9/22 In Class–Newton's Laws

Newton's Laws

First Law: An object at rest, or in uniform motion, remains at rest or in uniform motion unless acted upon by a net force.

Second Law:

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

Third Law: Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first object.

$$\vec{F}_{2on1} = -\vec{F}_{1on2}$$

Examples

1. A 1.5kg book rests on a force plate (just like bathroom scale that reads Newtons) on a horizontal surface on earth.
   (a) Draw a free body diagram for the book.
   (b) What is the force of gravity on the book?
   (c) What is the normal force on the book?
   (d) Which force does the bathroom scale read?
   (e) For the last few parts, imagine we move the book and scale into an elevator. What would the scale read if the elevator accelerated down at 2m/s^2?
   (f) What would the scale read if the elevator accelerated down at 9.8m/s^2?
   (g) What would the scale read if the elevator accelerated up at 2m/s^2?
2. A child pulls a 3kg wagon across flat, level ground. Assume friction is negligible. The child pulls with a force of 15N at an angle of 50° relative to the horizontal.
   (a) Draw a sketch of the wagon.
   (b) Draw a free body diagram for the wagon.
   (c) Write $\Sigma \vec{F} = m\vec{a}$ and start from there. On the next line, replace $\Sigma \vec{F}$ with all the forces in your free body diagram. Then replace those with column vectors. At this step, or the next, put in any zeros that you know.
   (d) What is the normal force on the wagon?
   (e) What is the acceleration of the wagon?
3. A 1kg book slides down a frictionless incline. The incline makes an angle of 30° relative to the horizontal.

(a) Draw a sketch of the book and incline.

(b) Draw a free body diagram for the book.

(c) Very clearly label some angles. You might need to make a couple sketches with a couple triangles to figure out which angles are 30 and which are 60 and which are 90.

(d) I highly recommend rotating your coordinate axis so that plus x is along the incline and y is along the Normal Force. It makes solving for the acceleration easier. Why? (You might want to answer this last.)

(e) Write $\Sigma\vec{F} = m\vec{a}$ and start from there. Show all your work very carefully on this one.

(f) What is the weight force of the book?

(g) What is the normal force on the book?

(h) What is the acceleration of the book?

4. Repeat the last problem taking friction into account. The coefficient of kinetic friction between the book and the surface is 0.2.

5. Two blocks, $m = 0.5$kg and $M = 1$kg are connected by a string. They both start at rest on a horizontal (frictionless) surface. Block m is on the left (horizontally) and I pull it to the left with a force of 20N.

   (a) Draw a separate free body diagram for the each block.

   (b) Apply the second law to each block. (This is the safest way. If you have more than one object, using Newton's 2nd Law on each object always works.) You will get two equations and two unknowns. What is the acceleration of each block?

   (c) What is the tension in the string between the two blocks?

   (d) Could you have done this problem pretending it was one block of mass 1.5kg? All of it? Which parts? Explain your answers carefully.