HERC Funding – Final Report 2013

Project Titles: Project #1: Onsite Wastewater Treatment System
Project #2: Disposable Diaper Recycling

Inception: Fall 2012

Project Overview: Curriculum materials for **ENGR 2270 – Computer Engineering Drafting**.

ENGR 2270 is required by all students in Biological Engineering, Environmental Engineering and Civil Engineering. Currently, a majority of the assignments and activities are geared towards civil engineering students. It is important that the biological and environmental students see a need for the use of the software in the course. To address this issue we developed activities, assignments and other materials related to **green energy and environmental systems** for use in the course. These activities, assignment and other materials were developed during the fall and spring semesters (2012-13) and piloted in the ENGR 2270 course spring 2013. The problems developed are included in the following section.

Student Support:

Ting Song and **Stacie Gregory** (EED graduate students) assisted in the development of the problems. They worked 10 hours per week during the fall and spring semesters to complete the problems, pilot test the problems and make modifications to the problems.

Problem #1 – Onsite Wastewater Treatment

Title: Onsite Wastewater Treatment System

Scale: You choose appropriately to fit on B sized paper. **Precision:** 0.001 M

Objectives:

1. Students will be able to create a section drawing of a onsite wastewater treatment system, specifically concrete septic tank and dispersal system.
2. Students will be able to correctly interpret appropriate design criteria provided through Utah rule for onsite wastewater treatment systems, UAC R317-4. Key design information from the rule is included within this project description for your use.
3. Students will be given an introduction into the application of CAD for the Civil/Environmental/Hydraulic engineering disciplines.

Background

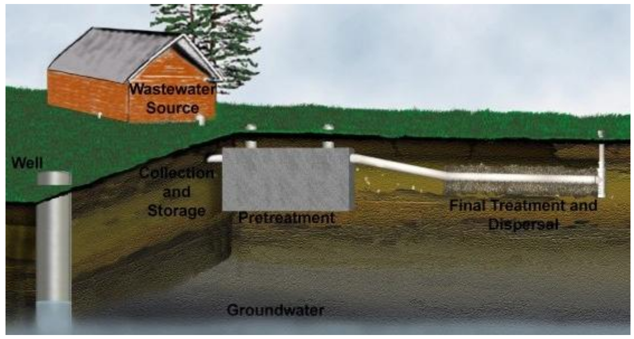
The French are considered the first to use an underground septic tank system to treat the wastewater in the 1870s. By the mid 1880s, two-chamber, automatic siphoning septic tank systems, similar to those used today, were being installed in the United States. Even now, more than a century later, septic tank systems represent a major household wastewater treatment option. Fully one-fourth to one-third of the homes in the United States use such a system.

On-site sewage disposal systems are used in rural areas where houses are spaced so far apart that a sewer system would be too expensive to install, or in areas around cities where the city government has not yet provided sewers to which the homes can connect. As populations continue to expand beyond the reach of municipal sewer systems, more families are relying on individual on-site wastewater treatment systems and private water supplies. Onsite wastewater treatment typically involves treatment in confined units such as anaerobic septic tanks, followed by additional treatment units such as aerobic bioreactors or constructed wetlands. The treated effluent is discharged to the environment via a dispersal unit. The most common type of dispersal unit utilizes a network of subsurface soil infiltration trenches (leach field) where the effluent is further treated as it percolates through the vadose zone before recharge to local groundwater. The expertise on inspecting, maintaining, and installing these systems generally rests with the environmental health staff of the local county or city health departments.

Domestic wastewaters contain a variety of organic wastewater contaminants (OWCs) such as pharmaceuticals and personal care products. Safe, sanitary, nuisance-free disposal of wastewater is a public health priority in all population groups, small and large, rural or urban. Wastewater should be disposed of in a manner that ensures that 1) community or private drinking water supplies are not threatened; 2) direct human exposure is not possible; 3) waste is inaccessible to vectors, insects, rodents, or other possible carriers; 4) all environmental laws and regulations are complied with; and 5) odor or aesthetic nuisances are not created. To place the septic tank and absorption field in a way that will not contaminate water wells, groundwater, or streams, the system should be 5 to 20 feet from the house and other structures, at least 5 feet from property lines, 100 feet from water wells, and 50 feet from streams. The minimum separation from the bottom of the absorption trench and any ground water is 24 inches. Additionally, a minimum of 48 inches of suitable soil is required from the absorption trench to any impervious soil or bedrock.

The first step in determining site feasibility for an onsite wastewater system is to determine a soil log describing soils within the proposed trench area, any needed soil testing including a percolation test, and a site evaluation to document any potential site constraints that might affect or limit system placement. A summary of site evaluation criteria needed for a system design is included in the problem definition below.

The entire system area should be easily identifiable.



Problem:
Assume you are an Environmental Engineer employed by a company in Utah. Your client needs an onsite wastewater treatment system using concrete septic tank for a four bedroom house. Assume the wastewater loading rate is 0.4 gpd/ft^2, trench width is 3 feet, and undisturbed soil width between trenches is 7 feet. Followings are the design requirements included in the state rule for onsite wastewater systems, R317-4.

- Utah rule recommends that the scale for plan drawings be 1 inch to 30 feet. Other scales are acceptable if needed to clearly show property details, system details and construction details. Determine appropriate scale based on property size and paper size.
- The wastewater design flow is based on the number of bedrooms allowing 150 gpd per bedroom.
- Sewage lines carrying solids from the house to the tank should have sufficient slope to maintain velocities that keep solids moving. For household size lines, a slope of 2 percent (1/4 inch per foot) is usually required.
- The septic tank should be sized based on Table 1 below.
- The invert of the inlet pipe shall be located at least 3 inches above the invert of the outlet when the tank is level.
- The outlet device should generally extend below the liquid surface a distance equal to 35 percent of the liquid depth.
- Utah rule includes several options for type of absorption trench. Assume the use of a 'standard trench' consisting of a gravel filled absorption trench per the details shown in Figure 3 below.
- General slope of property is 8% grade towards the northwest.
- Soil profile is:
  - 0-12 inches – organic topsoil
  - 12-53 inches – silty clay loam, prismatic structure
  - 53-110 inches – sandy loam, massive structure

Table 1. Minimum and Recommended Septic Tank Capacity
Based on the Number of Household Bedroom. *

Number of Bedrooms 150 gpd/bedroom	Septic Tank Capacity (Gallons) Minimum	Recommended
1-3	1,000	1,350
4	1,250	1,800
5	1,500	2,250

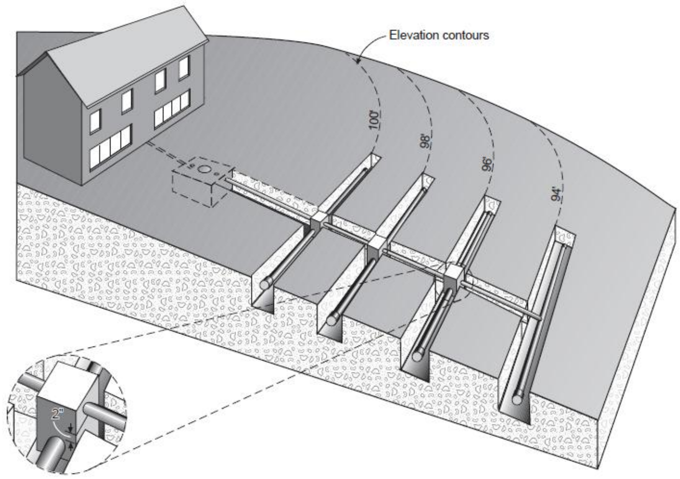


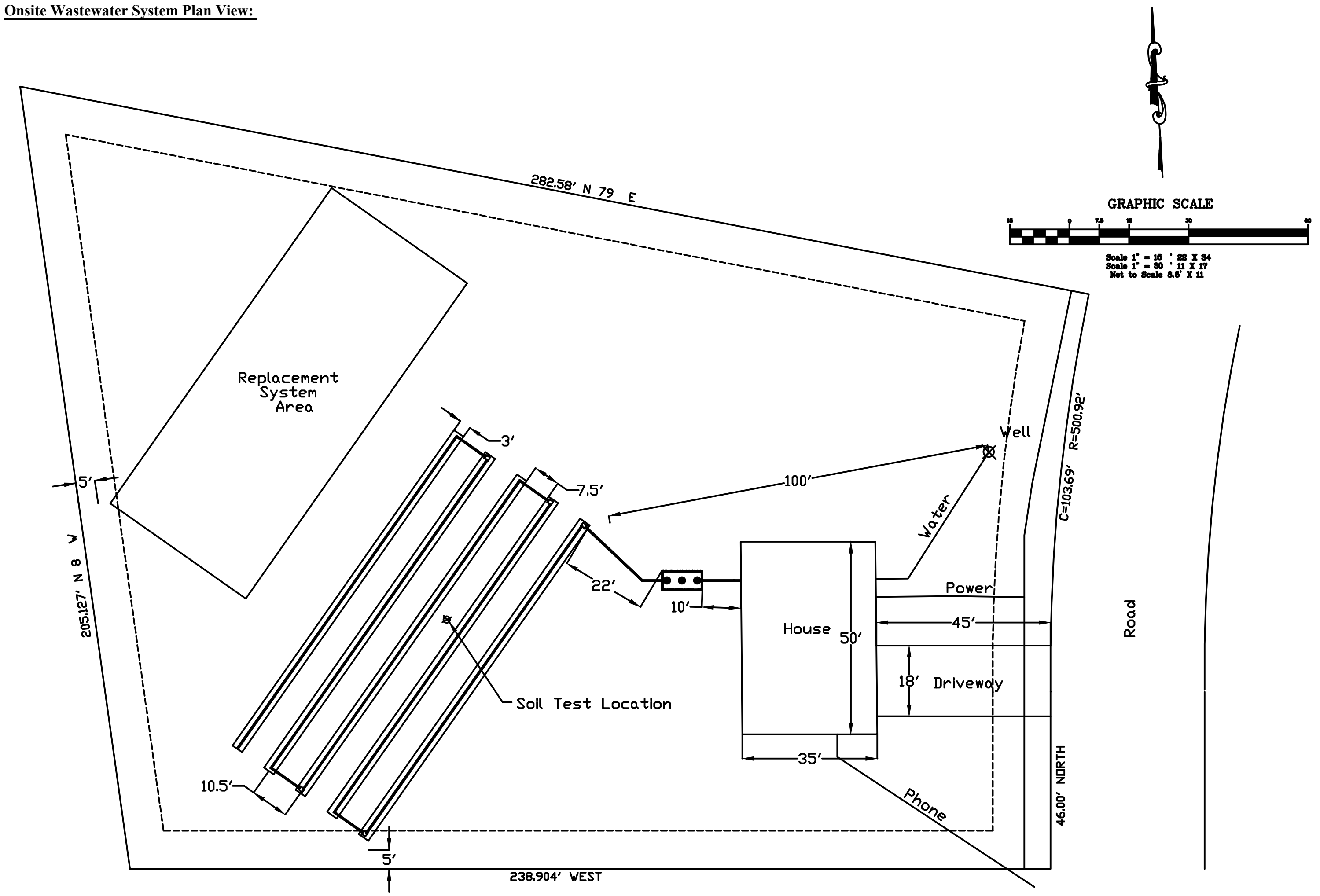
Figure 2. Typical Step Down or Serial Distribution System

Absorption field size is dependent on two factors: wastewater flow and soil loading rate. You will have to do some math here. Here is an example of how to use the variables to determine the field area. An area of the same size should be reserved for future replacement.

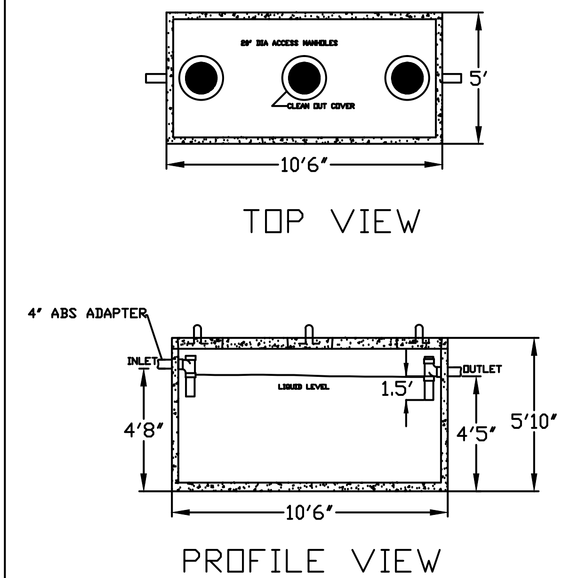
*Wastewater flow = number of bedrooms * flow rate (gpd)*
Absorption area = wastewater flow / loading rate
Trench Length = absorption area / trench width
*Field area = (number of trenches * trench width) + (number of bedrooms * undisturbed soil between trenches) (feet)*

Volume Formula: L X W X D = Cubic Feet
Cubic Feet X 7.47 = Gallons

Onsite Wastewater System Plan View:



1,250 Gallon Septic Tank Details:
Scale: nts



NOTE:

WEIGHT: 11,000 LBS
EXCAVATION DIMS: 7' X 12'6"
FLOW LINE: 56"
SEALED WITH BUTYL ROPE
2-4" SANITARY TEES

REINFORCING:

TANK 6X6-6X6 WELDED WIRE FABRIC CAGE
#4 BAR OVERLAP 2' O.C.
LID: #4 BAR 8" O.C.E.W.

SPEC'S ON THICKNESS:

WALL'S 3"
FLOOR 4"
LID 5"

General Construction Notes:

A. Any deviations from this plan must be approved by the designer and the local health department.
B. Installation shall not commence without the necessary permit, approval and inspections required by the local health department.
C. The contractor shall verify all field dimensions, existing conditions, and noted assumptions. Any deviations shall be coordinated with the designer and the local health department prior to proceeding with the related work concerning the deviation.
D. All plan dimensions shall take precedence over the scale shown on the plans, elevations, sections and details.

Design Basis:

4 Bedrooms
1.250 gallon septic tank
150 gallons per day per bedroom
Design flow = (150 gpd/bedroom)(4 bedrooms) = 600 gpd

Soil Profile Description:

Size absorption area based on soil profile
0" - 12" Organic Topsoil
12" - 53" Silty clay loam, prismatic structure
53" - 110" Sandy loam, massive structure

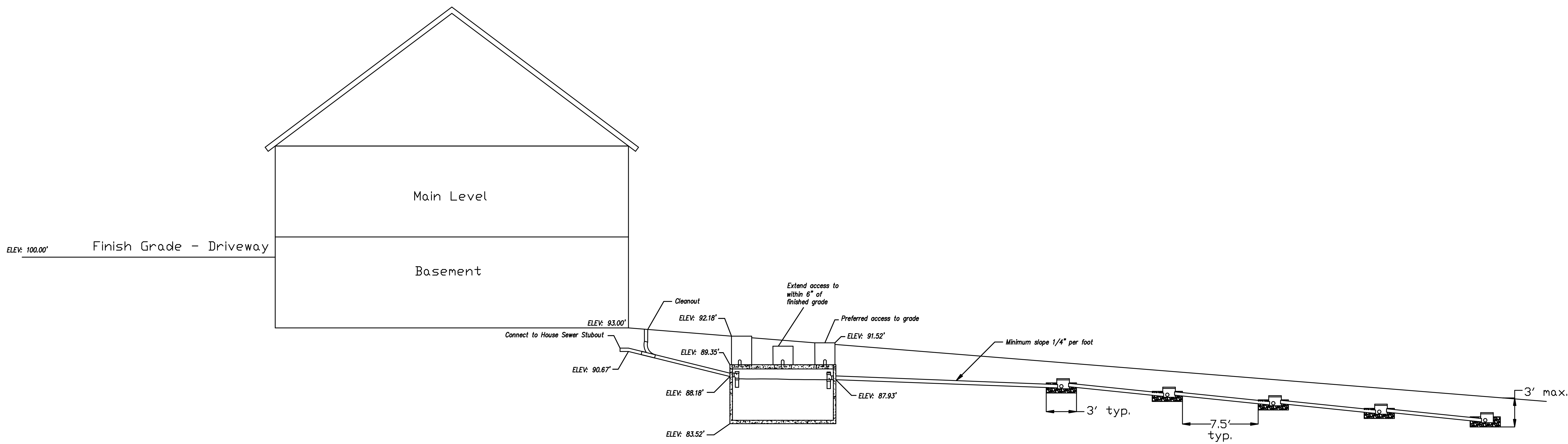
Absorption System Sizing:

Silty clay loam determines soil loading rate:
Use 0.4 gpd/ft2
(600 gpd) / (0.4 gpd/ft2) = 1,500 ft2
Use 3 ft wide standard trench
(1,500 ft2) / (3 ft2 per lineal foot) = 500 LF

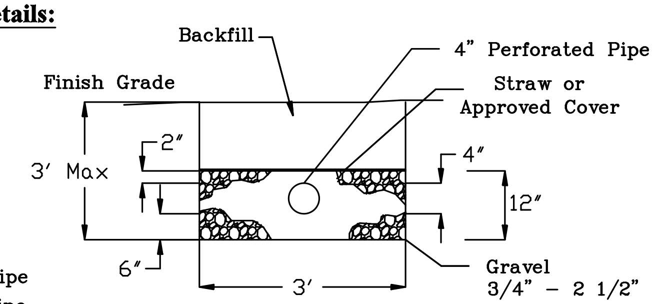
Utility Easements:

Utility easements exist on property along all boundary lines.
Utility easements are as follows:
Front - 15'
Side - 10'
Rear - 10'

Title: Onsite Wastewater System Design		Date: OCTOBER 6, 2012
Property Owner: John & Jane Doe	Drawing: 1 OF 2	Scale: 1" = 30'

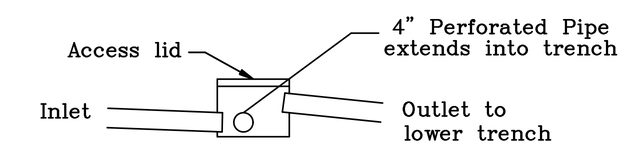


Absorption Trench Details:
Scale: nts



Min. 6" gravel under pipe
Min. 2" gravel above pipe
Min. 12" gravel total depth

Drop Box Detail:
Scale: nts



Outlet invert to be 4" to 6" above invert of distribution pipes in trench

Profile Detail Notes:

Ground elevation at driveway is relative datum of 100' elevation
All other elevations provided are based on relative elevation datum
Floor elevation of basement is walkout to existing ground slopes (8% to northwest)
Minimum cover above septic tank is 6". Greater than 12" preferred.
Maximum depth of absorption trenches is 36" below existing grade.
Minimum depth of backfill above gravel is 6", preferred depth is 12" minimum.
Drop boxes to be used to sequentially load trenches from top to bottom

Title: Onsite Wastewater System Design	Date: *October 6, 2012*
Property Owner: John & Jane Doe	Drawing: *2 OF 2*
	Scale: *1" = 10'*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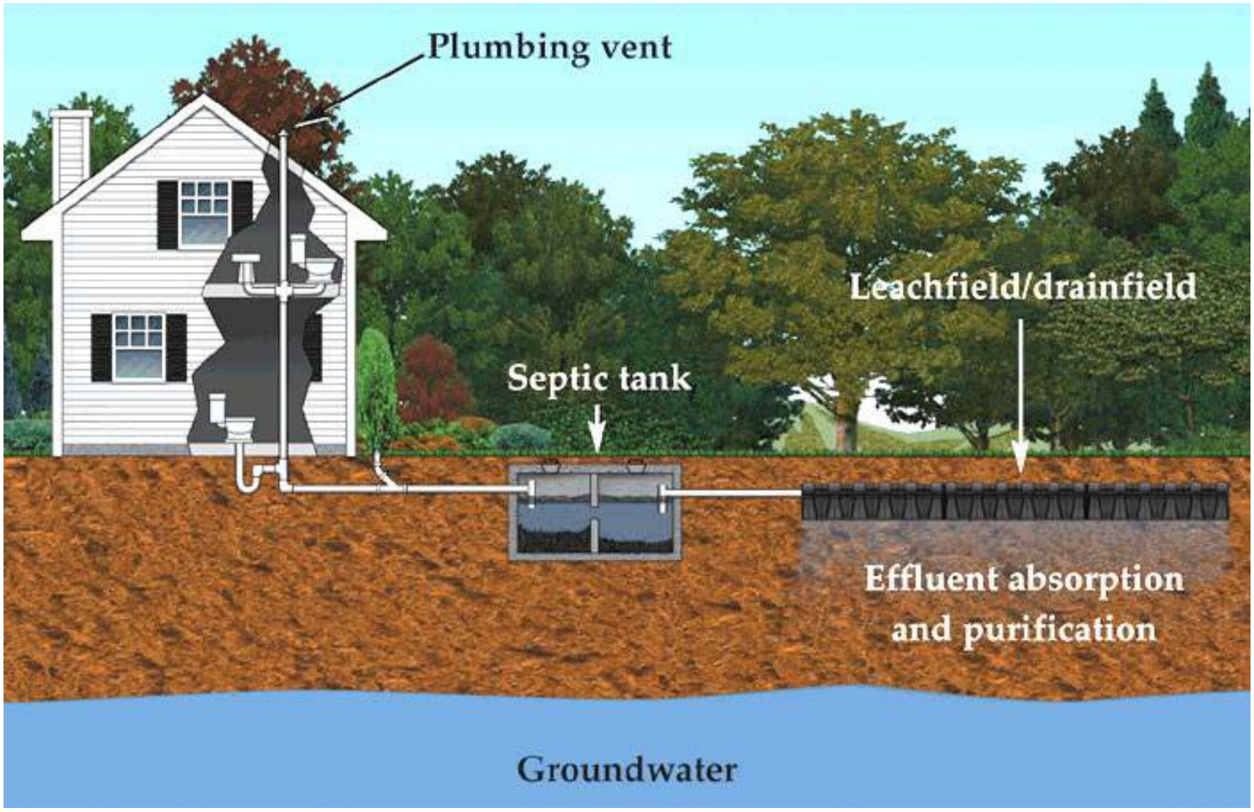
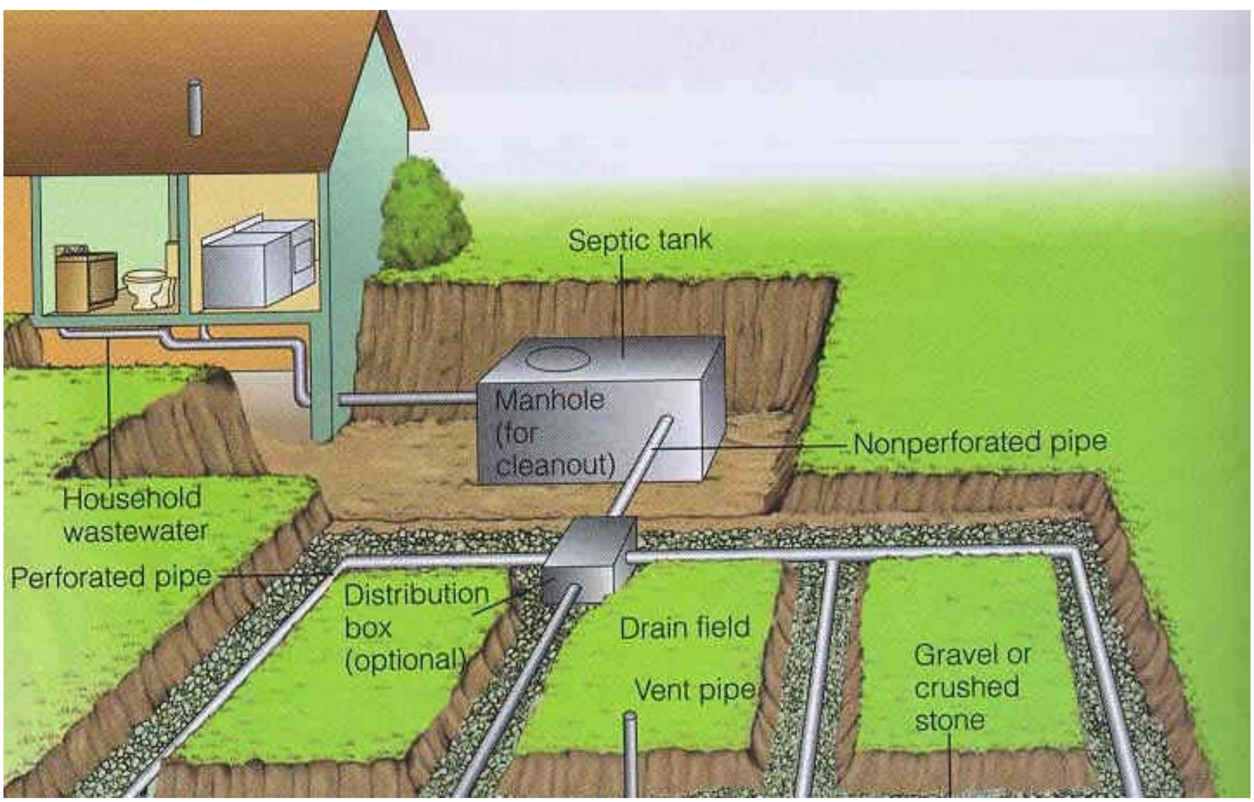
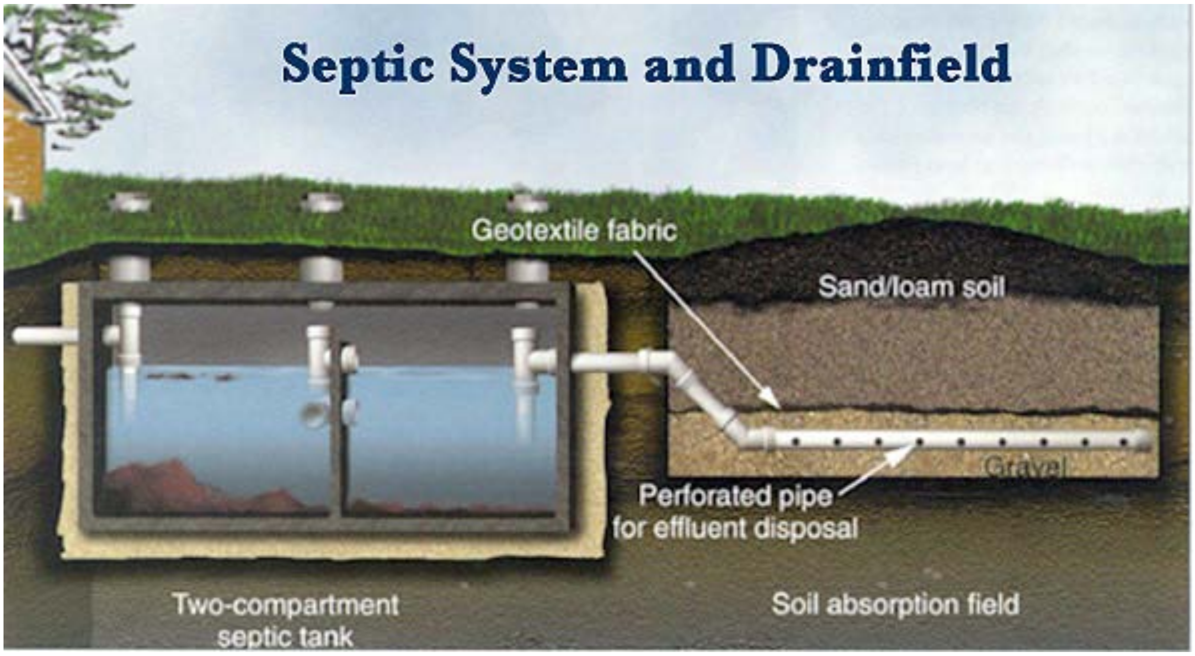
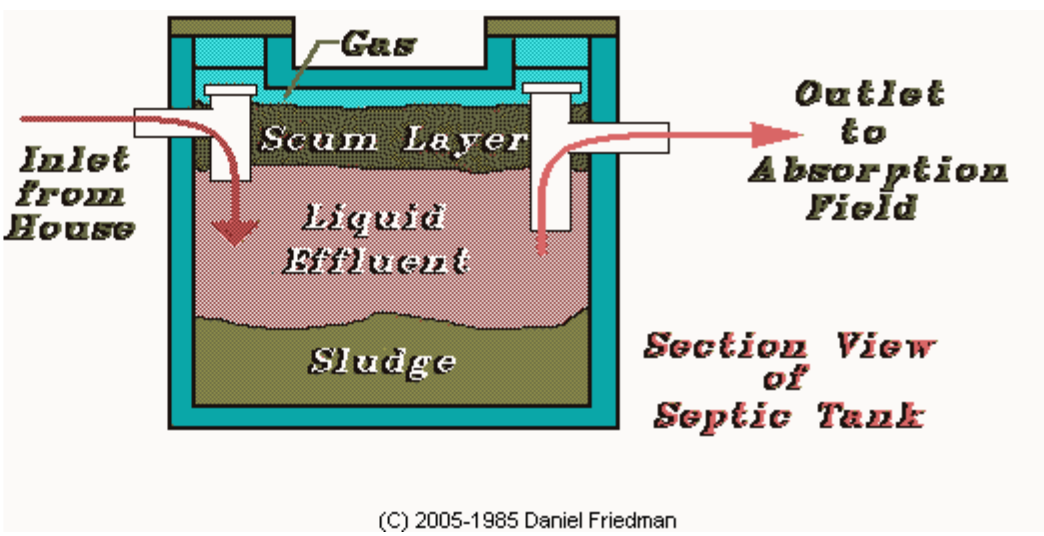
TITLE: TITLE
ETE 2270 TTh
DATE: DATE?
DRAWN BY: NAME
ASSIGN: #
SCALE: SCALE

Septic Design






Septic System and Drainfield
Geotextile fabric
Sand/loam soil
Gravel
Perforated pipe
for effluent disposal
Two-compartment
septic tank
Soil absorption field


Gas
Scum Layer
Inlet
from
House
Liquid
Effluent
Outlet
to
Absorption
Field
Sludge
Section View
of
Septic Tank
(C) 2005-1985 Daniel Friedman

Problem #2 - Disposable Diaper Recycling

Title: Disposable Diaper Recycling

Plot Scale: ¾" = 1"

Objectives:

Students will be able to

1. Use multiple parts to create working and assembling drawings.
2. Work effectively in teams of two to create working and assembling drawings.

Background:
When it comes to baby diapers, Huggies™ and Pampers™ are the industry standards for high-quality disposable diapers. **Huggies**™ are manufactured by Kimberly Clark and Proctor & Gamble produces **Pampers**™. As major competitors striving to dominate the disposable diaper market, each of these diaper "giants" is relentless about manufacturing top-notch, supreme quality products.

What happens when diapers are manufactured that do not meet the standards set by each of these reputable companies? For many years, these diapers were just scrapped and trashed. As the companies evolved, they begin to sell these "second" quality diapers to developing countries where the population could not afford the high cost of their premium diapers. (*Although these diapers may be perfectly usable and sometimes as reliable as their first quality product, Kimberly Clark does not want to sell these diapers in the U.S. because they would then be competing with themselves*.) With the push for more green manufacturing processes, environmentally responsible companies began to investigate ways to not only reduce their material needs, they also sought avenues to reuse and re-purpose products that did not meet the standards of a premium product suitable. Kimberly Clark was no exception.

Recognizing the value in the materials used to produce diapers, diaper manufacturers developed creative processes to reclaim these resources. Many of the reclaimed materials are introduced back into the production line. Materials that are reclaimed, but not re-introduced into production are packaged, sold and re-purposed. Reclaiming diapers is not only better for the environment, it is a cost effective strategy that allows manufacturers to re-coup some of the expense associated with manufacturing rejected diapers.

Disposable diapers are composed of the following:
1) Polyethylene Film
2) Polypropylene Non-Woven – Hydrophobic and Hydrophilic
3) Absorbent Core - Wood Pulp Fluff
4) Super Absorbent Polymer (SAP)
5) Elastics – Lycra/Spandex
6) Quick Wicking Layer
7) Adhesive – Hot Melts and Elastomeric
8) Fastening Tape – Stick Type/Hook and Loop Type
9) Moisturizer and Fragrance Lotions
10) Breathable/Cloth-Like Back Sheet

Among all the parts, four are reclaimed and either re-introduced into the production process or sold and repurposed. (**Figure 1**).

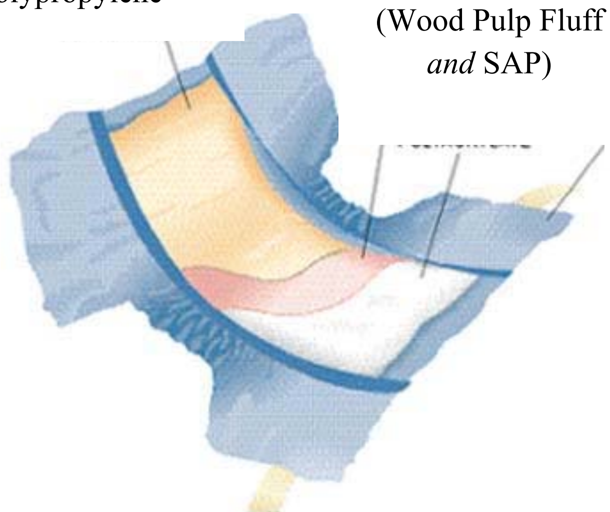


Figure 1: Four Reclaimed Components of Rejected Diapers
http://www.fibre2fashion.com/industry-article/pdffiles/12/1124.pdf

The diaper cover is comprised of a polyethylene film and polypropylene nonwoven. The polyethylene film is a hydrophobic nonwoven material that is impermeable to liquids. It prevents body fluids from traveling through the diaper. Polypropylene gives the diaper a comfortable shape and helps prevent leakage. The absorbent core is specially designed to absorb and retain body fluids. The core is made of *cellulose fibers (also known as Wood Pulp Fluff) mixed with* superabsorbent polymers (SAP). Wood Fluff Pulp (**Figure 2**) is a type of fiber from a plant or plant-based material; and S.A.P. **(Figure 3**) is a polymer with the ability to absorb and retain extremely large amounts of a liquid relative to their own mass.

Figure 2: Wood Pulp Fluff
http://www.fibre2fashion.com/industry-article/pdffiles/12/1124.pdf

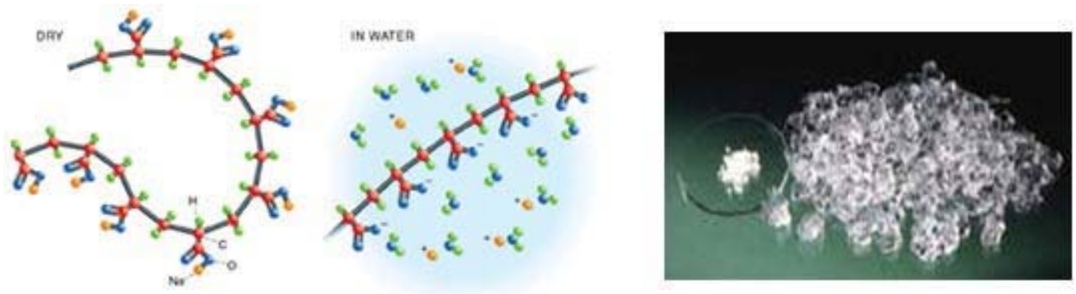


Figure 3: Super Absorbent Polymer (SAP)
http://www.fibre2fashion.com/industry-article/pdffiles/12/1124.pdf

Since disposable diaper companies have a 3-5% scrap rate, it is logical for these manufacturers to reclaim the fluff pulp, SAP and nonwoven fibers. These reclaimed materials are reintroduced back into to manufacturing process or sold and re-purposed.

The reclaim procedure is an "assembly-line" process (**Figure 4**).

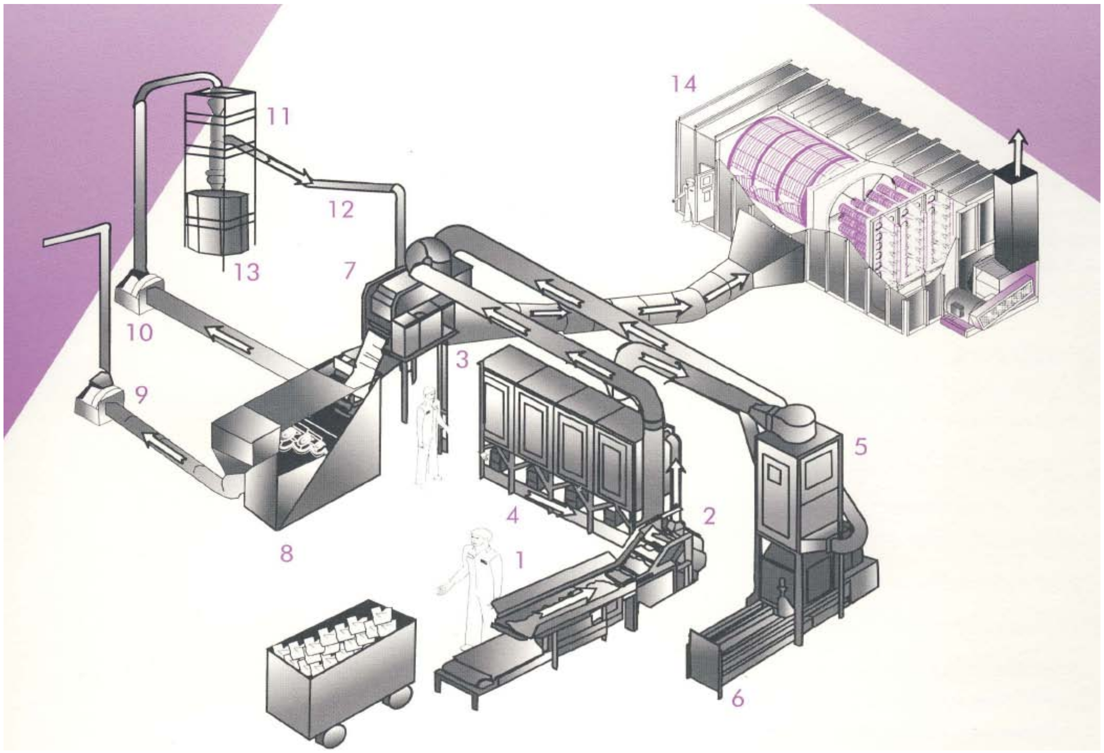


Figure 4: Disposable Diaper Reclaim Process Picture From: ibis International: http://www.ibis-usa.com

1. Reject Product Hopper
2. Buster Fan
3. Multi-Stage Separator
4. Scrap Fans (Behind Separator)
5. Scrap Collector
6. Scrap Baler
7. Fluff Condenser
8. S.A.P. Extractor
9. Fluff Fan to Process/Volumetric Feeder
10. S.A.P. Fan to Aspirator
11. Cyclone and Aspirator/Classifier
12. Residual Fluff to Condenser
13. Reclaimed S.A.P.
14. Rotary Drum Filter System

During the reclaim process, whole diapers (**Step 1**) are feed into a fan (**Step 2**). The fan opens the soft disposable diapers (**Figure 5**) while conveying them to the first stage of the multistage separator. Through a series of separators, the diapers' internal components are separated from the nonwoven cover (**Step 3**). After separation, the nonwoven material is transported to a scrap collector (**Step 5**) and then conveyed into a baler (**Step 6**). Baled scrap materials are packaged and sold to recycling companies. The wood pulp fluff/SAP is conveyed to either:

a. Fluff/SAP Baler (**Step 7**): Packaged for sale to be re-purposed into other products or sold to other diaper manufactures (**Figure 6**)
b. Conveyed to a SAP extractor (**Steps 8, 10, 13**): Packaged for sale and re-purposed (**Figure 7**)
c. Reintroduced into the product line via a Volumetric Feeder (**Steps 8 & 9**)

Figure 5: Shredded Diapers

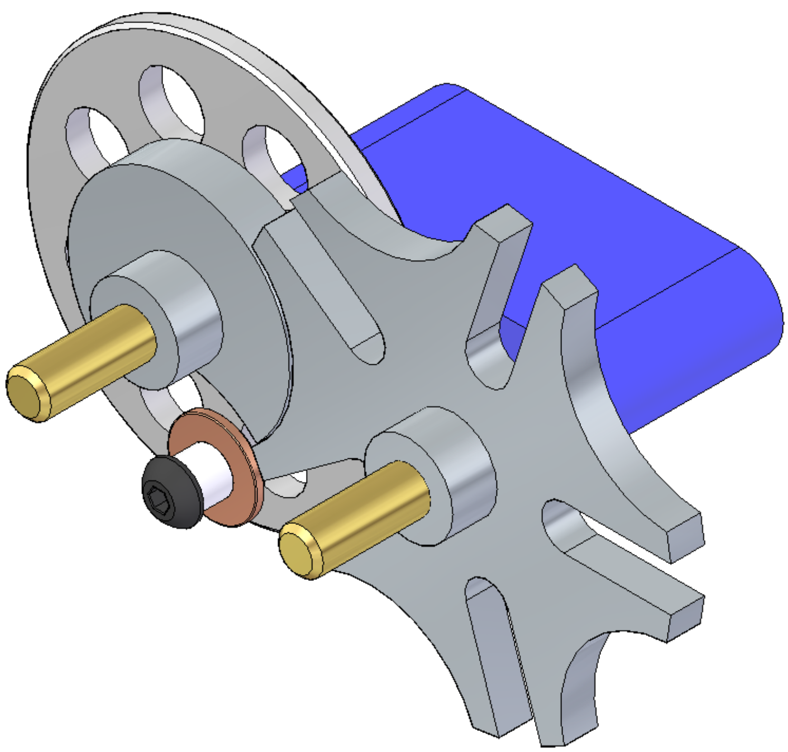
Figure 6: Baled Wood Pulp Fluff/SAP

Figure 7: Extracted SAP

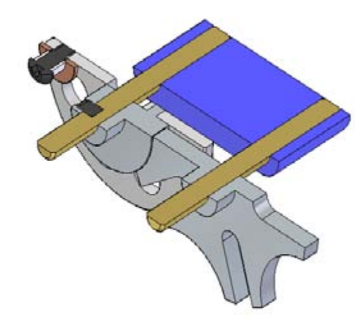
Problem:
For the past 10 years, a diaper manufacturer has taken advantage of reclaiming materials from their diaper rejects. This process has not only proven to be profitable, it is also in alignment with the company's mission to reduce its carbon footprint. However, for the past two months, less reclaimed pulp fluff has made its way back into the diaper manufacturing process. As the environmental engineer assigned to rectify this issue, you discover a "timing" issue interfering with the separation of the materials. A Geneva Cam, which drives the rotary motion of the blade responsible for slicing the diaper, is defective. The outdated Geneva Cam is sticking; thus, inhibiting the rotation of the blade. This limiting blade rotation is causing the separation of the pulp from the plastic to occur at much lower efficiency. During your research, you locate a more modern version of a Geneva Cam. However, due to the specialized nature of the pulp separator system in this diaper reclaim process, you must design a Cam with very specific dimensions.

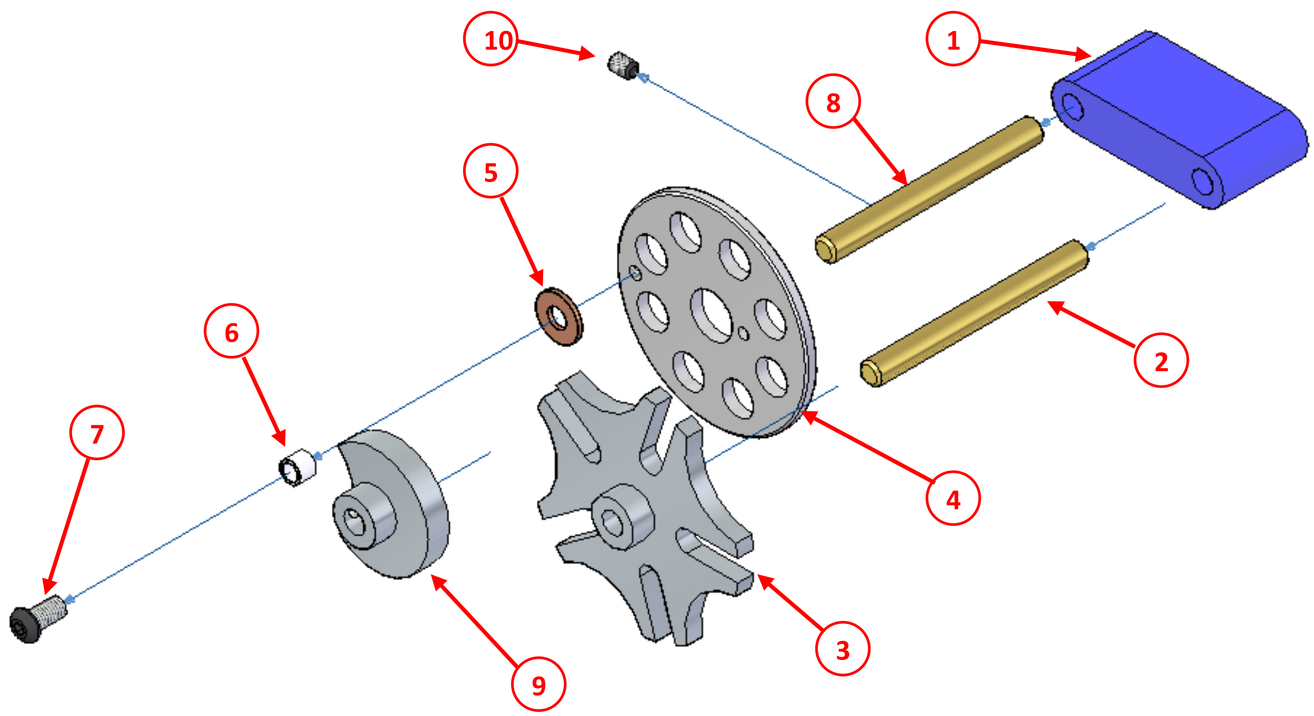
Assignment:
This project aims at introducing you to three dimensional AutoCAD. You will create the **Index** (part #3) and **Index Plate** (part #4) of the Geneva Cam in 3D.

Geneva Cam



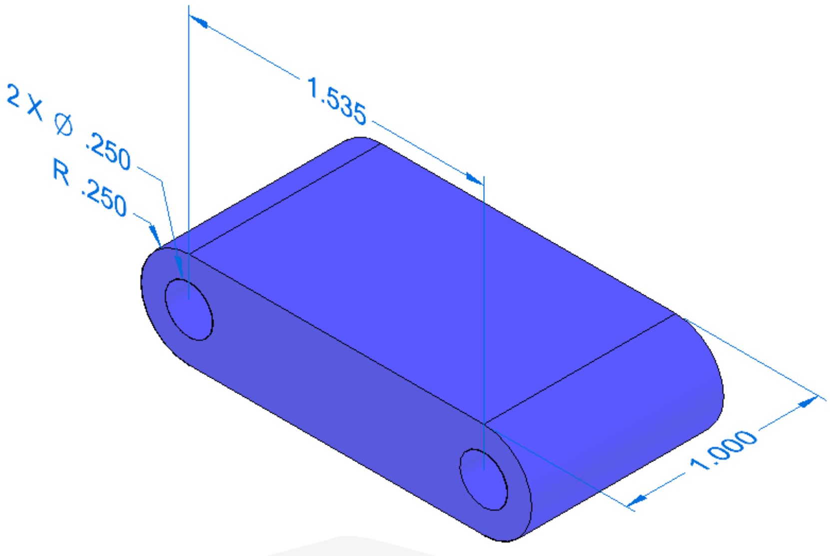
This simple machine transmits rotational motion into intermittent rotational motion on another shaft. You have access to an AVI (Geneva.avi) of this assembly demonstrating this motion. A list of parts, materials, and sizes can be found on the page below. You will notice that the Geneva is locked to the index plate with a pin allowing the two to rotate in synch. Assume a press fit between the index and its shaft. The index rests on top of the washer when rotational motion engages the two parts.



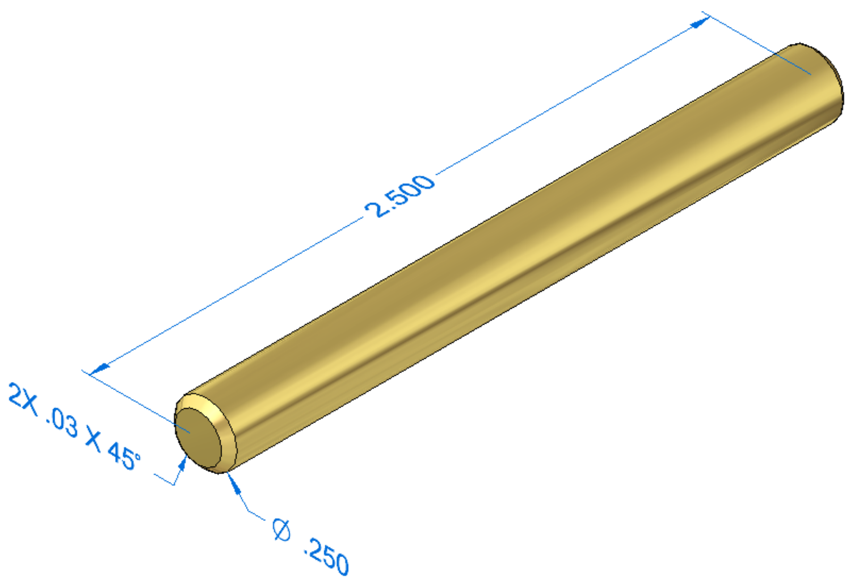


ITEM	QTY	NAME	DESCRIPTION
1	1	Base	Cast Iron
2	1	Shaft w/out Set Screw	Steel
3	1	Index	Steel
4	1	Index Plate	Steel
5	1	Washer	#10 ANSI Type A Plain Steel
6	1	Bushing	Brass
7	1	Button Head Cap Screw	#10 X 24 UNC X .375 Steel
8	1	Shaft w/ Set Screw	Steel
9	1	Geneva	Steel
10	1	Standard Slotted Headless Set Screw	#8 X 32 UNC Flat Point Steel

Base

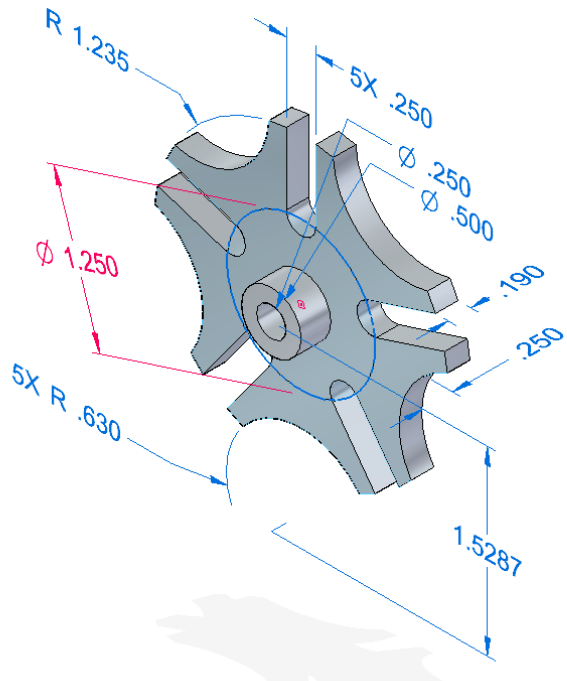


Shaft w/out Set Screw

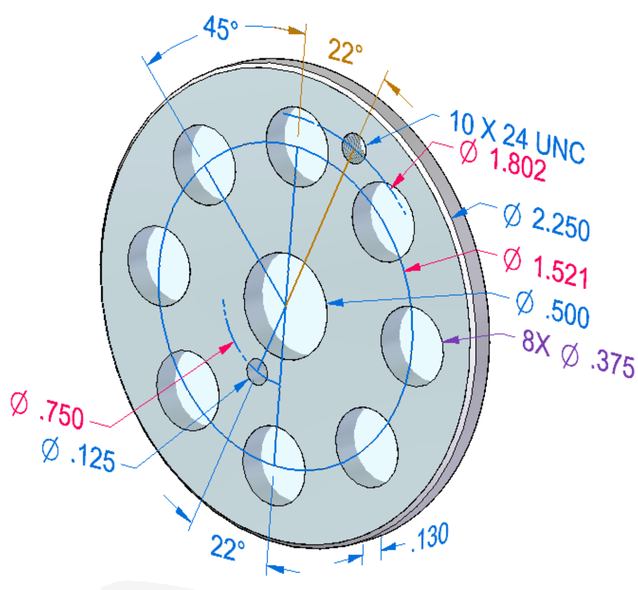


Figures intentionally not to scale

Index

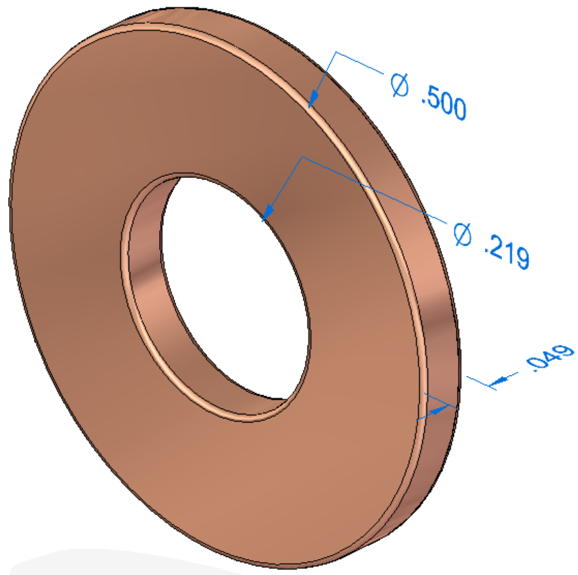


Index Plate

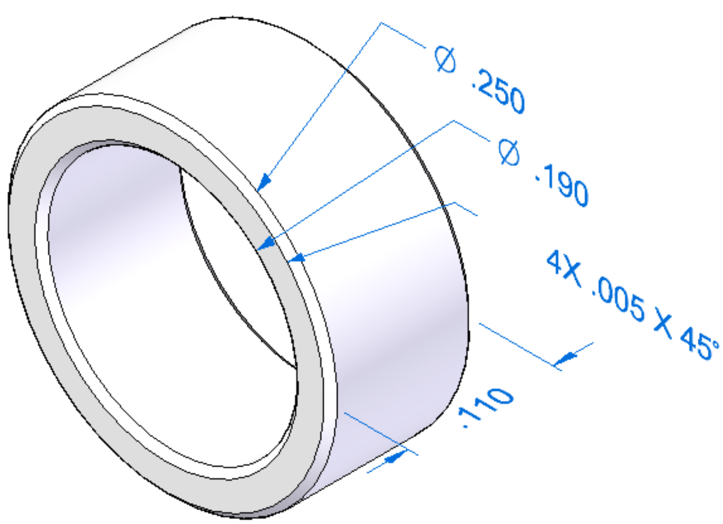


Figures intentionally not to scale

Washer



Bushing



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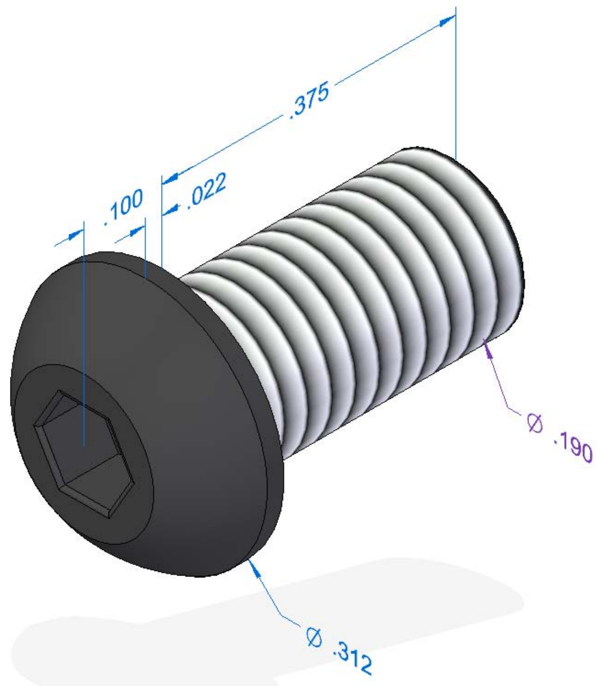
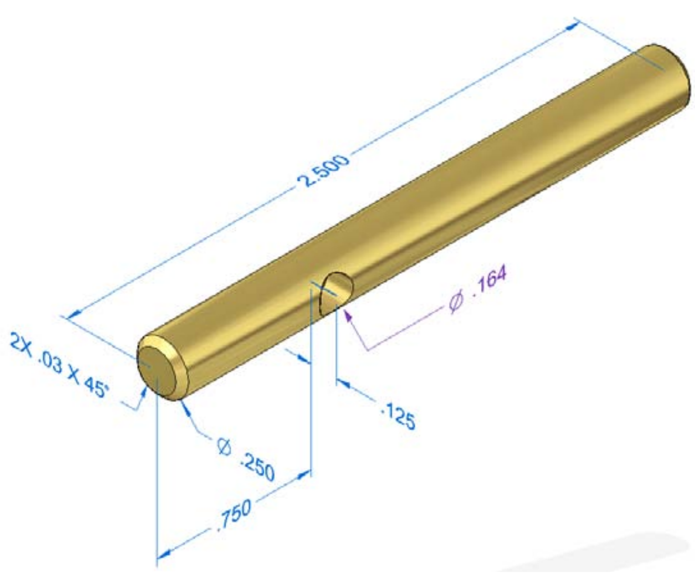
Button Head Cap Screw

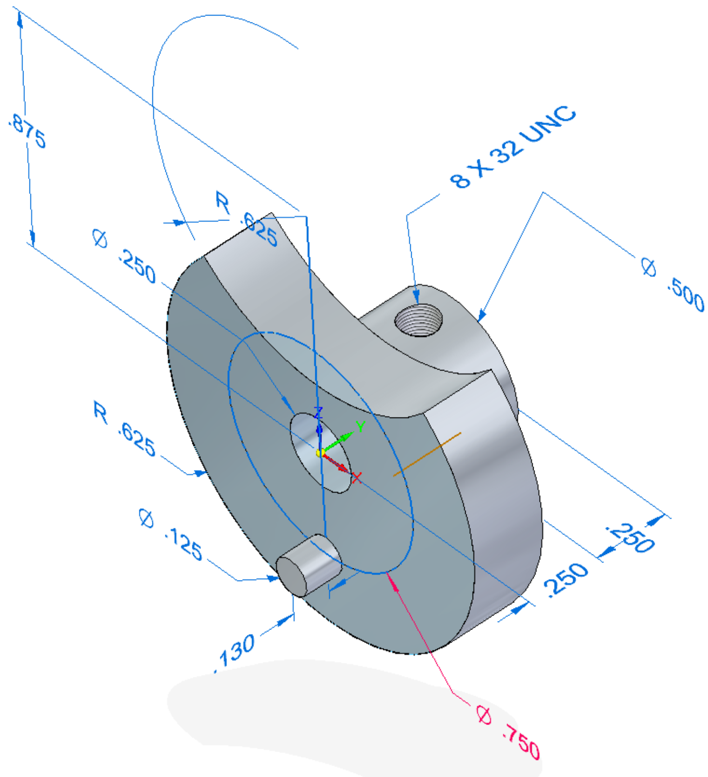


Shaft w/Set Screw

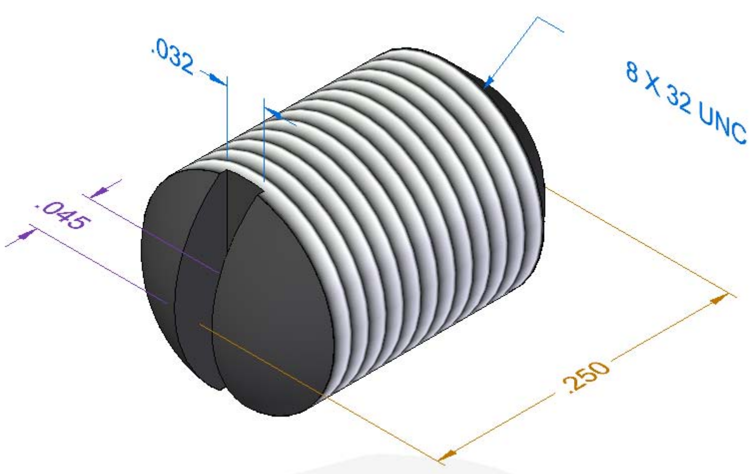


Figures intentionally not to scale

Geneva



Set Screw

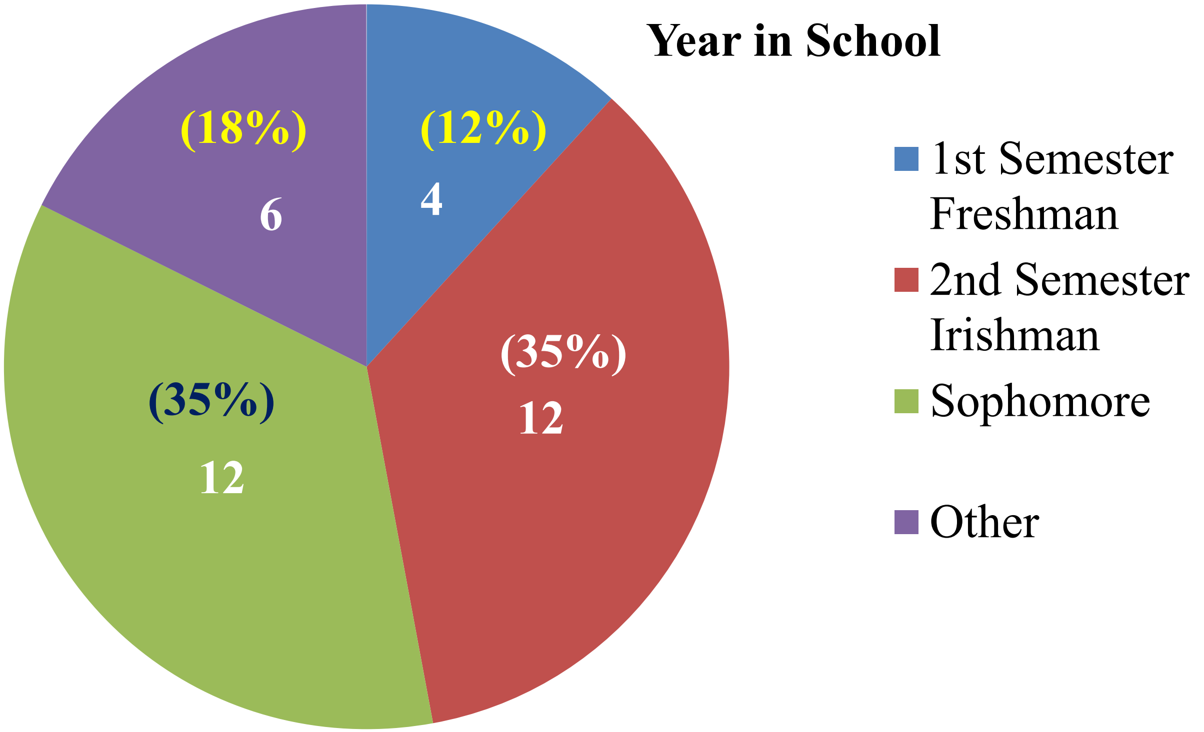


Figures intentionally not to scale

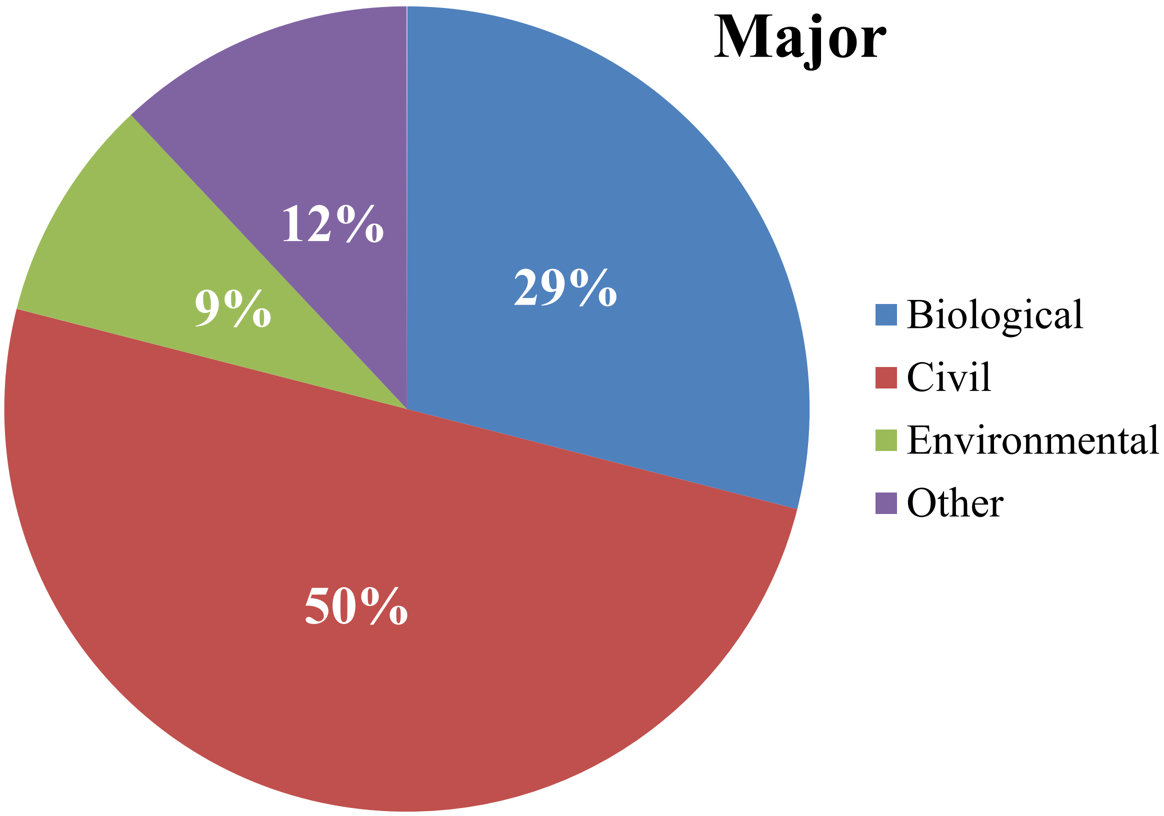
Pilot Results of Environmental Engineering Assignments

Results of Pilot Testing of Environmental Engineering Assignments (assignments # 9 and #10) as compared to the other assignments in the course.

AutoCAD Class Survey Results



AutoCAD Class Survey Results



AutoCAD Class Survey Results

Qualtrics Survey

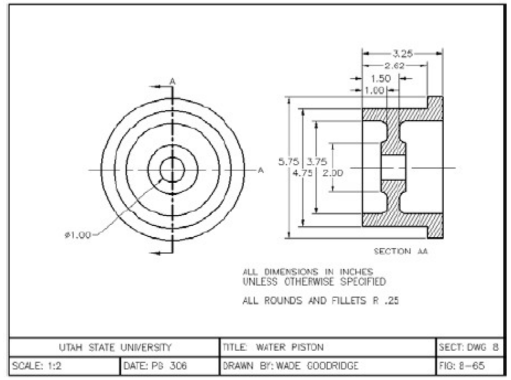
- Likert Scale: 1- 5
  - **1** Disagree
  - **3** Neutral
  - **5** Agree

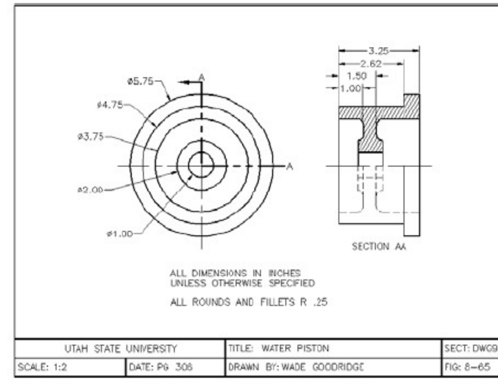
#	Problem
1	Gasket Problem
2	Tower Problem
3	Stop Plate Problem
4	Concrete Curb Problem
5	Water Piston Problem
6	Steel Column Problem
7	Artificial Disk Problem
8	Profile Drawings Problem
9	Waste Water Treatment Problem
10	Disposable Diaper Problem
11	3-D Print Problem

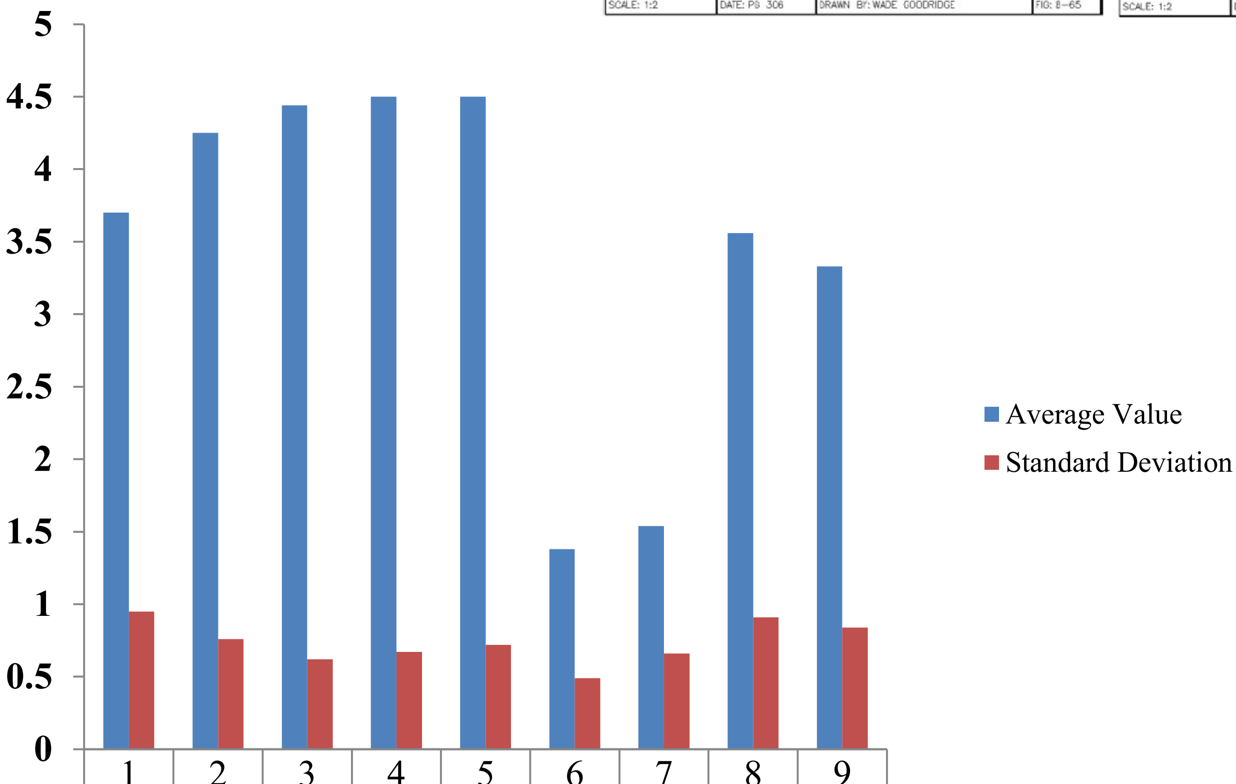
AutoCAD Class Survey Questions

#	Question
1	The assignment was applicable to the engineering field I plan to study.
2	I clearly understood the relevance of this assignment.
3	The assignment was written in a clear manner that facilitated understanding of the problem.
4	The expectations/requirements of this assignment were clear and straightforward.
5	The AutoCAD knowledge and skills taught in this class were sufficient to complete this assignment.
6	The assignment was too difficult.
7	The assignment required too much time to complete.
8	I enjoyed completing this assignment.
9	I would have preferred more assignments similar to this one.

P5: Water Piston Problem



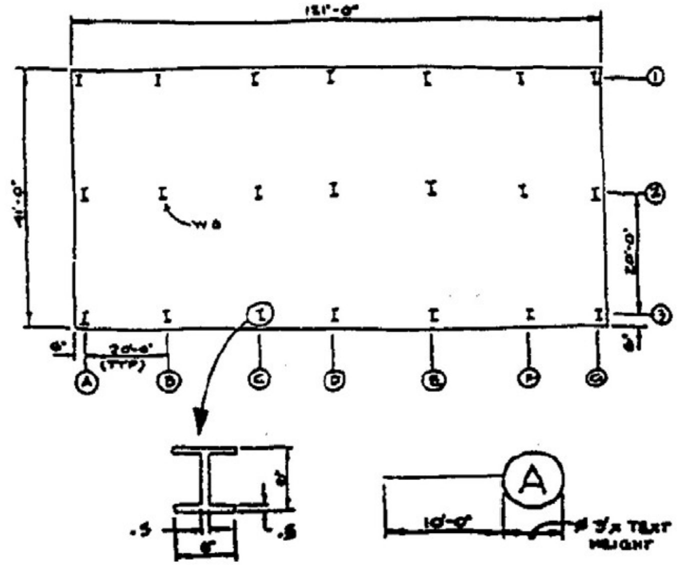


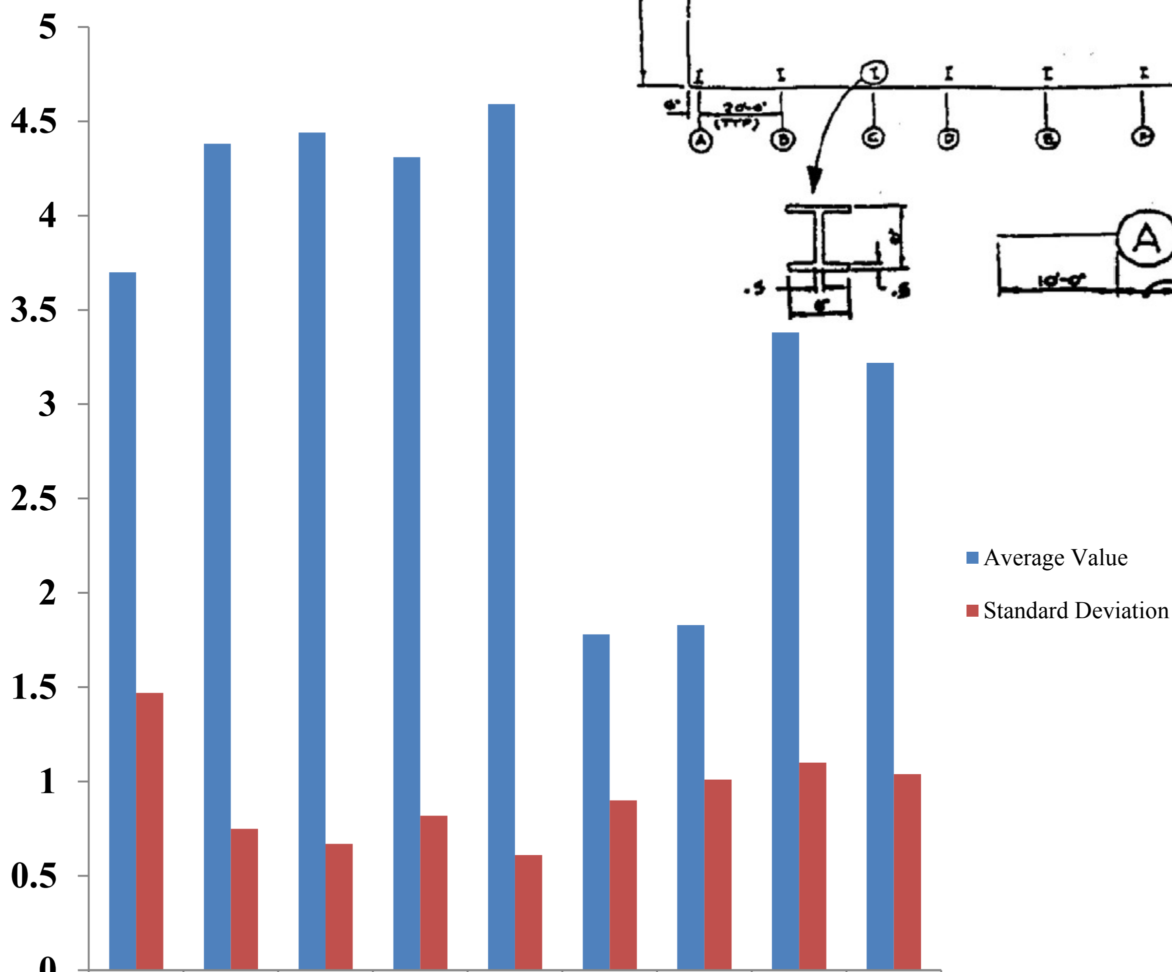


	1	2	3	4	5	6	7	8	9
Average Value	3.7	4.25	4.44	4.5	4.5	1.38	1.54	3.56	3.33
Standard Deviation	0.95	0.76	0.62	0.67	0.72	0.49	0.66	0.91	0.84

Q#	# Respondents
1	30
2	32
3	32
4	32
5	32
6	24
7	24
8	32
9	30

P6: Steel Column Problem

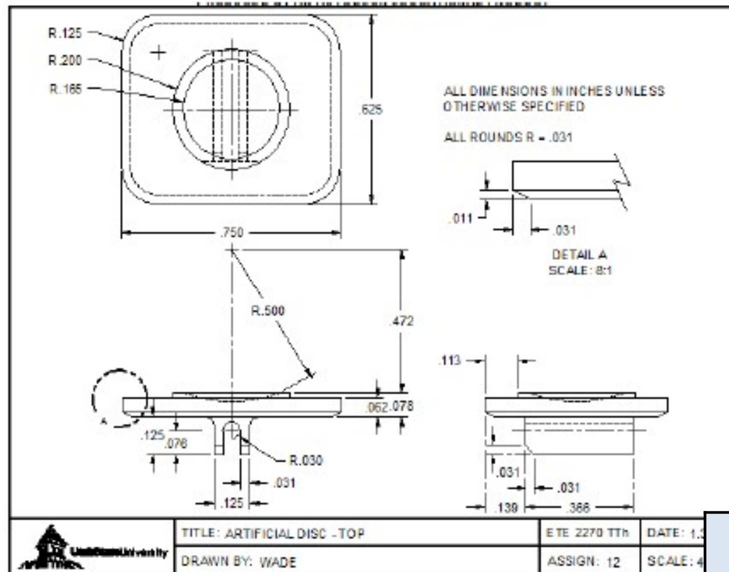


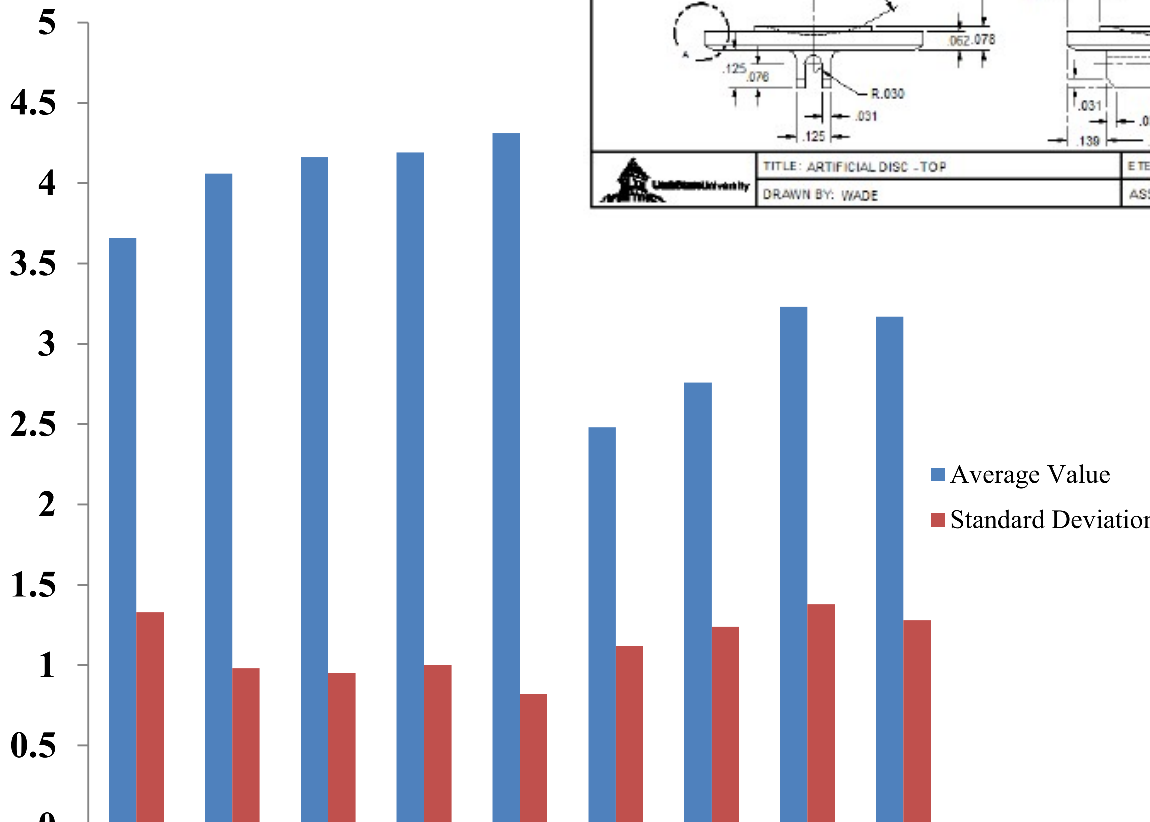


	1	2	3	4	5	6	7	8	9
Average Value	3.7	4.38	4.44	4.31	4.59	1.78	1.83	3.38	3.22
Standard Deviation	1.47	0.75	0.67	0.82	0.61	0.9	1.01	1.1	1.04

Q#	# Respondents
1	30
2	32
3	32
4	32
5	32
6	23
7	24
8	32
9	32

P7: Artificial Disk Problem

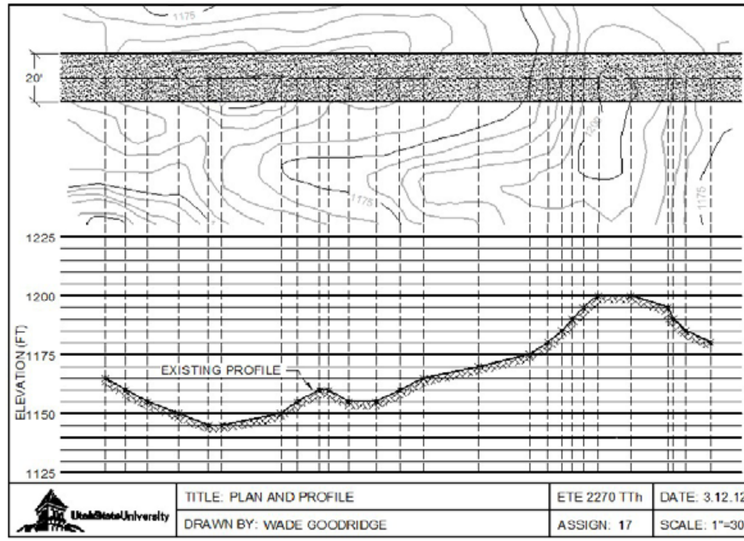


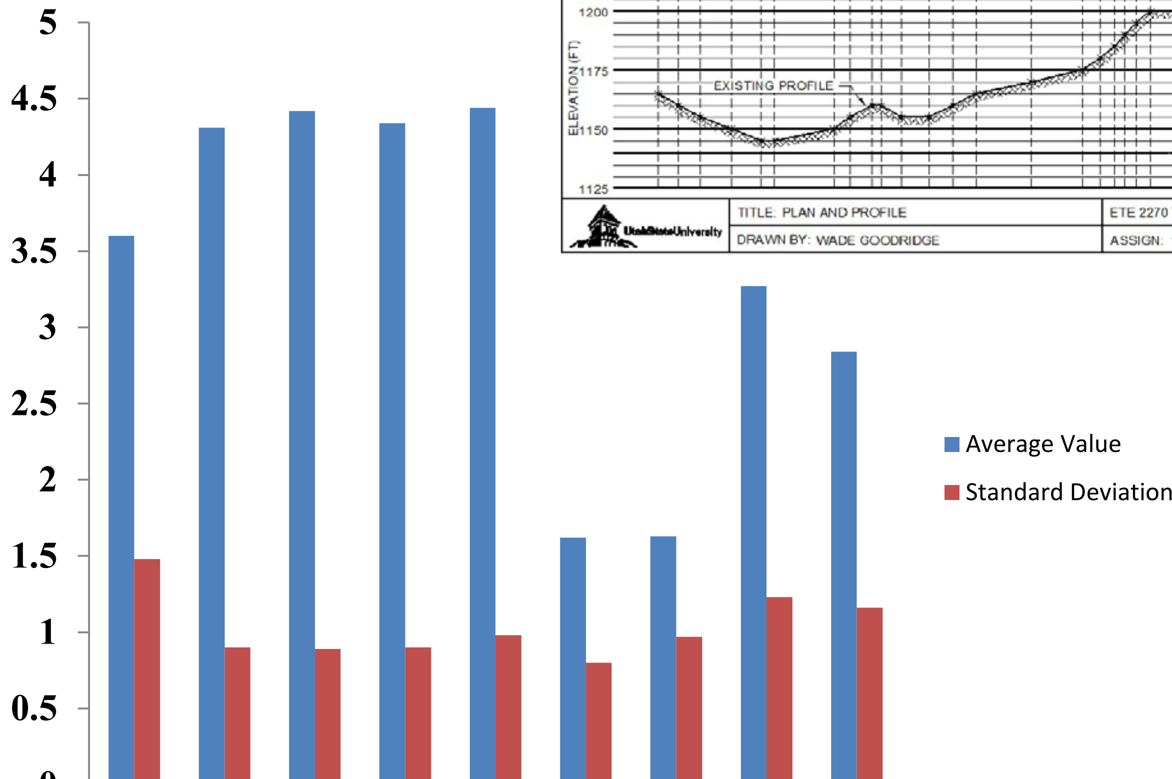


	1	2	3	4	5	6	7	8	9
Average Value	3.66	4.06	4.16	4.19	4.31	2.48	2.76	3.23	3.17
Standard Deviation	1.33	0.98	0.95	1	0.82	1.12	1.24	1.38	1.28

Q#	# Respondents
1	32
2	32
3	32
4	32
5	32
6	27
7	29
8	30
9	29

P8: Profile Drawings Problem

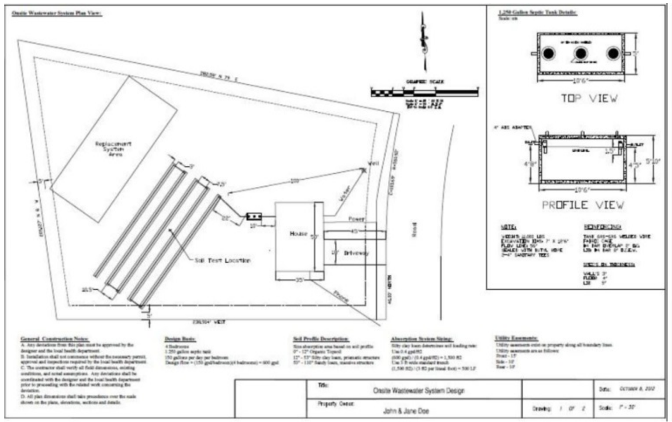


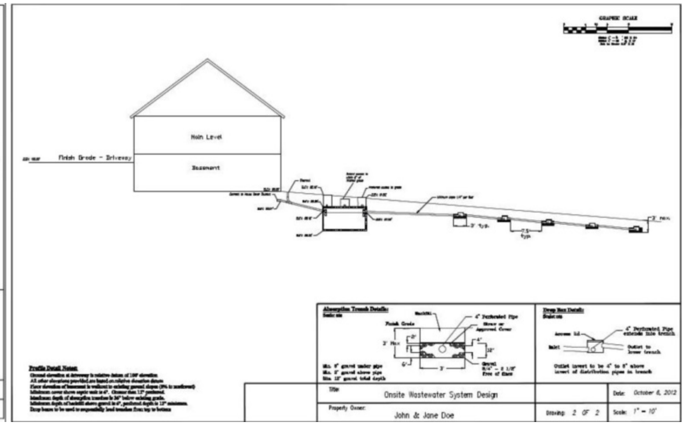


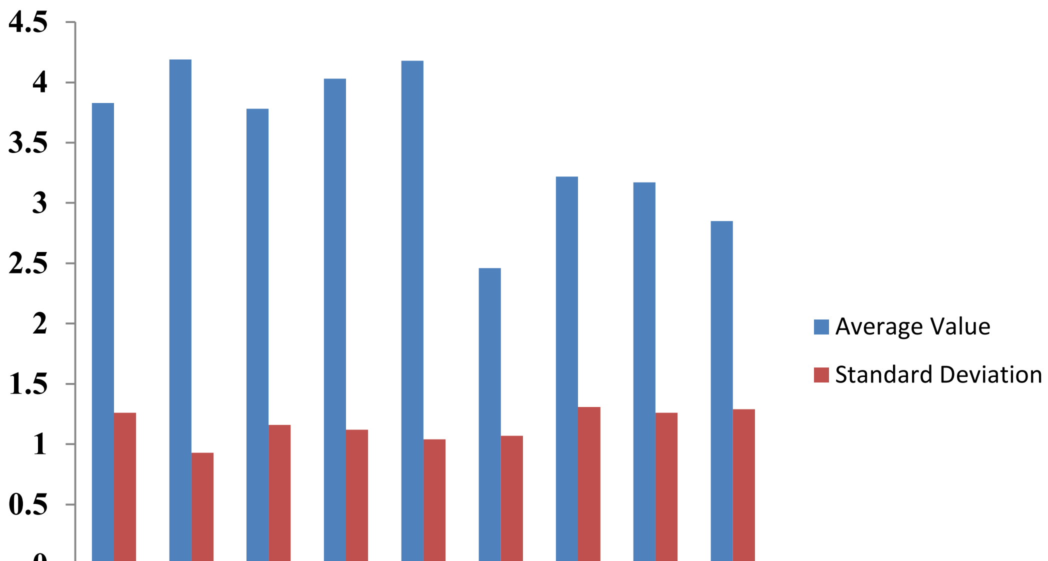
	1	2	3	4	5	6	7	8	9
Average Value	3.6	4.31	4.42	4.34	4.44	1.62	1.63	3.27	2.84
Standard Deviation	1.48	0.9	0.89	0.9	0.98	0.8	0.97	1.23	1.16

Q#	# Respondents
1	30
2	32
3	31
4	32
5	32
6	26
7	24
8	30
9	31

P9: Waste Water Treatment



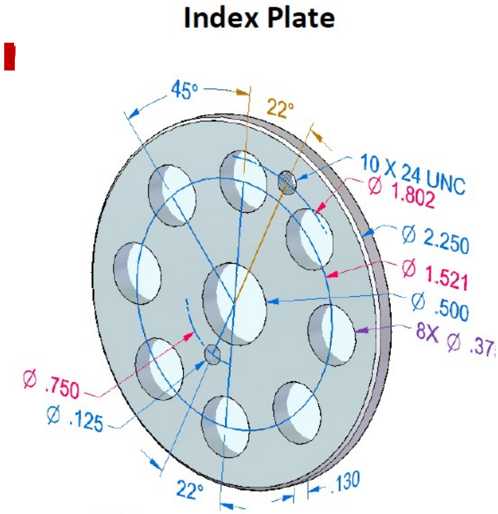


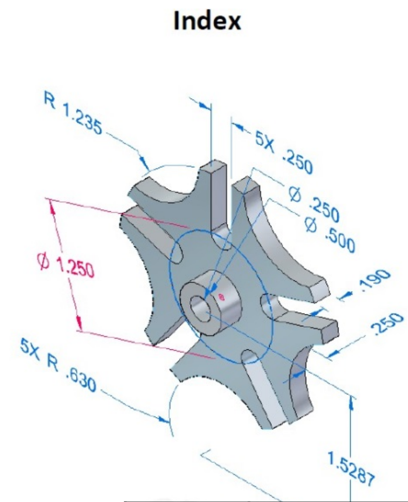


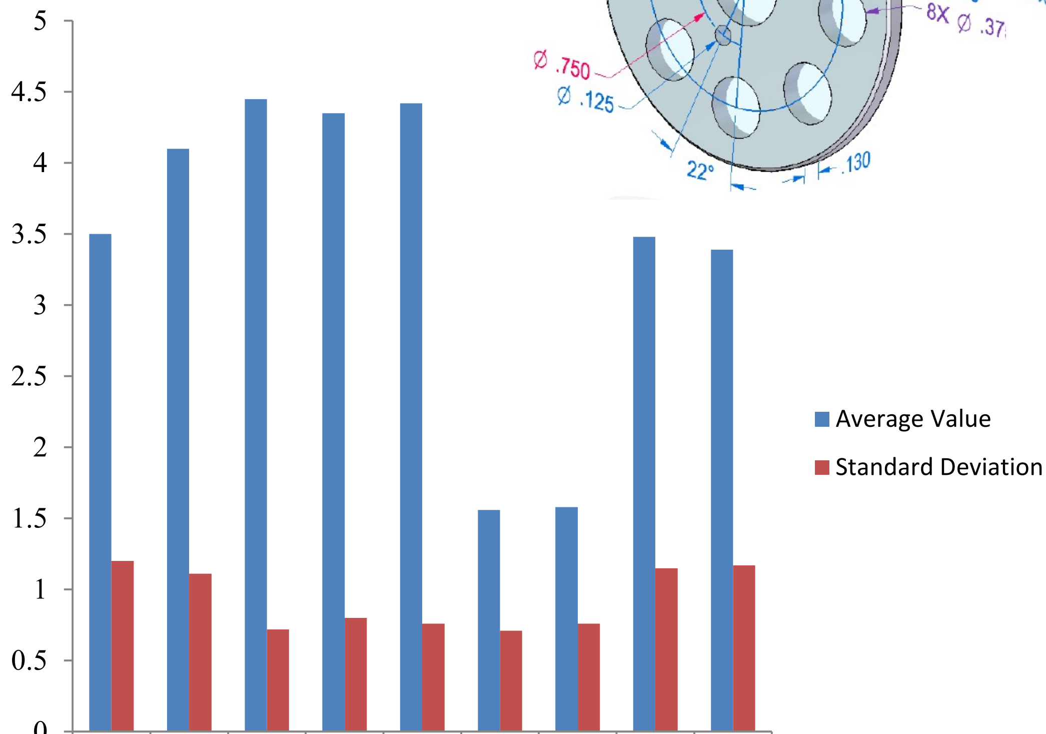
	1	2	3	4	5	6	7	8	9
Average Value	3.83	4.19	3.78	4.03	4.18	2.46	3.22	3.17	2.85
Standard Deviation	1.26	0.93	1.16	1.12	1.04	1.07	1.31	1.26	1.29

Q#	# Respondents
1	30
2	32
3	32
4	32
5	33
6	28
7	32
8	29
9	27

P10: Disposable Diaper Problem



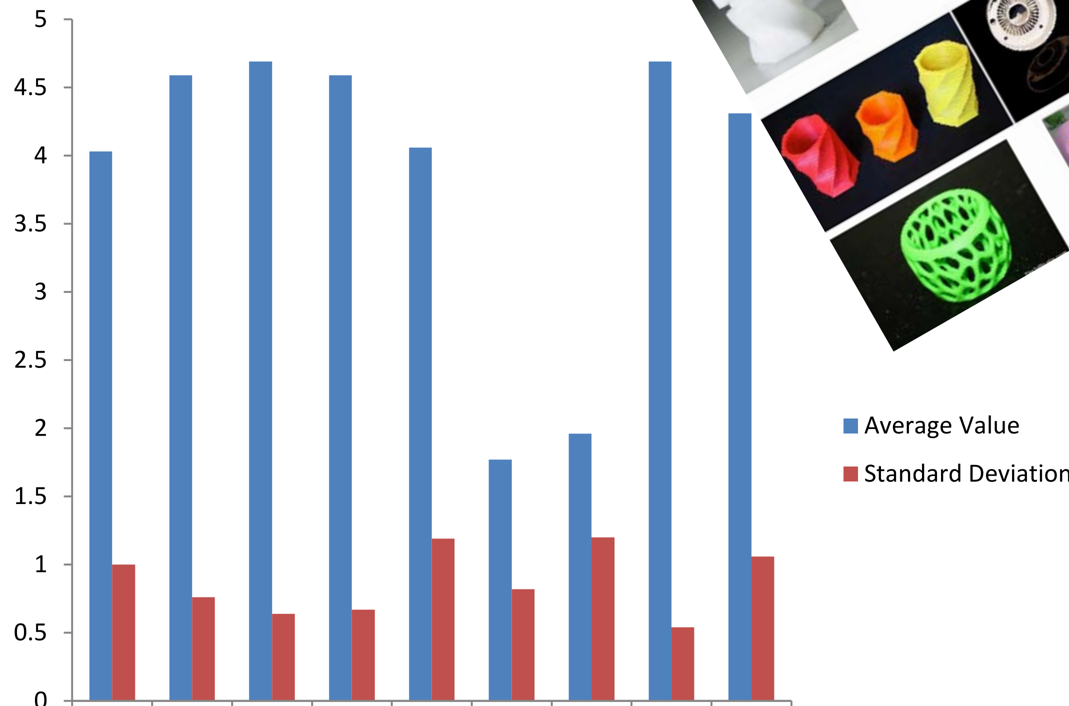




	1	2	3	4	5	6	7	8	9
Average Value	3.5	4.1	4.45	4.35	4.42	1.56	1.58	3.48	3.39
Standard Deviation	1.2	1.11	0.72	0.8	0.76	0.71	0.76	1.15	1.17

Q#	# Respondents
1	30
2	31
3	31
4	31
5	31
6	25
7	26
8	31
9	31

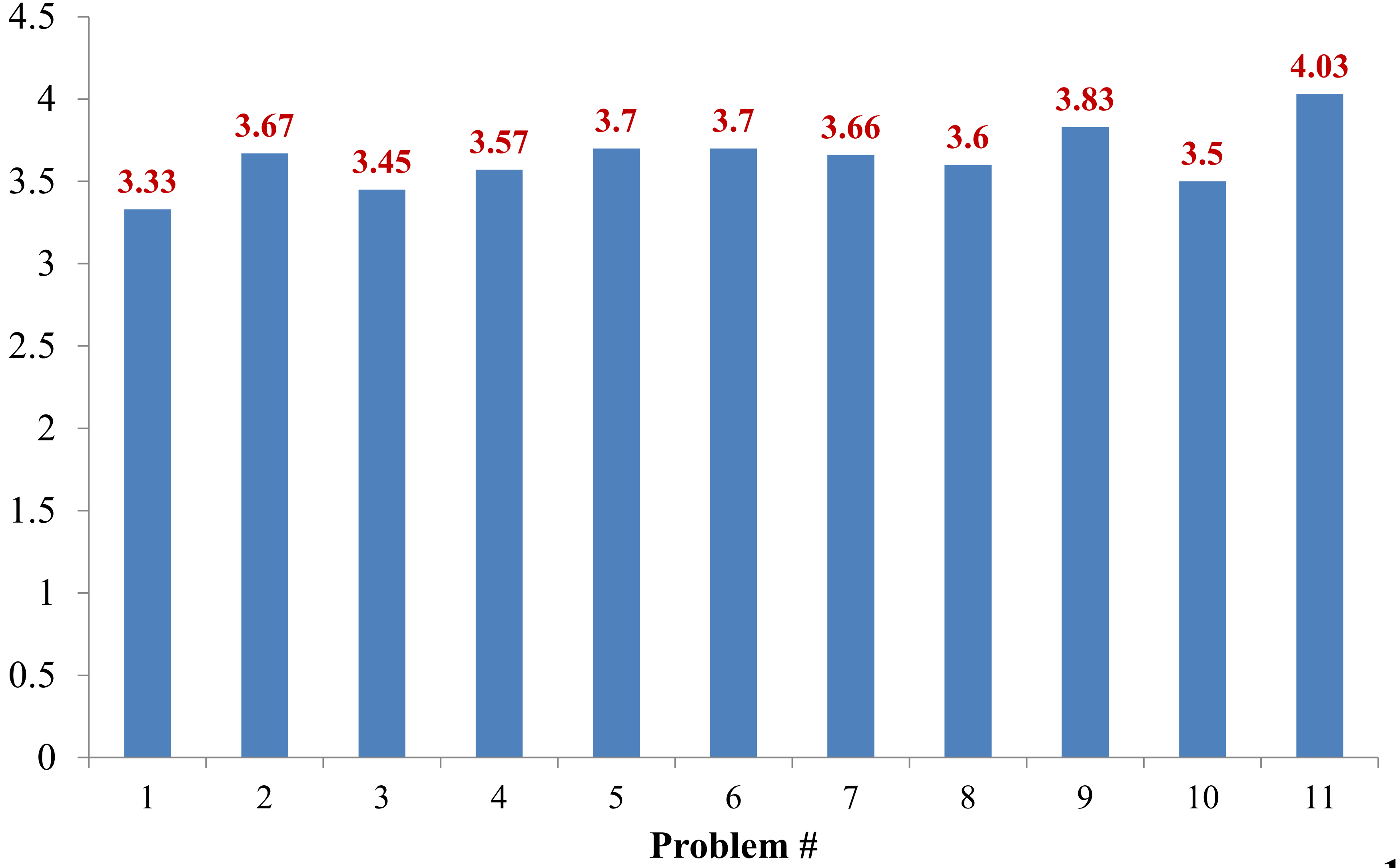
P11: 3-D Print Problem



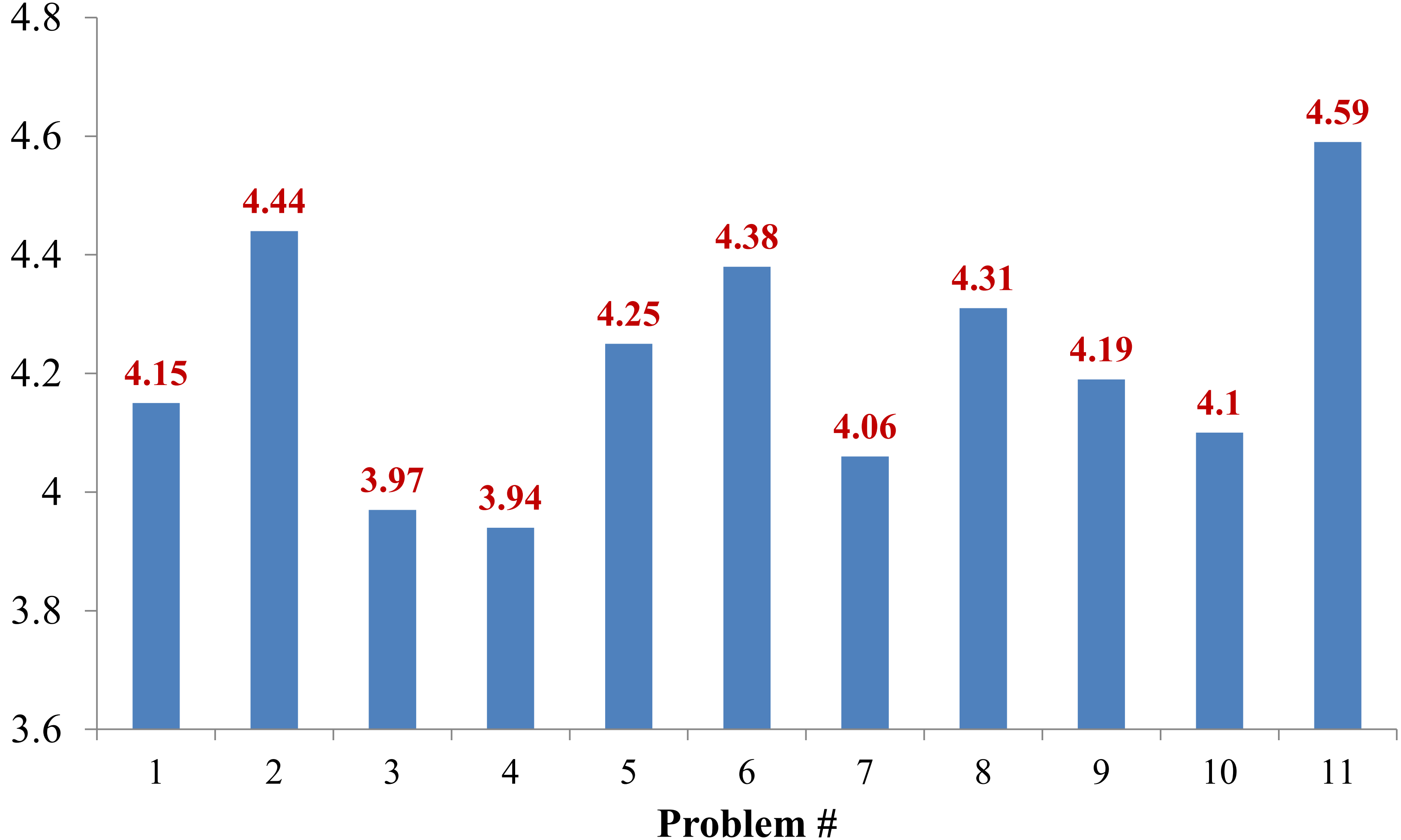
	1	2	3	4	5	6	7	8	9
Average Value	4.03	4.59	4.69	4.59	4.06	1.77	1.96	4.69	4.31
Standard Deviation	1	0.76	0.64	0.67	1.19	0.82	1.2	0.54	1.06

Q#	# Respondents
1	32
2	32
3	32
4	32
5	32
6	26
7	24
8	32
9	32

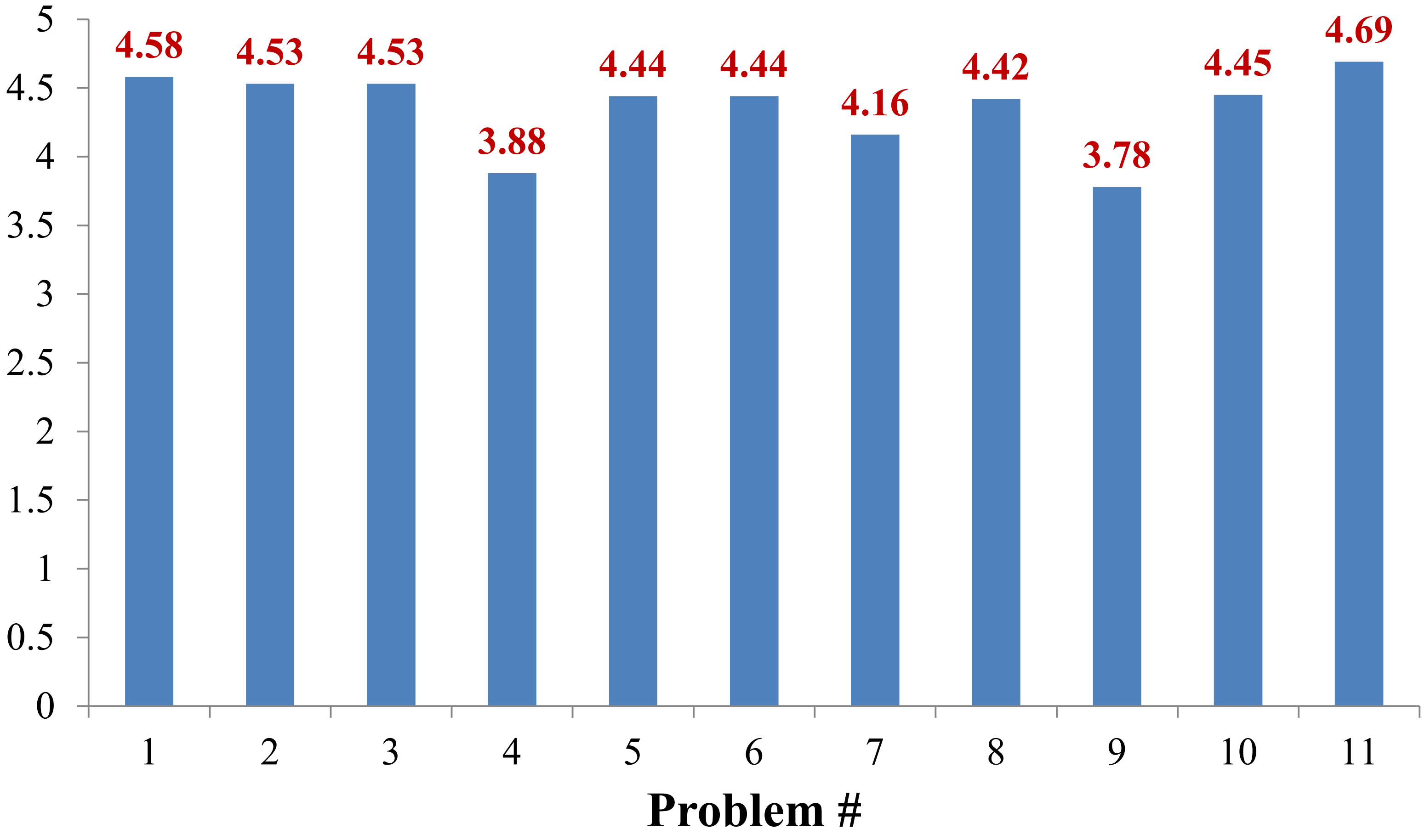
The assignment was **applicable** to the **engineering field** I plan to study.



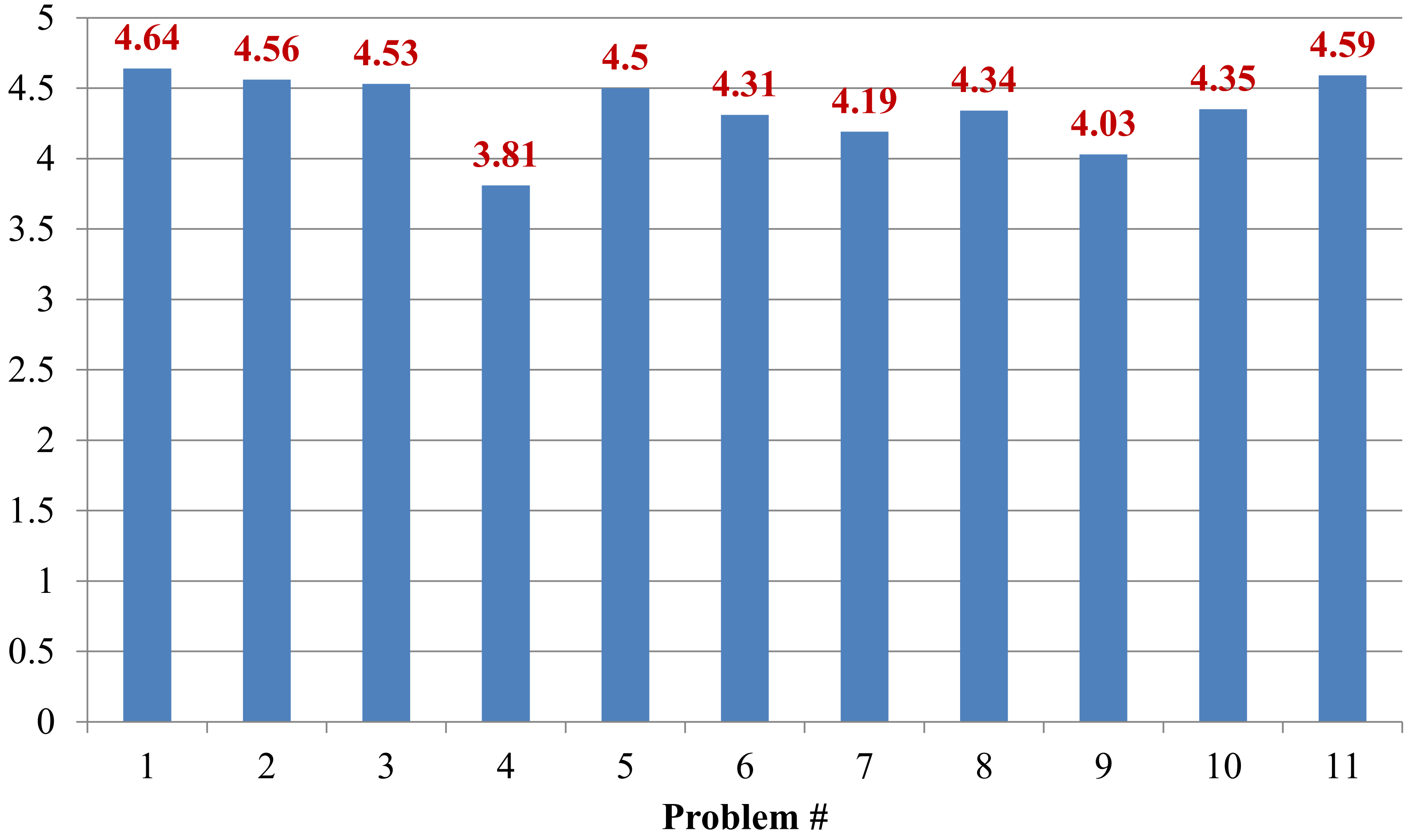
I clearly **understood** the **relevance** of this assignment.



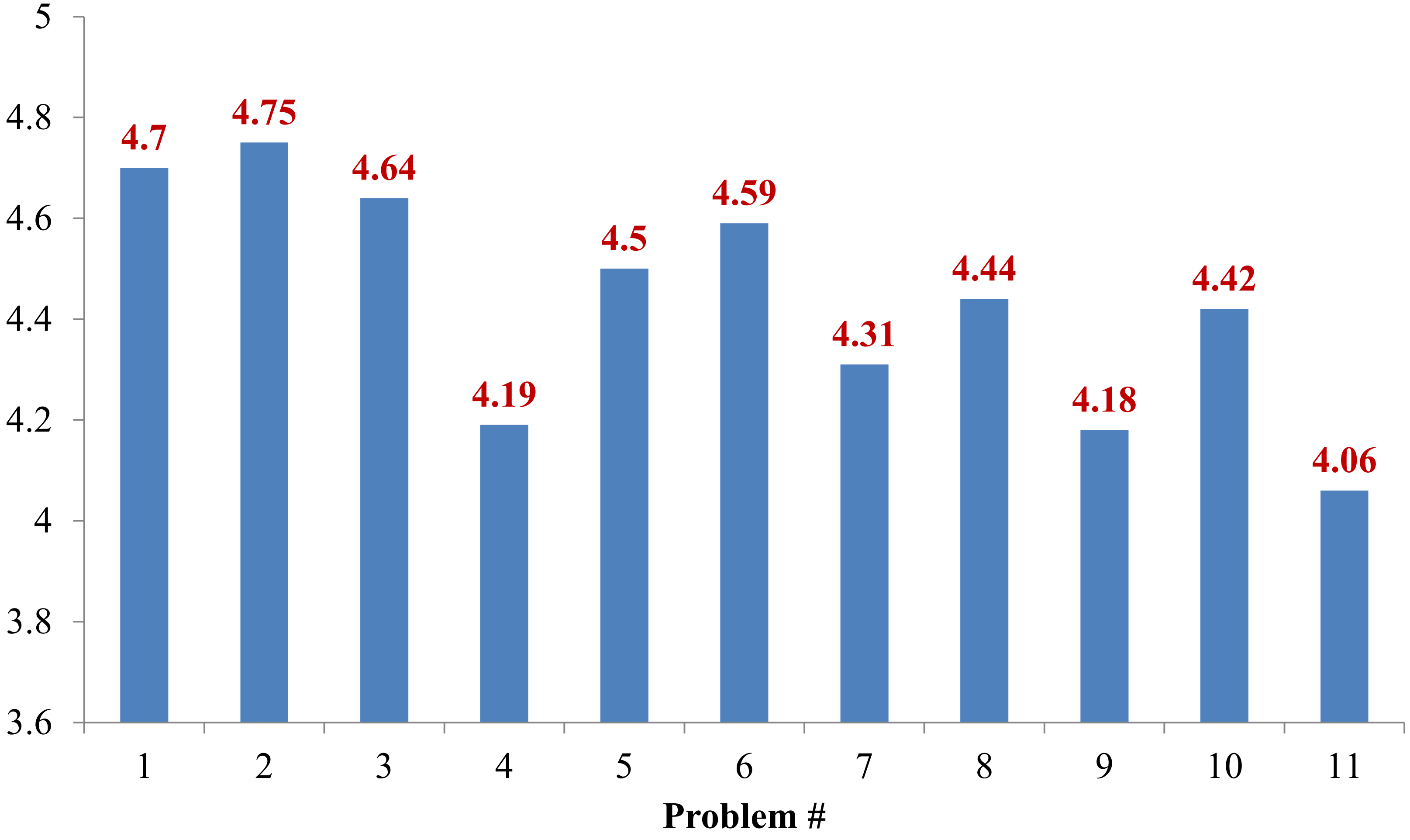
The assignment was **written** in a **clear manner** that facilitated understanding of the problem.



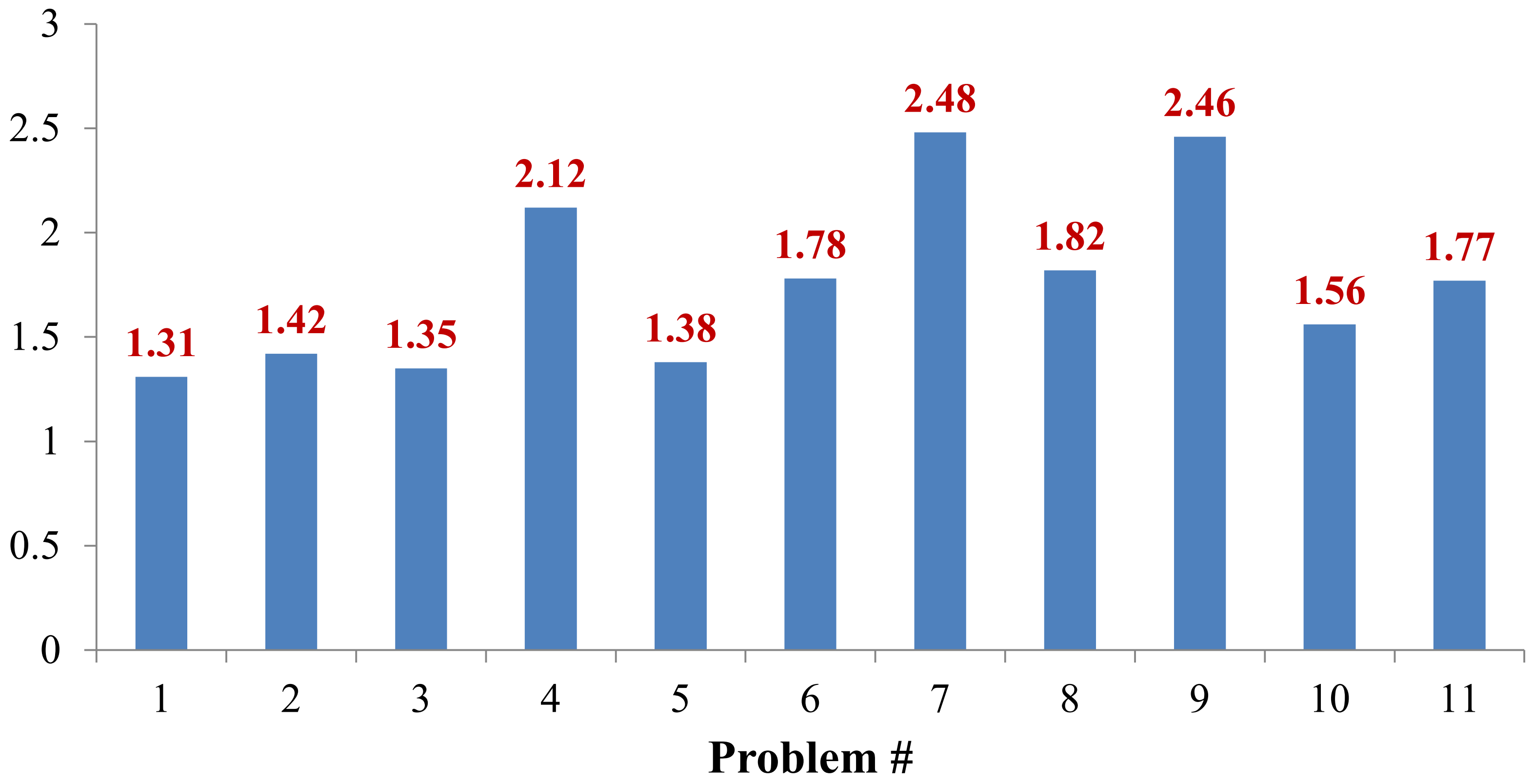
The **expectations/requirements** of this assignment were **clear and straightforward**.



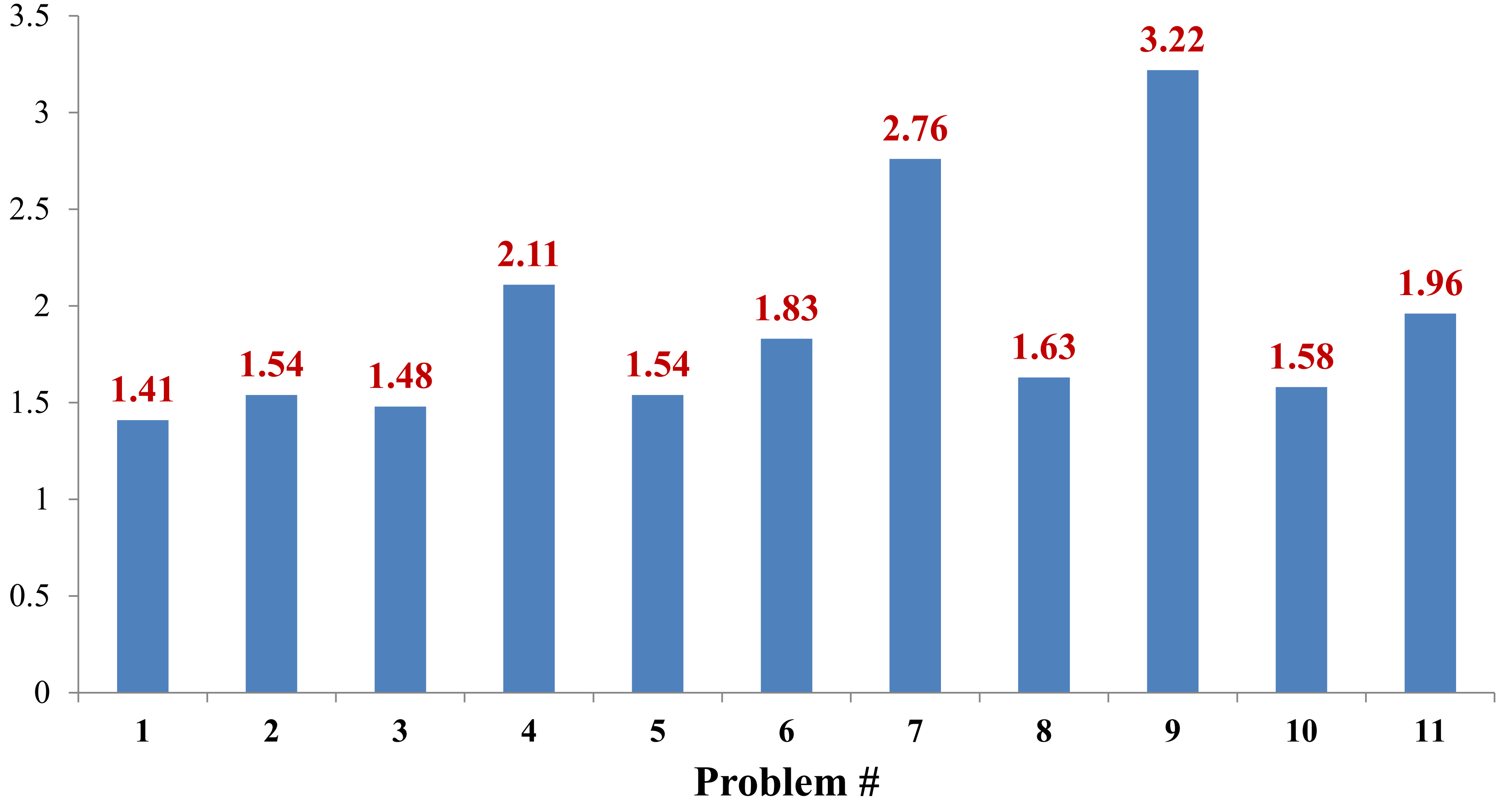
The **AutoCAD knowledge** and skills taught in class were **sufficient** to complete this assignment.



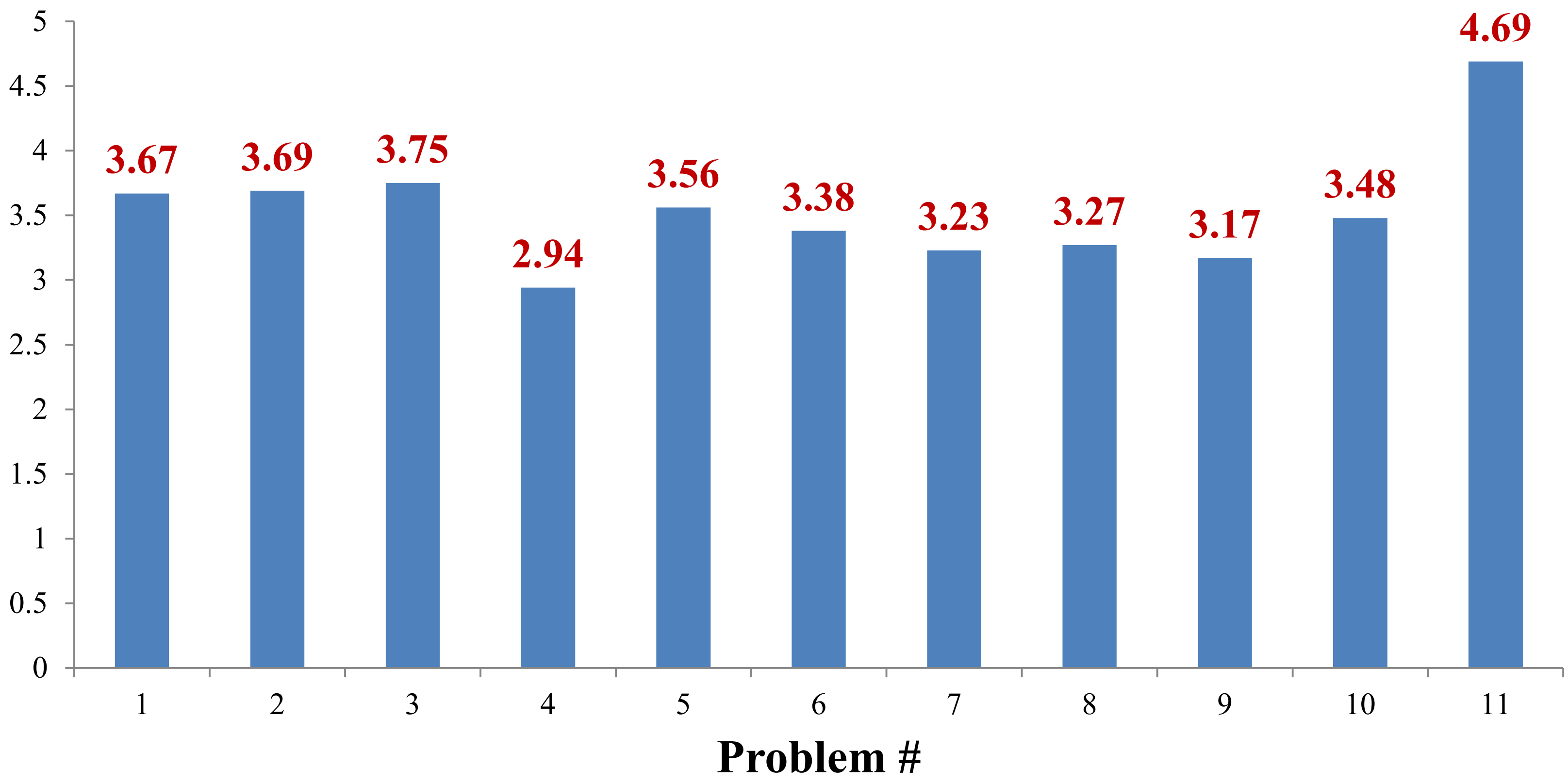
The **assignment** was **<u>too difficult</u>**.



The assignment required **too much time** to **complete**.



I **enjoyed** **completing** this assignment.



I would have preferred **more assignments <u>similar</u>** to this one.