Lecture 7
14 Ekim 2019 Pazartesi 10:39

Chapter 4

$\vec{r}(t) \rightarrow \vec{v}(t) \rightarrow \vec{a}(t)$

↳ What causes particles to move?

Dynamics — Newtonian Mechanics

⇒ Sir Isaac Newton

↳ Stated the Laws of motion ⟺ Galileo's observations

⇒ Force & Interaction

- → Do "something" (→)
- → ~~Movement~~

1) It has a direction → vector
2) It can displace an object → magnitude (push or pull)

Interaction between objects or between object and its environment

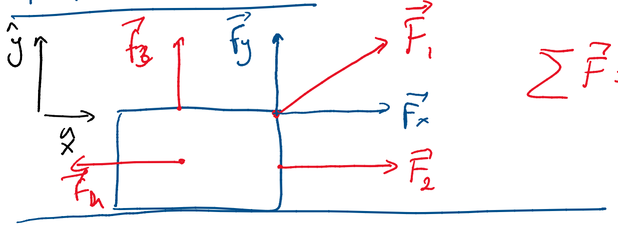
Contact forces
- ↳ Friction
- ↳ Tension
- ↳ Normal force

Non-Contact force | Fundamental forces of Nature
- ↳ Gravity
- ↳ Magnetism
- ↳ Electrostatic

(Magnetism + Electrostatic) → Electromagnetic force

- → Weak force — atoms
- → Strong force — Sub-atomic particles

Force Vector



$$\sum \vec{F} = \vec{R} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \cdots$$

$\vec{R}$ ↓ Net force acting on a body

Newton's Laws of Motion

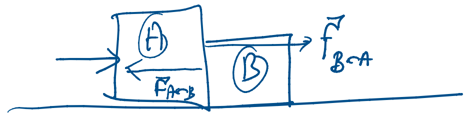
1) A body acted on by no net force has a constant velocity and zero acceleration.
   (constant: no change in time!)

2) If a net external force acts on a body, the body accelerates.
   The direction of the acceleration is the same as the direction

2) If a net external force acts on a body, the body accelerates.
The direction of the acceleration is the same as the direction of the net force and (mass of the body) $\times \vec{a} = \vec{F}$

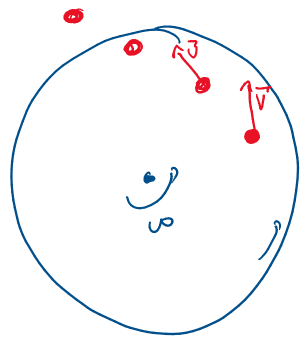
$$\boxed{\vec{F} = m\vec{a}}$$

3) For every action, there is an equal and opposite reaction:



⇒ The First Law

↳ "Inertia": tendency of a body to keep its motion state



Is this an inertial reference frame?

You need an inertial reference frame

⇒ the Second Law

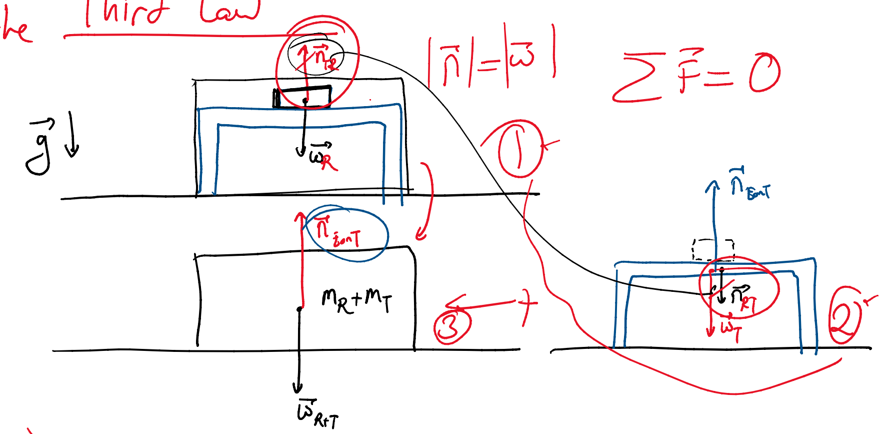
" $\vec{F} = m\vec{a}$ "

$1\ \text{Newton} = 1\ \text{kg} \cdot \text{m}/\text{s}^2$

⇒ the Third Law

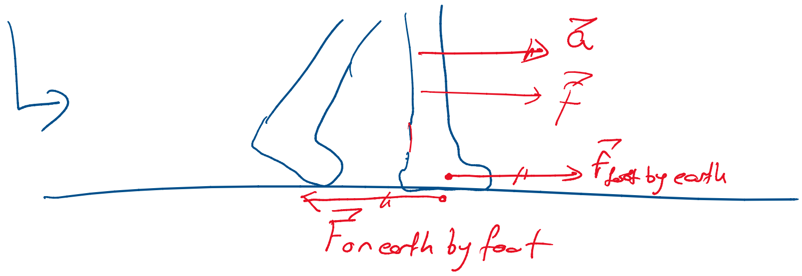
$|\vec{n}| = |\vec{\omega}|$

$\sum \vec{F} = 0$



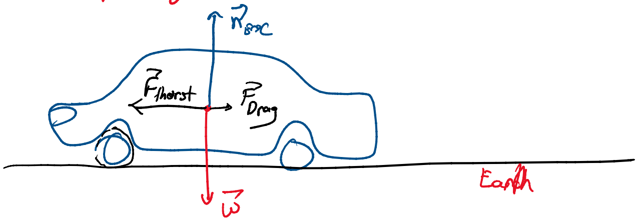
⇒ (Two forces in an action-reaction pair never acts on the same object!)

On the same object!

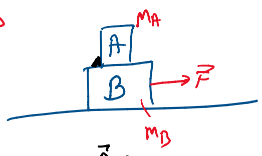


⇒ Free-body diagrams

1) Identify the body you study
2) Identify forces acting on the body
3) "Free body" diagram should only show the body itself



Ex)

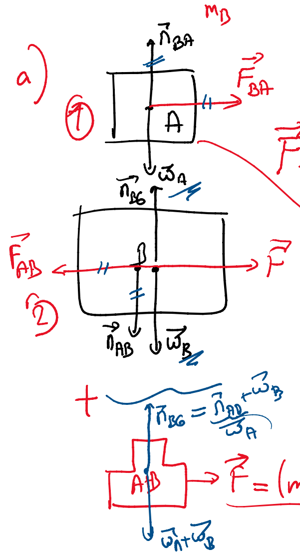


→ when pulled on B, A & B moves together

a) Draw free-body diagram when there is no friction

b) There is a friction between B & ground and the pull $|\vec{F}| = |\vec{F}_{fric}|$

a)

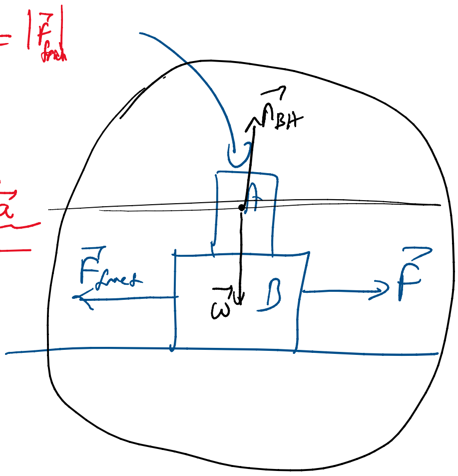


$\vec{F} = (m_A + m_B)\vec{a}$

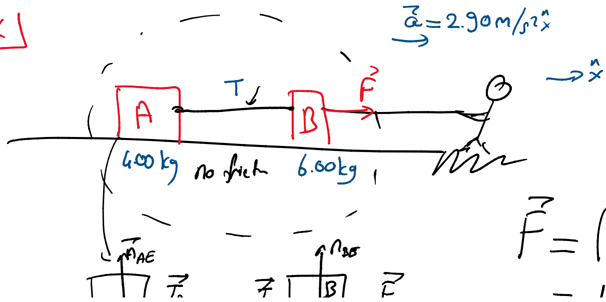
$\vec{F}_{BA} = m_a \cdot \vec{a}$

$\vec{n}_{BG} = \vec{n}_{AB} + \vec{w}_B$, $\vec{w}_A$

$\vec{F} = (m_A + m_B)\vec{a}$



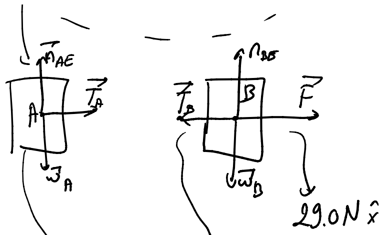
Ex)



$\vec{F} = ?$

$\vec{F} = (m_A + m_B)\vec{a}$

$= 10.00\ \ 2.90\ m/s^2\ \hat{x}$



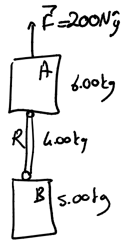
$$\vec{F} = (m_A + m_B)\,\vec{a}$$
$$= 10.00\,kg \times 2.90\,m/s^2\,\hat{x}$$
$$\vec{F} = 29.0\,kg\,m/s^2\,\hat{x}$$

$$\vec{T}_A = 4.00\,kg \cdot 2.90\,m/s^2\,\hat{x} = 11.6\,N\,\hat{x}$$

$$|\vec{T}_A| = |\vec{T}_B|$$
$$\Rightarrow \vec{F} - \vec{T}_B = m_B \cdot \vec{a}$$
17.4 N $\hat{x}$
$$\vec{T}_B = -11.6\,N\,\hat{x}$$

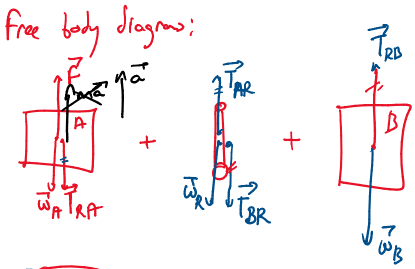
Ex)

$\hat{y}$ ↑ $\vec{g}$ ↓



~~$\vec{F} = (m_A + m_R + m_B)\cdot\vec{a}$~~
~~200N$\hat{y}$ = 15kg $\cdot\vec{a}$~~

Free body diagrams:



do not include $m\vec{a}$ in free body diagrams.

$$\sum \vec{F} = m\vec{a} = \vec{F} - (\vec{w}_A + \vec{w}_R + \vec{w}_B) = (m_A + m_R + m_B)\,\vec{a}$$

$m\vec{a}$ is not a force

$$200N\hat{y} - (m_A + m_R + m_B)\,9.8\,m/s^2\,\hat{y} = (\;)\,\vec{a}$$
15 kg 15 kg

$$\vec{a} = 3.5\,m/s^2\,\hat{y}$$

Ex)

$$\frac{\vec{F}(t)}{m} = \vec{a}(t)$$

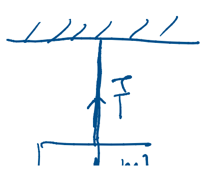
acts m, $v(0) = 0$, $r(0) = 0$
$\rightarrow r(t),\ v(t)$

integrate

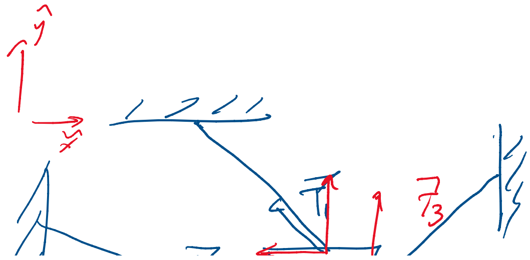
$$\int_0^t \vec{a}(t')\,dt' = \vec{v}(t) \xrightarrow{\text{integrate}} \int_0^t \vec{v}(t')\,dt' = \vec{r}(t)$$

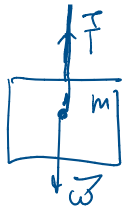
Chapter 5 → Applying Newton's laws

1.) Particles in equilibrium ⇒ $\sum \vec{F} = 0$

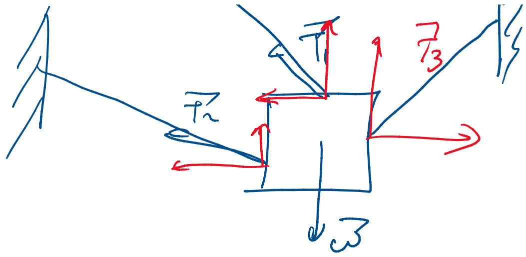


$$\vec{T} + \vec{w} = 0$$





$\vec{T} + \vec{w} = 0$



2.) Dynamics of particles

$$\sum \vec{F} = m\vec{a}$$