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”Try One Assignment”: A Practical Introduction to Alternative Grading

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“Try One Assignment”: A Practical Introduction to Alternative Grading

Abstract

Alternative grading methods, such as specifications grading and standards-based grading, are becoming more widely adopted in both K–12 and higher education due to their ability to promote mastery, reduce grading disputes, and cultivate a growth mindset. Unlike traditional points-based grading, these systems emphasize clearly defined standards, actionable feedback, and opportunities for revision without penalty. This approach helps ensure that grades accurately reflect what students can do, rather than how well they navigate a system of partial credit.

While instructors may be intrigued by the philosophy of alternative grading, many are hesitant to commit to a full-course redesign. This paper invites participants to start small by reimagining just one frustrating assignment (e.g., one that is especially time-consuming, produces low-quality student work, and/or often leads to grade complaints). Drawing on the "Four Pillars" of alternative grading (Clark & Talbert), participants will walk through a structured redesign process and leave with a plan to pilot an alternative grading approach on one assignment in their own course.

The authors represent a cross-disciplinary working group of faculty from mechanical engineering, electrical engineering, and physics, and have several years of experience implementing and refining alternative grading practices in a range of classroom settings.

1: Introduction and Background

Alternative grading encompasses a broad family of assessment and grading practices that depart from traditional points-based systems and may be more or less appropriate depending on discipline, course level, and instructional context. While implementations vary in structure and complexity, these approaches are united by two central commitments:

1. Maintaining high standards by awarding credit only for meaningful, demonstrable learning.
2. Providing effective feedback mechanisms that allow students to learn from mistakes and subsequently demonstrate mastery.

Clark and Talbert identify four core principles, or “pillars,” that appear in nearly all alternative grading systems [1]:

1. Clearly Defined Standards - Students know exactly what they must do to meet expectations.
2. Helpful Feedback - Feedback emphasizes how to improve rather than how many points were lost.
3. Marks that Reflect Progress Toward Mastery - Grades communicate attainment of learning objectives rather than averages of performance over time.

4. Reattempts Without Penalty - Students are allowed to revise and resubmit work, fostering a growth-oriented approach to learning.

Two common alternative grading approaches are Standards-Based Grading [2], [3], [4] and Specifications Grading [5] [6] [7]. While they share the principles outlined above, they tend to serve different instructional purposes. In general, Standards-Based Grading is good for assessing whether students can meet basic course learning outcomes (e.g., solving a particular class of differential equations) whereas specifications grading is often more effective for evaluating successful completion of complex or integrative tasks (e.g., projects, reports, or design work). Table 1 summarizes key differences between these approaches.

Table 1: Comparison of Specifications and Standards-Based Grading Approaches.

	Specifications Grading	Standards-Based Grading
Grading Style	Pass/Revise (based on clear criteria or specs)	3-5 tier rubric (e.g., "Developing" to "Proficient")
Focus	Successful completion of tasks that may include multiple concepts	Conceptual mastery of individual concepts
Feedback Cycle	Students revise their work until it is acceptable. Usually only a limited number of retake "tokens" are permitted.	Students have a limited number of attempts to demonstrate concept proficiency (e.g., multiple exam questions demonstrating the same concept)
Category Grade	The grade in a category (or course) is determined from the number of assignments successfully completed.	The grade in a category (or course) is determined from the number of problems completed at certain rubric levels.

Importantly, instructors are not required to adopt a single alternative grading system wholesale or apply it uniformly across an entire course. Many instructors begin by modifying only one component of their grading scheme or by combining elements from multiple approaches such as those presented in Table 1. One additional alternative grading technique that should be mentioned is "ungrading" which deemphasizes or eliminates grades entirely in favor of qualitative feedback and student reflection. In these cases, student performance could be evaluated via narrative feedback, self-assessment, and/or negotiated grades between the student and instructor [8] [9] [10].

Several terms commonly appear across alternative grading literature. These include *standards* (clear, observable demonstrations of learning), *specifications* (explicit criteria for acceptable work), *marks* (symbols or levels indicating progress toward mastery rather than points), *reassessment* (additional opportunities to demonstrate learning), and *tokens* (mechanisms that allow students limited flexibility in course policies such as deadlines or reassessments). Clark's alternative grading glossary provides a much more in-depth description of alternative grading related terms [11] and answers to many frequently asked questions [12].

Faculty choose to use alternative grading for either a single assignment, a set of assignments, or an entire course for several reasons. Alternative grading systems:

- allow students to reassess work using instructor feedback until standards or specifications are met
- replace points with marks that more clearly communicate learning progress
- present transparent expectations aligned with learning objectives
- enable students to make informed decisions about effort relative to desired course grades
- require students to take greater responsibility for their own learning.

A growing body of scholarship supports the design and implementation of alternative grading across disciplines, particularly in engineering, mathematics, and the sciences. E. Cilli-Turner et. al. is a great source for the design and implementation of mastery learning techniques throughout an entire course [13]. D. Oerther [14], C. Perez and D. Verdin [15] [16], provide useful reviews for the implementation of mastery learning in engineering courses. J. Kelly writes about how to overcome resistance by students and peers related to unfamiliar grading approaches [17]. The following represents alternative grading literature within specific fields of engineering:

- Fluid Mechanics [18]
- Statics [19] [20] [21]
- Dynamics [20] [22]
- Mechanics of Materials [23]
- Computer Applications [24]
- Electric Circuits [25]
- Signals and Systems [26]
- Thermodynamics [27]
- Capstone Design [28] [29]

PRIMUS has a special issue entirely dedicated to mastery grading in the undergraduate mathematics classroom. R. Campbell et al. provide an introduction to this issue which includes a table comparing author entries, alternative grading techniques, and class type [32]. B. Bunnell et al demonstrate specifications grading in Chemistry II [30] while J. Ring applies it in Organic Chemistry [31]. H.T. Evensen demonstrates specifications grading in a variety of physics courses [32].

2: Ease into Alternative Grading with One Assignment

In a traditional grading system, there are undoubtedly many assignments for which using points- or percentage-based grading is a massive undertaking. If the assignment covers one or more learning targets that students must complete with a high level of competency, however, it might be beneficial to allow them to revise or reattempt the assignment if the work is deemed to be below expectations. This is where using an alternative grading strategy can be very useful. Instead of determining whether substandard work is worth five or six out of ten points, for example, the grader could simply mark the work as “below expectations” and provide detailed feedback so that the student can learn from their mistakes and improve upon them on the next attempt.

While it is possible to overhaul the entire grading system in a course from a traditional points-based approach to an alternative grading system, it might be easier for someone new to the idea of alternative grading to reimagine the grading process for a single assignment (or group of similarly graded assignments). This might be an assignment that meets one or more of the following criteria:

- Students typically perform poorly or misunderstand key concepts.
- High competency on this task is essential for future coursework or professional practice.
- Grading is time-consuming or requires subjective decisions about partial credit.
- Students frequently question grades or focus on points rather than feedback.
- Students would benefit from revising or reattempting the work.

Once the assignment is chosen, redesign the assessment process according to alternative grading principles. Imagine how alternative grading could improve student learning while being less burdensome to grade. The "Four Pillars of Alternative Grading" by Clark and Talbert may be useful in guiding the redesign [1]:

1. Define Clear Standards - What would a successful submission clearly demonstrate? Consider what students must be able to do to show competency on this task.
2. Provide Helpful Feedback - What feedback would help students improve if they do not meet the standards? Focus on feedback that is actionable and forward-looking. Consider how the feedback would be delivered (written, rubric-based, in person, etc.).
3. Use Meaningful Marks Instead of Points - How could student performance be communicated without percentages or partial credit? Some examples include:
    - Pass / Not Yet
    - Meets / Developing / Does Not Meet
    - Exceeds / Meets / Needs Revision

   By adding an appropriate marking rubric and revision/reattempt policy, the assignment could be alternatively graded in a fraction of the time it might have taken to be traditionally graded while keeping the student focus on their accomplishment of the task rather than a numerical score
4. Allow Reassessment Without Penalty - How will students be allowed to demonstrate improvement? Would students be allowed to revise the original work, perform a similar task targeting the same learning objective, or a combination of both? Also, what will be the limit on reassessments? Some instructors use "tokens" that can be used throughout the course while some set a limit for each assignment. Whichever method is used, it is important to have limits so that students are intentional in their reassessment.

Depending on the extent to which alternative grading is used, the overall course grading scheme can be a mix of traditional grading for some assignments and alternative grading for the rest. If meeting expectations on the alternatively graded assignment(s) is critical for students to demonstrate their understanding of one or more course learning targets, the instructor could make it mandatory for a student to meet expectations on these alternatively graded assignment(s) to receive a passing grade.

3: Examples of Alternative Grading

The four examples that follow illustrate the “try one assignment” philosophy across various engineering contexts: 1) upper-division simulation work in mechanical engineering, 2) assessment in introductory physics courses, 3) exams for foundational mechanical engineering courses, and 4) lab-based coursework in upper-division electrical engineering course.

3.1 A Specifications Grading Approach for Simulation Work in an Upper Division Mechanical Engineering Course

3.1.1 Course Context

- Course Name: Finite Element Analysis (FEA)
- Course Description: This course is an introduction towards using computational simulations to predict whether a mechanical part or assembly would be able to survive its environmental operating conditions. The course includes both the theoretical framework and practical application of finite element analysis.
- Program: Mechanical Engineering
- Typical Level: Senior year
- Typical Enrollment Size: 20 students
- Format: Three meetings per week – two 50-minute lecture periods with one 110-minute lab period. This instructor typically gives a brief introduction to theoretical material during the first 10-15 minutes of each lecture period with the rest of the time being open for student work. The lab periods are also open for student work. Supplementary lecture material is available in video format.
- Forms of Assessment:
    - Exams to assess theoretical understanding
    - MATLAB based assignments to apply theory to simple FEA problems
    - Homework utilizing simplified 2D FEA code to demonstrate FEA concepts
    - Simulations to practice applying commercial FEA software to solve more realistic design problems
    - Final project to demonstrate FEA competency on a project of the student’s choosing

3.1.2 Identified Frustration with Traditional Grading

The following example describes one of the mechanical engineering instructors’ efforts to address frustrations related to simulation work in a senior-level finite element analysis (FEA) course. As a background, the first few simulation modules introduce students to FEA software and address fundamental FEA concepts such as recognizing when numerical convergence has been achieved. Once the simulation modules are completed, students are asked to perform simulation case studies which use FEA to address a design problem. As part of these case studies, students are asked to demonstrate the “FEA Workflow” which includes

- Pre-Analysis: Defining the problem clearly, listing assumptions, and outlining the analysis approach.
- Pre-Processing: Prepare the simulation model according to the approach listed in the “Pre-Analysis” section.
- Processing: Understanding the basic computational process when the simulation runs.
- Validation: Performing model checks to ensure that the simulation ran as expected.
- Post-Processing: Interpreting the results in order to address the problem outlined in the “Pre-Analysis” section and presenting these findings in the form of a PowerPoint presentation.

The goal of the simulation work is to prepare students for their final project where they would apply the same “FEA Workflow” to a component of their choosing (e.g., designing an “A-arm” for the suspension system for their Baja car team). Traditional grading of the simulation work was tedious due to the assignment of partial credit. It was also difficult to give credit towards a simulation assignment containing errors which would make its results meaningless. Additionally, the instructor noted that students repeated the same errors from their simulations in their final project. This indicated that students were not incorporating feedback from the instructor and were not ready to effectively use FEA to meaningfully address design problems. To address this issue, the instructor considered the following questions:

- How can students be required to incorporate feedback to prevent repeating the same errors?
- How can the instructor make the best use of their time when delivering feedback?
- How can students be more focused on learning the principles of FEA instead of on their grade?

3.1.3 Alternative Grading Intervention

Nilson’s “specifications grading” seemed to offer a reasonable solution to all three of those questions [5]. The following changes were made to the simulation grading approach:

1. In-Person Evaluations: The typical submission process with written feedback was exchanged for students presenting their work in-person during class. These discussions provide immediate, clear feedback, helping students understand what aspects of their work meet expectations and what require improvement. The in-person format also fosters a constructive and supportive environment, making critiques feel less personal and more focused on the work.
2. Focus on Correctness: Partial credit is also a thing of the past since it led to students turning in unfocused efforts and to arguments about their simulation grade. Knowing that their work must meet all requirements to receive credit encourages students to be more focused in their work and to ask more meaningful questions.

Incorporate Flexibility: Mistakes are a part of learning. Incorporating flexibility allows students to learn from their mistakes. Instead of giving partial credit, students are graded according to how many simulation modules and case studies they successfully complete within the semester. See

3. Table 2 for information on the simulation requirements.

Table 2: Requirements for simulation course grade.

Simulation Grade	Simulation Requirements
A	All ‘B” simulation requirements in addition to two simulation modules exploring more advanced topics (e.g., composite analysis)
B	All “C” simulation requirements in addition to: Two additional case studies with more advanced validation and post-processing components One simulation module introducing how to model assemblies and connections.
C	Foundational simulation modules on boundary conditions, numerical convergence, validation, and various modeling approaches. Two basic simulation case studies involving the FEA process

3.1.4 Logistics and Time Investment

The biggest difficulty in this process is keeping track of which simulation students are actively working on since it varies widely throughout the class. This only requires bringing solutions to all simulation assignments to each class period.

There is a substantial reduction in grading time due to the absence of partial credit. Time spent giving written feedback and evaluating partial credit has been exchanged for meaningful conversations with students. The only grading of simulations necessary outside of class time is to mark off completion within the learning management system.

3.1.5 Observed Outcomes

After incorporating this change, the quality of the final projects seemed to improve drastically, repeated mistakes between simulation case studies have decreased, student arguments about grades decreased, and meaningful conversations about FEA concepts increased. Of course, a more rigorous IRB-approved study would be required to quantify the actual improvement in student learning. From the instructor’s perspective, it has been much more enjoyable to have discussions with students about their simulations during their lab block than spending hours outside of class writing feedback that may never be read.

3.1.6 Lessons Learned and Recommendations

Some notes and recommendations about the process are included below:

- Many students wait until the last week of the semester to try and do many of the simulation case studies. This is incredibly frustrating for the students since they greatly underestimate the time requirement in each case study. It is also difficult for the instructor to manage the large uptick in student requests for help. It may be better to incorporate a system more in line with the Nilson's "Specifications Grading" where generous due dates are assigned and students are allowed tokens for submission after that date. Since the case studies are checked off in-person during class, it may be necessary to enforce a strict "one check per class period" limit to avoid haphazard checks.

- Student groups are assigned for simulation case studies. This allows students to collaborate and learn from each other while reducing the total amount of simulation work needed to be checked off in-person. They are assigned based on student preferences and observed behavior/motivation to ensure more balanced participation within each group.
- The class itself is structured as a partially-flipped classroom to offer students more time to work on their simulations. This is not required since the 110-minute lab period is sufficient for checking off simulation work and addressing student questions. The main benefit is to provide time when all students are available to work together since time is a limited resource for many upper-division engineering students.
- For reference, an alternative grading scheme is now applied throughout the entire course. This is by no means required as the simulation grading approach presented here could be easily incorporated within a traditional grading scheme for the course (e.g., the simulation grade being worth 30% of the overall grade). In this instructor's course students must satisfy grading standards for each assessment category to achieve a course grade (e.g., cumulative exam score >90%, all simulation work completed successfully, and an "A" on the final project to receive an "A" in the course) instead of relying on a score based on categorical weights. The goal of this approach is to mitigate gaps in understanding and reduce the motivation for cheating (e.g., a student could ride the coattails of his groupmates for the simulation case studies and final project but would still need to pass the exams to pass the course).

3.2 Applying Alternative Grading to Foundational Coursework: Mastery-Based Testing (MBT) in Introductory Physics

3.2.1 Course Context

- Course Name: Physics 1 Mechanics and Thermodynamics, and Physics II Electricity, Magnetism, and Optics.
- Course Description: Introductory physics is a calculus-based foundational class sequence in many technical courses of study such as engineering and serves as a place where students build problem solving skills. Students learn to combine their basic math, reading, reasoning and other skills to apply physics concepts and solve problems. While students encounter a variety of foundational physical phenomena, the problem-solving skills they develop are arguably more important and applicable across all subsequent technical coursework.
- Program: Requirement across engineering disciplines
- Typical level: Freshman/Sophomore year
- Typical Enrollment Size: 40 students maximum
- Format: Four meetings per week – three 50-minute lecture periods with one 1:50 lab period. Lecture periods are a mix of presentation of new material and active learning

exercises, with weekly quizzes. The lab periods are devoted to experiments that reinforce understanding in course topics but also extend to developing skills like data analysis and calculating uncertainty.

- Forms of Assessment: Assessment is primarily through weekly quizzes making up 50% of students' total grade. A final, evaluated with the same marking approach counts for 10% of students' grades. The remaining 40% is based on components such as lab and homework submissions.

3.2.2 Identified Frustration with Traditional Grading

Conversations with upper-level faculty reveal disturbing but all too familiar anecdotes like students making basic arithmetic mistakes or being unable to perform even simple problems. The natural question this elicits is: How do students get through their introductory coursework, let alone more advanced courses, if they are unable to do the basics? Perhaps grade-inflation, new forms of cheating, or that some students never develop strong basic skills because of over-reliance on AI all play a role.

One potential culprit, that faculty may have more control over in their classrooms, is grading [37]. As discussed in the introduction, traditional points-based systems can obscure deficiencies by aggregating performance and awarding partial credit for incomplete solutions, making it possible for students to pass without demonstrating full problem-solving proficiency. This does not have to be the case, and the grading structure described below has been designed to push back on these problems.

3.2.3 Alternative Grading Intervention: Mastery-Based Testing (MBT)

The scheme described here attempts to do so in the simplest fashion for assessments in introductory physics. This scheme has been developed and refined over the past three years and most directly influenced by work by Collins and Evensen [33] [32]. The fundamental motivation is that students should have to get something completely correct or nearly so on an assessment to count. "You had the right idea" does not count for anything in the real world.

This scheme is limited to assessment primarily because assessment (in class) is arguably the most meaningful class component (what does homework mean when most students use AI?) but also because this allows for a simpler transition and implementation. Rather than having to revamp all course activities, only assessments are changed. The physics instructor adopts Collins' terminology for this scheme: mastery-based testing (MBT) as opposed to other similar terminology like standards-based grading as this term emphasizes the focus on assessment.

The students' assessment grade in this system is derived from their mastery of objectives (question types) from a list (of about 30) for the course. These are generated directly from course outcomes. Students mastering (i.e. checking off) different numbers of objectives correspond to different eligible assessment grades. As an example to convey the idea (real thresholds are designed by the instructor for a particular course), consider a scenario where mastering 20/30 counts as a C, 24/30 counts for B, 28/30 counts for A, see Table 3. The list and required thresholds are prorated as the term progresses. E.g. if 15 of the objectives have been assessed 8 weeks into the course, the thresholds would be 10/15, 12/15 and 14/15 for students to earn a C, B or A respectively.

Table 3: Example MBT quiz thresholds and numerical mapping.

Threshold	Eligible MBT quiz grade
28/30	A (100%)
24/30	B (88% at authors' institution)
20/30	C (80% at authors' institution)

Students demonstrate mastery of objectives primarily on weekly in-class quizzes assessing from one to three objectives, although a longer quiz (midterm) is also an option. There are three possible marks on quiz questions: E (excellent), S (satisfactory) and N (not yet), elaborated on in Table 4.

Table 4: MBT quiz marking rubric.

Mark	Description
E (Excellent)	Excellent: work and results are correct, including proper units and e.g. unit vectors when applicable. No corrective feedback is needed from the instructor, "A-level" work, 100%.
S (Satisfactory)	Satisfactory: a proper approach and reasonable result although there may be an improper or omitted unit or other similar minor issue. Instructor is satisfied the student would learn little from asking them another such quiz question, "B-level" work, (88% at authors' institution).
N (Not yet)	Not yet: student has demonstrated either multiple small errors or more profound misunderstanding and inability to properly solve the question. A multi-part question may have one part correct but others not. The instructor is not convinced the student has command of the question type and so another attempt is warranted, anything below "B-level" work, worth zero.

Students' assessment grades are derived from the threshold and weighted average of the E then S scores they have earned up to that threshold. As a simple example using the thresholds above, if at the end of the term a student had gotten 12 E and 13 S marks, they would be eligible for a B and would have earned a numerical score of: (12/24*1+12/24*0.88)*0.88 = 0.83. Student progress is recorded in a spreadsheet and students are provided with a report of their progress weekly via email (the institutional learning management system LMS is not conducive to tracking mastery progress).

If students do not earn an E or S on an objective, there is an additional opportunity to demonstrate mastery on a "requiz" (a quiz on the same objectives) during office hours the following week. Class time is not used for reassessment. A final exam can serve as an additional requiz opportunity as well. If an objective should prove to be particularly difficult for the class it can be offered again in class or for more than one requiz opportunity.

3.2.4 Logistics and Time Investment

While alternative grading approaches exist that are comprehensive, involving every aspect of a class, this MBT scheme has intentionally been limited to assessment (approximately 50% of students' overall grade), in part for simplicity. Even so, it is complicated compared to traditional exams and will require additional time and energy to set up, especially the first time.

A system like this that awards grades based on mastery of a certain threshold number of objectives requires mapping out the list of objectives in a fair amount of detail beforehand and careful consideration of appropriate thresholds. Also, since the way assessment grades are computed is more involved than in a traditional system, it is a good idea to test systems like grade calculation spreadsheets beforehand to avoid delays and problems during the term. In addition, since the institutional learning management system may not easily allow communicating student progress in such a system, incorporating additional class structures such as office hour conferences or automated progress reports may be a good idea.

That said, a complicated system also means there are ample mechanisms for modifying the system along the way as needed. For example, students will never complain if objectives need to be dropped from the list in the interests of time or if the thresholds eased to tweak class difficulty.

In terms of week-to-week class responsibilities, the volume of grading is likely to be more than in a traditional system but greatly simplified because of the lack of partial credit in the marking scheme. Additional time is also required to generate, administer and grade reassessment questions.

3.2.5 Observed Outcomes

Anecdotally, some students have expressed that the system feels easier and that they learn more compared to a traditional system. Students see (and quickly become accustomed to understanding) that incomplete, sloppy, sub-par work is pointless because it does not count for any credit. This scheme hopefully reduces stress for students relative to a high-stakes exam approach and promotes a growth mindset because students have an opportunity the following week to demonstrate mastery of an objective they miss the first time. Traditional assessment does not give students a chance to respond to a poor midterm performance until their next midterm on different course material. This scheme hopefully also encourages student ownership of their success because they need to strategize which objectives to focus on and take it upon themselves to pursue requiz opportunities.

A deemphasis on comprehensive exams in favor of weekly quizzes that incrementally assess mastery of objectives is one aspect of this system that has received some critique. While quizzes and exams both serve to demonstrate student mastery on individual objectives, it could be argued that the exam's longer duration requires more focused effort from the student. To address this concern, more recent versions of this MBT scheme also incorporate a midterm and final exam, graded in the same fashion as quizzes but with more questions. At this time, it is not known how this quiz approach compares to an exam approach on metrics such as content retention, but this could be an interesting avenue of future more quantitative investigation.

3.2.6 Lessons Learned and Recommendations

The MBT approach described in this section was applied in introductory physics and limited to assessment. Students work to check off assessment objectives from a course list by demonstrating mastery. Their assessment grade is based on how many objectives they master rather than an average that inevitably incorporates significant partial credit as in more familiar grading approaches. This scheme requires generating and grading many assessment questions and so would likely be of use in other introductory technical courses that feature relatively simple assessment question types, such as math or circuits.

From a faculty perspective, the simple and clear approach to grading is a tremendous benefit. It is nearly impossible to imagine going back to giving incorrect work anything other than a zero. Additionally, there are advantages in terms of differentiation for students with different levels of preparation. It is common that introductory physics includes students with a broad range of experience where some will have taken AP physics and some have little prior experience with the subject. Students who are having trouble need to spend more time engaging with class material and in assessments (requizzes) to improve while students who are advanced do not. In addition, since the grade is derived from the number of objectives students master, by including some hard objectives in the list, this allows a fair way to incorporate asking students a broader range of question difficulties and tailoring course difficulty. It is not unreasonable to expect students to have to answer some hard question types in order to earn an A and this system explicitly builds that in. B- or C-level students may elect to skip a tough objective but they do so knowing that they do not have to answer such a question to get their goal grade.

Some students will be uncomfortable with an unfamiliar system. This does not mean students will not come around to like it (the vast majority have reported in surveys preferring it in this instructor’s experience), although there are always some that will not. Significant time needs to be devoted to fielding student questions about how the system works and putting them at ease as they learn to navigate it. Students are not averse to a complex system but if it seems opaque or arbitrary because it has not been explained well, that is a legitimate reason for pushback. In addition to fielding student questions, updating students on their progress in a recurring transparent fashion is important. Students need to know where they stand.

3.3 A Mastery-Based Exam Grading Approach for Mechanical Engineering Foundational Courses

3.3.1 Course Context

- Course Name: Engineering Mechanics II: Dynamics
- Course Description: This course is an introduction to the study of motion (kinematics) and forces (kinetics) which affect particles and rigid bodies.
- Program: Mechanical Engineering
- Typical Level: sophomore year
- Typical Enrollment Size: 20 students
- Format: Three 50-minute lecture meetings per week.
- Forms of Assessment:

- Homework to reinforce understanding and knowledge retention
- Exams to assess theoretical understanding and problem execution

3.3.2 Identified Frustration with Traditional Grading

Mechanical engineering undergraduate courses such as statics and dynamics are foundational for mechanical engineering students. From an instructional assessment perspective, assessing student performance in these courses, particularly on exams, often presents challenges. Traditional points-based grading assessments can be difficult to apply in a fair and transparent manner when exam problems have multiple valid solution methods. For example, a particle kinetics problem in a dynamics course may often be solved using several acceptable approaches. In such cases, assigning partial credit (e.g., 5/10 versus 6/10) often feels somewhat subjective, and in the instructor's experience leads to student confusion or questions about grading consistency and fairness. In addition, conventional points-based grading assessments often allow students to pass an exam without demonstrating clear mastery of any individual problem, as partial credit across questions may lead to a passing exam score.

To address these challenges, section 3.3.3 presents an alternative exam grading approach for mechanical engineering foundational courses that is designed to emphasize mastery, improve grading transparency, and maintain high academic standards while remaining practical for instructors to implement. The proposed approach retains the familiarity of a points-based system for students, while reducing the ambiguity of any partial credit awarded. Students are provided multiple opportunities to demonstrate understanding, and the approach ensures that students must show some level of mastery to achieve a passing exam score.

3.3.3 Alternative Grading Intervention

This section presents an alternative grading intervention for exams in a sophomore-level mechanical engineering dynamics course. The exam grading rubric presented in this section was developed and refined over multiple course offerings, and it is broadly applicable to other foundational engineering courses (e.g., statics) that have a similar course structure. In the instructor's view, the rubric is particularly well suited for courses in which the types of exam problems and associated solution methodologies are well defined and repeatedly emphasized throughout the term.

The rubric is designed for an exam consisting of four problems, each selected to be representative of standard textbook problems encountered in dynamics. However, the approach can be readily adapted for exams with fewer or more questions. Each exam problem is graded on a 10-point scale using categories that correspond to different levels of mastery in terms of a student's conceptual understanding and quality of execution.

An example rubric for a sophomore-level dynamics course is provided in Appendix A. Students may receive a score of 10, 8, 6, 4, 2, or 0 on each problem, with each score aligned to a clearly defined level of mastery. The use of discrete score levels substantially reduces subjectivity in grading, while still allowing instructors to recognize multiple valid solution approaches.

3.3.3.1 Rubric Structure and Performance Levels

Each performance level in the rubric reflects both a student's conceptual understanding of the problem and the quality of their execution. High-level descriptions of the scoring categories are provided in Table 5. This rubric provides a general framework instructors can use. Scores of 10 and 0 are generally straightforward to assign, as they correspond to fully correct solutions and nearly nonexistent or wholly incorrect work, respectively. Intermediate scores are determined based on the presence of minor mathematical errors (e.g., calculator error, algebra mistake) and minor or major errors in execution. For example, a minor error may consist of a sign mistake in an equation of motion, whereas a major error may involve an incorrect free-body diagram or an inappropriate application of fundamental principles. The example rubric shown here does not specifically define minor or major errors, as these would need to be defined by the instructor as it relates to their specific course. As an example, Appendix A provides a rubric that highlights minor versus major errors for each scoring level for a sophomore-level dynamics course.

Table 5: Example mastery-based problem scoring rubric.

Score	Level	Description
10	*Masterful*	The solution is fully correct, all relevant work is clearly shown, and the final answer is correct with appropriate units.
8	*Excellent*	The student uses an appropriate solution approach and demonstrates strong understanding. At most, one minor mathematical error is present.
6	*Good*	The student demonstrates general understanding of the problem but makes one minor execution error or multiple small mathematical errors.
4	*Partial*	The student exhibits partial understanding but makes multiple minor errors in execution or one major error that significantly impacts the solution.
2	*Minimal*	The student demonstrates limited understanding, with multiple major errors in problem setup or execution.
0	*None*	The student makes no meaningful attempt to solve the problem or provides work that is largely incorrect and unrelated to an appropriate solution approach.

3.3.3.2 Mastery-Based Exam Scoring

Following exam grading, each student receives an exam score out of 40 points, along with the corresponding percentage. To reinforce mastery and provide a structured opportunity for improvement, students are offered the option to complete one additional exam problem one week after the original exam, after receiving feedback on their original work. Limiting reassessment to a single problem maintains exam rigor while providing a focused opportunity for students to demonstrate improved mastery without substantially increasing grading workload. The score earned on this follow-up question replaces the student's lowest-scoring problem from the original exam. For example, a student who initially earns scores of 8, 8, 10, and 4 on the four exam problems and subsequently earns an 8 on the follow-up question would have their revised exam scores adjusted to be 8, 8, 10, and 8, resulting in a total score of 34 out of 40 (85%). Instructors may use the grading scale of their choosing. However, the rubric was developed with a grading scale in which a score of 90% or higher corresponds to an A, while scores below 60% correspond to an F, with intermediate letter grades assigned accordingly.

3.3.3.3 Comparison to the SMART Assessment Model

The structure described in this section partially resembles the SMART assessment model developed primarily within the mechanical engineering department at Michigan State University by G. Recktenwald, R. Averill et. al. [21] [23] [34] [35] [36] [37]. The SMART assessment model has shown quantifiable improvements over traditional grading. The model proposed here blends advantages of the SMART assessment model with the familiarity of traditional grading. A comparison of the two approaches is described in Table 6:

Table 6: Comparison with the SMART assessment model.

	Author's approach	SMART assessment model
Rubric	See Table 5	100% if fully correct 80% if only minor error exists (similar to 8/10 in Table 5) 0% otherwise
Reattempt	One problem reattempt following each midterm exam. Score may replace lowest score from original exam attempt.	Each midterm exam is given two full attempts – highest score is retained.

The softer rubric proposed here still enforces a high standard but hopefully reduces student pushback since they can earn some points (albeit still failing) for incorrect problem approaches. The single problem reattempt model may not be a complete demonstration of student improvement but does save valuable class time.

3.3.4 Logistics and Time Investment

The additional time investment required for this intervention is minimal compared to traditional exam grading approaches. The instructor still develops an exam rubric and explains to students how it will be applied, and the same rubric is used consistently across all exams in the course. While some additional time is needed to allow students the opportunity for reassessment, this process only takes about 15 minutes of class time per exam. Additionally, the exam grading process itself is typically faster than with more conventional approaches.

3.3.5 Observed Outcomes

Observation of results over several course offerings suggest that the approach significantly increases student learning. In general, students are appreciative of the high standard this method establishes, and students appreciate the structured opportunity for reassessment. One observed benefit of the approach is the students use of the rubric outside of summative assessment. Many students use the rubric when completing homework problems or preparing for exams. The rubric acts as a scaffold which clarifies performance criteria, defines what constitutes a complete and high-quality solution, and it reduces ambiguity around expectations.

From an instructor's perspective, the structured grading has enhanced assessment transparency and has streamlined the grading workflow. As a result, grading is both more efficient and more consistently aligned with the course learning objectives.

3.3.6 Lessons Learned and Recommendations

The mastery-based grading rubric presented addresses common limitations of traditional points-based exam grading in foundational mechanical engineering courses. By emphasizing clearly defined mastery levels, reducing subjectivity in partial credit assignment, and incorporating a structured opportunity for reassessment, the approach aligns grading practices closely with instructional goals and student learning outcomes. At the same time, from the instructor's experience the rubric has proven practical to implement, adding minimal grading time while potentially improving student outcomes. Recommendations for instructors looking to incorporate this type of rubric include the following:

- Instructors are encouraged to provide the rubric to students ahead of time to ensure clear grading expectations.
- Instructors may adjust the number of additional exam problems based on the course content difficulty. For example, a more challenging exam may include two additional questions that replace original exam problem scores.
- It is advised to provide an opportunity for students to take a sample exam problem and score it prior to the first exam. This will ensure that students understand how they will be assessed.

Overall, the proposed mastery-based grading framework provides a practical alternative to traditional exam assessment in foundational mechanical engineering courses. Emphasizing demonstrated mastery at the problem level, the approach has the potential to improve grading transparency, consistency, and meaningful student learning.

3.4 A Specifications Grading Approach for Laboratory Work in an Upper Division Electrical Engineering Course

3.4.1 Course Context

- Course Name: Digital Signal Processing (DSP)
- Course Description: This course is an introduction to digital signal processing following a course in continuous-time signals and systems. The course includes discrete-time signals and systems, z-transforms, Fourier analysis, and digital filter design.
- Program: Electrical engineering (also taken by biomedical and computer engineering students)
- Typical Level: Junior or senior year
- Typical Enrollment Size: 20 students per section
- Format: Three meetings per week – two 50-minute lecture periods and one 110-minute lab period. Lab periods typically start with a 10-to-15-minute introduction with the rest of the time available for student work.

- Forms of Assessment:
    - Exams to assess theoretical understanding
    - Homework and Canvas quizzes to introduce basic DSP problems
    - MATLAB assignments to simulate digital signals and systems
    - Real-time DSP assignments to implement C programs for digital filters and other DSP algorithms (signal generation, FFT, etc.)

3.4.2 Identified Frustration with Traditional Grading

Before the electrical engineering instructor adopted alternative grading for the DSP course, he used points-based rubrics for grading lab assignments. Whereas the lab assignments did not greatly change from year to year, lab assignment grading was generally quite time-consuming, especially in cases where the instructor needed to compare similar work by two or more different students to see which warranted a slightly lower or higher numerical score. Moreover, groups of students were submitting nearly identical work (some even using screenshots copied from other students' work), and the instructor wanted to ensure that students were submitting original work.

3.4.3 Alternative Grading Intervention

In this DSP course, the overall course grade is based on three criteria: the percentage of prep work (homework and quizzes) satisfactorily completed by the student, the number of lab assignments marked at M (meets expectations) or better, and the number of exam questions marked at M or better. At the beginning of the semester, students are given a fixed number of tokens (six in the current semester) that can be applied to extend assignment due dates or to revise assignments marked below expectations. Revised work must be submitted within one week of the original deadline. Each student also has one special token that can be used to revise or submit one assignment after its revision deadline.

After choosing to adopt an alternative grading scheme similar to specifications grading for the DSP course, the EE instructor developed a universal marking rubric for lab assignments as described in Table 7. Following is a general specifications list for lab assignments used in several of the instructor's courses, including DSP:

1. Originality: Your lab submission should include work generated by you, and questions should be answered in your own words. Screenshots of code should include your name, the date(s) the code was generated or modified, and your comments. Screenshots of results should include a timestamp and device identification. Screenshots of another student's work must credit the other student and are only allowed with the instructor's permission. Any use of AI is acknowledged in the submission where appropriate.
2. Clarity/presentation: All work should be readable at a standard (100%) zoom level. Screenshots should include all relevant information and exclude extraneous details. All questions should be answered succinctly using full sentences which have been proofread for spelling and grammar errors. Questions should be answered in the order in which they are presented in the assignment file.
3. Correctness of results: Your results should agree with theoretical expectations to the extent possible given the limitations of the experiment setup and device(s) used to

acquire the results. Where results significantly disagree with theoretical expectations, a sufficient explanation is provided for the difference(s): for example, what went wrong and what you would do to correct the error(s).

4. Correctness of analysis: Questions focused on analysis of results are answered mostly correctly with no significant gaps or errors. Refer to the "Originality" specification regarding the use of AI.
5. Excellence: The work exceeds the expectations of the assignment. Communication is clear and complete. Mastery of the concepts is evident. There are no nontrivial errors. This work could be used as a classroom example.

Labs are then marked as Excellent (E), Meets Expectations (M), Progressing (P), or Not Assessable (X) based on the number of general specifications met by the student's submission, as indicated in Table 7.

Table 7: Example lab marking rubric.

Mark	General specs met (refer to above list)
E	Specs 1-4 are all satisfactory and spec 5 is excellent
M	Specs 1-4 are all satisfactory
P	Spec 1 and at least one of {2, 3, 4} are satisfactory
X	Not original or failed all of {2, 3, 4}

To address the concern of students submitting unoriginal work, an in-person demonstration was added to each of the real-time DSP assignments, so that students would be required to demonstrate and explain their own results for a key part of the assignment, rather than copying the work of another student so as to claim the work as their own. An otherwise satisfactory lab assignment submission will be marked X if the student does not perform the required demonstration.

3.4.4 Logistics and Time Investment

Using tokens for assignment revision or extension has come with a few drawbacks. Some students fall behind early and use nearly all of their tokens on a weekly basis to extend deadlines. Other students save their tokens for other purposes, for example, to revise exam questions, and inquire late in the semester about using remaining tokens to extend or revise lab assignments far past their deadlines. However, typically fewer than 10% of students submit labs one week late due to extension or revision, not significantly impacting the grading load for the instructor.

Adding in-person demonstrations to lab assignments has made the lab sessions more interactive. Students are more confident to ask questions of the instructor as well as to ask other students for help. Additionally, the grading load is reduced, since the instructor does not need to spend much time reviewing the work that has already been demonstrated in lab. The simpler rubric used for marking assignments also simplifies the grading process, since the grade is no longer dependent on a points-based rubric, where partial points are given for each instance of substandard work.

3.4.5 Observed Outcomes

After incorporating these changes, several things have improved: the quality of lab submissions by students, a much lower frequency of unoriginal student work, a lower frequency of grade negotiation, a higher frequency of in-person interaction with students, and higher student satisfaction scores. Students who revise work marked less than M use the instructor's feedback to submit revised work that frequently meets (and occasionally exceeds) expectations. Although students occasionally ask for clarification regarding this alternative grading scheme, most students favor this over traditional grading, once they realize that this was chosen to support and encourage them to learn the material well.

3.4.6 Lessons Learned and Recommendations

Notes and recommendations about the process are included below:

- The "Excellence" criterion was recently added to identify "A"-level work without requiring students to do additional challenge-level work.
- The number of tokens should be limited so that students cannot extend every lab assignment or revise every exam question. This forces them to be selective about which assignments to revise or leave marked as P or X. This also helps to minimize the additional grading load from revisions and extensions, since the instructor is responsible for all the grading (no grad TAs at our institution).
- Requiring students to attach timestamp and device metadata to their results helps verify the originality of student work.
- AI-generated content in recent student submissions has complicated instructors' ability to discern authentic student work. This instructor permits the use of AI when students disclose it responsibly and avoid using it to circumvent the learning process. Yet students often underreport their AI use, making it difficult to assess their understanding of submitted work. Since AI often produces answers that sound smarter than the typical undergraduate student, it is wise to overlook these types of answers for low-impact questions and focus on answers that analyze important lab results, especially those that AI may have difficulty interpreting, such as numerical results from a screenshot of oscilloscope data.

3.5 Synthesis of Example Interventions

An alternative grading approach does not need to change every aspect of class. Each of the example interventions targeted a specific grading frustration rather than attempting wholesale course redesign. Sometimes these interventions lead to other interventions such that over time the course structure may resemble its original form. However, the goal is that by making incremental changes, instructors are more likely to attempt improvements and are less likely to be overwhelmed in the design process or thrown off by unintended effects. Additionally, instructors maintain their motivation for years to come leading to continual improvement instead of burning out.

Table 8 provides an overview of the impact from the example interventions. The following commonalities exist between each of the example interventions:

- Grading approaches were simplified from the traditional grading approach previously administered.
- Students were required to demonstrate a high level of competence to earn passing grades.
- Students were offered opportunities to implement feedback and try again
- Student effort appears more focused on genuinely learning course content in order to be successful on assessments that require a high level of proficiency and do not reward or incentivize mediocre work with partial credit.
- Student behaviors that might marginally increase grades in a traditional system but contribute little or nothing to student understanding are suppressed.
- For faculty, grading effort is reallocated, with a deemphasis on demotivating tasks like calculating partial credit for mediocre work, and more room for more meaningful feedback mechanisms.

Please note that any remarks regarding student performance are only based on instructor perception and are not quantitative. IRB approval would be needed for evaluation of student performance and to present student perceptions of the intervention.

Table 8: Overview of Impact from Example Interventions

Course Description	Frustration Addressed	Intervention	Observed Impact
Finite Element Analysis – senior level simulation course in mechanical engineering program	Students not implementing feedback Time consuming grading with partial credit Giving credit for unacceptable work	Simulations marked as complete or incomplete Students present work in-person Students offered multiple reattempts	Grading time exchanged for meaningful discussions There seems to be less repetition of the same error type between simulations and in the final project
Introductory Physics, freshman/sophomore level course sequence common across engineering programs	Students not mastering the basics Faculty time and effort spent evaluating partial credit for unsatisfactory work	Assessment scheme that features simple marks, requires mastery to earn credit but allows reassessment Assessment grade derived from the number of course objectives mastered	Student effort is more directly linked to course progress and a growth mindset Faculty grading effort is streamlined and more purposeful Student learning benefit
Dynamics – sophomore level	Inconsistent grading	Exams graded on a 10-point scale with	Higher student learning

course in mechanical engineering program	Students passing without an acceptable level of understanding Time consuming grading with partial credit	little partial credit provided Students offered one problem reattempt	Improved consistency in grading Reduced grading time Improved student satisfaction
Digital Signal Processing – junior level lab course in electrical engineering program (also taken by biomedical and computer engineering students)	Time consuming grading with partial credit Students not learning from their mistakes Students copying work submitted by other students	Labs marked as Excellent, Meets Expectations, Progressing, or Not Assessable Students demonstrate key lab results in person Students apply tokens to extend deadlines or revise substandard work	Grading time spent focusing on overall quality of work rather than nitpicking for points Much lower frequency of copied work Improved student satisfaction

4: Discussion and Conclusion

Each of the examples presented here demonstrates established alternative grading principles such as the "four pillars" outlined by Clark and Talbert [1]. Each author's example emphasizes that only meaningful work may be accepted for passing credit. Clear standards are articulated to students so that they understand what is expected of their work. Revision cycles are designed to require students to incorporate feedback they receive. As a result, the student-instructor interactions shift from grade negotiation to how they can grow in their understanding of the material.

The goal of alternative grading is to create an experience that is more meaningful and rewarding to both the student and the instructor. While the benefits to student learning are emphasized throughout alternative grading literature, the alternative grading process should ultimately also create a more enjoyable teaching experience for the instructor. After all, if the instructor "burns out" then they cannot provide a quality learning experience for the student. A successful alternative grading scheme would give the instructor more time to spend on creative endeavors (e.g., designing meaningful assessments) by removing burdensome tasks associated with traditional grading.

With that context in mind, the authors have identified several lessons from their grading revision process that may help others avoid unnecessary complexity and instructional burden. The first is to be very clear about what the goal of the assignment (or set of assignments) is. Next is to explicitly identify how traditional grading falls short of that goal. Together, these steps establish a well-defined target that can streamline the design of an alternative grading system. A common theme across the authors' examples is that traditional grading allows students to earn passing grades without developing sufficient understanding to be prepared for subsequent coursework or professional engineering practice.

Once a well-defined target for the alternative grading scheme has been identified, instructors should focus on developing the simplest grading modification that directly addresses that concern. Importantly, the simplest solution is not always the first one conceived and often emerges through reflection, discussion, and review of existing implementations. Rushing the development of an alternative grading approach may introduce unnecessary complexity and unintended consequences that cost more time and energy than they save. Instructors are encouraged to review relevant examples from the literature, solicit feedback from colleagues, and critically evaluate whether elements of the grading scheme can be removed or simplified without undermining the intended outcome. This is why the emphasis in this paper is to start small - starting with one assignment allows the instructor to dip their toes into the alternative grading arena without completely upturning their course.

Additionally, setting a firm decision deadline prior to the start of the term helps ensure that course materials, the syllabus, and the learning management system can be updated in a timely manner. Initial implementations will inevitably reveal shortcomings which should be viewed as valuable feedback rather than failures. The examples presented in this paper represent revisions from earlier iterations and continue to evolve. By starting with a limited-scope implementation, unforeseen issues remain manageable and serve to clarify the instructor's longer-term vision for alternative grading.

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Appendix A

Points	Description
10 points	**Masterful Understanding and Execution** ❑ The student takes an appropriate approach to solve the problem. ❑ The problem setup is flawless (includes all correct coordinate systems, free-body diagrams, identifying knowns/unknowns and what needs to be found, etc.) ❑ The dynamics principles (kinematics, Newton's Laws, work-energy, impulse-momentum, correct units, etc.) are applied correctly and thoroughly. ❑ The final answer is correct with appropriate units.
8 points	**Excellent Understanding and Execution** ❑ The student takes an appropriate approach to solve the problem. ❑ The problem setup is flawless (includes all correct coordinate systems, free-body diagrams, identifying knowns/unknowns and what needs to be found, etc.) ❑ The dynamics principles (kinematics, Newton's Laws, work-energy, impulse-momentum, correct units, etc.) are applied correctly and thoroughly. ❑ The final answer is incorrect due to ***one small mathematical error*** (e.g., calculator error, algebra mistake, derivative/integral calculation mistake).
6 points	**Good Understanding and Execution** ❑ The student takes an appropriate approach to solve the problem. ❑ The problem setup is flawless (includes all correct coordinate systems, free-body diagrams, identifying knowns/unknowns and what needs to be found, etc.) ❑ The dynamics principles (kinematics, Newton's Laws, work-energy, impulse-momentum, correct units, etc.) are applied, but there could be ***one minor mistake in execution*** (e.g., one incorrect variable definition, incorrect limits of integration, incorrect gravitational constant, incorrect units, one sign error in an equation of motion, etc.) ❑ The final answer is incorrect due to one minor mistake in applying underlying dynamics principles or it could be incorrect due to ***more than one small mathematical error.***
4 points	**Partial Understanding and Execution** ❑ The student takes an appropriate approach to solve the problem. ❑ The problem setup is flawless (includes all correct coordinate systems, free-body diagrams, identifying knowns/unknowns and what needs to be found, etc.) ❑ The dynamics principles (kinematics, Newton's Laws, work-energy, impulse-momentum, correct units, etc.) are applied, but there are ***multiple minor mistakes*** or ***one major mistake*** (e.g., incorrect free body diagram, incorrect equation used, etc.) in execution. ❑ The final answer is incorrect due to multiple minor mistakes in execution or one major mistake in execution.
2 points	**Minimal Understanding and Execution** ❑ The student may or may not take an appropriate approach to solve the problem. ❑ The problem setup may not be flawless. There could be errors in the free-body diagram, coordinate systems used, etc. Some of the problem setup should be correct. ❑ The dynamics principles (kinematics, Newton's Laws, work-energy, impulse-momentum, correct units, etc.) are applied, but there are ***multiple major mistakes*** (e.g., incorrect free body diagram, incorrect equation used, etc.) in execution. ❑ The final answer is incorrect due to multiple major mistakes in understanding and execution.
0 points	**No Understanding and Execution Shown** ❑ The student makes no meaningful attempt to solve the problem. No correct setup, dynamics principles, or calculations are applied. ❑ The page is either blank or almost everything written is incorrect.