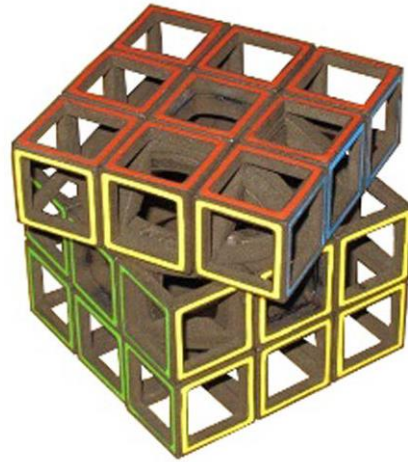


# Design Make Sell

MAE 2250

Hod Lipson



# Design, Make, Sell

- Product design A-Z
  - From idea to a physical product on sale
- Face real trade-offs
  - manufacture, cost, time, marketing
- Face the blank page
  - Minimum constraints

Why?



Illustration by Chris Gash

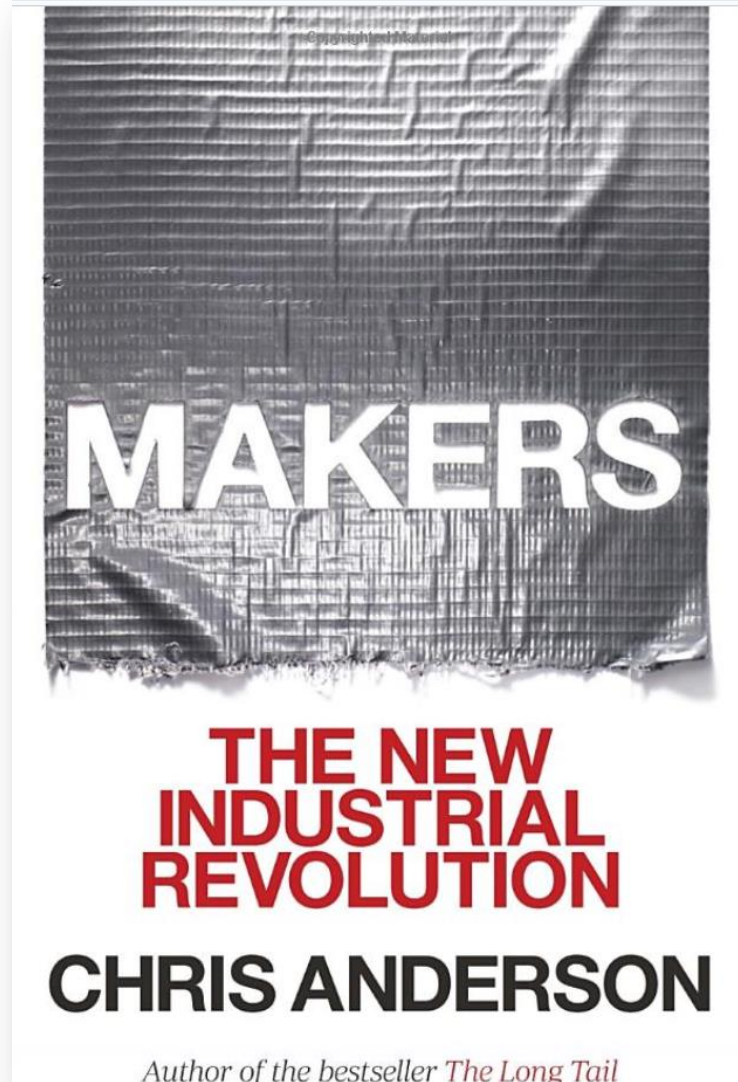






# Design





**“Over the past ten years, the internet has democratized publishing, broadcasting, and communications, leading to a massive increase in the range of participation in everything digital – the world of bits.**

**Now the same is happening o manufacturing – the world of things”**















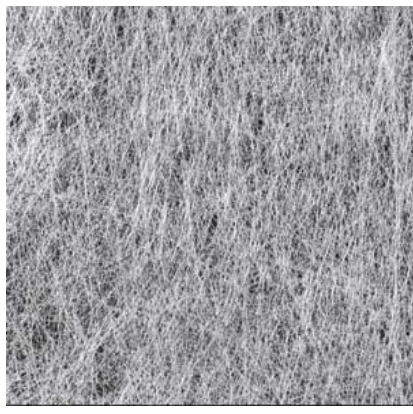












# The accelerated innovation landscape

- Music/MP3
- Photo/print
- eBooks
- Iphone Apps

**Direct from designer to consumer**

# Question

- Have you ever designed a consumer product?
  - A: Yes
  - B: No
  - C: Kind of
  - E: Whatever

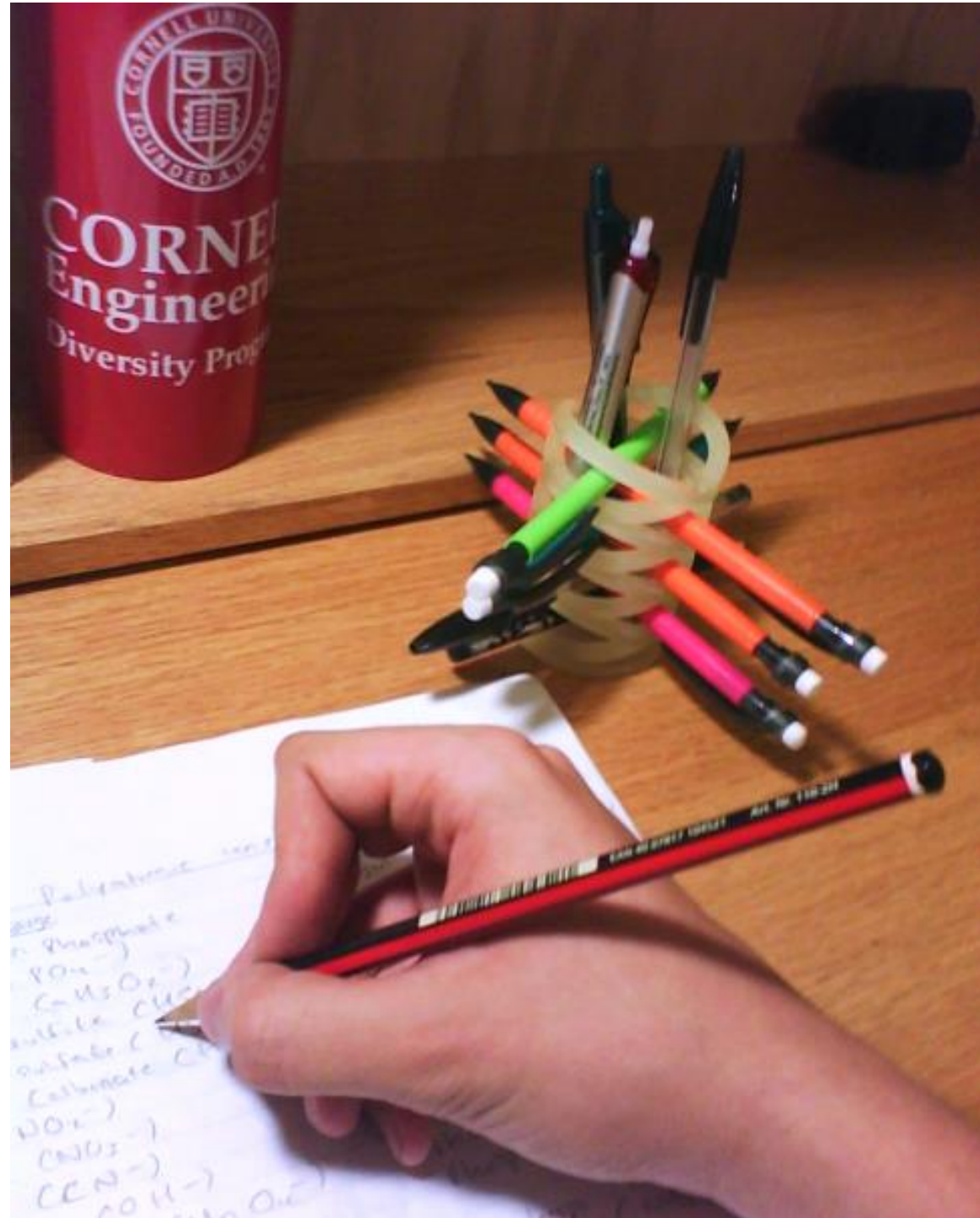
















Brush

'eM!



kids.





**HASHI**  
chopstickaid and spoon rest



7Plain









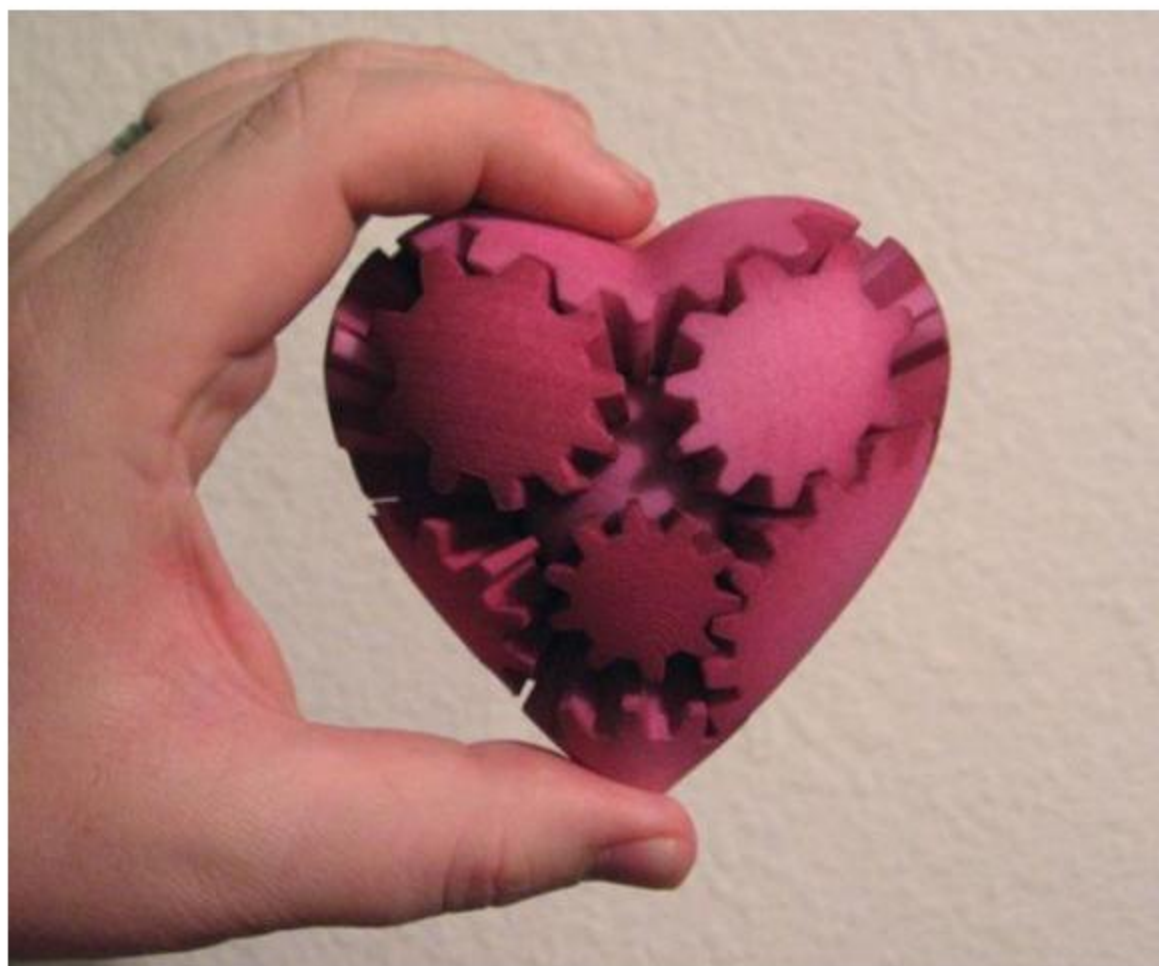




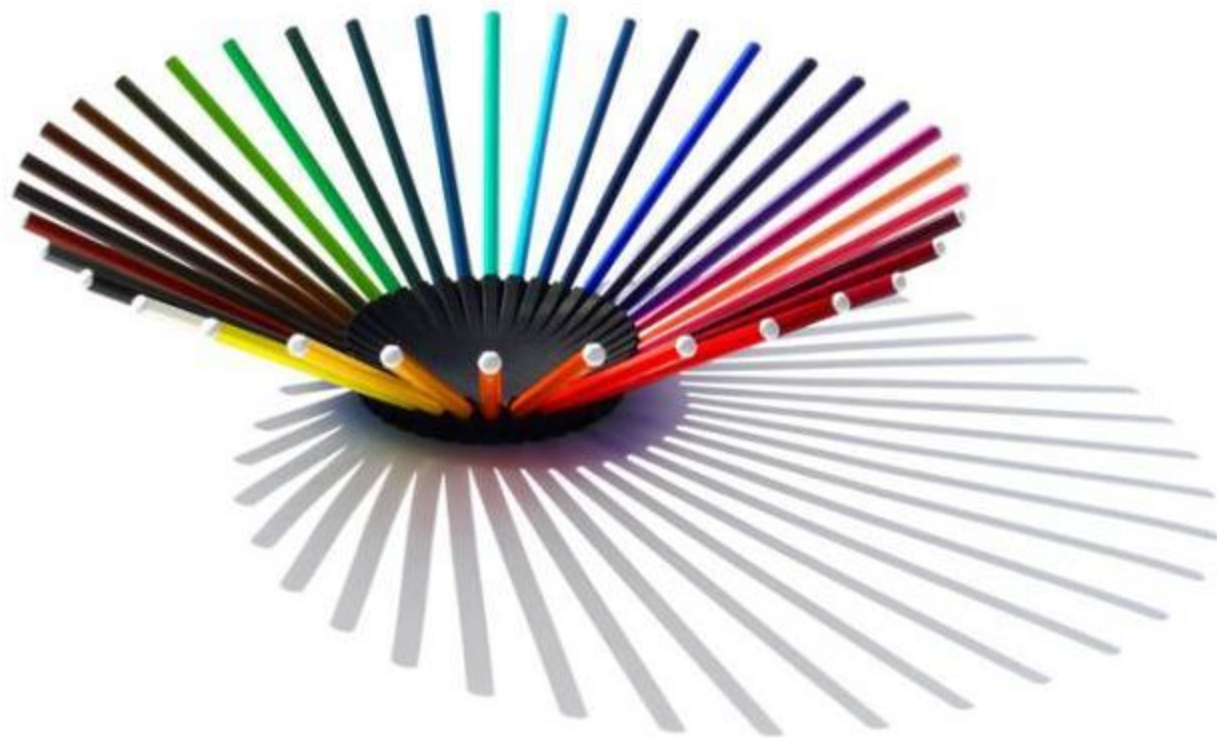
THIS IS A TWO PART MODEL,  
HORN AND BASE  
SOLD SEPARATELY









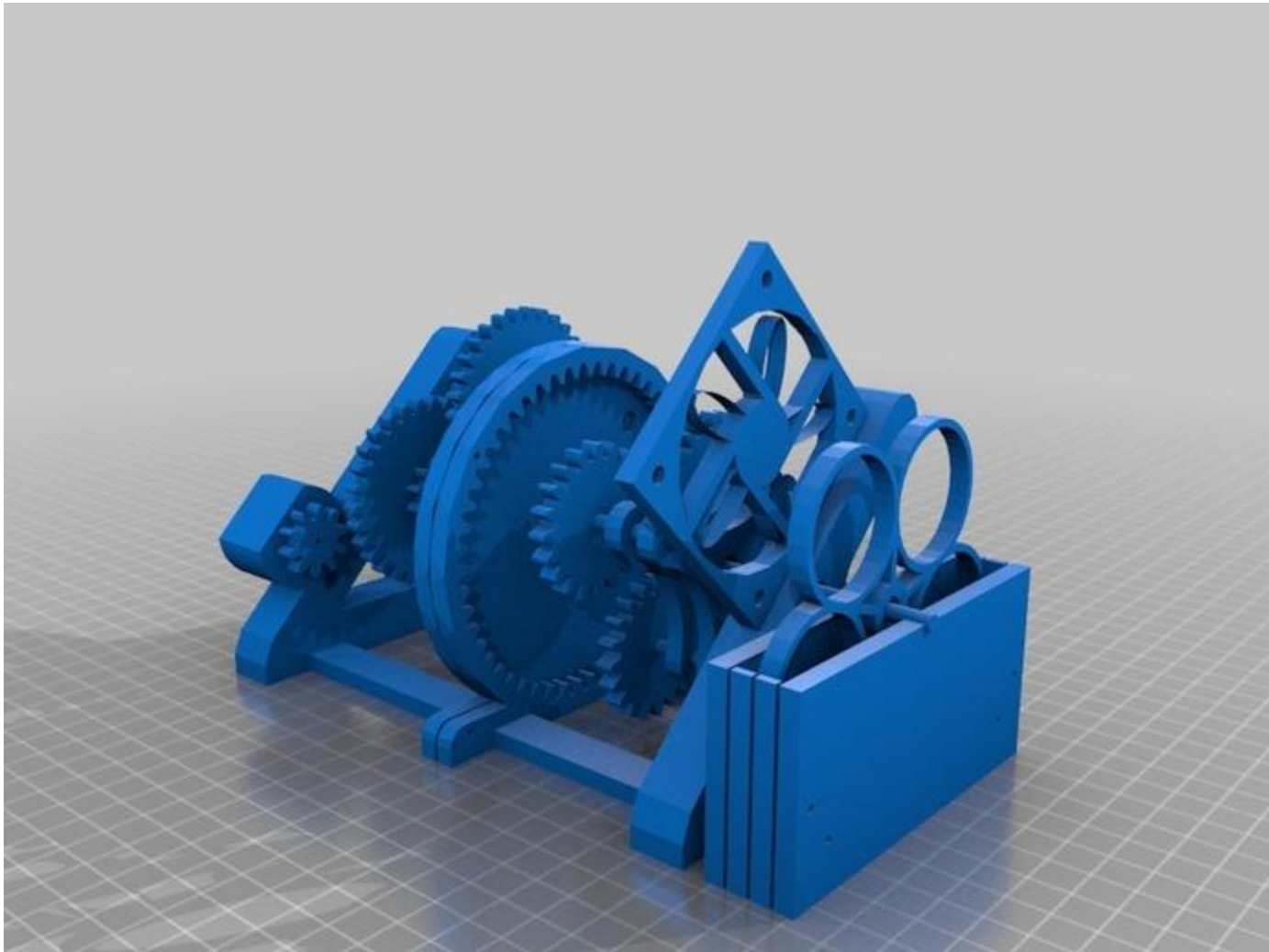


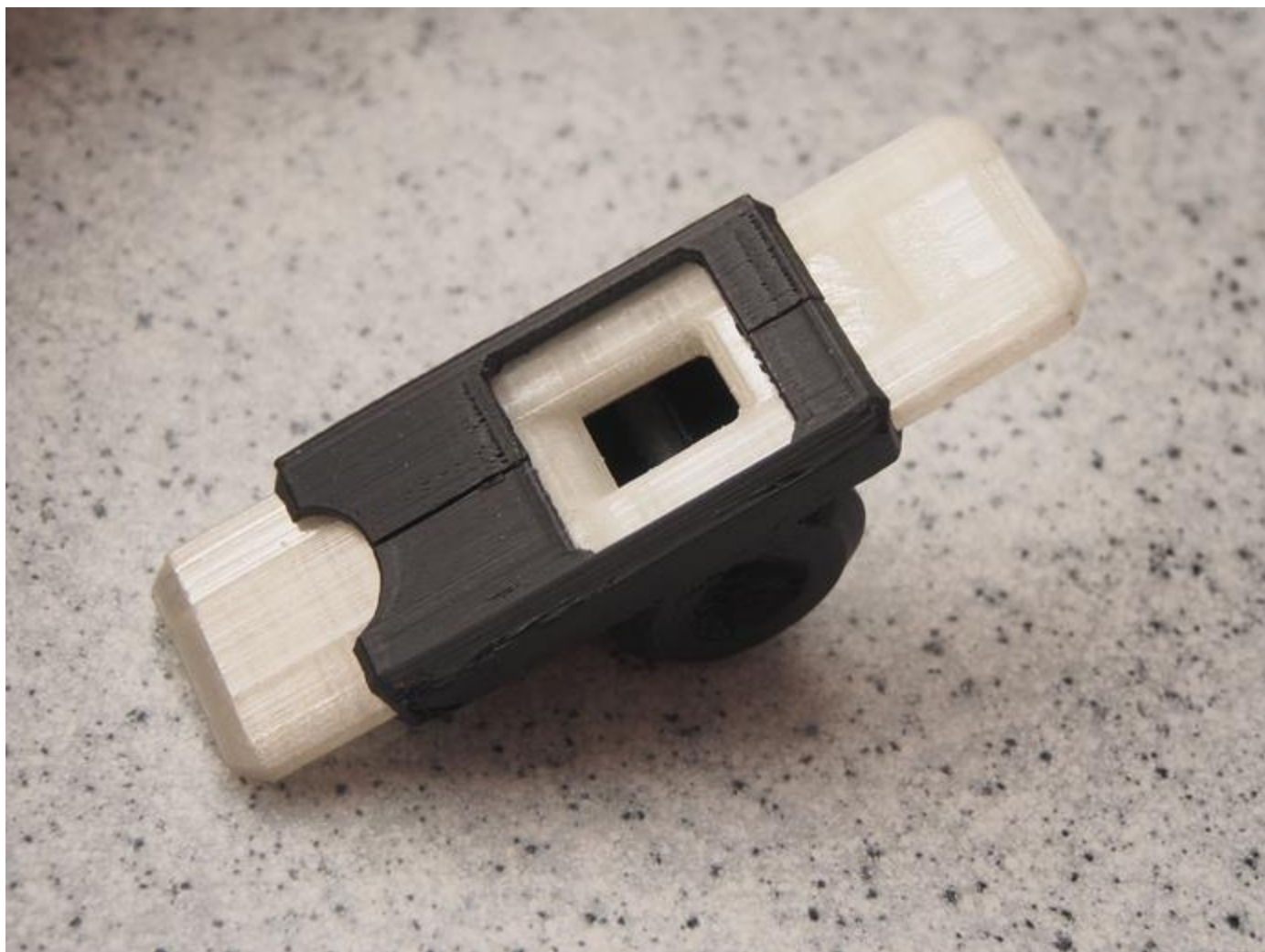
















LA VIE N'EST PAS A VENDRE









# Shower Head

make it rain

















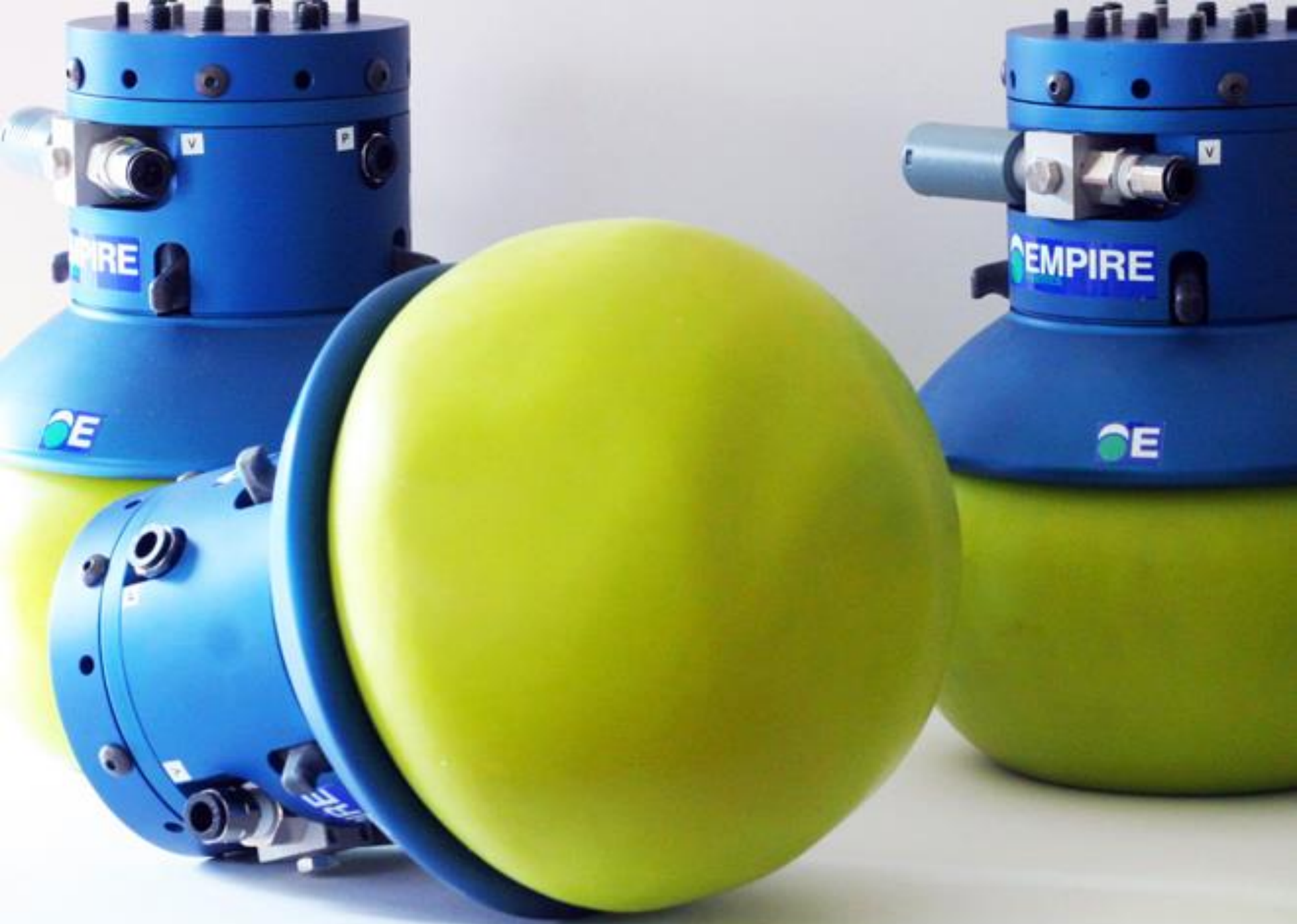








John Amend





# New Innovative Design & Curriculum

## MAE 2250: DESIGN-MAKE-SELL

What would you make if you could make anything? That's the question posted to last year's MAE2250 course – 'Mechanical Synthesis'. This course introduces fresh sophomores to the art and science of product design and manufacturing, from identifying customer needs, to generating, benchmarking and testing concepts. For many years, that's where the course ended: A working prototype. But this year, we took it one step further: Make and sell the real product online.

Like everything else, products' life cycle is accelerating. For many years, the time from design conception to mass production has taken years. But new computer aided design tools, online retail and marketing, and now digital manufacturing tools like 3D printers, are rapidly removing barriers of skill, time and cost, condensing the product life cycle into months if not weeks.



Daniel Cellucci, PhD, from the Creative Machines Lab shows Professors Kirby and Lipson the robot *Aracna* (designed by Sara Lohmann). All parts (minus the motor) were 3D printed in the lab.

For the first time, we offer students the thrill of designing and making a product that will actually be offered for sale online. Within one semester, they can go from a vague idea to an automatically produced product that can be sold in quantity. In teams of four, students designed a variety of household products, from a smartphone mount to new kinds of teacups, eyeglasses and camera lens mounts. The range of products was remarkable.

The open-market nature of this exercise brings a fresh new perspective to the challenge and a breath of realism. Prof. Lipson states, *"If I could, I would give an 'A+' to anyone who was able to sell a product to a paying customer who does not know them personally."* But it also creates a challenge: If you are designing a smartphone case, it needs to be superior, in some way, to the thousands of other cases out there. The

market is real, but competition is real too and as one student said, *"Getting a low grade is not as bad as getting a phone call from an angry customer."* One team was contacted by an investor to discuss mass production of their teabag-free teacup. Another team was able to design a pair of shutter shade glasses where the slats were shaped like the initials of the university. The design was such a hit, that fifty orders poured in from customers anxious to have their pair delivered by Slope day. The team, however, panicked as they could not guarantee on time delivery. It wasn't the instructors or TAs that created that priceless sense of a deadline – it was the paying customers.



teabag-free teacup (designed by Amanda Bouman, Stephanie Fleischer, and Shaun Koh).

The advent of accessible manufacturing tools also has some students stumbling. If the fear of the blank page creates the author's block, the fear of the open design canvas coupled with a constraint-free manufacturing tool leaves some students searching for ideas. When Prof. Lipson asked students what product they would buy if they could buy anything, hands shot up aplenty. But when asked what they would make if they could make anything, the more creative students – many of which had more than one answer – stood out.

For many students, the main reason for joining MAE is to learn how to design and make products. With new tools of design and production, we can bring the product design cycle into the classroom, unleashing a new kind of creativity, and a deeper educational experience.



3D printed earbud holder (designed by Christian Karakachian and Michael Dijamco).









# The New York Times **Sunday Review**



*Dinner is printed*











# Requirements

- Functional product
  - not just art/decorative. Must include analysis
- Assemble from printed parts + components
  - No extra machining, handcraft
- Cost  $\leq$  \$99





### Alumide

Brittle Nylon Plastic that's filled with Aluminum dust. Also available polished & smooth.

Starting from:  
**\$1.99/cm3** +\$1.50



### Strong & Flexible Plastic

Great starter material—easy design rules, feels a bit rough, but available in polished finish.

Starting from:  
**\$1.40/cm3** +\$1.50



### Fine Detail Plastic

Acrylic based polymer that can print fine details. Smooth and slightly shiny.

Starting from:  
**\$2.99/cm3** +\$2.50



### Frosted Detail Plastic

UV-cured acrylic plastic that prints fine details and walls. Smooth and translucent.

Starting from:  
**\$2.39/cm3** +\$5.00



### Stainless Steel

Great for jewelry and durable pieces. The shiny surface is slightly pitted & rough.

Starting from:  
**\$8.00/cm3** +\$6.00



### Sterling Silver

(92.5% silver). Perfect for jewelry. Available in glossy, polished finish.

Starting from:  
**\$20.00/cm3** +\$30.00



### Full Color Sandstone

Gypsum printable with color textures on the model's surface. Feels like matte clay.

Starting from:  
**\$0.75/cm3** +\$3.00



### Ceramics

Food-safe glazed ceramics. Available in glossy and satin finishes, and a variety of colors.

Starting from:  
**\$0.18/cm2**





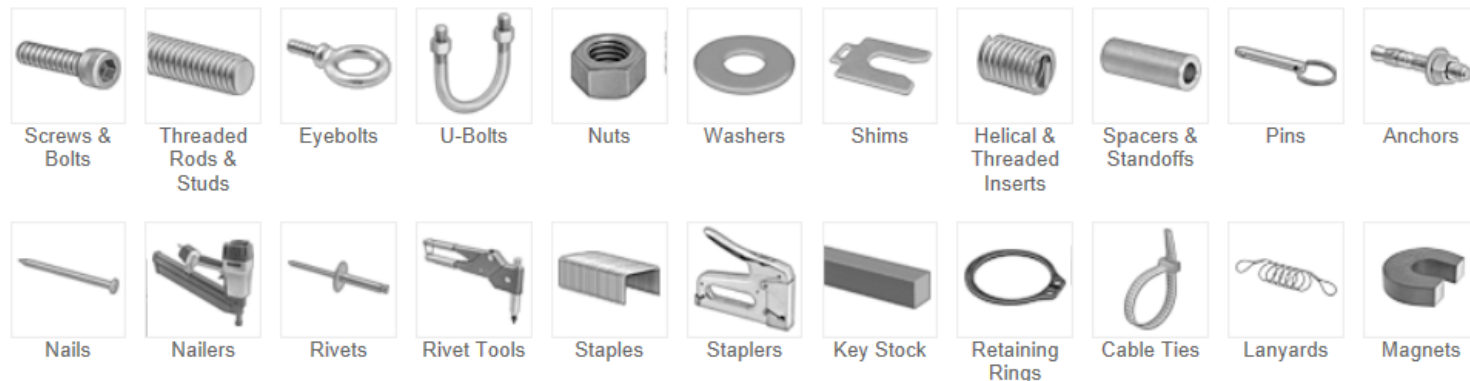
## Choose a Category

Abrading & Polishing  
 Building & Grounds  
 Electrical & Lighting  
 Fabricating  
 Fastening & Joining  
 Filtering  
 Flow & Level Control  
 Furniture & Storage  
 Hand Tools  
 Hardware  
 Heating & Cooling  
 Lubricating  
 Material Handling  
 Measuring & Inspecting  
 Office Supplies & Signs  
 Pipe, Tubing, Hose & Fittings  
 Plumbing & Janitorial  
 Power Transmission  
 Pressure & Temperature Control  
 Pulling & Lifting  
 Raw Materials  
 Safety Supplies  
 Sawing & Cutting  
 Sealing  
 Shipping  
 Suspending

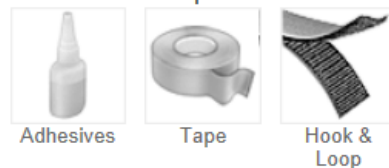
## All Categories

### Fastening & Joining

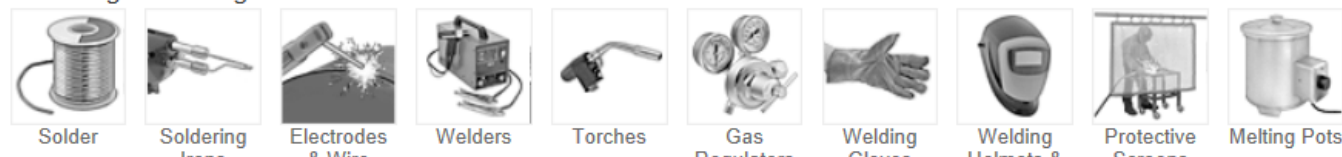
#### Fasteners



#### Adhesives & Tape



#### Soldering & Welding





To avoid













## MAE 2250: Mechanical Synthesis - Spring 2014

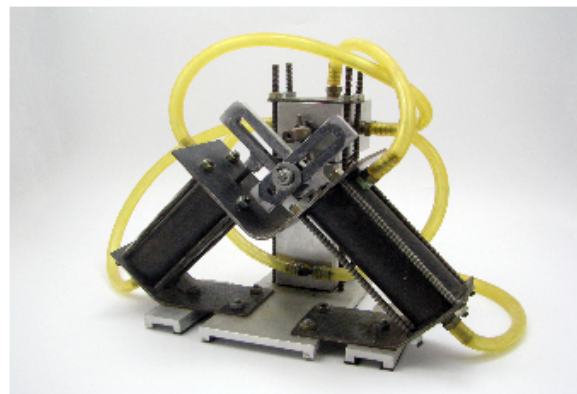
### synopsis

M&AE 2250 is a course that focuses on product design . You will experience a comprehensive "Product Realization" process to meet customers' needs, including considerations of performance, cost, manufacturing, marketing, etc. You will interact with others and apply design methodology. These design experiences will simulate real-world engineering practices and include system/project approaches, teamwork, and graphic and oral communication.

Design has no unique path of progression or definitive 'rules' – each design task may follow different methods of approaching the problem. You will learn the values and priorities that help you create and select solutions that meet customer specifications. You will cultivate an ability to work with teammates, and to function in a project having 'fuzzy' objectives. Design education is challenged by a relative lack of rigor, a wide-ranging technical content and personal preferences of individual designers, but offers many opportunities for creativity and innovation.

Overall, MAE 2250 should

- Stimulate original thinking and creativity;
- Integrate engineering knowledge with personal experience in multi-disciplinary applications;
- Foster an understanding of the unstructured nature of design;
- Provide practice in problem definition and solution synthesis;
- Provide training in graphical thinking and communication;
- Introduce fabrication methods necessary for practical implementation of designs;
- Introduce critical economic evaluation of design concepts.



Mondays, Wednesdays and Fridays 11:15AM - 12:05PM in UPSON B17. [See full schedule.](#)

### Administrative

[Syllabus](#): objectives and methods.  
[Schedule](#): topics, tasks and deadlines  
[Course staffing](#), office hours, [emerson coverage](#)  
[Piazza](#) Q&A discussion board  
[CMS](#) Course management system (upload assignments)  
[Cornell i>Clicker setup for students](#)  
[Course management](#): TAs Only

### Projects & Exercises

[Lamp project](#)  
[CAD Project](#)  
[Design Make Sell](#)  
[Air Motor Project](#)

### Resources

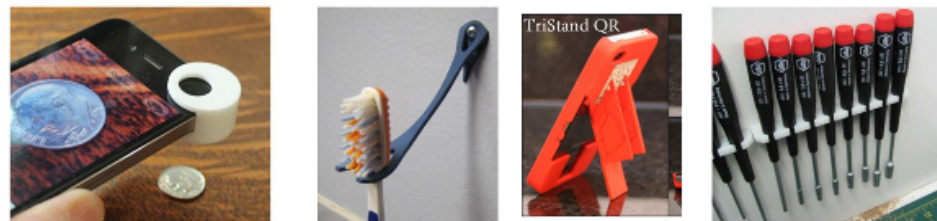
[CAD Systems in M&AE](#)  
[Emerson shop guides and information](#)  
[Myers-Briggs personality test](#)  
[TA midterm evaluations](#)  
[Using 3D Printing](#)  
[Using Laser Cutter](#)  
[Ordering parts](#)  
[What should be included in the project report?](#)  
[Other Resources](#)

**Objectives:**

The goal of open design project is to experience the full design process from concept to realization to marketing. You will also experience optimization of a design with respect to objectives and constraints, as well as online digital fabrication and distribution techniques ([read more](#)).

**PROBLEM STATEMENT:**

Your design team has been contracted to design a successful consumer product that can be sold for a profit at a retail price of \$99 or less. Your task is to design and build a cost effective, high quality product, demonstrate it in reality, and create a website to market your product (without false advertising!).



(Image source: Shapeways)

**MINIMAL CUSTOMER NEEDS:**

The object must be manufacturable using a combination of 3D Printing of non-standard parts, and assembly of standard parts (from [McMaster.com](#) only) Maximum cost of your product (3D printed parts, laser cut parts, and components) should be \$99 or less.

**COSTS:**

Calculate the final product cost using [Shapeways Pricelist](#) and McMaster pricing, and pro-rate when using only partial amounts of a pack. For example, if your product involves printing 2 cm<sup>3</sup> of steel, 8 cm<sup>3</sup> of plastic, and ten 1/2" stainless 2-56 screws, then you would calculate the product cost by summing up the [materials costs on Shapeways](#) (Steel: 2\*\$8+\$6, Plastic: 8\*\$1.4+\$1.5), plus 20% of a 50-pack of screws from Macmaster (20% \* \$6.18) for a total of \$35.94

Your prototyping budget for this project is \$100 (including 3D printing, laser cutting, and parts). This is the total amount you are allowed to spend purchasing materials from McMaster (via the TA only), 3D printing, or Laser cutting, even if you end up not using the parts. Even if you only use one screw from a pack of 50, the entire pack counts towards your prototyping budget. So you may want to think twice before ordering, and perhaps coordinate with other teams.

Do not order parts on your own from McMaster or elsewhere, even if you find something cheaper or better. Do not bring your own components to class. If you need a component that is not available on McMaster and cannot be 3D-Printed or laser-cut, let the TA know.

**PROJECT ORGANIZATION:**

*Teams:* Each team will consist of 3-4 members.

**Deadlines (see [schedule](#))**

- Weekly [project report](#) uploaded to CMS by end of every week.
- Preliminary design review (10 min presentation): 1st week of your project
- Critical design review (10 min presentation): 2nd week of your project
- Prototype demonstration (5 min presentation): 4th week of your project
- Website of the product: 4th week (create on [blogs.cornell.edu](#) or any alternative location of your choice).

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- Website of the product: 4th week (create on [blogs.cornell.edu](http://blogs.cornell.edu) or any alternative location of your choice).
- Final presentation (15 min): 5th week of your project week
- Final report: Upload to CMS on the 5th week of your project
- Team Assessment: Each team member will complete a [confidential team assessment sheet](#) (also available in [MS Word](#)) and upload to CMS. These scores will be aggregated and used to rebalance the grade if there are severe discrepancies in effort and contribution.

## Grading (and 50% Bonus):

30% of final grade. Grading based on report, presentations, and self-grade

**Bonus:** 50% bonus if you posted this product online (e.g. Shapeways, Materialise, Etsy, Amazon), and someone that does not know you personally (i.e. not your sister, your second cousin, or your dad's friend) bought it at cost or higher (keep the profit), within 3 months after project completion. If this happens, Congratulations! contact the instructor for further details. This might push your final grade into an A+.

## MATERIALS:

Nonstandard parts: [3D-print](#) or [laser cut](#) from 0.25" acrylic (provided).

Standard parts: Order [standard components](#) from Emerson, and anything else from McMaster.com using [TA order sheet](#) (bolts, lights, USB flash drives, anything)

# Project Deliverables

- Phase 0: Product plan
- Phase 1: Conceptual design and project plan
- Phase 2: Detailed design
- Phase 3: Analysis
- Phase 4: Fabrication and testing
- Phase 5: Presentation & Marketing
- Phase 6: Post-analysis and revisions



# Phase 0: Product plan

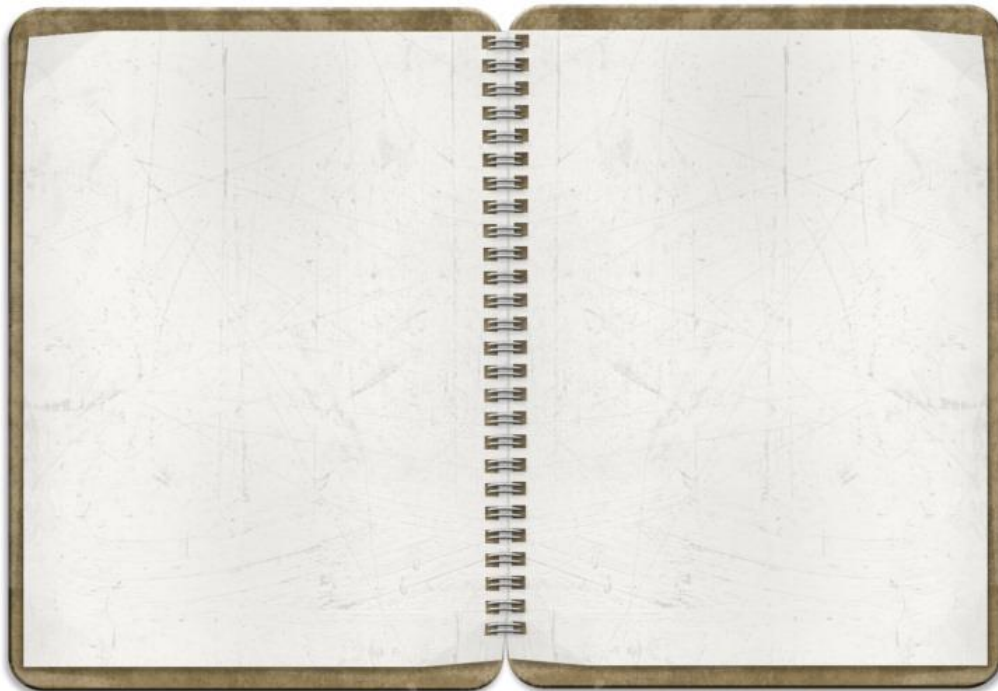
1. Which product will you make?
  - Minimum two ideas per team member
  - Pros/Cons for each
2. Final Choice
  - Decision rational
  - No consensus? Recombine ideas, revisit 1

Focus on *needs*, not *solutions*



# Brainstorm

- What would you make if you could make anything?



00:00.0

# Phase 1: Conceptual Design






























































































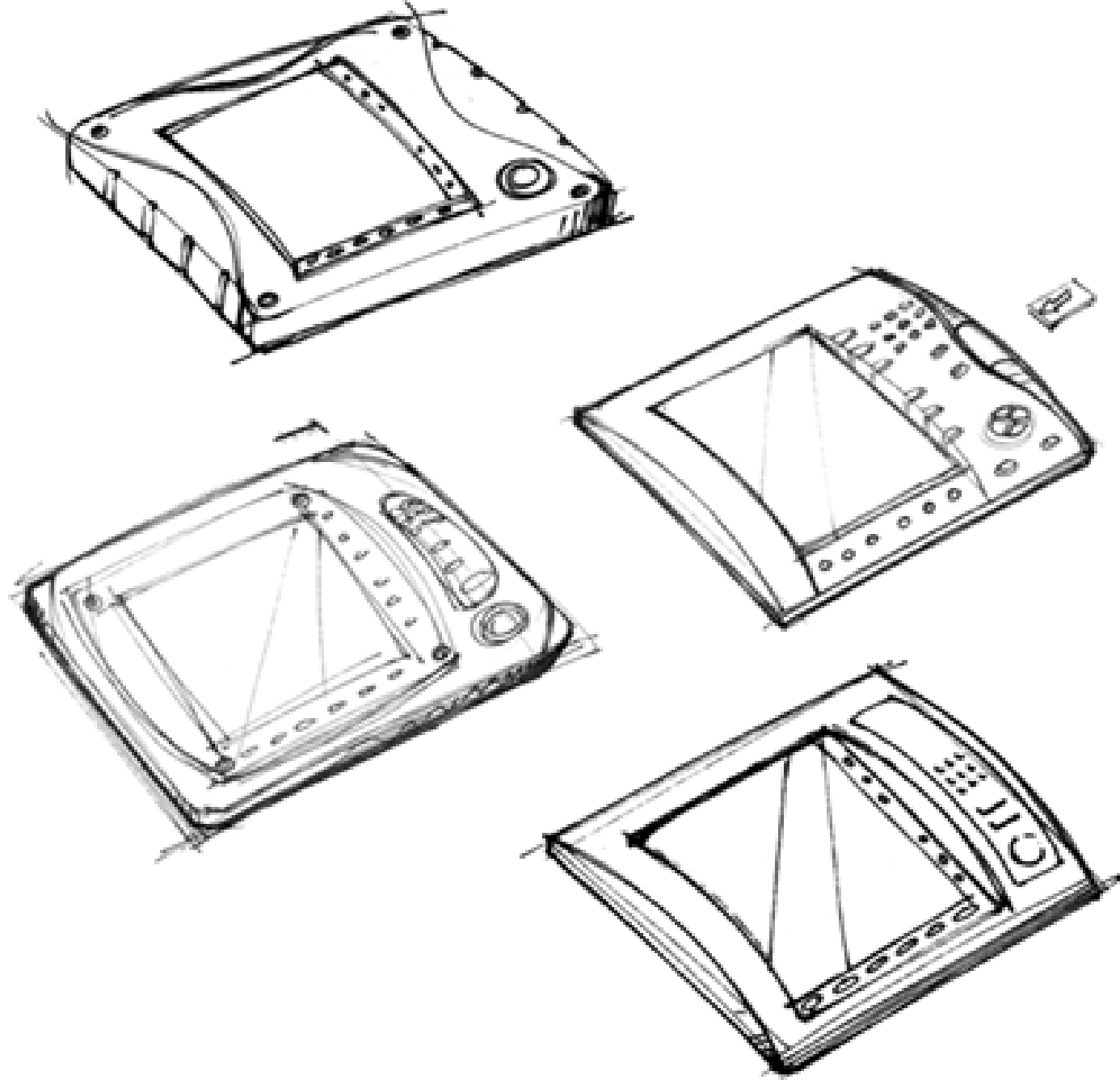


# Morphological Chart

solutions →

sub functions ↓

'human power'	 stilstaan	 1 been afzetten	 2 been afzetten	 2 armen trekken	 huppen links en rechts	 schuilen huppen	 huppen draaien	 schuilen huppen	 stappen	 dries links en rechts	 huppen huppen	 schuilen huppen		
steering	 verdraaiend wiel	 inwendig + tand	 gevoelingswiel	 Achterwiel	 voorwiel	 draaiend wiel achter	 parallel	 schuivende as	 inwendig	 20%	 schuivende delen	 40%	 link & rechts	 sturing links
transmission	 afbremsel	 'kruisende'	 driest	 V-wiel	 vijfwegkoppeling	 driest	 cruiser	 overstap	 ruw-wiel	 driest	 kruisende tanden	 2 tandwiel	 tanden op tanden	 tanden op tanden
surprise	 verrassend	 omgekeerde voor	 verrassend wiel	 extra juwt	 verrassend input en output	 kleinverandering	 verrassend effect en tactisch	 verrassend verandering	 verrassend verandering	 verrassend verandering	 verrassend verandering	 verrassend verandering	 verrassend verandering	 verrassend verandering
learning effect	 verrassend van tevoren	 balans	 'timing'	 'verrassend' effect										
acceleration	 verrassend versnelling	 verrassend versnelling	 verrassend	 verrassend	 verrassend									
'human power' 2	 spat	 afzetten	 huppen	 stapen	 schuilen	 armen huppen	 draaien	 afzetten	 stapen	 huppen	 schuilen	 afzetten	 schuilen	 stapen
steering 2	 schuivende delen	 schuivende delen	 schuivende delen	 schuivende delen	 schuivende delen	 schuivende delen	 schuivende delen	 schuivende delen	 schuivende delen	 schuivende delen	 schuivende delen	 schuivende delen	 schuivende delen	 schuivende delen



671.



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Member: Hod Lipson

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- WE MARKET--Ship From Hong Kong   
**\$2.23** + Free Shipping
- 42 new** from \$0.02
- Have one to sell?

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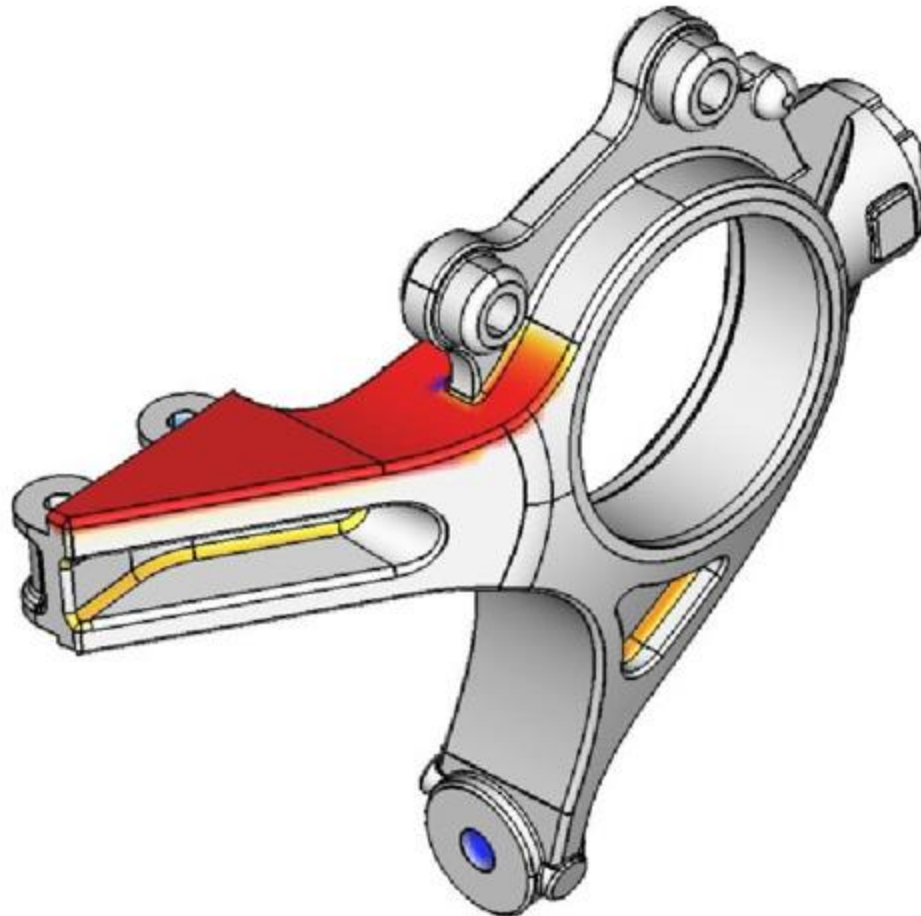
**Frequently Bought Together**

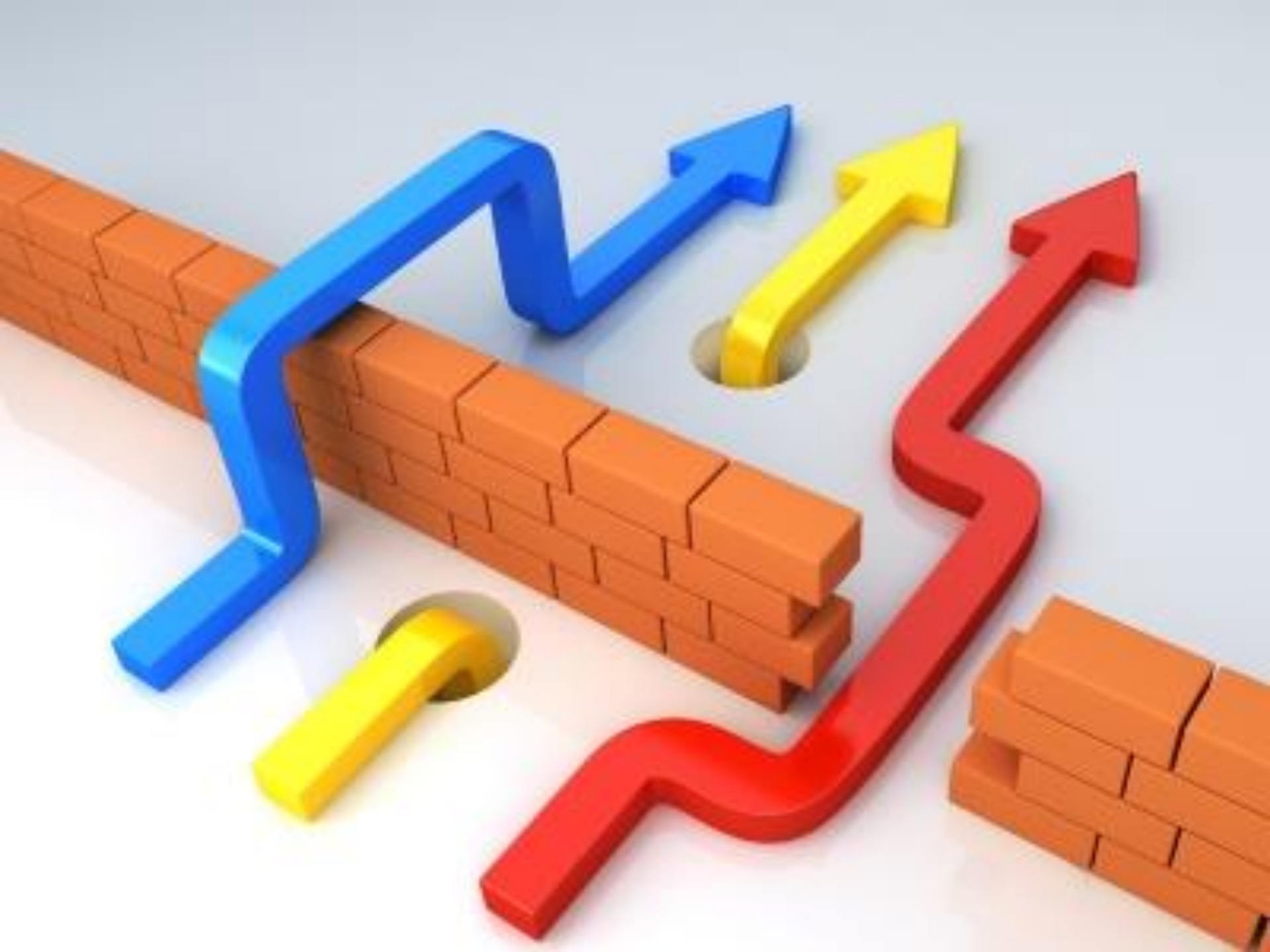


**Iterate**



# Phase 2: Detailed Design

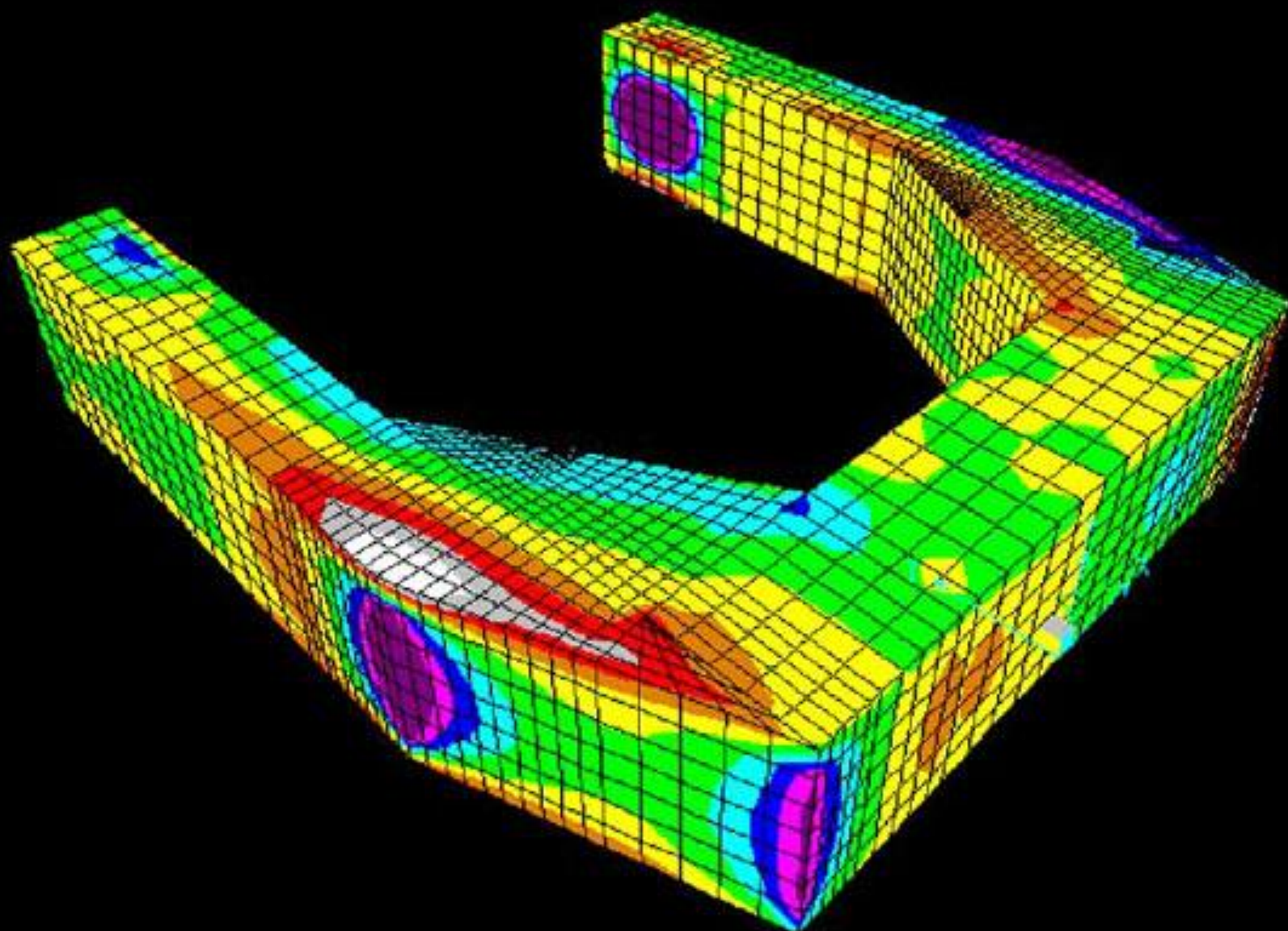




# Phase 3: Analysis









$$\begin{aligned}
C_j(S_j) = & a_j \mu_j^{DC} + \frac{A_{0j} + g_j}{R_j} \\
& + h_j \left\{ \frac{\mu_j^{DC} R_j}{2} + S_j - \mu_j^{DC} (R_j + L_j) + (1 - b_j) E[D_j(R_j + L_j) - S_j]^+ \right\} \\
& + \left[ \frac{\pi_j + (1 - b_j)(\pi_{0j} - a_j)}{R_j} \right] E[D_j(R_j + L_j) - S_j]^+.
\end{aligned}$$

# Engineering Analysis



# Brainstorm

- What performance aspect could you analyze quantitatively?



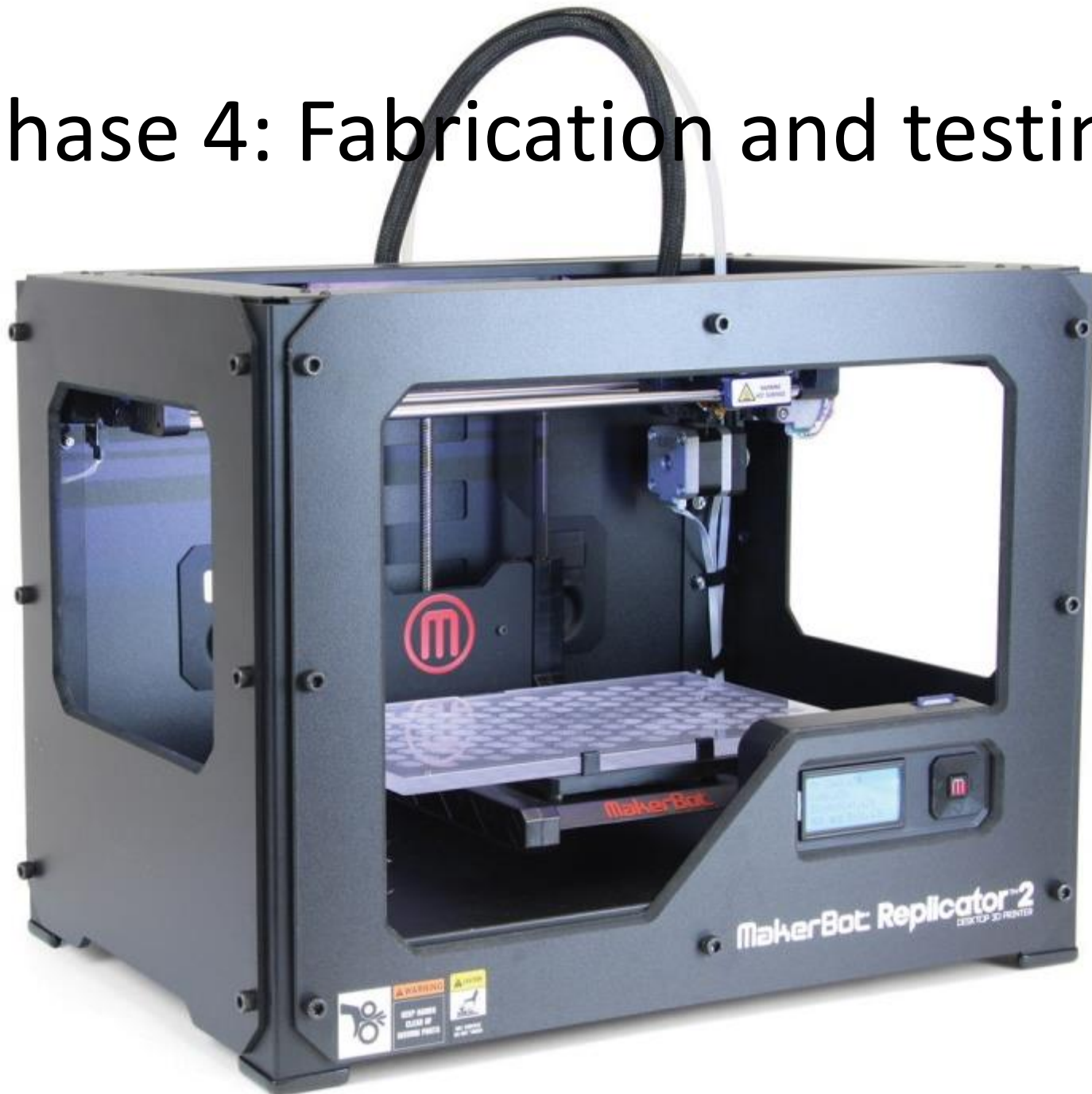
00:00.0

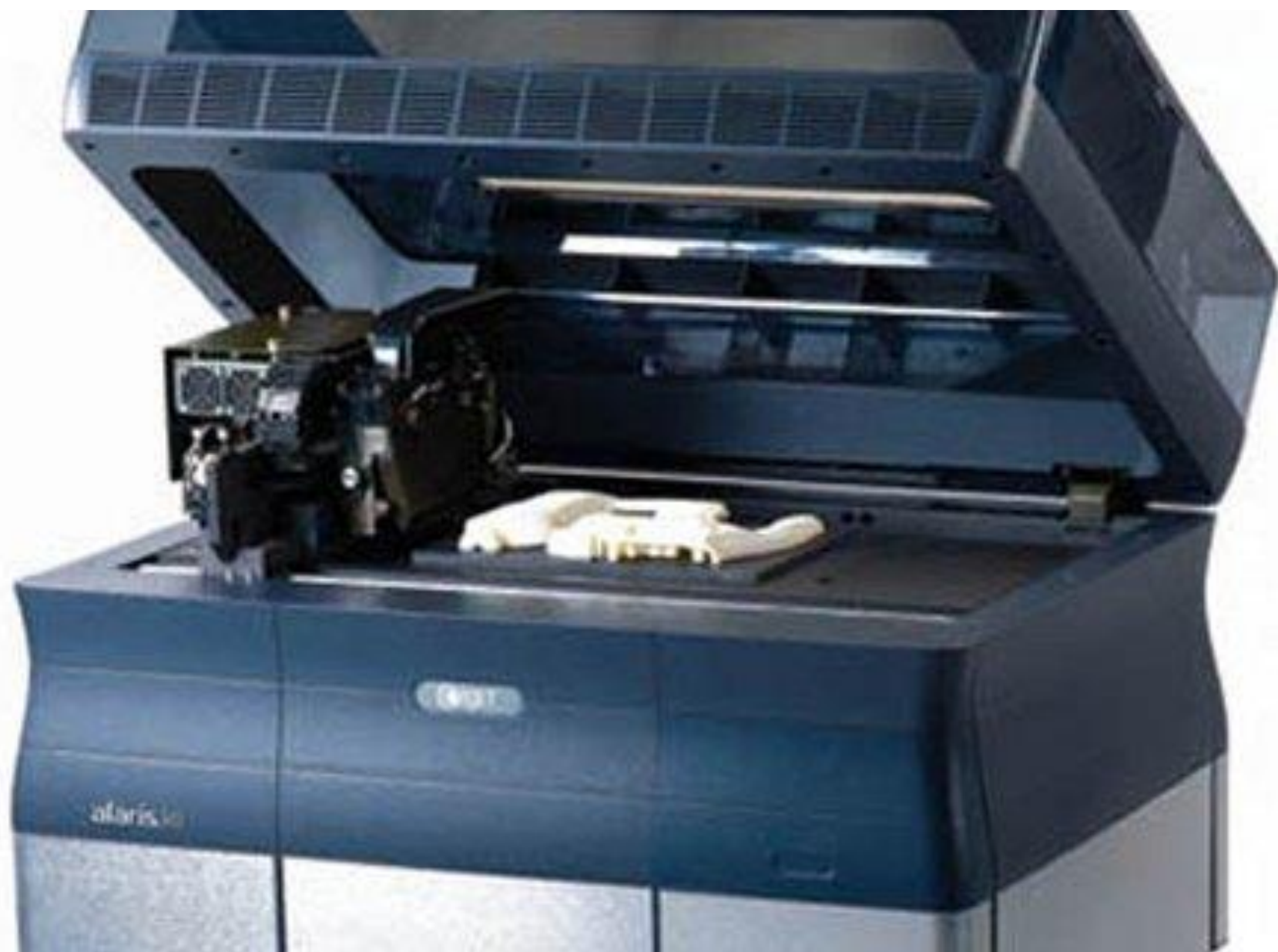


**Iterate**



# Phase 4: Fabrication and testing









Legend 36EXT

[www.epilog.com](http://www.epilog.com)










# Phase 5: Presentation & Marketing

Price: \$19.99

 Choose Your Options

## Biologic Bike Mount for iPhone 3/3G/3GS

Stock status: 5+ in stock

Overview

Features

Warranty

Use your iPhone as a bike computer!

Attach your iPhone 3G/3GS to your bike's handlebars for navigation, training, or just to obsessively track your GPS position, your speed, or distance traveled while you ride with GoogleMaps or the abundant other GPS apps for the iPhone.

Weatherproof with a welded touch sensitive membrane to completely protect your iPhone from weather, but the phone is fully functional while inside the case.

Silicone lining makes it shock resistant. Pivot the mount to either portrait or landscape mode. Take photos or shoot movies while you ride; the camera lens peeks out through a membrane-protected opening.



click image to enlarge











# Requirements

- Weekly [project report](#)
  - uploaded to CMS by end of every week.
- Preliminary design review
  - (10 min presentation): 1st week of your project
- Critical design review
  - (10 min presentation): 2nd week of your project
- Prototype demonstration
  - (5 min presentation): 4th week of your project
- Final presentation
  - (15 min): 5th week of your project
- Final report:
  - Upload to CMS on the 5th week of your project
- Team assessment

# Logistics

- Presentations in section
- TA cuts/prints components, you machine
- TA consolidates McMaster orders
- Wordpress website at [blog.cornell.edu](http://blog.cornell.edu)