ES201 - Examination II Fall 2005-2006 5th/6th hours

NAME: ____ SECTION: ________________

CM #: ________________

Problem 1 (25) ________________

Problem 2 (38) ________________

Problem 3 (37) ________________

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Total (100) ________________

INSTRUCTIONS

- **Closed book/notes exam. (Unit conversion page provided)**
- **Help sheet allowed. (8-1/2 x 11" sheet of paper, one side)**
- **Laptops may be used; however, no pre-prepared worksheets or files may be used.**

1) Show all work for complete credit.
   - Start all problems at the ANALYSIS stage, but clearly label any information you use for your solution.
   - **Problems involving conservation principles MUST clearly identify the system and show a clear, logical progression from the basic principle.**
   - Don't expect us to read your mind as to how or why you did something in the solution. Clearly indicate how your arrived at your answer.
   - **Always crunch numbers last on an exam**. The final numerical answer is worth the least amount of points. (Especially if all I would have to do is plug in the numbers into a well-documented solution.)
2) Useful Rule of Thumb (Heuristic): (100 point exam)/(50 min) = 2 points/minute. That means a 10 point problem is not worth more than 5 minutes of your time (at least the first time around).
3) Please remain seated until the end of class or everyone finishes. (Raise your hand and I'll pick up your exam if you have other work you need or want to do.)

USEFUL INFORMATION	SI	USCS	Molar Mass	
Ideal Gas Constant: R_u	= 8.314 kJ/(kmol-K)	= 1545 (ft-lbf)/(lbmol-°R)	Air	28.97
		= 1.986 Btu/(lbmol-°R)	O_2	32.00
Standard Acceleration of Gravity: g	= 9.810 m/s^2	= 32.174 ft/s^2	N_2	28.01
Density of liquid water	= 1000 kg/m^3	= 62.4 lbm/ft^3	H_2	2.016
		= 1.94 slug/ft^3	CO_2	44.01

Length

1 ft = 12 in = 0.3048 m = 1/3 yd

1 m = 100 cm = 1000 mm = 39.37 in = 3.2808 ft

1 mile = 5280 ft = 1609.3 m

Mass

1 kg = 1000 g = 2.2046 lbm

1 lbm = 16 oz = 0.45359 kg

1 slug = 32.174 lbm

Temperature Values

(T/K) = (T/ ^{o}R) / 1.8

(T/K) = (T/ ^{o}C) + 273.15

(T/^{o}C) = [(T/ ^{o}F) – 32]/1.8

(T/^{o}R) = 1.8(T/K)

(T/^{o}R) = (T/ ^{o}F) + 459.67

(T/ ^{o}F) = 1.8(T/ ^{o}C) + 32

Temperature Differences

(ΔT/^{o}R) = 1.8(ΔT / K)

(ΔT/^{o}R) = (ΔT/^{o}F)

(ΔT / K) = (ΔT/^{o}C)

Volume

1 m^3 = 1000 L = 10^6 cm^3 = 10^6 mL = 35.315 ft^3 = 264.17 gal

1 ft^3 = 1728 in^3 = 7.4805 gal = 0.028317 m^3

1 gal = 0.13368 ft^3 = 0.0037854 m^3

Volumetric Flow Rate

1 m^3/s = 35.315 ft^3/s = 264.17 gal/s

1 ft^3/s = 1.6990 m^3/min = 7.4805 gal/s = 448.83 gal/min

Force

1 N = 1 kg·m/s^2 = 0.22481 lbf

1 lbf = 1 slug·ft/s^2 = 32.174 lbm·ft/s^2 = 4.4482 N

Pressure

1 atm = 101.325 kPa = 1.01325 bar = 14.696 lbf/in^2

1 bar = 100 kPa = 10^5 Pa

1 Pa = 1 N/m^2 = 10^{-3} kPa

1 lbf/in^2 = 6.8947 kPa = 6894.7 N/m^2

[lbf/in^2 often abbreviated as "psi"]

Energy

1 J = 1 N·m

1 kJ = 1000 J = 737.56 ft·lbf = 0.94782 Btu

1 Btu = 1.0551 kJ = 778.17 ft·lbf

1 ft·lbf = 1.3558 J

Energy Transfer Rate

1 kW = 1 kJ/s = 737.56 ft·lbf/s = 1.3410 hp = 0.94782 Btu/s

1 Btu/s = 1.0551 kW = 1.4149 hp = 778.17 ft·lbf/s

1 hp = 550 ft·lbf/s = 0.74571 kW = 0.70679 Btu/s

Specific Energy

1 kJ/kg = 1000 m^2/s^2

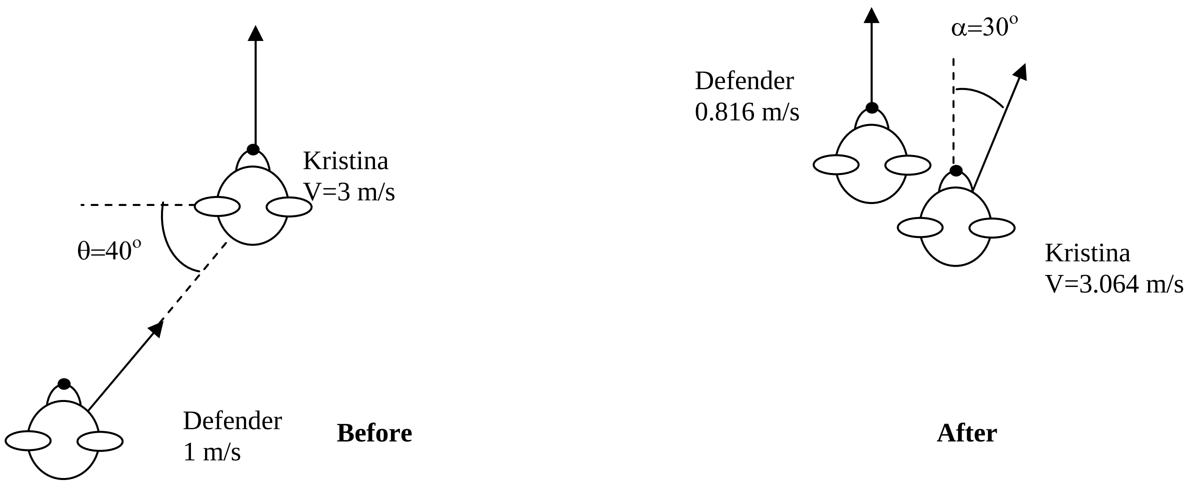
1 Btu/lbm = 25037 ft^2/s^2

1 ft·lbf /lbm = 32.174 ft^2/s^2

<u>Problem 1 (25 points)</u>

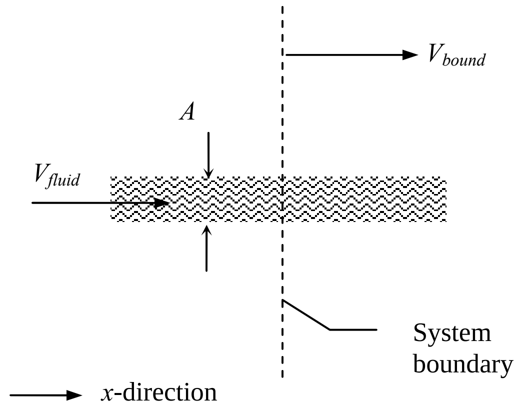
a) At the teddy bear picnic, the Grizzlies played the Cleveland Browns for the soccer championship. Grizzly Kristina was running towards the ball was bumped by a Browns defender and significantly deflected. (The Teddy Bear League is tough—no blood, no foul.)

i. Given the information on the picture below, what was the defender's weight relative to Kristina's weight?



ii. What was the impulse exerted on Kristina during the impact? (Assume now that Kristina's mass is 60kg.)

b) A fluid stream of constant cross sectional area A and density ρ crosses a system boundary as shown in the figure. The *absolute* velocities of the fluid stream and the system boundary are V_{fluid} and V_{bound}, respectively.



i. What is the mass flow rate into the system? (Circle one)

- $\dot{m} = \rho A V_{fluid}$
- $\dot{m} = \rho A V_{bound}$
- $\dot{m} = \rho A (V_{fluid} - V_{bound})$
- $\dot{m} = \rho A (V_{fluid} + V_{bound})$
- None of the above

ii. What is the rate of x-direction linear momentum transfer into the system due to mass flow at this boundary? (Circle one)

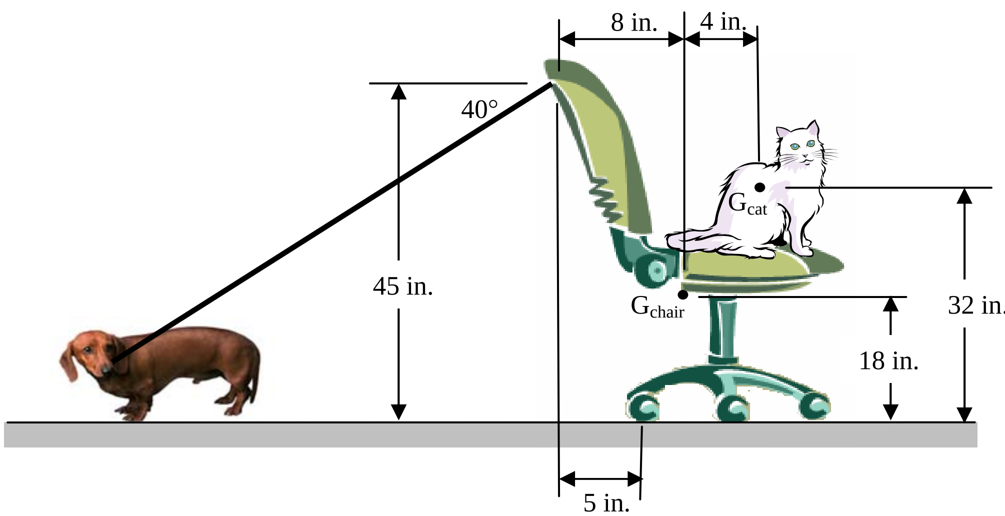
- $\rho A V_{fluid}{}^2$
- $\rho A V_{fluid} V_{bound}$
- $\rho A (V_{fluid} - V_{bound}) V_{bound}$
- $\rho A (V_{fluid} - V_{bound}) V_{fluid}$
- None of the above

Problem 2 (38 points)

Puffy the cat is peacefully sitting on a chair as shown when her arch enemy Fido pulls on the rope as shown. Puffy weighs 8 lbs and the chair weighs 14 lbs. The centers of gravity of the cat, G_{cat}, and of the chair, G_{chair} are shown. Assume the wheels allow the chair to roll freely (that is no friction).

a) Determine the equations necessary to determine the magnitude of the force in the rope so that the chair and cat are about to tip over (much to Fido's delight) assuming the cat does not move relative to the chair. DO NOT SOLVE THE EQUATIONS. You answer should consist of a clear set of numbered equations and a list of unknowns. Show all work for credit.

b) Assuming the resulting acceleration from part a) is 1.4 ft/s^2, determine the friction force between the cat and the chair assuming $\mu_s = 0.5$ and $\mu_k = 0.3$.



Problem 3 (37 points)

Marvin Monkey is chasing Pete Parakeet around with a Super Soaker water gun when suddenly Pete ducks behind a toy snow plow. Marvin's water gun stream is then deflected by the plow as shown in the figure. Known quantities include the water stream cross sectional area A, the density of water ρ, the water stream velocity V, the mass of the truck m_{truck}, the angle θ, and all lengths and heights l_i and h_i. You may assume that there is no friction between the tires and the surface.

a) Find the horizontal force that Pete must exert on the truck to keep it stationary. Express your answer in terms of the known quantities

b) Find the remaining equations needed to find the normal forces the surface exerts on the truck. *You do not need to solve these equations*. Simply label your unknowns and equations used to solve for them.