Cornell University | Human Centered Design | Syllabus

DEA 6210: Architectural Robotics

- 3 credits; letter grade only; no final exam; priority given to DEA, FSAD, and MAE majors.
- Recommended prerequisite: permission of instructor (cap of 15 students)

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NOTE: The most current and complete documentation for this course is found online at https://arl.human.cornell.edu/DEA6210_Arch_Robotics.htm.
This pdf is for basic information; some aspects (e.g., grading, policies) may not be current.

COURSE DESCRIPTION | DEA 6210

Embedding robotics into the fabric of the built environment fosters a more interactive and potentially more intimate relationship between the spaces we live in and us, and represents a new frontier for design, computing, and psychology. Part-seminar, part-lab, this course considers the design, technical, social, ecological, and ethical challenges and opportunities of architectural robotics.

PREREQUISITES | ENROLLMENT | *Cap of 12 students*

• *All students require professor's permission.*
• **Preference is given to** student-majors in HCD, MAE, and IS (my affiliations) and students enrolled in the Robotics Minor; otherwise, as space permits.
• Enrollment is limited to **twelve students** to make full use of the D2FS, the digital and manual fabrication shop and staff located across the corridor from our teaching space.
• This course is for 3 credits, for letter grade only. There is no final exam.

SYLLABUS | SEE ALSO MY DEA 5210 & DEA 2730

LEARNING OUTCOMES

Architectural Robotics aims to cultivate new vocabularies of design and new, complex realms of understanding towards realizing artifacts and systems responsive to people and the planet. Four learning outcomes are expected of this course.
Outcome 1: To understand the design, technical, social, ecological, and ethical challenges and opportunities of architectural robotics.

Outcome 2: To conceptualize and evaluate design alternatives responsive to the challenges and opportunities of an ecosystem that is biological, artificial, and digital, using a variety of design and evaluation strategies.

Outcome 3: To iteratively design an Architectural Robotic device, furniture, room, building, and/or metropolitan area manifested as a **physical prototype at model scale** (e.g., 1 ft. = 2 inches) and demonstrate an ability to do so in class presentations and a video.

Outcome 4: To demonstrate, in a written report, an ability to communicate the motivations for, iterative development of, and expected use of the Architectural Robotic artifact that was prototyped, as well as assess its shortcomings.

Students with no coding or electronics experience have done well in this course. The Grove hardware kit components make "physical computing" accessible to the novice who is willing to "roll up the sleeves" and work at it.

This course is foremost focused on "thinking big" and "thinking different" about designing the physical environment. Given this ambition, I ask that you to take responsibility for your education by attending class, participating, and submitting and presenting assignments that advance thinking in the field.

H I S T O R Y O F T H I S C O U R S E -

This course is the "next chapter" of a course that I have taught for many years, initially at Clemson University with Professor Ian Walker, under the same title, cross-listed in Architecture and Electrical & Computer Engineering. The course pedagogy has been the subject of a paper presented at ICRA (the *IEEE International Conference on Robotics and Automation*) and a paper published in *RAM (IEEE Robotics and Automation*, Rethinking the Machines in Which We Live.) I also co-authored, with Mark Gross, an overview of Architectural Robotics for ACM interactions. Required reading for this course, my book, Architectural Robotics: Ecosystems of Bits, Bytes, and Biology (MIT Press), establishes this subfield at the intersection of robotics, (environmental) design, and psychology.

I N T R O D U C T I O N -

Unlike a conventional building that has a limited range of designed responses to dynamic, changing conditions, architectural robotic environments are intimately bound together with their users and local conditions in a designed *performance*.
More practically, architectural robotics is defined by the movement of physical mass and by its interactivity with and adaptivity to things outside it (e.g. people, other living things, objects, information).

The prospect of this kind of environment was anticipated some fifty years ago by MIT Media Lab founder Nicholas Negroponte in his vision of "a man-made environment that responds to and is 'meaningful' for him or her" [5]. *Wired* editor Kevin Kelly later imagined a "world of mutating buildings" and "rooms stuffed with co-evolutionary furniture" [3]. And while Bill Gates envisions "a robot in every home" [2], William Mitchell, the late Dean of MIT's *School of Architecture and Planning* and director of its Media Lab, envisioned homes "as robots for living in" [4].

Architectural Robotics meanwhile raises such critical questions as:

- *How will we program the built environment, from furniture to cities?*
- *How will architectural robotics recognize activities taking place inside and surrounding them?*
- *How will designers design built environment configurations responsive to particular human and ecological conditions?*
- *How to design cross-operability and collective interactivity/intelligence of multiple architectural robotic artifacts (furnishings, furniture, rooms, buildings, cities) operating together as cyber-physical "ecosystems"?*
- *What are the safety, security and privacy issues related to architectural robotics, and how do designers design architectural robotics to protect property and living things from hackers, operating failures, and other harmful impacts?*

Architectural Robotics must go beyond simplistic formal achievements; it must strive to improve life, enhance existing places, and support human interaction. This is no Utopian dream in which technology or design transforms completely our everyday reality. Instead, design and technology as a cyber-physical system supports human activity, responds naturally, and performs according to our needs and wants.

Architectural Robotic habitats must complement and redefine living habits. Answers to life problems and opportunities will come not from computational or design solutions alone, but through the way computation, embedded in the physical, built environment, helps support and enhance the interactions across people and their surroundings to create places of social and psychological significance.
For philosopher Andrew Feenberg, "technology is not simply a means but has become an environment, a way of life" [1]. Architectural Robotics is more than an aesthetic search, a stylistic possibility, or a technological quest; it is, instead, a way to develop new possibilities for dwelling in support of and augmenting people and their surroundings.

References
[1] Feenberg, A. *Transforming Technology,* (Oxford University Press, 2002), 8.
[2] Gates, B. "A Robot in Every Home," *Scientific American*, December 16, 2006.
[3] Kelly, K. *Out of Control.* (Cambridge, MA: Perseus, 1994), 472.
[4] Mitchell, W. J. *e-topia* (Cambridge, MA: MIT Press, 2000), 59.
[5] Negroponte, N. *Soft Architecture Machine* (Cambridge, MA: The MIT Press, 1975).

M A T E R I A L S   N E E D E D -

You will be provided the following in class:

- 1 Grove Beginner Kit for Arduino ($23.88 from Mouser).
- 1 Grove Servo ($6.90 from Mouser).
- 1 Grove Ultrasonic Sensor ($4.30 from Mouser).
- 1 Grove Gesture Sensor ($10.99 from Mouser).
- 1 Grove RGB LED Stick (15-WS2813 Mini; $5.40 from Mouser).
- 1 Grove Switch ($3.20 from Mouser).
- 1 USB Battery Pack - 2200 mAh Capacity - 5V 1A Output ($14.95 from Adafruit).
- Panels (pre-cut) to make an enclosure for your assignment-1. If you need a different size enclosure, you can work with D2FS on laser-cutting panels to-size from digital files you generate using CaseMaker.

You will need in class:

- **Your laptop.** You need your laptop in class, every class session. If your laptop is not equipped with a port to plug in a USB-A cable (that comes with the Grove Kit), then you need a **USB-C hub** (here's one) that plugs into your laptop's port and provides a USB-A port. Newer Mac laptops need this USB-C hub, as Macs no longer have USB-A ports on them.

You may also need:

- **1 sketchbook** like this one or a comparable one found in our bookstore.
- **Fabrication materials for early, rapid prototyping.** These include: cardboard from shipping boxes, plastic from fruit and vegetable containers, and craft materials needed to construct your prototypes. Many of these materials you have already, at no-cost; other materials are available from the Cornell Bookstore, Michael's at the Ithaca Mall, and online at Utrecht, Blick, and Amazon.
- **Fabrication materials (as needed) for high-fidelity prototyping**
  • Coroplast corrugated plastic is easy to work with and low-cost. I like the colorless, translucent

finish found on eBay via Duco Plastics.
• Honeycomb cardboard is inexpensive and rigid enough to build furniture from it.
• Acrylic sheets and other plastics are available online from TAP Plastics (cut to your size with reasonable precision) and from ePlastics (cut to size, less expensive than TAP, but less control over cutting dimensions and multiple cuts).
• Cut2Size Metals.
• Aluminum Composite Material (ACM) as in the red entry of HEB as well as my LIT ROOM project; available locally (in Syracuse) from Polymershapes, contact Kevin Passerell.

- **Additional Grove components** available from Mouser electronics with competitive pricing and quick shipping. Grove components are also available from Amazon (often at a higher price), from DigiKey, from other vendors listed on this page, below, and from its manufacturer, Seeed Studio, which ships from its US warehouse.
- **An inexpensive book on human-centered design methods:** *The Pocket Universal* ***Methods*** *of Design:* ***100 Ways*** *to Research Complex Problems,...* available from the Cornell Bookstore and from Amazon. **Do not** purchase the similarly titled, *The Pocket Universal* ***Principles*** *of Design:* ***150 Essential****....*
- **If you don't have access to video editing software:** try **Open Shop**, a free video editing app for windows https://www.openshot.org/. And if you don't have Adobe suite, try Canva (free 30-day trial) and Paint.net.

R E Q U I R E D   R E A D I N G S -

Readings for each class meeting are listed in the CLASS SCHEDULE (below). Please read the readings **ahead of their assigned class session**.

- **Architectural Robotics: Ecosystems of Bits, Bytes, and Biology (MIT Press)**, widely available in hardcover or eBook and from the Cornell bookstore.

O P T I O N A L   R E A D I N G S -

Primary sources considered in my book that are especially important:
• Alexander, C., et al. 1977. *A Pattern Language* (excerpts*)*. Oxford.
• Brooks, R. I, Rodney Brooks, Am a Robot. *The Singularity*, *IEEE Spectrum*, v. 45.
• Dourish, P. 2001. *Embodied Interaction*. MIT (paper).
• Hayles, N. K. 1999. *How We Became Posthuman* (excerpt). U. Chicago.
• Negroponte, N. 1975. "Intelligent Environments" in *Soft Architecture Machines*, MIT.
• McCullough, M. 2004. *Digital Ground* (excerpts). MIT.
• Pask, G. 1969. The Architectural Relevance of Cybernetics*. Architectural Design*.

C L A S S   O R G A N I Z A T I O N -

1. I will present the **case study** of the day.

2. On Mondays, we will consider an **assigned reading.**

• **Every student** will read the reading listed for each class **ahead** of that class meeting.
• **Every student,** beginning Week 02, will upload to our shared Box folder, ahead of that class meeting, a one-page Word document that includes the following for each assigned reading:

[a] **Three bullet points** that you draw from the reading that capture the **content** and **significance** of that

reading for architectural robotics.

[b] **Two questions** related to the reading that you would like us to consider in class.
• **One student will be assigned one reading for a given class meeting** and will present this reading in class. Here is a good example of slides prepared tor a presentation for this course. This presentation should conclude with the presenter sharing with us the most compelling questions submitted by student peers in their reviews found in the shared folder.

3. **Students (for assignment 1) and student teams (for assignment 2) will present status reports and** demos on their design activities, as per the weekly schedule (below) under the heading, "In class." Your status report can be a physical model, a powerpoint slide, a digital image (e.g., a 3D model), a Word document, or any other document that communicates the status of design development. For demos, you simply share your current physical prototype; or, you can take a smartphone video of your working prototype, upload the video (or a URL to it) to our shared folder, and share the video with us. (Sharing the video is a good approach, as robotics demos often fail!) **Reports are uploaded to the shared class folder ahead of class presentations.**

• **Students will also...**

- Benefit from **informal exchanges** with peers.
- Deliver **formal presentations** at designated milestones throughout the semester.
- **Work with shop staff** in the D2FS on fabricating your project.

S C H E D U L E B Y W E E K -

I N T R O

Week 01 | 08.21 INTRO TO THE COURSE + D2FS SHOP TRAINING
• **Case Study:**
M Ori Living; bumblebee
W Paper•Mech & Mechanisms
• **Readings** *(hereon presented by assigned student, one student per session)*
W *Architectural Robotics*: chapter 1 (link to this if you can't get the book in time).
• **In class**
M Intro to course; D2FS shop training, to be confirmed.
W Intro to Assignment-1.

Week 02 **| 08.28 RAPID PROTOTYPING**
For Assignment-1, after considering the pages from *Here* (see below), rapid-prototype your interactive artifact. If you have no or limited coding experience or you anticipate this being a busy week, **you are strongly encouraged** to limit your design to the materials provided you: the box enclosure, the Grove modules, and the Arduino codes (see below; cut & paste one!).
Expect to have a working, refined prototype completed by the end of Wednesday's class session. We will, in any case, review these finished prototypes next Wednesday! In the few class sessions following next Wedesday's review of your prototype, you will complete Assigment-1 by writing a scenario and creating a video and written report.

Week 03 | 09.04 DEMO DAY > NO CLASS MONDAY
• **Case Study:**

W Hyperbody/TU Delft. Pop-Up Apartment;
• **In class:**
W Demo of working, refined, prototypes; for next **M**, write a scenario as part of story.

P A R T - 1 | **C O N C E P T S**

Week 04 | 09.11 PATTERNS
• **Case Study:**
M The Shed
W eva/TODO/Blackboard, Kinetic Wall**;** Reconfigurable facades
• **Readings:**
M *Architectural Robotics*: chapter 2.
• **In class:**
M Present a scenario for Assignment-1 inserted into the story + demo your prototype.
W Present a draft video; iterate your video; Physical computing; WOz (e.g. *Nest*).

Week 05 | 09.18 INTERACTIONS
• **Case Study:**
M W. Ju. Mechanical Ottoman; Aarhus Univ., coMotion
W M. Goulthorpe/dECOi/MIT, HypoSurface
• **Readings:**
M *Architectural Robotics*: chapter 3.
• **In class:**
M Present your iterated video; A walk through Parc Güell.
W Demo Day: screeningfinal videos + demo your prototype.

Week 06 | 09.25 (M: Assignment-1 deliverables due.)
• **Case Study:**
M W. Ju. Mechanical Ottoman; Aarhus Univ., coMotion
W M. Goulthorpe/dECOi/MIT, HypoSurface
• **Readings:**
M *Architectural Robotics*: chapter 3.
• **In class:**
M Intro to Assignment 2; GIF and ex.1, 2, 3, 4, 5, 6.
W Present your GIFs; form teams based on GIFs; for next class: 1 new GIF from team.

Week 07 | 10.02 BODY BUILDING
• **Case Study:**
M N55 Walking House; Walking City (Archigram, 1964).
W Holger Schnädelbach**.** ExoBuilding
• **Readings:**
M *Architectural Robotics*: chapter 5, 8, 11. In class, view together 2001.
• **In class:**
M Present team GIFs.
W Team workshoping to advance Assignment-2 projects.

P A R T - 2 **| S C A L E S & I M P A C T S**

Week 08 | 10.9 HABIT-ATIONS > NO CLASS MONDAY | Fall Break
• Case Study:
W ARL's Space-Making Robot Surface
• In class:
W Progress reports from each team.

Week 09 | 10.16 WORKSTATIONS
• Case Study:
M AWE; AWE in AR; AWE in *interactions*; Roomware
W TU Delft's InteractiveWall
• Readings:
M *Architectural Robotics*: ch. 4.
• In class:
M Storyboard your design for Assignment-2 (example).
W GUEST: Henriette Bier; review scenarios; revised GIF from each team for next class.

Week 10 | 10.23 FURNITURE & FURNISHINGS
• Case Study:
M Loop chair; ARL's ART and its pneumatic surface
W Aarhus University's, Kirigami Table**;** Bill Gaver's Drift Table: pdf and video
Readings:
M *Architectural Robotics*: chapter 6.
• In class:
M Intro to morphological charts; ex.s 1, 2, and one from class; review revised GIFs.
W Progress reports on design development.

Week 11 | 10.30 LIVING ROOMS
• Case Study:
M ARL's LIT ROOM, LIT KIT
W Domestic Transformer (Gary Chang, 2007); Futuristic Kitchen (1970)
• Readings:
M *Architectural Robotics*: chapter 7.
• In class:
M Making videos [my guide]; ex.s: CHI17, CHI18, GrowBot; progress reports.
W Progress reports on design development.

Week 12 | 11.06 CITIES
• Case Study:
M Futuristic City of Tomorrow (1960s); Intel smart city
W The Experimental City**.** Google's Quayside, its termination, and lessons learned
Readings:
M *Architectural Robotics*: chapter 9.
• In class:
M Intro to Role Play; progress reports on design development.
W Progress reports on design development.

Week 13 | 11:13 ECOSYSTEMS OF BITS, BYTES, & BIOLOGY
• Case Study:
M IBM TRIRIGA
W ARL's pheB, a soft robotic wall for wellbeing in tight confines
Readings:
M *Architectural Robotics*: chapter 10.
• In class:
M Progress reports on design development.
W Progress reports on design development; Steve Jobs on presenting.

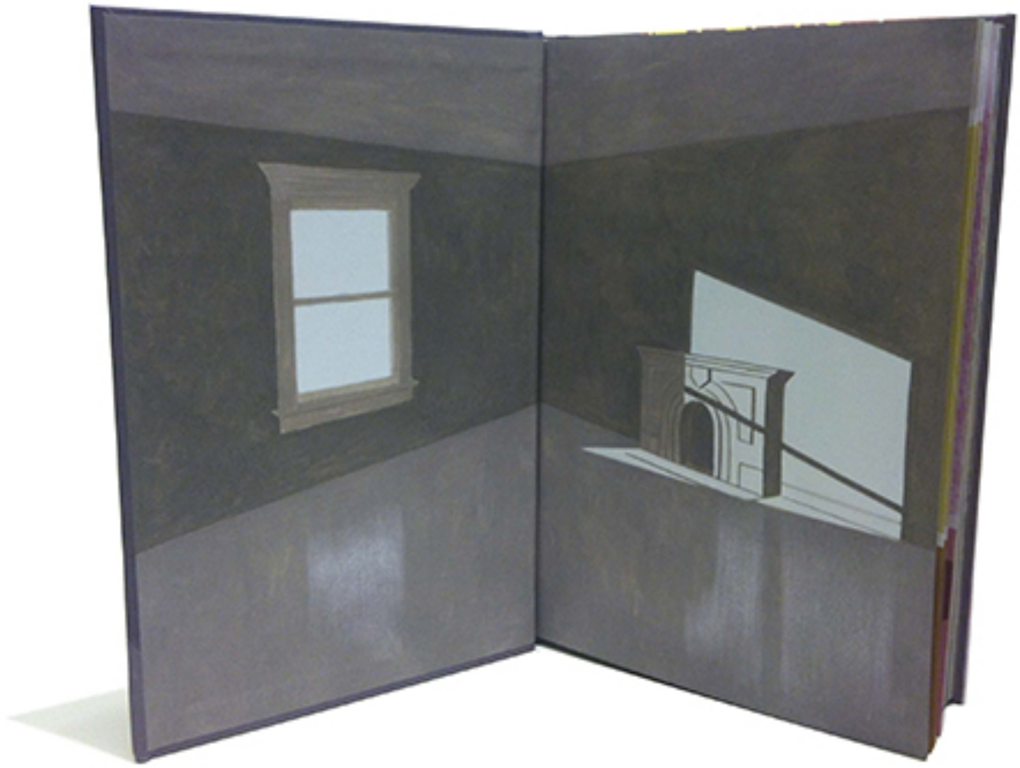
P A R T - 3 **| M O V I N G & T H I N K I N G**

Week 14 | 11.20 **| [WORKSHOP] > NO CLASS WEDNESDAY**
• In class:
M Advance prototypes and video; prepare a draft video to present next class.

Week 15 | 11.27 INTELLIGENT?
M Riding in a Self-Driving Tesla; AI Scorecard.
W John Searle's Chinese Room; Google's RT-2 on Google's DeepMind**.**
• Readings:
M *Architectural Robotics*: chapter 12.
> Debate: Architectural robotics: When? Where? For whom? Why?
• In class:
M Present draft videos; advance final prototypes and supporting documents.
W Present draft videos; advance final prototypes and supporting documents.

Week 16 | 12.04 DEMOS, DRAFT VIDEO SCREENING | LAST CLASS MONDAY
M Demo day: demo you prototypes, screen your videos. *After this final class, you still have time to improve anything of assignment-2 until the date/time listed below.*

12.12 | 4:30pm | DEADLINE: TEAM REPORT & VIDEO, uploaded for final grading:
Upload on or before this date/time as specified in October by Cornell Registrar.



A S S I G N M E N T S -

There are two assignments for this course.
The first assignment, undertaken by each student, is intended to be a fast-paced engagement.
The second assignment is undertaken by teams of 2-4 students and provides a longer, deeper development of the design following a trajectory like this:

- Conceptualization
- Prototyping / Rapid, low-fidelity
- Concept Generation: GIF, Scenario, Morphological Chart, Storyboard
- Prototyping / Hardware/Software
- User Testing
- Video making and Reporting
- Documentation

Team composition for the second assignment will be formed by the instructor(s) based partly on proposals pitched in class by class members.
Your development of both assignment may beneft, intellectually, from:

- Gopnik, Adam. 2018 (July 30). "What Can We Learn from Utopians of the Past? Four nineteenth-century authors offered blueprints for a better world...." *The New Yorker*.

Keep in mind: this course asks you to develop architectural robotic artifacts that have at least **one input and one output which moves physcial mass**.
Assignment-1 | "Here" (45% of the course grade; individual effort)

Using the Grove kit (or an Arduino and breadboard, if you wish), develop an interactive, physical device at small scale that enables or augments one or more of *Here*'s characters, in that room, at a single instance shown in one pair of pages (one image of the room) from *Here*. You may integrate any manner

of input device, actuator, hacked device (e.g. a toy, a camera) and any technological approach (e.g., machine learning, computer vision, AR).
To get us started quickly (while you are waiting for your copy of Here to arrive), use one of the following five instances of the room from the book:
Here, 1933, holding hands and hanging a picture
Here, 1957, trying to remember
Here, 1964, dancing
Here, 2005, with the pull-out bed
Here, 2213, in the future

Practically, your box enclosure must be constructed from the panels provided in class. If you need a different size enclosure, you can work with D2FS on laser-cutting panels to-size from digital files you generate using CaseMaker.

Intellectually, your "small" assignment may take inspiration from the boxes of artist Joseph Cornell (one such box is in Cornell's Johnson Museum of Art), the words of Brian Eno (producer of, e.g., Coldplay's "Viva La Vida", ambient music pioneer, and member or the band Roxy Music), and three perspectives on affective computing / designing for emotion:

- Affective Computing (emotion as biologically-based cognition), by Roz Picard (her TEDx Talk).
- Affective Interaction (emotion as a culturally-determined construct), by Phoebe Sengers of Cornell IS, Paul Dourish, Kristina Höök.
- Technology as Experience (emotion as part of a larger interactive experience), by John McCarthy and Peter Wright, Don Norman, and Bill Gaver.

The kind of artifact we are striving for is small in scale, whimsical/poetic, beautifully crafted, interactive in simple ways, and meaningful/purposeful. You do not have to generate code on your own: you can select one of the codes provided under the heading below, "Arduino Codes You Can Copy & Paste." (An effective way to tailor your code to your wants without coding experience is to use ChatGPT as described below.) However, you may also pursue the following options as time constraints and your abilities permit:

- You may use an Arduino board and breadboard in place of the Grove system.
- You may integrate a hacked device (e.g., a toy, a camera), any technological approach (e.g., machine learning, computer vision, AR), and any other hardware modules – Grove or otherwise Arduino-compatible.
- You may create a different enclosure for your design than that provided (For this, you may benefit from using CaseMaker to generate digital files and working with the staff of D2FS to fabricate from them.)

Assignment 2 | "Repairing 'Stellavista' (45% of your grade; team effort)
Read J G Ballard's short story, "The Thousand Dreams of Stellavista" (1962).
Inspired by Ballard's story, design a module 8' wide x10' deep x 8' high that you insert in a hotel room (this one from Marriott for which we have a scale model) that repairs something you discover in Ballard's fictionalized suburban, architectural-robotic dystopia. **Essentially, Architectural Robotics that are going wrong in Ballard's story you will make "right" in the space of a 10'x8'x8' module within a Marriott hotel room.** Your user/clients are Fay and Howard Talbot, the couple in the story that purchases and moves into a home in Stellavista. Imagine your hotel room as Fay and Howard's place-of-stay while they shop for their new home. Write a paragraph that you insert strategically inBallard's story that dscribes this hotel room and how it fosters a better future for Fay and Howard, a couple in distress, amplified by living in their new home.

The provided scale model of the hotel room is this one from Marriott, scaled to 1 ft. = 2 inches to match the 12-inch wooden human figures you can purchase, for instance, here ($6.99) that you might use in your videos and documents. You can alternatively print images of people found in Google images and adhere these printed figures to cardboard backing.
The prototype should be interactive by way of sensors and actuators that move physical mass, You are encouraged to add lighting and/or sound. You may use the Grove kit for this assignment; you have the option of using any additional means listed above for Assignment 1.

G R A D I N G / G R A D I N G R U B R I C - - - - - - -- -

Please review carefully the ***POLICIES*** found in the narrower column on the left-side of this page. These policies are **not** negotiable except under grave circumstances.
Throughout this course—an intimate and intensive "conversation" across students and the professor—students will have ample opportunity to receive feedback on their work. Here is **my grading rubric** for the two major assignments.
The list that follows names and describes the graded components for this course. Each component is worth so many points, as shown in red type. The sum of all of these components equals the final grade of 100 points. The numerical scale for grading is as follows: A+ (98–100), A (93–97), A- (90–92), B+ (88–89), B (83–87), B- (80–82), C+ (78–79), C (73–77), C- (70–72), D+ (68–69), D (65–67), D- (below 65).

(10 points) attendance, participation.

- An attendance sheet must be signed by you in the first ten minutes of class for you to be counted as present. If you expect to be later than 10 minutes on a given day, or if you will be absent, email both the professor and the TAs ahead of the class session with the cause for your late arrival or absence; these will be considered as a valid excuse or not. To assess participation during class, names may be pulled "from a hat" to identify student critics who will then peer-review the developing work accomplished by other students; the quality of the student critique will form part of the 10 point assessment.

(45 points) for each assignment; the deliverables are the same for both:

- **PROTOTYPE at model scale**, made interactive by way of sensors and actuators to create combinations of movement, lighting, displays, and/or sound.
- **VIDEO** [my guide] communicates a full, cohesive story of your designed, interactive artifact, answering *why*, *for whom*, *where,* and *for what purpose.* **Upload to our shared folder an MP4 file reduced to < 30MB** using, e.g., Handbrake (see my video guide). **In your Documentation, include a URL link** to your video uploaded to Vimeo or YouTube. The video will otherwise adhere to the requirements for a Video Showcase submission to the ACM conference, CHI, a benchmark for design research. (Videos from a previous Video Showcase.)
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Video tip: For your video, you may want to add a remote environment (e.g., the interior of the International Space Station) as the physical context; however, such an environment may not be readily accessible to you. An easy strategy for adding this physical context is as follows: video record your working prototype (with "actors" or scale figures of people if your prototype is to-scale) in front of a white wall; then, in Zoom, add your background context photo (i.e.,, a photo of the ...) as a "virtual background" and "record" your screen.

- **DOCUMENTATION of your design**, in the form of **a written report (pdf)**, that includes every aspect listed in my grading rubric. Upload your documentation to our shared drive as a print quality pdf document. These examples from previous classes are model reports (1, 2, 3, 4) but they may not contain every requirement in my linked grading rubric. My grading rubric offers the most current expectation for documenting your design.

C O U R S E   P O L I C I E S -

No exceptions but for the gravest circumstances, documented.

P1. Come to class. You might discover something.
Unlike a large lecture course, this course is about:

- case study videos
- debates
- discussions of previous student examples
- critiques by the professor, TA, and student-peers of developing student work
- answers to student questions
- guest visits

When you miss a class, you miss these rich classroom experiences and fail to share your work and your voice to benefit yourself and your peers. Come to class, undistracted: you might be surprised to discover something important here. **In design, we work together.**

P2. Follow instructions for the assignments.
Follow instructions carefully for all assignments. Failure to abide by the instructions for any assignment will lower your grade for that assignment.

P3. Get the file format right.
Your submitted work must be submitted in the format stated on the course page for each assignment. Digital files and URLs (e.g., links to videos) must be accessible, without us requesting access-privileges. *Google Docs are never acceptable.* 3 points (of the 100 points total for the semester grade) will be deducted from *each assignment* that does not comply.

P4. Extensions will be granted, but only for grave circumstances.
If you need an extension for any assignment, email both the instructor and the TA (if there is one) *ahead* of the due date and make a case for your extension, attaching evidence when available. Extensions may be granted for illness, injury, or family emergency requiring your travel. No extension will be granted because work is due for other classes, or because you are traveling for a non-emergency. Don't even ask.

P5. If you want a high grade, match or better the quality of the best previous work.
The course page for this course offers student examples of "best work" from previous semesters. Your work will be evaluated relative to these "best work" examples when available. If you disagree with a grade for any work in this course, make a case for reconsideration in an email both to the instructor and the TA (if there is one). *Why does your work merit a better grade?* Do not ask for reconsideration during, before, or after a class session; your request must be submitted in writing by email. And if you ask for reconsideration of a grade for an assignment, you grant the instructor and the TA permission to reconsider your grade for any part of that assignment, which may result in a better grade, no change of grade, or lowering of the grade.

PROTOTYPING HELP------------------------------------

- Paper•Mech
- Mechanisms (ex.)
- AI generative design tools
- MAKE and Instructables
- WOz prototyping (ex. *Nest*)

USING GROVE & ARDUINO CODE------------------------

GETTING STARTED

Follow **my slides** to install Arduino and the USB Driver on your computer, to begin working with Grove and Arduino coding, to fix common errors, and to use ChatGPT for solving coding and hardware issues and modifying and generating Arduino code.

- View this video on Grove and review the Grove Beginners Kit for Arduino **Wiki.**
- More in an article and a video on how to use ChatGPT to code Arduino for you!

ARDUINO CODE YOU CAN COPY & PASTE

Paste these codes in Arduino! Change values in the code! Modify with ChatGPT!

- A Sound Sensor controls a single LED [code].
- A Button controls a single LED and a Buzzer [code].
- A Potentiometer (i.e., Rotary Angle Sensor) controls a Servo Motor [code].
- An Ultrasonic Sensor controls a Servo Motor and an RGB LED Stick [code].
- A Gesture Sensor controls a Servo Motor and a single LED [code].
- A Light Sensor controls a Servo Motor and an RGB LED Stick; a Switch turns the whole system on/off [code].

FINDING ARDUINO CODE

- You can find lots of code already built into the Arduino software (IDE): open **Arduino**, select **File** > **Examples**, select an example and it will open in an Arduino window, ready to upload to your Arduino board!
- All of the built-in examples are thoroughly described here**.** Follow their logic to construct the code for your project.
- An Arduino Library LIst for Grove components. Find code for lots of modules here!

A DEEPER DIVE INTO GROVE & ARDUINO **GITHUB**

- Seeed Studio's open source community (here and here) and Help Forum.
- GitHub is the open-source repository of code, including code for Grove Arduino.
- 15-Video Tutorial for Arduino (free) from Jeremy Blum, Cornell alumn! **- great!**

ABOUT HARDWARE

- Use circuito.io to drag-and-drop Arduino and Raspberry Pi components you select from a menu, which then produces for you the breadboard prototype (wiring, circuits, components) and the code for that system.
- How to convert your servo for continuous rotation (how to guide).
- How to use a **cheap** stepper motor with a ULN2003 driver (guide; buy at Amazon)
- How to breadboard prototype; about basic electronics.
- How to work with wire: stripping, soldering, crimping, braiding it.

- How to extend (chain together) Grove kit wires.
- How to use an LED strip: solder it to a Grove connector and code it.
- How to make two Arduinos communicate wirelessly using Blynk or NRF.
- About LiDAR sensors - measure distance and generate/identify objects and gestures.
- Use *MIT App inventor* to create an app that interacts with or controls your device.
- About using relays - "electronic switches."
- About making Arduino robots.