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Exam 1

CM3120

Tuesday 21 January 2020

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) A 20^oC water stream flows into a pipe at 3.9 gallons per minute (gpm). What would be the outlet temperature of the stream if we added $53\ kW$ of heat to the stream using a heat exchanger?

2. (20 points) To calculate pressure drops in real pipes, we rely on data correlations from the literature for dimensionless wall drag (Fanning friction factor f) versus dimensionless flow rate (Reynolds number, Re).

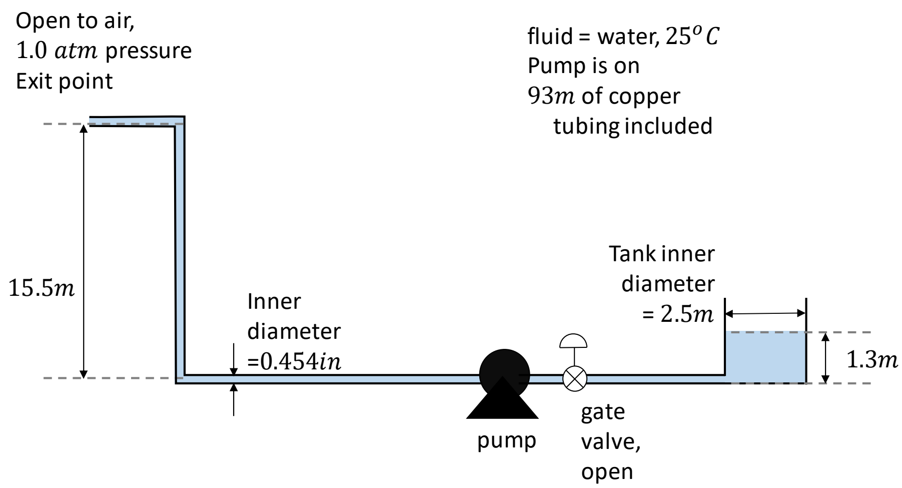
    a. Provide an equation for such a data correlation that applies in the turbulent flow regime.
    b. What is the pressure drop in room temperature water flowing in a pipe (inner diameter $25.4\ mm$, length $120\ m$, $\rho_{steel} = 8.05\ g/cm^3$) at an average fluid velocity of $1.55\ m/s$?

3. (20 points) For steady, radial heat conduction in a solid wire (radius is $R,$ thermal conductivity k) with electric current flowing, we simplify the microscopic energy balance to the following differential equation for $T(r)$ (assumptions: $\underline{v} = 0, \theta$-symmetry, long wire, constant energy production due to current $S_0\ W/m^3$, no chemical reaction, wire surface temperature known as T_w):

$$0 = \frac{k}{r}\frac{d}{dr}\left(r\frac{dT}{dr}\right) + S_0$$

    a. Solve for $T(r)$ in terms of the integration constants. You do not need to re-derive the differential equation.
    b. What are the boundary conditions? You must write the boundary conditions mathematically. You do not need to solve for the integration constants, just provide the needed boundary conditions.

4. (20 points) In the apparatus shown below, a pump delivers room temperature water at $2.0 \times 10^1\, gpm$ (gpm=gallons per minute) to the elevated exit point on the left side. The shaft work on the fluid for the whole system is $267\ W$ and the tubing is the same size throughout. What is the pressure (in kPa, absolute) on the inlet side of the pump (that is, at a point between the gate valve and the pump)? You may neglect friction in your calculations.



5. (20 points) What is the steady state temperature distribution within a long cylindrical shell (a long pipe of density ρ, thermal conductivity k, heat capacity C_p) if the inner wall is held at T_1 and the outer wall is held at T_2? ($T_1 > T_2$). Show how you obtain your answer from the basic physics.