Classical Relativity - Newton

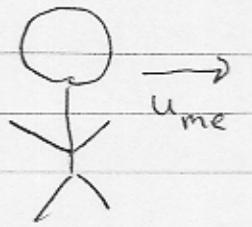
- The Stars and Planets are in constant motion (w) respect to each other

- Why should a person on jupiter have a different set of rules (for example $F = ma$, $KE_i + PE_i = KE_f + PE_f$) Than us. "And So, instead of absolute places and motions, we use relative ones

Need a set of rules which relate (the measurements we make (x, t, a, F) to an observer on Jupiter (x', t', a', F')

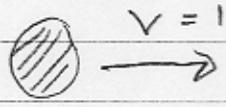
Example:

I run with a speed of 2 m/s



I say my velocity is $u_{me} = 2 m/s$

And jupiter is moving with speed



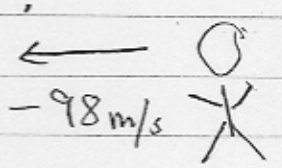
Jupiter

$V = 100 m/s$

(2)

Someone on jupiter sees

Cartoon:



jupiter

Equation:

my velocity

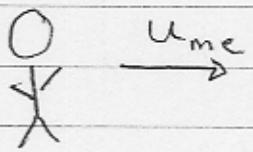
$$u'_{me} = u_{me} - v$$

my velocity as measured by someone on jupiter

$$-98\,m/s = 2\,m/s - 100\,m/s$$

(3)

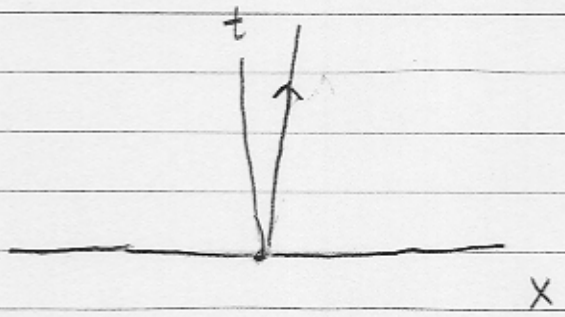
What about coordinates?



What is my position verse time (Earth Observer)

$$x_{me} = u_{me} t \qquad \left(\text{Velocity} = \frac{\text{distance}}{\text{time}}\right)$$

Space - Time Graph (Earth Observer)



For an observer on jupiter what is my position verse time

$$x'_{me} = u'_{me} t'$$

The rules of physics are the same in all frames

velocity = distance

So assume $\boxed{t' = t}$

" Absolute, true and mathematical time, of itself, and from its own nature, flows equably without relation to anything external "

— Sir Isaac Newton

Then: u'_{me} t'

$$x' = (u_{me} - v)\, t$$

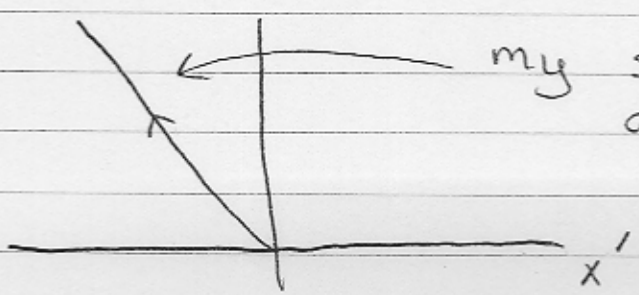
$$x' = \underbrace{u_{me} t}_{x_{me}} - vt$$

$$\boxed{x' = x - vt}$$

Space time Graph

$$x' = u'_{me}\, t'$$

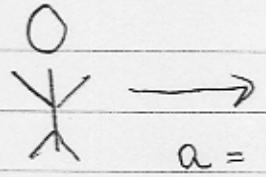
$$x' = -98\ m/s\ t'$$



my space time trajectory according to someone on jupiter

(5)

Acceleration:



$a = 2 \frac{m/s}{s}$

I'm getting faster all the time

Jupiter observer sees ?

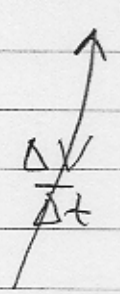
$$a = \frac{\Delta u}{\Delta t}$$ True in earth frame

So jupiter sees

$$a' = \frac{\Delta u'}{\Delta t'}$$ (The rules of physics are the same)

$$a' = \frac{\Delta u'}{\Delta t}$$

$$= \frac{\Delta (u - v)}{\Delta t} = \underbrace{\frac{\Delta u}{\Delta t}}_{a} - \frac{\Delta v}{\Delta t}$$



(Jupiter moving at constant velocity)

$$\boxed{a' = a}$$

Acceleration is the same in all inertial frames ($a_{frame} = c$

How does force change?

We know that

$$F = ma \quad \text{on earth}$$

So

$$F' = m'a' \quad \text{on jupiter}$$

Now assume that

$$\boxed{m' = m}$$ (needs to be reconsidered)

Then

$$F' = m'a' = ma = \boxed{F = F'}$$

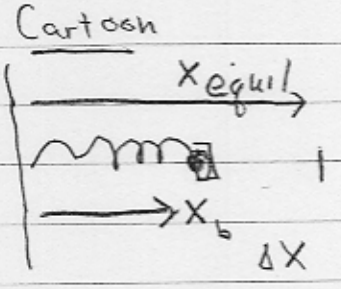
Forces are the same in all inertial frames

Example: A spring

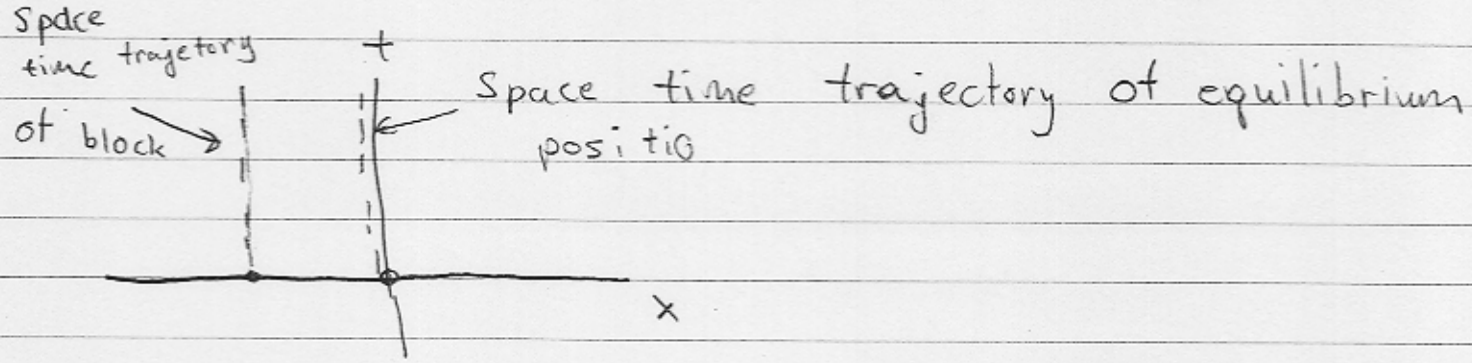
$$F_{sp} = -k\,\Delta X$$

$$F_{sp} = -k(x_b - x_e)$$

Cartoon

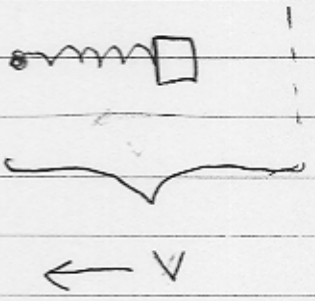


Spacetime Graph



What does the Jupiter observer see?

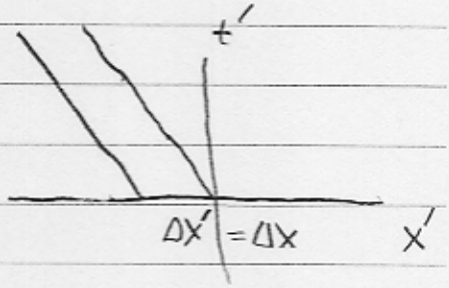
Cartoon



Position of Block

$$x'_b = x_b - vt$$

Space Time graph



Position of Equilibrium

$$x'_e = x_e - vt$$

Now

$$\Delta x' = x'_b - x'_e = (x_b - vt) - (x_e - vt) = \overbrace{x_b - x_e}^{\Delta x}$$

$$\boxed{\Delta x' = \Delta x}$$

So all relative distances are the same in all frames

Check

$F' = F$

$F' = -k\Delta x'$

$F = -k\Delta x$

$\Delta x' = \Delta x$

Consistency ✓

Summary

An observer on earth measures

$t, x, u, a, m, F, \Delta x$

↑ velocity

While an observer moving @ speed v measures

$t' = t$

$x' = x - vt$

$u' = u - v$

$a' = a$

$m' = m$

$F' = F$

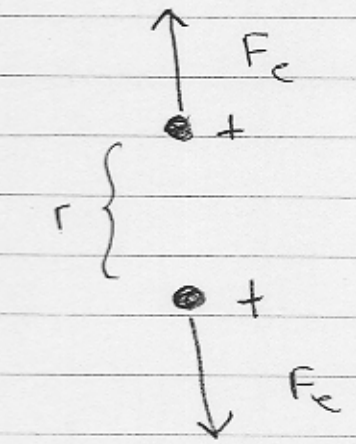
$\Delta x' = \Delta x$

But the rules are the same

$F' = m'a'$

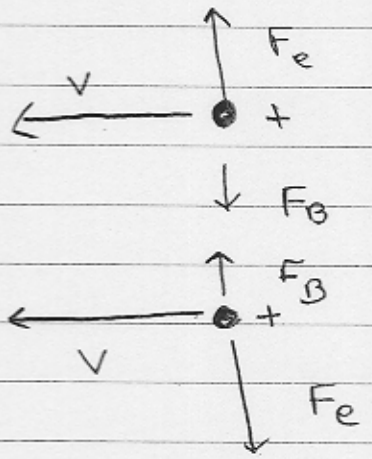
Except: E + M doesn't seem to work

Consider two point charges on earth



$$F_e = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$$

The jupiter observer sees



- Sees to charges moving. like to wires carrying current.
- Two wires carry current attract each other

$$F_E = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}$$

F_B = Given By Biot-Savat Law

$$= \frac{\mu_0}{4\pi} \frac{q_1 q_2}{r^2} v_1 v_2$$

E + M Does not respect classical relativity:

Einstein: "What led me more or less directly to the special theory of relativity was the conviction that the electromagnetic force acting on a body was nothing else but an electric field"

Need to relate:

$$E', B' \quad \text{to} \quad E, B$$

Also need to change the rules:

$$t', x' \longleftrightarrow t, x$$

Can see that the speed of light is important:

Remember: Maxwell Equations gives rise to waves of E and B fields