



Lesson 2.2: The Law of conservation of energy and Elastic potential energy

Part 1: The Law of conservation of energy (Ch 4.5)

Energy is neither created nor destroyed. It can only change form.

By considering total mechanical energy (i.e., energy that is possessed by an object due to its motion or due to its position) of a moving object, it remains the same at every point of the path, which gives $E_{Ti} = E_{Tf}$. For the situations involving **only** gravitational potential energy and kinetic energy, the equation can be written as:

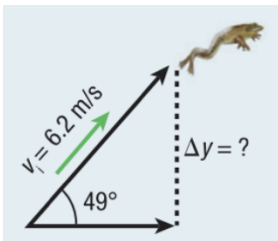
$$E_{gi} + E_{ki} = E_{gf} + E_{kf}$$

For the equation above, the energy losses due to non-mechanical energy such as heat (caused by friction), acoustic energy (caused by sound), radiant energy (caused by light), nuclear energy, electric energy or other effects were negligible, the statement will be *refined later in this lesson*.

Example 1: Determining maximum height and speed using the law of conservation of energy

The Figure shows a 0.45 kg bullfrog jumping with an initial speed of 6.2 m/s at an angle of 49° above the horizontal. Assume that energy losses due to air resistance are negligible and can be ignored.

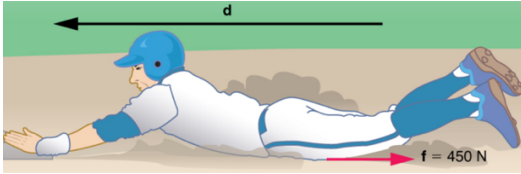
- Calculate the maximum height of the bullfrog's jump.
- Use energy conservation to calculate the bullfrog's velocity when it first reaches a height of 0.82m.



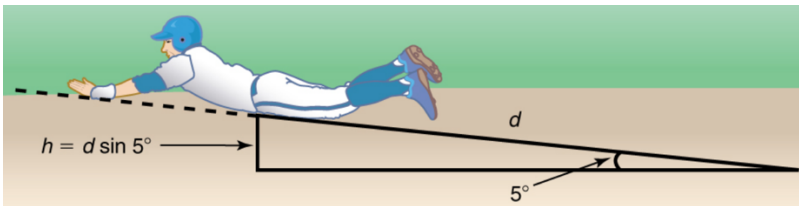


Example 2: Calculating distance traveled

Consider the situation shown in the picture, where a baseball player slides to a stop on level ground. Using energy considerations, calculate the distance the 65.0 kg baseball player slides, given that his initial speed is 6.00 m/s and the force of friction against him is a constant 450 N.



Now, let suppose that the player is running up a hill having a 5.00° incline upward with a surface similar to that in the baseball stadium. The player slides with the same initial speed. determine how far he slides.



<https://opentextbc.ca/physicstestbook2/chapter/nonconservative-forces/#import-auto-id1908314>

In this case, the work done by the friction force on the player reduces the mechanical energy.



Example 3: Determine how far does the box travel up the ramp until it stop.

Part 2: Power: is the rate of work done by a force over time, mathematically, $P = \frac{W}{\Delta t}$.

Example 4: A car accelerates from rest to a speed of 27.8 m/s in 7.7s. The mass of the car is $1.1 \times 10^3 \text{ kg}$. Ignoring friction, determine how much power the car requires.



Part 3: Hooke's Law

Other than kinetic energy and gravitational potential energy, another important type of potential energy is associated with springs and elastic objects.

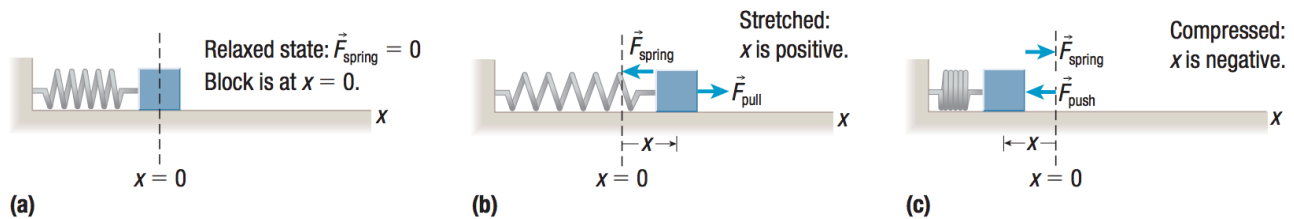


Figure 2 The force exerted by a spring is always opposite to the displacement of the end of the spring. (a) When a spring is unstretched and uncompressed, the force exerted by the spring is zero. (b) The spring is stretched by pulling it to the right, so the force exerted by the spring is to the left. (c) The spring is compressed, and the force exerted by the spring is to the right.

In the Figure 2a), the spring is under the relaxed state where it does not have any potential to be stretched or compressed so that no capability to do work to cause any changes of kinetic energy of the object attached.

However, in Figure 2b), suppose you pull on the spring with an applied force, causing the spring to stretch to the right. Spring simultaneously exerts a restorative force to the left and tend to restore to its natural length.

The amount of force exerted by a spring is proportional to the spring's displacement, mathematically, **Hooke's Law** is: $\vec{F}_{spring} = -k\Delta\vec{x}$, where k is spring constant.

An essential feature of Hooke's law is that the direction of the spring force is _____ to the direction of displacement from equilibrium.

Example 5: A spring hangs at rest from a support. If you suspend a 0.46 kg mass from the spring, its deflection is 7.9cm.

- Determine the spring constant.
- Calculate the displacement, in centimetres, of the same spring when a 0.75 kg mass hangs from it instead.
- Suppose the 0.75 kg mass is pushed upward, so that it rises past the spring's unstretched position, compressing the spring about 5.3 cm. Determine the acceleration of the mass once it is released.