An interaction designer wants to augment a smartphone with additional sensors in order to both make some one-handed interactions easier and minimize screen occlusion caused by the hand when touching the screen. Figure 1 illustrates the two options he is considering for enabling one-handed and occlusion-free continuous control:

1. **(Tech1) Pressure+Proximity**: the smartphone is equipped with a single sensor, which is located under the thumb tip, and that is able of capturing both pressure and proximity. To increase a continuous value, the user moves his thumb away from the sensor while remaining in the smartphone’s plane. To decrease a continuous value, the user applies a pressure to the sensor. The speed of control depends either on the force applied to the pressure sensor or on the distance between the thumb tip and the sensor. To stop control, the user either stops applying pressure or puts his thumb out of the smartphone’s plane (either towards the front of the device or towards the rear of the device).
2. **(Tech2) Pressure+Pressure**: the smartphone is equipped with two pressure sensors that are co-located on one of its sides. To increase a continuous value, the user applies a pressure with its index (and/or middle) finger on the upper sensor. To decrease a continuous value, the user applies a pressure with its little (and/or ring) finger on the lower sensor. The speed of control depends either on the force applied to the pressure sensor or on the distance between the thumb tip and the sensor. To stop control, the user stops applying pressure.

**Designer’s intuition**: Our designer has the intuition that (i) technique **Tech1** will be more efficient for horizontal virtual controls such as sliders than **Tech2** while (ii) technique **Tech2** will be more efficient for vertical controls such as scrollbars. He wants to design an experiment to test his intuition.

1. What is a research hypothesis? Provide a definition and the research hypotheses corresponding to our designer’s intuition. (1pt)
2. What is the null hypothesis? Provide a definition and the null hypotheses for the specific case presented here. Why do we need to formulate the null hypothesis for analyzing empirical results? (1pt)
3. Operationalization:
   a. identify the primary factor(s) and measure(s) that are necessary to test the hypotheses. Using these factor(s) and measure(s), sketch the typical chart(s) that would support the stated research hypotheses. (2.5pt)
   b. describe the experimental task(s) that participants will have to do during the experiment. Introducing secondary factor(s) may be necessary so as to maximize the external validity of collected observations. Illustrate those task(s) using sketches. (2.5pt)