We have seen in class that, in order to restore an irreversible process, we leave a "trace" on the environment and the surroundings of the system (rest of universe). Can we find a criterion for this behavior? Using thermodynamic properties of the system, can we formulate a criterion that makes the distinction between reversible and irreversible processes?

Let's conduct 4 different thought experiments, where all the systems have the same initial state \((U_1, V_1)\) and the processes are all adiabatic.

A, B, C are all irreversible processes – we leave a mark on the environment when returning to initial state

D is the only reversible process among these adiabatic processes – there is no friction, no dissipation – we don’t leave a mark on the environment when returning to initial state
Let us return to the question stated earlier: can we find a criterion that determines whether a process is reversible or irreversible using the thermodynamic properties of the system?

For all the cases above, we looked at the changes in $U$ and $V$. Let us construct a $U$-$V$ diagram and draw these processes.

\[ dU + PdV > 0 \quad \text{adiabatic, irreversible processes} \]

\[ dU + PdV = 0 \quad \text{adiabatic, reversible process} \]

Can we find an indicator $S$ that has the same behavior as $dU + PdV$ for adiabatic processes (note that there is no heat interaction with the surroundings):

\[ dS > 0 \quad \text{adiabatic irreversible} \]
\[ dS = 0 \quad \text{adiabatic reversible} \]

In addition we would like $S$ to have the following features:

- $S$ should be appropriate for non-adiabatic systems as well
- $S$ should be an extensive property (as are $U$ and $V$)
- $S$ should not be path dependent

As we will see in Chapter 5, we can indeed find a new property $S$ that we call *entropy* (in Greek: ἑντροπία, where ἑντροπία means "inside or inner" and τροπή is "direction"). The definition and behavior of this new property $S$ is what we call the *Second Law of Thermodynamics*. 