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ID #: _____

University of Saskatchewan
Department of Mechanical Engineering
ME 327 – Heat Transfer

October 16, 2008	Mid Term Exam	90 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.

Question 1 (3 points each, 15 points total)

a) Briefly explain one difference between thermodynamics and heat transfer.

b) A home improvement store is selling an insulation that has an RSI-value of 3.85. If the nominal thickness of this insulation is 140 mm, what is its thermal conductivity?

c) Two objects are cooled by placing them on a table. The first is allowed to cool on its own, while the second is cooled using a fan. For which of the two objects is the lumped heat capacity method more likely to be valid? Why?

d) Write the basic equation we have used in ME 327 to perform energy balances on a rate basis for a control volume. How (and why) does this equation change when we perform an energy balance on a surface?

e) Write Fourier's law. Why is there a minus sign in this equation?

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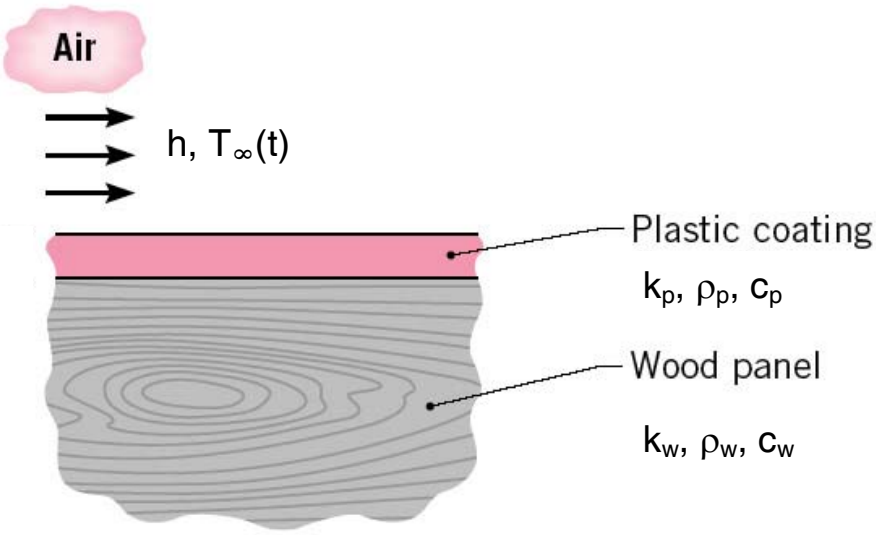
Question 2 (5 points each, 15 points total)

Write the appropriate form of the Fourier field equation, and the boundary and initial conditions that you would use to solve your differential equation for each of the following situations. Clearly state the assumptions that you have used to develop your differential equation, and boundary and initial conditions. **You do <u>not</u> need to solve the differential equation.**

a) A 25 mm thick wood panel, which is covered by a 3 mm thick plastic coating, is attached to the walls of an environmental chamber for a standard test. Prior to testing, the temperature in the panel and plastic coating is T_i. The temperature in the chamber is controlled so that it increases during the test, while the convection heat transfer coefficient remains constant. Derive equations for the temperature distributions inside the plastic coating and the wood panel for the first minute of the test.



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b) The outer surface of a spherical satellite in space is exposed to a net heat flux of q_o" due to solar radiation. The inner surface of the outside shell of the satellite is very well insulated in order to protect the electronics inside the satellite. Determine the steady-state temperature distribution in the outer shell of the satellite.

c) A hot fluid run through a pipe, such that the inside surface temperature of the pipe remains at T_{S1}. The inner diameter of the pipe is D_i, while the outer diameter is D_o. The pipe is partially buried in the ground such that half of the pipe is above the surface, while the other half is buried in the ground. The temperature across the portion of the outer surface of the pipe that is buried is T_g. The convection heat transfer coefficient on the exposed outer surface of the pipe is h_o and the ambient temperature is T_∞. What is the temperature distribution within the pipe?

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Question 3

a) Consider a 1.2 m high by 2 m wide glass window with a thickness of 6 mm which is located on the exterior wall of a living room. The outside air temperature is -5°C, while the room temperature is maintained at 20°C. The convection heat transfer coefficients on the inner and outer surfaces of the window are 10 $W/m^2.°C$ and 25 $W/m^2.°C$, respectively. Determine the rate of heat transfer through the window and the temperature on the inner surface of the window, assuming that radiation heat transfer is negligible. (10 points)

b) How would the rate of heat transfer change if the outside air temperature was -40°C and the room temperature remained at 20°C? (5 points)

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Question 4

a) One end of a 0.3 m long copper rod is connected to a wall, which is at a temperature of 200°C. The other end is connected to a second wall, which is maintained at 95°C. Air is blown across the rod and the convection heat transfer coefficient is estimated to be 15 $W/m^2 \cdot °C$. If the diameter of the rod is 5 cm, and the ambient temperature is 30°C, what is the rate of heat transfer by convection from the rod to the air? (10 points)

b) What is the difference between fin efficiency and effectiveness? Which of the two quantities would be best to use when determining whether or not to use fins on a surface? (5 points)

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Question 5

a) In order to ensure food safety, regulators specify that a particular meat product must be kept at a temperature of at least 120°C for 20 minutes during preparation. A large slab of this meat is 20 mm thick, and is at a uniform temperature of 20°C when it is placed in an oven which is kept at a temperature of 220°C. The convection heat transfer coefficient inside the oven is estimated to be 20 $W/m^2 \cdot °C$.

   Calculate the minimum length of time the meat must remain in the oven to conform to the above food safety regulation. Assume the following thermal properties for the meat: thermal conductivity = 0.5 $W/m \cdot °C$, density = 1000 kg/m^3 and specific heat = 4000 $J/kg \cdot °C$.
   (10 points)

b) If the meat temperature is higher than 175°C damage will occur. Will the exposure time calculated in part (a) be acceptable, based on this criterion? (5 points)