1.	/20
2.	/20
3.	/20
4.	/20
5.	/20

First 3 letters of last name:
(Print capitals)

Name:

Final Exam

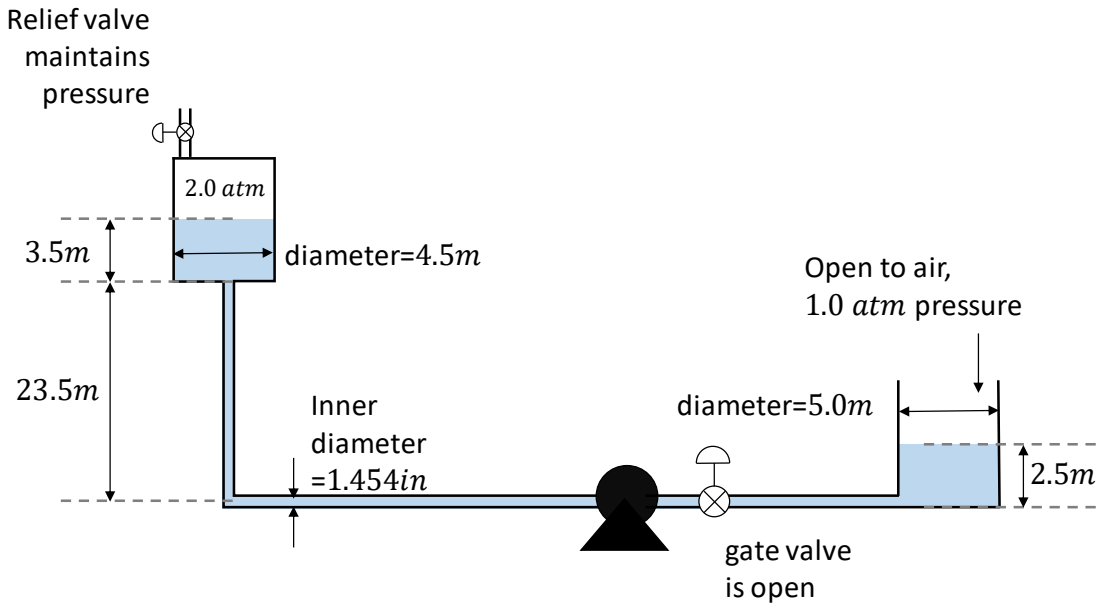
CM3120

Tuesday 30 April 2019

Instructions:

i. Closed book, closed notes. Two 8.5" by 11" study sheets allowed, two sided; you may use a calculator; you may not use the internet or a cell phone. All work on the exam must be your own.
ii. Write your solution on one side of the page only. Do not write on the back of any pages.
iii. Please be neat. Only neat answers will be granted partial credit.
iv. Significant figures always count.
v. Please box your final answers.

1. (20 points) Water (25^oC) is pumped from an open tank to a pressurized ($2.0\ atm$) closed tank at $5.0\ gallons/min$. The set-up is shown in the figure below. If the frictional losses in the system from start to finish are $F/g = 3.2\ ft$ (g is the acceleration due to gravity), what is the pump shaft work needed to maintain the flow? Please give your answer in units of $ft\ lb_f/s$.



2. (20 points) A brass sphere (diameter $= 2.54\ cm$) initially at 25.0^oC is suddenly immersed in vigorously stirred water (85.0^oC). After $5.0\ seconds$ the center of the sphere is observed to be 72.0^oC. How long will it take the center of the sphere to reach $T = 83.8^oC$?

3. (20 points) Environmental models of Lake Superior must keep track of the water evaporation rate from the lake. Our team wishes to estimate this rate. We need to model the evaporation, which is certainly caused by a combination of bulk convection (due to winds) and diffusion (from the large surface area).
    a. Between the two models for mass transfer we have considered, diffusion and linear driving force model, which is most applicable for mass transfer with a significant bulk convection?
    b. To determine the transport coefficient we need, we will rely on data correlations written in terms of dimensionless numbers. What do you expect will be the general form of the data correlation? Your answer should name and define (give the formula) the independent variable (a dimensionless number) and the dependent variables (two dimensionless numbers). No details of the functional form are needed, just the variables.
    c. Once you find in the literature the appropriate data correlation, what physical property data will you need to estimate the evaporation rate?

4. (20 points) An irreversible, instantaneous chemical reaction ($2A \rightarrow B$) takes place at a solid catalyst surface inside a tubular catalytic reactor. The reaction is very fast, but the time for reactants to diffuse to the catalytic surface and for products to diffuse away is slow (diffusion coefficient is D_{AB}). We use the film model (film of thickness δ) to calculate the flux of product B away from the surface. If the bulk concentration of species A at the edge of the film is x_{A0}, what is the steady state flux of B away from the surface?

(last problem on the next page→)

5. (20 points) The 8 Friday topics are listed below. Answer the following questions.
   a. What was your Friday project UO? In one sentence, what is the engineering purpose of that unit operation and what physics is exploited to achieve that purpose?

      For which of the 8 Friday unit operations is the separation ***significantly*** driven by:

      *(**note** that you can put a unit into more than one slot;*
      One unit is not used; write the unit name, not the number):

   b. Pressure: (1)_____

      (2)_____

   c. Heat:

      (1)_____

      (2)_____

      (3)_____

   d. Rotary motion: (1)_____

      (2)_____

   e. Diffusion: (1)_____

1. **Evaporators** (single, multiple effect)	2. **Membrane Separation** (reverse osmosis, microfiltration, ultrafiltration)
3. **Dryers** (batch continuous	4. **Filtration** (conventional, continuous)
5. **Absorption** with a "**B**"	6. **Distillation**(conventional, azeotropic, multicomponent)
7. **Adsorption** with a "**D**"	8. **Centrifugation** (batch, continuous)