845-CHME, Homework Set # 6, due 4/22/22, 5 pm

In class, we discussed the coupling of reaction and diffusion in the case of a solid porous catalyst with "infinite" slab geometry. Fogler's textbook (5th edition) in section 15.2.2, provides valuable information as to what the equations governing a similar situation in spherical catalytic pellets are. You can adapt the lecture's and Fogler's concepts to derive meaningful equations for the infinitely long fiber case.

Suppose that you have such porous fibers loaded with an entrapped enzyme, and you use a nonwoven mat of the fibers to run a reaction that follows the standard Michaelis-Menten (MM) equation. The substrate (S, the reactants) is at a concentration outside the fibers equal to 10^{-4} (in arbitrary units), and no film diffusion issues (external mass transfer) are present. The MM parameters are $V_{max} = 0.5$, and $K_m = 10^{-5}$ (both also in arb. units). The diffusion coefficient is 0.0003 (also in arbitrary units), and the radius of the fibers is 0.001 (in arb. units).

a) Produce a plot of substrate concentration vs radius i.e., the concentration of reactant in the fibers. (3 points)
b) Calculate the effectiveness factor (2 points).
c) Calculate the fiber radius necessary to achieve an effectiveness factor equal to 0.97 (4 points).