f = \frac{343\,m/s}{343\,m/s + 10.3\,m/s}\ 860\,Hz = 834.9\ Hz$