**Current Brainstorming Ideas**

**Hand Ideas:**

**Joint Ideas**

* Ways to move joints:
  + Pneumatics
    - Pros: will already have pneumatic components (due to granular jamming)
    - Cons: sudden and loud, bad range of motion, hard to control
  + Motors (one per joint)
    - Pros: very precise control
    - Cons: very complex to control, very bulky, very expensive (~15 motors/hand)
  + **Cables (selected method)**
    - Pros: Near-natural range of motion, fewer motors required/finger, simple control
    - Cons: unable to move just one joint at a time (moves all 3 in tandem)
  + Motors and Cables (motors at base of fingers):
    - Pros: allow for better range of motion than cables only
    - Cons: bulky, complex, cables and motors may interfere with each other
* Gear teeth at joint interface
  + Pros: can hold position (to a degree)
  + Cons: finite “steps” for motion, holding position is not a huge benefit
* External joint locks
  + Pros: allows user to disable joints & hold them in stable positions
    - Necessary for typing, etc
  + Cons: Would require the user to snap them in/out (assumes use of the other hand)

**Cabling Ideas**

* One cable per finger (uses 5 motors)
* One cable per finger, share cable for ring and pinky fingers (uses 4 motors)
  + Pros: saves space, complexity
  + Cons: sacrifices some dexterity
* One cable per joint per finger (uses 15 motors)
  + Pros: much more dexterous than one cable per finger
  + Cons: expense/complexity/space (also not sure how to implement it)
* One cable for 2 joints per finger (uses 10 motors)
  + Pros: fewer motors than for each joint
  + Cons: still expense/complexity/space (also not sure how to implement it)

**Straightening out Hand:**

* Long rubber bands
  + Pros: Cheap, proven
  + Cons: if one snaps that whole finger will be useless until it is replaced
* Dental rubber bands
  + Pros: Cheap, proven, easily replaced
  + Cons: may be fragile
* Flat springs
  + Pros: More robust than rubber bands
  + Cons: May be hard to replace
* Another set of cables
  + Pros: allows for hyperflexation, allows the hand to flop when relaxed, like the real thing
  + Cons: requires a lot of motors

**Sensing Grip:**

* Don’t sense grip, instead just have a button to run the vacuum
  + Pros: simple
  + Cons: Requires user to press button (assumes they have another arm)
* Place bump sensor under granular jamming pad
  + Cons: electronic component (cannot get wet), wires must be housed in fingers and thus flexed a lot, causing wear and tear
* Place encoder on servo motor, read to see if motor is stalled
  + Pros: Does not require electronic components to be in the hand
  + Cons: possible wear and tear on the motor

**Granular Jamming Ideas:**

* The first step in the granular jamming gripper development process should be to test out balloons filled with different granular jamming materials to see what works well
* The second step should be to test different layouts with one finger to ensure that air gets sucked out well/evenly

**Granular Jamming Material**

* Coffee grounds
  + Pros: proven to work
  + Cons: Not a viable long-term choice
* Sand (just a guess)
* Beanie Baby Pellets (just a guess)

(Also I have a bag of these in my room if anyone wants to test them)

* Definitely do some research on other appropriate materials because I don’t know much about this

**Housing Material**

* Balloons
  + Pros: Proven to work
  + Cons: Not the right shape for the application
* Silicon casting, like they use for art/maskmaking
* I’m honestly pretty stumped on what material to use! Any suggestions?

**Layout**

* **Continuous pad with finger shapes, like a thin glove**
  + Pros: Simple, maximum contact
  + Cons: Will material get in the way as the finger is folding in?
* **1 pad for each major section of each finger, palm pad (about 15 total)**
  + Pros: eliminates problem of getting in the way
  + Cons: kind of complex
  + Also to do this you need to think about how (or even if) you want to connect them
    - Pinching them in like the end of a whoopee cushion
      * Pros: easy
      * Cons: when vacuum is on, it may just pinch itself off and prevent the vacuum from sucking air out of the pad
        + Now if you let the granular jamming material in there it probably won’t collapse, but will that get in the way?
        + Use foam to allow air through, but not granules instead of a thin cloth material
    - Attaching them with small sections of fairly rigid plastic tubing
      * Pros: Won’t collapse
      * Cons: Not sure how to attach the tubing to the pads (epoxy?), also it needs to be determined if the granular jamming material can get into these connecting tubes or not. If not, then some kind of filter needs to be added to the ends of the tubes to keep the material from shifting, while still allowing air through
      * Can use foam to allow air through, but not granules instead of a filter
* **1 pad for each fingertip, one for the palm**
  + Pros: less complex than 3 pads/finger
  + Cons: Less grip (but also the fingertip seems to be used the most)
* **1 pad for each fingertip, 1 for finger base, one for the palm**
  + Pros: less complex than 3 pads/finger, more grip than 1/1
  + Cons: Less grip (but also the fingertip seems to be used the most)
* **Connecting vs. not connecting the pads**
  + You can either have each pad for each finger connect to the next one down, to the next one down, into the palm, and have one tube from the palm to the vacuum, or you can have one tube come up from each pad, run through the finger, and have them join at the wrist. If you run them serially you have the problem of the connections getting in the way of the joints, if you run them parallel then you have the problem of the tubes getting in the way of the joints if they are very rigid, so it’s really something that has to be thought about.

**Other Ideas:**

* Perhaps use polycarbonate plastic for the final hand model, it is much stronger than PLA or ABS plastics (you’d have to make sure the Stevens printers can print in polycarbonate first though, it requires higher temperature printing)
* Add a material to the tip of the index finger that allows use with touch screens
* Wrapping the granular jamming material up over the tip vs not
* Add nails—nails are actually used for some tasks (such as opening cans)