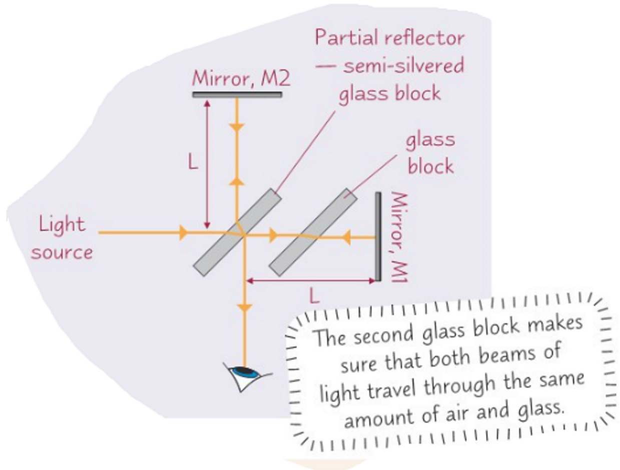
Turning Points - Speed of Light and Relativity

20 March 2020 13:35



Before Einstein physicists believed that everything moved relative to a background substance. They called this substance, which was stationary, the 'ether'.

It was known that the earth was moving through space. If we assume that direction of movement is left to right, then as the light travelled left to right then it was thought that the beam travelling along left to right would go slightly faster than the beam going back. Imagine throwing a ball on a train carriage - to an external observer the ball is going either faster than the train, or slower than the train.

The same was expected with light - in other words the speed of light wasn't fixed, because it depended on how fast the torch that created the light was its self travelling.

Michelson and Morley carried out the practical as in the diagram. Where the eye is there would be seen a diffraction pattern where the rays from the two mirrors superpose. Indeed they did. So far so good. However, they then turned the whole apparatus through 90^{O} thus changing the travel time of both beams, and therefore they expected to see a shift in the diffraction pattern.

No such shift could be detected. After much head scratching it was concluded:

- There is no such thing as absolute movement - so there is no ether
- The speed of light is the same, no matter where you observe it.

This second point is referred to as 'the invariance of the speed of light'.

Inertial Reference Frames

- Recall Newtons first law - and object does not accelerate unless there is an external force. In other words things carry on as they are without an external force. We call this tendency - inertia
- A reference frame is just an volume of space - like a set of coordinates - so we can use them to say where something is. This can be stationary or moving, in any way you like.

So an inertial reference frame is one which obeys Newton's first law. This takes a bit of getting your head around. You have to suspend your common sense a bit...

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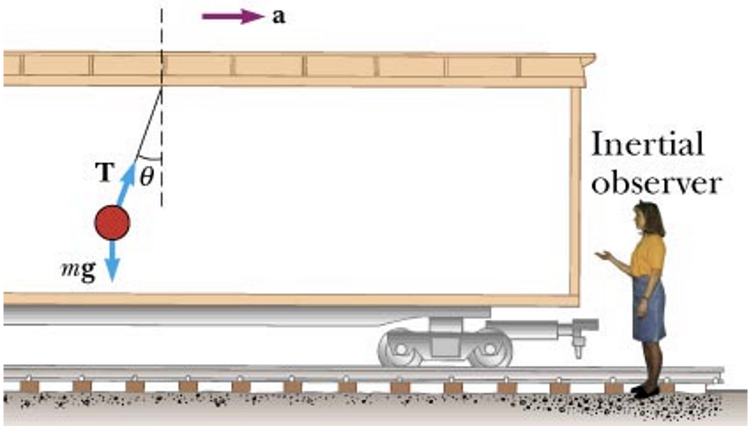
<td>
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<td>train carriage accelerates to the right.
The mass on the spring goes to an angle as shown. When the lady looks at the mass she sees it accelerating past her. 'This is fine' she says, 'because the T has to have a horizontal component to provide the acceleration for the mass'.

She is happy with her physics because Newton one is being obeyed</td>
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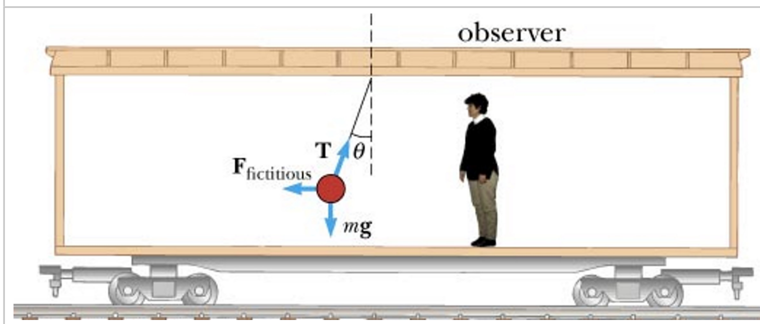
<td>
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<td>Same train, same acceleration only a man is observing from inside the train. As far as he is concerned the bob is not accelerating - yet it is not hanging straight. There must be some weird force here... "The ball is at rest compared to me" he says, 'How can there be a force there?'</td>
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Great images from : http://www.ux1.eiu.edu/~cfadd/1350/06CirMtn/AccFrames.html

Another example is to consider a coffee cup on a train table. You are sitting at the table.

1. Train stationary. Everything is as it should be. Coffee is still. Newton one applies. You are in an inertial reference frame
2. Train moving at a constant speed (no bumps). As number 1. All is well
3. Train accelerates. Coffee experiences a backwards force, and falls over. No force was applied to the coffee. Newton one does not work. You are no longer in an inertial frame of reference

Einstein's Special Relativity

- This works only in inertial reference frames (hence 'special' - not universal)
- Physics laws have the same form in all inertial frames. Do the same expt in any inertial reference frame you get the same result. One upshot of this is that its not possible to work out if you are in a stationary reference frame of one moving at a constant velocity.
- The speed of light (in a vacuum) never changes. Even if the observer is moving. Same value.