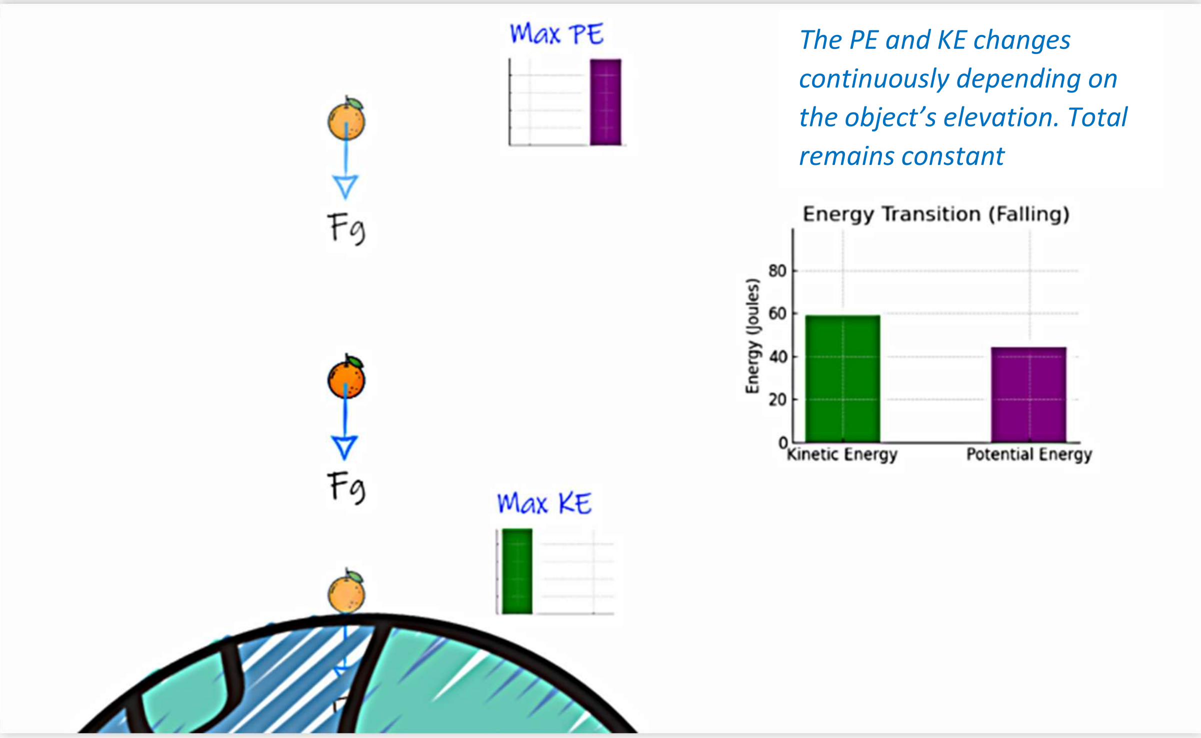
Conservative Forces and Non-Conservative Forces

Key Idea

A conservative force is one that conserves mechanical energy within a system. When a force is termed "conservative," it indicates that the total mechanical energy (kinetic energy + potential energy) of an object remains constant



Key Characteristics of Conservative Forces:

- Energy Conservation: The ability to convert energy between forms without loss.
- Path Independence: The work done by a conservative force on an object is independent of the path taken between two points.

Force of Gravity: A Conservative Force

Imagine tossing an orange upward. The system in question includes the orange and the Earth, dubbed the "Orange-Earth system."

Initially, the orange possesses KE given to it by the throw. As it goes up, gravity does work on the orange, converting its KE into PE. Upon reaching the top of its flight, the orange momentarily has maximum PE and zero KE. As it comes down, the process reverses, and the PE is converted back into KE.

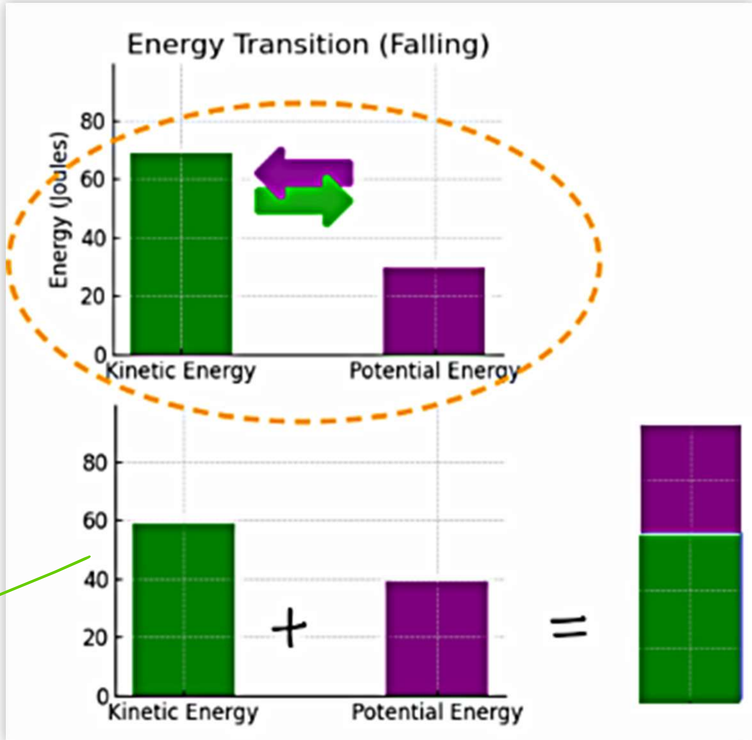
Observations from the Orange's Flight:

- At the peak, the orange's KE is minimum, and PE is maximum.
- The total energy (kinetic + potential) remains constant throughout the flight.

Conservative Forces allow interchange of energy

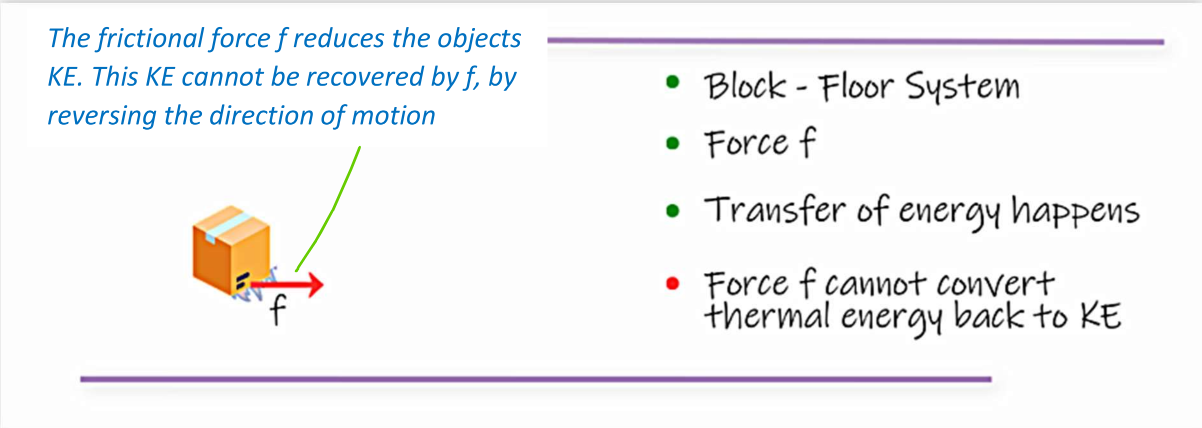
The gravitational force is a conservative force because it allows the two-way conversion between kinetic energy (KE) and potential energy (PE) without any loss of energy.

The PE and KE changes continuously – However the sum (KE + PE) remains constant at any position



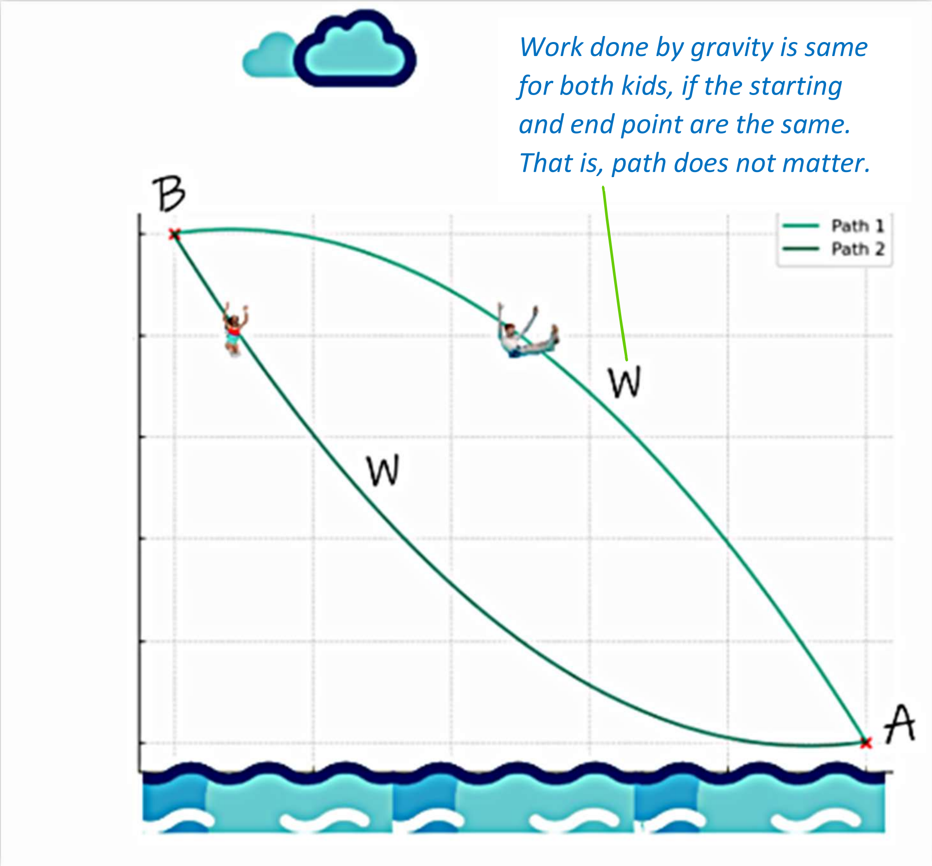
How Non-Conservative Forces are Different -

Non-conservative forces, such as friction and drag, do not conserve mechanical energy. They convert mechanical energy into other forms like thermal energy. These forms are not recoverable back into mechanical energy, leading to a net loss in the system's mechanical energy.

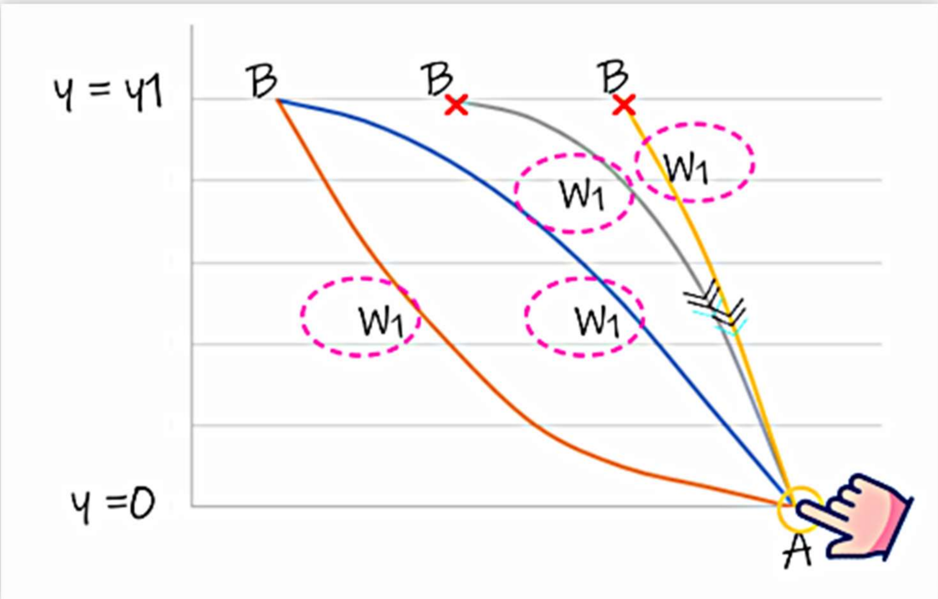


Path Independence and Work Done

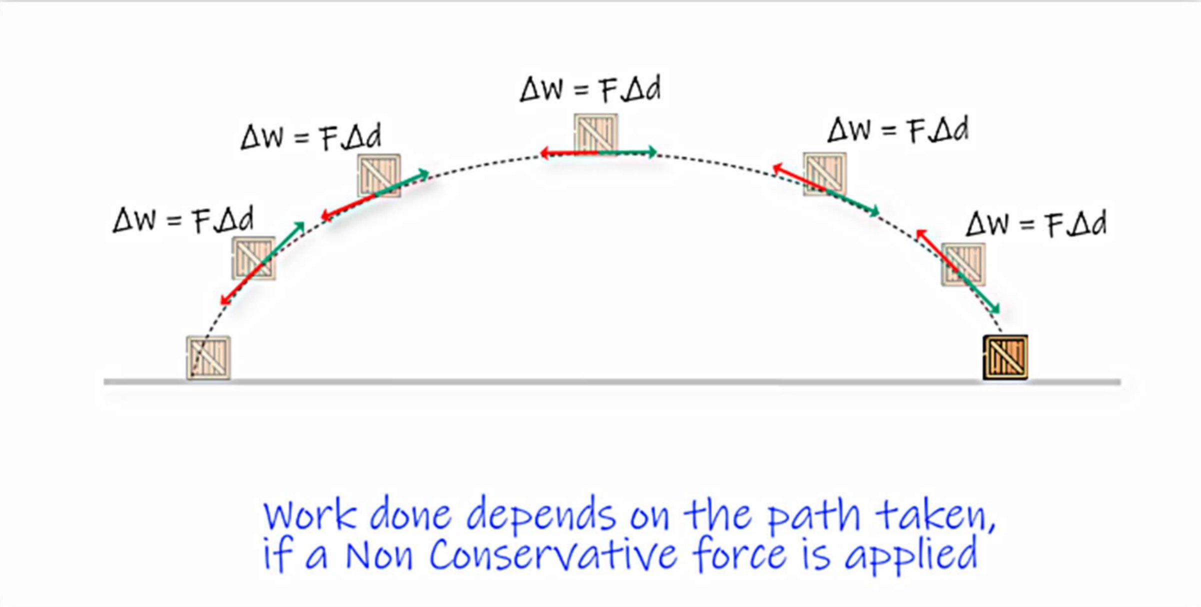
The work done by a conservative force is independent of the path taken between two points. For example, regardless of the path an object takes under the influence of gravity, the work done by gravity only *depends on the initial and final positions, not the path taken.*



Elevation is what determines the position when working around conservative forces. All points marked B are equivalent since they are all at y1.

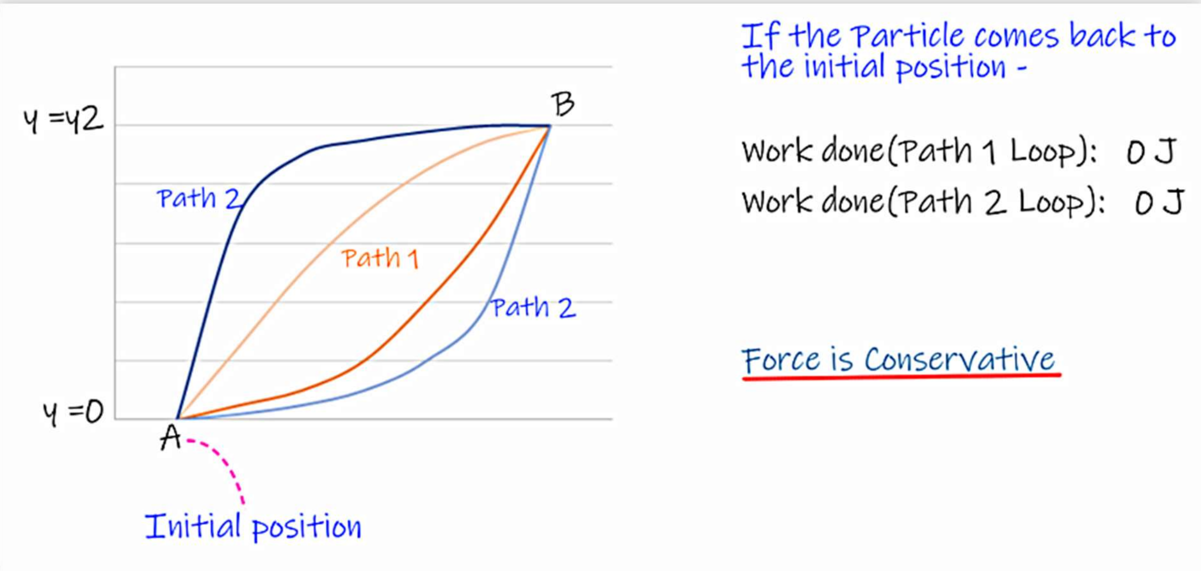


Work done by a non-conservative force is <u>path dependent</u>



Conservative Forces and Closed Paths:

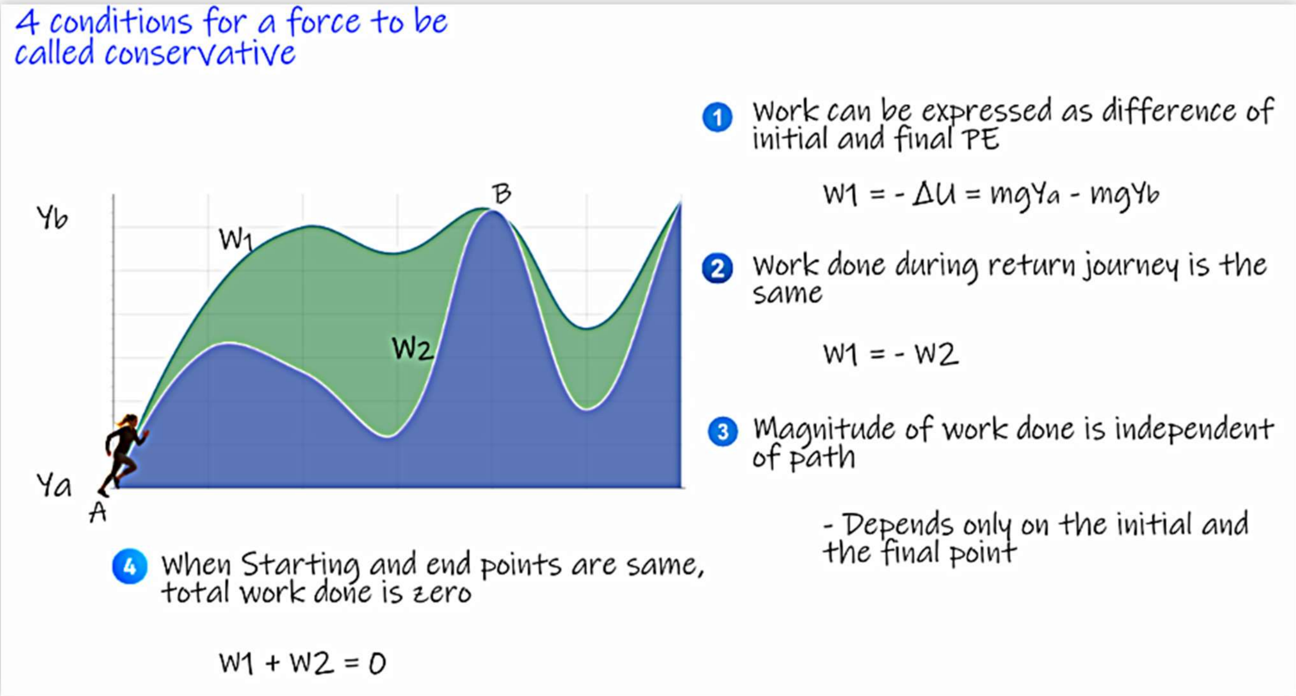
When a particle moves under the influence of a conservative force in a closed path (starting and ending at the same point), the work done by the conservative force is zero.



Summary: The Four Conditions of Conservative Forces

To determine if a force is conservative, the following conditions must be met:

1. *Expressible Work*: The work done can be expressed as the difference in potential energy between two points (W = -ΔU = mgy1 -mgy2)
2. *Work Restoration*: The force does equal amounts of work in opposite directions during a round trip.
3. *Path Independence:* The work done depends only on the starting and ending points, *not the path.*
4. *Zero Work on Closed Paths:* The total work done in a closed path is zero.



Summary of formulas and equations

SN	Equation	When to Use	Caution While Using
1.	W done by = $-\Delta U$ = $-(PE_{final} - PE_{initial})$	To calculate the work done by gravity on an object moving between two heights.	Negative sign indicates that gravity does negative work when the object moves upward and positive work when it moves downward.
2.	$W_{total} = 0$ (for a closed path)	To affirm the principle that the total work done by a conservative force over a closed path is zero.	Important to understand that this applies to conservative forces and closed paths, where the object returns to its initial position.
3.	$\Delta KE = -\Delta PE$	To illustrate the conservation of mechanical energy, showing that a decrease in PE results in an equivalent increase in KE, and vice versa.	Ensure no non-conservative forces (like friction) are doing any work, as this would violate energy conservation.
4.	$\Delta U = mgy_2 - mgy_1$	To find the change in potential energy as an object moves from one height (y_1) to another (y_2).	Keep the reference point for height consistent throughout the problem to avoid errors in calculating ΔU.