Last Name:______________First Name_________________Network-ID____________
Discussion Section:________Discussion TA Name:______________________________

Instructions—

Turn off your cell phone and put it away.
Calculators may not be shared. Please keep your calculator 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 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. **This Exam Booklet is Version A**. Mark the **A** circle in the **TEST FORM** box at the bottom of the front side of your answer sheet.

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. Do ***NOT*** write on the Formula Sheet.

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

8. Do not leave the answer side of the answer sheet exposed on your desk; protect your solutions from the eyes of other students

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

Before starting work, check to make sure that your test booklet is complete. You should have 13 ***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.**

Exam Grading Policy—
The exam is worth a total of 114 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 $\mathrm{m/s^2}$ *downward and ignore any effects due to air resistance.*

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

Assume that a pendulum is near the earth's surface.

The following 2 questions concern related physical situations:

1. A sound wave of frequency f travels from water (speed of sound is 1500 m/s) to steel (speed of sound is 5600 m/s). What is the ratio of the wavelength of this sound in water λ_{water} to that in steel λ_{steel}?

a. $\lambda_{steel}/\lambda_{water} = 0.25$.
b. $\lambda_{steel}/\lambda_{water} = 0.73$.
c. $\lambda_{steel}/\lambda_{water} = 1.00$.
d. $\lambda_{steel}/\lambda_{water} = 2.53$.
e. $\lambda_{steel}/\lambda_{water} = 3.73$.

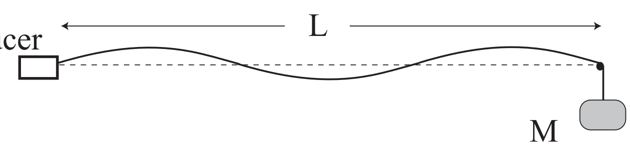
f = v/\lambda is independent of the medium, so the wavelength is proportional to the wave speed v! 5600/1500 = 3.733.

2. λ_{steel} is 35 cm for this sound. What is the frequency of the sound?

a. f = 7 kHz.
b. f = 12 kHz.
c. f = 16 kHz.
d. f = 19 kHz.
e. f = 21 kHz.

f = 5600/0.35 = 16000 Hz.

3. A uniform string is stretched between a transducer and a smooth peg. The string is stretched by a hanging block of mass M. The distance between the transducer and the peg is a fix distance, L.



Tension is Mg; do not confuse this mass with the mass of the string.

The number of nodes in the above figure is 4 (including both ends). We now change the block of mass M to another block of mass m, while keeping the frequency of the transducer the same. This produces a standing wave with 3 nodes on the string (including both ends). What is the required mass m of the new block?

a. m = 9M/4.
b. m = 7M/4.
c. m = 3M/2.
d. m = 5M/4.
e. m = 3M/4.

3 nodes imply \lambda = L
4 nodes imply \lambda = 2L/3 (as seen from the figure)

The frequency is constant, so \lambda is proportional to v, which is proportional to \sqrt{M}, so \sqrt{M}/(2L/3) = \sqrt{m}/L. That is, \sqrt{m} = (3/2)\sqrt{M}.

v = \sqrt{Mg/\mu}

10log[I(7)/I_0] -10log[I(9)/I_0]
= 10log[I(7)/I(9)]
= 10log[(I(1)/7^2)/(I(1)/9^2)]
= 10log[7^2/9^2] = 20 log(7/9)

\pi is pi

...estions concern related physical situations:

A siren gives a loudness β_7 when it is 7 m away and β_9 when it is 9 m away.

4. Find the difference $\beta_7 - \beta_9$.

a. $\beta_7 - \beta_9 =$ 0.98 dB.
b. $\beta_7 - \beta_9 =$ 1.58 dB.
c. $\beta_7 - \beta_9 =$ 2.18 dB.

```
I(r) = P/4\pi r^2 tells us that I(7) = I(1)/7^2,
I(9) = I(1)/9^2.  \beta = 10 log(I/I_0).
so
\beta(7) -\beta(9) = 10 log I(7)/I(9)
  = 10 log 9^2/7^2 = 20 log(9/7) = 2.183 dB
```

5. A single siren 9 meters away makes a sound of loudness β_9. What is the loudness, β of 3 sirens, identical to the first one, placed at the same location?

a. $\beta = \beta_9 + 4.8$.
b. $\beta = 3\,\beta_9$.
c. $\beta = 4.8\,\beta_9$.

```
I is additive.  Let I be the intensity of the sound of
the siren at 9 m.  Then, 3I is the intensity due to 3
sirens 9 m away, so
\beta = 10 \log 3I = 10\log 3 + 10 \log I
     = 4.77 + \beta_9.
```

\beta_9 = 1- log (I/ I_0)

The observer is running against the sound being observed.

6. You drive a car at a constant speed along a road. On the roadside is a stationary siren whose frequency observed by a bystander is f_0. When you are approaching the siren, you hear the frequency f_b = 740 Hz and when you are leaving the siren, you hear the frequency f_a = 690 Hz. Assume that the speed of sound is 330 m/s. What is the frequency f_0 of the siren?

a. 671 Hz
b. 690 Hz
c. 702 Hz
d. 715 Hz
e. 740 Hz

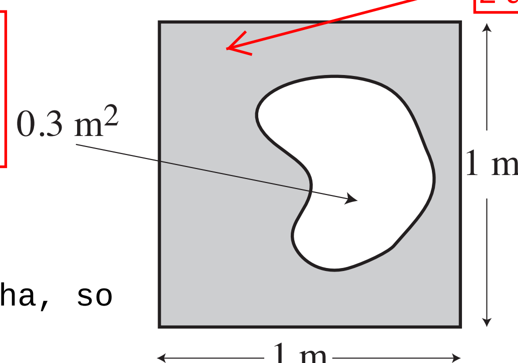
```
Approaching: v_o = -v, so 740 = f_0 (330 + v)/330.
Leaving: v_o = +v, so 690 = f_0 (330 - v)/330. Therefore,
     740 + 690 = 2f_0, so f_0 = 715 Hz.
```

7. On a 1 m square plate is a hole of area A = 0.3 m^2 at T = 200 K. The plate is made of a material whose linear thermal expansion coefficient is $\alpha = 13 \times 10^{-6}$ K^{-1}. What is the increase ΔA of the area of the window at T = 300 K compared with that at T = 200 K?

2 dimension

a. $\Delta A = 5.3 \times 10^{-4}$ m^2
b. $\Delta A = 7.8 \times 10^{-4}$ m^2
c. $\Delta A = 9.3 \times 10^{-4}$ m^2
d. $\Delta A = 11.2 \times 10^{-4}$ m^2
e. $\Delta A = 13.5 \times 10^{-4}$ m^2

The area expansion is
(1 + \a \Deta T)^2A
= (1+ 2a\Delta T)A



Dimension

```
The area expansion rate is just 2\alpha, so
\Delta A = 2 \alpha \Delta T \times A
  = 2 x 13E(-6) x 0.3 x 100 = 7.8E(-4) m^2.
```

?

The following two questions concern related physical situations:

In a container of volume $V = 0.5\ m^3$ is 0.8 kg of an ideal gas. Its pressure is $P = 1.25 \times 10^5$ Pa at temperature $T = 290$ K.

8. What is the molecular mass M of the molecules making the gas?

a. M = 22.3 amu
b. M = 30.8 amu
c. M = 33.5 amu
d. M = 41.1 amu
e. M = 49.0 amu

```
n = PV/RT = 25.93 = 800/M, so M = 30.8 amu.
```

must be in grams

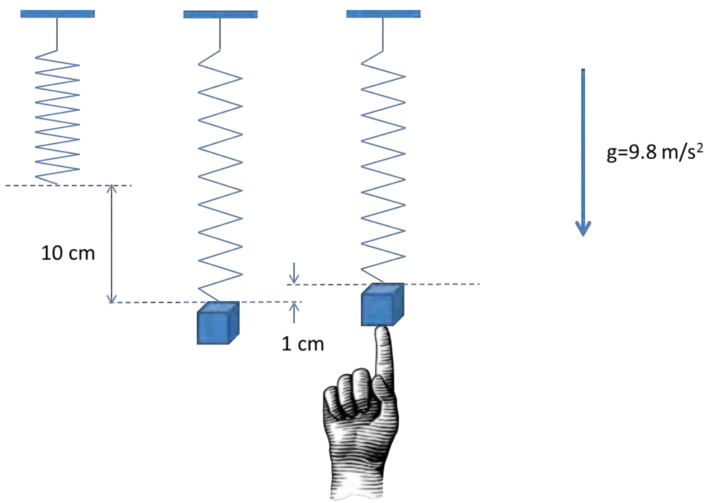
9. What is the ratio of the root mean square velocity v_{290} of the molecules at T = 290 K, and that v_{580} at T = 580 K?

a. $v_{580}/ v_{290} = 1.21$
b. $v_{580}/ v_{290} = 1.31$
c. $v_{580}/ v_{290} = 1.41$
d. $v_{580}/ v_{290} = 1.71$
e. $v_{580}/ v_{290} = 2.00$

```
v is proportional to \sqrt{T}, so \sqrt{2} must
be the answer.
```

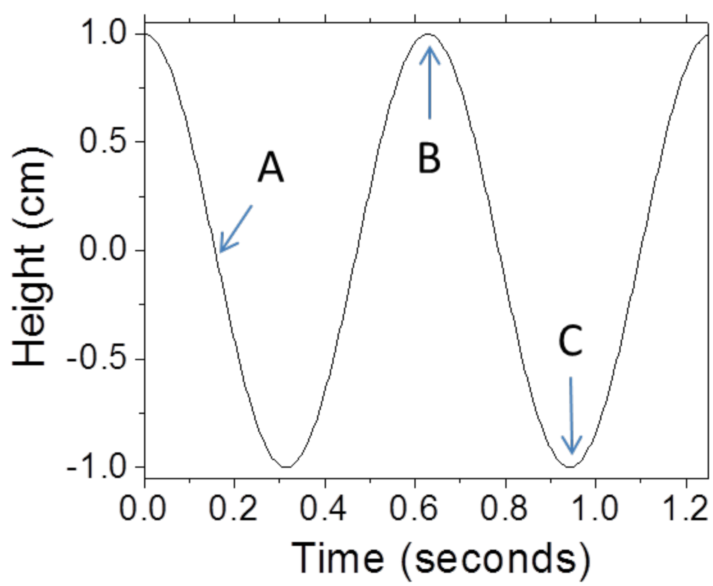
This exam continues on the next page.

The following 4 questions concern the same physical situation:



mg = kx = 2, so m = 0.204 kg.

An object of mass m is hanging from a vertical spring of spring constant k (= 20 N/m) near the surface of the earth. In equilibrium, the spring is stretched by 10 cm relative to the relaxed length of the spring. The spring is then compressed by 1 cm relative to the equilibrium position and is released into oscillation at time t = 0. The height of the object relative to the equilibrium height oscillates as shown below as a function of time.



10. Among the three time points marked (A, B, and C), when is the speed of the object the greatest?

a. A
b. B
c. C

This is the slope. At B and C v = 0.

11. Between the two time points marked (A and B), when is the acceleration of the object the largest in magnitude?

a. A
b. B

Changing rate of the speed. Around A the speed is almost consant.

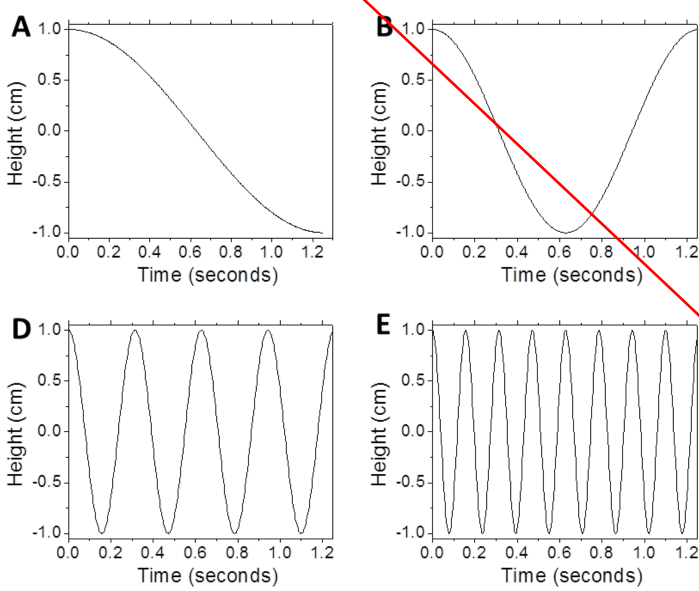
The next two questions refer to the previous page.

12. What is the mass m of the object?

a. 0.10 kg
b. 0.15 kg
c. 0.20 kg

Already answered.

13. Which of the following curves would best describe the height vs. time curve, if the mass of the object is quadrupled with all other quantities remaining the same?



\omega = \sqrt{k/m}, so the period doubles (the frequency is halved).

a. A
b. B
c. C
d. D
e. E

Let a be the upward acceleration of the elevator. Then, ma = T - mg, so the tension T needed to hang the mass is m(a+g). Therefore, the `effective' acceleration of gravity is a + g downward.

The next 2 questions concern the following situation:

A pendulum hanging from the ceiling of an elevator is swinging with the period of 2 seconds when the elevator is at rest. Assume that the elevator is near the surface of the earth. Suddenly, the elevator undergoes vertical acceleration and the period of the pendulum has changed to 2.2 seconds.

T = 2\pi\sqrt{L/g}

14. What is the direction of acceleration?

a. Upward
b. Downward

Since T increases, the effective g must be smaller than 9.8 m/s^2. That is, the acceleration a of the elevator is negative. Since the initial velocity is zero, the velocity immediately after starting motion must be negative = downward.

15. What is the magnitude of acceleration?

a. 1.4 m/s^2
b. 1.7 m/s^2
c. 2.0 m/s^2
d. 2.3 m/s^2
e. 2.6 m/s^2

```
Let us use the fact that
T is proportional to
1/sqrt{g}.
2\sqrt{g} = 2.2\sqrt{g+a), so g  = 1.21 (g + a), so
a = - 1.70 m/s^2.
```

The next 2 questions concern the following situation.

A container is filled with water to the brim and a uniform block of unknown density is added to the container. The block floats with 75% of its volume immersed in water and the amount of water overflowed from the container is 1 liter (1 liter is 10^{-3} m^3). Assume that the mass density of water is 1,000 kg/m^3.

This is the volume of the block below the surface, or the volume of the displaced liquid.

16. What is the mass density of the unknown material?

a. 1,250 kg/m^3
b. 1,100 kg/m^3
c. 900 kg/m^3
d. 750 kg/m^3
e. 600 kg/m^3

The mass of the block (1 kg) must be equal to the mass of the displaced liquid 0.75 V 1000 = 750 V. Thus, the density must be 750 kg/m^3.

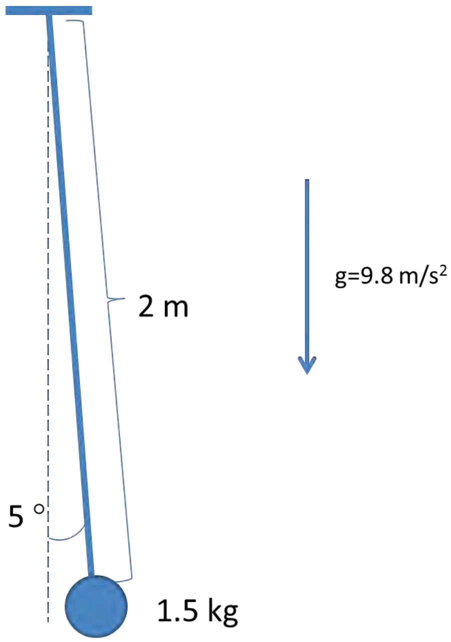
17. What is the weight of the block?

a. 9.8 N
b. 11.2 N
c. 12.5 N
d. 15.7 N
e. 18.2 N

Since the mass is 1 kg, 9.8 N is the gravitational force.

The next two questions concern the following situation.

A pendulum is made of a small weight of mass 1.5 kg attached to a string of length 2 m. The mass is released gently with the initial angle displacement of 5 degrees.




```
T = 2\pi \sqrt{L/g}
    = 2.838 s
```

4

18. How long does it take for the mass to reach its lowest point for the first time?

a. 2.84 s
b. 1.42 s
c. 0.71 s

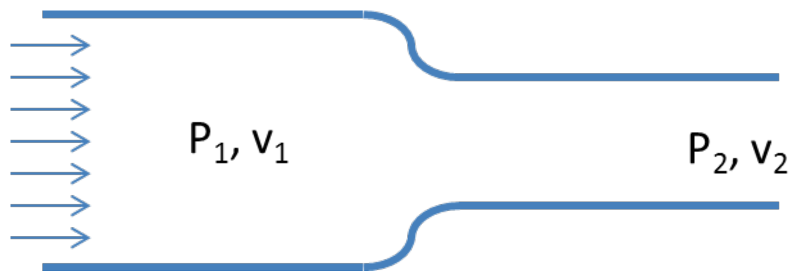
```
This must be T/4.
```

19. What is the maximum kinetic energy of the pendulum?

a. 0.33 J
b. 0.22 J
c. 0.11 J

```
Max kinetic energy is equal to the initial potential
energy (relative to the lowest point):
   U = mgh(1 - cos 5\deg) = 0.1119 J.
```

The next two questions concern the following situation.



An incompressible and non-viscous ßfluid flows from left to right through a circular pipe that changes its radius from r_1 to r_2 between regions 1 and 2 (see figure above, not to scale). The fluidic velocity in region 1 is v_1 (=3 m/s) and the fluidic velocity in region 2 is v_2 (=9 m/s). The density of fluid is 1,300 kg/m^3.

20. What is the ratio between r_2 and r_1?

a. $r_2/r_1=0.58$
b. $r_2/r_1=0.44$
c. $r_2/r_1=0.33$

```
Continuity equation implies that the volume speed must
be constant, so v_1 r_1^2 = v_2 r_2^2.
Therefore,
     r_2/r_1 = \sqrt{v_1/v_2} = \sqrt{1/3} = 0.577.
```

horizontal, so no potential energy need be considered.

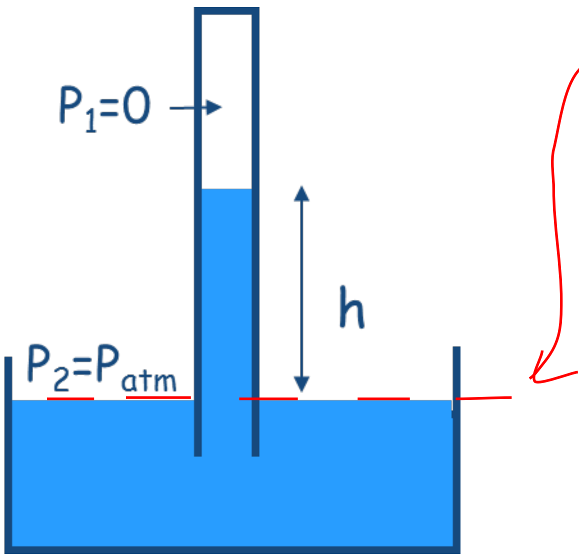
21. What is the magnitude of the pressure difference between the two regions?

a. $|P_2-P_1| = 24{,}500$ Pa
b. $|P_2-P_1| = 35{,}300$ Pa
c. $|P_2-P_1| = 46{,}800$ Pa
d. $|P_2-P_1| = 57{,}900$ Pa
e. $|P_2-P_1| = 0$ Pa

```
Bernoulli says
 P_1 + (1/2)\rho v_1^2 = P_2 + (1/2)\rho v_2^2,
so
  P_1 - P_2 = (1/2)1300(81 - 9) = 46800 Pa.
```

This exam continues on the next page.

22. Yuri constructs a barometer as shown below using water as the fluid in order to measure the atmospheric pressure. He takes it to the top of a mountain. The column of water reaches the height h of 9.18 m. The water density is 1,000 kg/m^3.



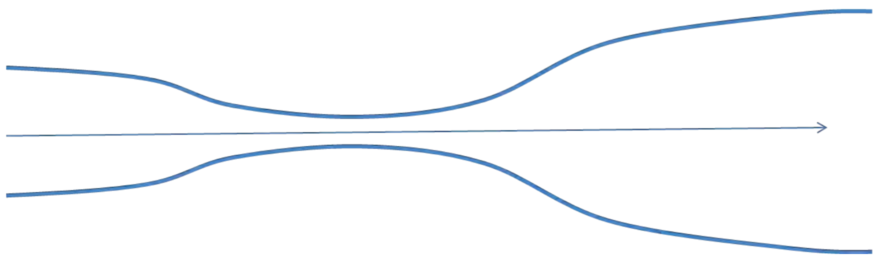
Consider the pressure balance at the line:
P_2 = P_1 + \rho g h
= 1000 x 9.8 x 9.18
= 89964 Pa.

What is the atmospheric pressure measured by the barometer?

a. 115,000 Pa
b. 105,000 Pa
c. 95,000 Pa
d. 90,000 Pa
e. 80,000 Pa

This exam continues on the next page.

23. A horizontal pipe becomes narrow and then widens as the fluid inside flows to the right as shown below.



This is a Bernoulli problem.

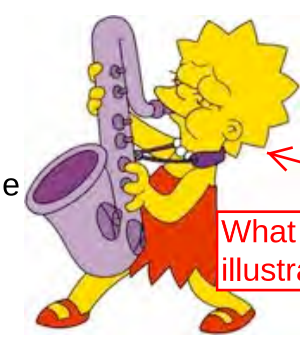
Which of the following statements is true?

a. The pressure of the fluid is everywhere the same because the average height of the fluid is the same everywhere the same.
b. The pressure of the fluid is smallest on the right end of the pipe because its diameter is the largest.
c. The pressure of the fluid is the smallest in the narrowed section because the velocity is the largest there.
d. The pressure of the fluid is the largest in the narrowed section because the velocity is the largest there.
e. None of the above statements is true.

24. When you blew on a pipe to make some sound, one end was open. Despite this, there was some reflection between the open end of the instrument and the surrounding air.

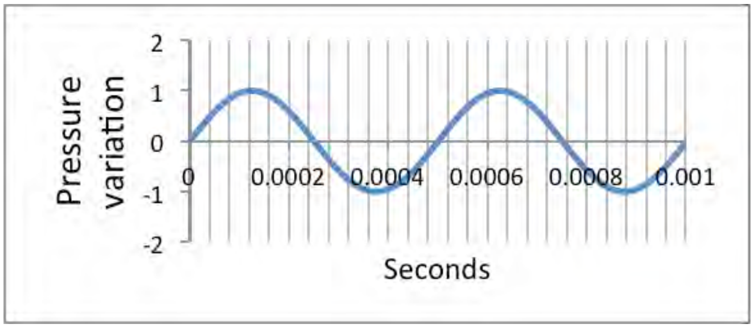
a. True
b. False

Without reflection there cannot be a standing wave inside the pipe.



What is this illustration for?

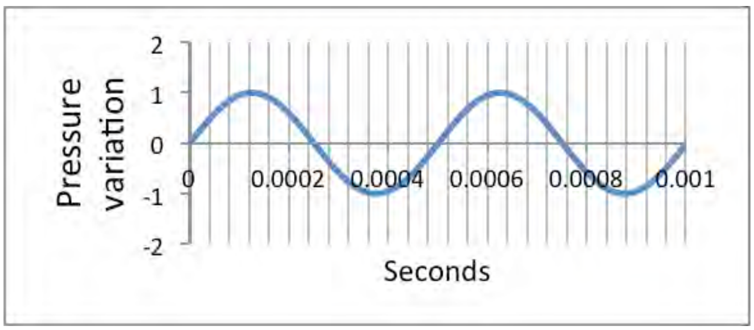
25. You blow into a pipe and record the output. The pressure variation as a function of time looks like:



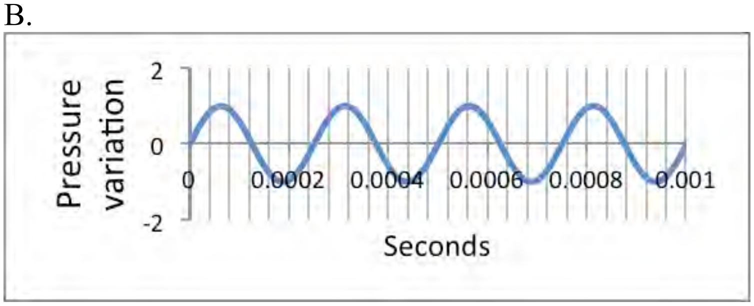
You then blow into another pipe and the output sound is lower in pitch. Which of the following is a possible pressure variation recorded just outside the pipe as a function of time?

smaller freq, longer period.

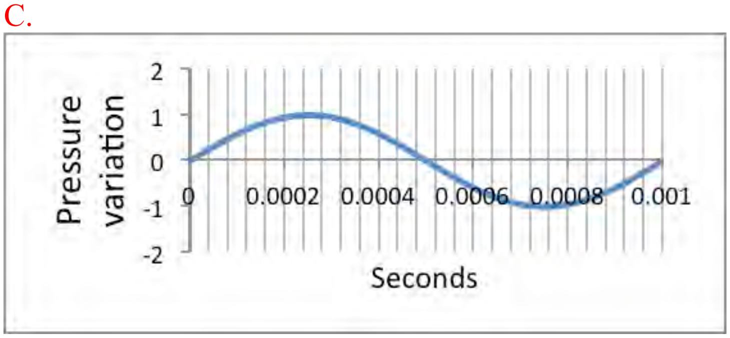
A.



B.



C.



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