8.286 Lecture 3
September 12, 2013
THE DOPPLER EFFECT
and
SPECIAL RELATIVITY
\( \Delta \ell = v \Delta t_S \)
(1) Observer

(2) Source

\[ \Delta l = v \Delta t_s \]
\( \Delta \ell = v \Delta t_s \)
(1) Observer

(2) \[ \Delta l = v \Delta t_s \]

(3)

(4)
(1') \hspace{1cm} \text{Observer} \hspace{1cm} \text{Source}

(2')

(3')
\[ (1') \]

Observer

Source

\[ (2') \]

\[ (3') \]

\[ (4') \]

\[ \Delta l = v \Delta t_O \]
(1')

Observer

Source

(2')

(3')

(4')

\[ \Delta \ell = v \Delta t_O \]
(1) **TIME DILATION:** Any clock which is moving at speed $v$ relative to a given reference frame will “appear” (to an observer using that reference frame) to run slower than normal by a factor denoted by the Greek letter $\gamma$ (gamma), and given by

$$\gamma \equiv \frac{1}{\sqrt{1 - \beta^2}} , \quad \beta \equiv \frac{v}{c} . \quad (1.10)$$
\[(1')\] 

\[(2')\] 

\[(3')\] 

\[(4')\] 

\[\Delta \ell = v \Delta t_O\]
(1') $v$  $\rightarrow$  Observer  $\leftarrow$  Source  $u$  $\rightarrow$

(2') $v$  $\rightarrow$

(3') $v$  $\rightarrow$

(4') $v$  $\rightarrow$

$\Delta l = v \Delta t_O$
(1') \hspace{8cm} (2') \hspace{8cm} (3') \hspace{8cm} (4')

$\Delta t' = \text{time between reception of two pulses in frame of the slide.}$
\( (1') \)

Observer \( v \) \hspace{2cm} Source \( u \)

\( (2') \)

\( v \)

\( (3') \)

\( v \)

\( (4') \)

\[ \Delta l = v \Delta t' \]

\[ \Delta l = v \Delta t_O \]

\[ \Delta t_O = \frac{\Delta t'}{\gamma} \]

\( \Delta t' = \) time between reception of two pulses in frame of the slide.
(1) TIME DILATION: Any clock which is moving at speed \( v \) relative to a given reference frame will “appear” (to an observer using that reference frame) to run slower than normal by a factor denoted by the Greek letter \( \gamma \) (gamma), and given by

\[
\gamma \equiv \frac{1}{\sqrt{1 - \beta^2}} , \quad \beta \equiv \frac{v}{c} .
\] (1.10)
(2) LORENTZ-FITZGERALD CONTRACTION: Any rod which is moving at a speed $v$ along its length relative to a given reference frame will “appear” (to an observer using that reference frame) to be shorter than its normal length by the same factor $\gamma$. A rod which is moving perpendicular to its length does not undergo a change in apparent length.
(3) RELATIVITY OF SIMULTANEITY: Suppose a rod which has rest length $l_0$ is equipped with a clock at each end. The clocks can be synchronized in the rest frame of the system by using light pulses. (That is, a light pulse can be sent out from the center, and the clocks at both ends can be started when they receive the pulses.) If the system moves at speed $v$ along its length, then the trailing clock will “appear” to read a time which is later than the leading clock by an amount $\beta l_0 / c$. If, on the other hand, the system moves perpendicular to its length, then the synchronization of the clocks is not disturbed.