

Applying Newton's Laws of Motion

Topic 2b

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Learning Outcomes for Topic 2b



- How to use Newton's first law to solve problems involving forces that act on a body in equilibrium.
- How to use Newton's second law to solve problems involving the forces that act on an accelerating body.

Overview of topic 2b



- Using Newton's first law
- Problem solving strategy
- Apparent weight & weightlessness
- Frictional forces
- Kinetic and static friction

Introduction



- Newton's three laws of motion can be stated very simply
 - applying these laws to real-life situations requires analytical skills and problem-solving techniques.
- In this chapter we'll begin with equilibrium problems
 - we analyze the forces that act on a body that is at rest or moving with constant velocity.
- We'll then consider bodies that are not in equilibrium, for which we'll have to deal with the relationship between forces and motion.

Using Newton's first law



- A body is in *equilibrium* when it is at rest or moving with constant velocity in an inertial frame of reference, and the net force acting on a body is 0
- The essential physical principle here is Newton's first
 law

Newton's first law:
$$\sum \vec{F} = 0$$
 ... must be zero for a Net force on a body ... $\sum \vec{F} = 0$... must be zero for a body in equilibrium.

Sum of x-components of force on body must be zero.

Sum of y-components of force on body must be zero.

$$\sum F_x = 0$$

$$\sum F_y = 0$$

Problem-solving strategy (1st Law)



- Identify the relevant concept: You must use Newton's first law.
- Set up the problem by using the following steps:
 - 1. Draw a sketch of the physical situation.
 - Draw a free-body diagram for each body that is in equilibrium.
 - 3. Ask yourself what is interacting with the body by contact or in any other way.
 - If the mass is given, use w = mg to find the weight.
 - 4. Check that you have only included forces that act on the body.
 - Choose a set of coordinate axes and include them in your free-body diagram.

Problem-solving strategy (1st Law)

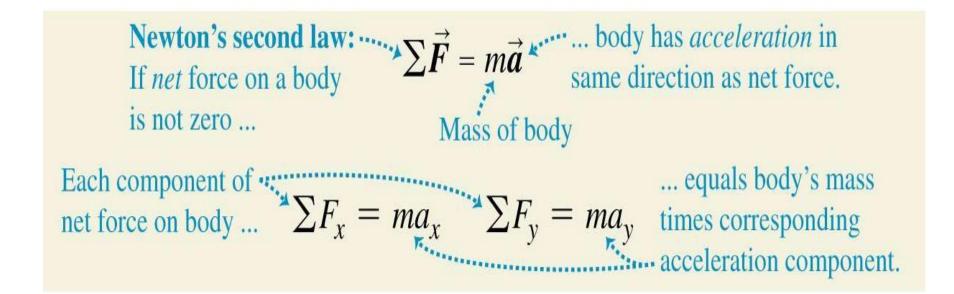


- Execute the solution as follows:
 - 1. Find the components of each force along each of the body's coordinate axes.
 - 2. Set the sum of all *x*-components and *y* components of force equal to zero in separate equations.
 - If there are two or more bodies, repeat all of the above steps for each body.
 - If the bodies interact with each other, use Newton's third law to relate the forces they exert on each other.
 - 5. Ensure that you have as many independent equations as the number of unknown quantities. Then solve to obtain the target variables.
- Evaluate your answer.

Problem-solving strategy (2nd Law)



- In dynamics problems, we apply Newton's second law to bodies on which the net force is not zero.
- These bodies are not in equilibrium and hence are accelerating:



Problem-solving strategy (2nd Law)



- Identify the relevant concept: You must use Newton's second law.
- Set up the problem by using the following steps:
 - Draw a simple sketch of the situation that shows each moving body. For each body, draw a free-body diagram that shows all the forces acting on the body.
 - 2. Label each force. Usually, one of the forces will be the body's **weight w = mg**.
 - 3. Choose your x- and y-coordinate axes for each body, and show them in your free-body diagram.
 - 4. Identify any other equations you might need.
 - 5. If more than one body is involved, identify if there are any relationships among their motions
 - for example, they may be connected by a rope.

Problem-solving strategy (2nd Law)



- Execute the solution as follows:
 - 1. For each body, determine the components of the forces along each of the body's coordinate axes.
 - 2. List all of the known and unknown quantities. In your list, identify the target variable or variables.
 - 3. For each body, write a separate equation for each component of *Newton's second law*. Write any additional equations that you identify (you need as many equations as there are target variables).
 - 4. Do the easy part—the math! Solve the equations to find the target variable(s).
- Evaluate your answer.



End