Machine building with Quentin, Jake, and Ilan

Quentin's Section:
- Why build machines?
    - A machine is: a mechanism with actuation and automation
        - Most often including: a motion platform and an end effector
            - Motion platforms have been explored to death but end effectors not
    - Machines we already use: digital fabrication tools
        - Digital: design files and machine instructions can be shared
        - Automated: beginners can run it without domain expertise
        - Commoditized: costs have dramatically reduced over past 20 years
    - Building machines gives you lifelong skills
        - Understand the components in everyday appliances
        - Being able to fix or modify existing machines
        - Thinking in terms of modularity and hierarchy
        - Solving complex problems with spiral development
- History:
    - Tied to MIT – where computer numerical control (CNC) was invented, first time they hooked up massive computer to milling machine in repeatable way
        - Nowadays, CNC machine is ~$600 (Genmitsu, can run without computer)
    - With digital fabrication, massive boom in maker spaces (fab lab network)
        - Fab 2.0 = fab labs making fab labs (prusa comes from this)
- Starting out:
    - Easiest and best starter project is the pen plotter
        - Cheapest, most harmless end effector (just a pen!)
        - Teaches you about motion platforms and speed
        - Low requirements, high fun
- Path planning:
    - You're already familiar with path planning / toolpaths in advance
    - Writing your own code for this is easier than it looks (but only half the problem!)
    - Second have is actual execution of the path by the machine
        - The machine needs to transform the path to its own coordinates
- Motion platforms:
    - Range from basic stacks to sophisticated parallel ends
    - Equations of motion can get increasingly complex, especially with angles
        - Need to solve those equations to drive the machine to a known point
    - Examples:
        - Stacked axis: simple but heavy which is tough for acceleration/deacceleration
        - CoreXY elegant solution, two motors that don't actually move, can go really fast for 2d motion
            - Prusapro, bambu both based on this
        - Stewart platform: angular degrees of freedom, 6 pistons

- End effectors:
  - This is where you can easily innovate, barely scratched the surface
  - Synchronizing end effector with the motion platform is often the
  - Even a contact-free end effector can do interesting thins
  - Examples:
    - Sand drawing, clay printing, light painting
- Inspiration: doesn't need to be complicated! Try to de-risk ideas early and do stuff that "works right away" – care about what it does, not so much how it does it
  - Label maker for tape - simple rotation of tape with pen
  - Writing day's headlines on toilet paper
  - DIY wire cutter machine
  - Hangprinter - printer held by cables that always keep tension (complex geometry problem)
    - Another example is a cable driven version, with tension provided by rods instead of suspended (didn't know why he made it but just did)
  - Haystack (art school in maine in the woods), had fantasy of doing light painting so made winches and orbs → walk into the woods, strap into the trees, they figure out where they are by doing a homing routine and tries to position the winches in space so data makes sense → then move around with precision
    - Good for long exposure light painting! Did cube rotating
    - Char live DJ'd it! **Talk more to jake about this → live performance where moving through higher dimensional sound**
  - Building your own simple robot (SCARA Robot Control good interface example)
    - Linked video was DIY XRAY TO 3D PRINT MACHINE
  - Chainsaw + robotic arm
  - Robot basketball hoop (stuff made here, tutorials surprisingly in depth)
  - Toy story claw machine (architecture in 2019 and last year did claws)
  - Quentin's xylophone machine (uses camera to track fingers before hitting the key then presses down)
    - **Talk to quentin about this one**
  - Jake whimsical machine
- They provide references for motion systems plus the kit

Ilan's Section
- Started doing machine building in Neil's lab in 2007 with low cost PCB mill
  - Then foamcore 3d printer, prints in ketchup or chocolate
  - The plaster disaster 3d printer
  - Vertigo: having machines write a love letter
    - You type in your name, it starts writing your name, then finishes with a love letter
  - Mighty mill: milling machine that overcomes damping and stiffness challenge bc built with bent aluminum channels that are cut and bent to make frame, and set up on a jig, pour plaster in it, solidifies, locks all motion component sin place very accurately, giving you rigid low-cost frame

- - Friendship bracelet jacquard loom: [friendshiploom.com](friendshiploom.com), 24 actuated cables that lift and lower but you're in charge of setting tension and overall process
    - Uses electromagnets to pull back on fingers the knife will lift – making all those coils was a huge pain, with screwdriver varied by 20-30% so either nothing works or some started melting → so he built a coil winder machine
  - Bot of the cloth: machine for drawing on fabric, but also made out of fabric so can carry it with you (borrows structure of table)
  - Popfab: portable multifabrication machine - kinematic coupling for toolhead changing
- Left PhD to cofound shaper tools!
  - Shaper origin: move it around by hand, but camera and very small automated stage and will do the fine motion within thousandths of an inch
    - Locates itself with camera by putting tape down; earlier project was tape printer for domino pattern
- Interactive fabrication: Thinking of fabrication as "can we move computer into the tool" rather than "can we move the tool onto the computer"
  - CAD / CAM / CNC workflow: one directional, CAD then CAM for toolpath then CNC for physical; if doesn't work goes back to the beginning
  - Malcolm mcculloch abstracted craft
  - Examples:
    - WORM painting machine for patterning and transformations
    - Playing the print → changing parameters for printing with MIDI
    - Digital pottery wheel → Wheel with 3d printing capabilities
      - Start with form factor (pottery wheel with 3d printing) then figure out the interactions that fall out of that
    - Modular plotter:
      - Step a sketch → etch a sketch controls
      - Harmonograph with pendulums for drawing
      - Game controller control
      - Multiple interfaces at the same time
    - Making 3d printed stencils on the fly, matching a designer's drawing mechanically → then push button to play back the drawing and will add stacked layers

Mechanics of the Week:
- Can collaborate however we'd like, but they've created git repos for us to push work in (good if writing in code for machine)
  - Both working CBA repo, but also website to describe the machine
- Between now and next thursday we should talk, bc that's when we'll receive the kit
- Talk to TAs! If never built a machine, don't know what's hard and what's easy
  - If need special part that's not more than like ~$200 (like a print head) they can order for us

- Having good organization is REALLY important! Cross group collaboration and communication so that not bottlenecking each other
  - be decisive - architects good at moving ahead even if don't know what will happen, which is the right attitude for this
  - Be nice to fellow group members
  - Don't be afraid to do part of the problem you're unfamiliar with
  - Don't be afraid to make mistakes
  - Have lots of fun! Can be very stressful but people often have a really good time doing it, don't take it too seriously (same with final project - really good project can be very simple, like tape labeling machine)
  - Can add TA's to backchannel whatsapp group, invite them to meetings when trying to figure stuff out

CBA ideas:
- Thinking of some kind of flipping machine - but very similar to last year
- Pasta cutting machine! Identify an outline of a subject and cut it out
- CBA people always make a great video


Pasta Group
- CBA has 100 pancake bot machines
- Could we extrude the pasta into a drawing??
  - If want to control drawing cutting is the way to go
- Noodle slurping machine?
- What if it's like the lady and the tramp slurping machine?? Keeps it at the perfect tension, then you kiss!
- Constraint is something you can demo into the classroom