Female Pioneers in Their Field – Awarded Best Collection

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Some students from Cal Poly's Women Involved in Hardware and Software decided that nothing would be more inspiring or welcoming to women in engineering than seeing female pioneers in their field. We sought to make aesthetically pleasing posters of these women, and also tried to focus on women of color as we wanted to foster and celebrate diversity at Cal Poly, as it is an area we hope to see improvements in the coming years. In these posters, we juxtaposed these female pioneers' impressive technical achievements and engineering feats with delicate flowers and soothing colors.

To represent Aerospace Engineering and to hopefully be displayed in an Aerospace lab or classroom, we chose Katherine Johnson: a Black American mathematician whose complex calculations on orbital mechanics as a NASA employee led to the success of the first US crewed spaceflights. Johnson's calculations were critical to the successes of manned space missions in the early 1960s as well as the 1969 moon landing. Her struggles as a Black woman in a male-dominated field were highlighted in the film Hidden Figures, and she became a huge inspiration to me in high school, which is why I wanted her to be the first poster I made for this art initiative, and why I hope she will be able to be displayed in an Aerospace engineering space, as it is a field that is lacking a lot of female representation.

To represent Civil Engineering and to hopefully be displayed in a Civil Engineering lab or classroom, we chose Emily Roebling. Emily Roebling was a collaborator on the Brooklyn Bridge, which was completed in 1883, and was a pioneer in constructing suspension bridges. Overcoming a predominantly male environment, she learned many aspects of engineering connected with bridge construction (such as specific calculations and the resistance of materials) and became one of the greatest exact science professionals in the country. She was also the first woman to head the American Society of Civil Engineers.

To represent Computer Science and to hopefully be displayed in a computer lab or classroom, we chose Grace Hopper: a United States Navy rear admiral who helped develop COBOL -- one of the first high-level programming languages -- and invented the first compiler, a program that translates programming code to machine language. Grace Hopper is also commonly recognized for coining the computer science term "bug", as a moth found in her machine was making a computer program behave incorrectly. I learned about Grace Hopper in a Cyber Security "Capture the Flag" competition and have always looked up to her, and since Cal Poly WISH sends students to the Grace Hopper Celebration Conference each year, I thought it would be really nice if they could learn a little more about her since there are still a lot of my colleagues who do not know who she is!

To represent Software Engineering and to hopefully be displayed in a computer lab or CSSE classroom, we chose Ada Lovelace: the first programmer in the world. Ada Lovelace was the first to recognize that computers had capabilities beyond pure calculation, and in the 1800s published the first algorithm for the proposed Analytical Engine. She is a huge inspiration to Software engineering women because although the field has actually gotten worse in terms of gender balance if you look at the big picture, it is really cool and inspiring to see that it all started with a woman.

Yvonne Clark was the first African-American woman to earn a degree in Mechanical Engineering at Howard University in 1951 and to receive a Master's degree in Engineering from Vanderbilt University in 1972. She was the first female faculty at the College of Engineering at Tennessee State University and worked tirelessly for women's inclusion in engineering. Projects she was part of include recoilless weapons at Frankfort Arsenal as well as Saturn V engines and receptacles for returning moon specimens to Earth at the NASA.

Dr. Hayat Sindi was the first Saudi woman to be accepted at Cambridge University to study biotechnology, and the first woman from any of the Arab States of the Persian Gulf to complete a doctoral degree in the field. Sindi helped create low-cost devices that can be used in developing countries to help diagnose diseases. To this end, she has invented a biochemical sensor that features thermoelastic probes, and she created the Magnetic Acoustic Resonance Sensor (MARS), both of which help diagnose illnesses quickly and on-site.

Glycerin Cocktail — Awarded Platinum & Dean's Appreciation

Tuyetthuc Nguyen & Wanjiku Gichigi (2022)

Is this a jellyfish? Or a bullet? The magic of this sequence is that it is found in a mundane, everyday occurrence: water emptying from a bottle. This piece reflects just a snippet of the research being explored by the Mayer Fluids Research Group in Cal Poly's Fluids Lab. Imagine this: You've got a bottle of water that's been sitting too long in a forgotten corner. You head to the sink, flip the bottle upside-down, and hear a little "glug." As you tap your foot and wait impatiently for the water to drain out, something interesting is happening inside that bottle. After that first "glug," a lone bubble rises within the bottle, undergoing a phenomenal transformation as it is pierced from within by a long and sharp microjet. This isn't just any microjet. This is a jet travelling at speeds of up to 15,000 mm per second – that's like zipping up from the bottom floor to the third floor of the Engineering IV building in a single second! This piece depicts a brief period of the bubble's journey after the microjet has pierced through the top of the bubble. At this stage, the bubble has "inverted" on itself and begun a process of disintegration. The images were captured with a Phantom v310 high-speed camera at 10,000 frames per second and the sequence has been rotated horizontally 90 degrees clockwise for artistic effect. The entire sequence depicted here occurs in the very short timeframe of 0.032 seconds – in other words, this extraordinary transformation happens in less than a tenth of the time it would take for you to blink. So, the next time you're emptying out a bottle, know that there's beauty there: a form of art hidden within the science of the ordinary.

The art of bottle emptying is a form that can only speak for itself. Although we don't think about it very often, the stages going from releasing the fluid to the conclusion of draining forms many shapes and even structures often unseen. The beauty of the shapes you see before you are often subjective; there is no right answer to what shape is produced or what figure you carve out of the liquid. For some, you can see an astronaut in the very right image while others may see a woman clasping her own hands and concealing her face from view. This, therefore, constitutes art as it allows viewers to interpret the images for themselves. This constitutes engineering because it was developed as a result of studying how fluid viscosity affects the flow and bubble formation of a fluid from an inverted bottle. The three phases showcase a few of the astonishing moments taken from a high-speed camera. At viscosities close to that of water these images would show shapes similar to a bullet puncturing a column of water. As we increase the viscosity, which in our case was done using a mixture of Glycerin and water, we can achieve slower rates of fluid emptying and construct more pronounced figures. To really highlight each phase of this process, a color selection corresponding to each phase was selected. These colors not only bring out the uniqueness of the three figures, but the use of primary colors in their bold states really speaks to the structures' striking effect on the viewer.

What you see before you is no ordinary object. Or is it? What may look like ancient columns in Greece, or a caryatid erected in Athens, turns out to be something we use every day. Well to be more accurate, at least 15% of it is used every day. To be clearer, the set of images you see are products of mixing glycerin with water to achieve the desired viscosity of an aqueous Glycerin solution recorded at approximately 110 Centipoises/mPa*S. Add this mixture to a wine bottle, invert it and you may very well have art in your hands. To really appreciate this phenomenon, let’s think back to our fluid dynamics class. We all know that viscosity is a measure of how resistant or cohesive the molecules within a fluid are. As we increase a particular fluid’s viscosity, not only do the shear forces between the molecules decrease causing the flow to slow down, but we get a sluggish effect that creates less movement and more pronunciation with the shapes it forms. In this case, as we are emptying the glycerin solution from a wine bottle, a bubble is formed as the solution leaves the enclosure and air comes in. A jet is then initiated, sending a high-speed trajectory to rupture through the bubble's base followed by the top surface. Recall that our fluid contains a highly viscous fluid at approximately 85%. Where water would have simply penetrated each surface of the bubble on its path, this solution moves at a slower rate, slugs as each molecule moves in cohesion, and resists every urge to deform giving us this unique piece of art resembling ancient structures found in ancient Greece.

To make a Glycerin Cocktail from scratch: Take 57 spoonfuls of pure Glycerin; ensure that it carries a Viscosity of approximately 110 Centipoises per MilliPascal-Seconds. Decant into a Bowl, and put with it 10 spoonfuls of Water. With a Screwdriver, stir the Fluids all about. When it is all mix’d, run it through a Funnel into a glass Bottle about six Thumbs high with a Diameter of approximately 1 Wiffle. Cork the Bottle with a sturdy Index Card, and flip the Bottle upside-down. The Mayer Fluids Research Group at Cal Poly has found the above recipe to generate a wondrous effect when the index card is released and the mixture is allowed to drain – one may observe the gradual metamorphosis of a bubble as it rises within the bottle, forming supernatural shapes. Such shapes are nearly imperceptible to the human eye, but we have captured them using a Phantom high-speed camera set to record at 10,000 frames per second. We have observed that, upon initial formation of the bubble, its center is punctured by a smooth microjet; as the bubble rises, ripples travel both across the bubble. The bubble inverts on itself, and at one point, forms a smooth, egg-like shape. This piece captures a single frame of the “egg,” juxtaposed in front of a reel of frames depicting the bubble’s journey. Of note is that our initial experiments did not use a Glycerin Cocktail; our focus was on the analysis of bubbles rising within bottles of pure water – these air-water bubbles had strikingly different physical characteristics compared to the Glycerin Cocktail bubble. Our goal in sharing this piece is to draw attention to a myriad of peculiar organic forms that are hidden within simple mixtures – such as that of our Glycerin Cocktail.

Life on Pluto? – Awarded Dean's Appreciation

Anna Reid, Gabe Limotta, Riley Froomin, and Angela Chawla (2022)

This piece is an animated short that I worked on in one of my classes. It relates to both art and engineering in that we had creative freedom with designing the models, while simultaneously learning about representing physics, movement, etc. in an animated setting.

The Knowledge Map – Awarded Gold

Kalen Goo (2022)

The Knowledge Map represents the complex relationship between courses and study programs at Cal Poly. It shows how the knowledge taught in classes is shared among study programs across the university. In this bipartite network model, small black nodes are associated with courses, and larger colored nodes stand for programs. A connection between a course node and a program node means that the course can be taken for study credit as a core or elective class in the program. The depicted layout is optimized using method used in yEd to better illustrate clusters and knowledge flows based on the underlying network structure. The beauty of this piece is the ability to present complicated curriculum data in a digestible format. Simple circles, colors, and lines convey information that spans 6 colleges, 51 departments, 84 programs, and 2565 courses. From afar, we can observe the relationships between different programs and courses with splashes of color and streams that run throughout the map. As we venture closer, we can focus on specific programs and trace their lines to find their respective courses. The Knowledge Map represent the synergy of art and engineering. Code was used to scrape, clean, and generate the network of catalog data. Design principles including proportion, contrast, and proximity were used to create an aesthetic representation of the data. Ultimately, The Knowledge Map is a discussion piece. With no apparent start point, initial students and faculty often gravitated to the programs and courses they were most familiar with. I want to invite people to explore The Knowledge Map and discover what resonates with them. Wherever you begin, you're guaranteed to find yourself connected in the end.

A True-Color Optical Micrograph — Awarded Silver

James Matthew Seidlinger (2022)

A true-color optical micrograph of the dendritic formation of the oxidized surface of Al2FeCoNiCu high-entropy alloy.

AI Sculpted Terrain— Awarded Dean’s Appreciation

Hunter Borlik (2022)

This image is composed of four different terrain elevation maps generated by a machine learning model. The terrain of Earth is often the central element of a scene, making up most visible details in games and everyday life. These images are the products of a project aimed at simplifying custom terrain creation. Rather than relying on the skill of an artist, the computer can create data that mimics real terrain features. By training it with many examples of terrain from Earth, it can learn features and mimic them. The model used to generate these images was trained with the publicly available NASA SRTMv1 dataset with a resolution of 30 meters per pixel. Each of the generated images covers an area of about 236 square kilometers. The machine learning model used is known as a Generative Adversarial Network (GAN). It is fundamentally two machines that work against each other. One creates fake data, the other tries to guess which data are fake. The generator tends to make more and more realistic data, and the discriminator gets better at identifying fake data. After repeating this process for about 6 hours, the generator outputs images like these. The machine effectively learns to create data that looks like the real thing. Creating unique terrains becomes as simple as asking the machine for something different. This entry is an example of procedural content generation. It shows how careful tuning of a machine learning network can be used to create artwork of any kind. Here, GANs were applied to synthesizing terrain data with the intention of increasing accessibly of custom maps in games. However, the raw data is also interesting to look at as terrain has many fractal patterns. The data is visualized by coloring different heights according to a color gradient. Low areas are blue, midlands are green, and mountains are brown and white.

Blade Profile– Awarded Dean's Appreciation

Josephine Maiorano (2022)

This picture shows the airfoil profile shapes as they change along the length of a wind turbine blade. The blade it is derived from was designed for the Cal Poly Wind Power club's competition turbine. The geometry is based on blade element momentum theory, and uses a combination of three different airfoil profiles (S833, S834, and S835) along the length of the blade. I was first mesmerizing by the beauty of this blade while panning the SOLIDWORKS (A 3D modeling software) rendering, and then again when I got to hold the 3D-printed blade. I originally came across this particular view while documenting the blade design for a report, and immediately realized that this image encapsulates the beauty I see in the blade. It shows the graceful curves of the blade, and how the profiles cross one another as the blade twists around. I love how this exemplifies engineering theory dictating grace; the gentleness of the changes promote smooth airflow, and the curves generate a pressure differential that makes the blades spin (really fast!). I spend so much time in engineering design focused on the performance and structural strenght of a design, that I sometimes forget to step back and appreciate the beauty of what I am creating. This piece is a reminder of that to me. Designing this blade was a true labor of love, and being able to see not only the functionality but also the beauty of what I created makes it that much more meaningful.