Fall'08
1.044J, 2.45J, 4.42J
Homework Set #6

1. A low density fiberglass insulation has an R value of 11 (BTU/hr ft^2 $^oF)^{-1}$ when used in a standard 2x4 wall cavity. To achieve a higher insulation, a contractor compresses the fiberglass so that there are two layers of the insulation in the 2 x 4 wall cavity. He states that the wall has an R value of 22. Do you agree? Explain.

2. A flat roof insulation system uses aluminum screws to hold down flat insulation panels. The screws are 1/4 inch diameter, 2 inches long and spaced 4 inches on center in a square array. The top of the insulation uses a thin aluminum sheet as a weather barrier and a reflective layer. Underneath the insulation is a corrugated steel roof. The insulation is two inches thick and has a conductivity of 0.015 BTU/hr ft ^oF. The screws pass through the insulation and are anchored in the corrugated roof. The effective U value of the insulation system plus screws is defined as U=q(total)/A(total)ΔT where q(total) is the sum of the heat transfer through the aluminum screws and the insulation. Assume that the convective heat transfer coefficient on the inside of the corrugated surface and on the outside over the top of the thin aluminum sheet is 2BTU/hr ft^2 ^oF. Calculate the U value for two limiting cases: 1) There is large lateral heat transfer and the corrugated sheet and the thin aluminum are each at a uniform temperature and ; 2) there is no lateral heat transfer through the corrugated sheet and the aluminum panel, heat transfer through the screws and the insulation occur in parallel with no interaction between the heat flows in the respective cross-sections.

3. A window has two vertical panes of glass separated by an one inch air gap. The glass panes can be considered black bodies at uniform temperatures of 40^oF and 60^oF, respectively. Estimate the total heat transfer, convection plus radiation, through the window space. Note: convection through a vertical space is a very weak function of the layer height, as a first approximation this effect can be neglected.

4. How much does the result of problem 3 change if one glass pane has a low emissivity coating which reduces its emissivity to 0.2. Instead of the low emissivity coating, a third layer of opaque glass is placed midway between the two; how much is the convective heat transfer changed, is the radiation also changed?

5. Estimate the total heat loss from a wood frame house in the Boston area for the heating season of one year. Boston averages 5634 degree days for a typical heating year. The walls are 2 x 4 filled with fiberglass and covered with one inch of polyurethane foam insulation sheathing. The windows are double glazed with a low e coating. The attic has 10 inches of low density fiberglass insulation. Neglect heat loss from the foundation. The house is a single story with 2000 ft^2 of floor area. The perimeter is 220 ft. and the outside walls are 12 feet high. Fifteen percent of the outside walls are windows. There are 0.3 air changes per hour in the house. Neglect additional losses through doorways, etc. Use values from other homework problems or reference tables to determine U values.

6. A person is seated in a room which has still air. The room surfaces are all black and at the same temperature as the air, 70^{o}F. The person is now seated in front of a large window which is cold, 50^{o}F. The window and the person can both be considered as a black body. The rest of the room walls are still at 70^{o}F. Estimate how much the room air temperature must be increased for the person to have the same net heat loss from their entire body surface as in the original case without the window? In both cases the surface temperature of the person is unchanged. You will need to estimate some values of the convective and radiative heat.

7. Estimate the surface temperatures of all of the components in a typical 2 X 4 frame wall as seen in class. Estimate the average heat transfer rate per square foot of wall area. Take the inside air temperature as 68^{o}F and the outside air temperature as 30^{o}F. Be sure to include heat transfer through the wood stud.

8. A forced hot air system has 6 inch diameter ducts installed in an uninsulated attic. Heated air at 100F flows through the ducts at 10 ft/s velocity. The ducts are made of aluminum and the contractor neglects to insulate them. If the attic is at 40F estimate the U value from the heated air inside the duct to the cold attic air. If the duct is 10 feet long what is the rate of heat loss from the duct? Neglect radiation. How much will the air temperature inside the duct change due to this heat loss?

4.42J / 1.044J / 2.66J Fundamentals of Energy in Buildings
Fall 2008