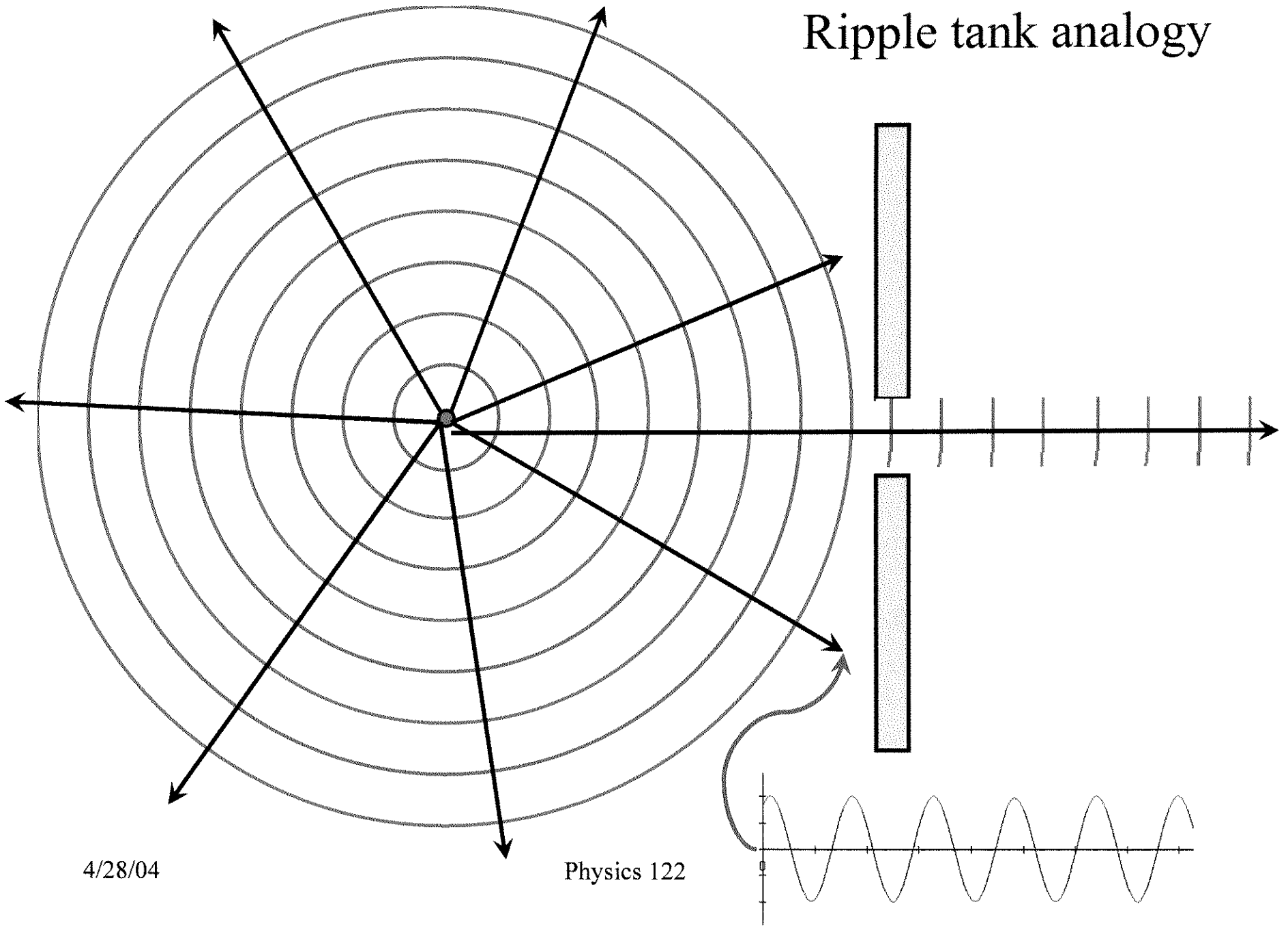
Lecture

4/14/05

The Wave Model of Light

- About the same time as Newton, Huygens proposed that light was a wave – a kind of oscillation in "the ether that fills empty space." (Whatever that means.)
- In fact, what we've seen is that "light moves in straight lines."
- Can we reconcile this with a wave model?

Ripple tank analogy



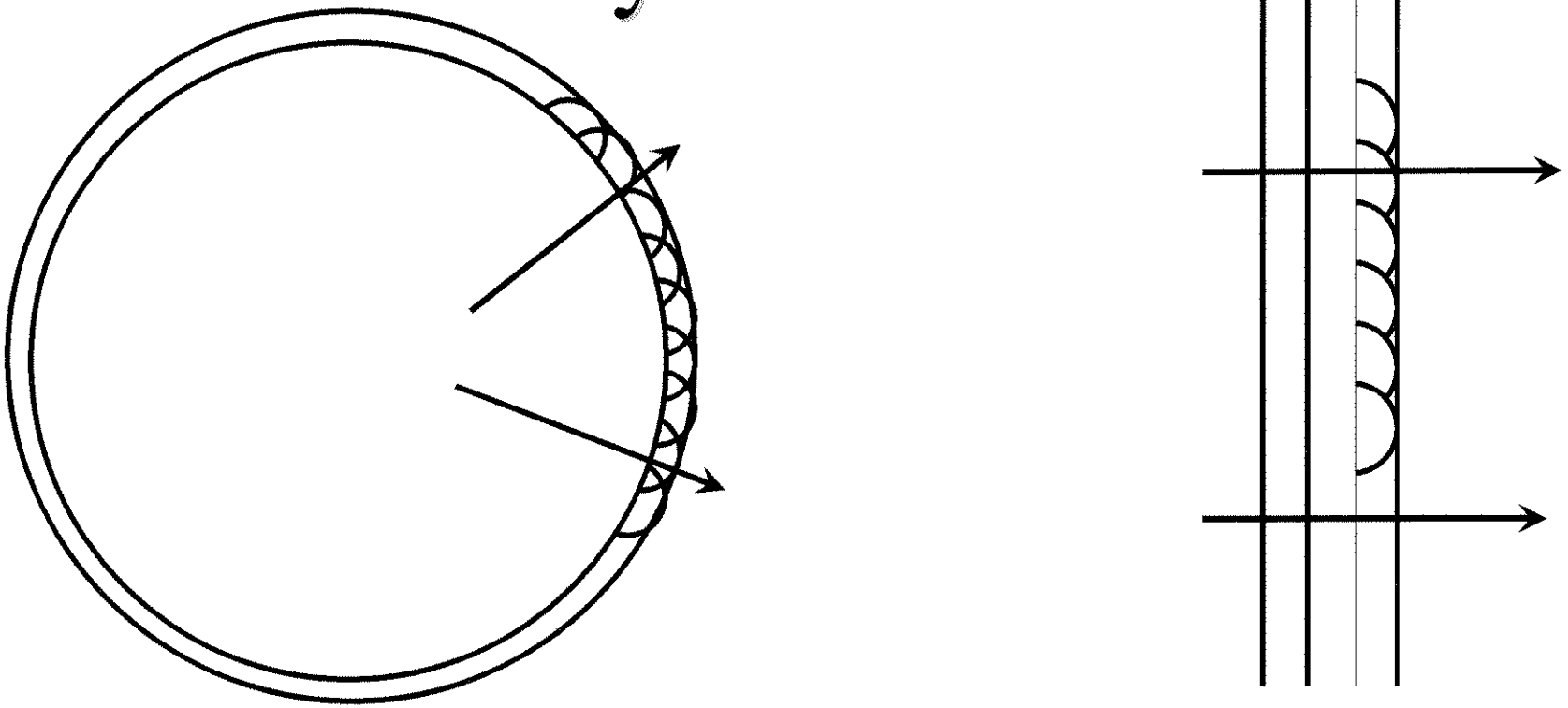
Waves to Rays

- We can isolate a small piece of a wave by passing it through a hole in a screen and treat it like a ray.
- We can consider the rays as going perpendicular to the wave surfaces of constant height.
- If the wavelength is small enough, we can ignore the oscillations.

Huygens' Principle

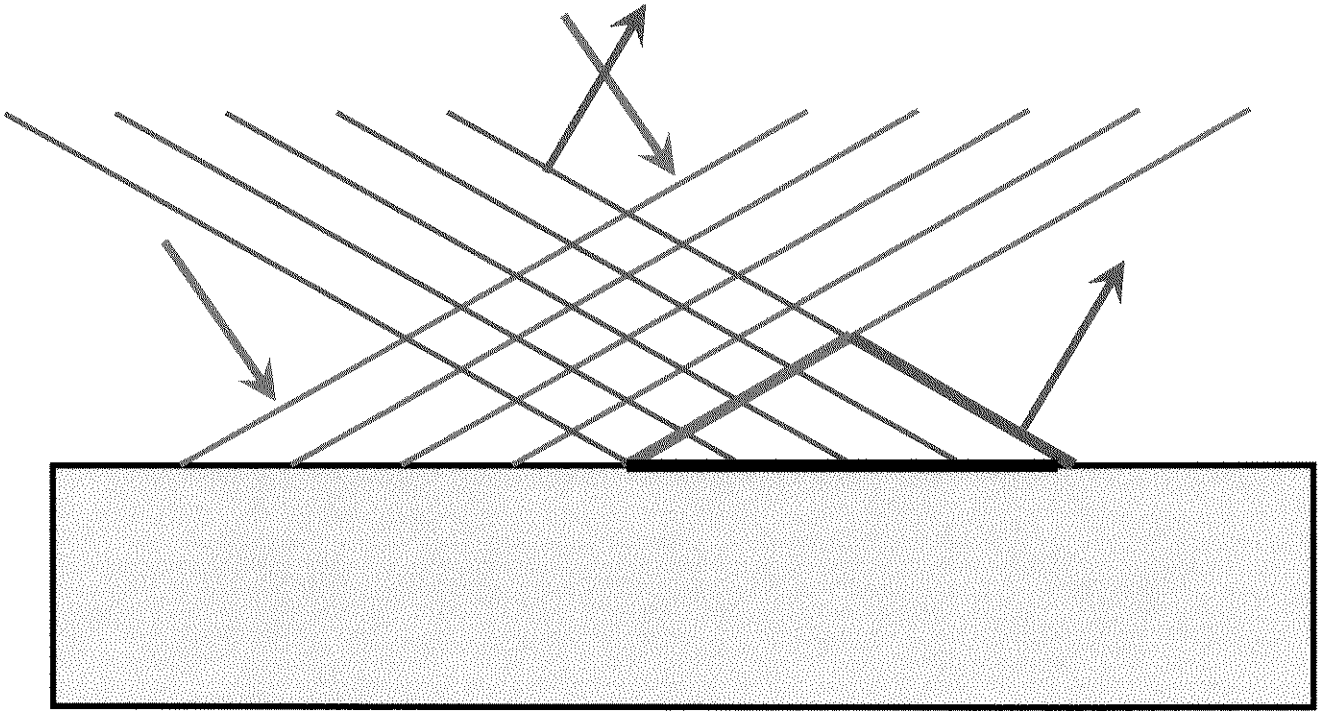
- Christian Huygens (a Dutch contemporary of Newton) proposed a way of thinking about how waves propagate.
- The critical structure for waves are the surfaces of equal amplitude: wavefronts.
- Huygens suggested:
  Each point on the surface of a wavefront acts as a point source for outgoing spherical waves (wavelets). The sum of the wavelets produces a new wavefront.

Propagation of Waves by Wavelets



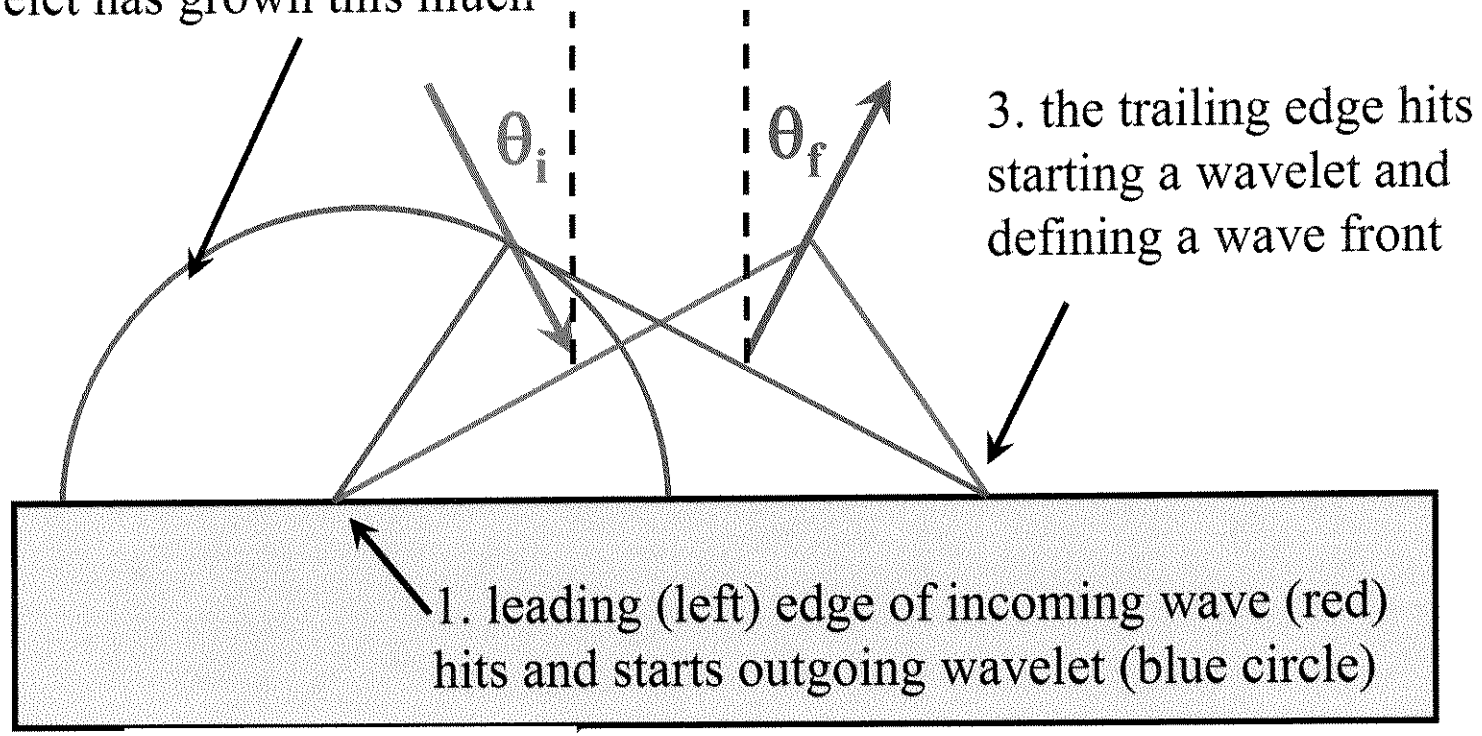
The wavelet model implies that a plane wave will travel in a straight line.

Reflection from a Mirror in Huygens' Wavelet Model



http://www.walter-fendt.de/ph11e/huygenspr.htm
http://www.phy.ntnu.edu.tw/java/propagation/propagation.html

2. by the time the trailing (right) edge of the incoming wave hits the wavelet has grown this much

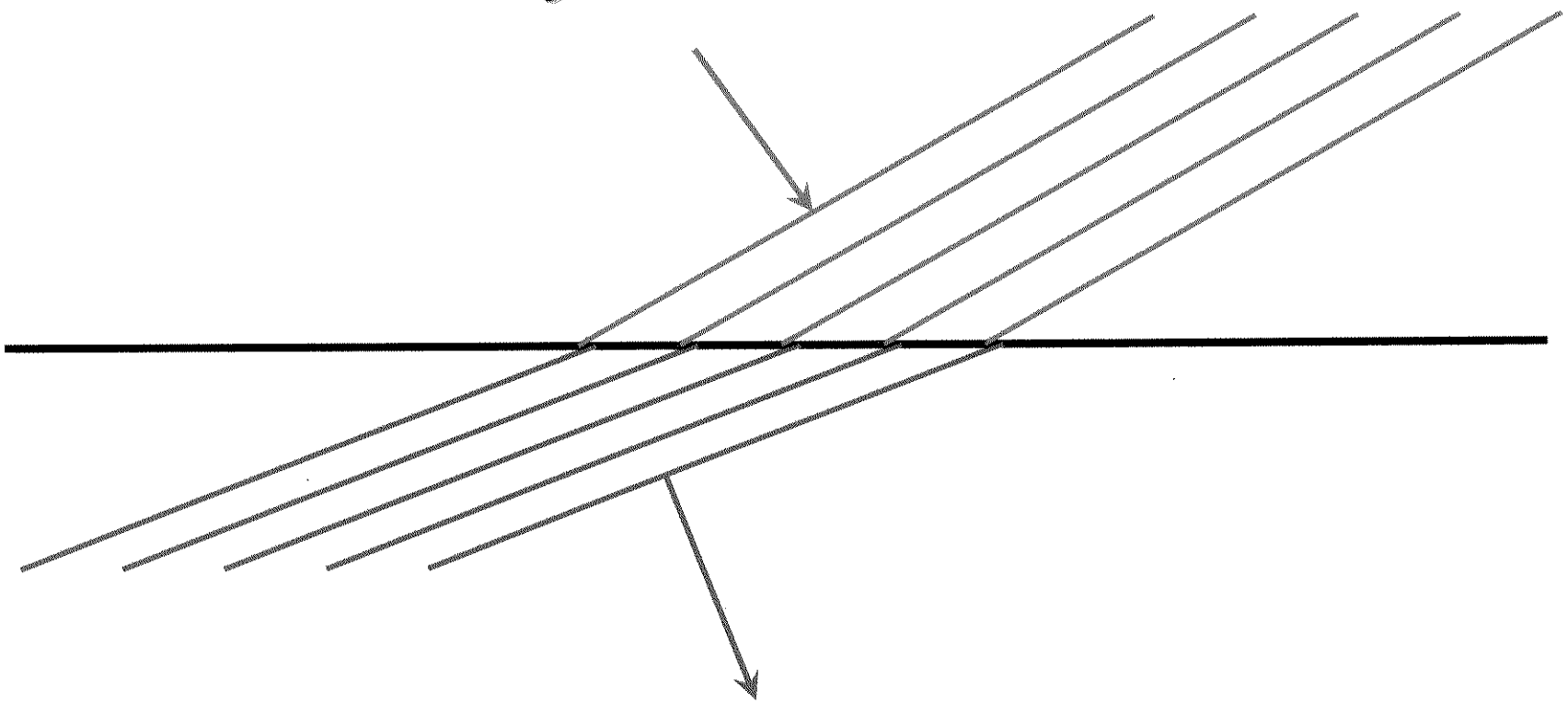


4. Since the red and blue triangles are similar, $\theta_i = \theta_f$

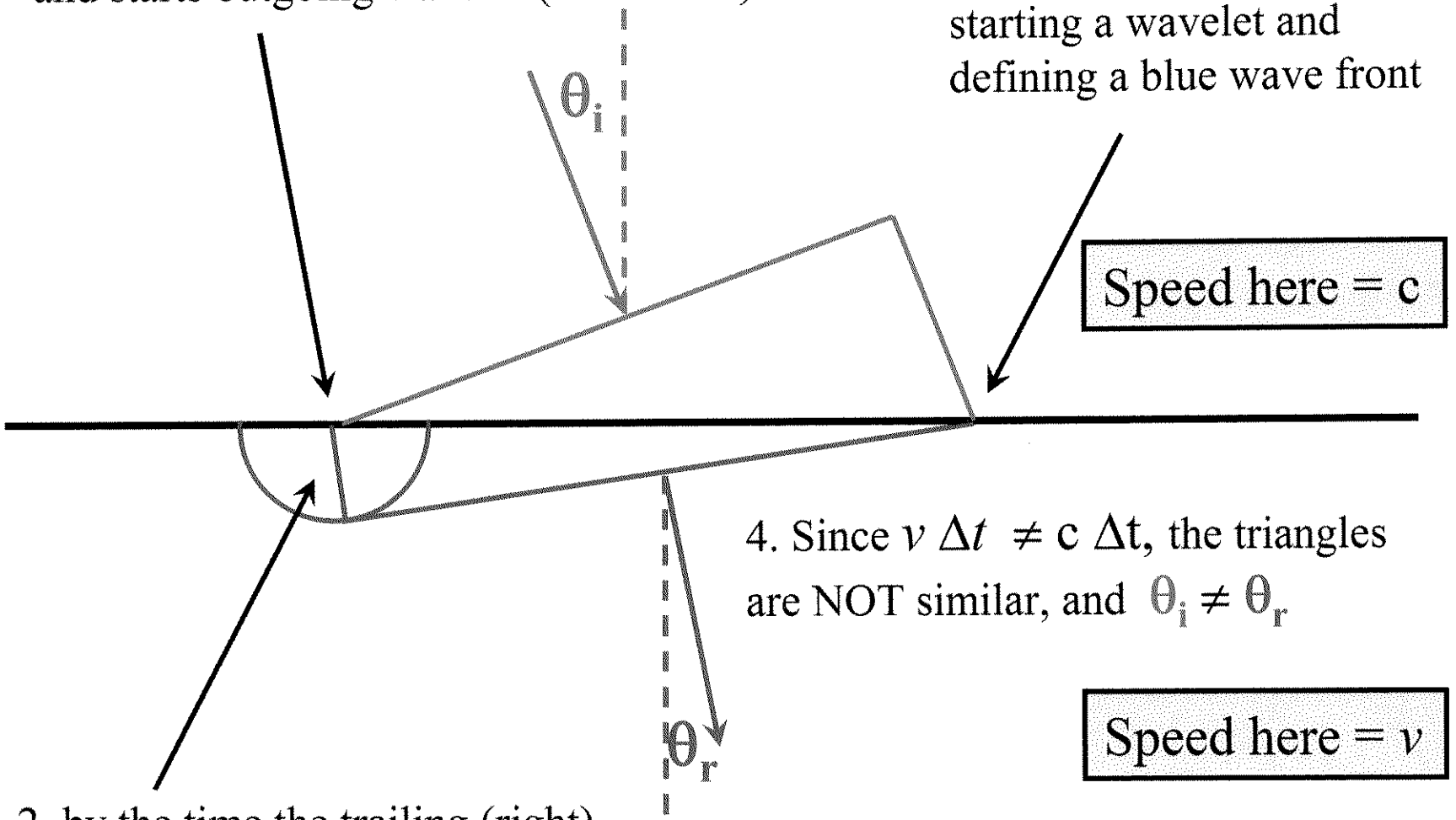
The wavelet model implies that a plane wave will reflect off a mirror according to the rule:

angle of incidence = angle of reflection.

Refraction of Waves by Wavelets



1. leading (left) edge of incoming wave hits and starts outgoing wavelet (blue circle)



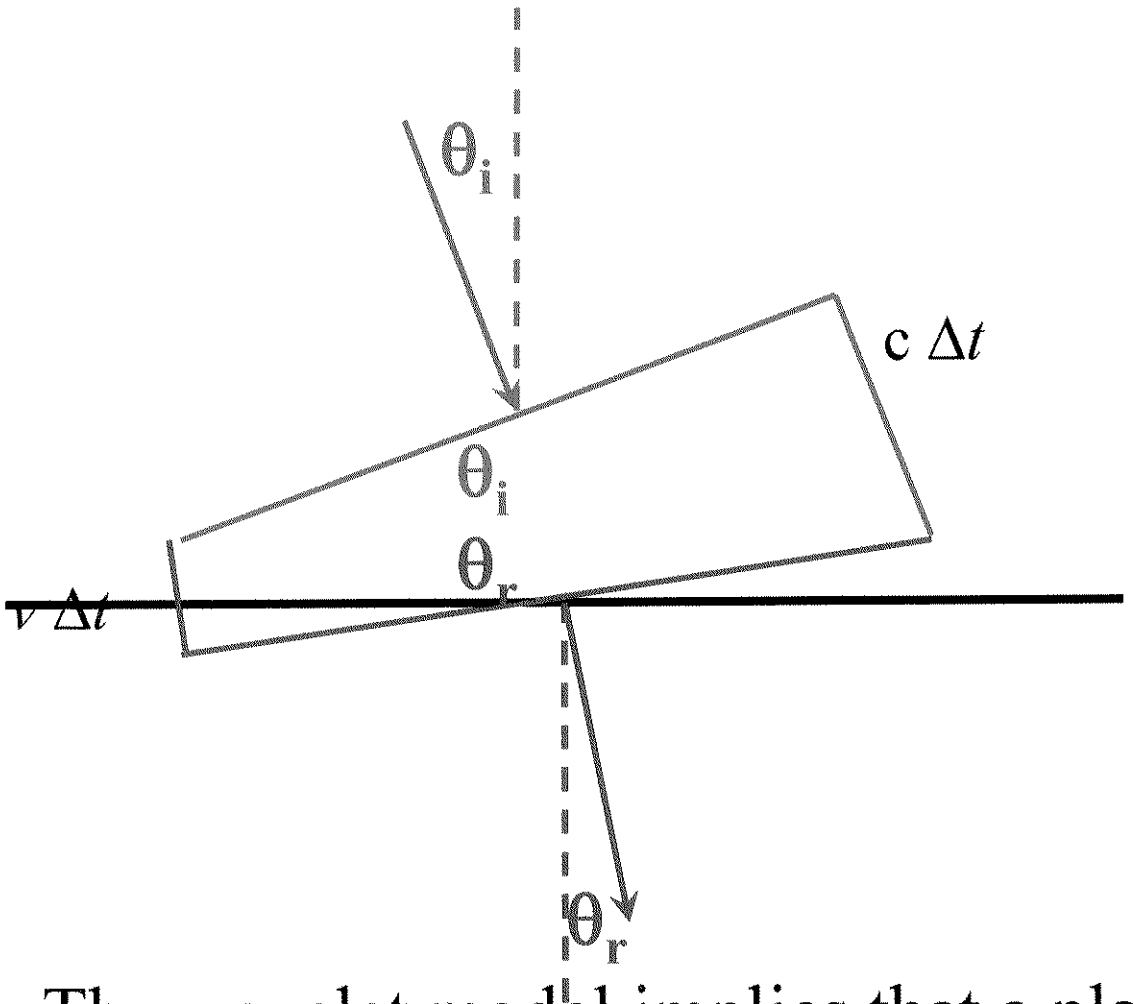
3. the trailing edge hits starting a wavelet and defining a blue wave front

Speed here = c

4. Since $v\,\Delta t \neq c\,\Delta t$, the triangles are NOT similar, and $\theta_i \neq \theta_r$

Speed here = v

2. by the time the trailing (right) edge of the incoming wave hits the wavelet has grown this much ($v\,\Delta t$)



$$\sin\theta_i = \frac{c\Delta t}{h}$$

$$\sin\theta_r = \frac{v\Delta t}{h}$$

$$\frac{1}{v}\sin\theta_r = \frac{1}{c}\sin\theta_i$$

The wavelet model implies that a plane wave will refract into a medium according to the Snell's law and tells us that n = c/speed of light in the medium.

http://www.walter-fendt.de/ph11e/huygenspr.htm
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