

Energy conservation, bar charts and power

AP Physics 1 (algebra-based) · Lab

Name: _____ Date: _____ Class: _____

How much power can a person produce climbing stairs? In this lab you time a climber at two different speeds, calculate the energy gained and compare the average power. It needs only a staircase, a tape measure and a stopwatch, so it works in school or at home.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 3

Aim

To measure the gain in gravitational potential energy and the average power of a person climbing a flight of stairs at two different speeds.

Equipment

- A staircase of at least 15 steps (a school corridor or a public building)
- Metre rule or tape measure
- Stopwatch (or phone timer) and a helper
- Bathroom scales to find the climber's mass

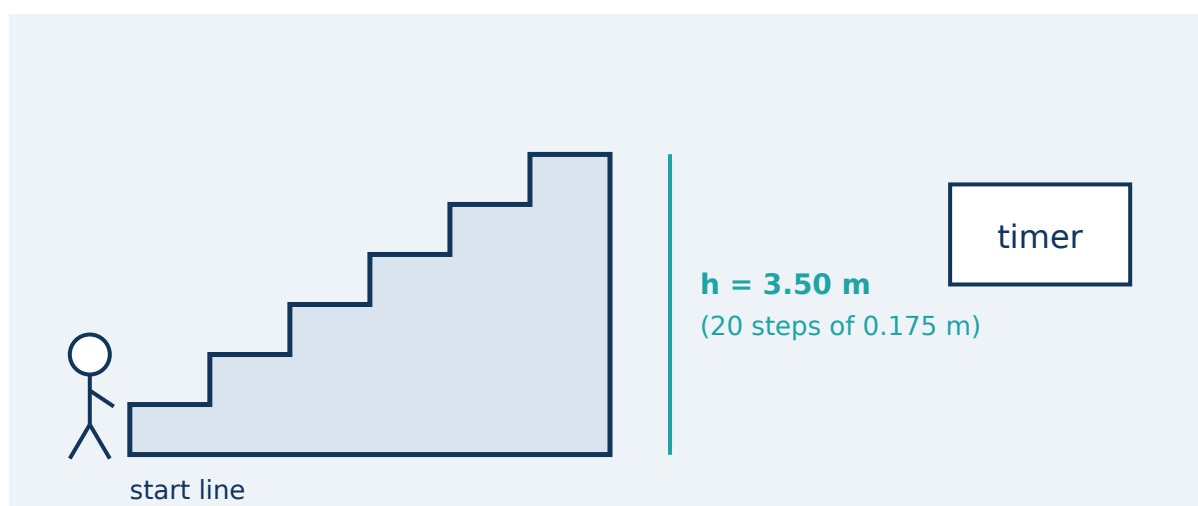
Safety

Safety

Use a dry, clear staircase with a handrail. Wear flat shoes with good grip. Walk down slowly after each run, never run down. Stop at once if the climber feels dizzy or short of breath.

Method

1. Measure the height of one step in three places and take the mean. Multiply by the number of steps to find the total vertical height h .
2. Find the climber's mass m on the scales.
3. Mark a start line level with the bottom step. The helper starts the timer when the climber moves.
4. The climber walks up at a steady comfortable pace; the helper stops the timer as the climber reaches the top landing. Repeat for five trials.
5. Repeat step 4 with the climber running up as fast as is safe, again for five trials.
6. Rest between trials and record every time in the table.



Set-up: the runner starts level with the first step and the timer stops when the runner touches the top landing.

Results

Sample data for a climber of mass 58 kg on a staircase of total height 3.50 m:

Trial	Walking time (s)	Running time (s)
1	14.2	8.2
2	14.8	7.9
3	14.5	8.1
4	14.6	7.8
5	14.4	8.0
Mean	14.5	8.0

Analysis questions

Question 1 Energy gained

Calculate the gain in gravitational potential energy of the climber in one ascent.

Question 2 Uncertainty in time

For each set of trials, estimate the uncertainty in the mean time as half the range of the five readings. Express it as a percentage of the mean.

Question 3 Walking power

Calculate the average power while walking.

Question 4 Running power

Calculate the average power while running.

Question 5 Same work, different power

Compare your two power values and explain why the energy gained is the same in both runs.

Question 6 Body efficiency

The muscles of the climber are about 25 % efficient. Calculate the chemical energy used in the running ascent, and explain where the rest goes.

Question 7 Sources of error

Suggest two sources of error in this lab and state whether each makes the calculated power too high or too low.

Question 8 Improving the lab

Suggest two improvements that would reduce the uncertainty in the power values.