Shaping Good Old-Fashioned Students: A Homework Methodology

Timothy A Wood, Ph.D., P.E.; Dan Nale, Ph.D., P.E.; and Kweku Brown, Ph.D., P.E.
The Citadel: The Military College of South Carolina

Abstract

The latest iteration of a dual submission homework methodology encourages strategic and critical thinking, multiple interactions with the homework materials, and reflection on how to improve content mastery and homework performance. The modern student needs instruction and practice to learn how to develop new skills and master new concepts. Through forced practice and guided reflection, students develop the habits of study and mind common to good students in every age. The presented dual-submission homework methodology supports multiple development goals. Student survey responses illustrate the degree to which students understand and appreciate the structure and impact of the homework methodology.

Keywords

Homework, Lifelong learning, Self-directed learning

Introduction and Background

Students entering college from the public schooling systems struggle to know how to take ownership of their learning. Public education's emphasis on creating a uniform and equitable society has caused many to ask if high school graduates know how to think critically, learn new skills and internalize knowledge apart from simple information recall [1–4]. Incoming engineering students often struggle to develop the math and science comprehension needed for success in college. That said, professional engineering organizations clearly understand that practicing engineers must be capable self-directed and lifelong learners [5]. For many years, the practice of having "weed out" courses functionally resulted in retaining only those students capable of some level of self-directed learning. One author's experience suggest that arrival at college equipped with the tools of learning [6] leads to interactions in the classroom as convenient redundancy in the learning process, rather than the pivotal component. However, this is simply not the case for many students entering engineering programs. The current, rightful emphasis on college retention has made the problem more difficult. Engineering programs seek to provide students with every progressive pedagogy and resource to support their learning, including flipped classrooms, active learning techniques, adaptive homework, and mastery. Yet with all these measures, students often fail introductory engineering mechanics courses at alarming rates [7]. Perhaps high failure rates have less to do with teaching innovation and more to do with a lack of student learning skill.

Furthermore, student expectations have shifted generationally. At one engineering school in the 1980s, the instructors assigned readings and homework problems with no intention of collecting homework or holding students directly accountable for reading. The small fraction of students who persevered through weed out courses often recognized that they must read and work homework problems to pass the class examinations. By the late 1990s and early 2000s, homework was collected in most classes and graded either comprehensively or by sample by the

instructor. Many students would ignore instructor feedback, simply content with a passing grade for the homework set, again often resulting in abysmal passing rates. Regardless of the era, students perform best in courses when they engage with homework in a way that actively increases their understanding. The most recent developments in a previously published homework methodology [8–10] develops students abilities as self-directed lifelong learners.

Conceptual Evaluation of Methodology

Effective homework, at the minimum provides for "practice, instructor observation, and self-assessment" [9]. The dual-submission methodology presented in the appendices consist of activities intended to walk the students through the habits of mind common to autodidacts and lifelong learners. In an initial submission coversheet, students are prompted to strategize about the intended goal of the homework (usually defined by the instructor in terms of course content learning objectives), whether they completed the homework, and then reflect on what they did and did not learn from the homework. Students then submit their homework on the learning management system. After the initial due date, the instructor posts solutions to the homework problems. Student then use a self-assessment coversheet to facilitate correcting their work, assessing of their performance, reflecting on what they still must learn and then submitting both corrections and self-assessment. This dual submission process provides students with the needed practice and self-assessment, while the coversheets give instructors an easy view of the development of student learning. [9]

Additionally, effective homework via the dual submission process supports the development of lifelong learning skills. The ASCE Body of Knowledge provides Bloom's Level Cognitive domain outcomes related to Lifelong Learning. Most students can "identify" their need for engineering knowledge and skills; therefore, they are taking engineering courses. By asking the students to strategize their approach to the homework on the initial attempt coversheet, students are forced to "explain" their need. This strategizing forces a level of intentionality in learning activities common to autodidacts. By attempting the homework problems, students actually "acquire new knowledge, skills, and attitudes" through practice. After completing their work, like good self-directed learners, students are asked to reflect on their experience and "analyze" what they have learned and what they have left to learn. [5]

The self-assessment continues to support the habits of lifelong learning. The process of correction allows students to "integrate" the knowledge solidified through correct homework attempts with awareness of what new knowledge they have yet to fully master [9]. By self-assessing their work and reflecting on what confusion might remain, students can "evaluate" the effectiveness of their learning efforts [9]. Ultimately, they end the homework process well positioned, whether they realize it or not, to attack the learning that remains through questions in the classroom and focused studies before exams. The dual submission homework methodology not only provides the "practice, instructor observation, and self-assessment" key to beneficial homework; it also engages students in the patterns of lifelong learning, holding them accountable for critical thinking and self-directed reflection about their homework. [5,9]

Value to Instructors

The dual submission homework methodology has been a significant help to instructors. Once students have been trained to complete the coversheets, particularly the punch lists (Appendix B), the faculty can quickly assign grades in a learning management system (LMS) using straight forward rubrics (Appendix C). Efficient grade assignment can significantly increase faculty time available for course development and office hours. Additionally, instructors can increase positive rapport with students even if they fall behind in grading since the students have interacted with the solutions in a timely manner. Typically, the rubrics also help the students take responsibility for their grade rather than quibbling over more subjective assignments of points.

Value to Students

In general, students also value the dual submission homework methodology. Figure 1 shows survey responses concerning engagement in learning. More than 90% of students felt engaged with their learning while attempting and correcting their homework.

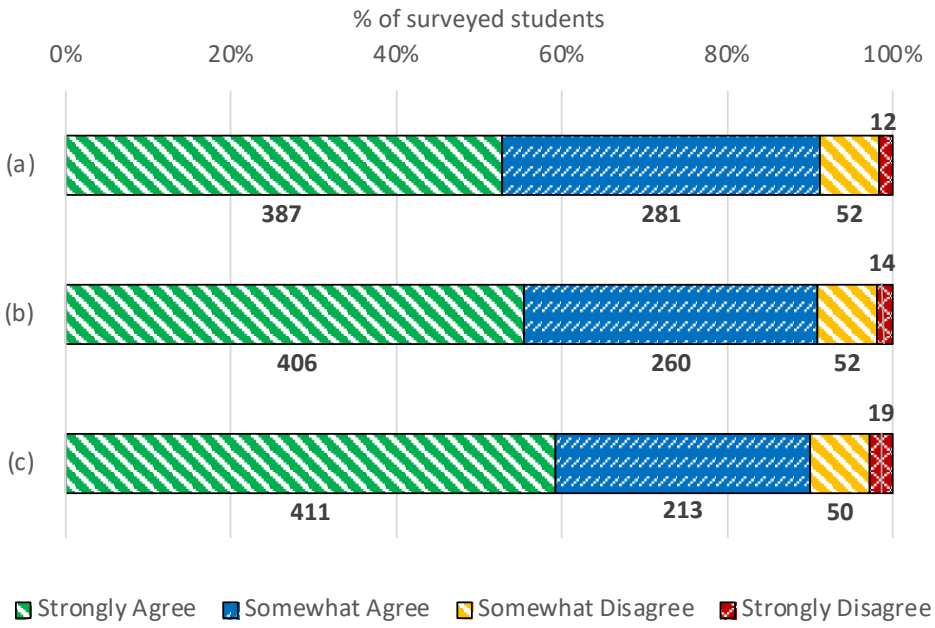

Figure 1. Student survey responses to (a) "During the dual-submission homework process, I feel engaged in my learning while attempting the homework the first time" (*n=732*) (b) "During the dual-submission homework process, I feel engaged in my learning while assessing my homework against the instructor's solution" (*n=732*), and (c) "During the dual-submission homework process, I feel more engaged in learning compared to previous experiences with instructor-graded homework." (*n=693*)

Figure 2 shows that the students are divided about the value of the reflections on the coversheets. Still, more than 60% of the students were engaging with those practices common to lifelong learners: strategizing, reflecting, and reviewing the effectiveness of their learning. Student perspectives on reflection might be increased through intermittent direct instruction on lifelong and self-directed learning.

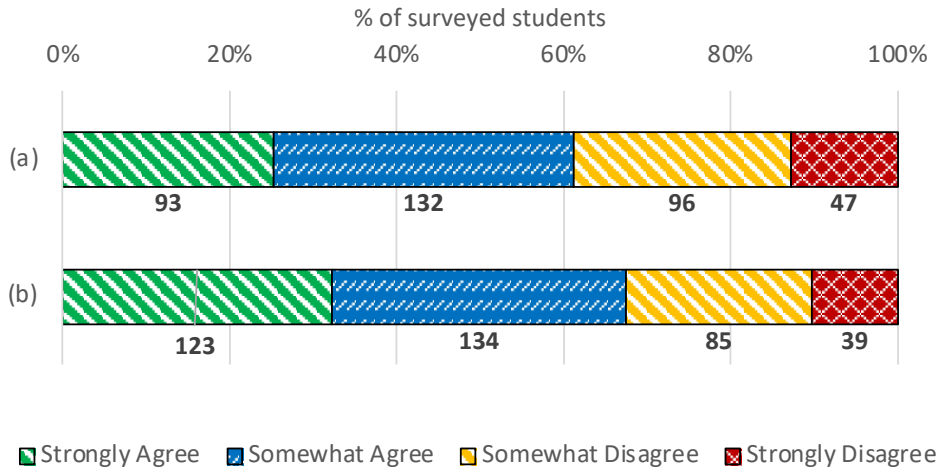

Figure 2. Student survey responses to (a) "The Initial Attempt Coversheet helped me consider what I learned and how to improve" (*n=368*) and (b) "The Self-Assessment Coversheet helped me consider what I learned and how to improve" (*n=381*)

Figure 3 shows that 57% of the students were most helped by the self-assessment portion of the homework. This self-assessment is the activity often completely neglected in more traditional, instructor-graded homework methodologies. However, the process of review solutions was key to success for the successful graduates of engineering programs in the past.

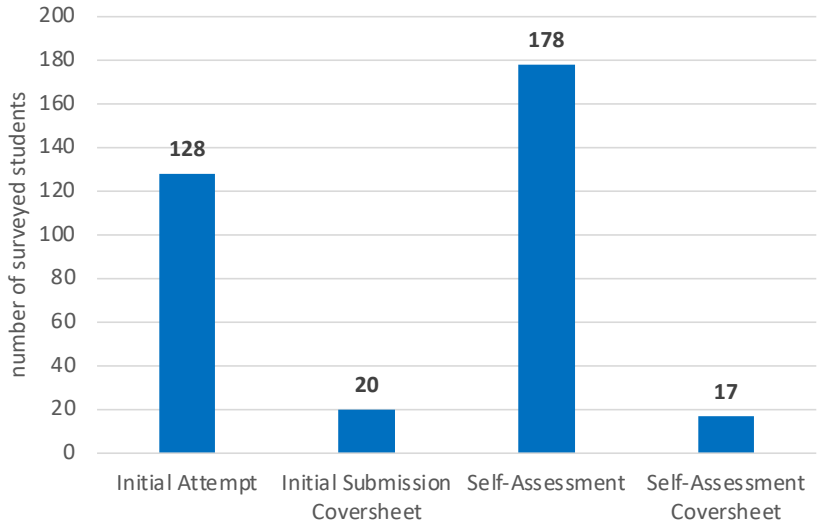

Figure 3. Student survey response to "The portion of the homework process that helped me learn the most was..." (*n=343*)

Figure 4 shows a strong preference for the grade assignment using the dual submission. Again, the instructors found that the student's control over the homework grade dramatically increased student rapport while homework grade distribution continued to fall within normal ranges.

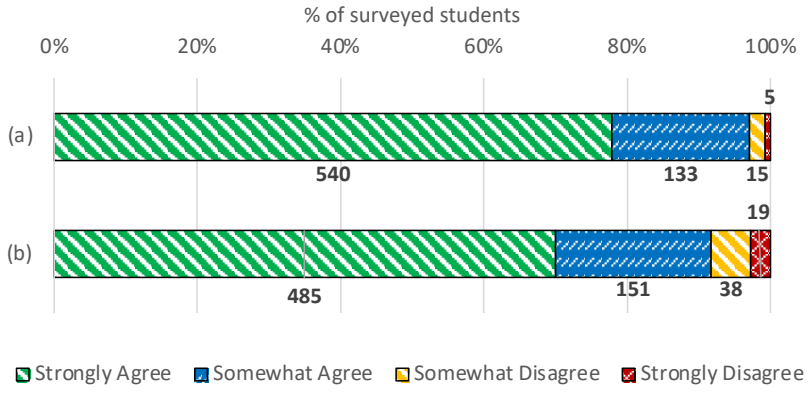

Figure 4. Student responses to (a) "I believe the earned grades to the dual-submission homework process is fair" (*n=693*) and(b) "I prefer the earned grades for the dual-submission homework process compared to previous experiences with detailed instructor-assigned homework grades" (*n=693*)

Figure 5 shows that 88% of students desire to see dual submission homework methodologies implemented in more of their classes. One measure of success is student interest in repeating an experience. On this measure, the dual submission homework methodology succeeds.

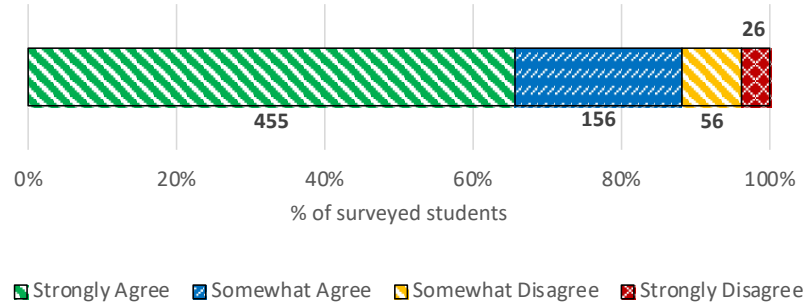

Figure 5. Survey response to "I hope more professors will use the dual-submission homework process" (*n=693*)

Conclusion

The dual submission homework methodology discussed in this paper achieves multiple positive outcomes for both students and instructors. The methodology achieves the basic requirements of beneficial homework by providing "practice, instructor observation, and self-assessment" [9]. The methodology also supports the development to lifelong learning disciplines including identifying, explaining, acquiring, analyzing, integrating and evaluating their understanding and how they are gaining those skills [5]. Both instructors and students have enjoyed the dual submission homework methodology.

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Timothy A. Wood, Ph.D., P.E.

Timothy A Wood is an Associate Professor of Civil and Environmental Engineering at The Citadel: The Military College of South Carolina. He acquired a Bachelor's in Engineering Physics Summa Cum Laude with Honors followed by Civil Engineering Master's and Doctoral degrees from Texas Tech University. His technical research focuses on structural evaluation of buried bridges and culverts. He encourages students through an infectious enthusiasm for engineering mechanics and self-directed, lifelong learning. He aims to recover the benefits of the classical model for civil engineering education through an emphasis on reading and other autodidactic practices.

Dan D. Nale, Ph.D., P.E.

Dan D. Dales is a Professor of Practice of Civil and Environmental Engineering at The Citadel. He received his BS in Civil Engineering from The Citadel, his Masters and Ph.D. in Civil Engineering from the University of South Carolina and his MBA from Mercer University. Dr. Nale's research interests are in Engineering Education and Aerospace Engineering. He previously worked for Gulfstream Aerospace for 35 years, retired as senior vice president of Programs, Engineering, and Test.

Kweku Brown, Ph.D., P.E.

Kweku Brown is an Associate Professor of Civil and Environmental Engineering at The Citadel. He received his Civil Engineering Master's degree from the University of Connecticut and his Doctoral degree at Clemson University. He is active in the transportation engineering communities including South Carolina Department of Transportation (SCDOT), Institute of Transportation Engineers (ITE), and Transportation Research Board (TRB). His research focuses on transportation safety utilizing geographic and spatial analysis methods.

Appendix A. Syllabus Extracts

Individual Homework.

Homework is *for the student*, for his or her learning, practice, and assessment. Many of the homework problems represent intentionally challenging, real-world problems. Working engineers and engineering students must practice problem formulation, problem solving, and solution documentation. Therefore, a proper solution format is required. Students may work together on homework assignments *to gain additional understanding*. More than any other academic activity, continuous practice of concepts establishes long-term mastery. The assigned homework is the *minimum* required practice.

Please consult the following book on problem formulation, solving, and documentation:

Polya, G., and Conway, J. H. (1945). *How to Solve It: A New Aspect of Mathematical Method.* Princeton University Press, Princeton, NJ.

Getting the most from the homework requires at least four separate events. First, students should strive to use the mental and mathematical models discussed in class and the textbook to solve the problem.

Second, before, during and after the process of solving each problem, students should consider why they are working the problem: What principle does the professor intend them to practice or explore? Why does the homework seem easy or hard? What questions remain after attempting the problem? Is the homework solution complete? The initial attempt coversheet explores and documents student answers to these questions.

Third, students must check their work against the solution. The solution should help answer remaining questions about the principles and processes explored in the homework. The student must make the correct processes and techniques his or her own to tackle similar problems on later homework, exams, and future courses.

Finally, students must consider how to align future homework attempts with the expectations of the instructor, and whether the questions about the concepts remain. The self-assessment coversheet provides opportunity for reflection.

Documentation

Students must document any help received from supplemental instruction, classmates, reference books, or the internet. Information from the course textbook (equations and outlines of procedures), class notes, or the professor is immediately available to all students and requires no documentation. For written homework, state who and/or what helped immediately after the provided content.

Solutions

The use of solutions during homework attempts is strongly *discouraged*. Relying on solutions from previous classes, the textbook, or the internet will result in poor performance during the exams. Nevertheless, if published solutions reveal errors, subsequent corrections require proper documentation.

Grading

Homework grading by problem emphasizes effort, completeness, timeliness, and accuracy. Each homework problem can earn up to 10 points. The grade is composed of 6 points for a complete, on-time homework attempt, 1 point if the attempt is correct, and 3 points for self-assessment of the homework attempt. An additional 2 points evaluate coversheet completion per submission.

1. *Initial Attempt:*

   The student will post their initial attempt on the LMS as a single PDF file.

   Each problem will be evaluated based on *timeliness*, *effort,* and *completeness* for up to 60% credit. An additional 10% will be earned for an *accurate* initial attempt. A problem missing any sections (see Appendix A), appropriate figures, and/or a good faith effort at the solution in the required homework format, even with a correct answer, may receive no credit.

   - Each solution attempt must follow the format, including a figure and an answer.
   - All problems in a homework set must be uploaded in a single PDF document. PDFs may be created using personal scanners, smartphone scanning apps or the document scanners at the Daniel Library.
   - The first page must be a complete initial attempt coversheet.

2. *Self-Assessment:*

   The student will post self-assessed homework on the LMS as a single PDF file.

   The remaining 30% credit will be earned by submitting the set of *complete* and *self-assessed* homework problems on Canvas. The professor will provide a minimum of 36 hours access to the solutions before requiring homework assessment. An incomplete assessment may receive no additional credit.

   - Assessment should provide clear documentation of corrections made in a different color.
   - Assessment should identify errors and comprehensively lead to the final correct answers.
   - A minimum of a check mark in a different color next to the correct answer is required.
   - The first page must be a complete self-assessment coversheet.
   - The second page must be the complete initial attempt coversheet from the initial attempt.

Typically, six potential grades can be earned per problem, as seen in Table 1.

Table 1. Potential grades per problem.

Initial Attempt	*Self-Assessment*	*Maximum Grade*
On-time, Complete, and Correct	On-time and Complete	100%
On-time and Complete	On-time and Complete	90%
On-time and Complete	Late or Unsubmitted	60%
Late or Unsubmitted	On-time and Complete	50%
Late or Unsubmitted	Late or Unsubmitted	0%

*Amnesty Day is typically the last class of the semester.

Mandatory Homework Structure

Neat, well-organized, and beneficial homework requires effort. Each complete homework problem must contain the structure and information required for understanding the context, scope, process, calculations, and reasonableness of the solution. Engineers check their work and the work of others; therefore, calculations must be clear, thorough, and presentable. Industry and consulting engineers need new graduates capable of solving problems *and* producing acceptable engineering calculations. A solution should read like a textbook example problem with pertinent details and text explaining the analysis, steps, equations, etc.

The professor will review homework submissions and may make suggestions for improvement. However, disorderly, poorly formatted homework may be returned without a grade. Students must follow the instructions listed below and the format shown on the next page.

Additional homework requirements.

- Tools
  - Work in pencil.
  - Write on 8.5 in. × 11 in., gridded engineering paper.
  - Use a straight edge, compass, and/or protractor to draw figures.
  - Consider acquiring engineering tools: https://rb.gy/xm4eqp
- Presentation
  - Include no more than one problem per page.
    - Number pages per problem if more than one page is needed.
    - Write on only one side of each sheet.
  - Each problem should have a neatly drawn figure(s).
    - Figures should be large enough to be easily read.
    - Variables should appear on figures.
    - Variables should be described using words and symbols.
  - Write legibly, in clear, easy-to-read print.
    - Completely erase any extraneous material.
    - No crossed-out material should appear on the solutions.
    - Leave blank lines between steps, providing space for correction, assessment, and comment.
- Organization using Homework Format (next page).

Homework Format.

Submittal Date Problem #, Page #/# Student Name

Problem #:

Statement: Briefly describe the problem.

Given: Identify known values. Symbolically note all the given information; include necessary figures.

Find: Identify unknown values. State the desired result(s) using words and symbols.

Procedure: Briefly outline the general approach to solve the problem and identify appropriate fundamental concepts.

Solution: Write out in detail the formulation of the solution following the outlined procedure. Text and figures must be neat and professional. Show all the pertinent details of the solution approach.

* The solution should begin with an appropriate figure.
* From the figure write the general equation(s) symbolically.
* Simplify the equation(s) explaining simplifications.
* Populate the simplified symbolic equations with physical quantities represented numerically with units.
* Calculate the final answer, round to appropriate significant figures, and determine the final units.
* Consider and describe the reasonableness of the results.

Answer: Copy those variables identified in the *Find* section and calculated in the *Solution* section.

* Confirm the reasonableness of the answer.
* Check the answer with other sources.
* If there is a discrepancy, go back and rethink the analysis.
* Do not attempt to reverse engineer the correct answer; consult with peers, the SI instructor, tutor, and/or the professor as needed to identify mistakes.

Appendix B. Cover Sheets

Name: _____ CWID:_____ Date: _____

INITIAL ATTEMPT COVERSHEET

Strategize

Write one sentence that summarizes the concepts to be practiced in this homework set.

What principle(s) from the course should shape the mental models required by this homework?

What is the most important concept to be practiced in this homework set?

Initial Attempt

Attempt for the assigned problems from the Semester Homework Problems.

Check Punch List

Evaluate each homework problem solution (√ / **X**) based on *completion* for:

- *Format*: Is the solution formatted as described in the syllabus, providing meaningful information in each section?
- *Figures*: Does the solution include at least one fully labeled figure or diagram as part of the *Given* and/or *Solution* sections?
- *Complete*: Does the solution generate the values(s) identified in the *Find* section and were those value(s) copied to the *Answer* section?

Problem #	*Format*	*Figures*	*Complete*

Reflect

What was the muddiest point in this homework set?

Reflect on how class preparation, class, and study contributed to confidence (or lack thereof) on this homework attempt. What will change to improve confidence?

Submit

Submit a single PDF document scan on Canvas (LMS) including this coversheet as the first page.

Name: _____ CWID:_____ Date: _____

SELF-ASSESSMENT COVERSHEET

Correct

Correct the initial homework solution attempt(s).

- Corrections must include drawing any missing figures and providing corrected work resulting in the correct final answer(s).
- Use a different color to mark errors and make corrections.
- Use check marks (√) by the answer where the initial attempt is correct.

Check Punch List

Evaluate each homework problem solution (√ / **X**) based on *initial attempt accuracy* compared to the instructor solution for:

- *Format*: Was the solution formatted like the instructor solution?
- *Figures*: Did the solution include the similar figures?
- *Complete*: Was the solution complete, calculating the value(s) identified in the instructor's *Find* and *Answer* sections even if not the correct value(s)?
- *Correct*: Did the solution generate the correct value(s) in the *Answer* section?

Problem #	*Format*	*Figures*	*Complete*	*Correct*

Self-Assess

Identify strengths and areas for improvement based on the correction of the initial homework solution compared to the instructor solutions. Provide a check (√) in the appropriate column (*Needs Work/Good/Excellent*) for each category.

Category	Needs Work	Good	Excellent	Strengths	Areas for Improvement
Format					
Interpretation					
Planning / Procedure					
Solution Execution					
Figures					
Equations					
Units					
Checking Work					

Reflect

Reflect on how to improve concept mastery and homework performance in the next homework. Consider the Initial Coversheet *Strategize* and *Reflect* questions.

Submit

Submit a single PDF document scan of self-assessed problems on Canvas (LMS) including this coversheet as the first page and the initial coversheet as the second page.

Appendix C. LMS Rubrics

Initial Attempt Rubric - 1

Initial Attempt Rubric - 1					
Criteria	**Ratings**				**Pts**
Initial Coversheet Followed instructions and used the initial coversheet correctly.	**2 pts** **Full Credit** Followed instructions AND meaningfully responded to all questions AND submitted problems on engineering paper AND submitted only one problem per page.		**1 pts** **Needs Work** Responded to some questions OR submitted problems on lined paper OR submitted multiple problems per page.	**0 pts** **No Coversheet** Initial coversheet not the first page of a single PDF submission.	2 pts
1st Problem Followed instructions and completed the problem with appropriate format, effort, and completeness.	**6 pts** **Completed 3 of 3 Required Elements** Followed the format AND included a figure AND found an answer.	**4 pts** **Completed 2 of 3 Required Elements** Failed to follow the format OR lacked a figure OR failed to find an answer.	**2 pts** **Completed 1 of 3 Required Elements** Only followed format OR included a figure OR found an answer.	**0 pts** **Inadaquate Attempt** Failed to follow the format AND lacked a figure AND failed to find an answer.	6 pts
					Total Points: 8

Self-Assessment Rubric - 1

Self-Assessment Rubric - 1							
Criteria	**Ratings**						**Pts**
Self-Assessment Coversheet Followed instructions and used the self-assessment coversheet correctly.	**2 pts** **Full Credit** Followed instructions AND meaningfully responded to all questions AND corrected problems in a different color.		**1 pts** **Needs Work** Responded to some questions OR corrected problems in a different color.		**0 pts** **No Coversheet** Self-assessment coversheet not the first page of a single PDF submission.		2 pts
1st Problem Followed instructions and corrected the problem with appropriate format, effort, and completeness.	**5 pts** **Self-Assessment without Initial Attempt** WARNING: This grade assigned because the initial attempt failed to follow the format AND lacked a figure AND failed to find an answer OR was completely missing.	**4 pts** **Correct and Complete** Followed the format AND included a figure AND found the CORRECT answer in a form similar to the instructor solution WITH a check mark by the answer.	**3 pts** **Completed 3 of 3 Required Elements** Initial attempt followed the format AND included a figure AND found an answer in a form similar to the instructor solution WITH corrections to the figure and/or solution.	**2 pts** **Completed 2 of 3 Required Elements** Initial attempt failed to follow the format OR lacked a figure OR failed to find an answer in a form similar to the instructor solution WITH corrections to the figure and/or solution.	**1 pts** **Completed 1 of 3 Required Elements** Initial attempt only followed format OR included a figure OR found an answer in a form similar to the instructor solution WITH corrections to the figure and solution.	**0 pts** **No Assessment** Initial attempt un-assessed: lacking a check mark by the correct answer OR corrections to the figure and/or solution.	5 pts
						Total Points: 7	