**Sibley School of Mechanical and Aerospace Engineering**

**MAE 3240 Heat Transfer**

Spring 2026

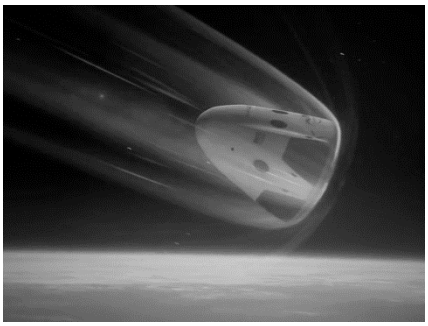
---

Problem Set #1

Posted: Monday, Jan 26 **Due: Tuesday, Feb 3, 11:59 pm**

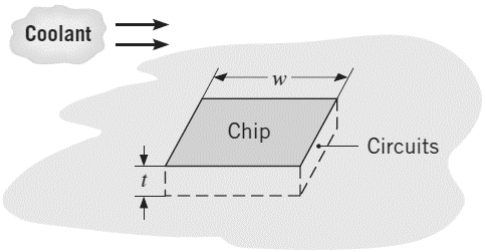
---

1. (30 pt) Consider a spacecraft traveling in the space *outside* the atmosphere, discuss the dominant heat transfer mode across the spacecraft and briefly explain. After completing the space exploration mission, this spacecraft returns to earth by traveling *through* the atmosphere. Please discuss the dominant heat transfer mode across the spacecraft and briefly explain.



*Note: you do not need to follow the recommended format for this problem, since this is a short-answer problem.*

2. (30 pt) A square silicon chip ($k$ = 150 W/(m·K)) is of width $w$ = 5 mm on a side and of thickness $t$ = 1 mm. The chip is mounted in a substrate such that its side and back surface are thermally insulated. The front surface is exposed to a coolant with convective flows. The chip dissipates 9 W energy under steady-state operation. Assume that thermal radiation is negligible in this problem. The coolant temperature is $T_\infty$ = 20 °C.




   (a) What is the steady-state temperature difference between back and front surfaces of the chip?

   (b) If the front surface temperature of the chip cannot be above 80 °C, calculate the minimum heat transfer coefficient required for the coolant flow. Compare your calculation with heat transfer coefficients shown in Table 1.1 of the textbook and discuss what convection processes can be used to cool this chip.

3. (40 pt) The emissivity of a roof material is $\varepsilon = 0.18$. The absorptivity of this material for solar irradiation is $\alpha_s = 0.76$.



(a) Consider a day of solar irradiation $G_s = 750$ W/m$^2$, ambient temperature $T_\infty = 300$ K, surrounding temperature $T_{surr} = 300$ K, and heat transfer coefficient of air flow $h = 10$ W/(m$^2\cdot$ K), calculate the temperature of the roof. Assume the bottom surface of the roof is thermally insulated. Assume the roof can be treated as a grey body to the irradiation of surrounding environment. Would the neighboring cat be comfortable walking on the roof constructed by this material?

(b) According to your calculation, discuss the dominant heat transfer mode in (a).