Turning Quantum Mechanics Course Notes Into Tutorials

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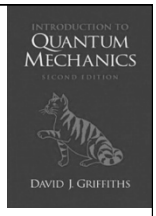
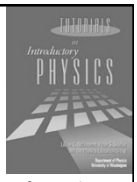
Original Course



- Standard introductory quantum mechanics course for junior/senior majors (and advanced sophomores) using Griffiths text and focusing on mathematical formalism.
- Taught three times using traditional lecture, with some computer demonstrations.

Motivation to Change



- Initial motivation to change my teaching came from the New Faculty Workshop in 2002.
- By 2008, quantum mechanics was my last "lecture holdout". I taught all my other courses (algebra-based intro sequence, classical mechanics, astronomy) with active learning methods (peer instruction, activities, homework presentation).
- Decided to shift to a tutorial approach (inspired by McDermott and Shaffer) in QM for Spring 2009.

Development of Tutorials

- Basic approach: recast my existing lecture material into tutorial worksheets.
- Tricky part: how much to give vs. how much the students should do (given constraints of 50 minute class period).
- Typical solution: give them a fair bit at the start of a new topic, but make them work through most of the rest (derivations and example problems) after that.
- I still lecture on some topics (approximately ¼ of class meetings are lectures, the rest are tutorials).

Tips for Making it Work

- Break derivations (and some example problems) into smaller, more manageable parts.
- Phrase many of the steps as "Show that …."
- Ask questions that connect to measurable results or that get students to think about the significance/reasonableness of the answer whenever possible. In other words, make sure to connect the mathematical formalism to the real world.
- LOTS of teacher-student interaction to prevent them from going too far down an unproductive path (and sometimes to give them a serious nudge in the fastest direction).

Time Challenges

- Different students work at different speeds.
  - Incorporate challenge problems for students who finish early.
- A given step/question may take too long.
  - On occasion I would show them the answer on the board, but only after they have worked on it for a while (so that they are interested).
- May have to cut some material.
  - I tend to sacrifice less critical derivations rather than example problems.
  - Some results may be derived in the text and you can point students to these rather than work through them in class. (Note: this is not ideal, but it may be no worse than lecturing to them on the same topic.)

Results (qualitative, anecdotal)

- Student performance on tests (which are similar to those I gave when it was a lecture course) was as good or better than in the past.
- A few students outperformed my expectations.
- Student feedback was very positive:
  - "Tutorials were great, the help we got in the groups was good and overall went nicely with the book and definitely helped understand the material better."
  - "The tutorials and help sheets (tip sheets, I guess) really caught the spirit of the material and helped for understanding. Very often I would start the homework and refer back to my tutorial over that material, rather than the book because I had done the tutorial and understood exactly what we were doing with it…"
- One students said he thought he did particularly well on the QM part of the Physics GRE because he had learned the material so well from my tutorial-based course.

Caveats

- My class sizes were VERY small (6 and 4).
- My students were all capable and reasonably well-prepared (not unusual for this kind of course).
- I have not (yet) done any objective, quantitative research to show that my tutorials are more effective than lecture (or other approaches).

Teaching Materials

- My stuff: tutorials, writing assignments, notes, etc available at facultyweb.berry.edu/ttimberlake/active_quantum/

  or just find my home page through Google (make sure to include the "Todd"!) and follow the link to the Active Quantum Mechanics page near the bottom.
- If you use any of my materials, please give me feedback (ttimberlake@berry.edu).