MISCELLENEOUS FORMULAS

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$1\ W = 3.412\ Btu/h$

$$Nu = \frac{hL}{k} \qquad Bi = \frac{hL}{k} \qquad \alpha = \frac{k}{\rho c_p}\left[\frac{m^2}{s}\right] \qquad Pr = \frac{\nu}{\alpha} \qquad Re_L = \frac{uL}{\nu} = \frac{\rho u L}{\mu}$$

$$h = \frac{Nu \cdot k}{L} \qquad Fo = \frac{\alpha t}{L^2} \qquad \nu = \frac{\mu}{\rho}\left[\frac{m^2}{s}\right]$$

For circular pipes:

$$R_D = \frac{4\dot{m}}{\pi \mu D} = \frac{\rho u_m D}{\mu}$$

$$C = \frac{5}{9}(F-32)$$

$$F = \frac{9}{5}C + 32$$

$$C = K + 273$$

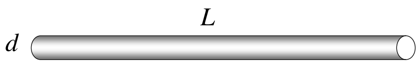
Rate of heat generation by electrical resistance (p.19, p.126)

$$q_g = \dot{E}_g = I^2 R'_e L = I^2 R_e \qquad R_e\ [\Omega] \qquad R'_e\ \left[\frac{\Omega}{m}\right]$$

$$q_g = \dot{q}V \qquad \dot{q}\ \left[\frac{W}{m^3}\right]$$

$$q_g = E \cdot I \qquad (\textit{electrical power, p.401})$$

For cylinder



$$\dot{q} = \frac{\dot{E}_g}{V} = \frac{I^2 R'_e L}{V} = \frac{I^2 R'_e}{\left(\frac{\pi d^2}{4}\right)} \qquad R_e = \rho_e \frac{L_e}{\left(\frac{\pi d^2}{4}\right)} \qquad q = I^2 R_e$$

ρ_e *electrical resistivity*

Rate of heat of vaporization (heating-off), p.120, p.634

$$q = \dot{m}_b \cdot h_{fg}\ [W]$$

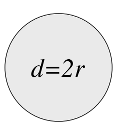
$\dot{m}_b$ *the rate at which liquid evaporates from the free surface (boils-off)* $\left[\frac{kg}{s}\right]$

Heat to melt volume V

$$Q = m \cdot h_{if} = (\rho V)\cdot h_{if}\ [J]$$

h_{if} *latent heat of fusion* (*p.24*) ($h_{ice\text{-}water} = 334$) $\left[\frac{J}{kg}\right]$

Circle



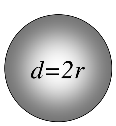
$$A = \frac{\pi d^2}{4} = \pi r^2$$
$$S = \pi d = 2\pi r$$

Characteristic Length $L_c = V/A_s$

for $Bi = \frac{hL_c}{k}$ (Lumped Capacitance)

for $Bi = \frac{hL_c}{k}$ (for Table 5.1 Approximate Solution)

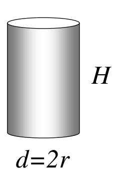
Sphere



$$A_s = \pi d^2 = 4\pi r^2$$
$$V = \frac{\pi d^3}{6} = \frac{4}{3}\pi r^3 \qquad L_c = \frac{d}{6} = \frac{r}{3} \qquad Bi = \frac{h}{k}\frac{r}{3} \qquad Bi = \frac{hr}{k}$$

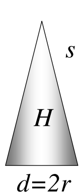
h is a convective coefficient

Cylinder

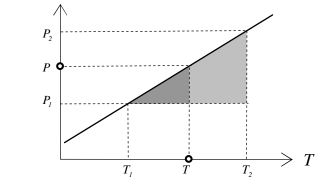


$$A_s = 2\pi r^2 + 2\pi r H \qquad L_c = \frac{d}{4} = \frac{r}{2} \qquad Bi = \frac{h}{k}\frac{r}{2} \qquad Bi = \frac{hr}{k}$$
$$V = \frac{\pi d^2}{4}h = \pi r^2 H$$

Cone



$$s = \sqrt{r^2 + H^2}$$
$$A_s = \pi r^2 + \pi r s$$
$$V = \frac{1}{3}\pi r^2 H$$



$$\frac{P - P_1}{T - T_1} = \frac{P_2 - P_1}{T_2 - T_1}$$

Linear Interpolation:

$$P = P_1 + \frac{P_2 - P_1}{T_2 - T_1}\cdot(T - T_1)$$