

Energy conservation, bar charts and power

AP Physics 1 (algebra-based) · Lab answers

The model answers use the sample data in the results table. Your own values will differ, but the method and the reasoning about uncertainty and efficiency should match.

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

Question 1 Energy gained

$$\Delta U = mgh = 58 \text{ kg} \times 9.81 \text{ N/kg} \times 3.50 \text{ m} = \mathbf{1.99 \times 10^3 \text{ J}} \text{ (1991 J)}.$$

Question 2 Uncertainty in time

Walking: range = $14.8 - 14.2 = 0.6 \text{ s}$, so uncertainty = 0.3 s , which is $0.3 \div 14.5 = 2.1 \%$.
Running: range = $8.2 - 7.8 = 0.4 \text{ s}$, so uncertainty = 0.2 s , which is $0.2 \div 8.0 = \mathbf{2.5 \%}$. The running time has the larger percentage uncertainty.

Question 3 Walking power

$$P = \Delta U \div t = 1991 \text{ J} \div 14.5 \text{ s} = \mathbf{137 \text{ W}}.$$

Question 4 Running power

$$P = 1991 \text{ J} \div 8.0 \text{ s} = \mathbf{249 \text{ W}}.$$

Question 5 Same work, different power

The climber gains the same energy because the vertical height and the mass are unchanged. Running does that job in less time, so the power is higher: $249 \div 137 = \mathbf{1.8}$ **times** greater.

Question 6 Body efficiency

$E_{\text{chem}} = \text{useful energy} \div \text{efficiency} = 1991 \text{ J} \div 0.25 = \mathbf{8.0 \times 10^3 \text{ J}}$. The remaining 75 % (about $6.0 \times 10^3 \text{ J}$) is transferred as thermal energy to the body and surroundings, which is why the climber feels hot.

Question 7 Sources of error

Reaction time in starting and stopping the timer adds or removes a few tenths of a second,

so power may be too high or too low (random). The climber also gains kinetic energy and may swing the arms, and the step height measurement may be a little off; ignoring these makes the calculated power slightly too low. **Reaction time is the largest error.**

Question 8 Improving the lab

Use light gates or two helpers with timers at the start and finish, and measure the height of the whole staircase with a long tape. Increase the number of trials, or use a taller staircase so that the timing error is a smaller fraction of the total time. **These reduce the percentage uncertainty.**