

ME265: Thermal Engineering & Heat Transfer

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4.4 Radiation: View Factor

Radiation heat transfer between surfaces depends on the following:

- Temperature of the surfaces
- Surface radiative properties
- How well the surfaces can see each other

View Factor / Configuration Factor /
Shape Factor / Angle Factor

It accounts for the **geometrical features** for the radiation exchange between two surfaces.

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4.4 Radiation: View Factor

□ Definition and Formulation

View factor, F_{ij}

- the fraction of the radiation leaving surface i that is intercepted by surface j .

$$F_{ij} = \frac{q_{i \rightarrow j}}{J_i} \quad \dots \dots (4.11)$$

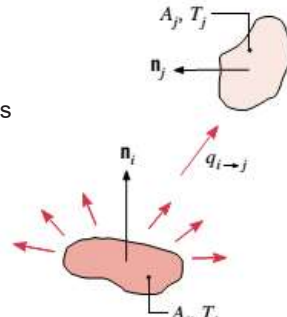


Fig. 4.4.12 Radiation exchange between surfaces

where

- $q_{i \rightarrow j}$: the radiative flux leaving A_i that is intercepted by A_j ;
- J_i : the radiosity of surface $A_i \Rightarrow$ the radiative flux leaving A_i in all directions.
- It is assumed that the surfaces are isothermal, diffuse, and have a uniform radiosity.

4.4 Radiation: View Factor

□ Definition and Formulation

$$F_{12} = \frac{1}{A_1} \int_{A_1} \int_{A_2} \frac{\cos \theta_1 \cos \theta_2}{\pi r^2} dA_2 dA_1 \quad \dots \dots (4.12a)$$

$$F_{21} = \frac{1}{A_2} \int_{A_1} \int_{A_2} \frac{\cos \theta_1 \cos \theta_2}{\pi r^2} dA_2 dA_1 \quad \dots \dots (4.12b)$$

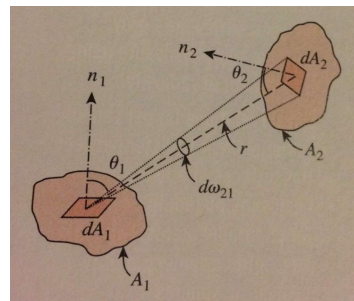


Fig. 4.4.13 Geometry for the determination of view factor

Therefore, $F_{12}A_1 = F_{21}A_2$

In general, $F_{ij}A_i = F_{ji}A_j \quad \dots \dots (4.13)$

This is termed as reciprocity relation

4.4 Radiation: View Factor

□ View Factor Algebra

1. Reciprocity relation

$$F_{ij}A_i = F_{ji}A_j$$

2. Visual Inspection

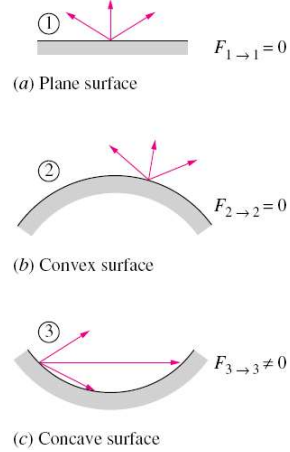
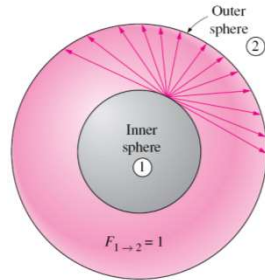


Fig. 4.4.14a View factors by inspection

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4.4 Radiation: Fundamentals

□ View Factor Algebra

3. Summation Rule

$$\sum_{j=1}^N F_{ij} = 1$$

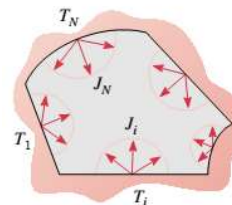


Fig. 4.4.14b Surfaces forming an enclosure

4. Symmetry rule

$$F_{12} = F_{13}$$

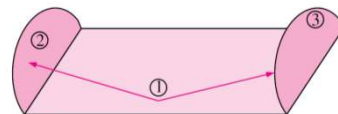


Fig. 4.4.14c Illustration of symmetry rule

5. Superposition rule

$$F_{1-(23)} = F_{12} + F_{13}$$

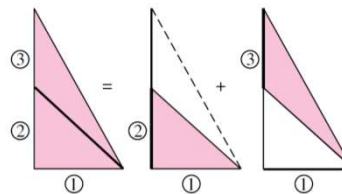


Fig. 4.4.14c Illustration of superposition

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4.4 Radiation: View Factor

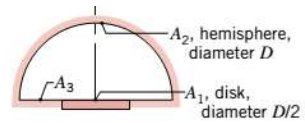
EP#6.2 View Factor examples

- (a) Hemisphere-disk enclosure-1
- (b) Hemisphere-disk enclosure-2
- (c) Long open channel

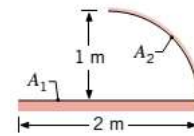
Find the view factors for the above cases



(a) Enclosure 1



(b) Enclosure 2



(c) Long open Channel

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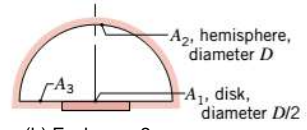


(a) Enclosure 1

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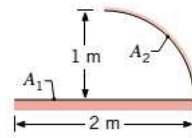


(b) Enclosure 2

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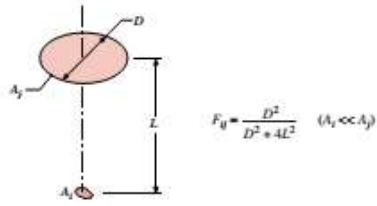
(c) Long open Channel

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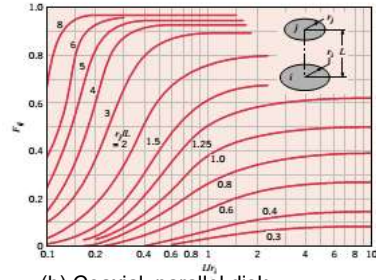
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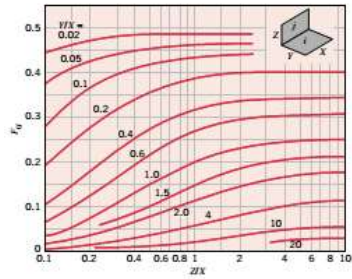
4.4 Radiation: View Factor



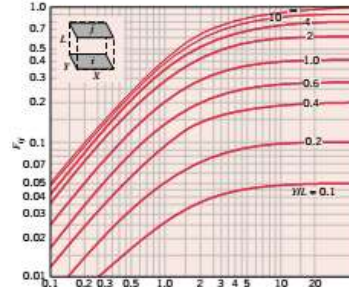
(a) Small coaxial, parallel disk



(b) Coaxial, parallel disk



(d) Perpendicular rectangles with common edge



(c) Aligned parallel rectangle

Fig. 4.4.15 View factors for 3D geometries

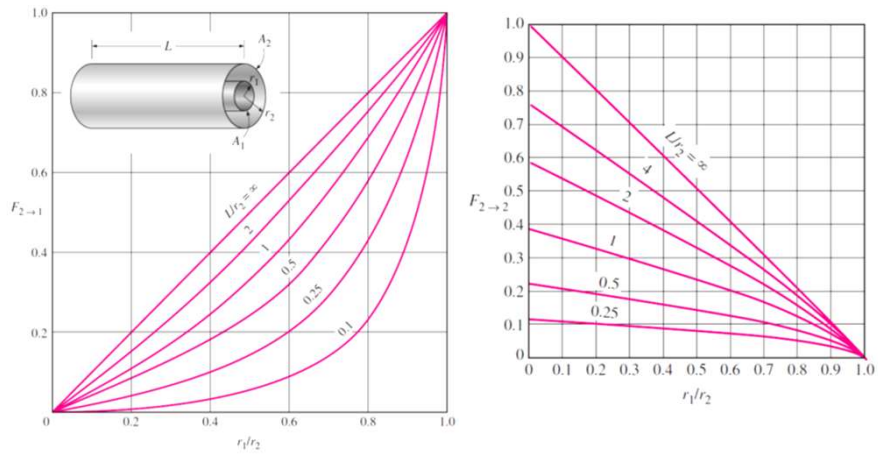


Fig. 4.4.15 View factors for 3D geometries: Concentric cylinder