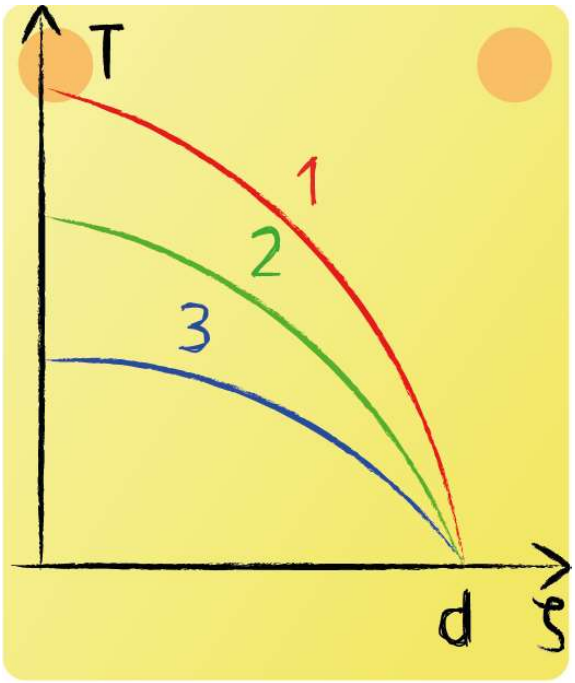
Lecture 13 - Question 3



A plate, a sphere and a cylinder are surrounded by a fluid with temperature T_∞ and convection coefficient α. All three object are made out of the same material with thermal conductivity λ. Heat is generated at the center of the objects at a constant rate $\dot{\Phi}'''$. For the plate ð= d and for the cylinder and sphere r_1 = d. Assign the temperature profiles to the corresponding objects.

1. Plate, 2. Sphere and 3. Cylinder.
Looking at the general temperature profile for a plate, cylindrical or spherical geometry and symmetry with source:

$$T(\zeta) = T_A + \frac{s^{\mathbf{2}}\cdot\Phi'''}{\mathbf{2}(n+\mathbf{1})\cdot\lambda}\left[1+\frac{2\cdot\lambda}{\alpha\cdot s}-\left(\frac{\zeta}{s}\right)^2\right]$$

The only difference is that for a plane n=0, for the cylinder n=1 and for the sphere n=2. At $\zeta = 0$ their temperatures will be respectively:

$$T_{plate}(0) = T_A + \frac{d^{\mathbf{2}}\cdot\Phi'''}{\mathbf{2}\cdot\lambda}\left[1+\frac{2\cdot\lambda}{\alpha\cdot d}\right]$$

$$T_{cylinder}(0) = T_A + \frac{d^{\mathbf{2}}\cdot\Phi'''}{\mathbf{4}\cdot\lambda}\left[1+\frac{2\cdot\lambda}{\alpha\cdot d}\right]$$

$$T_{sphere}(0) = T_A + \frac{d^{\mathbf{2}}\cdot\Phi'''}{\mathbf{6}\cdot\lambda}\left[1+\frac{2\cdot\lambda}{\alpha\cdot d}\right]$$

It can be seen that T for $\zeta = 0$ will be the biggest for the plate, and the smallest for the cylinder.