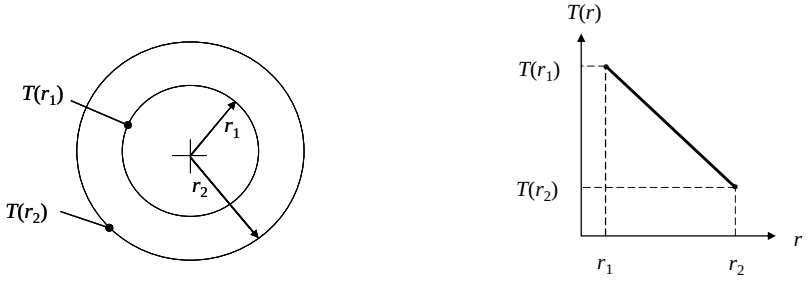
PROBLEM 2.39

KNOWN: Spherical shell under steady-state conditions with no energy generation.

FIND: Under what conditions is a linear temperature distribution possible.

SCHEMATIC:



ASSUMPTIONS: (1) Steady state, (2) One-dimensional, (3) No heat generation.

ANALYSIS: Under the stated conditions, the heat equation in spherical coordinates, Equation 2.29, reduces to

$$\frac{d}{dr}\left(kr^2\frac{dT}{dr}\right)=0$$

If the temperature distribution is a linear function of r, then the temperature gradient is constant, and this equation becomes

$$\frac{d}{dr}\left(kr^2\right)=0$$

which implies kr^2 = constant, or $k \sim 1/r^2$. The only way there could be a linear temperature distribution in the spherical shell is if the thermal conductivity were to vary inversely with r^2. <

COMMENTS: It is unlikely to encounter or even create a material for which k varies inversely with the spherical radial coordinate r in the manner necessary to develop a linear temperature distribution. Assuming linear temperature distributions in radial systems is nearly always both fundamentally incorrect and physically implausible.