Could Less Be More in the Introductory Kinematics Lab?

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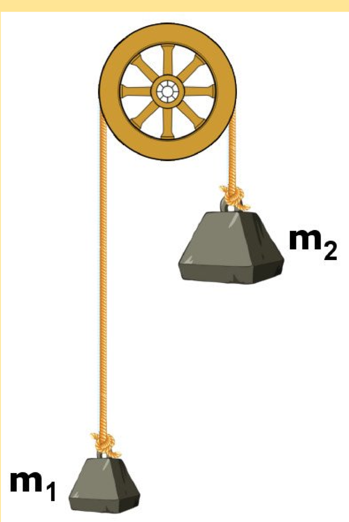
Summary: In earlier work, I created a custom "minimalist" interface for certain sensors in my introductory physics lab: unlike the standard commercial interfaces, these minimalist interfaces do not pre-calculate kinematic quantities (position, velocity, and acceleration). *In this study, I investigated whether the use of this minimalist interface actually improves student understanding of kinematics*. After randomly assigning each student in my introductory physics lab to use one of the two interfaces during one particular lab exercise, I administered a set of six questions (ungraded), drawn from two well-studied physics assessment instruments. As a result of low numbers and timing issues, the results are statistically inconclusive, but hint at enhanced student learning specifically of material not covered in lecture.

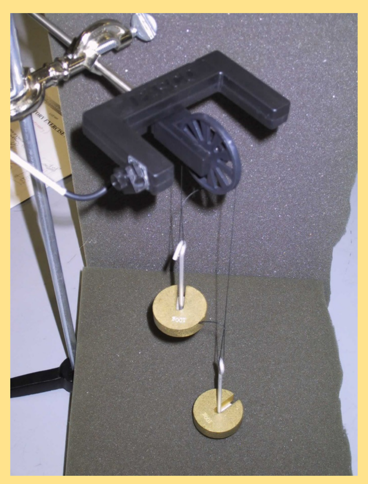
Background

- Learning goals of physics labs include both training in laboratory techniques and mastery of physics content.
- Students appeared to understand labs and perform well, but test and homework scores did not reflect understanding of the physics covered.
- The existing lab-computer interface pre-calculates several physical quantities—could this be hurting more than it was helping?
- I designed a "minimalist" interface (shown to the right) and tested it in lab (fall 2017). Students responded positively, and understood the lab techniques better, but was it helping them learn physics?

The Atwood Machine



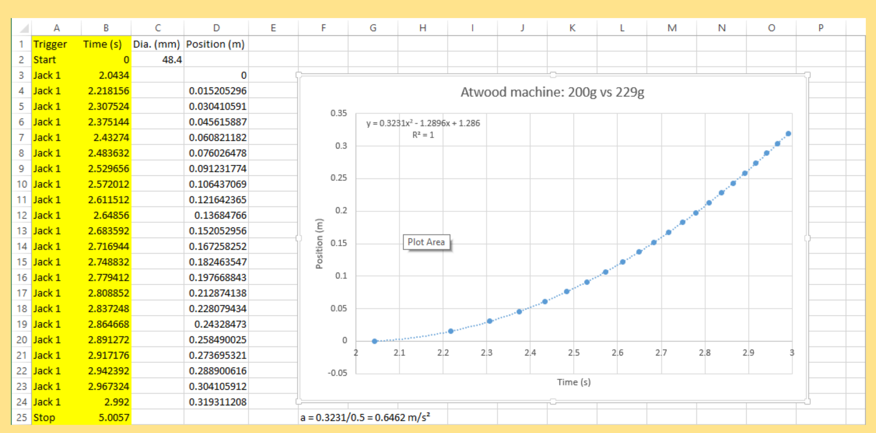
- A traditional kinematics lab
- Two unequal weights are suspended from either side of a pulley (left).
- When released, heavier weight sinks.
- Concepts covered: position, velocity, acceleration, time, force.



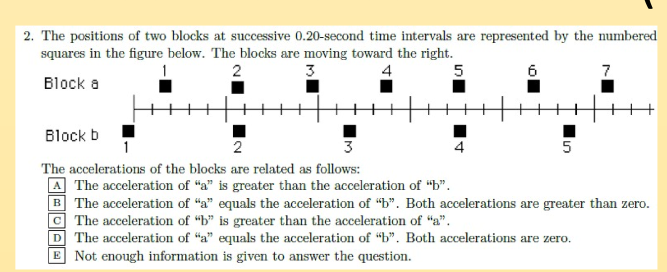
- Motion is measured with a *photogate* (right): a beam of light from one side to other of the C-shaped plastic piece is broken by the pulley's spokes. Times of breaking of the beam are recorded.

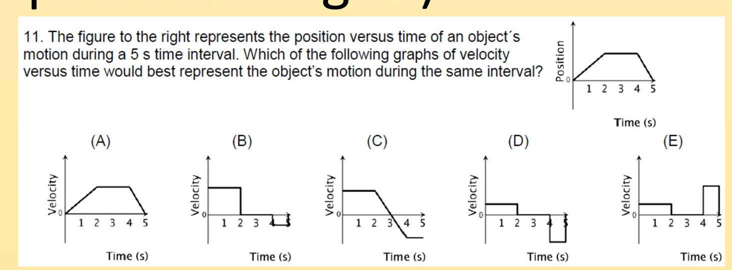
Methodology

- *Question: Is the use of the minimalist interface in the Atwood Machine lab associated with greater student understanding of the kinematic quantities (position, velocity, acceleration, and time) and of their relationships, as compared to the traditional interface?*
- *Student group:* This was a combined lab for calculus-based (N=6) and algebra-based (N=11) introductory physics. None were physics majors. For most, the class was required by their professional program.
- *Timing:* because of delays in obtaining IRB approval, I conducted the study during the penultimate lab period of the semester. All students had used both interfaces previously in earlier labs.
- *Procedure:* Student lab teams (which were chosen randomly as usual) were randomly assigned to use one of the two interfaces when completing the Atwood Machine lab. At the conclusion of the lab, each student individually answered six ungraded questions drawn from two standard physics assessment instruments.
- *Intervention:* Shown below are sample computer screens from the traditional (left) and minimalist (right) interfaces:



- *Assessment Instrument:* Two questions were drawn from the *Force Concept Inventory* (FCI), and used motion diagrams, which had not been covered in lecture. (Sample below left.) The other four were drawn from the *Test of Understanding Graphs—Kinematics* (TUG-K), and used time plots, which had been covered in class. (Sample below right.)





Preliminary Results

- N = 15
- No per-class breakdown. (Too few responses to class question.)

Interface used	*% correct: Motion diag.*	*% correct: Time plot*	*% correct: All questions*
Traditional	14.29%	39.29%	30.95%
Minimalist	18.75%	37.50%	31.25%
Combined	16.67%	38.33%	31.11%

- No significant difference between groups overall.
- Traditional group scored 1.79% better than minimalist group on question type covered in class.
- Minimalist group scored 4.46% better than traditional group on question type *not* covered in class.
- Results suggest a repeat study could be fruitful, but with greater N (if possible), earlier intervention, and grade points assigned to the instrument.

Acknowledgements

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