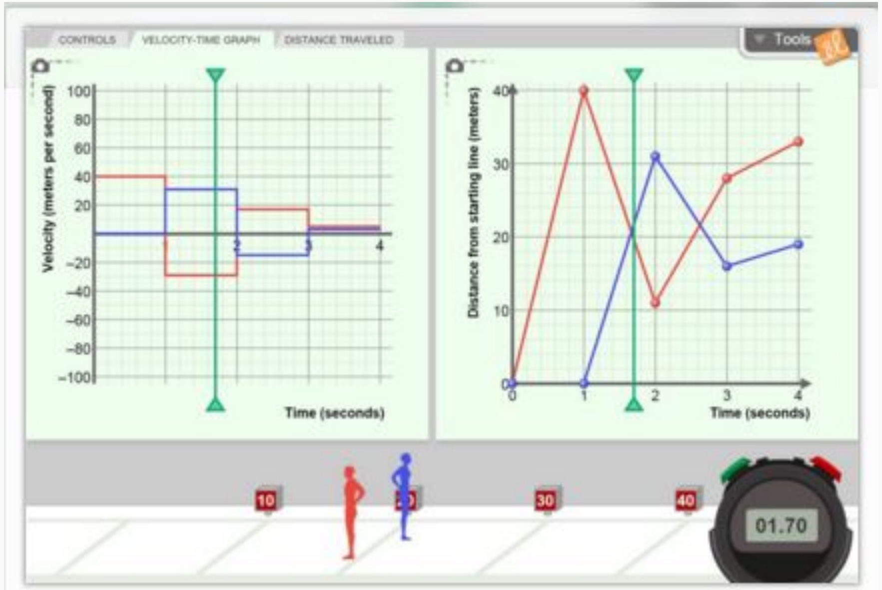
Physics Education Laboratory
Lecture 06
Content Knowledge for teaching Dynamics

Francesco Longo - 09/10/24

Distance -Time, Velocity-Time Graphs Metric

Create a graph of a runner's position versus time and watch the runner run a 40-meter dash based on the graph you made. Notice the connection between the slope of the line and the velocity of the runner. Add a second runner (a second graph) and connect real-world meaning to the intersection of two graphs. Also experiment with a graph of velocity versus time for the runners, and also distance traveled versus time.



https://www.explorelearning.com/index.cfm?method=cResource.dspDetail&ResourceID=626

Students' Exploration Sheet

Analyze the sheet
Observe the use of Multiple Representations
Add one or more exercises to improve the Multiple Representations usage of this sheet
What's missing?

Student Exploration: Distance-Time and Velocity-Time Graphs

[NOTE TO TEACHERS AND STUDENTS: This lesson was designed as a follow-up to the Distance-Time Graphs Gizmo. We recommend you complete that activity before this one.]

Vocabulary: displacement, distance traveled, slope, speed, velocity

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)
Dora runs one lap around the track, finishing where she started. Clark runs a 100-meter dash along the straight side of the track.

1. Which runner traveled a greater distance? ________________

2. Which runner had a greater change in position, start to finish?

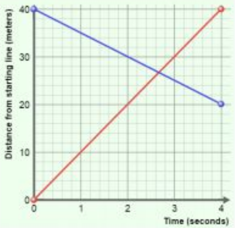
   ____

Gizmo Warm-up
The *Distance-Time Graphs* Gizmo shows a dynamic graph of the position of a runner over time. The *Distance-Time and Velocity-Time Graphs* Gizmo includes that same graph and adds two new ones: a velocity vs. time graph and a distance traveled vs. time graph.

The graph shown below (and in the Gizmo) shows a runner's position (or distance from the starting line) over time. This is most commonly called a *position-time graph*.

Check that the **Number of Points** is 2. Turn on **Show graph** and **Show animation** for both **Runner 1** and **Runner 2**.

1. Drag the points to create the graph shown to the right.
   - **Runner 1**'s line (the red one) should have endpoints at (0, 0) and (4, 40).
   - **Runner 2**'s line (the blue one) should have endpoints at (0, 40) and (4, 20).



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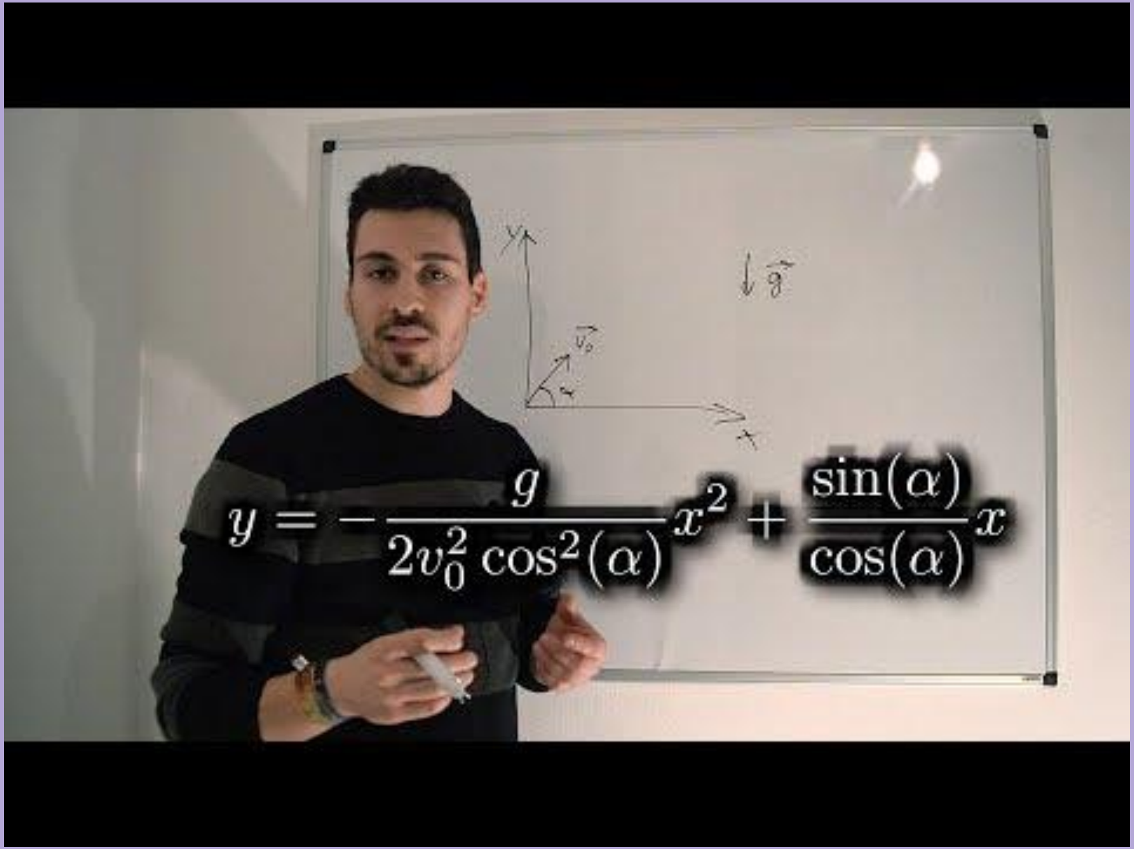
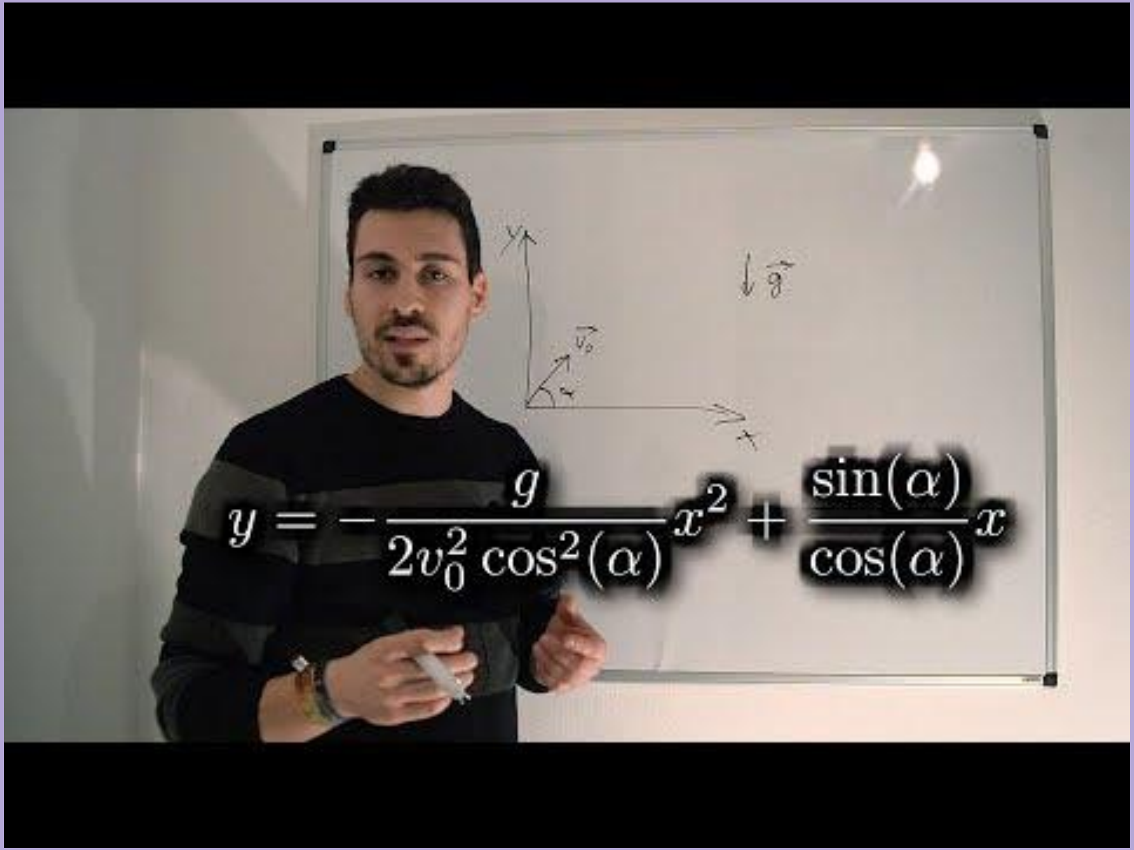
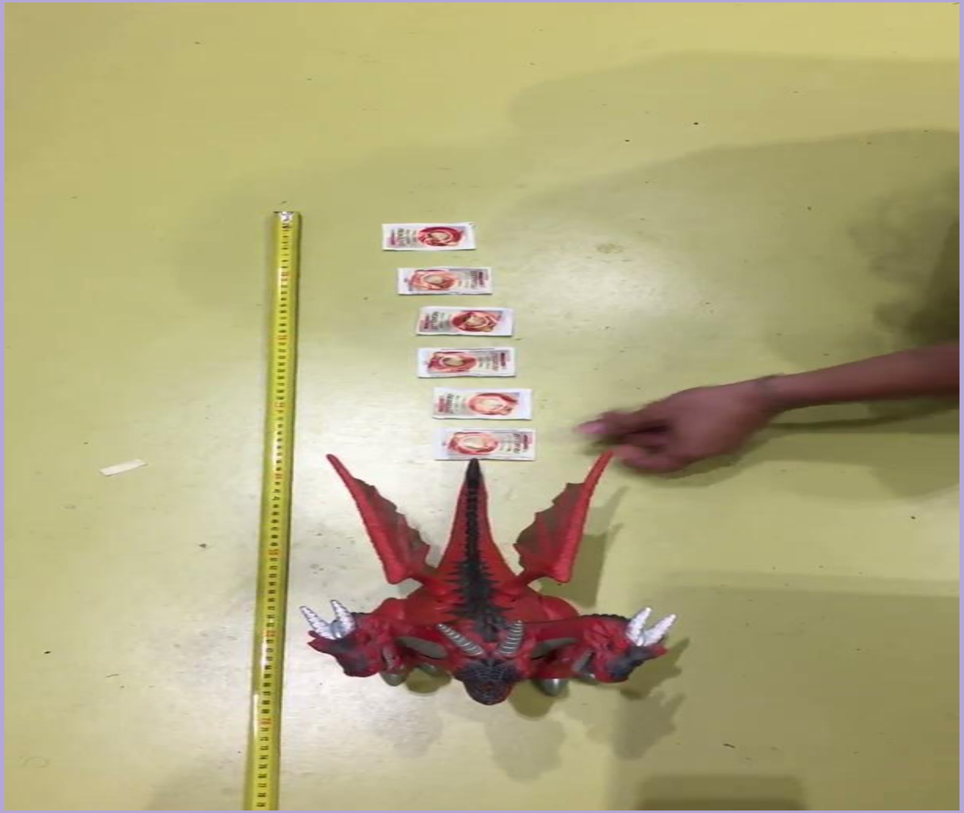


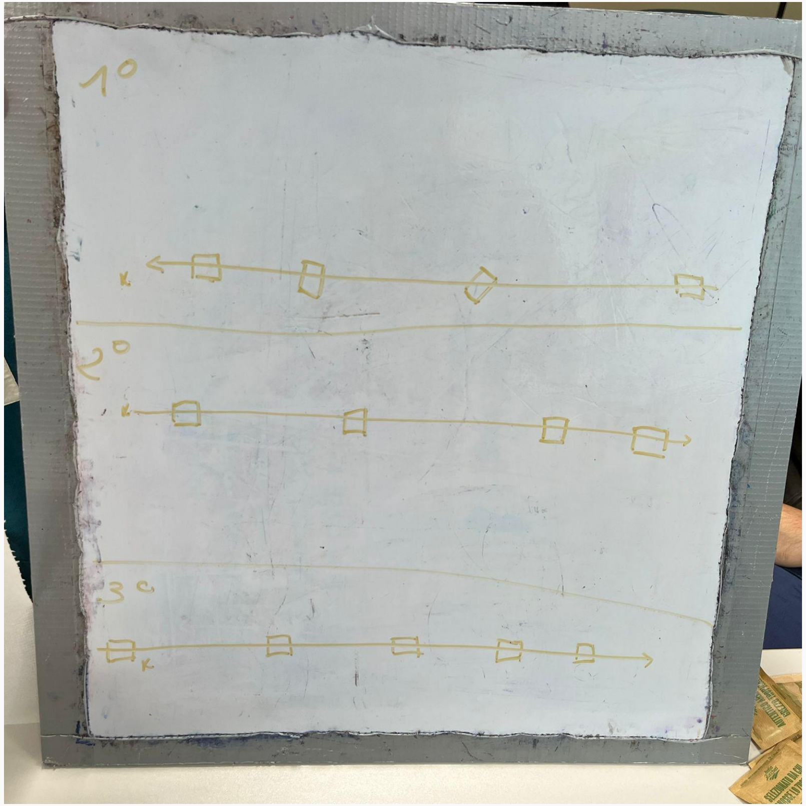
Video on Kinematics



How to build a knowledge on the uniform motion?



Let’s try …



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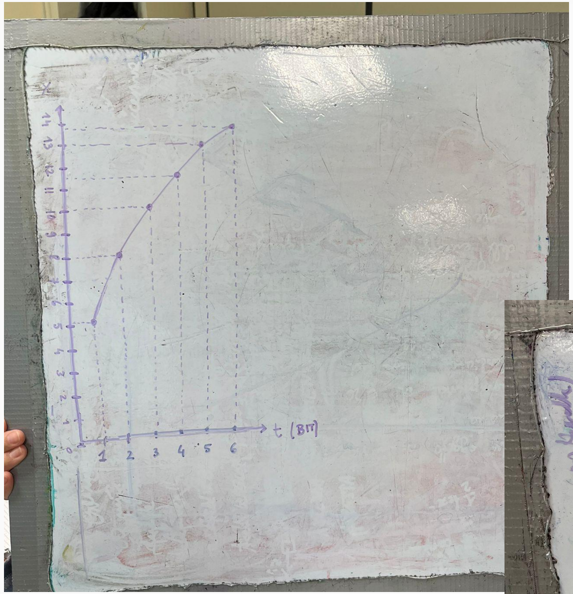
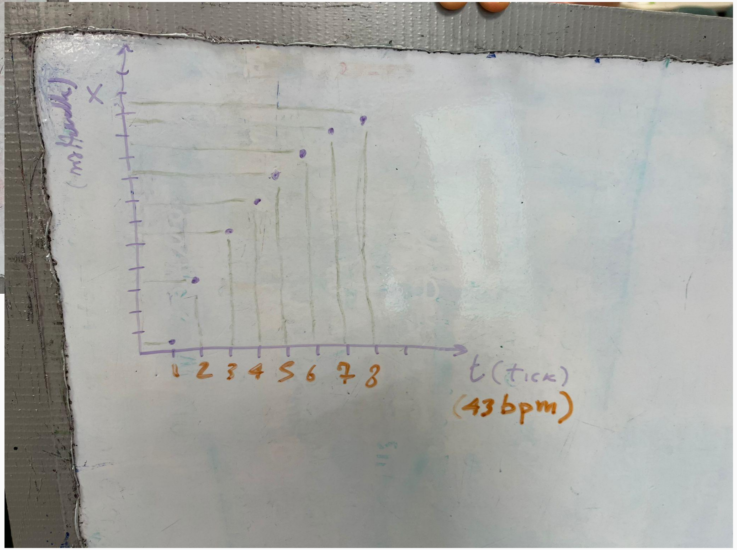
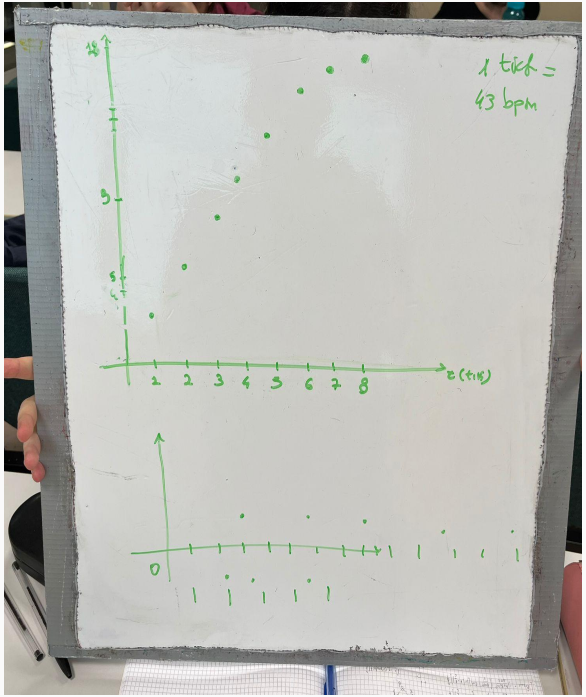






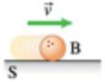
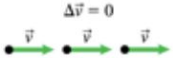
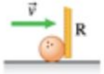
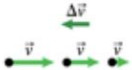
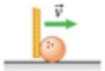
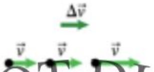
a. What patterns did you notice in the placement of the dots?

b. How can you use the distances between the dots to describe the motion of the bowling ball?

https://mediaplayer.pearsoncmg.com/assets/_frames.true/secs-experiment-video-1

Observational Experiment Table 3.1

How are motion and forces related?

Observational experiment	Analysis	
	Motion diagram	
Experiment 1. A bowling ball B rolls on a very hard, smooth surface S without slowing down. 		
Experiment 2. A ruler R lightly pushes the rolling bowling ball opposite the ball's direction of motion. The ball continues to move in the same direction, but slows down. 		
Experiment 3. A ruler R lightly pushes the rolling bowling ball in the direction of its motion. The ball speeds up. 		

Pattern

- In all the experiments, the vertical forces add to zero and cancel each other. We consider only forces exerted on the ball in the horizontal direction.
- In the first experiment, the sum of the forces exerted on the ball is zero; the ball's velocity remains constant.
- In the second and third experiments, when the ruler pushes the ball, the velocity change arrow ($\Delta\vec{v}$ arrow) points in the same direction as the sum of the forces.

Summary: The $\Delta\vec{v}$ arrow in all experiments is in the same direction as the sum of the forces. Notice that there is no pattern relating the *direction* of the velocity $\vec{v}$ to the direction of the sum of the forces. In Experiment 2, the velocity and the sum of the forces are in opposite directions, but in Experiment 3, they are in the same direction.

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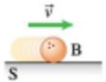
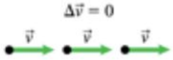
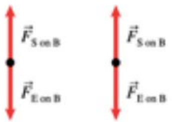
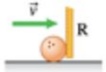
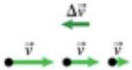
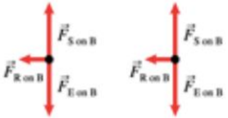
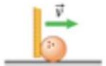
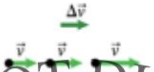
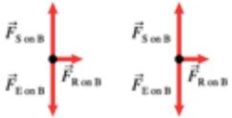
Experiment 1. A bowling ball B rolls on a very hard, smooth surface S without slowing down. 		
Experiment 2. A ruler R lightly pushes the rolling bowling ball opposite the ball's direction of motion. The ball continues to move in the same direction, but slows down. 		
Experiment 3. A ruler R lightly pushes the rolling bowling ball in the direction of its motion. The ball speeds up. 		

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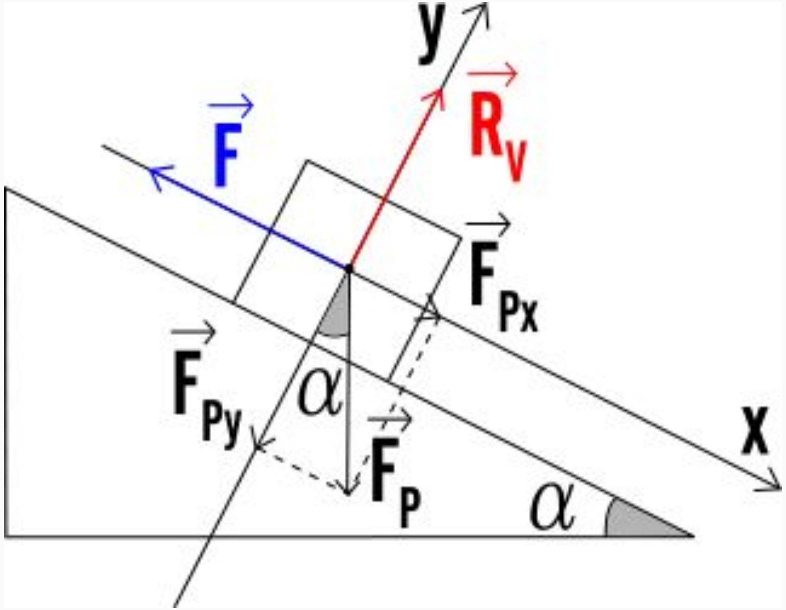
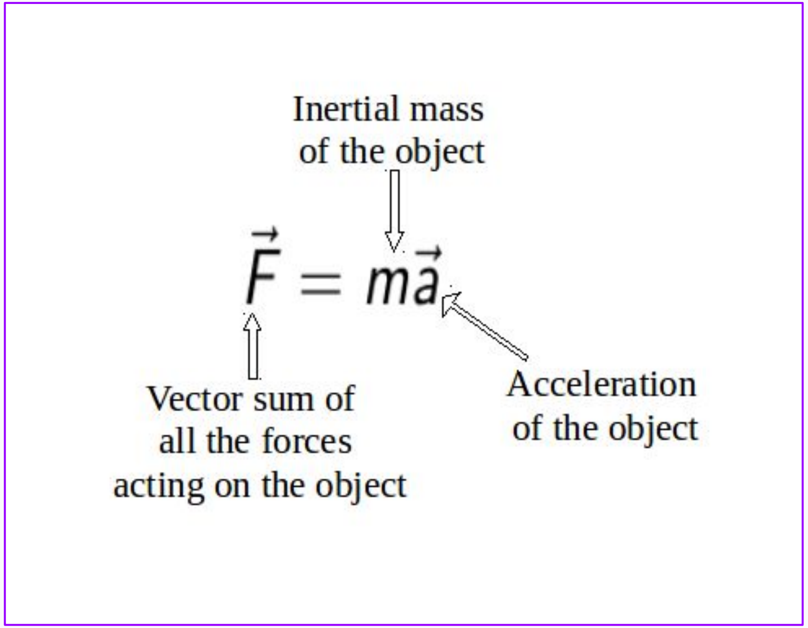
Key concepts in Dynamics

- The three laws of Dynamics
- The concept of acceleration
- The concept of linear momentum
- The vector nature of the force
- The observer system
- The inertial system



key concepts in Dynamics

- Newton's second law



key concepts in Dynamics

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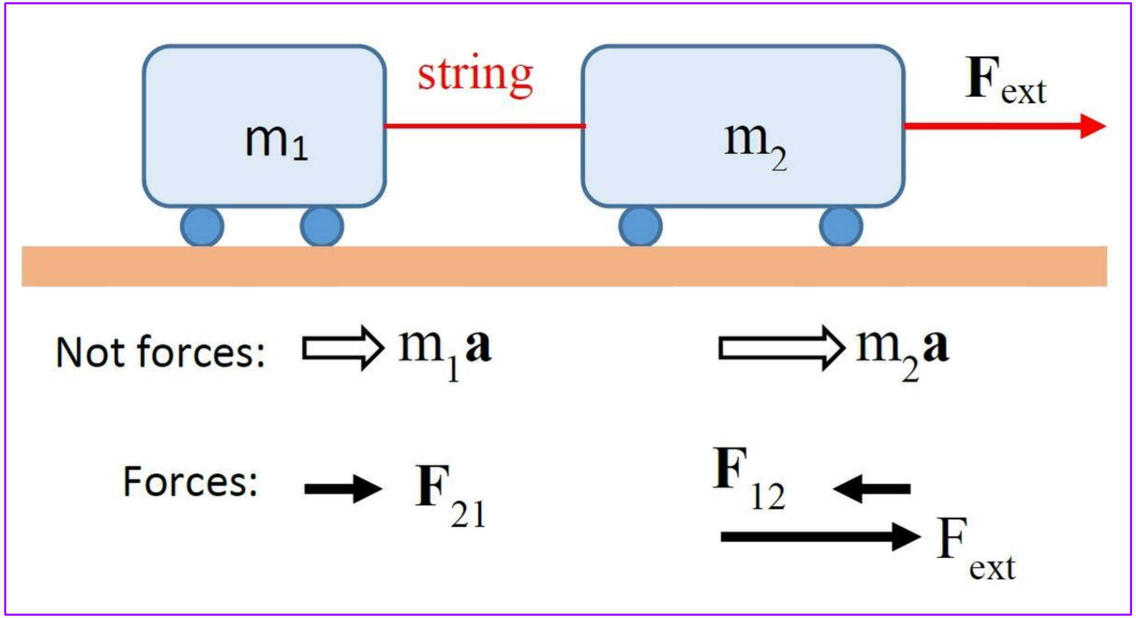
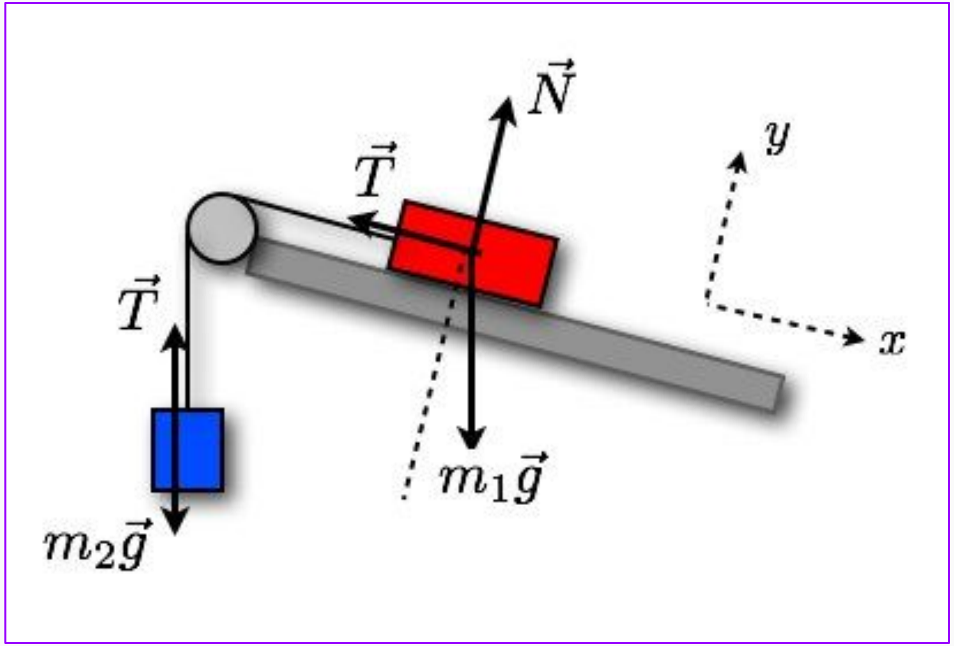
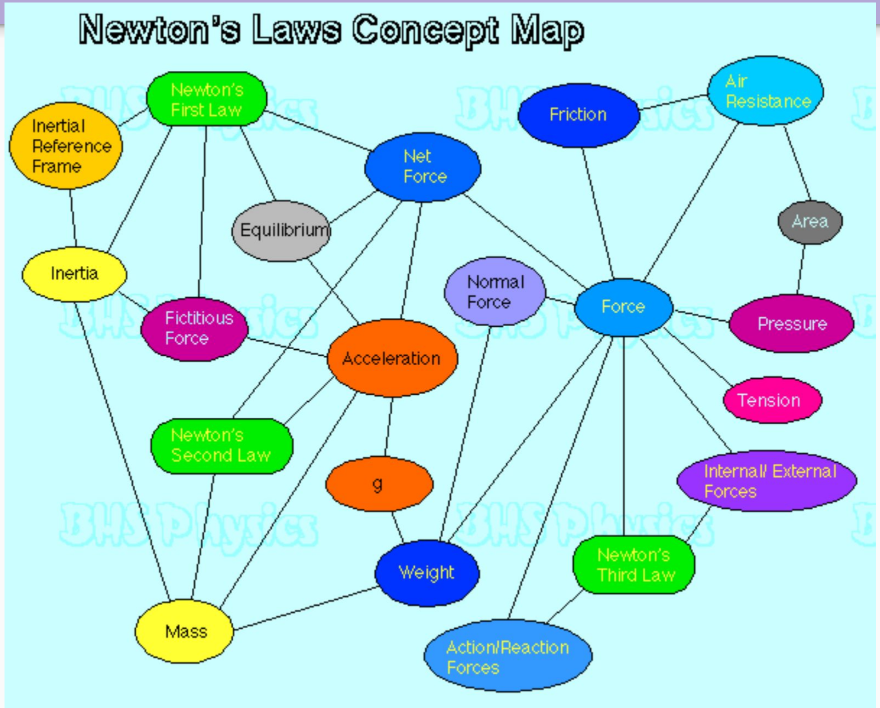


key concepts in Dynamics

- The Force …
- The free body approach
- “Force diagram”



A concepts' map



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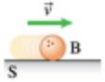
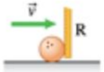
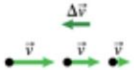
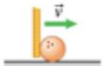
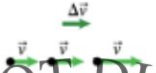
Experiment 1. A bowling ball B rolls on a very hard, smooth surface S without slowing down. 		
Experiment 2. A ruler R lightly pushes the rolling bowling ball opposite the ball's direction of motion. The ball continues to move in the same direction, but slows down. 		
Experiment 3. A ruler R lightly pushes the rolling bowling ball in the direction of its motion. The ball speeds up. 		

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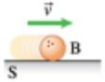
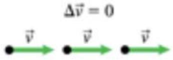
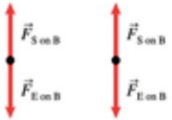
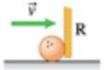
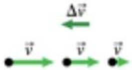
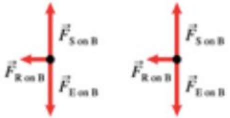
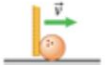
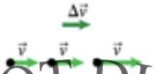
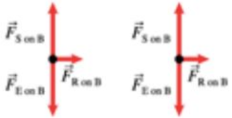
Experiment 1. A bowling ball B rolls on a very hard, smooth surface S without slowing down. 		
Experiment 2. A ruler R lightly pushes the rolling bowling ball opposite the ball's direction of motion. The ball continues to move in the same direction, but slows down. 		
Experiment 3. A ruler R lightly pushes the rolling bowling ball in the direction of its motion. The ball speeds up. 		

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