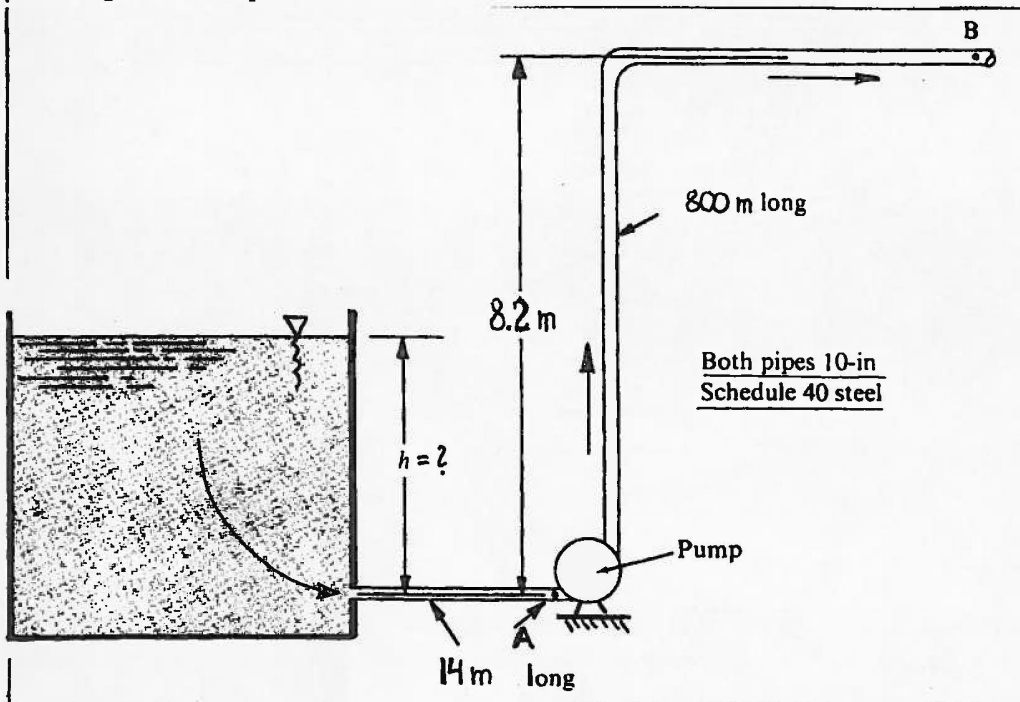


Problem 1:

The figure below shows portion of a fire protection system in which a pump draws water at 10 deg. C from a reservoir and delivers it to a point B at a flow rate of 6000 lit/min.

Note: only consider friction losses; the roughness of steel is $e = 0.046$ mm.

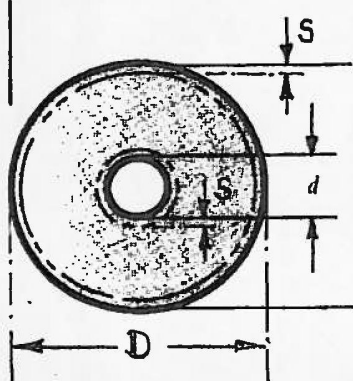
- a) Determine the **height h** (m) of the water level in the tank in order to maintain 35.00 kPa-g pressure at point A.



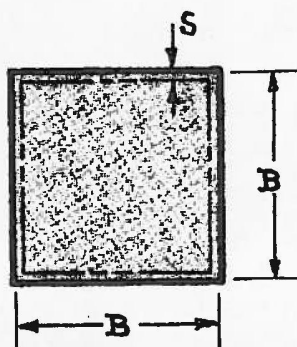
- b) Assuming a pressure at A of 35.00 kPa-g, determine the **pump power** (efficiency = 76%) to maintain a pressure at B of 600 kPa-g.

Problem 2:

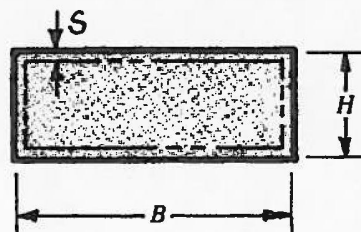
The figure below shows four different **thin-walled conduit cross sections**, i.e. an annulus, a square, a rectangle, and a pipe inside a square. **Choose two**, and determine the **hydraulic diameter** for the two chosen cross sections in terms of the shown parameters.



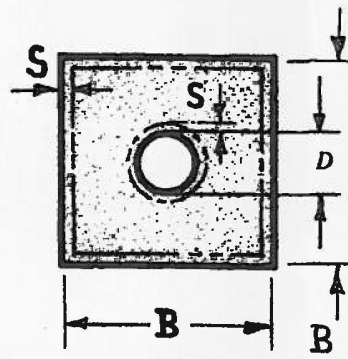
— A —



— B —



— C —

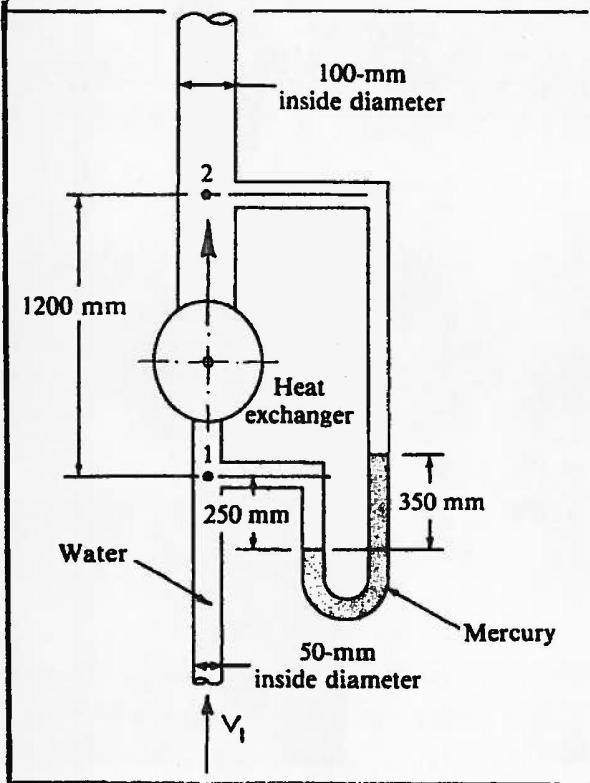


— D —

Problem 3:

The figure below shows a test setup to determine the energy loss due to a heat exchanger. Water at 50 deg. C is flowing vertically upward at 360 lit/min. Calculate the **energy loss** between points 1 and 2, and determine the **headloss coefficient k** for the heat exchanger based on the velocity in the inlet pipe.

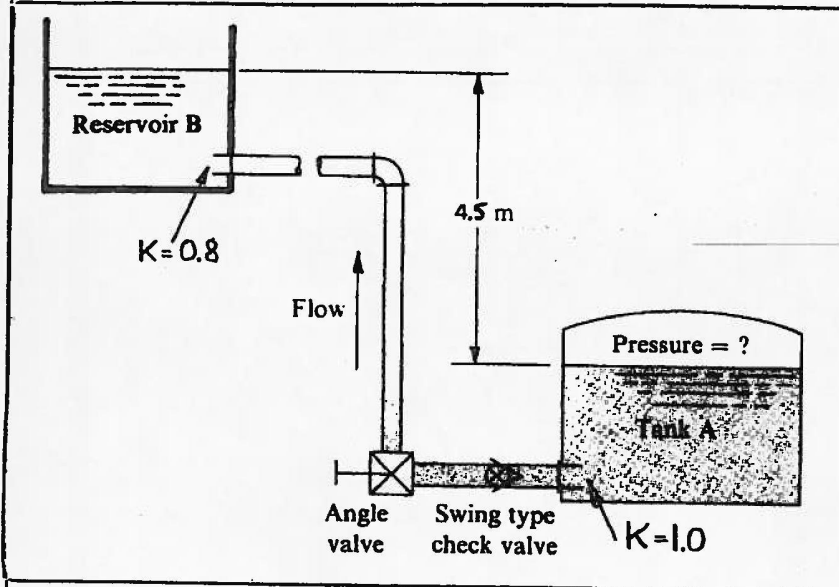
Note: the specific gravity of mercury is $sg = 13.54$, and $h_{loss} = k v_1^2 / (2g)$.



Problem 4:

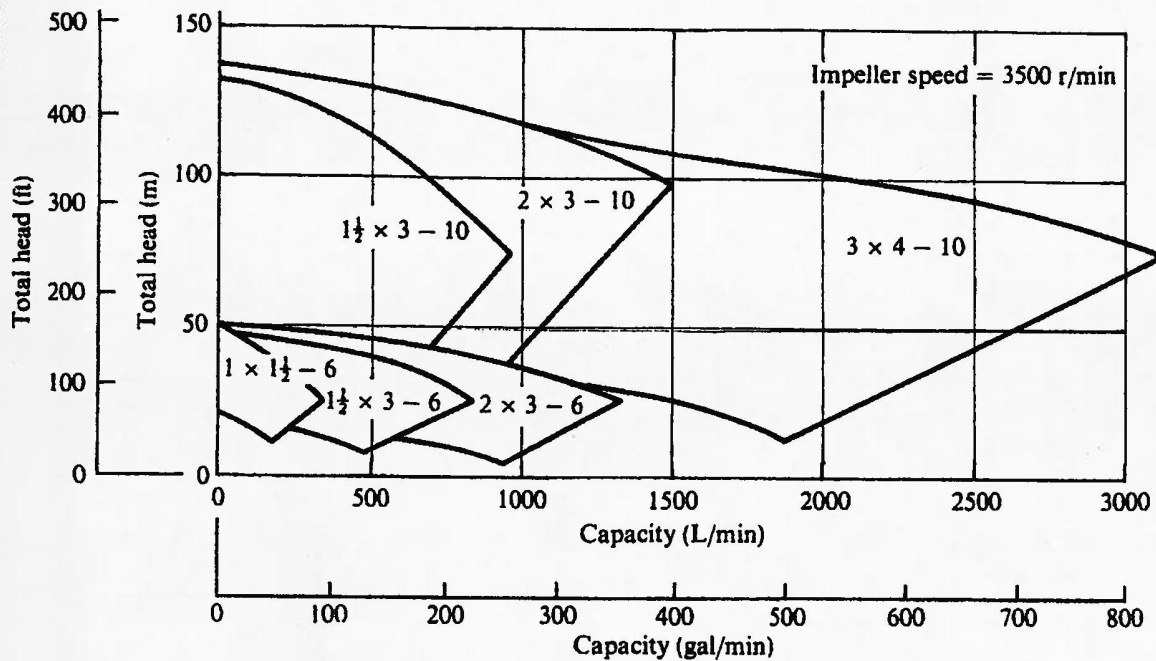
For the system shown below, kerosene at 20 deg.C ($sg = 0.82$) is to be forced from a sealed tank A to an open reservoir B by increasing the pressure in tank A. The total length of the 2-in Schedule 40 steel pipe is 40 m. The elbows are standard. Determine the **friction and fitting losses**, and the **pressure in tank A** to cause a flow rate of 400 lit/min.

Note: dynamic viscosity of kerosene = 1.8×10^{-3} Pa s, angle valve $L/d = 150$, swing type check valve $L/d = 100$, standard elbow $L/d = 30$.



Problem 5:

For the line of pumps shown in the chart below, specify a suitable size for delivering 1250 L/min of water at a total head of 80 m, and determine the ideal pump power required for water at 20 deg.C.

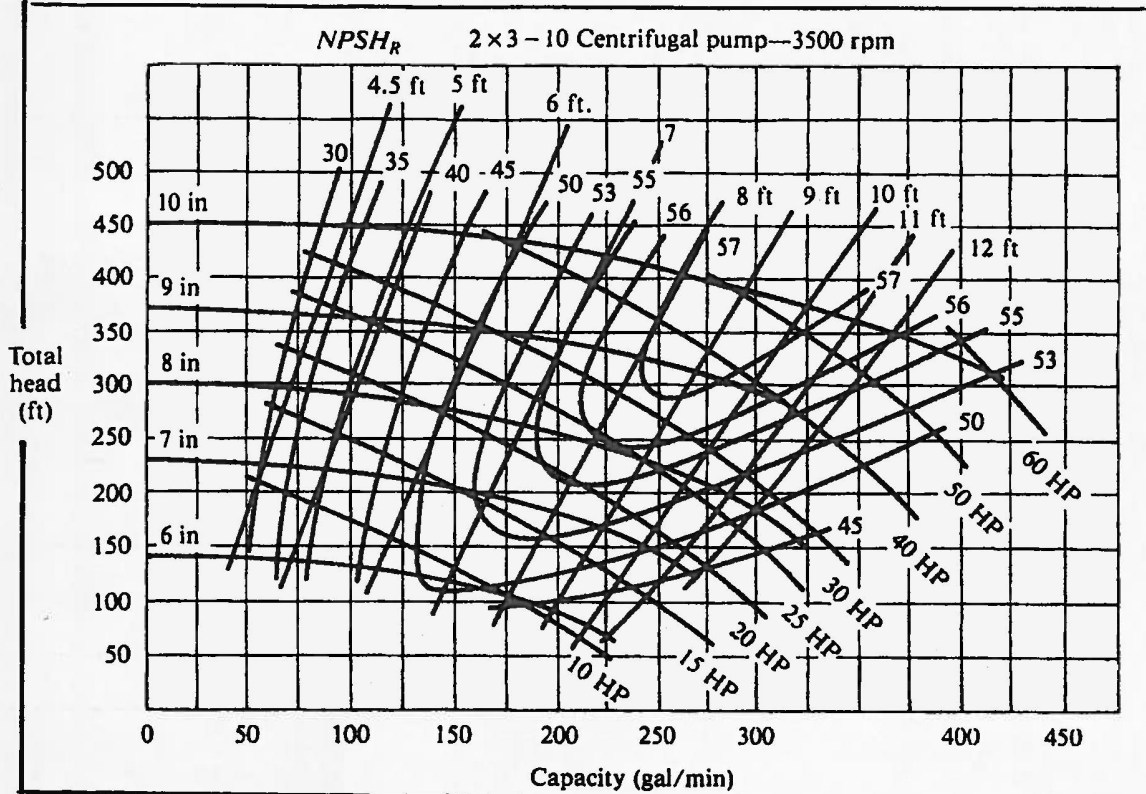


Composite rating chart for a line of centrifugal pumps.

Problem 6:

For the 2 X 3 – 10 centrifugal pump performance curve shown below, describe the performance that can be expected from a pump with a 9-in impeller operating against a system head of 350 ft at 3500 rpm.

a) Give the expected capacity, the power required, the efficiency, and the required NPSH.



b) If the pump speed is changed to 4000 rpm, determine the change in capacity, head, and power required.

Problem 7:

The arrangement shown below is used to supply a lubricating oil to the bearings of two large compressors with resistance coefficients 11.0 and 4, respectively. The lines in each branch are $\frac{1}{2}$ - inch commercial steel tubing with a wall thickness of 0.049 in. Each of the four bends in the piping system has an equivalent length of $L/d = 45$. **Include the effect of these bends, but exclude the friction loss** since the lines are short. The lubricant ($sg = 0.881$) has a kinematic viscosity of $2.5 \times 10^{-6} \text{ (m}^2/\text{s)}$. The piping system is in a horizontal plane, i.e. $z = \text{constant}$. Determine the **total flow rate (L/min)** of the lubricant through the system.

