**Minilab: Throw a ball up in the air**

*Analyzing a phenomenon using the momentum principle and the energy principle*

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.
Include appropriate units with your measurements and calculations.

Lab Section_____ Print your name_____

## Experimental observations

You need a ball, a stopwatch, and a meter stick. The experiment requires three people:

- One person throws a ball straight up as high as possible but not so high that it's difficult to measure the maximum height attained. This can be done in an ordinary room, though if you can find a stairs and can throw the ball higher, you'll be able to measure the longer time of flight more accurately.

- Another person starts the stopwatch just after the ball is released and stops it when the ball returns to the height at which it was released. This is twice the time required to go up to the maximum height (in the approximation that we neglect air resistance). Note that during this time (from just after release to when it returns to that height) no one is touching the ball.

- A third person stands off to the side, observes the flight of the ball, and uses a meter stick to determine how high the ball goes from the point where it was released.

| | | | |
|---|---|---|---|
| Trial 1 | $\Delta t_{round\ trip}$ = | $\Delta t_{one\ way\ trip}$ = | $\Delta y_{max}$ = |
| Trial 2 | $\Delta t_{round\ trip}$ = | $\Delta t_{one\ way\ trip}$ = | $\Delta y_{max}$ = |

***Turn the page to analyze your data.***

**Analysis of experimental observations**

Using the momentum principle, use your experimental observations to determine the initial speed.
Use ***m*** for the mass of the ball, ***v*** for the initial speed, and **Δ*t*** for the time to reach the top (which is approximately half the round trip time). As usual, use ***g*** to represent +9.8 N/kg.
Be careful of signs. ***Do not plug in any numbers until later.***

Initial momentum (just after leaving hand): $\vec{p}_i$ = < _____, _____, _____ >

Final momentum (at top): $\vec{p}_f$ = < _____, _____, _____ >

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

Impulse acting on the ball due to the force exerted by the Earth **(no numbers!)**: < _____, _____, _____ >

For the system of the ball,
write the momentum principle for *this specific situation*: _____

Solve for the initial speed **(no numbers!)**: *v* = _____

*Now* plug in your experimental numbers to predict the initial speeds for your two trials.
Show your calculations. Note that a professional baseball pitcher can throw a baseball at about 40 m/s (90 mi/hr).

Momentum principle: (trial 1) $v_{initial}$ = _____ m/s (trial 2) $v_{initial}$ = _____ m/s

Using the energy principle, use your experimental observations to determine the initial speed.
Use ***m*** for the mass of the ball, ***v*** for the initial speed, and **Δ*y*** for the maximum height.
Be careful of signs. ***Do not plug in any numbers until later.***

Initial kinetic energy (just after leaving hand): $K_i$ = _____

Final kinetic energy (at top): $K_f$ = _____

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

Displacement of the ball **(no numbers!)**: $\Delta\vec{r}$ = < _____, _____, _____ >

Work done on the ball by the force exerted by the Earth **(no numbers!)**: *W* = _____

For the system of the ball,
write the energy principle for *this specific situation*: _____

Solve for the initial speed **(no numbers!)**: *v* = _____

*Now* plug in your experimental numbers to predict the initial speeds for your two trials.
Show your calculations:

Energy principle: (trial 1) $v_{initial}$ = _____ m/s (trial 2) $v_{initial}$ = _____ m/s

Are your two kinds of determinations of the initial speed consistent with each other?_____

**Reflection: The momentum principle involves *time*; the energy principle involves *distance*. Look back over your analysis and see how the two principles complement each other, involving different kinds of information about the phenomenon.**

***Have an instructor check your work. Then review the instructions at the start of this worksheet.***