

Name: _____.

Mini-Exam 4

CM 3110

3 December, 2008

Note:

Significant figures count.

Please box your final answers.

Please show/explain your work.

Please be neat.

1. (50 points) A 2-4 shell-and-tube heat exchanger is used in a process. On the tube side (inside or cold side), water is heated from 25°C to 47°C (heat capacity = 4.182 kJ/kg K, thermal conductivity = 0.561 W/m K, mass flow rate = 4.9 kg/s, density = 996.08 kg/m³, viscosity = 8.937 x 10⁻⁴ Pa s). On the shell side (outside or hot side), a heat transfer oil enters at 90°C and exits at 79°C (heat capacity = 11.1 kJ/kg K, thermal conductivity = 1.24 W/m K, density = 988 kg/m³, viscosity = 1.51 x 10⁻⁴ Pa s).
 - a. What is the mean driving force for heat transfer in the 2-4 shell-and-tube heat exchanger?
 - b. If we used a double-pipe heat exchanger instead, and if the operating temperatures were all the same, what would be the driving force for heat transfer in the double-pipe heat exchanger?

2. (50 points) A black-top tennis court of dimensions 36 ft by 78 ft (10.97 m by 23.77 m) is heated by the sun to 50.0°C. The air over the surface is heated by natural convection and radiation and is at a bulk temperature of 35°C. Neglecting radiation, please estimate the total heat flow (kW) from the tennis court surface to the air. A table of the physical properties of air at various temperatures is attached. Note that for horizontal plates, L in the correlations is the average of the plate length and plate width.

BONUS ON OTHER SIDE

3. (Bonus: 12 points) The solar energy reaching the outskirts of the earth's atmosphere is known as the solar constant and it is equal to 1.4 kW/m^2 . If a flat plate is located in space just at the outer reaches of the earth's atmosphere and is hit by direct sunlight, a flux of 1.4 kW/m^2 will hit that plate.

The temperature of objects in space is roughly -270.425°C or 2.725 K .

A 1.00 m by 1.00 m square plate of steel (2.00 cm thick, thermal conductivity is 54 W/mK) is exposed to a heat flux of 1.4 kW/m^2 . The back side (away from the sun) of the plate is at a temperature of -270.425°C . What will be the temperature of the front side of the plate? You may consider only conduction (neglect any other heat effects).

Physical properties of Air at 1atms (absolute); from Geankoplis, Transport Processes and Unit Operations, 3rd Edition (Prentice Hall, Upper Saddle River, NJ, 1993)

T °C	T K	ρ kg/m ³	c_p kJ/kg K	μ Pa s	k W/mK	Pr	β 1/K	$g\beta\rho^2/\mu^2$ 1/K m ³
10.0	283.2	1.246	1.0048	1.78E-05	0.02492	0.713	3.53E-03	1.72E+08
35.0	308.2	1.148	1.0048	1.89E-05	0.02679	0.706	3.25E-03	1.18E+08
37.8	311.0	1.137	1.0048	1.90E-05	0.02700	0.705	3.22E-03	1.12E+08
42.5	315.7	1.121	1.0055	1.92E-05	0.02738	0.704	3.17E-03	1.06E+08
50.0	323.2	1.096	1.0066	1.96E-05	0.02799	0.704	3.10E-03	9.69E+07
65.6	338.8	1.043	1.0090	2.03E-05	0.02925	0.702	2.95E-03	7.75E+07
93.3	366.5	0.964	1.0090	2.15E-05	0.03115	0.694	2.74E-03	5.34E+07