

Einstein:

“It is not that I am so smart. It’s just that I stay with problems longer.”

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Announcements

- My office hour from 10 – 11 AM tomorrow is cancelled (I am training the TA’s for the coming Practicals)
 - I will be in my office tomorrow from 2 – 3 PM
- The Discussion Board now has a Relativity Forum

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Reminders

- There are Supplementary Course Notes (SCN) available via the **Course Documents / Relativity Classes** section of the course web site
- Reading assignment for this week: Textbook §37.1 - 37.6, SCN §A
- Suggested problems for this week: Textbook Chapter 37: 9, 13, 19. SCN 1
- MP Problem Set 8: due 11:59 PM Friday March 27

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About the *Supplementary Course Notes*

- If you find a typo or similar mistake, I will pay \$1 (CAN) to you:
 - Email to david.harrison@utoronto.ca
 - First person only gets the dollar
- If you find a sentence, phrase or similar that is not clear, I will pay \$2 (CAN) if you suggest a better wording:
 - Email to david.harrison@utoronto.ca
 - You will get an acknowledgement in the Notes
 - The decision of the judge (me) is final

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Syllabus

- I have dropped the **Galilean Transformations** sub-section of §37.2
- I have dropped §37.8 – **The Lorentz Transformation**
- I have added the **Principle of Equivalence** sub-section of §13.3

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Today

- Galileo's Principle of Relativity
- Einstein's Principle of Relativity
- The Constancy of the Speed of Light
- The Michelson-Morley Experiment

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Imagine That
This Room
Is Floating in
Free Space

"Drop Physics Module"



Kathryn C. Thornton aboard Columbia, November 1995

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Imagine That This Room Is Floating in Free Space

Either the room is stationary relative to the Sun
Or the room is moving at $\frac{1}{2}$ the speed of light
relative to the Sun in a straight line towards
Alpha Centauri

You can't look out of the room or receive signals
from outside, but can do any measurements
that you wish in the room. Can you tell which of
the two cases is true?

A. Yes

B. No

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Newton

- “**Absolute space**, in its own nature, without relation to anything external, remains always similar and immovable.”
- “**Absolute**, true and mathematical **time**, of itself, and from its own nature flows equably without regard to anything external, and by another name is called duration ...”
- “**Absolute motion** is the translation of a body from one absolute place into another ...”

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Light Waves From the Sun Travel Through Space and Reach the Earth

Can the space between the Sun and the Earth really be a vacuum?

- A. Yes
- B. No

For 19th century physicists, the answer was **No**.

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Recall (Jan 5/09): You pursue a sound wave at 99% of the speed of sound relative to the air

You will observe:

- A. A sound wave moving away from you at the speed of sound
- B. A sound wave moving away from you at about 1% of the speed of sound
- C. A stationary sound wave
- D. You can not pursue a sound wave at 99% of the speed of sound

Soon we will find out why I used the word ‘about’!

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Imagine That the Speed of Light is c With Respect to the Ether

If you are running after a light wave with a speed equal to 99% of c relative to the ether. You will observe:

- A. A light wave moving away from you at c
- B. A light wave moving away from you at about 1% of c
- C. A stationary light wave
- D. You can not pursue a light wave at 99% of c

$c = 1,079,253,000$ km/hr

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Galileo (~ 1600 ce)

- The laws of mechanics are the same in all inertial reference frames.

Einstein (1905 ce)

- All the laws of physics [including electricity and magnetism] are the same in all inertial reference frames.

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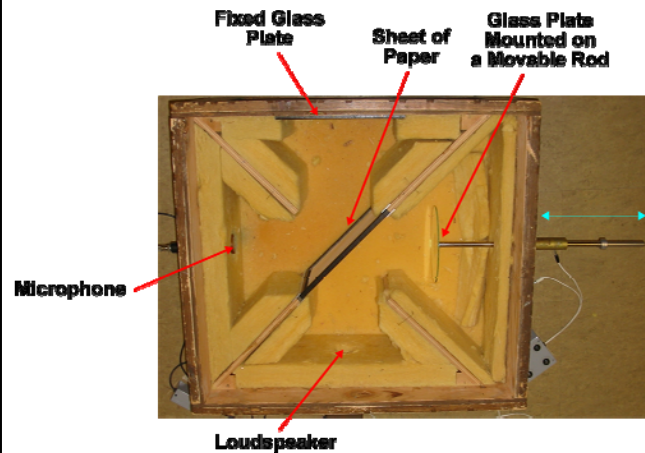
You pursue a light wave at 99% of the speed of light relative to the source of the light wave

You will observe:

- A. A light wave moving away from you at the speed of light
- B. A light wave moving away from you at about 1% of the speed of light
- C. A stationary light wave
- D. You can not pursue a light wave at 99% of the speed of light

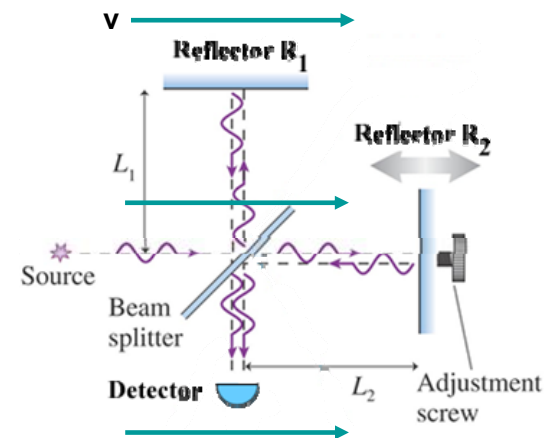
14

Acoustic Michelson Interferometer



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Michelson Interferometer (Slightly modified from Figure 22.20)



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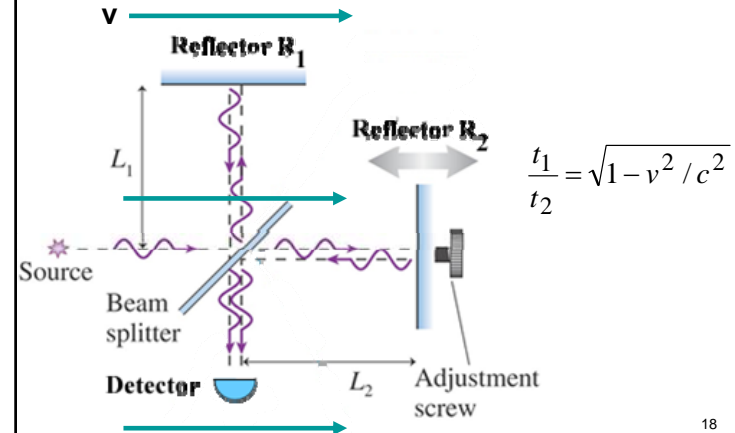
Imagine That the Speed of Light is c Relative to the Ether

Relative to an observer stationary on the surface of the Earth, the speed of light is:

- A. Exactly c
- B. $> c$
- C. $< c$
- D. One of A, B, or C depending on the place on Earth, the time of day, and perhaps the time of the year.

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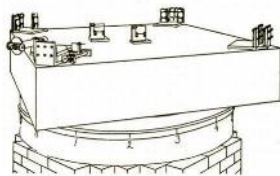
The Speed of Light is c Relative to the Ether



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Michelson-Morley Experiment

Photo of the original apparatus



Drawing of the apparatus

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Einstein at age 16 (1895)

“If I pursue a beam of light with the velocity c I should observe such a beam of light as a spatially oscillatory electromagnetic field at rest. ... From the very beginning it appeared to me intuitively clear that, judged from the standpoint of such an observer, everything would have to happen according to the same laws as for an observer who, relative to the earth, was at rest.”

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Einstein at age 26 (1905)

“... light is always propagated in empty space with a definite velocity c which is independent of the state of [relative] motion of the emitting body The introduction of a `luminiferous ether' will be **superfluous** inasmuch as the view here to be developed will not require an `absolutely stationary space' provided with special properties.”

Note: he does not say the ether does not exist

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