PHYS 325: Computational Physics III

Winter 2023

Exercise 4.1

1. Use Fermat's principle to determine the light path through a transparent medium. The path starts at $(0, 0)$ and ends at $(1, 1)$. The refractive index of the medium is $n = 1.0$ for $x <= 0.5$, and $n = 1.5$ for $x > 0.5$. Divide the medium into $N = 20$ layers of equal width and let $\{(x_i, y_i), i = 0, \ldots, N\}$ represent the path. Start with $y_i = x_i$.

   As discussed in class, randomly choose one value of i and change y_i by a random number uniformly distributed in the range $[-0.1, 0.1]$. Accept the change if it reduces the light travel time

   $$t = \sum_{i=0}^{N-1} n_i \sqrt{dx^2 + dy_i^2}/c\,,$$

   where n_i is the refractive index in layer i, $dx = 1/N$, and $dy = y_{i+1} - y_i$. Stop your calculation when 1000 successive trials fail to reduce t. Plot the path you obtain.