Last Name:_____First Name_____Network-ID_____

Discussion Section:_____Discussion TA Name:_____

Instructions—

Turn off your cell phone and put it out of sight.

Keep your calculator on your own desk. Calculators cannot be shared.

This is a closed book exam. You have ninety (90) minutes to complete it.

1. Use a #2 pencil. Do not use a mechanical pencil or pen. Darken each circle completely, but stay within the boundary. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner. Be especially careful that your mark covers the **center** of its circle.

2. You may find the version of **this Exam Booklet at the top of page 2**. Mark the **version** circle in the **TEST FORM** box near the bottom right on the face of your answer sheet. **DO THIS NOW!**

3. Print your **NETWORK ID** in the designated spaces at the *right* side of the answer sheet, starting in the left most column, then **mark the corresponding circle** below each character. If there is a letter "o" in your NetID, be sure to mark the "o" circle and not the circle for the digit zero. If and only if there is a hyphen "-" in your NetID, mark the hyphen circle at the bottom of the column. When you have finished marking the circles corresponding to your NetID, check particularly that you have not marked two circles in any one of the columns.

4. Print **YOUR LAST NAME** in the designated spaces at the *left* side of the answer sheet, then mark the corresponding circle below each letter. Do the same for your **FIRST NAME INITIAL**.

5. Print your UIN# in the **STUDENT NUMBER** designated spaces and mark the corresponding circles. You need not write in or mark the circles in the SECTION box.

6. Sign your name **(DO NOT PRINT)** on the **STUDENT SIGNATURE** *line*.

7. On the **SECTION** *line*, print your **DISCUSSION SECTION**. You need not fill in the COURSE or INSTRUCTOR lines.

*Before starting work, check to make sure that your test booklet is complete. You should have 9 **numbered pages** plus two Formula Sheets.*

*Academic Integrity—*Giving assistance to or receiving assistance from another **student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including dismissal from the University.**

This Exam Booklet is Version A. Mark the **A** circle in the **TEST FORM** box near the bottom right on the face of your answer sheet. **DO THIS NOW!**

Exam Grading Policy—

The exam is worth a total of **110** points, and is composed of three types of questions.

MC5: *multiple-choice-five-answer questions, each worth 6 points.*
Partial credit will be granted as follows.

(a) If you mark only one answer and it is the correct answer,
you earn **6** points.
(b) If you mark *two* answers, one of which is the correct answer,
you earn **3** points.
(c) If you mark *three* answers, one of which is the correct answer,
you earn **2** points.
(d) If you mark no answers, or more than *three*, you earn **0** points.

MC3: *multiple-choice-three-answer questions, each worth 3 points.*
No partial credit.

(a) If you mark only one answer and it is the correct answer,
you earn **3** points.
(b) If you mark a wrong answer or no answers, you earn **0** points.

TF: *true-false questions, each worth 2 points.*
No partial credit.

(a) If you mark only one answer and it is the correct answer, you earn **2** points.
(b) If you mark the wrong answer or neither answer, you earn **0** points.

You should assume that the acceleration of gravity near the surface of the earth is 9.8 m/s² downward, and ignore any effects due to air resistance.

PROBLEMS 1+2 NOT ON EXAM 3

1. A steel tape measure is marked in such a way that it gives accurate length measurements at 20° C. Suppose this tape measure is used on a cold day when the temperature is 0° C. Assuming that the object you are measuring has a much smaller linear expansion coefficient than steel, the length measured with this tape measure will be

   a. too long
   b. too short
   c. accurate

2. A washer has a hole in the middle of it. As the washer is heated, the radius of the hole decreases.

   a. true
   b. false

3. Four vehicles are moving as shown below.
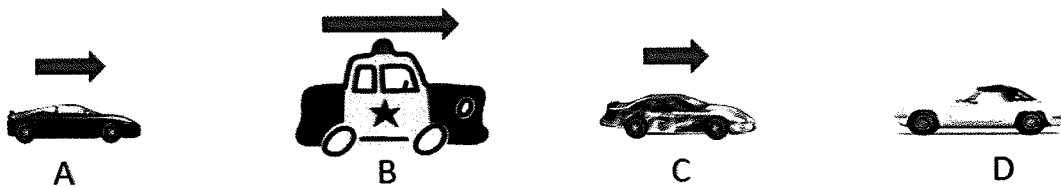
Each has its own driver. Vehicles A, B, and C are moving in the same direction (to the right) but vehicle B is moving faster than vehicles A and C. Vehicle D is not moving. Vehicle B is a police car and its siren is producing a sound of a certain frequency f_B as heard by the driver in vehicle B. What is the relationship between f_A, f_B, f_C and f_D, the frequencies of the siren heard by drivers of the respective vehicles?

   a. $f_D > f_A > f_B > f_C$
   b. $f_D > f_C = f_B > f_A$
   c. $f_A > f_C > f_B > f_D$
   d. $f_D > f_B > f_C > f_A$
   e. $f_D > f_C > f_B > f_A$

4. A siren, 10 m away, produces a sound of loudness 30 dB. Now, two sirens identical to this are placed 5 m away from you. What is the loudness that you hear?

   a. 31 dB
   b. 33 dB
   c. 39 dB

$$I_2 = 2 \times 4 \, I_1$$
$$\underset{2 \text{ sirens}}{\uparrow} \qquad \underset{I = \dfrac{P}{4\pi r^2}}{\uparrow}$$

$$\beta_2 = \beta_1 + 10 \text{ dB } \log_{10} \frac{I_2}{I_1}$$

$$= 30 \text{ dB} + 10 \text{ dB } \log_{10} 8$$

$$= 39 \text{ dB}$$

The next two questions pertain to the same situation.

One end of a string with length L = 2 m and mass density μ is attached to a weight with mass 4.3 kg. The other end of the string is fixed to a transducer that vibrates at a frequency of 212 Hz. A standing wave results, with the wavelength as shown in the snapshot below

$4\lambda \Rightarrow \lambda = 0.5\ m$

L = 2m

Transducer (212 Hz)

4.3 kg = M
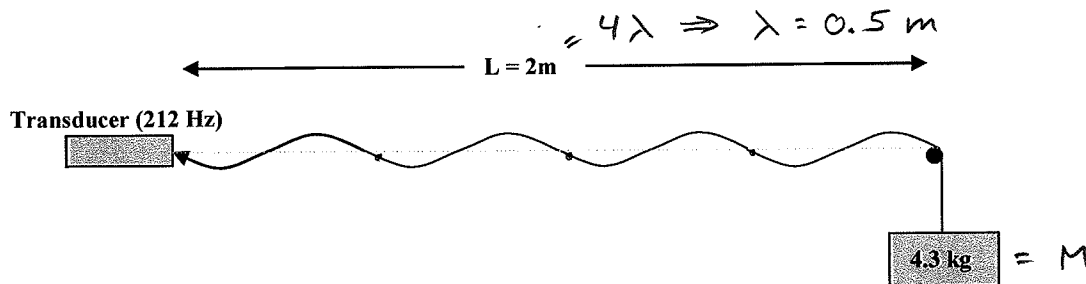
5. What is the mass of the string?

   a. 2.27 g
   b. 3.75 g
   c. 5.56 g
   (d.) 7.50 g
   e. 12.1 g

$$v = \lambda f = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{Mg}{m/L}} = \sqrt{\frac{MgL}{m}}$$

$$m = (\lambda f)^{-2} M g L$$

$$= (0.5\ m \times 212\ 1/s)^{-2} 4.3\ kg \times 9.8\ m/s^2 \times 2m$$

$$= 0.0075\ kg = 7.5\ g$$

6. If the mass of the weight were quadrupled (i.e. increased to 17.2 kg), what would happen to the number of wavelengths in the standing wave?

   a. It would quadruple
   b. It would double
   c. It would not change
   (d.) It would decrease by a factor of two
   e. It would decrease by a factor of four

$$\lambda f = \sqrt{\frac{Mg}{\mu}}$$

$$\lambda' f = \sqrt{\frac{(4M)g}{\mu}} = 2\sqrt{\frac{Mg}{\mu}} = 2\lambda f$$

$\Rightarrow \lambda' = 2\lambda$ Wavelength doubles

$\Rightarrow$ number of wavelengths halves

7. In a container of volume V = 0.5 m³ is 0.4 kg of an ideal gas. Its pressure is P = 1.25 × 10⁵ Pa at room temperature (23 °C). What is the molecular mass M of the molecules making the gas?

   a. M = 15.4 amu
   b. M = 30.9 amu
   c. M = 33.5 amu
   d. M = 41.1 amu
   e. M = 61.6 amu

NOT ON EXAM 3

8. The small piston of a hydraulic lift has a cross sectional area of 5 cm² and can lift a 15,000 N weight by applying a force of F=250 N. What is the area of the large piston, assuming both pistons are at the same height, as shown in the drawing?

a. 0.15 m²
b. 0.03 m²
c. 3.0 m²
d. 15 m²
e. 300 m²
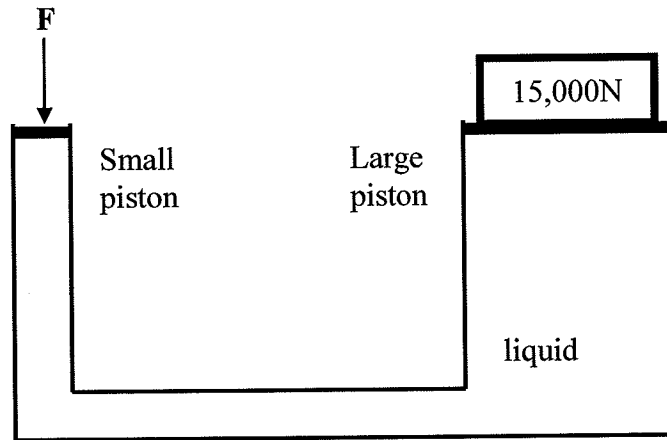
$$P_1 = P_2$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\Rightarrow A_2 = A_1 \frac{F_2}{F_1} = 5\,cm^2 \times \frac{15,000}{250}$$

$$= 300\,cm^2 = 0.03\,m^2$$

9. At an air show, an airplane is flying by you at 200 m/s. If you hear the frequency of the sound from the airplane is 310 Hz when it is flying away from you, what frequency will you hear as the airplane flies toward you? (Assume that the speed of sound is v = 340 m/s).

$$f_o = f_s \frac{V_{sound}}{V_{sound} + V_s}$$
$$\uparrow\,away$$

$$f_s = f_o \frac{V_{sound} + V_s}{V_{sound}}$$

$$= 310\,Hz\,\frac{340 + 200}{340} = 492\,Hz$$

$$f_o = f_s \frac{V_{sound}}{V_{sound} - V_s}$$
$$\uparrow\,toward$$

$$= 492\,Hz\,\frac{340}{340 - 200}$$

$$= 1195\,Hz$$

a. 129 Hz
b. 240 Hz
c. 570 Hz
d. 800 Hz
e. 1196 Hz

10. Many home WiFi routers use the frequency of 2.4 GHz (1 GHz = 10⁹ Hz). What is the wavelength of this microwave?

a. 0.6 cm
b. 1.25 cm
c. 6.0 cm
d. 12.5 cm
e. 21 cm

$$c = \lambda f$$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^{10}\,cm/s}{2.4 \times 10^9\,1/s} = 12.5\,cm$$

11. In an experiment in lab shown in figure, you studied the motion of a mass M hanging from a vertical spring with spring constant k. The mass was initially at its equilibrium position. It was then lifted up by a small distance and released. It afterward starts to oscillate vertically. Assuming the period of oscillation is T and frequency of the oscillation is f. Which of the following individual potential energy (P.E.) and kinetic energy (K.E.) vs. time graphs is correct?


(a)   (b)   (c)
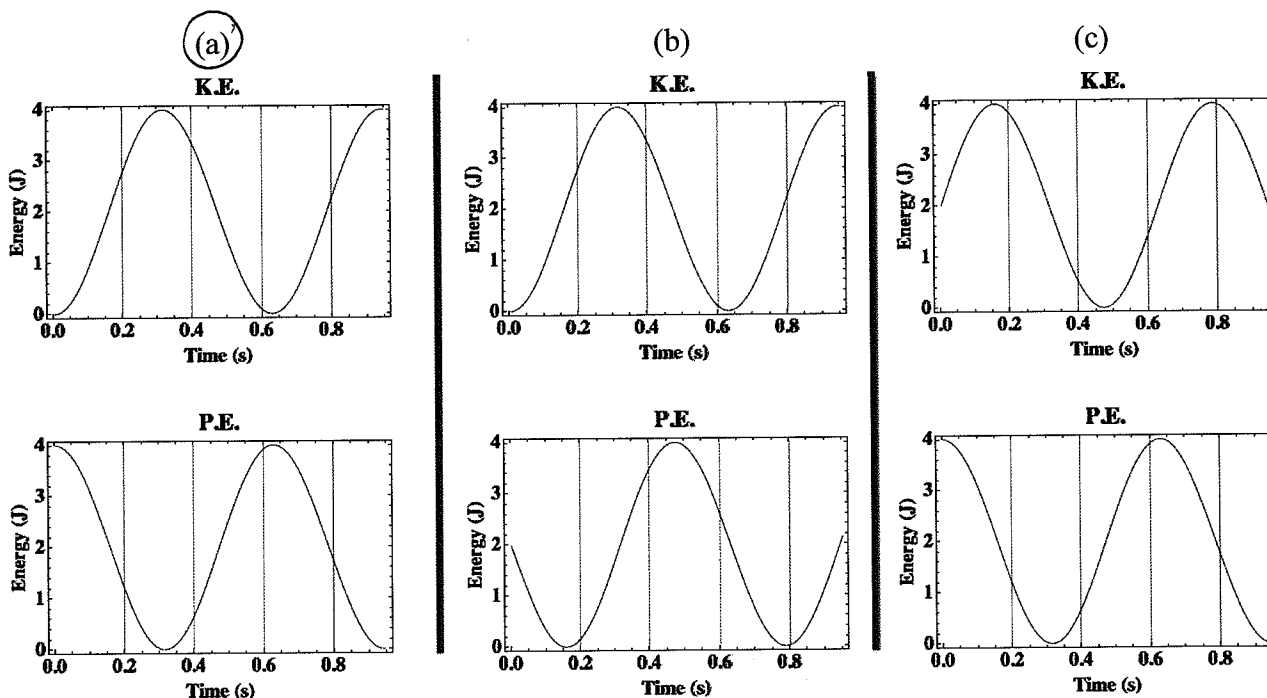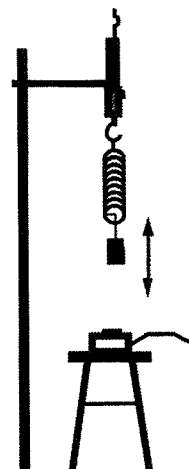
12. Consider two containers with the same volume, each containing the same mass of gas. One is filled with molecular oxygen (each molecule has an atomic weight of about 32), the other with molecular nitrogen (each molecule has an atomic weight of about 28). Which has the larger number density?

NOT ON EXAM 3

a. oxygen
b. nitrogen
c. not enough information given

The following two problems concern the same physical situation.

A barrel of cement is lowered from a ship into a river until it reaches the bottom of a river at a depth of 125 m. Assume that the density of water is 1000 kg/m^3 and neglect atmospheric pressure. The barrel is a cylinder 2m in length with radius 40cm and is completely filled with concrete at a density of 2000kg/m^3.
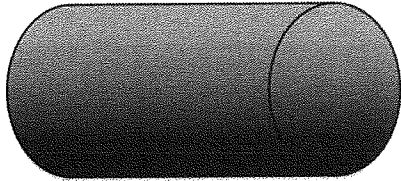
13. What is the water pressure at the river's floor?

   a. 4.1×10^4 Pa
   b. 1.9×10^5 Pa
   (c.) 1.22×10^6 Pa
   d. 4.9×10^7 Pa
   e. 9.8×10^8 Pa

$P_2 = P_1 \overset{=1\,atm}{+} \rho g h$ neglect

$= 10^5 \text{Pa} + 1000 \text{ kg/m}^3 \times 9.8 \text{ m/s}^2 + 125 \text{ m}$

$= 1,225,000 \text{ Pa}$

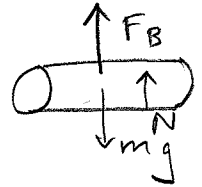14. What is the magnitude of the total force that the barrel exerts on the river floor?

   a. 4925 N
   (b.) 9850 N
   c. 19700 N

$F_B + N = mg$

$N = mg - F_B = \rho_{concrete} V g - \rho_{water} V g$

$= (\rho_{concrete} - \rho_{water}) g \times \pi R^2 \times L$

$= (2000 - 1000) \text{ kg/m}^3 \times 9.8 \text{ m/s}^2 \times \pi$

$\hookrightarrow \times (0.40 \text{ m})^2 \times 2\text{m} = 9852 \text{ N}$

The following two questions relate to the same situation:

15. A pendulum is constructed by hanging a 0.5 kg mass on a massless string. It has a period of 1.5s. How long is the string?

   a. 26 cm
   b. 42 cm
   (c.) 56 cm
   d. 73 cm
   e. 99 cm

$T = \dfrac{2\pi}{\omega} = 2\pi \sqrt{\dfrac{L}{g}} \Rightarrow L = g\left(\dfrac{T}{2\pi}\right)^2$

$= 9.8 \text{ m/s}^2 \left(\dfrac{1.5s}{2\pi}\right)^2$

$= 0.56 \text{ m} = 56 \text{ cm}$

16. Suppose the pendulum is in an elevator that is moving steadily downward (no acceleration). What will its period be?

   a. more than 1.5 s
   b. less than 1.5 s
   (c.) 1.5 s

no acceleration

The following three questions concern the same physical situation.

A cylindrical garden hose with radius 1.5 cm, has water flowing at a speed of 0.5 m/s. Assume that the hose is laying flat on a level yard.

17. How long will it take to fill a 1 liter (10^{-3} m³) bucket with water?

$= 10^3 \text{ cm}^3$

a. 0.31 s

b. 2.83 s

c. 11.3 s

Flow rate $= Av = \pi r^2 v = \pi (1.5 \text{ cm})^2 \times 0.5 \text{ m/s} = 353 \frac{cm^3}{s}$

Flow rate $\times \Delta t = V \Rightarrow \Delta t = \frac{V}{\text{Flow rate}} = \frac{10^3 \text{ cm}^3}{353 \text{ cm}^3/s} = 2.83 s$

18. Suppose that the hose is bent somewhere along its length (still laying flat), and at this location its cross-sectional area is decreased by a factor of 4. What is the speed of water flow at this location?

a. 0.13 m/s

b. 0.5 m/s

c. 1.0 m/s

d. 1.5 m/s

e. 2.0 m/s

$A_1 v_1 = A_2 v_2$

$v_2 = v_1 \frac{A_1}{A_2} = 0.5 \text{ m/s} \times \frac{A_1}{\frac{1}{4} A_1} = 2 \text{ m/s}$

19. The water pressure in the hose at the place where it is bent is:

a. larger

b. smaller

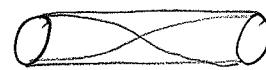c. the same

Big $v \rightarrow$ Small P

20. A pipe organ with length 5.2 m is open at both ends. What is its fundamental frequency (corresponding to the longest possible wavelength)? The speed of sound is 343 m/s.

a. 33.0 Hz

b. 107.2 Hz

c. 214.4 Hz

$v = \lambda f$

$f = \frac{v}{\lambda} = \frac{343 \text{ m/s}}{10.4 \text{ m}}$

$= 33 \frac{1}{s}$

$L = \frac{\lambda}{2} \Rightarrow \lambda = 2L = 10.4 \text{ m}$

The following three questions concern the same physical situation:

A block of mass 15 kg is resting on a horizontal frictionless surface and is attached to a spring with a force constant k = 370 N/m. A force of **F** is applied to the block in the x-direction, thereby compressing the spring from its equilibrium length by 0.2 m.
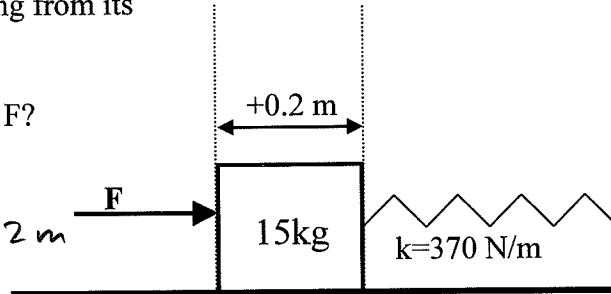
21. What is the magnitude of the force F?

    a. 33 N
    b. 54 N
    c. 74 N

$|F| = kx$

$= 370 \, N/m \times 0.2 \, m$

$= 74 \, N$

22. The force is removed and the block starts to oscillate. How long does it take to complete one oscillation?

    a. 1.26 sec
    b. 1.71 sec
    c. 2.51 sec
    d. 3.69 sec
    e. 4.76 sec

$T = \dfrac{2\pi}{\omega} = 2\pi\sqrt{\dfrac{m}{k}} = 2\pi\sqrt{\dfrac{15 \, kg}{370 \, N/m}} = 1.26 \, s$

23. What is the speed of the block when it reaches the equilibrium position for the first time?

    a. 0.24 m/s
    b. 0.73 m/s
    c. 0.99 m/s
    d. 1.64 m/s
    e. 2.28 m/s

$\frac{1}{2}kA^2 = \frac{1}{2}mv^2$

$v = A\sqrt{\dfrac{k}{m}} = 0.2 \, m \times \sqrt{\dfrac{370 \, N/m}{15 \, kg}} = 0.99 \, m/s$

24. A bar of copper (Cu) with length 200.01 m and a bar of aluminum (Al) with length 200.00 m are sitting at room temperature, T=25°C. At what temperature will the two have the same length? $\alpha_{Cu} = 1.60 \times 10^{-7} \, K^{-1}$ $\alpha_{Al} = 2.25 \times 10^{-7} \, K^{-1}$.

    a. 794 °C
    b. 1203 °C
    c. 2011 °C
    d. 3094 °C
    e. 3455 °C

NOT ON EXAM 3

Did you bubble in your name, exam version, and network ID?
Check to make sure you have bubbled in all your answers.