PHYS 2211L - Principles of Physics I Laboratory

Laboratory Advanced Sheets
Atwood Machine and the Law of Conservation of Mechanical Energy

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Objective. To test the law of conservation of energy.

Theory. This laboratory investigates the law of conservation of mechanical energy by studying the motion of a connected two-body system called the Atwood machine. The English mathematician George Atwood invented the machine in 1784 to study the laws of motion with constant acceleration. The system can also be used to measure the acceleration due to gravity. The ideal Atwood machine consists of two objects of mass M_1 and M_2, connected by an inextensible massless string hanging over an ideal massless pulley. Figure 1 presents the schematic diagram of the system, while Figure 2 is a cool illustration of the Atwood machine from 1905.

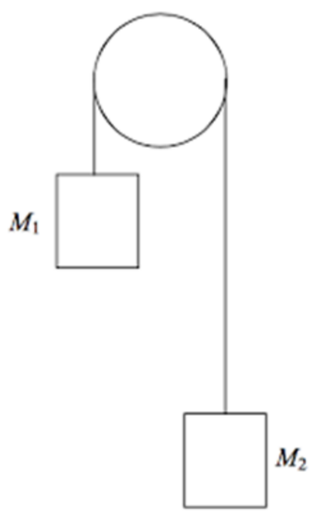

Figure 1. Schematic diagram of the Atwood machine.

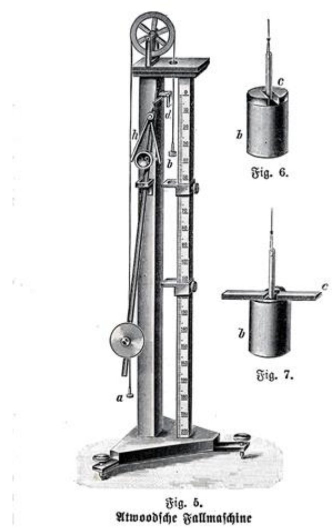

Figure 2. Historic illustration of the Atwood Machine. *Emmanuel Muller-Baden, Ed. (1905) Bibliothek allgemeinen und praktischen Wissens für Militäranwärter Band III, Deutsches Verlaghaus Bong & Co., Berlin, Leipzig, Wien, Stuttgart.*

Since we assume the pulley to be frictionless and neglect the air resistance, there are no nonconservative forces present in the system and the total mechanical energy of the system must be conserved. We can express the total mechanical energy of the system as

$$E = \frac{1}{2} M_1 {v_1}^2 + \frac{1}{2} M_2 {v_2}^2 + M_1 \, g y_1 + M_2 \, g y_2$$

where M_1 and M_2 are the two masses that compose the system,

v_1 and v_2 are the speeds of the masses at a given instant (assumed to be the same),

g is the acceleration due to gravity, and

y_1 and y_2 are the vertical positions of the masses M_1 and M_2 correspondingly.

The first two terms represent the total kinetic energy of the system while the last two describe the gravitational potential energy of the two masses in the gravitational field of the Earth. The law of conservation of energy states that

$$E_i = E_f$$

where the initial and final subscripts refer to any two arbitrary moments during the motion of the system.

Apparatus and experimental procedures.

- Equipment.
    1. Meter stick/ruler.
    2. Kitchen scale.
    3. Pulley.
    4. Masses (2).
    5. Thread.
    6. Camera.
    7. Computer with the Tracker software.
- Experimental setup. The experimental setup for the measurements is provided in the theory section of this report.
- Capabilities. To be provided by the student.

. **Requirements**.

- In the laboratory.

1. Your instructor will introduce you to the procedures to be used in the experiment.

2. Release the masses from their initial position. Take a video of the motion.
3. Measure the masses M_1 and M_2.

- After the laboratory. The items listed below will be turned in at the beginning of the next laboratory period. A complete laboratory report is not required for this laboratory.

- **Para. 3. Apparatus and experimental procedures**. Provide a description of the capabilities of the equipment used in the experiment.

Para. 4. Data.

1. Provide a video of your experiment.
2. Provide a copy of your spreadsheet with calculations. Include the following:
   A. The Tracker data for the two masses.
   B. Graphs of the *y*- coordinates of two masses as a function of time with the quadratic regression equation included on the graph.
   C. Calculation of the magnitude of the velocity of the two masses.
   D. Calculation of the potential, kinetic, and total mechanical energies of the two masses as a function of time.
   E. Calculation of the total energy of the system as a function of time.
   F. Graph of the total mechanical energy of masses M_1 and M_2 and the total energy of the system as a function of time.
   G. Calculation of the Percent Discrepancy between the experimental and predicted total energy of the system.

Para. 5. Results and Conclusions.

- **Results**.
  1. A statement regarding the verification of the law of conservation of energy for the Atwood machine.
  2. A statement of the Percent Discrepancy between the experimental and predicted total energy of the system.

- **Conclusions**.
  1. Describe sources of systematic error in the experiment.
  2. Describe sources of random error in the experiment.