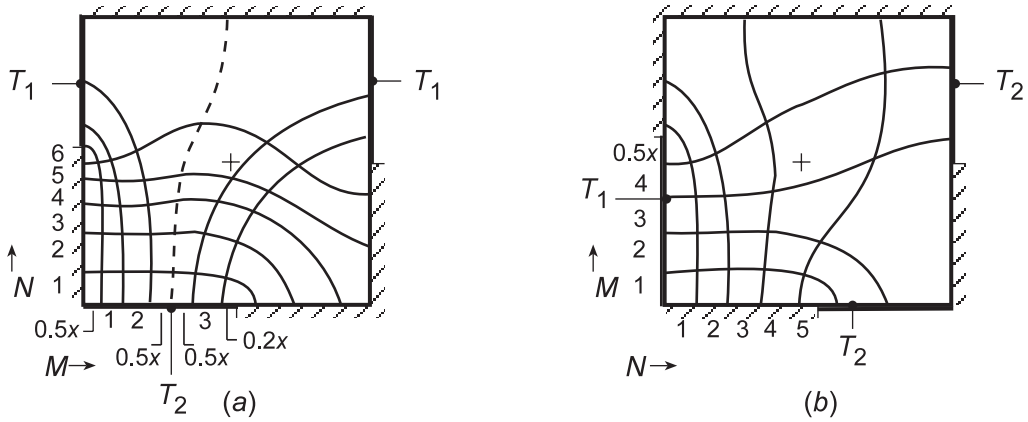
## PROBLEM 4S.8

**KNOWN**: Two-dimensional, square shapes, 1 m to a side, maintained at uniform temperatures as prescribed, perfectly insulated elsewhere.

**FIND**: Using the flux plot method, estimate the heat rate per unit length normal to the page if the thermal conductivity is 50 W/m·K

**ASSUMPTIONS**: (1) Steady-state, two-dimensional conduction, (2) Constant properties.

**ANALYSIS**: Use the methodology of Section 4S.1 to construct the flux plots to obtain the shape factors from which the heat rates can be calculated. With Figure (a), begin at the lower-left side making the isotherms almost equally spaced, since the heat flow will only slightly spread toward the right. Start sketching the adiabats in the vicinity of the $T_2$ surface. The dashed line represents the adiabat which separates the shape into two segments. Having recognized this feature, it was convenient to identify partial heat lanes. Figure (b) is less difficult to analyze since the isotherm intervals are nearly regular in the lower left-hand corner.




The shape factors are calculated from Equation 4S.7 and the heat rate from Equation 4S.6.

$$S' = \frac{M}{N} = \frac{0.5 + 3 + 0.5 + 0.5 + 0.2}{6} \qquad S' = \frac{M}{N} = \frac{4.5}{5} = 0.90$$

$$S' = 0.70$$

$$q' = kS'\left(T_1 - T_2\right) \qquad q' = kS'\left(T_1 - T_2\right)$$

$$q' = 50\,W/m\cdot K \times 0.70\left(100 - 0\right)K = 3500\,W/m \qquad q' = 50\,W/m\cdot K \times 0.90\left(100 - 0\right)K = 4500\,W/m \quad <$$

**COMMENTS**: Using a finite-element package with a fine mesh, we determined heat rates of 4780 and 4575 W/m, respectively, for Figures (a) and (b). The estimate for the less difficult Figure (b) is within 2% of the numerical method result. For Figure (a), our flux plot result was 27% low.