

The Introductory Physics Course Revisions at Illinois

(Mats Selen, UIUC Department of Physics)

- Overview
 - What we teach & who we teach it to.
 - How it used to work.
 - How we do it now.
 - Some Feedback
- A glance at the key aspects of our approach.
 - WEB-centric organization (for us as much as them)
 - Peer instruction in Discussion & Lab sections (TA training).
 - ACTs & Preflights in Lecture
 - Homework & Interactive Examples
 - Exams
- Concluding Thoughts

The UICU intro physics sequences

Engineering Sequence (calculus based)

- Total enrollment of about 3500 students/year
 - Physics 111 (4 hrs, mechanics)
 - Physics 112 (4 hrs, E&M)
 - Physics 113 (2 hrs, thermo/stat-mech)
 - Physics 114 (2 hrs, waves/quantum)

Pre-Med Sequence (algebra based)

- Total enrollment of about 1100 students/year
 - Physics 101 (5 hrs, mechanics, heat, fluids, waves)
 - Physics 102 (5 hrs, E&M, Light, Atoms, Relativity)

How it used to work:

- **Tradition, Tradition, Tradition**

- Lecturer "owns" the course and is free to "reinvent the flat tire" every semester.
- Discussion TAs pretty much on their own.
- Labs intellectually disconnected from rest of course.

- **RESULTS: NOBODY IS HAPPY !!**

- Professor dislikes it since it's a monster teaching assignment.
- Students dislike it because the professor dislikes it (and because course is always Version 1.0)
- The college dislikes it because students dislike it.

How we do it now:

- Integrate all aspects of a course using active learning methods in a sustainable team teaching environment.
 - Typically 3 faculty share the load:
 - » Lecturer (lectures, ACTs, preflights, exams).
 - » Discussion Director (TA training, quizzes, exams).
 - » Lab Director (TA training, web homework, exams).
 - Course administration is shared responsibility:
 - » Faculty meet at least once a week with each-other and with their TA's to plan the campaign.
 - » Overall co-ordination is very tight (web helps this).
 - » Everybody works on creating exams.

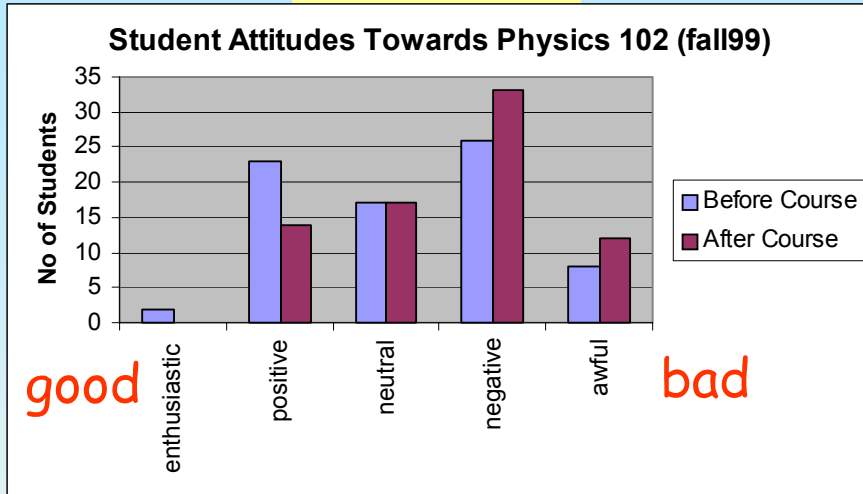
- Course material changes adiabatically:
 - » Recycled & tuned from semester to semester.
 - » People don't need to re-invent the whole stew, but can focus on the spices!

Advantages of this approach:

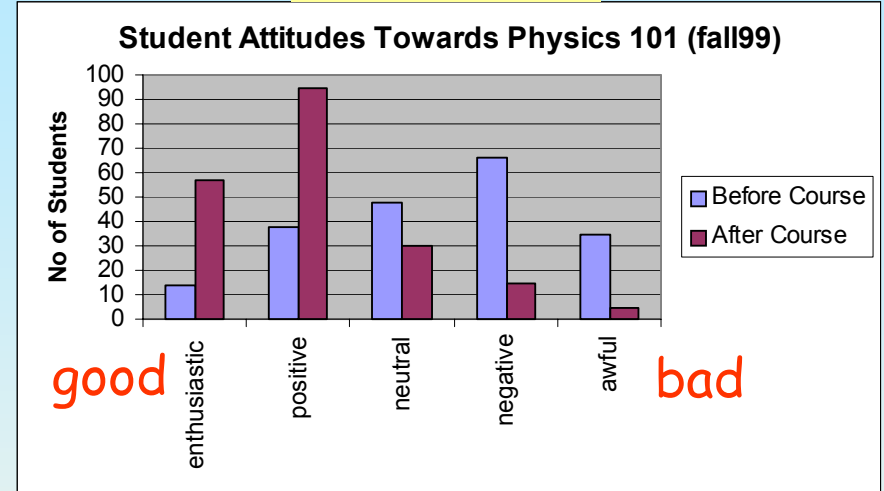
- Existing (evolving) infrastructure lowers the bar for participation.
 - » This is now seen as a reasonable teaching load.
 - » Most of our new junior faculty start teaching in these courses (i.e. not a heavy assignment).
- Pain & Gain are shared
 - » No burnout & No heroes.
 - » Makes it possible to keep quality high and material consistent even though instructors are changing.
 - » 47 faculty have taught in these courses !

Positive Feedback

THE OLD



THE NEW



THE OLD Spring 95

Total Physics TAs = 77
 # "Excellent" = 15
19 ± 5 %

THE NEW Spring 01

Total Physics TAs = 75
 # "Excellent" = 58
77 ± 6 %

8 of the last 25 College of Engineering Awards for excellence/innovation in teaching have gone to Physics faculty (we are 15% of COE faculty)

The key to the whole thing is faculty buy-in.

Some Key Aspects

WEB-centric organization

Makes life
much easier for us

Peer instruction in Discussion & Lab sections

ACTs & Preflights in Lecture

Homework & Interactive Examples

Exams

WEB-centric organization

- All course materials available on-line.
 - Lectures, discussion & lab materials, exams...
 - Makes our job easier (copy spring01 → fall01).
- All students do several on-line assignments every week:
 - Homework, Interactive Examples, Quizzes
 - Preflights for lectures, labs & discussion
 - Exam preparation & exam results
 - All grades & progress throughout the semester
 - » Students know in advance what everything is worth and the final thresholds for A,B,C,D,F etc

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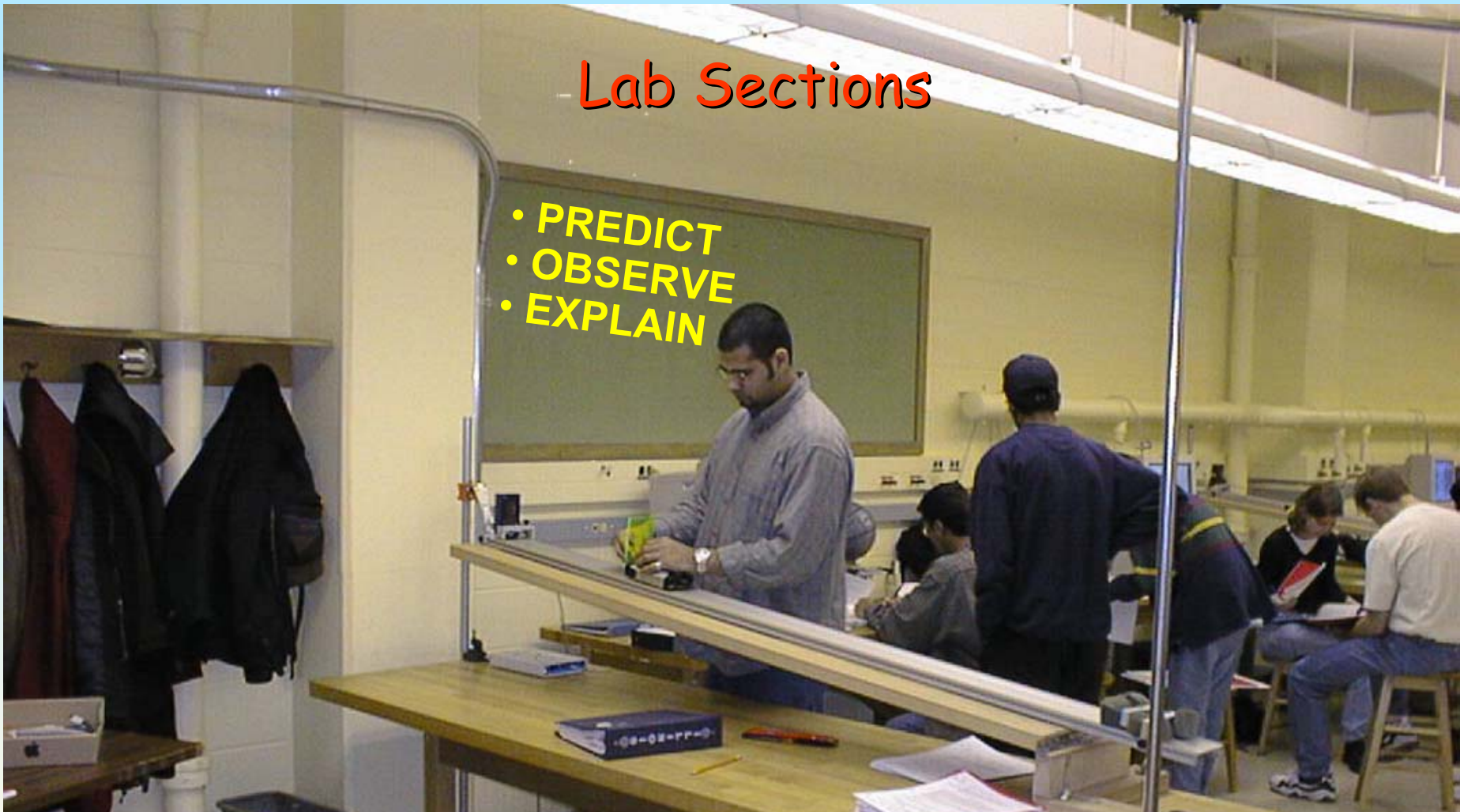
Discussion Sections



- Key Idea: Collaborative Learning
 - ➔ Students work in groups of 4 on problems prepared by the senior staff. TAs act as facilitators, not lecturers.
 - ➔ TA preparation very important (extensive training program).
 - » Orientation, Weekly Meetings, Mentor TAs, Observation
 - ➔ Typically: 45 min tutorial (U.W.), 45 min problems, 20 min quiz

Lab Sections

- PREDICT
- OBSERVE
- EXPLAIN



- Engage the students in the learning process and promote mastery of concepts by manipulation of experimental apparatus.
- Prelab assignments; Lab reports finished within class period.

Details of some key components:

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Active Learning in Lecture (ACTs): What's the big idea ?

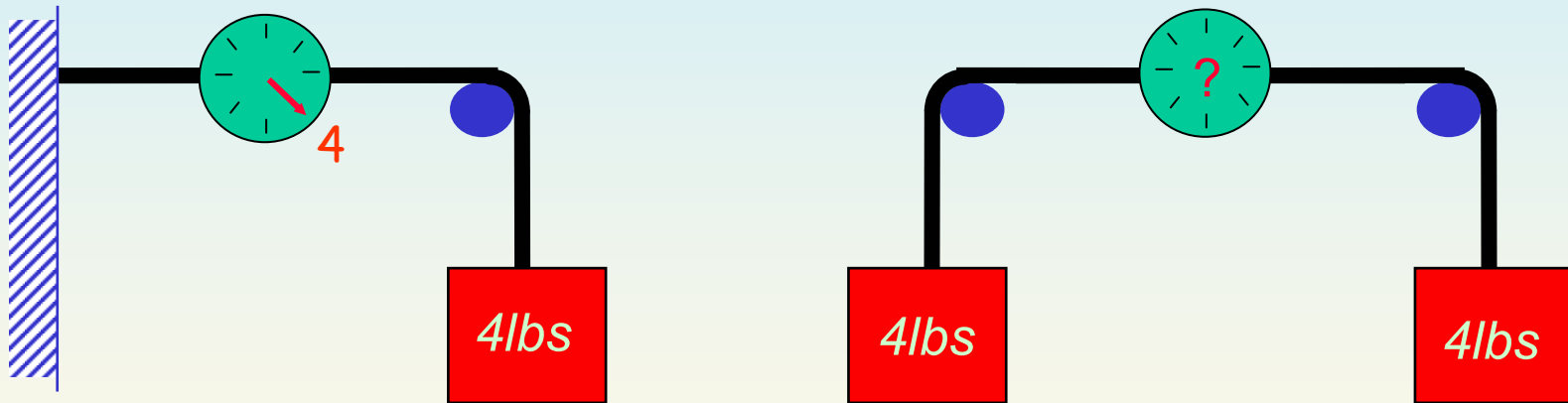
- Break the lecture into 10-15 minute segments (attention span).
- Lecture segments separated by 3-5 minute Active Learning Segments (ACTs).
 - Students work in groups of 3-4 on a conceptual problem posed by the lecturer.
 - Lecturer and (several TA's) wander around the room asking leading questions.
 - » This helps the students figure out problem and also helps the lecturer understand the students misconceptions.
 - Students "Vote" on the correct answer (in groups)
 - Lecturer presents solution and discusses perceived misconceptions.
 - Lecturer does appropriate demo (if possible).

See "Peer Instruction" by E. Mazur

Example: Lecture 5, Act 4

Force and acceleration

- A block weighing 4 lbs is hung from a rope attached to a spring scale. When the other side of the scale is attached to a wall it reads 4 lbs. What will the scale read when the other side is instead attached to another block weighing 4 lbs?



(a) 0 lbs.

(b) 4 lbs.

(c) 8 lbs.

Most people get this wrong ... fuel for discussion
(pros & cons)

Pre-Flights !!

- Students are asked to answer a set of conceptual questions (on the Web) prior to every lecture.
- The main structure is:
 - Students read about material in text.
 - Students answer pre-flight questions on material prior to lecture.
 - » Physics 101 PF's due at 6am, lecture starts at 1pm.
 - » Graded on participation, not correctness.
 - Instructor uses pre-flight responses to guide lecture preparation.
 - » Stress difficult material
 - Pre-flights are reviewed during lecture, often presented again as ACTs, and often capped off with a demo.
- With careful preparation, pre-flights form the "backbone" of the lecture.

See "JiTT", G. Novak, E. Patterson, A. Gavrin, W. Christian

What the students see on the web:

Lecture 2 Preflight

(6 questions)

If you change any of your answers, be sure to click on Store My Answers at the bottom of this page before you leave. The deadline for storing your answers is 0600 on 01/24/2001.

1) If the average velocity of a car during a trip along a straight road is positive, is it possible for the instantaneous velocity at some time during the trip to be negative?

Yes No

2) Briefly justify your answer:

3) If the velocity of some object is not zero, can its acceleration ever be zero?

Yes No

4) Briefly justify your answer:

5) Is it possible for an object to have a positive velocity at the same time as it has a negative acceleration?

Yes No

6) Briefly justify your answer:

Store My Answers

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What I typed in a simple text file:

```
title "Lecture 2 Preflight";

question "If the average velocity of a car during a
trip along a straight road is positive, is it
possible for the instantaneous velocity at some
time during the trip to be negative?";

right "Yes";
wrong "No";

radioh;

question "Briefly justify your answer::";

textarea;

question "If the velocity of some object is not
zero, can its acceleration ever be zero?";

right "Yes";
wrong "No";

radioh;

question "Briefly justify your answer:";

textarea;

question "Is it possible for an object to have a
positive velocity at the same time as it has a
negative acceleration?";

right "Yes";
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question "Briefly justify your answer:";

textarea;
```

Lecture 2, Pre-Flights 1&2

If the average velocity of a car during a trip along a straight road is positive, is it possible for the instantaneous velocity at some time during the trip to be negative?

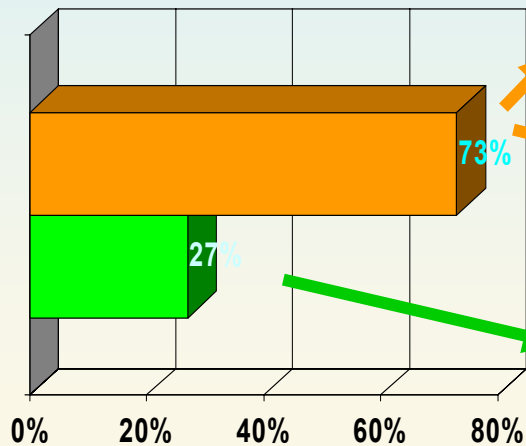
1 - Yes ← correct

2 - No

As long as the net distance traveled over the given time was positive, the average velocity will be positive—regardless of whether the car went in reverse at any point during that time.

I could have forgotten something at home and had to turn around, but eventually I reached my destination away from my starting pt.

Velocity cannot be negative in reality.



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Exams

- Three mid-terms & one comprehensive final (typically).
- Combined worth ~ 60% of final grade.
- **All multiple choice (machine graded).**

→ PROS:

- » Uniform & Fair.
- » Useful for tracking changes, education research...
- » WEB interface possible for practice (before exam night) and help/explanations (after exam).

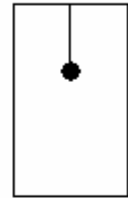
→ CONS:

- » Harder to give partial credit...
- » But not impossible: we have a scheme !

About 1/3 of exam score is conceptual (2 & 3 choice)

14. A ball of mass M is suspended vertically from the end of a string. The other end of the string is attached to the ceiling of an elevator, as shown in the figure. The elevator is initially moving downward at constant speed. Just before reaching the bottom floor, the elevator slows down. As it is slowing down, the tension in the string will be

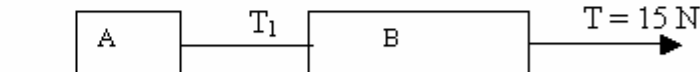
- greater than Mg
- equal to Mg
- less than Mg



The following two problems relate to the same physical situation.

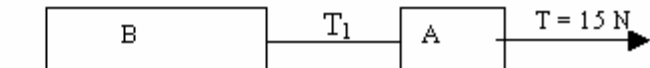
15. Block A of mass 2 kg and block B of mass 4 kg are attached to each other by a string. The two blocks are sitting on a horizontal frictionless surface. Another string is attached to block B and the whole system is pulled to the right so that both blocks accelerate together, as shown in the figure. If the tension T is 15 N, as shown in the figure, what is the tension T_1 in the string connecting the two blocks?

- 1 N
- 3 N
- 5 N
- 12 N
- 15 N



16. In the preceding problem, suppose the order of the two blocks is reversed so that block A is in front and B is in back, with the same tension $T = 15$ N, as shown in the figure. Compared to the preceding problem, the tension T_1 is now ?

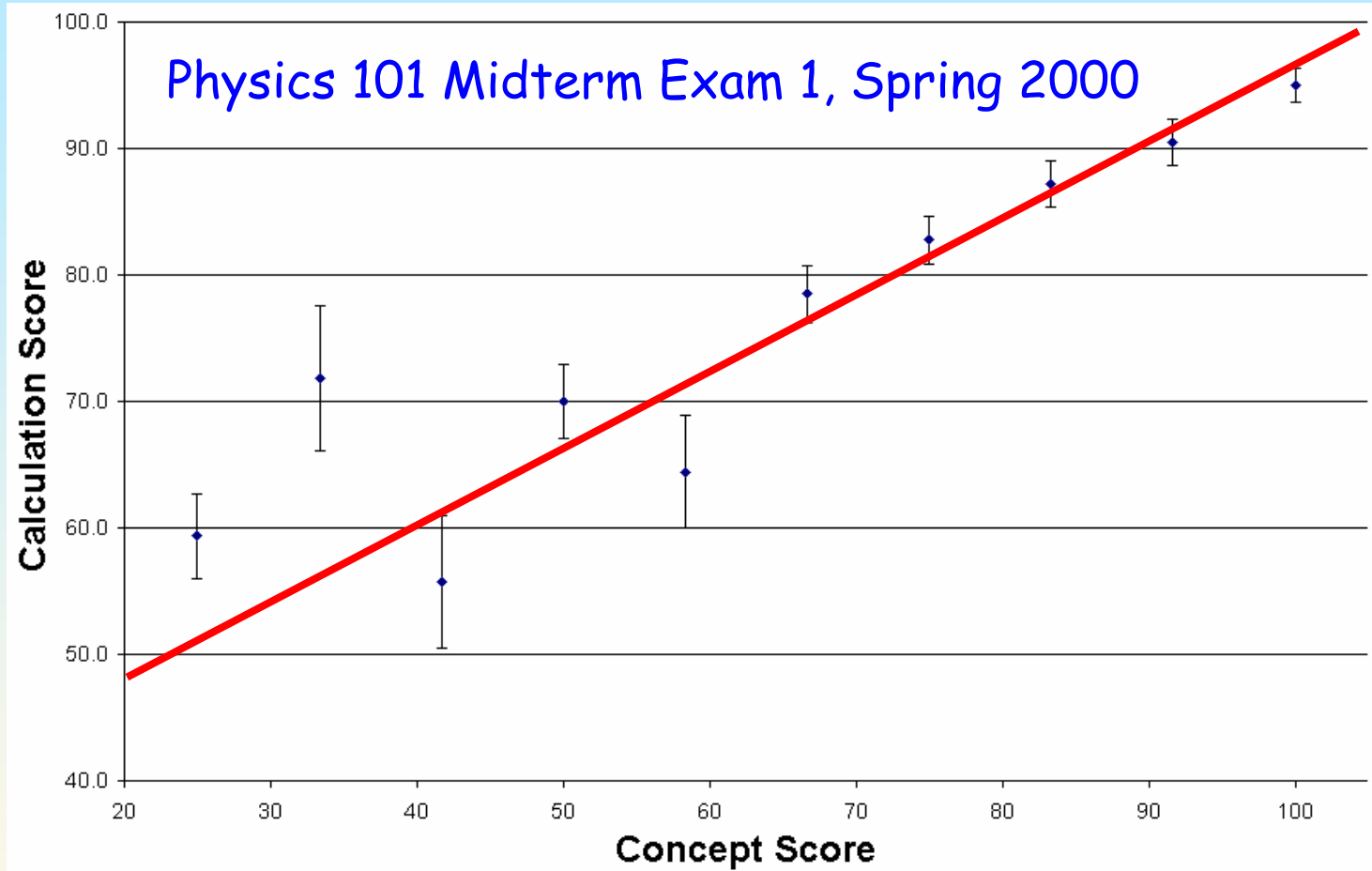
- greater
- less
- the same



Quantitative problems (5-choice) allow students to select up to 3 answers.
Partial credit!

Conceptual and quantitative problems are often paired.

Analysis of exam "data" is very interesting
(and useful for education research).



More sophisticated analyses can be used to rate the effectiveness of various approaches to designing exam questions.

Instant exam feedback is possible:

- The minute they leave the exam, students can go on the web, enter their answers into a web version of the exam they just took, and see what their raw score is:

QUESTION 25**

Consider two identical satellites, each in circular orbit around the earth but at different distances from the center of the earth. Which satellite has the higher speed?

- (a) the one further from the center of the earth
- (b) the one closer to the center of the earth
- (c) they both have the same speed

SCORE MY ANSWERS

Students LOVE this !

- After the exam has been graded (next day) students can find detailed statistics on each problem on the web.

Why Is The Revision Program Working at UIUC ?

- Key 1: Design Process was a Collective Effort
 - Committee of eight met for a year to generate the design
 - These people became the core
- Key 2: Infrastructure
 - People (veteran faculty, computing help, lecture, lab & secretarial support)
 - Computing (all materials on NT server, faculty get NT machine for desk while teaching)
 - Welcome to 1XX, here's how we do things....
- Key 3: Team-Teaching
 - All faculty (3-4 per course) do faculty-type jobs
 - Pain and Gain are shared ... no more burnout... NO HEROES
- Key 4: Administrative Support
 - Released time essential for initial creation of materials
 - Total support for systemic change... **JUST DO IT!**
 - Continuing support (e.g., new Assoc Head position) to maintain the system as the "newness" wears off.

What Does it Take to Work Elsewhere?

- ORGANIZATIONAL CHANGE
 - An Unnatural Act ??
 - Probably more important than any of the substantive details presented earlier!
- MAJOR OBSTACLES: FACULTY!!
 - Cultural issue: "My" Course
 - » Course is NOT just lectures
 - » Progress comes from contributions of many
 - Character issue: The Arrogance of Physicists
 - » Its hard to learn (i.e. accept guidance) from others !
 - » What makes effective instruction is largely an empirical question.

Overcoming these obstacles is a liberating experience