Physics 121.
February 5, 2008.

My favorite airline.

Physics 121.
Tuesday, February 5, 2008.

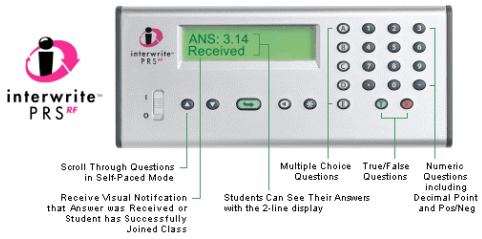
- Topics:
  - Course announcements
  - Quiz
  - Newton's Law of Motion:
    - Force
    - Newton's First, Second, and Third Law of Motion
    - Problem Solving Strategies

Physics 121.
Course announcements.

- Homework set # 2 is now available on the web.
- This set will be due on Saturday morning, February 9, at 8.30 am. Do not wait until the last moment to start working on this set! By start to work on this assignments when it becomes available, you can benefit from the workshops and office hours to get help if you need it.
- We will try to respond to all course-related emails, but due to the volume of emails, we will not be able to respond instantaneously. Emails send after 5 pm on Fridays are unlikely to be answered before the homework is due.

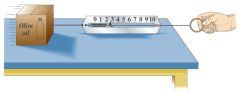
Physics 121.
Quiz Lecture 5.

- The quiz today will have 3 questions.



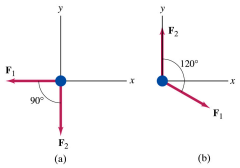
Forces.

- When an object all of a sudden changes its velocity and/or direction, we can always find an interaction between that object and its surroundings that is responsible for this change.
- We state that the surroundings exert a **force** on the object studied.
- Under the influence of a force, an object will accelerate.



Forces.

- A force acting on an object will cause the object to accelerate.
- A force is a vector:
  - It has a magnitude
  - It has a direction
- The acceleration produced by the force is also a vector:
  - Its magnitude is proportional to the magnitude of the force
  - Its direction is the same as the direction of the force.



Understanding motion.

- In order to understand motion we have to understand the following laws:
  - **The force laws**: allow us to calculate the force(s) acting on a body from the properties of the body and its environment.
  - **The motion laws**: allow us to calculate the acceleration of the object under influence of the force(s).
- Once we know the acceleration of the object we are looking at, we can use the equations of motion to determine its trajectory.

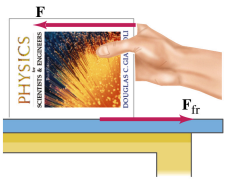
Understanding motion.

- In today's class we will focus on the **laws of motion**.
- We will **not** ask the question how the forces are generated, but discuss only the effect that these forces have on the motion of the object on which they act!

Newton's first law of motion.

- First Law:

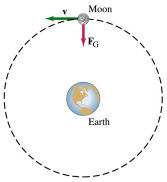
Consider a body on which no net force acts. If the body is at rest, it will remain at rest. If the body is moving with constant velocity, it will continue to do so.



- Notes:
  - **Net force:** sum of ALL forces acting on the body.
  - An object at rest and an object moving with constant velocity both have **no acceleration**.

Newton's first law of motion.

- Some consequence of Newton's first law:
  - In order to carry out circular motion, we need to apply a force.
  - In the absence of a force, circular motion becomes linear motion.
  - In order to make a turn in your car, you need a force. As we will see later in this course, the required force is provided by the friction between your tires and the road. If there is no friction (e.g. due to ice on the road) Newton's first law tells you that you will not be able to turn!

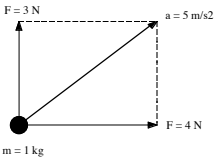


Newton's second law of motion.

Second Law:

The acceleration of an object is directly proportional to the net force acting on it and it inversely proportional to its mass. The direction of the acceleration is in the direction of the net force acting on the object:

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

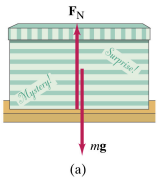


Newton's second law of motion.

- Newton's second law is used to define the concept of force.
- The unit of force is the Newton (abbreviated by N). 1 N is also equal to 1 kg m/s^2.
- A force of 1 N is the force that will generate an acceleration of 1 m/s^2 when it acts on a body with a mass of 1 kg (in the absence of other forces).
- The force due to gravity acting on an object close to the service of the earth is $-mg$.

Newton's second law of motion.

- If an object is at rest (and remains at rest), the net force acting on its must be zero.
- Consider a package sitting on a table:
  - If it remains at rest in the vertical direction, the net force in the vertical direction must be zero.
  - In addition to the gravitational force, there must be at least one other force, with the same magnitude as the gravitational force, but acting in the opposite direction.



(a)

Newton's second law of motion.

Weight and Mass are not the same!!!!!!

- The weight of an object is the force of gravity. Thus, the weight of an object not only depends on its mass, but also on the gravitational acceleration. The weight of an object is thus position dependent.
- When you determine your mass, you usually measure your weight and use what is known about g to determine your mass.
- Now that we are told that we going to colonialize the moon, I can already see the adds from Weight Watchers: "All it takes to loose weight is to travel to our moon colony". Of course they are correct, but they do not tell you that you get your usual weight back when you return to Earth.

Newton's second law of motion.

- Another way to change your weight is to travel in an accelerating elevator.
- The net force on the person in this elevator must be equal to $-ma$.
- This net force is supplied by the gravitational force and the "scale" force:

$$-ma = -mg + F_N$$

- The "scale" force is thus equal to

$$F_N = mg - ma = m(g-a) < mg$$

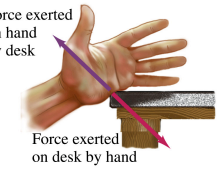
Newton's third law of motion.

Third law:

Suppose a body A exerts a force (FBA) on body B. Experiments show that in that case body B exerts a force (FAB) on body A. These two forces are equal in magnitude and oppositely directed:

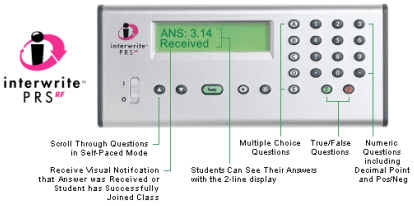
$$\vec{\mathbf{F}}_{BA} = -\vec{\mathbf{F}}_{AB}$$

Note: these forces act on different objects and they do not cancel each other.



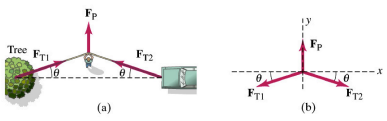
Newton's laws of motion.

- Let's test our understanding of the laws of motion by looking at the following concept questions:
  - Q4.1
  - Q4.2
  - Q4.3



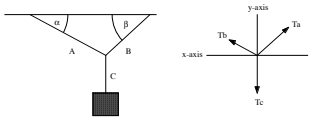
Newton's laws of motion. Problem solving strategies.

- The first step in solving problems involving forces is to determine all the forces that act on the object(s) involved.
- The forces acting on the object(s) of interest are drawn into a free-body diagram.
- Apply Newton's second law to the sum of to forces acting on each object of interest.



Newton's laws of motion.
Problem solving strategies: an example.

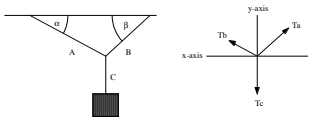
- Consider a block hanging from three cords. What is the tension in each cord?
- Step 1: Draw the free-body diagram of the place where the three cords meet.
- Step 2: What do we know about the next force at this point? Assuming the system is at rest, it must be zero!



Newton's laws of motion.
Problem solving strategies: an example.

- Step 3: The horizontal component of the net force must be zero:

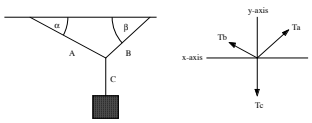
$$\sum \vec{\mathbf{F}}_x = 0 = -\cos\alpha\, T_A + \cos\beta\, T_B$$



Newton's laws of motion.
Problem solving strategies: an example.

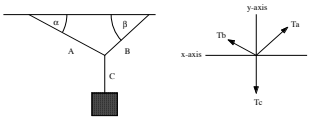
- Step 4: The vertical component of the net force must be zero:

$$\sum \vec{\mathbf{F}}_y = 0 = \sin\alpha\, T_A + \sin\beta\, T_B - T_C$$



Newton's laws of motion.
Problem solving strategies: an example.

- Step 5: Determine what is known and what is not known. Two equations and three unknowns? Can I really solve this? Of course you can, but not after realizing that you know T_C.
- Step 6: Determine T_C by considering the forces on the block, and requiring that the net force is equal to 0 N. This tells us that $T_C = mg$.

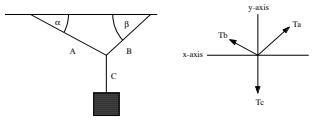


Newton's laws of motion.
Problem solving strategies: an example.

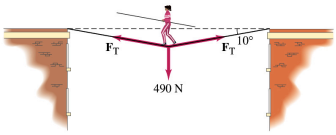
- Step 7: Solve two equations with two unknown.

$$T_B = T_C \frac{\cos\alpha}{\sin\alpha\cos\beta + \cos\alpha\sin\beta} = mg\frac{\cos\alpha}{\sin(\alpha+\beta)}$$

$$T_A = T_B \frac{\cos\beta}{\cos\alpha} = mg\frac{\cos\beta}{\sin(\alpha+\beta)}$$

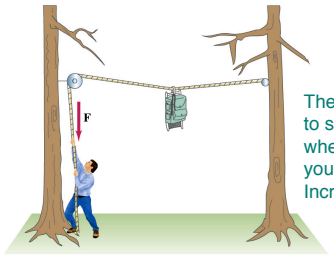


Newton's laws of motion.
Interesting effects.



The rope must **always** sag!
Why?

Newton's laws of motion.
Interesting effects.



The force you need to supply increases when the height of your backpack Increases. Why?

That's all!
On Thursday: friction.