Boston University
College of Engineering
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2/21/03

Report on

ENGINEERING ETHICS CONTENT IN EK 301, FALL 2002

Contents

1. Introduction

During the fall 2002 semester, an effort was made to insert a significant amount of engineering ethics awareness and content into EK 301, Engineering Mechanics I. EK 301 is a sophomore mechanics course required of all engineering majors in the College. In the fall 2002 semester, there were six sections of the course totaling about 240 students. The same ethics content was inserted into all sections. There were three parts of the course into which ethics were explicitly inserted:

- Ethics/Plagiarism Quiz at start of semester
- Modifications to three textbook homework problems to include ethics content
- Ethics portion of the term truss design project

Each one of these will be explained more fully below, along with examples of student work. In addition, at the end of the semester, a student feedback survey was conducted to assess the success of the introduction of engineering ethics into EK 301. As explained in the following section, the effort seems to have been very successful.

2. Student Feedback Survey on Ethics Content at End of Semester

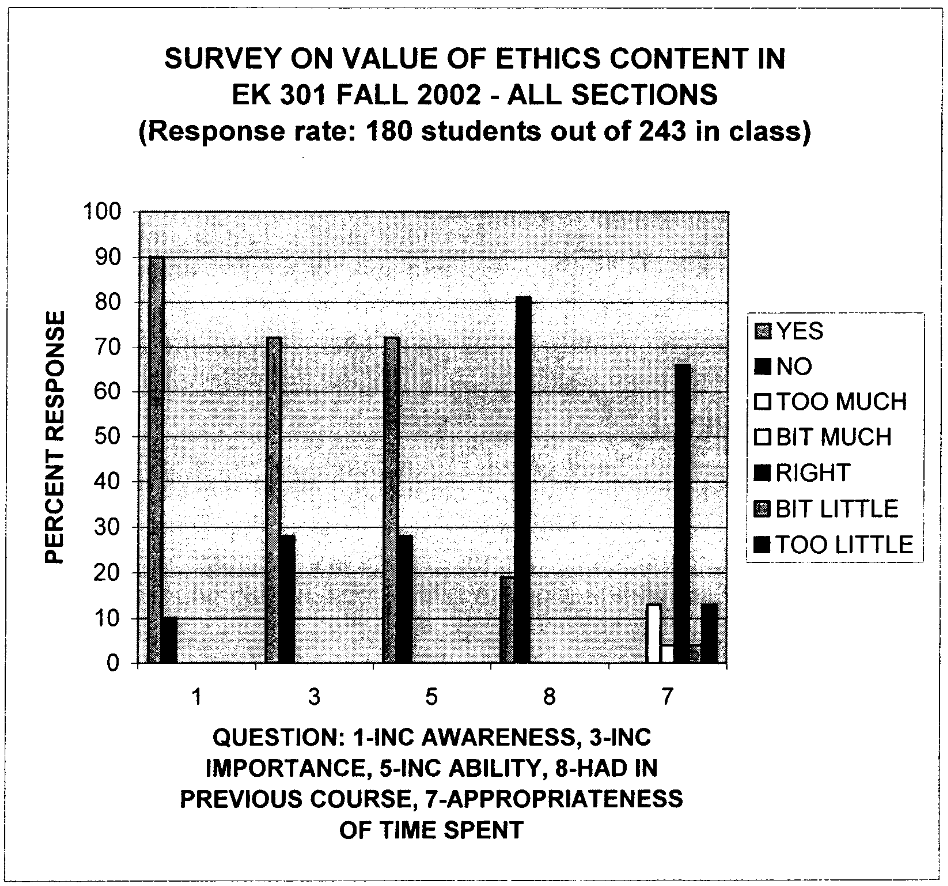
At the end of the semester, an anonymous survey was conducted to determine the success of our efforts to insert engineering ethics content into EK 301. As can be seen on the following page, the survey showed that we were successful in our efforts. The response rate was 75% of the students in the class. Of these, 90% said the course increased their awareness of engineering ethics, while over 70% said it increased their appreciation of the importance of engineering ethics and their ability to deal with such issues. Less than 20% had had any engineering ethics content in previous classes. About 65% said just the right amount of time was spent on the subject in the course, while the rest were evenly divided in saying too much time or too little time had been spent.

Examples of student responses to the student feedback survey are included in Appendix A, at the end of the report. Even though the answers to the yes/no questions showed conclusively that we succeeded in our efforts to introduce engineering ethics to the students in a meaningful way, the write-in comments showed a wide range, and how to interpret them is not clear. It appears some students do not appreciate the fact that the technical and professional aspects of engineering are intertwined. Perhaps this is an indication that we have not yet done the best possible job making the connection.

Ethics Survey EK 301 Fall 2002 (All Sections)

Question	Yes (%)	No (%)					
1	90	10					
3	72	28					
5	72	28					
8	19	81					
7			13	4	66	4	13
			too much	bit much	just right	bit little	too little

Q1: Did this course increase your awareness of ethics issues likely to arise in your professions or job?
Q3: Did this course do anything to change your understanding of the importance of professional or business ethics?
Q5: Did this course increase your ability to deal with the etchial issues it raised?
Q8: Did you have any professional or business ethics in a class befor this one?
Q7: In your opinion, did this course spend too much time on professional or business ethics, too little, or just the right amount?



3. Ethics/Plagiarism Quiz at Start of Semester

Below is shown an excerpt from Course Information Sheet handed out on the first day of class, which describes the Ethics/Plagiarism quiz. The ABET Code of Ethics for Engineers along with Suggested Guidelines for Use with the Fundamental Canons of Ethics, which were also handed out on the first day of class, are included in Appendix B, along with some examples of student responses on the quiz.

> Cheating on homework, projects, and tests is a form of plagiarism, and plagiarism is unprofessional. You are in training to become professionals, and the conduct of engineering professionals is governed by engineering ethics. Plagiarism is an infringement of every code of engineering ethics. The Code of Ethics of Engineers promulgated by the Accreditation Board for Engineering and Technology (ABET), the national organization that accredits all engineering programs in the United States, is included in this information packet. On the second day of class you will be tested on how plagiarism violates this code. Please be prepared for the test. It will be graded and count towards your term grade. It will be an "open book" test, so please bring your copy of the code with you. You will have only 10 minutes (so you must prepare ahead of time) to answer the following question: Identify (by number and letter) three places in the "Suggested Guidelines to the Fundamental Cannons of Ethics" that are applicable to issues of plagiarism. For each place you identify, write a very short, clear, and legible paragraph (no more than two short sentences) explaining the connection with plagiarism. (Note that the course staff has identified at least six places). Each correct answer is worth five homework points.
>
> In addition, you will be asked to sign an Academic Honesty Pledge, the text of which is attached to this information sheet.

The outcome of the quiz was disappointing, but enlightening. The quiz could not be used for credit since most students included portions of the "Guidelines" that were applicable to other forms of unprofessional behavior, such as intellectual property theft, perjury, and conflict of interest. This appears to indicate that students coming into the sophomore year are not aware of what plagiarism really is, let alone all the other types of unacceptable professional behavior.

4. Modifications to Homework Problems to Include Engineering Ethics Content

Below is shown an excerpt from the section of the course information sheet, handed out on the first day of class, dealing with homework. The course syllabus highlighting the special homework problems with engineering ethics content; copies of the problems along with grading keys to the graders and extra material gone over in lecture after the problems had been turned in; and examples of student work are all included in Appendix C.

> In addition, on a few of the homework assignments, there are special problems that involve your making a judgment based on engineering ethics and good engineering practice. These additional parts of the problems will be graded separately, even if the rest of the problem is not graded in depth. A copy of the Code of Ethics of Engineers promulgated by the Accreditation Board for Engineering and Technology is included in this information packet to help you with these problems. Also, good engineering practice usually requires the use of safety factors in the design of real devices. You will learn more about how to choose and use safety factors in the more advanced design courses later in your curriculum. For the special homework problems in this course, the safety factor (SF) will be defined as:
>
> $$SF = \frac{\text{Minimum force that will break a part}}{\text{Maximum force to which the part is subjected in your design}}.$$
>
> Also, for these special problems, the appropriate safety factor to use if there is no threat to human safety is SF = 2, while the appropriate safety factor to use if there is a threat to human safety is SF = 3.

The homework problems appear to have been successful in sensitizing the students to the issues of public safety and safety factors.

5. Ethics Portion of the Term Truss Design Project

Below are shown excerpts from the "Final Report Format" and "Final Report Content" sections of the term design project assignment. Copies of the packets handed out in class on the Hartford Civic Center roof collapse and associated engineering ethics issues, along with examples of student work are included in Appendix D.

Final report format:

1. An appendix containing the minutes of your team meeting discussing the ethical implications of the Hartford arena roof collapse, with special attention paid to the use of computer programs. In this meeting also discuss an appropriate safety factor to be used for your truss if it were to be used in a case where human life is at risk. What actual load would you claim for it in this case? Consider variability in materials and construction and any other factors that you deem relevant. Be sure to keep in mind: "Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties," Fundamental Cannon No. 1 from the Code of Ethics of Engineers, Accreditation Board for Engineering and Technology, 1997.

Final report content:

h. The minutes from your professional ethics team discussion should follow these guidelines:

1) The date, time, and place of the meeting should be recorded along with the names of the participants. The (acting) chair of the meeting and the recorder (minute taker) should be identified.

2) The planned agenda should be attached.

3) The important points should be summarized (along with who suggested each)

4) The conclusion(s) should be recorded and any action items with the responsible person listed.

5) The date, time, and place of the next meeting should be given, if scheduled, or the disposition of the group made explicit, e.g., by when a follow-up meeting is to be planned or that no further meetings of this group are needed (anticipated)

Most student teams did a reasonable job of discussing the Hartford Civic Center collapse, but did not indicated clearly that they had read and considered any of the other articles in the handouts.

6. Conclusions

While the introduction of engineering ethics into EK 301 in the fall of 2002 appears to have been quite effective, it was not done without cost. Lecture time was used for in-class discussions related to safety factors and homework problems involving them, the Code of Ethics for Engineers, and the Hartford Civic Center roof collapse. Lecture time was also used for the in class ethics/plagiarism quiz and end of term ethics evaluation. In all, at least one full two-hour lecture period's worth of time (= ½ week, =4% of semester's lecture time) was devoted to engineering ethics. In addition, inserting ethics content into regular textbook homework problems in a meaningful way was not a trivial task, and required at least one full person-day of effort. Since new problems are used each semester, this will be a recurring time use.

Next year, the course staff and students will face the additional burden of using MATLAB without having had prior instruction for the students. This combined with the increased ethics content will require the reduction in coverage of the regular course topics. At this time, it seems likely that the topic of impact will be dropped from the syllabus. Angular momentum was dropped previously to make room for the design project, and now impact may also be dropped to make room for engineering ethics.

Boston University
ENG EK 301
Engineering Mechanics I

SYLLABUS FOR FALL 2002

(Update 10/4/02)

DATES AND READING FOR LECTURE SECTIONS

Text: Engineering Mechanics Statics and Dynamics (9th ed.) by Hibbeler

WEEK	DATES	READING	CLASS ACTIVITIES & HOMEWORK PROBLEMS	HW #	HW DUE DATE
1	9/3-5	1.1-1.6& 2.1-2.6	**READINESS TEST ON 9/4**	-	-
2	9/9-12	2.7-3.4	**ETHICS/PLAGIARISM QUIZE ON 9/9** 2-12,-50,-58*,-73*,-85,-96*,-108	1	9/11,12
3	9/17-19	4.1-4.6	2-111,-112; *3-8**,-24,-54,-67,-72	2	9/18,19
4	9/23-26	4.7-4.10& 5.1-5.3	4-12,-25, *4-41**,-55,-60,-77,-84,-96*	3	9/25,26
5	9/30-10/3	5.4-5.7& 6.1-6.3	**DESIGN PROJECT TEAMS FORMED** 4-101*,-116*,-131,-135*; *Ex 5-10** ,5-20*,-28,-99	4	10/2,3
6	10/7-10	6.4& 8.1-8.2	**DESIGN PROJECT ASSIGNED 10/7** STRAW TESTING 5-80,-90*,-91*; 6-9,-19,-23*	5	10/9,10
7	10/15-17	8.3& 12.1-12.3	STRAW TESTING 6-37*,-40; 8-8*,-16,-17*,-14	6	10/16,17
8	10/21-24	12.4-12.6	**TEST NO. 1 ON 10/21,22 COVERING 1.1-5.7**** STRAW TESTING 8-41,-65,-69	7	10/23,24
9	10/28-31	12.7-12.8	**STRAW TESTING REPORT DUE ON 10/28,29** 12-17*,-28*,-44*,-67,-83*, -94	8	10/30,31
10	11/4-8	12.9-12.10& 13.1-13.4	**STRAW DATA BACK TO CLASS ON 11/4** 12-100,-107*,-130*,-149*,-158*, -167*	9	11/6,7
11	11/11-14	13.5-13.6& 14.1-14.3	**DESIGN PROJECT PROGRESS REPT. DUE 11/11,12** 12-183,-202, -208, 13-4, -21*, -33, -38	10	11/13,14
12	11/18-21	14.4-14.6	**TEST NO. 2 ON 11/18,19 COVERING 6.1-12.8**** 13-63,-70,-93*, -102	11	11/20,21
13	11/25-26	15.1	-	-	-
14	12/2-5	15.2-15.4	14-27,-61,-90,-96,15-6,-9 **DESIGN PROJECT DUE & COMPETITION ON SAT. 12/7**	12	12/4,5
15	12/9-11	REVIEW	15-25*,36, 47,51,67	13	12/10,11

Footnote Key:

* See Homework Notes and Hints. May have an additional graded part.

■ See Homework Notes and Hints. Problem has additional parts related to Engineering Ethics and will be graded.

** For additional practice problems for class tests (with worked solutions) see the Study Packs and Study Guides packaged with textbook and also the problems from the FUNDAMENTALS OF ENGINEERING EXAM that appear in Appendixes C and D in the textbook. The FE Exam is the first step to professional registration for engineers in all fields, and is usually taken at the end of the senior year. Worked solutions appear at the end of each appendix.

* HOMEWORK NOTES AND HINTS *

2-58: HINT: Have the component of the resultant force in the direction of **F** go to zero.

2-73: NOTE: The light blue triangle is in the x-y plane and the dark blue triangle is perpendicular to the x-y plane.

2-96: NOTES: $\mathbf{F_B}$ goes through point B and "direction" means the coordinate direction angles.

3-8: **ADDITIONAL PARTS: The manufacturer claims the breaking strength of each cable is 415 N. Comment on whether or not this is a good design, <u>and why.</u> (Hints: Could people be hurt if it fails? How sure are you of a cable's breaking strength? Refer to the appropriate part of the Code of Engineering Ethics.)**

4-41: **ADDITIONAL PARTS: The pole shown is a utility pole and the picture shows a worker trying to pull a cable into position over the top of the pole. The cable has gotten stuck and the worker is trying to force it loose by pulling on it. Considering the information given and found in the rest of the problem, comment on whether the base of the pole has been properly designed and give your reasoning. Consider the Code of Engineering Ethics and good engineering practice.**

4-96: HINT: To check your answer, the magnitude of the resultant moment vector is 23.4 N·m.

4-101: ADDITIONAL PART: Sketch in your results on the diagram.

4-116: NOTE: Align the axes with the roof slope and specify the force in terms of its magnitude and angle relative to the axes aligned with the roof slope.

4-135: NOTE: A wrench is just a term to describe both a force and couple moment with lines of action in the same direction. For example, the wrench acting at Pt. A is composed of a force of 300 N **k** and a couple moment of 100 N·m **k**. The couple moment vector, of course, could be moved freely to any point. Partial answer: the z-component of the resultant force is 159 N, and the z-component of the resultant couple moment is 183 N·m.

Ex 5-10: **ADDITIONAL PROBLEM: With reference to Example Problem 5-10, as a junior engineer working for the concrete truck manufacturer, you must recommend to your boss which hydraulic ram (member B-C in Fig. 5-18(b)) to buy for installation on the trucks. You have a choice of four rams from the hydraulic cylinder manufacturer: (A) A ram costing $500, which can carry a maximum load of 2000 lb before failure; (B) A ram costing $1000, which can carry a maximum load of 4000 lb before failure; (C) A ram costing $2000, which can carry a maximum load of 6000 lb before failure; and (D) A ram costing $6000, which can carry a maximum load of 8000 lb before failure. When the maximum force is exceeded a ram will fail by becoming inoperative, not by collapsing, so the concrete shoot will freeze in the position it is in, but not collapse. All rams have the same length and other operating features. Which ram should you recommend to your boss? (HINT: Consider the Code of Engineering Ethics and the recommended safety factors <u>for this course</u>. Thoroughly explain the reasoning behind your answer.)**

5-20: PARTIAL ANS.: $B_y = 60.0$ N.

5-90: Hint: $\mathbf{F_2} = (-366.21\mathbf{i} + 211.43\mathbf{j} - 153.91\mathbf{k})$ N.

5-91: Note: Collar A does not support a thrust (axial) load.

6-23: Note: The truss is a simple truss since it can be constructed by starting with triangle BCF and adding two members connected at a joint each time to close the figure. Simple trusses do not have to be formed only of triangles.

6-37: Use method of sections.

8-8: Give your answer in terms of W. Note: The roll might slip at both supports, and just rotate around, or stick and pivot about B, lifting off of A. You must check for both modes of motion. Be sure to check the values of the normal forces to be sure the situation is physically realizable – e.g., a contact force cannot pull on a surface (unless the connection is glued together). Ans. 0.268 W.

8-17: Required additional part to problem: If the boy has a weight of 100 lb, and the coefficient of static friction between the floor and his shoes is $\mu_s = 0.8$, can he move the drum, or will his shoes slip backwards?

8-14: Hint: Consider separate free body diagrams for the two bodies. First find the forces on the drum from a moment balance, and then apply them to the brake bar. Note: This is called a "self energizing" brake, since the friction force actually decreases the required applied force. If M were in the opposite direction, it would be a "self de-energizing" brake because the friction force would increase the required applied force.

12-17: Note: The particles reverse their direction of travel during the period of interest. Where they reverse (time and position) can be found from setting $v = 0$. This information must be used to find the total distance traveled. **NOTE: ANSWER IN BOOK IS WRONG.** Total distance for A is 41 ft.

12-28: Hint: Use Eq. 12-3 to find v in terms of s, and then Eq. 12-1 with separation of variables.

12-44: ADD: Also sketch the distance vs. time graph from 0 to 60 s. Show the general behavior and correct slopes at t = 30 s and t = 60 s.

12-83: Hint: Solve simultaneously for the vertical velocity and vertical position at pt. C, the highest point in the particle's trajectory.

12-107: ADD: Draw a sketch of $\mathbf{a}_t$, $\mathbf{a}_n$, and $\mathbf{a}$ at the instant of interest in the problem on the circular trajectory shown in the problem statement. Hint: Integrate the speed to find the distance as a function of time and then find the time to go 20 m.

12-130: ADD: Find a_n in two ways: using the formula on the bottom of p. 51 to find ρ and then using it, and not using ρ (Hint: Find the angle between the x-direction and the velocity, and then the angle between the x-direction and the normal acceleration. Gravity is the only acceleration in the problem.) Also ADD: Draw a sketch showing $\mathbf{v}_t$, $\mathbf{a}_n$, $\mathbf{a}_t$, and $\mathbf{g}$ with respect to the x and y axes. Hint: For finding y = f(x), write an expression for x in terms of t, and for y in terms of t, and then t in terms of x, and then substitute into the y expression. Note: When the book asks for the ball's velocity, it really wants speed.

12-149: Note: The boy runs with a constant increase in radial speed. You are to determine the radial and transverse components of velocity and acceleration.

12-158: ADD: Sketch $\mathbf{a}_r$, $\mathbf{a}_\theta$, and $\mathbf{a}$ at t = 1s, on a copy of the drawing from the book.

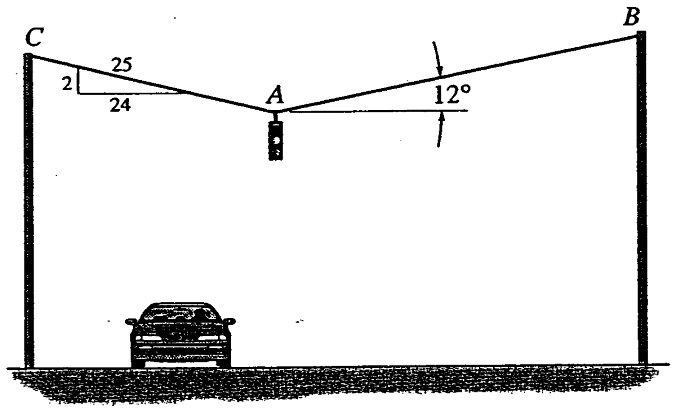
12-167: Hint: Use $v^2 = v_r^2 + v_\theta^2$ in terms of θ and $\dot{\theta}$ to find $\dot{\theta}$ at $v = 35$ ft/s, and $\theta = \pi/3$ rad.

13-21: Hint: assume the relative velocity of the cars is equal to zero and the force in the spring is constant.

13-93: Hint: use formula 13-10 in the text.

15-25 Use the principle of impulse and momentum to solve this problem.

***3-8.** Determine the force in cables *AB* and *AC* necessary to support the 12-kg traffic light.



3-8: Add: The manufacturer claims the breaking strength of each cable is 415 N. Comment on whether or not this is a good design <u>and why</u>. (Hints: Could people be hurt if it fails? How sure are you of a cable's breaking strength?), Refer to Code of Eng Ethics)

<u>Grading scheme:</u>

- Maximum score for entire problem: 20 pts.
- No answer to added part: ~~-4~~ pt.
- Yes: -7/~~6~~ pts.
- No: +1 pt.
- Safety paramount (with reference to Code): +1 pt.
- Could endanger humans if fail: +1 pt.
- No margin for error: +1 pt. (safety factor)

<u>Class discussion in next class following submission:</u>

- Code of Ethics
- Safety factors and accuracy of material properties