ES201 - Examination 2 Winter 2003-2004 Adams and Richards

NAME____BOX NUMBER____________

Please Circle One : Richards (Period 4) ES201-01 | Adams (Period 4) ES201-02 | Adams (Period 6) ES201-03

Problem 1 (12) ____________

Problem 2 (24) ____________

Problem 3 (24) ____________

Problem 4 (40) ____________

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(s). For FULL CREDIT, you must clearly *show and label all momentum transfers on a free-body diagram* for your system.**
   - **Don't expect us to read your mind** as to how or why you did something in the solution. Clearly indicate how you arrived at your answer and how you used the given information in the process.
   - **Always crunch numbers last on an exam**. The final numerical answer is worth the least amount of points. (Especially if all we would have to do is plug in the numbers into a well-documented solution.)
2) Useful Rule of Thumb (Heuristic): (100 point exam)/(90 min) ≈ 1 point/minute. That means a 10 point problem is not worth more than 10 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 [kg/kmol; lbm/lbmol]	
Ideal Gas Constant: R_u	= 8.314 kJ/(kmol-K)	= 1545 (ft-lbf)/(lbmol-^{o}R)	Air	28.97
		= 1.986 Btu/(lbmol-^{o}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

$(T/K) = (T/{}^oR) / 1.8$

$(T/K) = (T/{}^oC) + 273.15$

$(T/{}^oC) = [(T/{}^oF) - 32]/1.8$

$(T/{}^oR) = 1.8(T/K)$

$(T/{}^oR) = (T/{}^oF) + 459.67$

$(T/{}^oF) = 1.8(T/{}^oC) + 32$

Temperature Differences

$(\Delta T/{}^oR) = 1.8(\Delta T / K)$

$(\Delta T/{}^oR) = (\Delta T/{}^oF)$

$(\Delta T / K) = (\Delta T/{}^oC)$

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

Problem 1 (12 pts)

a) Consider a uniform pressure P acting on the left side of a hemisphere and a circular plate as shown in the figure. The hemisphere and circular plate have identical diameters, $D_{\text{hemisphere}} = D_{\text{plate}}$.

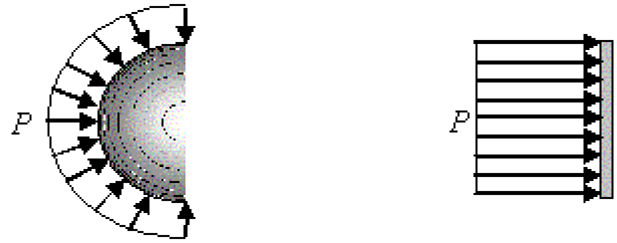
How does the net force due to the pressure compare for the two cases? (Circle one.)

i) $F_a > F_b$

ii) $F_a < F_b$

iii) $F_a = F_b$

iv) None of the above.



a) Hemisphere w/ $D = 1$ m   b) Circular plate w/ $D = 1$ m

b) What are the *dimensions* of angular momentum? What is a typical set of *units* for angular momentum?

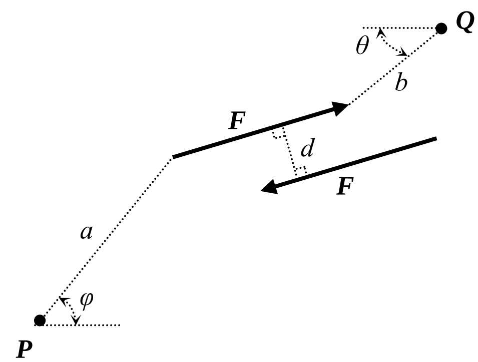
c) Two forces, both with magnitude F, are oppositely directed and separated by a constant distance d as shown in the figure. How does the net moment due to these two forces about point P compare to that about point Q? (Note: $a > b$, $\theta < \varphi$)

i) $M_P > M_Q$

ii) $M_P < M_Q$

iii) $M_P = M_Q$

iv) None of the above.

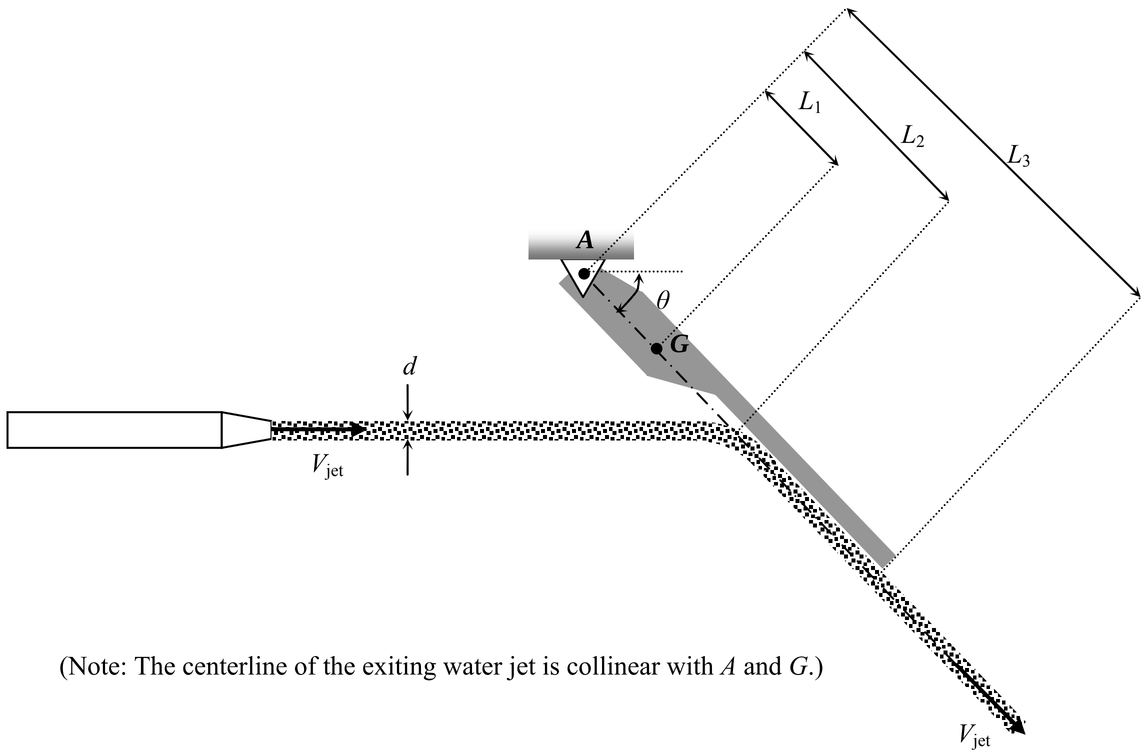


Problem 2 (24 pts)

A jet of water with density ρ hits a hinged flap with a mass m as shown in the figure. The velocity of the water of both the incoming and outgoing jet is V_{jet}. The incoming water jet is circular with a diameter d. Known dimensions are given in the figure.

a) Find the angle θ that the stationary flap makes with the horizontal. Express your answer in terms of the known quantities.

b) Find the horizontal and vertical reaction forces at the pin connection A. You may assume that θ is known from part (a).



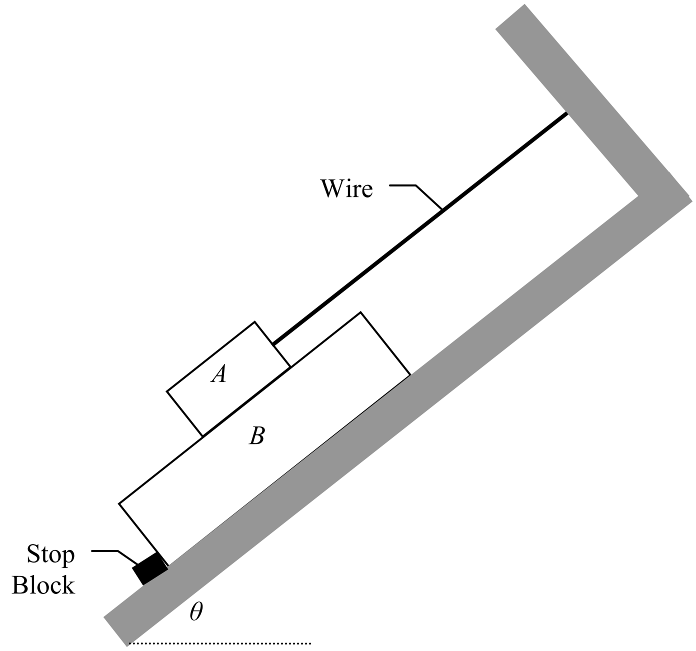
(Note: The centerline of the exiting water jet is collinear with A and G.)

Problem 3 (24 pts)

Two blocks rest on an inclined plane with $\theta = 35^{\circ}$ as shown in the figure. Block A has mass $m_A = 13.5$ kg and block B has mass $m_B = 40$ kg. The coefficients of static and kinetic friction between all surfaces are $\mu_S = 0.3$ and $\mu_k = 0.2$, respectively. Initially the blocks are stationary and are supported by a stop block and fixed-length wire, as shown on the figure.

When the stop block is removed the block B immediately starts to move because the angle θ is large enough to produce motion.

Find the acceleration of block B and the tension in the wire immediately after the stop block is removed.



Problem 4 (40 pts)

Moo's Dairy has entered the annual Dairy Drag Race at the State Fair. His drag racer is a fully-loaded milk truck shown in the figure. When fully loaded, the milk truck weighs 5000 lbf. The truck is a *rear-wheel* drive vehicle, and the front tires provide negligible frictional drag when rolling.

The maximum traction between the tires and the road occurs when there is no slip between the tires and the road, i.e. the force between the road and the tires is due to static friction. The static coefficient of friction between the rubber tires and the concrete pavement is $\mu_S = 0.80$.

(a)(16 pts) Determine the reactions between the tires and the road at points **A** and **B**, in lbf, when the truck is stationary.

(b) (24 pts) Determine the maximum acceleration possible for the fully-loaded, rear-wheel drive milk truck, in ft/s^2 *or* in g's. Also determine the corresponding reactions at points **A** and **B**, in lbf. Is there any danger of the truck tipping under these conditions?