FOLDABLE ROBOTICS

Dan Aukes

Today's Agenda

- About Me
- Syllabus
  - Book
  - Schedule
  - Blackboard
- Intro to Foldable Robotics
- Project - constraints & themes
- Homework Assignments

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About Me...

Started at ASU in 2016

IDEAlab

Integrating Design, Engineering, and Analysis

Harvard Microrobotics Lab

Stanford BDML

Northwestern University

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Syllabus

- Schedule
- Blackboard

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Operating System

- Show of hands
  - Windows
  - Ubuntu
  - Mac
  - Other?
  - None?

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Calendar

- Follow this Link
- Assignment Due Dates
- Due ***before*** class on Blackboard unless otherwise stated
- Upload a file, not a link.

General Weekly Plan

- Tuesdays: Individual assignments
  - Introductory concepts
- Thursdays: Group assignments
  - Advance individual work and apply to project
- Assignments due on blackboard, in .pdf format, before class

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Goal of this class

- Get you comfortable finding your own information
- Learn the keywords, you go from there
- I don’t know the right answer, I just know how to ask the right question.

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Foldable Robotics

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What will you do?

- Background
  - Origami, Robotics, Biomechanics and Bio-inspiration
- Make robots and mechanisms
  - Learn layer-based fabrication steps
  - Make mechanisms using rapid prototyping tools
- Work with actuators, sensors, microcontrollers
- Create design tools in Python which help us design, manufacture, simulate, and visualize these devices in action
  - Learn the essentials across many topics
  - Manufacturing, CAD, Dynamics, Kinematics, Graphics, CSG, Stiffness analysis, etc
- Evaluate and improve designs systematically using analytical, simulation-based and experimental methods.

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Benefits of Foldable

- **Low Mass:** The low mass of a small robot permits it to operate safely in the presence of many types of anti-personnel landmines which trigger in the 5 kg range.
- **Cheap:** The financial, human, and time impact of losing a single robot is small compared to other strategies.
- **Remote:** Hazardous operations can be accomplished away from human supervision.
- **Programmable:** Robots can be programmed remotely, allowing for faster scaling to many devices and more rapid deployment of successful routines and control strategies..
- **Low-Power:** Terrestrial robots consume far less power than aerial solutions, permitting them to carry heavier loads and work for longer periods between charges.
- **Parallel:** Robots which blend human guidance and local control would permit a small number of operators to deploy and operate a large number of robots which can run semi-autonomously for several hours at a time. This allows for larger areas to be swept and demined with fewer resources, and for the impact of false positives to be mitigated by more devices.

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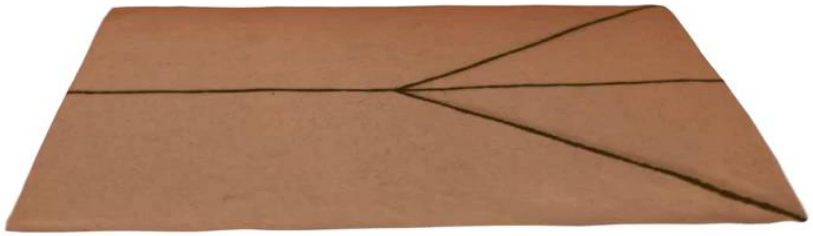
Folded Paper – Kinematics



Kinematics

- Language used to describe the rules of motion
- …to a point
- Then you have to start “bending” the rules
- Non-ideal materials which can act like hinges

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Origami

- Not just art, a rigorous mathematical study
- The math behind folding paper
- Kinematics, patterns

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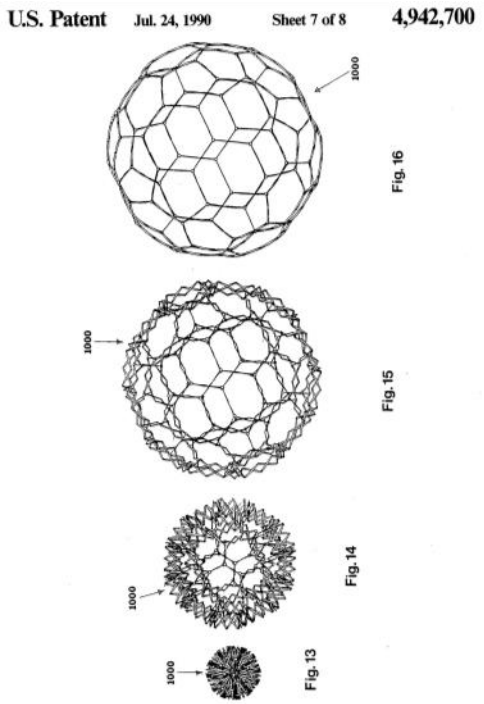
Deployable Structures



More on this later…

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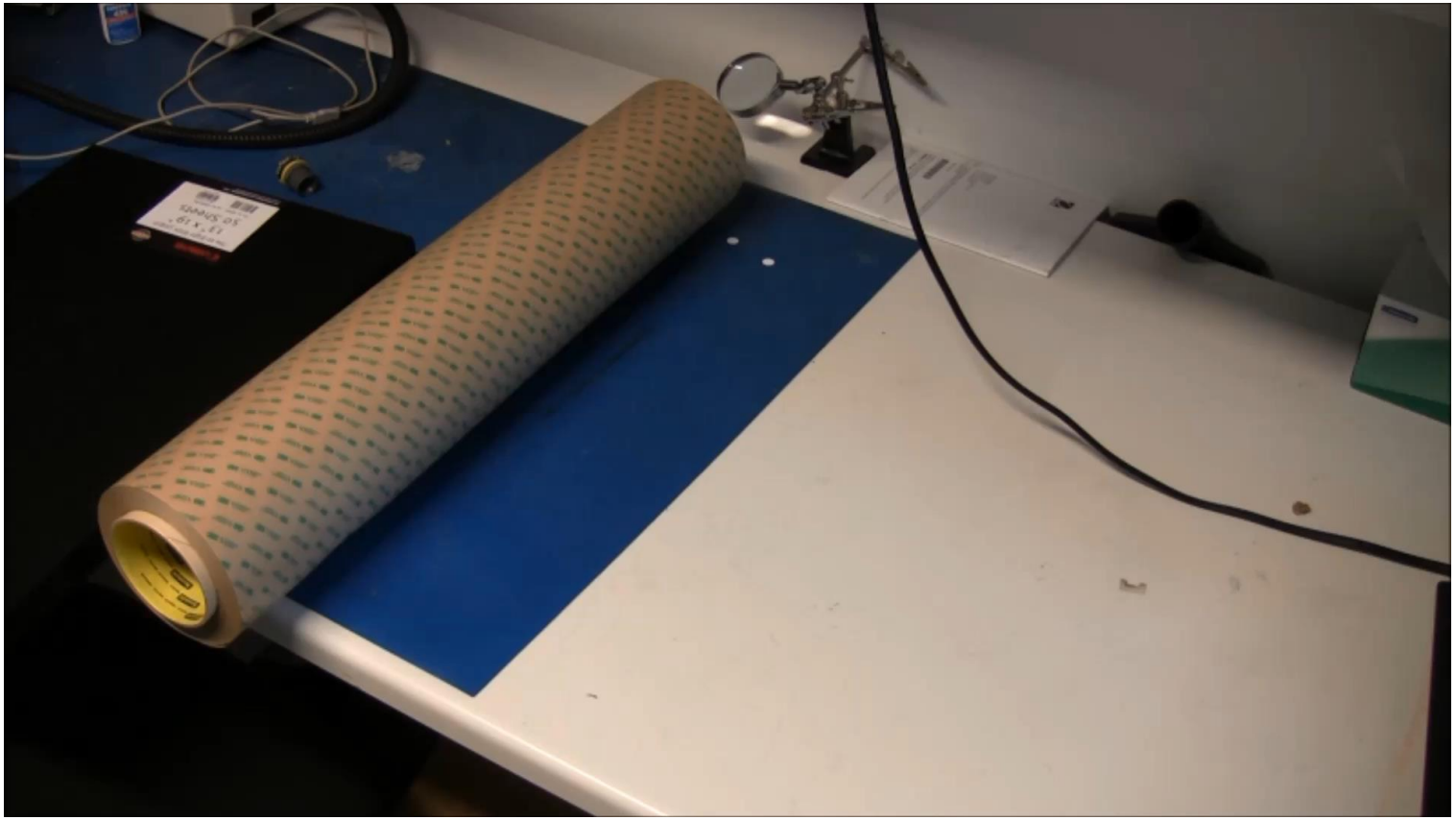
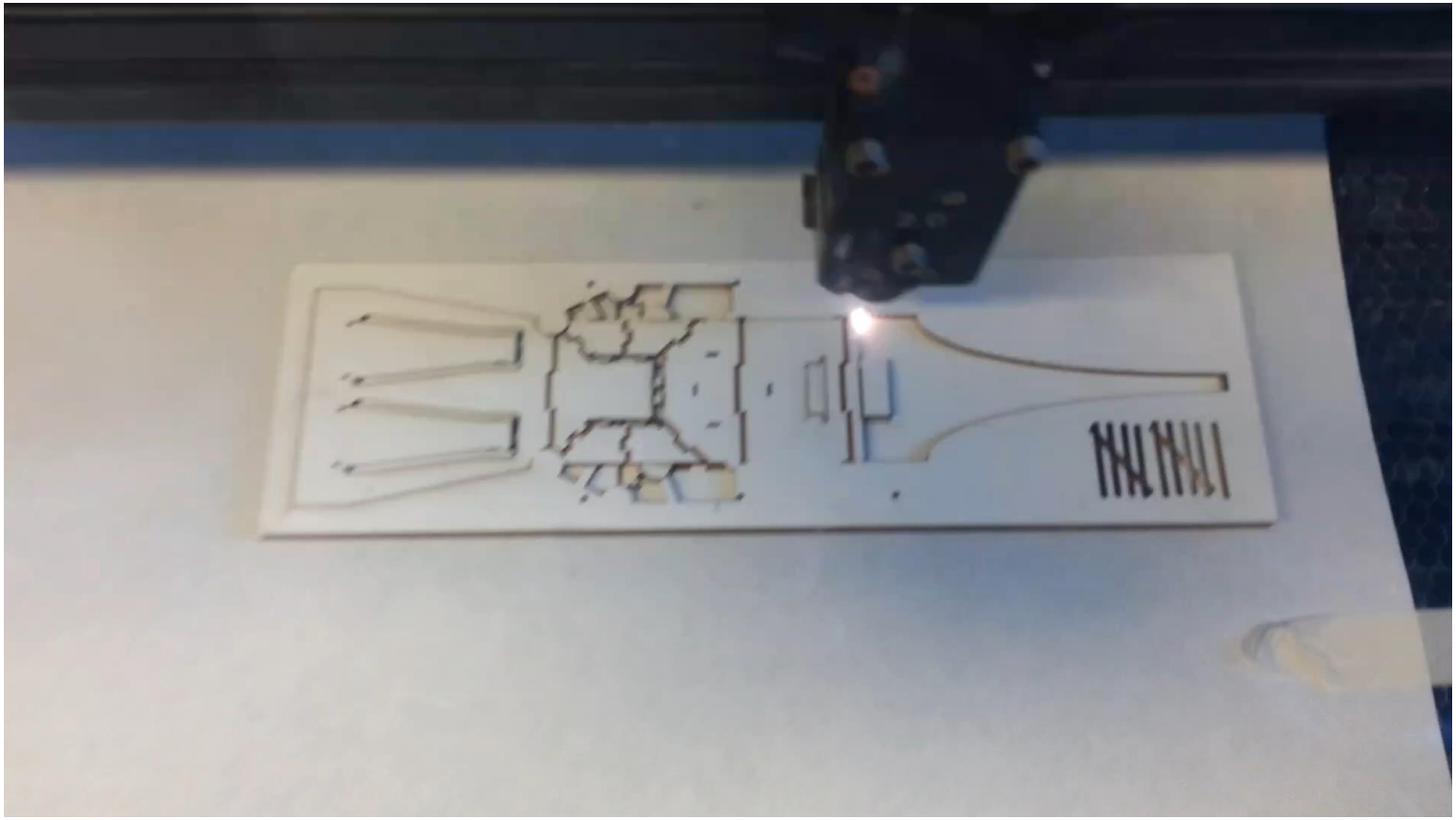
Fabrication



Laser Cutters



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Digital Fabrication

- CNC
- Removal Processes
  - Bulk: Machining, Milling, Routing
  - Line: Laser Cutting, EDM
  - How many axes
- Additive Processes
  - “How to make almost anything”
  - 3D Printers print plastic, food, concrete, etc.

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Coding Experience

- Show of hands
  - Matlab?
  - Python
  - C / C++?
  - Other?
  - None?

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Coding with Python

- Object-oriented
- Large scientific community
- Easy to learn, easy to scale
- Cross-platform
- Open Source
- Tricky to install in Windows.
  - Will be using the Anaconda distribution

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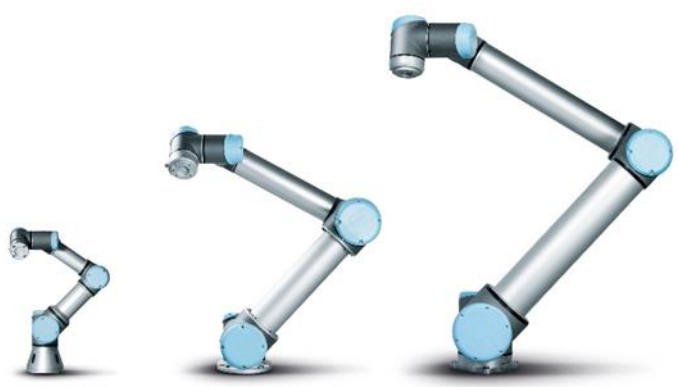
Robotics



- Kinematics: DH Parameters, Jacobians
- Dynamics: Motion, Mass
- Control: Inverse Kinematics, Dynamics
- Traditional Link-joint-link-joint construction
  - Typical materials: metal, gears, belts, drives

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Materials & Composites

- Advanced Materials
- Carbon Fiber
- Multi-material Devices
  - Shape Deposition manufacturing
  - *some* 3D printing

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Design, Software, Graphics

- CS Graphics community
- FEA community
- Mechanical Design Community
- Robotics/CS/Simulation Community
- Origami community

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Goals

- How do you want to feel about this class at the end?
  - Why did I bother?
  - I just wanted an A, why did he make it so hard?
  - I didn’t love the topic but I did it because...
  - This wasn’t interesting but I learned some valuable skills
  - I had to learn this topic to be able to do the things I really want to do.
  - I got to do all the things I enjoy, plus I learned some new things I didn’t know I liked
  - This course changed my life.

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What I want out of this class…

- Workflows for automatic generation and analysis of robots
- Exemplar devices which highlight foldable robotic strengths & capabilities
- New platforms for performing research on and writing new proposals
- Low-cost strategies for fabrication and testing

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What do you want out of this class?

- What do you want out of this class?
- Are there specific applications you wish to pursue with your project?
- Are there specific questions this class will help you answer?
- What skills do you hope to acquire?
- Describe your ideal project

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About You…

- Undergraduate, Masters, Ph.D.
- Eng, ME, CS, Other?
- Work Experience?
- Live in Tempe?

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Project Overview

- Make a small, bio-inspired robot
  - Must use laminate transmissions
  - Be able to move around in the world
  - Design process supported by simulation, experimentation & data-collection.
  - Must be able to sense its own state

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Project Timeline

- See Calendar

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Assignment 1

- Fill out the survey
- Posted to blackboard

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Assignment 2

- Popup mechanism
- Posted to blackboard

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Assignment 3: Project Pitch

- Presented in class next Thursday
- One slide summarizing project background
- One slide summarizing project goals
- Don’t say *how*.
- Integrate your popup assignment?
- Posted in Blackboard
- ***Multiple deadlines***

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Next Class

- Meet in the Innovation Hub in the Tech Center
- https://goo.gl/maps/dd8hU7AgsLC2

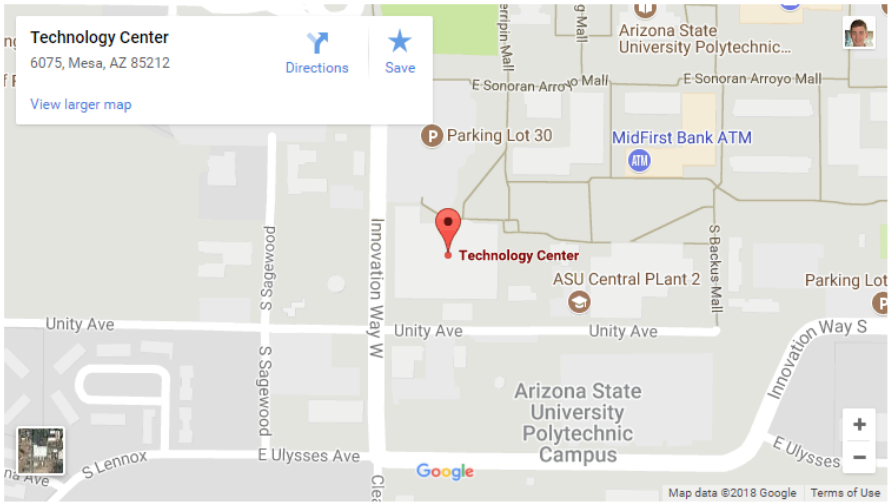
Office Location

Technology Center, Room 152
6075 S. Innovation Way West
Mesa, AZ 85212
Phone: 480-727-1894

Lab Location

Technology Center, Room 180
6075 S. Innovation Way West
Mesa, AZ 85212
Phone: 480-727-1573

Map



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