# FINS
# STUDY AID

## MECH-420 Heat Transfer

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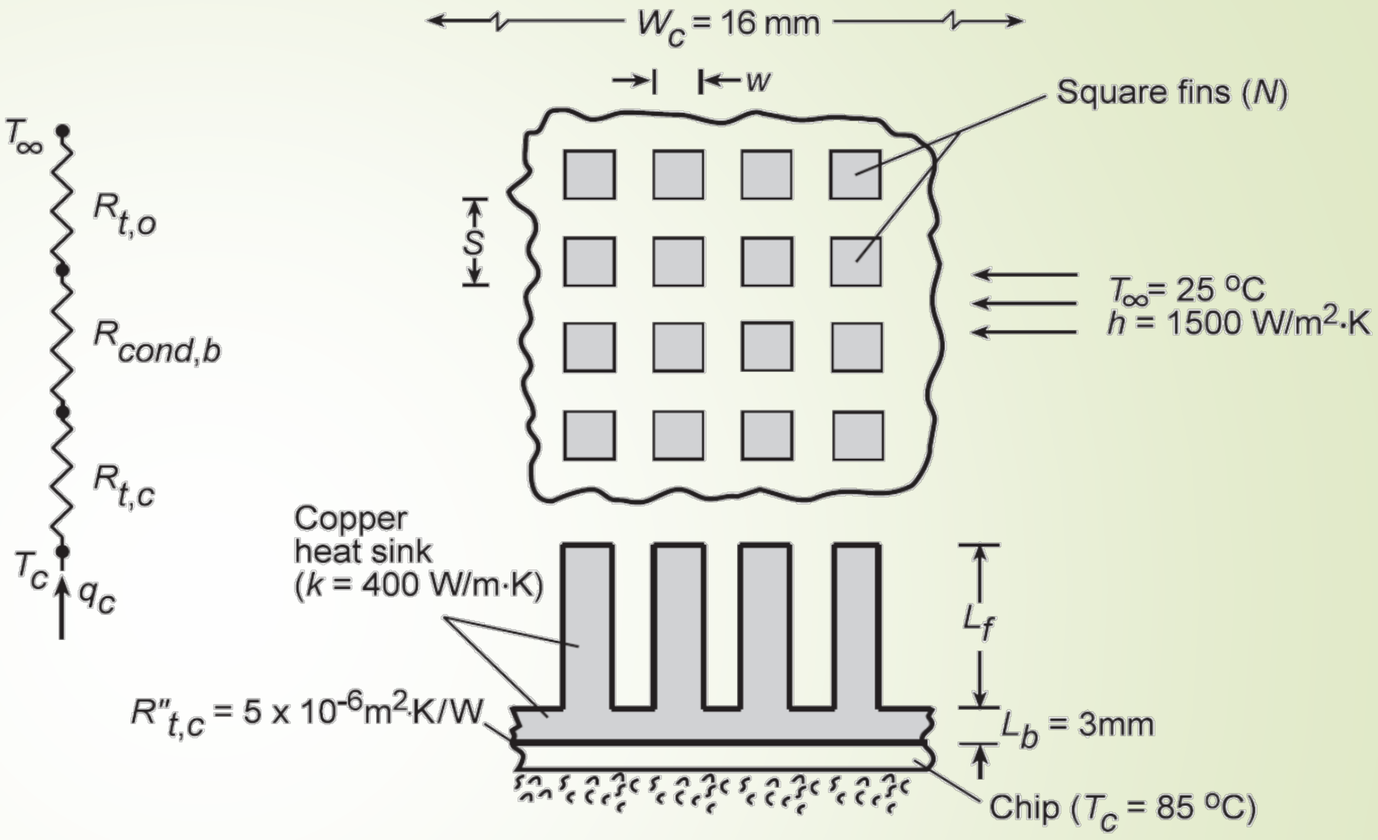
# FINS:
# EXTENDED SURFACES (CLICK)

**MECH-420 Heat Transfer**

**Section 3.6**


# Square Copper Heat Sink Fins attached to electronic chip.

Determine #fins required for desired power dissipation of 200W



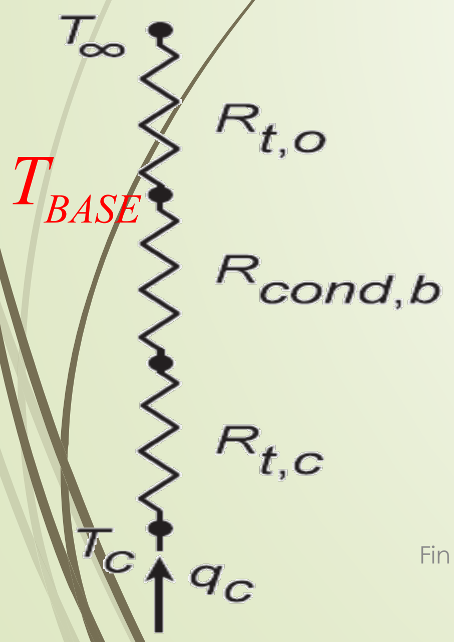
# Determine FIN Base Temperature Due to Contact Resistance

$k = 400 \frac{W}{m-K}$

$L_b = 3mm$

$L_f = 6mm$

$W_c = 16mm$




$$q = 200W = \frac{(T_c - T_{base})K}{\frac{R''_{tc}\left[\frac{m_2 - K}{W}\right]}{W_c^2[m^2]} + \frac{L}{kA}}$$

$W_C \rightarrow WIDTH$

$$T_{base} = T_c - q[\not{W}]\bullet\left(R''_{tc}\frac{\not{m_2} - K}{\not{W}}\left[\frac{1}{W_c^2\,\not{m^2}}\right] + \frac{L_b}{kA}\frac{m}{\frac{W-m^2}{m-K}}\right)$$

$$= 85C - \left[200W \bullet \left(\frac{5x10^{-6}}{\left(\frac{16}{1000}\right)^2} + \frac{3/1000}{400\frac{W}{m-K}\bullet\left(\frac{16}{1000}\right)^2}\right)\right]$$

$$= 85C - 200(0.01953 + 0.0293)$$

$$= 75.2C$$

# Find Heat Transfer for Single Fin (Case A)



$$k = 400\frac{W}{m^2-K}, h = 1500\frac{W}{m-K}, w = 0.25mm, T_\infty = 25C, T_b = 75.2C$$

$$P = 4w = 0.001m, L_f = 6mm$$

$$A_c = w^2 = 6.25E-08m^2$$

$$m = \sqrt{\frac{hP}{kA_c}} = \sqrt{\frac{1500\frac{W}{m-K}\bullet 0.001m}{400\frac{W}{m^2-K}\bullet 6.25E-08m^2}} = 245\frac{1}{meters}$$

$$M = \sqrt{hPkA_c}\theta_b = 0.006124\theta_b = 0.3074W$$

$$h/mk = 0.0153$$

$$mL = 1.47, \sinh(mL) = 2.06, \cosh(mL) = 2.29$$

$$q_f = M\frac{\sinh mL + (h/mk)\cosh mL}{\cosh mL + (h/mk)\sinh mL}$$

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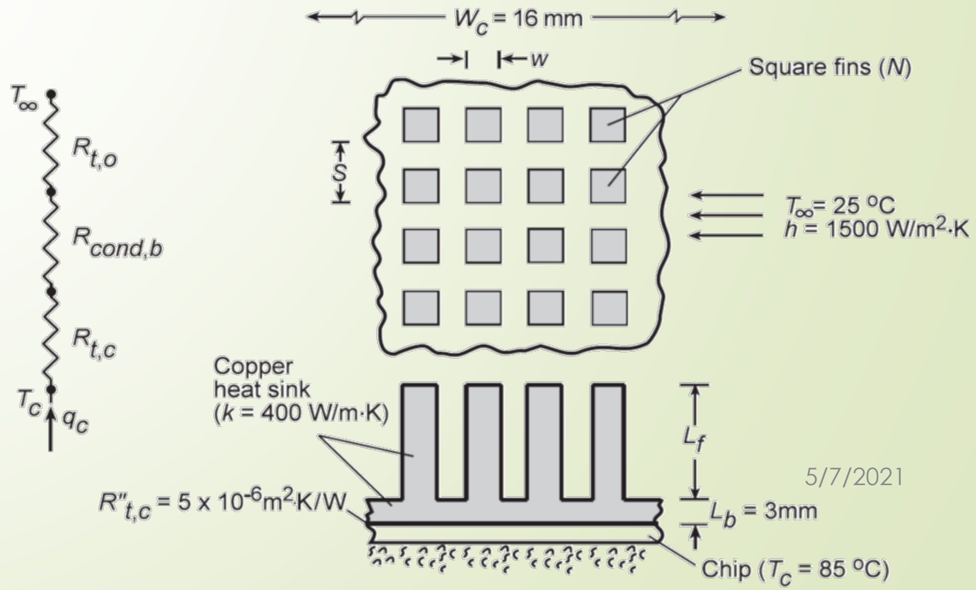
$$h/mk = 0.0153$$

$$mL = 1.47, \sinh(mL) = 2.06, \cosh(mL) = 2.29$$

$$q_f = 0.3074\frac{2.06 + 0.153\bullet 2.29}{2.29 + 0.153\bullet 2.06}$$

$$= 0.2844W$$



# Fin Efficiency

$$\eta_{fin} = \frac{\text{Fin Heat Transfer Rate}}{\text{MAX HEAT TRANSFER POSSIBLE}} = \frac{q_{fin}}{q_{max}} = \frac{q_{fin}}{hA_{FIN\ TOTAL}\theta_b} \rightarrow 0-1$$

$$A_{FIN\ TOTAL} = \text{TOTAL FIN AREA EXPOSED TO FLUID}$$

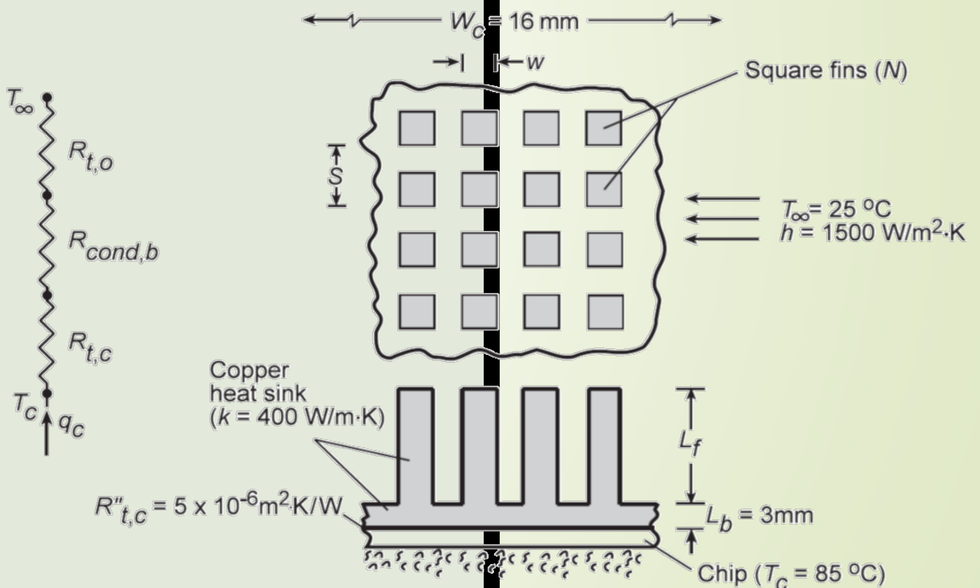
$$\theta_b = T_b - T_\infty$$

$$P = 4w = 0.001m, L_f = 6mm$$

$$A_{fin} = P \bullet L_{fin} + w^2 = 0.001m \bullet 0.006m = 6.0625x10^{-6} m^2$$

$$q_{max} = 1500 \frac{W}{m^2 - K} 6x10^{-6} m^2 (75.2 - 25) = 0.4518W$$

$$\eta_{fin} = \frac{0.2844}{0.4518} = 0.6295(63\%)$$



# MAX HEAT TRANSFER

$$q_{\max} = 1500\frac{W}{m^2-K}6x10^{-6}m^2(75.2-25) = 0.4518W$$

$$\eta_{fin} = \frac{0.2844}{0.4518} = 0.6295(63\%)$$

$$q_{\text{TOTAL}}[W] = N\eta_{fin}q_{MAXIMUM} + hA_0\theta_b \rightarrow \text{FIN BASE AREA}$$

$$A_0 = W^2 - w^2N \rightarrow$$

$$w = 0.25mm, \text{ W=16mm}$$

$$q_{\text{TOTAL}}[W] = N\eta_{fin}q_{MAXIMUM} + h\theta_b\left(W^2 - w^2N\right)$$

$$= N(\eta_{fin}q_{MAXIMUM} - h\theta_b w^2) + h\theta_b W^2$$

$$N = \frac{q_{\text{TOTAL}}[W] - h\theta_b W^2}{\eta_{fin}q_{MAXIMUM} - h\theta_b w^2}$$

$$= \frac{200 - 1500*50.2*0.016^2}{0.63*0.4518 - 1500*50.2*0.00025^2}$$

$$\approx 634 \text{ Fins (26x26 Fin Array @ Spacing 0.50mm/fin)}$$

$$= 13x13 \text{ mm}^2 \text{ Heat Sink}$$