Experiment 2
Verification of Newton's Second Law of Motion by Atwood Machine.

Physics Lab 1

Summer 2020-21

Department of Physics

American International University-Bangladesh

Objectives:

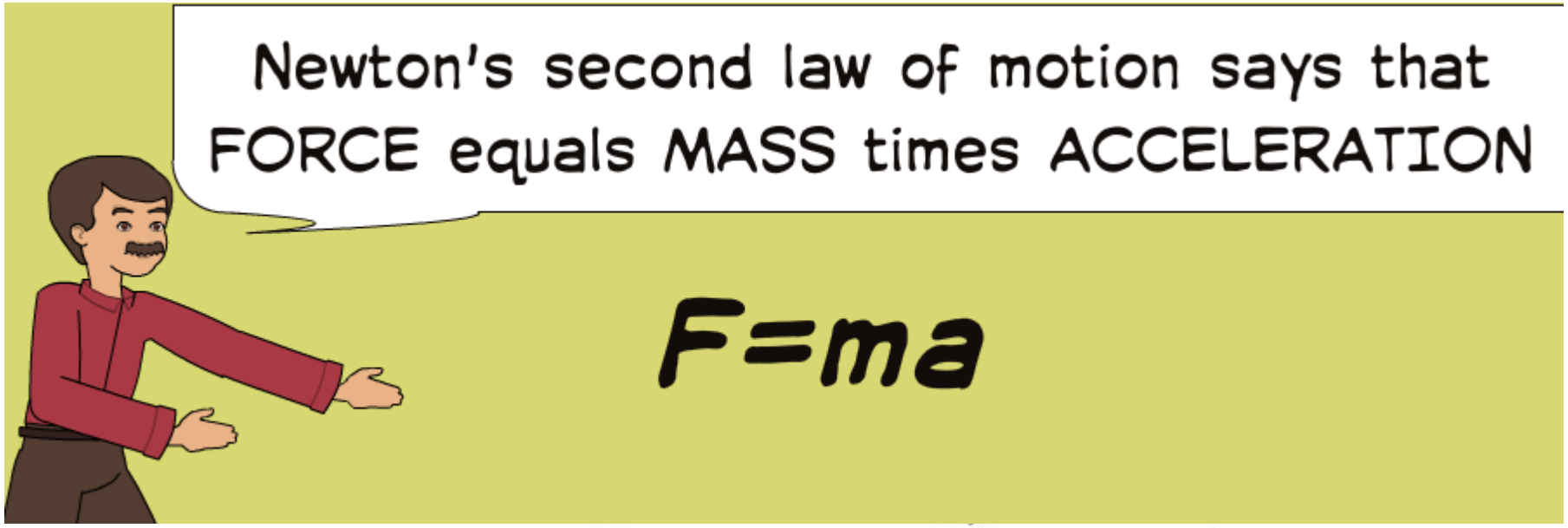
To establish the relationship between force and acceleration, thus verify Newton’s second law of motion.

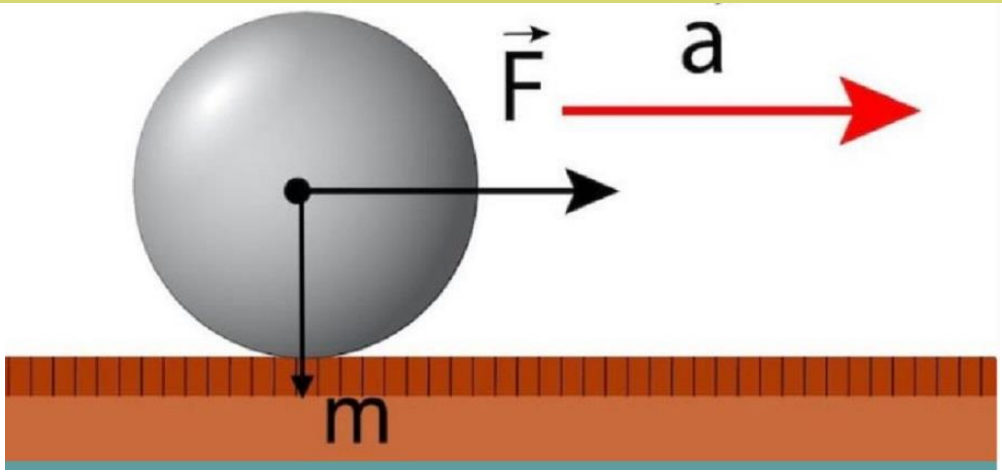
Outcomes:

After completing this experiment student should be able to answer the following questions:

- What is the relationship between force and acceleration for an object according to Newton's second law of motion?
- What is the basic concept of net force?
- How an Atwood machine can be constructed? How different forces and acceleration work for the Atwood machine.
- Why the experimental accelerations vary from the theoretical accelerations?
- What is the meaning of a linear relationship and how it looks in a graph?

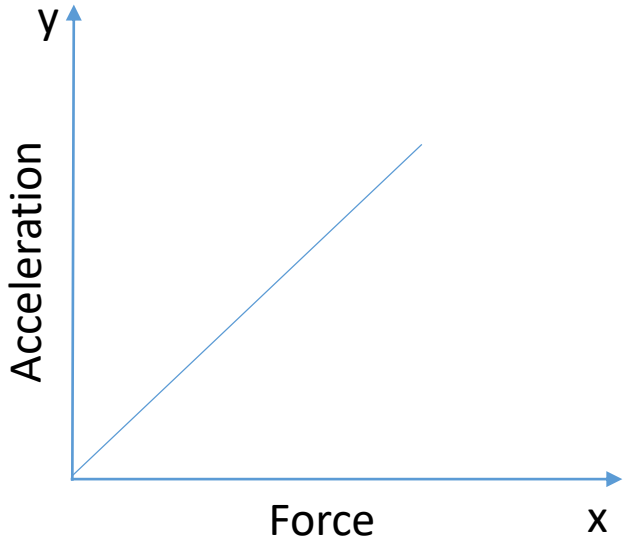
Theory: Newton's Second Law of Motion





For a particular mass:

$$Acceleration \propto Force$$



Atwood Machine: Theory

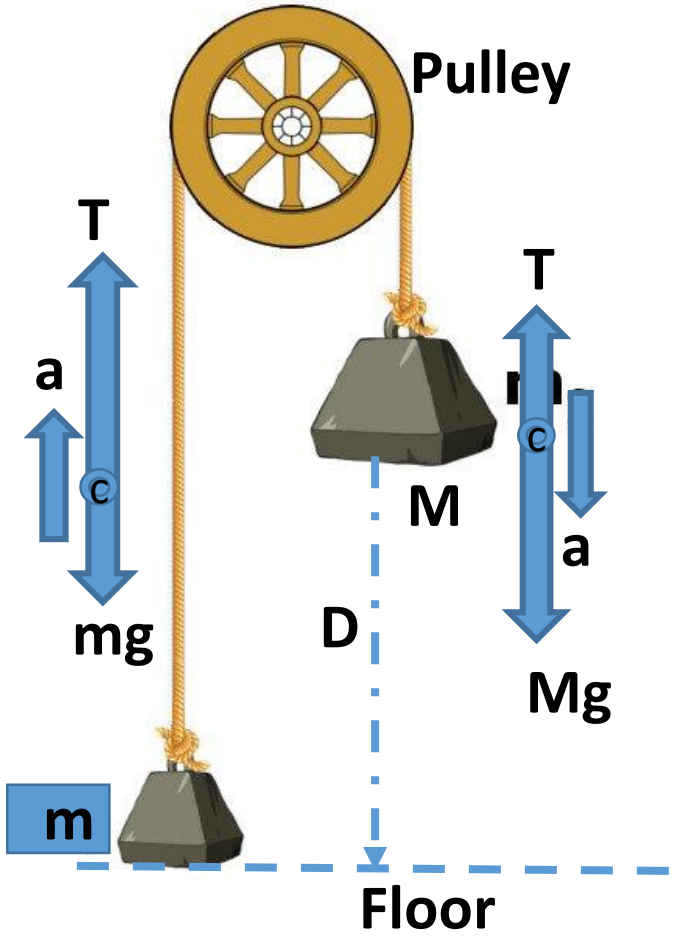
Applying Newton's 2nd Law: $\mathbf{F_{net} = ma}$

- For M: $\mathbf{F_{net} = T - Mg = Ma}$,
- For m: $\mathbf{F_{net} = T - mg = ma}$
- Solving these two equations: the theoretical acceleration

$$\mathbf{a_{th} = \frac{g}{(M + m)}\ (M - m)}$$

- Keeping (**M+m**) constant at any particular place (**g** is constant), we get

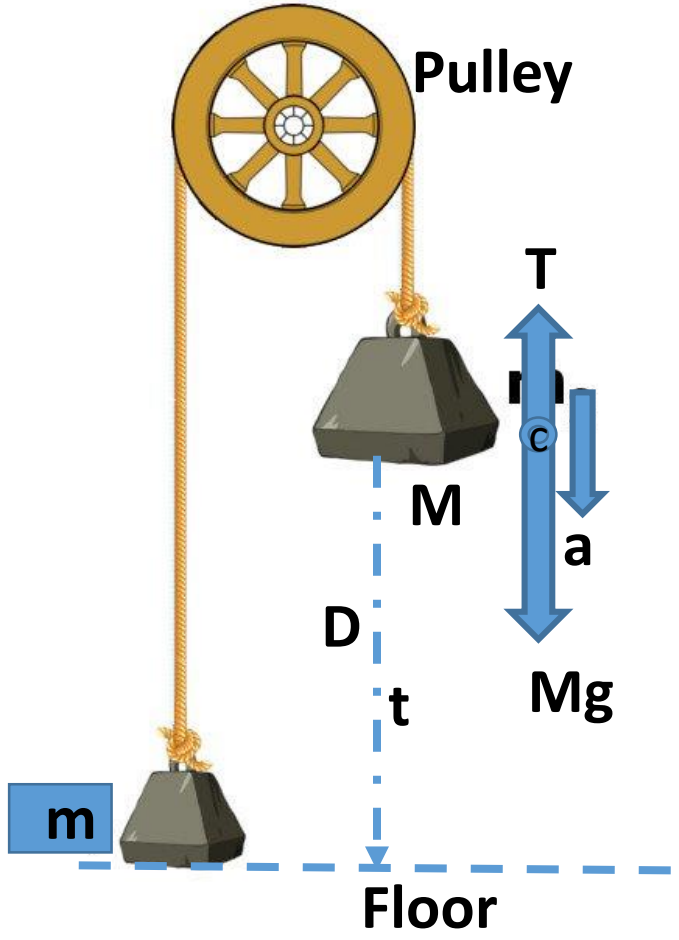
$$\mathbf{a_{th}} \propto \mathbf{(M - m)}$$



Atwood Machine: Experiment

- **M** falls a distance **D** in time **t** from rest.
- Applying the knowledge of equations of motion (**$D=ut+1/2at^2$**), we get the experimental acceleration

$$a_{ex} = \frac{2D}{t^2}$$



Verification of Newton's 2nd Law

- Newton's Second Law: Acceleration $\propto$ Force
- Atwood Machine: Theory Predicts

$$\mathbf{a_{th}} \propto (\mathbf{M - m})$$

- Atwood Machine: Experimental Result

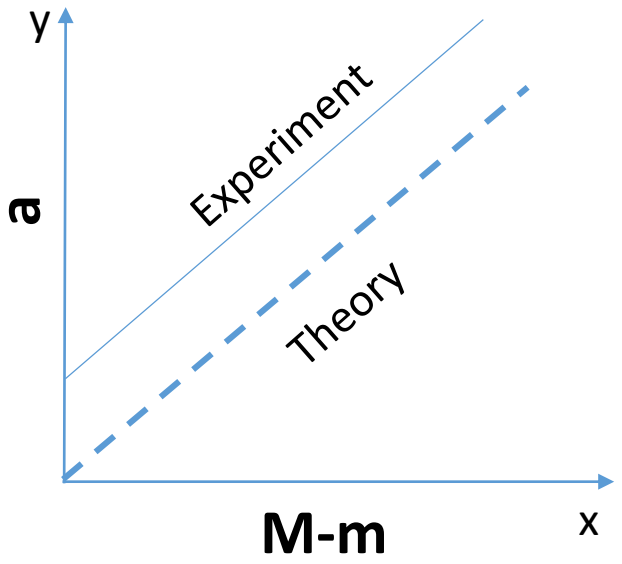
$$\mathbf{a_{ex}} = \frac{\mathbf{2D}}{\mathbf{t^2}}$$

- If we find

$$\mathbf{a_{ex}} \propto (\mathbf{M - m})$$

we can say, Newton's 2nd law is verified.

$$Acceleration \propto Mass\ difference$$



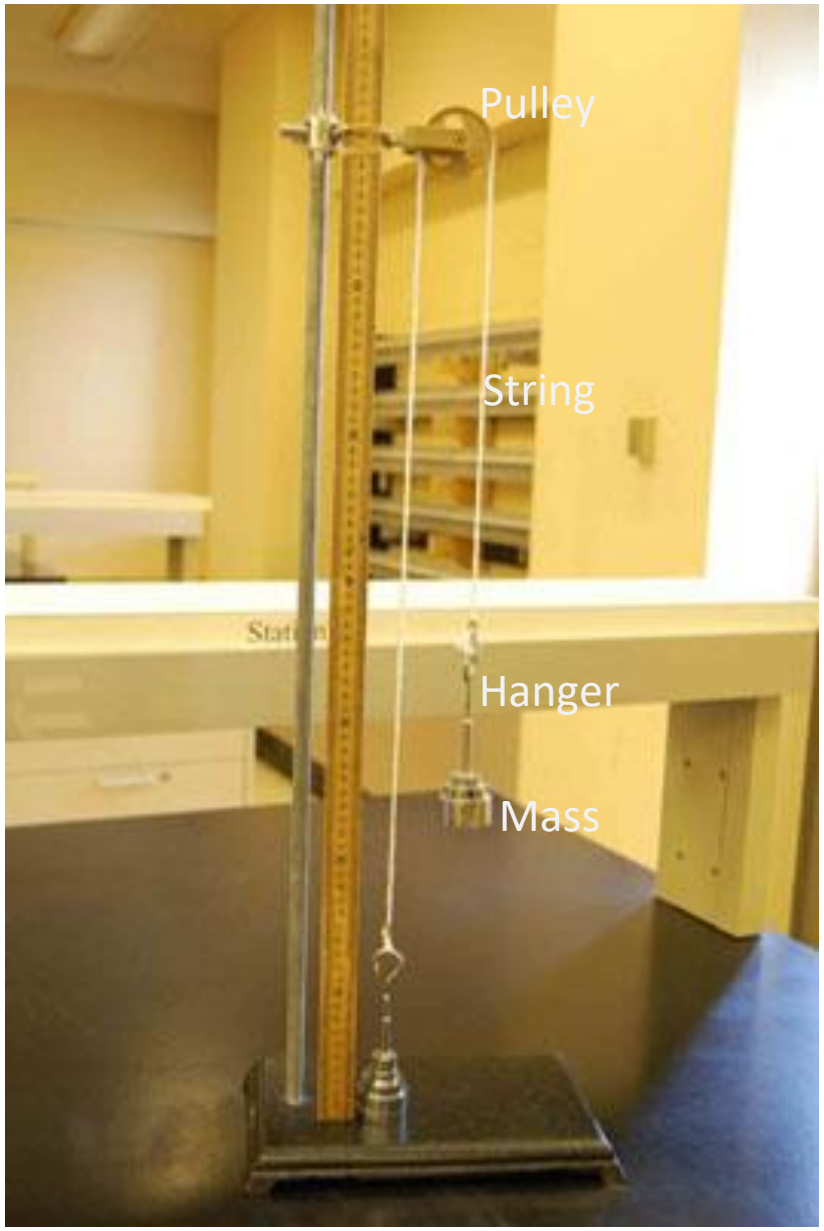
Apparatus

- Atwood Machine:

  Pulley, two hangers, different masses, string, stand and clamp.

- Measurement of D and t:

  Meter scale and stop watch.



Procedure:

- Hold the lighter mass on the floor attached to one end of a string. The heavier one attached to the other end of the string is up in the air at a height D from the floor. Measure D with a meter scale.
- Now release the lighter mass and measure the time the heavier mass takes to fall onto the floor. Run the experiment for 7 different mass-differences, (M - m). For each run, obtain the value of the acceleration in (m/s^2) experimentally as well as theoretically. Make sure to keep total mass (M + m) always constant.
- Using Excel plot acceleration (a_{th} and a_{ex}) versus mass difference (M - m) graph.

Video lecture on Procedure:

Lab Works:

- Complete the data table with the calculations.
- Draw the acceleration vs mass difference graph in Excel. Plot both the accelerations (theoretical and experimental) on the same graph paper.
- Analyze the result.

Discussion on Outcomes of the Lab

- What is the relationship between force and acceleration for an object according to Newton's second law of motion?
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