**ABE 308 – Spring 2018**

**Homework 7 - OPTIONAL**

**Deadline Friday April 27 at 5pm (so solutions can be posted before the exam)**

**Total 140 Marks**

**Problem 1**

Ripening of tomatoes can be retarded by storing in atmospheres that are rich in CO2 that replaces the O2 in the tissues with CO2. After a certain time, sampling of tissue in a assumed **spherical tomato** stored in a CO2 rich environment was found to have a CO2 concentration of 0.17 kg/m3 at a non-dimensional radius (r/R) of 0.80.

(1) Calculate the concentration at the center at this time. The tomato surface is maintained at a CO2 concentration of 0.18 kgCO2/m3. The initial concentration of CO2 in the tomato is 0.02 kgCO2/m3. Assume K\*=1

(2) If a concentration of CO2 of 0.16 kg/m3 is required at the center for the completion of the diffusion process, what additional time is needed? The diffusivity of CO2 in tomato is 2.3×10-8 m2/s. The average radius of the tomatoes is 4cm.

(3) How would the time of exposure to CO2 to reach the same concentration of CO2 at the center change for tomatoes that are half the diameter? Note: Only a simple numerical calculation is necessary.

**[40 marks]**

**Problem 2**

Assuming that the earth is a blackbody, what is its emissive power (in W/m2.m) at the microwave wavelength of 105m. The average surface temperature of earth is 14oC. If the wavelength band for microwaves is 104 – 105 m, how much energy (in W/m2 of earth surface) of microwave radiation the earth would emit? Since you cannot find values of the fraction of energy emitted as a function of T, assume that fraction of energy can be calculated as an average.

**[20 marks]**

**Problem 3**

Consider a pig alone in a large barn exchanging thermal radiation with the inside walls of the barn. The surface area of the pig can be approximated as 2 m2, with its skin temperature of 35◦C and a skin emissivity of 0.90. The mean radiant temperature of the inside walls of the barn is 5◦C. (1) Calculate the net radiative heat exchange (loss) from the pig. (2) Calculate the thermal radiation emitted by the pig and explain the difference between it and what is calculated in step 1.

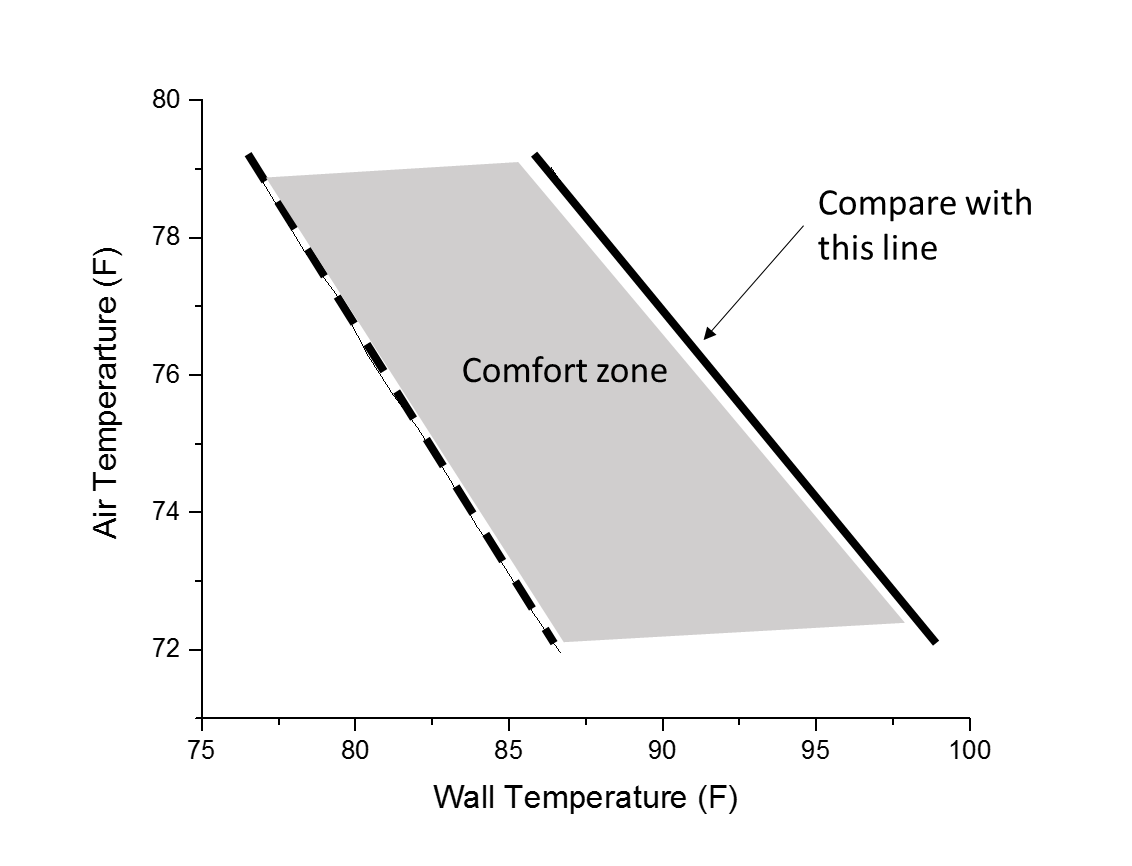
**[40 marks]**

**Problem 4**

It is necessary to develop a very simple model to describe the process of thermoregulation where both convective and radiative heat losses keep the body at steady state and in thermal comfort. Assume a person walking in a big mall and producing a heat generation of 90 W/m2 of body surface. The average surface area of the person body is assumed to be 2m2. The convective heat transfer coefficient can be assumed to be 12 W/m2.K. The clothed body temperature of the person is assumed to be 34oC; assume emissivity and view factor both equal to 1.

1. By ignoring evaporative cooling by sweeting, and considering only convective and radiative heat losses from the body derive an equation to estimate the air temperature as a function of the wall temperature for maintaining the same level of comfort (i.e. losing the same amount of heat) for the walking activity.
2. Compare the slope of the straight line obtained in (1) with the slope of the line in the figure below that is used to design heating/cooling temperatures to circulate in a temperature comfort zone. In the figure below, estimate qualitatively what condition the dashed line signify in terms of comfort?

**[40 marks]**

****