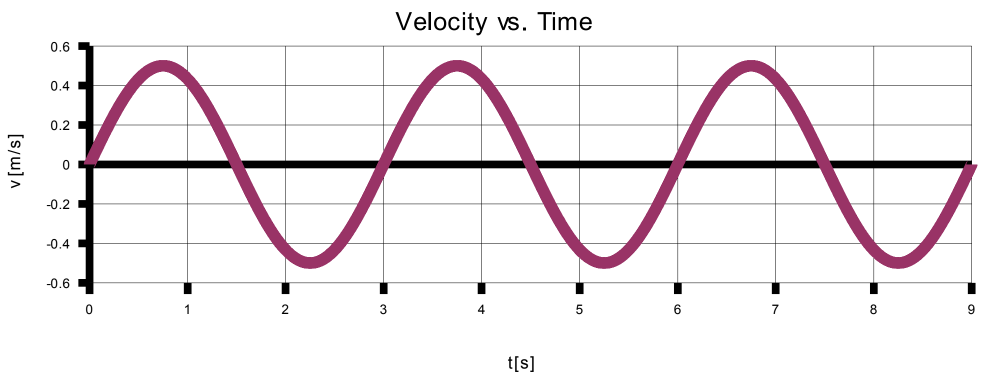
Name: ____

e-mail: _______________________________ Major: ____________________________________

Final Exam Phys 183 Applied Physics II Winter 2010-2011 final version

Multiple Choice (5 Points Each):



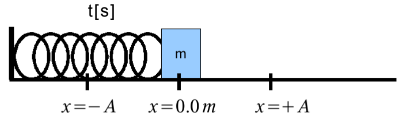


Figure One – Questions 1,2,3,4,5

1.Consider Figure One. A 20 kg mass is placed on a frictionless table and attached to a spring with a spring constant (k). The mass is pulled out to x = +A and released from rest. the mass oscillates back and fourth between x = + A and x = - A. The graph in Figure One shows the velocity versus time. What is the angular frequency (ω) of the oscillations?

a.) $\omega = 3.00\, s$
b.) $\omega = 0.33\, s^{-1}$
c.) $\omega = 1.50\, s$
d.) $\omega = 2.09\, s^{-1}$
e.) None of the above.

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{3\, s} = 2.09\, s^{-1}$$

2.Consider Figure One. A 20 kg mass is placed on a frictionless table and attached to a spring with a spring constant (k). The mass is pulled out to x = +A and released from rest. the mass oscillates back and fourth between x = + A and x = - A. The graph in Figure One shows the velocity versus time. What is the spring constant (k) of the spring?

a.) 0.011 N/m
b.) 100.00 N/m
c.) 56.89 N/m
d.) 87.73 N/m
e.) None of the above.

$$\omega = \frac{2\pi}{T} = \sqrt{\frac{k}{m}} \qquad k = m\omega^2 = 20\, kg\, (2.09\, s^{-1})^2 = 87.36 \frac{kg}{s^2} = 87.36 \frac{N}{m}$$

3.Consider Figure One. A 20 kg mass is placed on a frictionless table and attached to a spring with a spring constant (k). The mass is pulled out to x = +A and released from rest. the mass oscillates back and fourth between x = + A and x = - A. The graph in Figure One shows the velocity versus time. What is the amplitude (A) of the motion of the mass?

a.) A= 0.50 m
b.) A= 1.00 m
c.) A= 0.24 m
d.) A= 0.00 N/m
e.) None of the above.

$$|v_{max}| = A\omega \qquad A = \frac{|v_{max}|}{\omega} = \frac{0.5\,m/s}{2.09\,s^{-1}} = 0.24\,m$$

4.Consider Figure One. A 20 kg mass is placed on a frictionless table and attached to a spring with a spring constant (k). The mass is pulled out to x = +A and released from rest. the mass oscillates back and fourth between x = + A and x = - A. The graph in Figure One shows the velocity versus time. What is the maximum kinetic energy (K) of the motion of the mass?

a.) 0.00 J
b.) 10.0 J
c.) 2.50 J
d.) 5.00 J
e.) None of the above.

$$K_{max} = \frac{1}{2} m v_{max}^2 = \frac{1}{2}(20\,kg)(0.5\,m/s)^2 = 2.50\,J$$

5.Consider Figure One. A 20 kg mass is placed on a frictionless table and attached to a spring with a spring constant (k). The mass is pulled to x = +A and released from rest. the mass oscillates back and fourth between x = + A and x = - A. The graph in Figure One shows the velocity versus time. If you were going to add energy to this system so that the system would resonate, how would you do it?

a.) Add a large amount of energy at a constant rate.
b.) Add a small amount of energy at a frequency of 0.33 Hz
c.) Add a large amount of energy at a frequency of 3.00 Hz
d.) Add a small amount of energy at a frequency of 2.09 Hz
e.) None of the above.

$$F = \frac{1}{T} = \frac{1}{3\,s} = 0.33\,Hz$$

6.An air-filled, sealed balloon has a pressure of one atmosphere, a temperature of 22 degrees Celsius, and a volume of 0.02 cubic meters. Heat is added until the balloon reaches a temperature of 32 degrees Celsius. The balloon expands until it is at atmospheric pressure once more. What is the new volume of the balloon?

a.) 0.029 cubic meters
b.) 0.058 cubic meters
c.) 0.021 cubic meters
d.) 0.011 cubic meters
e.) None of the above

$$\frac{P_2 V_2}{P_1 V_1}=\frac{nRT_2}{nRT_1} \quad V_2=\frac{T_2}{T_1}V_1=\frac{(32+275.15)K}{(22+275.15)K}(0.02\,m^3)=0.021\,m^3$$

7.A heat engine undergoes a process and absorbs 800 J of heat dumps 200 J of heat every cycle. What is the efficiency of the process?

a.) 100 %
b.) 50 %
c.) 75 %
d.) 25 %
e.) None of the above

$$\%\text{eff} = \frac{W_{\text{out}}}{E_{\text{in}}} X\,100\% = \frac{(800\,J - 200\,J)}{800\,J} X\,100\% = 75\%$$

8. If the efficiency found in question 7 is the Carnot Efficiency, and the heat pump operates with a 1200 K hot reservoir, what is the temperature of the cold reservoir?

a.) 300 K
b.) 800 K
c.) 150 K
d.) 0 K
e. None of the above.

$$\%\text{eff}_C = 1-\frac{T_C}{T_H} = .75 \quad T_C=(1-0.75)T_H=300\,K$$

9.A Grandfather clock runs with a long metal rod with a mass attached which approximates a simple pendulum. The period of the pendulum in the winter when the temperature is $(T=10^o C)$ is exactly 2.00 seconds. How long is the rod?

a.) 0.248 m
b.) 1.00 m
c.) 0.496 m
d.) 15.46 m
e.) None of the above.

$$T=2\pi\sqrt{\frac{L}{g}} \quad L=g\left(\frac{T}{2\pi}\right)^2=1.00\,m$$

10.A Grandfather clock runs with a long metal rod with a mass attached which approximates a simple pendulum. What is the period of the pendulum when it is summer and $(T=90^o C)$?
$(\alpha = 19\,X\,10^{-4}\ {}^oC^{-1})$

a.) 1.00 s and the clock runs slow.
b.) 2.15 s and the clock runs slow.
c.) 1.00 s and the clock runs fast.
d.) 6.11 s and the clock runs fast.
e.) None of the above.

$$L=L_o(1+\alpha\Delta T)=1\,m(1+19\,X\,10^{-4}\,{}^oC^{-1}(90^oC-10^oC))=1.152\,m$$
$$T=2\pi\sqrt{\frac{L}{g}}=2\pi\sqrt{\frac{1.15\text{m}}{9.8\,m/s^2}}=2.15\,s$$

11. A 1.0 meter long tube is open at both ends. Tuning forks are used to send sound waves down the tube. The boundary conditions are that there must be a node at each end. What would you predict the the wavelength of the lowest frequency mode if the speed of sound is 343 /s?

a.) 4.00 m
b.) 2.00 m
c.) 1.00 m
d.) 3.00 m
e.) None of the above.

$$\frac{1}{2}\lambda = L \qquad \lambda = 2L = 2\text{m}$$

12. A 1.0 meter long tube is open at both ends. Tuning forks are used to send sound waves down the tube. The boundary conditions are that there must be a node at each end. If the air temperature is $(T = 25^o C)$, what frequency tuning for would you use to excite that lowest frequency mode?

a.) $f = 343\ Hz$
b.) $f = 173\ Hz$
c.) $171.5\ Hz$
d.) $86\ Hz$
e.) None of the above.

$$\frac{1}{2}\lambda = L \qquad \lambda = 2L = 2\text{mF} = \frac{v}{\lambda} = \frac{331\ m/s + 0.6(25^o C)}{2\text{m}} = 173\ Hz$$

13. A wave is modeled as: $y(x,t) = 0.2\,m \sin(6.28\,m^{-1} x + 3.14\,s^{-1} t)$ What is the velocity of the wave?

a.) $2.0\ m/s$ in the negative x-direction.
b.) $2.0\ m/s$ in the positive x-direction.
c.) $0.5\ m/s$ in the negative x-direction.
d.) $0.5\ m/s$ in the positive x-direction.
e.) None of the above.

$$v = \frac{\omega}{k} = \frac{3.14\,s^{-1}}{6.28\,m^{-1}} = 0.5\ m/s$$

14.A spring is attached from the ceiling. When a 300 kg mass is hung from the spring the spring stretches 4.0 cm. What is the spring constant (k) of the spring?

a.) 147000 N/m
b.) 0.000014 N/m
c.) 73500 N/m
d.) 300 N/m
e.) None of the above.

$$k\Delta y = mg \quad k = \frac{mg}{\Delta y} = \frac{300\,kg\,(9.8\,m/s^2)}{0.04\,m} = 73500\,N/m$$

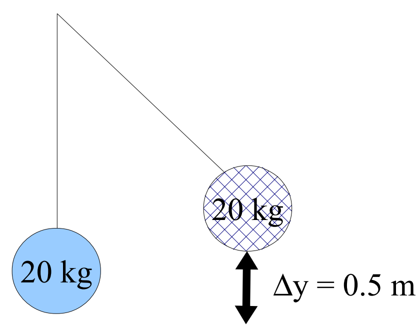


Figure Fifteen – Question 15

15.A simple pendulum is composed of a 20 kg mass (a bob) and a string as shown in Figure Fifteen. The mass is pulled to the left until it is 0.5 meters above the equilibrium position and it is then released from rest. What is the maximum speed of the bob?

a.) 0.0 m/s
b.) 3.13 m/s
c.) 6.26 m/s
d.) 98 J
e.) None of the above.

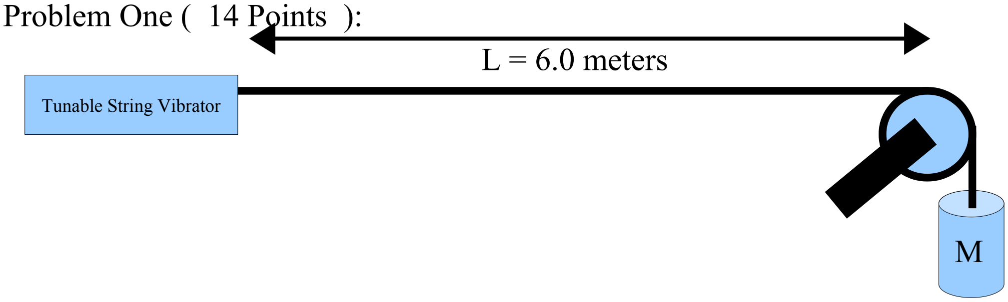
$$\frac{1}{2}mv^2 = mgh$$
$$|v| = \sqrt{2gh} = 3.13\,m/s$$

16.Resonance can be defined as:

a.) a group of circus clowns (or physicists if you prefer) crammed into one of those “tiny” clown cars.
b.) small amplitude driving force producing large amplitude waves.

c.) the ability of waves to “pass through one another”.
d.) the algebraic sum of two or more waves.
e.) None of the above.

Problem One (14 Points):

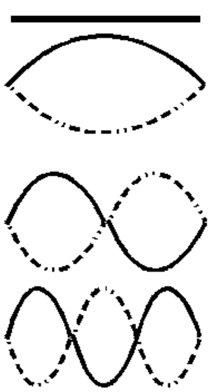


A string with a linear density of 0.0050 kg/m is tied to a string vibrator. The string vibrator is capable of vibrating the string at any frequency desired. The other end of the string is looped over a frictionless pulley and tied to a hanging mass. The hanging mass has a mass of 25 kg. The string vibrator is tuned through the first three normal modes which produce standing waves. The distance between the pulley and the string vibrator is 6.0 meters. Room temperature is 27 degrees C.

a. What is the speed of waves through the string?
b. Draw the first three normal modes of standing waves.
c. Label the wavelength of the first three normal modes.
d. Label the frequency of the first three normal modes.
e. The vibrator is tuned to a frequency that produces the 300th mode. What is the wavelength of the standing wave produced on the string?
f. The vibrator is tuned to a frequency that produces the 300th mode. What is the frequency of the standing wave produced on the string?
g. The 300th mode of the vibrating string produces a sound wave. What is the frequency of the sound wave?
h. The 300th mode of the vibrating string produces a sound wave. What is the wavelength of the sound wave?

a.) $v_{\text{string}}=\sqrt{\dfrac{F_T}{\mu}}=\sqrt{\dfrac{25\,kg\,(9.8\,m/s^2)}{0.0050\,kg/m}}=221.35\,m/s$

$L=6\,m$



$n=1 \quad \lambda_1=12\,m \qquad F_1=\dfrac{v}{\lambda_1}=\dfrac{221.35\,m/s}{12\,m}=18.45\,Hz$

$n=2 \quad \lambda_2=6\,m \qquad F_2=\dfrac{v}{\lambda_2}=\dfrac{221.35\,m/s}{6\,m}=36.89\,Hz$

$n=3 \quad \lambda_3=4\,m \qquad F_3=\dfrac{v}{\lambda_3}=\dfrac{221.35\,m/s}{4\,m}=55.34\,Hz$

e.) $\lambda_n = \frac{2}{n} L = \frac{2}{300} 6\text{m} = 0.04\, m$

f.) $F_{300} = \frac{v}{\lambda_{300}} \frac{221.35\, m/s}{0.04\, m} = 5508.75\ Hz$

g.) $F_{sound} = 5508.75\ Hz$

h.) $\lambda_{sound} = \frac{v_{sound}}{F_{sound}} = \frac{\left(331 + 0.6\left(27^o C\right)\right) m/s}{5508.75\ Hz} = 0.06\, m$

Problem Two (6 Points):

You are standing at rest on a corner in Philadelphia, as a police car approaches. You hear his siren at a frequency of 102 kHz, as he approaches at a constant speed, but you know the frequency of the siren is actually 100 kH.

1.) How fast is the police car moving?
2.) If the police car continues on at a constant speed after he passes you, what is the observed frequency of the police car as he speed away?

a.)

$$f_{obs} = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$$

$$f_{obs} = f\left(\frac{v}{v - v_s}\right)$$

$$f_{obs}\left(v - v_s\right) = f\, v$$

$$f_{obs}\, v - f_{obs}\, v_s = f\, v$$

$$v_s = \frac{\left(f_{obs} - f\right)}{f_{obs}} v = \frac{\left(102\, kHz - 100\, kH\right)}{102\, kHz} 343\, m/s = 6.7\, m/s$$

b.) $f_{obs} = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$

$$f_{obs} = f\left(\frac{v}{v + v_s}\right)$$

$$f_{obs} = 100\ KHz\left(\frac{343\, m/s}{343\, m/s + 6.73\, m/s}\right) = 102\, kHz$$

Extra Credit (4 points, but will be graded very critically.):

Discuss, in detail, any ONE topic covered in this class. Tell me everything you know about the topic. **Do not tell me if or why you "liked" it.** This is a chance to get credit for a topic you studied hard but did not make it onto the exam. Tell me everything you know about it.