0.1 Introduction

Write a thermodynamic derivative on the board, and ask the students to describe the experiment that you would perform in order to measure it, and draw a picture of the apparatus.

Student handout Your group will be given one of the following partial derivatives:

$$a)\ \left(\frac{\partial V}{\partial p}\right)_T \quad b)\ \left(\frac{\partial U}{\partial p}\right)_S \quad c)\ \left(\frac{\partial T}{\partial V}\right)_S \quad d)\ \left(\frac{\partial V}{\partial T}\right)_p \quad e)\ \left(\frac{\partial U}{\partial T}\right)_V \tag{1}$$

$$f)\ \left(\frac{\partial p}{\partial V}\right)_T \quad g)\ \left(\frac{\partial V}{\partial T}\right)_S \quad h)\ \left(\frac{\partial T}{\partial V}\right)_p \quad i)\ \left(\frac{\partial T}{\partial U}\right)_V \quad j)\ \left(\frac{\partial V}{\partial p}\right)_S \tag{2}$$

In your group, design an experiment to measure this derivative. Draw a sketch of the apparatus and describe how to convert directly measured data into a numerical value for the derivative.

If you finish with your derivative, you can try designing an experiment for the next derivative in the list.

Partials that should be considered for this activity:

Simple 3D $\left(\frac{\partial V}{\partial p}\right)_T$ $\left(\frac{\partial V}{\partial T}\right)_p$

Simple 1D $\left(\frac{\partial L}{\partial \tau}\right)_T$ $\left(\frac{\partial L}{\partial T}\right)_\tau$

Simple adiabatic $\left(\frac{\partial T}{\partial V}\right)_S$ $\left(\frac{\partial V}{\partial p}\right)_S$

First Law (challenging) $\left(\frac{\partial U}{\partial T}\right)_V$ $\left(\frac{\partial U}{\partial P}\right)_S$

A particularly challenging pair of derivatives are $\left(\frac{\partial p}{\partial S}\right)_T$ and $\left(\frac{\partial V}{\partial S}\right)_T$. In particular, the idea of "heating" something at constant temperature is quite counterintuitive. It may help to invoke the example of melting ice, in which you are heating the ice, but it stays at zero centigrade.

0.2 Student Conversations

- It's worthwhile inverting derivatives from time to time. Students who can understand $\left(\frac{\partial p}{\partial S}\right)_V$ may struggle with $\left(\frac{\partial S}{\partial p}\right)_V$, even though one is just the inverse of the other.
- The first time entropy is varied in a derivative, students may be very confused as to how one could either measure a change in entropy or induce a change in entropy.
- Students can confuse what is meant by "insulated system" and "isolated system."

0.3 Wrap-up

If many or most of the groups had trouble with a particular concept, it's worth bringing everyone together to discuss this. As well, if there was a particular group that had a unique solution, it is worth showing to the class as well. Here is a [[whitepapers:narratives:intro—narrative]] for this activity.