

4.42J/2.66J/1.044J
Quiz 2
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Open Book

1) (50) Estimate the energy performance of MIT's traditional single pane windows per square meter of surface area. Consider both convection and mid-long range infrared radiation from both the inside and outside surfaces of the window. Neglect air leakage, the window frame, and do not include solar radiation for parts a and b.

a) If the inside air temperature is 23 C and the outside is 0 C, estimate the rate of heat transfer through the window from inside to outside, Use typical numerical values for the heat transfer components. Assume the glass is a black body for the infrared radiation in the mid-long range wavelengths.

b) What is the total heat lost through one square meter of window over a typical heating season in Boston? Use the same assumptions used in part a.

c) Will the result in part b increase or decrease substantially when including each of the following: the window frame, air leakage, or solar radiation? Treat each of these individually. You do not need to do detailed calculations for part c.

2) (50) Consider what it takes to keep an indoor pool area at a comfortable temperature and humidity during the winter. Assume that there is one pool that is 50 m long and 20 m wide in a room that is 70 m long, 30 m wide and 10 m high. Assume that the pool room is to be kept at 28 degrees Celsius and 50 percent relative humidity and that the outdoor conditions are 0 degrees Celsius and 20 percent relative humidity.

- a) **(10) Calculate the latent heat load associated with evaporation of water from the pool.** Because the pool water is heated and air blows over the surface, some of the water near the surface of the pool evaporates into the air, removing heat from the pool water. Assume that 10 kg of water vapor per every 100 square meters of pool evaporates every hour. What is the latent heat load associated with evaporation from the pool?
- b) **(10) Determine the sensible heat fraction.** The latent heat and sensible heat loads are both important for determining how to condition air to keep the room at 28 degrees Celsius and 50 percent relative humidity. Assume that the latent heat load you found in part a) is the only latent load on the room. Assume that you find that there are sensible heat losses from the room that are one third the magnitude of the latent heat gains. What is the sensible heat fraction, $SHF = (\text{Sensible heat load}) / (\text{Total heat load})$, for the room?
- c) **(10) Draw the condition line on the psychrometric chart.** The condition line is the line on the psychrometric chart which defines the state of air supplied to the room to maintain desired indoor conditions. In general, the supply air state can be anywhere on this line. The slope of this line can be found using the SHF and the gauge in the upper left hand corner of the psychrometric chart.
- d) **(20) Determine the temperature and relative humidity of the supply air delivered to the room. Draw two lines on the chart representing the process to produce this supply air.** Assume that 20% of the air supplied to the room must be fresh, outdoor air. Mix the indoor air with outdoor air and sensibly heat it to achieve suitable supply air conditions in the most energy efficient way (a graphical solution is sufficient, you need not write equations). Draw the process lines on the psychrometric chart. What is the temperature and relative humidity of the supply air?

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