Homework 6

Homework due Apr 2, 2021 23:14 CDT Past due

Due Date

Friday, 4/2 at 11:59 PM ET *(4/3 at 03:59 UTC)*

Directions:

1. Answer each of the homework problems listed below.
2. Click the **Click here to open Gradescope button** below to access Gradescope.
3. Follow the prompts to submit your PDF to the assignment **HW 6**.

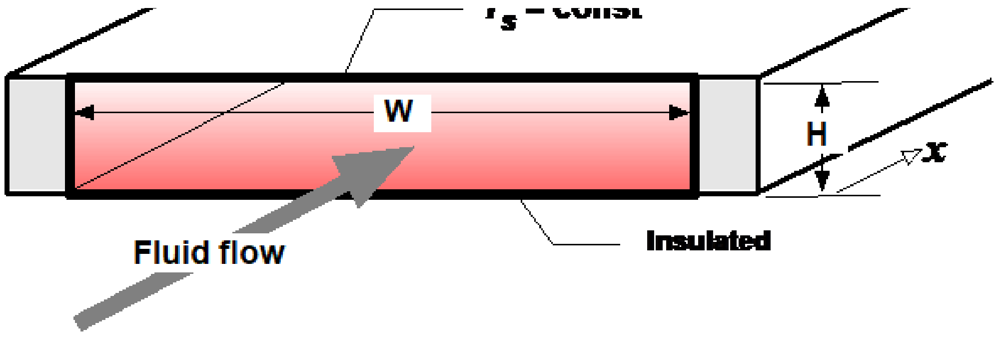
   Refer to the *Submitting Assignments With Gradescope* section of this course if you need a reminder of how to submit your assignment in Gradescope.

Homework Information and Guidelines:

1. Each student must turn in their own homework assignment and complete their own calculations, coding, etc. independently.
   - However, we encourage you to use most available resources including other textbooks, information from similar courses online, discussions with class and lab mates, office hours, etc. with the exception of using old solutions to the exact problems to complete the assignment.
   - Cite all your sources including discussions with colleagues and online websites. For example, if you and a friend compare answers or work together on a problem indicate this at the end of the problem. As an example, you might have a list like this at the end of each problem: "Resources used: [1] Fourier, J.B.J., *La Theorie Analytique de la Chaleur*, F. Didot, 1822. [2] Discussion with Joseph Fourier. [3] Wikipedia: Heat Flux, https://en.wikipedia.org/wiki/Heat_flux."
   - If we find papers with identical answers and approaches that do not indicate collaboration in the resource list, this is a violation of the academic honesty policy. Similarly, if your solutions match resources available online, this is a violation of the academic honesty policy.
2. Homework will be collected via Gradescope and is due at 11:59 PM ET. A grace period of 15 minutes is allowed in case of issues during the upload. Beyond that no late homework is accepted.
3. You may submit handwritten solutions or type up your solutions. We encourage you to use computer programs of your choice to solve problems, and some problems will require computational solutions. Recall "sketch" indicates you can draw something by hand, while "plot" indicates you should quantitatively calculate the curves and will likely use a computer program to create the graph. If "sketching" a curve, make sure trends, boundary conditions, etc. are clear.

Problem 1

Consider a fluid flow along a microchannel whose height is H and width is W (>>H) as shown below. The top surface maintains at a constant temperature, Ts, and corresponding heat transfer coefficient is *h*. The bottom surface is insulated. Assume the flow is fully developed both hydrodynamically and thermally. The mass flow rate is $\dot{m}$, and the mean velocity is V. Derive a differential equation to determine the mean temperature of the fluid. Then, determine the mean temperature as a function of x. You should clearly define your control volume and relevant heat transfer rates.

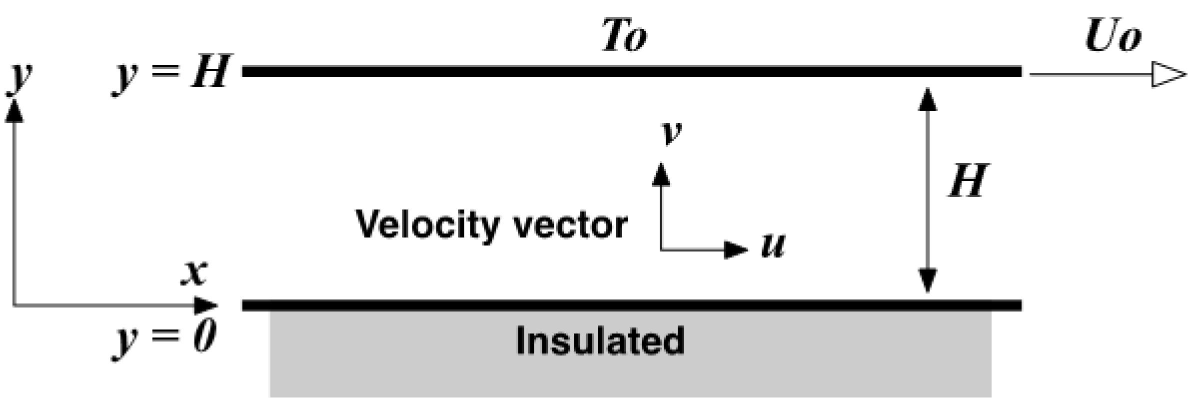


Problem 2

Consider a laminar, chemically reacting, plug flow that has a uniform velocity (*U*) between two parallel plates with a distance, *L*. The top plate is under constant heat flux (q''_s), while the bottom plate is insulated. The chemical reaction generates a uniform volumetric heat, q'''. Find an expression for temperature, T(*x,y*) in the thermally developed flow region using thermal conductivity *k* and other given parameters. Also plot the temperatures of both plates and the mean temperature as a function of *x* from the leading edge. State all assumptions clearly.

Problem 3

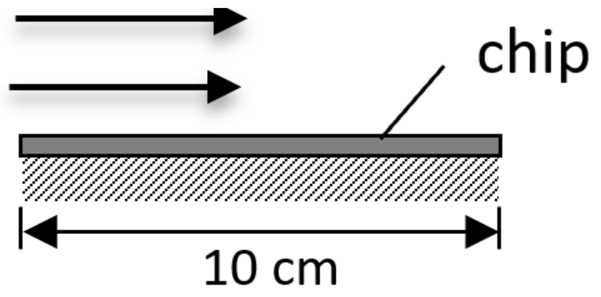
Consider a fluid between two infinitely large parallel plates, separated by a height H, as shown below. The top plate is moving at a constant velocity U_o and maintained at a temperature T_o. The bottom plate is stationary and insulated. Starting from the general governing equations discussed in the class, derive the continuity, momentum conservation, and energy conservation equations relevant to this specific problem. Assume that the flow between the plates is laminar, and the viscous dissipation is negligible. The fluid has constant properties, and gravity can be neglected.



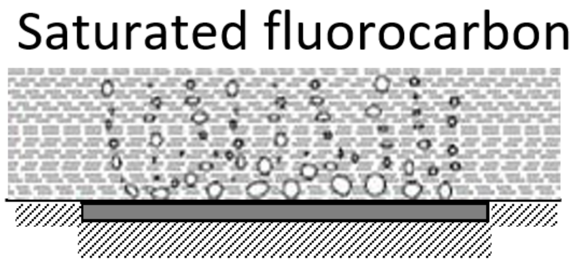
Problem 4

Advances in very large scale integration of electronic devices on a chip are often restricted by the ability to cool the chip. In a design, a thin film chip with a square cross section 10cm×10cm is mounted on a ceramic substrate. The chip dissipates heat 1,000 W, and for best operation, its average temperature should not exceed Tc = 100°C. The thickness of the chip can be neglected, and the bottom surface (ceramic substrate) can be assumed perfectly insulated.

- a) The conventional approach to cool the chip is to flow the ambient air at 20°C using a fan as shown below. Determine the minimum velocity of the air to maintain the chip temperature below Tc. Is this a reasonable cooling scheme? Properties of air are: $\nu = 20.92 \times 10^{-6}\ m^2/s$, $\alpha = 29.9 \times 10^{-6}\ m^2/s,\ k = 0.03$ W/m-K. Assume the chip is an isothermal flat plate and the boundary layer is tripped to turbulent from the leading edge of the chip.



- b) The alternative approach is to submerge the chip in saturated fluorocarbon liquid (*Tsat* = 57 °C) and boil this liquid as shown below. Determine the boiling mode and corresponding chip temperature. Properties of saturated fluorocarbon are: $c_{p,l} = 1,100$ J/kg-K, $h_{fg} = 84,400\ J/kg$, $\rho_l = 1619.2\ kg/m^3$, $\rho_v = 13.4\ kg/m^3$, $\sigma = 8.1 \times 10^{-3}\ kg/s^2$, $\mu_l = 440 \times 10^{-6}$ kg/m-s, and $Pr_l = 9.01$. The coefficients for the boiling correlations: $C_{s,f} = 0.005$ and $n = 1.7$



Gradescope (External resource) (100.0 points possible)

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Piazza

Post your questions/comments about Homework 6 to the *HW6* discussion forum in Piazza below (optional).

Piazza (External resource)

! This class has been made inactive. No posts will be allowed until an instructor reactivates the class.

Class at a Glance

Updated Just now. *Reload*

no unread posts

3 unanswered questions

5 unresolved followups

181 total posts
765 total contributions
178 instructors' responses
28 students' responses

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