Newton’s laws of Motion

Forces

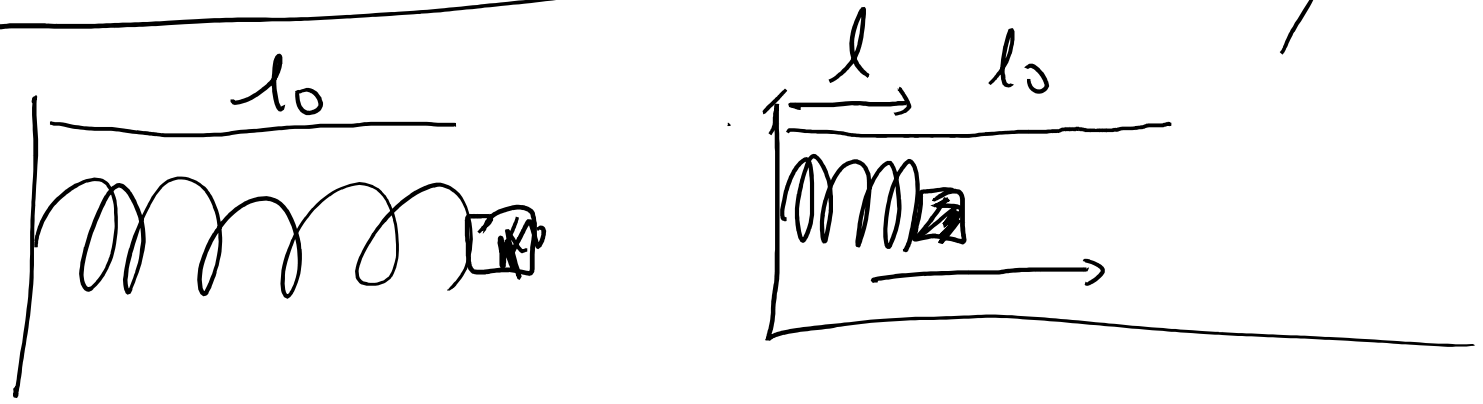
Mechanics — Kinematics
— Dynamics

Kinematics → does not care what cause the motion

Dynamics → Study motion, interogate what caused the motion

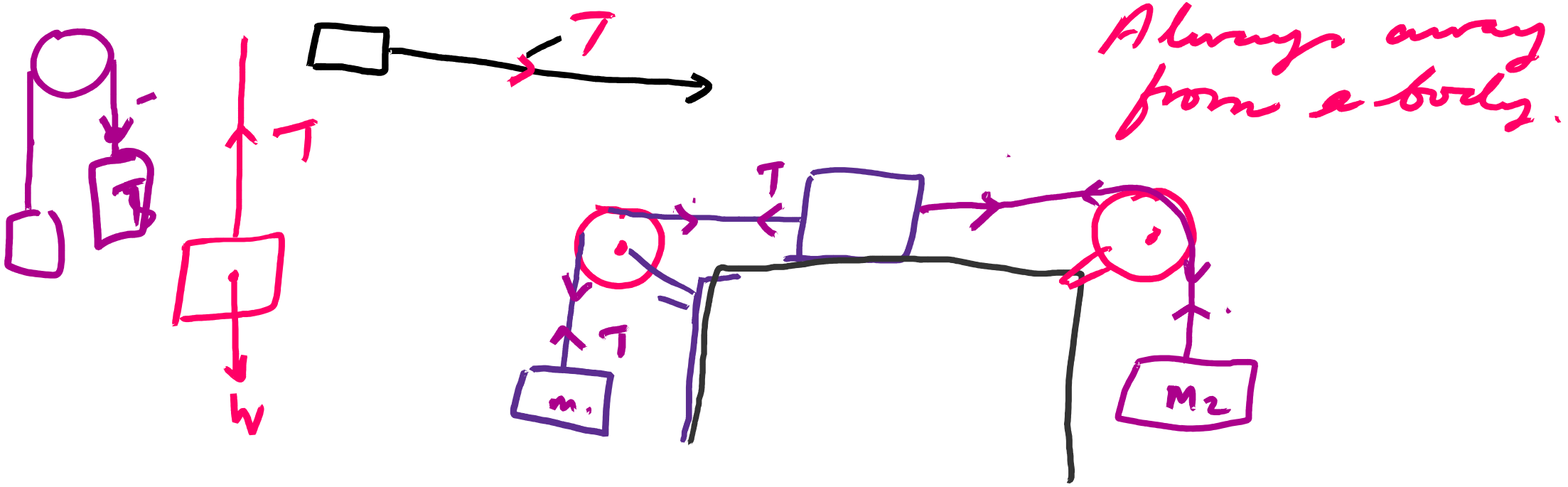
Causes of Motion

- Force ✓ **
- Energy ✓ ** → Elastic potential energy



Types of forces

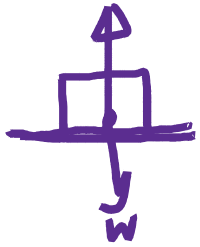
1. Tension – forces that pull on objects via strings, cables, ropes or other materials attached to objects



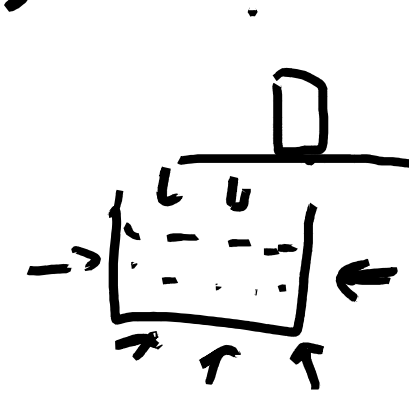
Always away from a body.

2. Force of Compression

- forces involving rigid objects which support a bear weight (shelves, floors, benches etc)



- Fluid pressure



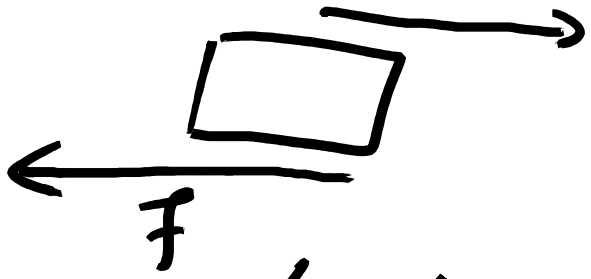
- Colliding objects

- Forces that occur perpendicular to the areas of contact, when solid objects are pushed together

3. Forces of friction

forces that resist motion

- sliding, slipping
- parallel to the direction of the motion



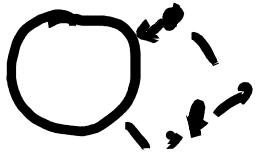
- Parallel but opposite to the direction of motion

4. Fundamental forces
- act on objects separated in space

a) Attractive force of gravity

$F_g = G\frac{m_1 m_2}{r^2}$ = Weight

$= mg$

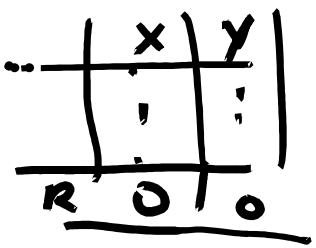


b) Electric force btn objects possessing electrical charge $F = kq_1q_2/r^2$

b) Magnetic force →

Newton's Laws of Motion

– They are 3 laws.



1. a) An object at rest remains at rest if there is no resultant force acting on it

b) A moving object continues to move with constant velocity if the vector sum of ~~object~~ forces acting on it are zero

$R = 0 : \Sigma F = 0$: Treating vectors

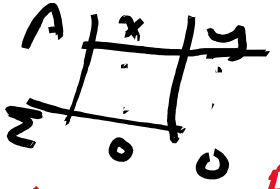
Newton's Laws of Motion

1. N- First Law of Motion

"Every object continues in its state of rest or uniform motion in a straight line unless a net external force acts on it"

- An object has constant velocity (which may be zero) until a force acts on it
- The first law defines what causes motion & accelerations.

In mathematical terms



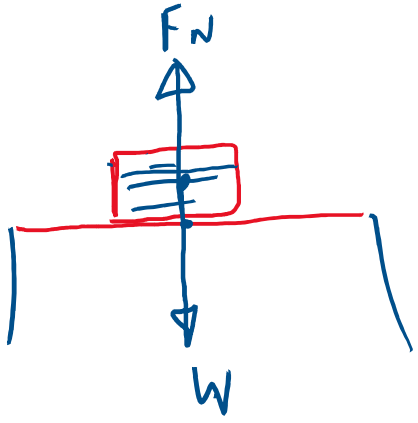
If a body has a # of forces $F_1, F_2, F_3 \ldots$ acting on it, it will remain in constant motion / rest only if

$\Sigma F = 0$ ✓

$\Sigma \equiv$ Sigma

Summation

F_N = normal force



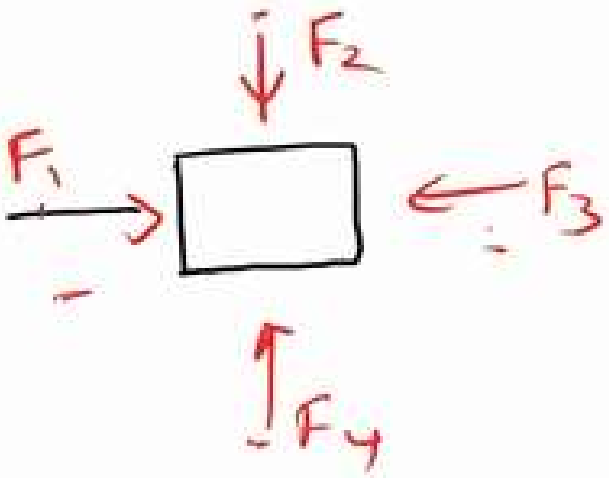
$F_N + (-W) = 0$

$F_N = W$: balance

$\Sigma F = 0$

$20 + (-20) = 0$

If multiple forces act on an object, the 1st law still applies when an object is at rest or moving with constant velocity



1.

Ve	x	y
F_1	F_1	0
F_2	0	$-F_2$
F_3	$-F_3$	0
F_4	0	F_4
R	0	0

$\Sigma F_x = 0$

$F_1 + (-F_3) = 0$

$F_1 = F_3$

$\Sigma F_y = 0$

$F_4 + (-F_2) = 0$

$F_4 = F_2$

$F_1 + 0 - F_3 = 0$

$F_1 = F_3$

$0 - F_2 + 0 + F_4 = 0$

$F_2 = F_4$

1st Law - Summary.

An object at rest will remain at rest or if moving will continue moving at constant velocity Unless there is a resultant force that acts on it [or as long as the resultant force is zero]

$\Sigma F = 0$: $v = 0$

$v =$ constant

Inertia

- Closely linked to the first law is the concept of Inertia.
- Inertia is the tendency of an object at rest to remain at rest & of an object in motion to remain in motion with its original velocity
- Inertia ≡ mass

Whiplash

- Neck bones are rather delicate and can be fractured by even a moderate force.
- Fortunately the neck muscles are relatively strong and are capable of absorbing a considerable amount of energy.
- If, however, the impact is sudden, as in a rear-end collision, the body is accelerated in the forward direction by the back of the seat, and the unsupported neck is then suddenly yanked back at full speed.
- Here the muscles do not respond fast enough and all the energy is absorbed by the neck bones, causing the well-known whiplash injury).

Consequences of 1st Law.

The neck & head tries to continue at its original speed but the body accelerates →

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Newton's Second Law.

- The net force (resultant force) acting on an object is proportional to the acceleration

$$F_{net} \propto a \quad : \quad F_{net} = ka$$

$$F_{net} = ma$$

But the net force is .....

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But the net force is Resultant

$$\therefore \sum F = ma$$

$\Sigma F = ma$: Add the force vectorially

$$\Sigma F_x = ma_x :$$

Add the forces in the x-direction and equate to ma_x.

$$\Sigma F_y = ma_y$$

Add the forces in the y-dir and equate to ma_z

$$\Sigma F_z = ma_z \ldots$$

$\Sigma F = ma$: Add the force vectorially

$\Sigma F_x = ma_x$:

All this means

Add the forces in the x-direction and equate to ma_x.

$\Sigma F_y = ma_y$

Add the forces in the y-dir and equate to ma_2

$\Sigma F_z = ma_z$ . . .

$$\Sigma F = m a$$

force	x-Comp	y-Comp
F_1	F_{1x}	F_{1y}
F_2	F_{2x}	F_{2y}
F_3	F_{3x}	F_{3y}
ΣF		

$$\Sigma F = ma$$

force	x-Comp	y-Comp
F_1	F_{1x}	F_{1y}
F_2	F_{2x}	F_{2y}
F_3	F_{3x}	F_{3y}
ΣF	ΣF_x	ΣF_y

$\Sigma F_x = ma_x = F_{net}$

$\Sigma F_y = ma_y = F_{net}$

A net force of one Newton is that force that causes an acceleration of $1\ m/s^2$ on a $1\ kg$ mass.

$$1\ N = (kg)\ m/s^2 = 1\ kg\ m/s^2 = N$$

What does net mean?

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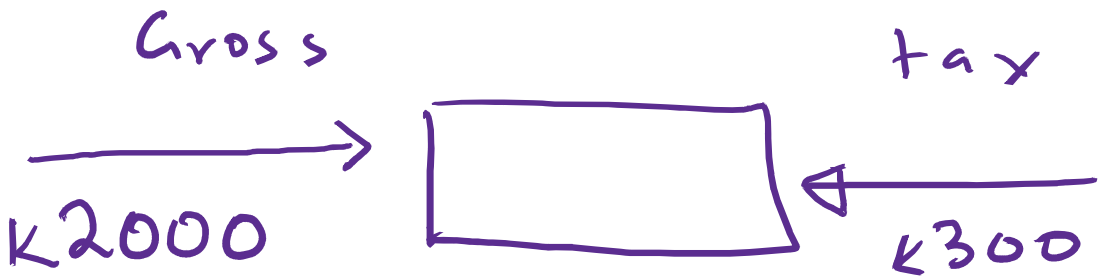
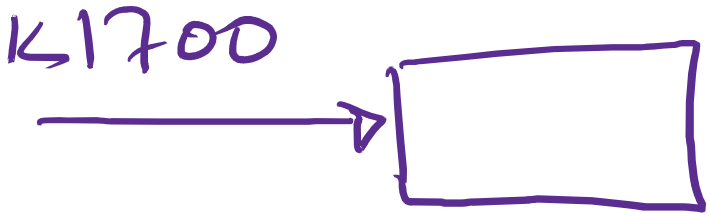
What does net mean?

Unbalanced!

Net Pay:



Net pay



Net force

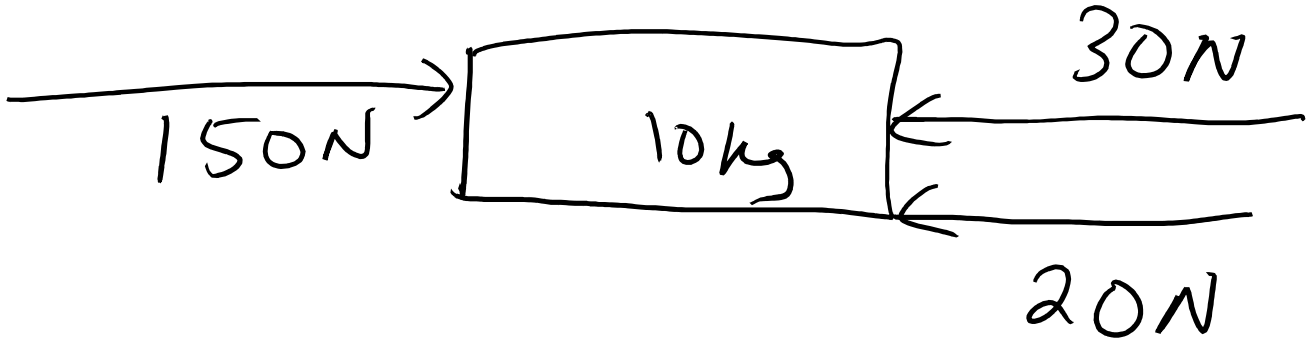
Net force = $F_{net} = \Sigma F = 500 + (-100)$

$= 400N$

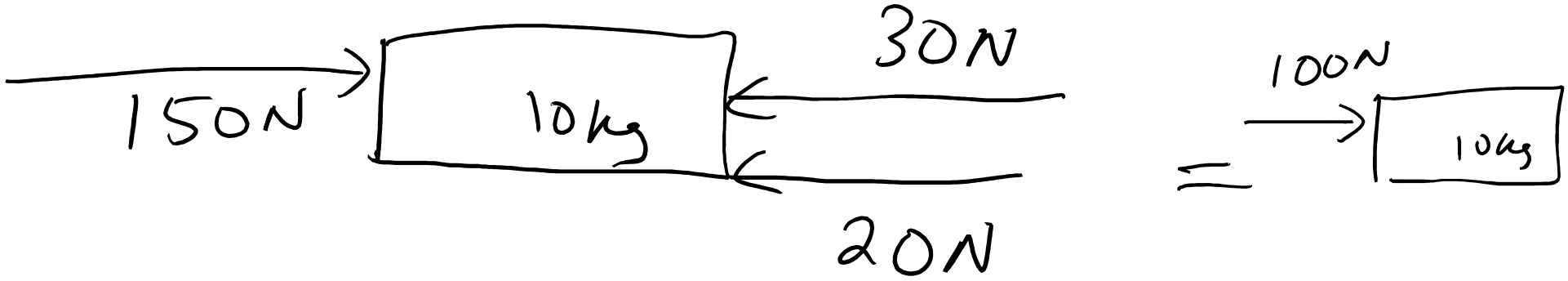
Net force

Net force = $F_{net} = \Sigma F = 500 + (-100)$

$= +400N$



What is the acceleration?

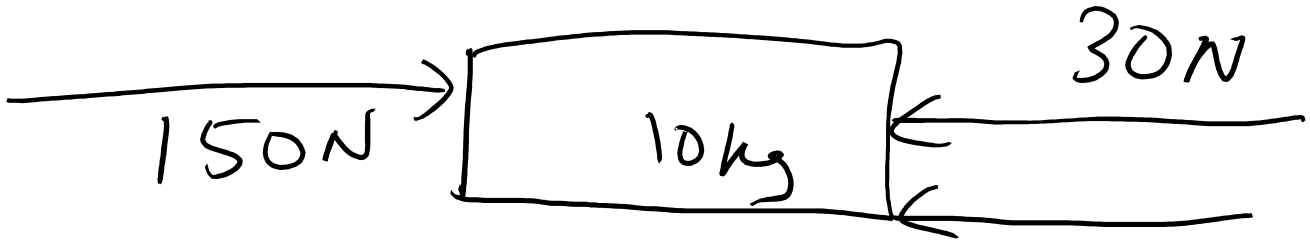


$$F_{net} = ma$$

$$150 + (-30) + (-20) = ma$$

$$100 = 10(a)$$

$$10 m/s^2 = a$$



This force overpowers

$\therefore \quad 150 - (50) = 100\,N$

EX

A 900 kg object is accelerated from rest to 12.0 m/s in 8.00 seconds along a straight road. How large is the force.

$$F_{net} = ma \qquad a = \frac{v - u}{t}$$

$$F = 900\,(1.5) \leftarrow = \frac{12 - 0}{8} = 1.5\ m/s^2$$

$$= 1350\ N \quad \checkmark$$