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Exam 1

CM3120

Wednesday 20 January 2021

Name:

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 midnight Wednesday 20 January 2021.
- ***Please copy the following Honors Pledge onto the first page of your exam submission and sign and date your agreement to it*.**

Honor's Pledge:

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

Signature ________________________________

Date _____________________

Exam Instructions:

i. You may work on the exam for up to two hours and 15 minutes (135 minutes).
ii. 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.
iii. Significant figures always count.
iv. Please box your final answers.
v. 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). If you take photos of your work, insert them into Word or Google Docs and create a PDF.
vi. Submit your exam study sheet as a separate PDF file; put your name on the first page (at a minimum)

1. (20 points) Saturated steam at 98^oC condenses in the outside chamber of a double pipe heat exchanger. The mass flow rate of the condensate is $1.5\ g/s$. What is the rate of heat flow from this stream? Give your answer in kW. A portion of the steam tables is included below.

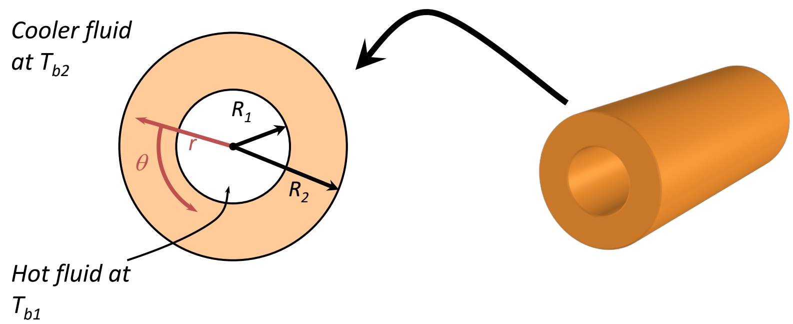
$T(oC)$	Vapor Pressure (kPa)	Specific Volume (m^3/kg)	Specific Volume (m^3/kg)	Enthalpy (kJ/kg)	Enthalpy (kJ/kg)	Entropy $(kJ/kg\ K)$	Entropy $(kJ/kg\ K)$
		Liquid	Sat'd Vapor	Liquid	Sat'd Vapor	Liquid	Sat'd Vapor
90	70.14	0.0010360	2.361	376.92	2660.1	1.1925	7.4791
95	84.55	0.0010397	1.9819	397.96	2668.1	1.2500	7.4159
100	101.35	0.0010435	1.6729	419.04	2676.1	1.3069	7.3549

2. (20 points)
    a. What is the definition of thermal conductivity? Give the units and the usual symbol.
    b. What is the definition of heat capacity? Give the units and the usual symbol.

More problems on the following pages
(5 problems total)

3. (20 points) A common boundary condition in heat transfer occurs when a liquid is in contact with a solid and the bulk fluid temperature is known. The boundary condition is called *Newton's law of cooling* ; this "law" serves as the definition of the heat transfer coefficient h.

   a. What is the equation for Newton's law of cooling?
   b. For one-dimensional radial heat conduction in an annulus (that is, a pipe, shown here), we can solve for the temperature profile in the pipe wall by simplifying and integrating the microscopic energy balance.

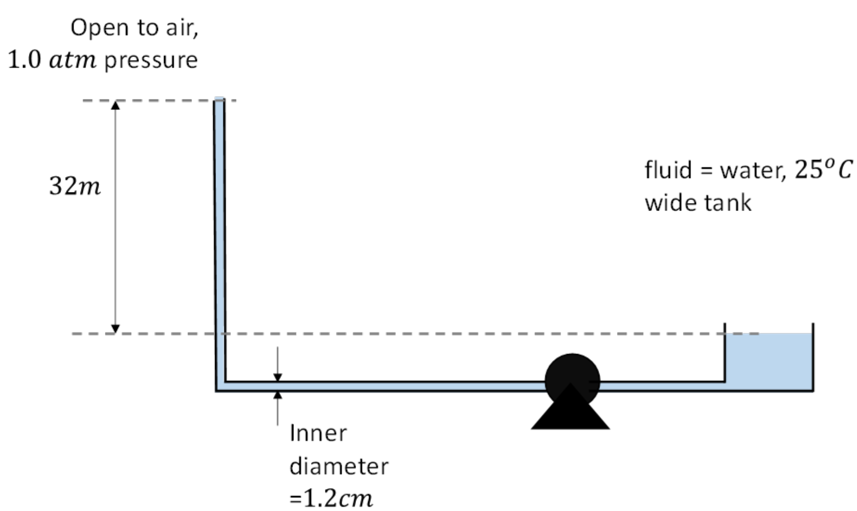


The result is the equation below for temperature as a function of radial position r, written in terms of two arbitrary constants of integration, C_1 and C_2.

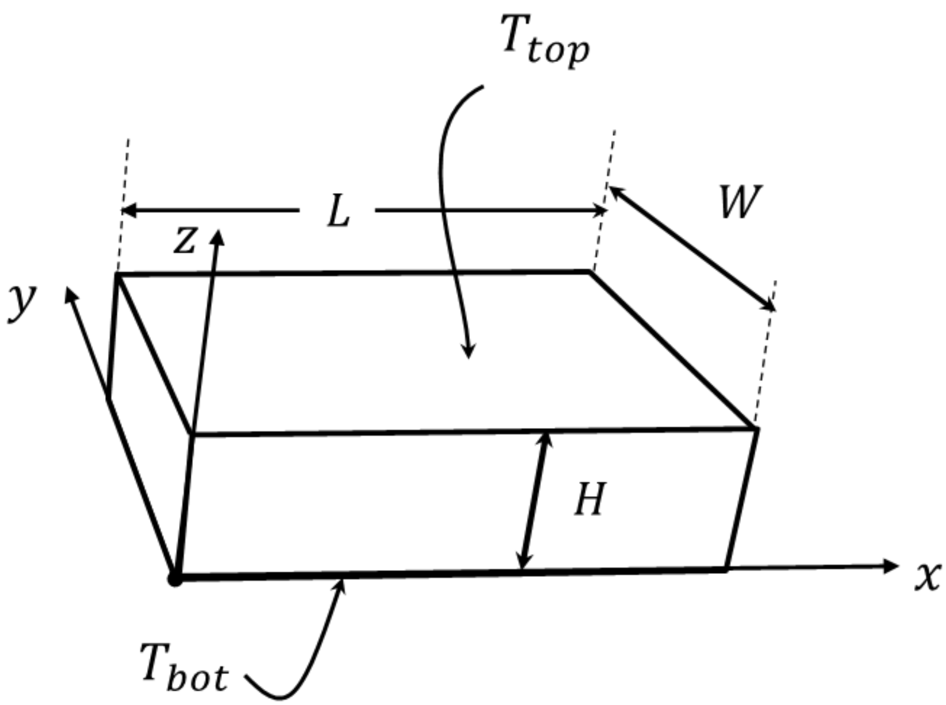
$$T(r) = C_1 \ln(r) + C_2$$

If the surface at R_1 is in contact with a fluid at temperature T_{b1}, and the surface at R_2 is in contact with a fluid at temperature T_{b2}, what are two equations we can write that will allow us to solve for C_1 and C_2? You do not need to solve for the integration constants; write the two equations in a form that can be solved directly for C_1 and C_2.

4. (20 points) What shaft work would be needed to be supplied by the pump to move water (25^oC) through the apparatus shown below at 2.5 gpm? There is a total of $105m$ of straight pipe in the apparatus. Do not neglect the friction of the straight pipe. Give your answer in W.



5. (20 points) What is the steady state temperature distribution $T(z)$ in a long, wide, rectangular nickel slab if the top is held at T_{top} and the bottom is held at T_{bot} (see figure below). The slab is of thickness H. Use the coordinate system shown and indicate the steps and assumptions that allow you to determine your answer.



- nickel slab
- $T_{top} > T_{bot}$