

1 PRINT YOUR NAME: _____

- 1) A cup of hot tea is sitting with a metal spoon in it. Describe the mechanism for the tea to cool down. At least 2 methods of heat transfer help to cool the tea down. A 'space blanket' has a coating of a shiny material. Explain why this helps keep you warm.

 - 2) 8×10^8 J of heat is added to 0.5 kg block of ice at -15° . What is the final temperature? Is the water solid, liquid, or gas? SHOW ALL WORK.

 - 3) A balloon is filled with 500 Kg Helium (which is behaving as an ideal gas). It is heated to 350 K. The pressure is held at 1 atmosphere. What is the volume of the balloon? _____ What is the velocity of the He atoms (atomic weight is 4gm/mole)? _____ How many moles of He is in the balloon? _____ What is the buoyant force exerted by the air around the balloon? _____

 - 3) What is the efficiency of an engine that has a hot reservoir at 500K and a cold reservoir at 300K? _____ You want to do 10,000J of work. How many Joules are removed from the hot reservoir? _____ How many Joules are transferred to the cold reservoir? _____

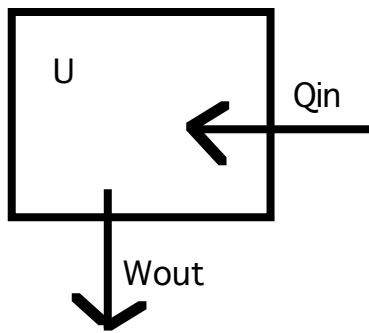
 - 4) A ball is dropped 0.5 m onto a spring with a spring constant of 1.2 N/m. The system comes to a halt for a moment as the ball compresses the spring. How far is the spring compressed. SHOW YOUR WORK. _____

 - 5) A 10 kg ball is dropped from 10 m onto a 200 kg stage. The ball (and stage) move together (down) after the collision. How fast will they move? _____ What is the kinetic energy of the system before and after the collision? _____

 - 6) A 25 m tank of water is open to the atmosphere. A small hole is made 13m from the top. The water sprays out initially with only velocity in the x direction. What is the initial velocity as the water leaves the hole? _____ How many meters from the tank does the stream of water hit the ground (assume no air resistance) _____ What is the velocity of the water as it hits the ground. (Give all components of the velocity) _____

 - 7) A 2.3 m ladder with a weight of 45 kg leans on a wall. It makes a 65° angle with the floor. Draw a figure showing the forces on the ladder. Assume the wall is frictionless, but the floor is not. Calculate the magnitude of all forces and torques so that the ladder remains stationary.
- 1 (5 pts) Using dimensional analysis demonstrate that $\rho hA = m$.

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3) 15 points

A) Positive W_{out} means the system expands or contracts? _____

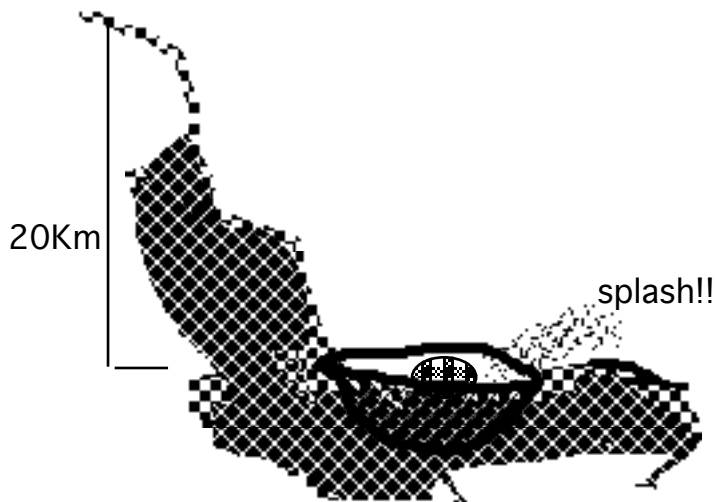
or contracts? _____

B) If I heat the system is Q_{in} positive or negative? _____

Put the change in internal energy ΔU in the table. Assuming its an ideal gas, put the final temperature if the initial temperature is 200 K.

	W_{out}	Q_{in}	ΔU	T_{final}
1	-500J	0J		
2	0J	-200J		
3	+100J	+100J		
4	-100J	-100J		
5	+300J	+500J		

4) 15 points

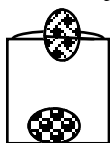


A 1000 Kg pure lead boulder falls 20 kilometers in a frictionless slide into a pond filled with 1000 kg water. (The height given is the height at the surface of the pond).

a) What is the volume of the lead boulder? _____

b) Will the boulder float or sink? _____ Why?

If it floats what fraction is submerged?

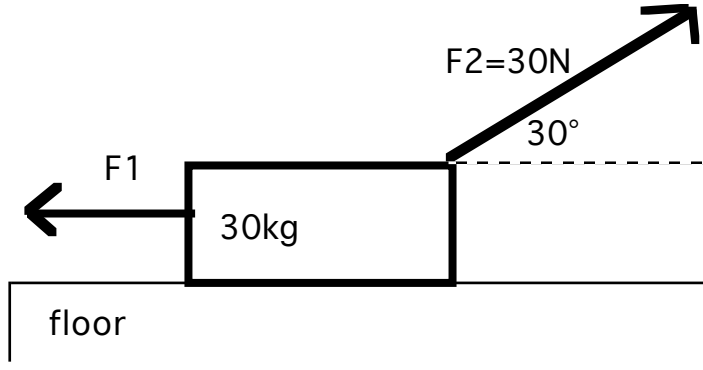


If the boulder fell into a lake of mercury would it sink or float? _____
 floats what fraction is submerged?

If it

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c) How fast will the boulder be going as it hits the surface. _____ d) If the lake is filled with water and it is a completely inelastic collision. What will happen to the temperature of the lake (neglect changes in temperature of the boulder).

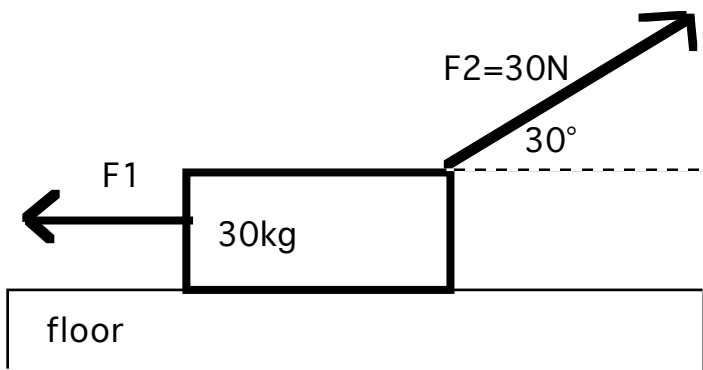


5) 20 points

NO ROTATION: NO

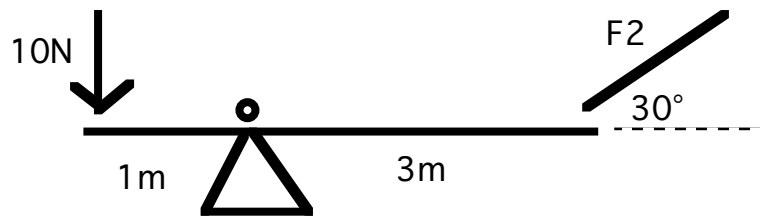
FRICTION

- a) what's the force F_1 necessary to keep the block from moving? _____
- b) If the rope 1 breaks so $F_1=0$ what will happen to the block?
- c) Add the normal force to the diagram.
 - i) what's the normal force if $F_1=F_2=0$
 - ii) What's the normal force if $F_2=30N$; and $F_1=0$



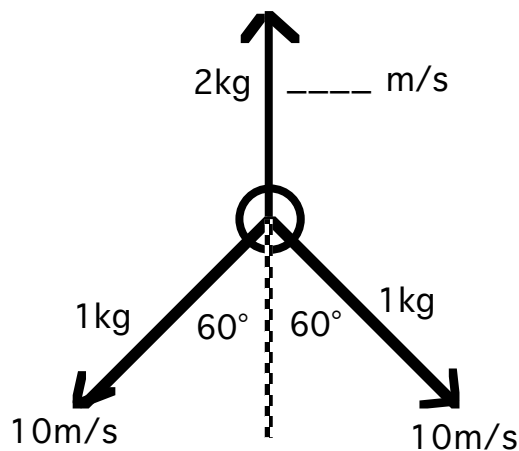
- d) F_2 acts for 10 s In the absence of F_1 (i.e. $F_1=0$)
 - i) What's the acceleration? _____
 - ii) How much work is done? _____
- III) What's the momentum? _____ Iv) What's the kinetic energy? _____ v) How fast is the block moving? _____
- vi) At 10s, F_2 is switched off, as the block has an elastic collision with a stationary 10 kg block. What are the velocities of the 2 blocks after the collision?

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6) 10 points For this to be stationary.
 What is the force F2 needed. _____ Put the arrow on F2 to show the direction. What force is the bolt exerting to keep the system stationary.

7) 10 points A spring needs 1N to compress it 0.1 m.
 How much force is needed to expand it by 0.4 m? ____
 How much work is necessary to expand it by 0.1m? ____
 How much work is necessary to expand it by 0.4m? ____
 If you have stretched it 0.1m how fast is it going when $x=x_0$?
 If you have stretched it 0.4m how fast is it going when $x=x_0$?



8) 10 points
 A 4 kg bomb explodes. what is the speed of the 2 kg fragment.

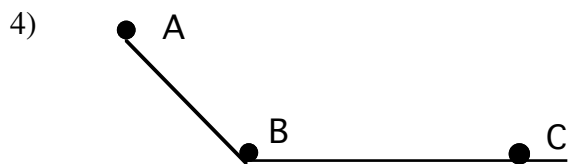
9 10 pts) What is the average velocity of the molecules in an ideal gas of O_2 at $20^\circ C$.

What happens to the temperature if the average velocity of the molecules is doubled?

- 1) Using dimensional analysis show that $P_2 - P_1 = \rho gh$ is ok. (That is show that the UNITS on the left side of the equation are the same as the UNITS on the right side of the equation. (4pts)
- 2) You have a beach ball (its mass ≈ 0) that has a volume of $2m^3$. If you want to submerge this ball under water, how much force do you need to keep the ball under the water? (4pts)
- 3) A can with 2 moles of ideal gas is sealed at 1 atmosphere pressure at $20^\circ C$. (16 pts)
 - (a) If the ideal gas is O_2 , what's the internal energy of the gas?
 - (b) What's the average velocity of the molecules in the gas?

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- (c) Keep the volume constant. What change in temperature will raise the pressure to 2 atmospheres?
- (d) Now keep the temperature constant. What change in volume will raise the pressure to 2 atmospheres?

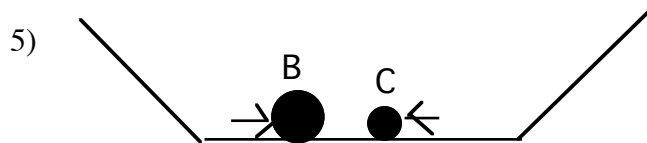


A 1000 kg lead ball rolls down a hill 50 m high. (no friction; initial velocity is zero) (forget about angular momentum!) (20pts tot)

- a) What's its speed at the bottom of the hill? (4 pts)
- b) Fill in the box (6 pts)

position	P.E.	K.E.	Tot.Energy	momentum
A				
B				
C				

- c) What's the volume of the ball? (4pts)
- d) The ball falls into a 1m^3 puddle of water at 23°C and comes to a halt. What happens to the temperature of the water? (give a numerical answer) without worrying about the temperature of the ball _____ (4pts)
- e) Now include the temperature of the ball and the water to get the final temperature of the system _____ (4pts-do this at the end of the exam)

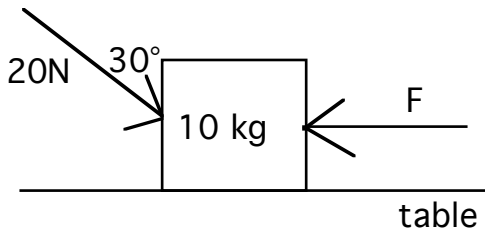


Forget the puddle! Now we have two balls let go from the top of two different hill. Ball B with a mass of 1000 kg rolls down a 50 m hill (50 m high-not 50 m long).; Ball C with a mass of 500 kg rolls down the other hill. When they run into each other they come to a halt. (there is no friction) (12 pts)

- a) What law of physics do we use to consider the motion after the collision (3pts)? b) What is the velocity of ball B just before the collision (from problem 4) ?
- c) In order for the balls to come to a halt, what is the velocity of ball C (4.5pts)?
- d) What is the height of the hill that Ball C comes down (4.5pts)? _____

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6)



(16 pts) This box is sitting on the table on earth. Its not moving.

a) What is the value of F (it is only in the x direction)? _____

For the other forces that are acting.

b) Draw them on the picture.

c) What is their magnitude?

d) If F is not there what is the acceleration? _____

7) You have a spring with a spring constant of 0.5 N/m. It is at equilibrium and not moving. You put a 0.2 kg mass on the spring. It now has a new equilibrium (unmoving length). How far is the spring extended (4 pts)? _____

8) You are swimming around 50 m below the surface of a lake.

What's the pressure? (4 pts) _____

b) What is the force on 0.1 m² your skin? _____

9) You have a cubic wooden crate with a density of 750 kg/m³ and a volume of 1 m³. If you put this in a lake of pure water what volume of the box will be submerged in the water?(4 pts) _____

10) Circle the correct terms and fill in the blank (4pts): If $W=+300\text{J}$ and $Q=+300\text{J}$ the system (does work/has work done on it) while heat is (added/ removed) from the system so that the internal energy goes (up/down) by _____ J.

11) Essay (10 pts) (

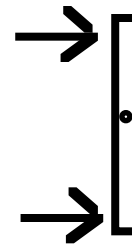
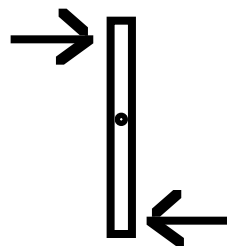
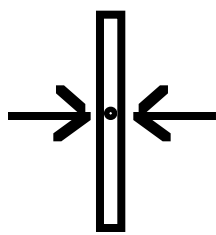
1 10 pts) In the diagram below, the two forces are of the same magnitude. The dot is the center of gravity for the object. Complete the following

There is NO translational acceleration if _____

There is NO rotational acceleration if _____

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Under each figure state if the object will undergo TRANSLATIONAL and/or ROTATIONAL acceleration. Show on the figure the direction of motion.:



2 18 pts) A new toy was described in the N.Y. Times Magazine section Sunday May 5, 1996 to be designed for long range under water throwing. If it is made of a plastic that has a density of 1100 kg/m^3 and has a volume of 0.001 m^3 . Assume earth gravity.

- If the toy is placed in a pool of water, show the forces that act on the toy in a free body diagram.
- Ignoring frictional forces, how long will it take the toy to fall to the bottom of a 5 m pool? _____
- How long would it take the toy to fall 5 m in vacuum? _____

3 18 pts) A 0.5 kg ball drops down an inclined plane (5 m high; 30° incline).

- If we assume there is no friction, what is the velocity of the ball at the bottom of the incline if there is no friction? _____ In the real world there is friction, and the ball is only going at 5 m/s when it reaches the bottom.
- What is the force of friction that acts on the ball? _____
- If the ball is made of lead what is its change in temperature due to the action of friction? (ignore any changes in temperature of the inclined plane) (hint: You CAN solve this without the answer to part b) _____

4 15 pts) How many joules does it take to heat 0.5 kg of ice from -10°C to form steam at $+110^\circ\text{C}$.

5 10 pts) You want to keep the temperature in your house at 65°F ($^\circ\text{C}$) when it is 100°F ($^\circ\text{C}$) outside. How much work do you have to do to transfer 1000J of heat out of your house to the outside world?

6 19 pts) There is 1.5 moles of a monatomic ideal gas (atomic weight= 8g/mole) at 0°C . a) What is the volume of gas? _____

b) What is the average velocity of the atoms? _____

The gas absorbs 2400 J of heat while performing 3000 J of work.

- What is its change in internal energy? _____
- What is the change in temperature? _____

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e) If the 3000J of work are carried out at constant pressure, what is the change in volume?

7) Your essay.

You must do problem 1. 1) You push a 0.3 kg lead block with a force of 12N. After 10 seconds the block is moving at 5 m/s. The initial velocity is zero. The force of friction is constant.

a) How fast would the block be moving if there were no friction? _____

b) What is the force of friction? _____

c) What is the friction coefficient μ ? _____

d) How much work do you do? _____

e) How much work does friction do? _____

f) If the work of friction heats the block how much does the temperature increase (ignore any change in temperature of the table)? _____

g) Draw a careful free-body diagram. Label the source and give the magnitude of each force. Provide the sum of the forces in the x and the y directions.

2) An airplane wing is designed so that the speed of the air across the top of the wing is 248 m/s when the speed of the air below the wing is 225 m/s.

a) What is the lift (the difference in force on the top and bottom) of a wing with an area of 25 m²?

b) What is the maximum mass this force could keep from falling? _____

3) You have 2 moles of ideal gas with a molecular weight of 32). The average velocity of the gas changes from 500 m/s to 400 m/s. The pressure is constant at 1 atmosphere and the initial temperature is 100°C.

a) What is the new temperature? _____ If temperature of 3 moles of ideal gas changes from 20°C to 200°C.

b) If the pressure stays constant (1 atm) what is the change in volume? _____

a) What is the change in the internal energy of the gas? _____

d) What is the change in Q? _____

e) What is the change in W? _____

4) On a hot day a person weighting 75 kg sweats and caused 0.1 kg of water to turn to vapor.

a) How much heat does it take to vaporize the water? _____

b) How much will the temperature of the person drop if they loose that many joules of heat (assume the specific heat of the person is the specific heat of water) _____

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5) Explain how a thermos works to keep the contents hot or cold. How is heat transfer by conduction, convection, and radiation minimized?

6) You have an engine with a hot reservoir at 1000C and a cold reservoir at 20 C.

a) What is the maximum efficiency of the engine? ____ If you want to get 10,000J of work from the engine

b) What is Q_{in} ? _____

c) What is Q_{out} ? _____

7) A 0.1 kg ball moving at 2 m/s south collides with a 0.15 kg ball moving at 1 m/s north. They move as one object after the collision.

What is the direction and speed of the combined balls? _____

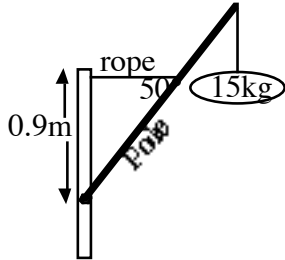
What is the momentum before and after the collision? _____

What is the total kinetic energy before and after the collision? _____

Is it ok if momentum is not conserved?

Is it ok if kinetic energy is not conserved?

8) **You must do the essay**



1) The pole is 3 m long. A mass of 15 kg is attached at the end of the post. The pole is held by a rope attached to the wall as shown. Give the forces and torques at the bolt, the weight and the rope. **(you must do this problem)**

	Force	F_x	F_y	Torque
bolt				
at weight				
on rope				

(2) Ball 1 (mass 0.40 kg) moves with an initial speed of 1.8 m/s (in the x direction). Ball I hits ball 2(mass of 0.4 kg) which is initially at rest. Ball 1 moves off at 30° from its original direction at a speed of 0.5 m/s. Find (after the collision) **(you must do this problem)** ball 1: v_x _____ v_y _____ speed _____ ball 2 v_x _____ v_y _____ speed _____

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(3a **do 3 of 4 parts of 3**) Heat is added to 0.05 kg water vapor raising the temperature by 70°. This is carried out at constant pressure of 10^5 Pa with an initial temperature of 400K. The increase in internal energy of the water is (ΔU) is 1600J/kg/°. Find ΔQ _____, ΔU _____, ΔW _____, ΔV _____.

(3b **do 3 of 4 parts of 3**) You have 1.5 moles of an ideal gas with the molecular weight of Argon at 350K and 1atm pressure. The internal energy/mole _____ The average kinetic energy/molecule _____ The average molecular velocity _____ The volume _____

(3c **do 3 of 4 parts of 3**) You mix together 0.25 kg of ice at -30°C into 0.5 kg of water at a temperature of 50 °C. Find the final temperature. _____ How many Joules of energy is needed to melt the ice to the water (at 0°C)? _____ When the system has reached its final temperature how many Joules of heat has been transferred from the water to the ice? _____

(3d **do 3 of 4 parts of 3**) You have an air conditioner running at maximal efficiency in your subway car You want to transfer 10,000 J of heat from the inside to the hotter outside. .

Q_C	Inside temp	Outside temp	Q_H	efficiency	work needed
10,000J	30 C	33 C			
10,000J	25 C	37 C			

(4a **do 3 of 6 parts of 4**) What coefficient of static friction will keep a 10 kg box stuck on a table if you are pushing with a force of 10N.

4b **do 3 of 6 parts of 4**) A force acts on a 10 kg object initially at rest. After 5s the object moves at 30 m/s. What is the force?

4c **do 3 of 6 parts of 4**) a 10 kg ball falls 10 m. What is the final v _____? How many joules are transferred to heat when the ball hits the ground and stops _____?

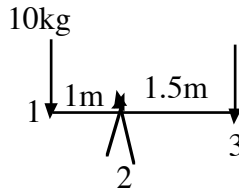
4d) **do 3 of 6 parts of 4**)

A what volume of a 10 Kg block of ice will be submerged in ice water.

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4e do 3 of 6 parts of 4) Water is pumped 10 m uphill through a pipe of constant diameter at 1m/s. What is the difference in pressure at the bottom and top of the pipe?

4f do 3 of 6 parts of 4)



What forces at 2 and 3 are needed to keep the board stationary.

5) essay

1) DO 2 OF THE 3 PROBLEMS. In each case draw a free body diagram and show the forces acting on the body.

A) What force will you need to keep a 0.35 m^3 box with a density of 920 kg/m^3 completely under water?

_____ value-and-units

B) How much work is done by friction to keep a 150 kg box centered in the back of a truck which is accelerates from rest at 2 m/s^2 for 10 s? _____ value-and-units

C) What is the torque exerted by a force of 1.5 N at a 30° angle to a board 0.2 m from the point of rotation. _____ What force must act at the bolt to keep the board from translational accelerations (it will experience rotational acceleration)? _____ value-and-units

2) State which mechanism of heat transfer is used in each situation. Define each mechanism in 1 sentence to justify your choice.

a) A potato will cook faster if you put a nail through it.

b) The sun can be focused by a lens to start a fire.

c) The fingers of people with good circulation do not get cold easily (the center of your body is warmer than the outside).

YOU MAY SKIP 1 OF THE PROBLEMS FROM 3 -7 3) You have 35g of Argon (which is behaving as an ideal gas) at $1.5 \times 10^5 \text{ Pa}$, in 0.02 m^3 . What is the temperature? _____ value-and-units

What is the velocity of each Argon atom (watch the units)? _____ value-and-units How many moles of Argon do you have?

_____ value-and-units What is the internal energy of the system? _____ value-and-units

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YOU MAY SKIP 1 OF THE PROBLEMS FROM 3 -7 4) You put a 0.23 kg chunk of ice (starting at -10°C) into a punch bowl (assume the heat capacity of the bowl is negligible). The punch is at 25°C.

After mixing 0.03 kg of ice remains. How many joules are transferred into the ice? _____
value-and-units

How many kg of punch were in the bowl? _____ What is the final temperature? _____
value-and-units value-and-units

YOU MAY SKIP 1 OF THE PROBLEMS FROM 3 -7 5) A box with 0.08 kg of (non-ideal) water vapor is heated from 110 to 150°C. The gas expands from 0.03 m³ to 0.04 m³ at a constant pressure of 1 atmosphere. (Make sure the sign of your answer is clearly stated) How much work is

done? _____ How much heat is added? _____ What is the change in internal energy?
value-and-units value-and-units

value-and-units

YOU MAY SKIP 1 OF THE PROBLEMS FROM 3 -7 7) You have a machine that pushes a 1000 kg sports utility vehicle up a hill that is 100 m high (assume no friction). The machine is run by an engine with a hot reservoir at 1200 K and a cold reservoir at 300 K. What is the efficiency of the engine?

_____ How much work is done by the engine? _____ How many joules are removed
value-and-units value-and-units

from the hot reservoir? _____ How many joules are added to the cold reservoir? _____
value-and-units value-and-units