Mock First Examination 28 February, 2000

Part I. (Closed Book)

1. (25 points)
   a. What is Fourier's Law?
   b. What is a heat transfer coefficient?
   c. What is the Biot number?
   d. Why can we describe a conduction process by an equivalent electrical circuit?
   e. What is Separation of Variables and where can the technique be used?

2. (25 points)
   The clay-firing kiln oven in a 250-year-old colonial farm is lined with three layers of brick. The inside wall is made of silica brick (4 in. thick); covered with masonry brick (8 in. thick) while the outside layer is common brick (6 in. thick). During operation, the inside wall reaches 1000 °F and the outside surface is 130 °F.

<table>
<thead>
<tr>
<th>Brick Type</th>
<th>$k$ (W/m°C)</th>
<th>$c_p$ (kJ/kg°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica brick</td>
<td>2.47</td>
<td>0.84</td>
</tr>
<tr>
<td>Masonry brick</td>
<td>1.04</td>
<td>0.69</td>
</tr>
<tr>
<td>Common brick</td>
<td>0.69</td>
<td>0.84</td>
</tr>
</tbody>
</table>

   a) Calculate the heat loss through the wall in BTU/ft²-hr
   b) Determine the temperatures at the interfaces between the brick layers.
Chemical Engineering 333
Heat Transfer

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Part II. (Open Book)

3. (25 points)
You have been asked to specify the material for a finned surface to cool a computer chip. The heat production of the chip during operation is 1 watt. The surface area of the chip is 15 cm\(^2\). The fins are 3 cm long, 1.5 cm high, and 1 mm thick. There are 10 such fins on the chip. The convective heat transfer coefficient for heat transfer from the fin to the air has been determined to be 15 watts/m\(^2\) °C. The air temperature is 25°C.

a) What is the temperature of the chip if the fins are 100% efficient?
b) What should the minimum thermal conductivity of the fin material be to ensure that the chip surface temperature is less than 35°C?

Reference - Incropera and Dewitt section 3.6

4. (25 points)
Electrical heater wires are installed in a solid wall having thickness of 10 cm and \(k = 2.75 \text{ W/m·°C}\). The right face is exposed to an environment with \(h = 50 \text{ W/m·°C}\) and \(T_\infty = 30\text{°C}\), while the left face is exposed to an environment with \(h = 75 \text{ W/m·°C}\) and \(T_\infty = 50\text{°C}\). What is the maximum allowable heat generation rate such that the temperature does not exceed 300°C?