Finite 1D Unsteady Heat Transfer, $T = T(t, x)$ or $T = T(t, r)$

Uniform initial temperature T_0; exposed to bulk temperature T_1; h known

- Flat plate long, wide, thickness $= 2x_1$ $T = T(t, x)$ $Y = Y(X, n)$
- Cylinder long, radius $= x_1$ $T = T(t, r)$ $Y = Y(X, n)$
- Sphere radius $= x_1$ $T = T(t, r)$ $Y = Y(X, n)$

$$\mathrm{Bi} = \frac{hD_{char}}{k} = \frac{hx_1}{k} = \frac{1}{m}$$

$$\mathrm{Fo} = \frac{\alpha t}{x_1^2} = X$$

$$\frac{x}{x_1} = \frac{r}{x_1} = n$$

$$\frac{T_1 - T}{T_1 - T_0} = Y \quad \left(\frac{T - T_0}{T_1 - T_0} = 1 - Y \right)$$

Note:
$D_{char} = x_1$,
<u>*NOT*</u> V/A

Ref: Geankoplis, 4th Ed, 2003

Gurney and Lurie Charts

Uniform initial temperature T_0; bulk temperature T_1; $T\left(m=\frac{1}{\mathrm{Bi}}, n=\frac{x}{x_1}, \mathrm{Fo}\right)$

- Flat plate long, wide, thickness $= 2x_1$ $T = T(t,x)$ $Y = Y(X,n)$
- Cylinder long, radius $= x_1$ $T = T(t,r)$ $Y = Y(X,n)$
- Sphere radius $= x_1$ $T = T(t,r)$ $Y = Y(X,n)$

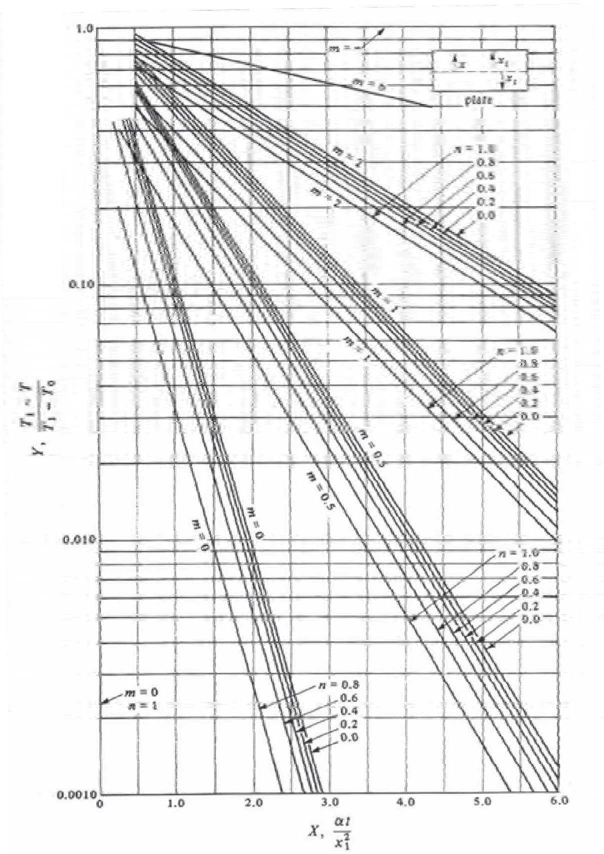


FIGURE 5.3-5. Unsteady-state heat conduction in a large flat plate. [From H. P. Gurney and J. Lurie, Ind. Eng. Chem., 15, 1170 (1923).]

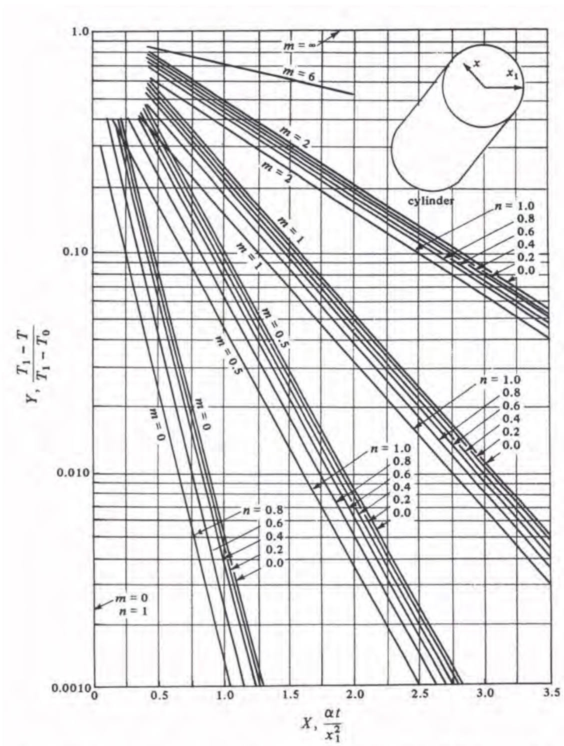


FIGURE 5.3-7. Unsteady-state heat conduction in a long cylinder. [From H. P. Gurney and J. Lurie, Ind. Eng. Chem., 15, 1170 (1923).]

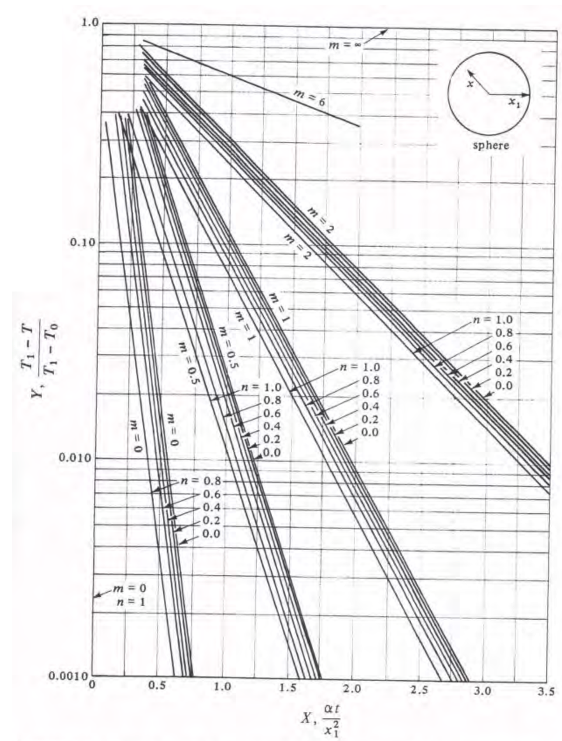
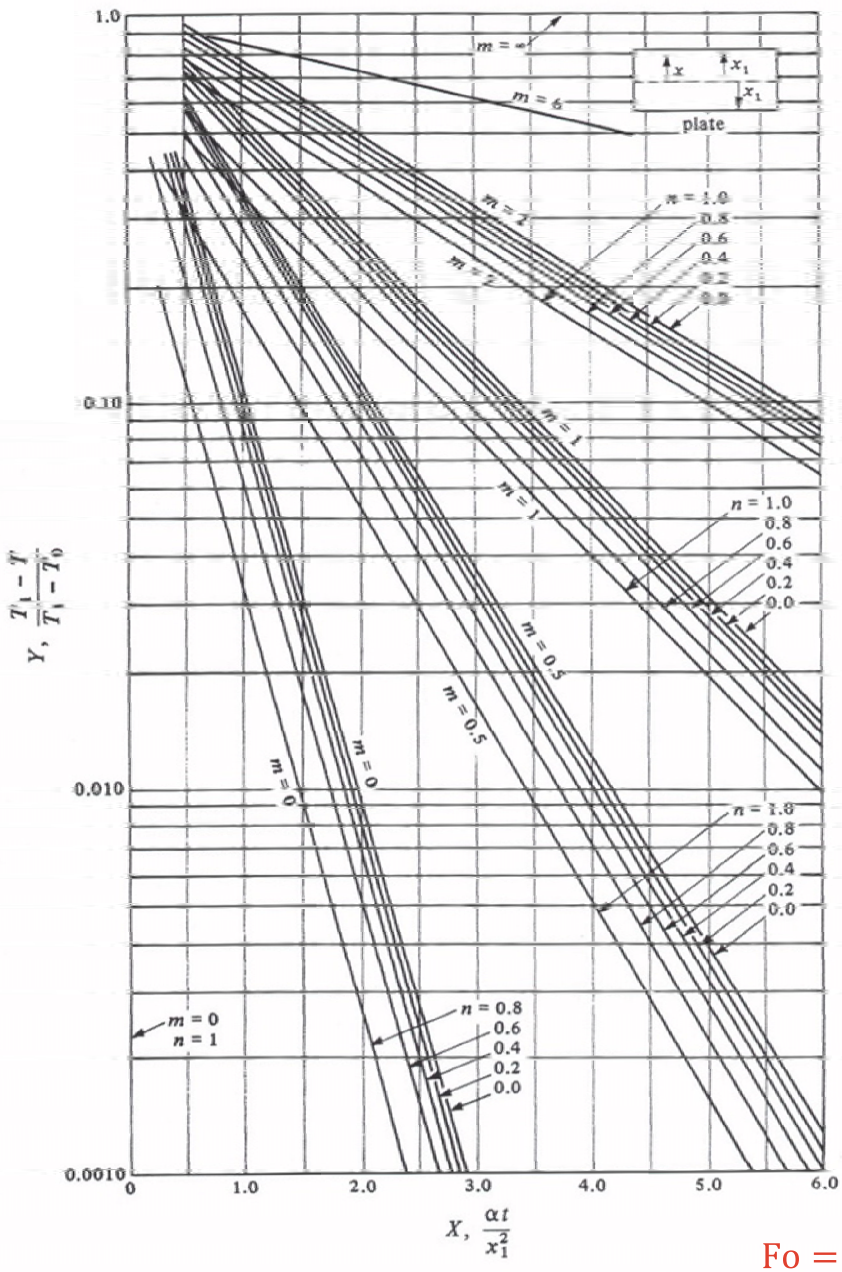


FIGURE 5.3-9. Unsteady-state heat conduction in a sphere. [From H. P. Gurney and J. Lurie, Ind. Eng. Chem., 15, 1170 (1923).]

$$\mathrm{Fo} = \frac{\alpha t}{x_1^2} = X$$

Gurney and Lurie Charts

Ref: Geankoplis, 4th Ed, 2003



$$\mathrm{Fo} = \frac{\alpha t}{x_1^2} = X$$

FIGURE 5.3-5. *Unsteady-state heat conduction in a large flat plate. [From H. P. Gurney and J. Lurie, Ind. Eng. Chem.,* **15**, *1170 (1923).]*

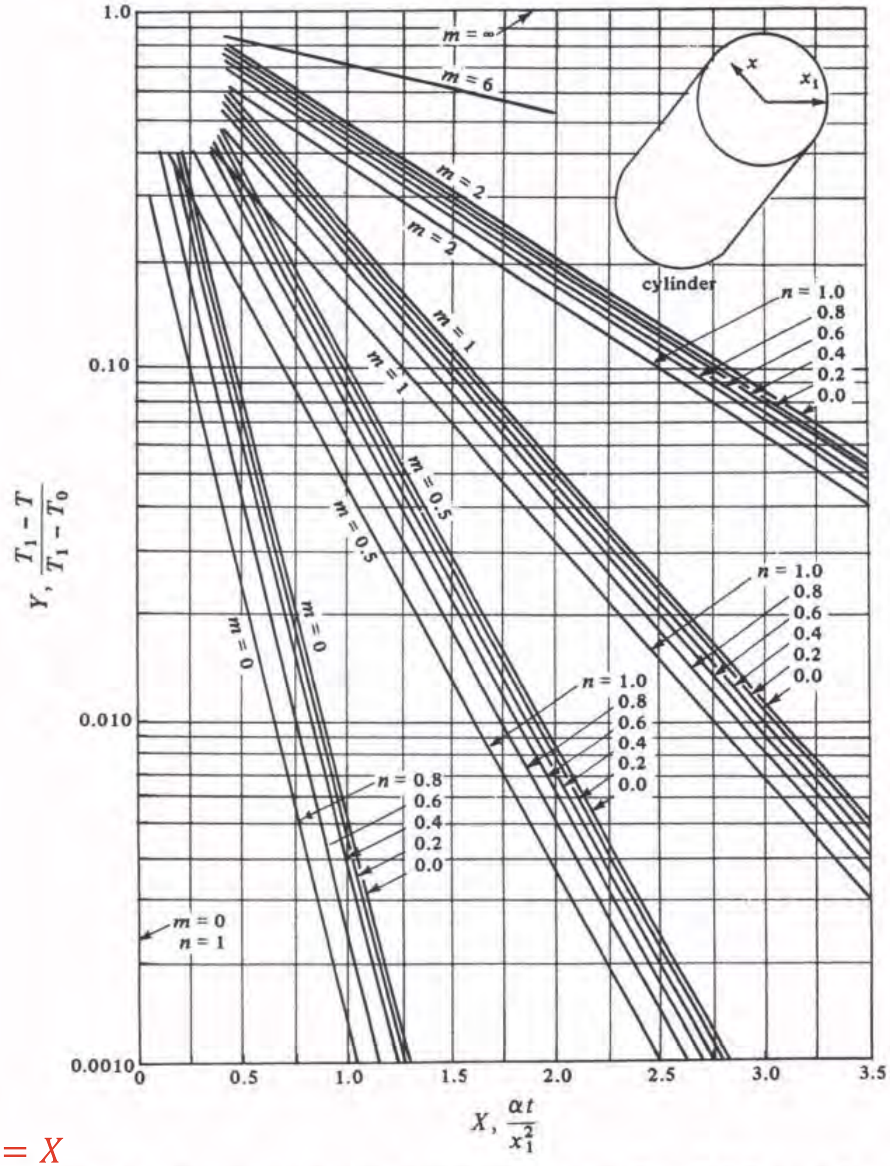


FIGURE 5.3-7. *Unsteady-state heat conduction in a long cylinder. [From H. P. Gurney and J. Lurie, Ind. Eng. Chem.,* **15**, *1170 (1923).]*

Heisler Charts

Uniform initial temperature T_0
Exposed to bulk temperature T_1
h known
Plots of temperature at the center

$$T\left(m=\frac{1}{\mathrm{Bi}}, x=0, \mathrm{Fo}\right)$$

Flat plate

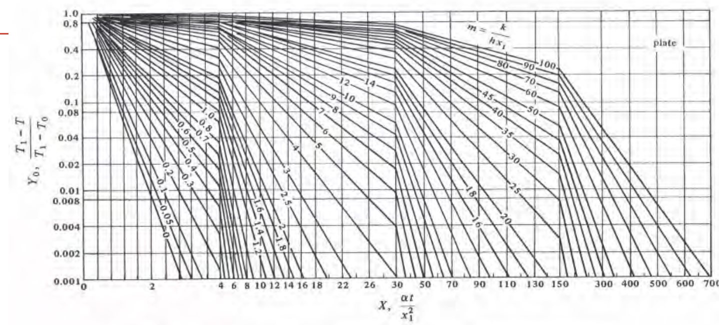


FIGURE 5.3-6. *Chart for determining temperature at the center of a large flat plate for unsteady-state heat conduction. [From H. P. Heisler, Trans. A.S.M.E.,* **69**, *227 (1947). With permission.]*

Cylinder

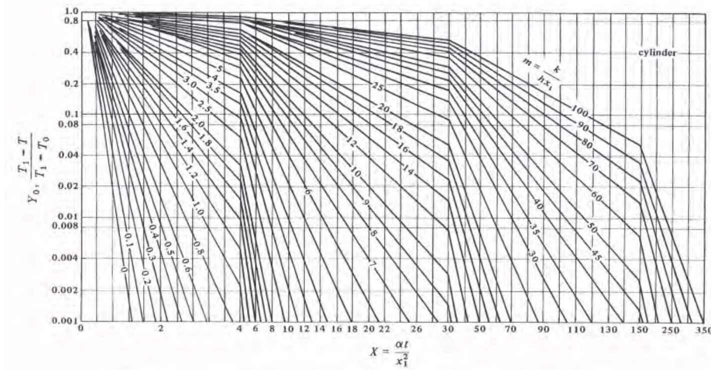


FIGURE 5.3-8. *Chart for determining temperature at the center of a long cylinder for unsteady-state heat conduction. [From H. P. Heisler, Trans. A.S.M.E.,* **69**, *227 (1947). With permission.]*

Sphere

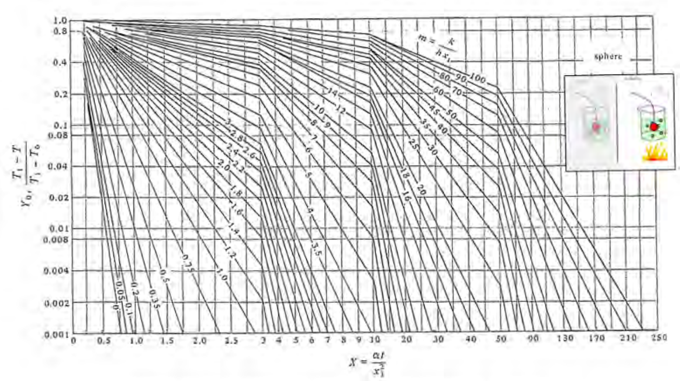


FIGURE 5.3-10. *Chart for determining the temperature at the center of a sphere for unsteady-state heat conduction. [From H. P. Heisler, Trans. A.S.M.E., 69, 227 (1947). With permission.]*

$$\mathrm{Fo} = \frac{\alpha t}{x_1^2} = X$$

Ref: Geankoplis, 4th Ed, 2003

Heisler Chart for Unsteady State Heat Transfer to a Sphere

(Geankoplis; see also Wikipedia)

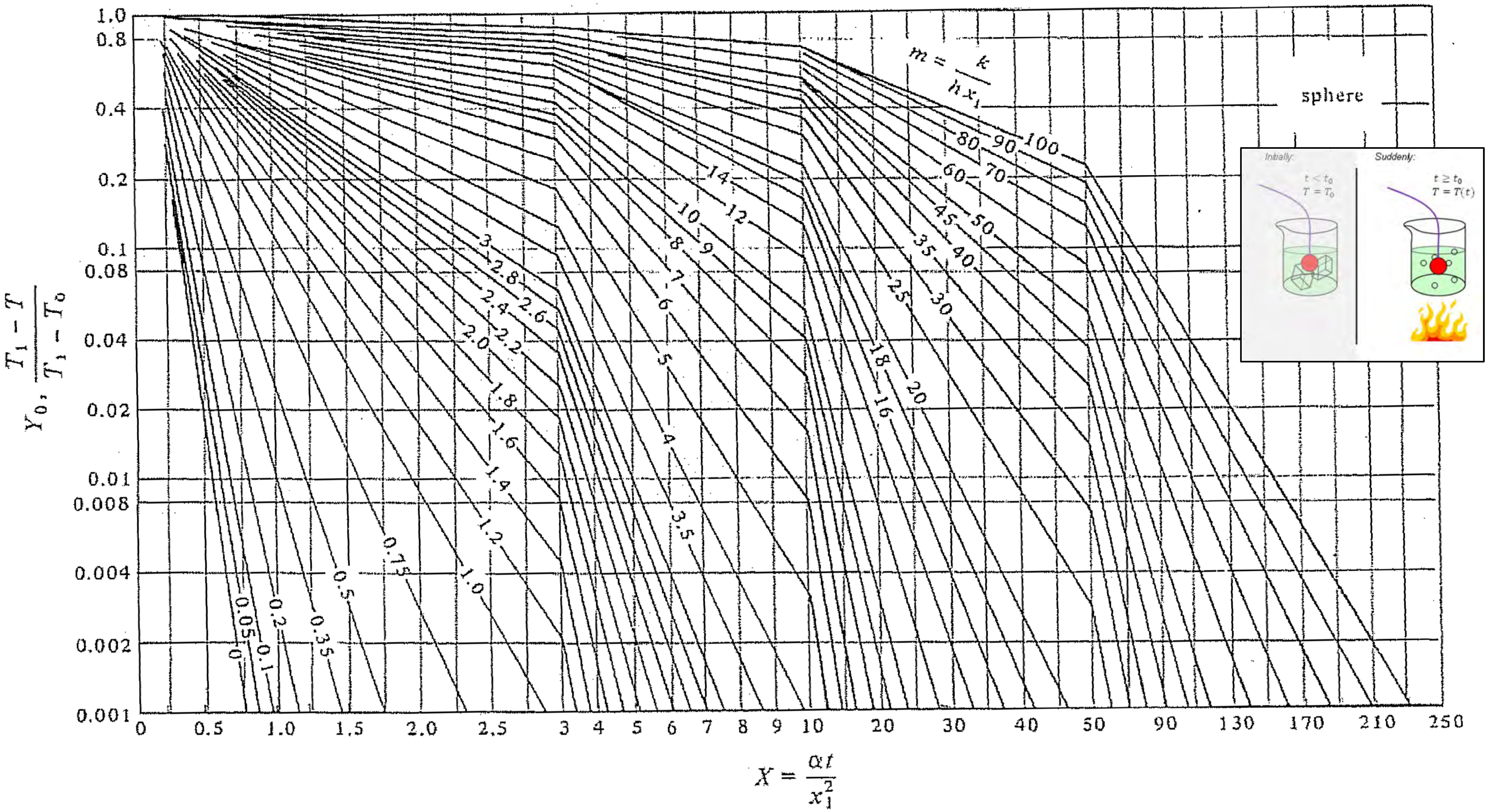


FIGURE 5.3-10. *Chart for determining the temperature at the center of a sphere for unsteady-state heat conduction.* [*From H. P. Heisler, Trans. A.S.M.E.*, 69, 227 (1947). *With permission.*]

From Geankpolis, 4th edition, page 374

Heisler Chart for Unsteady State Heat Transfer to a Cylinder

(Geankoplis; see also Wikipedia)

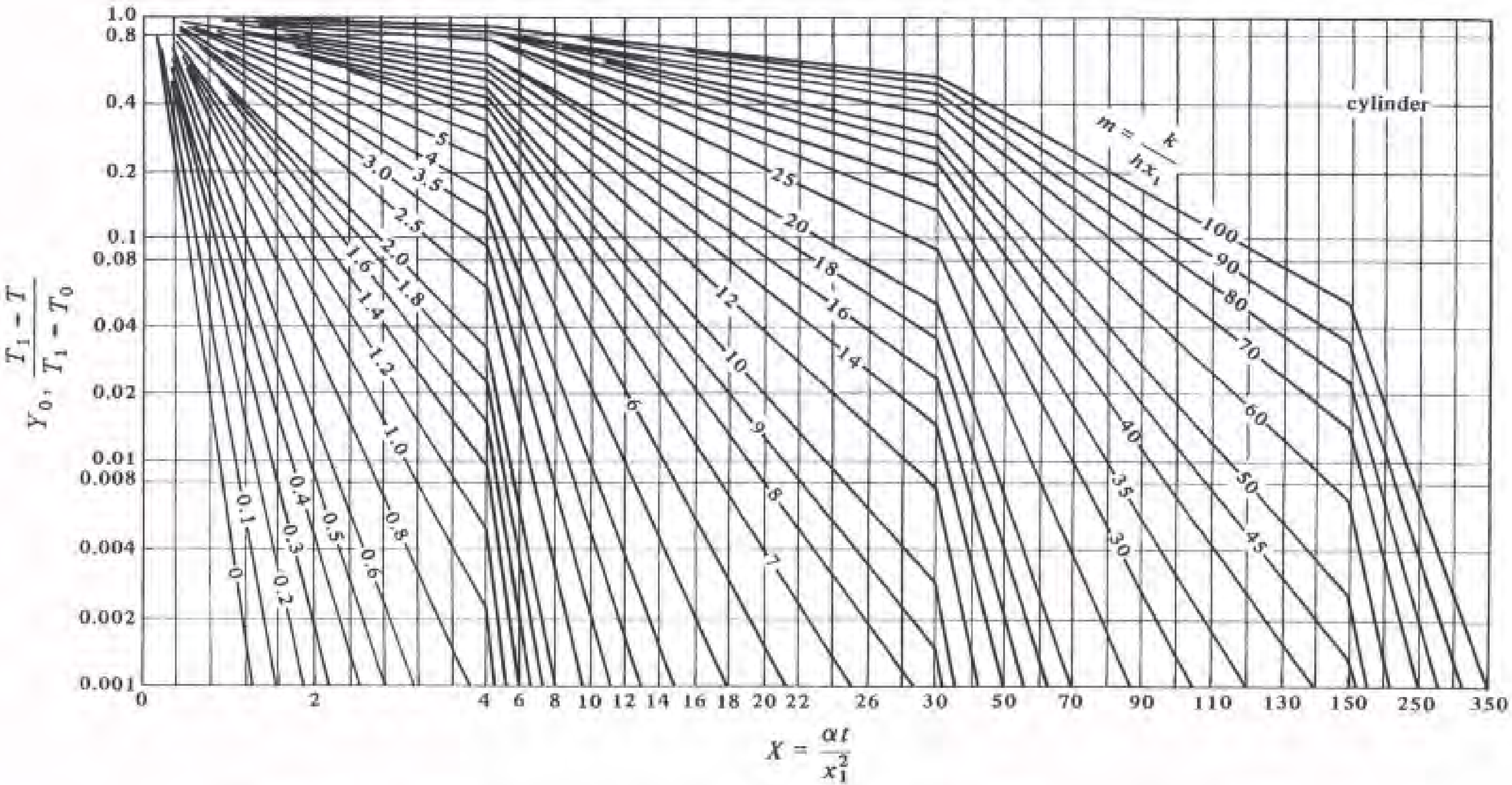


FIGURE 5.3-8. *Chart for determining temperature at the center of a long cylinder for unsteady-state heat conduction. [From H. P. Heisler, Trans. A.S.M.E.,* **69**, *227 (1947). With permission.]*

From Geankpolis, 4th edition

Heisler Chart for Unsteady State Heat Transfer to a Flat Plate

(Geankoplis; see also Wikipedia)

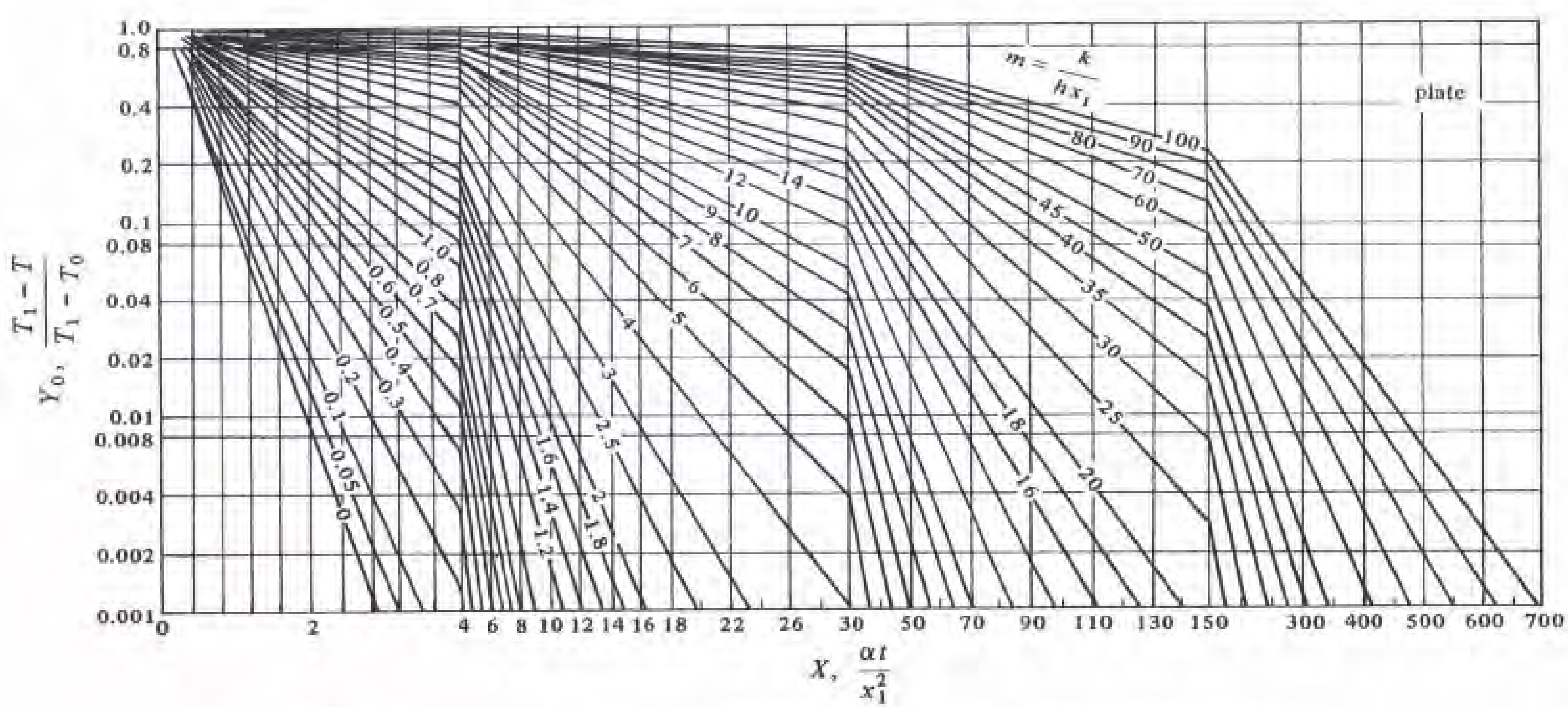


FIGURE 5.3-6. *Chart for determining temperature at the center of a large flat plate for unsteady-state heat conduction. [From H. P. Heisler, Trans. A.S.M.E.,* **69**, *227 (1947). With permission.]*

From Geankpolis, 4th edition