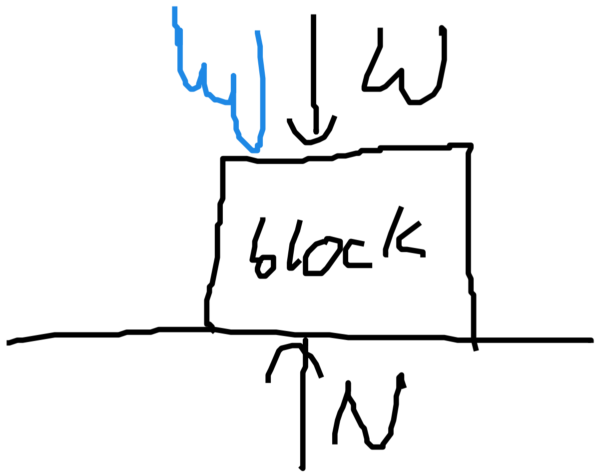
Newton's Third Law

If A pushes on B,
B pushes on A.

These two forces (force pair or force twins)

1) • same type of force
2) • Same magnitude
3) • opposite directions
4) • act on different objects

e.g.



What is the twin of the normal force on this block from the table?

Weight of the block? no

- violates 1: different types N vs W
- violates 4: N & W act on same object
- might violate 3 if other forces or if accelerating

$\downarrow N$

The table pushes on the block

The block pushes on the table.

$\uparrow N$

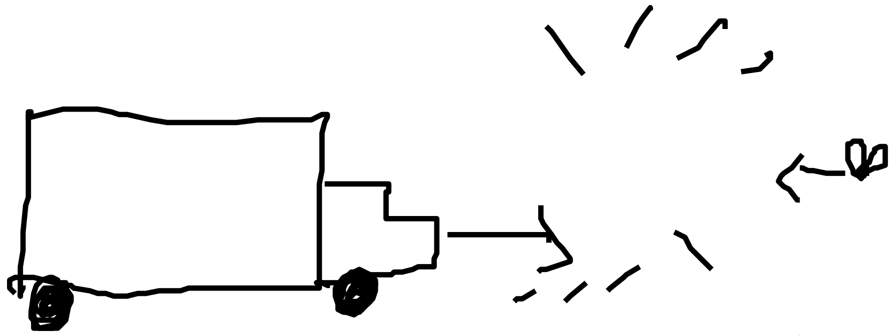
those are twins

What is the twin of the block's weight?

The earth pulls on the block.

The block pulls on the Earth.

(We all exert gravitational force on the Earth, and on everything else.)



Truck & mosquito collide.

Which feels the larger force in the collision?

The truck crashes into the mosquito
The mosquito crashes into the truck

Force pair. equal magnitude
Both feel the same force!

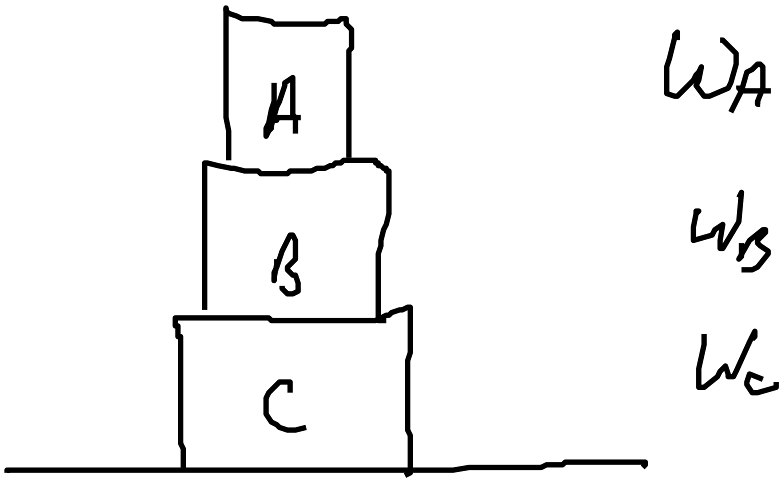
truck has greater mass

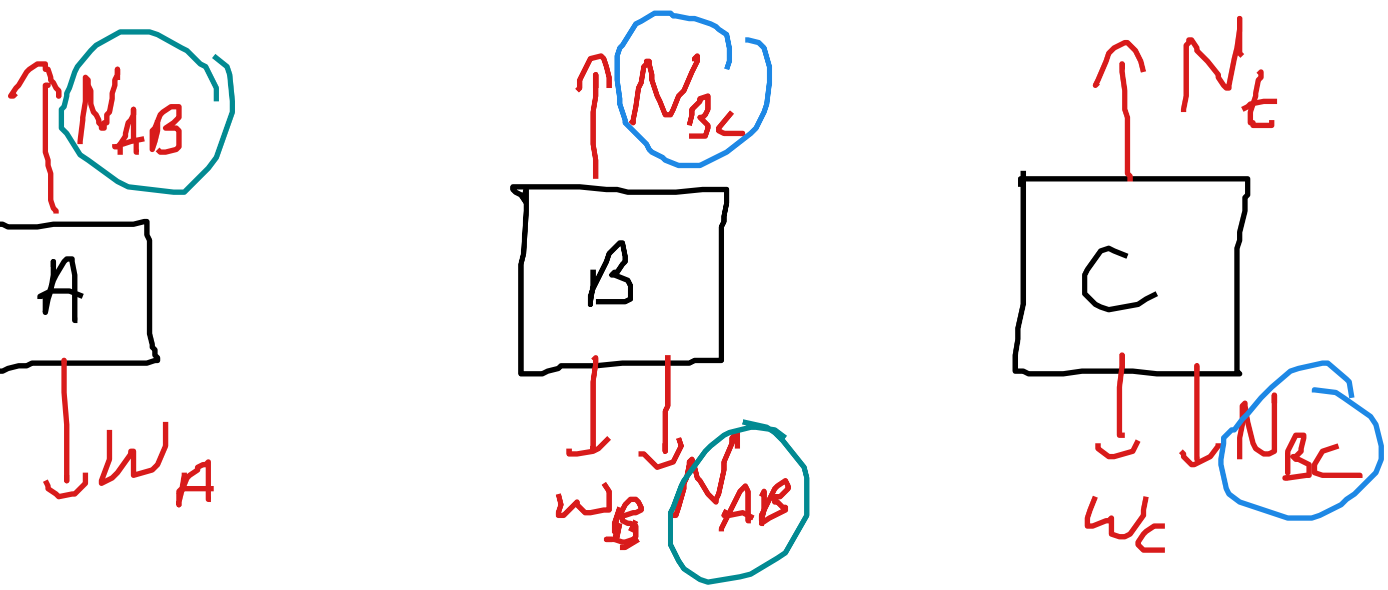
so less acceleration

$$F = ma$$

↑ cause

↑ effect (what we see)





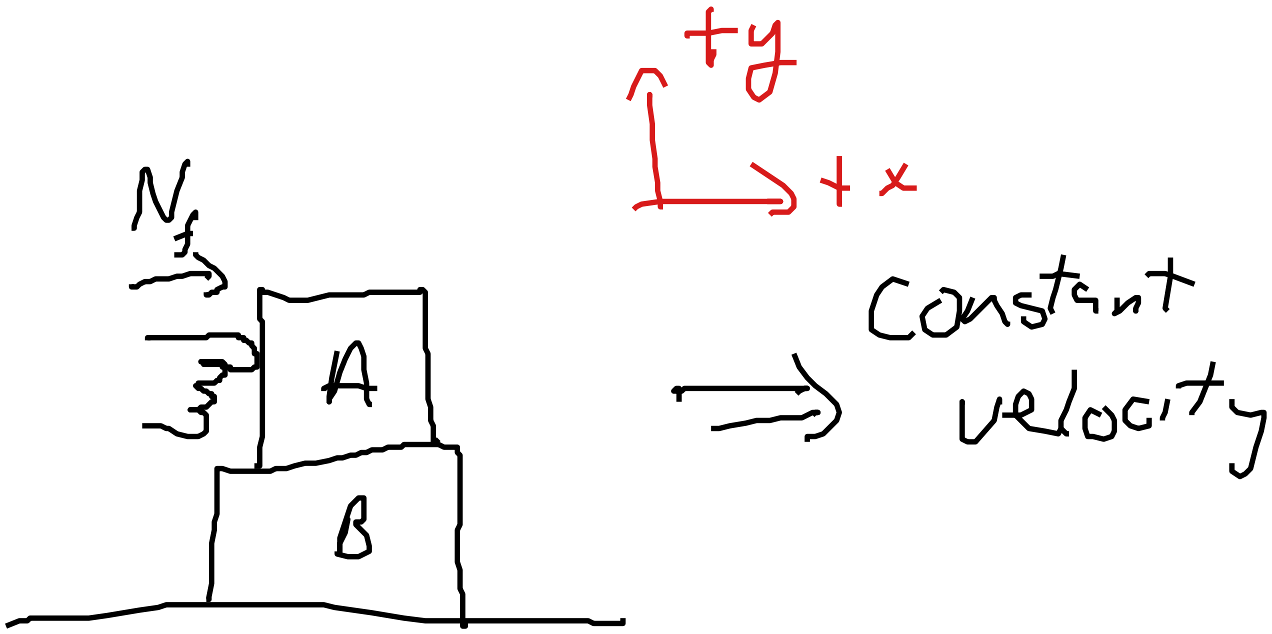
$N_{AB} = W_A$

$N_{BC} = W_B + N_{AB}$

$N_{BC} = W_B + W_A$

$N_t = W_C + N_{BC}$

$= W_C + W_B + W_A$



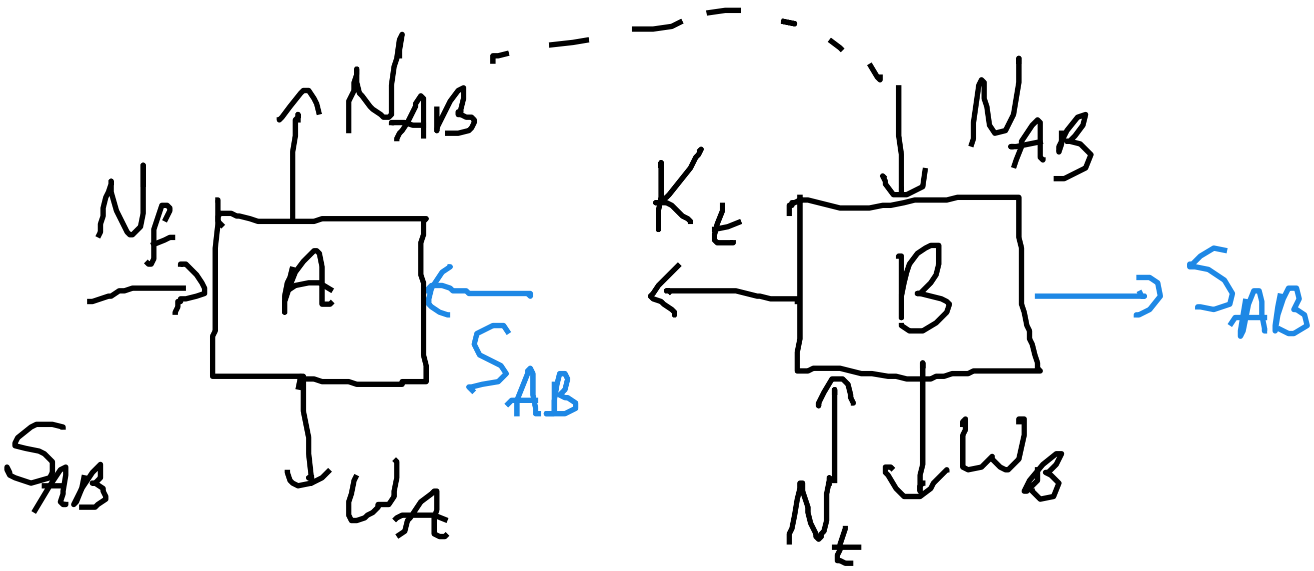
$\mu_k = 0.5$ between all surfaces

$\mu_s = 0.7$ between all surfaces

$W_A = 25N$ $W_B = 5N$

What is N_f?

Will block A slip?



A

	x	y
weight	—	$-W_A$
normal, finger	$+N_f$	—
normal, B	—	$+N_{AB}$
static friction, B	$-S_{AB}$	—

B

	x	y
weight	—	$-W_B$
normal, table		$+N_t$
k. friction table	$-K_t$	—
		$-N_{AB}$
	$+S_{AB}$	—

A/ need

$$N_f - S_{AB} = 0$$

$$-W_A + N_{AB} = 0$$

B)

$$-K_t + S_{AB} = 0$$

$$-W_B + N_t - N_{AB} = 0$$

$$K_{(t)} = \mu_k N_{(t)}$$

use N associated with the same surface as K

$$N_f = S_{AB}$$

$$N_f = S_{AB} = K_t = \mu_k N_t$$

$$N_f = 0.5 N_t$$

$$= 0.5 (W_B + N_{AB})$$

$$= 0.5 (5 + N_{AB})$$

$$N_{AB} = W_A = 25$$

$$N_f = 0.5(5 + 25)$$

$$= 15 N$$

Will block A slip?

$$S_{AB} \le \mu_s N_{AB} \quad \text{not slip}$$

$$N_f \le \mu_s W_A$$

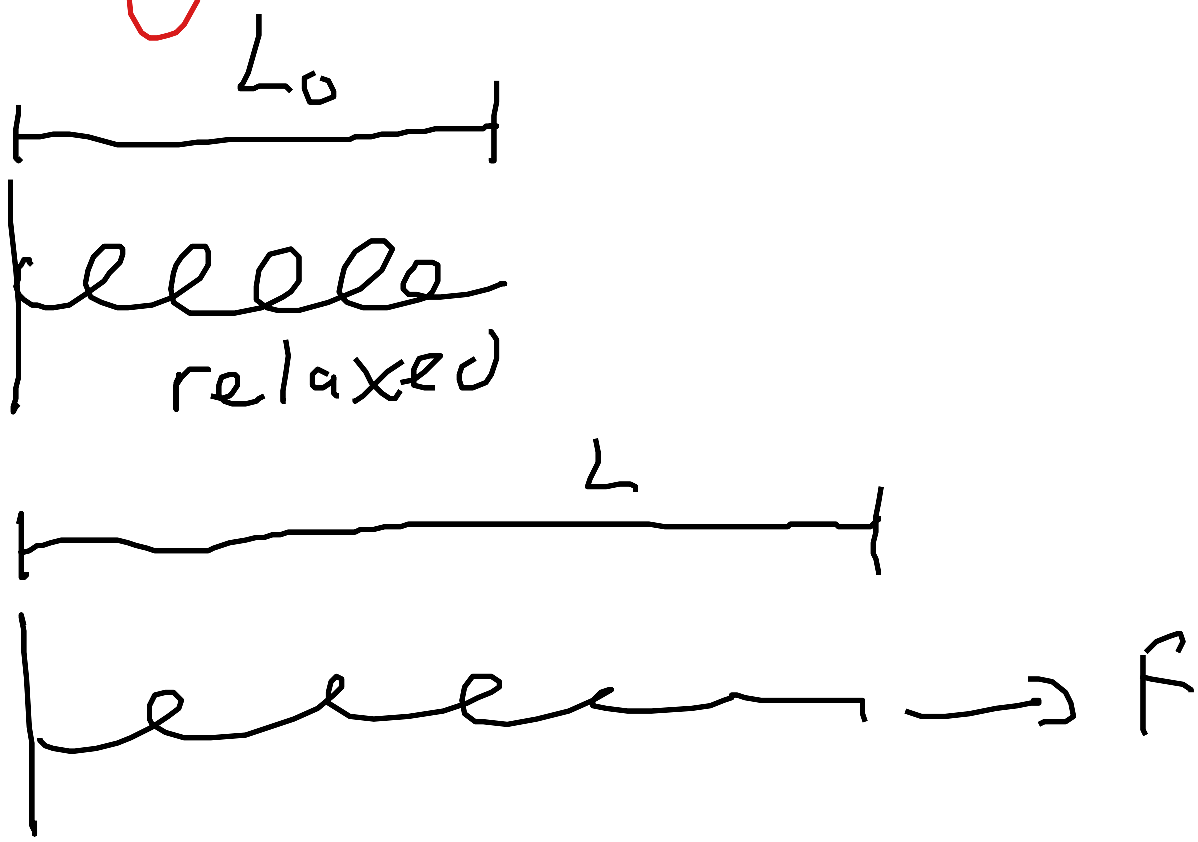
$$15 \le 0.7(25)$$

$$15 \le 17.5 \quad \text{true!}$$

So it doesn't slip

(a near thing!)

Spring



$$\Delta L = L - L_0$$

$$F = k \Delta L$$

k: spring constant
stiffness

N/m

$$F = k \Delta L$$

stress (effort applied to deform the spring)

modulus (resistance to deformation)

strain (amount of deformation)

Typically stress is proportional to strain up to a point

"elastic regime"

When stress crosses the "elastic limit", spring doesn't return to relaxed state. and proportionality is gone

1) Tensile stress

- try to stretch something

$$\frac{F}{A} = Y \frac{\Delta L}{L}$$

$\frac{F}{A}$: stress (A: cross-sectional area)

Y: Young's modulus

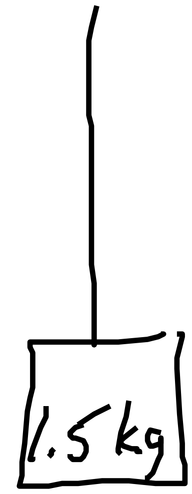
$\frac{\Delta L}{L}$: strain (fractional change in length, (%))

rubber: $10^7 - 10^8$ N/m^2

wood: $10-15 \times 10^9$ N/m^2

steel: 200×10^9 N/m^2

e.g. 1.5 m long wire
diameter of 0.4 mm



steel

$Y = 200 \times 10^{9}\ N/m^2$

How much (ΔL) does the spring stretch?

$$\Delta L = \frac{FL}{AY} = \frac{(1.5\,kg \cdot 9.8\,\frac{m}{s^2})(1.5\,m)}{(1.26 \times 10^{-5})(200 \times 10^{9})}$$

$$F = (1.5)(9.8) = 14.7\,N$$

$$A = \pi r^2 = \pi(.2 \times 10^{-3}\,m)^2$$

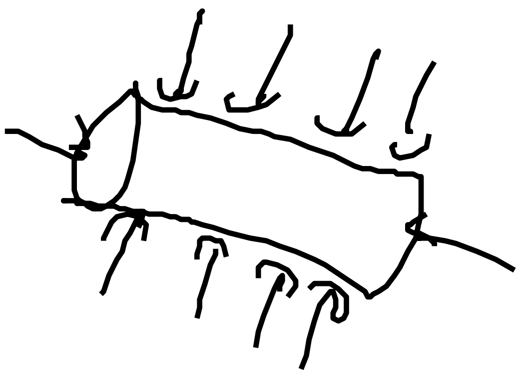
$$= 1.26 \times 10^{-5}\,m^2$$

$$\Delta L = 8.75 \times 10^{-6}\ m$$

$$8.75\ \mu m$$

- Compression or hydrostatic stress

- You try to compress an object



$$\left[\frac{F}{A}\right] = B \left[\frac{\Delta V}{V}\right]$$

pressure: F/A

A: surface area

B: bulk modulus

$\Delta V / V$: fractional change in volume

$B_{water} = 2.2 \times 10^9 \, N/m^2$

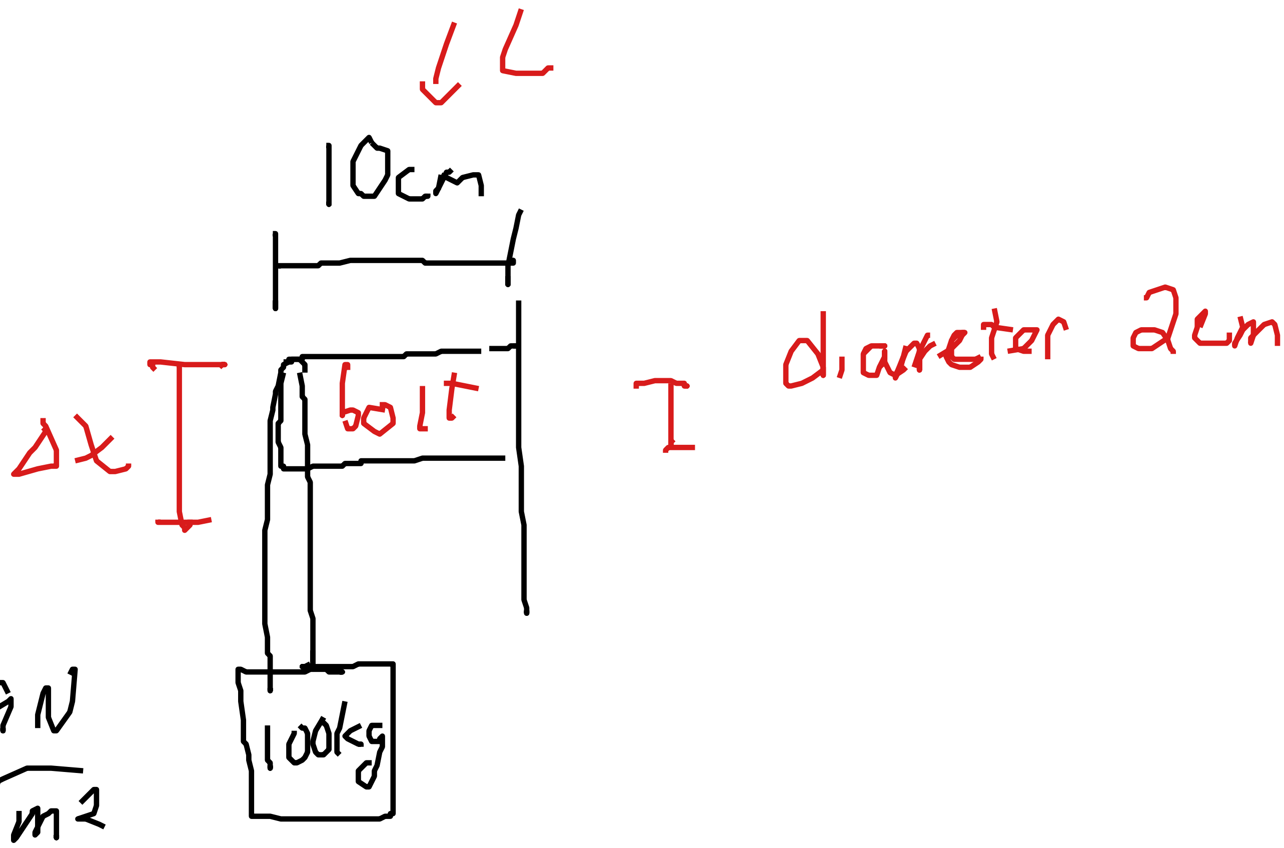
$B_{steel} = 160 \times 10^9 \, N/m^2$

Shearing Stress

- trying to bend an object

$$\frac{F}{A} = G \frac{\Delta x}{L}$$

A ← cross-sectional area



$G_{steel} = 80 \times 10^{9} \frac{N}{m^2}$

$$F = (100\,kg)(9.8\,m/s^2) = 980\,N$$

$$A = \pi(1\,cm)^2 = \pi(0.01\,m)^2 = 3.14\times10^{-4}\,m^2$$

$$L = 10\,cm = 0.1\,m$$

$$G = 80\times10^{9}\,N/m^2$$

$$\Delta x = \frac{FL}{AG} = \frac{(980)(0.1)}{(3.14\times10^{-4})(80\times10^{9})}$$

$$= 3.9\times10^{-6}\,m$$

$$= 3.9\,\mu m$$