

## **AC 2008-429: MULTI-DISCIPLINARY TEAM PROJECT WITH SOFTWARE**

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## **Multi-disciplinary Team Project with Software**

### **Abstract**

Multi-disciplinary team projects are an important element in the ABET accreditation of engineering programs. The basic manufacturing processes course in the Industrial Engineering (IE) Program at West Virginia University is one of only two IE courses which are required by other engineering majors. A software program was developed to assist students in the evaluation of costs when selecting different materials and shapes to meet specific load and deflection requirements. The program has been used for four semesters to develop an appreciation of the effect of material selection and design upon the total cost of a multi-constrained project. Students have indicated several problems which resulted in model changes and the development of an instruction manual. The project has been modified so that several reports are required before the final project. This paper discusses the student responses and the effect of the use of multiple reports.

### **Introduction**

The basic manufacturing processes course attempts to integrate material properties, mechanical properties, design criteria and economics to prepare students for the highly competitive global market via a team project. The project is started at the beginning of the course and is completed within 10 weeks to avoid conflicts with projects in other courses. The students have had courses on materials, strength of materials and the economic issues are presented during the first week of classes. The students are to consider various materials and shapes to meet the project design requirements. The software had been used for four semesters with various degrees of success and the results have been reported in previous papers<sup>1,2,3</sup>. The instructor was assigned to another course for one year and the course was taught by an adjunct professor as no other faculty member in the department would teach the course and the program was not used during that year. The regular instructor was reassigned to teach the course again for the 2007-8 academic year and resumed using the software.

There were various problems, such as some students did not have the materials background as that phase was omitted from the course (but that has been corrected), students would delay the project until the week before it was due, teams did not meet and thus some students did not actually participate in the project, and the computer program had some logic and programming errors. The computer software was sent to the students via e-mail and thus each student had access to the program. The project counted for 20 percent of the final grade and will be increased to 25 percent for the spring semester. The fall class is much smaller, only 40-45 students, versus a class of 110-125 students for the spring semester and thus more interaction can occur with the students during the fall semester. However, the spring semester class tends to perform better as they are the "in-phase" students.

This is the final course using the basic engineering course materials from the strength of materials and basic materials courses for the industrial engineering students and the only course emphasizing costs for the mechanical engineering students. There is no specific product design/development course in either program, but the mechanical engineers do have a senior design course consisting of several sections which focus on a specific project for each section. The manufacturing course does discuss the predominant methods for making the structural shapes such as extrusion and roll forming and relates these to the project.

### Project Description and Instructions

The project for the fall semester was the ladder design problem and the project assignment sheet is presented in Appendix 1. The ladder is the most difficult of the various projects assigned and thus would force students to ask questions as it requires some clarification. A schedule was developed as shown in Table 1 to force the students to be organized early and start the project. Team assignments are made during the last class of the first week and the teams are made by the students. The report schedule for the spring will be altered to give more time between the last 3 reports; the schedule for week due will be 2<sup>nd</sup>, 4<sup>th</sup>, 6<sup>th</sup>, 8<sup>th</sup> and 10<sup>th</sup> weeks as more time will be needed between reports for evaluation. Assessments forms were given to all students for evaluation of the software and project.

Table 1. Project Schedule for Interdisciplinary Team Project Reports

Report Number	Week Due*	Report Requirements	Report Weight(%)
1	3	Team members & e-mail addresses; team name; Special Material & Shape Selected	2
2	5	Use Program** for base materials and get results	3
3	7	Use program to evaluate all materials and shapes, Do sensitivity analysis	5
4	8	Draft Final Report	5
5	9	Final Report	85

\* Due last class of week

\*\* Students can make their own program

### Assessment Questionnaires

Three assessment questionnaires were given to the class for the students to complete in class, and they were requested to give their names for follow-up. The students were assured that the completion of the questionnaire would not have any negative effect upon their course grade, and they did give many unfavorable comments (alias constructive criticism). The assessments were given after the second, third and final reports.

The reports were evaluated by the instructor and returned to the students with comments, and in class, a general summary of the report comments was presented to the class. This also indicated to the students the progress of the other teams and gave them an indication of the other additional materials and shapes under consideration. The questionnaires had a 5 point scale with

“1” being complete disagreement with the statement and “5” being complete agreement with the statement. The first questionnaire had 9 statements (Appendix 2), the second questionnaire had 15 statements (Appendix 3) and the final questionnaire had 5 statements (Appendix 4). In addition all questionnaires had an “Other Comments/Recommendations” section and the final questionnaire had 4 additional completion questions indicating what were the three best factors you liked about the program, the three factors that you did not like in the program, what specific program improvements would you suggest and what additions would you suggest for the instruction manual. The numbers of responses for the questionnaires were 36 for the first, 34 for the second and 32 for the third. The class had an initial enrollment of 44 students and final enrollment of 43 students, so the response rate was over 70 percent for all of the questionnaires.

The results for Questionnaire 1 for the nine items that were given to the students are summarized in Table 2. Comments in the “Other Comments/Recommendations” section were:

1. Computer is broken and lab does not have macros.
2. Could not get the program to open even after changing macros.
3. I don’t like this project. I am not a “project” guy.
4. For the current team size 2-3 is better, more than that it is hard to get everyone together and get everyone to participate.
5. Not sure I got same results.
6. It is not transparent how calculations are made for values obtained.
7. I would sincerely consider cancelling the project, giving us all A’s and letting us go for the semester. If you disagree I am sure we will make D.

Some of the students did not understand that they had to change the security level on their computer to get the macros to work. This was explained and a revised set of instructions was given to the students. It was discouraging that after two weeks, 17 percent of the students didn’t try to open the program to start the project and 37 percent had not tried the program on the example data of two materials given to them in the handout and gone over in class.

Table 2. Responses for Assessment Questionnaire 1 in Percentage Form (Rounded to nearest 1 percent)

Question	Response Level					Average Score
	Complete Disagreement				Complete Agreement	
	1	2	3	4	5	
A	17	11	11	23	37	3.5
B	37	14	14	23	11	2.5
C	15	24	18	35	9	3.0
D	45	27	6	9	12	2.1
E	3	3	11	34	49	4.2
F	3	14	20	26	37	3.8
G	9	6	37	23	26	3.5
H	9	9	26	26	31	3.6
I	31	20	46	3	0	2.2

Questionnaire 2 had several of the same questions as well as several additional questions and the results are summarized in Table 3. Additional questions were asked and high responses of disagreement were expected on Questions J through O as this was at approximately the mid-point of the project. However, some teams had done some or part of this as they were trying to complete the project early. Also, the students were given feedback on what they had turned in and had a better idea of what was expected for the final report. Since there were more questions, there was less feedback on the “Other Comments/Recommendations” section.

Table 3. Responses for Assessment Questionnaire 2 in Percentage Form (Rounded to nearest 1 percent)

Question	Response Level				Complete Agreement	Average Score	
	Complete Disagreement	1	2	3			4
A		0	0	6	9	86	4.8
B		0	6	9	29	57	4.4
C		14	17	26	31	11	3.1
D		11	3	23	26	37	3.8
E		0	0	14	20	66	4.5
F		0	3	11	26	60	4.4
G		0	3	11	29	57	4.4
H		0	3	11	23	63	4.5
I		0	6	34	11	49	4.0
J		9	6	34	46	6	3.3
K		26	20	23	26	6	2.7
L		26	23	31	17	3	2.5
M		26	23	31	17	3	2.5
N		29	14	31	23	3	2.6
O		6	11	20	34	29	3.7

Comments in the “Other Comments/Recommendations” for Assessment Questionnaire 2 were:

1. We need more in-class description of what each progress report should be!
2. Your instructions explain how to add additional materials, but not add shapes, they should.
3. Team size: 2 team members is optimal, not difficult or involved enough for more.
4. Question C. Didn’t always work – run time error.
5. Would request to know what the sensitivity analysis consists of before it is due.

The comments were helpful as the program needed to adjust the starting factor for the hollow sections as the answer was smaller than expected and the search macro would not work. This was the cause of the run time error. It also became apparent that students often have difficulty in getting together for projects outside of class, and although they had e-mail addresses of the other team members, there was not that much communication. One group of 5 students broke into two groups of 2 and 3 members.

The third questionnaire had only 5 questions for a numeric response and another 5 questions soliciting written comments. The numeric responses for Assessment Questionnaire 3 are in Table 4. The questionnaire was given the day the project was handed-in for grading. Few comments were given in the comment section, but students who gave comments tended to give several comments. Question A was the same in all three questionnaires and the most favorable responses increased significantly from 37 to 83 percent going from the first to third questionnaire, but the second questionnaire had a slightly higher average score and the most favorable response was 86 percent. This was strange, but the some of the students responding in the second and third questionnaires were different.

Table 4. Responses for Assessment Questionnaire 3 in Percentage Form (Rounded to nearest 1 percent)

Question	Response Level				Complete Agreement	Average Score
	Complete Disagreement	1	2	3	4	5
A	0	3	10	3	83	4.7
B	13	27	20	20	20	3.1
C	3	3	10	40	43	4.2
D	33	20	20	10	17	2.6
E	0	0	27	30	43	4.2

Most of the comments were on the best desirable factors and the least desirable factor of the program. Some of the best factors that were given most were:

- very fast
- graphs were done (automatically)
- values easy to input
- free(students did not have a fee)
- pre-programmed shapes
- results organized

Some of the items disliked most were:

- security settings inconvenient
- inputting inertia for added shape
- had to re-enter additional material
- couldn't trouble shoot problems
- add a tab for user instructions

The other three sections had fewer comments, but several possible improvements were suggested as well as a few additions. Some of the specific improvements suggested were:

- make materials easier to add
- illustrations of the shape selections
- better description of the variables
- better description of hollow sections
- allow program changes to be saved
- better definitions of variables

- Some of the additions for the instructions were:
- better trouble-shooting section
  - more class instruction
  - display geometrical dimensions

### **Plans and Actions from Questionnaire Responses**

The project was rather difficult and will be improved before it is again offered. The difficulty was in the limitations for the shape as one wanted the width to be 1.5 inches and this would make it over-designed for shapes which had only one variable, such as a solid circle, square or equilateral triangle. Thus the reasonable solutions were the hollow shapes where the thickness was a variable, but this made the equations complex for the inertia. The rectangle and I-beam shape were possible, but many teams would put in too many inputs and thus not get the answers they expected. Some students also had difficulty in drawing the shapes and understanding the terms, even though each team had at least one mechanical engineering student.

The alternative projects of bridge spans and cantilever decks will be used as they do not have the problems that the ladder problem has. The factors on cold working and hollow sections will be removed from the input sheet as these were to be adjustments to the cost equations and these will be put on the individual materials as part of the material input.

More instruction will be given in class as suggested and a specific simple case will be assigned as a homework problem and each student will be required to do an individual solution. Currently only one or two members of the team actually use the program and they do not compare results to find out if they have made errors in the input values. The addition of a material will be illustrated and they will be shown how to add it permanently to their file. The students will be given an explanation of sensitivity analysis and how to utilize it in presenting their results.

The team size will be limited to a team of 4 as a maximum, with 3 being the optimal size. Since this is an interdisciplinary team project, the minimum size would be two, but that would not involve much team work. A team member evaluation sheet is given to each student on each team and the average rating is used to adjust an individual team member's project grade. This member performance generally varies from 85-110 percent, but more than 90 percent of the values are from 95-105. The form for each team member evaluation is in Appendix 5. The form is shown to the team at the beginning of the semester so they how know the evaluation will be performed.

### **Summary and Conclusions**

The project has accomplished its purpose of having students recognize the importance of material properties, mechanical properties and shape upon the cost of an item. It integrates these properties, but the many students have a difficult time as they have passed courses but not necessarily learned the materials that are taught in the courses. The students can develop their

own program, but have not done so and thus in spite of all the complaints, they use the program rather than develop their own program.

It was surprising to obtain as many responses and fewer questions will be used in the class of more than 100 students as it will take too long to analyze the responses. Perhaps the questions will be completed by the teams rather than by individual team members.

The project will be spread over 10 weeks instead of 9 to give more time between the individual reports, especially between the final draft and the final report. The students do prefer to have the project due before the last two weeks of the semester when all other projects and exams are given. More class time will be given to the project for instructions and for team meetings. The lecture materials can be reduced as the materials review will no longer be necessary. The project portion of the course will be increased from 20 to 25 percent to illustrate the importance of team work.

The program instructions will be reviewed and updated to address some of the specific comments. Modifications will be made for the factors concerning hollow shapes and cold working. Some trouble shooting hints will be added to the instructions as well as a better explanation of the output variables, but as engineers it is important to be able to sketch the section shapes to know if they have the correct solution.

This project is the only project that students have that integrates material properties, mechanical properties, and shapes for different design requirements of deflection and load that also considers costs. Although one does not like to make changes, it does prevent students from using previous project reports as the answers will change with the program changes, and thus there are some benefits to changing the program.

#### Bibliographic Information

1. Creese, Robert C. and Gupta, Deepak, "Economic Evaluation of Structures of Different Shapes and Materials with Processing Considerations", Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition, 2005, American Society for Engineering Education.
2. Creese, Robert C. and Gupta, Deepak, "Software for Materials Evaluation", Proceedings of the 2007 American Society for Engineering Education Annual Conference & Exposition, 2007, American Society for Engineering Education.
3. Creese, Robert C. and Gupta, Deepak, "An Integrated Approach to Manufacturing Design", Proceedings of the 2007 American Society for Engineering Education Annual Conference & Exposition, 2007, American Society for Engineering Education.



## Appendices

### Appendix 1. Project Problem for Fall 2007

IMSE 302 Manufacturing Processes – Fall 2007  
(Interdisciplinary Team Project – 2-3 member teams)

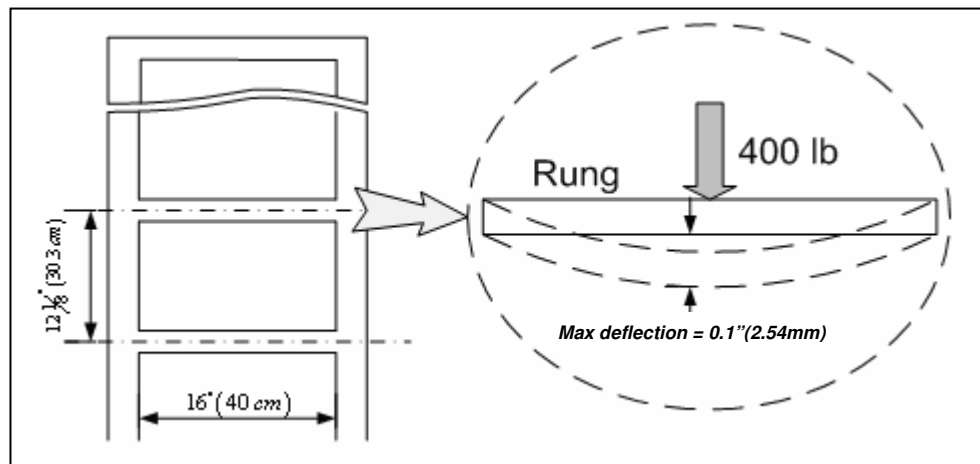
Design Problem with Alternative Materials and Shape Variations  
USA Version (metric version)

The CEO of RCC, LTD is entering the ladder business and wants the design team to design rungs for the ladder. The design engineer has estimated that the rungs will need to support a dead load of 400 lbs. (182 kg) with a maximum deflection of 0.100 inches (2.54 mm). The rungs have a length of 16 inches (40 cm) and the height between rungs is 12 1/8 inches (30.3 cm). The rungs have a cost penalty of \$ 0.50 per pound for every pound over 0.40 pounds as light weight is greatly desired for extension ladders. Assume the extension ladder will have 12 rungs and the sides will weigh 4 times the total weight of the rungs.

The initial materials and the material properties being considered are:

	Young's Modulus(E) (psi x 10 <sup>6</sup> )	Yield Strength( $\sigma$ ) (psi x 10 <sup>3</sup> )	Density ( $\rho$ ) (lb/in <sup>3</sup> )	Cost (\$/lb)	Melting Point (K)
Steel (low C)	30	50	0.28	0.80	1800
Aluminum	10	35	0.10	2.20	900

A sketch of the ladder loading is:



The design considerations for strength and stiffness for center single point loading with fixed ends are:

For Strength

$$\sigma = PLc/8I$$

where

For Stiffness

$$\delta = PL^3 / 192EI$$

For Square Cross-Section

$$b=h$$

$$c = h/2$$

$$I = (1/12) bh^3 = (1/12)h^4$$

$\delta$  = maximum deflection limit (0.10 inches, 2.54 mm)

L = rung length (16 inches, 40 cm)

P = design load (400 lb., 182 kg))

E = Young's Modulus

$\sigma$  = Yield Strength

b = rung width

h = rung height thickness

The total cost is the sum of the material cost, processing cost, and the cost penalty. The processing can be approximated by the expression:

$$C_p = (P/A_c) \times (T_{mp} / 1800) \times CW_f \times HT_f \times R_{pc} \times L \times A_c \times N_I$$

Where:

P = total Perimeter of Cross-section (in)

$A_c$  = cross-sectional area (in<sup>2</sup>)

$T_{mp}$  = melting point of alloy (degrees K)

$CW_f$  = cold work factor = 1.25 if material is cold worked, otherwise use 1.0

$HT_f$  = heat treating factor = 1.35 if material is heat treated, otherwise use 1.0

$N_I$  = hollow internal section factor = 0.70 if material has a hollow internal section, otherwise use 1.0

L = part length (in)

$R_{pc}$  = relative processing cost = 0.03 \$/in<sup>2</sup>

note:

1)  $PC/A_c$  = shape factor

2)  $T_{mp}/1800$  = temperature processing factor (materials with higher melting points are more difficult to process as the hot working temperatures are higher)

3)  $L \times A_c$  = volume factor

4) Some material costs already include the processing costs and the factors for cold working or heat treatment. If these are in the costs, then they do not need to be included again.

Base Solution – Shape is square cross-section; therefore  $I = (1/12) bh^3 = (1/12) h^4$  as  $b = h$ .

Deflection Constraint

$$\delta = PL^3 / 192EI = \delta = PL^3 / 192E(h^4/12) = PL^3/16Eh^4$$

thus

$$h = (PL^3 / 16E\delta)^{0.25} = (400 \times 16^3 / 16 \times E \times 0.10)^{0.25} = (1.024 \times 10^6/E)^{1/4}$$

Strength Constraint

$$\sigma = Mc/I = (PLc/8I) = ((PL h/2)/(8 \times h^4/12)) = ((3PL)/(4h^3))$$

thus

$$h = (3PL/4\sigma)^{0.333} = (3 \times 400 \times 16/4 \times \sigma)^{0.333} = (4.8 \times 10^3/\sigma)^{1/3}$$

thus to satisfy both constraints,

$$h = \max [ (1.024 \times 10^6/E)^{1/4}, (4.8 \times 10^3/\sigma)^{1/3} ]$$

for steel  $E = 30 \times 10^6$  psi and  $\sigma = 50 \times 10^3$  psi and thus

$$h_{\text{steel}} = \max[ 0.430 \text{ in}, 0.458 \text{ in} ] = 0.458 \text{ in (strength(load) is the binding constraint)}$$

for aluminum,  $E = 10 \times 10^6$  psi and  $\sigma = 35 \times 10^3$  psi and thus

$$h_{\text{Al}} = \max [ 0.566 \text{ in}, 0.516 \text{ in} ] = 0.566 \text{ in (stiffness(deflection) is the binding constraint)}$$

Cost Totals

Material Costs

$$C = C_R \times \rho \times A \times L$$

$$C_{\text{steel}} = 0.8 \text{ \$/lb} \times 0.28 \text{ lb/in}^3 \times (0.458 \text{ in})^2 \times 16 \text{ in} = \$ 0.752$$

$$W_{\text{steel}} = 0.28 \text{ lb/in}^3 \times (0.458 \text{ in})^2 \times 16 \text{ in} = 0.940 \text{ lb}$$

$$C_{\text{Al}} = 2.2 \text{ \$/lb} \times 0.10 \text{ lb/in}^3 \times (0.566 \text{ in})^2 \times 16 \text{ in} = \$ 1.128$$

$$W_{\text{Al}} = 0.10 \text{ lb/in}^3 \times (0.566 \text{ in})^2 \times 16 \text{ in} = 0.514 \text{ lb}$$

Penalty Cost(for weight above 0.40 lbs @ 0.50/lb)

$$\text{Steel} = (0.94 - 0.40) \times 0.50 = \$0.270$$

$$\text{Al} = (0.514 - 0.40) \times 0.50 = \$ 0.057$$

## Processing Costs

$$C_p = (P/A_c) \times (T_{mp} / 1800) \times CW_f \times HT_f \times R_{pc} \times L \times A_c \times N_l$$

$$C_{p\text{-steel}} = (4 \times 0.458 / 0.458^2) \times (1800 / 1800) \times 1.0 \times 1.0 \times 0.03 \times 16 \times 0.458^2 \times 1.0 = 0.879$$

$$C_{p\text{-Al}} = (4 \times 0.566 / 0.566^2) \times (900 / 1800) \times 1.0 \times 1.0 \times 0.03 \times 16 \times 0.566^2 \times 1.0 = 0.543$$

## Total Cost

$$\text{Steel} = 0.752 + 0.270 + 0.879 = 1.901$$

$$\text{Al} = 1.128 + 0.057 + 0.543 = 1.728$$

In this case, aluminum has a total cost advantage (about \$ 0.17). However, steel has a material cost advantage (about \$ 0.38). If the penalty costs were not included, steel would have a slight cost advantage (about \$ 0.04). Thus, one can understand the problems that occur in selecting materials, and that total cost is desired. The values for penalty costs and processing costs must be accurate to have accurate total costs.

Estimated total weight of the ladder:

$$\text{Steel} = 12 \text{ rungs} \times 0.94 \text{ lb/rung} \times 4 \text{ factor} = 45.1 \text{ lbs}$$

$$\text{Aluminum} = 12 \text{ rungs} \times 0.514 \text{ lb/rung} \times 4 \text{ factor} = 24.7 \text{ lbs}$$

Aluminum has a definite weight advantage.

## The Project Assignment

These costs are unacceptable to the CEO and he wants to see how much you can lower the costs without decreasing the load capacity or increasing the deflection limit, as more movement would be noticeable.

The CEO has been advised by his lawyer to increase the safety factor and increase the load to 800 pounds (364 kg) and his ergonomist has advised him to make the width of the rung at least 1.5 inches (3.81 cm).

Your team is to consider other materials [those in Table 6.2 (increase the costs by 50%) and select at least one additional material] You are also to consider the following shapes:

- 1) Rectangular – width = 2 x thickness  
width = 3 x thickness
- 2) Equilateral triangle (point down)
- 3) I-beam with flange thickness 1/8 inch (3.18 mm), I thickness = 1/4 inch (6.35 mm)
- 4) Hollow box beam (minimum thickness 0.080 inches or 2.03 mm) (determine height as width is specified)
- 5) Hollow Circle (diameter = 1.5 inches, minimum thickness is 0.080 inches (2.03 mm))
- 6) A flange shape (minimum thickness is 0.080 inches, height is variable)
- 7) Optional – one additional shape of your selection

Minimum additional design changes to be considered:

- 1) Making a wide-body ladder, that is increasing the rung length from 16 inches to 20 inches to meet the larger body and keeping the same constraints.
- 2) Increase the design load to 1,600-lb (727.3-kg)
- 3) Increase the maximum deflection to 0.200 inches (5.08 mm)
- 4) Decrease the maximum deflection to 0.050 inches (1.27 mm)

You may use the computer program developed by Mr. Gupta for many of the cases, but you may need to develop a program for the flange shape and hollow circular shape.

The output should include the dimensions of the rung and the parameter, such as thickness, for both constraints and the value selected. Put the results into tables in the report. In addition, any derivations for the formulas for the additional shapes should be included in the report.

The selection should consider the best material and the three next best alternatives. This should be done for total cost, material only cost, weight, and volume. If you use a combined weighing index, explain the index and why you used it.

Super students only – what would be the difference if the loading was considered as uniform loading instead of single point loading. Consider this for only your best scenario.

Prepare a report recommending your selection of which material and shape would be used. Include the cost savings your design versus the original square shape.

## Report Requirements

The report should be of the form of a research report. The report will be kept by the instructor, so make your own copy if you want one. The report should include:

**1. Title Page** – Project Title, Report Team, Date, Course, Instructor, and other important information

**2. Abstract** – A brief description of what was done and brief summary of the results. Maximum of 150 words

**Or**

**Letter of Transmittal** – A one-page letter to the report recipient summarizing the problem and constraints, the alternatives considered, and the solution recommended.

**3. Introduction** – Expands on the abstract's descriptive material, provides an overview of the organization of the report, the procedure used to arrive at the solution indicating the assumptions made and the objectives of the report. It does not include the results.

**4. Main Body** – 3 sections

a. Goals, Issues and Expectations

b. Formulas, analyses, assumptions and simplifications in sufficient detail so someone can reproduce results. Derivations of specific formulas should be included in the report as they are critical to your solution. Methods used for the solution(flow chart them) must be in the report. These will be evaluated upon validity and appearance.

c. Results of the models or experiments.

Note: **Tables have titles at the top of the table and Figures have titles below the figure.** Use tables and figures to illustrate critical points in the discussion of the results. Give appropriate numbers to figures and tables.

**5. Discussion of Results** – Relate the results back to the goals, issues, and expectations of the project. What is the significance and implications of the results? What are the uncertainties and possibilities of errors in assumptions, simplifications, specifications, and model? Also, include ideas and suggestions for improving the project.

**6. Summary, Conclusions, and Recommendations** – Conclusions are generalizations of the results from the project.

For example, solid sections and hollow sections were considered and what were their differences?

What is your recommendation for the project and why have you selected this material and design? What is your alternative material? What is your alternative design?

**7. References** – Critical sources of information and data used for the report, such as for formulas used, consultants used, data used, etc.

**8. Appendices** – Non-critical data from programs used to find values reported in tables, methods for generalizing the results from the data, etc. The work breakdown schedule of assigned tasks and task completion each week is to be included.

Evaluation – **An evaluation of the team effort(did you work as a team) and possible improvements. Grades may be modified for individuals based upon the performance on team and attendance at team meetings.**

This report guideline is a modified version of that by Corrado Poli in Design for Manufacturing, Pages 323-363.

## **Tentative Report Evaluation (maximum of 100 points)**

(Report will be evaluated based upon appearance and content)

### **1) A bound report, disk of report, and cover materials(5 points)**

### **2) Abstract/Cover Letter (5 points)**

### **3) Introduction(5 points)**

### **4) Main Body and results (60 points)**

a. (30 points)    b. (10 points)    c. (20 points)

a. Evaluation of Tables and Figures. Put the results for each of the cases into separate tables. Indicate the material required to meet the shape, load and deflection requirements and give the cost, weight, and material volume for each material. Rank each of the materials in order of your selection preference and discuss the ranking system used in the discussion section. Rank each of the materials according to cost, weight and volume and then use any other index, but define how the index is determined.

b. Give derivations of the expressions/formulas used for each of the additional shapes investigated and the sources used. Put these into a summary table for all expressions for comparison purposes of all the cases. Present the derived expressions and the derivations of the expressions in the report.

c. Discuss your results and give your conclusions/recommendations as to what shape and what material should be used. Give the best shapes for each material. A discussion of the effect of the shape upon the material costs, weights, and volumes should be presented. If possible, determine what would be the maximum additional processing costs that could be afforded for the different shaping processes.

Some specific questions to be addressed are:

i) The effects of the additional design changes

ii) The effect of your additional shape

iii) The effect of your additional material

### **5) Summary and Conclusions (5 points)**

### **6) References and Appendices (10 points) – neatness counts**

### **7) Project Evaluation (10 points)**

A separate one page evaluation of the project at the end of the report as to the amount of work, the amount of understanding/knowledge gained, the interdisciplinary team interactions, and what should be changed to improve this assignment. This should be a summary of the team meeting times, team member attendance at the meetings, and external consultants utilized. In addition, the meeting minutes should be included for each meeting indicating the meeting chair, the meeting agenda, meeting attendance, assignments, start and end times, and the assignments, date, and time for the next meeting. Each student should be chair of at least one meeting. This evaluation may be used for the ABET evaluation of the ME and IE programs.

The work breakdown schedule should be considered in the evaluation of individuals as individuals cannot be blamed for not doing work if they are not assigned work. Individuals who do not attend meetings are responsible for the work assigned and if it must be reassigned, that can be held against the individual in the peer evaluation performance rating. This peer performance rating will be done after the project is turned in and will alter the assigned final grade to the individuals.

## Appendix 2. Assessment Questionnaire 1

Name\_\_\_\_\_

Date\_\_\_\_\_

### IENG 302 Assessment Questionnaire 1 for Computer Program and Project Fall 2007 This survey will not unfavorably impact your grade.

To assist in understanding of the interaction of the material properties, mechanical properties, and the product shape upon the total material cost, the computer program was developed to reduce the calculation discrepancy in evaluating numerous shapes. You were requested to evaluate one or two shapes not in the compute program to illustrate that you understand the calculation process. The following questions are asked to assess the value of the software. Please use a scale of “1” to “5”, “1” being “**Completely Disagree**” or “**Definitely NO**” and “5” being “**Completely Agree**” or “**Definitely Yes**”.

A. You have opened the program and tried to use it.

(1) (2) (3) (4) (5)

B. You tried the program on the example data and obtained the same results

(1) (2) (3) (4) (5)

C. The program was relatively easy to understand and work with compared to other software program you have used.

(1) (2) (3) (4) (5)

D. You did try the graphics option and were you successful

(1) (2) (3) (4) (5)

E. The current team size of 2-5 students seems optimal for the project.

(1) (2) (3) (4) (5)

F. You have made the final selection on your additional material.

(1) (2) (3) (4) (5)

G. You have obtained all the necessary material properties and costs for the additional material.

(1) (2) (3) (4) (5)

H. You have made the final selection of your additional shape.

(1) (2) (3) (4) (5)

I. You have determined the expressions for the centroid and moment of inertia for your additional shape.

(1) (2) (3) (4) (5)

**Other Comments/Recommendations:**



### Appendix 3. Assessment Questionnaire 2

Name\_\_\_\_\_

Date\_\_\_\_\_

#### IENG 302 Assessment Questionnaire 2 for Computer Program and Project Fall 2007 This survey will not unfavorably impact your grade.

To assist in understanding of the interaction of the material properties, mechanical properties, and the product shape upon the total material cost, the computer program was developed to reduce the calculation discrepancy in evaluating numerous shapes. You were requested to evaluate one or two shapes not in the compute program to illustrate that you understand the calculation process. The following questions are asked to assess the value of the software. Please use a scale of “1” to “5”, “1” being “**Completely Disagree**” or “**Definitely NO**” and “5” being “**Completely Agree**” or “**Definitely Yes**”.

A. You have opened the program and tried to use it.

(1) (2) (3) (4) (5)

B. You tried the program on the example data and obtained the same results

(1) (2) (3) (4) (5)

C. The program was relatively easy to understand and work with compared to other software program you have used.

(1) (2) (3) (4) (5)

D. You did try the graphics option and were you successful

(1) (2) (3) (4) (5)

E. The current team size of 2-5 students seems optimal for the project.

(1) (2) (3) (4) (5)

F. You have made the final selection on your additional material.

(1) (2) (3) (4) (5)

G. You have obtained all the necessary material properties and costs for the additional material.

(1) (2) (3) (4) (5)

H. You have made the final selection of your additional shape.

(1) (2) (3) (4) (5)

I. You have determined the expressions for the centroid and moment of inertia for your additional shape.

(1) (2) (3) (4) (5)

**J.** You have done the sensitivity analysis(1=not started, 5 = completed)

☐ 1      ☐ 2      ☐ 3      ☐ 4      ☐ 5

**K.** You have plotted the changes in cost versus the changes in load.

☐ 1      ☐ 2      ☐ 3      ☐ 4      ☐ 5

**L.** You have plotted the changes in cost versus the changes in the deflection limit.

☐ 1      ☐ 2      ☐ 3      ☐ 4      ☐ 5

**M.** You have determined the amount you have saved(cost) over the initial square shape for the same load. (1=done nothing, 5 = completed)

☐ 1      ☐ 2      ☐ 3      ☐ 4      ☐ 5

**N.** You have determined the amount you have saved(weight) over the initial square shape for the same load. (1= done nothing, 5 = completed)

☐ 1      ☐ 2      ☐ 3      ☐ 4      ☐ 5

**O.** The required preliminary reports has helped your team better prepare your final project report.

☐ 1      ☐ 2      ☐ 3      ☐ 4      ☐ 5

**Other Comments/Recommendations:**

#### Appendix 4. Assessment Questionnaire 3

Name\_\_\_\_\_

Date\_\_\_\_\_

#### IENG 302 Assessment Questionnaire 3 for Computer Program and Project Fall 2007 This survey will not unfavorably impact your grade.

To assist in understanding of the interaction of the material properties, mechanical properties, and the product shape upon the total material cost, the computer program was developed to reduce the calculation discrepancy in evaluating numerous shapes. You were requested to evaluate one or two shapes not in the compute program to illustrate that you understand the calculation process. The following questions are asked to assess the value of the software. Please use a scale of “1” to “5”, “1” being “**Completely Disagree**” or “**Definitely NO**” and “5” being “**Completely Agree**” or “**Definitely Yes**”.

A. You have opened the program and tried to use it.

①      ②      ③      ④      ⑤

B. The program was relatively easy to understand and work with compared to other software program you have used.

①      ②      ③      ④      ⑤

C. The current team size of 2-5 students seems optimal for the project.

①      ②      ③      ④      ⑤

D. You developed your own program to calculate the sizes and costs for the different loads and shapes

①      ②      ③      ④      ⑤

E. The required preliminary reports helped your team better prepare your final project report.

①      ②      ③      ④      ⑤

F. What were the three (at least) best factors you liked about the program – please be specific.

1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

4. \_\_\_\_\_

**G.** What were the three items (or more) you disliked most about the program – please be specific.

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_

**H.** What specific improvements would you suggest making to the program to improve its usability?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

**I.** What additions do you have for the instructions(second set) to improve use of the model?

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_

**J.** Other comments and suggestions.

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_

## Appendix 5. Team Member Evaluation Sheet

### IMSE 302 Team Member Evaluation

The project is a team project and all members are expected to participate fully in the project work. The performance of the members and interaction is essential to group work. Each member is to be evaluated by the other team members as to their level of participation and performance. You should include your own performance level as well. Some descriptions of the levels can be considered as:

110% - The leader of the project and the most effective team member – truly outstanding; few groups will have one of these persons. No group would have more than one person in this category.

100% - Actively participated in the meetings, performed their share of the work and missed one or fewer team meetings. A full team member. Active teams with good meetings may have all or most members in this group.

93% - Did some work and/or missed two or fewer team meetings – worked & some contribution, but not a full member

85% - Did some work and missed two or more team meetings – adequate effort

77% - Did little work and missed two or fewer team meetings; no real contribution in the major decisions. – a slacker

70% - Did little work and missed three or more team meetings.- did some work, but rarely showed up

63% - Did little work and rarely participated in team meetings - mainly sat on the sideline, a few useful comments

55% - Did no work and rarely participated, but did attend 3 or more meetings – shows up, but no real help

45% - Did no work and attended 2 or fewer meetings – not really a team member

25% - Did no work and attended 1 or fewer team meetings – definitely not a team member

Team Number\_\_\_\_\_

Team Member	Rating
1. _____	_____
2. _____	_____
3. _____	_____
4. _____	_____
5. _____	_____