7.5 – Conservation of Energy

1. Review and Lead-In!
Consider this picture:
A. How much kinetic energy does the ball have?
   \[ K = \frac{1}{2}mv^2 \]
   \[ = \frac{1}{2} \times 5.6 \text{ kg} \times (14 \text{ m/s})^2 \]
   \[ = 550 \text{ J} \]
B. How much gravitational potential energy?
   \[ \Delta U_g = mgh \]
   \[ = 5.6 \text{ kg} \times 9.81 \text{ m/s}^2 \times 14 \text{ m} \]
   \[ = 770 \text{ J} \]
C. How much total energy?
   \[ 550 \text{ J} + 770 \text{ J} = 1320 \text{ J} \]

Total Mechanical Energy (Symbol = E)
The sum of kinetic and potential energy of a system is its Mechanical Energy.
\[ E = K + U \]
K = kinetic energy (J)
U = potential energy (J)

Note 1: Potential energy could be from any source (gravitational, spring, etc.).
Note 2: This works in a conservative system (no friction).

Force Types
Conservative force: work done is independent of the object’s path.
Ex: gravity. Under frictionless conditions, work done by gravity:
   \[ W = \Delta U \]
Nonconservative: work done depends on path length.
Ex: friction. The longer the path, the more work it’ll take to move:
   \[ W = Fd \]

Conservation of Energy
Energy is transferred within systems (non-conservative, and conservative), not created or destroyed.
Transfers can be complex, but total energy is equal when measured at an initial and final condition.
One upshot: the energy in the universe is constant.

Total Energy: Conservative Systems
Mechanical energy is the same at any point of a conservative process:
\[ E_1 = E_2 \]
\[ E_1 = \text{initial energy} \]
\[ E_2 = \text{final energy} \]

By finding kinetic and potential energy (initial and final), you can calculate other parameters.
### 2. Conservative System Example

A dropped 2.0 kg ball falls 16 meters. How fast is it when it hits the ground?

Hint: initial gravitational potential = final kinetic energy:

\[ E_i = E_f \]

\[ \Delta U_g = K \]

\[ mg\Delta y = \frac{1}{2}mv^2 \]

\[ g\Delta y = \frac{1}{2}v^2 \]

\[ v = \sqrt{2g\Delta y} = \sqrt{2 \cdot 9.81 \text{ m/s}^2 \cdot 16 \text{ m}} = 17.7 \text{ m/s} \]

### Energy: Non-conservative Systems

In a non-conservative (nc) system (with friction), some mechanical energy is lost as heat.

Work done by friction equals energy change:

\[ W_{nc} = \Delta E = E_2 - E_1 \]

### 3. Non-Conservative Example

A 0.75 kg block sliding at 2.0 m/s travels 2.0 m over a rough surface, experiencing a frictional force of 0.625 N.

How fast is the block going after that?

- **m = 0.75 kg**
- **\( F_f = 0.625 \text{ N} \)**
- **2.0 m/s**
- **2.0 m**

Friction work equals total mechanical energy change.

A. Calculate initial kinetic energy:

\[ K_i = \frac{1}{2}mv_i^2 \]

\[ = \frac{1}{2} \cdot 0.75 \text{ kg} \cdot (2.0 \text{ m/s})^2 \]

\[ = 1.5 \text{ J} \]

B. Calculate frictional work (will be negative):

\[ W_f = F_f \cdot d \]

\[ = 0.625 \text{ N} \cdot 2.0 \text{ m} = -1.25 \text{ J} \]

C. Mechanical energy = kinetic energy in this problem (no elevation change); subtract frictional work from initial energy to get final kinetic energy:

\[ W_f = \Delta K = K_2 - K_1 \]

\[ K_2 = \Delta K + K_1 \]

\[ = -1.25 \text{ J} + 1.5 \text{ J} = 0.25 \text{ J} \]

D. Final velocity:

\[ v = \sqrt{\frac{2 \cdot K_2}{m}} \]

\[ = \sqrt{\frac{2 \cdot 0.25 \text{ J}}{0.75 \text{ kg}}} \]

\[ = 0.82 \text{ m/s} \]

### Homework

Read 5.6 in your book

7.5 Problems in your Booklet

Due: next class