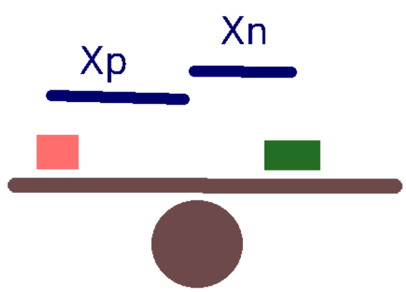
Pandemic Lab 06 At Home Scale

You should cut a piece of cardboard, over 11 inches in length here is fine and it should be about 1 inch wide. Don't hurt yourself cutting this out. It should be rather straight on the sides but it can have imperfections here.
You will also need a fairly large pill bottle: I used a huge bottle of Unisom here but you can use many variations of this. I also used 4 pennies on the sides of the bottle to keep it from rolling.

You will probably want to print off your own metric ruler if you have access to a printer. You can also use your own ruler. If it is only in inches, you will need to do the conversions to the metric system, more or less although here it will get a bit simpler. But you will need somehow to measure the distances from the pivot (which here will be the axis) to the coin.

You probably will want to refer to the video for details here.

The analysis of this is straight forward.



The physics of the problem is that in static equilibrium, the sum of the external forces and the sum of the external torques are equal to zero.

$$\sum \vec{F} = \vec{0} \quad \text{and} \quad \sum \vec{\tau} = \vec{0}$$

Since the system was initially balanced, and since we choose the axis at the center of mass of the cardboard, we do not need to worry about torques from the cardboard or the pill bottle because those forces are zero. Applying the second condition we have:

$$+m_p g X_p - m_n g X_n = 0 \Rightarrow m_p X_p = m_n X_n$$

I am going to imagine I want to measure the mass of the nickel and assume we know the mass of the penny is 2.5g. This gives:

$$m_n = m_p \left(\frac{X_p}{X_n} \right)$$

So knowing the mass of the penny and the two distances, we are able to determine the mass of the nickel. You should do this calculation. The mass of the nickel is 5 g. You can then calculate the % error by

$$\%\,\text{error} = 100 \times \left(\frac{m_{n,\text{measured}} - m_{n,\text{standard}}}{m_{n,\text{standard}}} \right)$$

In my work, I obtained about 10% error, and given the simple materials used, I thought it was pretty good. This type of physics actually has been used for centuries in markets although in normal application there, the lengths are the same and there is a standard weight on one side and enough material is placed on the other side until it is in equilibrium.

In this situation you can see the particular units of the length measurement is not important since the ratio is dimensionless.