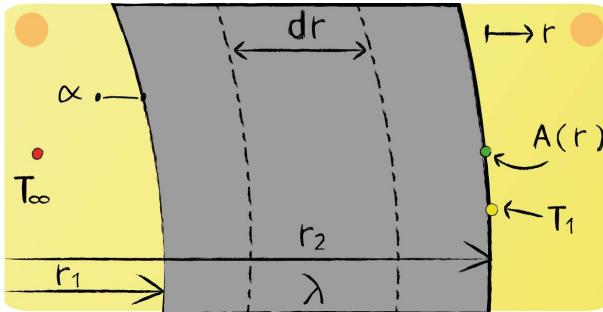


## Lecture 8 - Question 5



Develop an energy balance to calculate the temperature profile inside the pipe wall and give the boundary conditions. Assume one-dimensional steady-state heat transfer in radial direction. The expansion of the pipe in axial direction is  $L$ .

**Energy balance:**

$$\dot{Q}_{r,in} - \dot{Q}_{r,out} = 0$$

Since the type of heat transfer is steady-state, the sum of the in- and outgoing heat fluxes of the control volume should equal zero.

**Heat fluxes:**

$$\dot{Q}_{r,in} = -\lambda A(r) \frac{\partial T}{\partial r} = -\lambda 2\pi r L \frac{\partial T}{\partial r}$$

$$\begin{aligned} \dot{Q}_{r,out} &= \dot{Q}_{r,in} + \frac{\partial \dot{Q}_{r,in}}{\partial r} dr = \\ &= -\lambda 2\pi r L \frac{\partial T}{\partial r} + \frac{\partial}{\partial r} (-\lambda 2\pi r L \frac{\partial T}{\partial r}) dr \end{aligned}$$



The ingoing flux can be described by use of Fourier's law and the outgoing flux can be approximated by use of the Taylor series expansion.

**Boundary conditions:**

$$\frac{\partial T(r=r_1)}{\partial r} = -\frac{\alpha}{\lambda}(T(r=r_1) - T_\infty)$$

$$T(r=r_2) = T_1$$

The first boundary condition results from the fact that  $\dot{Q}_{r=r_1} = -\lambda A(r) \frac{\partial T(r=r_1)}{\partial r} = \alpha A(r)(T(r=r_1) - T_\infty)$ , the second one describes that the temperature at the surface equals  $T_1$ .