Class exercise
Simulation and Modeling (CSCI 3010U)

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Fermat experiment

The goal of this exercise is to write a program that can compute the path of a ray of light as it passes through materials having different index of refraction.
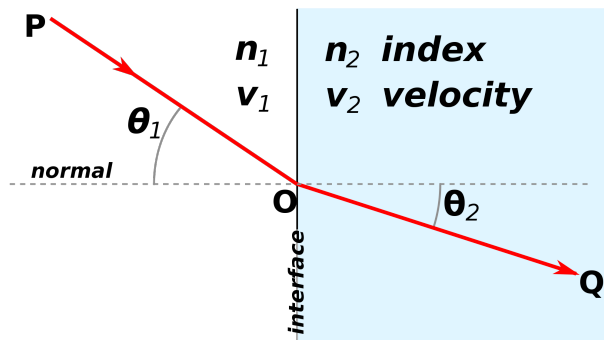

Figure 1: Snell's Law

The figure above illustrates this phenomenon. The ray of light bends as it enters the second medium. It turns out that by bending the ray of light takes the shortest amount of time to travel between point P and Q. The speed of light in a medium with index of refraction n is given by the following expression

$$v = \frac{c}{n},$$

where c is the speed of light in vacuum. The speed of light in vacuum is roughly 1080 million kilometers per hour.

Using the fact that the ray of light takes the shortest path (in time) when passing through materials having different index of refractions (see the figure below). We assume that the ray of light is initially travelling in vacuum and it exits in vaccum as well.

Code

We will use the following class to set up the layers appropriately.

```python
class Fermat:
    def __init__(self, N, dn):
        '''
        Sets up Fermat simulation -- light ray in media with different
```
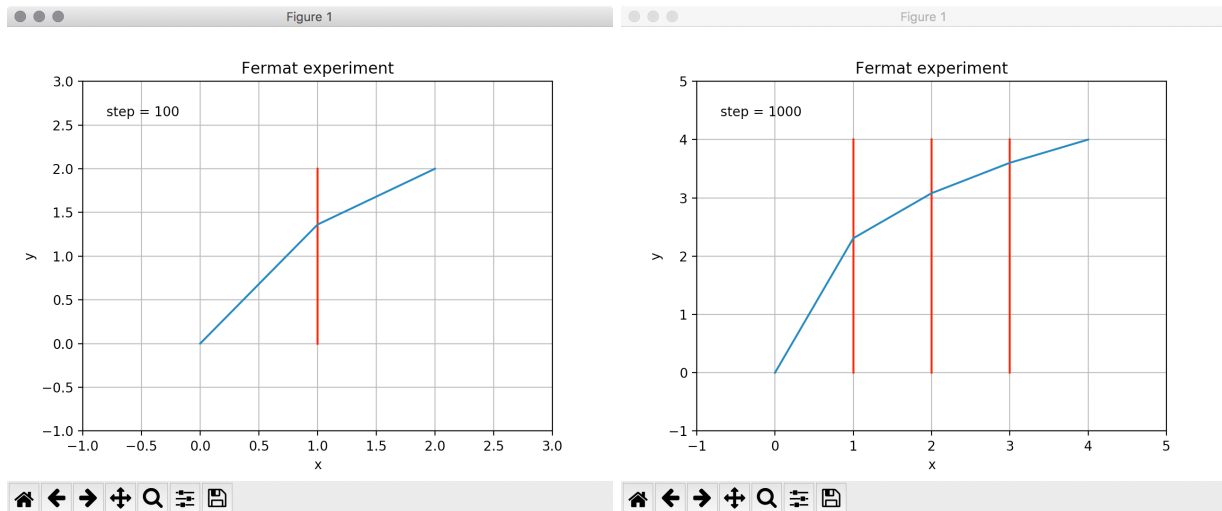
Figure 2: Ray path computed for 2 materials and 4 materials respectively

```
    index of refractions

    N = number of media layers
    dn = change in index of refraction from one region to the next

    '''
    self.dn = dn
    self.N = N
    self.y = np.empty((N+1)) # y coordinate of light ray, index is x coordinate
    self.v = np.empty((N))   # light speed of ray for medium starting at index value
    self.dy = 0.1            # max change in y at each step
    index_of_refraction = 1  # index of refraction for vacuum
    self.steps = 0

    for i in range(N+1):
        self.y[i] = i
    for i in range(N):
        self.v[i] = 1. / index_of_refraction
        index_of_refraction += dn
```

The above piece of code sets up a material with N layers. `v[0]` represents the velocity in vacuum. `v[1]` onwards store velocities in different layers. `y[0]` and `y[N]` represent the entry and exit locations of the ray of light. We are interested in computing `y[i]` for $i \in [1, N-1]$.

Available on the course website.

Submission

The exercise will be completed in class, and you do not need to submit anything. **Be prepared to show your work to the instructor**.