

Last Name: _____ First Name _____ Network-ID _____
Discussion Section: _____ Discussion TA Name: _____
Exam Room _____ Seat Number _____

Instructions—

Turn off your cell phone and put it away.

Calculators may not be shared. Please keep your on your own desk.

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 a pen. Fill in completely (until there is no white space visible) the circle for each intended input – both on the identification side of your answer sheet and on the side on which you mark your answers. 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.
2. Print your last name in the **YOUR LAST NAME** boxes on your answer sheet and print the first letter of your first name in the **FIRST NAME INI** box. Mark (as described above) the corresponding circle below each of these letters.
3. Print your NetID in the **NETWORK ID** boxes, and then mark the corresponding circle below each of the letters or numerals. Note that there are different circles for the letter “I” and the numeral “1” and for the letter “O” and the numeral “0”. **Do not** mark the hyphen circle at the bottom of any of these columns.
4. You may find the version of **this Exam Booklet at the top of page 2**. Mark the **version** circle on the **TEST FORM** box in the bottom right on the front side of your answer sheet. **DO THIS NOW!**
5. Stop **now** and double-check that you have bubbled-in all the information requested in 2 through 4 above and that your marks meet the criteria in 1 above. Check that you do not have more than one circle marked in any of the columns.
6. Do **not** write in or mark any of the circles in the STUDENT NUMBER or SECTION boxes.
7. On the **SECTION line**, print your **DISCUSSION SECTION**. (You need not fill in the COURSE or INSTRUCTOR lines.)
8. Sign (**DO NOT PRINT**) your name on the **STUDENT SIGNATURE line**.
9. **At the end of the exam, turn in your exam booklet and scantron.** You must write your **name on the exam booklet**, and your **seat number on the scantron**. Submit both before you leave the room,

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 on the **TEST FORM** box in the bottom right on the front side of your answer sheet. **DO THIS NOW!**

Exam Grading Policy—

The exam is worth a total of **117** 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.

Unless told otherwise, you should assume that the acceleration of gravity near the surface of the earth is 9.8 m/s^2 downward and ignore any effects due to air resistance.

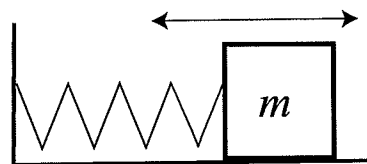
Choose the closest number to the correct answer when a numerical answer is required.

The next five questions pertain to the same physical situation.

A block of mass $m = 1.5 \text{ kg}$ is connected to a spring as shown in the figure. Both the block and the spring lie on a frictionless horizontal table. The graph plots the x coordinate of the block versus time. The x coordinate is measured in meters and the time is measured in seconds. Assume the block undergoes a simple harmonic motion about the equilibrium extension of the spring marked as $x = 0$.

1. What is the amplitude of the block's oscillation?

- a. 0 m
 b. 2 m
 c. 4 m

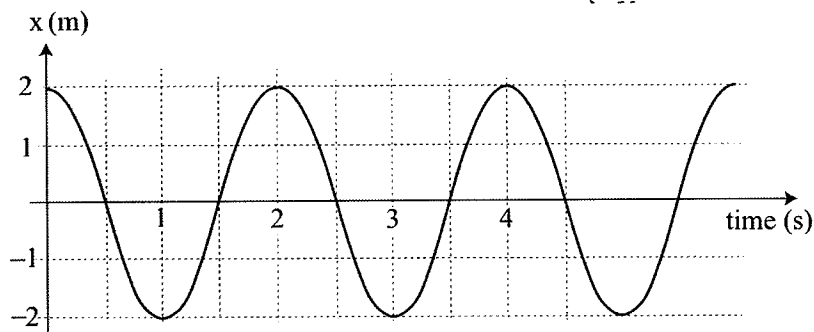


2. What is the frequency of the block's oscillation?

- a. 0.5 s^{-1}
 b. 1 s^{-1}
 c. 2 s^{-1}
 d. 3.14 s^{-1}
 e. 5 s^{-1}

$$T = 2 \text{ s}$$

$$f = \frac{1}{T} = 0.5 \text{ 1/s}$$



3. At which time does the magnitude of the total force applied to the block attain its minimum?

- a. $t = 0.5 \text{ s}$
 b. $t = 1.25 \text{ s}$
 c. $t = 2 \text{ s}$
 d. $t = 2.75 \text{ s}$
 e. $t = 3 \text{ s}$

$$F = -kx$$

4. At which time does the kinetic energy of the block attain its maximum value?

- a. $t = 0 \text{ s}$
 b. $t = 0.75 \text{ s}$
 c. $t = 1.5 \text{ s}$
 d. $t = 3 \text{ s}$
 e. $t = 3.25 \text{ s}$

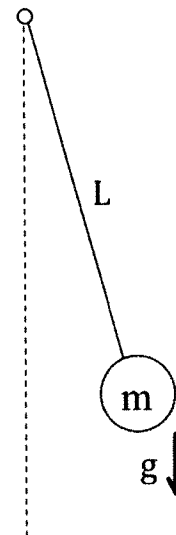
5. Now assume that at time $t = 2 \text{ s}$, a block of mass $M = 0.5 \text{ kg}$ is firmly attached to the original block. How would the maximum kinetic energy of the two blocks, KE_2 , for $t > 2 \text{ s}$ compare to the maximum kinetic energy of the single block m , KE_1 , for $t < 2 \text{ s}$?

- a. $KE_2 < KE_1$
 b. $KE_2 > KE_1$
 c. $KE_2 = KE_1$

Energy conservation

The following two questions pertain to the same physical situation.

At the surface of planet X, a small ball of mass $m = 3 \text{ kg}$ is suspended by a string of length $L = 5 \text{ m}$. The ball oscillates with a frequency of 0.25 s^{-1} and an amplitude of 10 cm .



6. What is the acceleration due to gravity at the surface of planet X?

- a. 3.4 m/s^2
 b. 6.8 m/s^2
 c. 9.8 m/s^2
 (d) 12.3 m/s^2
 e. 16.1 m/s^2
- $$\omega = 2\pi f = \sqrt{\frac{g}{L}}$$
- $$\Rightarrow g = L (2\pi f)^2$$
- $$= 5 \text{ m} (2\pi \cdot 0.25 \text{ s}^{-1})^2$$
- $$= 12.3 \text{ m/s}^2$$

7. How would the period of oscillation change, if the amplitude of the oscillation were doubled?

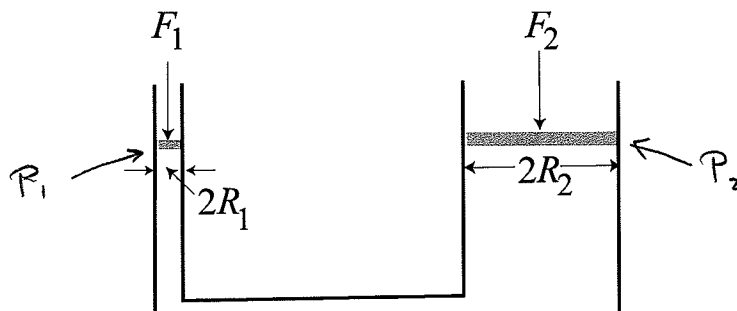
- a. The period would increase by a factor of $\sqrt{2}$.
 (b) The period would remain the same.
 c. The period would decrease by a factor of $\sqrt{2}$.

$$T = \frac{2\pi}{\omega} = 2\pi \sqrt{\frac{L}{g}}$$

The following question is by itself

8. The two cylinders of a hydraulic lift are $R_1 = 0.1 \text{ m}$ and $R_2 = 1 \text{ m}$ in radius. The piston in the narrow cylinder is subject to a force of $F_1 = 50 \text{ N}$ as illustrated. What force is exerted on the piston in the wide cylinder to maintain its position? Ignore the masses of the pistons. The pistons are at the same height.

- a. 1 N
 b. 50 N
 c. 200 N
 d. 1500 N
 (e) 5000 N



$$P_1 = P_2$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2} \Rightarrow F_2 = F_1 \frac{A_2}{A_1} = F_1 \frac{\pi R_2^2}{\pi R_1^2} = 50 \text{ N} \left(\frac{1 \text{ m}}{0.1 \text{ m}} \right)^2$$

$$= 5000 \text{ N}$$

The following two questions apply to the same physical situation.

A uniform cubic box of plastic is floating at the surface of a fresh water lake. The box is submerged in water by $1/3$ of its side. The side of the cube is 10 cm. The density of water is 1000 kg/m^3 .

9. What is the magnitude of the buoyant force that applies to the box?

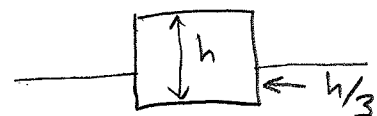
- a. 3.3 N
- b. 13.2 N
- c. 29.1 N
- d. 35.4 N
- e. 47.8 N

$$F_B = \rho V_{\text{sub}} g$$

$$= \rho h^2 \times \frac{h}{3} g$$

$$= \frac{1}{3} 1000 \text{ kg/m}^3 \times \overbrace{(10 \text{ cm})^3}^{0.1 \text{ m}} \times 9.8 \text{ m/s}^2$$

$$= 3.27 \text{ N}$$



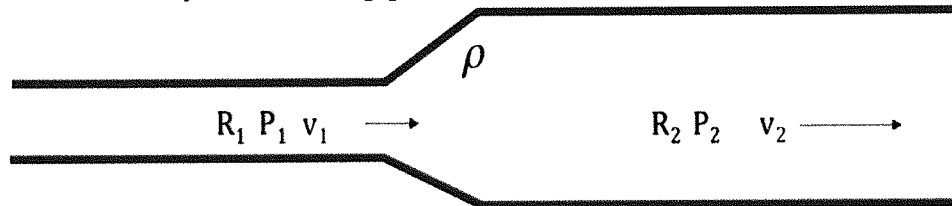
$h = 10 \text{ cm}$

10. Another uniform box of the same dimensions is floating nearby such that it is submerged by $1/2$ of its side. What can be said about the density of the second box ρ_2 in comparison with the density of the plastic box ρ_1 ?

- a. $\rho_2 > \rho_1$
- b. $\rho_2 < \rho_1$
- c. not enough information to tell

The following two questions pertain to the following situation:

Water flows through a cylindrical pipe of variable cross section as shown in the figure. The average water velocity in the narrow part of the pipe is 3 m/s. The radii of the narrow and wide sections of the pipe are $R_1 = 10$ cm and $R_2 = 20$ cm, respectively. Assume the density of water is constant everywhere in the pipe.



11. What is the average velocity in the wider section of the pipe?

- a. 0.33 m/s
- b. 0.75 m/s
- c. 1.5 m/s
- d. 3 m/s
- e. 6 m/s

$$A_1 v_1 = A_2 v_2$$

$$\Rightarrow v_2 = v_1 \frac{A_1}{A_2} = v_1 \frac{\pi R_1^2}{\pi R_2^2} = 3 \text{ m/s} \left(\frac{10}{20} \right)^2 = 0.75 \text{ m/s}$$

12. How does the pressure in the wider section of the pipe P_2 compare with the pressure in the narrow part of the pipe P_1 ?

- a. $P_2 > P_1$
- b. $P_2 < P_1$
- c. $P_2 = P_1$

Small $v \rightarrow$ High P and vice versa

The following question is by itself.

13. What is the pressure in the ocean 1 km below its surface? Assume that the ocean has a constant density of 1000 kg/m^3 and that the atmospheric pressure is 1 atm or 100,000 Pa.

- a. 1.5 atm
- b. 22 atm
- c. 53 atm
- d. 86 atm
- e. 99 atm

$$P_2 = P_1 + \rho g h$$

$$= 1 \text{ atm} + 1000 \text{ kg/m}^3 \times 9.8 \text{ m/s}^2 \times 1000 \text{ m}$$

$$= 9,900,000 \text{ Pa}$$

$$= 99 \text{ atm}$$

The following question is by itself.

14. A sound wave of frequency 1230 Hz has a speed of 410 m/s in medium A. The wave enters medium B, where its wavelength is halved. What is the speed of the wave in medium B?

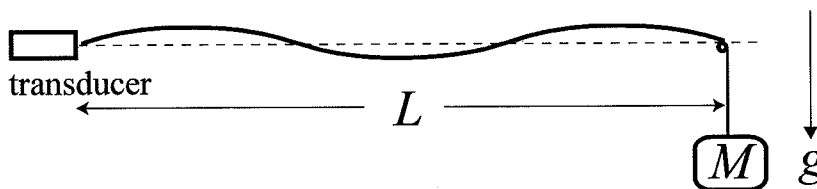
- a. 410 m/s
 (b) 205 m/s
 c. 820 m/s
 d. 307 m/s
 e. 615 m/s

$$v = \lambda f$$

$$v' = \lambda' f = \frac{\lambda}{2} f = \frac{1}{2} v = \frac{1}{2} 410 \text{ m/s} = 205 \text{ m/s}$$

The next two questions refer to the same situation.

As shown in the figure below, a string is attached at one end to a transducer. The string runs over a smooth peg a distance $L = 3.4$ m from the transducer. A mass M is attached to the end of the string opposite the transducer so that it hangs from the peg. The transducer and the peg are fixed to be the same distance from the horizontal ground. The tension in the string is controlled by the mass M . A standing wave of frequency f is produced between the transducer and the peg. One instance of the standing wave is drawn in the figure.



15. What is the wavelength of the standing wave in the figure?

- a. 3.4 m
 (b) 2.27 m
 c. 5.1 m
 d. 1.7 m
 e. 4.54 m

$$L = \frac{3}{2} \lambda \Rightarrow \lambda = \frac{2}{3} L = \frac{2}{3} 3.4 \text{ m} = 2.27 \text{ m}$$

16. Now, to double the frequency ($f \rightarrow 2f$) while maintaining the same number of nodes, the original mass M is replaced by a new mass m . What is the required ratio m/M ?

- a. $m/M = 1/4$
 b. $m/M = 1/2$
 c. $m/M = 1$
 d. $m/M = 2$
 (e) $m/M = 4$

$$\left. \begin{aligned} v &= \lambda f = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{Mg}{\mu}} \\ \lambda f' &= \lambda 2f = \sqrt{\frac{mg}{\mu}} \end{aligned} \right\} \Rightarrow 2 \sqrt{\frac{Mg}{\mu}} = \sqrt{\frac{mg}{\mu}}$$

$$4M = m$$

$$\Rightarrow \frac{m}{M} = 4$$

The following question is by itself.

17. Two identical sirens are placed 30 meters away from you. From them you hear a sound of loudness β_0 . How many sirens the same as these two sirens should be placed 60 m away from you to produce the sound of the same loudness β_0 ?

- a. 5
 - b. 6
 - c. 7
 - d. 4
 - e. 8
- $$I_1 = I_2 \quad I = \frac{P}{4\pi r^2}$$
- $$I_2 = N \times \frac{P}{4\pi (2r)^2} = 2 \frac{P}{4\pi r^2} = I_1$$
- $$\Rightarrow N = 8$$

The following question is by itself.

18. There is a siren at the side of a straight road. You drive a car toward it and then pass it by. You hear the frequency of the siren to change from $f_{\text{before}} = 860$ Hz to $f_{\text{after}} = 820$ Hz. What is the frequency of the siren measured by a stationary observer?

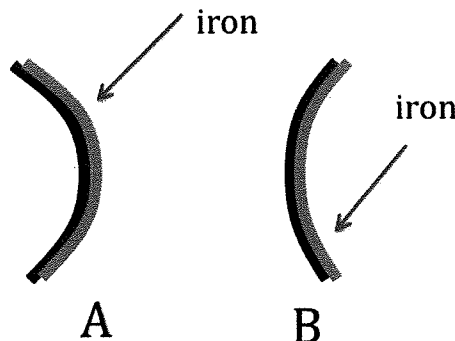
- a. 840 Hz
 - b. 830 Hz
 - c. 850 Hz
 - d. 845 Hz
 - e. 835 Hz
- $$f_o = f_s \frac{v_{\text{sound}} \pm v_o}{v_{\text{sound}}}$$
- $$f_o^{\text{toward}} + f_o^{\text{away}} = \frac{f_s}{v_{\text{sound}}} (v_{\text{sound}} + v_o + v_{\text{sound}} - v_o)$$
- $$f_o^{\text{toward}} + f_o^{\text{away}} = 2 f_s \Rightarrow f_s = \frac{1}{2} (f_o^{\text{toward}} + f_o^{\text{away}})$$
- $$= \frac{1}{2} (860 \text{ Hz} + 820 \text{ Hz})$$
- $$= 840 \text{ Hz}$$

The following question is by itself.

19. A bimetallic strip is made from an aluminum strip placed at the left and an iron strip placed at the right. The linear thermal expansion coefficient of aluminum is $1.6 \times 10^{-5}/\text{K}$ and that of iron is $1.2 \times 10^{-5}/\text{K}$. The bimetallic strip is straight at 300 K. Now, the temperature is increased to 370K. Which way does the bimetallic strip bend, to the iron side (right) or to the aluminum side (left)?

- a. leftward (A)
- b. rightward (B)

NOT ON EXAM 3



The following question is by itself.

THESE PROBLEMS NOT ON
EXAM 3

20. There is a cubic box of size a . When its temperature is raised from 230 K to 340 K, its surface area increases by 2.2 %. What is the % increase of its volume in the same situation?

- a. 1.5 %
- b. 3.3 %
- c. 2.2 %
- d. 2.7 %
- e. 4.4 %

The following question is by itself

21. An ideal gas thermometer is a small rigid container of volume 120 cm^3 containing 0.03 moles of ideal gas. From its pressure the temperature is measured. The thermometer is dipped in a liquid and, after thermal equilibrium is reached, the pressure of the thermometer is 293 kPa. What is the temperature of the liquid?

- a. 390 K
- b. 141 K
- c. 297 K
- d. 401 K
- e. 323 K

The next two questions refer to the same situation.

A tank of volume 1.3 m^3 contains an ideal gas consisting of a chemical species A, whose pressure is $P = 490 \text{ kPa}$ and temperature $T = 320 \text{ K}$.

22. How many molecules are there in the tank?

- a. 0.31×10^{24}
- b. 1.44×10^{24}
- c. 1.12×10^{25}
- d. 1.44×10^{26}
- e. 0.31×10^{26}

23. The root-mean-square velocity of the gas molecules is 257 m/s. What is the molecular mass of chemical species A? Express your answer in unit of unified atomic mass u . $1 u = 1.66 \times 10^{-27} \text{ kg}$.

- a. 163 u.
- b. 121 u.
- c. 49 u.
- d. 82 u.
- e. 103 u.