Device Lab

Activity 4.1.2. Building a blood vessel to a specification you cannot fudge

You learn a CAD program and then build solid models of four coronary arteries to dimensions given to a hundredth of a millimetre. Then somebody else checks your work against the numbers. That last part is the whole point.

WORTH 5 POINTS | HELPS ON THE WEBXAM | AT A COMPUTER. NO LAB HAZARDS | ABOUT 90 MINUTES

What this is and why it is worth doing

Heart disease is the leading cause of death in the United States. Coronary artery disease affects the arteries that supply blood to the heart, and it is usually caused by atherosclerosis, where plaque narrows the lumen, the opening a blood vessel carries blood through.

One common treatment is a **stent**, a tiny mesh tube. It is threaded into the narrowed artery on a balloon-tipped tube, the balloon is inflated, and the stent expands and locks in place, compressing the plaque and holding the vessel open so blood flows more freely. The Device Lab at Innovation, Inc. is developing a stent made from a new material coated with a drug that seeps into the vessel wall, hoping to reduce the risk of thrombosis, which is clotting at the site of the stent, by causing less inflammation and allowing better healing.

Before any of that, they need model arteries to test flow through. Four of them, each representing a different patient. You build them.

DOES THIS HELP ON THE WEBXAM? YES

It feeds **Biotechnology Research and Experiments**, which is 46.07 percent of WebXam 072110. The reason is not the software. It is that you build to a numeric specification and then someone independently verifies it against that specification. Measurement, tolerance, and independent verification are exactly what that domain is testing. No bench handling, so it does not touch the other domain.

ONE WORD, TWO MEANINGS, INSIDE ONE ACTIVITY

In this activity **CAD** means two different things. **Coronary artery disease** is the condition. **Computer-aided design** is the software. PLTW uses both in the same pages and does not flag it. Read which one is meant from what is around it.

How long it takes and what you need first

- **About 90 minutes**, and it splits cleanly. Roughly 45 minutes to learn the tools, roughly 45 minutes to build the four models and get them checked.
- **A computer with a browser.** Tinkercad runs in a browser and is free. A tablet works but a mouse is much easier than a touchscreen for this.

- **A Tinkercad class code and student nickname from Mr. Mendoza.** Get this before you sit down. It is the only thing here you cannot do on your own.
- **A partner, at some point.** Step 12 needs a second person to verify your models. It does not have to be the same day and it does not have to be in class. Any classmate who has done this item can check yours.
- No safety equipment. This one is at a desk.

The scale question. Settle it before you build

PLTW'S OWN MATERIAL CONTRADICTS ITSELF HERE, SO HERE IS THE RULING

The narrative asks the department for *larger-than-life models of arteries*. The specifications are given in millimetres at true anatomical size. Tinkercad defaults to millimetres. Those three facts do not agree, and if two people resolve them differently the peer verification in step 12 fails for no real reason.

Build at the stated dimensions in millimetres, exactly as printed. That is what gets verified. The larger-than-life language describes what the lab would print physically, which is a printer setting, not a modelling decision.

If you want to scale up anyway, you may, on two conditions: multiply *every* dimension by the same factor, length and both diameters together, and write the factor at the top of the model. A model scaled on diameter but not on length is a different shape, not a bigger one.

The steps

1. Get your Tinkercad class code and student nickname from Mr. Mendoza. Log in and follow the activation steps.

   Done when: you are logged in and looking at your dashboard.

2. Select **Create new design**. Hover over each icon in the top toolbar to learn what it does, and write the function of each one in your notebook.

   Done when: a written list of toolbar icons and their functions exists.

3. Click the Tinkercad icon at the top left to return to the dashboard, then open the **Resources** tab and the **Learning Center** at the bottom left of the menu.

4. Work through these Starter tutorials in order: **Place It, View It, Move It, Rotate It, Size It Up, Group It, Align It.** Start at step 1 on the left of the screen. Click Next when a tutorial is complete, Reset to practise a skill again, Done to move on, Continue for the next project.

   Done when: all seven tutorials show as complete.

5. Work through **More with Tinkercad** to learn resizing, making holes in objects, and making shapes hollow. Practise each one yourself as you watch, do not just watch.

   Done when: you have resized an object, put a hole through one, and hollowed one out, by hand.

6. Practise the **additive method**: group two solid objects into one shape.

   Done when: two solids are grouped into a single object.

7. Practise the **subtractive method**: group a solid shape with a hole shape to remove part of the solid. **This is the technique the whole build depends on.** A tube is a solid cylinder with a hole cylinder taken out of it.

   Done when: you have made a hole through a solid using a hole shape and grouping.

8. Set your units to millimetres and confirm it before you place the first object.

   Done when: the workplane is in mm.

9. **Build all four patient vessels** from the specifications on the next page. For each one: place a cylinder at the external diameter and the stated length, place a second cylinder at the internal diameter and set it as a hole, make the hole cylinder longer than the vessel so it passes all the way through, align the two on both horizontal axes and on the vertical, then group them.

   Done when: four separate models exist, each named with its patient number.

10. Check each model against the specification yourself before you show anyone. External diameter, internal diameter, length. Three numbers, three checks, four models.

    Done when: you have re-measured all twelve numbers in Tinkercad, not just trusted what you typed.

11. **Share your models with another student and verify each other's against the requirements.** Check the numbers, not the appearance. Two vessels can look identical and differ by 0.2 mm.

    Done when: a second person has checked all four of your models and written down what they found.

12. Make any alterations your partner's check turned up, then note what changed and why.

    Done when: every model meets its specification, and any correction is written down.

THE FOUR SPECIFICATIONS

WORK OUT THE WALL THICKNESS COLUMN YOURSELF. WATCH WHAT YOU ARE SUBTRACTING.

PATIENT	LENGTH (MM)	INTERNAL DIAMETER (MM)	EXTERNAL DIAMETER (MM)	WALL THICKNESS (MM)
1	15.5	2.82	3.0	
2	32.1	2.91	3.1	
3	23.3	3.11	3.3	
4	27.31	2.90	3.1	

THE WALL THICKNESS COLUMN IS A TRAP AND IT IS WORTH WALKING INTO CAREFULLY

External diameter minus internal diameter is not the wall thickness. It is the thickness of *both* walls added together, because a diameter crosses the whole tube and passes through the wall twice. Work out what you have to do to that difference to get the thickness of one wall, then write both numbers in the table so a reader can see you knew the difference.

What finished looks like

Your submission is these five things.

1. Screenshots of all four finished models, each showing the model and its dimensions.
2. Your completed specification table with the wall thickness column filled in for all four patients, and one sentence saying how you got from the diameters to a wall thickness.
3. Your verification record: who checked your models, what they measured, and what they found.
4. A written description, aimed at a nervous patient, of what happens during a coronary stent placement. Written for that person, not for a doctor. This is a real deliverable in the activity and it is harder than it looks.
5. Two short answers: which steps of the design process modelling is useful in and why, and one case where a solid model or a 3D visualisation would help a doctor prepare to treat a patient.

WORKED EXAMPLE OF THE FORMAT

PRACTICE EXAMPLE PRACTICE-CAD-1. AN INVENTED FIFTH PATIENT, NOT ONE OF YOUR FOUR

Specification. Patient 9. Length 19.0 mm, internal diameter 2.40 mm, external diameter 2.6 mm.

Wall thickness. 2.6 minus 2.40 is 0.20 mm, and that is both walls, because the diameter crosses the tube and passes through the wall on each side. One wall is half of that, 0.10 mm.

How I built it. Cylinder at 2.6 mm diameter, 19.0 mm long. Second cylinder at 2.40 mm diameter, set to hole, made 25 mm long so it passed right through with room to spare. Aligned both on all three axes using the align tool rather than by eye, then grouped.

My own check. Re-measured in Tinkercad after grouping: outer 2.6, length 19.0. Confirmed the bore by hiding the solid and measuring the hole cylinder before grouping, 2.40.

Verification by Jordan, period 3. External 2.6 correct. Length 19.0 correct. Internal measured 2.45, not 2.40. Cause: I typed 2.45 into the hole cylinder and misread my own note. Corrected to 2.40 and regrouped. Jordan rechecked and passed it.

What that error would have cost. A bore 0.05 mm too wide is 2 percent, which sounds like nothing. Flow through a tube depends on the bore very steeply, so a small diameter error is a much larger flow error, and a flow test on this model would have reported a number that belonged to a different patient. Nothing on the screen would have flagged it. Only the second pair of eyes did.

WHAT THAT EXAMPLE DOES THAT YOU SHOULD COPY

- It shows the arithmetic for wall thickness rather than just the answer.
- It says how the model was built, including the detail that the hole cylinder was made longer than the vessel, which is the step most people miss.
- It reports its own check separately from the partner's check.
- **It reports an error and names the cause.** A verification record with an error found in it is more convincing than one without, because it proves the check was real.
- It says why the error would have mattered. That last paragraph is the difference between following a procedure and understanding one.

Where people get stuck

Making the hole cylinder the same length as the vessel.

It ends up flush with the ends and can leave a thin skin across one or both, so you have a sealed tube. Make the hole cylinder clearly longer than the vessel and let it stick out both ends.

Aligning by eye instead of with the align tool.

A bore that is off centre gives you a wall that is thick on one side and paper thin on the other. It looks fine from the outside. Use the align tool on all three axes, every time.

Typing the internal diameter into the outer cylinder.

Easy to do and invisible afterwards. Re-measure everything after grouping, and let your partner measure independently rather than reading your numbers back to you.

Rounding 27.31 to 27.3, or 2.82 to 2.8.

The specifications are given to two decimal places on purpose. Working to the given precision is the skill being assessed here.

Not checking the units.

If the workplane is in inches or centimetres every model is wrong by a factor and every one of them looks right. Confirm millimetres before you place the first object.

Peer verification that is really just agreement.

"Looks good" is not verification. Your partner measures three numbers on four models and writes down what they measured. If they find nothing, they should say what they measured anyway.

Writing the patient explanation in medical language.

The task says a nervous patient. Lumen, thrombosis and percutaneous are the wrong register. Write it for someone who is frightened and does not have your vocabulary. That is the assessment.

How to submit and how it is credited

THIS ITEM IS WORTH 5 POINTS

Four models, a verification record from a second person, and three short written pieces. Remember the 20 point per semester cap across all extra credit.

- **Where it goes.** The same place as everything else. Your class form on the portal, or handed to Mr. Mendoza in person. Nothing about extra credit needs a different route.
- **What to hand in.** Photographs of your work where the handout asks for them, plus your written pages. Photographs of handwritten pages are fine. A photograph you cannot read is not.
- **Put your name and period on every page and every photograph filename.** Unlabelled work cannot be credited and it is the single most common way points get lost.

- **When.** Any day after the pack opens, right up to the last week of the semester. There is no deadline inside that window and no penalty for going slowly.
- **Feedback.** You get it back with a note. If a piece is short of full credit you may fix the named thing and resubmit once.

Words this activity uses

Medical device

A device intended for a medical purpose: prevention, diagnosis, treatment or rehabilitation.

Coronary artery disease

A condition affecting the arteries that supply blood to the heart. Also abbreviated CAD.

Atherosclerosis

Plaque building up in a blood vessel and narrowing it. The usual cause of coronary artery disease.

Lumen

The opening inside a tube. In a blood vessel, the space blood actually flows through.

Stent

A small wire mesh tube placed inside a narrowed artery to hold it open. Delivered on a balloon-tipped tube and expanded in place.

Drug-eluting

Coated with a drug that is released slowly into the surrounding tissue.

Thrombosis

Clotting. A risk at the site where a stent has been placed.

Inflammation

The body's response to injury or irritation. Here, a response to the stent itself.

Computer-aided design

CAD. Software for building models on a computer. In this activity the same three letters also stand for coronary artery disease.

Solid model

A 3D digital model of an object, which can be sent to a 3D printer.

Additive method

Grouping two solid objects into one combined shape.

Subtractive method

Grouping a solid with a hole shape to cut part of the solid away. How you make a tube.

Tolerance

How far a built thing is allowed to differ from its specification and still count as correct.

Model

A simplified representation of a real thing. Simplifying means deliberately removing some of what makes the real thing complex, which is a choice with consequences.