HERC Funding – Final Report 2016

***Part 1*: Project Title: Environmental Engineering Curriculum Materials for ENGR 2270 – Computer Engineering Drafting**.

Project Period: September 2015 to August 2016

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

ENGR 2270-Computer Engineering Drafting is required by all students in the biological engineering, environmental engineering and civil engineering programs. In the past, course assignments and activities used in the course were geared towards civil engineering students as those students made up a majority in the course. In recent years', environmental engineering and biological engineering student enrollments have been on the rise and it is important that the biological and environmental students see a need for the use of AutoCAD software in the course. To address this issue, in the fall of 2014, we started developing activities, assignments and other materials related to **green energy, environmental systems and biological systems** for use in the course. These activities, assignment and other materials were developed during the fall semester of 2015 and spring semester 2016. The assignments developed are included in the Assignments Developed section below.

Assignments Developed: Five new assignments were developed and include the topic areas of:

- Macromolecules Separation Device (Gel Comb)
- Solar Water Heater (PV Array)
- Bioreactor
- Pipette Device
- Piezometer

Each of the new assignments is included below.

Student Support: Utah State University students were used to develop the materials for the course. **Murad Mahamud** (engineering education graduate student) and **Nat Herbert** (undergraduate engineering student) assisted in the development of the assignments and materials. They worked 10 hours per week during the fall and spring semesters to complete the assignments. During the summer 2016, these assignments were pilot tested by two Civil and Environmental engineering undergraduate students (**Celeste Hancock and Dallin Polson**) who had been Teaching Assistants (TA) in the course. These two students worked 4 hours per week during the summer to pilot test the assignments and make modifications.

Five (5) Assignments:

Macromolecules Separation Device (Gel Comb)

Photovoltaic

Bioreactor

Pipette

Piezometer

Title: Gel Comb

Plot Scale: 2" = 1"

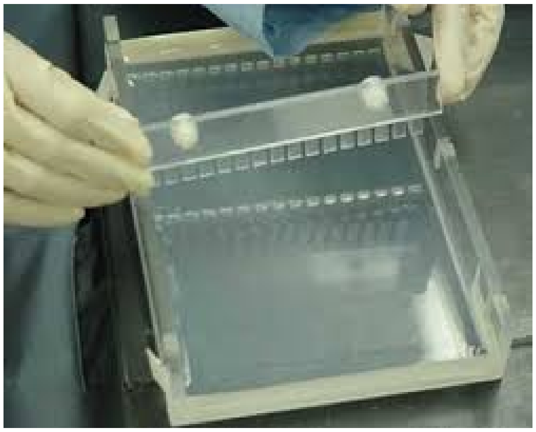
Objective:

Students will be able to:

1. Utilize the circle and arc commands to draw the figure.
2. Set up a drawing in model space using **Units**.
3. See the advantages to using construction lines in determining distances between center-points.
4. Use template file of **title block** drawing thus defining all previously assigned layers.
5. Become familiar with the LTSCALE command and exercise it appropriately.
6. Appreciate the OSNAP commands available.
7. Draw circles utilizing the pull down menu to access the 6 ways of initiating a circle.

Background:

Gel electrophoresis is a method for separation and analysis of macromolecules such as DNA, RNA, and proteins along with their fragments, based on their size and charge. It is used in clinical chemistry to separate proteins by charge and/or size and in biochemistry and molecular biology to separate a mixed population of DNA and RNA fragments by length. The purpose is to estimate the size of DNA and RNA fragments or to separate proteins by charge. When making these gels, there are several steps that are required to be performed in order produce a gel that will work. The first step is to gather the proper molds and combs that the gel will be poured into. The comb is used to create "lanes" that the sample may be poured into; getting the lanes correct is critical to running a successful experiment. Once this has been done the gel will be poured into the mold with the comb and allowed to set. Once set, the comb may be removed from the gel and the gel may be used. Below is a video on how to make gels.
https://www.youtube.com/watch?v=EZjNuqSEPbY



A picture of a scientist inserting a comb into a liquid gel to create the lanes for sample loading

A picture of a typical comb that is used for gel electrophoresis

Problem:

The T.I. Harris Company, which specializes in the manufacturing of various gels and gel products, is developing a new gel comb that uses less material in its manufacture. This gel comb is manufactured from a single piece of plastic and is cut out using automated systems. For these systems to work properly there needs to be a model that the machine can use as a template. As the lead engineer in charge, your team is tasked with creating this model in AutoCAD. Your final drawing should appear something similar to what is shown below with the same dimensions.

Commands:

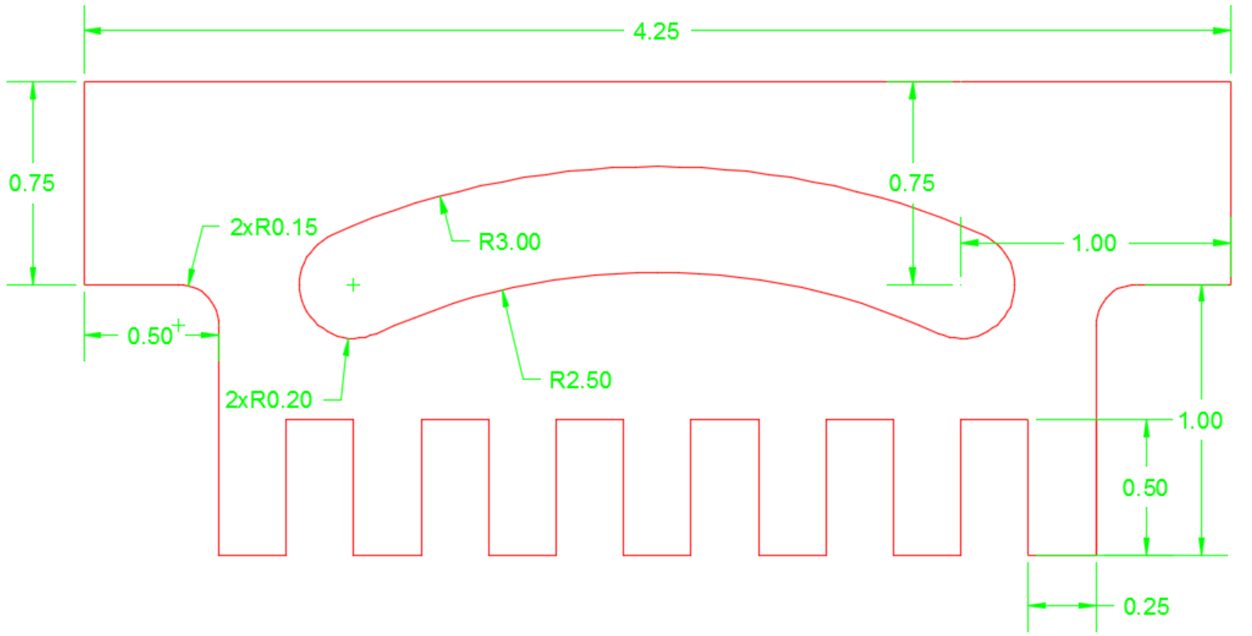
Text	Line	Layers	Undo
Layer	OSNAP	Grid	Limits
Units	Scale	Circle	Trim
Break	Arc	LTSCALE	

Procedure:

1. We will be creating a front view and scaling in paperspace at 2"=1". The object can be seen above. Do not forget to add center lines and project them ¼" beyond the edge of the object they define as they extend out from the center point.

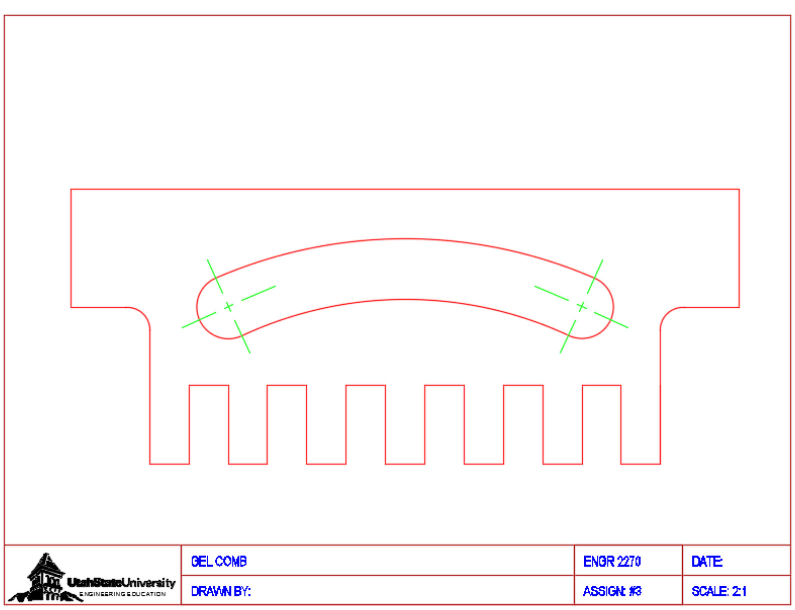
2. Use the <u>template</u> file of the **Title Block** and begin this drawing by setting up your **Units** correctly **(Decimal with a Precision of 2 decimal place**s). The command sequence you are aiming for here can be found under the Home tab, draw palette, circle command and continues to tan, tan, radius. Yes! You are going to draw an arc by first creating a circle and then trimming it away. This technique is used a lot in CAD drafting. Now draw centerlines appropriate to their respective objects, check all lines for appropriate layers, and center the drawing before turning it in.

3. Draw two circles to locate the ends of the slotted opening on the gel comb and then complete the arcs w/ the **TAN, TAN, RADIUS** command found in the Home tab, draw palette, and the **circle** pull down menu. Make sure the TAN points chosen are on the <u>outside</u> of the circles' centerlines for the upper arc and <u>inside</u> the circles for the lower arc.



Gel Comb in CAD with dimensions

4. Your centerlines may now appear to have the wrong dash spacing. This can be resolved with the LTSCALE command. LTSCALE stands for **line type scale** and has a default value of 1. If you are scaling your drawing you will have to change LTSCALE by a ratio equal to the scale you are plotting at. Try changing it to see its impacts on the lines you've selected.
5. Grab grip points and type in the extending value to accurately extend centerlines past their circles or arcs (¼" beyond).
6. Check text heights and add any notes



Final Product

Title: Bioreactor

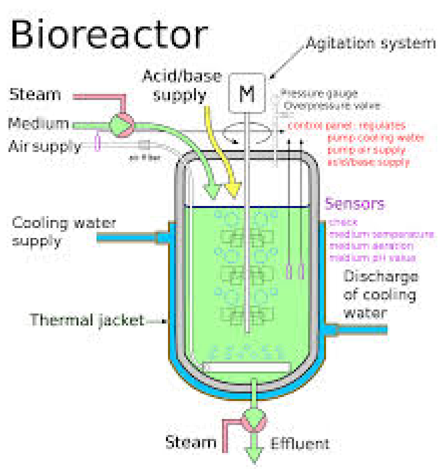
Plot Scale: 1:1 Precision: .001 (3 decimal places)

Objective:

1. Student will be able to scale a drawing in AutoCAD.
2. Student will be able to apply centerlines as symmetry lines.
3. Student will become familiar with the LTSCALE command and exercise it appropriately.
4. Student will be able to interpret hidden features and incorporate them into their drawings utilizing hidden lines.
5. Student will be able to appreciate the OSNAP commands available and use them when applicable.
6. Students will be able to use DIMSTYLE to set up a proper dimensioning style (Annotative).
7. Students will be able to follow appropriate dimension guidelines to FULLY describe the Bioreactor.

Background:

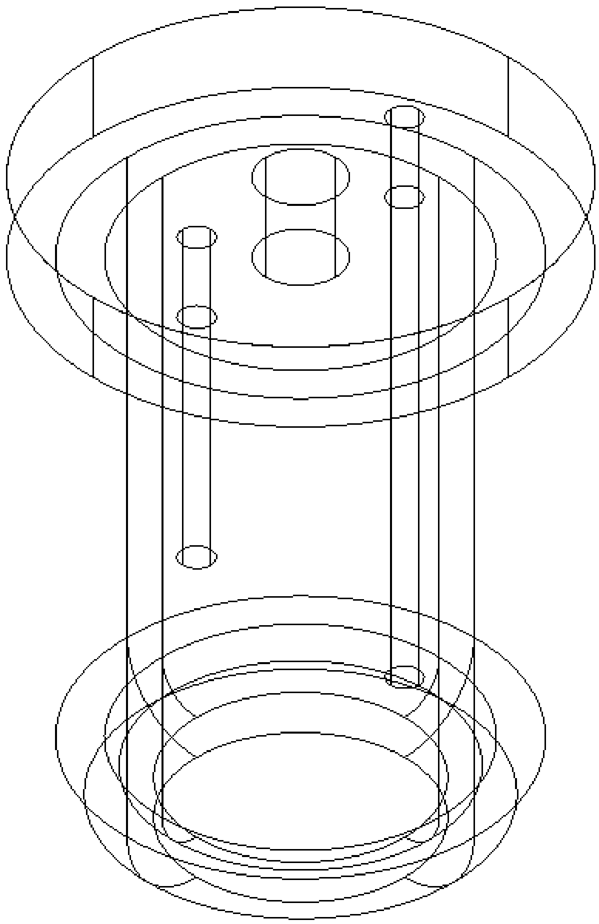
A bioreactor may refer to any manufactured or engineered device or system that supports a biologically active environment. In one case, a bioreactor is a vessel in which a chemical process is carried out that involves organisms or biochemically active substances derived from such organisms. This process can either be aerobic or anaerobic. These bioreactors are commonly cylindrical, ranging in size from liters to cubic meters, and are often made of stainless steel or glass. On the basis of mode of operation, a bioreactor may be classified as batch, fed batch or continuous.



Examples of various sizes of bio-reactors along with a flow diagram

Problem:

Life technologies, a company that produces equipment for the growth of various organisms in bioreactors, recently released a new design of bioreactor. This new bioreactor requires less energy and allows for easier growth control. As the head engineer of this company, you are tasked with creating several orthographic projections of this new bioreactor in AutoCAD. These orthographic projections are to include the front, top and side view of the metal parts of bioreactor as shown below.



Bioreactor

Commands:

Text	Line	Layers	Undo
Layer	Dimstyle	OSNAP	Grid
Limits	Units	Offset	Circle
Trim	Break	Leader	LTSCALE
Dimension	Radius	Diameter	Aligned
Linear	Angular	Baseline	Center Mark

How To:

This drawing is very straight forward. Let **OSNAP** work for you in applying the dimensions and place the dimensions 3/8" on the first and subsequent dims on ¼".

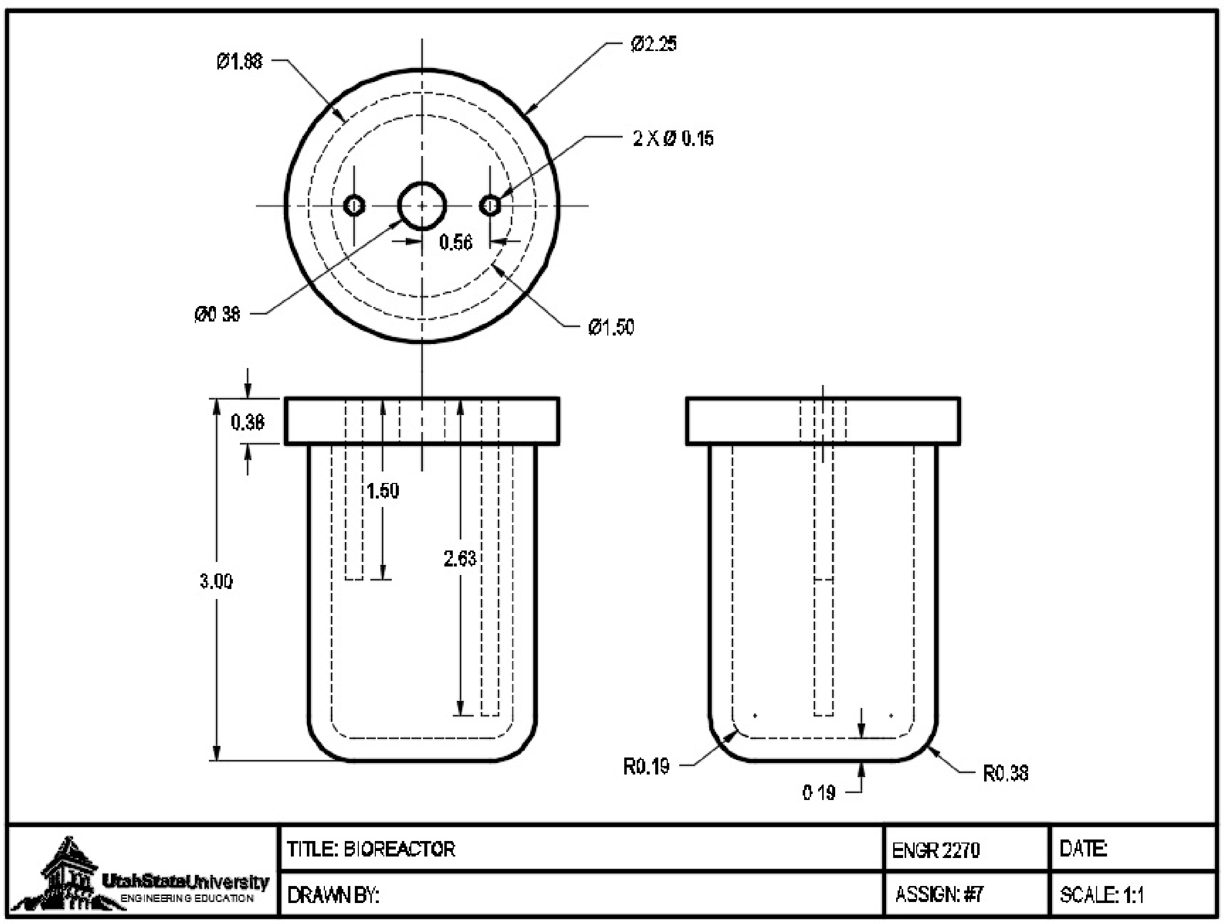
Procedure:

Draw your object full size after setting up **Units** (3 decimal places). Utilize the offset, copy and move commands to speed up your drawing time. Using projection lines to locate object characteristics between views will also speed up your drawing time considerably. Apply center lines; you will be dimensioning to them later. Make sure all hidden features are represented correctly. Extend centerlines ¼" past the feature they describe. Fill in any important information in the title block and notes and plot to extents while centering the plot.

Begin dimensioning the bioreactor. Do not use any redundant dimensions, even between views. The first dimension line should start no less than 3/8" from the object with subsequent dimension lines following ¼" from the previous. Arrowheads should be 1/8" long. They should be filled solid. All dimension text should be .125" tall.

Remember to use **Annotative Text** to determine text heights. Note: Labels under views should be **¼" height** and title should be **3/8" height**.

Note: Use this drawing as a guide for dimension layout.



Title: Photovoltaic Module

Plot Scale: 1” = 5”

Objectives:

Students will be able to:

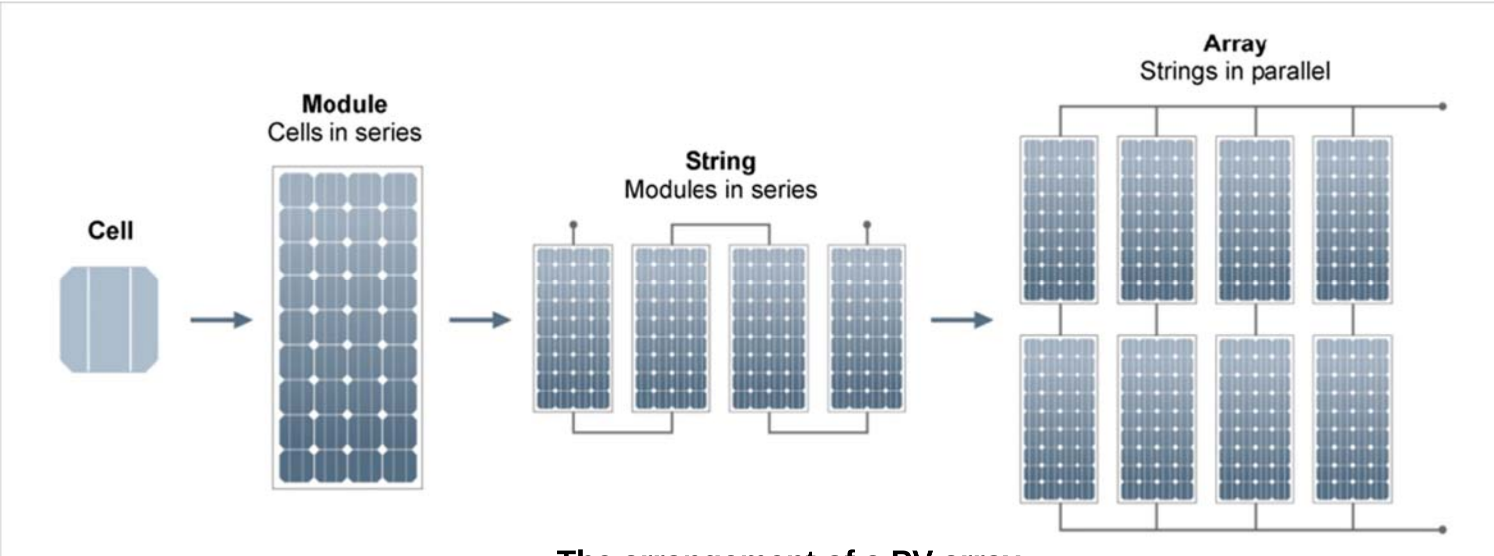
1. Use 3D commands in AutoCAD create a 3D model.
2. Print the assignment in 3D representation.

Background:

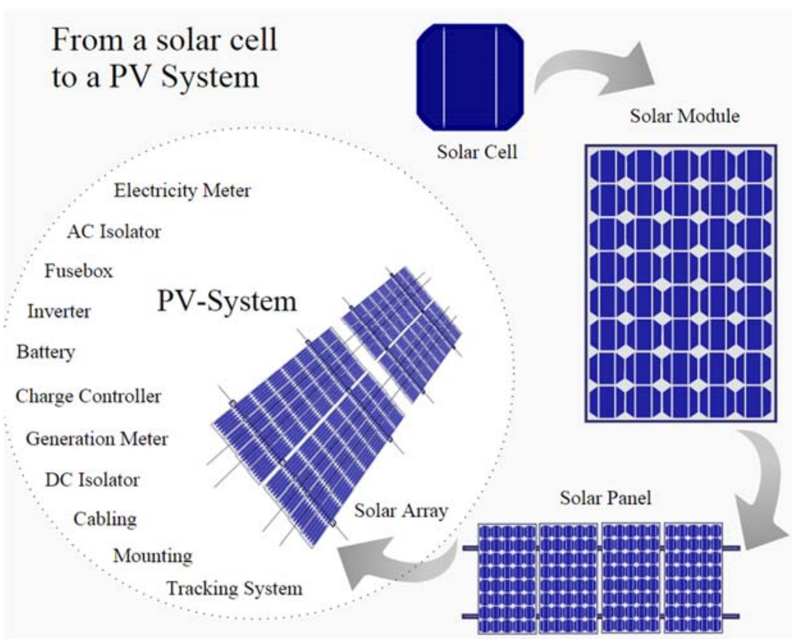
Photovoltaic is the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, an electric current results that can be used as electricity. A French physicist, Edmund Becquerel, first noted the photoelectric effect in 1839; he found that certain materials would produce small amounts of electric current when exposed to light. In 1905, Albert Einstein described the nature of light and the photoelectric effect on which photovoltaic technology is based, for which he later won a Nobel Prize in physics. Bell Laboratories built the first photovoltaic module in 1954. It was billed as a solar battery and was mostly just a curiosity as it was too expensive to gain widespread use. In the 1960s, the space industry began to make the first serious use of the technology to provide power aboard spacecraft. Through the space programs the technology advanced, its reliability was established, and the cost began to decline. During the energy crisis in the 1970s, photovoltaic technology gained recognition as a source of power for non-space applications. Today, photovoltaic technology is used to generate power using silicon PV cells.

A typical silicon PV cell is composed of a thin wafer consisting of an ultra-thin layer of phosphorus-doped (N-type) silicon on top of a thicker layer of boron-doped (P-type) silicon. An electrical field is created near the top surface of the cell where these two materials are in contact, called the P-N junction. When sunlight strikes the surface of a PV cell, this electrical field provides momentum and direction to light-stimulated electrons, resulting in a flow of current when the solar cell is connected to an electrical load. A typical solar PV cell can produce approximately 225 watts of energy. When put together into an PV array, a lot of energy can be produced.

Typical PV Cells



The arrangement of a PV array

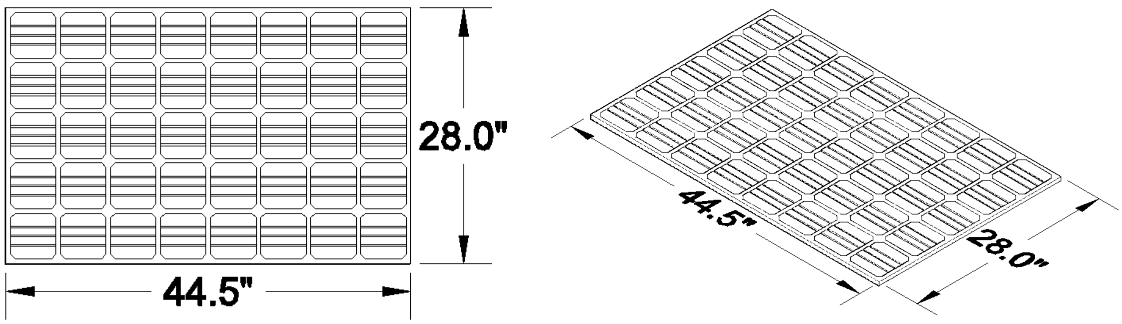


The components of a PV array

Problem:

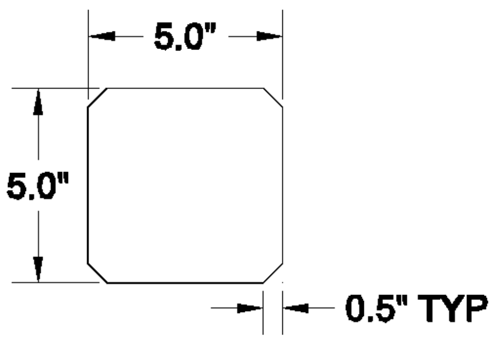
Solar Energy Systems, a company that specializes in the production of high efficiency photovoltaic cells, is releasing a new solar panel. This solar panel features an array of their latest photovoltaic cells. The company wants you to design a full size 3-D model of the solar panel to feature at an upcoming trade show. As the lead engineer in charge, your team is tasked with creating this model in AutoCAD. This model will be full size with the dimensions as shown below. Your final drawing should appear something similar to what is shown below.

Step-by-Step Instructions:



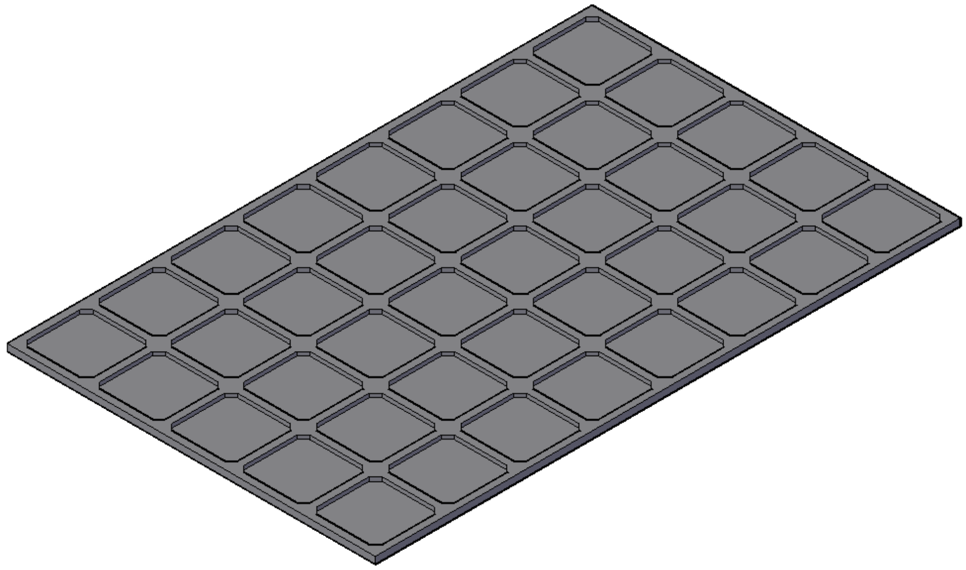
Solar Module

1. Draw a **3D solid** of the 44.5” × 28” × 0.5” solar module frame (see frame above). The 3D solid (frame) will appear as a solid box, not like the finished module.
2. Draw the cell’s shape (as a 3D solid) <u>without the grooves</u> as shown in the picture below with a <u>thickness</u> of 0.3”.



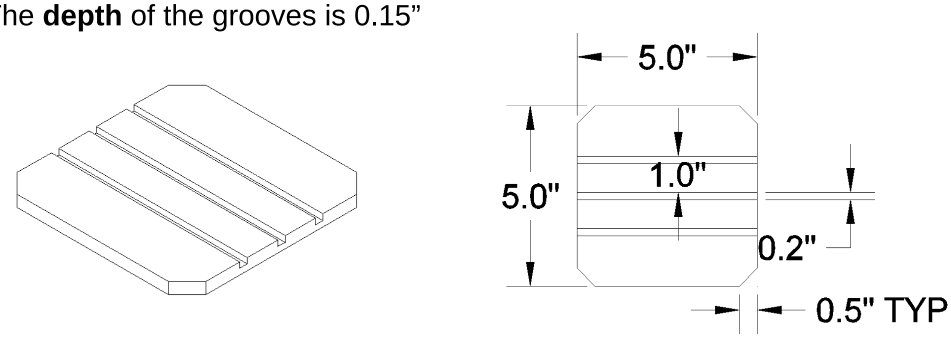
Step 2: The general shape of the PV cell.

3. Place the first cell in the <u>lower right corner</u> of the frame at a distance of 0.5” from the bottom and 0.5” from the left edge.
4. Use the **array** command to duplicate the PV cell 8×5 with a spacing of 0.5” in both directions.
5. **Subtract** the array (PV cell) from the solar module’s frame to open space for the actual cells. <u>*Hint*</u>: Explode the array before you subtract. Look at the example below (step 5).



Step 5. This is what the panel should look like after subtracting.

6. Draw the cell’s actual shape as shown in the figure below as a 3D solid with a height of 0.3”. The **depth** of the grooves is 0.15”

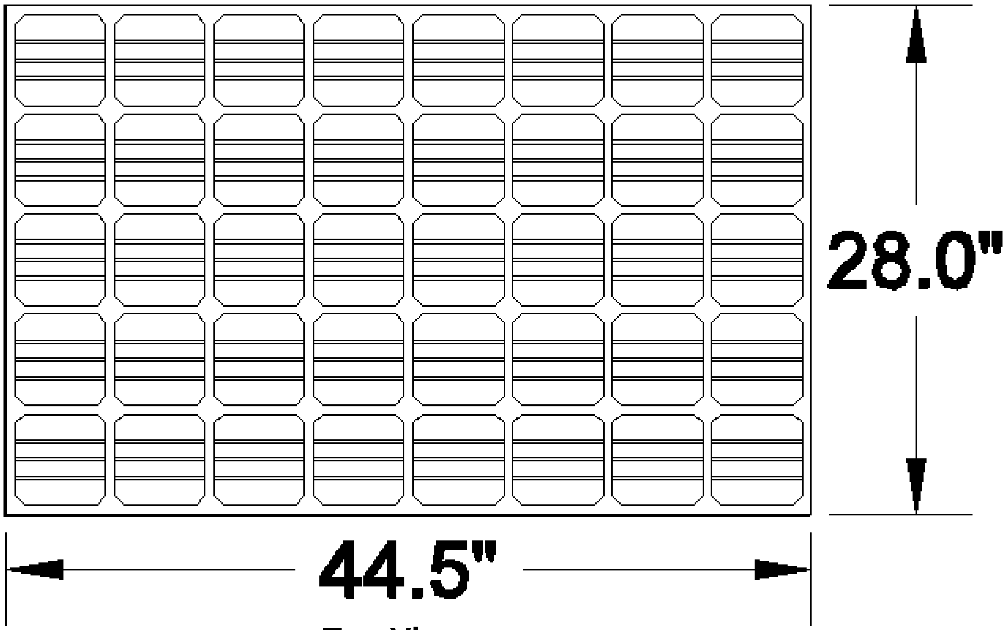


Step 6: The shape of the PV cell.

7. Place the cell in the lower right corner of the frame at a distance of 0.5” from the bottom and 0.5” from the left edge which is the first indentation.

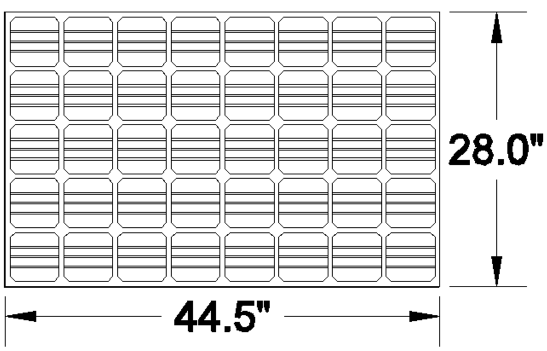
8. Use the array command to duplicate the PV cell 8×5 with a spacing of 0.5” in both directions.

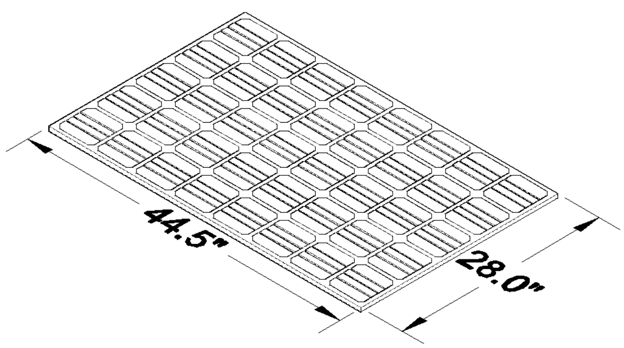
9. The completed array should look like the view below.



Top View

10. Plot on A-Size sheet to show top view and 3D isometric view (side by side).



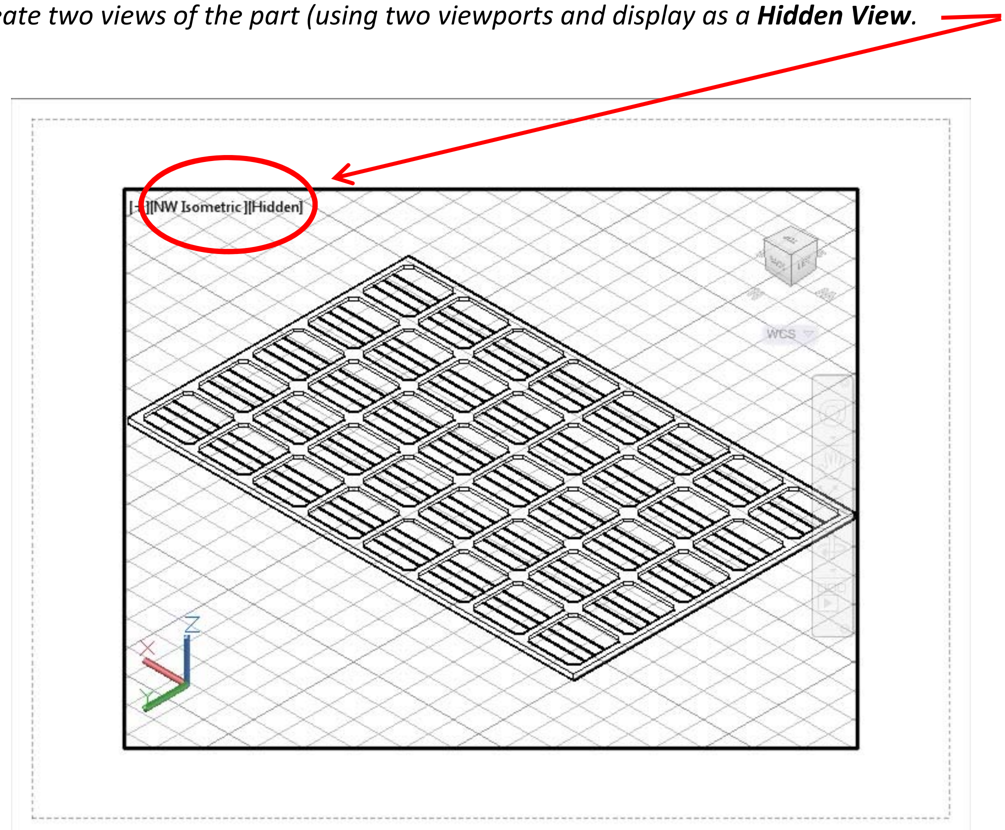


Top View

Isometric View

Printing as a hidden model (PaperSpace)

1. *Using template file (A-Size titleblock,) draw the 3D part in modelspace.*
2. *Create two views of the part (using two viewports and display as a* ***Hidden View****.*



Title: **Pipette** (draw one full section and one half section drawing) – 2 sheets,1 DWG file

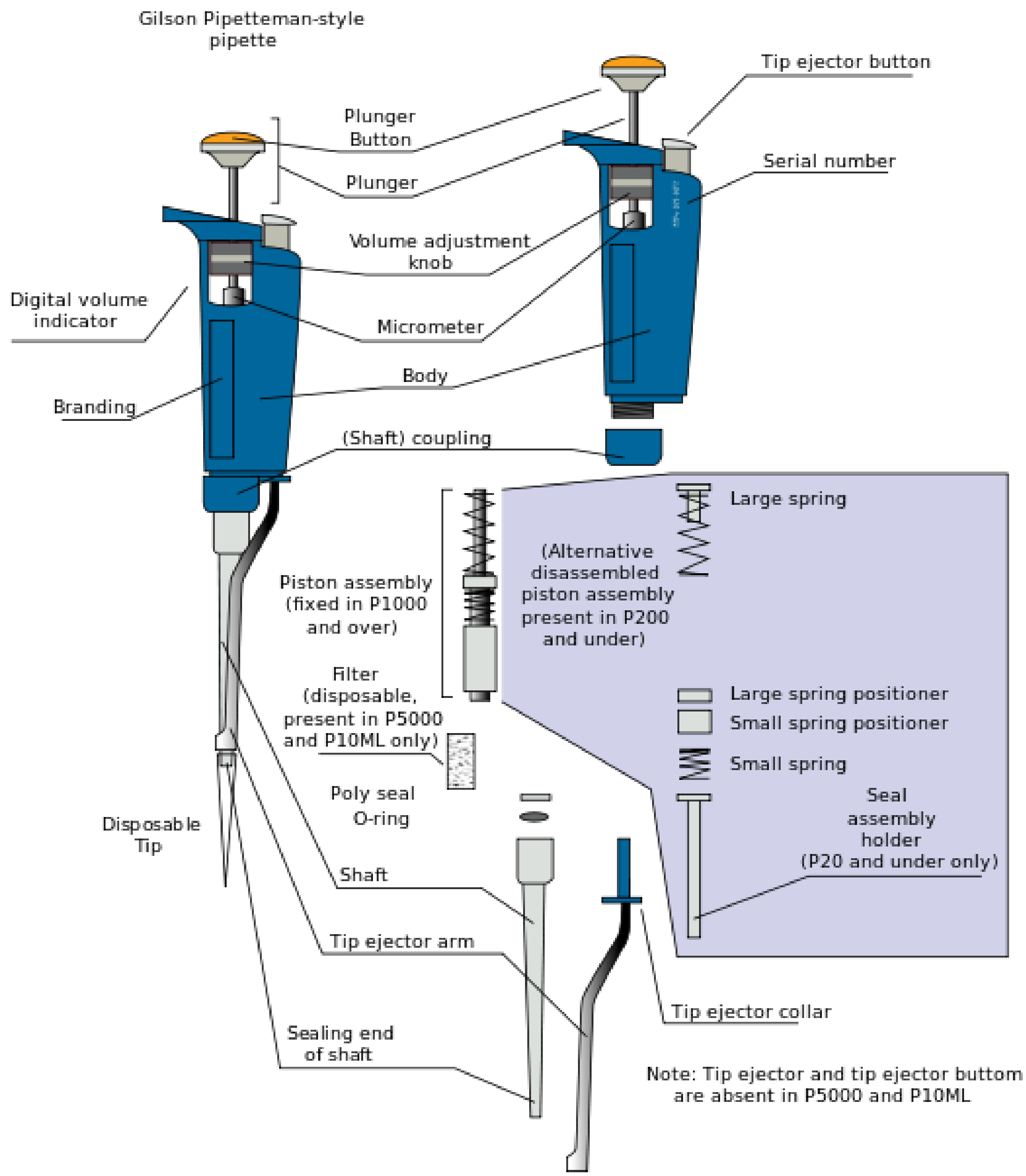
Plot Scale: 2:1 **Precision:** .00”

Objective:

Students will be able to:

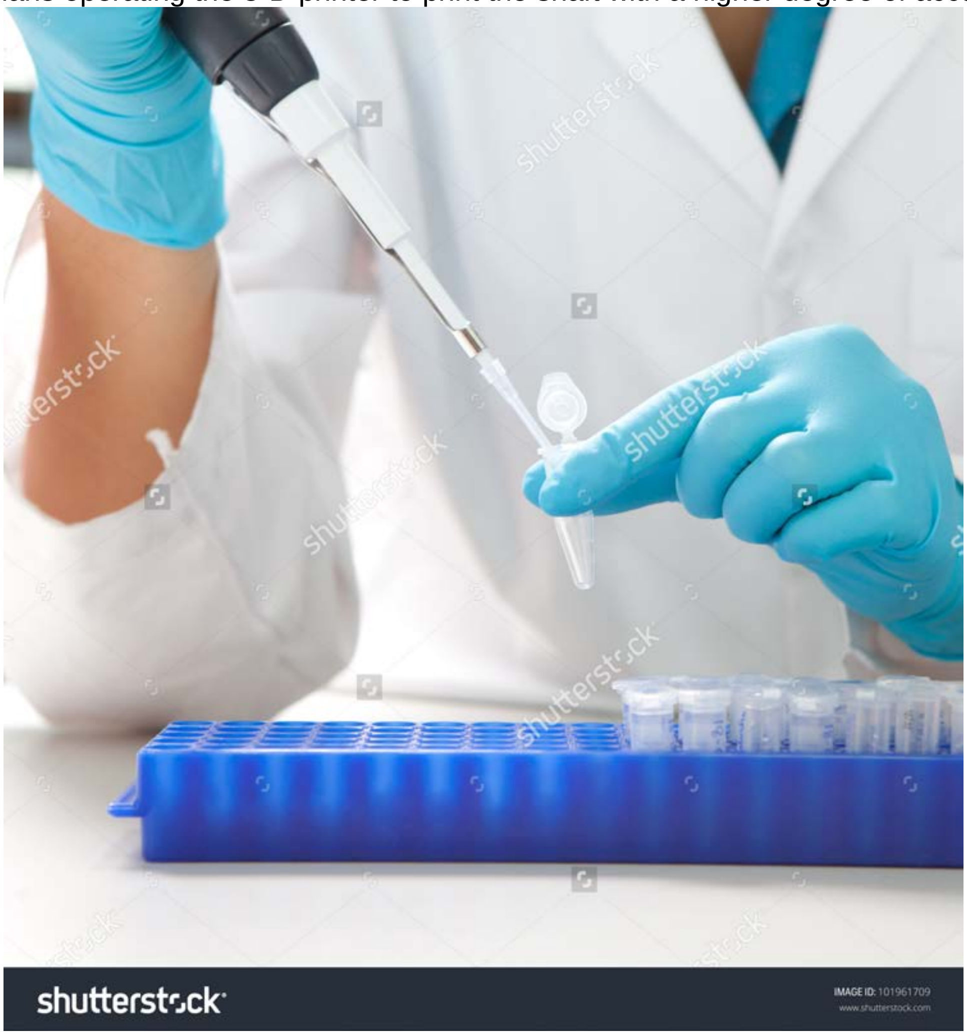
1. Demonstrate an understanding of model/paper space and how to alter and plot from each.
2. Recognize how to scale a drawing in AutoCAD through paper-space.
3. Apply cutting plane lines appropriately to designate sight direction for both full and half sections.
4. Apply section lines to the object representing the cutting planes path.
5. Correctly identify the characteristic view and assign it as a front view in a multi-view drawing.
6. Identify the appropriate number of views to identify an object.
7. To interpret hidden features and incorporate them into their drawings utilizing hidden lines.
8. Follow appropriate dimension guidelines to FULLY describe this object.
9. Utilize multiple layouts in paper space to plot two drawings from one original model space drawing. They will demonstrate control over the scales of each.
10. Dimension utilizing a baseline dimensioning technique.

Background:
A pipette is a laboratory tool commonly used in chemistry, biology and medicine to transport a measured volume of liquid, often as a media dispenser. Pipettes come in several designs for various purposes with differing levels of accuracy and precision, from single piece glass pipettes to more complex adjustable or electronic pipettes. Many pipette types work by creating a partial vacuum above the liquid-holding chamber and selectively releasing this vacuum to draw up and dispense liquid. Measurement accuracy varies greatly depending on the style. The first simple pipettes were made in glass, such as Pasteur pipettes. Large pipettes continue to be made in glass; others are made in squeezable plastic for situations where an exact volume is not required. The first micropipette was patented in 1957 by Dr Heinrich Schnitger. The founder of the company Eppendorf, Dr. Heinrich Netheler, inherited the rights and started the commercial production of micropipettes in 1961. The adjustable micropipette is a Wisconsin invention developed through interactions among several people, primarily inventor Warren Gilson and Henry Lardy, a professor of biochemistry at the University of Wisconsin-Madison. Although specific descriptive names exist for each type of pipette, in practice any type of pipette will merely be referred to as a "pipette" and the desired device will be obvious from context. Sometimes, pipettes that dispense between 1 and 1000 µl are distinguished as micro-pipettes, while macro-pipettes dispense greater volumes.



An example of a pipette, with the parts labeled

Problem:
Pipette Innovations, a company that specializes in the production of pipettes and pipette parts, recently introduced a new pipette shaft. This shaft is innovative by having a high degree of accuracy in its measuring, while also being 3-D printed. This 3-D printing makes the shaft stronger and smoother allowing for ease in operation. As the lead engineer in charge of this project, you have been asked to create several views of the shaft in AutoCAD, which will allow the technicians operating the 3-D printer to print the shaft with a higher degree of accuracy.



Sample Pippette used to create this assignment

Commands:

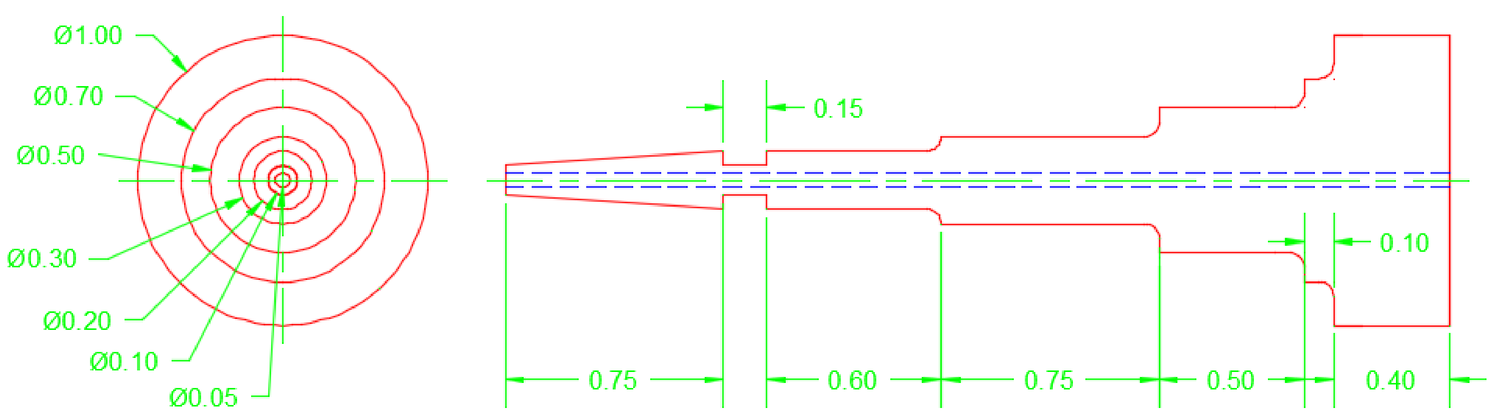
Text	Line	Layers	Undo
Layer	OSNAP	Grid	Limits
Units	Offset	Circle	Trim
Break	Leader	LTSCALE	Dimension
Radius	Diameter	Aligned	Linear
Angular	Baseline	Center Mark	Baseline
Precision	Hatch		

Hints:

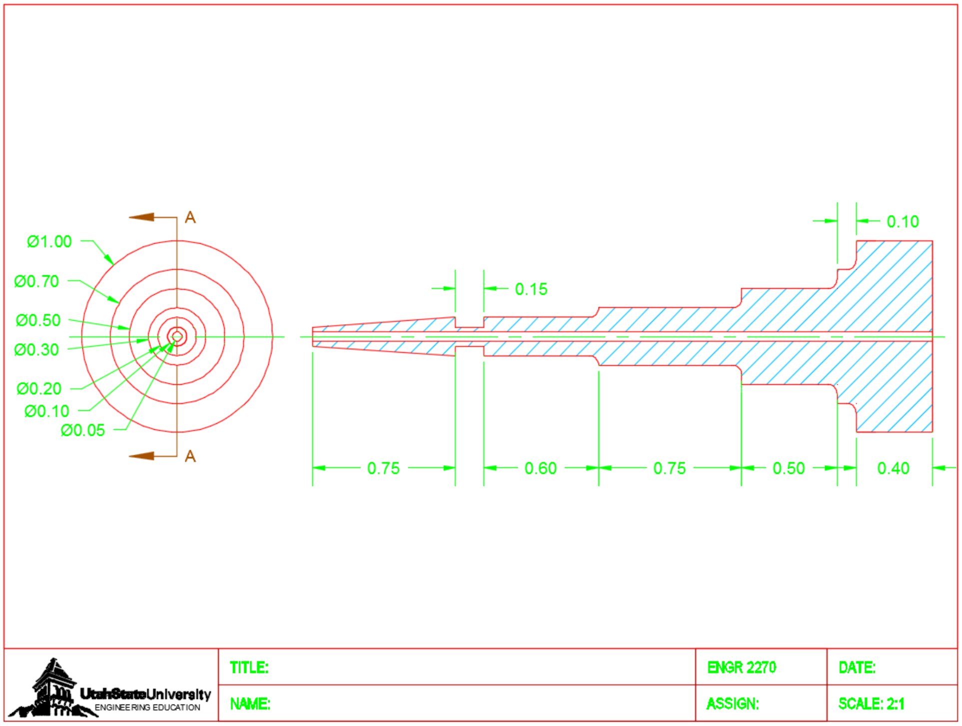
Draw your object full size after setting up units. Utilize the offset, copy and move commands to speed up your drawing time. Using projection lines to locate object characteristics between views will also speed up your drawing time. Draw your details taking care to locate them accurately. Remember, a section view is very similar to a side view with hidden lines now being erased or converted to object lines. Make sure circles are concentric. Apply center and symmetry lines; you will be dimensioning to them later. Make sure all hidden features are represented correctly. Only the top and right side views are necessary for both drawings. Apply the phantom line representing the cutting plane to the front view paying particular attention to its direction of sight. Apply section lines to the side view noticing the difference between a half and full section. Dimension according to the rules you have previously learned. Fill in any important information in the title block and the notes. Print the two drawings to proper scale.

Drawings:

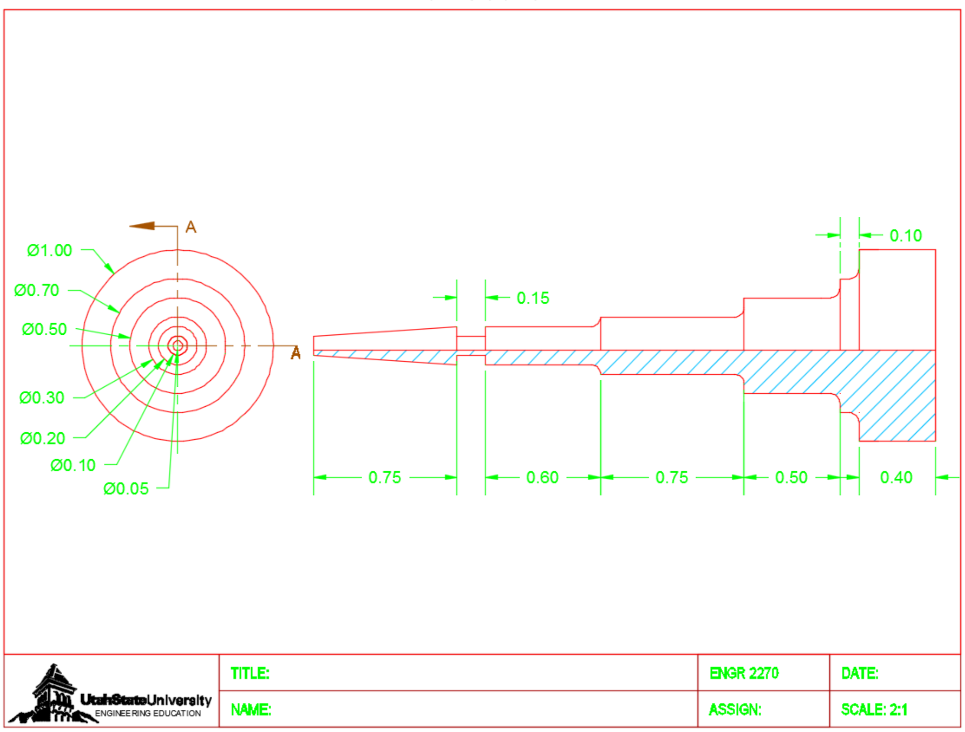
Your drawings should look <u>similar</u> to this. The first drawing is a <u>full section</u> of the water piston while the second is a <u>half section</u> (remember, this is <u>one</u> dwg file). They both require the appropriate application of a cutting plane lines to the front view. Notice how all the views align. Do not forget center lines or dimensions. Label the section and cutting plane lines and place both a material note as well as a dimension note into the drawing. Plot scale should be 2:1.



Pippette with Dimensions



Full Section



Half Section

Title: Piezometer

Plot Scale: 1:1

Objective:

Learn how to obtain orthographic projections from a 3D object complete with hidden lines.

Background:

A piezometer is either a device used to measure liquid pressure in a system by measuring the height to which a column of the liquid rises against gravity, or a device which measures the pressure of groundwater at a specific point. Piezometers are often placed in boreholes to monitor the pressure or depth of groundwater. There are various types of piezometers that include standpipe, vibrating wire, pneumatic and titanium piezometers. These various types all have different intended uses and each type has a specialized purpose.

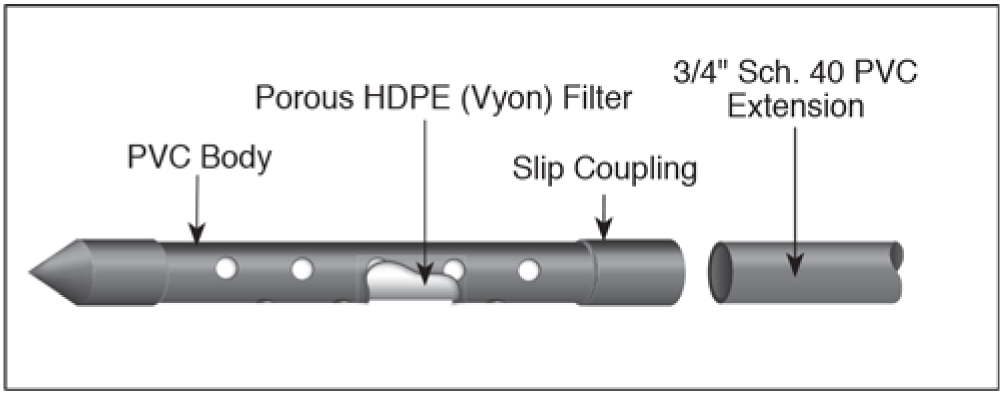
An example of a Standpipe Piezometer

An example of a Vibrating Wire Piezometer

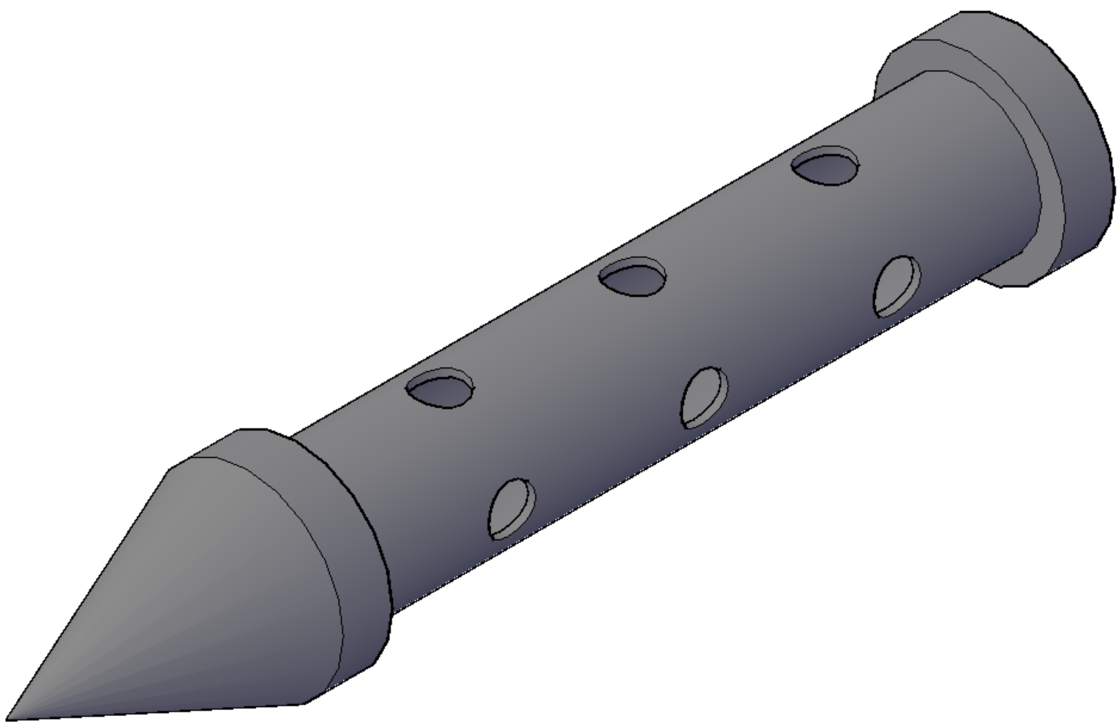
An example of a Pneumatic Piezometer

An example of a Titanium Piezometer

Problem:
The company **Water Pressures Incorporated** recently released a new design of their latest piezometer. This new piezometer allows for a higher degree of detection and accuracy than previous models allowed. As the lead engineer of this project, you have been tasked with creating a 3-D model of this piezometer as well as the three major views (front, top and right). This 3-D model will allow engineers to verify the design using modeling software to validate the piezometer's function. A picture of the piezometer in question is shown below.



Piezometer Design



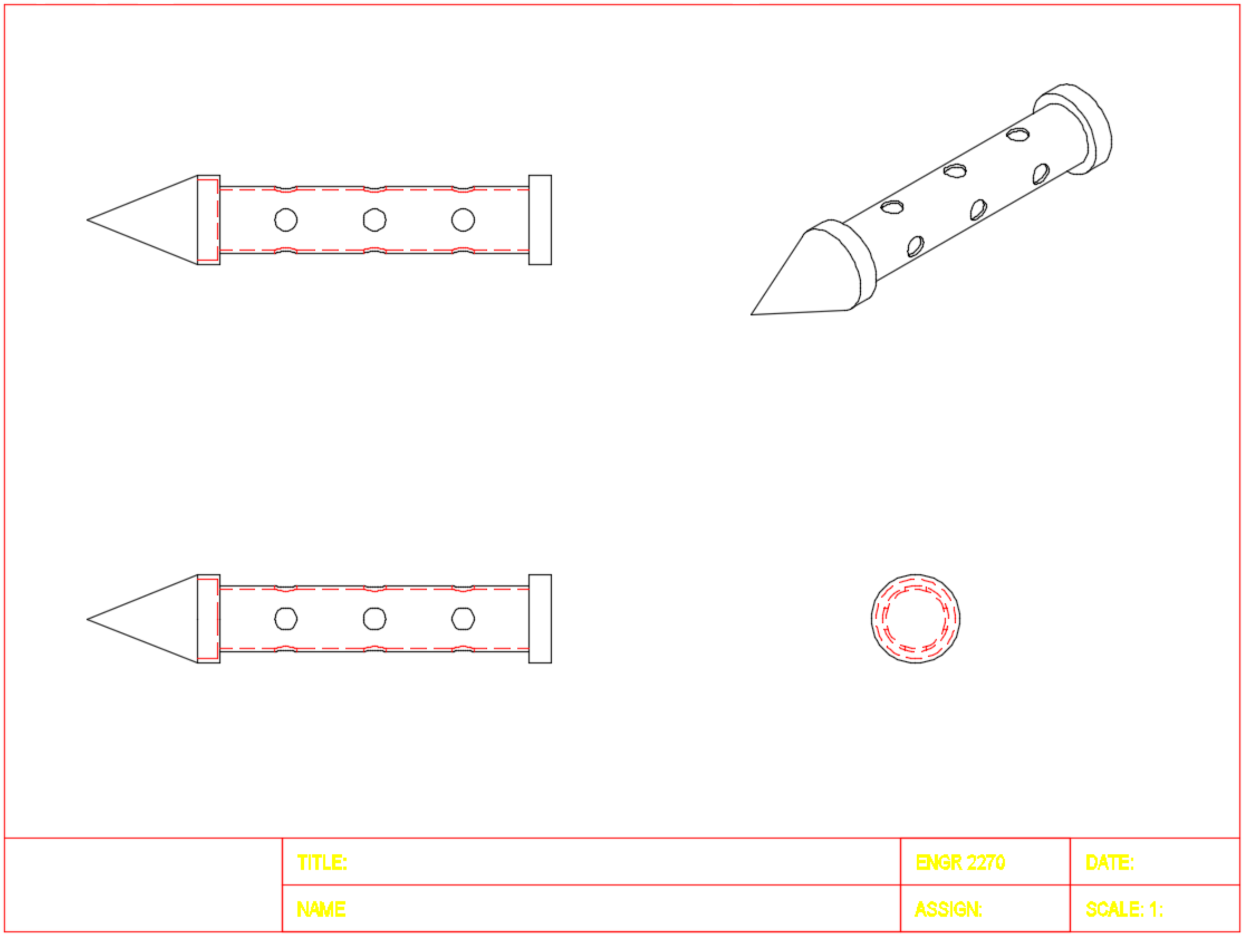
Provided 3D Drawing

Commands:

Text	Line	Layers	Undo
Layer	OSNAP	Grid	Limits
Units	Offset	Circle	Trim
Break	Leader	LTSCALE	Dimension
Radius	Diameter	Aligned	Linear
Angular	Baseline	Center Mark	Baseline
Precision	Hatch		

Hints:

1. Download the file Piezometer.dwg available on Canvas. This is the 3D drawing for the piezometer. You will generate multiple orthographic views from the 3D view.
2. Switch to the layout where you have the title block and type the command ‘viewports’, and choose ‘four equal’ and setup to ‘3D’ then make sure to change views to have the front, top and right views and SE isometric and click ok then draw the viewport as normal within the boundaries of the title block.
3. Double click inside one of the views to activate it and then type ‘zoom’ and use 1 as the zoom amount.
4. Repeat step 3 for all views.
5. Type the command ‘solprof’ and choose one of the views and press enter. The command will ask you three questions, press enter on all three which answers yes to all of them.
6. Repeat step 5 for all four views.
7. Go into the layers and you 8 new layers should have been generated. PV layers represent visible (object) lines and PH layers represent hidden lines. Make sure you choose the linetype hidden for PH layers as well as changing their color to red.
8. Turn off layer 0 as well as the hidden layer corresponding to the Isometric drawing
9. Adjust the linetype scale to appropriately show the hidden lines and then print. The final product is shown below.



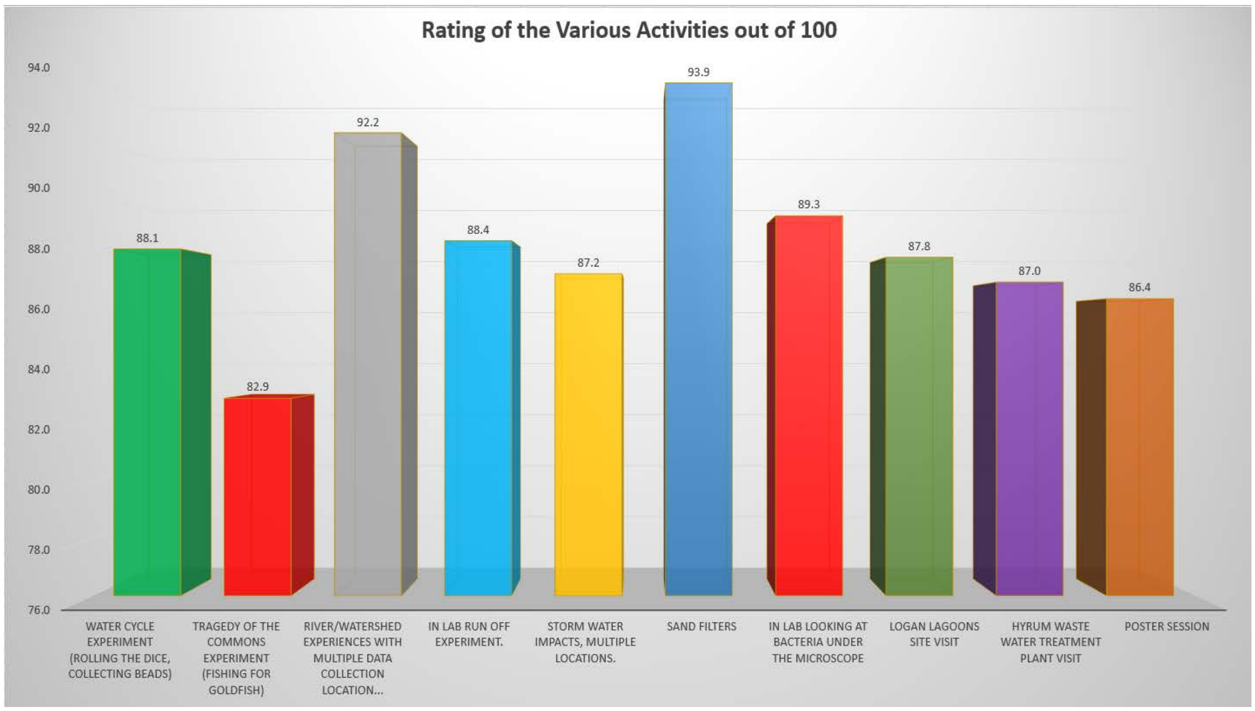
Final Product

Part 2: Results of GEAR UP Program Match Funding

This past summer (July 2016) HERC, along with the Department of Education's GEAR UP program organized and executed a summer outreach workshop designed to increase the interest and motivation of middle school students to go into Science, Technology, Engineering and Mathematics (STEM) fields, specifically environmental engineering. This workshop is part of a seven year $32.8 million grant funded by the Department of Education as part of the GEAR UP program. The grant's overall goal is to help more than 3,000 middle and high school students understand higher education over the period of seven years. This summer program targets 6 to 12th grade underrepresented students and science teachers. The workshop discussed here is one component of the GEAR UP grant.

The workshop included hands-on field-based engineering experiences, competitive design projects and fieldwork focusing on water and environmental engineering as well as discussions of various career options in those fields. The students and teachers spent a week preforming real engineering research investigation in collaboration with engineering research faculty from a local university to study the interaction of urban and natural areas and their effect on water quality in a local water shed. The camp culminated in research posters and slide (PowerPoint) presentations where teams of students led by one science teacher each described what they did in the week-long workshop. The teams discussed an environmental engineering research hypothesis and a simple experiment to follow to verify that hypothesis helping them think like environmental engineers. The workshop also included a professional development component for the teachers participating in the workshop where they developed classroom lessons to meet the new science standards (SEEd standards) as well as the Next Generation Science Standards (NGSS) framework to be implemented in the following school year.

Motivation and Interest surveys were administered to the participating students and teachers at the beginning and end of the camp. Each of the activities were included in the surveys (see figure 1).



Results showed a very high overall satisfaction with the camp activities by the students. The survey results also show the success of the workshop and clearly points towards student appreciation of learning using hands-on experiences rather than being passive learners. This aligns with the constructivist theories on education where student-centered learning is shown to be more effective. The teachers were also satisfied with the experience and with learning the new standards they will be using in the next school year. This workshop was the first of many similar summer workshops to take place over the seven years of the project. The partnership between HERC and GEARUP proved to be very positive.