Gently remove this page from your exam when you begin. Write clearly in the space provided on this Answer Sheet the letter which you believe to be the best answer to each question on the End-Material Mini-Test and on the Final Exam, found on the following pages.

ONLY THIS ANSWER SHEET will be looked at for scoring. Make sure your chosen answers are on it!

Neither calculators nor notes can be used during the test.

Relax, Read carefully, Think - and then read it again !!!

If you become bogged down on a problem, go to the next one and return later to the hard one. Think before plunging into math manipulations. Basic principles may give you an easy answer. Never leave a multiple-choice question blank. Guess at the end if you must.

EM Mini-Test Score = Final-Exam Score =

Mini-Test Responses (10 pts each) Final-Exam Responses (10 pts each)

Use a BLOCK letter to answer each question: A, B, C, or D (not lower case such as b or script such as ℰ)

em - 1)_____ 1)_____ 7)_____ 13)_____  
em - 2)_____ 2)_____ 8)_____ 14)_____  
em - 3)_____ 3)_____ 9)_____ 15)_____  
em - 4)_____ 4)_____ 10)_____ 16)_____  
em - 5)_____ 5)_____ 11)_____ 17)_____  
6)_____ 12)_____ 18)_____
**END-MATERIAL MINI-TEST**

**em-1.** A U-shaped glass tube has both ends open to the atmosphere. Two fluids, Fluid A and Fluid B, are in the tube, floating above the water in the lower portion of the tube, as shown in the diagram. The diameter of the tube’s left portion is $2d$, while the right end has diameter $d$. Fluid A has a column height $H$, while Fluid B has column height $2H$. The top surface of Fluid A is level with that of Fluid B. The density of Fluid A is half that of Fluid B. What is ratio of the density of Fluid B divided by the density of water?

A) $\frac{1}{2}$  
B) $\frac{2}{3}$  
C) $\frac{1}{3}$  
D) $\frac{3}{8}$

**em-2.** A wave is traveling at a speed of 36 m/s. It is described by the equation $y(x,t) = 3 \sin(-\frac{1}{2}\pi x - \omega t)$ in SI units, where $\omega > 0$ and the positive $x$ direction is to the right. What is the frequency $f$ of the wave (in Hz), and in which direction is it traveling (left or right)?

A) 9, right  
B) $18\pi$, right  
C) 9, left  
D) $18\pi$, left

**em-3.** You are flying a glider due west at $\frac{1}{5}$ the speed of sound. A friend is flying an identical glider in the direction of $37^\circ$ south of east at $\frac{1}{6}$ the speed of sound. Just as that glider crosses behind you, both you and your friend honk your identical horns. You hear your horn honk with frequency $F$. What is the frequency of the horn honk that you hear from your friend’s glider?

A) $\frac{12}{13}F$  
B) $\frac{13}{35}F$  
C) $\frac{12}{17}F$  
D) $\frac{24}{35}F$

**In Questions em-4 & em-5 below, an ideal DIATOMIC gas is taken through the process $A \rightarrow B$ as shown in the P-V diagram at the right.**

**em-4.** In this process, the change of internal energy of the gas is:

A) positive  
B) negative  
C) to the upper left  
D) zero

**em-5.** The heat energy that flows into the gas during this process is:

A) $7P_oV_o/2$  
B) $-7P_oV_o/2$  
C) $9P_oV_o/2$  
D) $P_oV_o/2$
Physics 23 – Fall 2012

**FINAL EXAM**

Assume that \( g = 10 \text{ m/s}^2 \), air-resistance is negligible, and springs are ideal unless otherwise stated!
You can use front and back of any test sheets for diagrams and/or calculations.

1. A ball is dropped from rest from height \( H \) above the ground. The elapsed time between the instant when the ball is released to the instant when it is halfway down to the ground is:
   
   A) \( \frac{H}{g} \) \hspace{1cm} B) \( \frac{H}{2g} \) \hspace{1cm} C) \( \frac{2H}{g} \) \hspace{1cm} D) \( \frac{2H}{g} - \frac{H}{g} \)

2. A stone is thrown into the air at an angle above the horizontal. There is negligible air resistance. Which graph best depicts the speed \( v \) of the stone as a function of time \( t \) after it was thrown?
   
   A) A \hspace{1cm} B) B \hspace{1cm} C) C \hspace{1cm} D) D

3. A woman riding in a moving elevator lets go of her briefcase. It falls more slowly to the elevator’s floor than it would if the woman released it when the elevator is at rest. It **must** be true that the elevator’s:
   
   A) velocity is aimed downward. \hspace{1cm} B) acceleration is aimed downward.
   C) velocity is aimed upward. \hspace{1cm} D) acceleration is aimed upward.

4. A small rock is thrown horizontally from the top edge of a vertical cliff that is a height \( H \) above the ground. The rock hits the ground at a horizontal distance \( L \) from the base of the cliff. With what speed was the rock thrown from the cliff?
   
   A) \( \frac{2gH}{g} \) \hspace{1cm} B) \( \frac{g}{H} \) \hspace{1cm} C) \( \frac{g}{2H} \) \hspace{1cm} D) \( \frac{g}{2(H-L)} \)

5. Two blocks, with masses \( M_A \) and \( M_B \), are in contact on a horizontal frictionless table. Force \( P \) pushes on block \( A \), causing the blocks to move across the table. The magnitude of the force that block \( B \) exerts on block \( A \) is:
   
   A) zero. \hspace{1cm} B) \( P \) \hspace{1cm} C) \( P \left( 1 - \frac{M_B}{M_A} \right) \) \hspace{1cm} D) \( P \frac{M_B}{M_A + M_B} \)

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6. A small car with mass $m$ travels at **constant speed** on the inside of a track that is a **vertical** circle. If the magnitude of the normal force exerted by the track on the car when it is at the top of the track is $N$, what is the magnitude of the normal force of the track on the car when the car is at the bottom of the track?

A) $2mg + N$  
B) $2mg - N$  
C) $mg$  
D) $2mg$

7. A man pushes a crate of mass $M$ up a rough incline of length $L$ that has coefficient of friction $\mu$ and makes an angle $\theta$ with the horizontal. After he has pushed the crate along the incline’s entire length, the work done by gravity is:

A) $-MgL$  
B) $-(MgL + \mu)$  
C) $-MgL\sin\theta$  
D) $MgL(\sin\theta - \mu \cos\theta)$

8. A block is held down on a compressed vertical spring. When released, the block flies upward. When the block is at its highest point, the total mechanical energy of the spring-block system is ______ the mechanical energy it had upon release.

A) the negative of  
B) less than  
C) equal to  
D) greater than

9. A 6-kg particle moving along the $x$-axis has a potential energy given by $U(x) = 2x^3 + 13$ in SI units. When the particle is at $x = -2$, what is the $x$-component of its acceleration in SI units?

A) 0.5  
B) $-0.5$  
C) 4  
D) $-4$

10. A ball of mass $M$ bounces off a wall with the same speed $V$ and angle $\theta$ at which it hit the wall, as shown at the right. The impulse delivered to the ball by the wall

A) is aimed to the left.  
B) has magnitude $2MV$.  
C) is aimed downward.  
D) has magnitude $MV\cos\theta$.  

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11. A putty ball of mass $M$ is moving to the right with speed $V$. A second putty ball of mass $\frac{1}{2}M$ moves to the left with speed $5V$. The balls collide and stick together. The final speed of the combined putty object is
A) $\frac{1}{2}V$  B) $-V$  C) $\frac{3}{2}V$  D) $V$

12. The mass of a certain planet is six times the mass of the earth. Its radius is twice the radius of the earth. The free fall acceleration at this planet’s surface is:
A) $g/2$  B) $12g$  C) $3g/2$  D) $24g$

13. A disk with initial angular speed $\omega_0$ comes to rest after one revolution. If the disk had an initial angular speed $3\omega_0$, how many revolutions would it take the disk to stop, assuming the same constant acceleration?
A) 1  B) 3  C) 6  D) 9

14. The following objects roll without slipping on a horizontal surface. Which of the objects has the largest fraction of its total kinetic energy in the form of rotational kinetic energy?
A) solid cylinder  B) thin-walled hollow cylinder  C) thin-walled hollow sphere  D) all have the same fraction

15. A thin uniform bar of mass $3M$ and length $L$ is supported by a horizontal frictionless axle $P$ passing through its center. Two small balls, each of mass $M$, are glued on the ends of the bar, as shown on the diagram. Suddenly, the glue fails on the right-hand ball and it falls off due to gravity – but the left-hand ball remains attached. What is the magnitude of the angular acceleration of the left-hand ball about $P$ just after the right-hand ball falls off?
A) $2g/L$  B) $4g/L^2$  C) $g/L$  D) $g/L^2$
16. For which axis of rotation below (dashed lines) is the American football’s moment of inertia the greatest?

A) left figure  B) center figure  C) right figure  D) All have the same moment of inertia

17. A solid uniform disk of mass $M$ and radius $R$ can rotate about a frictionless axle perpendicular to the disk’s plane and passing through its center $C$. The disk is initially at rest. A particle of mass $m$ travelling with speed $V$ hits the disk’s edge at a perpendicular distance $R/2$ above the disk’s center and sticks there, as shown in the diagram. Assume gravity has no effect. The disk’s angular speed just after the collision is:

A) $\frac{mV}{(M+2m)R}$  
B) $\frac{mV}{\frac{1}{2}M + m} \frac{R}{R}$  
C) $\frac{mV}{M + \frac{1}{2}m} \frac{R}{R}$  
D) $\frac{mV}{\frac{1}{2}M + \frac{1}{2}m} \frac{R}{R}$

18. A pendulum consists of a small ball attached to a massless rod. If you bring this pendulum to a planet where the free-fall acceleration due to gravity is four times greater than that on the Earth, the period for small oscillations of the pendulum on the planet will be ___________ its period on Earth.

A) one-half  B) two times  C) one-fourth  D) four times

The teaching staff of Physics 23 all wish you a wonderful Holiday Season!

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