Section: (circle one)

0A (9am)

0B (11am)

First 3 letters of last name:
(Print capitals)

CM3120 EXAM 2

Name:

Please put your name on the next page as well.

A.3-16 Thermal Conductivities, Densities, and Heat Capacities of Metals

Material	t (°C)	ρ $\left(\frac{kg}{m^3}\right)$	c_p $\left(\frac{kJ}{kg \cdot K}\right)$	$k(W/m \cdot K)$		
Aluminum	20	2707	0.896	202 (0°C) 230 (300°C)	206 (100°C)	215 (200°C)
Brass (70–30)	20	8522	0.385	97 (0°C)	104 (100°C)	109 (200°C)
Cast iron	20	7593	0.465	55 (0°C)	52 (100°C)	48 (200°C)
Copper	20	8954	0.383	388 (0°C)	377 (100°C)	372 (200°C)
Lead	20	11 370	0.130	35 (0°C)	33 (100°C)	31 (200°C)
Steel 1%C	20	7801	0.473	45.3 (18°C) 43 (300°C)	45 (100°C)	45 (200°C)
308 stainless	20	7849	0.461	15.2 (100°C)	21.6 (500°C)	
304 stainless	0	7817	0.461	13.8 (0°C)	16.3 (100°C)	18.9 (300°C)
Tin	20	7304	0.227	62 (0°C)	59 (100°C)	57 (200°C)

Source: L. S. Marks, *Mechanical Engineers' Handbook,* 5th ed. New York: McGraw-Hill Book Company, 1951; E. R. G. Eckert and R. M. Drake, *Heat and Mass Transfer,* 2nd ed. New York: McGraw-Hill Book Company, 1959; R. H. Perry and C. H. Chilton, *Chemical Engineers' Handbook,* 5th ed. New York: McGraw-Hill Book Company, 1973; National Research Council, *International Critical Tables.* New York: McGraw-Hill Book Company, 1929.

Mechanism	$h, \frac{BTU}{hr\ ft^{2\,o}F}$	$h, \frac{W}{m^2K}$
Condensing steam	1000-5000	5700-28,000
Condensing organics	200-500	1100-2800
Boiling liquids	300-5000	1700-28,000
Moving water	50-3000	280-17,000
Moving hydrocarbons	10-300	55-1700
Still air	0.5-4	2.8-23
Moving air	2-10	11.3-55

Reference: C. J. Geankoplis, Magnitude of Some Heat-Transfer Coefficients, page 241

1.	/20
2.	/20
3.	/20
4.	/20
5.	/20

Exam 2

CM3120

Tuesday 11 February 2020

Name:

Instructions:

i. Closed book, closed notes. One 8.5" by 11" study sheet allowed, two sided; you may use a calculator; you may not use the internet or a cell phone. All work on the exam must be your own.
ii. Write your solution on one side of the page only. Do not write on the back of any pages.
iii. Please be neat. Only neat answers will be granted partial credit.
iv. Significant figures always count.
v. Please box your final answers.

1. (20 points) To obtain heat transfer coefficients in turbulent fluid flow in pipes for real systems, we rely on data correlations from the literature (other people's data), For dimensionless heat transfer coefficient (Nusselt number) correlations for steady turbulent pipe flow, answer the following questions:
   a. What is the formula for Nusselt number? Identify each quantity that appears in the formula and give SI units (metric).
   b. For steady turbulent flow of liquids in pipes, what are the dimensionless numbers that appear in the correlation?
2. (20 points) Heat loss per area through the outside wall of a building is determined with an infrared sensor to be $140\ W/m^2$. The external surface temperature of the walls is 17^oC. The house is basically a cube ($13.45m$ square, $12m$ tall), covered with asbestos board. On the day of the measurement, the outside air temperature is $5^oC\ (41^oF)$. Under these conditions, what is the heat transfer coefficient between the wall of the house and the environment?
3. (20 points) A cube of copper (length of side = $5.0cm$) is subjected to annealing (heat treatment in a furnace) at 100.0^oC and subsequently placed in a 25^oC flowing air stream to cool. If the heat transfer coefficient in the air stream is $51\ W/m^2K$, what is the temperature of the cube after 30. seconds?
4. (20 points) A large, iron structure (approximate dimensions $3m \times 3m \times 3m$, iron) initially with a uniform temperature of 98^oC is exposed to outside air conditions (air temperature $= 25^oC$, heat transfer coefficient $= 2.0 \times 10^1 W/m^2K$). What is the wall temperature after 15 minutes?
5. (20 points) A hollow sphere of inner radius R_1 and outer radius R_2 is exposed to an external fluid at constant bulk temperature T_{b2}. The inside surface temperature of the spherical shell is maintained at constant temperature T_{w1} by an unspecified system. What is the steady state heat flux as a function of position in the hollow spherical shell? Note that outer surface temperature of the spherical shell is not equal to the bulk fluid temperature at that location.