

# BME Design-Spring 2026 - DOMINIQUE GOODEN Complete Notebook

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on

May 05, 2026 @12:31 AM CDT

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## Team contact Information

SOPHIA SPEECE - May 05, 2026, 12:29 AM CDT

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[Download](#)**Team\_Contact\_Info.JPG (94.6 kB)**



## Project description

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SOPHIA SPEECE - May 05, 2026, 12:28 AM CDT

**Course Number:** BME 402

**Project Name:** Microvascular Channel Bioprinting Shutoff Valve

**Short Name:** N/A

**Project description/problem statement:** To create an **automated, programmable valve** to seamlessly **shut off** or **switch** between **KSM outputs** and **multiple hydrogel resolutions**.

**About the client:** The Osteo Engineering Lab focuses on providing tools for the surgical reconstruction or regeneration of skeletal structures. Our research includes the use of Computer Aided Design (CAD) software to prepare patient specific implants, implant components, and surgical devices that are rendered via additive manufacturing (3D printing). We have used these techniques to prepare restorative cranial implants for patients. However, a major focus of our preclinical research program has been the 3D printing of tissue engineered (resorbable) bone scaffolds and metallic skeletal fixation devices. In our bone tissue engineering research we seed cells, for example Mesenchymal Stem Cells (MSCs) and/or vascular progenitor cells, onto solid, 3D printed polymer scaffolds or within hydrogels. Those constructs may then be cultured, perhaps in a bioreactor, before implantation. The intent of pre-culturing scaffolds is to fill and/or coat them with tissue that the body perceives as a "tissue engineered bone graft." Our work with 3D metal printing involves two alloys, NiTi, also referred to as nitinol or nickel-titanium, and magnesium (Mg) alloys. Our NiTi research currently focuses on stiffness-matched NiTi skeletal fixation devices, i.e., stiffness matched to the surrounding bone. Our Mg alloy research focuses on resorbing skeletal fixation devices.



## January 27 Team Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Jan 27, 2026, 5:41 PM CST

**Title:** January 27 Team Meeting

**Date:** 27 January 2026

**Content by:** Steph

**Present:** Steph, Sophie, Ana, Mahathi, Dominique

**Goals:** Project logistics, short-term goals

**Content:**

- Things Steph wants to discuss: Email from Josh, Preliminary Presentations NEXT FRIDAY, goals for semester (small teams?), finalize time to meet with Josh THIS WEEK
- Meeting with Josh - email sent
  - Friday 1-1:30
  - Friday 4:45
- Look into IP this semester
- Continue with IRE - based on Josh's email
  - Research linear actuators
  - For preliminary presentation - maybe focus on linear actuator research
- What do we need for our preliminary presentation?
  - Do we need a design matrix for our improvements? Ask Dr. Campagnola at the meeting on Friday
    - Less detailed, but several matrices? Because could all be iterative solutions
  - Silicone for IRE? - adjust shore to make it better to use
- Timeline
  - By Friday - prelim research
  - By Jan 31 - overall plan of short-term goals
  - Make goals ahead of time
- Could try to arrive to Dr. C's meeting early to sum up what happened that week to be on same page - additional beginning of week meetings

**Conclusion/Action Items:**



## February 10 Team Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Feb 10, 2026, 5:34 PM CST

**Title:** February 10 Team Meeting

**Date:** 10 February 2026

**Content by:** Steph

**Present:** Steph, Sophie, Dominique, Mahathi

**Goals:** Discuss journal selection, divide into smaller teams, plan moving forward

**Content:**

- Not a ton of room to move forward with clamp design - dominique could move to cells/rotary valve
- First order of action for Sophie - modify holder
  - Then materials
- Cells - incubator appeared off on Friday, will have to check that and where to source cells
- Rotary valve ideas
  - Not too different from previous set-up
  - Make sure timing of switching KSMs and rotary valve match
- Electronics portion
  - Best to continue with Arduino for now
  - Improve the progress from last semester
  - Make it spin without button, maybe use MatLAB
  - Look for higher torque motor for IRE
  - Use values Josh gave us and convert it into time
- Sophie will put her ideas into a doc so everyone is on the same page
- 3 people work on mechanical side, 2 people work on electronic side
- Mainly meet as a team before Dr. Campagnola's meeting Fridays
- Journals
  - Could go with journal that Dr. Dean's article was published in
- Can ask Dr. Dean about IP - could try to get it on IRE

**Conclusion/Action Items:**

No meeting with Dr. Campagnola on Friday

Start with our smaller portions



## Feb 25 SS Subteam

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Feb 25, 2026, 9:00 PM CST

**Title:** February 25 Team Meeting

**Date:** 25 February 2026

**Content by:** Steph

**Present:** Steph, Sophie

**Goals:** Updated leaking testing

**Content:**

- following functionality testing gelatin preparation protocol
- Steph is working on modifying the servo and CEVIC holder in Solidworks --> adding a hole for the wires to fit through; working on some inner circles to hold the CEVIC and not allow turning
- ran functionality testing similar

**Conclusion/Action Items:**



## April 14 Team Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Apr 14, 2026, 5:46 PM CDT

**Title:** April 14 Team Meeting

**Date:** 14 April 2026

**Content by:** Steph

**Present:** Steph, Ana, Sophie, Dominique, Mahathi

**Goals:** Split up poster, presentation, final deliverables

**Content:**

- Do we want to compete in Executive summary competition?
- Have poster & send to Paul by Monday, make edits by Tuesday/Wednesday to print
- ask which image Paul liked for poster
- divide up paper later



## January 30 Client Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Jan 30, 2026, 1:27 PM CST

**Title:** January 30 Team Meeting

**Date:** 30 January 2026

**Content by:** Steph

**Present:** Steph, Sophie, Mahathi, Ana, Dominique

**Goals:** Goals for the semester

**Content:**

- Goals for semester
- Good 1st step - continue with IRE
  - Want movement of printhead, so look at way to attach current design to some linear actuator
- Biggest problem: printing by hand & it is really inconsistent
  - Replace hand by having simple system to move printhead along print surface
  - When get voron, put printhead on
- Modular KSM
  - Have lined up so can print 2 channels currently. Can stop printing, turn KSM, resume printing. then 4 channels, then 8.
  - Problem: connecting of branches between changes in KSM
- Voron - very basic 3D printing, has actuator
- Look into Rockwell Automation downstairs in ECB
- Can work on improving IRE
- Dominique - looking more into more automated clamp valve
- Fluid flow - would need someone else; someone else is picking it up (not us)
- Goals: get branching down - prove this printing technique can produce branches
- Final goal: integrate chaotic printing into proper, very accurate 3D printer
  - For now: simplify linear actuator
- Going to get Rasberry Pi with printer, and should be able to program - printer & IRE

**Conclusion/Action Items:**

- Main goal: attach IRE to linear actuator
- Divide up tasks into smaller teams



## February 6 Client Meeting w/ Dr. Dean

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Mar 13, 2026, 1:54 PM CDT

### Presentation feedback:

- Dr. Dean suggested a particular cell line (started with L) that we could use to do testing. Concern about adhesion and cell detection with current cells
- Might be overthinking the clamping mechanism. Can simply draw fluid out. Further explore how this works with voron.

### 2/6 Client Meeting

Look at paper figure for appropriate setup for the bioprinting setup

- X and Y axis direction at bottom with motors assisting with platform movement

Instead of fixing nozzle, move the platform and keep the nozzle. Stationary platform so it is easier to control fluid flow and platform kinematics.

Plan is to build a replica of the machine here at UW. Purchase aerotech motor as a simple setup and attach the KSM on a linear track to deposit hydrogel. The motors are very expensive and have a different programming setup.

Goal is to control everything from one interface: switching of rotary valve and the printhead movement.

This gives automation while enhancing precision control of the device's linear movement

If u move printhead rather than the platform, there are less things to keep track of.

Shutoff valve —> rotary valve —> sheet printing

Get shutoff and rotary valve to work.

Specification: Moving 2 cm, switch every 250 microns

Working with 2-3cm in area total.

whole thing about 2 cm - wrap around mouse femur

Aerotech motor (200 nm) - not right now - would take long to be delivered and would have to learn the coding

Team - linking rotary valve to shutoff v

Voron - "braindead" - will not have sufficient accuracy

Something in the middle to move left & right and suspend above whatever collector is

Still focusing on switching between KSMS of different elements

Other focus is on how to attach the CEVIC to the Voron system

-----  
Rotary valve vs IRE



## February 20 Client Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Feb 20, 2026, 1:22 PM CST

**Title:** February 20 Team Meeting

**Date:** 20 February 2026

**Content by:** Steph

**Present:** Steph, Sophie, Mahathi, Ana, Josh

**Goals:** Update on progress

**Content:**

- Updates
  - Sophie - 3d modeling & mechanism
    - do we want to purchase higher torque motor
    - IRE out of flexible material
    - future improvements
  - Steph
    - Modifications to the holder
  - Josh
    - trying to order rotary valves & voron, but hold-ups
    - Buying 1 linear actuator - let that idea go

**Conclusion/Action Items:**



## March 6 Client Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Mar 06, 2026, 1:31 PM CST

- Josh has ordered rotary valve - HOPEFULLY before April 15
- Hopefully transfer agreement from OSU
- Best course of action:
  - Manual approach with manifold - split into 2 outputs
  - Somehow get hands on another syringe pump - test 2 KSMs instead of 1
- Voron is ordered and should hopefully come next week
-



## March 20 Client Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Mar 20, 2026, 2:45 PM CDT

- voron & rotary valve arrived!
- update on group's progress for the week
- Can pause syringe pump as you switch KSMs
- Work on integrating with everything
- Print tons of KSMs by next week



## March 24 Client Meeting w/ Dr. Dean

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Mar 24, 2026, 4:47 PM CDT

**Title:** March 24 Advisor Meeting

**Date:** 24 March 2026

**Content by:** Steph

**Present:** Dr. Dean, Josh, Steph, Sophie, Dominique, Mahathi

**Goals:** Be on same page for project; discuss purchasing; discuss IP

**Content:**

- Group's design & goals
  - Showing current design setup and how it fits into overall device
  - Looking to purchase servo motor w/ higher torque
    - to have tighter fit for no leakage, need a bit stronger motor
- Rotary valve, arduino, syringe pump - how everything is controlled together, timed up
- What will happen this semester, where it integrates into the system
  - Integrate our part with the voron
- Voron controlled with RaspberryPi
- Syringe pump - focus on how both interact at the same time
- Hopefully Voron set up by end of this week or next week
  - Voron just moves horizontally
- Stick with programming the arduino (switching) and think about raspberryPi after that
- Project end goals
  - Test everything and make sure it functions best
- Try to find motor through university approved vendor
- Budget for project
  - "hundreds and hundreds of dollars to make this happen"
- Hope to use the project by the summer/fall
- Model of flow - by another undergraduate student
  - We are not doing this this semester, it was tried last semester
- Materials still needed
  - Manifold - for manual testing
  - Rotary valve - just arrived so we have not tested with it
- Show him all the pieces together
- "Syringe has to go back" - we have had some success with our design
- Focus on automation with arduino - move translationally with hand
- Put notes on what/how to improve in the future; and what we have done with the design
  - Is there work on it to be done and where for summer/next fall
- If design works, COULD be included as IP
  - Several patents submitted on CEVIC and microvascular sheet printing
- Purchasing
  - Team is responsible for purchases & send receipt for reimbursement
  - Client makes purchasing account and we purchase through that

**Conclusion/Action Items:**

 **April 10 Client Meeting**

SOPHIA SPEECE - Apr 10, 2026, 1:42 PM CDT

**Title:** Josh and Voron**Date:** 04/10/2026**Content by:** Sophia Speece**Present:** Sophia Speece, rest of team in teaching lab for testing**Goals:** check out the Voron and make sure our current holder can integrate with the setup**Content:**

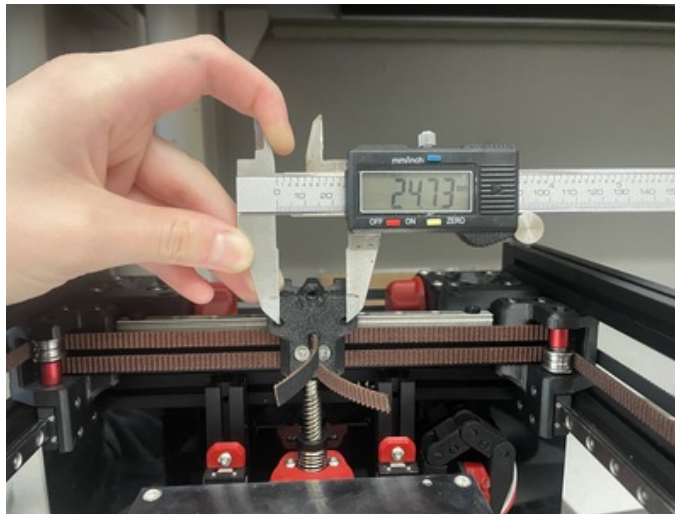
Include a slight bit of clearance when redesigning to account for the screws.

see images for distances and diameters of the holes and reference to model

**Conclusions/action items:**

Modify holder design to fit with voron print head

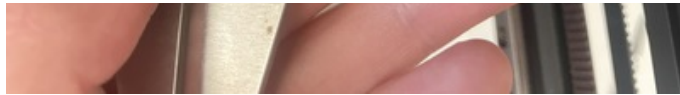
SOPHIA SPEECE - Apr 10, 2026, 1:43 PM CDT

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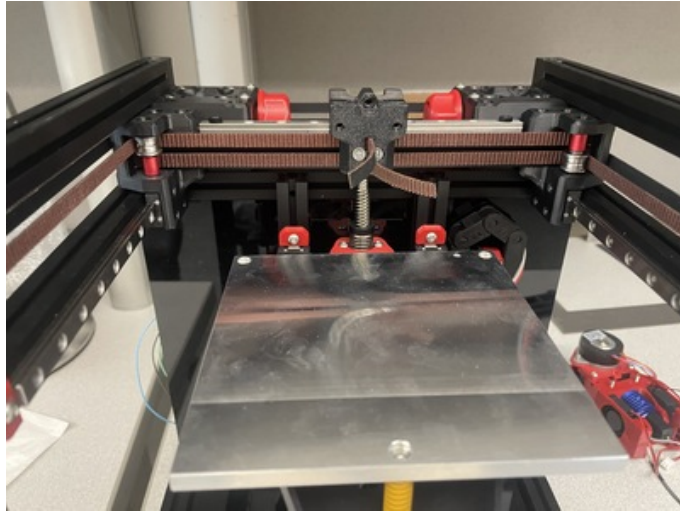




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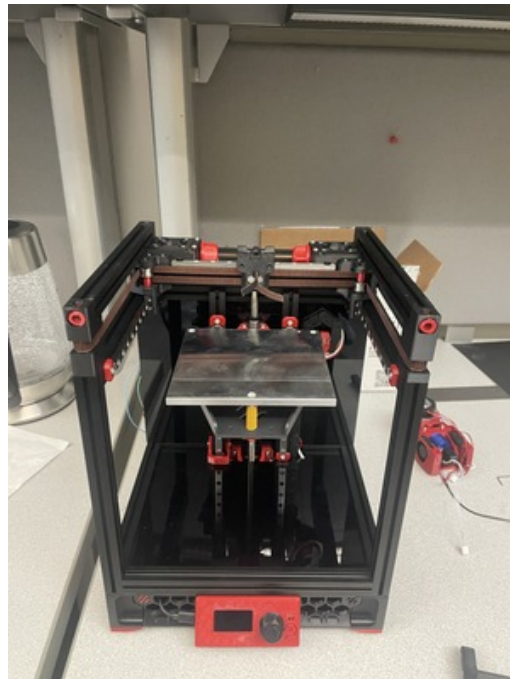
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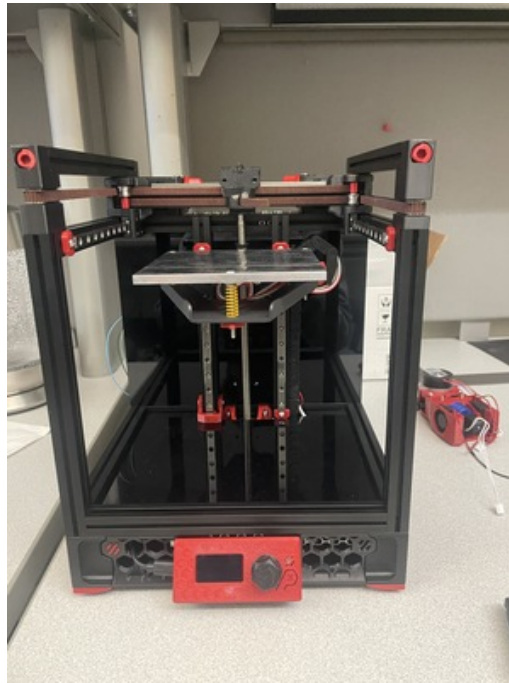
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## January 23 Advisor Meeting

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STEPHANIE VIGMOND (vigmond@wisc.edu) - Jan 25, 2026, 12:57 PM CST

**Title:** January 23 Advisor Meeting

**Date:** 23 January 2026

**Content by:** Steph

**Present:** Steph, Sophie, Ana, Mahathi

**Goals:** Recap after Winter break & plans for semester

**Content:**

- Meeting with Josh would be helpful & Dr. Dean **\*\*first order of business**
- Set up new notebook
- Preliminary report just do Dr. Campagnola (not whole group)
  - Focus more on what we will do for testing
- Final report in form of paper is different, will start talking about it sooner than later
- Team meeting before next Friday

**Conclusion/Action Items:**

- Send out when2meet to determine group meeting and client meeting times
- Send email to Josh about goals for semester



## January 30 Advisor Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Jan 30, 2026, 1:46 PM CST

**Title:** January 30 Advisor Meeting

**Date:** 30 January 2026

**Content by:** Steph

**Present:** Steph, Sophie, Ana, Mahathi, Dominique

**Goals:** Recap after client meeting & plan for next week presentation

**Content:**

- Just had meeting with Josh
- Preliminary presentation
  - Focus on plans for semester
  - Skip background
  - 12 minutes on what we are going to do this semester
- How to choose journal
  - start looking into journal
  - Write report in form of paper
- Start working on project this week

**Conclusion/Action Items:**

- Work on Preliminary Presentation
- Make timeline for semester



## February 20 Advisor Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Feb 20, 2026, 1:58 PM CST

**Title:** February 20 Advisor Meeting

**Date:** 20 February 2026

**Content by:** Steph

**Present:** Steph, Sophie, Ana, Mahathi, Dominique

**Goals:** Review from the week

**Content:**

- Updates
  - Sophie
    - 3D modeling & 3D printing
    - Want to make 1 locking mechanism so IRE can rotate both ways
    - Will do leak testing with new IRE (material)
  - Dominique
  - Steph
    - Similar to Sophie
    - Higher torque motor
  - Ana
    - Worked on report
    - Next week will work on electronic testing
  - Mahathi
    - Plan for electronics
    - Test some things for electronics

**Conclusion/Action Items:**

Extra week for paper

Thinking about patent disclosure



## February 27 Advisor Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Feb 27, 2026, 1:56 PM CST

**Title:** February 27 Advisor Meeting

**Date:** 27 February 2026

**Content by:** Steph

**Present:** Steph, Sophie, Ana, Mahathi, Dominique

**Goals:** Review from the week

**Content:**

- Ana - Mahathi & Dominique met yesterday; trying to find values for electronic testing; ideas for security measures for code to make sure it does not exceed limitations of motor/device
- Mahathi - work on testing protocols; motor & rotation; manual button; eventually switch to non-manual switches; motor with better torque
- Dominique - beefcake relay - small screwdriver
- Sophie & Steph - leak testing with new CEVIC & flexible IRE - better than it was, but still some leakage
  - once we get rotary valve may be able to relieve some pressure
  - find a way to sand down weird bits in center of IRE
  - will print new CEVIC out of biomed clear; may look at more flexible material (eg. silicone)
  - modeling to integrate current attachment to linear actuator - make sure CEVIC does not rotate
- draft of paper due Wednesday - no "client, team, prototype, ..."
- pretty good **introduction, methods**, results, etc.
- leave space for discussion

**Conclusion/Action Items:**



## March 6 Advisor Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Mar 06, 2026, 1:57 PM CST

**Title:** March 6 Advisor Meeting

**Date:** 6 March 2026

**Content by:** Steph

**Present:** Steph, Ana, Mahathi, Dominique

**Goals:** Review from the week

**Content:**

- Report
  - Discussion & Results
    - Results - results & fabrication process
    - Discussion - limitations, advantages, why you did it, what you found (expand on this section)
  - Background pictures do not put in the paper
  - A lot of what we had in the beginning we should put into methods
  - Make as formal as you can - you are writing this for someone skilled in the field
- Intellectual Property
  - Email Dr. Dean
  - File disclosure - very unlikely (in general) to pick them up
- Things to do
  - Order stronger servo motor

**Conclusion/Action Items:**



## March 13 Advisor Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Mar 13, 2026, 1:53 PM CDT

**Title:** March 13 Advisor Meeting

**Date:** 13 March 2026

**Content by:** Steph

**Present:** Steph, Sophie, Mahathi, Dominique

**Goals:** Review from the week

**Content:**

- issues with 3D printing CEVIC
- want to do leak testing with new CEVIC and syringe
- purchasing issues - we need the motor for our design
- email Dr. Dean - our understanding you are supposed to commit funds (have a budget) for the project, we think this motor will help progress our project because our design needs the higher torque \*\*\*. Want to meet \*times\*.

We presented a timeline, expected to be in testing phase, so need materials. Project is wrapping soon.

- send email for meeting with Dr. Dean.
- Sophie wants to talk about intellectual property space
- Thursday night 5:45 pm
- make sure to pause the motor between turns - hysteresis



## March 19 Advisor Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Mar 19, 2026, 5:54 PM CDT

**Title:** March 19 Advisor Meeting

**Date:** 19 March 2026

**Content by:** Steph

**Present:** Steph, Sophie, Ana, Mahathi, Dominique

**Goals:** Review from the week

**Content:**

- executive summary for competition - do design one (due april 8); executive summary by APRIL 6 OR 7; meet on the 8th to go over it
- executive summary is long/detailed abstract, 500-600 words
- Ana & Dominique & Mahathi- working on electronics part
- Sophie & Steph - printed holder with linear actuator attachment; leak testing - any leakage due to bumpiness of prints; aiming for together testing
-



## March 27 Advisor Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Mar 27, 2026, 1:21 PM CDT

**Title:** March 27 Advisor Meeting

**Date:** 27 March 2026

**Content by:** Steph

**Present:** Steph, Sophie, Ana

**Goals:** Review from the week

**Content:**

- integration testing today after meeting
- failed KSMS
- higher powered motor needs external power
- Prof Campagnola away on 10th, summary due by that tuesday
  - executive summary - excellence of design; 1 page, about 3x abstract length
- meeting with Prof Campagnola April 8th online



## April 8 Advisor Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Apr 08, 2026, 6:16 PM CDT

**Title:** April 8 Advisor Meeting

**Date:** 8 April 2026

**Content by:** Steph

**Present:** Steph, Sophie, Mahathi

**Goals:** Review executive summary

**Content:**

- rewrite executive summary - break down into individual sections
- want it to be a bit more concise --> break into sections
- motor came in - plan to test Friday
- power motor if we want it at higher torque (can still code with arduino, power up to 8)
- Can ask Prof Nimunkar for help (more voltage or more current)
- Final deliverables Tuesday of Finals week
- Sections - motivation, prior work, methods, conclusion (move stuff around to fit that format)
  - be pretty concise
  - 6 point break between paragraph
- resent to Prof C by Monday



## April 17 Advisor Meeting

---

STEPHANIE VIGMOND (vigmond@wisc.edu) - Apr 17, 2026, 1:52 PM CDT

**Title:** April 17 Advisor Meeting

**Date:** 17 April 2026

**Content by:** Steph

**Present:** Steph, Sophie, Ana, Dominique, Mahathi

**Goals:** Prepare for poster

**Content:**

- assigned poster sections, did integration testing,
- Josh has a power supply for rotary valve, but probably too high power
- Dr. N recommends following the Amazon website cord
- Make a voltage divider if we use the too much power; check current (I) needs
- $V_{out} = V_{in} * R1/(R1 + R2)$
- Electronics - 1 more testing - look at difference between actual and predicted degree rotation
- Sophie adjusted the attachment for the voron & Steph reprinted
- make shorter pitch for judging



---

DOMINIQUE GOODEN (degooden@wisc.edu) - Mar 06, 2026, 1:30 PM CST



[Download](#)

**ire\_rotation.ino (849 B)**



# 2026/05/04 - Material and Expenses Table

ANA CLARA TOSCANO - May 04, 2026, 8:22 PM CDT

**Title:** Material and Expenses Table

**Date:** 2026/05/04

**Content by:** Whole Team

**Present:** Whole Team

**Goals:** keep track of the budget and costs

**Content:**

Item	Description	Manufac- turer	Mft Pt#	Vendor	Vendor Cat#	Date	#	Cost Each	Total	Link
<b>Category 1</b>										
	Flexible 80A IRE print					2/18/26	1	3.06	\$3.06	
	CEVIC locking mechanism					2/18/26	1	0.32	\$0.32	
	CEVIC locking mech - updated					2/19/26	1	0.24	\$0.24	
	Updated servo & CEVIC holder					2/26/26	1	0.15	\$0.15	
	Clip and Gear					3/17/26	1	0.13	\$0.13	
	Small KSMs					3/17/26	1	4.00	\$4.00	
	CEVIC Servo Connector with tapped holes					3/18/26	1	0.18	\$0.18	
	Replacement CEVIC bottom half					4/22/26	1	1.31	\$1.31	
	HobbyPark Waterproof RC Servo 25KG High Torque Metal Gear Digital Servo for 1/12 1/10 RC Car Truck Buggy Programmable 2BB Control Angle 180° HV (Coreless Motor)					4/10	1	29.97	\$29.97	
								<b>TOTAL:</b>	<b>\$39.18</b>	

 **Leak Testing Protocol**

SOPHIA SPEECE - May 05, 2026, 12:08 AM CDT

**Title:** Leak Testing Protocol**Date:** 05/04/2026**Content by:** Sophia Speece**Present:** Sophia Speece, Steph Vigmond**Goals:** Test different IRE materials and evaluate leakage**Content:**

See attached PDF file for leak testing protocol. See the experimentation folder for raw leak test data as well as analyzed results

**Conclusions/action items:**

Save for future use

SOPHIA SPEECE - May 05, 2026, 12:08 AM CDT

**Microvascular Bioprinting Shut-off Valve  
Functionality Testing****Purpose**

The purpose of this testing is to evaluate the performance of different materials against leakage.

**Equipment and Materials**

This test uses the following equipment:

- 50 mL beaker
- 10 mL graduated cylinder
- CEVICard IRE
- KSM
- 2x 20mL Syringes
- Syringe pump
- Tubing
- Razor blade or x-acto knife

This test using the following materials:

- DI Water

**Procedure****Preparation**

1. Plug in and turn on the syringe pump
2. Ensure the syringe pump is set to 20 mL syringe size and 1.5 mL/hr speed
3. Attach tubing to the ends of the 20 mL syringes
4. Fill a 50 mL beaker with DI water
5. From the 50 mL beaker fill the syringes with 20 mL of water each
6. Place and secure both syringes into the syringe pump cradle
7. Tape the top of the graduated cylinder and cut a small slit in the top, just long enough for the bottom of the CEVIC to fit through

**Testing**

1. Select the first IRE sample (control, flexible, or sanded)
2. Prepare the CEVICard IRE in the "open" position, where the holes in the CEVIC align with the hole in the IRE
3. Connect the tubing from the syringe pump to the KSM, then fit the KSM into the "open" slot in the CEVIC

[Download](#)**Leak\_Testing\_Protocol.pdf (70.5 kB)**

# Leak Testing Raw Data

SOPHIA SPEECE - May 04, 2026, 8:18 PM CDT

**Title:** Leak Testing Raw Data

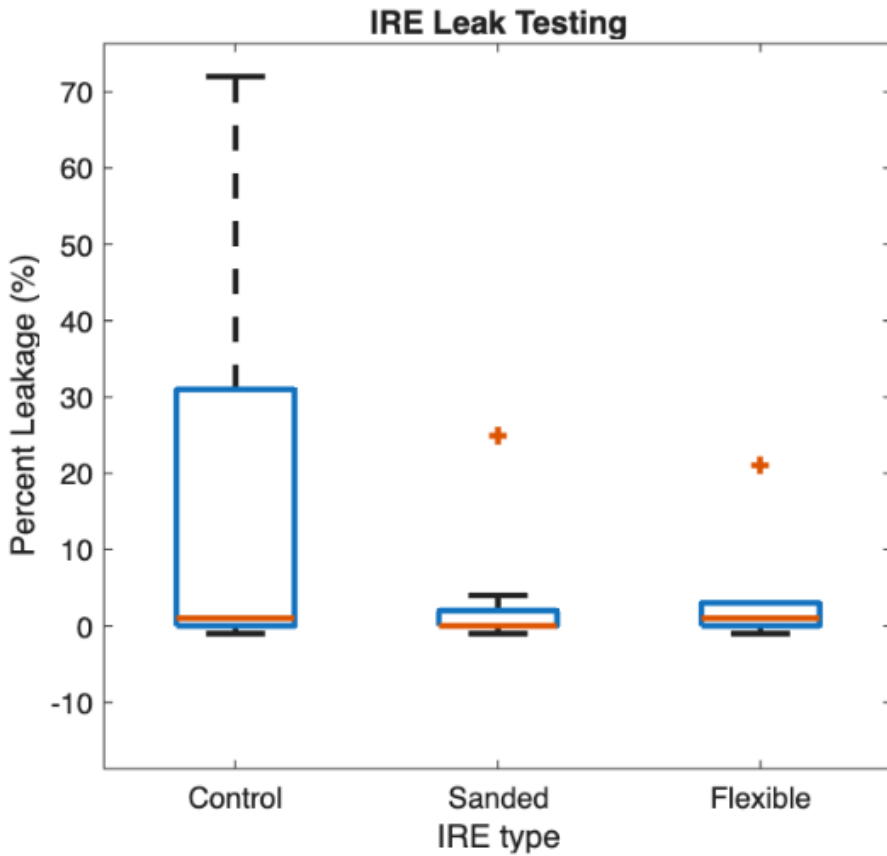
**Date:** 05/04/2026

**Content by:** Sophia Speece

**Present:** Sophia Speece, Steph Vigmond, Ana Toscano

**Goals:** Identify differences in leakage between a control IRE (BioMed Clear Resin, Sanded, and Flexible 80A Resin)

**Content:**



Box and whisker plot of IRE testing results

See attachment for raw data

**Conclusions/action items:**

Analyze raw data

SOPHIA SPEECE - May 04, 2026, 8:18 PM CDT

The screenshot shows a spreadsheet with multiple columns and rows of data. The columns include "IRE type" and "Percent Leakage". The data points correspond to the values shown in the box plot above.

IRE type	Percent Leakage
Control	-1
Control	0
Control	1
Control	31
Control	72
Sanded	-1
Sanded	0
Sanded	1
Sanded	2
Sanded	4
Sanded	25
Flexible	-1
Flexible	0
Flexible	1
Flexible	3
Flexible	4
Flexible	21

[Download](#)

**Leak\_Testing\_-\_Sheet1.pdf (54 kB)**



## CAD Files: Servo Motor and Clip

---

SOPHIA SPEECE - May 02, 2026, 10:28 PM CDT

**Title:** CAD Files: Servo Motor and Clip

**Date:** Entered 05/02/2026

**Content by:** Sophia Speece

**Present:** N/A

**Goals:** Have a Servo motor file to help with measurements and SolidWorks Assemblies

**Content:**

The attached files include the SolidWorks and .stl files for the Servo motor and a small clip that can be optionally used to secure the motor onto the CEVIC-Servo holder. Also included is a SolidWorks assembly of the final design.

**Conclusions/action items:**

Use to assist with dimension and modeling

Save for future use

SOPHIA SPEECE - May 02, 2026, 10:29 PM CDT

[Download](#)

Clip2.STL (2.68 kB)

SOPHIA SPEECE - May 02, 2026, 10:29 PM CDT

[Download](#)

Standard-Servo.stp.SLDPRT (384 kB)

 **CAD Files: IRE and Gear**

SOPHIA SPEECE - May 02, 2026, 10:21 PM CDT

**Title:** CAD Files: IRE and Gear**Date:** Entered 05/02/2026**Content by:** Sophia Speece, Steph Vigmond**Present:** Sophia Speece, Steph Vigmond**Goals:** Design and print the IRE**Content:**

Attached are the SolidWorks and .stl files for the IRE and gear. The most recent IRE is the "NEW IRE" and the most recent gear is the "ServoGearPrint95percentSize" (named this way because scaling the 3D print to 95% of the original size actually fits on the Servo and interfaces with the IRE better than full size.

**Conclusions/action items:**

Print and test

Save for future use

SOPHIA SPEECE - May 02, 2026, 10:22 PM CDT

[Download](#)**AssemGearIRE.SLDPRT (576 kB)**

SOPHIA SPEECE - May 02, 2026, 10:22 PM CDT

[Download](#)**AssemGearIRE.STL (217 kB)**

SOPHIA SPEECE - May 02, 2026, 10:22 PM CDT

[Download](#)**NEW\_IRE.SLDPRT (595 kB)**

SOPHIA SPEECE - May 02, 2026, 10:22 PM CDT

[Download](#)

**NEW\_IRE.STL (217 kB)**

SOPHIA SPEECE - May 02, 2026, 10:22 PM CDT



[Download](#)

**ServoGearPrint95percentsize.SLDPRT (552 kB)**

SOPHIA SPEECE - May 02, 2026, 10:22 PM CDT



[Download](#)

**ServoGearPrint95percentsize.STL (157 kB)**

 **CAD Files: CEVIC-Servo Connector**

SOPHIA SPEECE - May 02, 2026, 9:39 PM CDT

**Title:** CAD Files: CEVIC-Servo Connector**Date:** Entered 05/02/2026**Content by:** Sophia Speece, Steph Vigmond**Present:** Sophia Speece, Steph Vigmond**Goals:** Design connector to hold CEVIC and Servo in such a way that the IRE and the Gear interface, while also having an attachment point to the Voron**Content:**

The attached files include both SolidWorks and .stl files for all iterations of the CEVIC-Servo connector, with the most recent named "Final CEVIC Servo Connector"

**Conclusions/action items:**

Print and test

Save for future use

SOPHIA SPEECE - May 02, 2026, 9:40 PM CDT

[Download](#)

CEVIC\_Servo\_connector\_2.3mf (33.2 kB)

SOPHIA SPEECE - May 02, 2026, 9:40 PM CDT

[Download](#)

CEVIC\_Servo\_connector\_2.SLDPRT (114 kB)

SOPHIA SPEECE - May 02, 2026, 9:40 PM CDT

[Download](#)

CEVIC\_Servo\_connector\_2.STL (14.5 kB)

SOPHIA SPEECE - May 02, 2026, 9:40 PM CDT

[Download](#)

**CEVIC\_Servo\_connector\_SLIM.STL (27.9 kB)**

SOPHIA SPEECE - May 02, 2026, 9:40 PM CDT



[Download](#)

**CEVIC\_Servo\_connector.SLDPRT (99.6 kB)**

SOPHIA SPEECE - May 02, 2026, 9:40 PM CDT



[Download](#)

**Final\_CEVIC\_Servo\_connector.SLDPRT (245 kB)**

SOPHIA SPEECE - May 02, 2026, 9:40 PM CDT



[Download](#)

**Final\_CEVIC\_Servo\_connector.STL (110 kB)**

SOPHIA SPEECE - May 02, 2026, 9:40 PM CDT



[Download](#)

**March12CEVIC\_Servo\_connector.SLDPRT (156 kB)**

SOPHIA SPEECE - May 02, 2026, 9:40 PM CDT



[Download](#)

**March17\_CEVIC\_Servo\_connector\_trying\_hole\_wizard.SLDPRT (219 kB)**

SOPHIA SPEECE - May 02, 2026, 9:40 PM CDT



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**March17\_CEVIC\_Servo\_connector.SLDPRT (224 kB)**

SOPHIA SPEECE - May 02, 2026, 9:40 PM CDT



[Download](#)

**March18\_CEVIC\_Servo\_Connector\_Threaded\_Holes.SLDPRT (241 kB)**

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SOPHIA SPEECE - May 02, 2026, 9:40 PM CDT



[Download](#)

**March18\_CEVIC\_Servo\_Connector\_Threaded\_Holes.STL (108 kB)**



## CAD Files: Locking CEVIC

SOPHIA SPEECE - May 02, 2026, 9:34 PM CDT

**Title:** CAD Files: Locking CEVIC

**Date:** Entered 05/02/2026

**Content by:** Sophia Speece

**Present:** N/A

**Goals:** save Solidworks and .stl files for future use

**Content:**

This page contains the the SolidWorks files for the two halves of the twist-lock CEVIC. There are two top halves, one that locks when rotating counter-clockwise and one that rotates rotating clockwise. There is only one bottom half.

**Conclusions/action items:**

Print and test

Save for future use

SOPHIA SPEECE - May 02, 2026, 9:35 PM CDT



[Download](#)

**BottomHalfwithlockingpin.SLDPRT (384 kB)**

SOPHIA SPEECE - May 02, 2026, 9:35 PM CDT



[Download](#)

**BottomHalfwithlockingpin.STL (814 kB)**

SOPHIA SPEECE - May 02, 2026, 9:35 PM CDT



[Download](#)

**TopHalf\_LocksCCW\_2.SLDPRT (329 kB)**

SOPHIA SPEECE - May 02, 2026, 9:35 PM CDT



[Download](#)

**TopHalf\_LocksCCW\_2.STL (287 kB)**

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SOPHIA SPEECE - May 02, 2026, 9:35 PM CDT



[Download](#)

**TopHalf\_LocksClockwise\_2.SLDPRT (321 kB)**

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SOPHIA SPEECE - May 02, 2026, 9:35 PM CDT



[Download](#)

**TopHalf\_LocksClockwise\_2.STL (287 kB)**



## Preliminary Presentation

---

SOPHIA SPEECE - May 05, 2026, 12:17 AM CDT

**Title:** Preliminary Presentation

**Date:** Entered 05/04/2026

**Content by:** Team

**Present:** Team

**Goals:** Recap progress from previous semester and establish goals for the spring

**Content:**

See attachment

**Conclusions/action items:**

Divide goal up among team members and begin semester progress

---

SOPHIA SPEECE - May 05, 2026, 12:17 AM CDT



[Download](#)

**402\_Microvascular\_Shutoff\_Valve\_Preliminary\_Presentation\_2\_.pdf (4.06 MB)**

 **Preliminary Report**

SOPHIA SPEECE - May 05, 2026, 12:19 AM CDT

**Title:** Preliminary Report**Date:** Entered 05/04/2026**Content by:** Team**Present:** Team**Goals:** Reiterate previous semester progress and current semester goals in the form of a research article**Content:**

See attachment

**Conclusions/action items:**

Continue moving forward with the project

SOPHIA SPEECE - May 05, 2026, 12:19 AM CDT

BME Design: 380, 381, 382, 381, 480 and 482

**Microvascular Channel Bioprinter Shutoff Valve**  
*Preliminary Report*

BME 402 Design

03/04/2026

Client: Dr. David Dean  
University of Wisconsin-Madison  
Department of Biomedical EngineeringAdvisor: Dr. Paul Campagnolo  
University of Wisconsin-Madison  
Department of Biomedical EngineeringTeam:  
Co-Leader: Dominique Cecchin, [dc3000@wisc.edu](mailto:dc3000@wisc.edu)  
Co-Leader: Mahesh Karthikayan, [mkarthikayan@wisc.edu](mailto:mkarthikayan@wisc.edu)  
Communicator: Shrey Vignarajah, [svignaraj@wisc.edu](mailto:svignaraj@wisc.edu)  
BMECE: Sophia Speece, [spseece@wisc.edu](mailto:spseece@wisc.edu)  
BPA/Cs: Arun Taranam, [ataranam@wisc.edu](mailto:ataranam@wisc.edu)[Download](#)**BME\_402\_Design\_Preliminary\_Report.pdf (15.5 MB)**



SOPHIA SPEECE - May 05, 2026, 12:21 AM CDT

**Title:** Executive Summary**Date:** Entered 05/04/2023**Content by:** Team**Present:** Team**Goals:** Expand upon project abstract and write an executive summary to prepare for the BME design awards consideration**Content:**

See attachment

**Conclusions/action items:**

Practice short presentation for the BME poster session

SOPHIA SPEECE - May 05, 2026, 12:21 AM CDT

402 - 25 - chaotic\_printing - Executive Summary

**Motivation**

One main challenge of tissue engineering is vascularizing these engineered biomaterials to achieve the pattern and resolution of branching arteries and capillaries (down to 10  $\mu\text{m}$  in diameter), as well as mimicking to other vasculature and mimicking the circulatory system's functionality. Researchers in the Deast lab have identified a solution through chaotic printing. Kansas State Minors (KSMs) create an alternating pattern of bio- and fugitive ink, which is deposited through Continuously Extruded Variable Internal Channeling (CEVIC) technology. The CEVIC device consists of all the KSMs to a nozzle that extrudes a fluid hydrogel output, containing the vasculature from arteries down to capillary level (i.e., from largest to finest resolution). However, challenges remain with instantaneously switching between KSM outputs to achieve the appropriate output. Manual methods were unable to achieve timely switching. Additionally, the inclusion of a rotary valve to switch between KSM inputs did not fix leaking issues in the device. Therefore, the objective is to create an automatic, programmable valve to seamlessly switch between KSM outputs. In addition to automating, the client requires that the device maintain hydrogel patterning, integrate with the current lab setup, be biocompatible, and produce a 2-3 cm long hydrogel strand with the resolution switching every  $\sim 200 \mu\text{m}$ .

**Prior work**

Many present devices utilize various bioprinting approaches to extrude hydrogel. Wong et al. (2016) extruded hydrogels using a visible-light based microphotography system. Additionally, Ceballos-Gonzales et al. (2022) examined other print applications on closely related KSM-based technology. The competing vascularization bioprinting technologies are diverse, but none achieve the same hierarchical multi-extrusion resolution switching that CEVIC technology brings. Conventional extrusion bioprinting achieves resolutions only around 100  $\mu\text{m}$  in addition to requiring physical repositioning, making continuous extrusions demanding.

**Methods**

The Integrated Rotary Element (IRE) was devised to address the challenge of seamless switching between microvascular channel resolutions. The IRE fits within the CEVIC device, blocks residual flow from all except the desired output channel, and rotates to cut off one channel/opens the rest. The apparatus includes the IRE itself complete with teeth to interface with a gear on a Servo motor which rotates the gear, a CEVIC device modified into two ports that interlock around the IRE, and a holder to keep the Servo and CEVIC connected. The IRE and two CEVIC halves were designed in SolidWorks and OnShape, and printed using biocompatible Photoclear Formlabs resin. The Gear and Holder were printed from Bambu Lab PLA. The Servo motor was programmed and powered by an Arduino. Testing was conducted using water, gelatin, and acellular hydrogel (7% GelMA and 0.3% HEC) at 1.5 mL/min and 0.3 bar to evaluate switching behavior, leakage, and backflow across multiple KSM cycles.

**Conclusion**

The IRE meets its most critical requirement of automated switching between KSM outputs, but leakage and backflow were observed during testing, so the device fails to meet the leakage requirements. The rotating element does not fully block inactive KSM ports, which undermines channel resolution and pattern integrity. However, the automated switching feature of the IRE allows researchers to program a hydrogel to print across multiple KSM resolutions.

[Download](#)

402 - 25 - chaotic\_printing - Executive\_Summary\_1\_.pdf (79.1 kB)



# Final Poster Presentation

SOPHIA SPEECE - May 05, 2026, 12:23 AM CDT

**Title:** Final Poster Presentation

**Date:** 04/24/2026, Entered 05/04/2026

**Content by:** Team

**Present:** Team

**Goals:** Create and present final poster

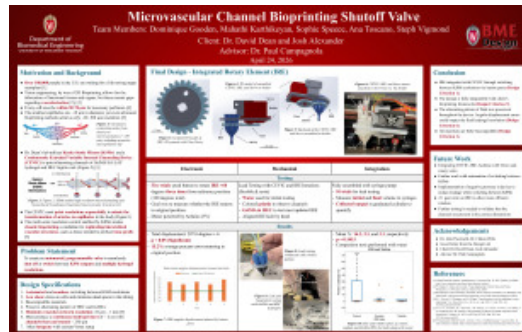
**Content:**

See attachment

**Conclusions/action items:**

Practice and present final poster

SOPHIA SPEECE - May 05, 2026, 12:23 AM CDT



[Download](#)

**BME\_402\_Poster\_Presentation\_2\_.pdf (1.49 MB)**



## Bioinks in 3D Bioprinting

DOMINIQUE GOODEN (degooden@wisc.edu) - May 04, 2026, 12:54 AM CDT

Title: Current Status of Bioinks for Micro-Extrusion-Based 3D Bioprinting - PMC

Date: 2/17/26 (published to labarchives 4 May 2026)

Authors: Amit Panwar, Lay Poh Tan

Goal: Overview bioinks used in bioprinting, as well as chemical methods to improve shape fidelity and bioink printability.

Summary:

Strategies to improve bioink printability:

1. Blending inks together. Create interpenetrating hydrogels to overcome the individual limitations of one particular polymer in a hydrogel
  - Benefit: Improves viscosity
  - Challenge: Decreases cell viability
2. Implement co-axial nozzle
  - a. Benefits
    - i. Improves resolution
    - ii. Ease of facilitation printing low viscosity bionk
    - iii. Multimaterial deposition possible
  - b. Challenges
    - i. Reduced cell viability during printing
3. Nanoparticle loaded bioink
  - a. Benefits:
    - i. Improves shear thinning so that when pressure is applied, the viscous gel can extrude through the bioprinter with ease
    - ii. Safeguards cells from stress effects, preserving cell function and viability during print
  - b. Challenge:
    - i. Low cell viability after the print

Strategies to improve shape fidelity:

1. Ionic and photochemical crosslinking
  - a. Benefit: increases mechanical strength
  - b. Challenge: decreases cell viability
2. Implement sacrificial scaffolds and bioink for nanoporous scaffolds
  - a. Benefits:
    - i. Sacrificial scaffold could help serve as a precursor to printing complex geometries
  - b. Challenges:
    - i. Synthetic polymers could have toxic effects
3. Crosslink print with supportive scaffold
  - a. Benefits:
    - i. Implantable and can degrade efficiently in body
    - ii. Enhanced strength and stability
  - b. Challenge:
    - i. Body degrades the construct fast

Strategies for improving cell viability

1. Decellularize the extracellular matrix
  - a. Benefit: Provides native microenvironment with reduced immunogenicity
  - b. Challenge: Viscosity too low; resolution is poor
2. RGD peptide modification
  - a. Benefits: the RGD can attract synthetic or bioinert materials better, improving cell adhesion
3. Print temperature:
  - a. Benefit: Improves cell viability if not too hot
  - b. Challenge: bioink becomes challenging to print

Bioink library

1. Natural:

## 1. Natural

### a. Alginate

- i. Ionic Crosslinking mechanism
- ii. 400-600um post blending
- iii. Cannot support cell adhesion well due to lacking binding domains

### b. Gelatin

- i. Covalent bonding, also can endure enzymatic, physical and thermal crosslinking
- ii. Low viscosity leading to poor mechanical integrity

### c. Collagen I

- i. High (>1000um) printing resolution
- ii. Extremely effective with cell support as collagen is a basement membrane protein in the extracellular matrix

### d. Hylauronic acid:

- i. Physical and covalent binding
- ii. Not as stable compared to other bioinks

### e. Chitosan

- i. Ionic bonding
- ii. Lacks mechanical strength, cannot support cells long term

## 2. Synthetic

### a. PEG

- i. Covalent binding and swells in response to water
- ii. No cell binding domains

### b. Pluronic acid

- i. Binds via covalent bonds
- ii. Cannot support cell adhesion and lacks mechanical strength

## 3. Self-assembled bioinks

### a. DNA peptide:

- i. Forms non-covalent bonds
- ii. Print resolution 500 um
- iii. Lacks mechanical strength and viscosity.

Future work: Choosing biomaterial that can sustain the bioprint process.

Citation: Panwar A, Tan LP. Current Status of Bioinks for Micro-Extrusion-Based 3D Bioprinting. *Molecules*. 2016 May 25;21(6):685. doi: 10.3390/molecules21060685. PMID: 27231892; PMCID: PMC6273655.



Title: Assessment Methodologies for Extrusion-Based Bioink Printability - PMC

Date: 9 February 2026 (uploaded 4 May 2026)

Authors: [Gregory Gillispie](#) [Peter Prim](#) [Joshua Copus](#) [John Fisher](#) [Antonios G Mikos](#) [James J Yoo](#) [Anthony Atala](#) [Sang Jin Lee](#)

Summary:

This article evaluates methodologies for extrusion based bioinks and attempts to standardize current assessment methods for how bioink printability is measured. The authors mention how printability can be interpreted differently based on the biomaterial used and the modality. The difference in opinion also causes researchers to weigh the importance of printability differently.

Additionally, extrudability measurements are highly variable from project to project. One study established a threshold for a reasonable print time and pressure level to minimize damage. Another study measured extrudability by impacting how certain processing steps impacted the hydrogel print.

How to define printability?

- a. Extrudability → defined as the amount of pressure to extrude bioink, relative to its storage and material composition. The authors mention how bioinks “must both be extruded above a minimum flow rate to achieve a reasonable print time and under a maximum pressure/shear stress to achieve reasonable cell viability.”
- b. Shape fidelity → defined as the bioink’s capacity to retain its original shape post-extrusion
  - i. Poor shape fidelity is indicated by uneven extrusion lines that flatten
  - ii. Adding more layers creates a flattening effect as the material lacks the stiffness to support additional layered material deposits.
  - iii. If filaments lack support, pores create laterally which can weaken the final material integrity
- c. Print quality
  - i. Measured on a scale of 0-2 for print uniformity and stability.
  - ii. Grid pattern printed and was evaluated for excessive deposition, optimal deposition, or incomplete deposition
    1. Excessive deposition → merged filaments and closed pores
    2. Optimal deposition → filaments evenly spaced out
    3. Incomplete print → discontinuous filaments
  - iii. Also asks if the print quality is reproducible over multiple prints
- d. Cell mixing + suspension
  - i. Bioink must be thin enough but not too viscous for appropriate cell suspension
  - ii. Thermoresponsive bioinks help evenly distribute cell populations
    1. Cells initially mixed in bioink with low viscosity
    2. Mixture transferred to a temperature synonymous with increased viscosity to help the cells remain in place as the material solidifies.
    3. Presently no literature exists for minimum and maximum viscosity for homogenous cell mixing and cell seeding
- e. Resolution
  - i. Pressure, feed-rate, nozzle shape and diameter impact resolution. The material quality (it’s ability to remain viscosity) may also impact the viscosity separate from these conditions
  - ii. Thinner filaments generally corresponds to longer print times
  - iii. Polymer could disentangle and “return to their natural entropy maximizing state after exiting the nozzle tip” as it leaves the nozzle, creating larger than intended filaments
  - iv. Stronger gels may endure higher feedrates before it reaches a breaking point and separates its filaments

One significant limitation of measuring printability is an inability to control material deposition upon the material leaving the extruder and print head. Researchers previously modulated feedrate or extrusion pressure to observe improvements in material deposition. However, the authors note that it was hard to distinguish whether bioprint defects stemmed from over/under deposition or whether a material-specific property contributed to the bioprint. The authors recommend that future research focuses on identifying parameters to quantify maximum feedrates, ideal nozzle heights and shapes, and to characterize the type of filament that forms pre and post extrusion. The authors also suggest studying ambient humidity and air pressure's impacts on printing reproducibility.

Citation:

Gillispie G, Prim P, Copus J, Fisher J, Mikos AG, Yoo JJ, Atala A, Lee SJ. Assessment methodologies for extrusion-based bioink printability. *Biofabrication*. 2020 Feb 19;12(2):022003. doi: 10.1088/1758-5090/ab6f0d. PMID: 31972558; PMCID: PMC7039534.

Title: [Robotic-assisted automated in situ bioprinting](#)

Date: 4/19/26 (uploaded 4 May 2026)

Authors: [Hui Dong](#) [Bo Hu](#) [Weikang Zhang](#) [Wantao Xie](#) [Jin Mo](#) [Hao Sun](#) [Junyi Shang](#)

Summary:

*In situ* bioprinting (ISB) is a technology that directly prints on specified anatomical positions *in vivo*. The article reviews robotic applications for ISB and its applications for academic research and industry projects.

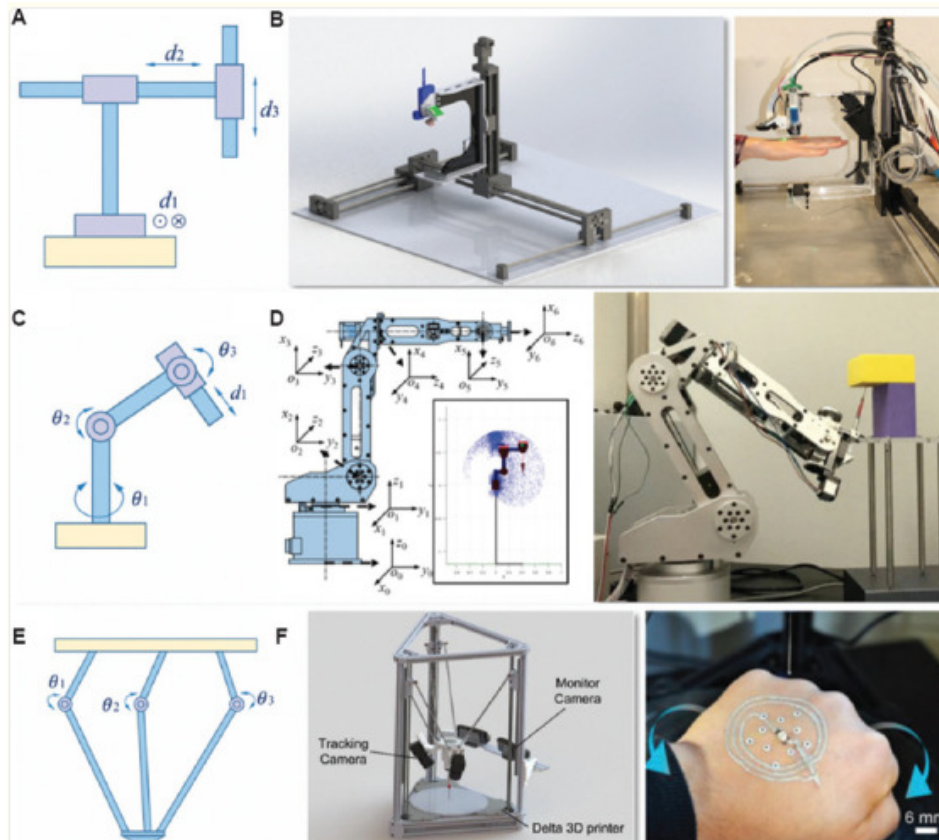


Figure 3 from paper: A-B is Cartesian robot diagram. C-D is an articulated robot. E-F is parallel robot with the human hand depicting adaptive printing onto live surfaces.

Cartesian Coordinate robots:

- Cartesian Coordinate robots combines extrusion, inkjet, and optics based methods to produce precise bioprints.
- Display high mechanical stiffness using low cost strategies. However, it experiences surface distortion of neighboring layers.
- Cannot print on irregular surfaces, which could pose a barrier for material integration *in vivo* where there are many different surfaces and substrate attachments.

Articulated Robots

- Contains rotary joints that operate in 360 DOF, allowing for precise print modifications in multi-dimensional space from different areas that traditional cartesian coordinates may not reach as efficiently.
- Rotary joints powered by servo motors and operated by advanced kinematics algorithms
- Some setups are perceived as overly complex, having more robot arms (DOF) than necessary for improving dexterity significantly.
  - Li [et.al.](#), 2021 → achieved osteochondral defect repair or rabbit cartilage in 1 minute using a 6 DOF articulated robot
  - Zhang [et.al.](#), 2022 → designed an articulated robot printer with 6DOF to print 3D vascular scaffolds

Parallel robots:

- 3 arms attached to a base; multiple arms control each joint.
- More simplified design and integration, while maintaining high precision at efficient speeds

- Experienced significant leakages

Citation:

Dong H, Hu B, Zhang W, Xie W, Mo J, Sun H, Shang J. Robotic-assisted automated *in situ* bioprinting. *Int J Bioprint*. 2022 Oct 28;9(1):629. doi: 10.18063/ijb.v9i1.629. PMID: 36636132; PMCID: PMC9830995.

Li L, Shi J, Ma K, et al. Robotic in situ 3D bio-printing technology for repairing large segmental bone defects. *J Adv Res*. 2021;30:75–84. doi: 10.1016/j.jare.2020.11.011. <https://doi.org/10.1016/j.jare.2020.11.011>

Zhang Z, Wu C, Dai C, et al. A multi-axis robot-based bioprinting system supporting natural cell function preservation and cardiac tissue fabrication. *Bioactive Mater*. 2022;18:138–150. doi: 10.1016/j.bioactmat.2022.02.009.

Title: Novel Biomaterials Used in Medical 3D Printing Techniques

Date: 3/11/26 (uploaded 4 May 2026)

Authors: [Karthik Tappa](#) [Udayabhanu Jammalamadaka](#)

Goal: learn about other bioprinting techniques out of curiosity + clarify what additive manufacturing means

Summary: This paper reviews 3D bioprinting applications. The paper overviews additional additive manufacturing techniques. Additive manufacturing is the process of creating 3D structures from depositing materials in a layer-by-layer design based on a CAD model. 3D bioprinting is a category of additive manufacturing, but there are also many subcategories of 3D bioprinting that are used for surgical and medical research applications.

- a. Fused Deposit Modeling/Free Form Fabrication
  - i. Thermoplastic material dispenses through heated print head and builds layers upon itself to create the desired shape
  - ii. Print head is easily removable
  - iii. Common thermoplastic materials include Acrylonitrile Butadiene Styrene, which is known for its low melting point, chemical resistance, and rigidity. Other thermoplastics used nylon and polycarbonate.
- b. Extrusion based bioprinting
  - i. Material extruded via pneumatic pressure through a print head.
  - ii. No heating procedures required, making it suitable for tissue engineering
  - iii. Platform allows for precise control over cell seeding deposits and the rate of which they are deposited.
  - iv. There is often a post processing to structurally reinforce the material through chemical or UV means
  - v. Common inks include Polyethylene Glycol, hyaluronic acid, collagen, gelatin and alginate. The variety of biomaterials allows researchers to create a diverse array of bioprints.
  - vi. Higher amounts of polymer needed for final product, creating a dense hydrogel with limited capacity to vascularize
    1. Addressed by utilizing sacrificial biomaterials to reinforce void spaces.
- c. Inkjet based printing
  - i. Liquid carefully dropped onto surface to bind through thermal and piezoelectric heads
    1. Thermal head unit vaporizes the material so it deposits as droplets
    2. Piezoelectric head generates pressure and velocity changes in the liquid to make the bioprints
  - ii. Cannot accommodate printing of multiple materials at once
- d. Polyjet printing
  - i. Photopolymer resin printed and cured via UV into a supportive construct (hydrogel or sacrificial material)
  - ii. Can accommodate printing multiple materials at once at high resolution

Action Items/Future work: N/A

Citation: Tappa K, Jammalamadaka U. Novel Biomaterials Used in Medical 3D Printing Techniques. *J Funct Biomater*. 2018 Feb 7;9(1):17. doi: 10.3390/jfb9010017. PMID: 29414913; PMCID: PMC5872103.



Title: [Current Advances in 3D Bioprinting Technology and Its Applications for Tissue Engineering - PMC](#)

Date: 4/21/26 (published to labarchives 4 May 2026)

Authors: [JunJie Yu](#) [Su A Park](#) [Wan Doo Kim](#) [Taeho Ha](#) [Yuan-Zhu Xin](#) [JunHee Lee](#) [Donghyun Lee](#)

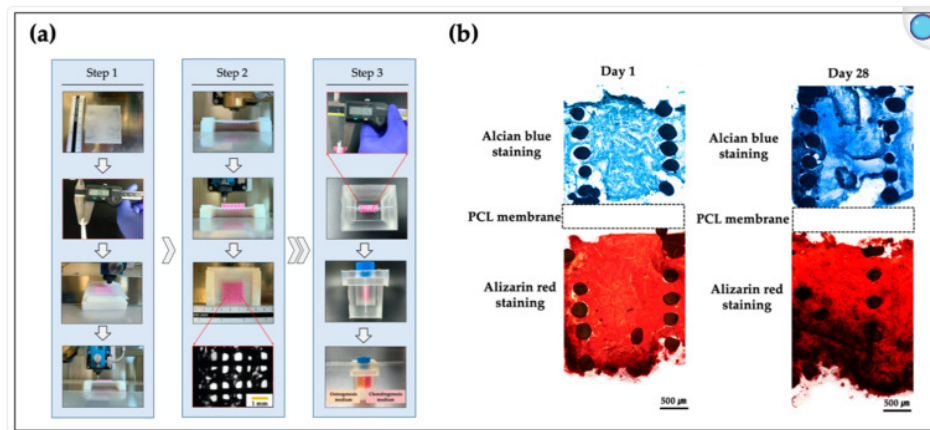
Goal/Summary: This review paper overviews the 3D bioprinting industry and its various applications, from bioprinter types + methods, to bioinks and tissue constructs. I have covered similar content on bioprinter types and extrusion based methods in other research entries so I will not discuss that here. But the paper did mention applications of tissue engineering for bone and osteocartilage, which is relevant to the 400/402 project, so I will talk about that.

#### Bone tissue engineering

Bone tissue is unique in its diversity of mechanical properties. Human bone tissue is composed of cortical and cancellous bone tissue, where cortical bone is hard and provides structural strength, while cancellous bone is spongy and contains bone marrow for immune cell production. Cell encapsulation efficiency in bone constructs is important for ensuring adequate perfusion, biocompatibility, and strength, and current engineering approaches must consider mechanical stiffness properties when designing a bone tissue construct. The authors mention one such example of bioprinting bone tissue scaffolds using PCL and alginate bioinks with a CaCl<sub>2</sub> crosslinker (Lee et. al., 2013). The cells in the scaffold were dispersed evenly and achieved 84% cell viability 3 weeks post seeding. The authors compared these results to another study that studied osteogenic effects in 3D printed bone constructs of PEGDMA-GelMA bioink (later seeded with proteoblast cells, Gao et. al, 2015). The results found that adding GelMA to PEGDMA enhanced osteogenic potential, which is crucial for the differentiation of mesenchymal stem cells to osteoblasts. Additionally, a cell survival rate >80% was achieved. The results from Gao et. al., 2015 demonstrate that bioprinted constructs containing both synthetic (PEGDMA) and natural (GelMA) materials could offer unique material advantages without outcompeting each other.

#### Osteo-cartilage engineering

Osteochondral tissue is composed of cartilage and subchondral bone. Given the heterogeneous nature of osteocartilage, various bioprinting strategies have been considered. One study fabricated bone and cartilage separately and assembled them upon maturation (Daley et. al, 2014). While functional osteochondral constructs were achieved with the help of a dual perfused bioreactor, this process was manual and required lots of sophistication that makes it hard to reproduce. Years later, a study attempted to fabricate a melt electrowritten fiber infused hydrogel scaffold. The scaffold materials were GelMA (seeded with mesenchymal stem cells), and PCL and PEG copolymers. The fibers were trilayered to create different alignments that represent cartilage, calcified cartilage, and bone layers. The composite scaffold nature promoted chondrogenic and osteogenic differentiation to produce osteogenic cartilage during in vivo tests.

**Figure 5.**

Fabrication process and histopathologic results of osteochondral scaffold [173]. (a) The fabrication process of bipartite scaffold using a 3D bioprinting system; (b) histological results at day 1 and 28.

Conclusions: This paper demonstrates that it is possible to fabricate complex biomaterials to match unique tissue heterogeneity. Further work is needed to make process improvements and improve reducibility for broader tissue engineering applications.

Citation:

Yu J, Park SA, Kim WD, Ha T, Xin YZ, Lee J, Lee D. Current Advances in 3D Bioprinting Technology and Its Applications for Tissue Engineering. *Polymers (Basel)*. 2020 Dec 11;12(12):2958. doi: 10.3390/polym12122958. PMID: 33322291; PMCID: PMC7764360.

Daley E.L., Kuttig J., Stegemann J.P. Development of Modular, Dual-Perfused Osteochondral Constructs for Cartilage Repair. *Tissue Eng. Part C Methods*. 2019;25:127–136.

Qiao Z., Lian M., Han Y., Sun B., Zhang X., Jiang W., Li H., Hao Y., Dai K. Bioinspired stratified electrowritten fiber-reinforced hydrogel constructs with layer-specific induction capacity for functional osteochondral regeneration. *Biomaterials*. 2021;266:120385. doi: 10.1016/j.biomaterials.2020.120385.





# Title: **Bioprinting 101: Design, Fabrication, and Evaluation of Cell-Laden 3D Bioprinted Scaffolds**

Date: 19 February 2026 (uploaded 4 May 2026)

Authors: [Kaivalya A Deo](#) [Kanwar Abhay Singh](#) [Charles W Peak](#) [Daniel L Alge](#), [Akhilesh K Gaharwar](#)

Summary: This article is a review of bioprinting fabrication strategies for 3D Scaffolding. Bioprinting falls under a broader category of additive manufacturing, which is an iterative process to generate multi-dimensional objects. There are many techniques to fabricate 3D bioprints, including extrusion based bioprinting, laser assisted printing, and more. Generally, bioinks are loaded into holding vessels and dispensed at a rate between 700 mm- 10 um per second.

The article evaluated process improvement factors that intertwine with extrusion based bioprinting. Some of those considerations are:

1. Bioink maintains a low viscosity profile to minimize cell shear stress and mechanical clogging. Bioink must be able to solidify fast and maintain its structural integrity.
2. Bioink must not drastically change its viscosity throughout the extrusion. Choose a material that is not sensitive to changes in stress, temperature, or pressure.
3. Bioink must overcome a minimum yield stress for deposition. However, the yield stress exerted on the bioink must not be excessive to avoid cell seeding issues and mechanical breakdowns.

Some factors relevant to the extrusion process include:

1. Pre extrusion - cells must be homogeneously dispersed to minimize yield stress
2. During extrusion - maintain a shear rate consistent with the viscosity. Higher shear rates are more appropriate for low viscosities and lower shear rates appropriate for high viscosity materials.
3. Post extrusion - Resulting print must be biocompatible and crosslinked enough with a high elastic modulus to promote cell viability (>80%).

Factors relevant to polymer selection:

1. Molecular weight → impacts degree of hydrogel swelling. This swelling may impact management of cellular byproducts in the hydrogel.
2. Crosslinking density →
  - a. Natural polymer derivatives like GelMA sensitive to matrix metalloproteinases making degradation more likely.
  - b. Synthetic polymer derivatives can be engineered to withstand MMP activity
  - c. Crosslinking mechanism based on polymer R groups. Thiol is mentioned as a polymer for crosslinking.
3. Polymer dispersity index → indicates how similar a material's molecular weight composition is.
  - a. Low PDI means the molecules have similar MWs, suggesting predictable polymer behaviour and mechanical properties. Generally natural polymers have lower PDIs compared to synthetic polymers.
  - b. Higher PDI suggests the polymer may have varying lengths of chains, leading to a higher MW and less predictable mechanical properties.

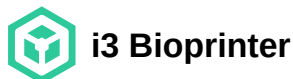
- c. Strong polymer choice is alginate as it can shear thin, crosslink, and not produce an excessive immune response in the body.

Conclusions: Gained understanding of mechanical effects on cell viability and polymer usage in bioprinting applications.

Action items: N/A, given no cell work was done this semester. However, future work could establish optimizing parameters in the extrusion bioprinting framework to produce higher quality hydrogel outputs

Citation:

Deo KA, Singh KA, Peak CW, Alge DL, Gaharwar AK. Bioprinting 101: Design, Fabrication, and Evaluation of Cell-Laden 3D Bioprinted Scaffolds. *Tissue Eng Part A*. 2020 Mar;26(5-6):318-338. doi: 10.1089/ten.TEA.2019.0298. PMID: 32079490; PMCID: PMC7480731.



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DOMINIQUE GOODEN (degooden@wisc.edu) - May 04, 2026, 1:28 AM CDT

Title: [Step-by-step assembly and testing of a low-cost bioprinting solution for research and educational purposes - PMC](#)

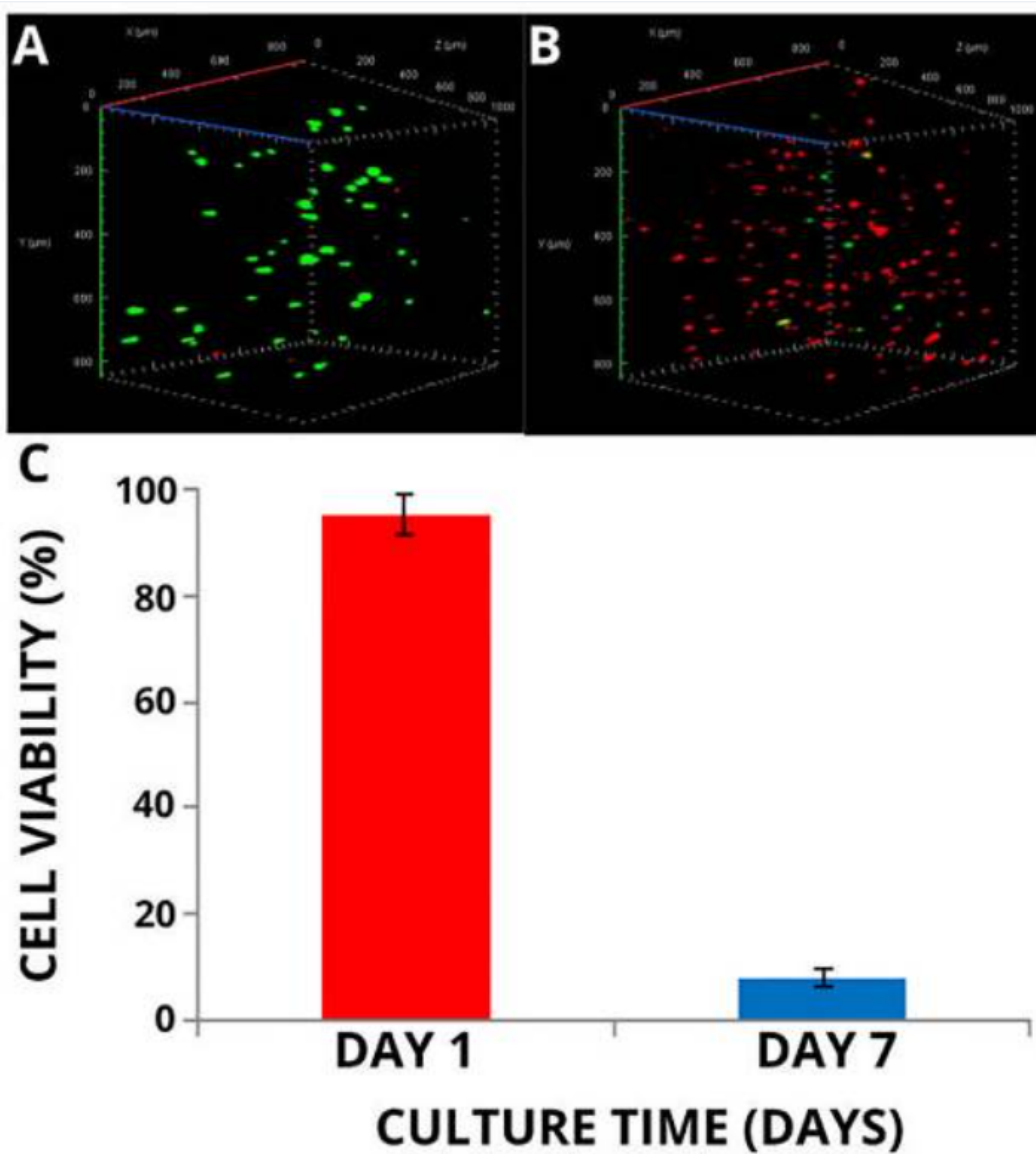
Authors: [John Robert Honiball](#) [Michael Sean Pepper](#) [Earl Prinsloo](#)

Citation: Honiball JR, Pepper MS, Prinsloo E. Step-by-step assembly and testing of a low-cost bioprinting solution for research and educational purposes. *MethodsX*. 2020 Dec 17;8:101186. doi: 10.1016/j.mex.2020.101186. PMID: 33376679; PMCID: PMC7758549.

Date: 22 April 2026 (published to labarchives 4 May 2026)

Goal: learn about how bioprinters are set up

Summary: The authors sought to implement cost efficient modifications to the ReRap Prusa iteration 3 (i3) 3D printer, given the high cost of bioprinting technologies. The assembly process is described below, but the key modification made was modifying the syringe microextrusion print head to control bioink deposition. They then validated the bioprinting functionality by printing cell-laden sodium alginate stains. A live/dead staining assay to assess cell survival and viability. Freeform Reversible Embedding of Suspended Hydrogels (FRESH) was the bioprinting method utilized, as the prints happen inside a gelatin slurry support bath to hold the biomaterial print in place as it cures.



Results indicated that cell viability decreased from day 1 to day 7 with FRESH printing. Additionally, the bioprinted objects deformed from their original positions, leading to low printing accuracy. The authors believe that X-ray microtomography could develop more accurate conclusions from shape analysis.

Below is a summary of the i3 printer and the setup.

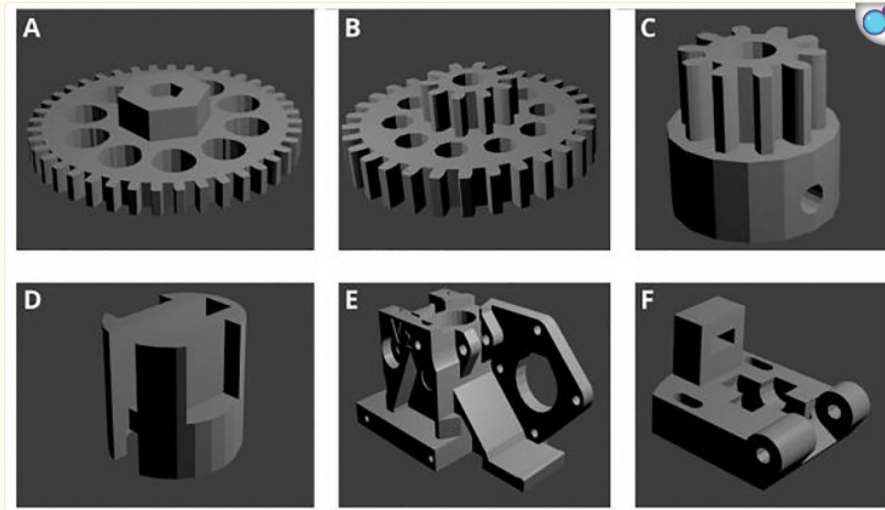
i3 printer is a Cartesian coordinate-based printer that is operated by an 8 bit microcontroller.

The researchers utilized this framework to setup the universal paste extruder:

1. Download 3D files for the gears, syringe cap, and idlers. Modify as necessary to ensure components can attach.
2. Print the components and mount the stepper motor to the print body with M3 x 10mm screws.
3. Attach the printed motor drive gear to the stepper motor with eight M4 washers and a 624ZZ bearing.

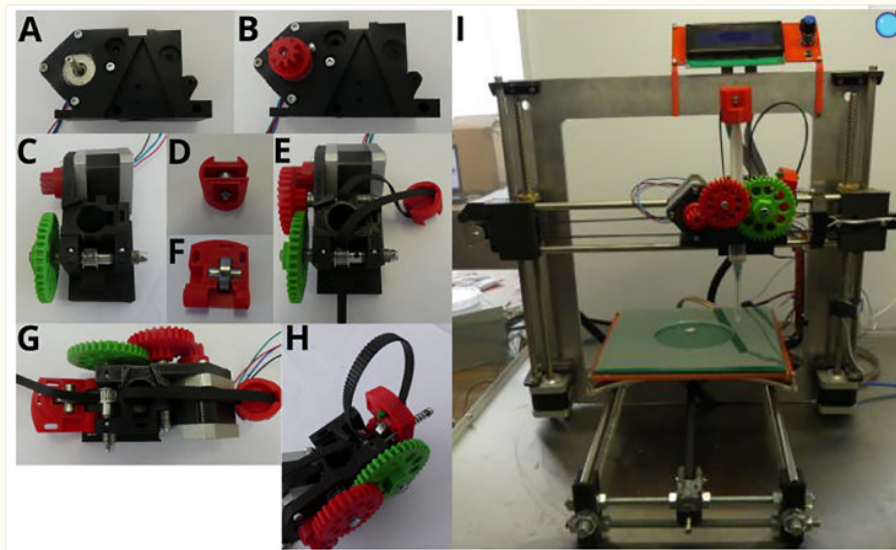
4. Insert the 624ZZ bearing into the syringe cap.
5. Feed a GT2 toothed rubber timing belt through syringe cap.
6. Secure the double gear to the extruder body
7. Attach the 608ZZ bearing to the idler.
8. Secure the idler base to the extruder body.

Fig. 1.

[Open in a new window](#)

Three-dimensional (3D) printed parts required for universal paste extruder assembly. A: Large gear. B: Double gear. C: Drive gear. D: Syringe cap. E: Extruder body. F: Idler. Images were rendered in Blender (v2.78).

Fig. 2.

[Open in a new](#)

Universal paste extruder assembly process. A: Stepper motor mounting. B: Drive gear attachment. C: Large gear attachment. D: Syringe cap bearing attachment. E: Double gear attachment. F: Idler bearing attachment. G: Idler attachment. H: GT2 belt attachment. I: Modified Prusa i3 based bioprinter with mounted extruder.



DOMINIQUE GOODEN (degooden@wisc.edu) - May 04, 2026, 5:26 PM CDT

Valve	Dimensions	Max PSI	Cost	Ports	Type	Notes	Location	Package	Time to print
<a href="#">Pneumatic Valve</a>	1.000 in x 1.000 in	90	1.00	2	2.0 Port 2.0 way	How much is 1.000 in in dimensions			
<a href="#">Pneumatic Valve</a>	1.000 in x 1.000 in	90	1.00	2	2.0 Port 2.0 way	1.000 in x 1.000 in 1.000 in 1.000 in			
<a href="#">Pneumatic Valve</a>	1.000 in x 1.000 in	20	1.00	2	2.0 Port 2.0 way	Customize variable 2.000 in 1.000 in 1.000 in			

[Download](#)

**Pneumatic\_Valves.pdf (33.3 kB)**

DOMINIQUE GOODEN (degooden@wisc.edu) - May 04, 2026, 5:26 PM CDT

 **updated code**

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DOMINIQUE GOODEN (degooden@wisc.edu) - May 04, 2026, 12:57 PM CDT



[Download](#)

**360\_rotation.ino (577 B)**


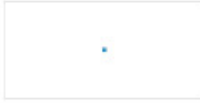
# angular displacement testing data

DOMINIQUE GOODEN (degooden@wisc.edu) - May 04, 2026, 5:20 PM CDT

Overview

Sheet: Sheet1

Year	Month	Day	Time	Angle (deg)	Displacement (mm)	Force (N)	Stiffness (N/mm)	Modulus (GPa)	Strain (mm/mm)	Stress (MPa)	Strain Rate (1/s)	Stress Rate (MPa/s)
2026	05	04	14:30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2026	05	04	14:31	0.1	0.1	10.0	100.0	100.0	0.001	10.0	0.001	10.0
2026	05	04	14:32	0.2	0.2	20.0	200.0	200.0	0.002	20.0	0.002	20.0
2026	05	04	14:33	0.3	0.3	30.0	300.0	300.0	0.003	30.0	0.003	30.0
2026	05	04	14:34	0.4	0.4	40.0	400.0	400.0	0.004	40.0	0.004	40.0
2026	05	04	14:35	0.5	0.5	50.0	500.0	500.0	0.005	50.0	0.005	50.0
2026	05	04	14:36	0.6	0.6	60.0	600.0	600.0	0.006	60.0	0.006	60.0
2026	05	04	14:37	0.7	0.7	70.0	700.0	700.0	0.007	70.0	0.007	70.0
2026	05	04	14:38	0.8	0.8	80.0	800.0	800.0	0.008	80.0	0.008	80.0
2026	05	04	14:39	0.9	0.9	90.0	900.0	900.0	0.009	90.0	0.009	90.0
2026	05	04	14:40	1.0	1.0	100.0	1000.0	1000.0	0.010	100.0	0.010	100.0



Download

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**BME402\_testing.xlsx (25.7 kB)**



## Thank You

Thank you for completing the Biosafety 106: Autoclave Use course.

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To obtain a printable record of this training, please use the [Training Record Lookup Tool](#) to look up your name and print the resulting list of completed trainings (please allow up to 5 days for your training record to show the most recent updates).

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Date stamped completion of Biosafety 106 Course after taking the quiz. Still waiting for **OVCR Training Information Lookup Tool** to update my training records but should update no later than 9 May 2026.



## 2026/01/30- Linear Actuator Basics Research

ANA CLARA TOSCANO - Jan 30, 2026, 10:35 AM CST

**Title:** Linear Actuator Modeling

**Date:** 2026/01/30

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Use a **linear actuator (up/down motion)** to dispense/print hydrogel, attach **CEVIC** to the actuator and develop a **program** to automate the dispensing process

**Citation:**

Philatenkov, P. I., Morozova, E. V., & Morozova, T. S. (2020). Linear Actuator Modeling. *2020 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus)*. <https://doi.org/10.1109/eiconrus49466.2020.9039171>

**Content:**

Linear actuators are widely used in **automation, medicine, and industrial processes** because of their **simple design, durability, quiet operation, and ability to work reliably under load**. For dispensing applications, vertical linear actuators are especially relevant, as they provide controlled motion of a dispensing nozzle or syringe.

The actuator's motion is typically generated using a **screw–nut (lead screw) mechanism**, where a DC motor rotates a screw to produce linear movement of a rod (staff). The **direction of motion** is controlled by changing motor polarity, which can be easily automated through a controller such as **CEVIC**.

The paper identifies **key selection criteria** for choosing a linear actuator:

- **Pushing/retracting force** (ability to extrude material)
- **Load capacity** (weight of syringe, hydrogel, and mounting hardware)
- **Stroke length** (dispensing height range)
- **Speed** (mm/s, affecting dispensing rate)
- **Duty cycle and lifetime** (reliability during repeated dispensing cycles)

Through calculations and modeling, the authors demonstrate how actuator performance depends on load, operating time, and mechanical efficiency. A **50% duty cycle** example shows how actuators can be safely used in repetitive, automated processes similar to hydrogel extrusion.

The selected **MK-150 linear actuator** uses an **acme (trapezoidal) screw**, which offers:

- **Self-locking behavior** (prevents backflow of hydrogel when stopped)
- **High load capacity**
- **Smooth, quiet operation**
- **No need for additional braking mechanisms**

A **3D and kinematic model** of the actuator is developed, showing how simulation and modeling support integration into automated systems.

**Conclusions/action items:** The use of a **screw–nut (acme) transmission** offers additional advantages, including **self-locking behavior**, which prevents unintended motion or material backflow when the system is stopped. This eliminates the need for external braking mechanisms and improves system reliability.



## 2026/02/19 - Vascularization in Tissue Engineering

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ANA CLARA TOSCANO - Apr 27, 2026, 3:33 PM CDT

**Title:** Vascularization in Tissue Engineering

**Date:** 2026/02/19

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Review why vascularization is a critical limitation in tissue engineering and define the physiological scale needed for perfusion.

**Citation:** E. C. Novosel, C. Kleinhans, and P. J. Kluger, "Vascularization is the key challenge in tissue engineering," *Adv. Drug Deliv. Rev.*, vol. 63, no. 4, pp. 300–311, Apr. 2011, doi: 10.1016/j.addr.2011.03.004.

**Content:**

Tissue engineering depends on creating functional structures that can survive and integrate with the body, but a major barrier is vascularization. For engineered tissue to receive enough oxygen and nutrients and remove waste, every cell must be within about 50–70 micrometers of a blood vessel. The smallest capillaries are about 10 micrometers in diameter, so the design challenge is to reproduce vessel sizes and branching patterns that mimic arteries, arterioles, capillaries, venules, and veins.

**Conclusions/action items:**

Vascularization remains the key biological challenge for larger engineered tissues. Future work should focus on improving microchannel resolution, reducing leakage, and better matching physiological vessel branching and perfusion distances.



## 2026/02/19 - Biology and Physiology Background: Circulatory Structure and Perfusion Needs

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ANA CLARA TOSCANO - Apr 27, 2026, 9:54 PM CDT

**Title:** Vascularization in Tissue Engineering

**Date:** 2026/02/19

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Document the perfusion constraint that motivates the microvascular printing approach.

**Citation:** E. C. Novosel, C. Kleinhaus, and P. J. Kluger, "Vascularization is the key challenge in tissue engineering," *Adv. Drug Deliv. Rev.*, vol. 63, no. 4, pp. 300–311, Apr. 2011, doi: 10.1016/j.addr.2011.03.004.

**Content:**

A major limitation in tissue engineering is that cells in thicker constructs cannot survive without adequate perfusion. The report states that engineered tissues often fail when they lack a functional vascular network, and that constructs rarely exceed about 2 mm in thickness before central regions become hypoxic and necrotic. This is why microvascular channel fabrication is essential for clinically relevant tissue constructs.

**Conclusions/action items:** The biology problem is not just making tissue shape; it is making tissue that can stay alive. The next archive entry should link this physiology directly to the resolution and switching requirements of the CEVIC/IRE system.



## 2026/03/12 - Biology and Physiology Background: Cell Survival and Nutrient Exchange

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ANA CLARA TOSCANO - Apr 27, 2026, 9:58 PM CDT

**Title:** Biology and Physiology Background: Cell Survival and Nutrient Exchange

**Date:** 2026/03/12

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Record the cell-level reason that vascularization matters in printed hydrogels.

**Citation:**

A. Lee, A. R. Hudson, D. J. Shiwerski, J. W. Tashman, T. J. Hinton, S. Yerneni, J. M. Bliley, P. G. Campbell, and A. W. Feinberg, "3D bioprinting of collagen to rebuild components of the human heart," *Science*, vol. 365, no. 6452, pp. 482–487, Aug. 2019, doi: 10.1126/science.aav9051.

**Content:**

Cells in engineered tissue require a nearby vessel network to exchange oxygen, nutrients, and waste. Without that exchange, the inner regions of a construct lose viability as diffusion becomes insufficient over larger distances. The report describes the target as keeping every cell within 50–70 micrometers of a blood vessel, which gives a practical physiological design constraint for the printed channel layout.

**Conclusions/action items:** Use the 50–70 micrometer distance as the main physiology justification in future entries. Tie this directly to why higher-resolution channel switching is important for the project.



## 2026/03/12 - Biology and Physiology Background: Need for Hierarchical Vasculature

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ANA CLARA TOSCANO - Apr 27, 2026, 10:01 PM CDT

**Title:** Biology and Physiology Background: Need for Hierarchical Vasculature

**Date:** 2026/03/12

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Explain why the device must create multiple channel sizes instead of one uniform network.

**Citation:**

Ryan Hooper, Caleb Cummings, Anna Beck, Javier Vazquez-Armendariz, Ciro Rodriguez, and David Dean, "Sheet-based extrusion bioprinting: a new multi-material paradigm providing

**Content:**

Natural vasculature is hierarchical, meaning vessel size changes gradually from large arteries down to small capillaries. The project's printing system is designed to mimic this progression using multiple KSM resolutions, which allows the hydrogel to form channels at different scales. This matters because a single uniform channel size would not accurately represent the circulatory system or provide realistic perfusion behavior.

**Conclusions/action items:** The archive should continue to emphasize hierarchy, not just channel formation. Note that sequential switching between resolutions is a biological requirement because it imitates the transition from arteries to capillaries. Get image for poster.



## 2026/04/07 - Competing Device Review: 3D-Printed Microfluidic Multiport Rotary Valve (Diehm et al.)

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ANA CLARA TOSCANO - Apr 14, 2026, 7:18 PM CDT

Title: Competing Device Review: 3D-Printed Microfluidic Multiport Rotary Valve (Diehm et al.)

Date: April 7, 2026

Content by: Ana Toscano

Present: Ana Toscano

Goals: Review the most directly analogous existing valve technology for KSM output switching

Citation: Diehm et al., "Configurable 3D Printed Microfluidic Multiport Valves with Axial Compression," *Micromachines*, vol. 12, no. 10, p. 1247, 2021. <https://www.mdpi.com/2072-666X/12/10/1247>

Content: A 3D-printed multiport rotary valve with axial compression actuated by a stepper motor. Demonstrated no measurable leakage in static conditions and less than 0.5% leakage during dynamic switching. Explicitly cited as a competing design in the Dean lab's preliminary design presentation.

Conclusions/action items: Most analogous existing validated device to the IRE. Key limitation is that testing was conducted at 800  $\mu\text{m}$  channel dimensions, leaving performance at the 10  $\mu\text{m}$  scale and with viscous GeIMA hydrogels unproven. Use as primary benchmark for IRE seal performance testing.



## 2026/04/07 - Competing Device Review: On-Chip Liquid-Metal Microvalve (Liu et al.)

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ANA CLARA TOSCANO - Apr 14, 2026, 7:21 PM CDT

Title: Competing Device Review: On-Chip Liquid-Metal Microvalve (Liu et al.)

Date: April 7, 2026

Content by: Ana Toscano

Present: Ana Toscano

Goals: Review Galinstan-based on-chip microvalve as a competing switching mechanism

Citation: J. Gong, Q. Wang, B. Liu, H. Zhang, and L. Gui, "A Novel On-Chip Liquid-Metal-Enabled Microvalve," *Micromachines*, vol. 12, no. 9, p. 1051, 2021. <https://doi.org/10.3390/mi12091051>

Content: A Galinstan-based on-chip valve with no detectable leakage at pressures up to 320 mbar and a leakage rate of no more than 0.043  $\mu\text{L}/\text{min}$  at 330 mbar. Cited as a competing design in the Dean lab's preliminary presentation.

Enables precise directional flow control at microscale.

Conclusions/action items: Excellent sealing performance, but gallium-based liquid metals raise significant biocompatibility concerns and require electrochemical cathodic protection to prevent oxidation-induced failure. Does not address sequential KSM switching or hierarchical branching. Not suitable for direct adaptation without material biocompatibility resolution.



## 2026/04/07 - Competing Device Review: Pneumatic PDMS Membrane Valve (Bertsch/Serex et al.)

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ANA CLARA TOSCANO - Apr 14, 2026, 7:31 PM CDT

Title: Competing Device Review: Pneumatic PDMS Membrane Valve (Bertsch/Serex et al.)

Date: April 7, 2026

Content by: Ana Toscano

Present: Ana Toscano

Goals: Review pneumatically actuated on-chip PDMS membrane valve as a competing switching mechanism

Citation: Serex et al., "Microfluidics: A New Layer of Control for Extrusion-Based 3D Printing," *Micromachines*, vol. 9, no. 2, p. 86, 2018. <https://www.mdpi.com/2072-666X/9/2/86>

Content: Pneumatically actuated PDMS membrane valves integrated on-chip, achieving switching in 500 ms with dead volume minimized to approximately 12.6 nL. This approach is used commercially in the Aspect Biosystems RX1 bioprinter platform.

Conclusions/action items: Dead volume performance is excellent and switching speed is adequate. However, adapting this for KSM output switching requires custom chip fabrication, and PDMS is not autoclave-compatible, which conflicts directly with the client's sterilization requirement of 121°C, 15 psi, 15 minutes.



## 2026/04/07 - Competing Device Review: Rapid Continuous Multi-Material Pneumatic Switching (Lewis Lab)

---

ANA CLARA TOSCANO - Apr 14, 2026, 7:35 PM CDT

Title: Competing Device Review: Rapid Continuous Multi-Material Pneumatic Switching (Lewis Lab)

Date: April 7, 2026

Content by: Ana Toscano

Present: Ana Toscano

Goals: Review pneumatically driven multi-channel bioprinting switching as relevant prior art

Citation: Sun et al., "Multi-Material 3D Printing of Biologically-Relevant Materials," *Advanced Materials*, 2017. <https://pmc.ncbi.nlm.nih.gov/articles/PMC5235978/>

Content: A 7-channel pneumatically actuated bioprinting platform from the Harvard Lewis Lab that switches between material reservoirs with near-zero gap time using digitally controlled pneumatic valves. Demonstrates the feasibility of programmable, automated multi-channel switching in a bioprinting context.

Conclusions/action items: Validates the concept of digitally programmable multi-channel switching for bioprinting. Does not replicate hierarchical patterning within a single extrusion stream. Pneumatic actuation is a potential design direction for future IRE iterations to reduce mechanical sealing complexity.



## 2026/04/07 - Competing Device Review: Commercial Multi-Position Rotary Valves (VICI, Fluigent, Rheodyne)

---

ANA CLARA TOSCANO - Apr 14, 2026, 7:37 PM CDT

Title: Competing Device Review: Commercial Multi-Position Rotary Valves (VICI, Fluigent, Rheodyne)

Date: April 7, 2026

Content by: Ana Toscano

Present: Ana Toscano

Goals: Review commercial rotary valve platforms for applicability to KSM output switching

Citation: VICI Valco Instruments, Multiposition Microelectric Valve Actuators. <https://www.vici.com/act/micmp.php>;

Fluigent M-Switch, Beonchip. <https://beonchip.com/product/m-switch>

Content: VICI multiposition actuators support up to 96 positions with RS-232 programmable logic. Fluigent M-Switch is an 11-port rotary valve with millisecond-level switching and software automation. Rheodyne/IDEX MXP9900 and MXP9960 series are PEEK-bodied 2-position valves rated to 6,000 psi with biocompatible wetted surfaces.

Conclusions/action items: Offer automation and programmability that meets the client's control requirements. However, all are designed for chromatographic-scale aqueous or solvent flow rates, not viscous hydrogels. Risk of clogging, dead-volume contamination between KSM outputs, and incompatibility with GelMA viscosity must be evaluated before adoption.



## 2026/04/07 - Competing Device Review: Solenoid and Pinch Valve Systems for Bioprinting

---

ANA CLARA TOSCANO - Apr 14, 2026, 7:39 PM CDT

Title: Competing Device Review: Solenoid and Pinch Valve Systems for Bioprinting

Date: April 7, 2026

Content by: Ana Toscano

Present: Ana Toscano

Goals: Review solenoid and pinch valve approaches as non-contact switching alternatives

Citation: The Lee Company, VHS Nanolitre Solenoid Valves. <https://www.theleeco.com/insights/miniature-vhs-solenoid-valves-play-significant-role-in-the-viability-of-3d-bio-printing-of-human-cells-uk/>

Content: The Lee Company VHS solenoid valves have been used in drop-on-demand bioprinters at Heriot-Watt University. Biocompatible pinch valves such as the Sartorius BioPAT and PrecigenomeLLC SwitchEZ offer non-contact tube pinching, eliminating wetted metallic components. Programmed switching is achievable via solenoid actuation.

Conclusions/action items: Non-contact design eliminates wetted surface biocompatibility concerns, which is a significant advantage. However, repeated tube pinching causes tubing fatigue and eventual failure, which was specifically identified as a weakness in the Dean lab's own preliminary clamp design concept. Dead volume between switches remains a concern.



## 2026/04/07 - Competing Device Review: FRESH Bioprinting (Feinberg Lab, CMU)

---

ANA CLARA TOSCANO - Apr 14, 2026, 7:42 PM CDT

Title: Competing Device Review: FRESH Bioprinting (Feinberg Lab, CMU)

Date: April 7, 2026

Content by: Ana Toscano

Present: Ana Toscano

Goals: Review FRESH as a competing vascularization bioprinting strategy

Citation: US Patent Application US20240367382A1; Feinberg lab, Carnegie Mellon

University. <https://patents.google.com/patent/US20240367382A1/en>

Content: FRESH (Freeform Reversible Embedding of Suspended Hydrogels) prints low-viscosity hydrogels into a gelatin microparticle support bath, enabling fabrication of soft structures that would otherwise collapse. Recent advances achieve channel diameters down to approximately 100  $\mu\text{m}$ . Covered by US patent application US20240367382A1.

Conclusions/action items: Does not achieve the 10  $\mu\text{m}$  capillary-scale resolution targeted by CEVIC, and cannot produce hierarchical branching mid-extrusion within a continuous construct. Competes at the broader vascularized tissue engineering level, not at the valve switching level. Defines the clinical resolution performance bar that CEVIC must surpass.



## 2026/03/20-Training Documentation Spring 2026 semester

ANA CLARA TOSCANO - Apr 27, 2026, 10:07 PM CDT

**Title:** Completed training Proof

**Date:** 2026/03/20

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Finish training in all semesters

**Content:**

File attached below

**Conclusions/action items:** None

ANA CLARA TOSCANO - Apr 27, 2026, 10:08 PM CDT



[Download](#)

**Training\_throughout\_the\_curriculum\_-\_Ana\_Toscano\_1\_.pdf (122 kB)**



## 2026/03/06 -Tong Distinguished Entrepreneur Lecturer Series Notes

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ANA CLARA TOSCANO - Apr 27, 2026, 10:15 PM CDT

**Title:** Tong Distinguished Entrepreneur Lecturer Series: From Imagination to Implantation

**Date:** Friday, March 6, 2026

**Content by:** Ana Toscano

**Present:** Ana Toscano

**Goals:** Reflect on Prof. Justin Williams's lecture and summarize the main takeaways about translational neuroengineering, entrepreneurship, and brain technology.

**Citation:** Speaker information and lecture title provided in the event details.

**Content:**

Prof. Justin Williams

One of my biggest takeaways was that innovation in biomedical engineering is about building the systems to test, refine, and translate that idea into clinical use.

I also found it interesting that he did not follow a perfectly linear career path. He explained that opportunities, persistence, and collaboration played a big role in shaping his career, which made the lecture feel encouraging and realistic for students.

The idea of developing technologies in parallel with clinical translation seems important because it can shorten the time between discovery and patient care.

**Conclusions/action items:**

This lecture reinforced that biomedical engineering can extend beyond the lab and into real-world impact through entrepreneurship and translation. My main action item is to think more intentionally about how engineering projects can be designed with eventual clinical use in mind.



---

MAHATHI KARTHIKEYAN - Apr 24, 2026, 5:48 PM CDT

**Title:** Solenoid Valves

**Date:** 4/24

**Content by:** NA

**Present:** NA

**Goals:** To learn about different types of valves to use for slow.

**Content:**

**Solenoid Valve:**

- A solenoid valve is a valve controlled electrically that controls the flow of media
- These valves can be controlled remotely and automatically
- At rest a solenoid valve at a normally closed valve is de energized
- When it is energized a magnetic field is created and it moves

**Conclusions/action items:**

- This a valve that might work however it can not rotate as **precisely** as a rotary valve so will discuss with .

Citation: Tameson, "Solenoid Valve Types," *tameson.co.uk*. [Online]. Available: <https://tameson.co.uk/pages/solenoid-valve-types>. [Accessed: Apr. 24, 2026].

# multi-material-extrusion bioprinting

MAHATHI KARTHIKEYAN - May 04, 2026, 1:08 PM CDT

**Title:** Rapid Continuous Multi-Material Extrusion Bioprinting

**Date:** 4/30/26

**Content by:** NA

**Present:** NA

**Goals:** to learn more about the technology of multi-material-extrusion bioprinting because it is alternative bioprinting mechanism

**Content:**

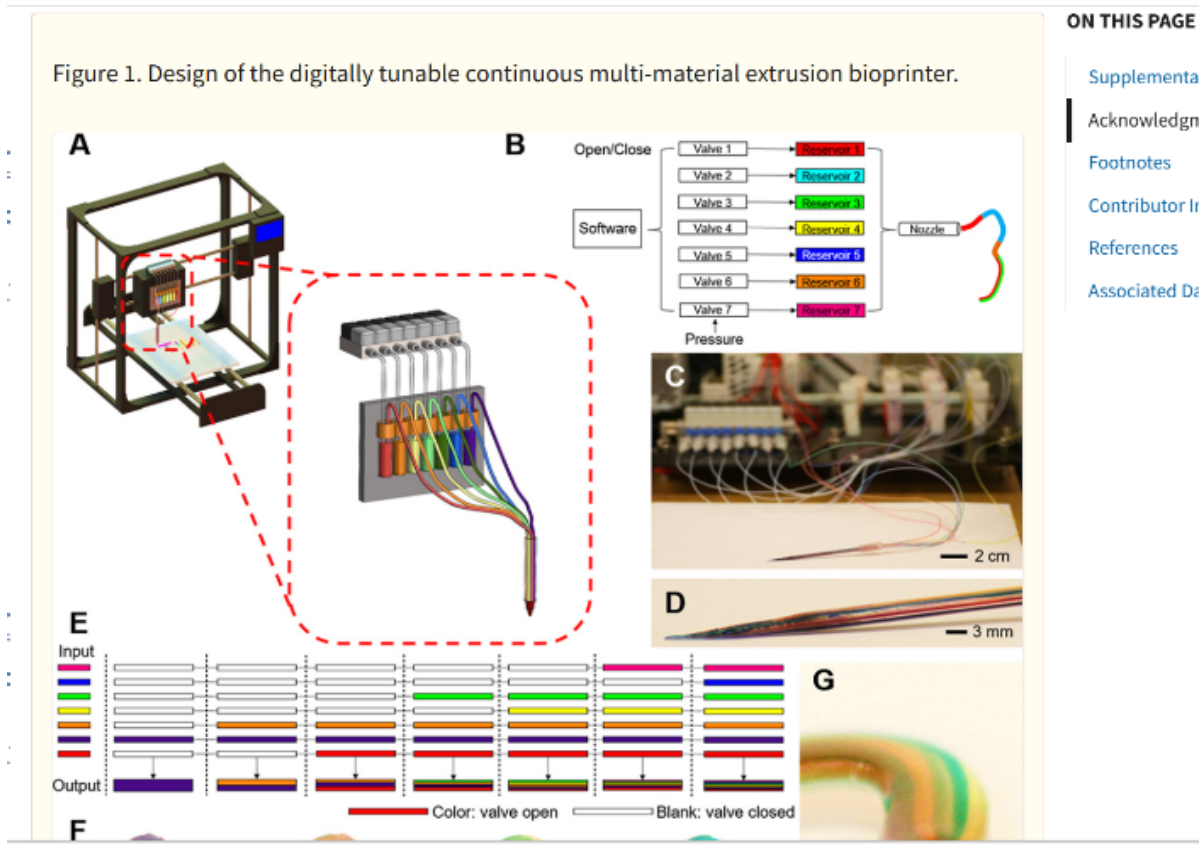
- This technology is capable of printing multiple coded bioinks.

- Each of the 7 bioinks could be continuously printed in equivalent lengths along the direction of the individual microfibers, with equal or incremental spacing between the adjacent lines

- The bioprinter can achieve up to 15\* the speed than other existing bioprinting nozzle setups.

- The bioprinter can print a whole range of different patterns

- It can also be integrated with bioelectronics such as sensors.



**Conclusions/action items:**

Shows that digitally programmable multi-channel switching for bioprinting can be done. However can not replicate the hierarchical patterning within a single extrusion stream. Can be used for future IRE considerations



## Arduino code for stepper motor and button

MAHATHI KARTHIKEYAN - Apr 14, 2026, 5:07 PM CDT

**Title:**Code for the button which is integrated for the stepper motor

**Date:** 4/3/2026

**Content by:** NA

**Present:** NA

**Goals:** To make a arduino code to rotate the motor 60 degrees for each KSM resolution

**Content:**

```
#include <Servo.h>
```

```
Servo myServo;
```

```
int currentAngle = 0;
```

```
void setup() {
```

```
  pinMode(2, INPUT_PULLUP);
```

```
  myServo.attach(9);
```

```
  myServo.write(0);
```

```
}
```

```
void loop() {
```

```
  if (digitalRead(2) == LOW) { // button pressed
```

```
    currentAngle += 60;
```

```
    if (currentAngle >= 360) {
```

```
      currentAngle = 0; // reset back to start after 180
```

```
    }
```

```
    myServo.write(currentAngle);
```

```
    delay(300); // debounce
```

```
  }
```

```
}
```

**Conclusions/action items:** Talk to team about direction of motor clockwise or counterclockwise

 **Testing for electronics protocol**

MAHATHI KARTHIKEYAN - Apr 18, 2026, 12:51 PM CDT

**Title:** Electronic Testing protocol**Date:** 4/10/26**Content by:** NA**Present:** Mahathi Karthikeyan, Ana**Goals:** - Come up with quantitative measures for electronics testing and values to document**Content:****3.4 Comprehensive Electronics Testing**

Electronics testing was conducted to validate the automated control system responsible for actuating the Integrated Rotary Element (IRE). Testing evaluated servo motor accuracy, repeatability, response time, angular precision, electrical stability, long-term reliability, and integration with the mechanical switching system. The objective was to ensure reliable, programmable, and precise switching between Kenics Static Mixers (KSMs) without compromising hydrogel resolution or system integrity.

**3.4.1 Response Time and Switching Speed (need to do)**

Switching speed directly impacts hydrogel transition length between channel resolutions. Using Arduino timing functions, the time required for:

- 60° rotation
- 120° rotation
- 180° rotation

was recorded across 15 trials.

Performance requirements:

- Rapid switching to minimize transition regions
- Stable motion without overshoot or oscillation

The servo achieved smooth and controlled motion without observable overshoot. Switching time was consistent across trials, demonstrating reliable PWM control and sufficient torque output.

**3.4.2 Torque and Load Performance**

To simulate hydrogel back-pressure conditions, the servo was tested under moderate mechanical resistance applied to the IRE. The system was evaluated for:

- Stall behavior
- Angular lag
- Gear slippage
- Power fluctuations

The servo maintained full rotation under expected operating loads. No gear skipping or disengagement was observed, indicating sufficient torque margin for hydrogel switching applications.

### 3.4.5 Electrical Stability and Power Integrity (security reasons)

Voltage across the servo supply lines was monitored during operation to detect transient drops or instability. Measurements confirmed:

- Stable 5V supply during actuation
- No brown-out conditions
- No unintended Arduino resets

Signal integrity of the PWM control line was verified by observing consistent motion response across repeated cycles.

---

### 3.4.6 Fail-Safe and Position Retention Testing

Testing was conducted to evaluate system behavior under power interruption. The servo was powered down mid-rotation and re-energized to observe:

- Position retention
- Unexpected movement upon restart
- Need for recalibration

The servo maintained position during short power interruptions. However, since standard hobby servos do not include absolute position encoding, recalibration procedures may be necessary in future iterations for clinical reliability.

---

### 3.4.7 Long-Term Continuous Operation Testing

To simulate extended fabrication sessions, the servo executed continuous 60° switching cycles for five minutes, corresponding to the production time of one hydrogel sheet. The test evaluated:

- Motor heating
- Performance degradation
- Increased angular deviation over time

Temperature remained within safe operating limits, and no observable degradation in switching performance occurred.

---

### 3.4.8 Integration Testing with Hydrogel Extrusion

Electronics performance was validated during functional hydrogel extrusion tests using differently colored gelatin. During switching:

- The servo rotated 60° precisely per command
- Distinct channel transitions were observed
- No electrical lag disrupted hydrogel patterning

Backflow observed during functionality testing was determined to be a fluid management issue rather than an electronics control failure.

### Recommended Control & Safety Improvements

1. Add Position Verification (Limit Switches or Sensors) - if gear slips or falls you wouldn't know
2. Add a Rotation Timeout (Stall Detection)

Code Concept: (Protects servo motor, Prevents mechanical damage)

```
unsigned long startTime = millis();
```

```
servo.write(60);
```

```
while (!positionReached) {
```

```
    if (millis() - startTime > 1000) {
```

```
        // stop system
```

```
        errorFlag = true;
```

```
        break;
```

```
    }
```

```
}
```

### Conclusions/action items:

Test and get values and evaluate any code changes for integrative testing with the other team

## AC power connection

MAHATHI KARTHIKEYAN - Apr 18, 2026, 1:05 PM CDT

**Title:** How to connect the AC power source

**Date:** 4/17/26

**Content by:** NA

**Present:** NA

**Goals:** To figure out how to connect the AC power source

**Content:**

- The green wire goes to earth ground
- The black wire goes to Live
- The white wire goes to neutral



connect my AC power cord



**Conclusions/action items:**



**Title:** Electronics testing for circuit

**Date:** 4/19/26

**Content by:** NA

**Present:** Ana Dominique

**Goals:** To test the angular displacement of the circuit

**Content:**

- 25 teeth on the gear

$-360/25 = 14.4$  degrees per teeth

Trial 1:  $14.4 * 5 = 72$  degrees

Trial 2 :  $14.4 * 4 = 57.5$  degrees

Trial 2:  $14.4 * 5 = 72$  degrees

Trial 1 : 187.2

Trial 2: 187.2

Trial 3: 187.2

**Conclusions/action items:**

This shows that there is a angular displacement error.



---

MAHATHI KARTHIKEYAN - Apr 25, 2026, 11:29 AM CDT

**Title:** Rotary Valves

**Date:** 4/25/26

**Content by:** NA

**Present:** NA

**Goals:** Learn more about Rotary Valves as they will be integrated with the Voron.

**Content:**

- It can act as an integrated motor to switch between different materials
- The valve is used to manage the flow of bioinks.
- It is controlled using stepper motors for control over movement

Citations:

[1 H. Wang *et al.*, "Valve-based consecutive bioprinting method for multimaterial tissue-like constructs with controllable interfaces," *Biofabrication*, ] vol. 13, no. 3, p. 035001, Apr. 2021, doi: [10.1088/1758-5090/abdb86](https://doi.org/10.1088/1758-5090/abdb86).

**Conclusions/action items:**

- Use this information to discuss valve applications with Voron.

## Higher torque motor information

MAHATHI KARTHIKEYAN - May 04, 2026, 12:24 PM CDT

**Title:** High torque motor**Date:** 4/30**Content by:** NA**Present:** NA**Goals:** To get more information about the higher torque motors that is used for the project because it would be beneficial to have a higher power motor.**Content:**

- This motor can go up to do 8.4V and is high torque
- The motor can go up to 180 degrees
- The motor has a response has time of 0.08 seconds.
- It has high precision and can be used for more accurate angle measurement.



Source:

[1 "Amazon.com: HobbyPark Waterproof 45kg High Torque Servo Brushless Motor 8.4V HV Servo Metal Gear Digital Servo Stainless Steel Gear for RC Crawler RC Car RC Truck RC Buggy Control Angle 180° 0.08sec 2BB : Toys & Games." Accessed: May 04, 2026. [Online]. Available: <https://www.amazon.com/HobbyPark-Waterproof-Brushless-Digital-Stainless/dp/B0DTPKHTT4>

**Conclusions/action items:**

- Talk to team and see if this is the right motor fit.
- Would need to find a power source to fit the power that can go through the motor



**Title:** Training through curriculum

**Date:** NA

**Content by:** nA

**Present:** NA

**Goals:** picked HIPAA training

**Content:**

**OVCR Training Information Lookup Tool** **University of Wisconsin-Madison**



**WISCONSIN**  
UNIVERSITY OF WISCONSIN-MADISON

This certifies that Mahathi Karthikeyan has completed training for the following course(s):

Expand All
Collapse All

Course	Assignment	Completion	Expiration
2023-24 HIPAA Privacy & Security Training	HIPAA Attestation	11/9/2023	
2025-2026 HIPAA Privacy & Security Training	2025-2026 HIPAA Privacy & Security Training	3/20/2026	
Biosafety 105: Biosafety Cabinet Use	Biosafety 105: Biosafety Cabinet Use Quiz	10/30/2025	No Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024	3/8/2024	3/8/2029
Chemical Safety: The OSHA Lab Standard	Final Quiz	3/8/2024	

Data Last Imported: 05/04/2026 12:27 PM

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**Conclusions/action items:**

NA

 **Higher Torque Servo Motor**

SOPHIA SPEECE - May 02, 2026, 7:46 PM CDT

**Title:** Higher Torque Servo Motor**Date:** Researched 02/06/2026, Entered 05/02/2026**Content by:** Sophia Speece**Present:** N/A**Goals:** Find a higher torque servo motor to assist in rotating the IRE (overcome friction forces) when it is clamped between the two CEVIC halves**Content:**

"HobbyPark," Amazon.com. Accessed: Feb. 05, 2026. [Online]. Available: <https://www.amazon.com/stores/HobbyPark/page/90C3B66F-5965-4466-951E-8B01E4FC1B56>

**Features:**

- Waterproof and programmable up to 180 degrees
- coreless motor and metal gears (stainless steel), allowing for smooth operation for the long term
- 35kg torque
- High voltage, can support up to 8.4 volts

**Conclusions/action items:**

Coordinate purchase with the client and implement the new motor into the design



# Locking Mechanism for CEVIC

SOPHIA SPEECE - May 02, 2026, 7:53 PM CDT

**Title:** Locking Mechanism for Two CEVIC Halves

**Date:** Researched 02/06/2026, Entered 05/02/2026

**Content by:** Sophia Speece

**Present:** N/A

**Goals:** Identify a way to keep the top and bottom half of the CEVIC both from rotating with respect to each other and keep the distance between them constant

**Content:**

“Mechanical Parts Threading Help Quality,” Original Prusa 3D Printers. Accessed: Feb. 05, 2026. [Online]. Available: <https://forum.prusa3d.com/forum/?language=de>

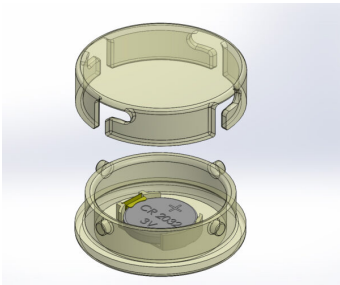


Figure 1: Example of a twist lock mechanism to inspire a SolidWorks modification of the CEVIC

**Conclusions/action items:**

Model a twist lock mechanism for the two CEVIC halves in SolidWorks

**Title: Flexible 80A Resin****Date:** Researched 02/06/2026, Entered 05/02/2026**Content by:** Sophia Speece**Present:** N/A**Goals:** Research Flexible 80A resin as a possible material for the IRE. Hypothesis: the deformation of the material when clamped between the two CEVIC halves will for a water- (or hydrogel-) tight seal**Content:**

"Flexible 80A Resin," Formlabs. Accessed: Feb. 05, 2026. [Online]. Available: <https://formlabs.com/store/materials/flexible-80a-resin/?srsltid=AfmBOoqhMtvyyqZE-X2t93nVCo58sPGWbsFpxFPPXkP4HbO42dOjW0Dm5>



Figure: hand model printed out of Flexible 80A Resin

- Durable, elastic modulus  $E$  - 8.9 MPa
- Compressible but not stretchable, so it can maintain rigidity while allowing some give for a potential seal
- Not biocompatible, however, there is a BioMed Flex 80A Resin (see BioMed Flex 80A Resin labarchives entry)
- Is available at the UW Madison Makerspace

**Conclusions/action items:**

Compare to other materials in a material improvement design matrix

Print an IRE out of this material and leak test



## BioMed Flex 80A Resin

---

SOPHIA SPEECE - May 02, 2026, 9:06 PM CDT

**Title:** BioMed Flex 80A Resin

**Date:** Researched 02/06/2026, Entered 05/02/2026

**Content by:** Sophia Speece

**Present:** N/A

**Goals:** Evaluate BioMed Flex resin as a biocompatible flexible resin options

**Content:**

"BioMed Flex 80A Resin," Formlabs. Accessed: Feb. 05, 2026. [Online]. Available: [https://formlabs.com/store/materials/biomed-flex-80a-resin/?srsltid=AfmBOoprVlpD\\_MQFSJF4hNxBoq\\_vZf6ZgXkfl-TDe23Npl1z-kcBEpi6](https://formlabs.com/store/materials/biomed-flex-80a-resin/?srsltid=AfmBOoprVlpD_MQFSJF4hNxBoq_vZf6ZgXkfl-TDe23Npl1z-kcBEpi6)

- Tensile strength of 7.2 MPa
- 4.5 MPa stress at 100% elongation
- Same shore (80A) as the flexible 80A resin
- Not available at the Makerspace, would have to be outsourced

**Conclusions/action items:**

If flexible 80A passes leak testing and a biocompatible option is needed, consider outsourcing IRE prints



## Medical Grade Liquid Silicone Rubber (LSR)

---

SOPHIA SPEECE - May 02, 2026, 9:11 PM CDT

**Title:** Medical Grade Silicone Rubber (LSR)

**Date:** Researched 02/06/2026, Entered 05/02/2026

**Content by:** Sophia Speece

**Present:** N/A

**Goals:** Research medical silicone rubber as an alternative IRE material to assist with leakage

**Content:**

"Medical Grade Silicone - Seal Design Guide | Apple Rubber Products." Accessed: Feb. 05, 2026. [Online]. Available: <https://www.applerubber.com/seal-design-guide/material-selection-guide/medical-grade-silicone/>

- Many options with tailorable durability, elasticity and shore
- fulfills USP Class VI and ISO 10993 requirements
- Low abrasion resistance

**Conclusions/action items:**

Include LSR in the team's material improvements design matrix



## Design Idea: Locking CEVIC Mechanism

---

SOPHIA SPEECE - May 02, 2026, 9:25 PM CDT

**Title:** Design Idea: CEVIC Locking Mechanism

**Date:** Designed 02/06/2026, Entered 05/02/2026

**Content by:** Sophia Speece

**Present:** N/A

**Goals:** Model a twist lock mechanism for the two CEVIC halves

**Content:**

See attachments

See Team Project Files folders for the SolidWorks and stl files

**Conclusions/action items:**

Print and leak test

SOPHIA SPEECE - May 02, 2026, 9:25 PM CDT

[Download](#)

**BottomHalfwithlockingpin.SLDDRW (355 kB)**

SOPHIA SPEECE - May 02, 2026, 9:25 PM CDT

[Download](#)

**TopHalf\_LocksCCW\_2.SLDDRW (281 kB)**



## Design Idea: CEVIC-Servo Holder

---

SOPHIA SPEECE - May 02, 2026, 9:31 PM CDT

**Title:** Design Idea: CEVIC-Servo Holder

**Date:** Designed 02/06/2026, Entered 05/02/2026

**Content by:** Sophia Speece

**Present:** N/A

**Goals:** Create a holder to connect the CEVIC and Servo motor so that the IRE and gear interface, as well as a way to mount our design onto the Voron

**Content:**

See attachments

For Solidworks and stl files, see the team's project folders

**Conclusions/action items:**

Recap only the most significant findings and/or action items resulting from the entry.

SOPHIA SPEECE - May 02, 2026, 9:31 PM CDT



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**Final\_CEVIC\_Servo\_connector.SLDDRW (161 kB)**



**Title:** OpenSim - Training throughout the Semester

**Date:** Completed 04/14/2026, Entered 05/02/2026

**Content by:** Sophia Speece

**Present:** N/A

**Goals:** Complete the OpenSim tutorial online in order to be more proficient in inverse kinematics and dynamics

**Content:**

[OpenSim Tutorial 1 for an introduction to Musculoskeletal Modeling](#)

[OpenSim Tutorial 3: Scaling, Inverse Kinematics, and Inverse Dynamics](#)

Question 1: Intro to Musculoskeletal Modeling

Follow the prompts in the [OpenSim Tutorial 1 for an introduction to Musculoskeletal Modeling](#).

## II. Musculoskeletal Model of the Lower Extremity

### 1. Degrees of Freedom

a. Use the Coordinates panel to view the degrees of freedom of the model. How many degrees of freedom, in total, does the model have? List the degrees of freedom of the right leg.

There look to be 23 degrees of freedom in this model. The right leg has the following 7 degrees of freedom:

- Hip flexion/extension
- Hip adduction/abduction
- Hip rotation
- Knee flexion/extension
- Ankle flexion/extension
- Subtalar angle (ankle inversion/eversion and abduction/adduction)
- Mtp angle (toe flexion and extension)

b. All models are approximations. Compare the degrees of freedom in the model to the degrees of freedom in your lower limbs. Give an example of a joint motion in the model that has been simplified. Give an example of a motion that is not included in this model.

Foot inversion/eversion and abduction/adduction seem to be simplified and lumped together in subtalar angle.

One motion that is not included in this model is knee rotation, as the knee is often simplified into a single DOF lever. However, we know from a previous lab analyzing joint angles that the knee can most slightly in other ways.

### 2. Muscles

a. How many muscles are in the model? How does this compare to the number of degrees of freedom in the model? What is the minimum number of muscles required to fully actuate the model?

*Hint: Full actuation of the knee, for example, means both knee flexion and knee extension.*

The muscles in the model include the gluteus medius, gluteus minimus, semimembranosus, semitendinosus, biceps femoris (long and short head), adductor longus, adductor brevis, adductor magnus, TFL, pectineus, gracilis, gluteus maximus, iliacus, psoas, quadriceps femoris, inferior gemellus, piriformis, rectus femoris, vastus medialis, vastus intermedius, vastus lateralis, medial gastrocnemius, lateral gastrocnemius, soleus, tibialis posterior, flexor digitorum longus, flexor digitorum brevis, tibialis anterior, peroneus longus, peroneus brevis, peroneus brevis, extensor digitorum, and extensor hallucis longus, erector spinae, and two more on the anterior side of the torso that I couldn't figure out the names of. 36 muscles per side total. This is significantly more than the 23 degrees of freedom.

The minimum number of muscles to fully actuate the model would be 23, or one "muscle" per type of motion. This is not applicable to the human body, however, because several muscles are able to actuate more than one type of movement, are often synergists, and are usually present in a right and left copy.

b. Name two muscles, other than the gluteus medius, in the model that are represented by multiple lines of action. Why do you think these muscles are represented in this way?

*Hint: Other muscles with multiple lines of action use the same naming convention as the gluteus medius.*

One muscle represented with multiple lines of action would be the adductor magnus, which in this model has three lines of action. This is because the muscle has a large surface area and attaches to different spots on the femur and has several origin sites on the pelvis. Because of this, in order to model the muscle more accurately, the muscle is modeled with several lines of action. See figure 1 below.

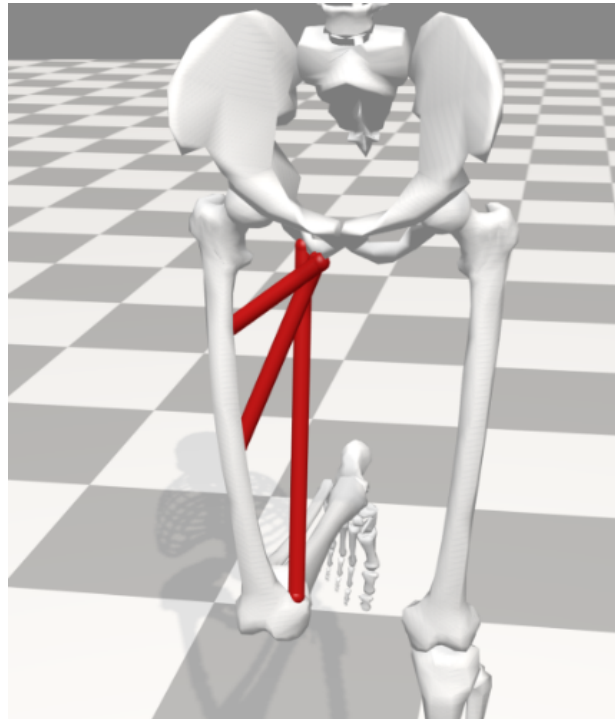


Figure 1: OpenSim Model Gait 2392 with three segments modelling the adductor magnus

Another muscle represented with multiple lines of action is the biceps femoris. This muscle is modeled with two segments to represent its two heads, a long and a short head, one with an origin on the pelvis and one with an origin on the femur. See figure 2 below.

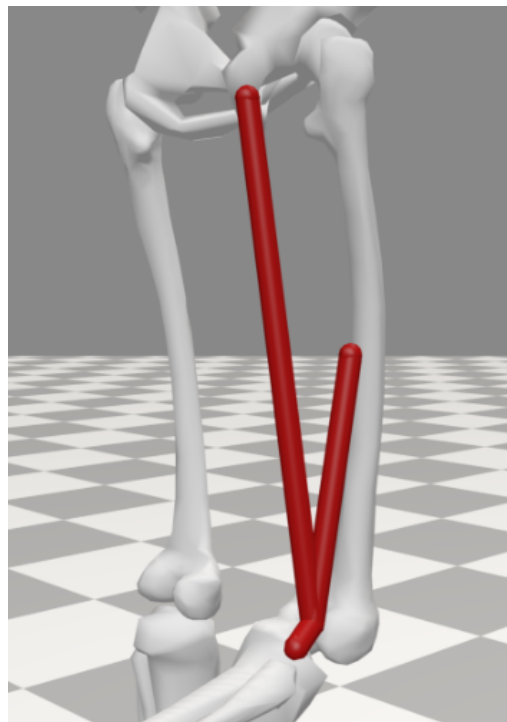


Figure 2: OpenSim Model Gait 2392 biceps femoris long and short head

c. Which knee extensor muscles have wrapping points? At what knee angles do the wrapping points appear for each of those knee extensors? A muscle may have more than one wrapping point.

The rectus femoris has one wrapping point that appears around -80°.

The vastus intermedius has two wrapping points, one that is present throughout the extension and one that appears around -80°.

The vastus lateralis has two wrapping points, one that is present throughout and one that appears around  $-80^\circ$ .

The vastus medius has two wrapping points, one that is present throughout and one that appears around  $-80^\circ$ .

### 3. Modeling Limitations

a. Zoom in on the right hip, and display only the glut\_max3\_r muscle (right hip extensors group). Examine this muscle for the full range of hip flexion angles. What problems do you see with the path of glut\_max3\_r through the range of motion? In what ways are point-to-point representations of muscle paths a simplification of musculoskeletal geometry?

At the extreme ends of the range of motion, the muscle model becomes convoluted. The line is not continuous like the muscle fibers would be, but jagged because of the approximated points. An example of this convolution is seen in figure 3 below. Point-to-point representations are simplifications because they don't represent the non-linearity of muscles as they bend around other anatomical structures.

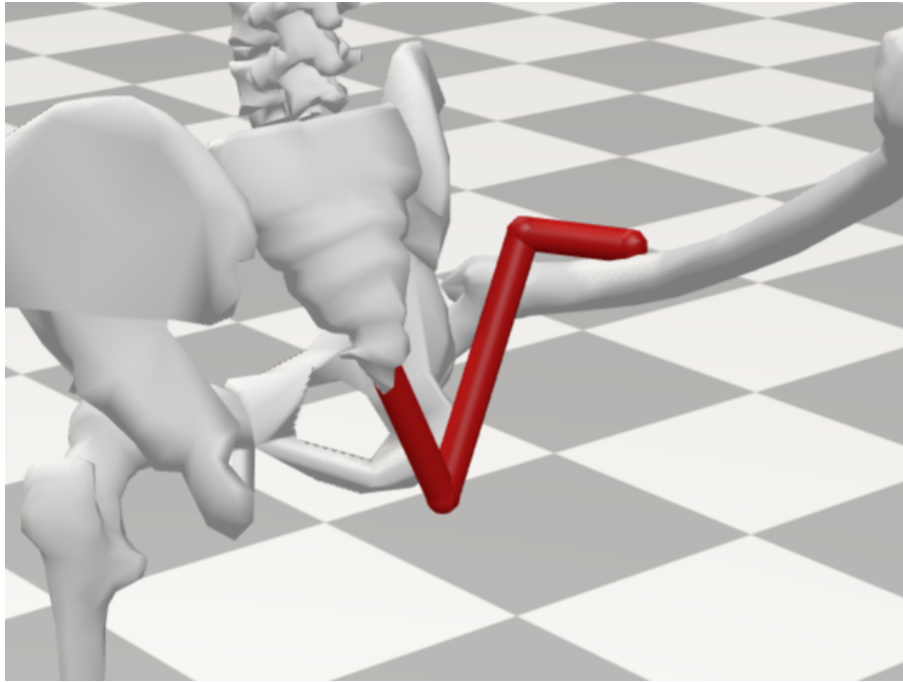


Figure 3: OpenSim Model Gait 2392 convoluted approximation of the gluteus maximum at maximum hip extension.

## III. Joint Angles, Muscle-tendon Lengths, & Moment Arms

### 4. Muscle Fiber Length vs. Joint Angle

a. Study the plot of muscle fiber length vs. knee angle. For each of the rectus femoris and vastus intermedius, do you expect the fiber-length curve be different if the right hip was flexed? Why or why not?

The rectus femoris originates on the pelvis. Therefore, the fiber length will be different if the right hip is flexed even if we are looking at knee angle. Conversely, the vastus intermedius originates on the femur and does not cross the hip joint. Therefore, it is expected that the fiber length curve does not change when the knee is flexed.

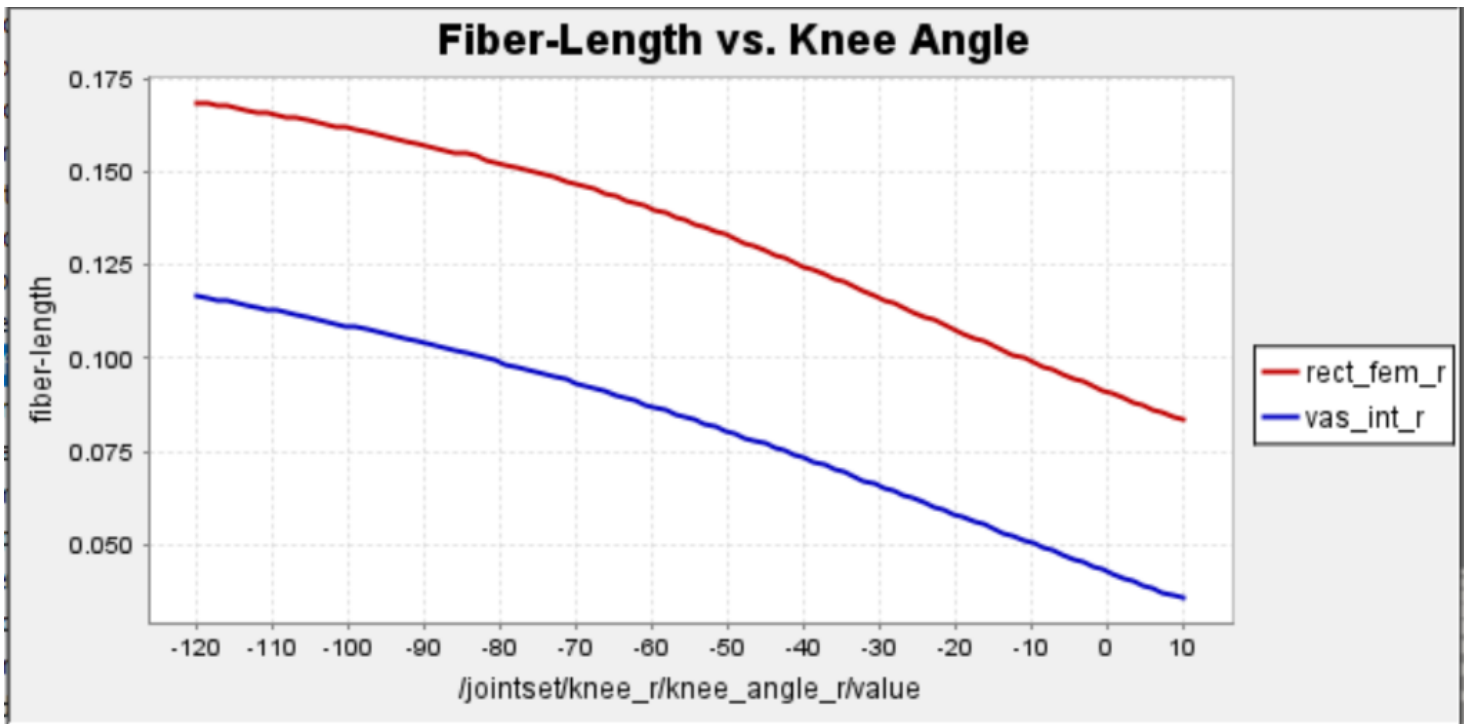


Figure 4: OpenSim plot of the rectus femoris and vastus intermedius fiber length over knee angle

b. In the Coordinates window, adjust the model's **right hip flexion to 45 degrees** (save the pose as **r\_hip\_flex\_45**), add rectus femoris and vastus intermedius fiber-length curves for 45° hip flexion. Compare the muscle curves for the model with an unflexed hip you plotted previously to the curves for the model that you just plotted. How have the curves changed? Explain your findings. How can bi-articular muscles complicate analysis?

*Note: To select multiple curve names, hold down Ctrl (PC) or Command (Mac) while selecting. To print or save a plot, right-click on the plot and select Print or Export Image.*

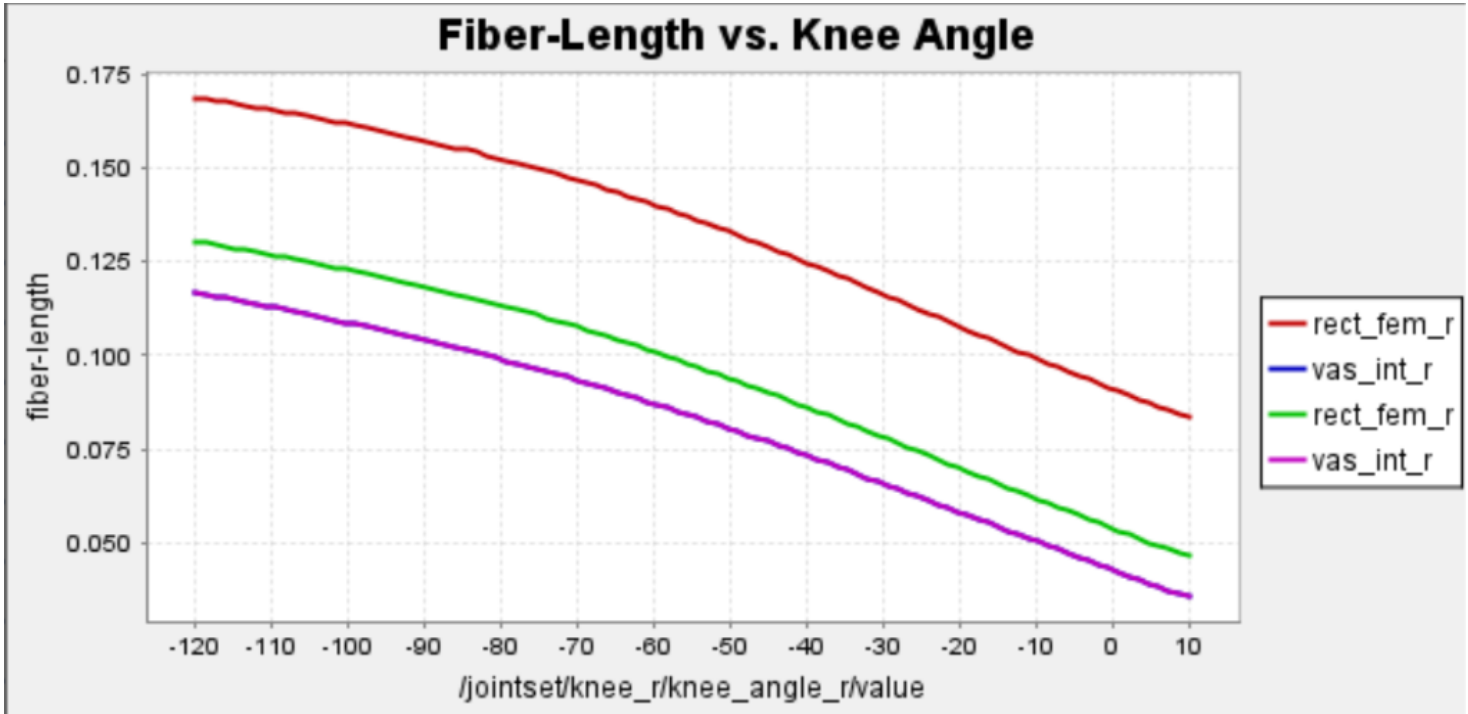


Figure 5: OpenSim plot of the rectus femoris and vastus intermedius fiber length over knee angle at 0 and 45 degrees of knee flexion

My prediction was correct, in that the fiber-length for the vastus intermedius remained the same while the rectus femoris fiber-length shortened.

##### 5. Muscle Moment Arm vs. Joint Angle

Return the model to its original position with no hip flexion (click **Poses > Default**). Now plot the knee extension moment arm vs. knee angle for the right rectus femoris and vastus intermedius muscles.

- In a new plotter window, click **Y-Quantity** > **moment arm** > **knee\_angle\_r** and click **X-Quantity** > **knee\_angle\_r**.
- Select the right rectus femoris (**rect\_fem\_r**) and vastus intermedius (**vas\_int\_r**) muscles as before.
- Set the plot title to **Knee Extension Moment Arm vs. Knee Angle**
- **Add** the curves to the plot.

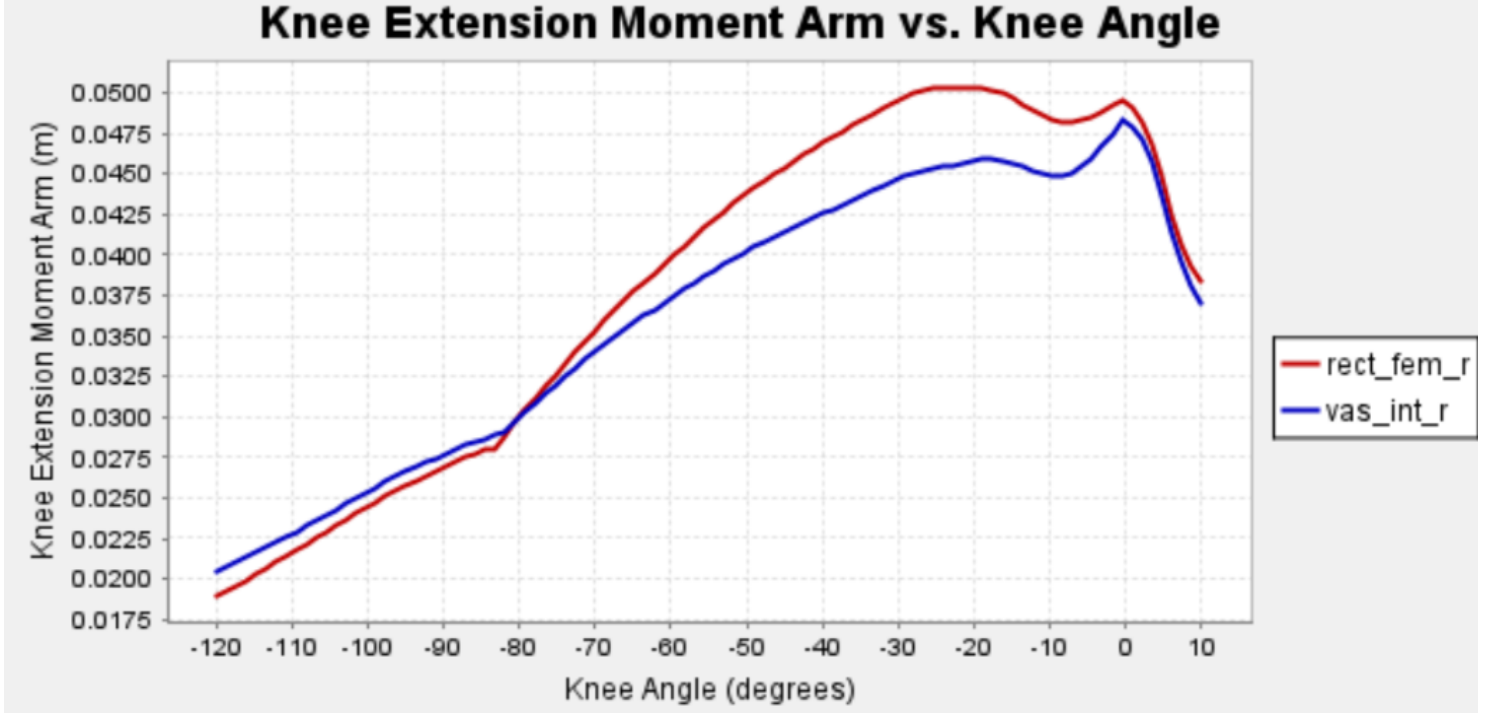


Figure 6: OpenSim plot of the moment arm for the rectus femoris and vastus intermedius over knee extension angle

a. What are the peak moment arms for each muscle and at what knee angle do they occur?

Note: If you hover the cursor over a curve, a tool tip will give the coordinates at that particular point.

The peak moment arm for the rectus femoris is about 5 cm and occurs around -25 degrees. The peak for the vastus intermedius is 4.8 cm and occurs at just about 0 degrees.

b. At what knee angle(s) are the moment arm curves not smooth (i.e. have points where the derivative is not continuous)? What do you think causes this?  
Hint: Look at Question 2.c

There are sharp non-continuous points for both muscles around -80 degrees and 0 degrees. The latter change occurs because that is the transition from maximum knee extension to flexion, but the former occurs because a wrapping point appears around 80 degrees of knee flexion.

#### Question 2: Scaling, Inverse Kinematics, and Inverse Dynamics using OpenSim

Follow the prompts in the [OpenSim Tutorial 3: Scaling, Inverse Kinematics, and Inverse Dynamics](#) or follow the summarized prompts here and answer the questions below.

## II. Generic Musculoskeletal Model

To Load the Generic Musculoskeletal Model:

- Click the **File** menu and select **Open Model**.
- Find the *Gait2354\_Simbody* folder in your default OpenSim resources directory— `\Documents\OpenSim\Models for PC and Mac`.  
Note: When you first launch OpenSim, you are prompted to provide a path to install the resources folder, the default is in your systems Documents folders.
- Open the *Gait2354\_Simbody* folder, select the file *gait2354\_simbody.osim*, and click **Open**.

## III. Scaling A Musculoskeletal Model

To scale the generic model and register the markers:

- Click the **Tools** menu and select **Scale Model**.

- At the bottom of the *Scale Tool* dialog, click **Load** to input a settings file.
- In the file browser, ensure that you are in the *Gait2354* folder, select the file *subject01\_Setup\_Scale.xml* and click **Open**.
- In the *Scale Tool* dialog, click **Run**.
- When complete, a new, scaled and registered model entitled *subject01* will appear in *Visualizer* window. Notice the pink model markers around the new model.
- To save the scaled model, either click **File** and select **Save Model**, or right-click on the model name, **subject01**, in the Navigator window, and select **Save As**.
- Save the scaled model as *gait2354\_scaled.osim*, and click **Save**.  
*Note: ensure that you are in the Gait2354 folder.*

### Questions

1. Based on information in the Scale Tool dialog, what is the mass of the generic musculoskeletal model? What was the mass of the subject?

The generic model has a mass of 75.16 kg. The subject has a mass of 72.6 kg.

2. What frequency was the experimental motion data captured?

*Hint: Look for the box titled Marker Data.*

The capture frequency is 60 Hz.

3. Click on the **Scale Factors** tab. Which body segments were scaled manually?

The right and left femur and tibia were scaled manually.

## IV. Inverse Kinematics

- Open OpenSim
- Click **File>Load Model** then open *gait2354\_scaled.osim* that you created in Tutorial 3.
- Click **Tools> InverseKinematicsTool**.
  1. In the dialog box, click **Load**. Choose *subject01\_Setup\_IK.xml* and click **Open**.
  2. Click **Run**. Allow the Inverse Kinematics to solve, then **close** the dialog.
- Under the **Navigator** tab on the left, you should see **IKResults**. **Right click** on it and choose **Associate Motion Data**. Choose *subject01\_walk1.trc*.

### Questions

4. In the Inverse Kinematics Tool dialog window, click the **Weights** tab and scroll through the list of markers in the top half of the weights tab. *Which markers have weighting values less than one? Why?*

*Hint: Think about joints that have not been modeled.*

The right and left acromium, and top of the head, have weighting values less than one. These markers are likely weighted less because when analyzing the kinematics of the lower body, markers on the upper body are of less significance.

5. *Based on information in the Messages window, what is the root-mean-squared (RMS) error of all the markers in the last frame of the motion? Include units. Does this seem reasonable? Explain.*

The RMS error for the last frame, frame 96, 0.0209265 m. This means an average error of about two centimeters between the model and the markers. This makes sense, because bony landmarks that markers are placed over are often beneath a certain amount of skin, muscles, or fat tissue.

6. *What was the value of the maximum marker error in the last frame? Include units. Which marker had this maximum error, and why?*

*Hint: Think about the weighted least squares problem.*

The marker error in the last frame, frame 96, is 0.079239 m, from the right acromium. It makes sense that the acromium markers has a larger error because it is not modelled as closely as some of the lower extremities to analyse inverse kinematics

## V. Inverse Dynamics

To setup an inverse dynamics analysis:

1. Open the inverse dynamics tool dialog window by clicking the **Tools** menu and selecting **Inverse Dynamics**.
2. Load an inverse dynamics tool setup file by clicking **Load**, selecting file *subject01\_Setup\_InverseDynamics.xml*, and clicking **Open**.

*Note: If the Motion From File textbox appears red, this means the textbox was filled with an inappropriate file name. Make sure the motion file was saved with the correct file name in the Inverse Kinematics section.*

Note the folder listed in the Directory textbox, located in the Output section of the dialog. The storage file containing the inverse dynamics results will be saved in this folder: Documents\Opensim\Models\Gait2354\ResultsInverseDynamics.

A detailed explanation of the Inverse Dynamics Tool can be found on the [Inverse Dynamics](#) page of the documentation.

3. Click **Run**. Notice the progress bar in the lower right-hand corner of the program. Wait until the bar disappears before proceeding.

*Note: Closing the inverse dynamics tool dialog during the analysis doesn't affect the Inverse Dynamics tool running.*

4. To visualize the inverse dynamics solution, animate the model by using the motion slider and video controls. The model should walk through one full gait cycle.

*Note: You can loop and control the speed of the animation.*

5. It is often useful to view the ground reaction forces with the inverse dynamics results. In the Navigator panel, go to **Motions** and right-click on **IDResults** (which are what the Inverse Dynamics Tool created).

6. Choose **Associate Motion Data** from the drop-down menu. Choose *subject01\_walk1\_grf.mot* and click **Open**. Green arrows are now shown that represent ground reaction force vectors collected from a force plate.

7. **Close** the inverse dynamics tool dialog window.

When completed, examine the results of the inverse dynamics solution by plotting the net moments at the left and right ankles:

1. Click **Tools** and select **Plot**.
2. In the Plotter window, click the **Y-Quantity** button and select **Load File**.
3. In the file browser, go to the ResultsInverseDynamics folder, select the file *inverse\_dynamics.sto*, and click **Open**.
4. In the menu, select **ankle\_angle\_r\_moment** and **ankle\_angle\_l\_moment** by clicking the corresponding checkboxes, then click **OK**.

*Note: To quickly find these quantities, type ankle into the pattern text box.*

5. Click the **X-Quantity** button, select **time**, and click **OK**.
6. Back in the *Plotter* window, click **Add** to add the moment curves to the plot.
7. Print your plot by **right-clicking** on the plot and selecting **Print**.  
*Note: To export the plot as an image by right-clicking the plot and selecting **Export Image**.*
8. After printing the plot and answering questions 7-8, Close the Plotter and inverse dynamics dialog window

1. Use your ankle moment plot to answer the following questions. It may be helpful to move the coordinate through the slider to visualize the skeleton during gait.

1. On your plot of the ankle moments, identify when heel strike, stance phase, toe off, and swing phase occur for each curve (i.e., left leg and right leg). **(2 marks)**

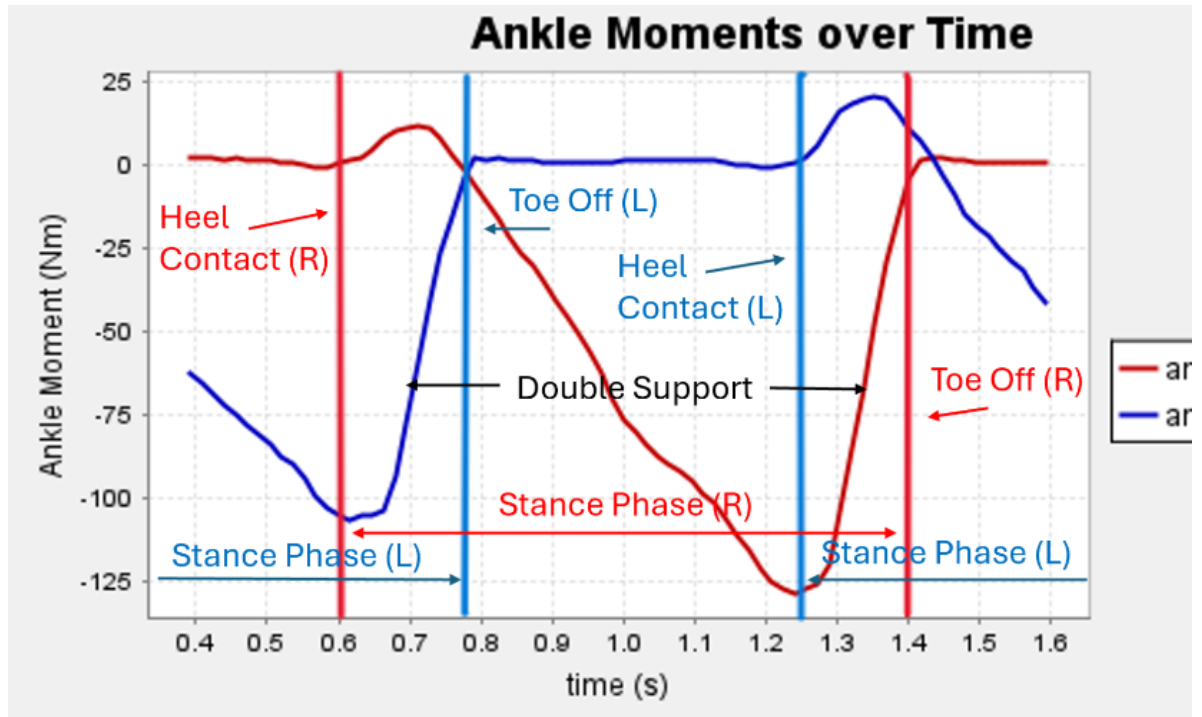


Figure 7: Ankle moment plot

2. Why does the right ankle moment go from positive to negative at time  $\approx 0.77$ s? What is happening with the ground reaction force at this time? (1 mark)

Around 0.77 is when heel contact occurs for the right foot. It goes from positive to negative because initially the foot is trying to slow forward momentum from the swing phase, but then it is generating forward movement through pushing during the stance phase.

3. Is this an internal or external moment? Explain. *Hint: it may be helpful to look at the ankle angle convention* (2 marks)

This is an internal moment because it is generated by the ankle itself rather than exerted on the ankle.

4. Describe, in terms of muscular contributions of dorsiflexor and plantarflexor muscles, what is happening in the right foot between time 0.77s and 1.24s. Why do you think the moment is becoming more negative? (1 mark)

Before heel strike, the dorsiflexor muscles are engaged to keep the toes and ball of the foot elevated so that first contact is by the heel. Then, after contact, the plantarflexors are engaged to propel the body forward. The moment is negative due to the sign conventions used in this OpenSim model. The moment could be increasing in magnitude for two reasons. One, the force required to propel the body forward increases throughout the stance phase, or two, as the foot rolls from heel to toe, the moment arm from the ankle increases in length, thus increasing the moment.

5. How could you confirm your description in 3iv? *Hint: What measurement tool could help you determine if a muscle is contributing to a moment?* (1 mark)

One way to confirm when the dorsiflexors versus plantar flexors are engaged would be to plot active or passive fiber force for the ankle flexor muscle group. A way to confirm why the moment becomes more negative during the stance phase could be to plot the moment arm over time rather than the moment, or the force of the ankle flexor muscle group over time.

#### Conclusions/action items:

Now know how to used OpenSim Inverse Kinematics and Inverse Dynamics functions



## Spring 2026 Tong Lecture

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SOPHIA SPEECE - Mar 06, 2026, 12:09 PM CST

**Title:** Spring 2026 Tong Lecture - Professor Justin Williams

**Date:** 03/06/26

**Content by:** Sophia Speece

**Present:** BME Design Students

**Goals:** Reflect on Tong Lecture

**Content:**

**Conclusions/action items:**



## 2026/28/01 - Linear actuator

STEPHANIE VIGMOND (vigmond@wisc.edu) - May 02, 2026, 9:40 PM CDT

**Title:** What is a Linear Actuator?

**Date:** 28 January 2026

**Content by:** Steph

**Present:** N/A

**Goals:** Learn what a Linear Actuator is

**Search term:** What is a linear actuator

**Citation:** "What is a linear actuator? - Learn how they work here," [Linak-us.com](https://www.linak-us.com), 2025. <https://www.linak-us.com/products/linear-actuators/what-is-a-linear-actuator/>

**Link:** <https://www.linak-us.com/products/linear-actuators/what-is-a-linear-actuator/>

**Content:**

- mechanical device that converts rotational motion into linear motion, or vice-versa
- Helps position objects along a straight path
- Many different types (e.g., electric, hydraulic, mechanical, etc.) - all operate in slightly different ways but have the same goal of linear motion

**Conclusion/Action Items:**

- At the time of this entry originally, it was unknown what kind of linear actuator Dr. Dean's lab was going to use, so I was understanding what a linear actuator was. Now it is known they are using a Voron

STEPHANIE VIGMOND (vigmond@wisc.edu) - May 02, 2026, 9:41 PM CDT

5208, N 407M What is a linear actuator - Learn how electric actuators work

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Home / Products / Linear actuators / What is a linear actuator

### What is a linear actuator?

Electric actuators is a mechanical device that converts rotational motion into linear motion, or vice versa, to achieve precise positioning or control of objects along a straight path. It typically consists of a motor, a lead screw, and a nut assembly, although there are various designs available depending on the specific application and this is what will create linear motion.



- How does a linear actuator work?
- Types of linear actuators
  - Electric Linear Actuator
  - Hydraulic Actuator
  - Pneumatic Actuator
  - Mechanical Linear Actuator
  - Piezo-electric Actuator
- Range of electric linear actuators from LINAK

<https://www.linak-us.com/products/linear-actuators/what-is-a-linear-actuator/>

[Download](#)

**Linear\_actuator.pdf (2.39 MB)**



## 2026/10/02 - Journals

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STEPHANIE VIGMOND (vigmond@wisc.edu) - Feb 10, 2026, 4:30 PM CST

**Title:** Journals for BME Design

**Date:** 10 February 2026

**Content by:** Steph

**Present:** N/A

**Goals:** Research some journals that we could base our final paper off of

**Search term:** N/A

**Citation:** N/A

**Link:** N/A

**Content:**

- Starting with Ryan Hooper et. al., (article Dr. Dean gave us for reference). Seeing what journal it is published in
  - Seems to be published in IOPscience, under biofabrication journal
  - Could be something we look into since the original article is published here, and our project is working with and expanding that project.
- Can look into other relevant journals
- <https://iopscience.iop.org/journal/1758-5090>

**Conclusion/Action Items:**

Will discuss with team at meeting later today.



## 2026/22/03 - Resin printing materials

STEPHANIE VIGMOND (vigmond@wisc.edu) - Mar 22, 2026, 5:47 PM CDT

**Title:** Materials for resin printing

**Date:** 22 March 2026

**Content by:** Steph

**Present:** N/A

**Goals:** Research some materials for resin printing

**Search term:** why would biomed clear resin expand after curing

**Citation:** I. Formlabs, "Obstructed interior holes after curing elastic resin," Formlabs Community Forum, Jun. 18, 2019.

<https://forum.formlabs.com/t/obstructed-interior-holes-after-curing-elastic-resin/23754> (accessed Mar. 22, 2026).

**Link:** <https://forum.formlabs.com/t/obstructed-interior-holes-after-curing-elastic-resin/23754>

**Content:**

- interior spaces may not be flushed and clear of resin before resin curing, so the interior may be cured (can spray compressed air to help)
- if thin areas are soaked in IPA too long, they can swell, so want to make sure it is dry so there is no other resin to be cured
- a syringe of IPA inside may help clear the inside

**Conclusion/Action Items:**

We have been having some problems with printing the CEVIC and KSMs, where sometimes they come out plugged, they don't fit in the dimensions they should, and others. This is particularly evident with the biomed clear resin. While I did not find anything explicit online about that one material, other people have had similar issues with curing resin.

Currently we have switched to just clear resin (no longer biomed clear) because at the Makerspace it is not true "biomed" resin, but if we want to ever go back, we could put some instructions to flush the interior spaces before curing, making sure it is not soaked too long during curing to limit swelling.

STEPHANIE VIGMOND (vigmond@wisc.edu) - Mar 22, 2026, 5:48 PM CDT

3/22/26, 5:48 PM Obstructed interior holes after curing elastic resin - Support & Troubleshooting - Formlabs Community Forum

### Obstructed interior holes after curing elastic resin

**jenalodge** 1 June 18, 2019, 10:52pm

I am making medical models with the elastic resin on the Form2. These models have lots of spaces - arteries and veins. While these spaces are perfectly clear after the cleaning phase, the curing process seems to cause many of these interior hollows become obstructed. Entire small sections that started out as holes become solid. I have turned off all interior supports so these spaces should be clear. Does anyone else have this issue? Thoughts on resolving it? What during the curing process can cause this? Thanks!

**Ben** 2 June 19, 2019, 4:05am

It may still have something to do with the washing process. It's good to make sure the interior spaces are thoroughly flushed and clear of uncured resin before curing, and if they're open-ended so that you can spray compressed air or gas (gently) through them, that can help.

If thin areas of the part are soaked in IPA for too long, though, they can swell, and so it can also be helpful to make sure the part is not only clear of uncured resin but dry of any wash IPA or other solvent that might still be carrying a sizable amount of resin in it.

If you can take a before and after picture, that might help reveal what's going on, or if you could share a representative section of a model this happens with, I'd be interested to try reproducing the problem.

**jenalodge** 3 June 19, 2019, 8:27am

You can try with a syringe filled with API to flush the arteries using a small needle. Even if the holes have a closed end it helps.

<https://forum.formlabs.com/t/obstructed-interior-holes-after-curing-elastic-resin/23754>

[Download](#)

**Obstructed\_interior\_holes\_after\_curing\_elastic\_resin\_-\_Support\_Troubleshooting\_-\_Formlabs\_Community\_Forum.pdf (145 kB)**



## 2026/22/03 - Resin printing supports

STEPHANIE VIGMOND (vigmond@wisc.edu) - Mar 22, 2026, 5:59 PM CDT

**Title:** Support requirements for resin printing

**Date:** 22 March 2026

**Content by:** Steph

**Present:** N/A

**Goals:** Research if supports are required for flat printing in resin

**Search term:** can you print on resin printers without supports

**Citation:** I. Formlabs, "Flat bottom parts need supports?," Formlabs Community Forum, Dec. 26, 2014. <https://forum.formlabs.com/t/flat-bottom-parts-need-supports/3086> (accessed Mar. 22, 2026).

**Link:** <https://forum.formlabs.com/t/flat-bottom-parts-need-supports/3086>

**Content:**

- larger prints often print better with supports because you can angle them to minimize the area of each layer
- layers that have smaller area are easier to peel from the tank, resulting in a better print
- angling is important to minimize pooling of the resin during printing
- compression layers are the first layers and are pressed more to make them stick to the plate

**Conclusion/Action Items:**

We want to minimize the supports on the bottom of the model, so we are considering printing the model flat. This seems to be fairly uncommon when resin printing because you ideally want the layers of resin as small as possible, so this may not print the best. We are planning to print one updated IRE as you normally would and one IRE flat and see the outcome.

STEPHANIE VIGMOND (vigmond@wisc.edu) - Mar 22, 2026, 5:58 PM CDT

3/22/26, 5:11 PM The bottom part need support? - General Discussion - Formlabs Community Forum

### Flat bottom parts need supports?

[Carter West](#) 1 December 26, 2014, 7:07pm

New to SLA and Form 1+ and I have only printed a couple parts so far. One of the parts was basically flat, so I chose not to use supports and it came out just fine.

I read somewhere if I don't use supports, even on a flat part, it may be dimensionally inaccurate. What would make this difference between a flat part using supports, vs. the same flat part not using supports?

I print many such parts and would really like to do this without the added time and materials - and extra finish time.

Thanks!  
Happy New Year 2015

---

[Aaron Stiller](#) 2 December 27, 2014, 12:12am

Hi @Carter West .

Great question.

Some prints come out fine with no supports printed right on the build platform. If your parts work, and are dimensionally accurate enough for your purposes, feel free to print with no supports.

Larger parts often print better with supports because you can angle them to minimize the area of each layer. Layers that have smaller areas are much easier to peel from the tank, and often, this results in a better print.

We do recommend angling flat prints with supports so that resin flow is optimized and so that resin does not end up "pooled" on flat surfaces during the print, which can result in lost details. If that works for you, by all means print things flat!

You must be very conscious of layer area and resin flow while printing with an SLA printer. Often, you can optimize these (and subsequently, the quality of your print), but angling a part with supports. There are benefits to each method of printing (flat, directly on the platform vs. angled with supports). As you experiment more with the printer, you will learn which one is best.

<http://forum.formlabs.com/t/flat-bottom-parts-need-supports/3086>

[Download](#)

Flat\_bottom\_parts\_need\_supports\_-\_General\_Discussion\_-\_Formlabs\_Community\_Forum.pdf (137 kB)





**Title:** Hierarchical Bioprinting

**Date:** 2 May 2026

**Content by:** Steph

**Present:** N/A

**Goals:** Research current bioprinting vasculature

**Search term:** Hierarchical bioprinting vasculature

**Citation:** O. Y. Dudaryeva et al., "Multi-scale Engineered Vasculature and Hierarchical Porosity via Volumetric Bioprinting-Guided Photopolymerization-Induced Phase Separation," *Advanced Materials*, vol. 38, no. 9, Dec. 2025, doi: <https://doi.org/10.1002/adma.202521171>.

**Link:** <https://advanced.onlinelibrary.wiley.com/doi/10.1002/adma.202521171>

**Content:**

- Vascularization is still a major challenge in hydrogel engineering
- Achieving vascularization down to 10 um (capillary) is a critical bottleneck
- This paper's approach produced constructs with light-controllable micron-scale and hierarchical porosity
- vascular structures formed in the pore spaces with feature sizes on the scale of capillaries, crucial to provide oxygen and nutrients to all regions of the hydrogel
- They fabricated materials permissive for cell infiltration and vascular outgrowth using photocontrolled phase-separating bioinks: **gelatin & PEG**
- Integration of gelatin is essential for large-scale bioprinting applications because no other commonly available biomaterial combines intrinsic cell bioactivity with cost-effectiveness at this scale
- presence of cell-adhesive motifs and enzymatically degradable sites (MMPs) eliminates need for challenging and expensive chemical modifications like peptide conjugation
- This enabled them to generate prints with **large pores or channels (mm-scale)** interconnected with **micron-sized channels (<10 um)** within a **single porous construct**
- shape architecture control at millimeter-scale combined with control over the intrinsic porosity at micron-scale
- multi-scale constructs were populated with vascular endothelial cells to create endothelial structures down to the microcapillary range

**Conclusion/Action Items:**

- this seems to be an almost competing "design" for the Dean lab
- they say they have achieved the hierarchical structure (but in a different way)

**RESEARCH ARTICLE**

**Multi-scale Engineered Vasculature and Hierarchical Porosity via Volumetric Bioprinting-Guided Photopolymerization-Induced Phase Separation**

Oksana Y. Dudaryeva, Maj-Britt Bushholz, Gabriel Gröbbercher, Sofia Amadori, Sammy Florczak, Camille Bonhomme, Alvaro Rojo Ferrer, Mark W. Tibbitt, and Riccardo Levato\*

**1. Introduction**

Blood vessels form complex networks that deliver nutrients and provide structural support, providing critical nutrients and oxygen while removing metabolic waste. In addition, vascular networks are dynamic and highly adapt to physiological changes to meet the changing metabolic demands of tissues. In this review, they are essential for making functional constructs and supporting cellular function. Vascular disorders, such as atherosclerotic cardiovascular disease, that impair blood flow have a significant impact on human health. Thus, all-angled, multi-scale, and multi-scale constructs are essential for making functional constructs and supporting cellular function. Vascular disorders, such as atherosclerotic cardiovascular disease, that impair blood flow have a significant impact on human health. Thus, all-angled, multi-scale, and multi-scale constructs are essential for making functional constructs and supporting cellular function.

Vascularization remains a major challenge in hydrogel-based engineered tissues due to the inherent non-scale porosity of common synthetic and natural hydrogels. Critically, the most common impediment to vascular networks within blood vessels outgrowth, required for oxygen and nutrient delivery. Despite advancements in the biofabrication of microchannels (1–100 μm), achieving vascularization (with capillaries down to 10 μm) throughout mm-scale bioprinted constructs remains a critical bottleneck. Herein, phase separation in triggered, cell-instructive gelatin–methacrylate hydrogels with volumetric bioprinting to generate architecturally defined constructs with multi-scale porous channels and interpenetrating micro-scale porosity. This novel approach produced porous constructs designed with light-controllable micro-scale and hierarchical porosity. Importantly, this porosity enabled endothelial cell infiltration and microvessel outgrowth deep into the engineered tissue. Vascular structures formed in the pore spaces with feature sizes on the scale of capillaries (<10 μm), crucial to





## 2026/03/05 - Silicone mold at home

STEPHANIE VIGMOND (vigmond@wisc.edu) - May 03, 2026, 7:17 PM CDT

**Title:** Silicone mold at home

**Date:** 3 May 2026

**Content by:** Steph

**Present:** N/A

**Goals:** Learn how to make a mold

**Search term:** silicone mold at home replicable

**Citation:** "How to Make Silicone Molds: A Practical Guide," Formlabs. <https://formlabs.com/blog/how-to-make-silicone-molds/>

**Link:** <https://formlabs.com/blog/how-to-make-silicone-molds/>

### Content:

- Casting silicones allows us to expand the properties of 3D printed parts to include bendable and stretchable components using materials readily accessible
- Silicone is highly flexible and stretchable solid
- Liquid silicones are typically 2-part or single part with small amount of catalyst added
- Silicone molds are advantageous because they are durable, can use them repeatedly; inorganic makes it resistant to heat and cold, chemical exposure, fungus
- Also, flexibility, stability, durability
- Good for prototyping
- there are kits that can do it at home

### Conclusion/Action Items:

- one method considered to duplicate the IRE or allow use of other materials was making a mold - this could allow more squishy materials such as silicone, and for more identical replications of the IRE

STEPHANIE VIGMOND (vigmond@wisc.edu) - May 03, 2026, 7:13 PM CDT

← All Posts

## How to Make Silicone Molds: A Practical Guide

🕒 15 minutes read 📁 Guides, Engineering

### Table of Contents

#### About Silicone

Why Make Silicone Molds?

Flexibility

Stability

Durability

Limitations

Common Applications for Silicone Molds

Prototyping

Jewelry

Consumer Goods

Food and Beverage

DIY Projects

How To Make the Molds for Silicone

Molding



Throughout history, artisans have used molds to make everything from Bronze Age weaponry to modern-day consumer products. While early molds were commonly shaped in stone, modern science has given rise to materials that are far easier to work with, such as silicone.

Soft components are a ubiquitous part of most commercial goods, from rubbery feet on a laptop to the ergonomic grip on a pair of scissors. Rubbery materials like polyurethanes, silicones, neoprene, and latex enable product applications from roofing materials to medical devices. Casting of silicones specifically allows us to expand the properties of

Getting Started With  
.....

3D printed parts to include bendable and stretchable components using  
materials readily accessible from hardware stores, art and science

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**How to Make Silicone Molds - A Practical Guide - Formlabs.pdf (9.31 MB)**



# Trainings as of March 2026

STEPHANIE VIGMOND (vigmond@wisc.edu) - Mar 26, 2026, 12:30 PM CDT



This certifies that Stephanie Vigmond has completed training for the following course(s):

Course	Assignment	Completion	Expiration
2025-2026 HIPAA Privacy & Security Training	2025-2026 HIPAA Privacy & Security Training	2/12/2026	
Biosafety 102: Bloodborne Pathogens for Laboratory and Research	Biosafety 102: Bloodborne Pathogens Safety in Research Quiz 2025	1/24/2026	1/24/2027
Biosafety 105: Biosafety Cabinet Use	Biosafety 105: Biosafety Cabinet Use Quiz	1/24/2026	No Expiration
Biosafety 106: Autoclave Use	Biosafety 106: Autoclave Use: Safety and Efficacy - Verification Quiz	1/24/2026	No Expiration
Biosafety 107: Centrifuge Safety	Biosafety 107: Centrifuge Safety Verification Quiz	9/7/2025	No Expiration
Biosafety Required Training	Biosafety Required Training Quiz 2024	2/14/2024	2/14/2029
Biosafety Required Training	Biosafety Required Training Quiz 2024-2025	1/24/2026	1/24/2029
Chemical Safety: The OSHA Lab Standard	Final Quiz	1/19/2024	
UW Human Subjects Protections Course	Basic/Refresher Course - Human Subjects Research	9/7/2025	9/7/2028

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**Screenshot\_2026-03-26\_at\_12.29.49\_PM.png (304 kB)**



## 2014/11/03-Entry guidelines

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John Puccinelli - Sep 05, 2016, 1:18 PM CDT

Use this as a guide for every entry

- Every text entry of your notebook should have the **bold titles** below.
- Every page/entry should be **named starting with the date** of the entry's first creation/activity, subsequent material from future dates can be added later.

You can create a copy of the blank template by first opening the desired folder, clicking on "New", selecting "Copy Existing Page...", and then select "2014/11/03-Template")

**Title:** Descriptive title (i.e. Client Meeting)

**Date:** 9/5/2016

**Content by:** The one person who wrote the content

**Present:** Names of those present if more than just you (not necessary for individual work)

**Goals:** Establish clear goals for all text entries (meetings, individual work, etc.).

**Content:**

Contains clear and organized notes (also includes any references used)

**Conclusions/action items:**

Recap only the most significant findings and/or action items resulting from the entry.



# 2014/11/03-Template

---

John Puccinelli - Nov 03, 2014, 3:20 PM CST

**Title:**

**Date:**

**Content by:**

**Present:**

**Goals:**

**Content:**

**Conclusions/action items:**



# BME400 NB - Fall 2025

DOMINIQUE GOODEN (degooden@wisc.edu) - Jan 23, 2026, 5:22 PM CST

## BME Design-Fall 2025 - DOMINIQUE GOODEN Complete Notebook

PDF Version generated by  
SOPHIA SPEECE  
on  
Tue, 19, 2025 @ 10:55 PM CST

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**Microvascular\_Shutoff\_Valve\_BME400\_Notebook.pdf (11.9 MB)**