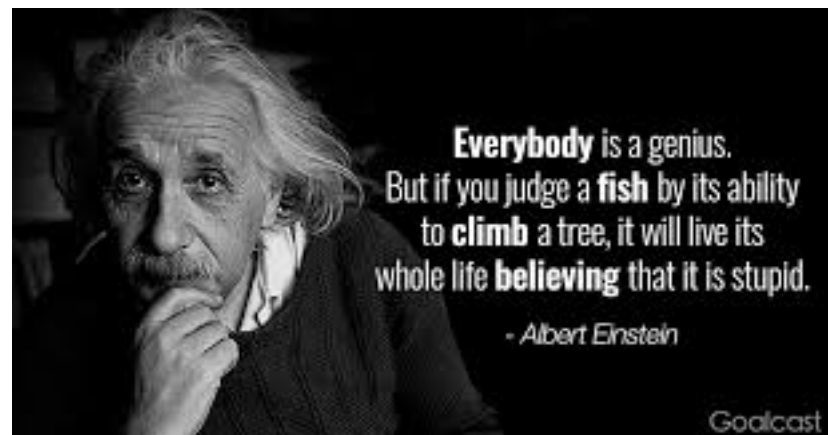


# Theory of Relativity

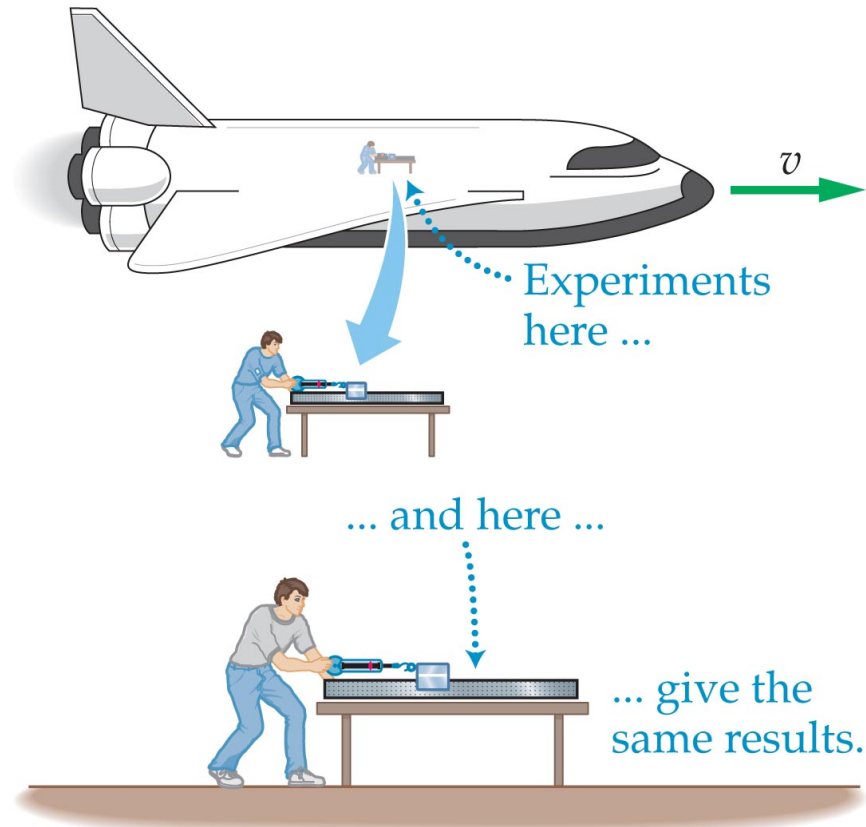
## Special Relativity (no acceleration)

Postulates:

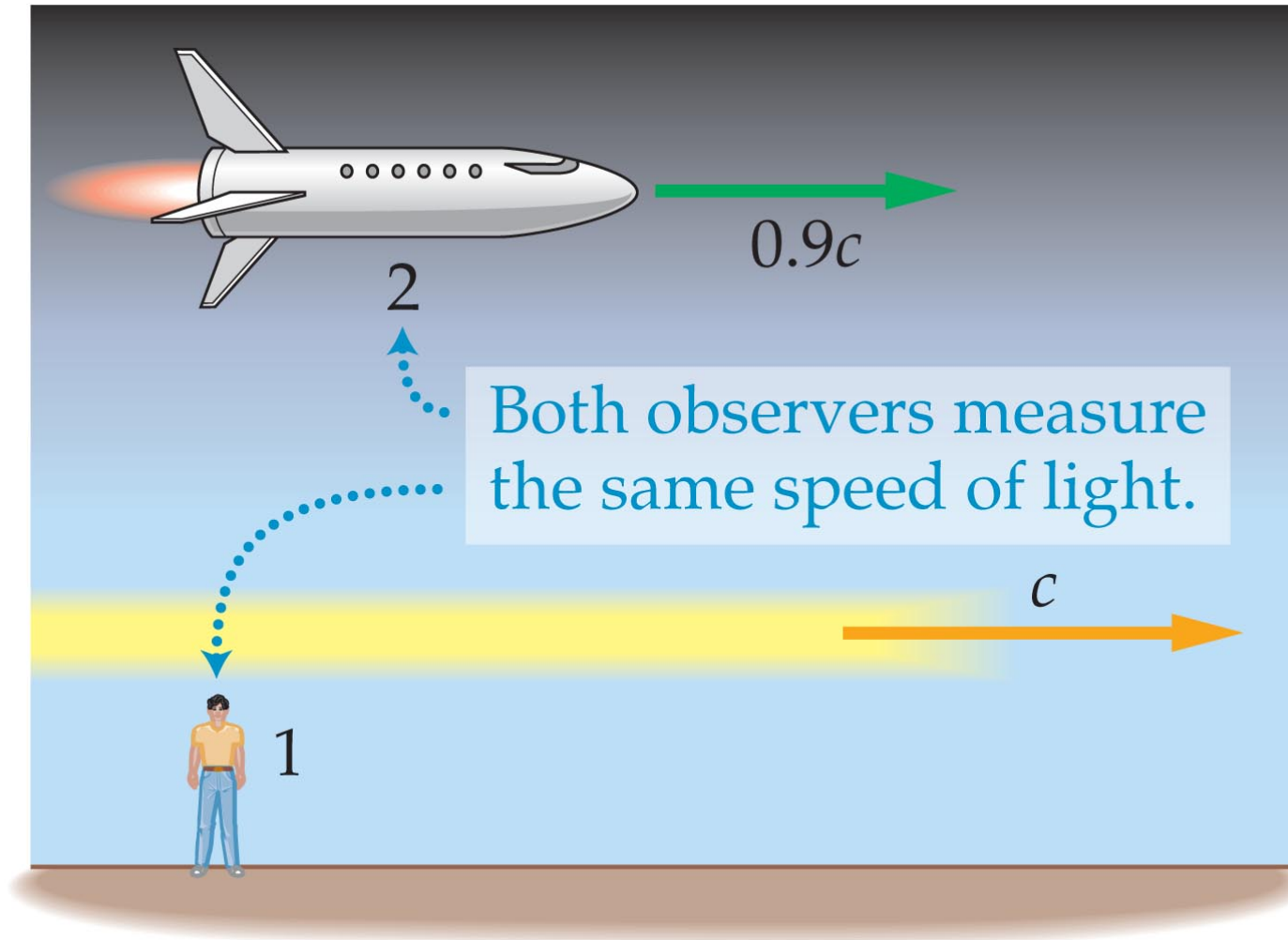
1. The laws of physics are the same in all inertial reference frames
2. The speed of light in a vacuum is the same for all inertial observers.



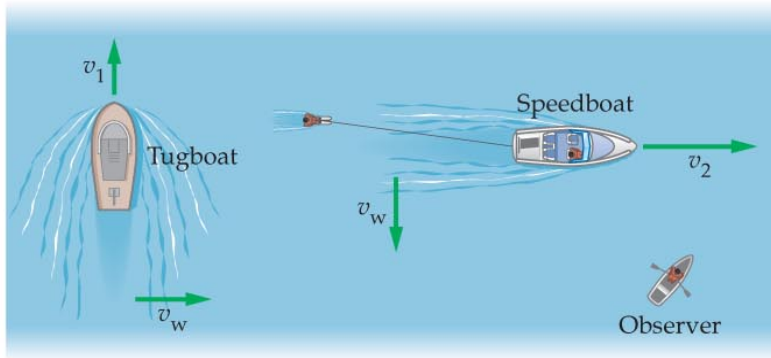
# The first postulate seems obvious!



But the second; not so much!

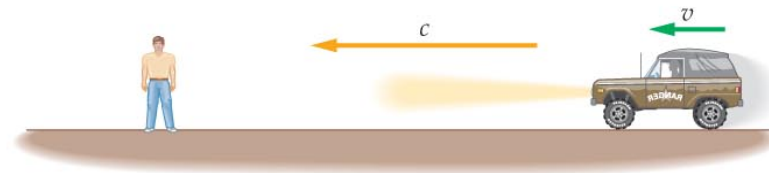


But the second; not so much!



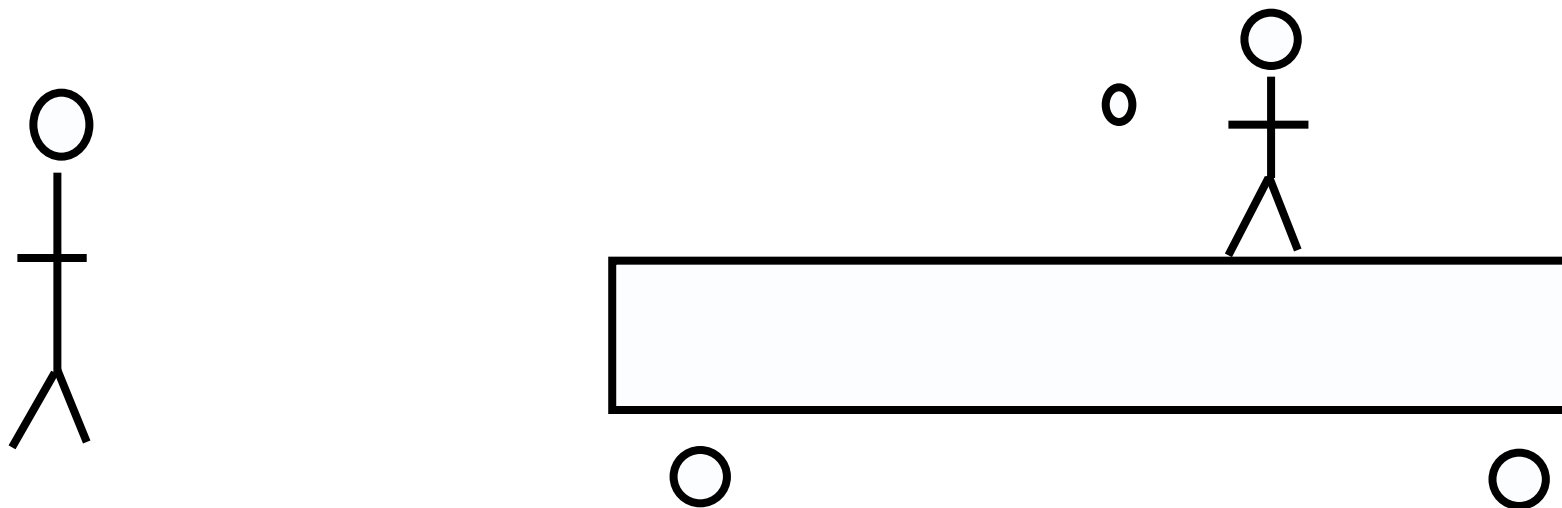
(a) Speed of water waves independent of speed of source

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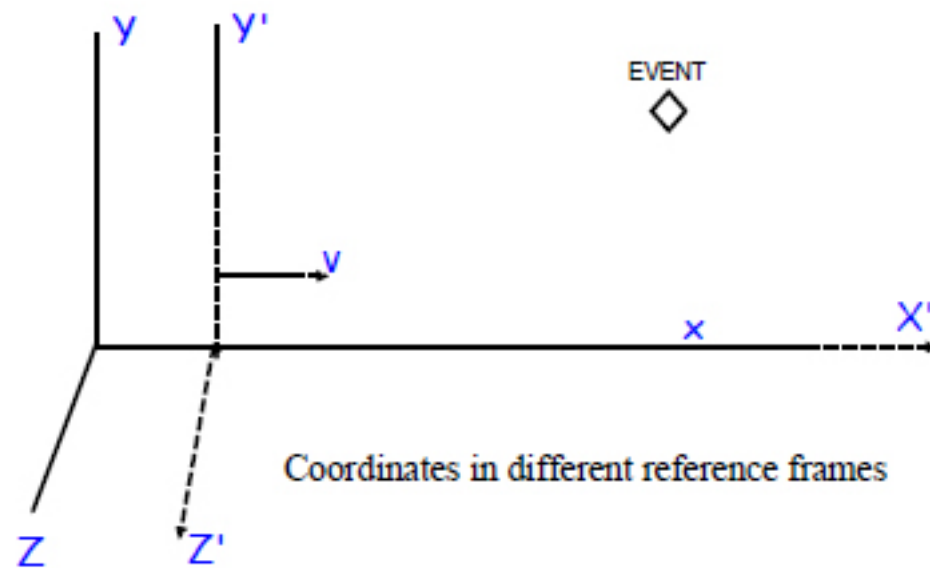


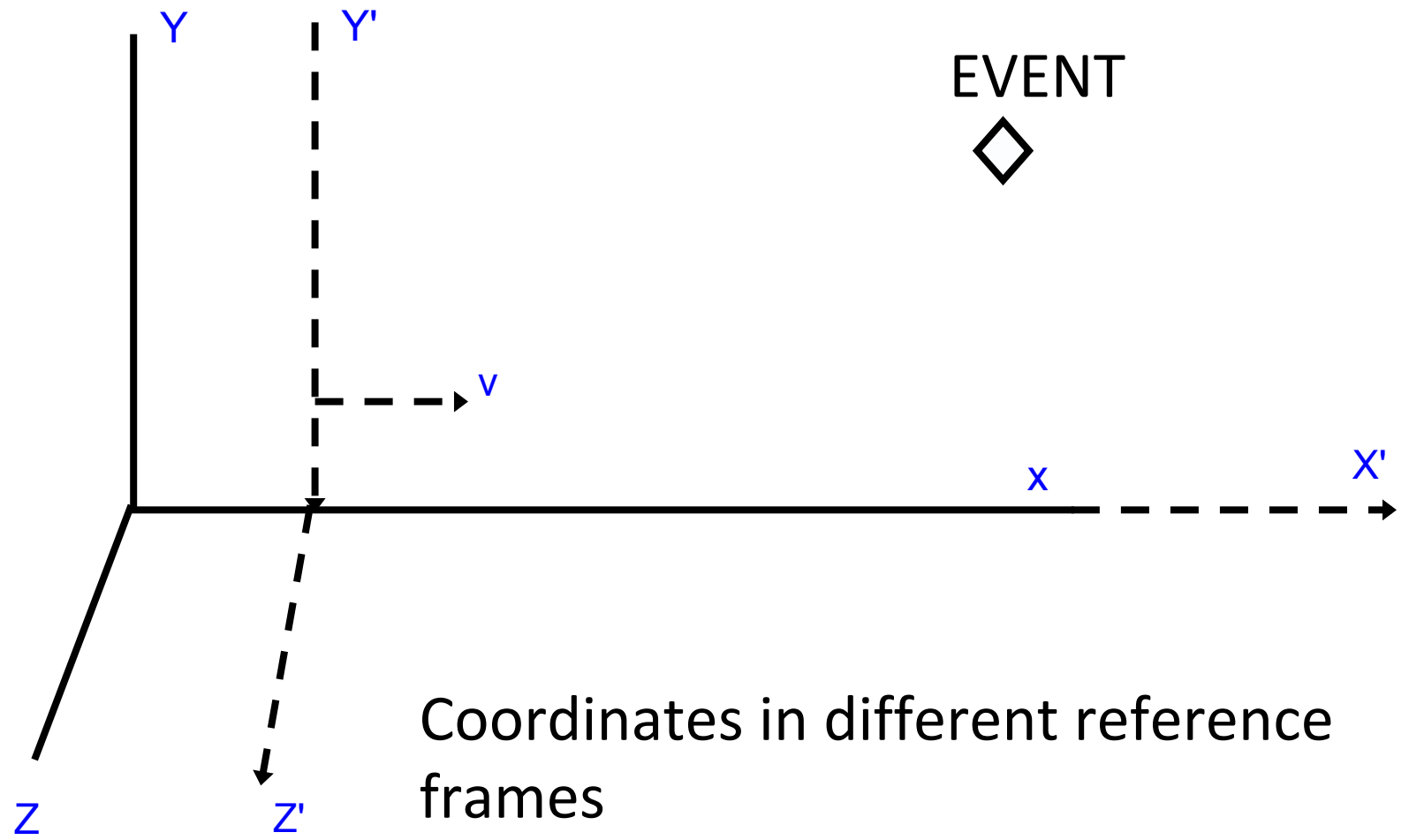
(b) Speed of light waves independent of speed of source

Adding speeds.



Two observers, one in stationary frame  $x, y, z$   
the other in  $X', Y', Z'$  moving at constant velocity  $v$





Position

$$X' = \frac{X - vt}{\sqrt{1 - v^2/c^2}}$$

$$E = mc^2$$

Length Contraction

$$L = L_0 \sqrt{1 - v^2/c^2}$$

Time Dilation

$$t = t_0 \frac{1}{\sqrt{1 - v^2/c^2}}$$



## Adding Velocities

$$V = v_1 + v_2 \text{ (common sense)}$$

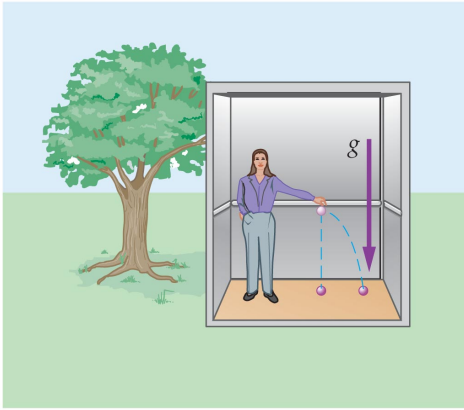
$$V = \frac{v_1 + v_2}{1 + \frac{v_1 v_2}{c^2}} \quad \text{(Relativity)}$$

	$v/c$	$v^2/c^2$	L if $L_0=1$	t if $T_0 = 1$	$L \cdot T$
Speed of sound	0.000001	1E-12	1	1	1
	0.1	0.01	0.994987437	1.005037815	1
	0.5	0.25	0.866025404	1.154700538	1
	0.9	0.81	0.435889894	2.294157339	1
	0.99	0.9801	0.14106736	7.08881205	1
	0.999	0.998001	0.044710178	22.36627204	1
	0.9999	0.99980001	0.014141782	70.71244595	1
	0.99999	0.99998	0.004472125	223.6073568	1

Changes are very, very, very small  
until you get near the speed of light.

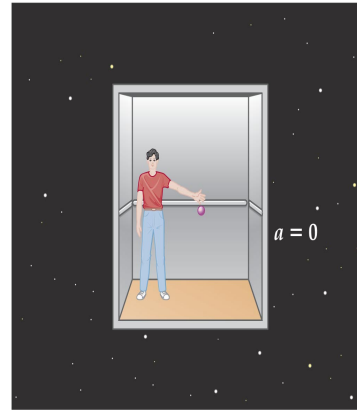
General Relativity applies to accelerating reference frames.

Any experiment conducted in a uniform gravitational field and in an accelerated reference frame will give identical results.



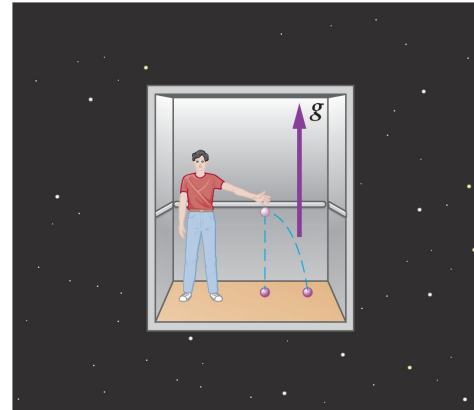
(a) A frame of reference in a gravitational field

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(b) An inertial frame of reference with no gravitational field

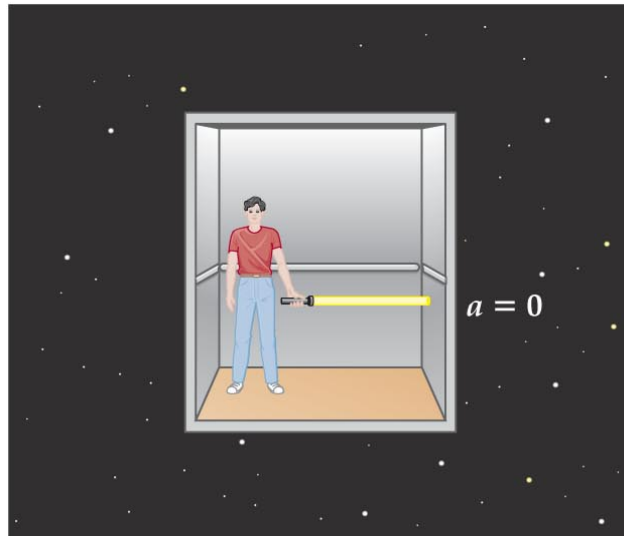
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(c) An accelerated frame of reference

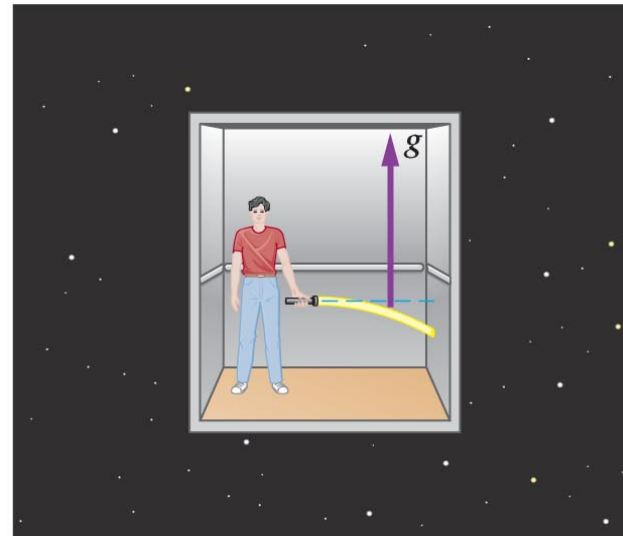
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General Relativity implies that gravity bends light.



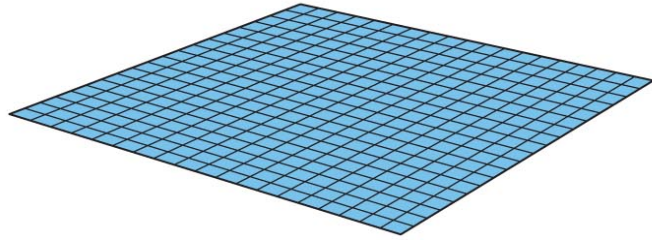
(a) Nonaccelerating elevator

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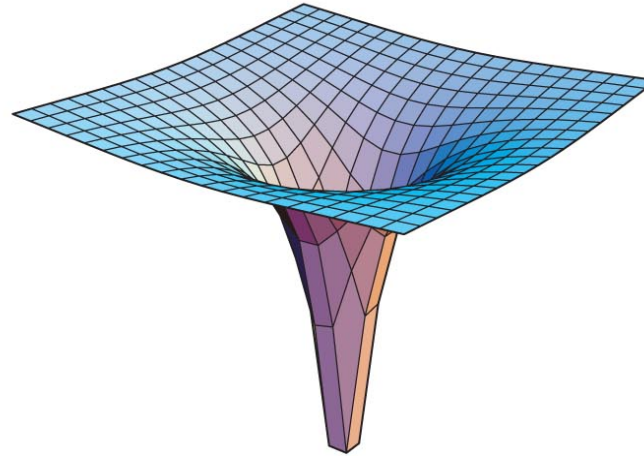
(b) Accelerating elevator

# And warps space and time!

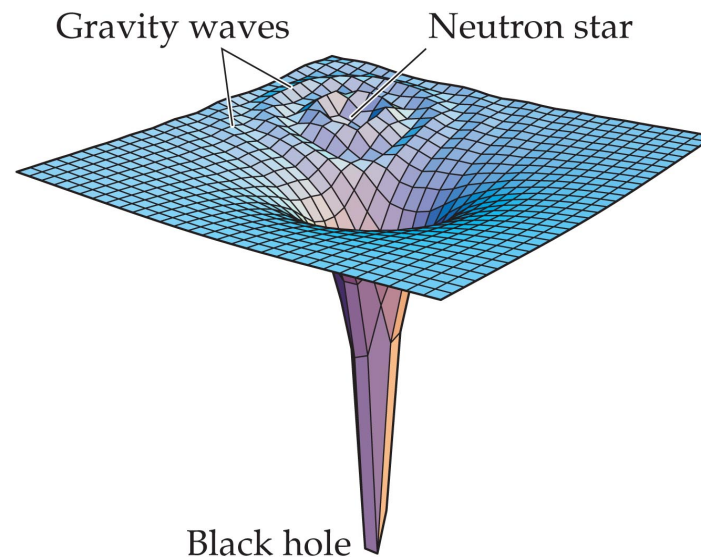


**(a)** Flat space, away from massive objects

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**(b)** Warped space, near a massive object



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# You tube: Theory of Relativity

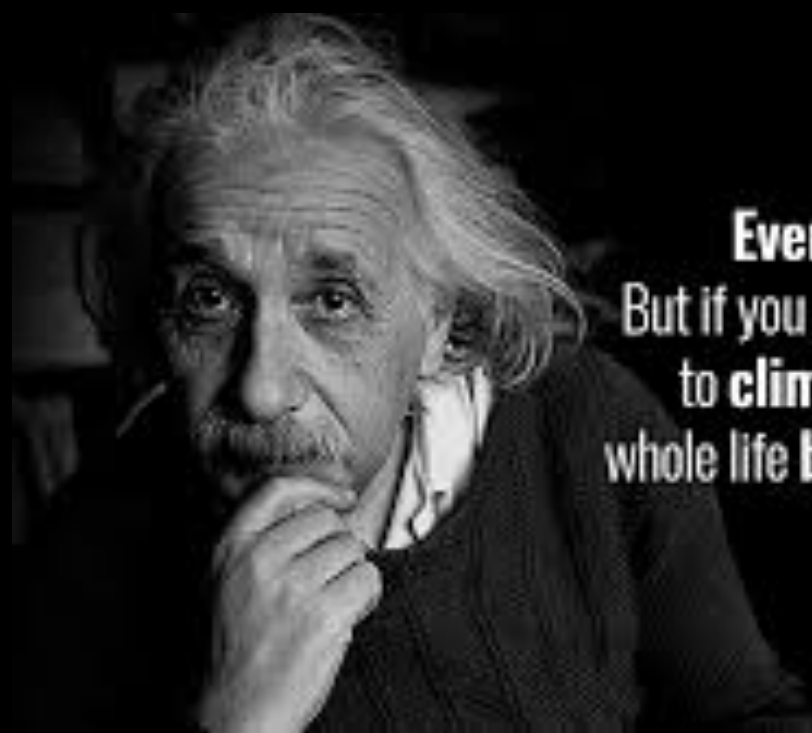
[http://www.youtube.com/watch?v=AZ6N85INgHY&feature=PlayList&p=50193D62F125C243  
&index=0&playnext=1](http://www.youtube.com/watch?v=AZ6N85INgHY&feature=PlayList&p=50193D62F125C243&index=0&playnext=1)

## Einstein's Big Idea

[http://www.youtube.com/watch?  
v=V7vpw4AH8QQ&feature=PlayList&p=50193D62F125C243  
&index=1](http://www.youtube.com/watch?v=V7vpw4AH8QQ&feature=PlayList&p=50193D62F125C243&index=1)

## Time Travel Is Possible?

<http://www.youtube.com/watch?v=X02WMNoHSm8&NR=1>



**Everybody** is a genius.  
But if you judge a **fish** by its ability  
to **climb** a tree, it will live its  
whole life **believing** that it is stupid.

- Albert Einstein

Goalcast