CH EN 3453 – HEAT TRANSFER – FALL 2014

HOMEWORK #11

Due Monday, December 1 at 4:00 PM

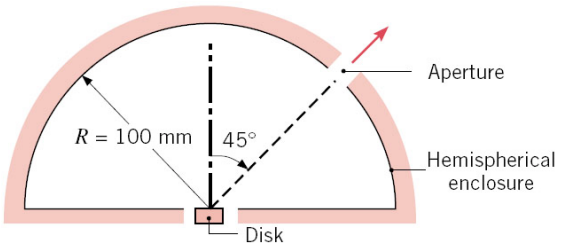
Turn in to the CH EN 3453 basket at the main desk of the Chemical Engineering offices (MEB 3290)

There is no help session for this homework assignment!

1.* (20 pts) An opaque surface, 2 m by 2 m, is maintained at 400 K and is simultaneously exposed to solar irradiation with G = 1200 W/m^2. The surface is diffuse and its spectral absorptivity is α_λ = 0, 0.8, 0 and 0.9 for $0 \le \lambda \le 0.5$ μm, $0.5 \le \lambda \le 1$ μm, $1 \le \lambda \le 2$ μm and $0\ \lambda > 2$ μm, respectively. Determine the following for this surface:

(a) Absorbed irradiation
(b) Emissive power
(c) Radiosity
(d) Net radiation heat transfer

2.* (20 pts) A small disk 5 mm in diameter is positioned at the center of an isothermal, hemispherical enclosure. The disk is diffuse and gray with an emissivity of 0.7 and is maintained at 900 K. The hemispherical enclosure, maintained at 300 K, has a radius of 100 mm and an emissivity of 0.85. Calculate the radiant power leaving an aperature of diameter 2 mm located on the enclosure as shown.



3.* (20 pts) A sphere (k = 185 W/m·K, $\alpha = 7.25 \times 10^{-5}$ m^2/s) of 30-mm diameter whose surface is diffuse and gray with am emissivity of 0.8 is placed in a large oven whose walls are of uniform temperature at 600 K. The temperature of the air in the oven is 400 K, and the convection heat transfer between the sphere and the oven air is 15 W/m^2·K.

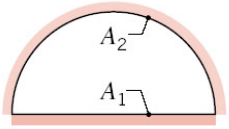
(a) Determine the net heat transfer to the sphere when its temperature is 300 K
(b) What will be the steady-state temperature of the sphere?

More problems on the other side…

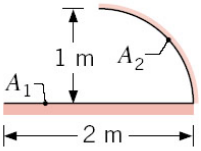
* Solutions for these problems are available on the course website: www.chen3453.com

4.* (20 pts) Determine F_{12} and F_{21} for the following configurations using the reciprocity theorem and other basic shape factor relations. Do not use tables or charts in the book. (Problem lettering matches online solutions.)

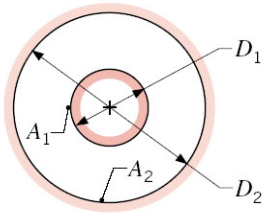
(c) Long duct. What is F_{22} for this case?



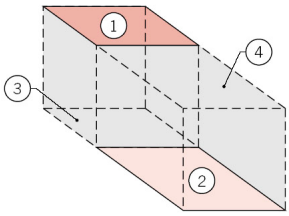
(g) Long, open channel



(h) Long concentric cylinders



5.* (20 pts) Consider the parallel rectangles shown schematically.



Show that the view factor F_{12} can be expressed as:

$$F_{12} = \frac{1}{2A_1}\left[A_{(1,4)}F_{(1,4)(2,3)} - A_1F_{13} - A_4F_{42}\right]$$

where (1,4) means the entire top surface and (2,3) means the entire bottom surface. All view factors on the right-hand side of the equation can be evaluated from Figure 13.4 (see Table 13.2) for aligned parallel rectangles.

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