Physics 2130-080
Exam IV (Makeup Ver. 1)
April 19, 2010

Name: Key

CLOSED BOOK and NOTES, but calculators are allowed. 16 Multiple Choice questions (5 points/question) and 2 problems. This exam is worth 100 points. For the MC questions: CIRCLE the LETTER of the response that best answers the question. For the problems, you must write clearly and draw diagrams clearly (if needed) and show your work leading to your answer to receive full credit, circle your answers.

Some possibly useful information

\[ g = 9.8 \frac{m}{s^2} \]

\[ F_{\text{net}} = 0 \] (sum of forces must be zero)

\[ \tau_{\text{net}} = 0 \] (sum of torques must be zero)

\[ x(t) = x_m \cos(\omega t + \phi) \] (displacement)

\[ \omega = \frac{2\pi}{T} = 2\pi f \]

\[ T = 2\pi \sqrt{\frac{m}{k}} \] (period of a spring)

\[ v_m = \omega x_m \]

\[ a_m = \omega^2 x_m \]

\[ v = \frac{\omega}{k} = \frac{1}{T} = \frac{1}{2\pi} \]

\[ y(x, t) = y_m \sin(kx - \omega t) \]

\[ u_{\text{max}} = y_{\text{max}} \omega \]

\[ f' = f \frac{v \pm v_0}{v \pm v_s} \] (general Doppler effect)

\[ f = \frac{1}{T} \]

\[ v = \frac{\tau}{\mu} \]

stress = \frac{F}{A}
Section 1: Multiple Choice (16 problems, 5 pts each). Circle the LETTER of the response that best answers the question. No partial credit.

1. The conditions that the net force and the net torque both vanish:
   A. hold for every rigid body in equilibrium
   B. hold only for elastic solid bodies in equilibrium
   C. hold for every solid body
   D. are always sufficient to calculate the forces on a solid object in equilibrium
   E. are sufficient to calculate the forces on a solid object in equilibrium only if the object is elastic

2. For a body to be in equilibrium under the combined action of several forces:
   A. all the forces must be applied at the same point
   B. all of the forces form pairs of equal and opposite forces
   C. the sum of the components of all the forces in any direction must equal zero
   D. any two of these forces must be balanced by a third force
   E. the lines of action of all the forces must pass through the center of gravity of the body

3. The center of gravity coincides with the center of mass:
   A. always
   B. never
   C. if the center of mass is at the geometrical center of the body
   D. if the acceleration due to gravity is uniform over the body
   E. if the body has a uniform distribution of mass

4. To determine if a rigid body is in equilibrium the vector sum of the gravitational forces acting on the particles of the body can be replaced by a single force acting at:
   A. the center of mass
   B. the geometrical center
   C. the center of gravity
   D. a point on the boundary
   E. none of the above

5. An object attached to one end of a spring makes 20 vibrations in 10s. Its period is:
   A. 2 Hz
   B. 10 s
   C. 0.5 Hz
   D. 2 s
   E. 0.50 s

\[ \frac{20 \text{ Vibrations}}{10 \text{ seconds}} = \frac{2}{1} \frac{1}{s} = 2 \text{ Hz} \]

\[ T = \frac{1}{f} = \frac{1}{2 \text{ Hz}} = 0.5 \text{ s} \]
6. A block attached to a spring oscillates in simple harmonic motion along the x axis. The limits of its motion are x = 10 cm and x = 50 cm and it goes from one these extremes to the other in 0.25 s. Its amplitude and frequency are:

A. 40 cm, 2 Hz
B. 20 cm, 4 Hz
C. 40 cm, 2 Hz
D. 25 cm, 4 Hz
E. 20 cm, 2 Hz

\[ \text{Peak to Peak = 40 cm} \]
\[ \text{Ampl = 20 cm} \]
\[ T = 2 \left( \frac{0.25 \text{ s}}{0.5} \right) = 0.5 \text{ s} \]
\[ f = \frac{1}{T} = \frac{1}{0.5} = 2 \text{ Hz} \]

7. An object is undergoing simple harmonic motion. Throughout a complete cycle it:

A. has constant speed
B. has varying amplitude
C. has varying period
D. has varying acceleration
E. has varying mass

8. A particle is in simple harmonic motion with period T. At time t = 0 it is halfway between the equilibrium point and an end point of its motion, traveling toward the end point. The next time it is at the same place is:

A. \( t = T \)
B. \( t = T/2 \)
C. \( t = T/4 \)
D. \( t = T/8 \)
E. none of the above

9. A wave is described by \( y(x, t) = 0.1 \sin(3x - 10t) \), where \( x \) is in meters, \( y \) is in centimeters, and \( t \) is in seconds. The angular frequency is:

A. 0.10 rad/m
B. 3.0\pi rad/m
C. 10\pi rad/m
D. 20\pi rad/m
E. 10 rad/s

10. For a given medium, the frequency of a wave is:

A. independent of the wavelength
B. proportional to wavelength
C. inversely proportional to wavelength
D. proportional to the amplitude
E. inversely proportional to the amplitude
11. Let \( f \) be the frequency, \( v \) the speed, and \( T \) the period of a sinusoidal traveling wave. The angular frequency is given by:

A. \( \frac{2\pi}{T} \)
B. \( 2\pi f \)
C. \( vT \)
D. \( 2\pi f \)
E. \( \frac{T}{f} \)

\[ \omega = \frac{2\pi}{T} = \left[ 2\pi \left( \frac{100 \text{ Hz}}{2\pi} \right) \right] \left( \frac{2\pi \text{ Hz}}{2\pi \text{ m/s}} \right) \]

12. A transverse traveling sinusoidal wave on a string has a frequency of 100 Hz, a wavelength of 0.040 m, and an amplitude of 2.0 mm. The maximum acceleration in m/s\(^2\) of any point on the string is:

A. 0
B. 130
C. 395
D. 790
E. 1600

\[ a_m = \omega^2 a_n = \left( 2\pi \right)^2 a_n = \left( 2\pi \left( 100 \text{ Hz} \right) \right)^2 (2 \times 10^{-3} \text{ m}) \]

13. The speed of a sound wave is determined by:

A. its amplitude
B. its intensity
C. its pitch
D. number of harmonics present
E. the transmitting medium

14. Which of the following properties of a sound wave determine its "pitch":

A. amplitude
B. distance from source to detector
C. frequency
D. phase
E. speed

15. A stationary source S generates circular outgoing waves on a lake. The wave speed is 5.0 m/s and the crest-to-crest distance is 2.0 m. A person in a boat heads directly towards S at 3.0 m/s. To this person, the frequency of these waves is:

A. 1.0 Hz
B. 1.5 Hz
C. 2.0 Hz
D. 4.0 Hz
E. 8.0 Hz

\[ f = \frac{v - v_b}{v} = 2.5 \text{ Hz} \]

16. A source emits sound with a frequency of 1000 Hz. It and an observer are moving toward each other, each with a speed of 100 m/s. If the speed of sound is 340 m/s, the observer hears sound with a frequency of:

A. 3400 Hz
B. 1830 Hz
C. 1000 Hz
D. 545 Hz
E. 294 Hz

\[ f = f_0 \left( \frac{v_0 + v}{v_0 - v} \right) = \left( 1000 \text{ Hz} \right) \left( \frac{340 + 100}{340 - 100} \right) \]

\[ f = 1830 \text{ Hz} \]
Section 2: Problem 1 (To receive full credit, show your work and write your answer in the space provided.)

An oscillating block-spring system takes 0.75s to begin repeating its motion.

a) (3 points) Find the period.

\[ \text{Period} = \frac{0.75 \text{ s}}{1} \]

b) (3 points) Find the frequency.

\[ f = \frac{1}{t} = \frac{1}{0.75 \text{ s}} \]

The frequency = \(1.33 \text{ Hz}\)

c) (4 points) Find the angular frequency in radians per second.

\[ \omega = 2\pi f = 2\pi (1.33 \text{ Hz}) \]

The amplitude = \(8.4 \text{ rad/s}\)
Section 2: Problem 2 (To receive full credit, show your work and write your answer in the space provided.)

The equation of a transverse wave traveling along a very long string is 
y = 6.0\sin(0.020\pi x + 4.0\pi), where x and y are expressed in centimeters and t is in seconds. If the wavelength is 1.0 x 10^{-2} cm and the frequency is 2 Hz:

a) (3 points) What is the speed of the waves on the string?

\[ v = \frac{\omega}{k} = \frac{4.0 \pi}{0.02 \pi} = 200 \]

\[ v = \frac{\lambda}{T} \]

Wave speed = 200 cm/s

b) (3 points) What is the maximum transverse speed of a particle in the string?

\[ \omega_m = y_m \omega = (6 \text{ cm})(4.0 \pi) = 75 \text{ cm/s} \]

Transverse speed = 75 cm/s

c) (4 points) What is the transverse displacement at x = 3.5 cm when t = 0.26s?

\[ y(x, t) = 6 \sin[0.020\pi(3.5) + 4.0\pi(0.26)] = -2 \text{ cm} \]

Transverse displacement = -2 cm
Section 3: Extra Credit Multiple Choice (Four problems, 5 points each). Circle the LETTER of the response that best answers the question. No partial credit.

1. In simple harmonic motion:
   A. the acceleration is greatest at the maximum displacement
   B. the velocity is greatest at the maximum displacement
   C. the period depends on the amplitude
   D. the acceleration is constant
   E. the acceleration is greatest at zero displacement

2. A 3-kg block, attached to a spring, executes simple harmonic motion according to \( x = 2\cos(50t) \), where \( x \) is in meters and \( t \) is in seconds. The spring constant of the spring is:
   A. 1 N/m
   B. 100 N/m
   C. 150 N/m
   D. 7500 N/m
   E. none of these

3. A fire whistle emits a tone of 170 Hz. Take the speed of sound in air to be 340 m/s. The wavelength of this sound is about:
   A. 0.5 m
   B. 1.0 m
   C. 2.0 m
   D. 3.0 m
   E. 340 m

4. To raise the pitch of a certain piano string, the piano tuner:
   A. loosens the string
   B. tightens the string
   C. shortens the string
   D. lengthens the string
   E. removes some mass