

Powerhouse Lab

Teacher's Guide

Topic:

Work, Energy and Power

The following information is provided to the student:

Question:

What is my power requirement for climbing a staircase - both by walking and by running?

Purpose:

To determine my power requirement for climbing a staircase - both by walking and by running.

A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion. The Data section should include a table of both measured and calculated data for both walking and running up a flight of stairs. The rows and columns should be labeled; units should be identified. Work should be shown for each calculation; the work should be labeled and easy to follow. The Conclusion should (as always) answer the questions posed in the Purpose.

Materials Required:

Staircase; meter stick; stopwatch.

Description of Procedure:

Students form a long line at the base of a staircase. On the teacher's signal, the student in the front of the line runs up the staircase. The teacher uses the stopwatch to determine the elapsed time. Students repeat the process walking. Students measure the height of the staircase and calculate their mass. This data can be used to determine their power - both by walking and by running.

Alternative Materials and Procedure:

If the school administration frowns on the use of hallways and stairwells for labwork, consider having students measure their wrist power. Tie a hefty mass to a rope; attach the other end of the rope to a long cylindrical dowel rod or PVC pipe. Students measure the time required to raise the mass a given distance using their wrists to turn the dowel rod or pipe.

Safety Concern:

There is always a higher than usual level of risk associated with working in a science lab. Teachers should be aware of this and take the necessary precautions to insure that the working environment is as safe as possible. Student *horseplay* and off-task behaviors should not be tolerated. Caution should be taken to insure that students do not trip on the steps.

Suggestions, Precautions, Notes:

1. You could allow students a running start and simply start the timer the moment the first step is reached. Allow students to skip steps so that the lab becomes a measure of power and not of foot quickness. You can also allow students to use the hand railing; this enhances the safety of the student and prevents unfortunate falls, chipped teeth and broken noses.

The Laboratory

2. A number of assumptions are made in this lab; some might be worth discussing with your students. First, it is assumed that the ascent of the staircase occurs at a constant speed with a constant force which is equal to the weight of the student. While neither of these two assumptions are correct (it wasn't a constant speed and it definitely wasn't a constant or continuous force), it ends up that the work done is equal to the weight of the student multiplied by the change in height. This was actually the take-home lesson from the It's All Uphill - The Sequel Lab. Second, it is assumed that the work which is done by the students contributes to their change in height and not to any change in speed. Giving students a little *head start* into the staircase means that whatever force is applied to the step is mostly a downward force which results in an upward reaction force that elevates the student to the next step. A forward force is not needed to sustain the student's horizontal motion. Finally, it is assumed that the work done on the student is equal to the work done by the student. The work done on the student is equal to the student's weight ($m \cdot g$) multiplied by the student's change in height.
3. Many students are very conscious of their weight. Rather than have them step on a balance, it might be less threatening to have them calculate their mass in kilograms from their weight in pounds.

$$\text{mass in kg} = \text{Weight in pounds} \cdot (2.2 \text{ kg} / 1 \text{ pound})$$

4. Consider establishing a new club in your school - the Horsepower Club. Membership in this club is dependent upon the ability to generate 750 W of power (that is 1 horsepower) during this lab. If some students feel left out, establish another club known as the Pony Club - anyone can join.

Auxiliary Materials:

None

Scoring Rubric:

E3. Powerhouse Lab	Score
<ul style="list-style-type: none">___ Included, labeled and organized all parts of the lab report.___ Data section includes a table of both measured and calculated data for walking and running; data is organized in labeled columns; units are stated. Data are relatively accurate. Work is shown and labeled for each type of calculation.___ Conclusion answers the <i>question</i> posed in the Purpose; <i>answer</i> is reasonable; units are stated.	___/___

Connections to The Physics Classroom Tutorial:

The following reading is a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/Class/energy/u5l1e.cfm>

Connections to Minds on Physics Internet Modules:

Sublevel 2 of the Work and Energy module is a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/mop/module.cfm>