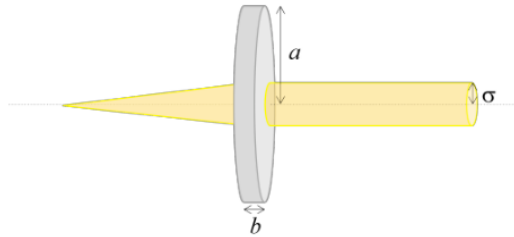


T1: Thermal lens (10 pts)

When an intense laser beam falls onto a semitransparent plate, the transmitted light can self-focus to a point behind the plate due to the inhomogeneous heating of the material. This effect, known as thermal lensing, is observed in materials whose index of refraction increases with temperature, characterized by a positive thermo-optic coefficient $\gamma = \frac{dn}{dT}$.

A semitransparent disk with radius $a = 15.0$ mm, thickness $b = 0.2$ mm and optical absorption coefficient $A = 0.1$ is composed of a material having thermal conductivity $k = 0.3 \text{ W m}^{-1} \text{ K}^{-1}$ and thermo-optic coefficient $\gamma = 2.5 \cdot 10^{-4} \text{ K}^{-1}$. The outer rim of the disk is thermally connected to a circular metallic holder (not shown in the figure) maintained at a constant temperature $T_h = 20^\circ\text{C}$. A parallel laser beam of radius $\sigma = 0.5$ mm and power $P_L = 20$ mW is incident normally onto the center of the disk. The intensity distribution is homogeneous across the cross-section of the beam.



a) (2 pts) Sketch a qualitative graph of the temperature profile $T(r)$, where r denotes the distance from the axis of the beam. Indicate clearly on the graph the illuminated region $0 \leq r \leq \sigma$ and the outer region $\sigma \leq r \leq a$.

b) (4 pts) In the vicinity of the center of the disk, the temperature profile can be represented by a quadratic function $T(r) = T_c + mr^2$. Calculate the parameters T_c and m .

c) (4 pts) Show that the beam is focused in one point and find the distance f from this point to the disk. If you failed to obtain T_c and m in part b), you may use them as parameters in your final answer.

Do not consider the thermal expansion of the disk. Neglect the thermal radiation and the heat exchange between the disk and the surrounding air. Assume that the index of refraction of air is $n_{\text{air}} = 1$.