

Name: \_\_\_\_\_

A#: \_\_\_\_\_

**MAE 3440: HW #4**

Due January 31, 2020

1. A thin metallic wire of thermal conductivity  $k$ , diameter  $D$ , and length  $2L$  is annealed by passing an electrical current through the wire to induced a uniform volumetric heat generation  $\dot{q}$ . The ambient are around the wire is at a temperature  $T_\infty$ , while the ends of the wire at  $x = \pm L$  are also maintained at  $T_\infty$ . Heat transfer from the wire to the air is characterized by the convection coefficient  $h$ . Obtain an expression for the steady-state temperature distribution  $T(x)$  along the wire.

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2. A long, circular aluminum rod is attached at one end to a heated wall and transfers heat by convection to a cold fluid.

- (a) If the diameter of the rod is tripled, by how much would the rate of heat removal change?
- (b) If a copper rod of the same diameter is used in place of the aluminum, by how much would the rate of heat removal change?

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3. A brass rod 100 mm long and 5 mm in diameter extends horizontally from a casting at 200°C. The rod is in an air environment with  $T_{\infty} = 20^{\circ}\text{C}$  and  $h = 30 \text{ W/m}^2\text{-K}$ . What is the temperature of the rod at 25 mm, 50 mm, and 100 mm from the casting?

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4. In this problem you will be comparing the derived Fin equations for the different tip conditions (convective, adiabatic, and infinite fin) to an Energy 2D model. Specifically, you will compare the temperature distribution and the fin heat rate (per unit depth into the page/screen) for a straight fin. Complete the following table and plot the temperature distribution for each case using each end condition along with the averaged temperature data from each case in Energy 2D.

The fin dimensions are fixed with a length of 6 m and a thickness of 0.5 m. The equations derived in the book were based on 2D analysis and then presented based on 3D geometry. In this case you will be analyzing an infinitely deep fin so we will calculate the heat rate on a per unit depth into the page/screen. In order to do this we must assume  $P = 2D$  and  $A_c = tD$ . With those assumed,  $m^2 = \frac{2h}{kt}$  and  $M = D\sqrt{2hkt}\Theta_b$ . With this, we can eliminate  $D$  from our heat rate equations to give  $q'_f = q_f/D$  and in Energy 2D, we can convert the measured heat flux to the heat rate per unit length using  $q'_f = q''_f * t$ .

For the data plots, use a plotting software of your choice and plot  $T$  vs.  $x$  separately for each case where the temperature distributions of the derived solutions are plotted as lines and the Energy 2D data points are individual averaged values at the location they were measured. For averaging your temperature and heat flux data, please allow the simulation to reach a steady state condition (not changing with time). This could take a couple minutes so plan ahead. An example plot is given below the table to be completed. In addition to completing the table and making 4 plots, comment on which end condition is most appropriate for each case and which end condition is most appropriate for all cases (if you're lazy and don't want to calculate them all). Explain any difference you see between the Energy 2D data and the 3 models and provide your reasoning for the difference.

case	$k_{fin}$ W/m-K	$h$ W/m <sup>2</sup> -K	$mL$	$q'_f$ convective	$q'_f$ adiabatic	$q'_f$ infinite	$q'_f$ E2D
1	10	3					
2	30	3					
3	100	6					
4	400	7					

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