ROSE-HULMAN Institute of Technology
Sophomore Engineering Curriculum

ES201 –Conservation & Accounting Principles | Winter 2015-2016

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

Name ______________________

CM ______________________

Exam 2

Jan 26, 2016

Problem 1	______/ 33
Problem 2	______/ 34
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.

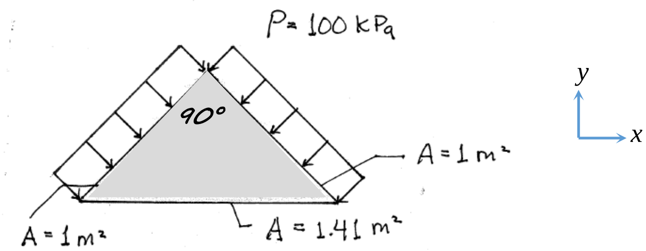
Fail bomb!

Problems involving conservation principles **must clearly identify the system in a separate drawing and show a clear, logical progression from the basic principle; otherwise no credit will be given.**

- 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 [33 pts]

(a) [4 pts] A pressure of $P = 100$ kPa acts on two surfaces of a triangular solid as shown in the figure. The net force in the y-direction due to this pressure is



- o F = -70.7 kN
- o F = -141 kPa
- o F = -141 kN
- o F = -200 kPa
- o F = 200 kN

(b) [15 pts, 3 pts each]

True False The linear momentum of a non-accelerating system must remain constant.

True False A force is a rate of linear momentum transport across a non-flow boundary.

True False For a non-moving object making contact with a surface with friction, the friction force must always be $f = \mu_S N$.

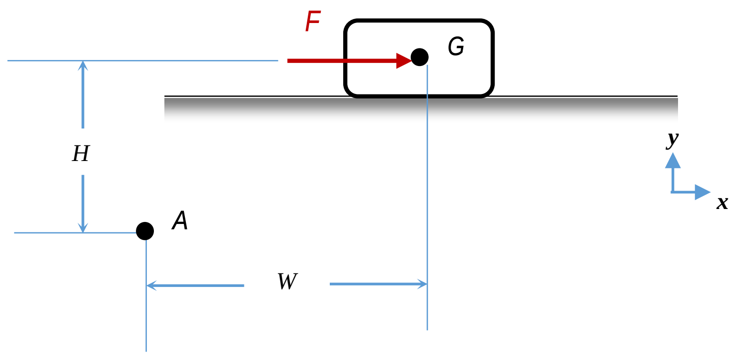
True False When calculating mass flow rate, you must always use fluid velocity relative to the system boundary.

True False Conservation of linear momentum for a steady-state system always reduces to

$$d\mathbf{P}_{sys}/dt = \Sigma \mathbf{F}_{external}$$

because $\sum \dot{m}_{in} = \sum \dot{m}_{out}$.

(c) [6 pts] A force F is applied to the center of mass of a box sliding along a *frictionless* horizontal surface. The box has a mass of m.



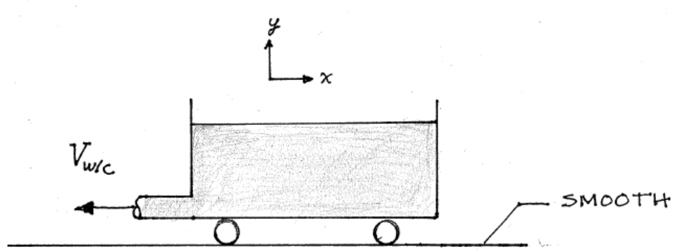
The <u>moment due to force F about point A</u> is

- O 0
- O $-HF\,\mathbf{k}$
- O $-WF\,\mathbf{k}$
- O $-\sqrt{(H^2+W^2)}F\ \mathbf{k}$
- O $WF\,\mathbf{i} + HF\,\mathbf{j}$

The <u>rate of angular momentum change about point A</u> is

- O 0
- O $-Hma_x\,\mathbf{k}$
- O $-Wma_x\,\mathbf{k}$
- O $-\sqrt{(H^2+W^2)}ma_x\ \mathbf{k}$
- O $Wma_x\,\mathbf{i} + Hma_y\,\mathbf{j}$

(d) [8 pts, 2 pts each] A cart full of water is initially at rest on top of a smooth (frictionless) surface. Suddenly it starts ejecting water to the left (negative x-direction) at a constant velocity relative to the cart of $V_{w/c}$. Immediately after the cart starts ejecting water…



O The acceleration of the cart is

to the right | equal to zero | to the left | cannot be determined

O The net horizontal force acting on the cart is

to the right | equal to zero | to the left | cannot be determined

O The absolute velocity of the water leaving the cart is

to the left | zero | to the right | cannot be determined

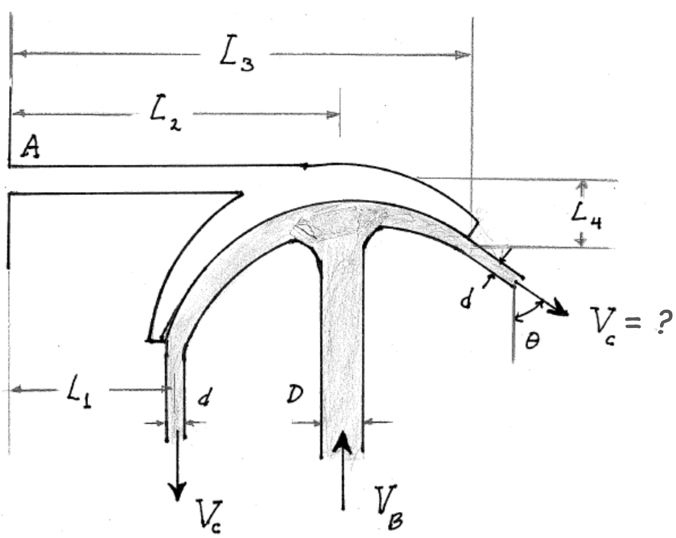
O The x-direction linear momentum of the cart is

increasing | not changing | decreasing | cannot be determined

Problem 2 [34 pts]

The steady flow of a fluid with constant density ρ is diverted by a curved vane as shown in the figure. The vane is held in place by a fixed support at *A*. The fluid streams can be considered to be cylindrical in shape, and the weight of the vane is negligible. Known quantities are given in the figure.

(a) Find the <u>velocity of the diverted streams</u>, V_C in terms of the known quantities.
(b) Find the <u>reaction at *A*</u>; that is, the forces and/or moments that the fixed support exerts on the vane. Express your answers in terms of the known quantities.



Known: V_B, L_1, L_2, L_3, L_4, D, d, θ, ρ

Problem 3 [33 pts]

Two masses are sliding along rough surfaces as shown in the figure. The mass of each box is $m_A = m_B = 14$ kg. The masses are connected via a rope wrapped around a frictionless, massless pulley so that at the time shown the *magnitude* of the acceleration of each box is $a = 0.6$ m/s^2.

Find the coefficient of kinetic friction between the boxes and the surface.