October 23, 2009 | Mid Term Exam | 120 minutes

75 Points Total – 5 questions, each worth 15 points

Open Book Exam – students are permitted to bring their course notes, assignments and the course text (**or** one other heat transfer book of their choice) into the exam. Other materials are not permitted. Programmable calculators are permitted in exams. Cell phones, PDA's, computers, and tape, CD and digital music players are not permitted.

For numerical questions – please show all work in the space provided.

For descriptive questions – please answer each question in a concise and clear fashion in the space provided using proper spelling and grammar.

15

Question 1 (3 points each, 15 points total)

a) What are the three modes of heat transfer? Which mode of heat transfer would be of greatest importance in space applications?

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The three modes of heat transfer include conduction, convection and radiation. Radiation is of greatest importance in space applications because it can transfer heat through a vacuum.

b) Briefly explain the difference between the thermal energy storage and thermal energy generation terms in an energy balance. What is an example of thermal energy generation?

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Thermal energy storage is energy stored in the control volume either by increasing its temperature or by causing a phase change. Thermal energy generation is when energy of another kind is converted to thermal energy inside a control volume.
Heat generation from a current carrying wire, $P = I^2R$, is thermal energy generation.

c) What is the maximum thickness of copper plate that can be treated using the lumped heat capacity method if the plate is heated on one side by a gas stream that is at 800°C (convection heat transfer coefficient of 20 W/m^2·°C) and the other side is perfectly insulated?

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from table A.1 for copper $k = 401 \frac{W}{mK}$

$B_i < 0.1$ for lumped capacitance.

$\frac{hV}{A_s k} < 0.1$

$\frac{20 A_s L}{A_s 401} < 0.1$

$L < 2.005\ m$

$\therefore L_{max} = 2.004 m$

d) Is the heat transfer rate constant in a cylinder under steady state conditions in which there is no thermal energy generation? How about the heat flux?

3

The heat transfer rate is constant because the temperature of the cylinder is not changing. The heat flux is not constant because