Physics 117A – Final Exam – Fall 2006

Only calculators and pens/pencils are allowed on your desk. No cell phones or additional scrap paper. You have 1.5 hours to complete the exam.

Name ____

Section (Circle):	Hutson	MWF 10:10-11:00
	Sheldon	TR 11:00-12:15

I pledge my honor that I have neither given nor received aid on this work.

Signed ____

MC(50) = ______ Prob11(13) =_______ Prob12(12) = ______ Prob13(25) = ______ Total = _______

Multiple choice, circle the correct answer (5 pts each).

1. Which of the following are Newton's Third Law Pairs? Circle the letter of each that is.

(a) You are standing on the surface of the earth: Your weight.
Your gravitational force on the Earth.

(b) A boat is floating in the water: The buoyancy force on the boat.
The weight of the water displaced by the boat.

(c) You are walking across the floor. The frictional force of the floor on you.
The horizontal component of your shoe pushing against the floor.

(d) A book hangs from the ceiling via a cord. The weight of the book.
The tension in the cord.

(e) A train pulls a caboose. The train pulling the caboose, accelerating it.
The caboose pulling on the train.

2. A brick is dropped into a pool of water. As the brick slowly sinks to the bottom of the pool, the pressure on the brick is:

(a) The same on all surfaces of the brick.
(b) Greatest on the top of the brick.
(c) Greatest on the bottom of the brick.
(d) Greatest on the sides of the brick.
(e) Greatest on the face with the largest area.

3. Consider how the orbits of satellites around the earth would be different if the force of gravity was proportional to $1/r^3$ instead of $1/r^2$. Specifically, if

$$F_G = \frac{GMm}{r^3}; \quad \text{where } G = 6.67 \times 10^{-11} \frac{N \cdot m^3}{kg^2},$$

what would the velocity of a satellite be that was orbiting the earth in a circle of radius 2.20 R_E, where R_E is the radius of the earth?

(a) 5330 m/s
(b) 1.43 m/s
(c) 2.61 m/s
(d) 7220 m/s
(e) Stable orbits would not be possible at this radius.

4. A 10.0 kg mass is traveling to the right with a speed of 2.00 m/s on a smooth, horizontal surface when it collides with and sticks to a second 10.0 kg mass that is initially at rest but is attached to a light spring with a force constant of 80.0 N/m. What is the amplitude of the subsequent oscillations?

(a) 0.500 m
(b) 1.00 m
(c) 0.707 m
(d) 0.250 m
(e) 0.800 m

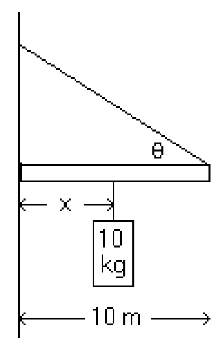
5. The temperature of espresso coffee (mostly water) can be increased by adding 100.0 °C steam to it. How much steam in grams is needed to heat up a 50.0 gram cup of espresso from 45.0 °C to 70.0 °C?

Water freezes at 0.0 °C and its latent heat of fusion is 334 J/gram. Water boils at 100.0 °C and its latent heat of vaporization is 2256 J/gram. The specific heat of water is 4.186 J/gram °C, and of steam is 1.850 J/gram °C.

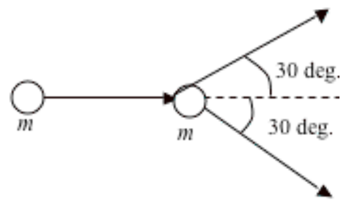
(a) 2.20 grams
(b) 2.32 grams
(c) 41.7 grams
(d) 94.3 grams
(e) 2.46 grams

6. In the figure below, a 10.0 m long bar is attached by a frictionless hinge to a wall and held horizontal by a rope that makes an angle θ of 35.0 degrees with the bar. The bar is uniform and weighs 59.2 N. What distance x from the hinge should a 10.0 kg mass be suspended for the tension T in the rope to be 157 N?

(a) 9.19 m
(b) The situation is impossible, the sign would have to be farther away than the length of bar.
(c) 3.83 m
(d) 0.81 m
(e) 6.17 m



7. A puck of mass m = 0.500 kg that is sliding on a level plane of ice at an initial speed of v_0 = 1.00 m/s strikes another puck (at rest) of equal mass m. After the collision, both pucks are observed to have the same final speed v_f and the velocity of each makes an angle of θ = 30.0 degrees w.r.t. the direction of the initial puck. What is the speed (v_f) of the second puck after the collision?



(a) 0.500 m/s
(b) 0.577 m/s
(c) 1.15 m/s
(d) 1.00 m/s
(e) Not enough information is given to solve the problem.

8. In a certain process 1510 J of heat flows into a system, and at the same time the system expands against a constant external pressure of 7.00 x 10^4 Pa. If the volume of the system increases from 0.020 m^3 to 0.060 m^3, calculate the change in internal energy of the system.

(a) +1290 J
(b) +1510 J
(c) –4310 J
(d) –1290 J
(e) –1510 J

9. Consider the equation $Q = \Delta U + W$. Which of the following statements is FALSE?

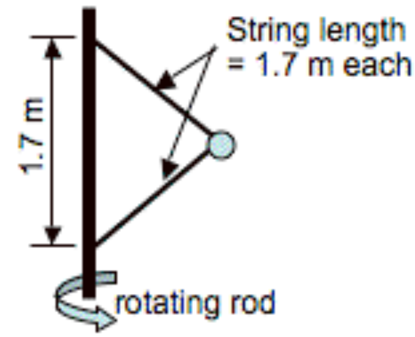
(a) W is the work done BY the system, and not ON the system.
(b) This is a statement of conservation of energy.
(c) Q can be positive or negative.
(d) Q is positive if heat is added TO the system.
(e) None of the above statements is false.

10. Two loudspeakers are driven in phase. You are standing 5.3 m from one of the speakers and 3.6 m from the other. The speakers begin by playing a note at a frequency of 625 Hz and gradually increase the frequency to 789 Hz. At what frequency do you first hear destructive interference from the two speakers? The speed of sound in air is 344 m/s.

(a) 688 Hz
(b) 708 Hz
(c) 769 Hz
(d) 749 Hz
(e) 728 Hz

11. (13 pts) As shown in the figure, a 1.34 kg ball is connected by means of two massless strings to a vertical, rotating rod. The strings are tied to the rod, are taut, and form two sides of an equilateral triangle. The tension T_1 in the upper string is 35 N. Note that all angles of an equilateral triangle are 60°.

a. Draw a free body diagram for the ball.
b. On the figure given, clearly indicate the direction of the net force on the ball.
c. Calculate the tension T_2 in the lower string.
d. Find the speed of the ball.



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12. (12 pts) A 32-kg meteorite is heading straight towards the earth. When it is a distance of 3 earth-radii ($3R_E$) from the center of the earth (or 2 R_E above the earth's surface), the meteorite is moving with a speed of 8010 m/s. Assume at this point that the meteorite is outside the atmosphere of the earth.

The meteorite eventually crashes into the earth's surface at 11,700 m/s. How much work was done by the force of air drag as the meteorite raced through the earth's atmosphere?

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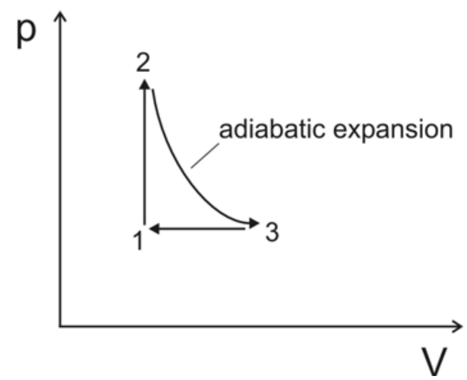
13. (25 pts) A heat engine operates according to the cycle shown. The working substance is 2.00 moles of monatomic helium gas (He). Assume it can be treated as an ideal gas.



Assume that during the "adiabatic expansion" shown, the pressure and volume of the gas obeys the following:

$$p_2(V_2)^{1.67} = p_3(V_3)^{1.67}$$

At state #2, the He gas reaches a temperature of 327 °C. The pressure in states #1 and #3 is 1.00×10^5 Pa and the pressure in state #2 is 3.00×10^5 Pa.

Subparts of this problem (A-D) are on this sheet and the two following it.

A. (6 points) Fill in the remainder of the table below describing the pressure, volume and temperature of the He gas at the endpoints of each step in the cycle. **Show your work.**

pVT	**1**	**2**	**3**
p	1.00×10^5 Pa	3.00×10^5 Pa	1.00×10^5 Pa
V			
T			

B. (12 points) Fill in the table below describing the change in internal energy, the work done BY the gas and the heat added to (or taken from) the gas in each segment of the cycle. **Show your work.**

Energy	**1→2**	**2→3**	**3→1**
ΔU_{int}			
W			
Q			

C. (4 points) Demonstrate whether your results for the entire heat engine cycle are or are not consistent with the 1st Law of Thermodynamics.

D. (3 points) How efficient is this engine at converting heat input to work?

You can double-check your work by noting that the 2nd Law or Thermodynamics implies a maximum attainable efficiency of $e_{\max} = 1 - T_c / T_H$, where T_C and T_H are the temperatures of the hot and cold reservoirs between which the engine operates.