Vectors and Forces

Brown Science Prep: Equilibrium
Fall 2011

Objectives	Students will be able to: o Define a force o Draw vectors to represent the magnitude and direction of forces in diagrams o Balance unbalanced force diagrams
Questions	o What is a force? What is Newtonian physics? o What is a vector? What is a scalar?
Materials	Calculators, toy car/cart, balloon, ropes/string, protractors, force gauges, scales, ring, masses

Warm Up

Ask students what causes the object's state of motion in each demo/situation.

- Move a book.
- Drop a penny to the floor.
- A rubber duck floating in the bathtub water.
- A man in an elevator goes from the 1st floor to the 3rd floor
- A book still on a table.
- A block/book on a ramp.

Discussion: How can you change an object's motion?

Explanation of Key Concepts

What is a force?

- Force is a vector quantity that is experienced as pushing/pulling on objects—but the force b/w objects doesn't need to be even touching.
- Newton's Laws
  - 1st law: Law of inertia: An object has constant velocity unless acted upon by an outside force. (mention that 0m/s is also a constant velocity)
  - 2nd law: F = m * a
  - 3rd law: For every force there is action, there is a reaction equal and opposite
- Units for force: Newton
- Define velocity, acceleration and mass.
  - Velocity: speed in a certain direction (vector → see next section)
  - Acceleration: rate of change in velocity
- Types of forces (depending on what you'd like, go into a few of these forces, go into the force equations and their derivations)
  - Contact: frictional (static and kinetic), tension, normal, air resistance, applied force, spring force

Action at a Distance: gravitational (mass vs. weight, large planetary bodies), electrical, magnetic

- Kinds of motions: translational, rotational, circular
- Mechanical equilibria

  Forces in equilibrium: two equal and opposite forces that cause no acceleration, net force is zero

What is a vector?

- Vectors represent magnitude and direction. Emphasize UNITS for magnitude.
- Scalars represent magnitude. Give examples of scalars and vectors, then ask the students to determine if it's a vector or scalar.
- Go over important mathematic concepts: TRIG!

  Resolution of forces: a force can be resolved into 2 components

  Horizontal component $Fx = F\cos(\theta)$

  Vertical component $Fy = F\sin(\theta)$

How to use free body diagrams to balance force vectors

- 2 forces in equilibrium-example: 2kg block resting on the table a) weight of block, b) the normal reaction
- 3 forces in equilibrium: teach them to rearrange the triangle of forces in one direction in order-example: a steel sphere of 12 kg is suspended from a rope pulled to the side 30 degrees by horizontal force of M and tension from rope is N. a) triangle of forces b) calculate M and N.
- resultant force: adding and subtracting vectors is easy when in line together
- two methods:

  -at an angle, resultant force is determined by parallelogram method: tail of first vector joined to tail of second vector and you can draw a diagonal that represents the resultant force

  -triangle method: tip of first vector joined to tail of second vector and you draw a line to complete the triangle, which represents the resultant force

Refer to Worksheet (individually fill out or work in pairs)

Engagement (in groups)

Experiment 1: Tie three strings to the ring. Tie the different masses to the strings—two of the masses are known. Lie the set up such that the ring is stationary in the center of the table. If the table were divided like a grid, rest one of the known masses such that it is at 0°. Ask the students to figure out how to determine the mass of the last object. (Assume the string is inelastic.)

Let them work in groups or as a big group. Provide them with the materials and just help/guide them problem solving, and try to step back. (Here are some guidelines from the website Mike sent out.)

Understand the Problem

Explore the Curriculum

Resolve the Problem

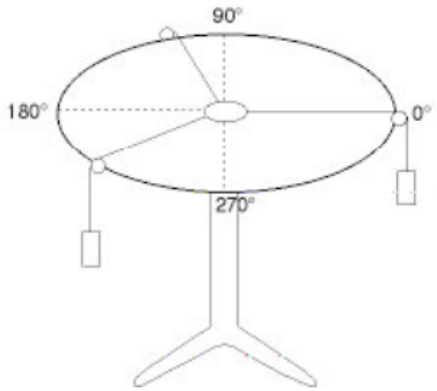

Fig. 1

Conceptual Experiment 2: "Physics of Rock Climbing" – When rock climbing, anchors are used to guide and support a rope attached to the climber. It is critical to set up anchors so that in the event of a fall, the forces generated on the anchor will not cause it to fail. Students design and optimize various anchor systems to support a "climber" represented by a 10 N weight. Real climbers depend on belaying partners and anchors to control the rope should they fall. If either the anchor or the belayer fails, the result can be catastrophic.

<u>See these websites for more info! It's pretty cool. You'll have to review frictional forces.</u>
http://ffden-2.phys.uaf.edu/211_fall2002.web.dir/lubtak_sobolesky/index.html
http://ffden-2.phys.uaf.edu/211_fall2002.web.dir/lubtak_sobolesky/index.html
http://ffden-2.phys.uaf.edu/211_fall2002.web.dir/lubtak_sobolesky/index.html
http://ffden-2.phys.uaf.edu/212_spring2005.web.dir/Ryan_Boothe/page%203%20%20Falling%20Forces.html
http://www.youtube.com/watch?v=VSHxa9WI7Qw

Elaboration/Extension

- Frame of reference
- Go into more forces
- Discuss some criticisms of classical Newtonian mechanics and the changes after quantum mechaninics

Evaluation

Exit Ticket: Why do we use force vectors?

Why does this matter?

- Physics is life in motion! And it helps us model/predict interactions between/among objects.