**ABE 30800 HEAT AND MASS TRANSFER**

**EXAMPLES – RADIATION**

**Problem 1**: The sun can be treated as a blackbody is at temperature 5800 K. What is the wavelength λ1 below which 10% of the solar emission is concentrated? What is the wavelength λ2 above which 10% of the solar emission is concentrated? Determine the maximum spectral emission power of the sun and the wavelength at which this emission occurs?

**Problem 2**: The radiation emitted from the human body has been used for a variety of applications ranging from military night vision devices to diagnostic medical imaging. For thermoregulation, i.e., maintaining body temperature, human being has to lose energy. Consider a standing person (do not consider clothes) in the center of a large room. Approximate the person as a vertical cylinder of 1.8 m tall and 0.3 m diameter. Average surface temperature of the person is 33◦C, the room surface temperature is 20◦C, and the emissivity of skin surface is 0.95. Consult Appendix C.8 for properties of air. (1) Calculate the net radiative heat transfer between the person and the room. Neglect heat loss from the ends of the cylinder. (2) What is the wavelength λmax where the maximum amount of energy will be radiated? (3) What region (primarily) of electromagnetic spectrum is the radiation calculated in step 2? (4) If a detector is available that can detect only in the wavelength range λmax ± 5 μm, what fraction of the total energy from the human being will this detector be sensitive to? (5) Calculate the natural convection heat loss from this person for room air temperature of 20◦C. For the vertical surface of the cylinder, formulas for vertical plate can be used. Neglect heat loss from ends of this cylinder. (6) Compare the convective heat loss with radiative heat loss and state if they are close.

**Problem 3**: Consider a flat orange leaf of surface area 10 cm2 parallel to the ground. The top surface of the leaf radiates to clear night sky and the effective radiation temperature of the sky is assumed at 140 K. The leaf absorbs all incident radiation and its emissivity is 1. The bottom surface of the leaf radiates to the ground and the ground temperature is 7◦C. Both the top and bottom surfaces are also exchanging heat with the air through convection. The air temperature is 5◦C. Consider the leaf to be very thin so that theentire leaf (including the top and the bottom surfaces) is at one temperature. (1) By making an energy balance on the leaf involving the convection and the radiation, write an equation from which you can solve for leaf temperature. (2) For a convective heat transfer coefficient of 25 W/m2 ·K, calculate the leaf temperature.

(3) What would be the simplest or least expensive solution to prevent the leaf from freezing?

**Problem 4**: The thermocouple, a temperature measuring device, can introduce measurement errors due to its radiative exchange with the surroundings. Consider a cylindrical thermocouple sheath that is 4 mm diameter and with a surface emissivity of 0.5. It is kept horizontal during the measurement in a large room where the air can move only by natural convection. The air temperature is 25◦C and the mean radiant temperature of the wall surfaces is 35◦C. (1) What temperature will the thermocouple indicate? (2) What is the measurement error, i.e., the difference between indicated temperature and true air temperature?

**Hint**: Consider natural convection from the thermocouple and the air properties are provided in Appendix C.8.