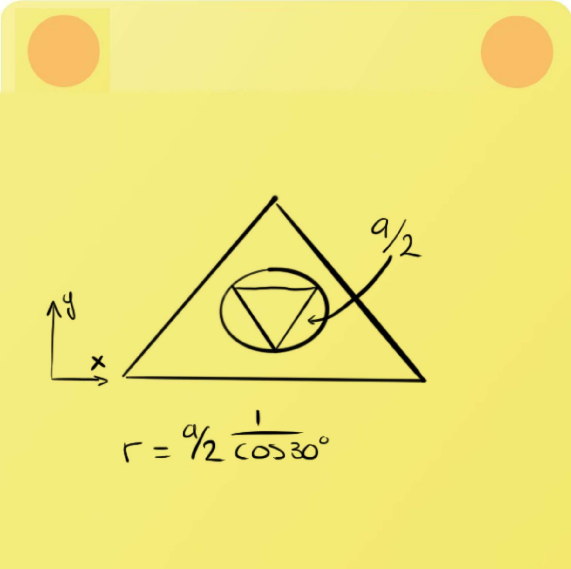
Exam Preparation - Radiation



Consider a circular pipe of radius $r = 4cm$ centered inside a triangular duct with all sides of the triangle $a = 10\ [cm]$. The pipe and duct have length $L = 10\ [m]$. The temperature of the duct is $T_d = 20\ [°C]$ and the temperature of the pipe $T_p = 100\ [°C]$. Both pipe and duct surfaces radiate as blackbodies.

(a) Determine the view factor Φ_{dp} from the duct to the pipe.

(b) Compute the *net* rate of heat transfer by radiation from the outside wall of the pipe to the inside wall of the duct.

(c) What is the maximum radius of the pipe that can fit in the duct ?

Circular pipe (p) in triangular duct (d)
$T_p = 100\text{C}$
$T_d = 20\text{C}$
$r = 0.04\,m$
$a = 0.1\,m$

a) $\Phi_{pd} = 1$
$\Phi_{pp} = 0$
$A_d\Phi_{d\to p} = A_p\Phi_{p\to d}$
$\Phi_{dp} = \frac{A_p}{A_d} = \frac{\pi DL}{3aL} = \frac{0.08\pi}{0.03} = 0.834$

b) $\dot{Q} = A_p\Phi_{pd}(T_P^4 - T_d^4) = \pi DL \cdot 0.836 \cdot 5.67 \cdot 10^{-8}(373^4 - 293^4) = 567\,W$

c) Max radius of pipe that fits in the duct: from center to middle of triangular side: $r_{max} = \frac{a}{2}\frac{1}{cos(30)}$
a = 10 cm
$r_{max} = \frac{a}{\sqrt{3}} = 0.058\,m$