

More Einstein:

“Space and time are modes by which we think, not conditions under which we live.”

Ikhwan al-Sufa (900 CE)

“Space is a form abstracted from matter and exists only in consciousness.”

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Announcement

- Pre-Class Quiz 10 (Relativity 2) is released
 - Due by 10 AM Monday March 30

2

Last Time

- All motion is relative (Galileo)
 - But acceleration is absolute
- Inertial Reference Frames
 - Pre-1905: stationary or in uniform motion relative to absolute space
- Ether: a medium for light
- Einstein (1905): the speed of light is the same for all observers
- Michelson-Morley: the speed of Earth relative to the ether is experimentally equal to zero

Abbreviations: **wrt** = “with respect to”

IRF = “Inertial Reference Frame” 3

Today

- A loose end: Inertial Reference Frames after 1905
- Events and Measurements
- Time Dilation: moving clocks run slowly
- Relativistic Doppler effect
- Length Contraction: moving objects are shorter

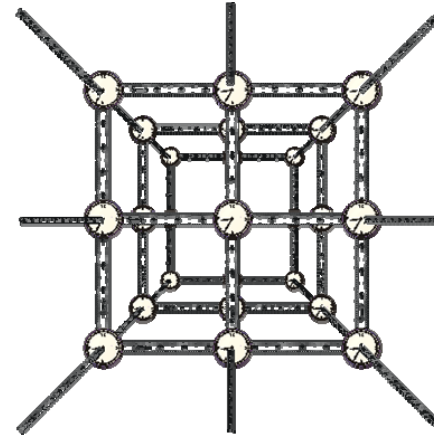
4

Inertial Reference Frames

- A frame in which the Principle of Inertia, Newton's 1st Law, is true
- The laws of physics are only true in inertial reference frames
- Pre-1905: Stationary relative to absolute space or in uniform motion in a straight line relative to absolute space
- Pre-1905: Presumably, the ether is stationary relative to absolute space
 - The ether might *be* absolute space

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Lattice of Meter Sticks and Clocks



6

Assume There is a Perfect Clock in This Room

At some moment we see the clock read exactly 3:00

What time is it?



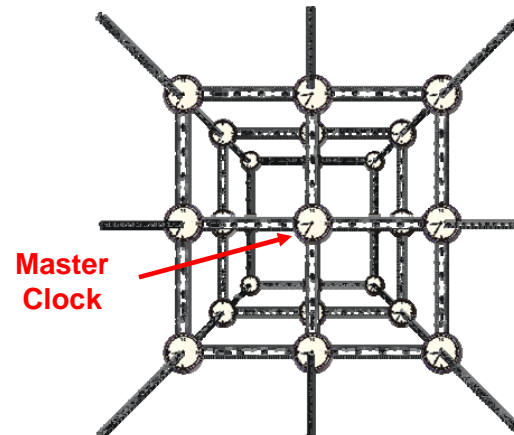
A. Exactly 3:00

B. A little later than 3:00

C. A little earlier than 3:00

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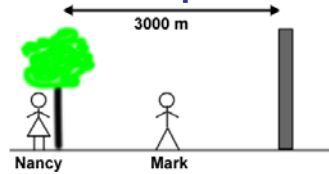
Lattice of Meter Sticks and Clocks



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A tree and a pole are 3000 m apart

Mark is at rest half way between the tree and the pole. Nancy is at rest under the tree.



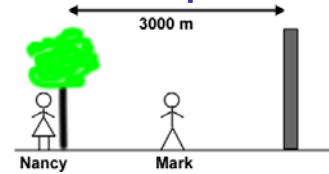
Lightning bolts strike the tree and the pole. Mark sees the flashes from the two bolts at the same time. **Were the two events, the lightning hitting the tree and the pole, simultaneous for Mark?**

- A. Yes
- B. No

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A tree and a pole are 3000 m apart

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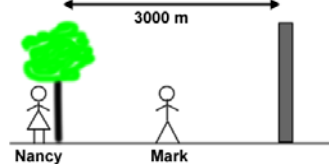
Lightning bolts strike the tree and the pole. Mark sees the flashes from the two bolts at the same time. **Does Nancy see the two flashes at the same time?**

- A. Yes
- B. No, she sees the flash from the lightning striking the tree first
- C. No she sees the flash from the lightning striking the pole first

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A tree and a pole are 3000 m apart

Mark is at rest half way between the tree and the pole. Nancy is at rest under the tree.

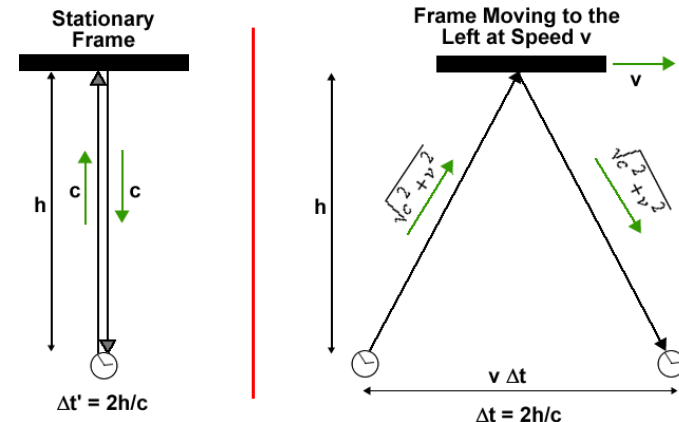


Lightning bolts strike the tree and the pole. Mark sees the flashes from the two bolts at the same time. **Were the two events simultaneous for Nancy?**

- A. Yes
- B. No, for her the lightning struck the tree first
- C. No, for her the lightning struck the pole first

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The Speed of Light is c Relative to the Ether



Textbook Mistake

- First paragraph of the **Experimental Evidence** sub-section of §37.6: “Nonetheless, the traveling clock, upon its return, was 200 ns behind the clock that stayed at home ...” **WRONG**
- The correct data are given in the Practicals Relativity Module Activity 4

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The Chain of Reasoning so Far

Einstein: the speed of light is the same for all observers

THEREFORE

Moving clocks run slowly (experimentally confirmed)

14

You are in a rocket traveling at $0.8c$ relative the Earth

You have an MP3 player or iPod that is playing your favorite Twisted Sister song. Does the music sound slow to you?

- A. Yes
- B. No, it would sound normal to you
- C. No, it would sound fast to you
- D. It depends
- E. I don't know

Personal opinion: a “favorite” Twisted Sister song does not exist!

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George stays home on Earth. Helen blasts off in a rocket to a distant star, travels to the star at high speed, and then returns at high speed to Earth.

George: Helen was traveling with respect to me so ends up younger than me.

Helen: George was traveling with respect to me so ends up younger than me.

- A. George is right, Helen is wrong
- B. Helen is right, George is wrong
- C. Both George and Helen are right
- D. Neither George or Helen are right

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