TAM 2030, Spring 2013, ABET assessment

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1 Documentation for this report

The end-of-semester ABET assessment consists of these 7 items:

1. **This 8-page assessment.** ABETReportTAM2030Spring2013.pdf (click on link to see file).
2. **The 2 page course syllabet.** This briefly describes the course and its objectives: TAM2030SyllabetACTING.pdf
3. **Proposed new course syllabet.** This includes changes to the syllabet suggested by this ABET report: ME2030SyllabetProposed.pdf.
4. **Exams.** The prelims and exams given, with solutions (32 pages). All2030ExamsSpring2013.pdf
5. **Course survey.** The results of the course questionnaire completed by 102/163 of the students. Students were told that all responses would be read, and that critical comments were encouraged. (31 pages): 2030CourseSurveySpring2013.pdf
6. **Staff survey.** Survey of the course staff about successes at ABET educational outcomes (14 pages): 2030StaffSurveySpring2013.pdf
7. **Course WWW site.** All information about the course, including these ABET documents: ruina.tam.cornell.edu/Courses/TAM2030-Spring2013

2 Objectives and outcomes

The objectives and outcomes include

1) Broad course goals (Sec. 2.1, below), and

2) Subject-specific gain in student knowledge (Sect. 2.2).

2.1 Broad course goals

General objectives, things that somewhat transcend the subject-specific academic content of the course, include:

- Increase general student problem solving ability.
- Reinforce and build on students' general engineering, mathematical and computer knowledge and working ability.
- Increase students' communication abilities.
- Increase students' interest in, and curiosity about, the subject, about engineering and more generally.
- Build student self confidence.
- Increase student satisfaction with their overall educational experience.

2.1.1 Success at broad course goals

One gauge of success in some of these areas is student perception. The most direct assessment of this is the end-of-semester course survey (separate document that is part of this report).

Some course survey responses

Q#	Question content:	Response # 1	2	3	4	5	Completed by 102 of the 165 students	
13.	Course educational value:	2%	5%	30%	46%	16%	⇒	mean = 3.7/5
1.	Textbook:	4 %	17 %	35 %	34 %	10 %	⇒	mean = 3.3/5
3.	Problem sessions (‘labs’):	8%	9%	15%	36%	32%	⇒	mean = 3.76/5
8.	Lecturer overall:	3%	7%	29%	34%	26%	⇒	mean = 3.74/5
16.	Academic integrity:	1%	1%	6%	11%	81%	⇒	mean = 4.70/5 (!)

Observations about evaluations.

1. 7% of the students found this course to be **worse than average in educational value** (responses #1 and #2 on question 13). From reading the text responses, some of the cause of the discontent seems to be stylistic (unfortunately course survey data is not given to faculty in a way that allows comparison of numeric responses with text responses). Indications include comments like “lecturer was conceited” and “book and www site are too wordy”. And some is disinterest in, or difficulty with the material “I spent the most time in this class out of any other class and am still not doing as well in it.”

2. 21% **disliked the textbook** (responses #1, #2 on question 1). The book was written by Ruina, the professor. Some found it too wordy. Others found it too similar to lecture. However, no textbook for this course has had, as best we recall, better ratings than this. Some students compared the book, unfavorably, to the Statics and Strength of Materials books from TAM 2020. However, in our experience Dynamics books are more poorly rated than statics books, even if part of the same series by the same authors. This is even evident on Amazon.com reviews where both Meriam and Beer& Johnston Statics books get lower ratings than their Dynamics books ().

3. 17% thought the **problem solving sessions were not especially educational**.

4. 10% thought **the professor was worse than average**. The response to the professor was very similar to that for the course overall, with a few extra people tending to especially both like and dislike the professor, relative to the course educational value.

5. 2% thought that **academic integrity standards were not well enforced**. We did something right. More or less we defined academic integrity violations away in the homework. And on the exams we carefully proctored.

The conspicuous problems named by students on evaluations.

1. Almost all ME sophomores are taking the same 4 courses (ME2250, ME2120, TAM2030 & Math2940). They want the work load, especially the prelims and major project due dates, distributed rather than bunched.

2. Some students felt under-prepared for Matlab and Differential Equations.

3. Other complaints were less systematic about lecture clarity, TA preparation, difficulty of exams, similarity of text to lecture, too much Matlab, etc.

   More use of the course survey data, below.

The conspicuous strengths named by students on evaluations. Features that students commented on appreciating include similarity of homework to exams, lecture demonstrations, the grading scheme, the problem-solving sessions. More discussion later.

2.2 Subject-specific educational objectives

The educational objectives on the current ABET syllabet are these:

> *Upon completion of the course, students should be able to:*
>
> 1. *Draw free-body diagrams, distinguishing forces from inertial effects (a);*
> 2. *Describe particle motion in 1-D, 2-D and 3-D employing Cartesian and path coordinates (a);*
> 3. *Characterize 2-D motion, including vector angular velocities and accelerations (a);*
> 4. *Apply Newton/Euler laws to the motion of particles and rigid bodies (a);*
> 5. *Use the principles of linear/angular impulse-momentum and work-energy to solve dynamics problems (a); and*
> 6. *Recognize simple harmonic motion for 1-degree-of-freedom mechanical systems (a).*

Our assessment of the achievement of these objectives comes by considering homework, recitation, problem-solving sessions, office hours and exam performance.

> **Caveat.** One approach is to use exam-question performance to compare success in the course from one year to another, or from one course to another. However, such objective quantitative comparative assessment is not practically possible. This is because, for example
>
> - the given topic-related question overall difficulty may vary from year to year,
> - the alignment of the question with assigned homework or with lecture examples may vary,
> - the degree with which the problem wording may hint or direct students may vary;
> - the grading laxness or strictness may vary;
> - the alignment of the question content with the desired educational goals may vary;
> - time pressure on the exams may vary; and
> - the coincidence of the exams with other exams the students are taking may vary.

This caveat could be obviated by the creation of a stable question bank, and corresponding objective grading scheme, that was so exhaustive and so focussed that that teaching to the test would be equivalent to teaching the deeper goals. No such question bank and grading scheme is now available for this course.

For some purposes a national measure, such as the multiple-choice test called '*The Dynamics Concept Inventory*' might be appropriate (http://www.esm.psu.edu/dci/). But, for example, that test does not seem to directly measure student ability to formulate and carefully solve problems.

Notwithstanding that objective quantitative cross-year comparison is prohibitively difficult, and thus not attempted here, assessment for the purpose of looking for room to improve *is possible*.

Question #	Score #/25	1. FBDs	2. Paths	3. Ang. vel. & acc.	4. Eqs of motion	5. Cons. laws	6. Harmonic osc.
Prel 1: 1	20.3	X			X	(X)	X
2	19.8	X	X		X		
3	17.6	X			X		X
Prel 2: 4	14.8	X			X		
5	14.4	X		(X)	X		X
6	15.8	X			X		
Prel 3: 7	17.2	X		X	X	X	X
8	14.9	X		X	X		
9	15.2	X	X	X	X		
Final: 13	14.9	X	X	X	X		
14	14.6	X	X	X	X	X	
15	11.8	X	X	X	X		
16	18.7	X			X		X
17	7.3	X		X		X	

Table 1: **Coverage of the 6 learning outcomes on the exams.** Column 2 shows the average of student scores, out of 25 (raw, unscaled, not-regraded). An ’X’ in a given column indicates that that topic was covered by the given question. Some students were rushed on the last final exam question (Q17) and may have strategically chosen to not spend time on it because of the ‘drop-the-lowest’ grading policy. The exam questions and solutions are provided in a separate document.

2.3 Quantitatively gauging success at learning outcomes

We have two measures:

1. Performance on exam questions (see Table 1 and Fig. 1).
2. Staff subjective assessment of outcomes based on all exposures to students (see staff assessment, item 6, from page one).

As mentioned in the ‘caveat’ on page 3, any supposed quantitative measures should be taken with more than a grain of salt.

For each of the 6 educational outcomes at least 1 staff member rated the educational success as 100% and at least said it was as low as 50%. In general the undergraduate TAs were more positive about the outcomes than were the graduate TAs than was the professor. The detected patterns in student weakness had more to do with broader problem-solving ability than with one or another subject-specific skill.

Table 1 shows that the questions on the final exam well-cover the desired educational outcomes. Because the scores range in median from 3/25 - 18/25 one might judge wide disparity in the success at various topics. And, indeed, it is the staff sense that conservation laws, the topic of the lowest scoring question # 17, were perhaps not covered as much as they should have been. However, the disparity in the scores is probably not indicative of the disparity in knowledge because it was the last question on the exam, and for grade-strategy reasons students might have chosen to not give it time.

2.4 Some issues appearing in some student work

Many students were engaged with, and improved at, the skills and concepts we were attempting to teach. The staff report However, we did *not* achieve near universal competence. The best students were much more functional than the weaker ones. More specifically (paraphrasing Ken Birman’s description of students in CS 2110), the students to whom we ultimately gave a grade of A were probably not 100 times more able to usefully solve new dynamics problems than students who ultimately got a C, but more nearly infinitely so. More specifically, some of the weaker students

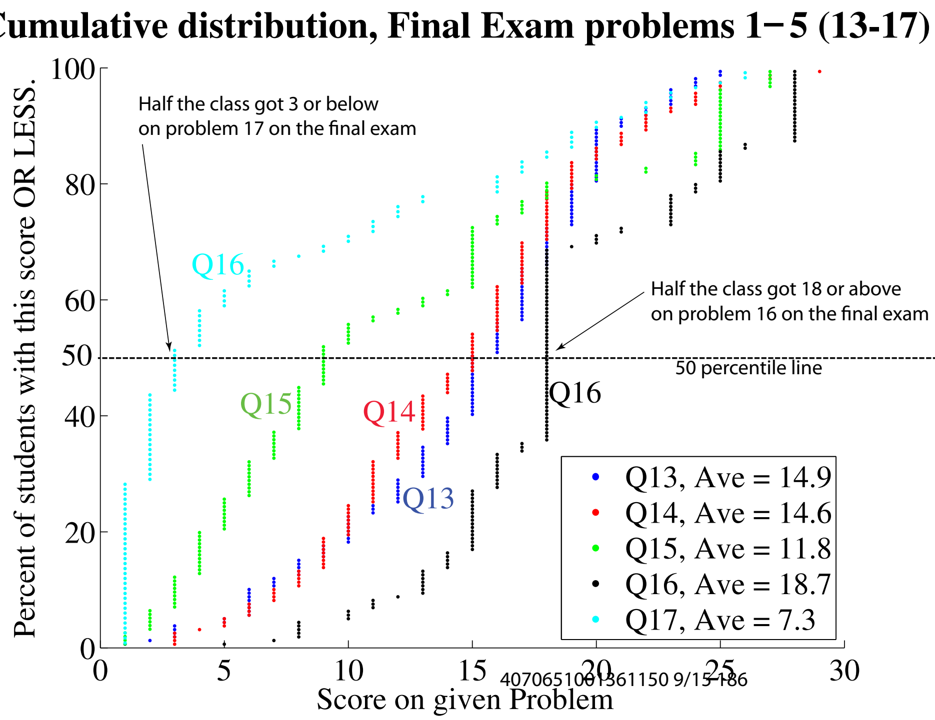

Figure 1: **Distribution of scores on the final exam questions.** The five exam problems (numbered 13-17 because 12 prelim questions preceded them). These curves (one small dot for each student) are the integrals of the density function (*i.e.,* if the scores were normally distributed these curves would be error functions). Where the curves are steep or vertical, many students had those scores. If one curve is above another, more students got the given score or lower, meaning student scores were generally lower for that question. So, question 16 (black, lowest curve) was the highest scoring (with the highest mean=18.7 and median of 18) and question 5 (light blue, top curve) was the lowest scoring (with the lowest mean=7.3 and median of 3).

1. Resort to **highschool-physics-like-approaches** like conservation of energy even when it doesn't apply;

2. Use **scalar approaches** when vector approaches are demanded;

3. Try to plug in any number of **freshman physics formulas** independent of their relevance;

4. Never learned the basics of **Matlab** for Dynamics;

5. Had trouble **doing familiar things in unfamiliar contexts**.
   Example: when a pendulum had on it quadratic air drag (first problem on final) they forgot that it only had one degree of freedom (they treated it like a particle in space with quadratic air drag);

6. Similarly, students who could apply one algorithm or another, did not have a good sense of **when to use which algorithm**.
   Example: on the last problem on the final exam (colliding block) many people tried to (inappropriately) use conservation of energy or (again inappropriately) to set up ODEs;

7. Many students were uncomfortable using **matrices** for setting up solution to linear equations or for vibration problems. They were mostly in Math 2940, but considered it a divorced topic because it was not a co-requisite course;

8. Most students did not have time to master the understanding and usage of the **5 term**

acceleration formula (that is,
$\vec{a}_{P/\mathcal{F}} = \ddot{\vec{r}}_{O'/O} + \vec{\omega}_{\mathcal{B}} \times (\vec{\omega}_{\mathcal{B}} \times \vec{r}_{P'/O'}) + \dot{\vec{\omega}}_{\mathcal{B}} \times \vec{r}_{P'/O'} + {}^{\mathcal{B}}\ddot{\vec{r}}_{P/O'} + 2\vec{\omega}_{\mathcal{B}} \times \vec{v}_{P/\mathcal{B}}$).

9. More generally, from looking at the final exam work one gets the impression that some portion of the class maintained a **sense of alienation from the material**. Whether this was from
   - lack of time (*e.g.,* competing courses or activities);
   - lack of interest;
   - lack of ability,
   - lack of self-esteem; or
   - dislike of the professor, book, etc,

   is not clear. But these students seem to never have made a choice to learn the new things presented in any more than a pattern-matching, superficially imitative manner.

3 Non-standard course features and their success

This course has various features that, although not radical, are not standard.

1. **TA meetings.** *All graders and TAs met once per week and did, all of them, problems at the blackboard.* By this means the TAs own strengths and weaknesses were shown to them. And by this means I, Andy the Professor, could show the course staff approaches that I hoped the TAs, and thus the students, would learn. A problem I have had with many courses is that the whole staff is not really pulling together. This TA problem-solving meeting really helped. It's the second semester I've done it. The TAs like it, it builds their confidence and makes them more of a team. It reduces conflicting advice between staff. It seems to help the course overall.

2. **Many class demos.** There were 31 in-class demonstrations (listed on the course www page). 9 students commented positively about these.

3. **Drop the lowest.** Grading was based on an elaborate drop-the-lowest scheme, slightly tuned from previous use. It is described in detail on the course www pages. Informal discussions indicate that this scheme, in all it's complex detail, was regarded as a big stress-reliever for many students. On the surveys 9 students volunteered positive comments on this, and 1 negative.

4. **'I worked 6 hours'.** Students were given full credit for a homework assignment if they wrote at the top "I wrote 8 hours on this" Or any other number of hours ≥ 6. No complaints from students about this.

   Suggested change: only check the homework's, don't grade any of them in detail (as per the suggestion of Brian Kirby from his experience this past semester in a different course). We should save the TA/grader time for more direct student interactions. The basic problem is that we don't have the staff time to grade in meticulous detail. Furthermore, the students seem to make little use of the feedback they get on graded homework.

5. **Solutions posted before homework was due.** Students liked this. And it cut down on crowds in office hours. Students who are just trying to drag themselves through the homework have a means to do so without using staff time. I have mixed feelings about it. Certainly some students took too much advantage (hurting both their education and their exam grades). On the other hand, it was a pressure relief and staff time saver also. On balance I would repeat this, warning students as much as possible not to cheat themselves.

6. **Clickers.** Clicker questions were given in most classes. Having the question at the start of the class (again as per a suggestion of Brian Kirby) seems to get the students into a topic-related

frame of mind. Students commented positively on getting 4 points for voting and 1 more for the right answer. They said they prefer this to having, as in some other courses, the clicker questions to be like exams. Although to some extent the clicker questions are merely a means to increasing class attendance, some students seem to appreciate getting a direct reward for doing that which they might otherwise tend to skip.

7. **Problem Sessions.** Four times a semester, for two-hours each time, groups of 12 students met in Thurston 204 (blackboards on 3 of 4 walls) and worked in pairs solving problems with a TA. This is the second semester we have tried this. I will give a presentation about this the Mechanical Engineering Undergraduate Program Committee in the fall. We got about 80 positive comments on the surveys and 23 negative.

   Suggested change: About 23 students said they wanted more sessions. About 30 students said 2 hours was too long. Suggested change: Replace recitations with problem sessions (still with only 12 students per session). This will demand pre-scheduling the few small rooms with adequate blackboard space.

8. **Lectures were videotaped.** There were no negative comments on this and a few positive comments. Through the semester, however, we got many positive comments on the usefulness of having video lectures. This can be video note or home brew (directions for home brew are here: `http://ruina.tam.cornell.edu/wiki/tiki-index.php?page=Classes`).

9. **Lecture notes posted.** One student's beautiful notes were posted on the day of the lectures and recitations. One student explicitly commented on this, but we suspect that many used it.

10. **Redos for exams.** Students who got 19/25 or less on an exam question could redo it, graded out of 20. The recorded grade was then the average of the original and redone grade. This was regarded as a huge pressure-relief for many students. Many students probably did this mindlessly. Some commented about learning through fixing errors.

11. **Extra time on prelims.** An attempt was made to write prelims so that a good student could complete them well in under 90 minutes. All students were given up to 3 hours to do all prelims. There were no complaints about this. This was a big pressure relief.

12. **A single makeup prelim.** At the end of the semester there was a single makeup exam for all those who could not take one of the prelims. One 90-minute exam (for which they had 3 hours to work), kind of a mini-final for all such students. Any and all excuses were accepted for missing earlier exams. There was no threat or intent that the makeup would be harder than other exams. This was mostly a pressure relief for the staff.

13. **Extensive office hours.** The Prof, TAs, undergrad TAs and graders had a total of 39 office hours per week, all in The Conway Room. Several students commented positively about this.

14. **One point for survey.** We gave 1 point (/100) for completing the course survey. In the past this has led to up to 89% participation. No complaints about this from students. This time we forgot to remind students of this at the end of the semester and only got 63% participation.

4 What to do with labs, recitations and problem sessions?

This was the first semester, in at least 35 years, where the course had no lab. This will be a topic of discussion at the UPC next fall.
Here are student opinions

- Have a lab and no problem sessions? 6 said yes
- Have problem sessions and no lab? 58 said yes

- Have both? 12 said yes
- Have neither? One student suggested this

Proposal:

1. **Eliminate the old labs**

2a. **15 problem sessions.** Instead of recitations. 12 students each.

2b. **Optional evening recitations.** These would be for students who want conventional lecture-style recitations for problem solving tips or course summaries. Just one for the whole class in a big room. Done by top TAs. Effectively office hours, but done lecture style. Offered once or twice per week on Mondays or Wednesdays.

3. **Labs light.** Try to include simple physical problems associated with some of the calculations in problem sessions.

4. **Lecture demos.** Aim for an average of 1 demo per lecture.

5 Summary of suggestions for Spring 2014

1. Keep the four 2-hour physical labs dropped.
2. Preserve the at-least-once-per-lecture physical demonstrations.
3. Don't grade homeworks in detail, save the staff time for in-person interactions.
4. Move problem sessions into recitation times, try to use physical examples in problem sessions.
5. Add optional (like office hours) evening lecture-style recitations that are mostly remedial.
6. Coordinate prelims and projects with other Spring ME courses and Math 2940.
7. Make Matlab an official pre-req to this course.
8. Make Math 2940 an official co-requisite.
9. Extra help sessions for Matlab (outside of lecture, could be in evening recitation time)
10. Drop the 5-term acceleration formula from the course and spend the extra time with practicing conservation laws and with harder problems.
11. Coordinate better with tutoring services (a student complained that he/she couldn't find a tutor).
12. In office hours each student must, through the semester, do 4 old HW problems on his/her own with no references. *Graded toughly* for free body diagrams, layout, vector vs scalar, etc. Students can do as many as they like, the best 4 will be counted.
13. At least as a one-time experiment, test the students with the Dynamics Concept inventory, or something similar, at the start of the semester and at the end (http://www.esm.psu.edu/dci/).