Module 04 Heat Transfer Problem

(You may screen shot or paint this page and insert in in your exam package to save time)

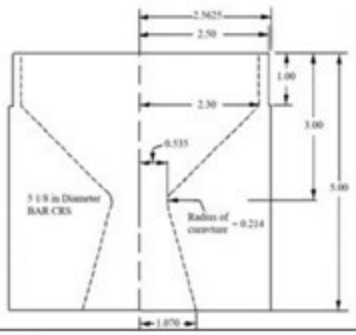
1. **Name:** _____
2. **Given:**

A small test rocket uses heat sink cooling of the nozzle throat by making this part out of a thick metal. The baseline nozzle material is **steel** and the alternative material is **copper**.
Assume 1-D transient conduction in the metal and that the thickness of the nozzle material is much greater than the heat-affected zone.

For the $(T_\infty - T_i)$ term use:

- Temperature of Throat = $2667.2K = T_\infty = T_x$
- Initial Temperature = $298K = T_i$

4. **Schematic**



Material Properties

Steel	Copper
$h = 10{,}000\ W/(m^2 \cdot K)$	$h = 15{,}100\ W/(m^2 \cdot K)$
$k = 60.5\ W/(m \cdot K)$	$k = 380\ W/(m \cdot K)$
$\alpha = 17.7 \times 10^{-6}\ m^2/s$	$\alpha = 7.75 \times 10^{-6}\ m^2/s$
$T_{melt} = 1643K$	$T_{melt} = 1185\ K$

5. **Find:**
   a) A plot of the steel thermal profiles (x from 0.0 to 3.0) at 2, 5, 10 and 15 seconds.
   b) Determine the time when steel reaches melting point.
   c) A plot of the copper thermal profiles (x from 0.0 to 3.0) at 2, 5, 10 and 20 seconds.
   d) Determine the time when copper reaches melting point.
   e) Compare the thermal properties of each material and describe the parameters help extend the possible test and why they effect the answer.
6. **Assume:**

7. **Analysis**
   - Show equations used in symbolic form.
   - You do not have to show sample calculations with units.
   - You can use the software developed on your homework assignment to make the calculations.
   - Put a screen shot of tabular data and graphs in Exam Upload
   - Upload any software used to make your calculations

Write your answer to question (b) in the box below before the end of the exam period.