ES202 | Winter 1999-2000 | J. Mayhew
Thermal & Fluid Systems | | D. Richards

EXAM I

NAME____ BOX _____________

Problem 1 (55) ______________

Problem 2 (45) ______________
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TOTAL (100) ______________

NOTE:

(1) Anytime you apply a conservation or accounting principle in solving a problem, you must **sketch and clearly identify the system** you have selected. In addition, you must **clearly indicate how your assumptions or information given in the problem simplifies the general equations.**

(2) Closed book/notes; however, you may use any of the following:
... charts and tables provided by instructor
... equation page provided by instructor with your notes added.
... units conversion page

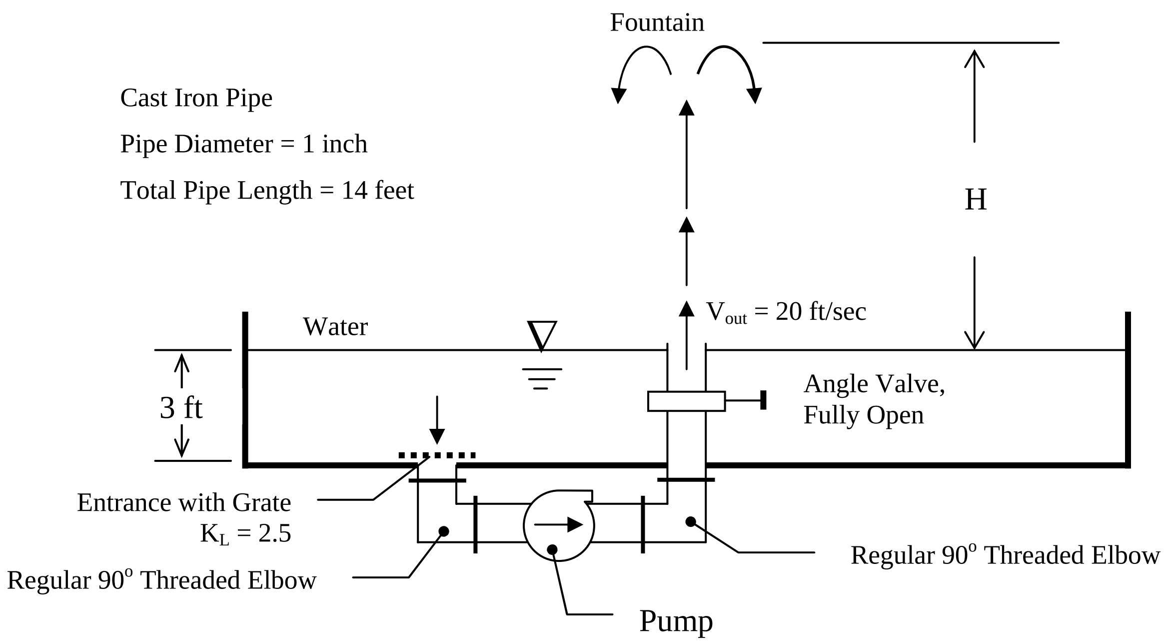
(3) For maximum credit,
... solve problems symbolically first showing logic and reasoning for solution,
... substitute numbers into the equations clearly showing any required unit conversion factors
... then and only then crunch numbers on your calculator.
If I only have to punch your numbers into a calculator to get a correct answer (including units) you will receive full credit. **Don't make me guess what you are doing and why you chose to do this.**

Problem 1 (55 points). A fountain of water shoots up into the air from a 1-inch diameter pipe and lands in a small reservoir as shown below. The pump operates at steady state and draws water from the reservoir through an opening covered by a grate (K_L = 2.5 for entrance and grate combined). The pipe system is 14 feet long overall, is made of cast iron, and includes two regular 90^o threaded elbows and a fully-open angle valve. The combined length of the elbows, pump, and valve is negligible compared to the 14-foot length of pipe. The average velocity of the water at the base of the fountain is 20 ft/sec.

a. (12) Find the height *H* that the fountain shoots water, in feet.

b. (38) Assuming no losses in the pump, find the power supplied to the pump, in horsepower.

c. (5) List one pipe material that could be used instead of cast iron in order to reduce the pump power required. Briefly indicate how your choice reduce the required pumping power?



Problem 2 (45 points). As a way of "load shifting" electrical demand to reduce air-conditioning costs, companies can build cooling systems that operate by freezing water into ice at night when electrical energy is cheap and then using the ice as a source of "cold" in the daytime when electricity is expensive.

In the system shown below, cooling is accomplished by circulating liquid brine through a coil of copper tubing embedded in ice. The copper tubing has a diameter D = 2 cm and a length L = 50 m. As the ice melts, it cools the circulating liquid flowing at 5.7 m^3/h. The circulating liquid is a solution of calcium chloride and water that can be modeled as an incompressible substance with the following properties:

$$\rho = 1070 \text{ kg/m}^3 \;; \quad c_p = 3.40 \text{ kJ/(kg·K)} \;; \qquad \mu = 3.0 \times 10^{-3} \text{ N·s/m}^2$$

The steady-state operating conditions for the system are shown on the figure.

Determine

a) (28) the magnitude and direction of the heat transfer rate between the liquid brine and the ice, in kW,

b) (17) the rate of entropy generation for the liquid brine flowing through the copper tubing, in kW/K.