# Forces, Energy, and System Analysis

**Lesson Notes**

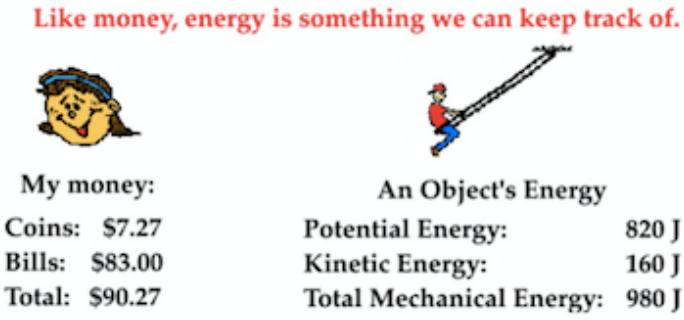
## Learning Outcomes

- What is meant by a system and how can it be used to conduct an energy analysis?
- What is a conservative force and how is it related to the amount of mechanical energy?
- What effect do non-conservative forces have on the energy of a system?

## Energy as a Book Keeping Tool

Goal: to use energy as a book keeping tool in order to predict answers to questions like how fast, high high, and how far.

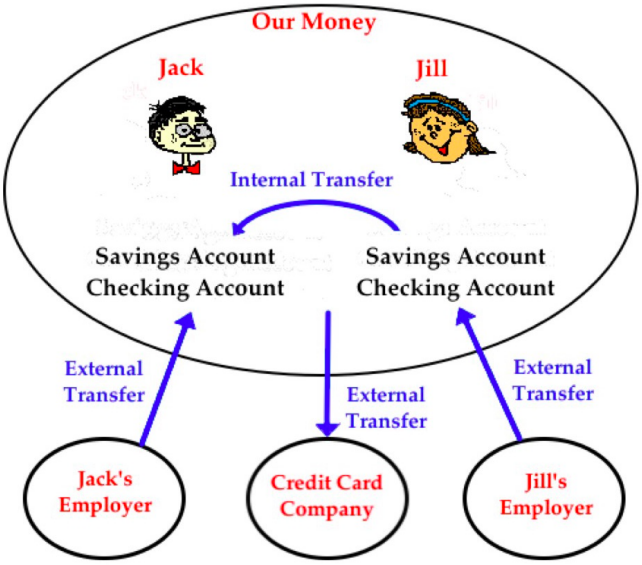
Energy is a lot like money.You can keep track of it, know how much you have, know what form it is in, know whether it is coming in or going out, know if the amount is increasing or decreasing, etc.




## System Analysis

Jack and Jill are married and have individual accounts at the bank. They also own things *in common*. The task of keeping track of their money is facilitated by considering Jack and Jill to be a single entity - to be part of *a system*.

- Individual $$ vs. *together* $$.
- Internal transfers vs. external transfers.
- A boundary separates the system from surroundings.



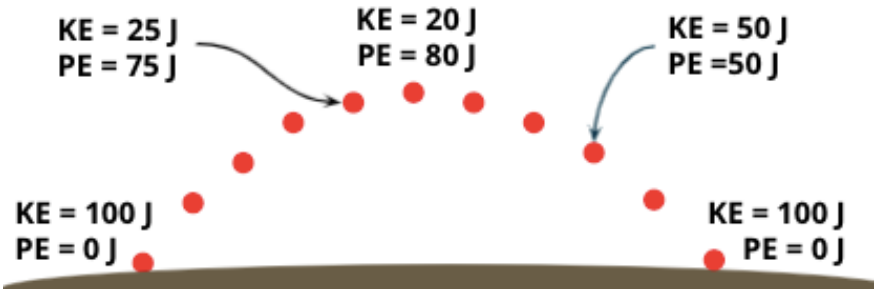

## Energy Analysis

When analyzing a motion, it is important to identify the system … and the boundary that separates the system from the surroundings.

- What is the system?
- Is work being done on the system by objects outside of it to cause any energy changes in the system?
- Are forces acting between objects within the system to transfer energy between them without changing the total amount?

## Conservative Forces and Mechanical Energy

- Technically speaking … a force is a **conservative force** if the amount of work it does in moving an object between two points is independent of the path taken between the two points.
- Gravity forces ($F_{grav}$) and spring forces ($F_{spring}$) are conservative forces.
- When conservative forces are the only forces doing *net work* on an object, then the total amount of mechanical energy of the object is conserved. Potential energy (PE) is converted to kinetic energy (KE) or vice versa, but the total of KE+ PE remains constant.




## Non-Conservative Forces and Energy

When non-conservative forces do *net work* on a system, there is a change in mechanical energy of the system. Such forces transfer energy across the system boundary.


System: Football

The foot does + work on the ball, transferring E to the ball.

System: Hammer

The nail does - work on the hammer, removing E from the hammer.

System: Barbell

The *strongman* does + work on the barbell, adding E to the barbell.

## Law of Conservation of Energy

- Energy is neither created nor destroyed … but only transferred from one form to another.
- The total energy possessed by *the universe* is conserved.
- If there is a loss of one form of energy then there is a gain in another form of energy … such that the total energy remains constant.


$KE_{ball}$ ↑

$KE_{foot}$ ↓

Chemical E ↓

Vibrational E ↑