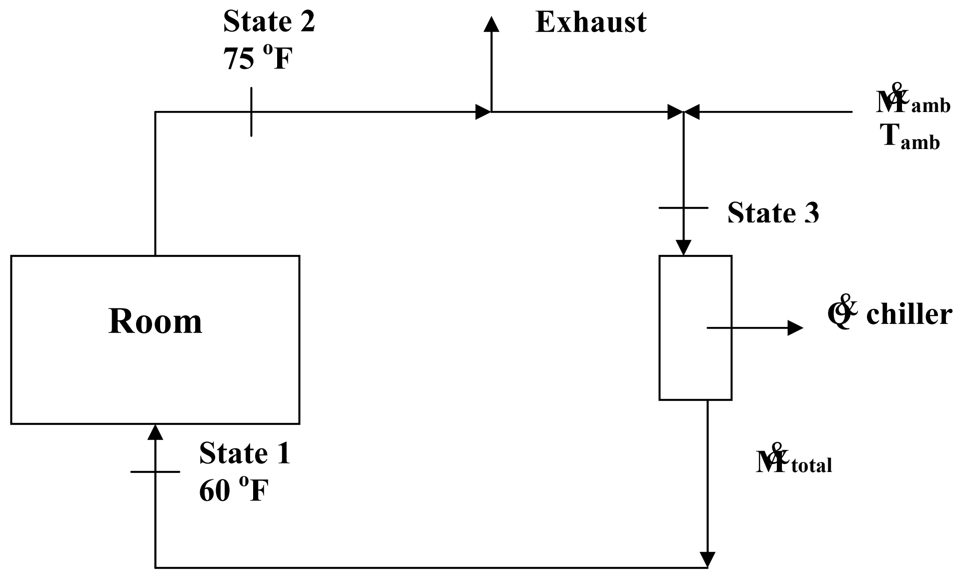
Fall'03
1.044J, 2.45J, 4.42J
Homework Set #4

1.



A room at steady state has a supply air stream of cool air entering at 60°F. The lights, office appliances and people transfer heat to the air so that it leaves at 75°F. Consider only sensible heat transfer for this problem, with all temperatures given as dry bulb temperatures. After the air leaves the room some is exhausted from the building. The remainder mixes with ambient air. The mixture is cooled by the chiller down to 60°F. For ventilation requirements m_{AMB} must be at least 20 percent of the total flow rate. The total air flow rate to the room and the entering temperature, state 1, are held constant. The amount of ambient air can be varied from 20 percent up to 100 % of m_{TOT} (with corresponding increases in the exhaust flow to keep the total flow constant). The temperature changes are small so C_p can be considered constant.

a) For an arbitrary ambient temperature develop an expression for $Q_{chiller}$ in terms of m_{AMB}/m_{TOT}.

b) As the ambient temperature varies between 50°F and 85°F what should m_{AMB}/m_{TOT} be to minimize $Q_{chiller}$?

Show a diagram of the optimum m_{AMB}/m_{TOT} versus T_{AMB}. At different ambient temperature levels, e.g., 60, 75 °F, the strategy to minimize the chiller cooling requirement may change. This is known as an economizer cycle.

2. An office space is to be kept at 73^{o}F. If cool air is constantly supplied to the space at 60^{o}F and the space can be assumed to be at a uniform temperature, what is the required air mass flow in lb/hr and volume flow in CFM? The same flow of air continually leaves the space. The heat transfer into the space from the outside through an exterior wall is 16,000 BTU/hr. Internal "heat gains" in the office space can be taken as <u>2.5</u> W/ft^2 for office equipment and computers and <u>250</u> BTU/hr per person. Assume the space ft^2 is occupied by 40 people. The heat given due to people assume is only sensible heating, i.e., it neglects any evaporation or changes in the moisture level in the air. Assume steady state conditions prevail. The floor area of the office is 1500 ft^2.

2b. If all the heat gains are doubled what options are available for the cool air supply to keep the office space at 73^{o}F? What other factors must be considered in choosing an option?

3. A water to air heat exchanger is used to heat the air of a home interior. The air flow rate is 2000 lbm/hr; the air enters in steady flow at 70^o F and leaves the heat exchanger at 100 ^{o}F. Heating water enters at 130^{o}F and leaves at 110^{o}F.

   a) If the heat exchanger is operating in steady state and there is negligible heat loss from the outside casing of the exchanger to its surroundings what is the required water flow rate?

   b) Do you think it's possible to design a heat exchanger with a water temperature drop from 130^{o}F to 110^{o}F while the air outlet temperature is raised to 125^{o}F (for suitable air and water flow rates)?

   c) Is it possible to have an air outlet temperature of 135^{o}F with these same water temperatures?

4. An air conditioning system uses R-12 (Freon-12) as a working fluid. The flow rate of refrigerant is 1,000 lbm/hr and it is steady. The refrigerant is condensed in the condenser to saturated liquid at 120^{o}F. From the condenser, it passes through an expansion valve where the pressure is lowered and the outlet temperature is 20^{o}F. The expansion valve is insulated and there is no shaft work. After the expansion valve the Freon enters the evaporator where it receives heat at constant pressure corresponding to the saturation pressure of 20^{o}F. The heat transferred to the Freon in the evaporation provides the cooling to the air passing over the evaporator.

   a) Find the cooling capacity of the unit in BTU/hr if the outlet of the evaporator is saturated vapor. Find the cooling capacity in tons. Hint: Define a control volume around the evaporator and write the steady flow energy equation.

   b) Repeat part (a) if the outlet of the evaporator is super heated by 15^{o}F; that is, the vapor is heated at constant pressure to 15^{o}F above the saturation temperature. Assume the Freon-12 vapor is a perfect gas with C_p equal to 0.15 BTU/lbm ^{o}F.