Minilab: Human power

Applying the energy principle for two different choices of system

Everyone fills out a copy of this worksheet.
Clip or staple all copies for your group together, making sure that everyone has all of the data and analyses.

Lab Section___________ Print your name____

Experimental observations

Form a group of three people. Take a meter stick and a stopwatch. Find a stairs you can run up.

- Each person should run up at least two flights of stairs, as fast as possible. ***Run FAST!!***
- Time the run (Δt), and measure the height of the run (Δy). Estimate the mass m of the runner.
- Record the data for each runner. Note that 1 kg is 2.2 pounds.

Name of runner	Time interval Δt , s	Height Δy , m	Mass m, kg

Do the analysis on the next page, then return here to calculate average power. Show your calculations.
For comparison, note that one horsepower is about 750 watts.

Name of runner	Average power, watts

Review the instructions at the start of this worksheet!

Analysis of experimental observations

Using the energy principle, use your experimental observations to determine the average power.

Use ***m*** for the mass of the runner and Δy for the height of the run. Remember that ***g*** represents a *positive* number.

Be careful of signs. ***Do not plug in any numbers until later, so that you can use the final result for all runners.***

Analyze the system consisting of just the runner.
Initial state: at bottom, just before starting to run. Final state: at top, just after stopping running.

Force exerted on the runner by the Earth (**no numbers!**): $\vec{F}$ = < _________, __________, _________ >

Net displacement of the runner (**no numbers!**): $\Delta\vec{r}$ = < _________, __________, _________ >

Work done on the runner by the force exerted by the Earth: $W_{\text{Earth}} =$

Work done on the runner by the force exerted by the stairs on the bottom of the feet: $W_{\text{stairs}} =$

Total work done on the system of the runner (neglecting air resistance): $W_{\text{ext}} =$

Write the energy principle $E_f = E_i + W_{\text{ext}} + Q$ for *this* situation and choice of system (runner alone). Include terms for E_{internal}, the internal energy of the runner. In this fast process, you can neglect thermal transfer of energy (microscopic work) associated with a temperature difference between the runner and the surrounding air (Q). Be careful of signs.

Solve for the internal energy *change* in the runner (**no numbers!**): $\Delta E_{\text{internal}} = E_{\text{internal},f} - E_{\text{internal},i} =$

Why is $\Delta E_{\text{internal}}$ *negative*? ____

The average power expended is $|\Delta E_{\text{internal}} / \Delta t|$, in joule/s, or watts.

Repeat the analysis, this time choosing the Earth (including air) plus the runner as the system.

Use ***m*** for the mass of the runner and Δy for the height of the run. Remember that ***g*** represents a *positive* number.

Be careful of signs. ***Do not plug in any numbers until later, so that you can use the final result for all runners.***

Analyze the system consisting of the Earth (including air) plus the runner.
Initial state: at bottom, just before starting to run. Final state: at top, just after stopping running.

Total work done on the system (Earth plus runner): $W_{\text{ext}} =$

Write the energy principle $E_f = E_i + W_{\text{ext}} + Q$ for *this* situation and choice of system (*two* objects, Earth plus runner). Include terms for E_{internal}, the internal energy of the runner. In this process, you can neglect the change in energy of the air.

Solve for the internal energy *change* in the runner (**no numbers!**): $\Delta E_{\text{internal}} = E_{\text{internal},f} - E_{\text{internal},i} =$

This result should be the *same* as the result obtained when you analyzed the system of the runner alone.

Return to the first page to calculate the average power for each runner.