External Energy Transfer

Lesson Notes

Learning Outcomes

- How do you analyze situations in which work is done on a system by an external force?

Keeping track of Energy

- When analyzing a motion, it is important to identify the system … and the boundary that separates the system from the surroundings.
- When objects outside the system exert non-conservative forces on the system to do *net work*, there is a change in mechanical energy of the system. Such forces transfer energy across the system boundary.
- In such cases: $TME_{initial} \neq TME_{final}$

Conservative Forces

F_{grav}, F_{spring}

Non-conservative Forces

F_{frict}, F_{air}, F_{tens}, F_{norm}, etc.

Work-Energy Relationship

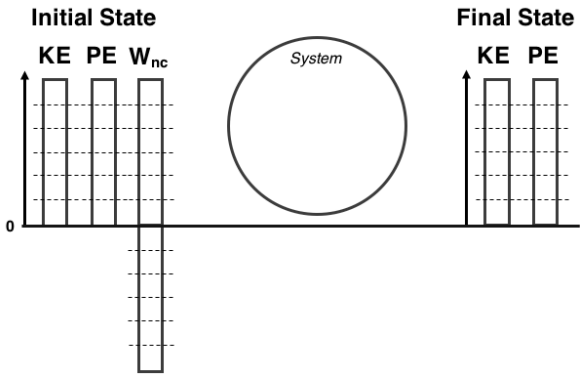
The work done by non-conservative, external forces (**W_{nc}**) is equal to the change in total mechanical energy (**ΔTME**) of the system.

$$KE_i + PE_i + W_{nc} = KE_f + PE_f$$

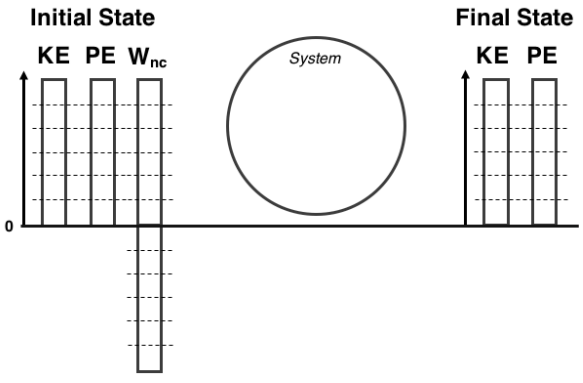
LOL Charts for External Energy Transfer

Complete the two LOL charts below for the given examples.

Consider + work done by a non-conservative force
Initially, the object is moving along the ground. The force is a horizontal force.



Consider - work done by a non-conservative force
Initially, the object is moving through the air. The speed remains constant.



Solve the following problems. Show your work.

Example 1: Raising the Bar

A barbell has 1500 J of PE. A weightlifter applies a 1000 N upwards force to the barbell to displace it upwards a distance of 0.25 m. What is the final PE of the barbell?

Example 2: Catching the Ball

A baseball is approaching home plate with 140 J . A catcher applies 1500 N of forward force to the ball to stop it. This is done while retracting the mitt backwards. Determine the distance the mitt retracts.

Example 3: Up the Hill

An 18.0 N force is directed parallel to an incline to pull a 2.2-kg cart along the incline a distance of 1.10 m at constant speed. Determine the final PE and final height of the cart.