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Exam 1

CM3120

Tuesday 22 January 2019

Name:

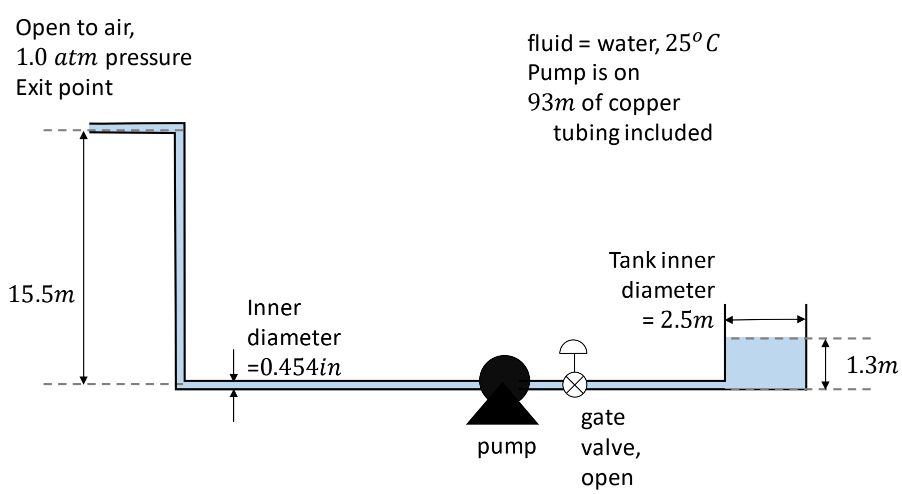
Instructions:

i. Closed book, closed notes. One 8.5" by 11" study sheet 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) How much heat would be required to raise the temperature of a water stream flowing at 3.4 gallons per minute (gpm) from $20.^o\ C$ to 82^oC?

2. (20 points) What information do we need to determine the dew point of a humid air stream (pressure of the stream is atmospheric, and the temperature is 31^oC) if the air stream is 1.7 $mole\%$ water? How would you determine the dew point of this stream? (Write out how you would do it if you had all the information you needed).

3. (20 points) For the apparatus shown below, and neglecting friction, how much work (in $Watts$) would the pump need to supply to deliver room temperature water at $20gpm$? (gpm=gallons per minute). Briefly describe how this number would change if we included the effect of fluid friction.



4. (20 points) For the steady, downward, laminar flow of water in a pipe, the relationship between flow rate and pressure drop is the famous Hagen-Poiseuille equation. Given the laminar flow velocity profile,

$$v_z(r) = \frac{\Delta p}{4\mu L}(R^2 - r^2)$$

and the flow rate expression below, derive the Hagen-Poiseuille equation. All symbols are defined below. The following quantities are constants:

Δp = fluid pressure drop across pipe length
L = pipe length
μ = fluid viscosity
R = pipe inner radius

Volumetric flow rate Q, expression for a pipe of radius R:

$$Q = \int_0^{2\pi} \int_0^{R} (v_z) \;\; r dr d\theta$$

where r, θ, z are cylindrical coordinate variables. Please show your work and box your answer.

5. (20 points) What is the steady state temperature distribution $T(x)$ in a long, wide, rectangular copper slab if the left side is held at T_1 and the right side is exposed to a fluid at bulk temperature T_{b2} (see figure below). The slab is of thickness B. Use the coordinate system shown and indicate the steps and assumptions that allow you to determine your answer.