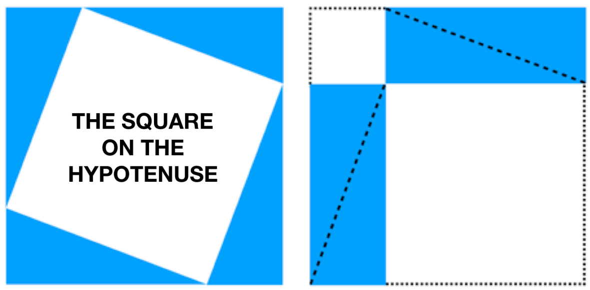
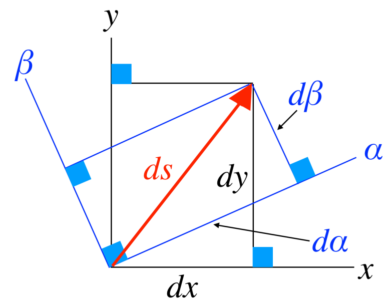
Albert Einstein explained **WHY GEOMETRY** won't let us go any faster than light !





Pythagorean Theorem's *proof*

Visual proof of the Pythagorean theorem: the two BIGGEST squares are the same size. Also, all ***8*** blue triangles are identical, and they therefore have identical areas.

So, if you take ***4*** blue triangles away from each of the two BIG squares, the areas that are left must be **exactly** the same in each!

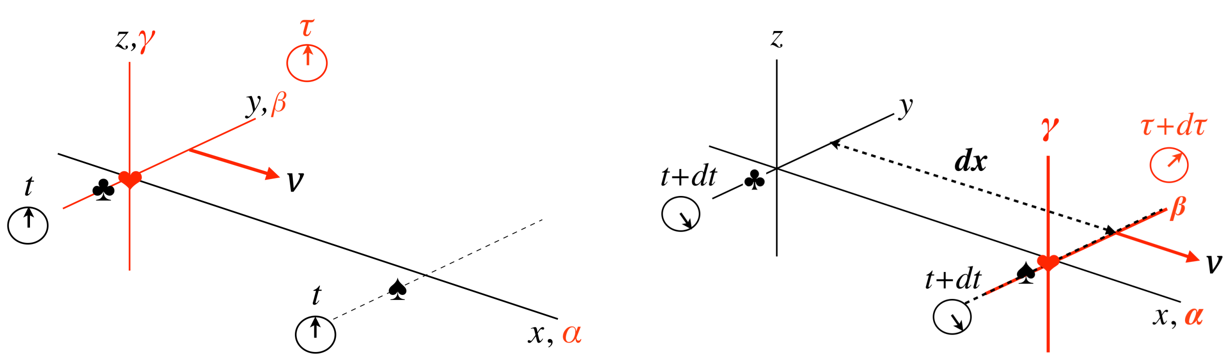
Pythagoras is **invariant under ROTATION**

The triangle with sides dx and dy has hypotenuse ds. But **so does** the triangle with sides $d\alpha$ and $d\beta$, so: ***ds*** is **invariant** under a ***rotation* —** here, the rotation that rotated the axes x, y into α, β. *All right ! But so what?* And **THEN ALGEBRA was invented!** Which provided us with a **rotational-invariance EQUATION :** $d\alpha^2 + d\beta^2 = ds^2 = dx^2 + dy^2$

AND SO at *long* last (in 1905) **the great discovery** by **Albert Einstein** of his **RELATIVITY:**

CONSTANT-MOTION invariance: $(d\alpha^2 + d\beta^2 + d\gamma^2) - d\tau^2 = (dx^2 + dy^2 + dz^2) - dt^2$

Twice, ❤ *snaps her fingers!* — as first ♣, and, later, ♠, see ❤ **move *dx*** at **constant *v*** :



❤-*moves* at ***v*** ⟹ $0 + 0 + 0 - d\tau^2 = dx^2 + 0 + 0 - dt^2$ ⟸ ♠ & ♣ both ***stationary*** in ***x, y, z***

$d\tau^2 = dt^2 - dx^2$ ∴ **❤'s time *slows*!** But $dx = v\, dt$ and so $d\tau^2 = dt^2(1 - v^2)$ and v ∴ ≤ 1

The square of *any* number is *positive!* If v were larger than **1**, the equation's right-hand side would be *negative* and so **could not** be equal to the left hand side***!*** So there is a *speed limit* ! *Algebra* claims that **velocities must be ≤ 1** (*just like* you can't go *north* of the North Pole!)

LIGHT does move at $v = 1$ **light-year/year** [∴ $d\tau = 0$ ∴ for LIGHT **NO time** *ever* passes*!*]

Experiment with particle accelerators shows: We ***can*** force **huge** energies onto particles— **BUT,** we **CANNOT** make them go faster than **1** light-year per year: **Einstein-proven-right!**

A Pythagoren **MINUS SIGN** gives **TIME** ← *Human-invented* **ALGEBRA**: **is miraculous !**

$\boldsymbol{Mass\ m\ =\ Energy\ E}$

Now we are ready to find Einstein's famous $E = m\,c^2$

Algebra just gave us: $d\tau^2 = dt^2(1 - v^2)$ and $v \therefore \leq 1$

So: $\left(\frac{dt}{d\tau}\right)^2 = \frac{1}{1-v^2}$ which $= 1$ if $v = 0$ but, which $\to \infty$ if $v \to 1$ $(\equiv c)$

$\left(\frac{d\tau}{d\tau}\right)^2 = \frac{1}{1-v^2} - \frac{v^2}{1-v^2}$ Multiply through by ❤'s *mass*^{2} $m^2 = \left(\frac{m}{\sqrt{1-v^2}}\right)^2 - \left(\frac{m\,v}{\sqrt{1-v^2}}\right)^2 \equiv E^2 - p^2$

$$E = \frac{m}{\sqrt{1-v^2}} = m + \frac{1}{2}mv^2 + \frac{3}{8}m\,v^4 + \cdots \qquad \text{— and —} \qquad p = \frac{m\,v}{\sqrt{1-v^2}}$$

BUT: ***if*** ❤ ***does not move*** v is ***zero*** and, sure, ❤*'s* $p = 0$ **BUT**: her $E = m$ ***!!!!***

Pythagoras *explains* Newton's $p = mv$, and his $E = 1/2\,mv^2$, **and** gives **Einstein's** $E = m$

That's the **END** — but *where the hell's the* c^2 ? We ***haven't*** got $E = m\,c^2$ yet ***!*** *If you insist*

$$\left(\frac{d\tau}{d\tau}\right)^2 = \frac{1}{1-\left(\frac{v}{c}\right)^2} - \frac{\left(\frac{v}{c}\right)^2}{1-\left(\frac{v}{c}\right)^2} \qquad or, rather, \qquad 1 = \frac{1}{1-\left(\frac{v}{c}\right)^2} - \frac{\left(\frac{v}{c}\right)^2}{1-\left(\frac{v}{c}\right)^2}$$

If you **measure speeds** v in *cm/s*, you **must** use $c = 3 \times 10^{10}$ *cm/s*

$$c^2 = \frac{c^4}{c^2} \times \frac{1}{1-\left(\frac{v}{c}\right)^2} - c^2\frac{\left(\frac{v}{c}\right)^2}{1-\left(\frac{v}{c}\right)^2} \quad so \quad m^2c^2 = \frac{c^4}{c^2} \times \frac{m^2}{1-\left(\frac{v}{c}\right)^2} - m^2c^2\frac{\left(\frac{v}{c}\right)^2}{1-\left(\frac{v}{c}\right)^2} \quad so \quad m^2c^2 = \frac{1}{c^2} \times \frac{m^2\,c^4}{1-\left(\frac{v}{c}\right)^2} - \frac{m^2v^2}{1-\left(\frac{v}{c}\right)^2}$$

$$so \quad m^2c^2 = \frac{1}{c^2} \times \frac{(m\,c^2)^2}{1-\left(\frac{v}{c}\right)^2} - \frac{m^2v^2}{1-\left(\frac{v}{c}\right)^2} \qquad so \quad m^2c^2 = \frac{1}{c^2} \times \left(\frac{m\,c^2}{\sqrt{1-\left(\frac{v}{c}\right)^2}}\right)^2 - \left(\frac{m\,v}{\sqrt{1-\left(\frac{v}{c}\right)^2}}\right)^2 \equiv \frac{(E)^2}{c^2} - (p)^2$$

$m^2c^4 = E^2 - c^2p^2$ *which you should compare with our* ***much better*** $\to$ $m^2 = E^2 - p^2$

$$E = \frac{m\,c^2}{\sqrt{1-\left(\frac{v}{c}\right)^2}} = m\,c^2 + \frac{1}{2}mv^2 + \frac{3}{8}m\left(\frac{v^4}{c^2}\right) + \cdots \quad \text{and} \quad p = \frac{mv}{\sqrt{1-\left(\frac{v}{c}\right)^2}}$$

AND, if $v = 0$ then momentum p is **0, and also** (***Einstein-style at last***): $E = m\,c^2$

For the rest of your life please **ignore** everything in the box above: $E = m$ or rather $m = E$

There is a limiting velocity in the universe, which is **1. No units!**

$$60.5\ mph = 60.5\ \frac{mile}{hour} \times \frac{hour}{\equiv 3600\ s} \times \frac{\equiv 1.6093440\ km}{mile} \times \frac{s}{\equiv 299{,}792.458\ km} = \mathbf{0.000{,}000{,}090}$$

You drive **DC-to-NYC** at **90** ***Billionths of a Light Year per Year,*** or, **90 billys** = **90** ***by***
Distance **DC-to-NYC** is **331 km**, or **35** ***Trillionths of a Light Year,*** or, **35 trills** = **35** ***tr***

1 trill (**1** ***tr***) is ~ 6 miles or ~ 10 kilometers

World: please adopt right now **the Hanke-Henry calendar**, **AND**: both **billys** and **trills** *!*

DC is **35 trills** (35 *tr*) from **NYC** You drive to **NYC** at **90 billys** (90 *by*)

Pythagoras, assisted—just a bit, by Newton and Einstein—provides: **the Atomic Bomb*!***