ES201 - Examination III **Fall 2016-2017**

NAME____ Campus Mailbox ______________

INSTRUCTOR (Circle One):

Cunningham (5th Period)	Livesay (5th Period)	Cantwell (6th Period)	
Richards (5th Period)	Richards (6th Period)	Lui (5th Period)	Lui (6th Period)

Problem 1 (35) ________________

Problem 2 (35) ________________

Problem 3 (30) ________________

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 or accounting principles MUST clearly identify the system and show a clear, logical progression from the basic principle(s).**
  - **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)/(50 min) ≈ 2 point/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**
Standard Acceleration of Gravity: g	= 9.810 m/s^2	= 32.174 ft/s^2
Universal Ideal Gas Constant: R_u	= 8.314 kJ/(kmol-K)	= 1545 (ft-lbf)/(lbmol-ºR) = 1.986 Btu/(lbmol-ºR)
WATER (Liquid): Density ρ	= 1000 kg/m^3	= 62.4 lbm/ft^3 = 1.94 slug/ft^3
AIR: Molecular weight M	= 28.97 kg/kmol	= 28.97 lbm/lbmol
AIR: Specific gas constant R	= 0.287 kJ/(kg-K)	= 53.3 (ft-lbf)/(lbm-ºR) = 0.0686 Btu/(lbm-ºR)

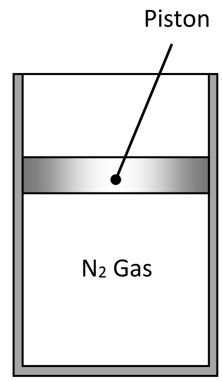
Problem 1 (40 points)

Nitrogen gas fills a piston-cylinder device as shown in the figure. The device contains 10 kilograms of nitrogen (N_2) gas initially at P_1 = 120 kPa and T_1 = 300 K.

During a constant-pressure expansion process, the gas volume doubles ($V_2 = 2V_1$).

Assume that nitrogen gas can be modeled as an ideal gas with constant, room-temperature specific heats:

R = 0.2968 kJ//kg-K; c_p = 1.04 kJ/kg-K; c_v = 0.743 kJ/kg-K



Determine the following:

(a) the work done *by* the gas *on* the piston during the expansion process, in kJ.

(b) the heat transfer of energy *to* the gas during this process, in kJ.

Problem 2 (35 points)

Two brine streams are mixed in a steady-state, adiabatic mixing chamber. Cold brine enters at Inlet 1 (10 °C and 110 kPa) and hot brine enters at Inlet 2 (75 °C and 100 kPa) with a mass flow rate of 10 kg/s. The product stream leaves at Outlet 3 (20°C and 100 kPa).

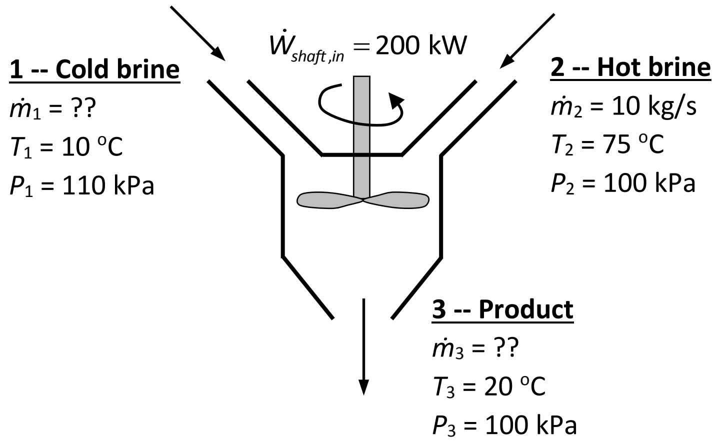
A mechanical stirrer that rotates at 500 rpm enhances the steady mixing process. The shaft power input for the mechanical stirrer is 200 kW.

Experience shows that changes in kinetic and gravitational potential energy are negligible. You may also assume the brine, which is a liquid, can be modeled as an incompressible substance with constant, room-temperature specific heats: ρ = 1150 kg/m^3 and c = 3.11 kJ/kg-K.

Determine the following:

a) the mass flow rate of the cold brine stream, in kg/s.

b) the torque developed in the rotating shaft of the stirrer, in kN-m.

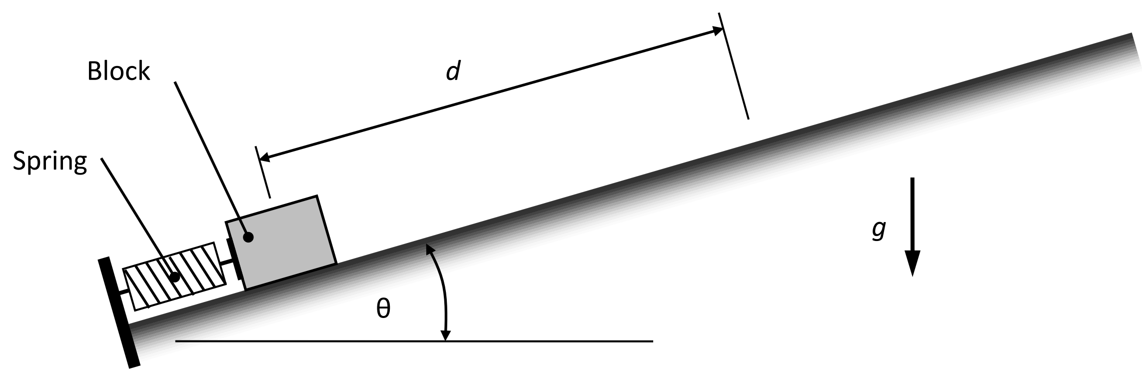


Problem 3 (30 Points)

A block with mass m is initially pushed against a spring compressing the spring length by δ. When the block is released, the spring expands and the block slides up the inclined surface. (The block is not attached to the spring.)

The inclined surface has a coefficient of kinetic friction μ_k and makes an angle θ with the horizontal as shown in the figure. The spring has a spring constant k.

Determine the speed V of the block after it travels a distance d up the inclined surface.
[SET UP the necessary equations but DO NOT SOLVE.]



Note: The spring is shown compressed.

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

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

$(\Delta T/{}^{o}R) = (\Delta T/{}^{o}F)$

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

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