Drawing, Outputs, and 3D Modeling (Solidworks)

Everyone should have at your desk:

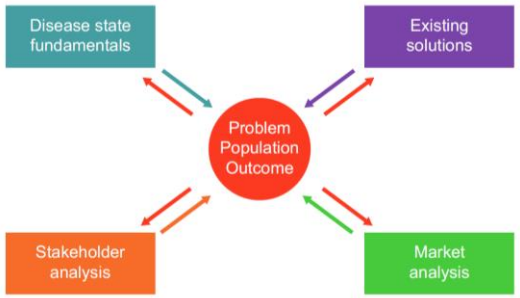
2 pieces of unlined paper

1 piece of grid paper

1 pencil

1 eraser

Optional: some tape to hold your papers in place



User Needs

User Need	Critical/ Non-Critical	Long/ Short Term	Design Requirement	Design Specification	Justification
1.1 Comfortable and safe for patients 0-2 years old	Critical	Long Term	Avoids laceration causing edges	Passes sharp edge test method according to **16 CFR 1500.49**	Passing the sharp edge test will ensure that our solution does not have laceration-causing edges that could harm the patient during the procedure. [16]

Design Requirement 1.1.1 Avoids laceration-causing edges

Given the unpredictable nature of an infant's movements, any solution produced must account for the possibility of the patient hitting the solution and potentially harming themselves. To account for this, we developed the design requirement that our solution must avoid laceration-causing edges. This design requirement has been classified as both long term and critical, as the solution will not be used in a clinical setting if it has the potential to harm the infant, especially when existing solutions are less likely to do so. Our solution will meet this design requirement if it can pass the sharp edge test method detailed in 16 CFR 1500.49, a standard for "Technical requirements for determining a sharp metal or glass edge in toys and other articles intended for use by children under 8 years of age".[16] The sharp edge test entails the use of a cylindrical mandrel covered in polytetrafluoroethylene (TFE), which will be in contact with an edge with a normal force of 6 N. If the edge cuts the tape by at least half an inch after one full revolution of the mandrel, the edge is considered sharp. Passing the sharp edge test will ensure that our solution does not have laceration-causing edges that could harm the patient during the procedure.

Design Input

Criteria	Current Design	Elastic Ring Holder	Multiple Loops	Bent Finger Holder	Weight
Safety	0	-1	0	-1	x3
Retractability	0	+1	+1	+1	x3
Component failure	0	-1	0	0	x3
Feasibility	0	+2	+2	0	x3
Holding capsule	0	0	0	0	x2
Release capsule	0	0	-2	0	x2
Bulkiness	0	+1	+1	+1	x2
Capsule stability	0	0	-2	0	x2
Cost	0	0	0	0	x1
Ease of Use	0	0	-1	0	-1
Visibility	0	+1	+1	+1	
Totals:	0	+6	+3	+3	

Much better: +2
Better: +1
Equal: 0
Worse: -1
Much worse: -2

Design Process

Brainstorming

Design Output

Verification

Validation

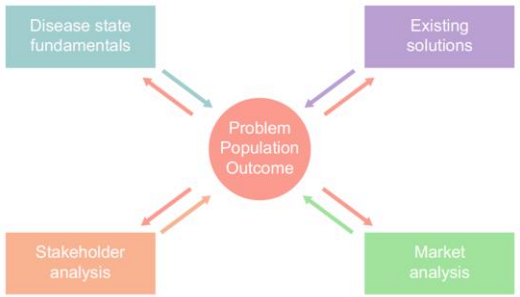
Review

Medical Device

Shift from Intro to Design and the FDA…
… to Detailed Design

Upon successful completion of this module, students should be able to:

1. **Visualize an object in 2D and 3D**
2. Use **Solidworks** to model a new part
3. Create an assembly with new and common parts
4. Develop an appropriate model, as a team, for their project
5. **Communicate** their design to a broad audience



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Feasibility	0	+2	+2	0	x3
Holding capsule	0	0	0	0	x2
Release capsule	0	0	-2	0	x2
Bulkiness	0	+1	+1	+1	x2
Capsule stability	0	0	-2	0	x2
Cost	0	0	0	0	x1
Ease of Use	0	0	-1	0	x1
Stability	0	+1	+1	+1	x1
Totals	0	+6	+3	+3	

Much better: +2
Better: +1
Equal: 0
Worse: -1
Much worse: -2

Design Process

Brainstorming

Review

Design Output

SOLIDWORKS

Verification

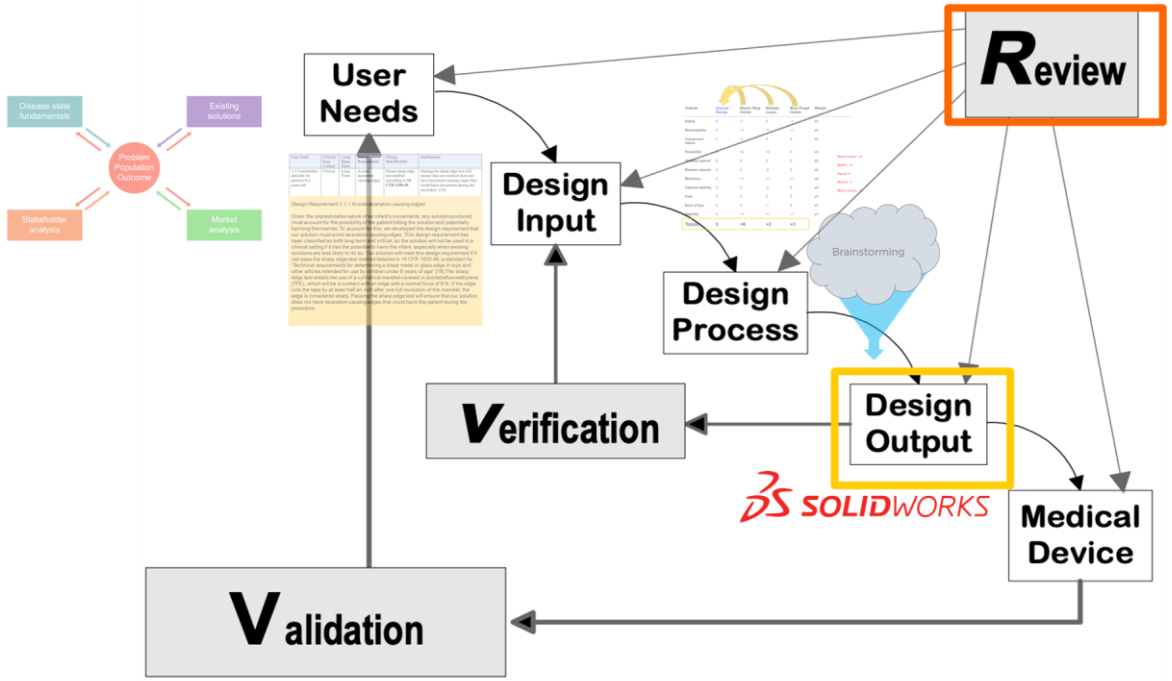
Validation

Medical Device

Preliminary Design Review

Slides due 9am the day of your Presentation

- Incorporate Feedback from User Needs and Design Inputs
- NEW content
  - Design Process
    - Pugh Matrices
    - Brainstorming overview
  - Design Outputs
    - **Final Design Layout**
    - **Solidworks**
  - Future Steps
    - Planning for COMSOL



Plan for Today

- Intro to Visual Communication
- Sketch!
  - 5 – 2 – 30!
- Draw!
  - Paper and a Straight Edge
  - Basic Shapes
  - 1- and 2-point perspective
  - Isometric
- *Break (around 3:30)*
- Intro to Design Outputs
- Solidworks 1 Tutorial introduction

Disclaimer:

I am not a trained professional in *teaching* art

I had a FANTASTIC Art Professor from Kendall College of Art and Design of Ferris State University

There is no right or wrong answer – only practice

Feel the tools and paper in your hand – your body, your style

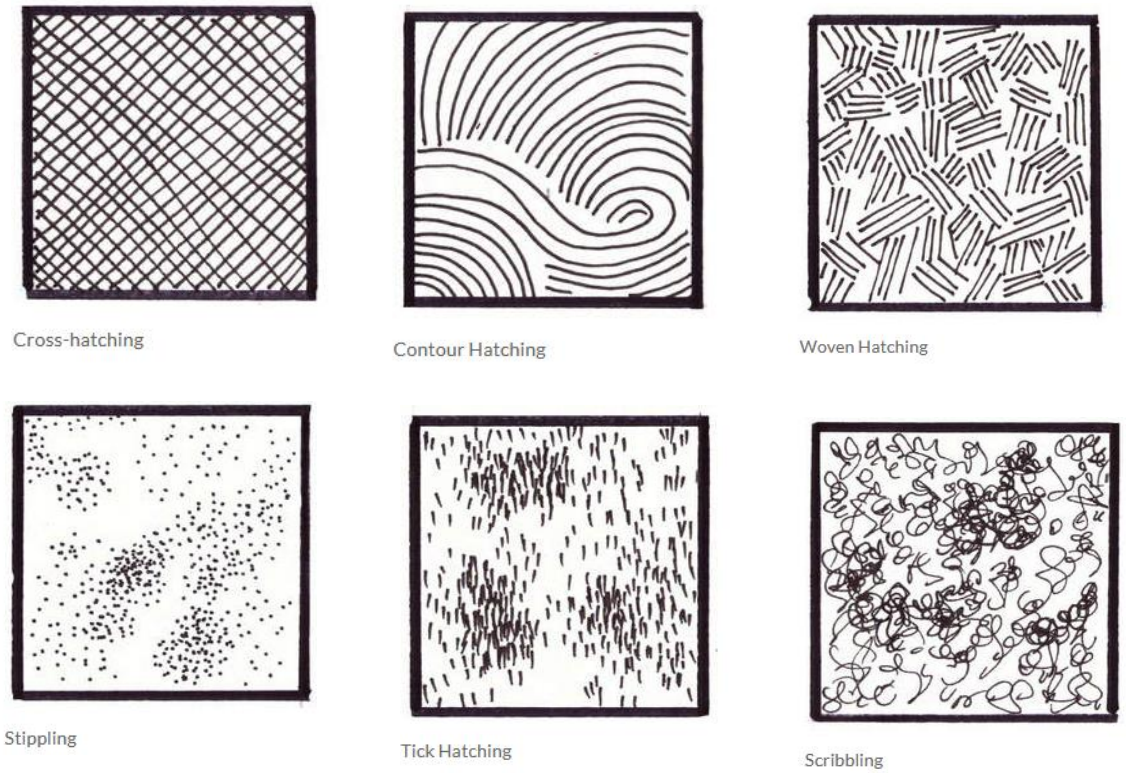
No one will be a masterful artist after this, BUT hopefully this will be helpful for the coming Solidworks assignments.

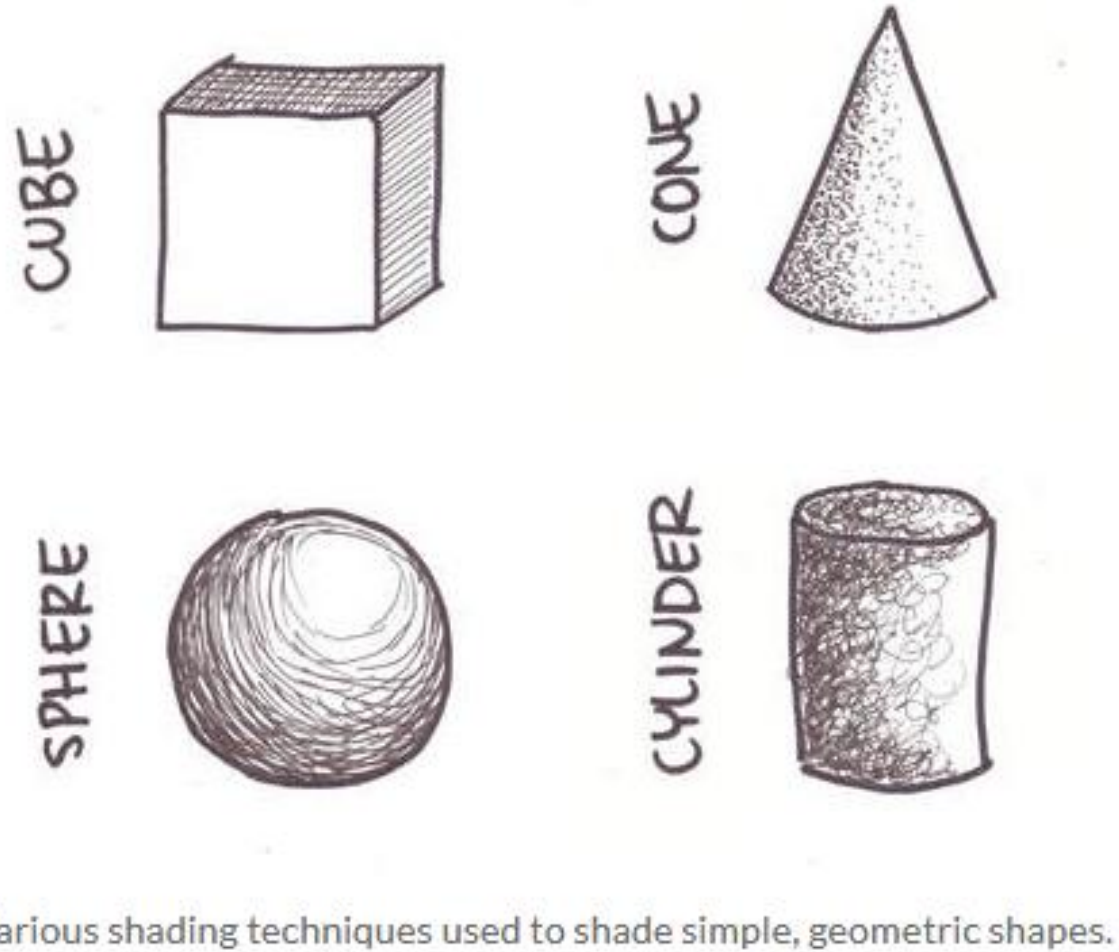
Visual Communication

Joseph F. Morey, Jr., CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons

Guide to Shading Techniques: Hatching, Cross-Hatching, Scribbling and Others

Erika Lancaster, 9/20/2017

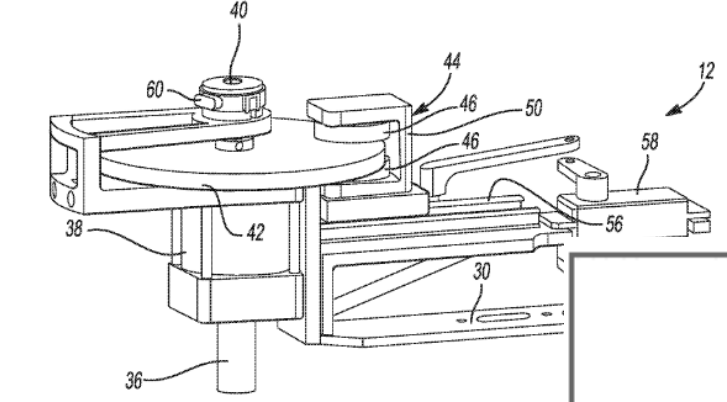




Various shading techniques used to shade simple, geometric shapes.

https://www.erikalancaster.com/art-blog/guide-to-shading-techniques-hatching-cross-hatching-scribbling-and-others

Now how about Drafting?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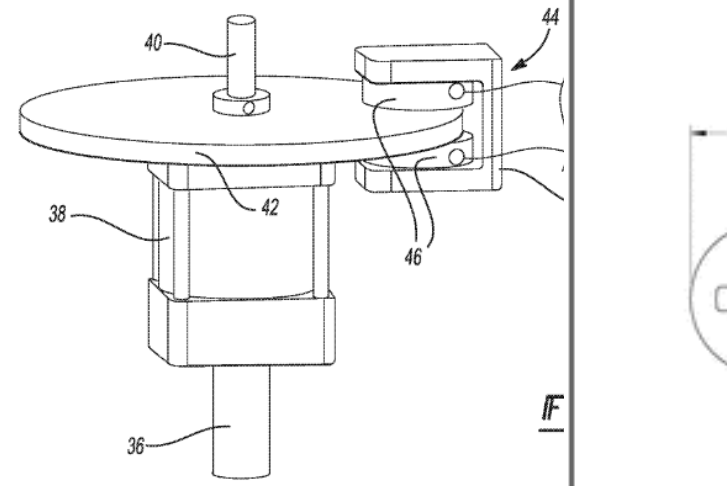
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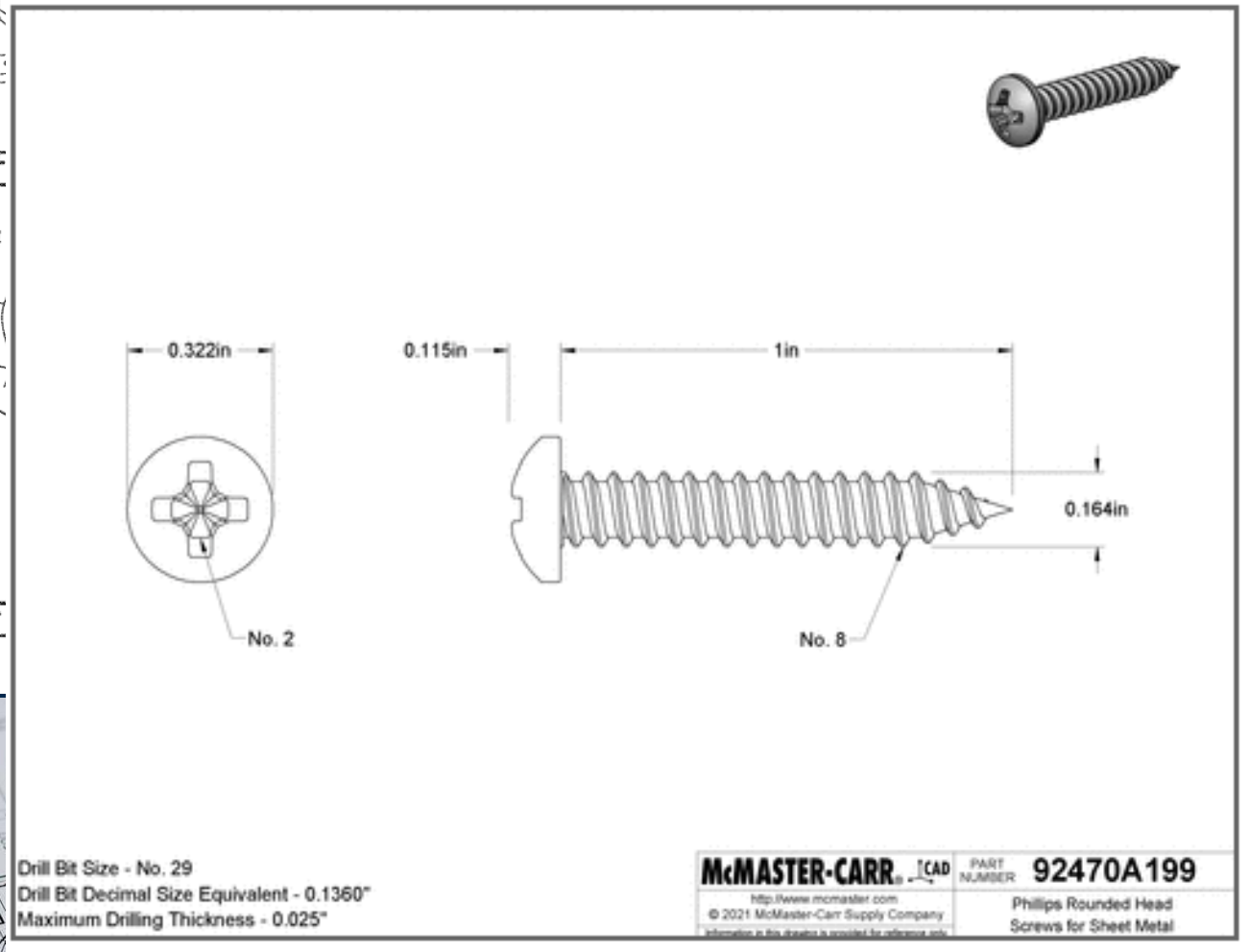

0.322in
0.115in
1in
0.164in
No. 2
No. 8
Drill Bit Size - No. 29
Drill Bit Decimal Size Equivalent - 0.1360"
Maximum Drilling Thickness - 0.025"
McMASTER-CARR
PART NUMBER 92470A199
Phillips Rounded Head Screws for Sheet Metal

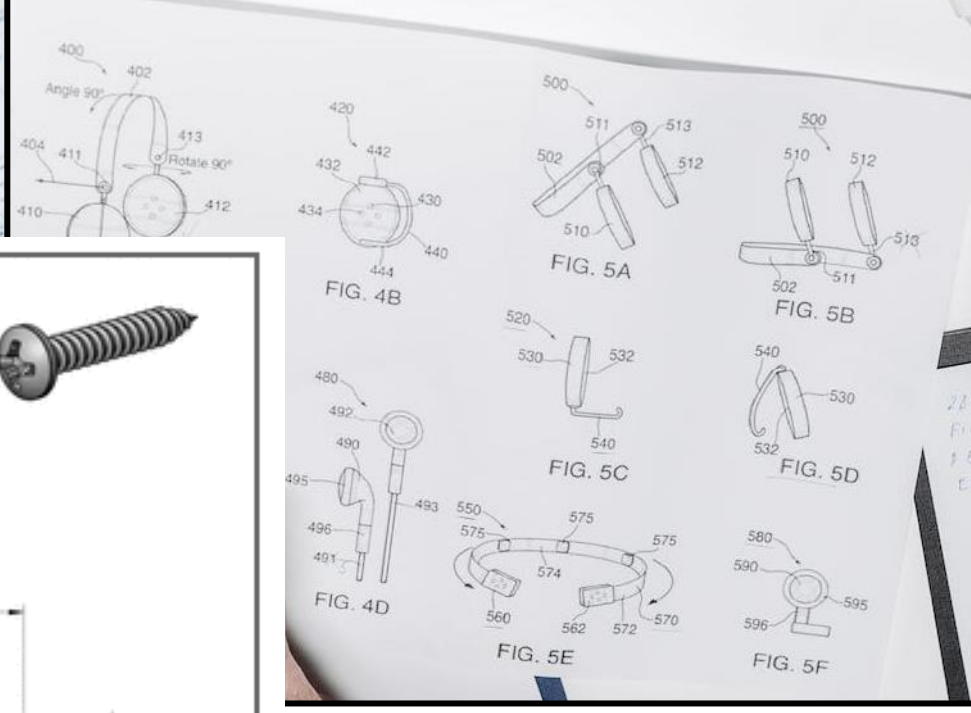
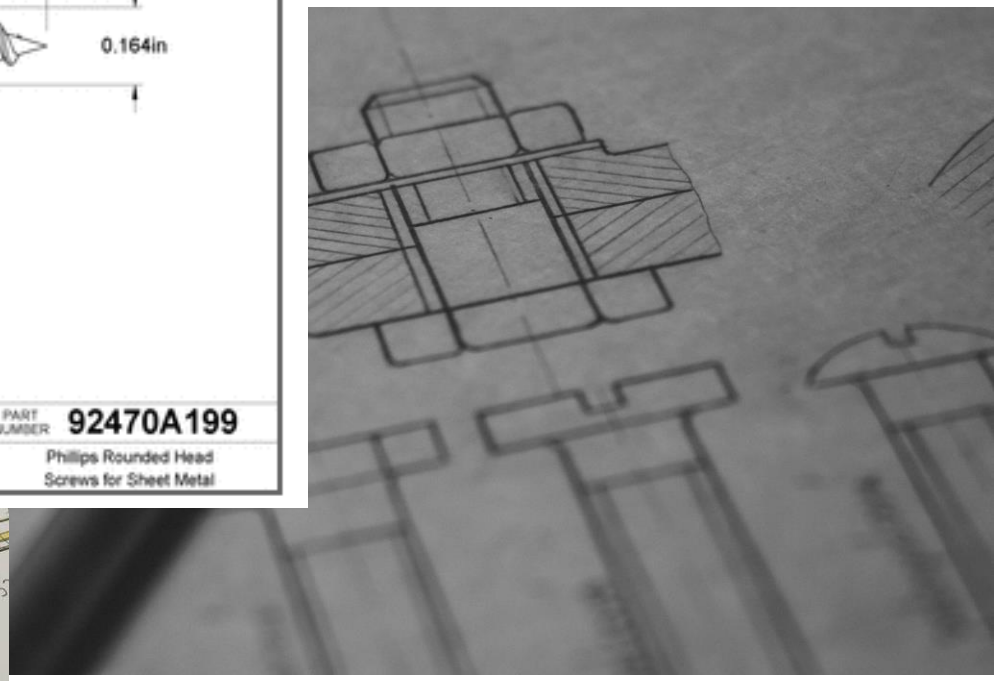


FIG. 4B
FIG. 5A
FIG. 5B
FIG. 4D
FIG. 5C
FIG. 5D
FIG. 5E
FIG. 5F



One More Disclaimer:

I am not a trained professional in *Architecture* or *Drafting*

I am not looking for precision and accuracy

(This is what Solidworks is for)

I will show techniques that, IF PRACTICED, could be considered drafting adjacent

No one will be an architect after this, BUT hopefully this will be helpful for the coming Solidworks assignments.

I *will* say that practicing scribbling, drawing, sketching, etc. will help your 3D visualization and modeling

(technically a hypothesis, with promising preliminary EER data to support it)

Let’s switch to the document Camera!

- Intro to Visual Communication
- Sketch!
  - 5 – 2 – 30
- Draw!
  - Paper and a Straight Edge
  - Basic Shapes
  - 1- and 2-point perspective
  - Isometric
- *Break*
- Intro to Design Outputs
- Solidworks 1 Tutorial introduction

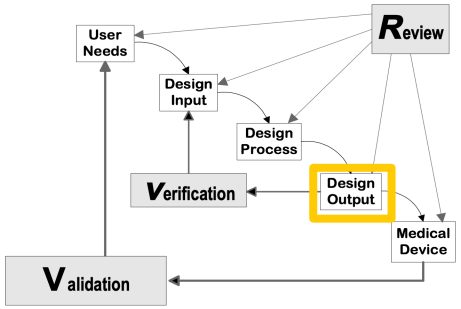
Take a 5-minute Break!

Versailles, France – August 2025

Plan for Today: Up Next

- Intro to Visual Communication
- Sketch!
- *Break*
- Draw!
- Intro to Design Outputs
- Solidworks 1 Tutorial introduction

What are Design Outputs?



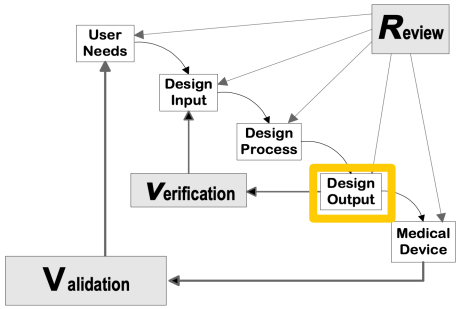
II. DEFINITIONS

§ 820.3(g) *Design output* means the results of a design effort at each design phase and at the end of the total design effort. The finished design output is the basis for the device master record. The total finished design output consists of the device, its packaging and labeling, and the device master record.

§ 820.3(y) *Specification* means any requirement with which a product, process, service, or other activity must conform.

Design output includes production specifications as well as descriptive materials which define and characterize the design.

SECTION D. DESIGN OUTPUT



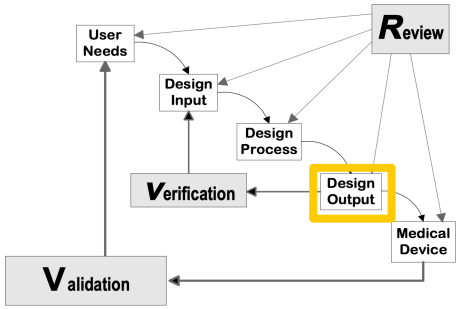
I. REQUIREMENTS

§ 820.30(d) Design output.

- Each manufacturer shall establish and maintain procedures for defining and documenting design output in terms that allow an adequate evaluation of conformance to design input requirements.
- Design output procedures shall contain or make reference to acceptance criteria and shall ensure that those design outputs that are essential for the proper functioning of the device are identified.
- Design output shall be documented, reviewed, and approved before release.
- The approval, including the date and signature of the individual(s) approving the output, shall be documented.

Cross-reference to ISO 9001:1994 and ISO/DIS 13485 section 4.4.5 Design output.

In other words

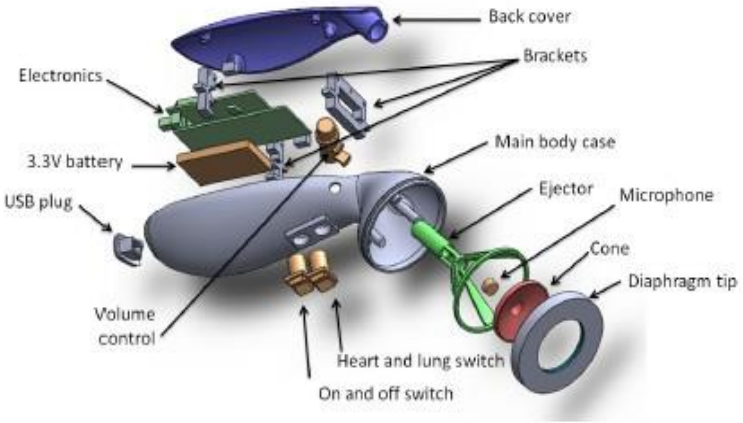


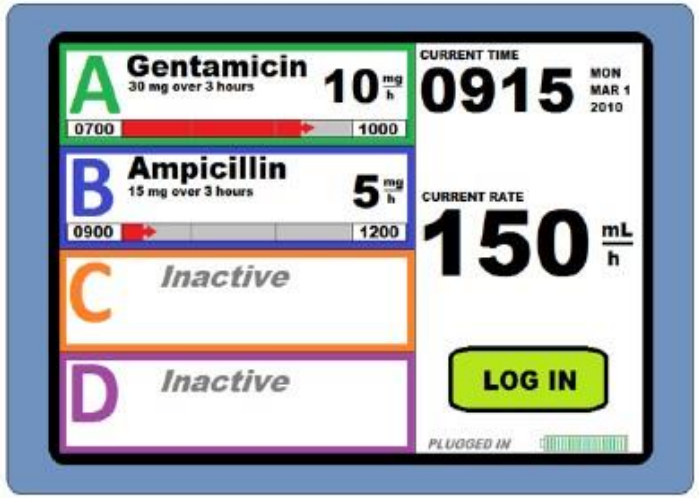
You have **justified** that your "Final" device **choices** matches what you set out to do!

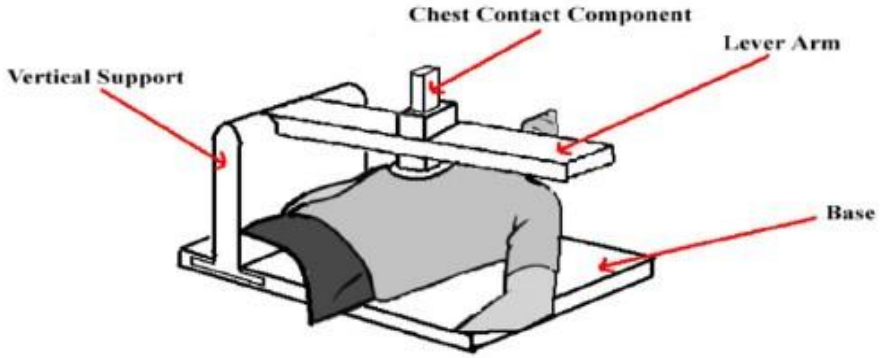
Your Outputs *are expected* to match your Inputs!

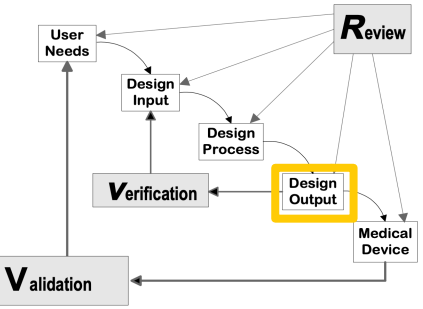
Design Inputs			**Design Outputs**
Design requirements	Target Specifications	Justifications	
Weight	< 15 lbs	[references]	Geometry & Material choice calculated to be: Weight = 13.2 lbs
Temperature (functioning)	0 F – 120 F	[references]	Sensors chosen that: Functional in -10F to 130F
Effects on cell viability	< 30% reduction	[references]	Material effective in literature review chosen

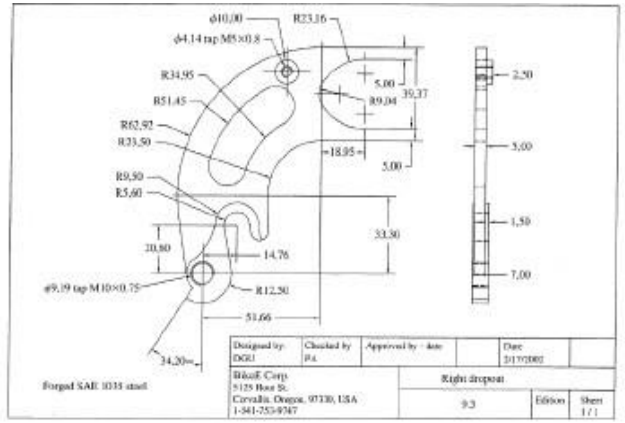
Example Outputs – details & big picture

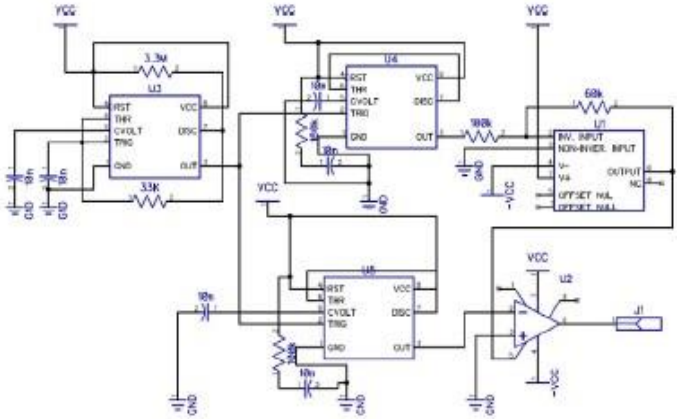




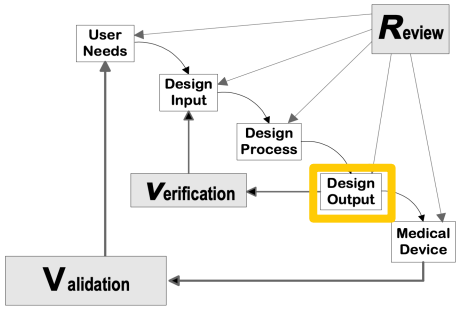








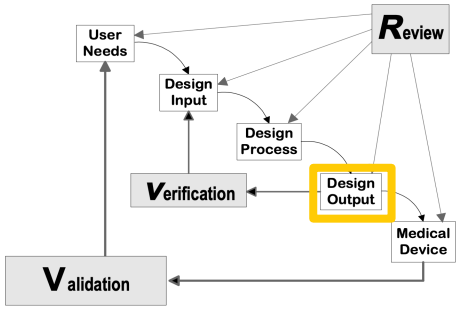
Drawings, Models, and Explanations



- **Dimensions** of device and parts
- **Materials**
- Off-the-shelf **parts**
  - Manufacturer, model number, thread size, head shape
  - In Solidworks 3, be sure to include the screws and washers you get from McMaster Carr in your Canvas submission!
- Connections between materials/parts
- Fabrication plans
- Technical Drawings

...all with sufficient **detail for someone else to build**!

Geometric Dimensioning & Tolerancing



- ASME Y14.5-2018 Dimensioning and Tolerancing
- ISO 1101 Geometrical Product Specifications

Figure C-2 Form and Proportion of Geometric Characteristic Symbols

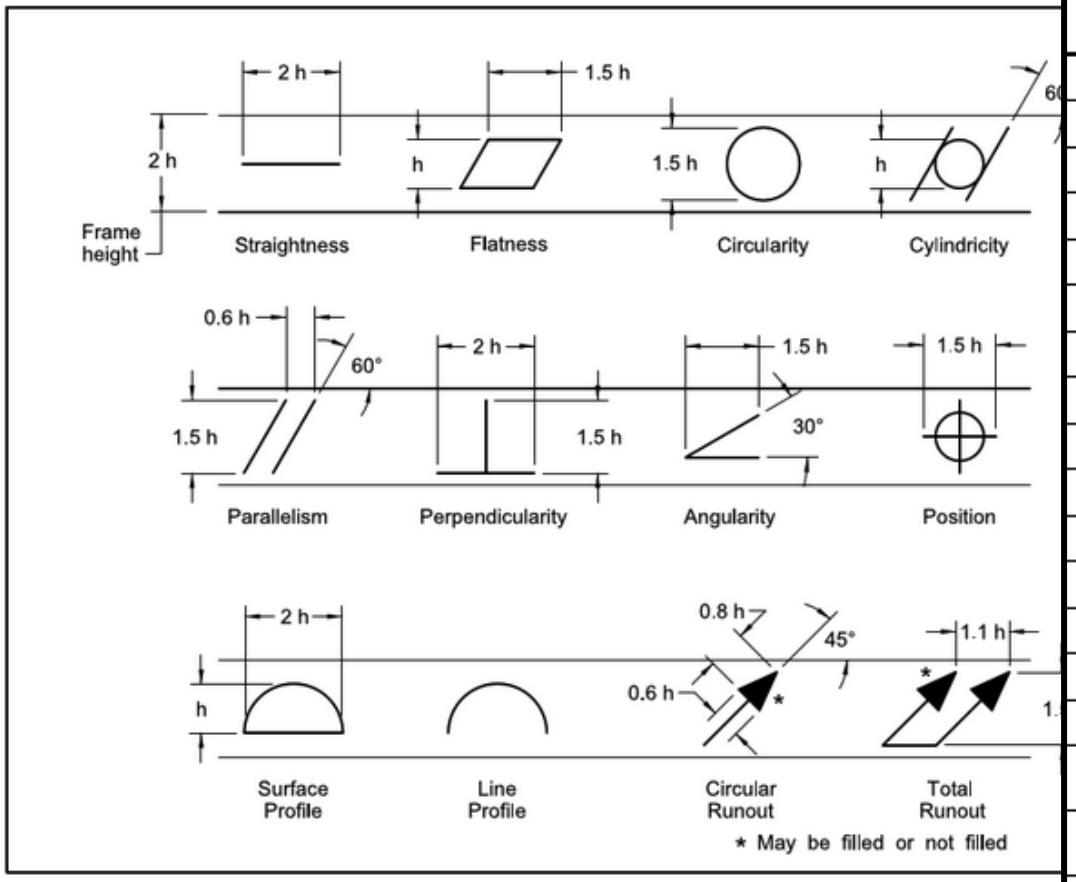
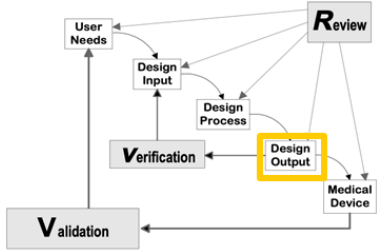


Figure C-6 Comparison of Symbols

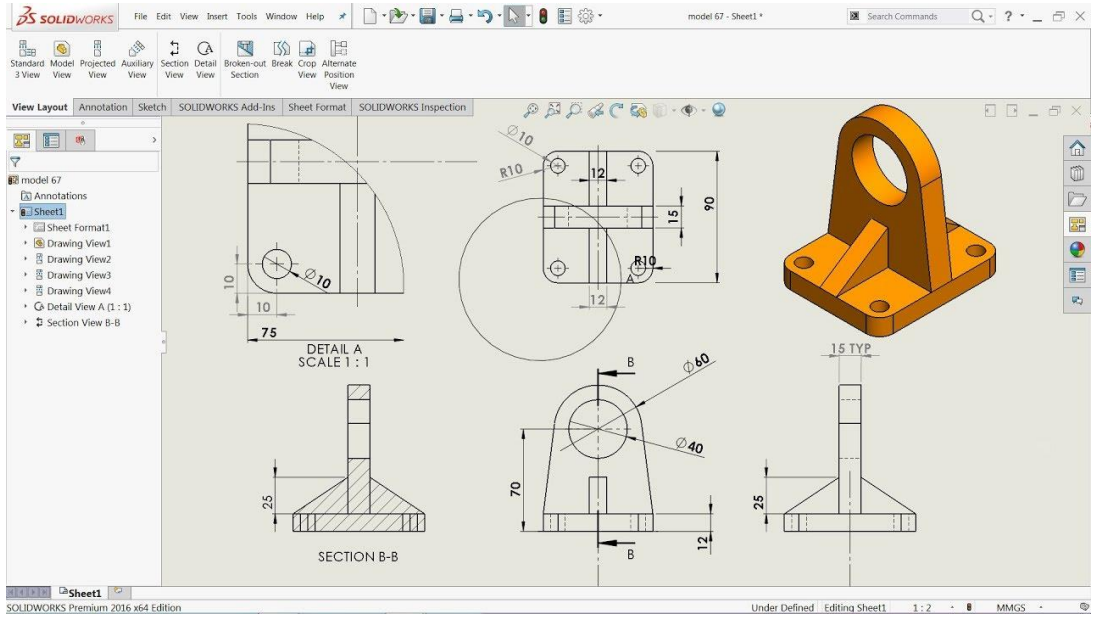
SYMBOL FOR	ASME Y14.5	ISO
STRAIGHTNESS	—	—
FLATNESS	▱	▱
CIRCULARITY	○	○
CYLINDRICITY	⌭	⌭
ANGULARITY	∠	∠
PERPENDICULARITY	⊥	⊥
PARALLELISM	//	//
POSITION	⌖	⌖
CONCENTRICITY and COAXIALITY	NONE	◎
SYMMETRY	NONE	⌯
PROFILE OF A LINE	⌒	⌒
PROFILE OF A SURFACE	⌓	⌓
CIRCULAR RUNOUT	*↗	↗
TOTAL RUNOUT	*⌰	⌰
ALL AROUND		
ALL OVER		
AT MAXIMUM MATERIAL CONDITION		Ⓜ



SOLIDWORKS

One of many Computer Aided Design (CAD) softwares

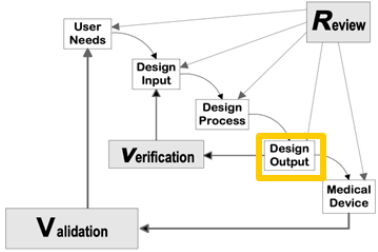
- NX
- Sketchup
- Blender
- OnShape



A **solid modeling**, **parametric** platform

https://www.autodesk.com/solutions/parametric-modeling

Why Solidworks? LOT of resources



DASSAULT SYSTEMES

> Welcome to SOLIDWORKS Online Help

SOLIDWORKS Help

- Welcome to SOLIDWORKS Online Help
- Help
- Legal Notices
- Administration
- User Interface
- Fundamentals
- Working with the 3DEXPERIENCE Platform and 3DEXPERIENCE Apps
- Moving from 2D to 3D
- Assemblies
- CircuitWorks
- Configurations
- SOLIDWORKS Costing
- Design Checker
- Design Studies in SOLIDWORKS
- Detailing and Drawings
- SOLIDWORKS File Utilities
- DFMXpress
- DriveWorksXpress
- FloXpress
- Import and Export
- Using 3DEXPERIENCE Marketplace |

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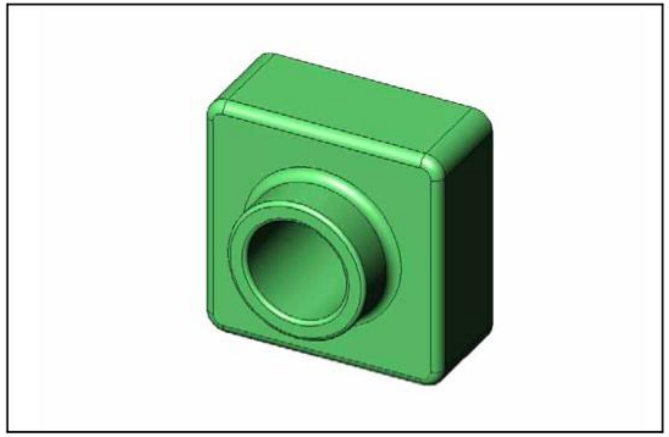
Student's Guide to Learning SolidWorks® Software



Dassault Systèmes - SolidWorks Corporation
300 Baker Avenue
Concord, Massachusetts 01742 USA
Phone: +1-800-693-9000

Outside the U.S.: +1-978-371-5011
Fax: +1-978-371-7303
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Tutorial 3 – How to create simple box
Tutorial 4 – How to create simple plate
Tutorial 5 – How to create allen key
Tutorial 6 – How to create 17" wheel
Tutorial 7 – How to sheet metal part
Tutorial 8 – How to create spring
Tutorial 9 – How to engrave text
Tutorial 10 – How to create hex bolt
Tutorial 11 – How to create helical gear
Tutorial 12 – How to create aeroplane wings
Tutorial 13 – How to create turbo fins
Tutorial 14 – How to create U bracket
Tutorial 15 – How to create bottle cap
Tutorial 16 – How to create usb head
Tutorial 17 – How to twist phone cord
Tutorial 18 – How to engrave text

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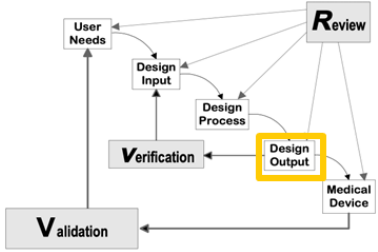
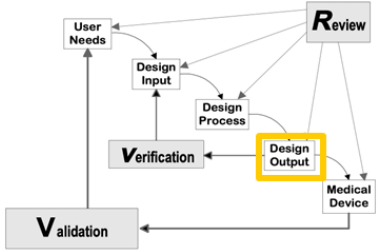
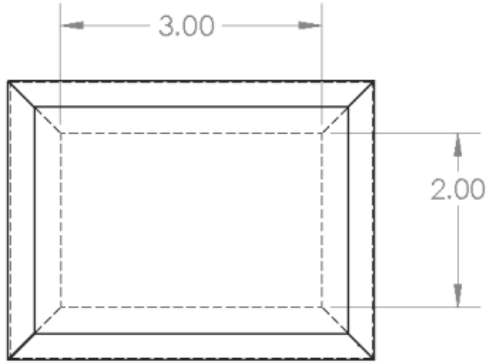
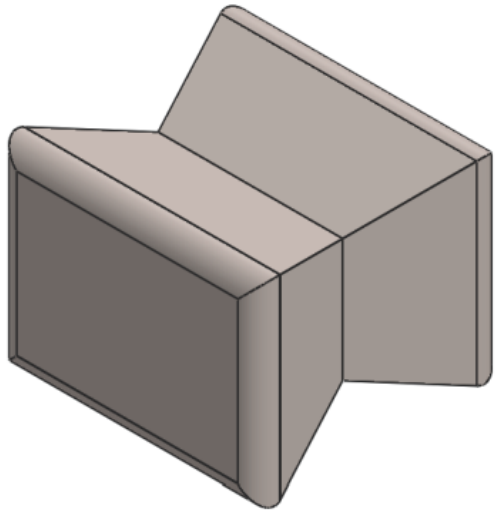
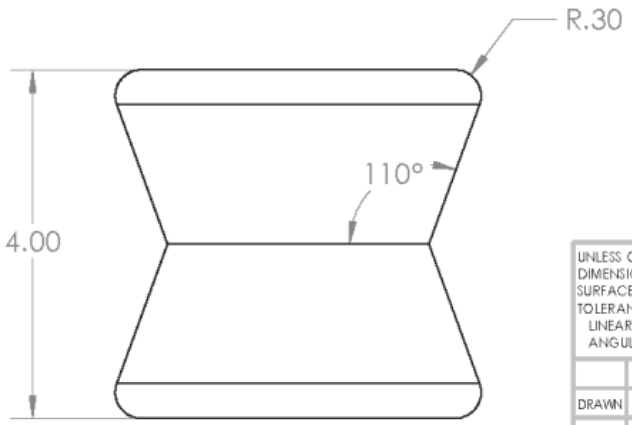


- Learning the Solidworks Interface (no *saved* files involved)
- Part 1 part (Part1.sldprt) and technical drawing (Part1.slddrw)
- Part 2 part (Part2.sldprt)
- Part 3 part (Part3.sldprt)
- Part 4 part (Part4a.sldprt, Part4b.sldprt) and assembly (Part4.sldasm)
- See **Grading checklist** at end of **Objectives and Grading document**









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	NAME	SIGNATURE	DATE			TITLE:	
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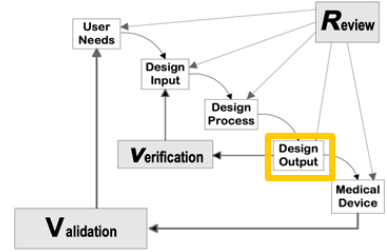
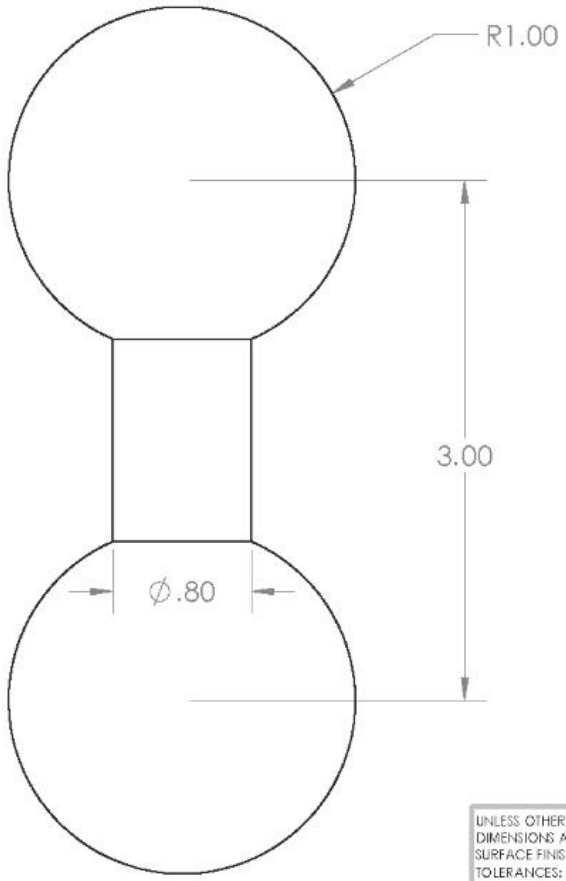
CHK'D							
APPV'D							
MFG							
Q.A				MATERIAL:		DWG NO.	A4
						Part1	
				WEIGHT:		SCALE:1:2	SHEET 1 OF 1

Include Units and Materials!





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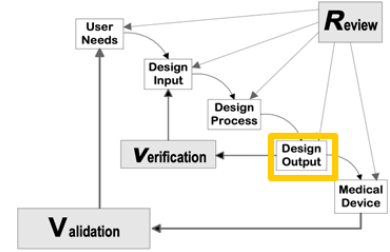

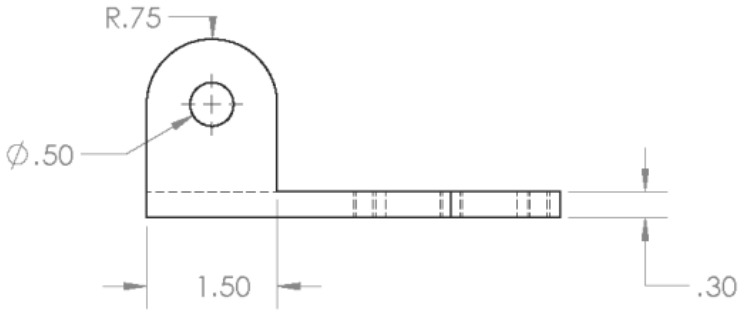

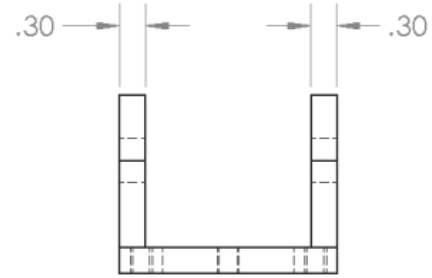

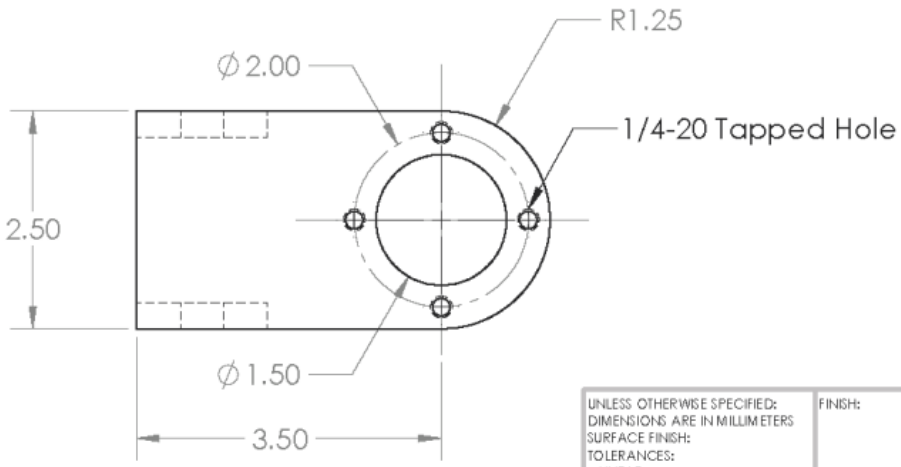

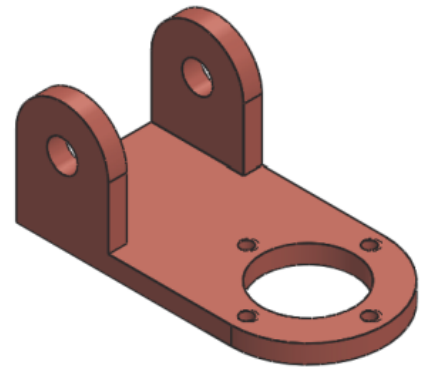

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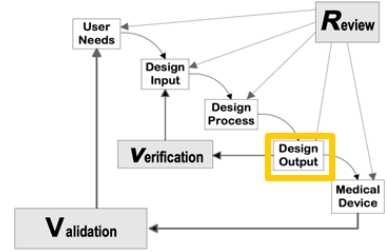

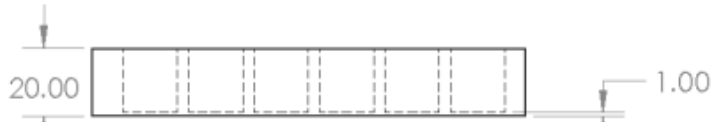

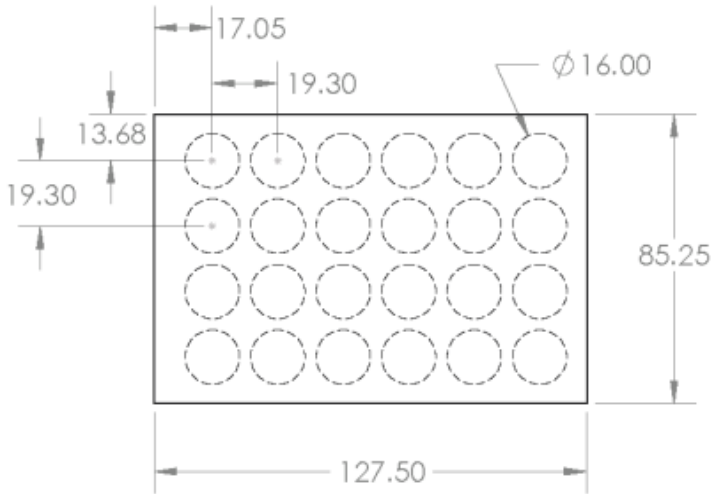

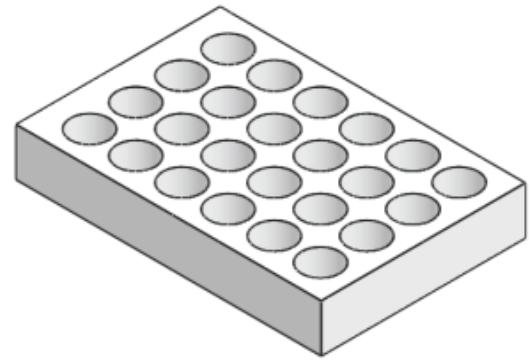

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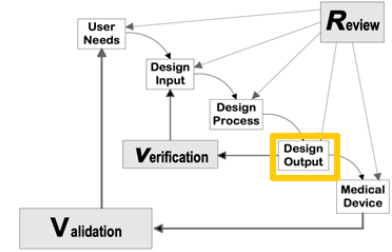
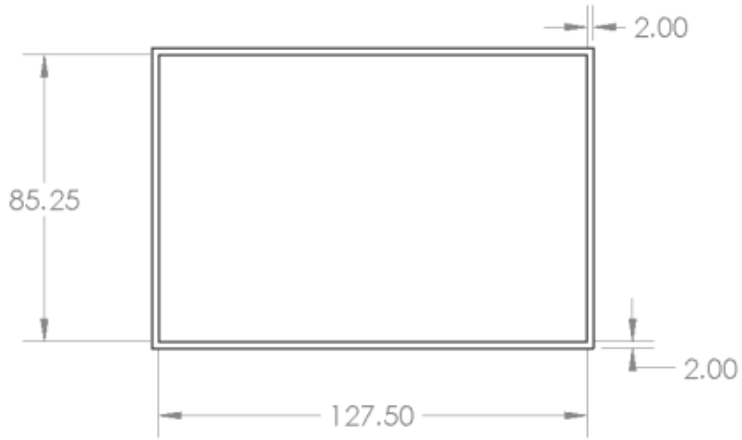
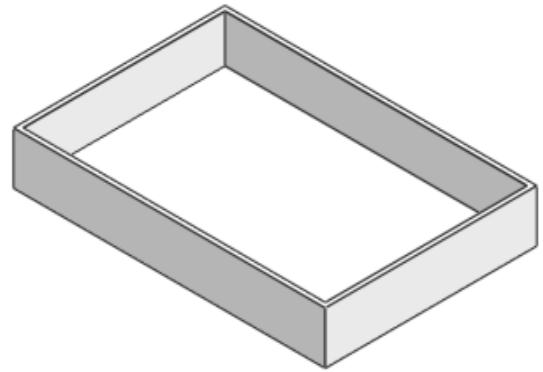
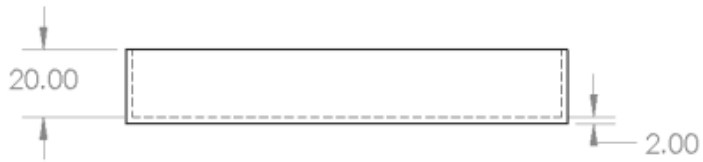
				WEIGHT:		SCALE:1:2	SHEET 1 OF 1









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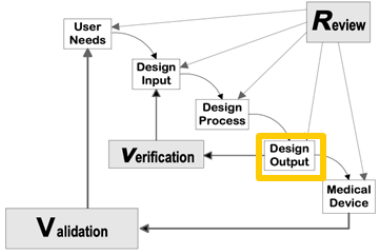
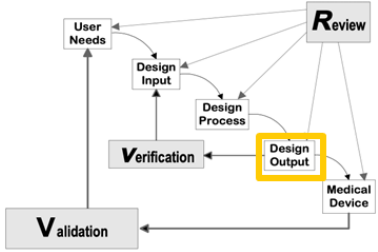
APPV'D							
MFG							
Q.A				MATERIAL:		DWG NO. Part4B	A4
				WEIGHT:		SCALE:1:2	SHEET 1 OF 1

Solidworks Tutorial #1



- Learning the Solidworks Interface (no *saved* files involved)
- Part 1 part (Part1.sldprt) and drawing (Part1.slddrw)
- Part 2 part (Part2.sldprt)
- Part 3 part (Part3.sldprt)
- Part 4 part (Part4a.sldprt, Part4b.sldprt) and assembly (Part4.sldasm)
- **See Grading checklist at end of Objectives and Grading document**

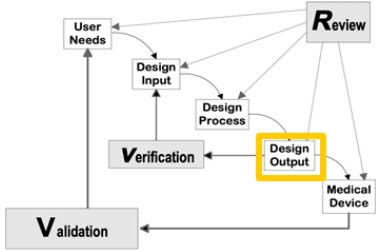
3 Solidworks Tutorials & Outputs for PDR



- Each tutorial is your computational (individual assignment)
- Expected that beyond the class time for Solidworks, you and your team develop models of product for PDR

Mon	2/2/2026	Drafting, 3D visualization, & Outputs	**Preliminary Design Review** Solidworks 1,2,3 In Class: sketches	
Wed	2/4/2026	Assignment work time (Solidworks 1&2)		Solidworks 1
Mon	2/9/2026	Brainstorming & Process Check-in: Delivery and Geometry Assignment work time (Solidworks 2)		Solidworks 2
Wed	2/11/2026	V&V Intro + Solidworks 3 work time		
Mon	2/16/2026	Assignment work time (Solidworks 3 / PDR)		Solidworks 3
Wed	2/18/2026	Teamwork Check-in & MATLAB	MATLAB HW	
Mon	2/23/2026	**Preliminary Design Review**	CATME Peer Reviews	**Preliminary Design Review Slides - Due 2pm**
Wed	2/25/2026	**Preliminary Design Review**		**Preliminary Design Review Slides - Due 2pm** CATME Peer Reviews Due 2/27 11:59pm

Consider how to split the modeling work



Hip

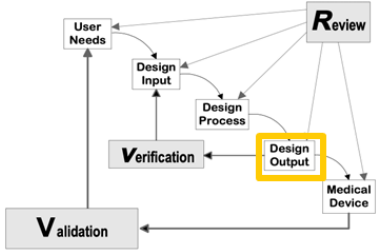
- Splitting the hip implant into pieces
  - Acetabular cup, lining, femoral head, femoral stem?
- Modeling a Femur
  - Will need for COMSOL

Bypass

- Making a peripheral artery with a bypass
- Peripheral artery **without** a bypass

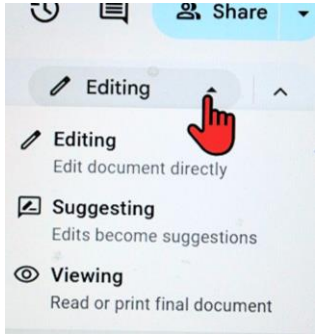
BOTH: sketch out plans BEFORE trying to model them
Where will drug/growth factor *go* on the model?
What are the dimensions you need? What basic shapes should you start with?

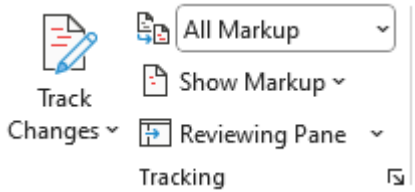
Assigning Tasks & Version Control
Communication & Labeling are Key!



Documents

- Name-date.docx
- Name-v1.docx
- Name-subpart-v1.2.docx
- Google version history
  - Suggestion Mode
  - Comments
- Microsoft Word Track Changes (Review)





Software Files

- Consider: Main and branches
  - Main is most stable version
  - Branches – “checked out” versions being edited.
- Solidworks has “rollback” options within a file

Consider how you want to communicate and organize so that one person is not stuck with the whole part/piece of a project

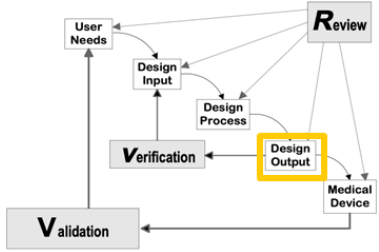
Trunk/Main can branch then merge

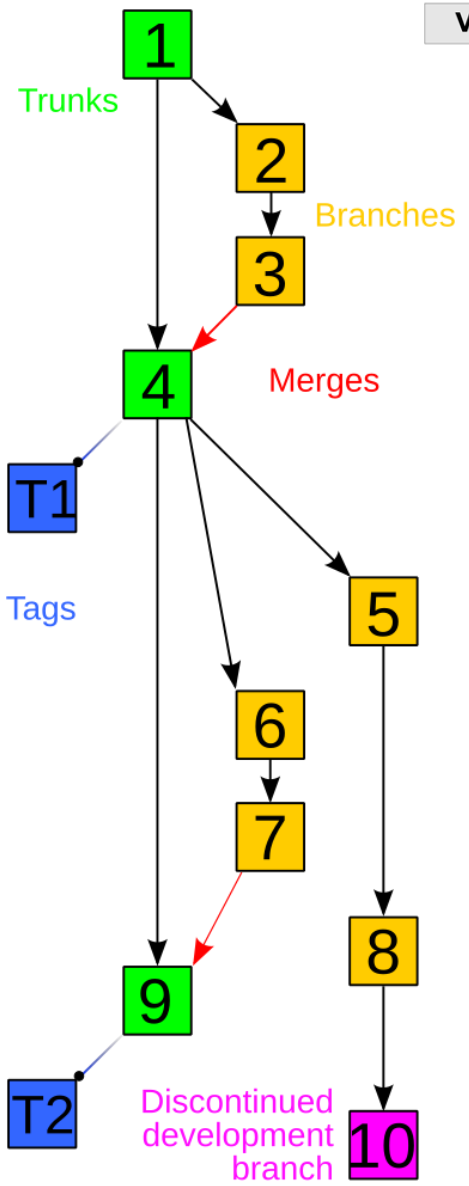
Once a branch becomes ~final, you can put it back into the main folder, and put the old “main” into a “prior versions” folder

- Part 1
  - Part1_v3.sldprt
  - Branches(folder)
    - Par1_V3.1
  - Older versions (folder)
    - Part1_v2.sldprt
    - Part1_v1.sldprt

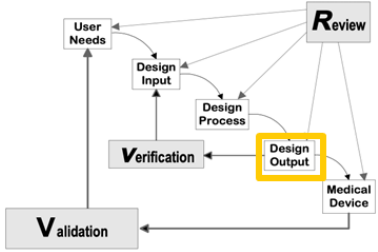
If you choose this route, consider “Checkout” and “Check-in” folders, texts, notes, or some kind of Communication with team.
(more examples: https://serengetitech.com/tech/introduction-to-git-and-types-of-version-control-systems/)

Avoid being stuck for days! Check something back in and let someone else work on it!





Next Two Weeks



- Solidworks Tutorial Resources
  - video
  - handout
  - Teaching team will be available to help troubleshoot during class
- If you finish your tutorial early
  - Work towards your project!
    - Brainstorming and researching Geometries
    - Split the implant/bypass into multiple parts for Solidworks?

There will be a few slides to introduce tutorials AND keep us on track for the PDR and add context for the PDR Rubric

Otherwise, use these classes as open office hours

Supplemental Slides

Originally, the art class was by itself and had time to cover a supplemental tool, an app called Spatial Vis

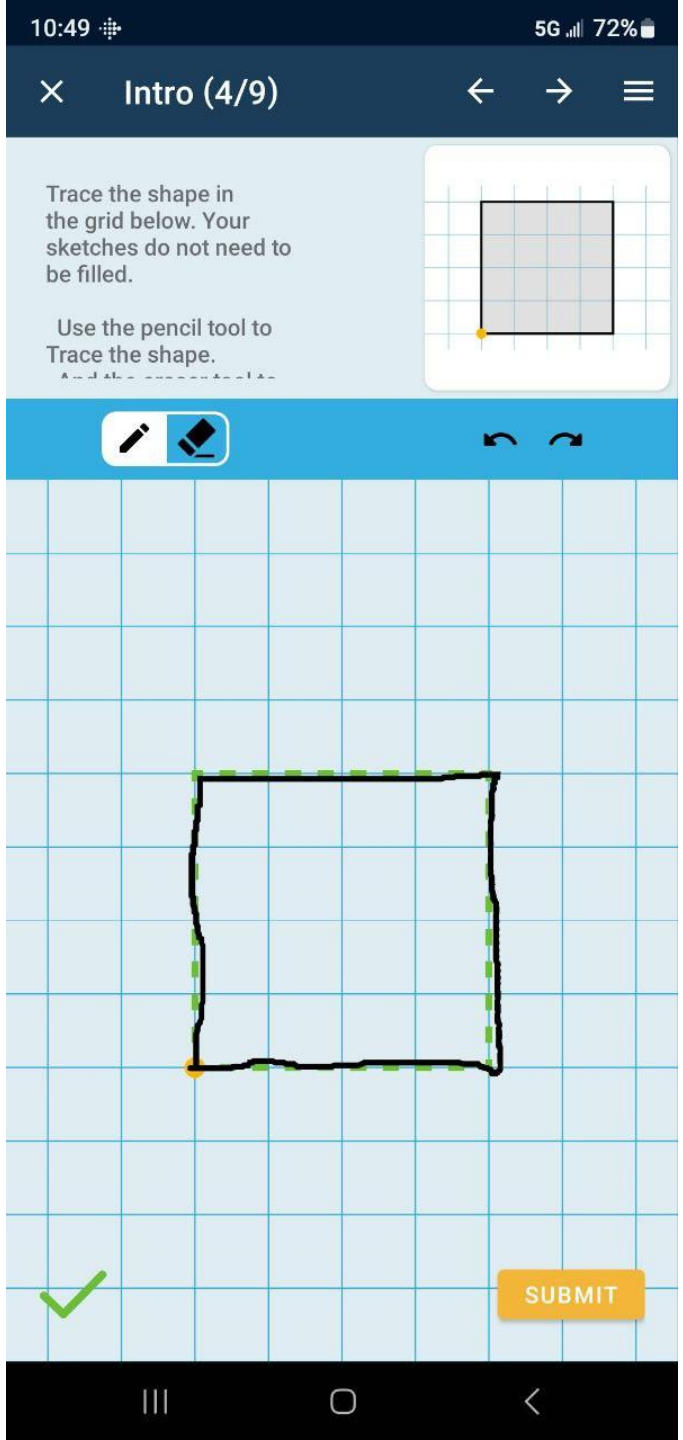
No time to cover this year, but in case you're interested see the following slides

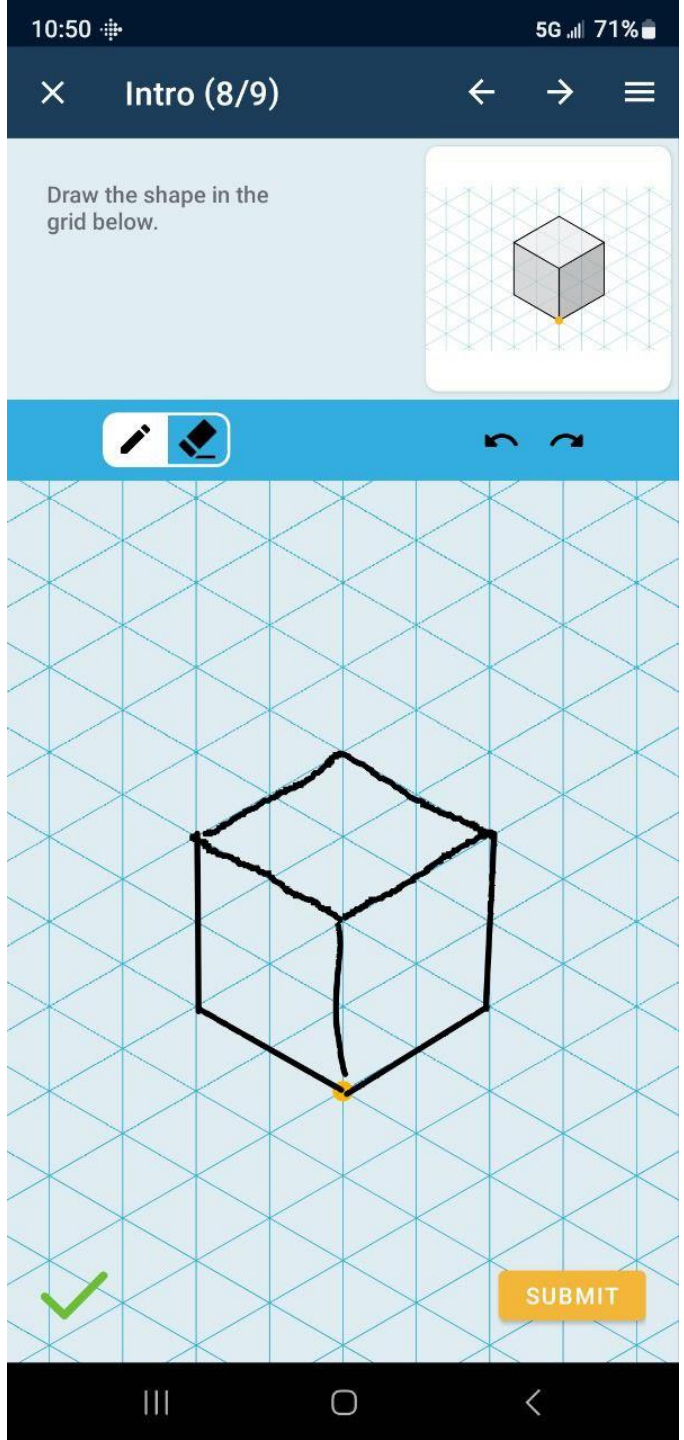
Spatial Vis App

Spatial Vis

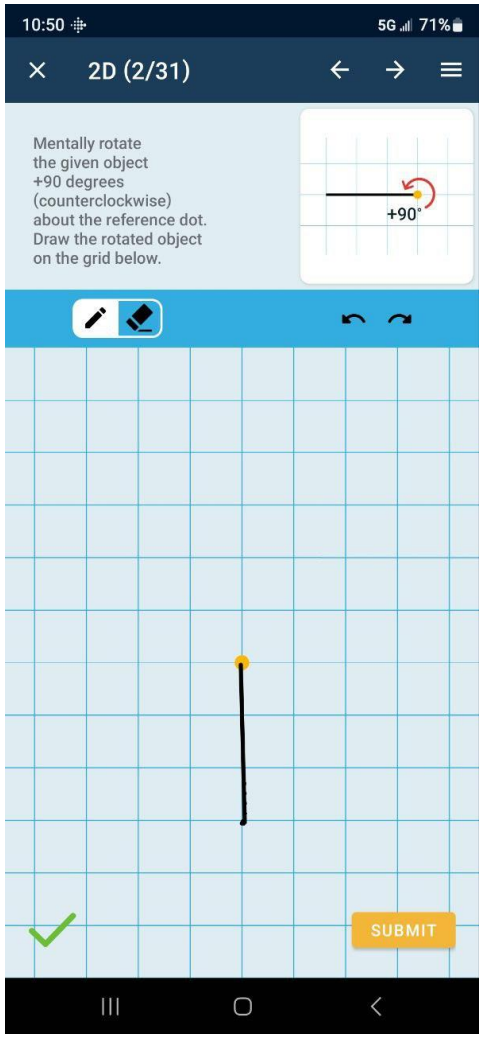
- *Suggested* Lessons
  - Intro
  - 2D Rotations
  - Iso Cubes
  - Ortho Cubes
  - 2D to 3D
  - Slopes and Curves
  - Assembly

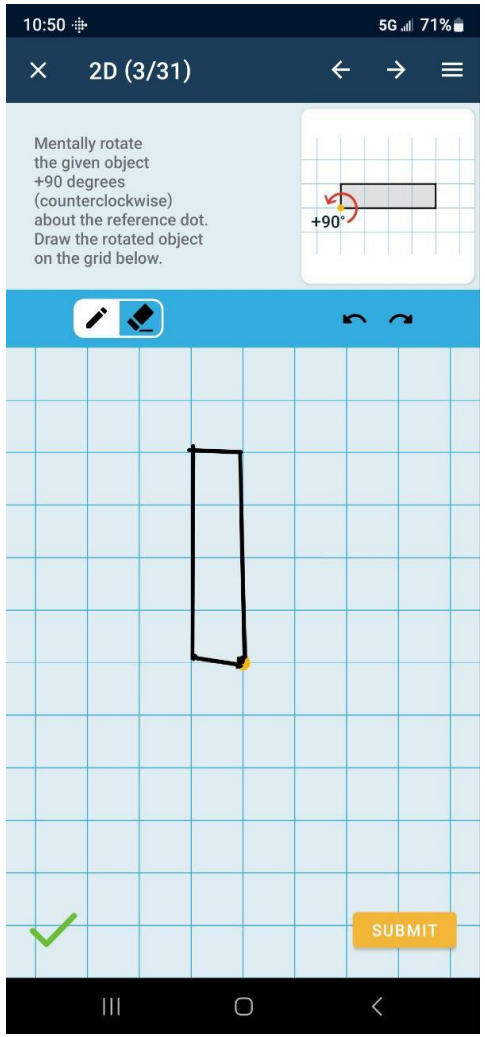
Intro

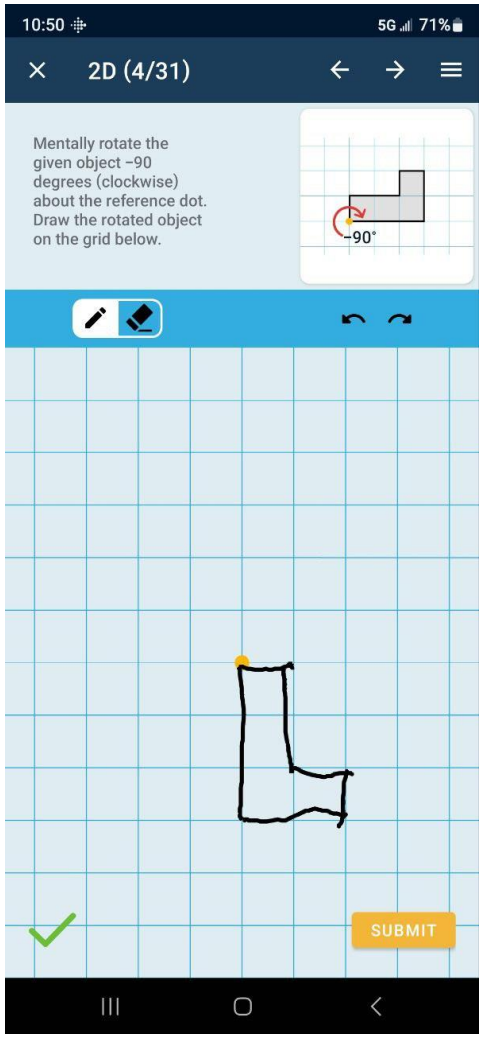

10:49
5G 72%
Intro (4/9)
Trace the shape in the grid below. Your sketches do not need to be filled.
Use the pencil tool to Trace the shape.
SUBMIT

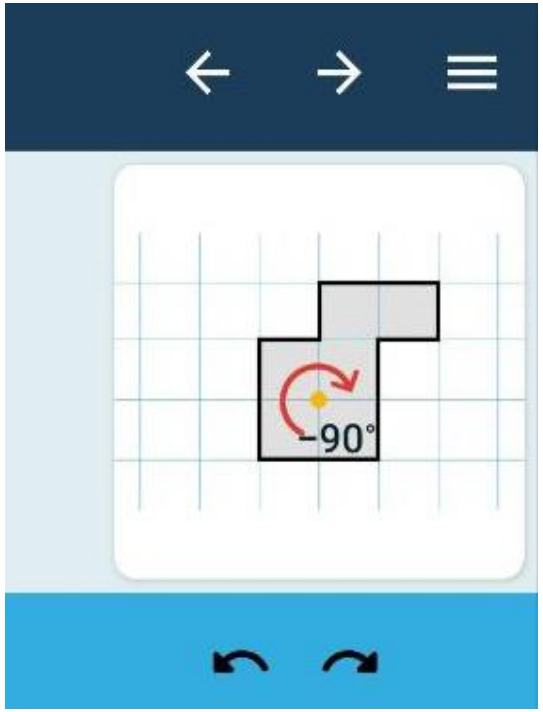

10:50
5G 71%
Intro (8/9)
Draw the shape in the grid below.
SUBMIT

2D rotations

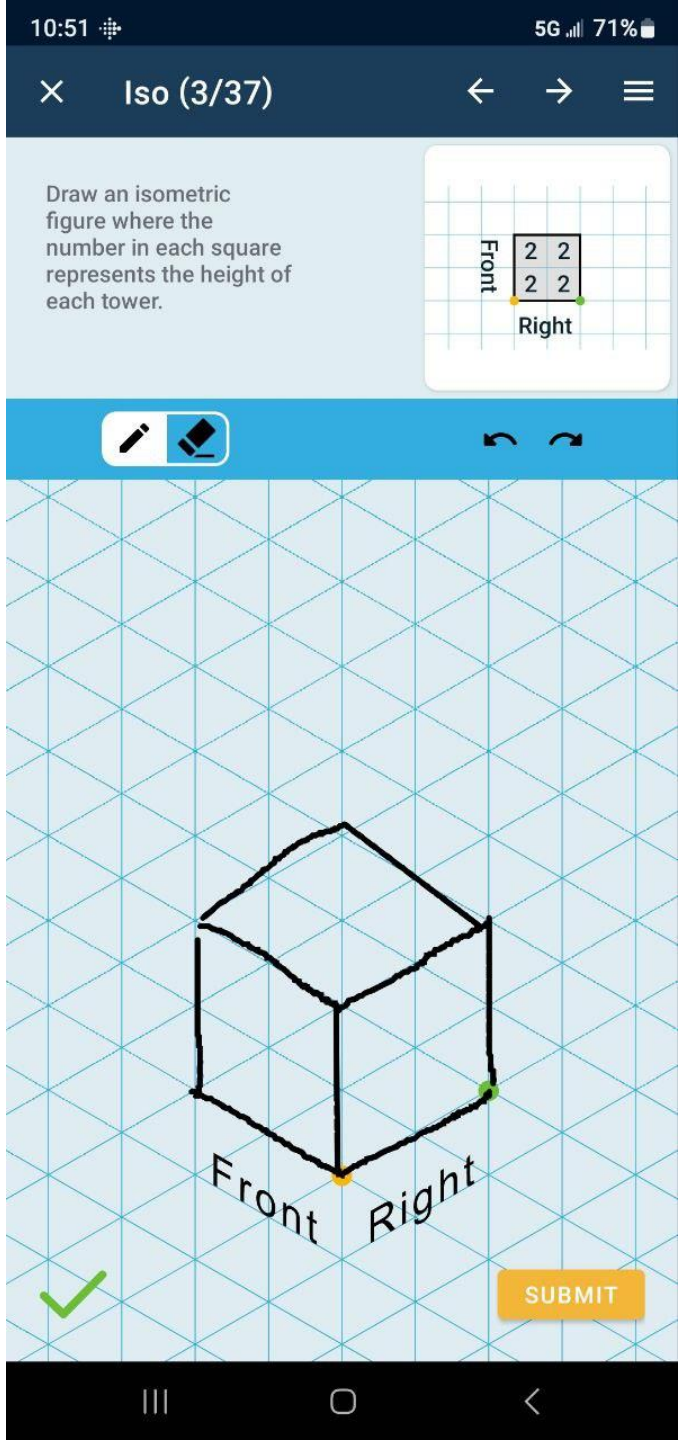


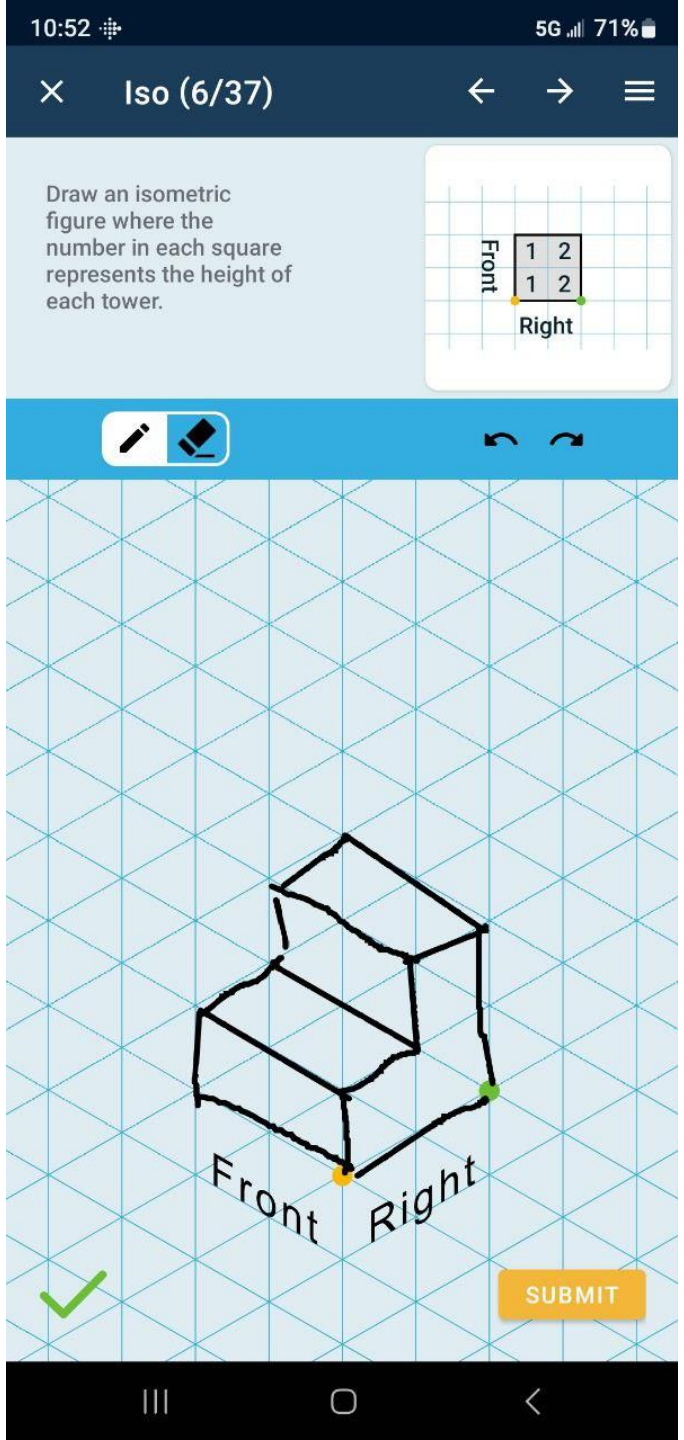


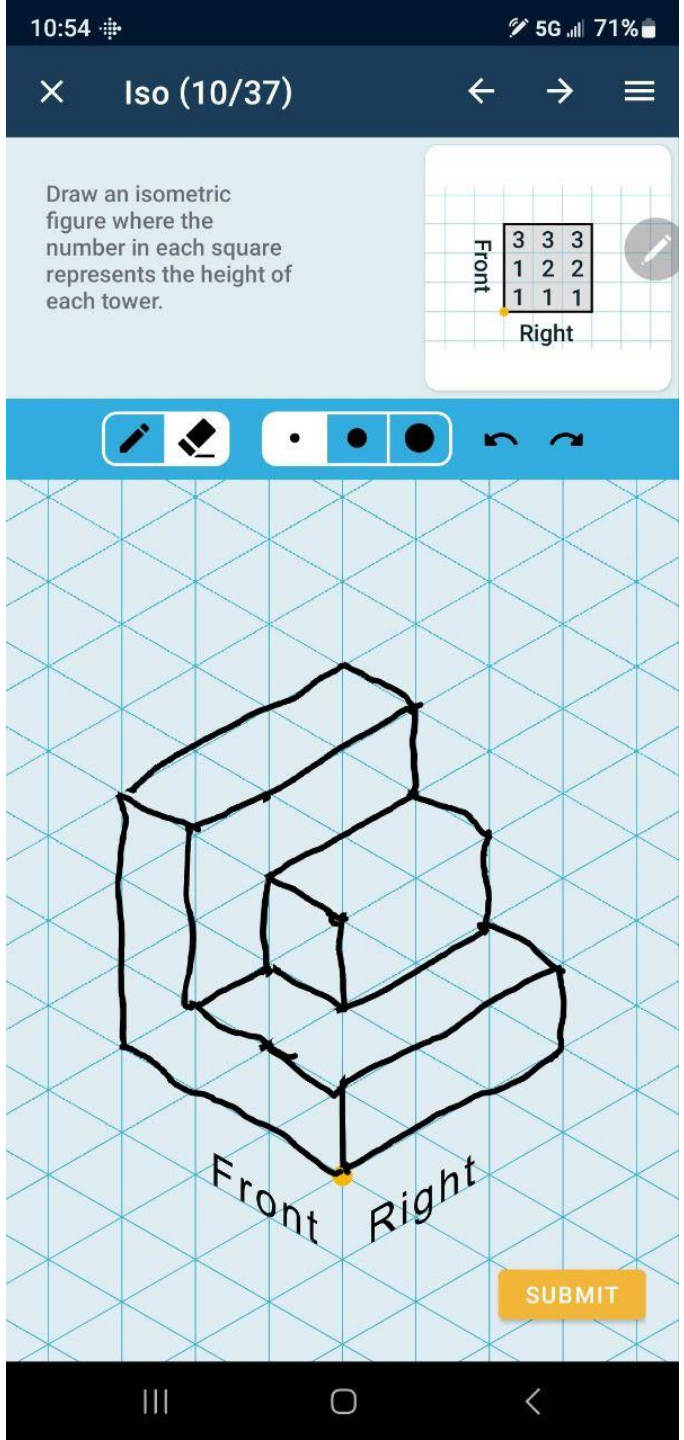




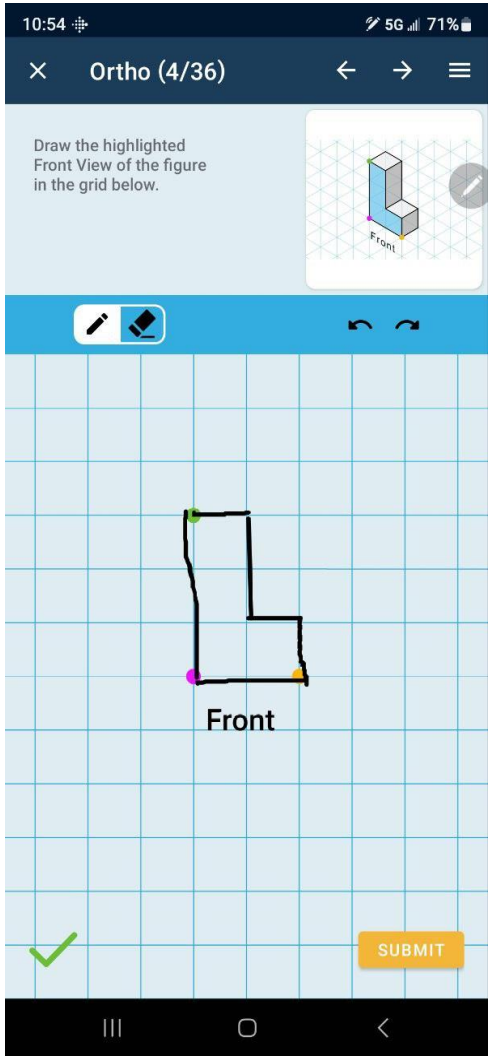
Iso Cubes

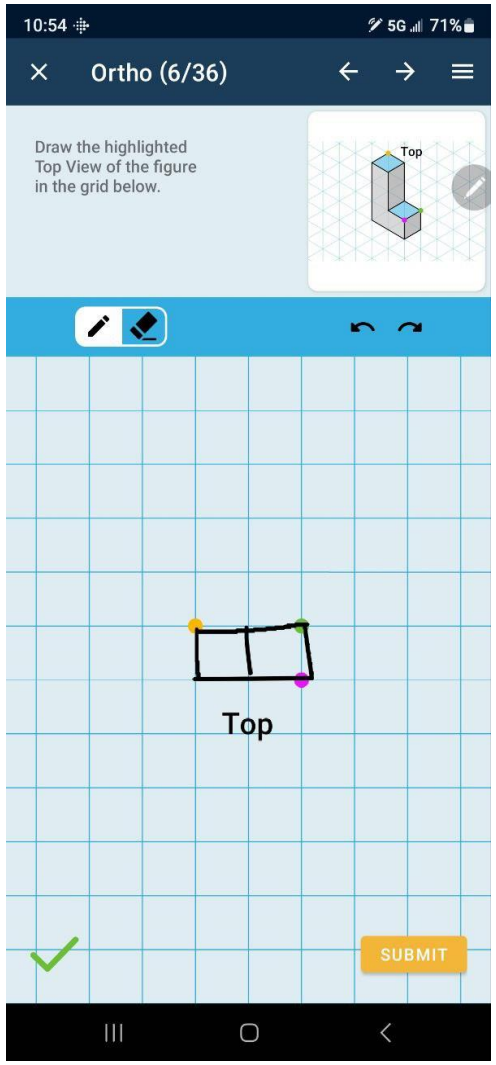

10:51
5G 71%
Iso (3/37)
Draw an isometric figure where the number in each square represents the height of each tower.
Front
2 2
2 2
Right
Front
Right
SUBMIT

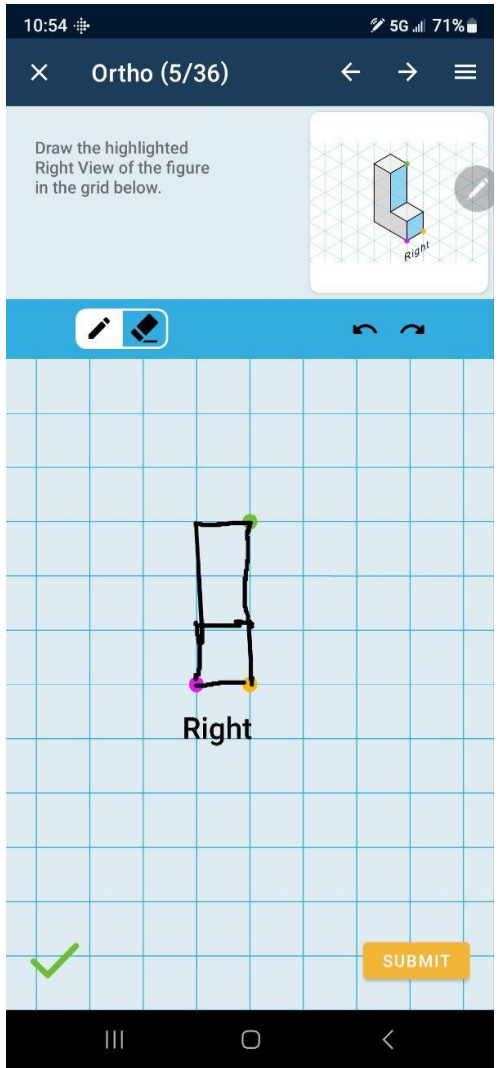

10:52
5G 71%
Iso (6/37)
Draw an isometric figure where the number in each square represents the height of each tower.
Front
1 2
1 2
Right
Front
Right
SUBMIT

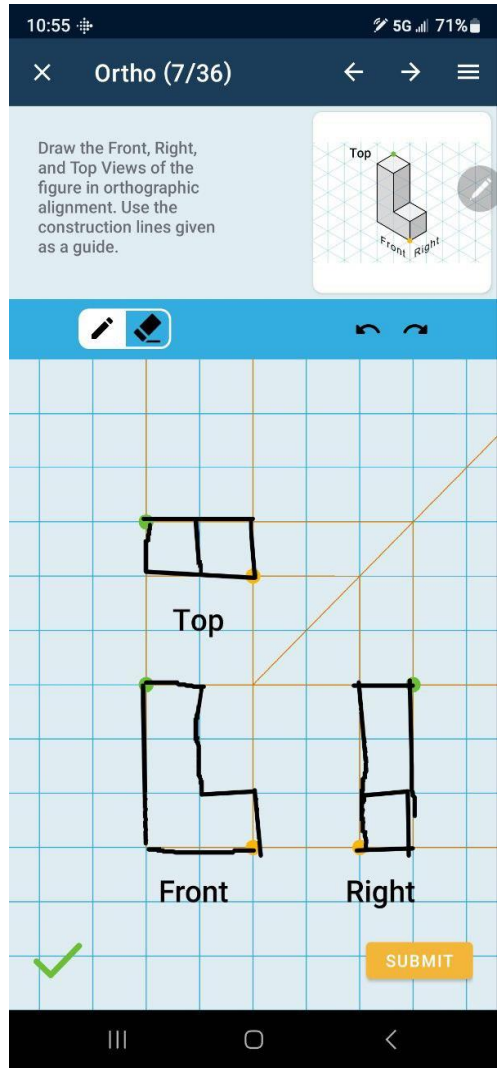

10:54
5G 71%
Iso (10/37)
Draw an isometric figure where the number in each square represents the height of each tower.
Front
3 3 3
1 2 2
1 1 1
Right
Front
Right
SUBMIT

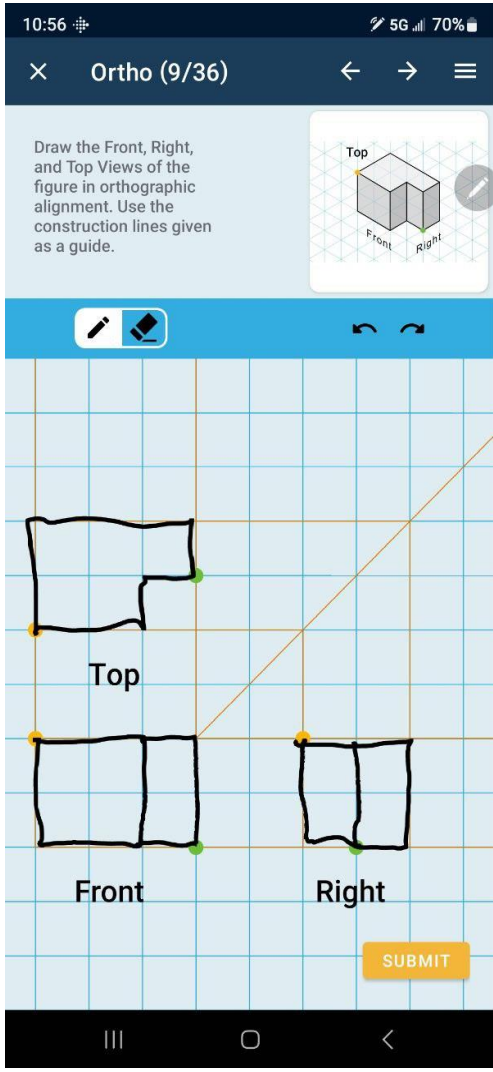
Ortho Cubes


10:54
5G 71%
Ortho (4/36)
Draw the highlighted Front View of the figure in the grid below.
Front
Front
SUBMIT

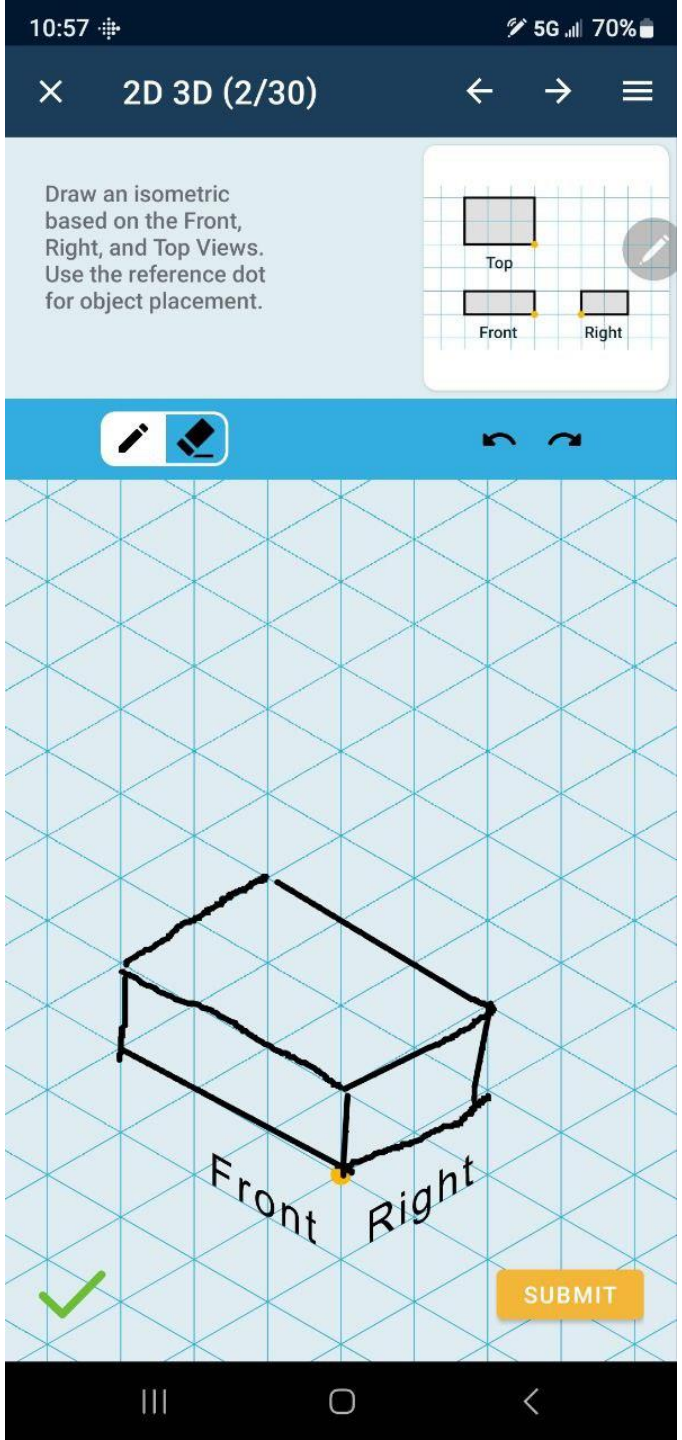

10:54
5G 71%
Ortho (6/36)
Draw the highlighted Top View of the figure in the grid below.
Top
Top
SUBMIT

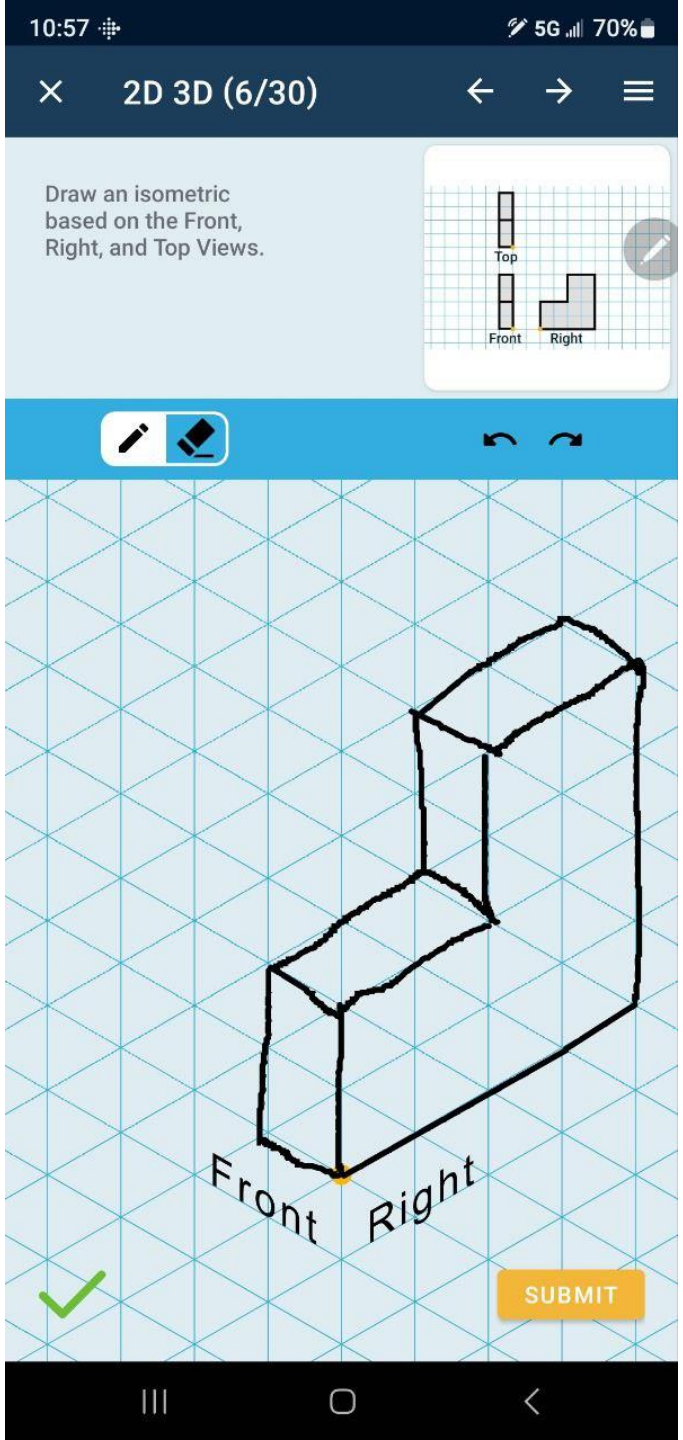

10:54
5G 71%
Ortho (5/36)
Draw the highlighted Right View of the figure in the grid below.
Right
Right
SUBMIT

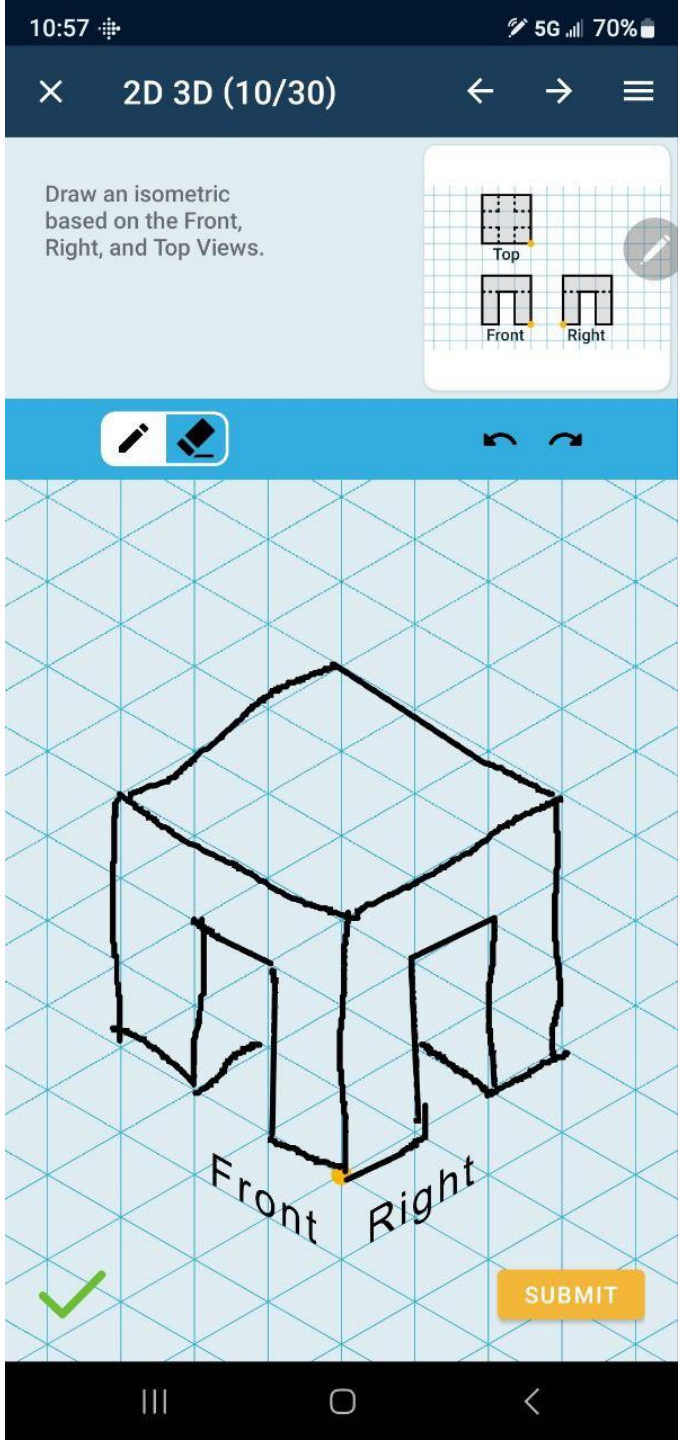

10:55
5G 71%
Ortho (7/36)
Draw the Front, Right, and Top Views of the figure in orthographic alignment. Use the construction lines given as a guide.
Top
Front
Right
Top
Front
Right
SUBMIT


10:56
5G 70%
Ortho (9/36)
Draw the Front, Right, and Top Views of the figure in orthographic alignment. Use the construction lines given as a guide.
Top
Front
Right
Top
Front
Right
SUBMIT

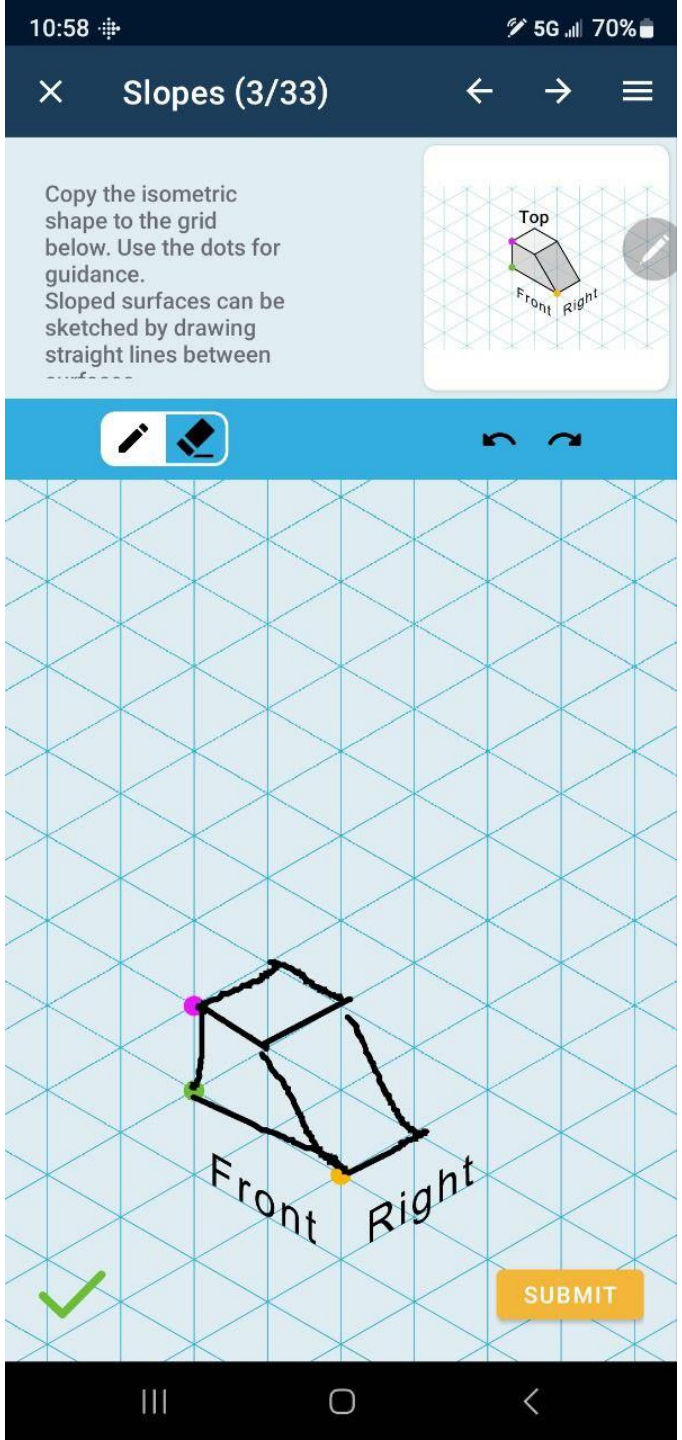
2D to 3D

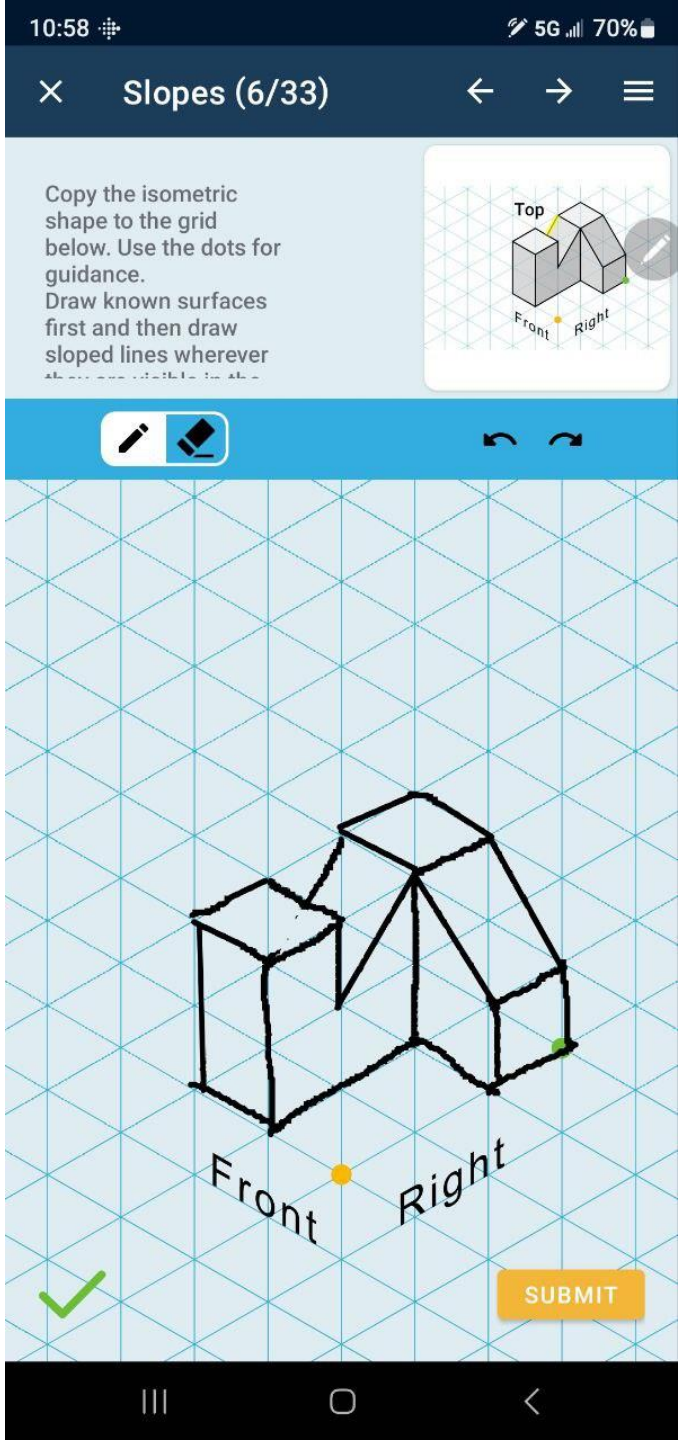

10:57
5G 70%
2D 3D (2/30)
Draw an isometric based on the Front, Right, and Top Views. Use the reference dot for object placement.
Top
Front
Right
Front
Right
SUBMIT


10:57
5G 70%
2D 3D (6/30)
Draw an isometric based on the Front, Right, and Top Views.
Top
Front
Right
Front
Right
SUBMIT

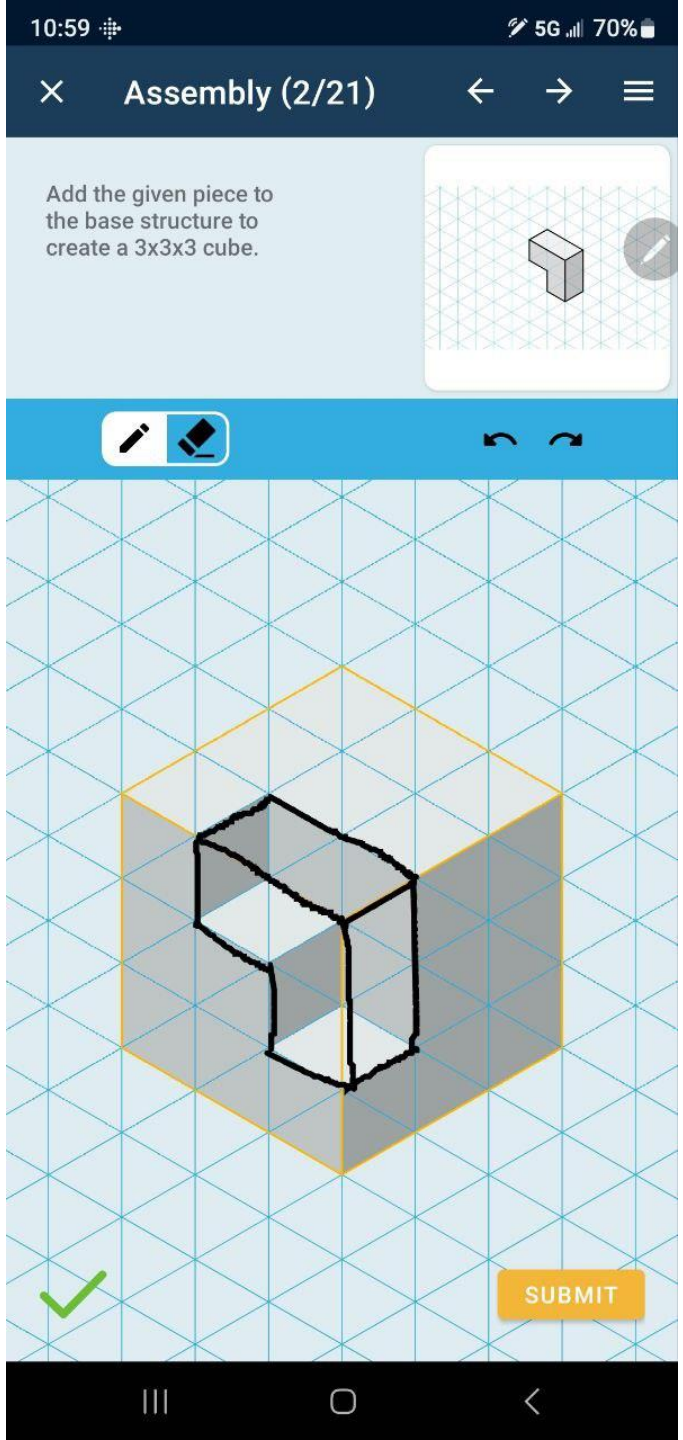

10:57
5G 70%
2D 3D (10/30)
Draw an isometric based on the Front, Right, and Top Views.
Top
Front
Right
Front
Right
SUBMIT

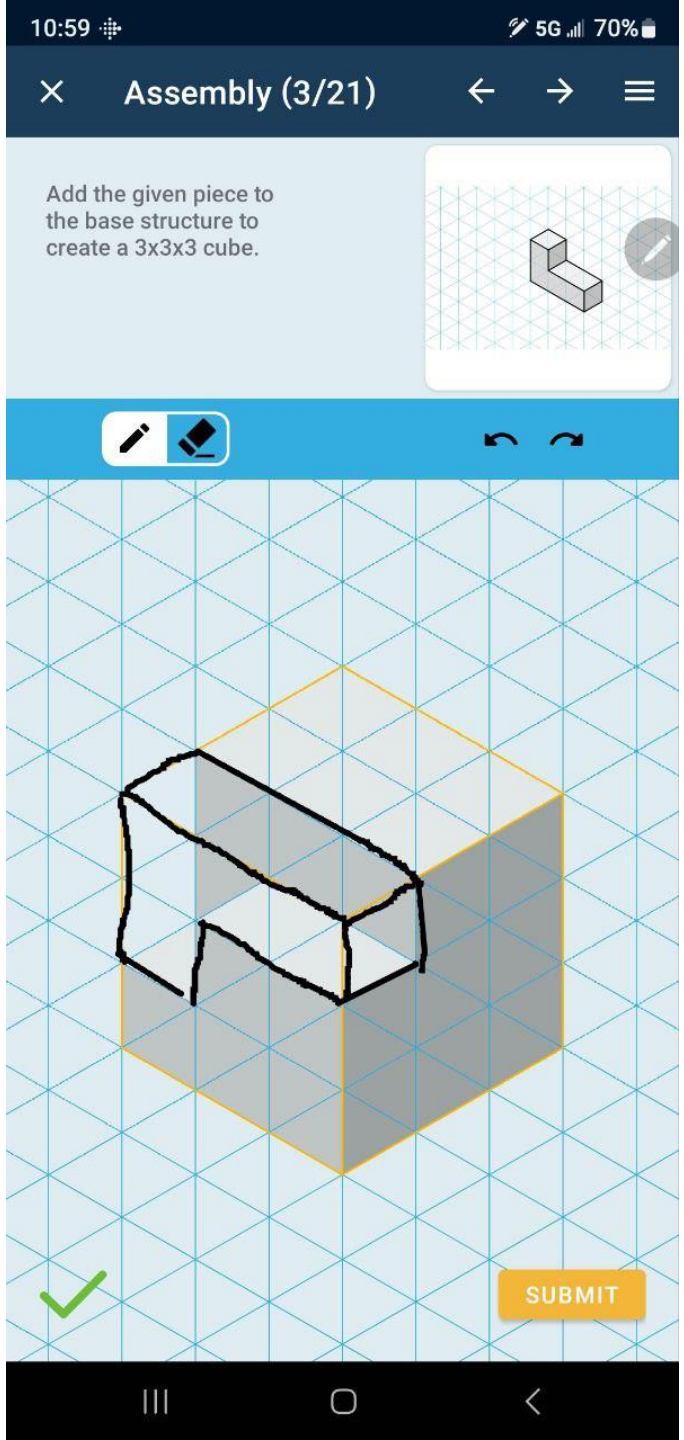
Slopes and Curves

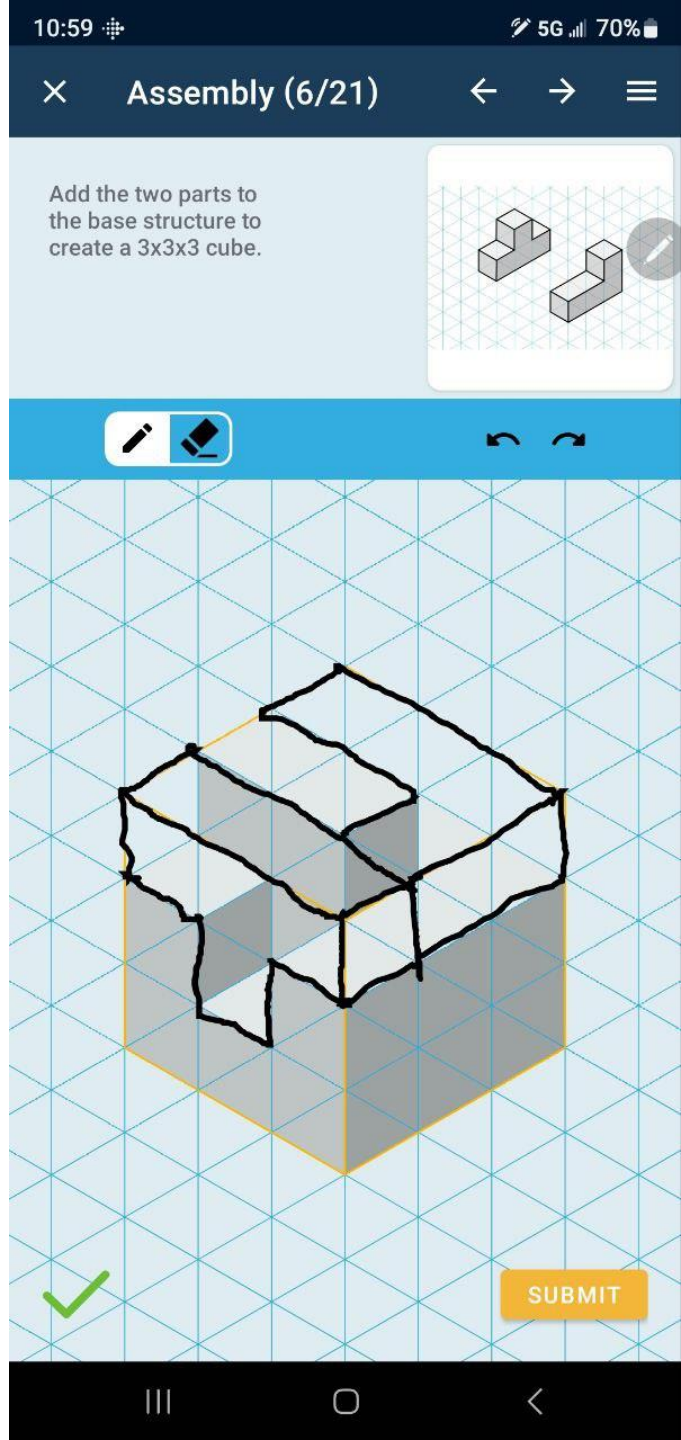




Assembly


10:59
5G 70%
Assembly (2/21)
Add the given piece to the base structure to create a 3x3x3 cube.
SUBMIT


10:59
5G 70%
Assembly (3/21)
Add the given piece to the base structure to create a 3x3x3 cube.
SUBMIT


10:59
5G 70%
Assembly (6/21)
Add the two parts to the base structure to create a 3x3x3 cube.
SUBMIT