Name: ____ 10/21/2014

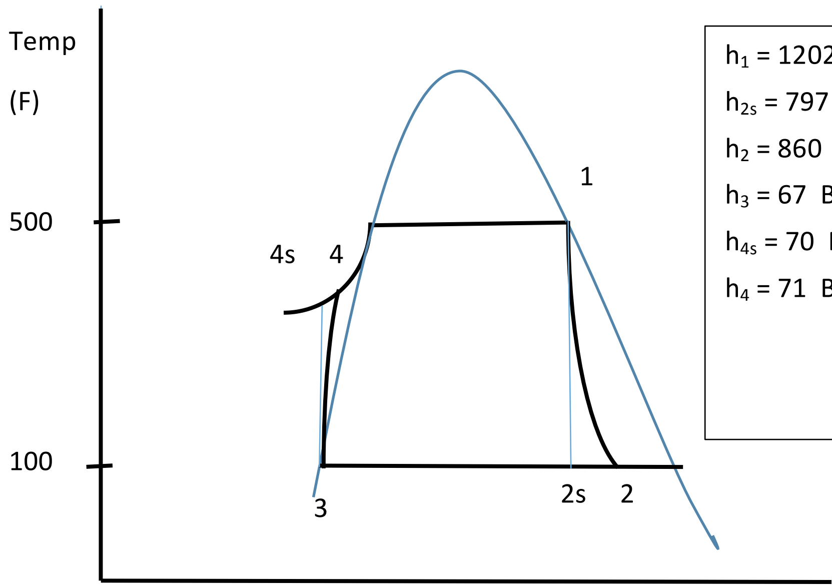
NE 161 Midterm

Multiple choice 1 to 10 are 2 pts each; then long problems 1 through 4 are 20 points each.

1. Which would have a higher mass flow rate out of a 1 ft^2 break,
    a. 200 psia subcooled water with h=200 Btu/lbm
    b. or 200 psia saturated water?
2. Which would have a higher velocity out of a 1 ft^2 break,
    a. 200 psia subcooled water with h=200 Btu/lbm
    b. or 200 psia saturated water?
3. Which is better to treat as though it were homogeneous pipe flow?
    a. Soda with bubbles in it going up a straw.
    b. Water and air moving through a partially filled culvert (highway drain pipe).
4. Where does the lowest pressure exist in a centrifugal pump?
    a. Suction pipe
    b. Near the center of the rotating impellor
    c. Discharge pipe
5. Where is the hottest point in a PWR reactor coolant system?
    a. The center of the fuel rods
    b. Near the top of the fuel rods
    c. In the pressurizer
6. Nuclear science dates back to:
    a. the discovery of the nucleus and electron clouds 50 years ago.
    b. the discovery of gamma rays 120 years ago.
    c. the discovery of beta radiation 200 years ago.
    d. Sir Isaac Newton's discovery that electron states in atoms are quantized.
7. A nuclear power plant's thermodynamic cycle is
    a. More efficient than the typical modern fossil fuel plant.
    b. Within a percent or 2 as efficient as a typical modern fossil fuel plant.
    c. Less efficient than the typical modern fossil fuel plant.
8. Vital power at a PWR is needed for (circle as many as needed):
    a. Safety Injection Pumps
    b. Accumulators
    c. Component Cooling Water pumps
    d. Condenser Circulation Water Pumps
9. A reactor that used heavy water to moderate is
    a. A Westinghouse PWR
    b. A GE BWR
    c. A B&WPWR
    d. A CANDU Reactor
10. When a PWR reactor trips offline suddenly, within the first ten minutes or so
    a. The temperature in the core spikes upward
    b. The water level in the pressurizer falls
    c. The flow rate to the condenser increases
    d. The steam generator stops producing steam

Name: ____ 10/21/2014

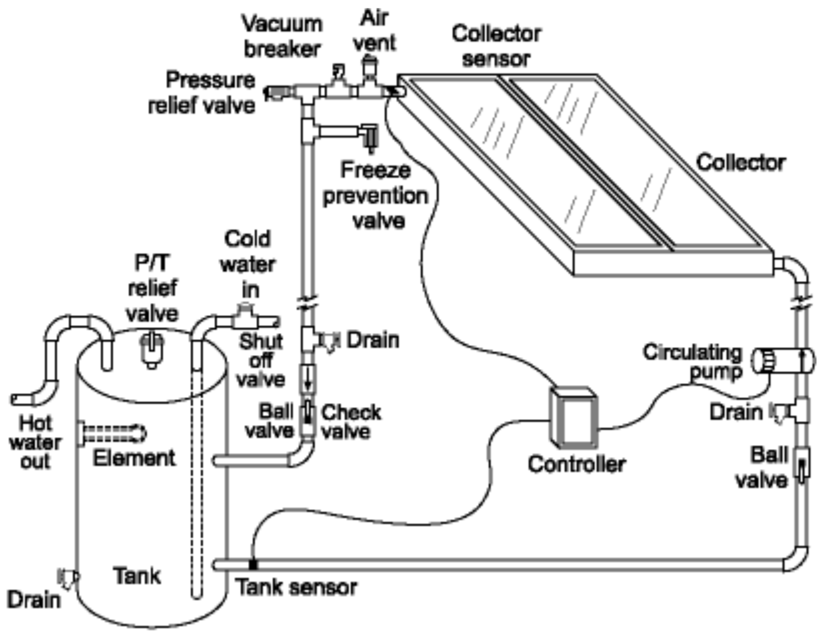
1. A Rankine cycle has the below characteristics.
    a. What is the turbine isentropic efficiency?
    b. What is the pump isentropic efficiency?
    c. What is the cycle efficiency (net work out/heat in)?
    d. What would the cycle efficiency be with perfect turbine and pump?
    e. What is the maximum efficiency possible for a heat engine operating between this hot and cold temperature?



h_1 = 1202 Btu/lbm
h_{2s} = 797 Btu/lbm
h_2 = 860 Btu/lbm
h_3 = 67 Btu/lbm
h_{4s} = 70 Btu/lbm
h_4 = 71 Btu/lbm

a. turb eff =actual/ideal enthalpy drops =(1202-860)/(1202-797) = 0.844
b. pump eff = ideal/actual enthalpy input =(70-67)/(71-67) = 0.75
c. cycle efficiency = (act. Turb Δh - actual pump Δh)/(boiler Δh) =((1202-860)-(71-67))/(1202-71) = 0.299
d. ideal cycle efficiency = (ideal Turb Δh - ideal pump Δh)/(boiler Δh) =((1202-797)-(70-67))/(1202-70) = 0.355
e. Carnot eff is (Th - Tc)/Th where are least the denominator must be in absolute temp =(500-100)/(960) = 0.417

Name: ____ 10/21/2014



2. Assume all the piping in this solar water heater is 1" in diameter. The solar collector is 30' above the bottom of the tank up on the roof, where the vacuum breaker makes sure that the pressure is 14.7 psia. Assume a total length of 80 feet of pipe; ball valve losses are the same as butterfly valves, both the tank and collector head losses can be ignored, but the pipe ends should be treated as inlets and exits. Don't forget all the tees.

(a) Get piping loss info from the data page following to figure out how strong a pump we will need (in head developed) if the velocity is 5 ft/s (assume fully turbulent flow).

(b) What is the pressure in the bottom of the tank when the pump is shut off? Water density is 62.4 lbm/ft^3.

(a) $h_L = (\Sigma k + f(L/D))v^2/2g = (3k_{elb}+5k_{teeR} + k_{teeB} + 2k_{exit}+2k_{ent}+2k_{ball}+k_{chk}+f*80/(1/12))*25/64.4$

$f_T = 0.023$, $k_{elb} = 30\ f_T$ $k_{teeR} = 20\ f_T$ $k_{teeB} = 60\ f_T$ $k_{exit} = 1$ $k_{ent} = .78$ $k_{ball} = 45\ f_T$ $k_{chk} = 50\ f_T$

$h_L = (3*30*.023+5*20*.023 + 60*.023 + 2 + 2*.78 + 45*.023 +50*.023 +.023*80/(1/12))*25/64.4$
$= 13.03$ feet

(b) Pressure = mgh = 62.4 lbf/ft^3*30 ft*1ft^2/144 $inch^2$ = 13 psig or 27.7 psia

Name: ____ 10/21/2014

3. An 80°F, 37 psia pressurized argon (MW=40) tank is connected by lines to a Volume Control Tank (argon is sometimes used in engineering systems because it is a noble gas, with outer shell just filled with electrons, so it doesn't react or combine with other elements). The designers have put in a nozzle orifice such that the entrance k-value equals 8 to limit the flow rate out of the tank should a line rupture. What would the mass flow rate be for a pipe break to 14.7 psia just downstream of the orifice (i.e., k=8)? The ratio of specific heats for argon is 1.66, but (a) calculate the flow rate as though the ratio were 1.4 so you can use the charts below, and (b) state whether the actual flow rate would be more or less than your answer to part a. (And state why.) To find the density, remember that all gases have the same number of atoms per volume at consistent pressure and temperature, and air (MW=29) has a weight density of 0.175 lbf/ft^3 at 80°F and 35 psia.

Crane formula: $\underline{m} = 0.525Yd^2*SQRT(\Delta P\rho/k)$ d in inches, ΔP in psi, ρ in lbf/ft^3, $\underline{m}$ in lbm/s

(a) The $\Delta P/P$value is (37-14.7)/37 = 22.3/37 = 0.60. From the chart below, this gives a Y-value of 0.75. The diameter is 1 inch. The ΔP is 22.3 psi. ρ = 40/29*0.175 = 0.241 lbf/ft^3. K is 8.

$\underline{m}$ = 0.525*.75*1^2*sqrt(22.3*.241/8) = 0.32 lbm/s

(b) Had we used the 1.3 chart, the only difference is that Y would have been 0.76, and the flow would have been slightly more. So by extrapolation in the opposite direction, the flow would be slightly less for a gas with cp/cv = 1.66.

4. A BWR recirculation line is connected to the top of the reactor pressure vessel where the fluid is saturated H_2O with 15% quality at 1000 psia. If the pipe is 1 ft^2 in area, what is a good bounding high flow rate? At 1000 psia, h_f = 543 and h_g = 1193

Answer: we ignore all piping and exit losses, and just use the Moody chart below. The pressure/Pref is 1000/100 = 10. The enthalpy is .85*543+.15*1193 = 640, so h/href = 6.4. From the graph below, G/Gref = 4, so G = 4000 lbm/sft^2. Here GA = 4000 lbm/s.

Name: ____ 10/21/2014

Table 5.1: Friction Factors f_T in Zones of Complete Turbulence from Crane Manual (these are the same values as developed for high Re values in Figure 5.11)

Size	½"	¾"	1"	1.25"	1.5"	2"	2.5-3"	4"	5"	6"	8-10"	12-16"	18-24"
f_T	.027	.025	.023	.022	.021	.019	.018	.017	.016	.015	.014	.013	.012

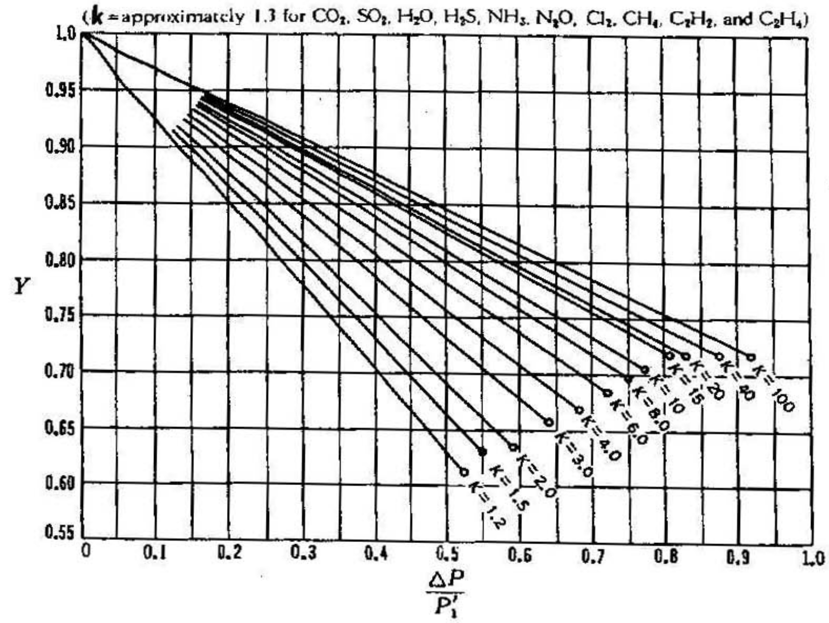
Table 5.2: K-values for common situations from Crane Manual (when needed, f_T values are from Table 5.1). Valve K-values are approximate generic values; actual valves are usually supplied with specified K-values or Cv values by the vendor.

Description	K-value
90 degree Elbow	30 f_T
45 degree Elbow	16 f_T
Tee – Flow through straight run	20 f_T
Tee – Flow turns 90 degrees	60 f_T
Pipe Entrance, Flush, Sharp edged	0.5
Pipe Entrance, projecting into reservoir	0.78
Pipe Exit, flush or projecting	1.0
Swing Check Valves	50 f_T
Full Open Gate Valve, constant area	8 f_T
Full Open Butterfly Valve	1" to 8" 45 f_T 10" to 14" 35 f_T 16" to 24" 25 f_T
Pipe diameter change, decreasing diameter by $\beta= D_1/D_2$ with contraction angle θ (θ = 180° for sudden contraction) (K-value is appropriate for velocity in D_1)	$\theta \le 45$ 0.8sin(θ/2)(1-β^2) $45<\theta\le 180$ 0.5*SQRT[sin(θ/2)](1-β^2) (K-values for lower velocity in D_2 segment are found by $K_2 = K_1 / \beta^4$)
Pipe diameter change, increasing diameter by $1/\beta= D_2/D_1$ with enlargement angle θ (θ = 180° for sudden enlargement) (K-value is appropriate for velocity in D_1)	$\theta \le 45$ 2.6sin(θ/2)(1-β^2) $45<\theta\le 180$ $(1-\beta^2)^2$ (K-values for lower velocity in D_2 segment are found by $K_2 = K_1 / \beta^4$)

Net Expansion Factor *Y* for Compressible Flow Through Pipe to a Larger Flow Area

k = 1.3

(*k* = approximately 1.3 for CO_2, SO_2, H_2O, H_2S, NH_3, N_2O, Cl_2, CH_4, C_2H_2, and C_2H_4)

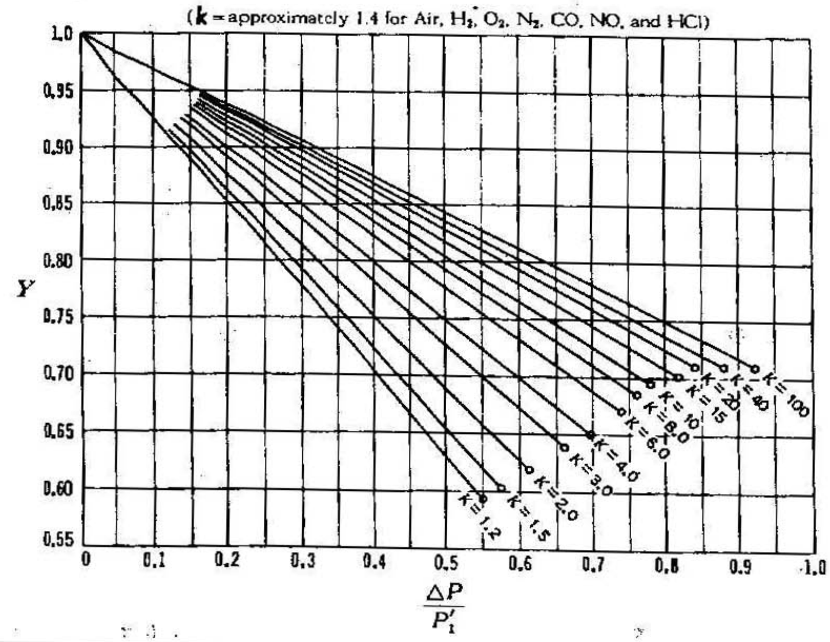


Limiting Factors For Sonic Velocity
***k* = 1.3**

K	$\frac{\Delta P}{P'_1}$	Y
1.2	.525	.612
1.5	.550	.631
2.0	.593	.635
3	.642	.658
4	.678	.670
6	.722	.685
8	.750	.698
10	.773	.705
15	.807	.718
20	.831	.718
40	.877	.718
100	.920	.718

k = 1.4

(*k* = approximately 1.4 for Air, H_2, O_2, N_2, CO, NO, and HCl)



Limiting Factors For Sonic Velocity
***k* = 1.4**

K	$\frac{\Delta P}{P'_1}$	Y
1.2	.552	.588
1.5	.576	.606
2.0	.612	.622
3	.662	.639
4	.697	.649
6	.737	.671
8	.762	.685
10	.784	.695
15	.818	.702
20	.839	.710
40	.883	.710
100	.926	.710

Name: ____ 10/21/2014