ES201 - Examination II　　　　　Fall 2007-2008　　　　　8th/9th hours

NAME____　　　　SECTION_______________

BOX NUMBER__________

Problem 1	(30)	________________
Problem 2	(30)	________________
Problem 3	(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.**
- **Doing a handstand on the table while your classmates rock it back and forth will result in a standing ovation, but unfortunately no extra points.**

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 IN A SEPARATE DRAWING 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.)

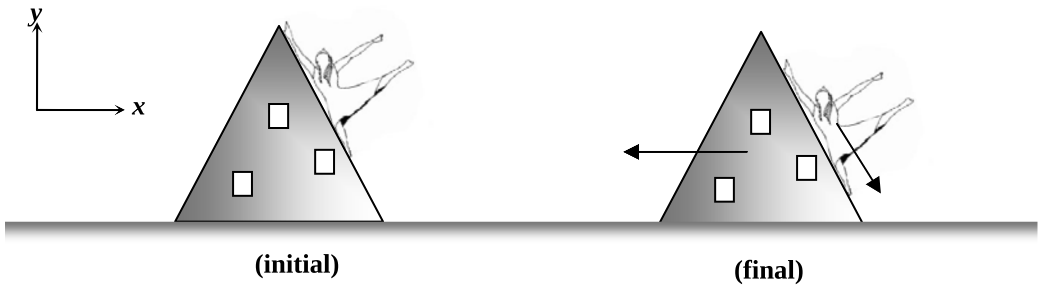
USEFUL INFORMATION	SI	USCS	Molar Mass	
Ideal Gas Constant: R_u	= 8.314 kJ/(kmol-K)	= 1545 (ft-lbf)/(lbmol-°R)	Air	28.97
		= 1.986 Btu/(lbmol-°R)	O_2	32.00
Standard Acceleration of Gravity: g	= 9.810 m/s^2	= 32.174 ft/s^2	N_2	28.01
Density of liquid water	= 1000 kg/m^3	= 62.4 lbm/ft^3	H_2	2.016
		= 1.94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

Problem 1 (30 pts)

Answer each of the following unrelated questions.

a) (5 pts) A Diavolo dancer is on a pyramid. Initially both the dancer and the pyramid are at rest. The dancer then slides down pyramid, causing it to slide across the stage in the opposite direction. If all surfaces are frictionless, the x-direction momentum of a system consisting of dancer and pyramid combined

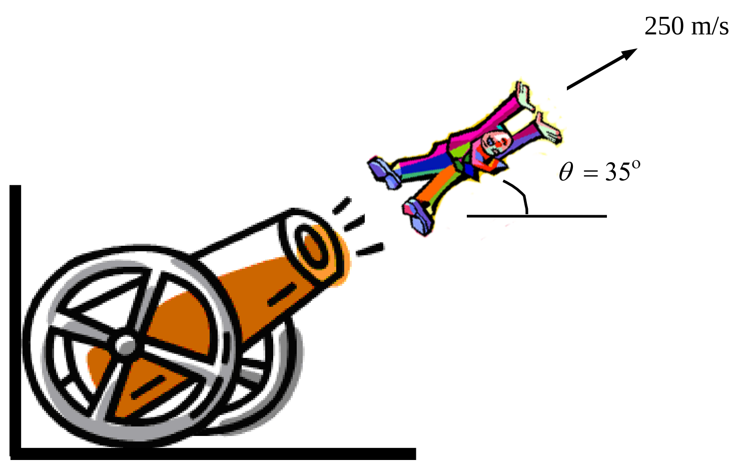
i. increases   ii. decreases   iii. remains constant



b) (5 pts) If there is kinetic friction between the pyramid and the stage for a) above, the x-direction momentum of a system consisting of dancer and pyramid combined

i. increases   ii. decreases   iii. remains constant

c) (7 pts) A young 40-kg Diavolo acrobat is launched by a 300-kg cannon at a speed of 250 m/s and an angle of 35° with respect to the horizontal. Determine the impulse exerted by the ground and the vertical wall on the cannon during the launching process.



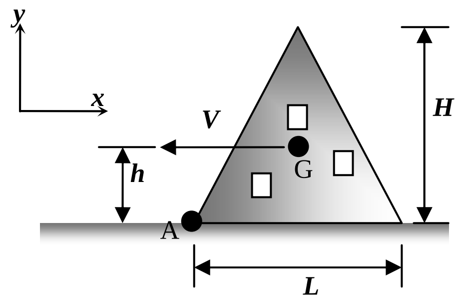
d) (5 pts) The Diavolo pyramid below is moving to the left at a velocity *V*. The angular velocity of the block about point A is

i. mHV cw ii. mHV ccw

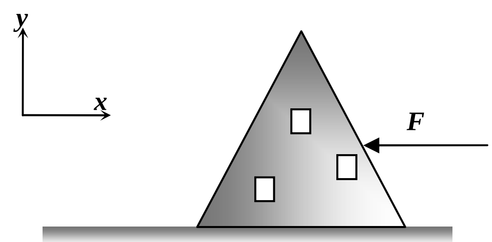
iii. mhV cw iv. mhV ccw

v. mLV cw vi. mLV ccw

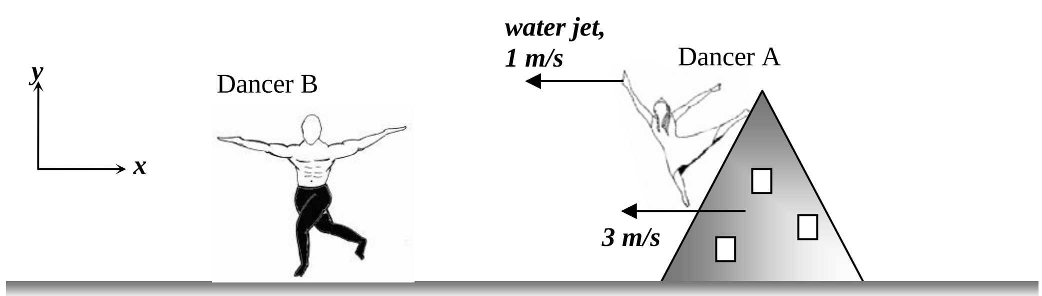
vii. 0 viii. None of the above



e) (4 pts) This Diavolo pyramid is not moving. It has a mass *m*, and the coefficients of static and kinetic friction between the pyramid and the ground are μ_k and μ_s, respectively. A force *F* is applied to the pyramid. What is the friction force exerted on the pyramid by the ground? (Indicate magnitude and direction.)



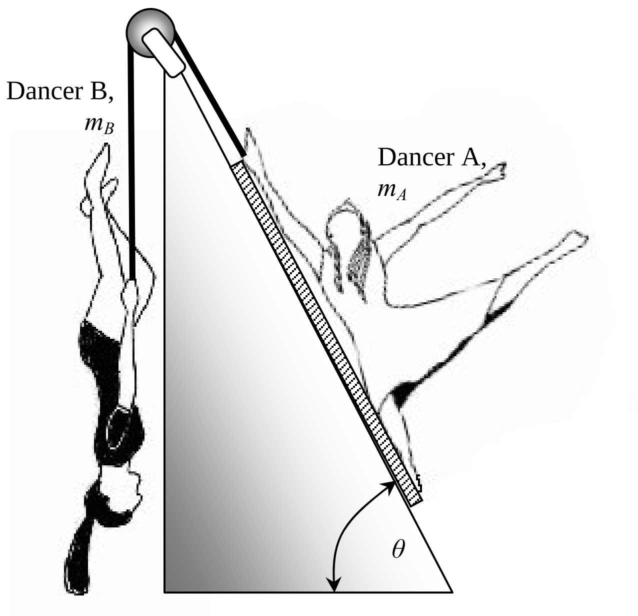
f) (4 pts) Dancer A rides a pyramid to the left at a velocity of 3 m/s. She squirts water, with a velocity relative to the platform of 1 m/s, at stationary Dancer B. What is the water velocity observed by Dancer B, i.e. what is the velocity of the water with respect to the ground?



i) 4 m/s to the left ii) 3 m/s to the left iii) 2 m/s to the left iv) 1 m/s to the left v) None of these

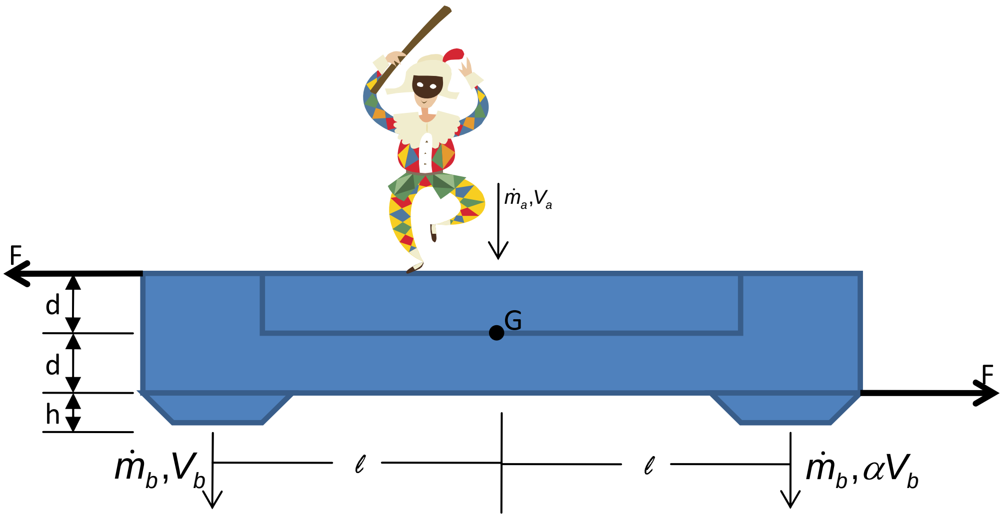
Problem 2 (30 pts)

In a new Diavolo piece, a dancer with mass m_A rides a sled upward on an incline of angle θ while another dancer with mass m_B descends toward the stage hanging upside down on a rope as shown in the figure. Dancer A and Dancer B are joined by an inextensible cord which is wrapped around a massless and frictionless pulley. The coefficient of friction between dancer A's sled and the incline is μ_k. Assuming both dancers are initially at rest, find the necessary equations to find the acceleration of each dancer and the tension in the rope. **YOU DO NOT HAVE TO SOLVE THE EQUATIONS**. **Clearly *label the equations* to be solved and *list the unknowns***.



Problem 3 (40 pts)

You have been hired to build a stationary hovering dancing platform for Diavolo. This platform consists of a large intake fan which draws air in with a flow rate of $\dot{m}_A$. This air is split evenly to two (2) fans below the platform such that **the outlet velocity of the front fan is proportional to the outlet velocity of the rear fan**, although the two mass flow rates are the same. Two other dancers apply equal forces to two ropes used to hold the platform at the correct locations on the stage. The cart and dancer have a combined mass of m_{cart} with a center of gravity at point G. Assume that F, $\dot{m}_A$, V_a, m_{cart}, g, ℓ, h, and d are known. We wish to find the remaining parameters (α, V_b, $\dot{m}_B$) so that the platform remains level and floats at a constant height above the stage. **SET UP THE EQUATIONS BUT DO NOT SOLVE THEM**. **Clearly *label the equations* to be solved and *list the unknowns***.



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