ROSE-HULMAN Institute of Technology
Sophomore Engineering Curriculum

ES201 –Conservation & Accounting Principles Winter 2014-2015

Section [1 pt]: □ 01 (1st period)
□ 02 (2nd period)

_____
Name [1 pt]

_____
CM [1 pt]

Exam 2

Jan 27, 2015

Problem 1	_____/ 31
Problem 2	_____/ 33
Problem 3	_____/ 33
Total	_____/ 100

Rules:

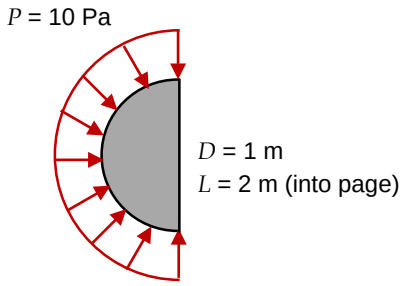
- Closed book/notes exam. (Unit conversion page provided)
- Help sheet allowed. (8-1/2 x 11" sheet of paper, one side, handwritten)
- Laptops may be used for computational purposes only; no pre-prepared worksheets or files may be used.

Instructions:

- 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 you 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.)

Problem 1 (31 pts)

(a) [4 pts] A half cylinder of diameter D=1 m and length (into the page) L= 2 m is subject to a pressure of P = 10 Pa as shown. What is the net force due to this pressure in the horizontal direction?

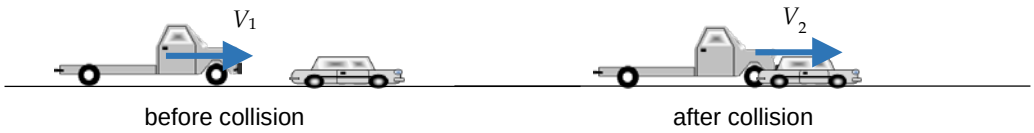


- O 0 N
- O 20 N to the right
- O 31.4 N to the right
- O 62.8 N to the right

(b) [4 pts] The nitrogen inside a storage tank has an absolute pressure of 24.7 psi. If atmospheric pressure is 14.7 psi, what is the gage pressure of the nitrogen?

- O -10 psi
- O 0 psi
- O 10 psi
- O 14.7 psi
- O 39.4 psi

(c) [8 pts] A truck driver runs into a car stopped at a traffic light. The truck has a mass of m_T and is originally traveling at V_1. The car has a mass of m_C and is **originally at rest**. After the collision, both the truck and car travel with a speed of V_2. If the total collision takes place in a time Δt, what is the magnitude of the impulse transferred from the truck to the car?



- O $m_T V_1 - m_C V_2$
- O $(m_T + m_C)V_2 - m_T V_1$
- O $[(m_T + m_C)V_2 - m_T V_1]/\Delta t$
- O $m_C V_2$
- O $[m_T(V_2 - V_1)]/\Delta t$

(d) [15 pts, (3 pts each)] Indicate whether the following statements are true or false.

True	False	If the vector sum of the forces acting on a closed system is **0**, then the system must be stationary.
True	False	An object that is not rotating it cannot have any angular momentum.
True	False	A force represents linear momentum crossing a system boundary.
True	False	A force represents a rate of linear momentum crossing a system boundary.
True	False	Mass flow *leaving* a system can *increase* the magnitude of the system's linear momentum.

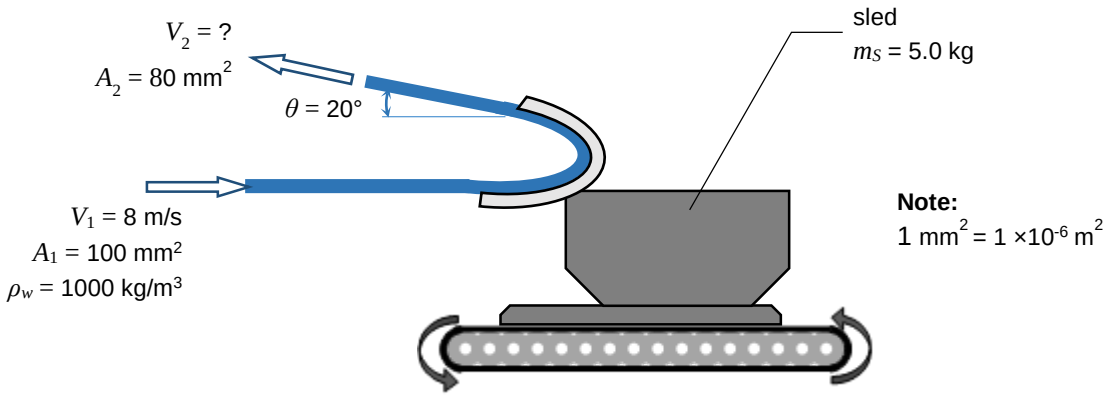
Problem 2 (33 pts)

A stream of water (ρ = 1000 kg/m^3) enters a vane on a sled at a velocity of V_1 = 8 m/s. The sled has a mass of m_S = 5.0 kg and **rests motionless on a conveyor belt, which steadily slips underneath it**. The cross-sectional area of the water entering the sled is A_1 = 100 mm^2, whereas the exit area is A_2 = 80 mm^2. The water leaves the vane at the angle of θ=20° as shown in the figure.

(a) [5 pts] Find the mass flowrate, $\dot{m}$, of the water through the sled (in kg/s) and the speed of the water leaving the sled, V_2 (in m/s).

For parts (b) and (c) assume the answers to part (a) are $\dot{m}$ = 0.9 kg/s and V_2 = 11 m/s. (They aren't.)

(b) [12 pts] Find the normal force (in N) that the belt exerts on the sled.
(c) [15 pts] Find the kinetic coefficient of friction, μ_K, between the belt and the sled.



Problem 3 (33 pts)

Two very large law books are stacked on a smooth table top. A force P is applied to the bottom book. The masses of both books are known, and the centers of mass of both books are at their geometric centers. Dimensions are shown in the figure. Assuming the books stick together,

(a) [30 pts] find the equations necessary to calculate the acceleration of the books and the maximum height L so that the books do not tip over. **Do not solve the equations**, but number the equations and list the unknowns.

(b) [3 pts] The friction force exerted on book B by book A is

- o $f = \mu_S \cdot m_A \cdot g$ to the left
- o $f = \mu_K \cdot m_A \cdot g$ to the right
- o $f = P$ to the right
- o $f = \dfrac{m_B}{m_A + m_B} P$ to the right