Physics 101A

Supposedly version A, but pay attention to the actual solutions.

Last Name:______________

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 in 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 in 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 **xxx** 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.

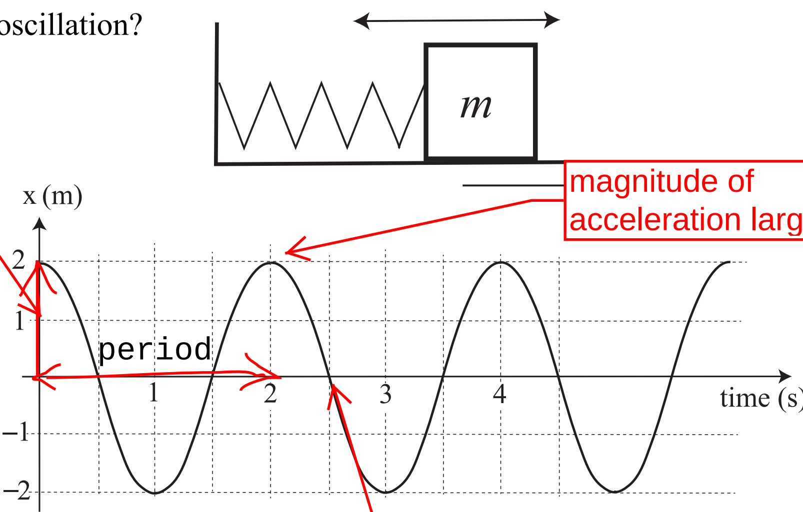
(a) If you mark only one answer and it is the correct answer, you earn **2** points.
(b) If you mark the wrong answer or neither answer, you earn **0** points.

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 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. 0m
b. 2m
c. 4m

amplitude A

magnitude of acceleration largest

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. $5\ s^{-1}$

f = 1/period (in sec), so f = 1/2 Hz.

speed is the largest, least accelerated.

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

a. t = 0.5 s — least accelerated, so magnitude of force = 0.
b. t = 1.25 s
c. t = 2 s — magnitude of force max
d. t = 2.75 s
e. t = 3 s — magnitude of force max

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

This implies the speed is max.

a. t = 0 s — acceleration max , speed = 0 so K = 0
b. t = 0.75 s
c. t = 1.5 s — speed max
d. t = 3 s — acceleration max , speed = 0 so K = 0
e. t = 3.25 s

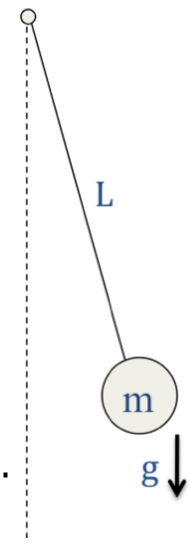
5. Assume now that at time t = 2 s, a block of mass M = 0.5 kg is firmly attached to the original block. How would the maximum kinetic energy of the two blocks, KE_2, for t > 2 s compare to the maximum kinetic energy of the single block m, KE_1, for t < 2 s?

a. $KE_2 < KE_1$
b. $KE_2 > KE_1$
c. $KE_2 = KE_1$ ~~5, 3b, 6a, 6a, 6e, 3e~~

At this moment, the speed is zero, so all the energy is in the potential energy stored in the spring. This has nothing to do with the mass change. This stored energy is totally converted to the kinetic energy when K is max.

The following two questions pertain to the same physical situation.

This is irrelevant. This is irrelevant.



At the surface of planet X, a small ball of mass m = 3 kg is suspended by a string of length L = 5 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

```
f = \omega/(2\pi)
  = (1/2\pi)\sqrt{g/L}.

Therefore, g/L = (2\pi f)^2 or
     g = L(2\pi f)^2
       = 5(\pi/2)^2 = 12.33 m/s^2.
```

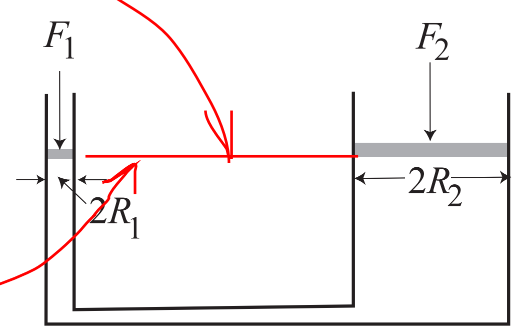
7. How would the period of oscillation change, if the amplitude of the oscillation were doubled?

a. The period would increase by a factor of √2.
b. The period would remain the same.
c. The period would decrease by a factor of √2.

The following question is by itself

8. The two cylinders of a hydraulic lift are R_1 = 0.1 m and R_2 = 1 m in radius. The piston in the narrow cylinder is subject to a force of F_1 = 50N 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

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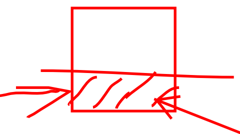
Mr. Pascal tells us that the
pressures at the bottom of the
pistons must be the same:
     F_1/(\pi R_1^2) = F_2/(\pi R_2^2)
or
     F_2 = F_1(R_2/R_1)^2 = 50(10)^2 = 5000 N.
```

~~3, 6d, 3b, 6e~~

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?

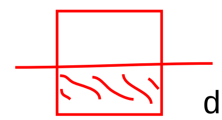


a. 3.3 N
b. 13.2 N
c. 29.1 N
d. 35.4 N
e. 47.8 N

```
Mr Archimedes tells us that the
buoyant force = weight of the displaced fluid
     = (0.1)^3/3 times 1000 g
     = g/3 = 3.27 N
```

(0.1)^3/3 m^3 is the displaced fluid volume.

10. Another uniform box of the same dimensions is floating nearby such that it is submerged by ½ 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?

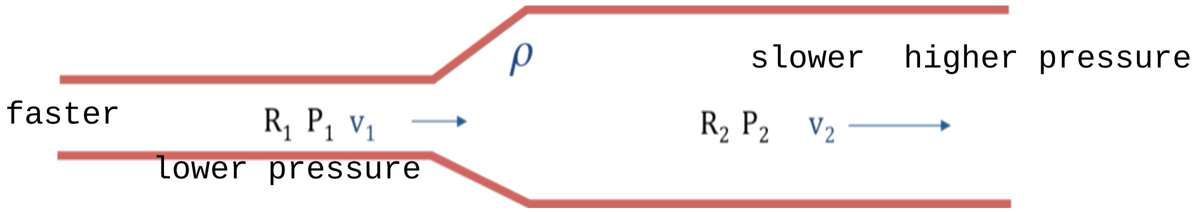


deeper

a. $\rho_2 > \rho_1$
b. $\rho_2 < \rho_1$
c. not enough information to tell~~2, 6a, 3a~~

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

```
Continuity (= conservation of mass) says
\rho v_1(\pi R_1^2) = \rho v_2 (\pi R_2^2),
or
     v_2 = v_1(R_1/R_2)^2
i.e.,
     v_2 = 3(10/20)^2 = 3/4 = 0.75 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. $P_2 = P_1$

```
Bernoulli tells us
     P_1 + (1/2)\rho v_1^2 = P_2 + (1/2)\rho v_2^2
so
     P_2 - P_1 = (1/2)\rho(v_1^2 - v_2^2) > 0.
```

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~~3, 6b, 3a, 6e~~

```
P(d) = P(0) + \rho d g
     = P_A +1000 x 1000 x 9.8
     = 1 + 98 (in atm)
```

The following question is by itself.

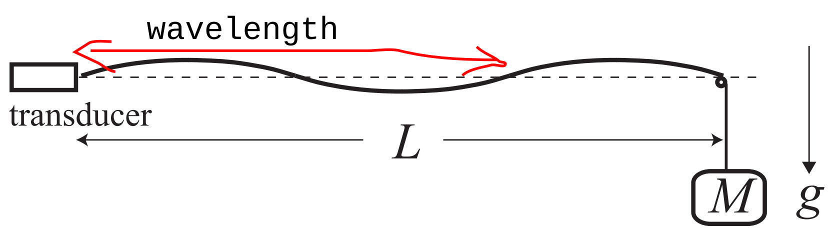
14. A sound wave of frequency 1230 Hz has a speed of 410 m/s in medium A. The wave enters medium B, where its wavelength is halved. What is the speed of the wave in medium B?

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

```
v = f \lambda
The frequencies in medium A and in B are the same.
Therefore, v/\lambda = f is constant.
     410/\lambda_A = v_B/(\lambda_A/2)
That is,
     v_B = 410/2 = 205 m/s.
```

The next two questions refer to the same situation.

The system includes a transducer, a smooth peg and a string. One end of the string is attached to a transducer. The other end of the string is bent over a smooth peg and attached to a mass M (see figure). Both the transducer and the peg are located the same distance away from the horizontal ground and are immobile. The tension in the string is controlled by the weight of 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. The distance between the transducer and the peg is L = 3.4 m.



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

```
2L/3 = 6.8/3 = 2.266666 m.
```

wavelength is maintained.

16. Now, to double the frequency (f → 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~~3, 6b, 6b, 6e~~

```
v = f\lambda generally, so f -> 2f implies
v -> 2v, that is, the speed is doubled.
The wave speed is given by
     v = \sqrt{F/\mu},
where \mu = line density of the cord (also
constant). F = Mg -> mg.  This changes v to
2v, so m should be 4M.
```

The following question is by itself.

P is the source power

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

```
Generally, \beta = 10\log_10(I/I_0), so we can simply compare I
directly.
2 sirens 30 m away  I = 2 x P/(4\pi 30^2),
n sirens 60 m away  I = n x P/(4\pi 60^2).
Therefore,
     2/30^2 = n/60^2.  That is, n = 2(60/30)^2 = 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_{before} = 860 Hz to f_{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_b = 860 = f [c - (-v)]/c,
f_a = 820 = f [c - v]/c.
That is,
     860 + 820 = 2f
or f = 840 Hz.
```

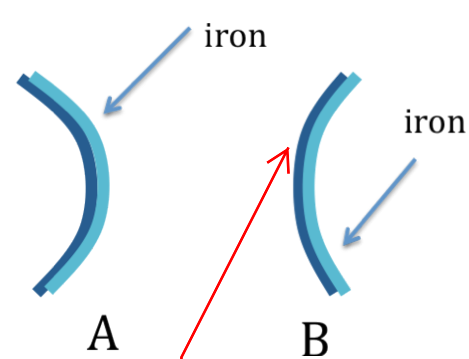
The observer is moving.

Before: the observer is running against the observed sound wave. Hence, -v

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 1.6×10^{-5} /K and that of iron is 1.2×10^{-5} /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)



Al is more sensitive to temperature change than Fe.

expands more

~~3, 6e, 6a, 2b~~

We use
(1 + x)^d ~ 1 + dx for small x. This dx is
the changing fraction due to expansion.

The following question is by itself.

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 %

```
For the area
A(T) = A(T') [1 + \a (T-T')]^2 = A(T') [1 + 2\a (T-T')].
This tells that 2\a(T - T') is 2.2%.
For the volume
V(T) = V(T') [1 + \a (T-T')]^3 = V(T') [1 + 3\a (T-T')].
Hence, 3\a (T-T') corresponds to 3.3%.
```

These are the fractional changes.

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. 401K
e. 323 K

```
PV = nRT, so T = PV/nR.
That is,
     T = (293x10^3) x (120x10^{-6})/[0.03x8.31]
       = 141.03 K.
```

1 cm^3 = 1 x 10^{-6} m^3

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 kPa and temperature T = 320 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}

```
PV = Nk_B T,
N = PV/k_BT = 490x10^3 x 1.3/[1.38x10^{-23}x320]
     = 1.442 x 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 = 1.66×10^{-27} kg.

a. 163 u.
b. 121 u.
c. 49 u.
d. 82 u.
e. 103 ~~4, 6b, 6b, 6d, 4b~~u.

```
(1/2)mv^2 = 3k_BT/2.
Therefore,
     m = 3k_BT/v^2 = 3 x 1.38 x10^{-23} x 320/257^2
Therefore, mN_A = 3 x 1.38 x6.022 x 320/257^2
     = 0.12079 (kg)
Thus, 1 mole is 121 g, so the molecular mass = 121 u.
```

With our usual unit system the obtained m is in kg.

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