

CM2120 Fundamentals of Chemical Engineering 2
Department of Chemical Engineering
Michigan Technological University

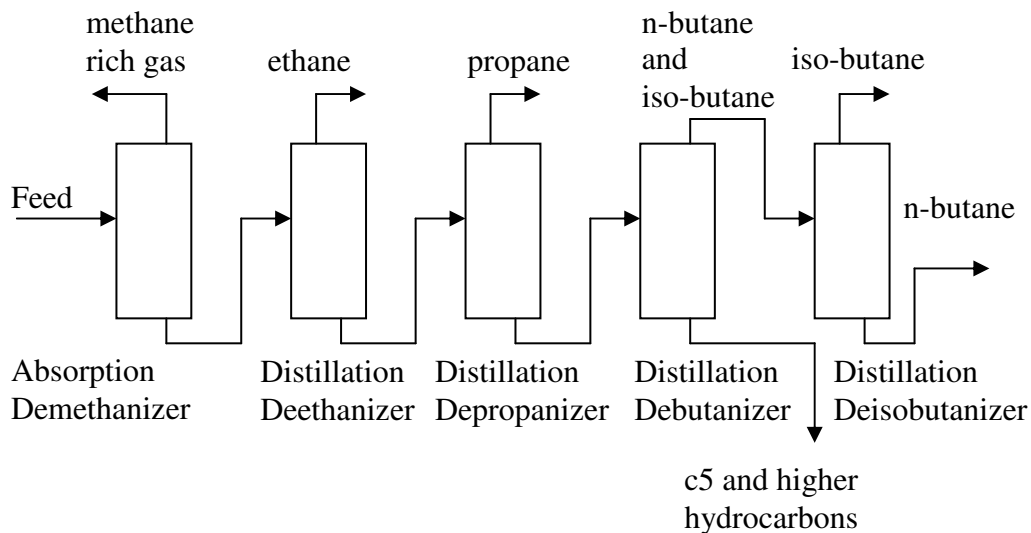
Homework 1
Due 21 January 2009

1. Separating Natural Gas (20 points)

Natural gas is a mixture of many short chained hydrocarbons, with a distribution shown in the following table:

Component	Typical Analysis (mole %)	Range (mole %)
Methane	94.9	87.0 - 96.0
Ethane	2.5	1.8 - 5.1
Propane	0.2	0.1 - 1.5
iso - Butane	0.03	0.01 - 0.3
normal - Butane	0.03	0.01 - 0.3
iso - Pentane	0.01	trace - 0.14
normal - Pentane	0.01	trace - 0.04
Hexanes plus	0.01	trace - 0.06
Nitrogen	1.6	1.3 - 5.6
Carbon Dioxide	0.7	0.1 - 1.0
Oxygen	0.02	0.01 - 0.1
Hydrogen	Trace	trace - 0.02

It is desired to separate out the methane, ethane, propane, and butanes for use in chemical processing. This is done using a separations train, as seen in the figure below.



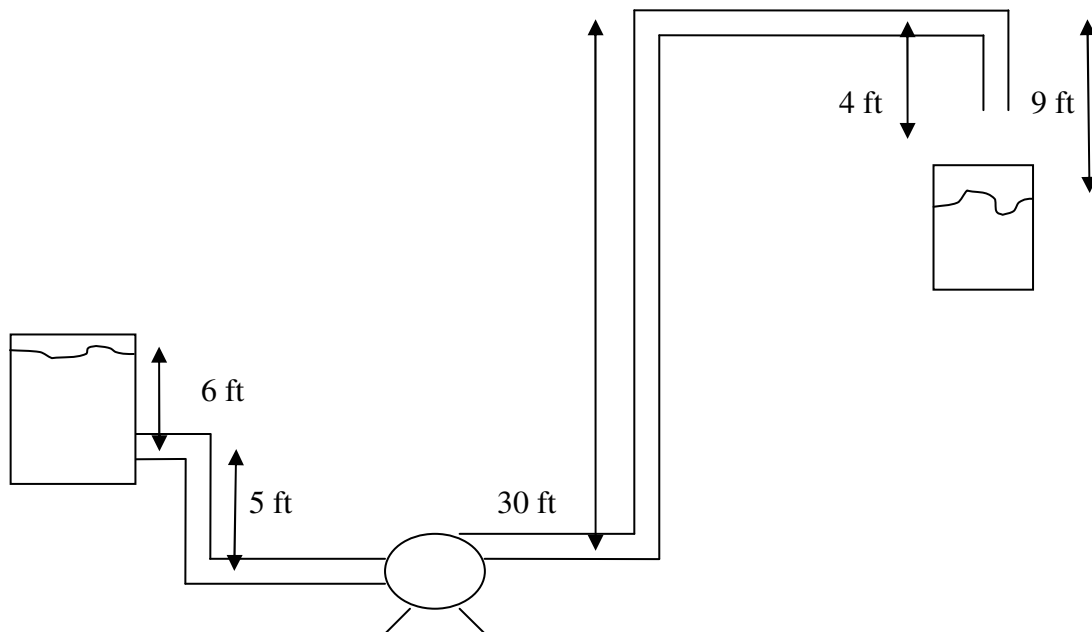
Make the following assumptions:

- Demethanizer - 90% (by moles) of methane fed to are removed as product, and that the rest of the chemicals go on to the deethanizer. All of the nitrogen, carbon dioxide, oxygen, and hydrogen leave with the methane-rich gas.
- Deethanizer – 95% (by moles) of ethane fed are removed as product along with 5% (by moles) of propane and the remaining methane. The rest of the chemicals go on to the depropanizer.
- Depropanizer – 97% (by moles) of propane fed are removed as product along with 7% (by moles) of iso-butane and 3% (by moles) of n-butane and the remaining ethane. The rest of the chemicals go on to the debutanizer.
- Assume perfect separation in the debutanizer and deisobutanizer. Any remaining propane ends up with the iso-butane stream.

Determine the molar flows in kgmol/hr of methane, ethane, propane, n-butane, and iso-butane in each of the process streams.

2. Bernoulli Equation (20 points)

Consider turbulent water flow in the system at a volumetric flow rate of 2 gal/min, as shown in the figure below. The water enters from an open tank through a 1 inch schedule 40 steel pipe (inside diameter 1.049 in). After passing through the pump, the water flows in a 1 ½ inch schedule 40 steel pipe (inside diameter 1.610 in). The schematic indicates height differences in feet.

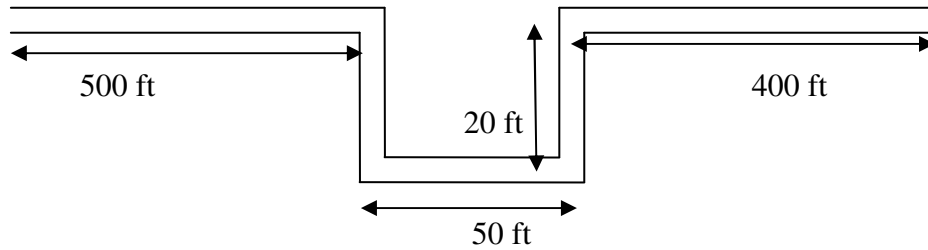


Noting that the water density is $62.4 \text{ lb}_m/\text{ft}^3$, use the Bernoulli equation to determine the pressure in psi units at the following locations:

- a) in the tank near the pipe exiting the feed tank
- b) at the pump inlet
- c) at the pump outlet

3. Friction factor (20 points)

Consider the flow of water in a horizontal system with 2 inch schedule 40 pipe as seen in the figure below. There are four 90 degree elbows, 2 ball check valves, and a total pipe length of 990 ft. The water density is 1000 kg/m^3 and the water viscosity is 1 cp.



- Convert the density and viscosity to English units (lb_m , ft, s)
- Determine the friction losses in $\text{lb}_f\text{-ft}/\text{lb}_m$ for a velocity of 1 ft/s, 2 ft/s, and 3 ft/s.
- An operator has suggested replacing the ball check valve with a globe valve. Is this a good idea?