Light attenuation of an object with arbitrary shape

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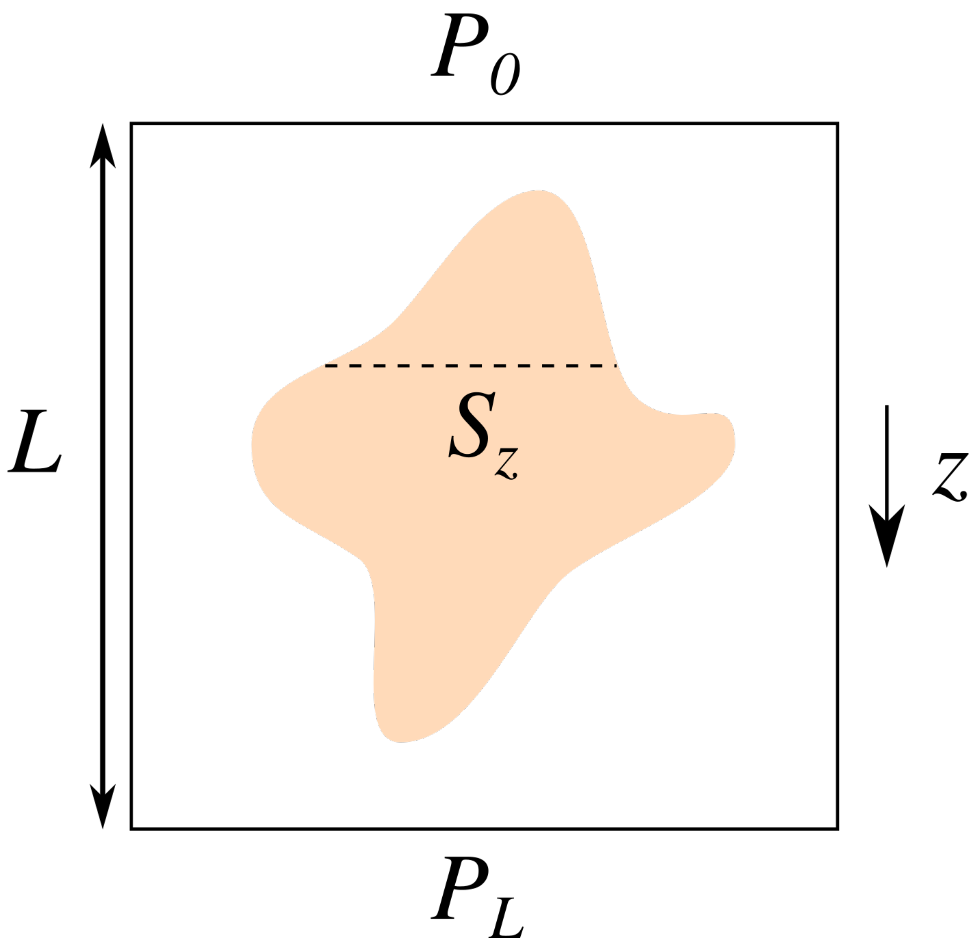

Consider a unit cell containing a light-absorbing object with an arbitrary shape, as shown in the schematic above. Let's assume the medium outside the object does not absorb any light (i.e. $\epsilon = 0$). The incoming light has power P_0 on the upper surface of this cell. This light gets weaker as it propagates through the cell and ends up with power P_L at the bottom of the cell. The cell has a length L along the direction of the incoming light, the z-direction. S_z denotes the cross section area of the object at position $z = z$.

We use the weak attenuation approximation of Beer's law:

$$I = (1 - \epsilon l c) I_0$$

where I_0 is the original light flux and I is the attenuated light flux. Note that the power of the light is the product of flux and area.

Using this approximation, we can examine the differential power difference at position z.

$$dP = -\epsilon c S_z dz$$

Integrate over the whole cell

$$\int_{P_0}^{P_L} dP = -\epsilon c \int_0^L S_z dz$$

Noticing that the integral on the RHS is the volume of the object V_{obj}, we have

$$P_L = P_0 - \epsilon c V_{obj}$$