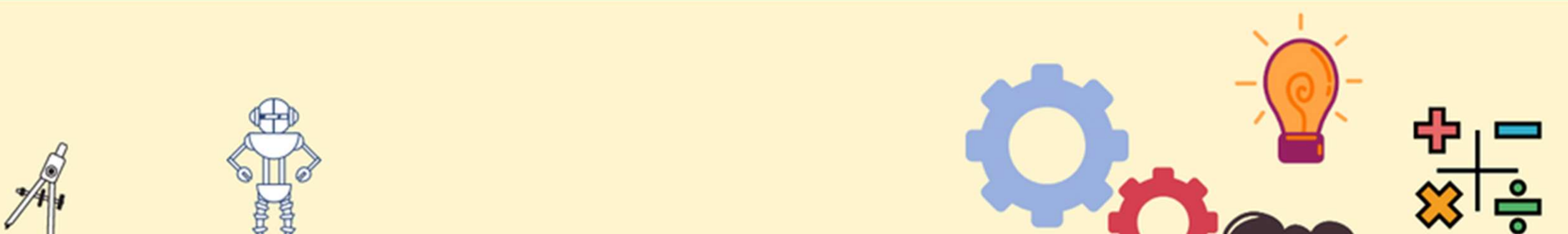
DeyGana Project Based Engineering: CAD CURRICULUM

Unknown Unknowns to Known Unknowns to Known Knowns: The Ultimate STEM/STEAM Progression to Achieve Proficiency

Created by DeyGana



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DeyGana STEAM

This isn't about building, it's about learning how to build
This isn't about building a good boat, it's about learning how to build a better boat

Vision

Teach students general knowledge within a particular subject matter and then place them within an environment to further develop those skills and discover what they don't know. They will then ask for answers about what they don't know, and we'll guide them towards those answers so that they can return to the development environment and keep working at it until they have more questions. Once all of this is done and they present their final creations, we will talk about it in class as a group so that you can see where everybody is, how the successful people did it, and how the unsuccessful did it so that all students can glean lessons from both sets of students. It allows them to see not only their teacher's perspective and approach, but also their classmates' perspectives and approaches

Unknown unknowns: subject matter & skills students don't know exist
Known unknowns: subject matter & skills students know about, but lack experience in
Known knowns: subject matter & skills students know about and can confidently explain/demonstrate

To summarize, students start with unknown knowns, we teach them general principles and give them a test to turn those unknown unknowns to known unknowns. Then by addressing those known unknowns, they become known knowns and the students can return to the test to discover more known unknowns that we can continue to transform into known knowns. Finally, the reflection should address other unknown unknowns that the initial lesson never brought up. A group reflection allows multiple students to say and discover something that the teacher never discussed in the first place, and we can also turn those unknown unknowns to known unknowns and finally known knowns!

This process allows you to efficiently create personalized education for your students because after the initial lesson which introduces students to the subject matter and transforms unknown unknowns to known unknowns, each student will only come to you **with questions specific to their progress**. They will discover what they need at their own pace, you just need to provide them with an adequate test and time to struggle and develop.

Curriculum Purpose

By the grace of God, we have been fortunate enough to build programs for multiple organizations across nations and continents that successfully and passionately pursue the goal of teaching students how to learn and providing them with resources to support their directions. The purpose of this curriculum is to introduce and expose students to state-of-the-art education methods through conversations, demonstrations, and challenges that will be fun, educational, and relevant. We aim to inspire students to take a deeper look into STEAM (Science, Technology, Engineering, Arts, Math) related activities, the humanities, finances, and everything else that contributes to holistic, caring, and action-oriented people.

In doing this, we understand that certain schools have resources that other schools across the globe don't have even in high GDP nations. We believe that while this plays a large role in why many of the affected schools don't have STEAM programs, it shouldn't. There is a lot of fat i.e content or hardware that is not critical in the initial stages, in many STEAM programs when it comes to equipment and curriculum. Upon growth and reflection, we noticed this within earlier iterations of our own program. As a result, we've found different tools to replace what we used to believe was necessary in the classroom. $500 robots have turned into free online simulators and $35 electronics kits. Lack of space for computers in the room to program microcontrollers has turned into virtual circuits on laptops where every student can individually build and program at their own pace without getting lost in a group.

Our curriculum aims to trim and simplify curricula to provide foundational essentials for the understanding of our students. We have seen teachers waste time training students who don't have the math and science foundation to understand HOW things work even though these same students don't need to understand how things work in order to use them just like you don't need to understand how a motherboard works to use a computer or how a car engine works in order to drive one. Some of our students cannot tell you the first thing about how an ATmega328 chip works or about flip-flops or motor controller functionality but they can use those same devices to build an electric skateboard with a brushless dc motor, a motor controller, and an Arduino to control some cool LED lights they attached to the bottom.

This revelation showed us that while technical knowledge and the *how* is good information to have around you, it only becomes useful when it is relevant to the task at hand. If not, then it's just extra information that the brain will soon purge. This is the reason why our classes are based on introducing students to a range of topics on a surface level just for exposure first; afterwards, we assign them projects that fall in line with their interests which will force them to learn the technical information and theory within their subject matter because it becomes relevant to them completing their projects. **It no longer becomes about learning information just for the sake of knowing it or passing a test. It becomes about learning the information in order to immediately apply it in attempts to craft a USEFUL solution to chosen project/problem statements.** We can continue to list more and more activities; however, we have demonstrated our point with these examples.

Not only will students be able to get a high quality STEAM education that will build their creativity, problem-solving skills, and technical abilities within coding, manufacturing, robotics, and other engineering, humanities, and financial spheres and beyond, but also they will be able to do it at a fraction of the cost of your average STEAM program in a **RELEVANT** way.

Our goal is to sever the relationship between a lack of resources/math and science foundation and a lack of a STEAM program. While those things are currently related in the way we look at STEAM these days, we truly don't believe that they have to be. We believe engineering is intuitive enough that anyone with zero background in it can be able to look at what's going on and at the very least say "even though I don't understand the ins and outs of how it works, you pointing out the different elements and their functions within the system makes sense as to why you built it that way." It's too vital to divorce those ideas from each other with where the world is headed because students who don't have the opportunity to explore this kind of education will be left behind due to the excuses we're providing as engineers, educators, and adults responsible for their lives.

What is STEAM & Why is it Important?

STEAM stands for Science, Technology, Engineering, Arts, and Mathematics. The point of a STEAM education is to complement a classical education in a developing world. While learning about theory is important, developing a problem-solving mindset is particularly important in this day and age to building a holistic citizen. A STEAM education places emphasis on subject matter that promotes this kind of logical and rational problem solving while collaborating with the arts in order to introduce creative and non-traditional elements to the process in order to produce truly limitless solvers of problems of the past, today, and beyond.

Why Project Based?

People tend to look at projects as a presentation/culmination of your knowledge on a subject. We actually look at projects as lectures, lessons, and teaching tools. It just so happens to be that the student is directing HOW they're going to learn their topic of interest. **E.g., a student is learning web development by embarking on a project to create a personal blog site that has at least x amount of pages and y amount of dynamic content.** This will involve all the HTML, JavaScript, CSS coding as well as learning about domains, hosting, servers, and SSL certificates all from a project about making a website.

A student is learning about Arduino powered mechatronics by embarking on a project that involves building and programming a robot hand as opposed to assembling one from a kit. This involves physically building the hand whether it's through CAD or hand built, sourcing appropriate motors, motor controllers, and other electronics. If it's wireless, they would include a transmitter and receiver. If not, they would use a controller or sensors compatible with the Arduino.

It involves all the programming that goes into making sure all the elements are properly integrated. It also involves **1)** learning about the electrical components and making sure the proper power is supplied and there are no shorts, **2)** learning about resistors and capacitors and their role in circuits, **3)** learning about soldering, stripping, and connecting, and insulating wires, and **4)** learning about prototyping on breadboards before creating permanent circuits with PCBs, among other things involving iterating on designs, comparing products before purchase, wisely spending budgets, etc. To successfully complete this project, the student must learn all these things on the way there. Learning these skills on their own can be boring and random because there is no theme and mission but as soon as you create a project that connects and necessitates those skills, they suddenly become relevant and elevated material.

A student is learning about flight dynamics by doing a project which will result in them building and successfully flying an RC plane. This means learning about different wings, propellers, power supplies for the plane, aerodynamics and the shape of the fuselage, wind resistance, transmitters and receivers and their range, etc.

In our programs, students are not building their projects to show off and demonstrate skills and knowledge they already have. That would be a waste of time. Why do what you already know unless you have a good reason to? They're doing these projects because they're trying to build on their current foundations, acquire new skills, and hone the ones they already have and what better way to do that than by building a project that makes all the skills you're trying to learn a necessary part of completing the task at hand

Curriculum Overview

These sessions will primarily be held for **3 different age groups**: **Elementary School (Grades 3-5), Middle School (Grades 6-8), and High School (Grades 9-12)** but can also be modified for varying experience groups of beginner, intermediate, and proficient as well**.** Each group will have its own set of stimulating activities and challenges depending on the date of the session they attend. While this is the general approach, please note that part of implementing the program is adjusting to the needs of students who either need more help or stronger challenges to properly engage with what is in front of them.

- **Grades 3-5:** The elementary group will typically be limited to computer education and robotics, easy assembly/pre-assembled materials, and craft work (popsicle sticks, LEGOs, straws, skewers, paper cups, and plates, etc.) that do not require much beyond tape, school glue, and safety scissors.

- **Grades 6-8:** The middle school group will typically be allowed to do more labor-intensive work on top of what the elementary group is already doing. They will also use simple craft items like popsicle sticks, and straws; however, they will be allowed access to more modification materials like hot glue guns, box cutters, soldering irons, etc. This group will also learn about coding logic and programming through different challenges.

- **Grades 9-12:** The oldest age group, the high school group, will have access to power tools like drills, power sanders, electric saws, epoxy, etc. Their challenges will also be more build intensive since they will have access to more building materials like 2x4s, plywood, PVC pipes, and other such materials. This group will also learn programming languages and those who are ready will have more intense programming challenges prepared for them.

There will be various challenges available depending on the skill levels of those participating. The point of these programs is to not hold back any students who are farther along in STEAM education than their peers. If this ever becomes the case, more advanced challenges should be provided.

The goal of these sessions is to provide students with access to the state-of-the-art in engineering and education, something that usually comes at a steep price, at a very low cost. This will allow students to not just read about engineering in textbooks or watch videos about it online, but experience it first-hand. It will open their world when they come to understand the possibilities that exist on a STEAM track. And finally, it may even give them an idea of the path they want to take in their future or reveal to them the path they do NOT want to take after spending time with our program allowing them to shift their focus and attention elsewhere.

Scalability

This program is scalable and sustainable because once students get knowledge in certain areas, they can teach each other and help their struggling classmates get up to speed. Many do it better than their teachers because they speak the language of their peers. And for the students who pick up the subject matter quickly, you can give them more challenging versions of the same assignment with less abstraction that can start to test not only the technical skills they are learning, but also their logic, reasoning, and knowledge of WHEN to apply different principles which is when they start to stand on their own feet and develop independence. That's the goal here: independence. Not just knowing programming techniques, but when to apply them. Not just knowing CAD techniques, but when to apply them. Not just knowing how to use a jigsaw or drill or hammer, but when to use it. Once students prove their efficacy in this area, the program has given them all you can give.

The only thing that is left to do is to give them projects/problem statements within the areas they're interested in growing their knowledge and let them go. Try to be as invisible as possible during this time. Do not be their first point of contact, second, or even third. If they don't have you there to lean on for answers, they'll start learning not only how to find answers on their own, but also how to find **RELEVANT, USEFUL, and APPLICABLE answers**. There is plenty of information on the internet, in books, and in other people. A lot of it is useful, a lot of it isn't. One of the most important skills this program can teach a student is how to differentiate between those two categories with regards to their goals. Just because something is useless today doesn't mean that it will still be useless tomorrow.

In these projects, they will develop depth in the skills that the program gave them surface level exposure in depth that cannot be simulated with a lesson or even an assignment. The reason is because of **RELEVANCE. That's the keyword here**. If the deepest level of relevance of any subject matter is attached to a grade, then the assignment is useless. Unless the student has their own agenda, the information will remain relevant to them until that grade has been submitted; however, if there is something outside of a grade attached to the subject matter like a problem statement/project that leans on the technical skills and knowledge in that subject matter, the student will have no choice but to constantly apply those technical skills and knowledge in that area until they solve the problem or come to the realization that the problem is beyond their current scope. With either of those results, the student either understands the problem because they've solved it or because they understand what it takes to solve it and why they're currently not in a position to do so.

Mentorship

We will create time during this program to allow people who work in various STEAM industries (automotive, cyber security, aviation, etc.) to engage with and speak to our students. We believe that it can be extremely important to know the background behind who someone is, what they do, and how they journeyed to where they are. It will give students an idea of different paths that may be available, the challenges and pitfalls that come with those paths, and most importantly how they can potentially overcome them. We also believe that it is important for students to see that being an engineer or a scientist is not the only career available in the STEAM fields. You can become a pilot, an astronaut, a programmer, an architect, project manager, and the list goes on and on. We are excited to collaborate with passionate professionals to show our students how exciting these different career opportunities can be!

Curriculum Topics

Coding/Programming

- **Needs**:
    - Laptop
    - Chromebook
    - Tablet
    - Raspberry Pi 400 (this is the best option because it allows students to learn CAD, coding/programming, and embedded systems either using an arduino or the raspberry pi itself)
- **Source Material**
    - code.org for introducing coding concepts such as sequencing, loops, conditionals, javascript, app building, etc.
        - Code.org technical requirements - https://support.code.org/hc/en-us/articles/202591743-Technical-requirements-for-Code-org
    - Edublocks for introducing python syntax

Video Game Development through Unity

- **Needs**
    - Laptop
    - Chromebook
- **Source Material**
    - Unity Website
    - Unreal Engine Website
    - Youtube
    - Code.org

Computer-Aided Design (CAD)

- **Needs**
    - Laptop
    - Chromebook
    - Tablet
    - Parametric CAD software: SolidWorks, Onshape, Fusion360
    - Direct Modeling software: TinkerCAD, Blender
    - 2D Photo Editing or Vector Graphics Software: Inkscape, Adobe Illustrator, Corel Vector
- **Nice to Haves**
    - 3D Printer: Prusa, Ender, etc.
    - Laser Cutter
- **Source Material**
    - Youtube
    - Forums

- CAD Software websites and FAQs

Mechatronics

- **Needs**
  - Laptop
  - Chromebook
  - Tablet
  - Mechatronics Simulator: TinkerCAD Circuits, micro:bit simulator, wowki
- **Nice to Haves**
  - Arduino Kit
  - micro:bit Kit
  - Raspberry Pi Kit
- **Source Material**
  - Youtube
  - Forums
  - Manufacturer Resources

Robotics

- **Needs**
  - Laptop
  - Chromebook
  - Tablet
  - Robotics Simulator: VEX VR
- **Nice to Haves**
  - LEGO Mindstorms/Robot Inventors kits
  - mBot kits
  - VEX kits
- **Source Material**
  - Youtube
  - Forums
  - Manufacturer Resources

Computer-Aided Design (CAD)

Purpose

CAD is used by engineers and architects to create models of their designs before physically building them. This has several advantages:

1. It allows them to see a visual representation of the final product before ever lifting a hammer or saw
2. It allows them to see potential faults in their designs before actually building it
3. It gives them the ability to rapidly prototype different designs with different material properties without ever actually having to build them thus saving time and money
4. It allows them to run load analyses on their designs to determine strengths and points of failure
5. It allows even those without handy skills to bring their concepts to life in a visual way
6. It facilitates sharing one's vision with others because they can now show people what they're talking about instead of having to rely solely on words or sketches.
7. It allows the ability to visualize an object, a part, or machine in 3D which gives design and construction teams an idea of what the finished project should look like,
8. Nowadays, with the increasing cloud capabilities of these CAD softwares, a whole team of engineers, architects, and even artists can easily work on projects together in real time and receive updates from/push updates to their construction team.
9. According to Procore, CAD increases productivity by enabling "designers to consider electricity, plumbing, and other elements, helping to create a more comprehensive design. Ultimately, this translates to fewer work changes and fewer surprises during construction."
10. If you want more info on CAD, check out this link. It also provided some of the info above -> What is CAD according to Procore?

Learning Methods

There are two primary softwares we will be using to learn CAD. These are both web based and so anyone with a computer and an internet connection can have access to these programs.

- The first is known as TinkerCAD. You can teach these same lessons with other **direct modeling software** like Windows' 3D Builder. We just happen to be using TinkerCAD because of its accessibility. We will use this to introduce students to CAD because it has a friendlier user interface. It is free to create user accounts and the program is webapp so all a student needs to run it is a computer with an internet connection. TinkerCAD also gives teachers the ability to create virtual classrooms where they can create accounts for students, see their parts, and monitor their progress. TinkerCAD also has resources for anyone who wants to be self-taught by way of lessons, follow along projects, and galleries of creations that users can attempt to remake.

- The second software we will be using is Onshape. Onshape is a cloud-based CAD webapp. Since Onshape is **parametric CAD software**, any parametric CAD software like Fusion360, Solidworks, etc. can also be used. What this means is that a user only needs an internet connection and an internet connected device like a phone, computer, or tablet to use it. Onshape is a professional CAD program and is utilized by engineering and design firms like Bellaseno, Xing Mobility, Fusion Biotec, and Voxel Innovations among others. Apart from its capabilities in design, it has also improved collaboration among designers on projects due to its cloud interface. The techniques students will be learning in Onshape--sketch, extrusion, loft, sweep, patterning, mirroring, assembling, technical drawings, dimensioning, etc.--are the same techniques designers use at these firms to bring parts and machines to life for construction, 3D printing, CNC machining, and laser cutting among other manufacturing methods.

Lessons: Onshape

Summary of Onshape Course

After completing this course, students should have the tools to be able to do the following:

1. Present visuals for any physical ideas they have
2. Create a 3D model of an object from a 2D image of it
3. Recreate a 3D model of an object from a 3D model of it and make modifications to it
4. Import 3D files in the various formats like .stl and .obj and make modifications to them
5. Export 3D files for sharing or 3D printing
6. Have a basic enough understanding about how 3D printing works so that they can create parts that are 3D printer friendly

Intro Video:

https://www.youtube.com/watch?v=U5R33hR51Vw

Lesson 1

1. Sign-up for Onshape using this link: https://www.onshape.com/signup
    a. Select "Education Account" under the Onshape Education box
    b. Click "Create Free Account"
    c. Fill in the information, check the box, then click "Create Edu Account"
    d. Fill in the required information in Step 2, check the boxes, then click "Create Account"
    e. Go to the email you provided and click on the verification link to verify your account
2. Navigating the Onshape Interface
    a. "My Onshape" contains all the documents you interact with. A document isn't a CAD file but rather contains CAD files, drawings, assemblies, etc.
    b. "Public" contains documents created by other users that decided to share their creations with the world
    c. The blue "Create" button allows you to create a new document, folder, label, and import files
    d. The "?" is where you go to get help. It contains resources like the "Learning Center" and keyboard shortcuts
    e. The "App Store" contains apps that work with Onshape to give it more features like rendering, simulation, and CAM
3. The Documents Page according to learn.onshape.com

Key Takeaways:

- View, organize, and manage your Documents on the Documents page.
- An Onshape Document is *not* a CAD file, but rather a generic container that consists of all data related to a project.
- Documents can contain any number of Part Studios, assemblies, drawings, PDFs, images, videos, imported CAD data, etc.

Lesson 2

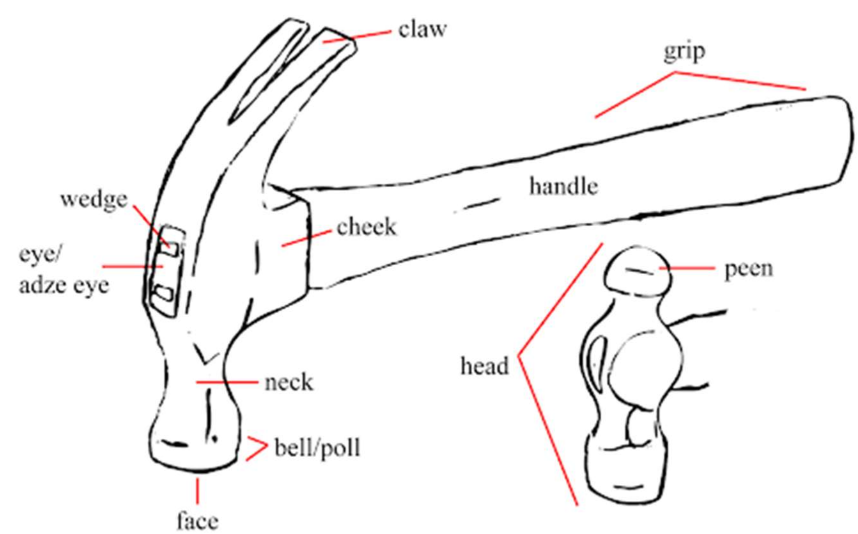
1. Create a new document
    a. Titling your doc
    b. Adding new features like part studios, assemblies, drawing, etc.
    c. Sharing doc with others
2. Views
    a. Right click to see more views
    b. Hold right mouse button to rotate views
    c. Click title to change title
    d. Click eyes under feature tab to hide work planes
3. Sketching
    a. Click sketch to start a drawing
    b. Click on the work plane you want to sketch on
    c. You can right click and select "Normal To" View option
    d. Use the different sketch tools like rectangles, circles, splines, line (fillet), polygons, etc.
    e. To change sketch **dimensions**, select the dimensions button and click on the dimensions you want to change
        i. You can actually type in the units for the dimensions (e.g. in, cm) and onshape will automatically convert it for you
4. Extruding
    a. Click on extrude
    b. Select the face you want to extrude
        i. It must be a 2D shape
    c. Types of extrusion
        i. Blind: extrudes from surface to a specified distance
        ii. Symmetric: extrudes evenly in both directions from the surface
    d. Show that you can create a sketch on the surface of a previous extrusion
5. Fillet
6. Key vocabulary
    a. Isometric View: An isometric drawing is a view in which all three axes appear at equal 120° angles with the plane of projection (g-wlearning)
    b. "Normal to" means perpendicular to

Lesson 2.1 Practice: Hammer

Give them a lesson that is hard enough to push them but still only primarily tests the skills from lesson 2

Here is a test I use after lesson 2:
I give the students a physical hammer that they can hold and view from all angles and ask them to make it onshape. Those are all the instructions I give. They have to figure it out. I also post images of hammers when I don't have enough hammers for the students. Give them a couple of class periods to finish this. About 2-3. Remember they need to learn the program as they're creating the hammer

Have students share their creations with you afterwards (students should click on the share button and enter your email associated with your onshape account. Have them change sharing options to "view only" unless you want editing privileges. These are their creations so I find it best to let them be the only editors)



Lesson 2.1 Reflection

Part 1

Choose 3 or 4 students whose creations you will display and ask them for one thing they did well and one thing they could improve on and why they chose those features. After that student comments on their work, pick 4 other students and ask them to comment on one thing they thought the student displaying their work did well and one thing they think that they can improve upon.

Part 2

1. Have the students create a google doc titled “First Name Last Name Engineering Reflections” e.g. “Baffour Osei Engineering Reflections”
2. Have them share the document with you via email
3. Have them title this reflection “date Onshape Hammer Reflection” e.g. “19/2/2021 Onshape Hammer Reflection”
4. Have them answer the following questions ONE at a time. Give them 1-2 minutes to write out their answer to each question in full sentences then go around the classroom and have each student read out their answer to the question. This is so that all the students can hear how their peers are doing and also so that they can get ideas from each other about how to better approach these tasks in the future. Make sure they answer the WHY portion of the question. This is very important because they need to be able to justify their actions, reasoning, and decisions.
   As they read their responses, try not to look at their answers as correct vs incorrect. Look at it from the lens of useful vs not useful and if you think their answer isn't useful, rather than calling them out on it, ask a follow-up question that will force them to think deeper and respond with a more useful answer.
   Anything worth doing is worth doing badly at first. Reflections don't always go the greatest or feel the most productive but they are worth it from my experience. Trust me.
   a. What was your approach to creating the hammer on Onshape? Why?
   b. Based on what you heard from your classmates about their approaches, would you change anything about your original approach? Why or why not?
   c. What was the most realistic part of your hammer design compared to the real thing? Why?
   d. What was the least realistic part of your hammer design compared to the real thing? Why?
   e. What was the most difficult part of making your hammer design? Why?
   f. What was the easiest part of making your hammer design? Why?
   g. If you had more time what would you change? Why?
   h. What's the hardest part about using Onshape for you so far? Why?
   i. What's the easiest part about using Onshape for you so far? Why?

Lesson 2.2 Practice: Clamp

Build this clamp on Onshape. Give it about 2-3 periods as well

- Video for different angles of the clamp: https://www.youtube.com/watch?v=BbiPyGiH050
- Have students share their creations with you afterwards (students should click on the share button and enter your email associated with your onshape account. Have them change sharing options to “view only” unless you want editing privileges. These are their creations so I find it best to let them be the only editors)

Lesson 2.2 Reflection

Part 1

Choose 3 or 4 students whose creations you will display and ask them for one thing they did well and one thing they could improve on and why they chose those features. After that student comments on their work, pick 4 other students and ask them to comment on one thing they thought the student displaying their work did well and one thing they think that they can improve upon.

Part 2

1. Have them title this reflection “date Onshape Clamp Reflection” e.g. “19/2/2021 Onshape Clamp Reflection”
2. Have them answer the following questions ONE at a time. Give them 1-2 minutes to write out their answer to each question in full sentences then go around the classroom and have each student read out their answer to the question. This is so that all the students can hear how their peers are doing and also so that they can get ideas from each other about how to better approach these tasks in the future. Make sure they

answer the WHY portion of the question. This is very important because they need to be able to justify their actions, reasoning, and decisions.
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Anything worth doing is worth doing badly at first. Reflections don't always go the greatest or feel the most productive but they are worth it from my experience. Trust me.

a. What was your approach to creating the clamp on Onshape? Why?
b. Based on what you heard from your classmates about their approaches, would you change anything about your original approach? Why or why not?
c. What was the most realistic part of your clamp design compared to the real thing? Why?
d. What was the least realistic part of your clamp design compared to the real thing? Why?
e. What was the most difficult part of making your clamp design? Why?
f. What was the easiest part of making your clamp design? Why?
g. If you had more time, what would you change? Why?
h. What's something new that you had to learn to make the clamp that you didn't need for the hammer?
i. Why do you think you did so much better at the clamp than the hammer?

Lesson 2.3 Practice: Glasses

1. Follow the instructions starting with step 3 for this fun and quick exercise (only one class period necessary): Eyeglasses Editing Exercise
2. Have students share their creations with you afterwards (students should click on the share button and enter your email associated with your onshape account. Have them change sharing options to "view only" unless you want editing privileges. These are their creations so I find it best to let them be the only editors)

Lesson 3: Assemblies, Mates, Exploded Views, and Animations

Discuss and demonstrate the following mates:

1. Fasten Mate - It fixes to parts to each other

Fastened mate (m)

Removes all degrees of freedom between two parts.

1. Hover over a part to display the available mate connectors.
2. Select a mate connector for each part.

Use the Shift key to maintain visibility of the current part's mate connectors.

2. Revolute Mate - It allows one part to rotate about the other part

Revolute mate (m)

Create a revolute mate constraint between two parts in an assembly. The parts rotate about the axis only.

1. Hover over a part to display the available mate connectors.
2. Select a mate connector for each part.

Use the Shift key to maintain visibility of the current part's mate connectors.

3. Slide Mate - It allows one part to slide relative to another part

Slider mate (m)

Create a slider mate constraint between two parts in an assembly. The parts can translate along the axis only.

1. Hover over a part to display the available mate connectors.
2. Select a mate connector for each part.

Use the Shift key to maintain visibility of the current part's mate connectors.

Demonstration Follow Along

Students should do this with you on their computers as you are demonstrating

1. Make a cube with 3 holes in it
2. Create another parts studio file and in it make a rod with a diameter that is the same size as one of the holes
3. Go to the assembly page and import the cube and rod into it
4. Use the fasten tool to mate the rod to the cube
5. Import another cube and use the revolute tool to mate the new cube to the rod
    a. You can check the "limit" box and limit how far around the rode the cube can rotate
6. Import another cube and use the slide tool to mate the new cube to the rod
    a. You can check the "limit" box and limit how far up and down the cube can slide on the rod
7. Demonstrate how to animate "moving" mates
8. Demonstrate creating exploded views of assembled parts

Lesson 3 Practice: Fidget Spinner

Create a fidget spinner, animate the rotation, and create an exploded view of its parts (this should take 3-4 class periods since they will be creating 4 parts and then assembling them)

- How fidget spinners work: https://www.youtube.com/watch?v=ryeRqMkHIyI
- Requirements: Create the parts separately and then assemble them in the assembly tab
    - Fidget spinner body - Can be whatever you want as long as it is even

    - Weights for fidget spinner
    - Bearings (just make a thick ring to represent the ball bearings)
    - Top cap
    - Bottom cap
    - Fasten mate for the top cap, bottom cap, and bearing
    - Fasten mate for weights to spinner body
    - Revolute mate for the spinner body and bearing
- Have students share their creations with you afterwards (students should click on the share button and enter your email associated with your onshape account. Have them change sharing options to "view only" unless you want editing privileges. These are their creations so I find it best to let them be the only editors)

Lesson 3 Reflection:

Part 1
Choose 3 or 4 students whose creations you will display and ask them for one thing they did well and one thing they could improve on and why they chose those features. After that student comments on their work, pick 4 other students and ask them to comment on one thing they thought the student displaying their work did well and one thing they think that they can improve upon.

Part 2

1. Have them title this reflection "date Onshape Fidget Spinner Reflection" e.g. "19/2/2021 Onshape Fidget Spinner Reflection"
2. Have them answer the following questions ONE at a time. Give them 1-2 minutes to write out their answer to each question in full sentences then go around the classroom and have each student read out their answer to the question. This is so that all the students can hear how their peers are doing and also so that they can get ideas from each other about how to better approach these tasks in the future. Make sure they answer the WHY portion of the question. This is very important because they need to be able to justify their actions, reasoning, and decisions.
   As they read their responses, try not to look at their answers as correct vs incorrect. Look at it from the lens of useful vs not useful and if you think their answer isn't useful, rather than calling them out on it, ask a follow-up question that will force them to think deeper and respond with a more useful answer.
   Anything worth doing is worth doing badly at first. Reflections don't always go the greatest or feel the most productive but they are worth it from my experience. Trust me.
    a. Describe your approach to making the actual body of your fidget spinner
    b. What was the most difficult part of making the body? Why?
    c. Describe your approach to assembling your fidget spinner
    d. What was the most difficult mate to make? Why?
    e. If you had more time, what would you change? Why?
    f. Why would an exploded view be useful?

Lesson 4: Mirroring and Linear, Circular, and Curve Patterns

Mirroring

1. Sketches (2D)
    a. Mirror across planes
    b. Mirror across lines
2. Solids and Surfaces (3D)
    a. Mirror across planes
        i. New - Creates new mirror
        ii. Add - Adds material to existing material on a part
        iii. Remove - Take away material from a part
        iv. Intersect - Only leaves material where the entity being mirrored intersects with other parts
3. Demonstration/Follow along
    a. Create random lines and shapes in sketch and mirror them across the lines and planes
    b. Create 3D objects and mirror, mirror-add, mirror-remove, and mirror-intersect
    c. Create really basic glasses frames (like paper 3D glasses) either using 3D or 2D mirroring. Use the linear pattern tool to create a pattern on the glasses. Give them about 20 minutes for this exercise. They don't need to create the temple/arms (part that goes over ears).

Linear, Circular, and Curve Patterns

1. Linear patterns
    a. 2D
    b. 3D: New, Add, Remove, Intersect
        i. Select direction - could be a plane or part face
2. Circular patterns
    a. 2D
    b. 3D: New, Add, Remove, Intersect
        i. Select revolve axis
3. Curve patterns
    a. 3D: New, Add, Remove, Intersect
        i. Select path for the pattern to run along

Lesson 4 Practice

1. Create a butterfly. You can create it from an image online

Lesson 5: Revolve and Sweep

Revolve

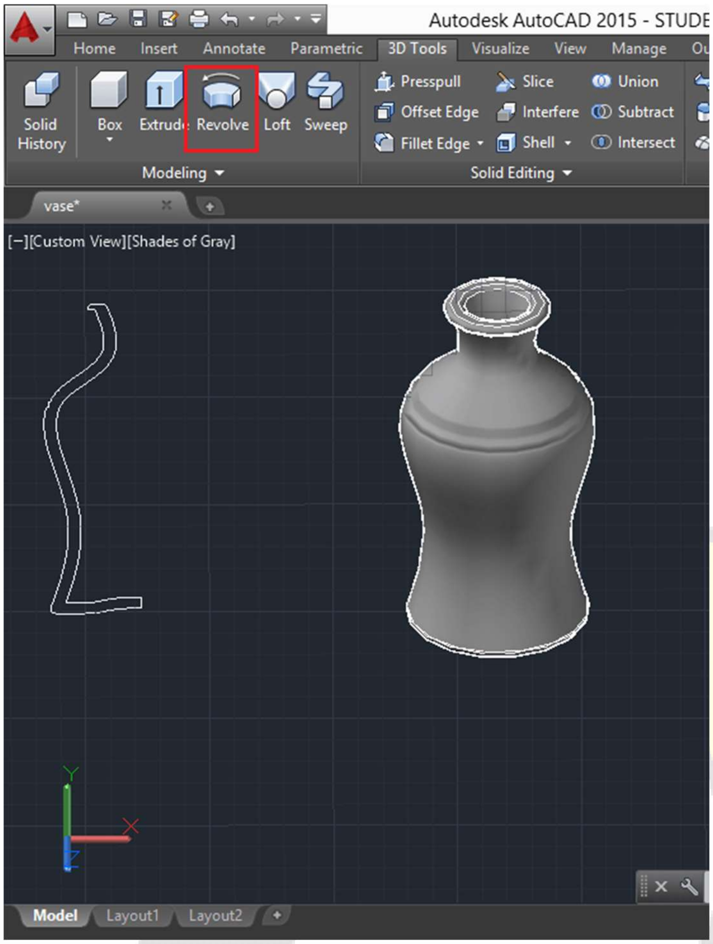
1. Create a sketch
2. Create an axis to revolve it about also in sketch
3. Choose the revolve tool, select the sketch region to revolve and then choose the revolve axis
4. Demonstration
    a. Sketch a circle or square, an axis, and revolve the shape

Sweep

1. Create a profile
2. Create a path
3. For best results, the profile and path should touch
4. Go to sweep and select the profile and path
5. Demonstration
    a. Sketch a circle or square, a path, and create the sweep

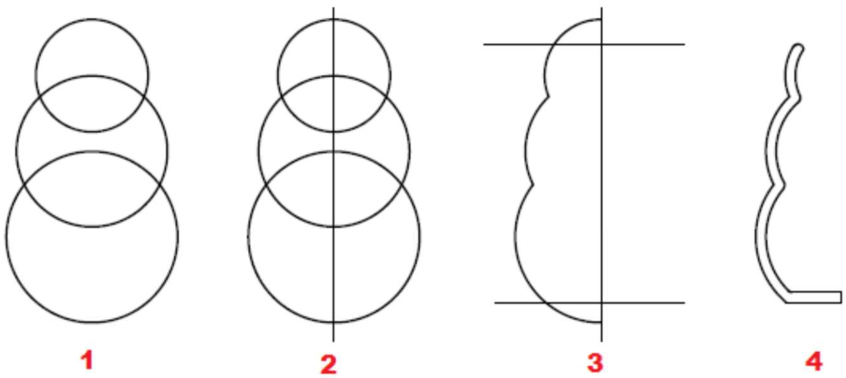
Lesson 5 Practice

1. Create a vase with revolve
    a. Helpful Link: https://tutorial45.com/model-a-vase-in-autocad/



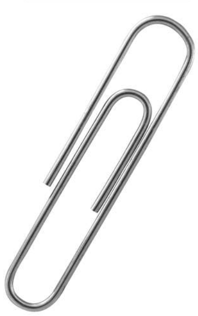
Here is another vase you can practice on.

Here is how you can draft the 2D profile



Although The video does not include the use of the REVOLVE command, it will help you grasp some techniques you can use to model a cup in AutoCAD.

2. Create a paperclip with sweep



Paperclip image link

Lesson 5 Reflection

1. What questions do you have about using the revolve tool?
2. What questions do you have about using the sweep tool?

Lesson 6: Extra Planes and Loft Tool

Extra Planes

1. Use the plane tool or
2. Right click on one of the standard planes and select offset plane

Loft Tool

1. Select the profiles you want the loft to span and Onshape will automatically generate them.
2. You can create profiles on parallel planes, perpendicular planes, different faces, etc.

Lesson 6 Practice

1. Create a stool like the one in class but use the loft tool to make sure the legs are angled

Stool image link

Lesson 6 Reflection

1. What was your approach to creating the stool on Onshape? Why?
2. Based on what you heard from your classmates about their approaches, would you change anything about your original approach? Why or why not?
3. What was the most realistic part of your stool design compared to the real thing? Why?
4. What was the least realistic part of your stool design compared to the real thing? Why?
5. What was the most difficult part of making your stool design? Why?
6. What was the easiest part of making your stool design? Why?
7. If you had more time, what changes would you make to your stool? Why
8. What's the hardest part about using Onshape for you so far? Why?

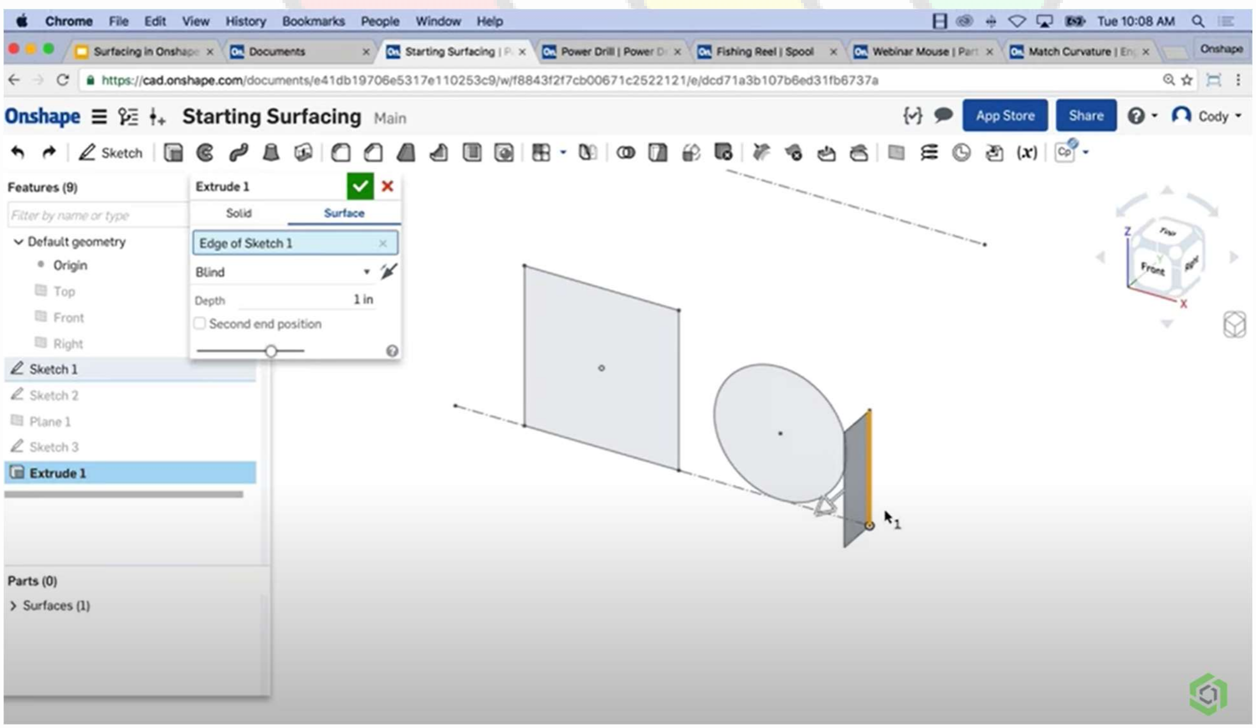
9. What’s the easiest part about using Onshape for you so far? Why?

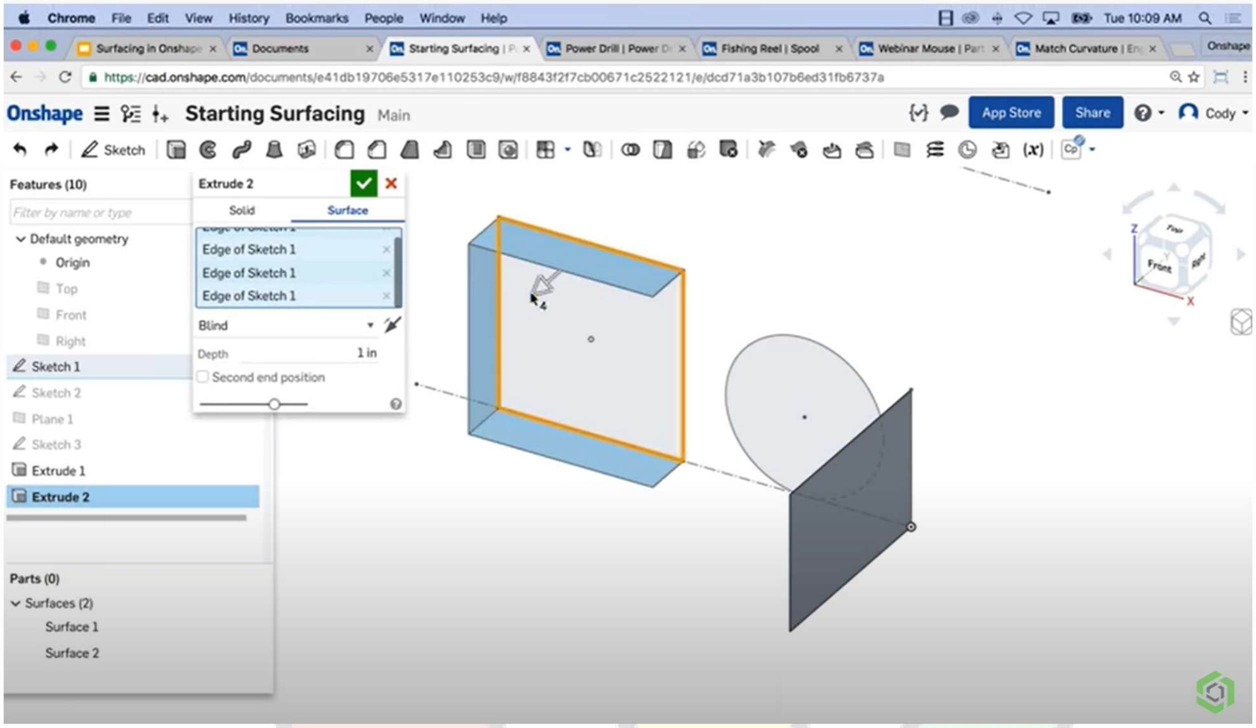
Lesson 7: Surface Modeling

Main point here is that you are not working with surfaces but edges. Surface models have no thickness. You may not use only surfacing to create a part. You will probably use it in conjunction with solid modeling to do what is known as “Mixed Modeling.” E.g. You can create a surface and extrude a solid part up to the face of that surface if it’s a complicated extrusion.

Surfaces may not necessarily be a part of your finished part. They could just be there to aid in construction. While you can’t trim surfaces, you can split them and delete them. You can also use a surface to build a solid model from scratch. To go from a shell of surfaces to a solid part, use thicken tool
[Surfacing in Onshape Webinar]

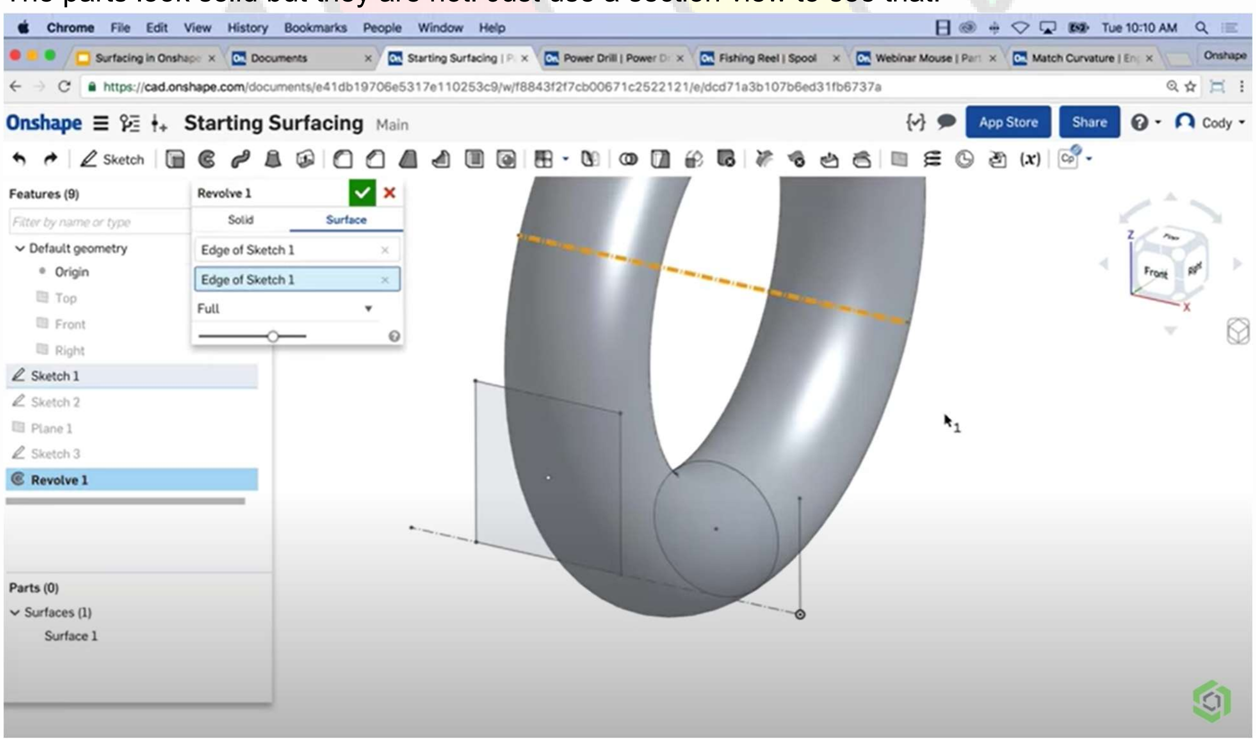
1. **Extrude**



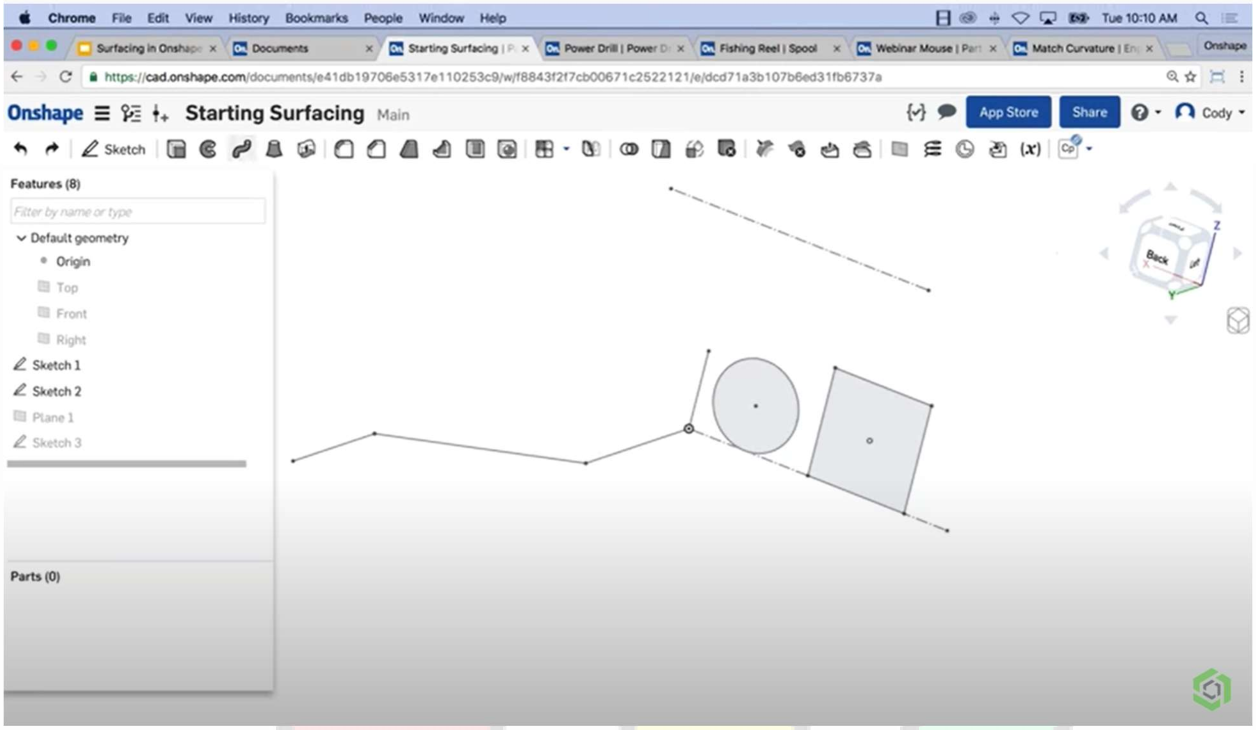


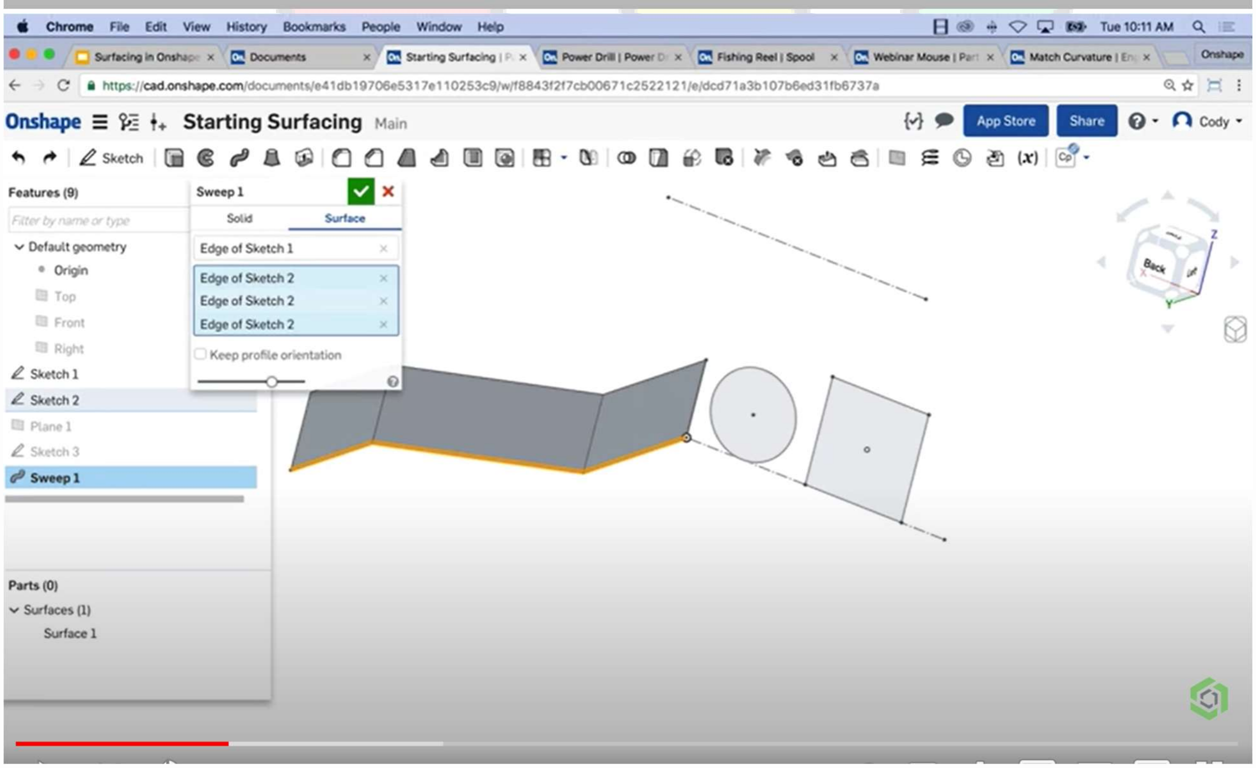
2. Revolve

The parts look solid but they are not. Just use a section view to see that.



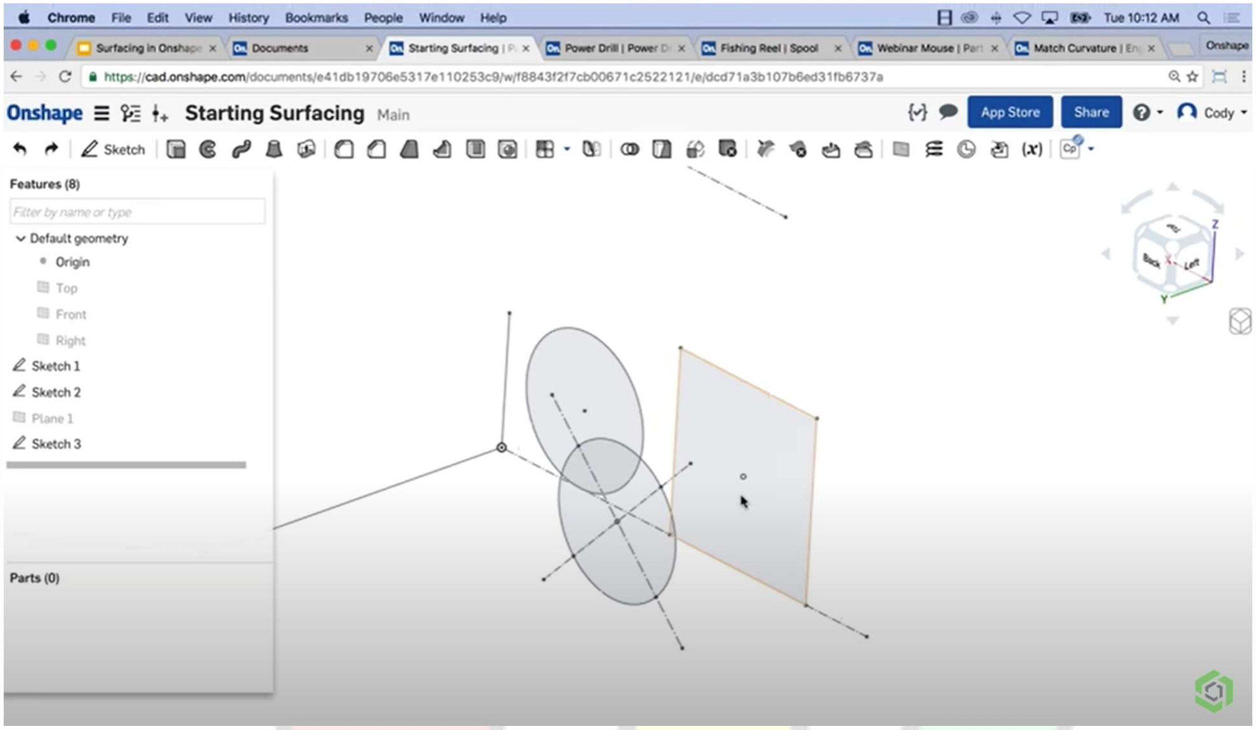
3. Sweep





4. Loft

Edge to edge. You can't go from a 4 sided square to a one sided circle
If lofting to a curved surface, just use match surface conditions options in loft menu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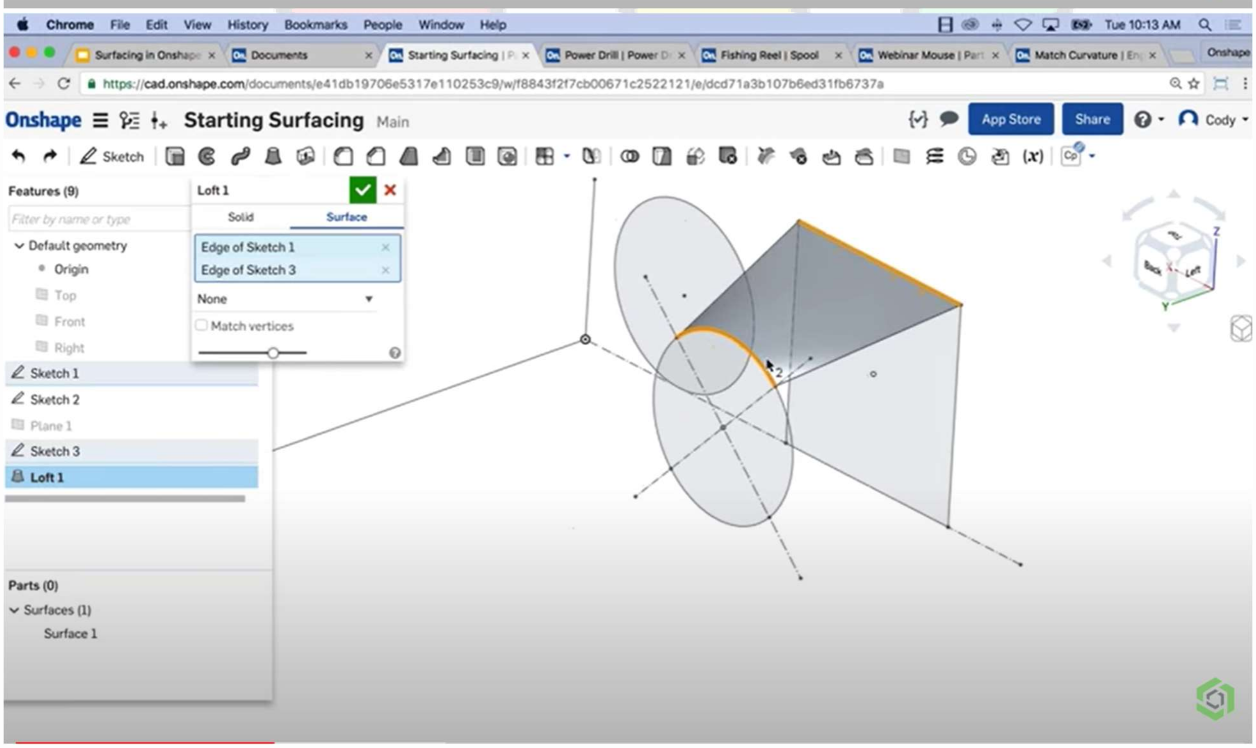
Surfacing in Onshape
Documents
Starting Surfacing
Power Drill | Power Dr
Fishing Reel | Spool
Webinar Mouse | Part
Match Curvature
https://cad.onshape.com/documents/e41db19706e5317e110253c9/w/f8843f2f7cb00671c2522121/e/dcd71a3b107b6ed31fb6737a
Onshape
Starting Surfacing
Main
App Store
Share
Cody
Sketch
Features (8)
Filter by name or type
Default geometry
Origin
Top
Front
Right
Sketch 1
Sketch 2
Plane 1
Sketch 3
Parts (0)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Onshape
Starting Surfacing
Main
App Store
Share
Cody
Sketch
Features (9)
Filter by name or type
Loft 1
Solid
Surface
Edge of Sketch 1
Edge of Sketch 3
None
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Right
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Sketch 2
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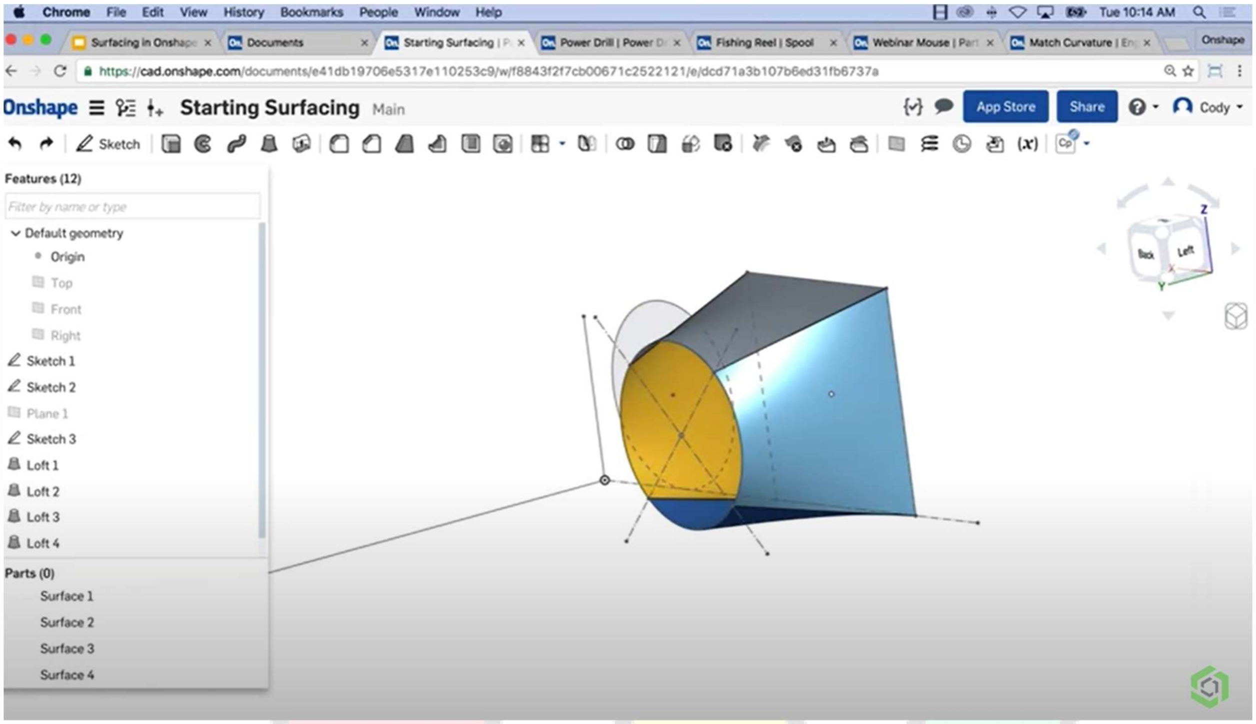
Sketch 3
Loft 1
Parts (0)
Surfaces (1)
Surface 1



Lesson 7 Practice

The mouse exercise from the video.

1. Create a mouse with just surfacing techniques
2. Use thicken tool and boolean to make the mouse a solid part

Lesson 7 Reflection

1. What was your approach to creating the mouse on Onshape? Why?
2. Based on what you heard from your classmates about their approaches, would you change anything about your original approach? Why or why not?
3. What was the most realistic part of your mouse design compared to the real thing? Why?
4. What was the least realistic part of your mouse design compared to the real thing? Why?
5. What was the most difficult part of making your mouse design? Why?
6. What was the easiest part of making your mouse design? Why?
7. If you had more time, what changes would you make to your mouse? Why
8. What's the hardest part about using Onshape for you so far? Why?
9. What's the easiest part about using Onshape for you so far? Why?

Lesson 8 Practice: Drawings

1. Choose one of your previous Onshape documents
2. Select a part from it

3. Create a technical drawing following this youtube video (maybe instead of giving them a video, ask them to find a video to learn from)

Lesson 8 Reflection

1. What was the hardest part about learning about Onshape features on your own?
2. What was the hardest part about finding a video

Beyond the Lessons

Future Development

At this point, they have learned a lot of what they can do in Onshape. The rest is just about practice. This practice will bring up the need for them to discover specific skills making them relevant at that time like importing models, changing materials, stress tests, etc. This practice will also now begin to grow the ability for them to learn about new Onshape skills independently just like the drawing assignment in lesson 8. This ability in particular is important because 1) you cannot teach them everything there is to know about Onshape and 2) there will come a time where Onshape will update its suite, and it is important for students to be able to keep up with or without a teacher present.

A good assignment for this is to tell them to pick a physical object that has a problem that is a nuisance and create an updated version of that object and fix the problem. I call this assignment Operation Kemet. For example, it is very easy to accidentally push remote control buttons because they are so high above the surface of the remote. My solution to this would be to redesign the remote control with indented buttons so that you cannot accidentally press those buttons as easily. **This assignment will test both their problem solving and CAD skills as they are not just copying a design but modifying it for the better**

You can also find images of different objects that will challenge their CAD capabilities on google or in the public Onshape gallery. You can also allow students to bring you images of things they would like to create and approve it based on the difficulty level. I rarely deny students a request; however, if I think it's too easy, I just ask them to pair it with another design so that they can get adequate practice

Additional Tips for Instructor

1. This guide isn't the Bible. You can adjust it however you see fit to cater to your students' needs.
2. Don't gloss over reflections. They are probably the second most important part of this curriculum outside of practice time. Make time for them. Use class time to write AND discuss reflection questions. Come up with your own reflection questions that you feel are more relevant to your students if you like.
3. Give your students TIME to actually practice the skills you teach them. Don't try to rush things forward by giving them answers so that they can finish faster.
4. Don't save them from the struggle. Let them persevere and come to find the answers with you only being a guiding presence. Their search for answers will only deepen their understanding
5. You're not the reason they learn. You're just there to facilitate the process by creating an environment and challenges conducive to learning.

6. You will feel useless at times because the better your students get, the less they will need you. That is great. That means you are doing well because they are becoming more independent. It means you have successfully taught them how to learn