Question: Does the relationship between a mass of a block and the mass of a liquid in a modified Atwood's machine represent a constant coefficient of static friction?

Hypothesis: The relationship between the weight of a block (m1) and the amount of liquid required to move it will be constant and linear, and it will be representative of the coefficient of friction.

Strategy:

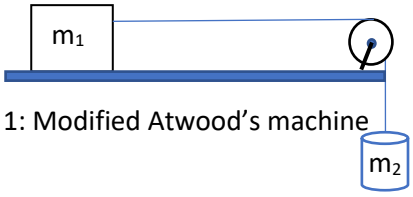

Fig 1: Modified Atwood's machine

- The hanging mass in the modified Atwood's machine was varied by adding water to a cup tied to the string until the machine started moving. The resulting volume/mass of the water was measured using a graduated cylinder.
- The mass of the block was varied by adding weights on top of it.
- The applied force (hanging weight) was graphed vs. the mass of the block to verify that it created a direct, linear function

Data:

The amount of water required to move different masses.

Trial #	Hanging Water (mL = g)	Added Mass (g)
1	56	0
2	52	0
3	62	50
4	66	100

The mass of the block was 137 g. One mL of water has one gram of mass.

Analysis:

The free body diagrams in Figure 2 show the forces on the masses in the modified Atwood's machine.

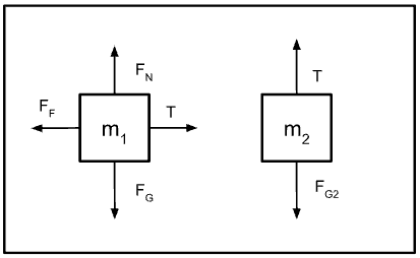

Figure 2: Free Body Diagrams

The following equations are based on the free-body diagram. Positive motion is defined as to the right for the weight, and down for the hanging mass. When static motion is happening, $F_{G2} = F_F$. Using the equations $F_F = \mu F_N$ and $F_G = mg$, the equation can be put in terms of μ and mass. The simplified equation can be written as:

$$m_2 = \mu(m,)$$

This equation can be linearized indicating that there is a linear relationship between the hanging mass (m_2) and the mass of the block (m_1). The slope of this line is μ, the static coefficient of friction.

A graph of the block's mass vs. hanging mass data for this experiment shows that it is indeed linear and that the slope is equal to 0.12.

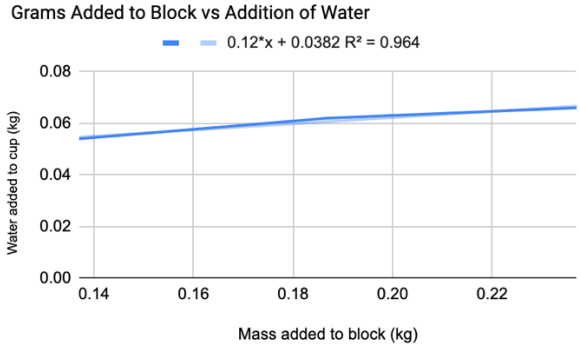

Figure 3: Water vs. Mass Graph

If the relationship between the hanging mass and the mass of the block, the coefficient of friction, is constant, then the data would show a linear trend. The high R^2 coefficient from Figure 3 (0.964) is very close to one, indicating a linear association. This constant linear relationship is representative of the coefficient friction, 0.12, supporting the hypothesis. In the future, the experiment could be modified to consider different factors to avoid potential inaccuracies. Such factors may include the uniformity of the surface, the mass of the string, and the friction between the string and the pulley.