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Developing Authentic Projects for a Senior Level Design Class

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Abstract

At Murray State University, Product and Tooling Design class is offered as a core course in the Engineering Graphics and Design program. The objective of the course is to enable students to integrate their design knowledge and skills to solve engineering design problems. Since the class is a senior level course, all of the students are expected to have acquired a set of skills and knowledge in manufacturing processes, industrial materials, engineering drawings, tolerance stack-up, solid modeling, motion analysis, and static analysis prior to this class. The course is built on four design problems with different goals and emphases on each problem. The first design problem is concentrated on engineering design process. Students practice how to start and finish a design project by following a proper methodology. The second project is a three dimensional statics problem for practicing finite element analysis. The third project requires integration of motion analysis and simulation tools to address a specific engineering problem. The focus of the last assignment is tool design and machining principles. For all four assignments, computer generated three dimensional models of parts and assemblies, engineering drawings and a report are common required deliverables. In addition, second and third assignments require the results of analyses and simulations. This paper explains how to set up an authentic problem setting for each assignment to create "Authentic Learning Tasks." An itemized scoring rubric is presented with the rationale behind each item. Students' common mistakes are shared with examples, as well. At the end, students' evaluation of the course is provided. It is believed that authenticity, meaningfulness and completeness of the assignments increase students' involvement and motivation for success.

1. Introduction

Design is best practiced and learnt by doing[1]. Thus, the course utilizes project based approach with authentic tasks to integrate previous knowledge and skills. In order for an activity or task to be considered as "authentic" it should be studied in an "enhanced educational setting with increased motivation and enthusiasm.[2]" In the literature[3] four characteristics of authentic tasks are listed as: "(1) real-world problems that engage learners in the work of professionals, (2) inquiry activities that practice thinking skills and metacognition, (3) discourse among a community of learners, and (4) student empowerment through choice." From these definitions, it can be concluded that the project itself and the environment determines the authenticity by enhancing the educational and motivational aspects of the project.

The initial step in designing an authentic task is to develop an engineering problem from real-world. Project size, level of difficulty, skills required, and task significance are important components to be considered to develop a motivating project. Job Characteristics Theory[4] from the field of organizational psychology is helpful to better understand how the project itself can motivate the students. The theory explains the employee motivation by analyzing the characteristics of the job. According to the theory, required level of skill variety, task identity and task significance are related with motivation and satisfaction. As employees experience meaningfulness and value in their work or the task they're completing, they show more satisfaction and motivation.

The course of Product and Tooling Design uses principles of Authentic Learning Tasks to develop assignments that motivate and educate students in (1) Engineering design process (2) Finite element analysis (FEA) with Creo/Simulate (3) Mechanism assembly analysis with Creo/Mechanism, and (4) Jig and fixture design. Course is a CAD based course and extensively utilizes Creo Parametric (formerly known as Pro/ENGINEER) software. In the next section, four assignments are explained and discussed for each subject area.

2. Design Projects

The class meets six hours a week for sixteen weeks. For each subject area four weeks are allotted, of those four weeks, two weeks are for lecture and two weeks are for project work. (The subjects and related assignments are summarized in Table 1.) Most of the project work consists of problem analysis, generating 3D models and engineering drawings with Creo Parametric, and report writing. For all modeling, drafting, and analysis purposes Creo software package is used. Class meets in a CAD lab with the capacity of twenty students, but in the last five years the maximum enrollment was fifteen students. Although all projects are individual projects, during the two weeks of project work, students are free to investigate different sources and discuss the project with their peers.

Table 1. Course outline

Time	Subject	Project
Weeks 1 to 4	Engineering design process • Objectives • Constraints • Priorities • Measuring • Functions • Specifications • Evaluation	Bicycle fender
Weeks 5 to 8	Finite element analysis (FEA) • FEA with Creo Simulate • Static analysis with Creo • Sensitivity analysis with Creo • Optimization with Creo • Assembly analysis with Creo	Power pin
Weeks 9 to 12	Mechanism motion analysis • User defined constraints • Creo Mechanism (Kinematic & dynamic analysis) • Creo Animation	Sensor attachment
Weeks 13 to 16	Jigs and fixture design • Functions of jigs and fixtures • Supporting and locating principles • Clamping and workholding principles • Basic construction principles • Tool drawings	Box jig

2.1 Engineering Design Process

Engineering design process is an organized approach to solve design problems. It is a proven methodology for better outcomes. The method is a common sense for most people with a technical background. An engineering or technology student also learns about most of the stages and tools of the design process in sophomore and junior years. In their senior year, students integrate their knowledge and skills that they learn in previous years. The course starts with "engineering design process" subject to demonstrate how these tools come together to solve a design problem. It's logical to start with engineering design process because for the rest of the semester students tackle different forms of design problems. At this point, emphasize is focused on defining the problem and asking the right questions to identify the real problem, objectives, constraints and priorities. For the initial two weeks, Dym & Little's "Engineering Design" textbook[1] is used as a reference to support lectures. The text is probably one of the most concise yet comprehensive books available.

The first project, bicycle fender (Appendix 1), is assigned at the beginning of the third week right after the lectures are finished. The first project is a critical assignment, because project deliverables and scoring rubric (Appendix 2) with grading procedures are introduced for the first time with this assignment.

The main focus of the first assignment is to enable students to practice asking questions and analyzing. The instructor takes the role of client and students are given a design project without clear definition of requirements. It is students' responsibility to ask questions to the client and identify the objectives, constraints and requirements of the project. (Full list of the customer requirements, which is not provided to students, is given in Appendix 3) After handing out the project outline, students are allowed to read and think about the project for 15 minutes. Then, a discussion type question and answer session is started to let the students ask as many questions as possible to clarify the project requirements. Project design envelope is determined through this investigative dialog and success of the project deliverables heavily depends on the questions asked.

Our department provides a secure folder to each student for every class. Those folders are located on the department server and accessible only by the student owner and the instructor. Students save their project deliverables such as Creo models, drawings and analyses to those student folders. For the "bicycle fender" project a Creo assembly model of a rear end of a bicycle is provided by the instructor to every student. (Figure 1)

For the first assignment, it is required to submit Creo models and engineering drawings of each part and assembly and a report. Report is mainly for clarifying students' intentions. It is not always clear and easy to follow students' intentions and it could be impossible to figure out how a part can be manufactured or an assembly can be put together by looking at the drawings. Thus, a one page report is required to specify the manufacturing and assembly processes suggested by the student. In this regard, report acts as a simple form of manufacturing specifications.

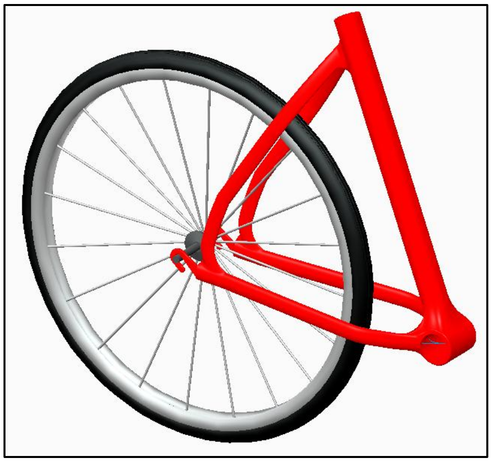

Figure 1. Creo assembly of a rear bicycle tire

2.2 Finite Element Analysis

With the second project, students are introduced to finite element analysis simulation with Creo Simulate (formerly known as Pro/Mechanica). Before taking this course students are required to take “Statics for technology” and “Strength of materials” courses. Students’ background in statics and strength helps to jumpstart to FEA with Creo/Simulate.

As mentioned in the course outline, week five and six are dedicated to lecture and small practice problems. Our goal for this subject area is to study static analysis of 3D solid models. The most critical step in a FEA is setting up the simulation. Simulation set up consists of generating 3D model, defining model parameters and simulation parameters. Biggest challenge for the students could be simplifying an existing 3D model (removing rounds, chamfers, detail features, etc…) without compromising model characteristics. Second challenge is to identify the model parameters such as forces and constraints. Another critical area is interpreting analysis results. To cover these areas Roger Toogood’s tutorials[5] could be a helpful introductory level reference book. For practice purposes four in-class problems are assigned to students during the initial two weeks.

The “power pin” design project (Appendix 4) combines all previously mentioned aspects of FEA on a 3D solid assembly model. The project requires designing a pin that is used on tractor drawbars to pull agricultural rear implements. A drawbar assembly with a drawbar, a hammer-strap, a power pin and two bolts are seen in Figure 2. An actual drawbar assembly is provided in Figure 3.

In addition to the project manual, students are provided with drawings of the drawbar and hammer-strap (Appendix 5). Also, a brief power-point presentation is presented to students to familiarize them with the tractor drawbars, their functions and key design considerations as stated in the project manual. In developing this project, actual standard dimensions are used from the ISO 6489-3:2004 document[6]. Instructor’s experience on tractor hitch design significantly helps to develop the project in a realistic fashion.

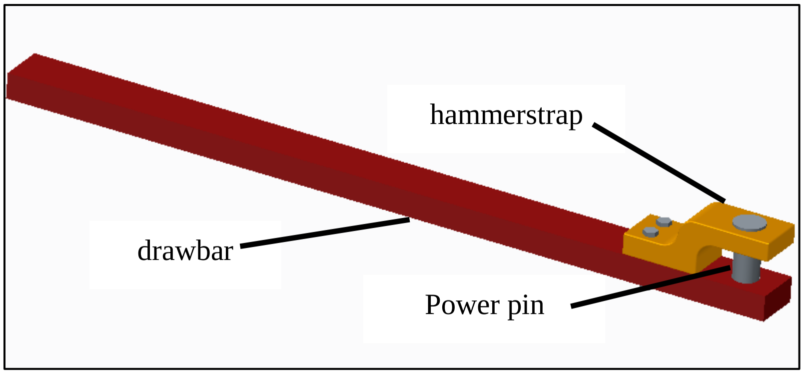

Figure 2. Creo model of a drawbar assembly

Figure 3. A John Deere category 3 drawbar

In order to successfully complete the project, students need to analyze the function of the drawbar and power pin system. Then, they need to conceptualize a design and model it. In the next step, FEA should be performed to verify if the design fulfills the project requirements. If the design passes the test, working drawings are generated. This project is a good opportunity to practice material selection with different mechanical characteristics, as well. Creo/Simulate has a library of common materials with predefined mechanical properties. If students want to use a material which is not available in the library they can create and define the characteristics of a new material and use it in their projects. Students are also free to search the internet to find standard hardware such as bolts, nuts, screws, pins, etc. (except the power pin).

Projects are not graded on their creativity. However, as seen in Appendix 6, students come up with different ideas to fulfill the design requirements.

2.3 Mechanism Motion Analysis

The third assignment is focused on mechanism motion analysis with Creo/Mechanism. For two weeks, Creo/Mechanism and relevant Creo tools are studied with in-class practice problems. During this period of time, user defined assembly constraints such as pin, planar, slider, cylinder, bearing, slot are explained and exercised. Those constraints help to create assemblies with parts that can move and rotate as in real life. After mechanism assembly constraints, servo motors are studied. Servo motors are used in Creo/Mechanism simulations for defining forces that generate linear and rotational motions. After model creation exercises, simulation set up is introduced. Creo/Mechanism has position, kinematic, dynamic, static, and force balance analyses options available. Among those types of analyses only kinematic and dynamic analyses are studied. Lastly, animation and video capturing modules are covered.

The third project (Appendix 7) is based on a kinematic analysis. The main goal is to attach an angular position sensor (N101101 85° Angular Position Sensor, Figure 4) to a 3 point tractor hitch (Figure 5 and 6) to measure the angular lift of the 3 point hitch. 3 point hitches are used on tractors to pull rear implements. They can be raised and lowered by hydraulic cylinders which are attached to lift arms. Position of the hitch with respect to the ground level is an important parameter that needs to be monitored and adjusted by the tractor operator. The fundamental requirement of the project is to develop a mechanical linkage system that will transfer the rotational motion of lift-arm to the position sensor. Center piece of the position center has a rotational range of 85°. Through the linkage system, rotational motion of the liftarm is transferred to the center piece of the sensor, and that angular motion is measured and transferred through electrical cables to tractors computing unit.

Figure 4. Angular position sensor

Figure 5. A John Deere 3 point hitch

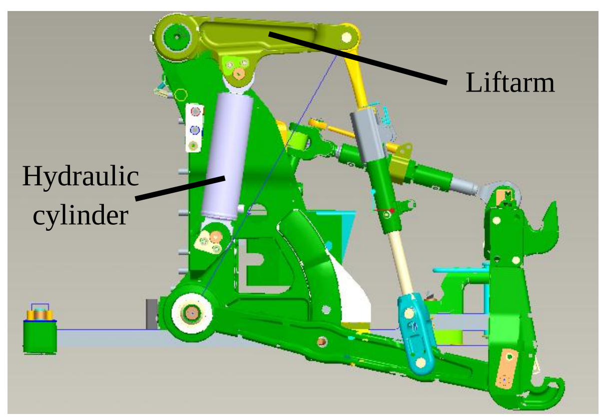

Figure 6. Creo model of a 3 point hitch

Students are provided with the actual position sensor and Creo models of 3 point hitch. Students are allowed to make minor changes on the 3 point hitch models, for creating flat, machined surface and screw holes to attach the position sensor. Most students approach to the problem as a four bar linkage, a gear design or a telescopic design problem. (Appendix 8) After the creation of the parts and the final assembly, a kinematic analysis is run to verify the system's ability to transfer the rotational motion of the lift-arm to the position sensor. Analysis results and a 10 second animation of the simulation run are part of the project requirements.

2.4 Jigs and Fixture Design

The last assignment is a box jig design project. Jig and fixture design is a very broad subject and requires a certain level of machining knowledge and experience. Prior to taking “product and tooling design” course, students are required to take “machine tool processes” course in which students acquire the fundamentals of metal machining processes. Two weeks of lecture strengthens the students’ knowledge in basic principles of jigs and fixtures. Subjects, such as functions and types of different jigs and fixtures, design principles, supporting and locating principles, work-holding and clamping principles, construction principles and tool drawings are studied in the first two weeks. Hoffman’s Jig and Fixture Design[7] is a comprehensive test book that is used as a reference material.

Fourth and the last project (Appendix 9) is designed to cover and evaluate all of the previously mentioned subjects related with jig design. The goal of the project is to design a box jig that will help to machine six holes on different faces of a single part. Engineering drawing of the part is provided with the project manual. Also, a web page with available standard hardware (pins, bushings, clamps, etc.) and their specifications is provided. Students can select appropriate hardware and use their dimensional specifications to generate their 3D models.

Project requires the box jig to be used in conjunction with the mill-vise available at the department’s machining lab. Thus, as part of the project, students need to examine the mill-vise and develop their design that can be held by that certain mill-vise. Linking the project to the real equipment and machinery available in our labs helps to create a more realistic setting for the assignment.

3. Scoring Rubrics and Evaluation of Assignments

Feedback through evaluation is an important educational component of this course. While developing the grading rubric (Appendix 2), the main concern was to reflect industry’s perspective. For this reason, a long list of items are identified and weighed according to their importance. During the semester, it is always explained that design deliverables such as drawings, manufacturing specifications and models are generated for manufacturing and they’re only good as long as they convey the design intent fully and correctly.

One rubric is developed for grading parts and another rubric is developed for grading final assembly. Overall final grade appears on that final assembly grading sheet. As seen on the grading rubric for parts, most of the emphasis is concentrated on the drawings’ completeness, accuracy and clarity. Grades of parts are averaged on the final assembly grading sheet and make up the 60% of the total final grade. Remaining 40 % is for the final assembly, report, analysis, and assemblability.

FEA and Mechanism are the two analyses performed for the course. Analyses are graded based on their set-ups and results. Material definitions, motion constraints, location, magnitude and direction of forces, and model simplifications are evaluated for the set-up of FEA analysis. The final design, design suggestions and their reasoning should be supported by analysis results. For FEA analysis the key parameter is Stress von Mises. Calculated stress values shouldn't exceed the selected material's yield strength. An example of FEA result window is provided in Appendix 10.

For mechanism analysis, connections, forces and servo motors are evaluated. Connection definitions are the most critical part of mechanism analysis setup. A four-bar linkage design requires pin type of connections, a gear system requires gear connections and a telescopic system can be defined by a slider or cylinder connections. Success of the connection definitions can be easily seen on the 10 second animation.

The assessment of the results is based on their interpretation and effects on the final design. Students discuss their designs and findings in their written reports. The analysis step can take very long time because of the computer processing time. So, the design criteria should be set in a way that it should be easy for the students to verify their design by the simulation. For example, for the FEA analysis, the design should withstand 10,000 lb horizontal force; this force is half of the actual requirement for this design. So, if the students don't make a very critical mistake they can easily verify their design and fulfill the stress requirements after two or three trials. Otherwise, they can get stuck in the analysis step and cannot move forward.

Assemblability item on the scoring rubric is the stack-up analysis for dimensional tolerances. In addition to the completeness of the drawings, each part drawing is analyzed for its assemblability and tolerance distribution.

Every single part is rigorously graded on its printed drawing, Creo drawing file and Creo part file. In the same way, printed final assembly drawings, Creo file of the drawing and the Creo assembly files are graded. Mistakes on every drawing are marked and corrected to provide feedback. This is also a common industry practice that any design goes through before it is finalized. The only downside of this kind of detailed grading is the time spent on grading by the instructor. For every project, students usually develop five or six individual components and an assembly. Grading of all component models, assembly model, drawing, analysis, report and tolerance stack-up takes around one hour per student. In this regard, it would be more convenient to implement this teaching method to smaller classes. However, this process should be considered as part of teaching, because it is an effective way to train students about the industry practices before the graduation. Technology graduates are expected to produce high quality drawings and models from day one.

4. Common Mistakes of Students

Most of the mistakes are related with the completeness and quality of the drawings, modeling and design intent of parts, and electronic file management.

For drawings, the most critical item is the completeness of the dimensions. In many instances, size and locational dimensions are missing or dimensions have missing references and tolerances. Redundant dimensions or over dimensioning is also a common problem. Beside the dimensional problems, unnecessary views with no dimensions, bad scale and size selection for views, missing auxiliary views, detail views, title block, material info, BOMs, and BOM balloons are observed during grading.

Modeling and capturing the design intent is challenging for most students with no industry experience. They model the parts and assemblies with missing components or specifications. Pins with no thread specifications or assemblies with missing hardware like bolts and screws are very common. They assume that everybody can figure out how things are supposed to work or come together in an assembly.

Handling of electronic files is another area that is emphasized through in-class studies and grading. Naming files properly and keeping all related files in the same folder is a good practice. Sometimes, after saving the files, students change the file names or change the location of files. If related part files, drawing files, format files or assembly files are not in the same folder, Creo cannot fetch those files and it fails to open.

Scoring rubric and feedback help students to educate themselves with every assignment. On the first assignment, almost everybody makes everything wrong according to the scoring rubric. However, the feedback given on the first assignment helps to improve the quality of next assignments tremendously. Assembly tolerance stack-up and improper dimensioning of irregular shapes are the most critical common mistakes that can be found even on the forth assignment. Sample of common student mistakes can be found on Appendix 11.

5. Survey

At the end of fall semester of 2012, a survey was conducted to measure the success of the course in motivating the students. Survey consists of three open-ended questions and seven response statements. For the response statement questions, a five-point scale was used (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree). Survey questions, statements, and corresponding mean values are given in Table 2.

Table 2. Survey questions

Statement	Mean
Course assignments are interesting and stimulating	4.0
The instructor stimulated interest in the course	4.2
Assignments enhanced my learning in the class	4.2
Assignment subjects were similar to real life problems	4.6
The way the grading system helped me understand what I needed to work on	4.0
The feedback on my work received after assignments helped my learning	4.2
Assignments support the course objectives	4.2
Questions	
What would you change about the course?	
-Course was great. Nothing to be changed	
What are the major strengths of this course?	

-You really get to know Creo. After course you can do anything with the program. -Independently figuring out solutions to real world problems. **What are the major weaknesses of this course?** -Not enough time to do everything to the best of your ability.

Responses to statements prove that students agree on the motivational and educational strength of the assignments and evaluations. There are not many responses received for open-ended questions. However, among those few answers there is no negative comment about the content of the course.

6. Conclusion

The goal of the course “product and tooling design” is to educate students about engineering design processes by incorporating their previous knowledge and skills in authentic projects. For this purpose, four design projects are developed. The subject of the assignments, the way they are presented to students, and the environment they work in contribute to the authenticity of the projects. Project subjects are real products based on real needs. Goals, requirements, and constraints for each project are defined completely and realistically. Students integrate their knowledge in statics, strength, material science, drafting, solid modeling and manufacturing to tackle different design problems. Evaluation of assignments also contributes to teaching. Completeness, accuracy, and clarity of the deliverables are valued more than creativity or originality of the deliverables.

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Appendix 1

Bicycle Fender Project

Instructions

A major bicycle manufacturer makes mountain bikes, as shown in picture below.

These heavy-duty bicycles are designed to be ridden on rough, often muddy trails. They have no fenders, since mud and debris would be easily trapped between tire and fender. Besides when riding on trails, the cyclist generally doesn’t care if he or she gets muddy. However, if the mountain bike is also to be used for street transportation-for instance, in commuting to work or school-then there will be a problem on a rainy day. On the street, the rider would naturally prefer to stay dry, but with no fenders, both rider and baggage will be splattered with water and mud.

The bicycle manufacturer has found from market surveys that there is need for a device to protect bike rider and baggage from road water and has initiated a project that will concentrate on controlling the spray generated by the rear wheel.

Deliverables

- A complete set of working drawings and Creo models for the parts and for the assembly.
- Assembly of parts on the provided model.
- A one page report for manufacturing specifications.

Appendix 2

Grading rubric for a single part

			Points possible	Points	Comment
Part Drawing	**Views**	Scale	5		
		Paper size	5		
		Projections	5		
		View style	5		
		Necessary views (Aux., sec., ...)	10		
		Unnecessary views	5		
		Orientation	5		
	Dimensioning	Complete dimensioning	50		
		Missing dimensional references	5		
		Redundant dimensions	5		
		Proper dimensioning	10		
	Quality	Center lines	5		
		Overlapping lines & features	10		
		Unhidden datum features	5		
		Extension lines	5		
	Miscellaneous	Title block	5		
		Material spec.	3		
		Surface spec.	3		
		Material treatment	3		
		Units	3		
		Tolerance note	3		
	Electronic file	Failure to open file/format	10		
		Naming	5		
		Unhidden datum features	5		
Part Modeling	**Manufacturability**	Manufacturability of the part and its features based on the material and manufacturing processes specified.	20		
	Quality	Surface continuity	5		
		Unhidden datum features	5		
Total			200		

Overall scoring rubric for the project (Final assembly)

		Possible points	Points	Comment
Drawings	Part drawings*	**30%**		
	Assembly drawing (Exploded view, offset lines, title block, BOM, BOM balloons, no failing file...)	**5%**		
	Assemblability?	**10%**		
Models	Part models**	**30%**		
	Assembly model (Correct assembly constraints, no failing or missing parts or geometries, no missing part files…)	**5%**		
	Does the design fulfill the design goals?	**10%**		
Analysis		**5%**		
Report		**5%**		
Total				

* "Part drawings" is the average of drawing grades multiplied by the number of drawings created divided by the required number of drawings

** "Part models" is the average of model grades multiplied by the number of models created divided by the required number of parts

Appendix 3

List of customers' requirements for the fender

- keeps water off rider
- easy to attach
- easy to detach
- quick to attach
- quick to detach
- won't mar bicycle
- won't catch water/mud/debris
- won't rattle
- won't wobble
- won't bend
- has a long life
- won't wear out
- lightweight
- won't rub on wheel
- attractive
- fits universally
- won't interfere with lights, rack, panniers, or brakes

Appendix 4

"Power Pin" Project

Objective

- Develop an original design for a special heavy duty equipment pin.

Design Criteria

- Mechanical Considerations
  - Pin must be able to withstand 10,000 pounds of horizontal force.
  - Because of the excessive amount of friction between the pin, attachment, and the hammer strap, the rotation of the pin must be prevented when it is in use.

- End User Considerations
  - The attachment will work 20" above the ground and the work environment is a rough terrain with dirt, mud, plants, and other unexpected elements constantly in contact with the equipment.
  - Pin shouldn't require any extra tool (wrench, hammer, screw driver, etc…) for the operator to install and uninstall the pin.

- Manufacturing Considerations
  - The cost of the pin must be reasonable. (less than $150)
  - The pin must be easily manufacturable and serviceable.

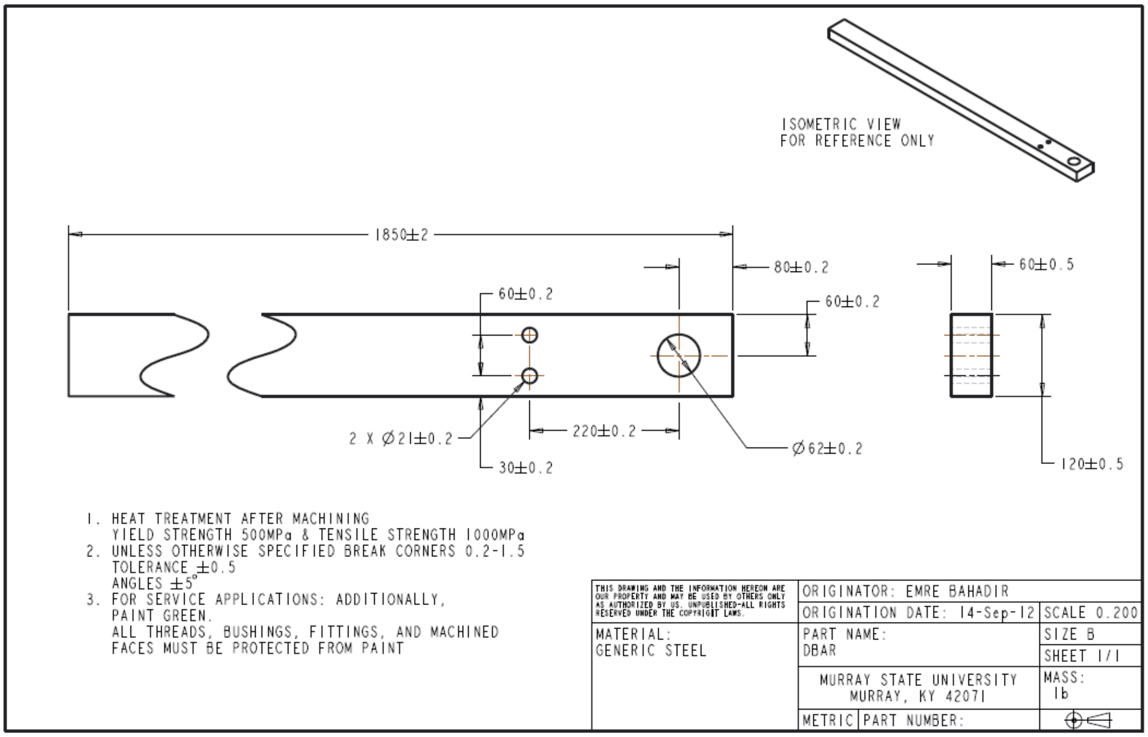
- Other Considerations
  - The design can have multiple parts.
  - The design of the hammer strap can be modified without affecting the strength of the design.
  - Use ±0.08mm tolerance for the bolt.
  - Pin mustn't be larger than 61.00mm

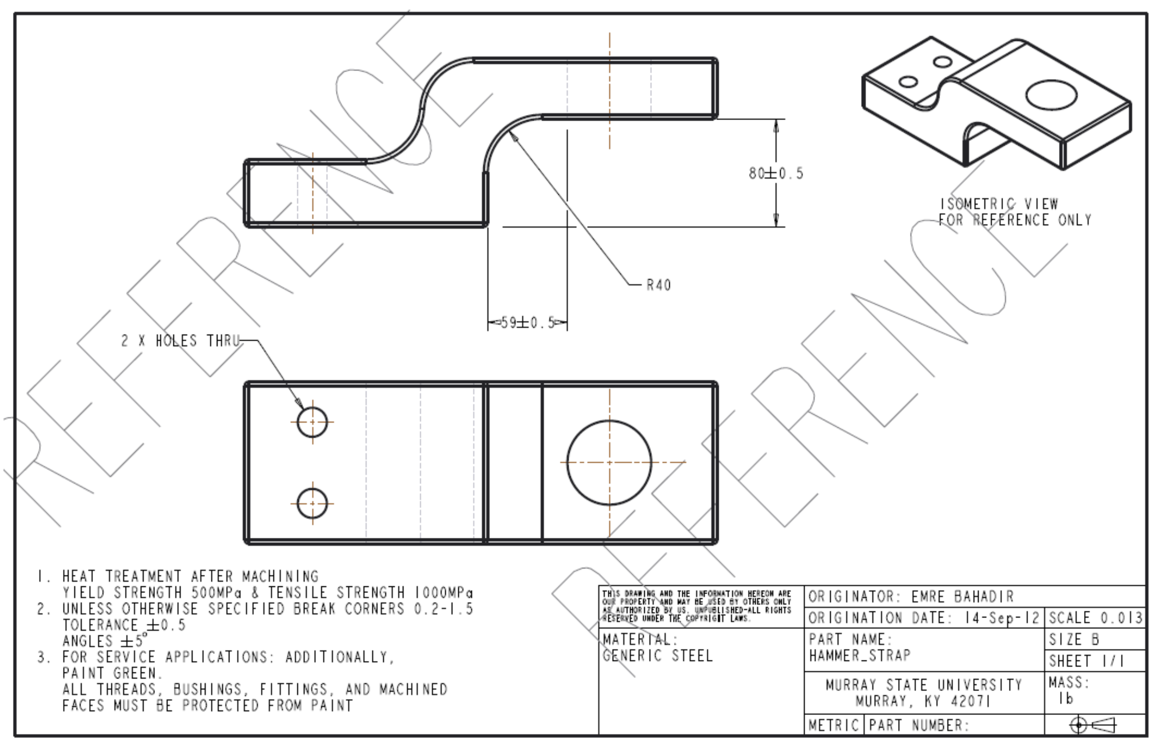
Deliverables

- Creo models of the parts and assembly.
- A complete set of working drawings for the parts and the assembly.
- Creo/Simulation analysis results for the final design. (Both printout and Creo/Simulation electronic file)
- One page report to summarize your work.

Appendix 5

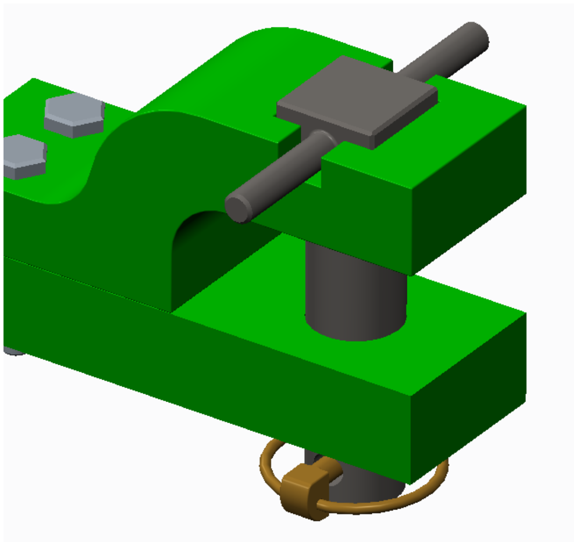
Drawbar and hammerstrap drawings

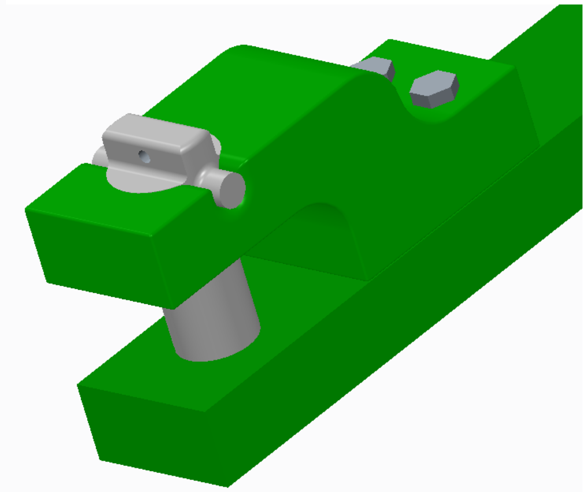


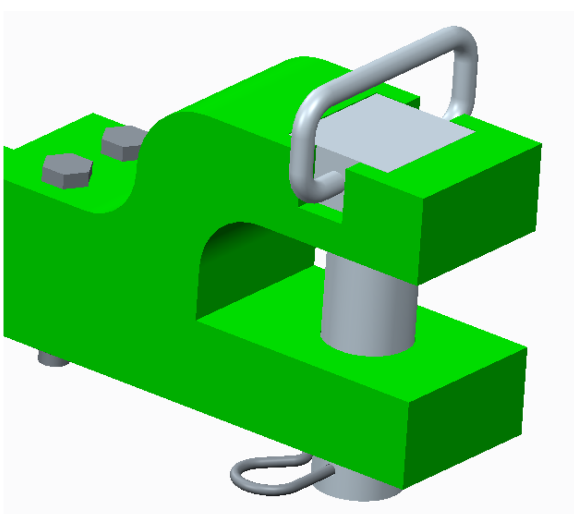


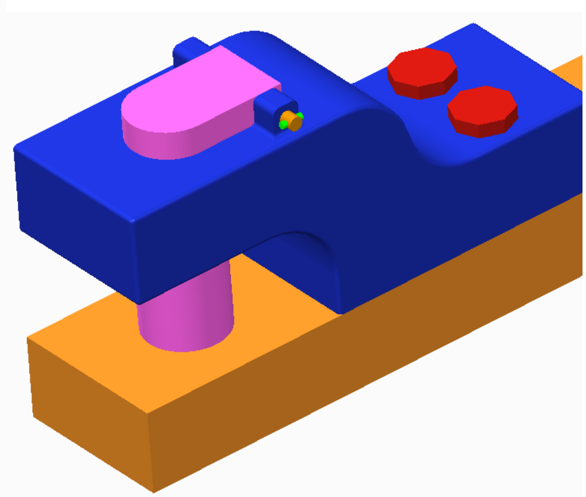
Appendix 6

Student designs of power pin project









Appendix 7

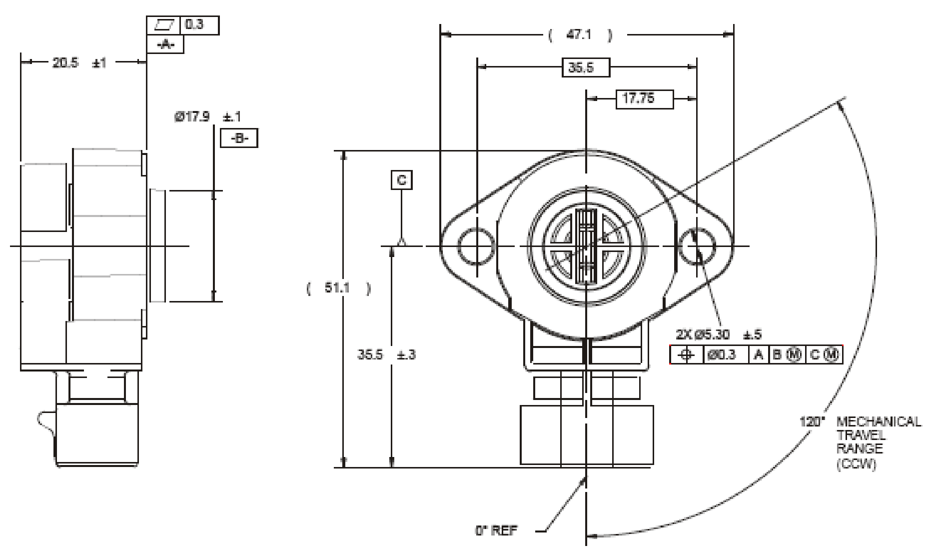
Sensor Attachment Project

Instructions

- Using the assembly and part models provided design an attachment system between the angular position sensor (POSITIONSENSOR.ASM) and the rockshaft housing assembly (ROCKSHAFT_HOUSING_ASSM.ASM) that transfers the rotational motion of the rockshaft housing assembly to the position sensor.
- The scope of the linkage assembly design project is restricted with the mechanical parts that will link the shaft, rockshaft or lift-arm to the position sensor. (No electrical cable or circuit design or modeling is necessary)
- Cast parts are subject to change. (Material addition and creating machined surfaces on the provided models are allowed)

Deliverables

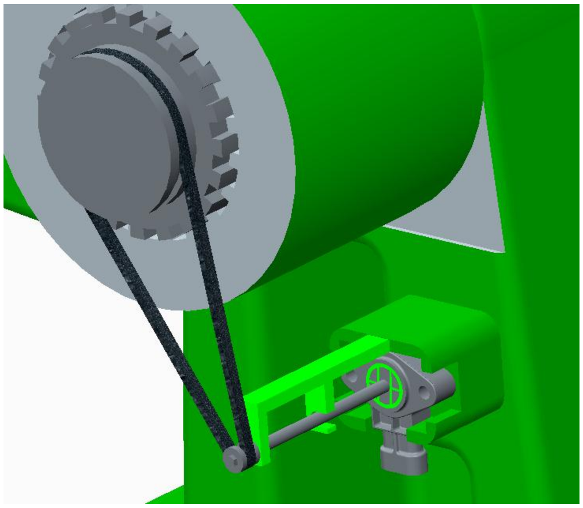
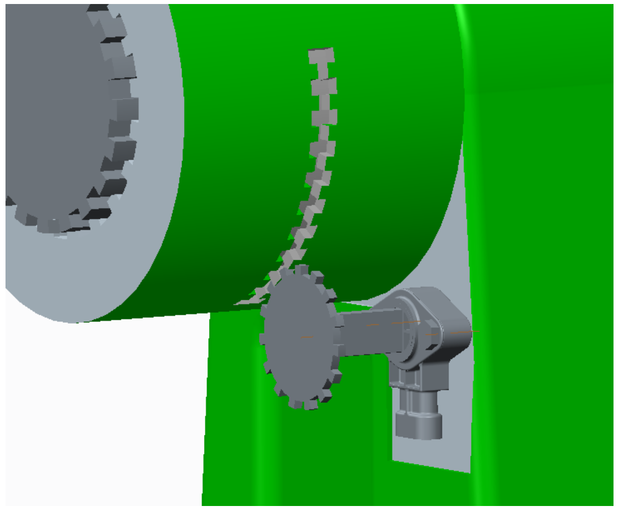
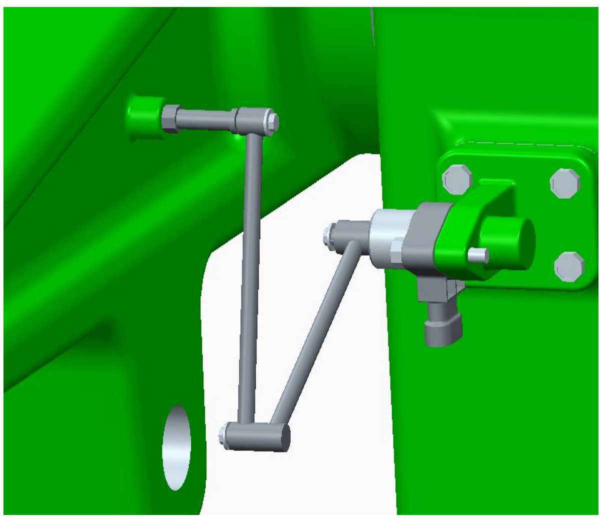
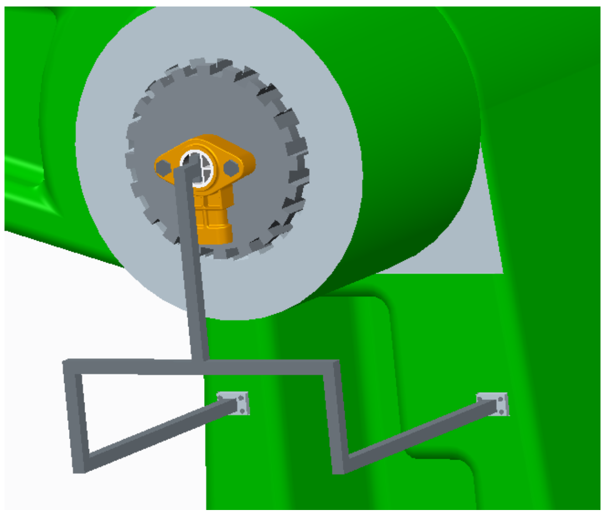
- A complete set of working drawings for the linkage assembly and the parts.
- Drawings of the provided parts with only functional dimensions on them. (Hint: Use machined surfaces and holes as references)
- Pro/Mechanica animation of the final assembly. (A short, 5-10 seconds, animation recording in mpeg format)
- 1 page report to summarize your step-by-step approach to the problem and brief explanation of your design. (Anything that requires further explanation)



N101101 85° Angular Position Sensor and Specifications

Appendix 8

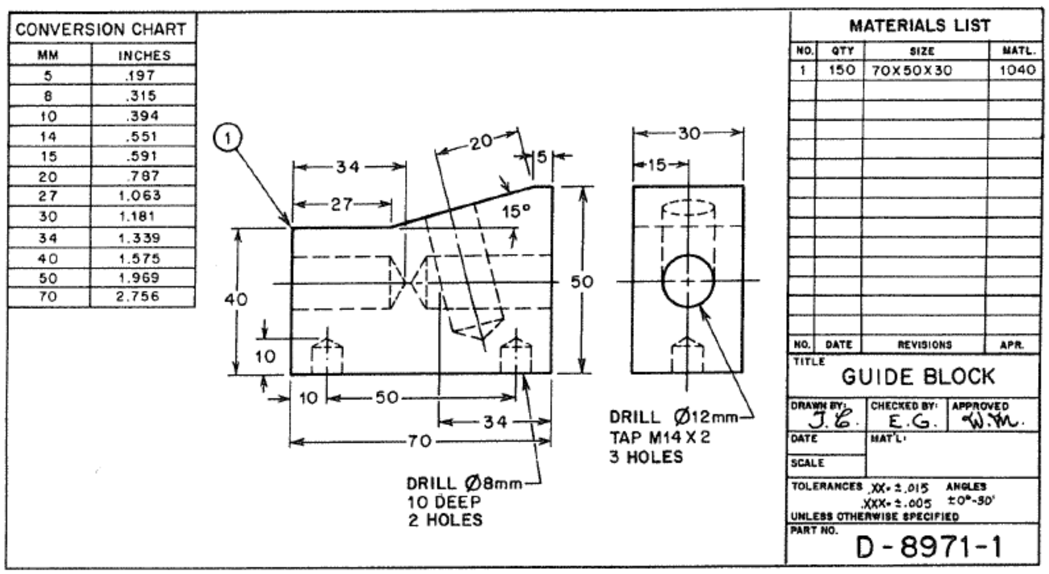
Student designs of sensor attachment project

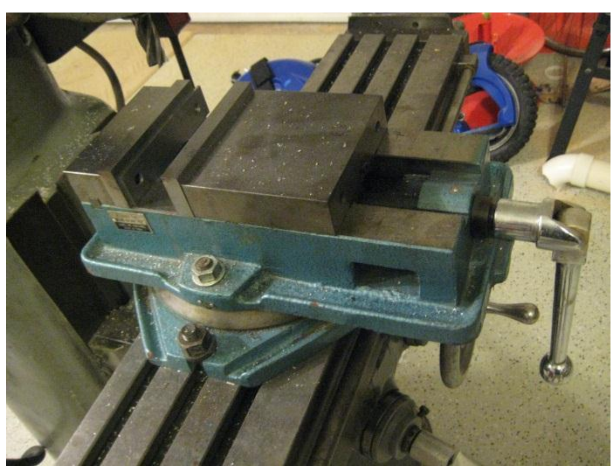





Appendix 9

Box Jig Project

Analyze the part drawing and production plan to determine all relevant information necessary to design a channel or box jig to drill the specified five holes on the part with a vertical milling machine. The jig will be held on a milling-vise that is available in our metal working lab.



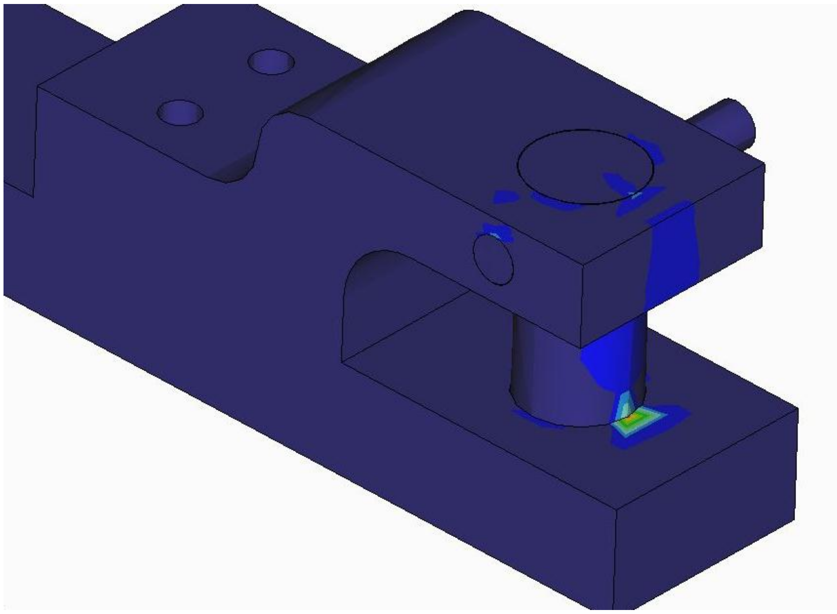


Deliverables

- Working drawings and models.
- One page report.

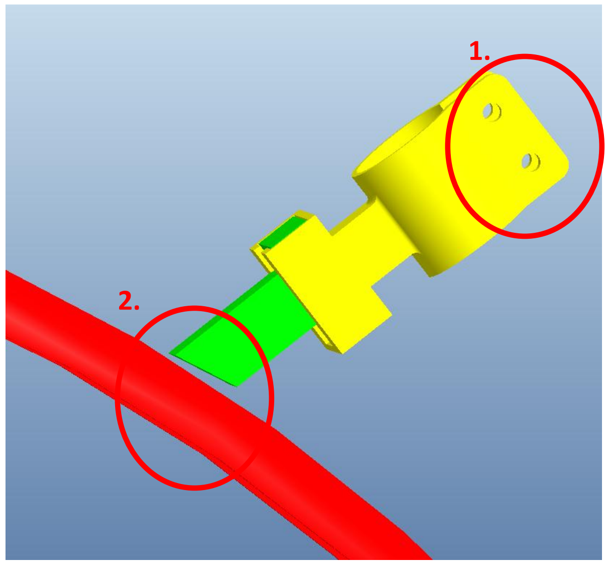
Appendix 10

An example of FEA result window

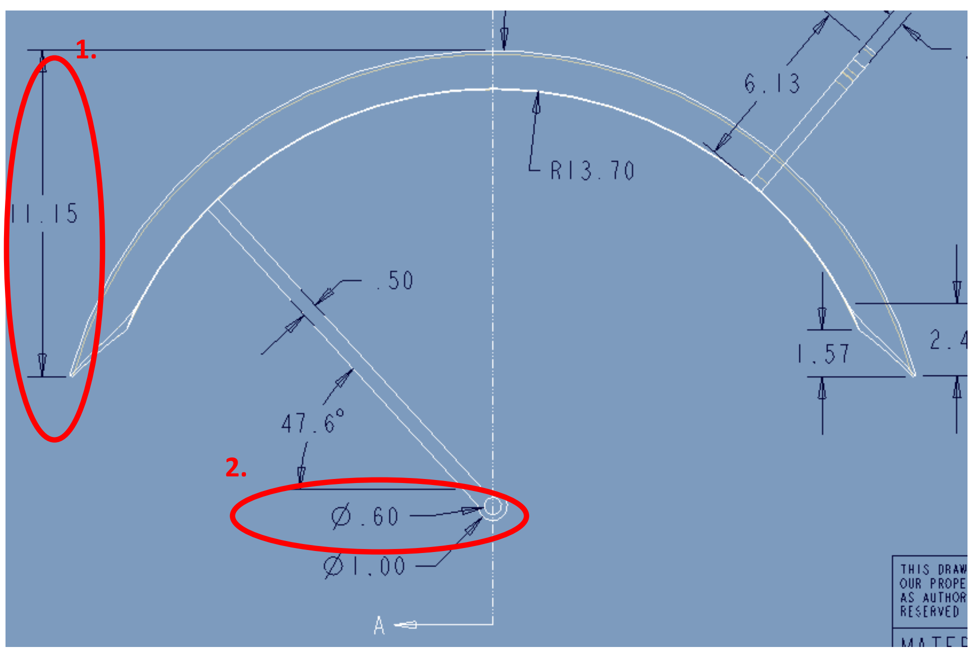


Appendix 11

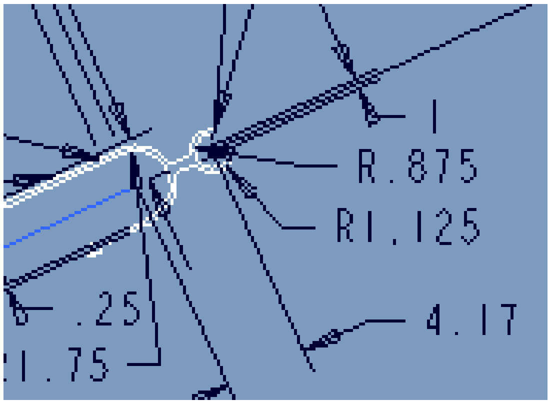
Common mistakes from student projects



1. Missing bolts or screws
2. Unclear assembly method (There is no subassembly drawing created for the assembly of these parts. Location of parts and assembly method is not specified)



1. An improper way of dimensioning an arc.
2. Missing reference feature
3. Missing centerline



1. View scale is very small
2. Unclear, overlapping dimension lines