WIP: Expanding Access and Engagement in Engineering Mechanics: An Open Educational Resource (OER) Transformation of Statics Instruction

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Abstract

Statics is a foundational course that introduces students to core engineering mechanics principles through problem-solving. Often regarded as a gatekeeper within the engineering curriculum, it plays a crucial role in shaping student persistence. Traditionally, Statics depends heavily on textbook-based lectures, standardized homework, and summative exams. However, research shows that reliance on traditional textbooks can negatively affect both affordability and student engagement—especially in engineering education—where high material costs can limit equitable access and hinder academic success.

To improve learning outcomes and reduce DFW rates in Statics, the instructors have implemented several initiatives over the past five years, including the addition of a one-hour problem-solving lab, experiential learning modules, and mastery-based assessments.

While these initiatives improved learning outcomes, they did not address accessibility to course materials, especially the textbook for a subject largely unchanged for 250 years. Although the textbook was referenced in class, students mainly relied on course notes, with homework sometimes using textbook problems or images that could be replaced. In response to these issues, the course was updated in Fall 2025 to a fully Open Educational Resource (OER) format. This change aims to reduce financial barriers, increase accessibility, and encourage more active and inclusive learning.

In selecting an OER textbook, the instructional team applied a set of criteria, including alignment with course learning objectives, integration of interactive components, compatibility with mastery-based assessment, and online accessibility. The adoption is expected to enhance affordability and to offer pedagogical adaptability. Course materials, including lecture notes and homework assignments, are being revised to integrate seamlessly with the selected OER, ensuring that students can benefit from a coherent and engaging learning experience.

This transformation represents a pivotal step in aligning pedagogical practices with the principles of equity, affordability, and evidence-based instruction in engineering education. While

preliminary implementation of the OER textbook and mastery-based structure has been well received, this initiative is still in progress. Importantly, the primary reductions in DFW rates occurred following mastery-based assessment and experiential learning reforms. The adoption of OER is therefore positioned as an access-focused intervention intended to remove financial barriers while maintaining those learning gains, rather than as the primary driver of performance improvement.

The full paper presents an evaluation of the OER adaptation using available course performance data, including DFW rates and grade distributions, along with student course evaluation results from early post-adoption semesters. Particular attention is given to whether student outcomes were maintained following the transition to OER within the existing mastery-based structure. Additionally, the paper discusses practical challenges encountered during implementation, including aligning legacy assessments with the new instructional framework and coordinating multiple instructors during adoption. These insights offer guidance for engineering programs seeking to integrate OER within broader pedagogical reform efforts.

Course Context and Prior Instructional Improvements

Engineering mechanics courses like Statics are often regarded as "gatekeepers," delaying or preventing many students from progressing toward an engineering degree. However, the instructors at Angelo State University have decided to take the opposite approach, treating the course as a "gateway," since most students who successfully complete it in their program go on to earn their civil or mechanical engineering degrees.

Therefore, to address unfavorable DFW rates, Angelo State University has implemented several initiatives over the past five years to improve learning [1]:

- One Hour Lab Session
    - The department implemented a one-hour lab session in each course to provide additional practice on key concepts.
    - Additionally, an upperclassman Student Instructor (SI) is assigned to the course and provides two SI sessions per week to assist with problem-solving.

- Mastery-Based Assessments
    - Mastery-based assessments were introduced in Statics, replacing primarily exam-based assessments with a series of weekly assessments.
- Experiential Learning Modules
    - Experiential learning modules were introduced to Statics labs, providing hands-on experiments to aid students' comprehension.

While these initiatives improved learning outcomes, they did not address accessibility to course materials, particularly the costly textbook for a topic that has remained largely unchanged for 250 years.

Motivation: Open Educational Resources to Enhance Student Experience and Affordability

Traditionally, Statics courses depend heavily on textbook-based lectures, standardized homework, and summative exams. However, research shows that reliance on traditional textbooks can negatively affect both affordability and student engagement—especially in engineering education—where high material costs can limit equitable access and hinder academic success [2]-[6].

As of Fall 2024, the textbook for the Statics course studied cost between $51 for an online rental, $80 for a printed copy, and $120 for a printed copy with an online practice platform. The adoption of only OER materials was expected to yield a per-semester savings of $1,275 to $3,000 for the course (based on the costs mentioned above) for the Academic Years 2025-2026 and 2026-2027, enhancing affordability while offering pedagogical adaptability. These estimates are based on enrollment counts and published textbook prices; actual student purchase behavior was not directly measured.

Adoption of OER is particularly important at a rural, regional institution like Angelo State University, where roughly 45% of degree-seeking undergraduates receive a Pell Grant (a government grant available for undergraduate students facing exceptional financial hardship). See Table 1 for actual course enrollment details and estimated savings.

Table 1. Estimated Cost Savings for Statics Course at Angelo State University

ENGR 2301- Statics: Estimated Cost Savings		
Semester	**Enrollment**	**Range of Cost Savings ($51-$120 per person)**
Fall 2024	24	-
Spring 2025	28	-
Adoption of OER		
Fall 2025	23	$1173 - $2760
Spring 2026	31	$1581 - $3720

Although the textbook was previously referenced in class, it seemed students mainly relied on course notes, with homework sometimes using textbook problems or images that could be replaced. Mastery tests already depended solely on instructor-created content. Therefore, it seemed appropriate to redesign the course into a fully Open Educational Resource (OER) format. The change aims to reduce financial barriers, increase accessibility, and encourage more active and inclusive learning.

The transformation replaced the commercial textbook with an OER textbook supplemented by a comprehensive suite of instructor-developed materials—including lecture notes, homework assignments, mastery exam questions, and concept check pre-class quizzes—delivered through Blackboard and explicitly aligned with ABET Student Outcome 1, which emphasizes the ability to identify, formulate, and solve engineering problems. The course is organized into modular units, each featuring clearly defined learning objectives, pre-class quizzes, scaffolded homework, and targeted mastery assessments. Weekly lectures, laboratory sessions, and online assessments are tightly integrated via Blackboard to provide a cohesive learning experience. Mastery tests and the group project, part of the mastery test module achievement, are setup as the major deliverables to support both formative and summative assessments. They reinforce student learning through iterative feedback and practical application.

Selection and Adoption of an OER for Statics

In selecting an OER textbook to replace the commercial text, the instructional team applied a structured set of criteria, including alignment with course learning objectives, integration of interactive components, compatibility with mastery-based assessment, and online accessibility. After reviewing several OER options, the team selected *Engineering Statics: Open and Interactive* by Dan Baker and William Haynes. This resource was chosen for its structured content delivery, openly licensed adaptability, and embedded interactive problems that support real-time learning assessment. The platform's feedback mechanisms allow students to identify their strengths and areas for improvement—making it especially well-suited to mastery-based instruction. The resource's open license permits adaptation, allowing faculty to embed, remix, and align content with ABET Student Outcomes, particularly Outcomes 1 (problem-solving) and 7 (lifelong learning strategies) [7]. Additionally, this OER is fully online and device-accessible, enabling flexible integration into Blackboard and weekly instructional modules.

The OER selected provides the appropriate textbook material for the class. Pre-reading from the textbook allows students to come to class prepared for learning the topic. Students might also use the online textbook to provide additional explanation after a given class. The topic of Statics is not rapidly changing, but the OER does update the student experience with enhanced and interactive visuals online at no cost. Figure 1 shows a typical example of the integration of the OERs into this course.

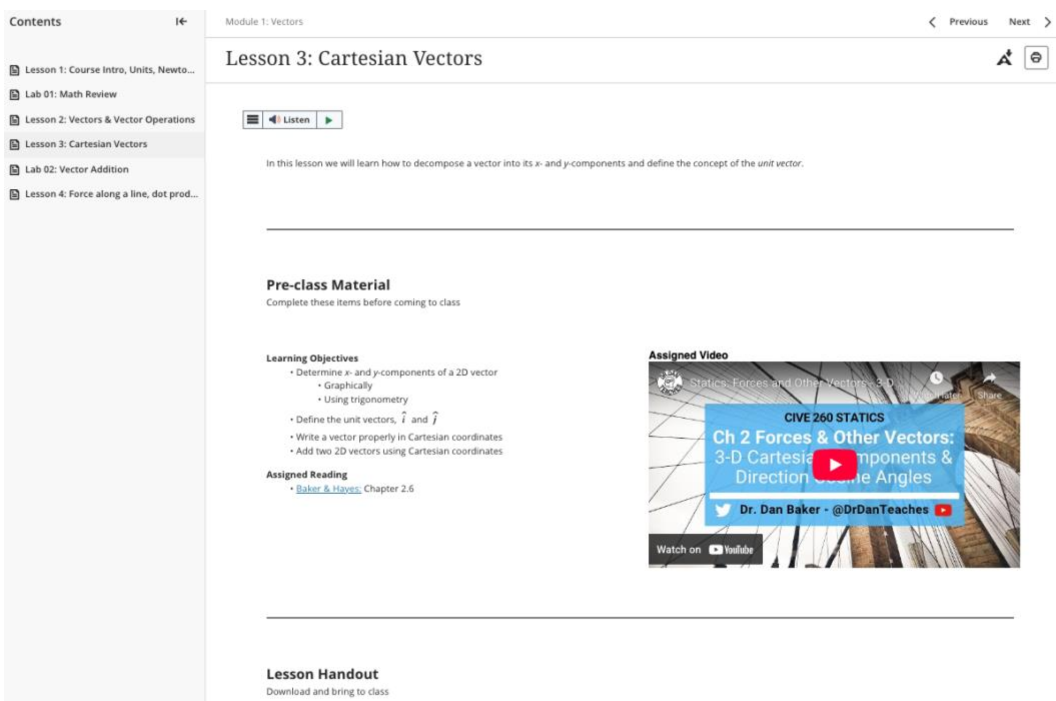

Figure 1. Screenshot of the Learning Management System (LMS) lesson page for "Lesson 3: Cartesian Vectors", illustrating pre-class learning objectives, assigned OER-based reading and video materials, and downloadable lesson handouts

Lastly, some class examples and homework problems have been updated to align with the OER practice problems, allowing students to use the OER to submit answers and receive immediate feedback on their learning progress. For difficult topics, students are encouraged to try other practice problems. One instructor observed that the students were excited to use the platform during class. Throughout the semester, the instructor would display an example problem, the class would work through it, and then the instructor would enter the answers in for a dramatic reveal! The students particularly teased the instructor for failing to enter the appropriate units one time, which caused the collective class to lose a few points on the platform's score.

Accessibility Requirements and Universal Design for Learning for Selected OER

As part of an ongoing grant program with the Texas Higher Education Coordinating Board to incentivize the implementation of OER in high-impact university courses, the authors were tasked with evaluating the accessibility of the selected OER and its alignment with Universal Design for Learning (UDL) Principles. The following assessment of accessibility and UDL alignment is based on the experience of the researchers, who are not experts in either accessibility or UDL, but who are teaching-focused faculty who must provide course content to meet applicable laws.

In the opinion of the researchers, the OER selected, *Engineering Statics: Open and Interactive* [7], generally meets accessibility requirements. The textbook is available on the website as HTML and offline as a downloadable pdf. The online HTML should be readable by a screen reader. The HTML format allows easy viewing on computers, tablets, and phones. Unfortunately, some of the interactive figures do not meet accessibility requirements. The authors do have related YouTube videos with transcripts available for further explanation of the material. In addition, all the source files for the textbook are available online, so there is an option to download the text in document format to modify or read. The downloadable pdf is bookmarked by chapter/topic and is fully searchable for content. An accessibility check on the downloaded pdf revealed some issues, particularly the lack of Alternative Text for images. However, a cursory review of different images seems to indicate the image captions do a good job of describing the significance of the associated figures. More information on accessibility is given on the authors' website [8].

The following outline of the principles for Universal Design are based on details described in the Texas Education Agency Universal Design for Learning (UDL) Guidelines (adapted from CAST) with an assessment of the selected OER written by the authors of this paper [9].

- Provide Multiple Means of Engagement
    - Provide Options for Recruiting Interest
        - The textbook, *Engineering Statics: Open and Interactive,* and its associated website allow students to explore other related topics not explicitly covered in-class or to explore greater depth than time allows in class
        - Instructors can select specific sections of the textbook as well as interactive online problem-solving activities within the selected OER to support student learning outcomes for the course
    - Provide Options for Sustaining Effort & Persistence
        - The online platform for *Engineering Statics: Open and Interactive* allows students to explore different degrees of difficulty for practice problems
        - Students can receive immediate feedback on practice problems on the online platform with options to see the correct answers and/or the solution procedure if a student struggles with a problem
    - Provide Options for Self-Regulation
        - Based on students' performance, a student could self-assess their ability on a topic and choose to practice more/less on similar problems
        - In the context of the course at Angelo State University, where Mastery Tests are used versus timed exams, students could attempt the Mastery Test (administered through Blackboard at the Institution) and then revisit practice problems if unable to successfully pass the Mastery Test
- Provide Multiple Means of Representation
    - Provide Options for Perception

        - The textbook is available as HTML and pdf, as well as downloadable text for modification
        - Some graphics are interactive to help facilitate understanding
        - Captions do a fair job of describing images (no alternative text seems to be included in downloadable pdf)
    - Provide Options for Language & Symbols
        - Important terms are bolded/italicized
        - Back Matter contains information on Notation, Useful Mathematics, Properties of Shapes
        - Figures and sections are hyperlinked to allow a student to easily navigate to a referenced figure or back to a previous section for knowledge reinforcement
        - Multiple media are used for presentation: website, videos, text, graphics
    - Provide Options for Comprehension
        - Not specifically identified
- Provide Multiple Means of Action & Expression
    - Provide Options for Physical Action
        - Alternate formats of material allow custom way to create notes: students could edit/mark up pdf with own notes, could download the full text files to make detailed edits, or could simply take notes and refer to online links
        - Interactive figures require students to physically move mouse over figure to change image to express concept
        - Interactive problem exercises require students to input answers and receive feedback (correct/not correct) and can see solution procedures
    - Provide Options for Expression & Communication
        - Again, videos and textbook provide flexibility for students' preferred media for communication

- Provide Options for Executive Functions
    - Not specifically identified

Case Study: Practical Challenges of OER Adoption

As with any pedagogical change, the instructors have encountered a number of implementation challenges. The following sub-sections highlight some of the difficulties experienced.

Figure Creation for Problems

To make the entire course OER, the instructors needed to rewrite a number of class examples and homework problems so they could stand alone from any textbook. For Statics, it is important to have clear, accurate, and neatly formatted problem figures to help first-time learners comprehend key Statics concepts. As an instructor, it is usually easy to copy and paste these problems from the associated textbook. However, to make the class entirely OER, the instructors have had to create their own figures, even down to creating a version of engineering graph paper. While not technically demanding, generating figures takes significant time and represents a barrier to instructors converting a course to OER. The instructors hope the materials from this adoption will be made available to others through the OERTX website.

Coordination of Instructors

At present, three instructors are teaching Statics at Angelo State University. To create a cohesive, consistent experience for students, the instructors have agreed to adopt the same OER textbook, lesson materials, homework assignments, and mastery-based assessments. The instructors use an MS Teams group to store documents semester to semester and to post updates or modifications as the OER materials are fully adopted and integrated. The centralized storage of documents and revisions has been extremely useful for coordination and is recommended for other institutions seeking to make the change, particularly if more than one instructor regularly teaches the course or multiple instructors teach the same course at the same time.

Furthermore, the instructors have divided the responsibilities for updating course content so that each item has a consistent format for students. For instance, one instructor updated all the homework assignments and solutions, while the other instructor updated the class lesson handouts and examples. A third instructor even helped out with the layout of the OER content and linked videos on the LMS, particularly since the university recently upgraded the LMS platform.

In addition, the collegiality of the instructors has been a key to the implementation thus far. While the associated grant for the project required the implementation of OER materials for at least 4 consecutive semesters, it is apparent that, as with the previous pedagogical changes outlined [1], the work done to convert the course materials to OERs will continue to benefit students in the future.

Selection of OER

At the start of the project, the instructors were a little overwhelmed by the task of finding and vetting various OERs for potential use in the class. In the end, the instructors realized that numerous excellent OERs are available for Statics, but the most important thing is to select one and implement it so students are relieved of the rising costs of traditional textbooks. While the paper describes the integration of *Statics: Open and Interactive* [7] and its perceived benefits, other online textbooks and online teaching apps were discussed at the outset of the project and may have led to similar success. If you are an instructor reading this paper, the authors encourage you to just go ahead and try using an OER for your class. In addition, resources developed through this project are available through the OERTX website.

Faculty Time to Adopt OER

While the authors have not officially tracked the time it has taken to adopt the OER for the course, it has been significant. One consideration is the task to link to the OER and its associated videos for supplemental instruction through links on the LMS. Fortunately, as part of a university upgrade of the LMS, the faculty already needed to redo content on the LMS as part of the transition, so linking to the new OER source was not additional time. In terms of the class notes, it has taken about 1-2 hours to redo each lesson to remove previous textbook content and replace it with instructor-based content or OER example problems/figures. The homework sets have taken about the same time to modify and produce new solutions. The instructors are continuing to find ways to better leverage the OER with the students and to encourage them to actually visit the site to practice. Fortunately, the authors have been partially compensated through a grant to perform this work, but it is recognized that faculty will have to commit to doing this for their students.

Results: DFW Rates and Student Grade Distributions

Once the OERs were integrated into the Statics course, the instructors wanted to ensure no negative impacts were experienced by the students as well as assess if student learning has improved.

Table 2 presents DFW (D, F, and Withdrawal) rates for Statics across multiple semesters, spanning several instructional interventions. Prior to major course redesign efforts (2016–2019), DFW rates were highly variable and frequently exceeded 40%, indicating persistent challenges typical of gateway Statics courses. The addition of a required 1-hour laboratory session beginning in Fall 2019 did not immediately improve outcomes; DFW rates remained elevated and peaked at 60.0% in Fall 2019, suggesting that increased contact time alone was insufficient to address underlying learning barriers.

Substantial and sustained improvements emerged following the introduction of mastery-based assessments in Fall 2021, when the DFW rate dropped sharply to 15.4%. This reduction coincided with a shift toward iterative assessment, explicit learning objectives, and opportunities for reassessment. Subsequent integration of experiential learning modules beginning in Spring 2022 was associated with consistently low and stable DFW rates, including a 0.0% DFW rate in Spring 2022 and most later semesters remaining below 22%. The adoption of open educational resources (OER) in Spring 2025 maintained these gains, with Fall 2025 showing the lowest non-zero DFW rate in the dataset (8%). While causal claims cannot be made, the observed trends suggest that assessment structure, experiential learning, and material accessibility play a more significant role in supporting student success than instructional time alone.

Table 2. DFW Data for Engineering Mechanics- Statics Course at Angelo State University

Semester	Enrollment	DFW Rate
Fall 2016	32	43.8%
Spring 2017	15	13.3%
Fall 2017	22	-
Spring 2018	23	21.7%
Fall 2018	27	48.1%
Spring 2019	31	45.2%
1 Hour Lab Session Added to Course		
Fall 2019	30	60.0%
Spring 2020	28	42.9%
Fall 2020	19	52.6%
Spring 2021	23	43.5%
Mastery-Based Assessments Added to Course		
Fall 2021	26	15.4%
Experiential Learning Modules Added to Course		
Spring 2022	18	0.0%
Fall 2022	21	19.0%
Spring 2023	19	21.1%
Fall 2023	23	13.0%
Spring 2024	19	21.1%
Fall 2024	24	16.7%
Spring 2025	29	20.7%
Adopted OER		
Fall 2025	25	8.0%
Spring 2026	-	-

In addition to the DFW rates, the instructional team attempts to ensure that pedagogical changes in Statics do not negatively impact student learning outcomes. Therefore, final grades before and after the various implementations of different initiatives over the last 10 years has been tracked [1]. The updated data is presented in Table 3.

Table 3. Longitudinal Data for ENGR 2301- Statics Final Grades

ENGR 2301: Final Grade Data by Percentage									
Semester	**Enroll-ment**	**A**	**B**	**C**	**D**	**F**	**W**	**AB**	**DFW**
Fall 2016	32	9.4%	18.8%	28.1%	9.4%	21.9%	12.5%	28.1%	43.8%
Spring 2017	15	6.7%	33.3%	46.7%	0.0%	6.7%	6.7%	40.0%	13.3%
Fall 2017	22	-	-	-	-	-	-	-	-
Spring 2018	23	13.0%	43.5%	21.7%	8.7%	8.7%	4.3%	56.5%	21.7%
Fall 2018	27	25.9%	11.1%	14.8%	11.1%	33.3%	3.7%	37.0%	48.1%
Spring 2019	31	19.4%	22.6%	12.9%	12.9%	19.4%	12.9%	41.9%	45.2%
1 Hour Lab Session Added to Course									
Fall 2019	30	3.3%	23.3%	13.3%	13.3%	16.7%	30.0%	26.7%	60.0%
Spring 2020	28	21.4%	17.9%	17.9%	3.6%	7.1%	32.1%	39.3%	42.9%
Fall 2020	19	10.5%	15.8%	21.1%	10.5%	15.8%	26.3%	26.3%	52.6%
Spring 2021	23	17.4%	17.4%	21.7%	0.0%	21.7%	21.7%	34.8%	43.5%
Mastery-Based Assessments Added to Course									
Fall 2021	26	34.6%	42.3%	7.7%	7.7%	3.8%	3.8%	76.9%	15.4%
Experiential Learning Modules Added to Course									
Spring 2022	18	66.7%	22.2%	11.1%	0.0%	0.0%	0.0%	88.9%	0.0%
Fall 2022	21	38.1%	38.1%	4.8%	9.5%	9.5%	0.0%	76.2%	19.0%
Spring 2023	19	36.8%	15.8%	26.3%	10.5%	5.3%	5.3%	52.6%	21.1%
Fall 2023	23	21.7%	34.8%	30.4%	0.0%	13.0%	0.0%	56.5%	13.0%
Spring 2024	19	47.4%	10.5%	21.1%	10.5%	10.5%	0.0%	57.9%	21.1%
Fall 2024	24	37.5%	8.3%	37.5%	4.2%	4.2%	8.3%	45.8%	16.7%
Spring 2025	29	37.9%	10.3%	31.0%	10.3%	10.3%	0.0%	48.3%	20.7%
Adopted OER									
Fall 2025	25	16.0%	36.0%	40.0%	0.0%	4.0%	4.0%	52.0%	8.0%
Spring 2026	31	-	-	-	-	-	-	-	-

As a work in progress, the final outcome of the OER implementation has yet to be determined. The primary impetus for moving to OER was to alleviate the financial burden to some students by removing a costly textbook from the course. The authors believe that the implementation will be a success as long as the DFW data does not trend upward after the adoption of the OER and the student final grades are not negatively impacted. Based on Fall 2025 data, it appears that adopting OER has not negatively affected student achievement. The primary benchmark for

OER success in this context is the maintenance of post-mastery learning gains without an increase in DFW rates. While the overall number of students achieving the grade of A decreased, the total number of students receiving an A or a B was consistent with recent post-mastery semesters. Because mastery assessment standards and grading thresholds remained unchanged during OER adoption, observed grade distributions are unlikely to reflect grading policy changes. It is also encouraging that the DFW rate dropped; however, the instructional team will continue to monitor outcomes as the transition continues.

In addition, it is noted that the OER was only partially adopted in Spring 2025, potentially offering insight into a semester without using a specific textbook, but not yet being fully linked to the online resources of the OER. For this semester, content from the OER was added to class notes and demonstrated in-class, but assignments directing students to the OER were not added. Based on the DFW data, Spring 2025 was consistent with the previous semesters since the inclusion of mastery-based assessments and the percentage of students receiving A or B grades was similar to the previous four semesters.

It is also important to note that the course has had at least 6 different instructors over the 10 years of data presented. Therefore, instructor variability is a definite concern in making definitive claims of how successful one pedagogical change is to another. This variability is explicitly acknowledged as a limitation of the longitudinal dataset. For this reason, the authors have emphasized the data since Fall 2021, when only 3 different instructors have rotated in the course, along with the introduction of the mastery-based assessment. Over this same period, the DFW and student outcome data have been relatively stable.

Results: Quantitative and Qualitative Feedback from Student Surveys

To gauge students' perceptions of the use of OERs, the following quantitative feedback from the student end-of-semester surveys (IDEA survey) was collected and presented in Table 4.

Table 4. Student Ratings of Learning on Relevant Objectives

(1- Strongly Disagree, 2- Disagree, 3- Neutral, 4-Agree, 5- Strongly Agree)

A. Gaining a basic understanding of the subject (e.g., factual knowledge, methods, principles, generalizations, theories)
B. Learning to apply course material (to improve thinking, problem solving, and decisions)
C. Developing specific skills, competencies, and points of view needed by professionals in the field most closely related to this course
D. Learning how to find, evaluate, and use resources to explore a topic in depth
E. [The instructor] Explained course material clearly and concisely
F. [The instructor] Encouraged students to use multiple resources (e.g., Internet, library holdings, outside experts) to improve understanding

Semester	Instructor	Survey Sample Size	Responses	Likert Scale Question Results- Average					
				A	B	C	D	E	F
Spring 2023	A	18	16	4.1	4.2	4.2	3.7	4.2	3.7
Fall 2023	B	23	22	4.1	4.1	4.1	3.2	4.0	3.9
Spring 2024	A	19	16	4.3	4.1	4.3	4.0	4.4	4.4
Fall 2024	A	22	19	4.5	4.5	4.4	4.2	4.4	4.3
Spring 2025*	C	28	14	4.3	4.4	4.3	4.0	4.5	4.4
Pre-Test Weighted Average	ALL	110	87	4.3	4.3	4.3	3.8	4.3	4.1
Adopted OER									
Fall 2025	B	23	7	3.7	3.9	3.7	3.3	3.9	4.3
Spring 2026	A	31	-	-	-	-	-	-	-

*OER material was introduced, but the course was not fully converted.

Based on the obtained data, no trends were observed. It should be noted that the IDEA instrument does not include direct questions about textbook use, the perceived rigor of the OER, or financial stress reduction. Therefore, these survey data cannot be used to draw conclusions about students' perceptions of OER specifically. It was hoped that the semesters using the OERs (Fall 2025 and partially Spring 2025) would have higher ratings on these relevant objectives and instructor ratings. Spring 2025 was slightly higher, but Fall 2025 was the lowest in the data set. There are two confounding factors: changes in instructors and response rates. Spring 2025 and

Fall 2025 had the lowest response rates among the studies, which might not accurately reflect the class data. When comparing the data for only instructor B, again, it is seen that Fall 2025 is lower than Fall 2023. The authors plan to monitor this data as OER adoption continues and to develop more targeted questions, as described in the following section.

Preliminary Conclusions and Future Work

Final conclusions on the use of the OER and its effectiveness on student engagement and learning outcomes are still forthcoming. At this point, the team is confident that using the OER is not negatively affecting student outcomes. However, the team will continue to determine ways to measure student engagement regarding the OERs.

To date, students have not indicated whether they enjoy the online textbook and interactive activities, either informally to instructors or in the end-of-semester course surveys. As outlined in the previous section, the course survey has questions related to how well the instructor "encouraged students to use multiple resources" to learn the material, but does not explicitly explore the use or attitudes towards the textbook for the course. In the coming semesters, the instructional team plans to seek student feedback by asking specific questions about their actual usage of the OER textbook and example problems (time spent), their perception of the quality and rigor of the OER as it relates to the topic, and their overall satisfaction or dissatisfaction with the OER as a free replacement for the traditional textbook.

Lastly, as previously presented, the instructors believe the use of mastery-based learning has been essential in helping students learn this crucial engineering topic and the most important pedagogical change in making Statics a gateway to a successful engineering degree.

Acknowledgements and Resources

The work carried out in this project is part of an ongoing Implementation Grant awarded by the Texas Higher Education Coordinating Board as part of its Open Educational Resources Grant Program. The grant seeks to support the substantial redesign of one or more courses to incorporate existing OER resources. Specific resources developed as part of this grant are available through the OERTX Repository [10].

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Appendix A. Example of Course Notes

Lesson 13: Frame

Learning Objectives

After completing this lecture, you should be able to:
- **Differentiate** between trusses, frames, and machines in structural systems.
- **Identify** two-force members in a frame, regardless of their geometry.
- **Isolate** each member of a frame and **construct** consistent free-body diagrams for individual members.
- **Analyze** frames to evaluate external reactions and internal forces.

Review: Structures Definitions

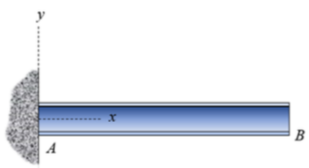
Trusses -

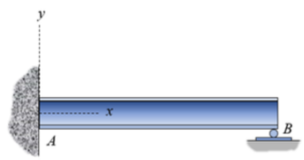
Frames -

Machines -

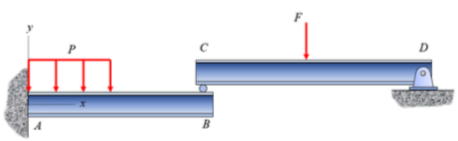
Two-force members -

Determinate versus indeterminate structures



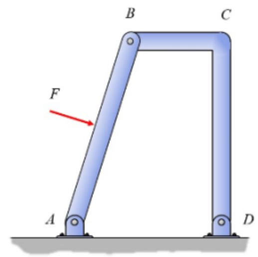


FBDs for Frames

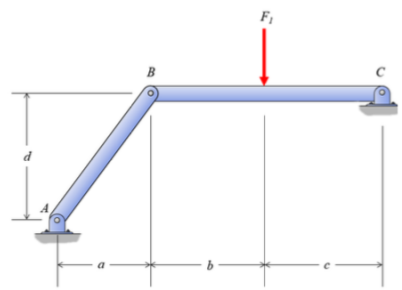


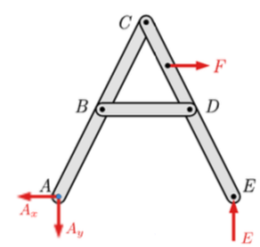
Lesson 13: Frame

FBDs for Frames (cont)



Recognizing Two force members





Chapter 6 Figures/Examples - Engineering Statics: Open and Interactive by Baker and Haynes

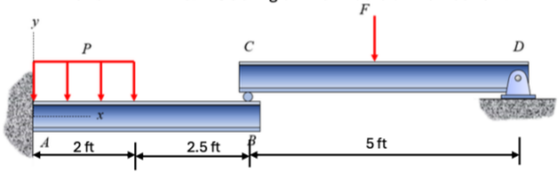
Lesson 13: Frame

Frames Analysis Procedure

1. Identify two-force members, if any (help to simplify calculations)
2. Solve external support reactions from overall equilibrium (if necessary)
3. Solve for forces on each member or member assembly
   - (a) Often requires multiple FBDs
   - (b) $\Sigma F_x = 0$; $\Sigma F_y = 0$; $\Sigma M_z = 0$ on each FBD
   - (c) Use Strategy to determine an optimum path

Example 13-1

Given: The frame with members AB and CD connected as shown. P = 15 lb/ft and F = 1114 lb. F is acting on the middle of member CD.



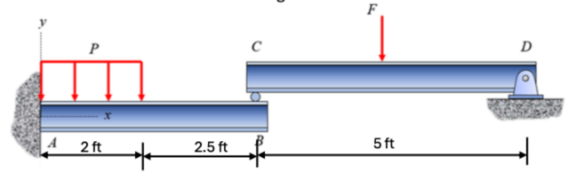
Find: Forces (reactions) at A, C, D.

Solution:

Lesson 13: Frame

Example 13-1 (cont)

Given: The frame with members AB and CD connected as shown. P = 15 lb/ft and F = 1114 lb. F is acting on the middle of member CD.



Find: Forces (reactions) at A, C, D.

Solution:

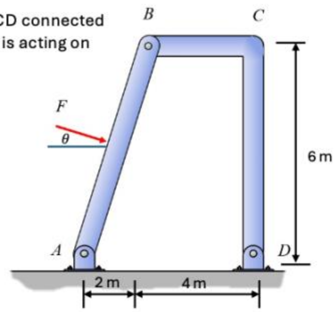
Lesson 13: Frame

Frames Analysis Procedure

Given: The frame with members AB and BCD connected as shown. F = 27 KN and $\theta = 22°$. F is acting on the middle of member AB.

Find: Forces (reactions) at A, B, and D.

Solution:



Appendix B. Example of Homework Assignment and Solution (Rigid Body Equilibrium)

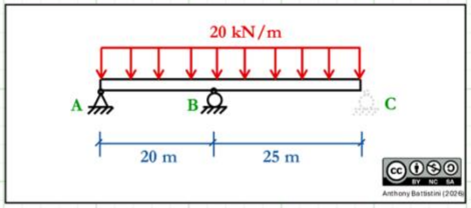
ENGR 2301: Statics
Homework D6
Problem 1

Angelo State University
David L. Hirschfeld Department of Engineering
Calculation Sheet

Sheet __ of __

Given: Incrementally launched construction is a method for constructing bridges over restricted land (railroad, environmentally sensitive) or inaccessible ground (deep ravine, canyon where typical crane not feasible). In this method, the beam is pushed over two supports A and B until it reaches support C on the opposite side. Reactions and internal forces will often reach a maximum immediately before the beam makes contact with support C.

The self-weight of the beam is shown below. At this instant, it is not contacting the roller at point C.



Find: Calculate the support reactions at A and B for the beam with loading shown.

Strategy:

Solution:

ENGR 2301: Statics
Homework D6
Problem 1

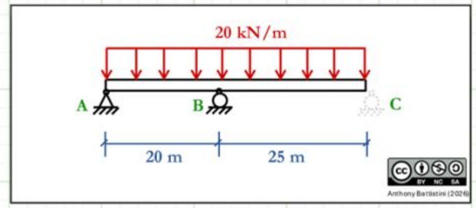
SOLUTION

Angelo State University
David L. Hirschfeld Department of Engineering
Calculation Sheet

Sheet 1 of 1

Given: Incrementally launched construction is a method for constructing bridges over restricted land (railroad, environmentally sensitive) or inaccessible ground (deep ravine, canyon where typical crane not feasible). In this method, the beam is pushed over two supports A and B until it reaches support C on the opposite side. Reactions and internal forces will often reach a maximum immediately before the beam makes contact with support C.

The self-weight of the beam is shown below. At this instant, it is not contacting the roller at point C.



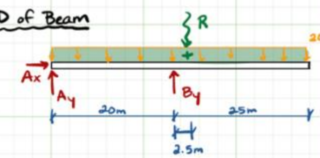
Find: Calculate the support reactions at A and B for the beam with loading shown.

Strategy:

- Draw FBD of Beam with appropriate support reactions
- Use equilibrium equations to solve

Solution:

FBD of Beam



$R = (20\,kN/m)(45\,m) = 900\,kN$

Equilibrium Eqns

$\xrightarrow{+} \Sigma F_x = \boxed{A_x = 0}$

$\circlearrowleft + \; \Sigma M_A = B_y(20m) - R(22.5m) = 0$

$\boxed{B_y = 1012.5\,kN \uparrow}$

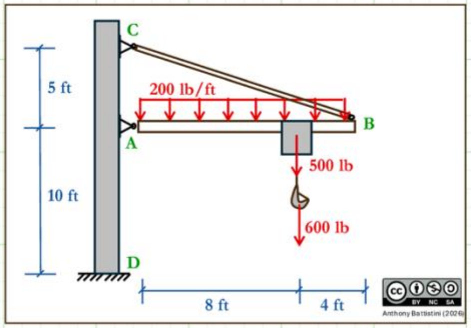
$+\!\uparrow \Sigma F_y = A_y + B_y - R = 0 \qquad \boxed{A_y = -112.5\,kN \downarrow}$

Angelo State University
David L. Hirschfeld Department of Engineering
Calculation Sheet

Sheet ___ of ___

Given: Jib Cranes are common lifting devices used in factories, warehouses, and construction sites.

The jib crane shown is mounted to a column using a pin connection at A and a tie rod BC. The self weight of the beam is 200 lb/ft, the weight of the crane is 500 lb, and the crane is set to lift a 600 lb engine block.



Find: Calculate the support reactions at A and tension in rod BC.

Strategy:

Solution:

ENGR 2301: Statics
Homework D6
Problem 2

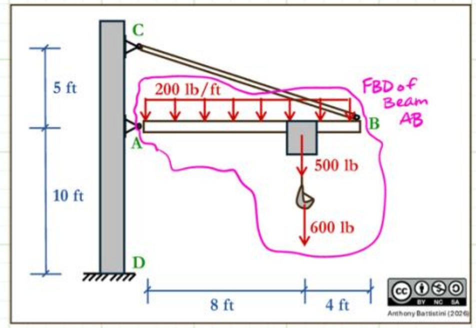
SOLUTION

Angelo State University
David L. Hirschfeld Department of Engineering
Calculation Sheet

Sheet 1 of 2

Given: Jib Cranes are common lifting devices used in factories, warehouses, and construction sites.

The jib crane shown is mounted to a column using a pin connection at A and a tie rod BC. The self weight of the beam is 200 lb/ft, the weight of the crane is 500 lb, and the crane is set to lift a 600 lb engine block.

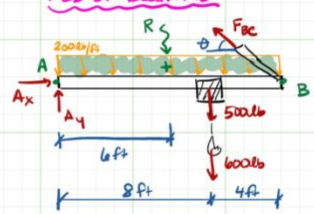


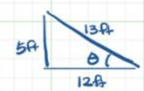
Find: Calculate the support reactions at A and tension in rod BC.

Strategy:
- Draw FBD of Beam AB
- Use equilibrium equations

Solution:

FBD of Beam AB





$\tan\theta = \frac{5}{12}$ $\quad\theta = 22.62°$

$R = (200 lb/ft)(12ft) = 2400 lb$

Equilibrium Equations

$\circlearrowleft + \Sigma M_A = -R(6ft) - 500lb(8ft) - 600lb(8ft) + (F_{BC}\sin\theta)(12ft) = 0$

$-2400lb(6ft) - 500lb(8ft) - 600lb(8ft) + (F_{BC}\sin 22.62)(12ft) = 0$

$\boxed{F_{BC} = 5026.6\ lb\ (T)}$

Solution:

Equilibrium Equations (cont)

$$\uparrow \Sigma F_y = A_y - R - 500\,lb - 600\,lb + F_{BC} \sin\theta = 0$$

$$A_y - 2400\,lb - 500\,lb - 600\,lb + (5026.6\,lb)\sin 22.62° = 0$$

$$\boxed{A_y = 1566.7\,lb \uparrow}$$

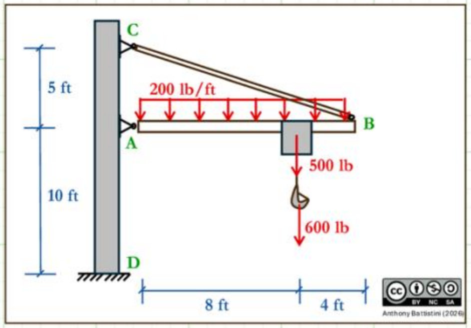
$$\rightarrow \Sigma F_x = A_x - F_{BC}\cos\theta = 0$$

$$A_x - (5026.6\,lb)\cos 22.62° = 0$$

$$\boxed{A_x = 4640\,lb \rightarrow}$$

Given: Jib Cranes are common lifting devices used in factories, warehouses, and construction sites.

The jib crane shown is mounted to a column using a pin connection at A and a tie rod BC. The self weight of the beam is 200 lb/ft, the weight of the crane is 500 lb, and the crane is set to lift a 600 lb engine block.



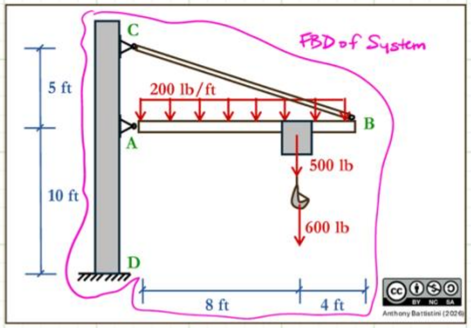
Find: Calculate the support reactions at the base of column D.

Strategy:

Solution:

Given: Jib Cranes are common lifting devices used in factories, warehouses, and construction sites.

The jib crane shown is mounted to a column using a pin connection at A and a tie rod BC. The self weight of the beam is 200 lb/ft, the weight of the crane is 500 lb, and the crane is set to lift a 600 lb engine block.

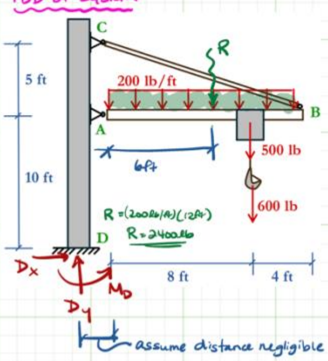


Find: Calculate the support reactions at the base of column D.

Strategy:

- Draw FBD of Entire System
- Use equilibrium equations

Solution:



Equilibrium Eqns

$\rightarrow \Sigma F_x = \boxed{D_x = 0}$

$\uparrow \Sigma F_y = D_y - 600\,lb - 500\,lb - R = 0$

$\boxed{D_y = 3500\,lb \uparrow}$

$\circlearrowleft + \Sigma M_D = M_D - R(6ft) - 500\,lb(8ft) - 600\,lb(8ft) = 0$

$\boxed{M_D = 23{,}200\,lb\cdot ft \circlearrowleft}$