CALCULUS-BASED PHYSICS-1: MECHANICS (PHYS150-01): WEEK 4

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WEEK 3 REVIEW

1. Displacement, velocity and acceleration vectors as functions of time
    - Breaking into components
    - Derivatives of components
2. Combining free-fall and vector components: projectile motion
    - The independence of velocity components
    - **Lab-activity: testing component independence**
3. Relative motion and reference frames
    - Relative motion in one-dimension
    - Relative motion in two-dimensions

WEEK 3 REVIEW PROBLEMS

A pilot is performing an airdrop maneuver, in which he must release a package of supplies to land on a beach. The plane is traveling towards the beach at a speed of 100 kilometers per hour, with an altitude of 500 meters. How far offshore must the pilot release the supplies such that the package lands on the sandy beach and not in the water?

- A: 280 m
- B: 410 m
- C: 100 m
- D: 170 m

Suppose the pilot is flying straight, adjusting for a cross-wind of 3 m/s. How far to the side of the flight path of the plane does the package land, assuming the package is released 280 m from the shore?

- A: 10.1 seconds
- B: 5.4 seconds
- C: 3.2 seconds
- D: 1.1 seconds

WEEK 4 SUMMARY

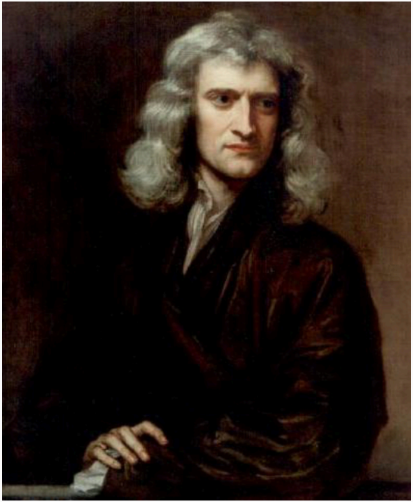

Figure 1: A portrait of Sir Isaac Newton.

WEEK 4 SUMMARY

1. Deep statements about physics: *dynamics* and *kinematics*
    - **Lab activity**: Force, mass and stretching springs
2. Newton's First Law
    - **Lab activity**: force tables
3. Newton's Second Law
4. Newton's Third Law
5. Applications
    - Free-body diagrams
    - Tension
    - Inclined surfaces
    - Restoring forces

Kinematics - A description of the motion of particles and systems
Dynamics - An explanation of the motion of particles and systems

What causes an object to move? **Forces**. Forces exist as a result of the interactions of objects or systems.

Evolution - A description of the change of biological species
Natural Selection - An explanation of change in biological species

What causes species to evolve? **Natural selection**. Natural selection exists because of election pressures, numerous offspring, and variation among offspring.

A force has units of *Newtons*, just like distance has units of *meters*. One Newton is the force required to make an object of mass 1 kilogram accelerate by 1 m/s^2.

A force must also be a *vector*: if a force acts on a system in a certain direction, the object will accelerate in that direction.

Force has to be related to mass in some way.

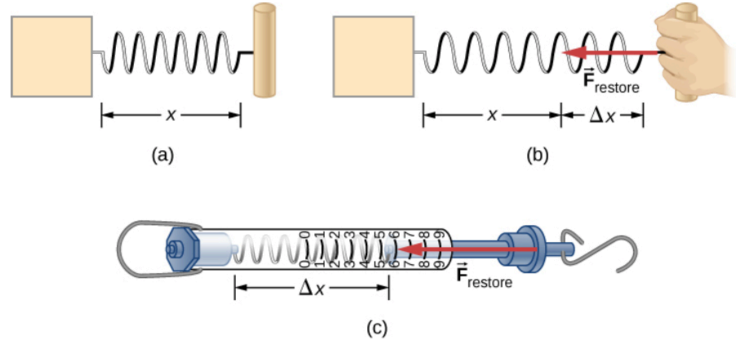

Figure 2: (a) No interaction is stretching the spring. (b) An interaction stretches the spring a distance Δx, and the spring pulls back. (c) A device that can compare forces by comparing Δx for different interactions (connecting to different weights, for example).

Lab activity: Force, mass, and stretched springs.

1. Obtain a set of weights, a force-meter (spring), and a ruler.
2. Hang a weight from the spring, and measure the extra distance the spring stretches.
3. Repeat with different weights, recording the stretched distances alongside the weights.
4. Compute the ratio of the mass of the weight to the stretched distance in each case. What is the result?

Thus, if a force causes *a system with some mass* to accelerate, the force must be *proportional to that mass*. "If it is heavier, we mush push it harder, to obtain the same acceleration."

Now, let's consider all the systems for which we have described the *kinematics*, where we made no use of the concept of a force...

NEWTON'S FIRST LAW

Newton's First Law

A body at rest remains at rest or, if in motion, remains in motion at constant velocity unless acted on by a net external force.

For most people in the late 15th and early 16th centuries, Newton's First Law was not intuitive. "When have you ever seen a thing move perpetually?"

The key is the last phrase: "*...unless acted on by a net external force*." Nothing moves unless forced, and if the net force is zero, the velocity does not change. Thus, if some object has a constant velocity, then it remains at that velocity unless some force (friction, air-resistance, gravity, a wall) interrupts.

`https://openstaxcollege.org/l/21forcemotion`

Lab activity: Force tables

1. Obtain a set of weights, and a force-table, with ring and pulley system.
2. Using knowledge of vectors, arrange weights on the pulleys such that the ring remains stationary in the center.
3. Double one of the weights, and find the angles the strings must make to keep the ring stationary in the center.
4. Define the force vectors as vectors with magnitudes equal to the masses of the weights, in the directions of the strings. Do the vectors add to zero?
5. Why does the ring remain stationary even though there are three forces from strings acting on it?

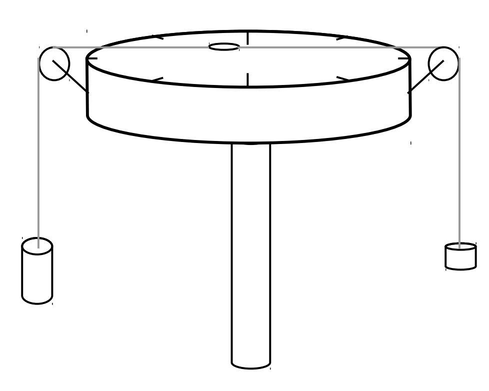

Figure 3: The force table setup includes a wheel with angles, strings and pulleys, and a central ring.

Newton's First Law may be thought of in terms of the following equation:

$$\boxed{F_{\mathrm{net}} = \sum_{\mathrm{i}} \vec{F}_{\mathrm{i}} = 0} \tag{1}$$

In the case of the force table ring, $\vec{F}_{\mathrm{i}} \neq 0$ but $\vec{F}_{\mathrm{net}} = 0$, so we observe no velocity. We can also have a situation with constant velocity and $\vec{F}_{\mathrm{net}} = 0$ but $\vec{F}_{\mathrm{i}} \neq 0$.

A man slides a palette crate across a concrete floor of his shop. He exerts a force of 60.0 N, and the box has a constant velocity of 0.5 m/s. What force cancels his pushing force, and what is the magnitude of that force?

- A: wind, 60.0 N
- B: friction: 60.0 N
- C: friction: -60.0 N
- D: weight: -60.0 N

Newton's First Law and Inertial Reference Frames. If an object has a constant velocity in one frame of reference, it has a constant velocity in another frame of reference moving at a constant velocity with respect to the first frame. Consider the prior problem, and a second man is walking in the opposite direction as the palette crate at a speed of 1 m/s. What is the speed of the palette crate from his perspective? What is the first man's force on the palette crate from his perspective?

- A: 1.5 m/s, 60.0 N
- B: 1.5 m/s, -60.0 N
- C: 0.5 m/s, 0.0 N
- D: -1.5 m/s, -60.0 N

CONCLUSION

ANSWERS

ANSWERS

- 280 m
- 10.1 seconds
- friction: -60.0 N
- 1.5 m/s, 60.0 N
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