Webcasts and Peer Review: yet more teaching experiments

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The problem

- Between 2008 and 2010 we'd made major gains in student learning of Physics concepts - our normalised gain had increased from 24% to 66%. Clickers, collaborative learning and better targeted lectures made this difference.
- But this was not translating into better solutions to complex mathematical problems.

Approach one

- Mastery Learning
- Don't let students go on from one topic to the next until they have mastered the first topic.
- This led to the weaker students spending a huge amount of time on the basics.
- Did it help?

No - no measurable difference

- It became clear that time on task wasn't the problem.
- Many 1st year Physics students had a very poor approach to solving problems.
- Given more time they just used the same ineffective strategy repeatedly, getting no better results.

I set “Context rich Problems”, e.g.

1. Imagine that you have been hired by the designers of a new water theme park.

(A) in one planned ride, the customers will slide down a frictionless slide, dropping 10 meters vertically. At the bottom of the slide they are launched sideways into the air. They then fly through the air for a bit before landing in a pool, three metres below the bottom of the slide. You have been asked to calculate how far sideways they will fly, so the designers can make sure the pool is wide enough.

(8 marks)

1 a) B ✓

b) $p_x = 0.55 \times 4$

$= 2.2\ kg\ m/s$

$\tan 25 = \frac{p_y}{p_x}$

$= \frac{p_y}{2.2}$

~~$p_y = F \times t$~~

~~$=$~~

$2.2 \tan 25 = p_y$

$p_{yf} = F_y \times 0.0025$

2 $\frac{2.2 \tan 25}{0.0025} = F_y$

$F_y = \frac{2.2 \tan(25^\circ)}{0.025}\ N$ ✓

Q 3

$v\frac{dx}{dx}$ $\quad \frac{dx}{dt} \cdot \frac{dv}{dx}$

a) $m\ddot{x} = 180 \times$ ~~...~~ s

$$\ddot{x} = \frac{180s}{0.6}$$

$$v\frac{dv}{ds} = \frac{180s}{0.6} = 300s$$

$$\int_{3}^{0} v\,dv = \int_{0.11}^{s_{max}} 300s\,ds$$

$$\left[\frac{v^2}{2}\right]_{3}^{0} = \left[\frac{300s^2}{2}\right]_{0.11}^{s_{max}}$$

$$-\frac{9}{2} = 150s_{max}^2 - 1.815$$

$$s_{max} = 13.38\text{ cm.}$$ ✓

b) $\left[\frac{v^2}{2}\right]^{v_{max}} = \left[150s^2\right]^{13.38\times10^{-2}}$

$$\left[\frac{v^2}{2}\right]_3^v = \left[\frac{300 s^2}{2}\right]_{0.11}^s$$

$$\frac{v^2}{2} - \frac{9}{2} = 150 s^2 - 1.815$$

$$v = \sqrt{2(150 s^2 + 2.685)}$$

$$= \sqrt{300 s^2 + 5.37}$$

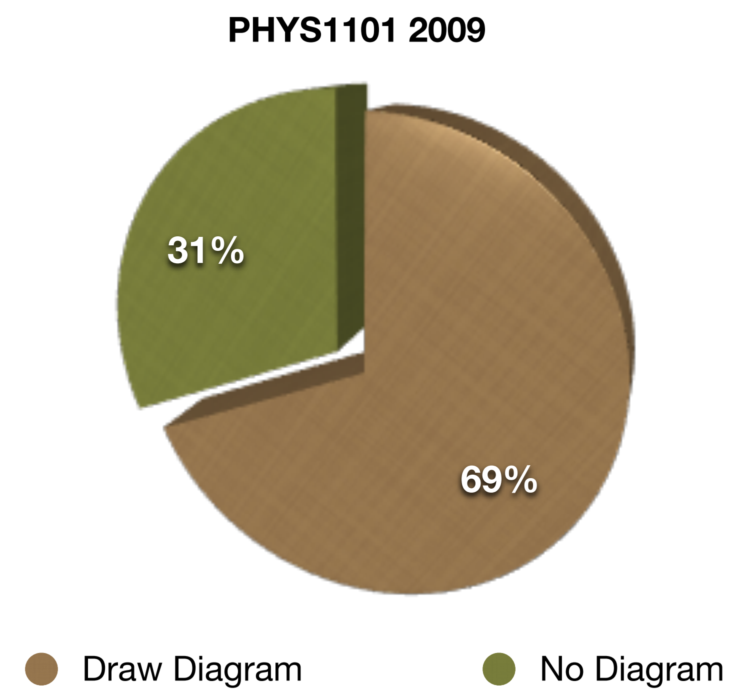
$\frac{ds}{dt} = v$:

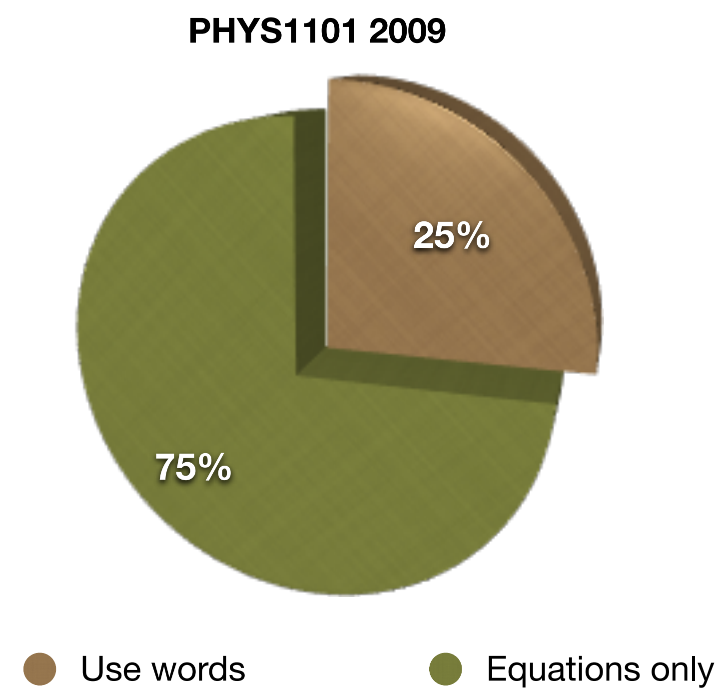
$$\frac{dt}{ds} = \frac{1}{v} = \frac{1}{\sqrt{300 s^2 + 5.37}}$$

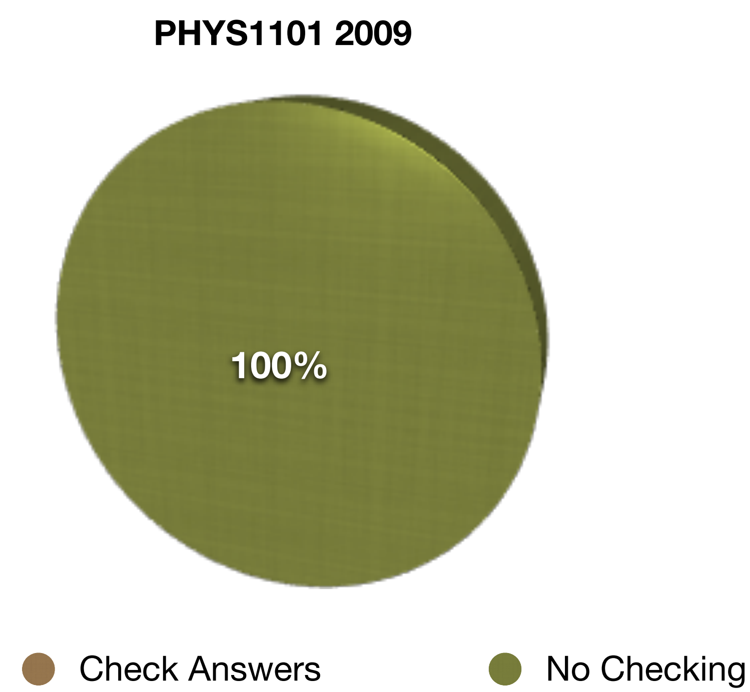
Characteristics

- No diagram.
- No words
- Equations put down and manipulated with no explanation.
- Sometimes correctly but usually the wrong equations are used in the wrong ways.
- Answers, no matter how ludicrous, are never commented on or checked.

How widespread? Figures from 2009 exam







Intervention...

- Make use of a proper problem-solving strategy one of the main learning goals of the course.
- Make it very clear to students that they will get marks for putting in diagrams, words, checking answers etc.
- Give detailed instructions on how to do this.
- Ask tutors to encourage this whenever possible.

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Learning Outcomes for the Course

- Kinematics
- Vectors
- Momentum
- Forces
- Constant Acceleration
- Oscillations
- Energy
- Angular momentum
- Uncertainties
- Critical Reflection
- Data Analysis
- Systems
- Rate of change problems
- Add up the bits problems
- Correct answers
- Working Notes
- Group Work
- Planning
- Mastery of Equipment
- Reflective Reading
- Matter and Electric fields
- Electric field of distributed charges
- Electric potential
- Magnetic field
- Electric circuits

Answer checking

Diagrams and words

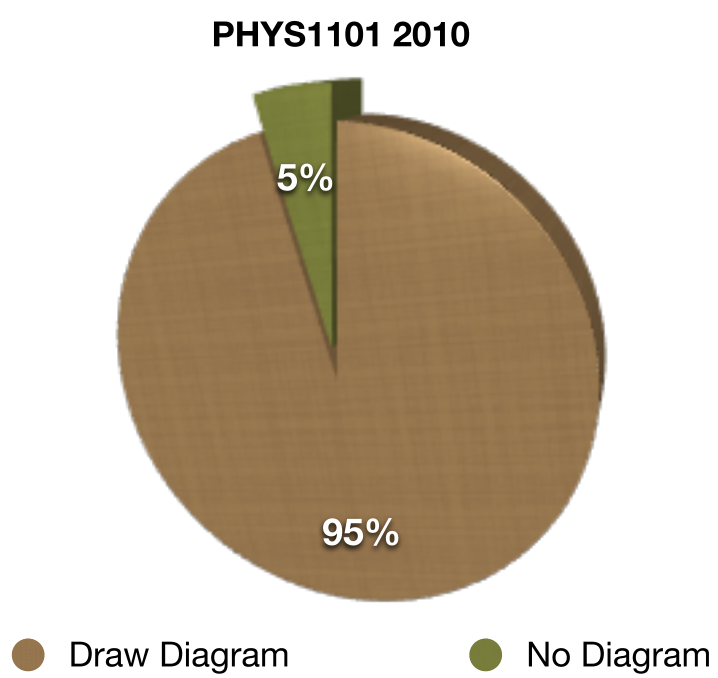
Skills

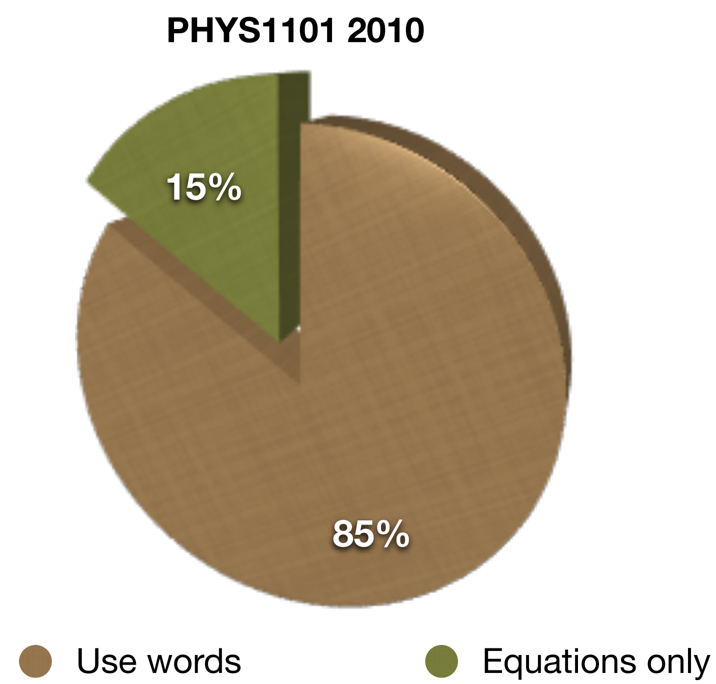
- Write legibly – so you and others can read/understand what you've put down.
- Write down why you take each step, not just what you do. So – if you use an equation, write down something like "Looks like momentum is conserved, so let's use p=mv", rather than just writing down "p=mv". If you measure something ten times, say why you chose this number. If you are unsure how to solve a problem, say something like "we could do it this way or that way – I don't know which is best, so we'll try this way first and see if it works."
- Include diagrams. These usually make it much clearer what is pushing on what, where the forces are, where the different bits fit etc. Annotated diagrams are much easier to understand than just text.
- If you make a mistake, don't erase it – leave it in with a note. Because you may well find out later that it was useful after all.
- When making measurements, record all the raw data immediately – don't do even the most trivial calculations before writing things down.
- If you plot graphs or data tables, include them directly into your write-up in the relevant place.
- All tables and graphs should be labelled, so that when you look at them later you will know what exactly you have plotted and tabulated.
- Quote units for all quantities.
- Only quote numbers with a reasonable number of significant figures.

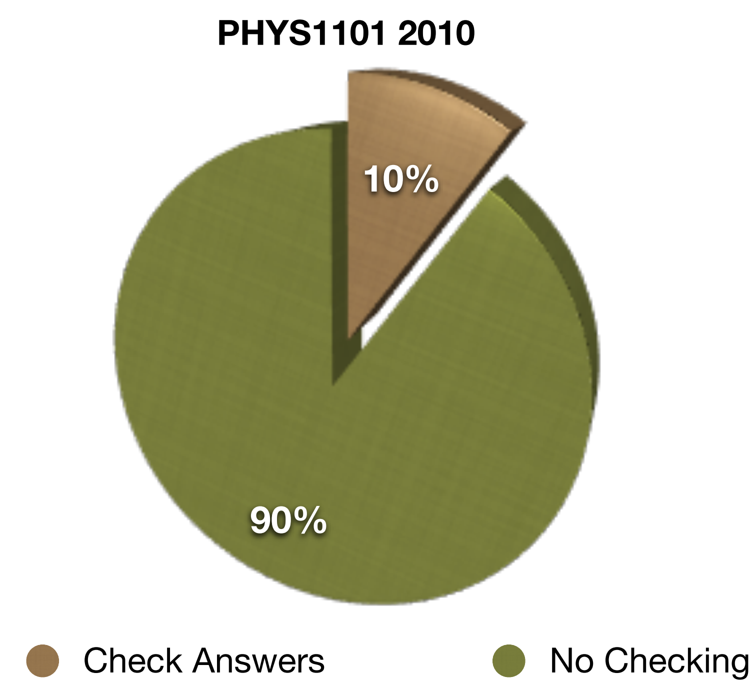
How it is assessed

- In all homework questions, exam questions and labs that are long enough to require working notes, you will be marked by how many of the above skills you demonstrate.

Some improvement: 2010 exam







Diagrams up from 69% to 95%

Use of words up from 25% to 85%

Checking up from 0% to 10%

But these numbers slightly overstate the improvement

- Students would put diagrams and words in, but sometimes they would be useless or irrelevant ones.

- And we were making little headway on answer checking despite pretty heavy pressure.

Innovations in 2011

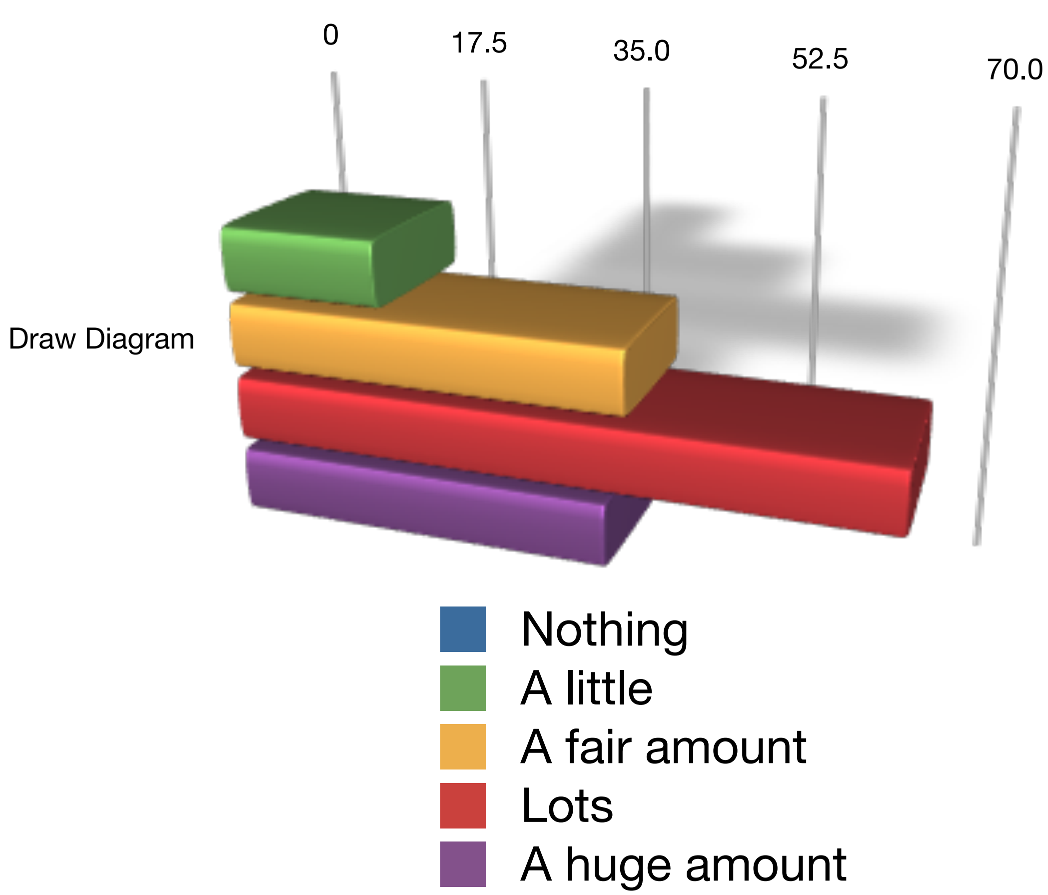
- Webcasts: I solve problems on my iPad, with voice-over.
- http://www.mso.anu.edu.au/~pfrancis/phys1101/questions/index.html

Motivation

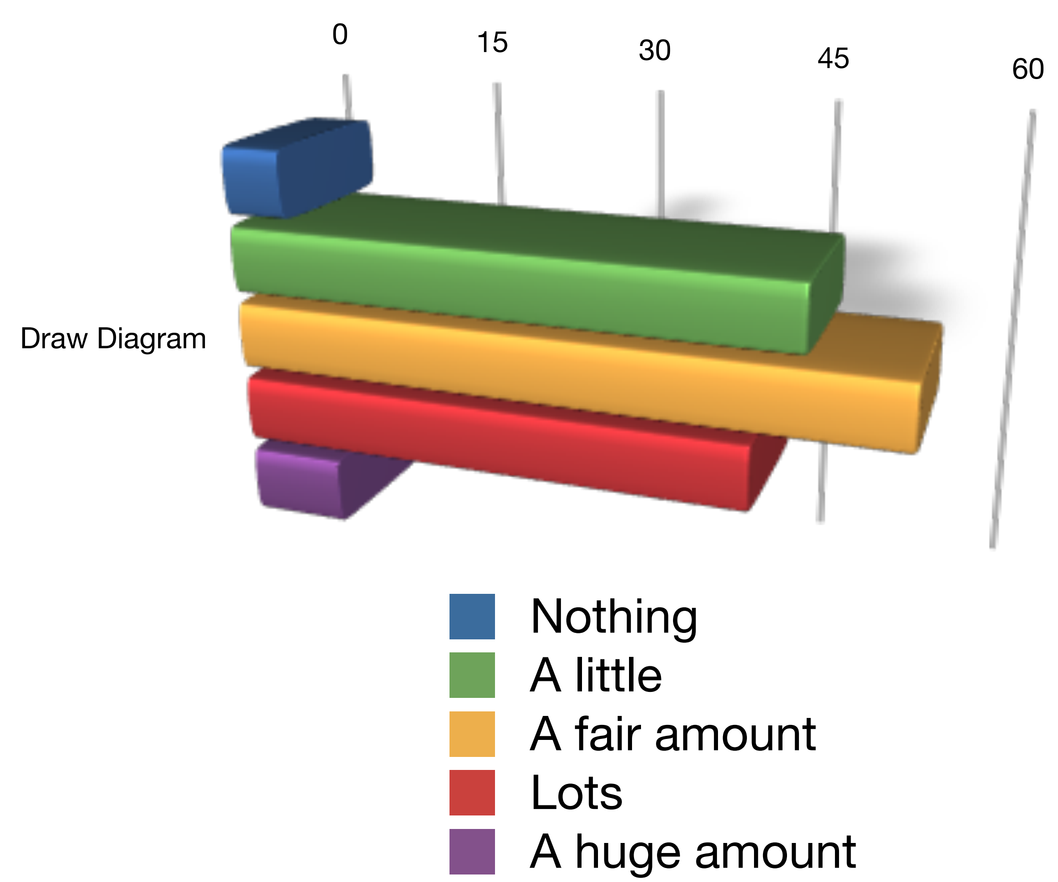
- I was worried that I was assuming that the students knew something - by doing the whole problem my way with voice-over I was sure I was covering all the steps.
- Evidence from Cognitive Psychology (Cognitive Load Theory) suggests that novices learn better from worked examples that from doing problems themselves.

How much did the students think they learned...

... from the Webcasts?



... from the Homework?



Student Feedback

- I really enjoyed the webcast and Paul's homework questions, because the webcast involved Paul talking through a problem, which is a technique I tried after I heard him do it and it really helps me solve complex mechanics problems!! The problem solving strategy was also very helpful.
- The webcasts were really good for revision/help for other questions but I didn't really learn all too much from them other than how to approach problems. But since that is what they are probaly for that is good,
- The webcasts were most valuabe by a long shot for me. Watching someone else do a problem and explaining the steps of thinking was very helpful.
- The webcasts were definitely fantastic.
- The webcasts were perhaps the most useful way to learn I have ever come across. Very informative and helpful, as well as accessable.
- I think that the web casts were probably the best part about this course, since I could watch how to solve these problems in my own time, at my own pace, and i could rewind, and watch some of the stuff that I missed, or pause it if I didn't understand it. This was really helpful.

Calibrated Peer Review

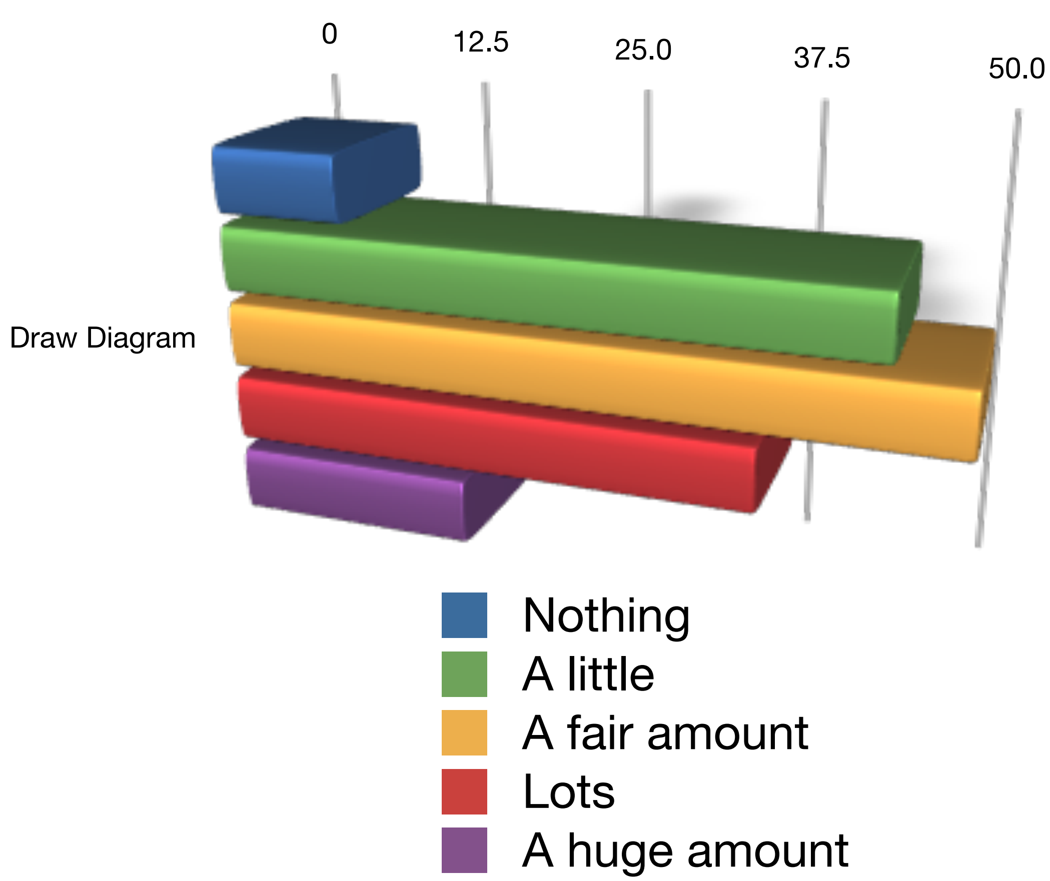
- http://cpr.molsci.ucla.edu/
- Students submit their own work, then mark three “calibrator pieces”, one good, middle and bad.
- They then mark three other student’s work, using the same criteria, and with a weighting from how well they did on the calibrators.
- And finally they mark their own work again.

How did it go?

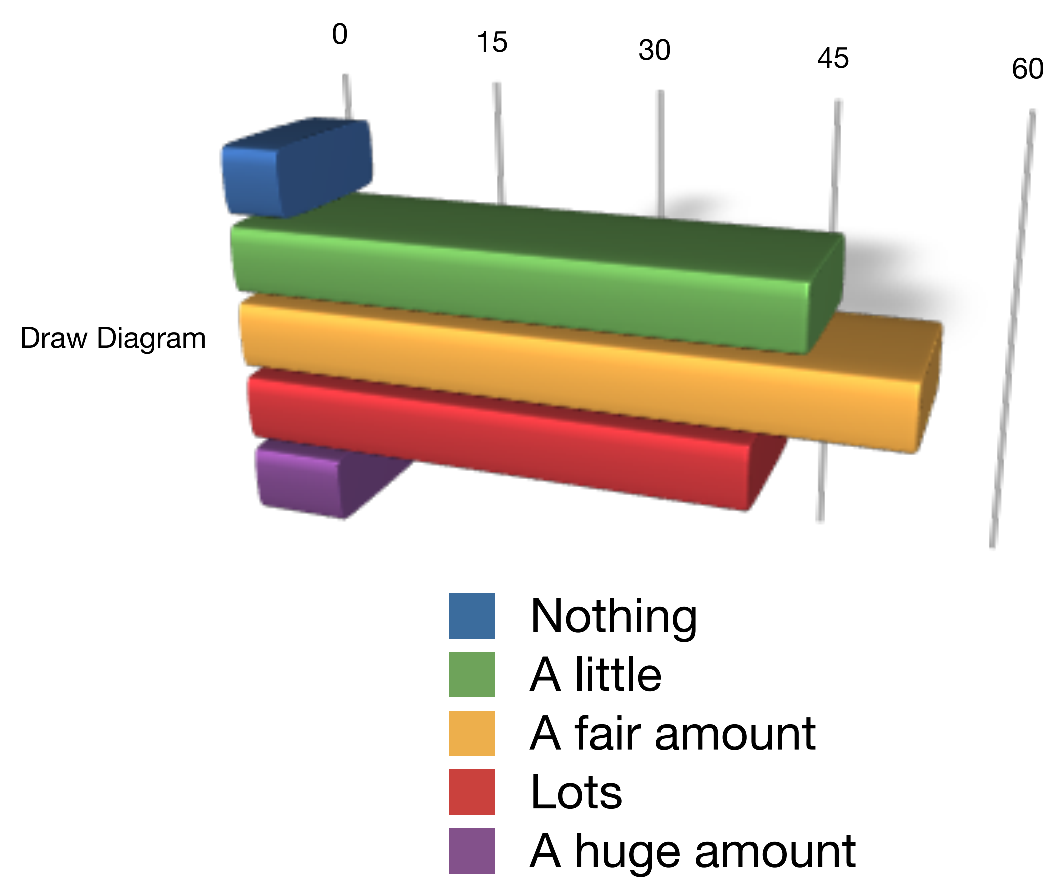
- Big technical problems.
- Not popular (though comparable to traditional tutor-marked homework).
- Student marks were actually pretty reliable.

How much did the students think they learned...

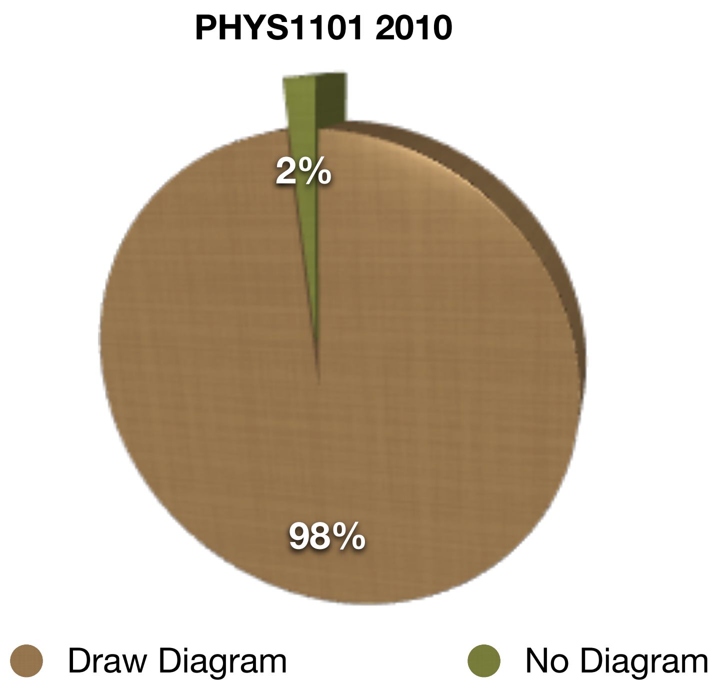
... from the CPR?

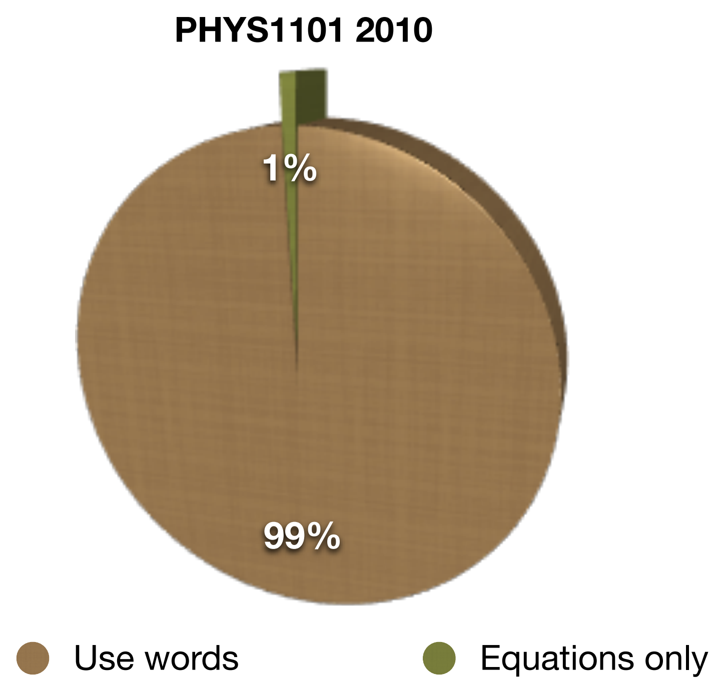


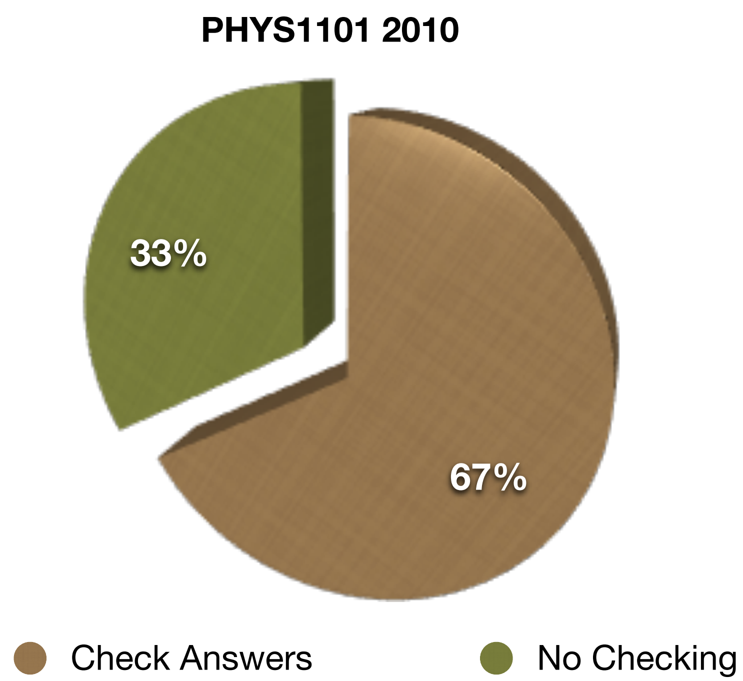
... from the Homework?



Did it make a difference? 2011 exam





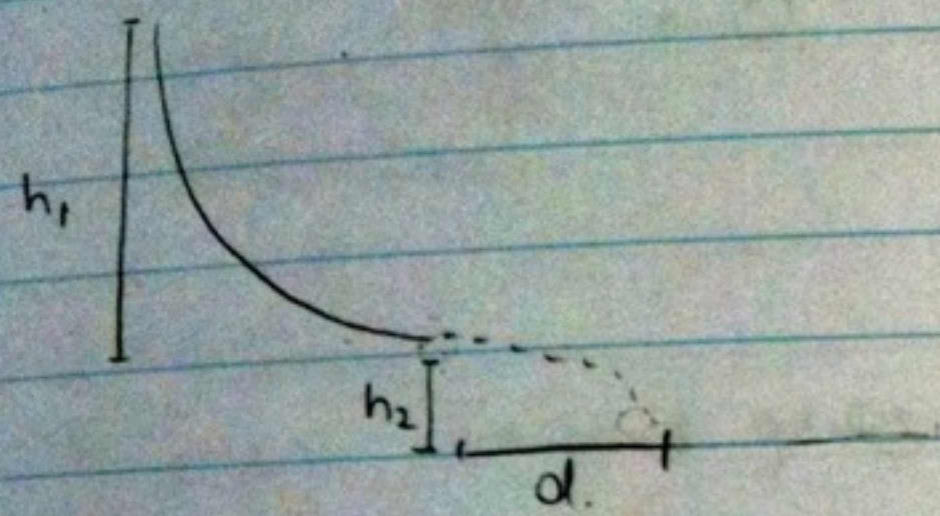


Diagrams:
2009: 69%
2010: 95%
2011: 98%

Use of words:
2009: 25%
2010: 85%
2011: 99%

Checking:
2009: 0%
2010: 10%
2011: 67%

22a.) Draw a diagram of the scenario.



where $h_1 = 10m$ $g = 9.8 m/s$

$h_2 = 3m$

$d = ?$

assuming air resistance and friction are negligible

Physics principles to use Energy and constant accel. equations

In order to find the horizontal distance, d, travelled the velocity at the bottom of the slide must be found.

using energy,

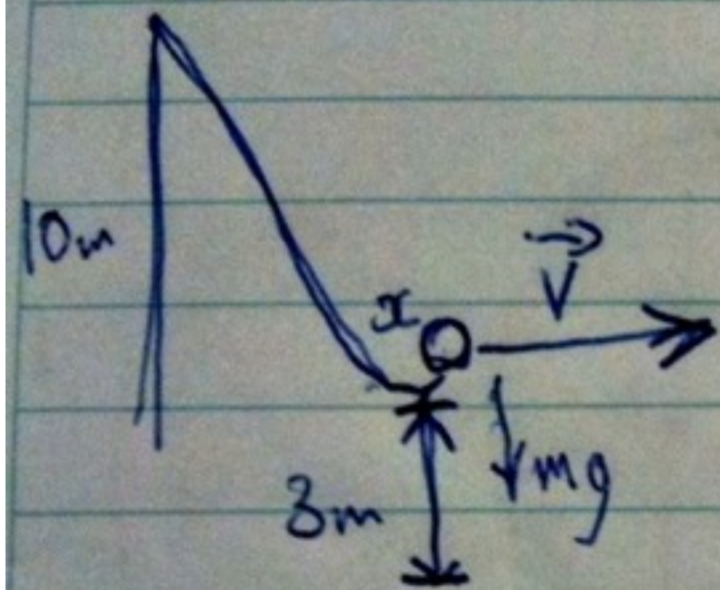
$$mg(h_1+h_2) = \frac{1}{2}mv^2 + mgh_2.$$

Solve for v,

$$g(h_1+h_2) = \frac{1}{2}v^2 + gh_2$$

$$gh_1 + gh_2 = \frac{1}{2}v^2 + gh_2$$

Customer slides down a frictionless slide, dropping 10m (h), and gaining a velocity V. This velocity is then turned to horizontal and the customer is projected off the slide (at velocity V) and falls to a pool 3m below



• work out horizontal velocity using energy (at x)

$$KE_i + PE_i = KE_f + PE_f$$

$$0 \quad mgh = \frac{1}{2}mv^2 \quad 0$$

$$V = \sqrt{2gh}$$

unit check: $\sqrt{\frac{m}{s^2} \cdot m} = \sqrt{\frac{m^2}{s^2}} = m/s$ ✓

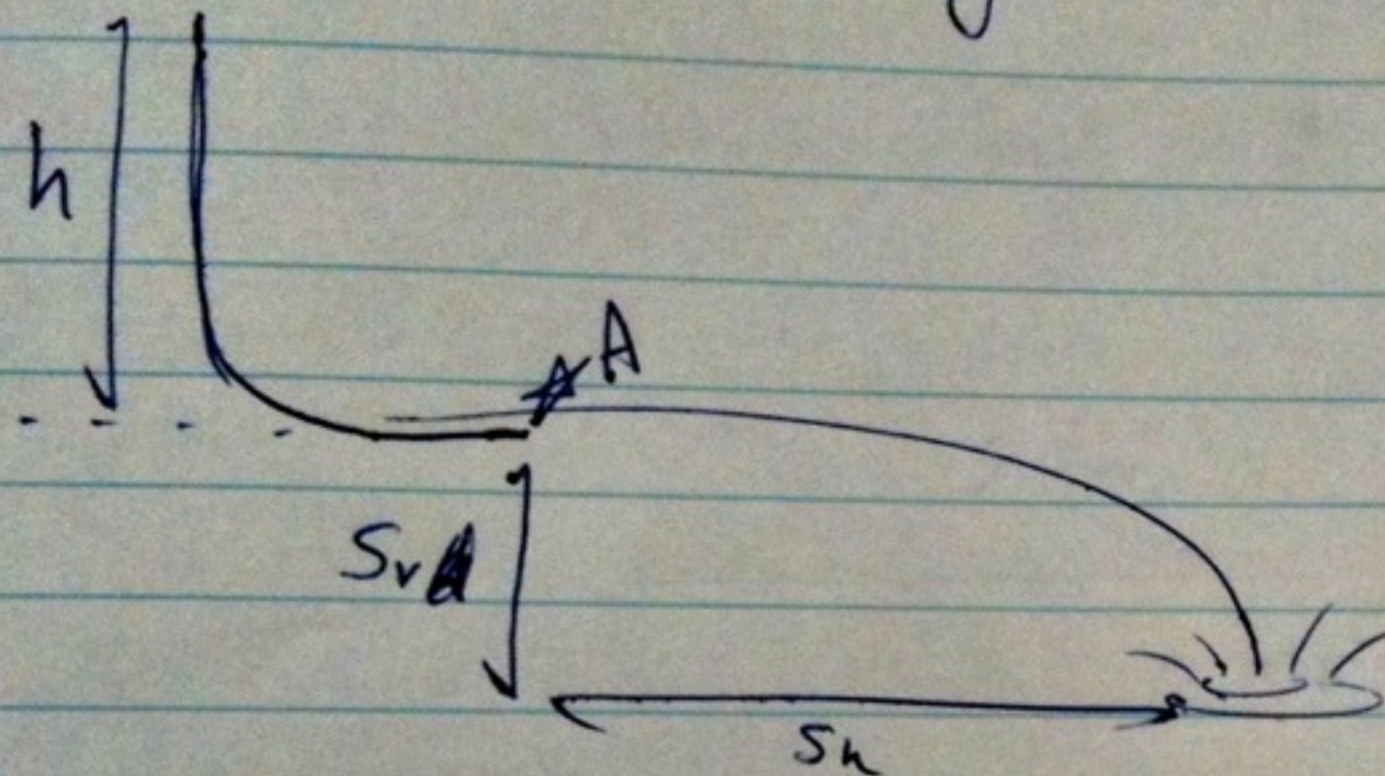
$g = 9.8$

$h = 10$ ✓

$\Rightarrow V = 14\ ms^{-1}$ ~~seems~~ sensible

next, find the time taken to fall 3m

Sideways as in laterally? ok.



~~wt~~ I will use conservation of energy and projectile motion here,
~~finding the v for the bottom~~

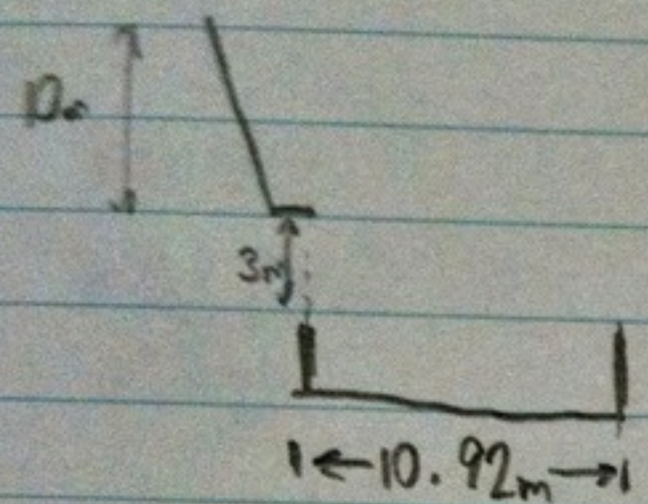
at the 'point of launch' (point A) at the bottom of the slide, ~~kinetic~~ potential energy will have been converted to kinetic.

@ P $\quad mgh = \frac{1}{2} mv^2$

$$v = \sqrt{2gh}$$ ✓

for the latter part of the Q, this v will be u_h

Australian National University



The pool must be at least 10.92m in width for the ride to be safe

Check

- All units are in m, seconds and m/s
- As velocity is increased distance travelled sideways increases
- Time to fall 3m seems reasonable, fall 9.8 m/s^2 therefore 0.78 seems plausible.

Anecdotal evidence

- Tutors were impressed by spontaneous self-checking in tutes, which they had never seen before.
- This was seen early in semester, implying that the webcasts, not the CPR, were responsible.
- Write-ups including words and explanations of principles seem to be continuing in second semester.

Conclusions

- Webcasts seem unreasonably effective.
  - Especially for the weaker students (which is most of them at first year)
- Jury is still out on CPR.
  - but even with all the technical problems, it still did as well as traditional tutor-marked homework.