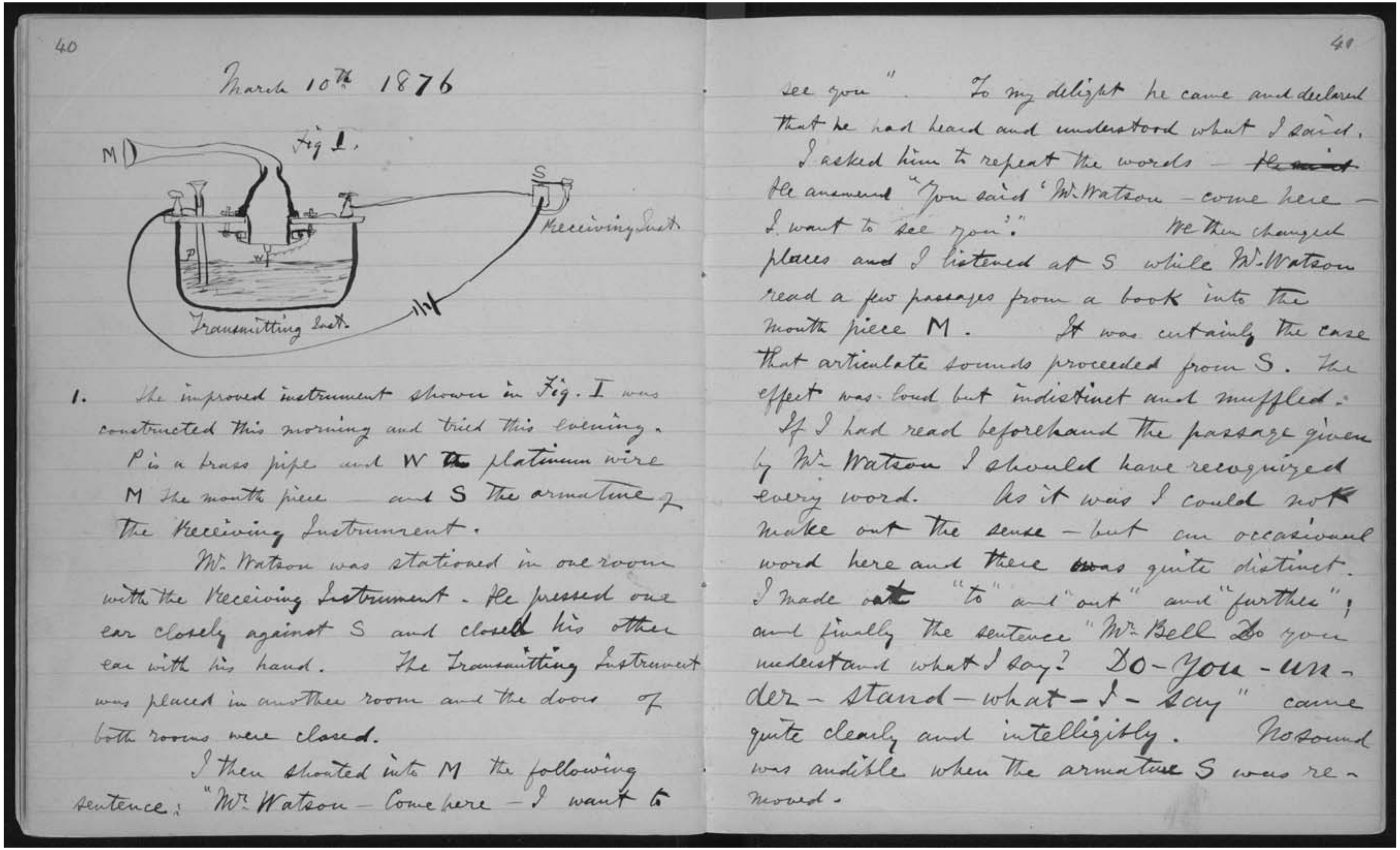
FIZ101E – Lecture 4
Applying Newton's laws

Alexandr Jonas

Department of Physics Engineering

Istanbul Technical University

What did we cover last week?



40

March 10th 1876

Fig 1.

M — S — P — W — Receiving Inst. — Transmitting Inst.

1. The improved instrument shown in Fig. I was constructed this morning and tried this evening. P is a brass pipe and W the platinum wire M the mouth piece and S the armature of the Receiving Instrument.

Mr. Watson was stationed in one room with the Receiving Instrument. He pressed one ear closely against S and closed his other ear with his hand. The Transmitting Instrument was placed in another room and the doors of both rooms were closed.

I then shouted into M the following sentence: "Mr. Watson — Come here — I want to

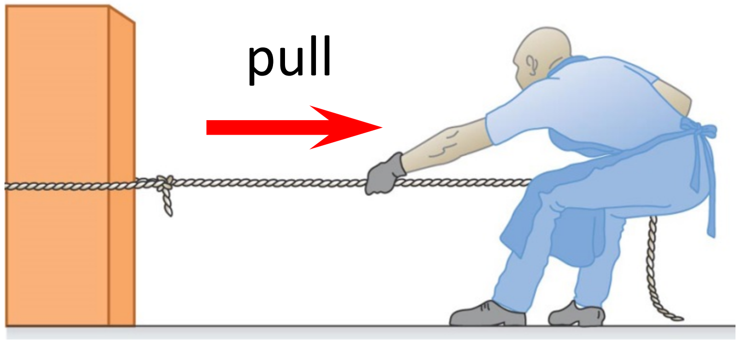
41

see you". To my delight he came and declared that he had heard and understood what I said.

I asked him to repeat the words — He answered "You said 'Mr. Watson — come here — I want to see you'." We then changed places and I listened at S while Mr. Watson read a few passages from a book into the mouth piece M. It was certainly the case that articulate sounds proceeded from S. The effect was loud but indistinct and muffled.

If I had read beforehand the passage given by Mr. Watson I should have recognized every word. As it was I could not make out the sense — but an occasional word here and there was quite distinct. I made out "to" and "out" and "further"; and finally the sentence "Mr. Bell Do you understand what I say? Do — you — un-der — stand — what — I — say" came quite clearly and intelligibly. No sound was audible when the armature S was removed.

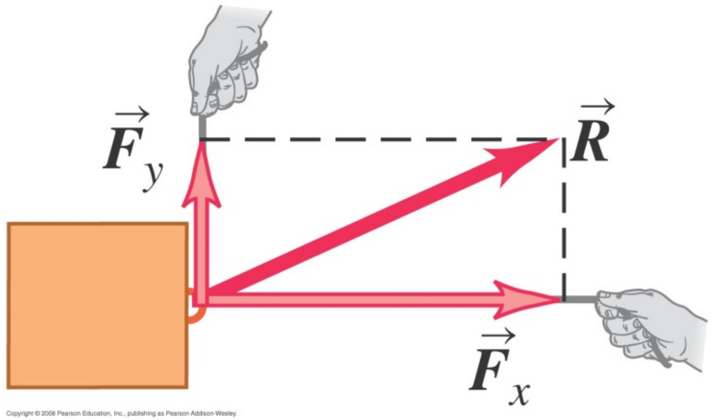
Force as a vector quantity characterizing interactions between bodies



<u>Force</u>

- quantitative measure of interaction between two bodies (unit: 1 newton = 1N)
- vector quantity with magnitude and direction

<u>Principle of superposition</u>



The total (net) force acting on a body is the <u>vector sum</u> of all the forces acting on the body:

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

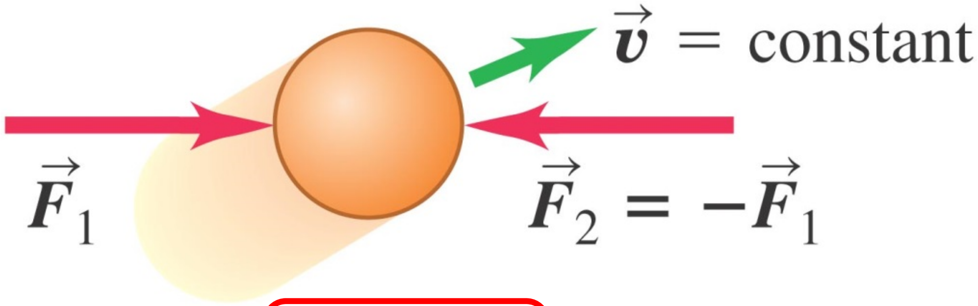
Expressing net force by components:

$$\vec{R} = R_x \hat{i} + R_y \hat{j} + R_z \hat{k}$$

$$R_x = \sum F_x \text{ and } R_y = \sum F_y \text{ and } R_z = \sum F_z$$

Newton's First Law: objects in equilibrium

"When the vector sum of all forces acting on a body (the net force) is zero, the body is in equilibrium and has zero acceleration. If the body is initially at rest, it remains at rest; if it is initially in motion, it continues to move with constant velocity."



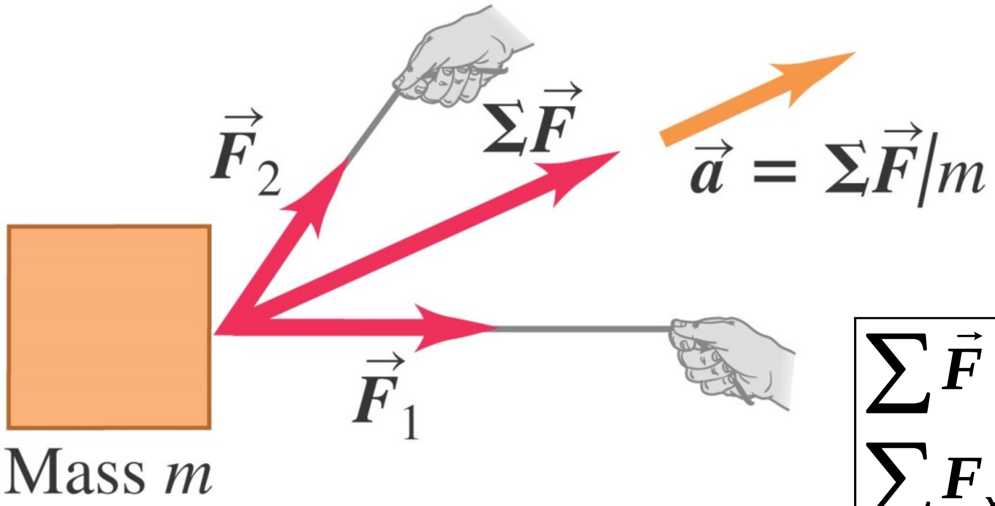
zero net force: $\Sigma\vec{F} = \mathbf{0}$

Caution:

Newton's 1st law is valid only in inertial (non-accelerating) frames of reference

Newton's Second Law: accelerating objects

"The acceleration of a body under the action of a given set of forces is directly proportional to the vector sum of the forces (the net force) and inversely proportional to the mass of the body."



resulting acceleration

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

$$\sum F_x = ma_x \, , \sum F_y = ma_y \, , \sum F_z = ma_z$$

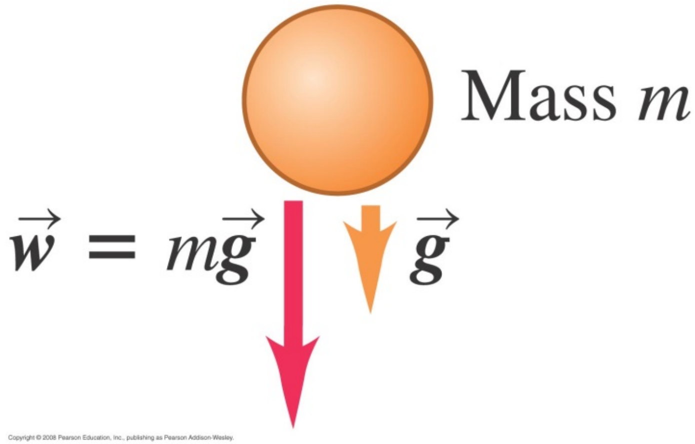
Caution:

Newton's 2nd law is valid only in inertial (non-accelerating) frames of reference

Mass and weight

The mass *m* of a body characterizes inertial properties of the body

The weight $\underline{\vec{w}}$ of a body is the gravitational force exerted on the body by earth



Newton's 2nd law: weight = mass x acceleration due to gravity

The weight of a body depends on the location of the body

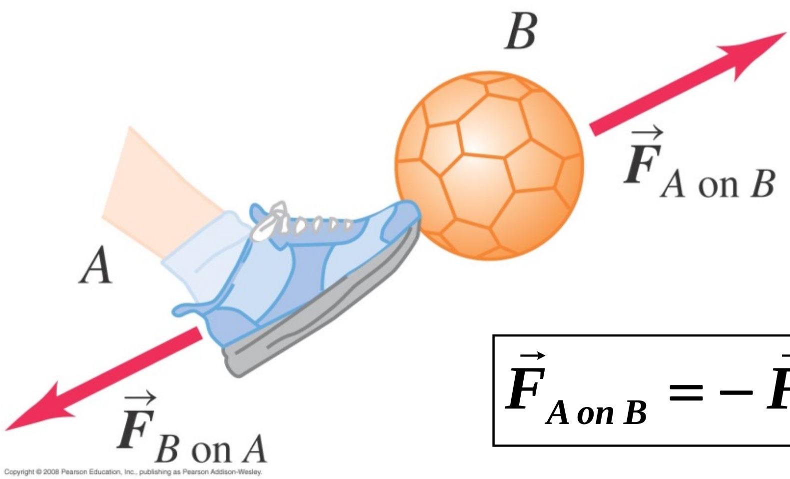
X

The mass of a body is location independent

Newton’s Third Law: action and reaction pairs

“When two bodies interact, they exert forces on each other that at each instant are equal in magnitude and opposite in direction. These forces are called action and reaction forces. Each of these two forces acts on only one of the two bodies; they never act on the same body.”

“action”



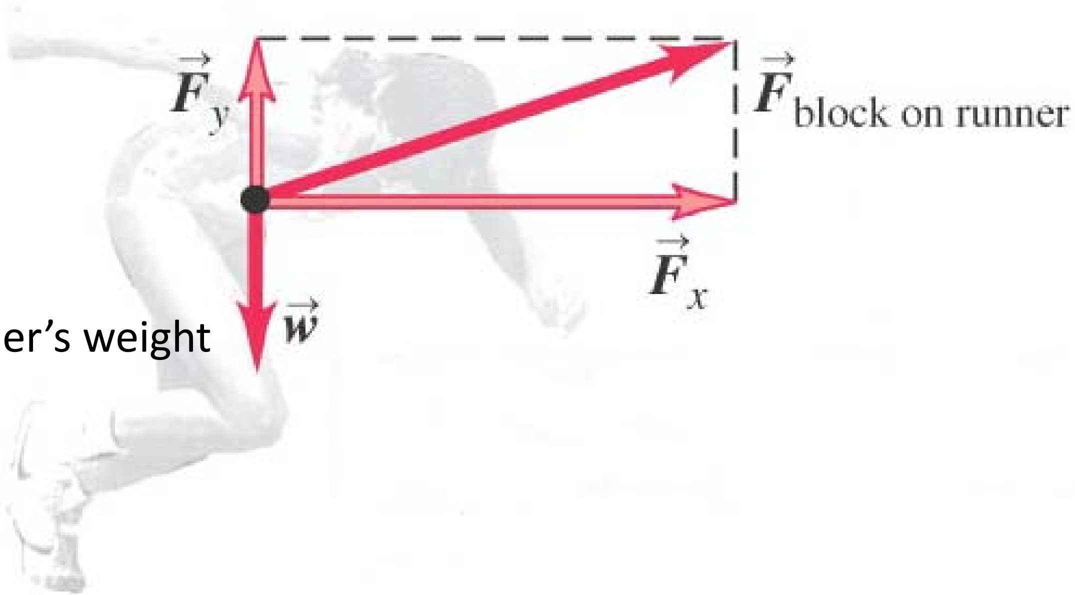
“reaction”

$$\vec{F}_{\text{A on B}} = -\vec{F}_{\text{B on A}}$$

Free-body diagrams

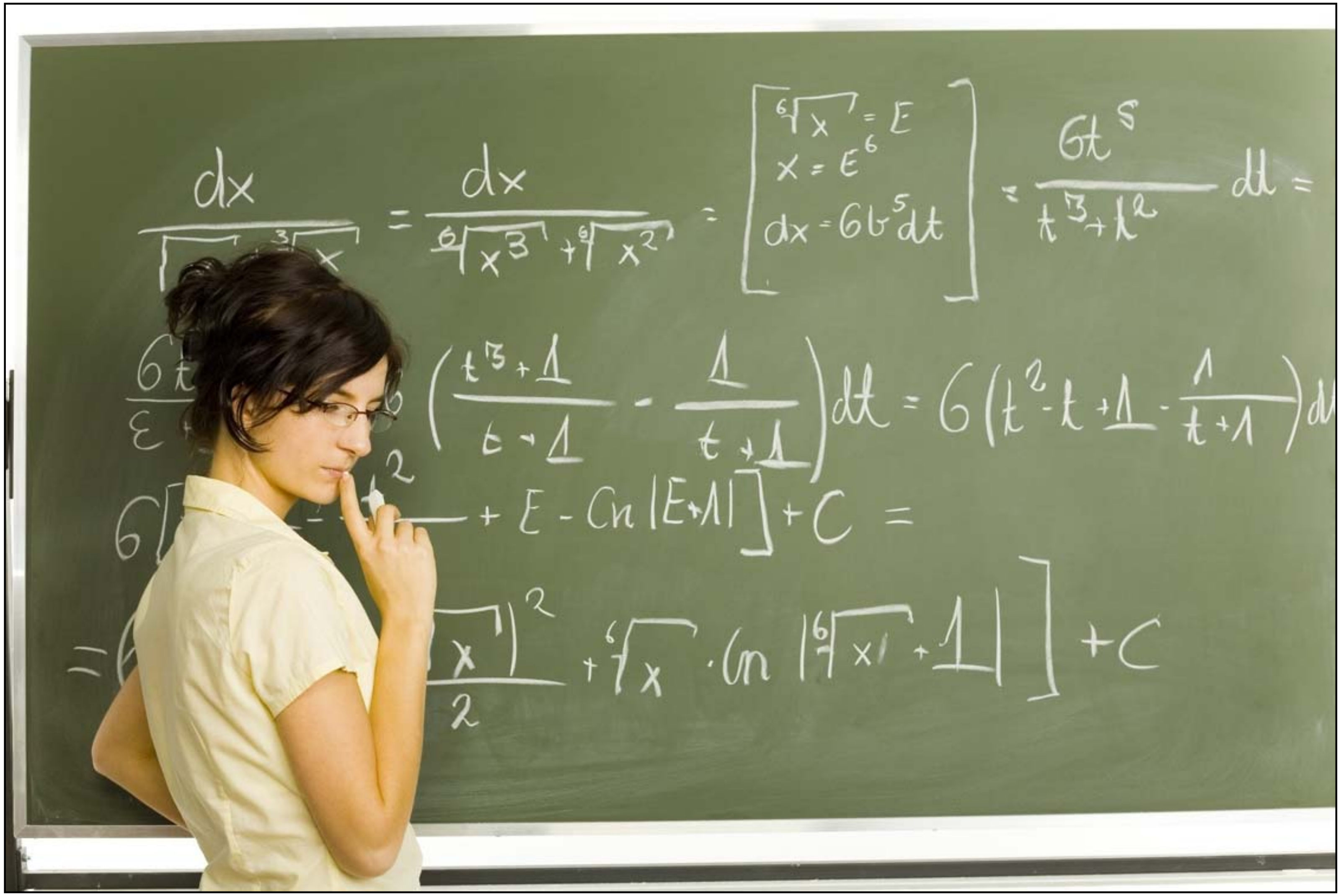
<u>Free-body diagrams</u> indicate magnitudes and directions of all the forces applied to the studied body by the various other bodies that interact with it.

pushing force of the starting block on the runner



runner’s weight

What will we cover today?



Lesson plan

1. Using Newton’s first law: particles in equilibrium

2. Using Newton’s second law: dynamics of particles

3. Frictional forces

4. Dynamics of circular motion