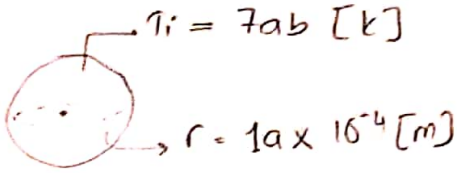
a)



c = 6ab [J/kg k]

k = 2a [W/m k]

ρ = 50ab [kg/m^3]

T = 4ab → find temperature of the object at the end of time = t.

$Bi = \frac{h L_c}{k}$ and $L_c = V/A_s$

$A_s = 4\pi r^2$

$V = \frac{4}{3}\pi r^3$

$\Rightarrow L_c = \frac{\frac{4}{3}\pi r^3}{4\pi r^2}$

$L_c = \frac{r}{3}$

Hence, $Bi = \frac{6ab \times 1a \times 10^{-4}}{2a \times 3}$

Check it if $Bi < 0.1$

For example, if a = 9, b = 1

$Bi = \frac{691 \times 19 \times 10^{-4}}{29 \times 3} = 0.015 < 0.1$ ✓

Now, we can apply Lumped capacitance method;

We need to calculate the time required for the object to reach 4ab [k] temperature.

That is;

$$\theta = T - T_\infty = 4ab - 3ab$$

$$= 100\ [k]$$

$$\theta_i = T_i - T_\infty = 7ab - 3ab$$

$$= 400\ [k]$$

time needed:

$$t = \frac{\rho V c}{h A_s} \ln \frac{\theta_i}{\theta}$$

$$t = \frac{50ab \times \cancel{4/3\pi r^3} \times 4ab}{6ab \times \cancel{4\pi r^2}} \times \ln\left(\frac{400}{100}\right)$$

$$t = \frac{50ab \times 10 \times 10^{-4} \times 4ab}{3 \times 6ab} \times \ln 4$$

b) $$t = \frac{\rho V_c}{h A_s} \ln \frac{\theta_i}{\theta} = \frac{\rho_c L_c}{h} \ln \frac{\theta_i}{\theta}$$

$$B_i = \frac{h L_c}{k} = \frac{6ab \times 1a \times 10^{-4}}{2a}$$

$$t = \frac{50\,ab \times 4ab \times 1a \times 10^{-4}}{6ab} \times \ln 4$$

c) $$L_c = t/2 = 10 \times 10^{-4}$$

$$B_i = \frac{6ab \times 1a \times 10^{-4}}{2a}$$

$$t = \frac{50ab \times 6ab \times 1a \times 10^{-4}}{6ab} \times \ln 4$$