Fermat's Principle

Statement from Jenkins and White:

> *The path taken by a light ray in going from one point to another through any set of media is such as to render its optical path equal, in the first approximation, to other paths closely adjacent to the actual one.*

Fermat's Justification

Nature is economical.

But this can only be a valid justification when the principle is one of "least time." The statement of the principle is however one of stationarity, including uneconomical maxima, as well as minima and stationary cases.

Principle of Least Time

In some parts of our subject, it is appropriate to speak of Fermat's principle as a principle of "least time." In particular, first-arrival transmission traveltime tomography is one such case. Then,

$$T = min_{paths} \int \frac{n}{c_0} \, dl^{path},$$

for various source-receiver combinations form our data.

Uniqueness?

Then, in acoustics we do not speak of the index of refraction, but instead of the slowness $s \equiv n/c_0$.
An infinitesimal increment of the trajectory along any potential ray path is dl^{path}.

There will always be at least one minimum time path, but it does not have to be unique. Then we must concern ourselves with multipathing.
Example: an acoustic lens.