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Exam 4

CM3110 Spring

Thursday 8 April 2021

Rules:

- Closed book, closed notes.
- Two-page 8.5" by 11" study sheet allowed, double sided; you may use a calculator; you may not search the internet or receive help from anyone.
- Please text clarification questions to Dr. Morrison 906-487-9703. I will respond if I am able.
- All work submitted for the exam must be your own.
- Do not discuss the contents of the exam with anyone before 11:59pm Thursday, 8 April 2021.
- *Please copy the following Honors Pledge onto the first page of your exam submission and sign and date your agreement to it.*

Honor Pledge:

On my honor, I agree to abide by the rules stated on the exam sheet.

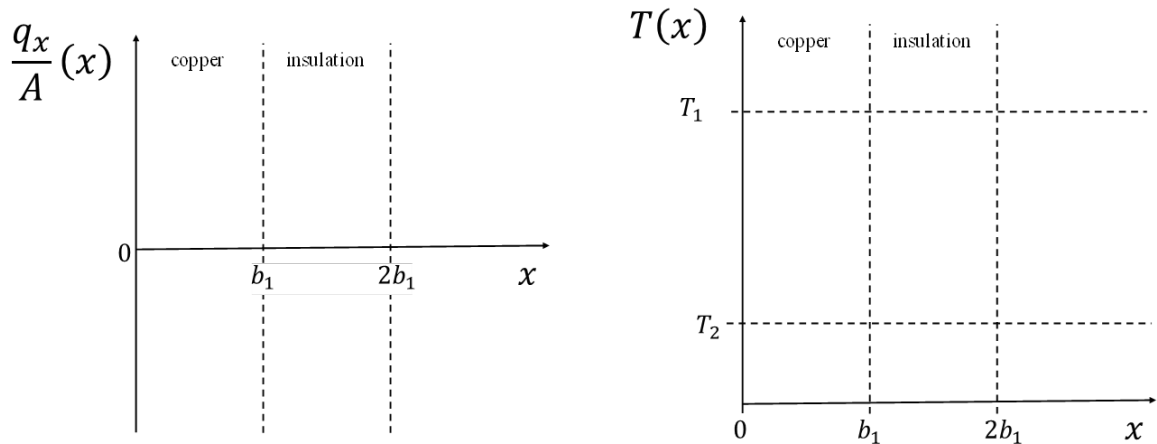
Signature _____

Date _____

Exam Instructions:

- You may work on the exam for up to two hours and 30 minutes (150 minutes).
- Please submit your exam work within 150 minutes of downloading the exam.
- Please be neat. Only neat answers will be granted partial credit. Please use a dark pencil or pen so that your work is readable once scanned.
- Significant figures always count.**
- Please box your final answers.
- Submit your work as a single PDF file; put your name on every page. (Genius Scan is a free app that can create a PDF from photos taken by your phone)
- Submit your exam study sheet as a separate PDF file; put your name on the first page (at a minimum)

- (20 points) How much heat (kW) would it take to raise the temperature of a liquid water stream flowing at 3.21 kg/s from $17^\circ C$ to $44^\circ C$?
- (20 points) Define thermal conductivity and explain how this quantity influences the heat-transfer behavior of materials (solids and fluids); contrast thermal conductivity with heat capacity. Please be concise.
- (20 points) A tall, deep composite wall is formed of copper (thermal conductivity k , thickness b_1) and insulation (much smaller thermal conductivity $k/10$, thickness also b_1). The left side of the composite wall is held at T_1 and the right side ($x = 2b_1$) is held at T_2 with $T_1 > T_2$. Sketch the following over the domain $0 \leq x \leq 2b_1$, using the axes provided below. Draw your profiles carefully.
 - Steady state flux of heat $\frac{q_x}{A}$ through the composite wall for $0 \leq x \leq 2b_1$
 - Steady state temperature distribution through the composite wall for $0 \leq x \leq 2b_1$



- (20 points) A tall, wide door constructed of steel (thermal conductivity k , heat capacity \hat{C}_p , density ρ) is part of a vacuum oven. The thickness of the door is D and the inside temperature of the door is T_1 . The vacuum oven sits in a large room that has a bulk air temperature of T_b ; note that $T_1 > T_b$. There are fans running in the room, and the heat transfer coefficient h between the oven door and the room air has been determined. What is the steady state temperature profile $T(x)$ through the thickness of the door? You may leave your answer as an equation with integration constants in it. For full credit you must clearly write the two equations needed to evaluate the integration constants (2 equations, 2 unknowns).
- (20 points) Water flows steadily in a Schedule 40 steel pipe (inner diameter = 1.05 inches , outer diameter 1.315 inches , length = 7.00 ft) in laminar flow (Reynolds number = 1.9×10^3). The inlet bulk temperature of the water is $15.0^\circ C$ and the outlet bulk temperature of the water is $60.6^\circ C$. What is the heat transfer coefficient that quantifies the heat transfer from the inner pipe surface to the bulk fluid? The temperature variation of the fluid viscosity near the pipe wall may be omitted from consideration in your calculations. Give your answer in $W/m^2 K$.