Final Project Discussion

Woodruff School of Mechanical Engineering
Georgia Institute of Technology
Atlanta, Georgia USA
Final design project

Theme: Space Jam

Learning Objectives:

• Tackle a constrained design problem
• Apply a structured design process to a real problem in a team environment
• Apply basic fabrication principles to produce a physical design to a functional specification
• Simulate, build and test designs to accomplish a physical task
• Communicate design outcomes
**Design tools – complete process**

### House of Quality

- **Goal:** Metric: Overall Benefits
- **Upper Left:** Customer Needs
- **Upper Right:** Customer Perceptions
- **Upper Center:** Metrics: Customer Health
- **Bottom Left:** Weighted Customer Benefits
- **Bottom Center:** Metric Targets
- **Bottom Right:** (optional) Exploring specification targets

### Specification Sheet

<table>
<thead>
<tr>
<th>Changes/DIM Requirement</th>
<th>Responsibility</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: Aids Recovery Efforts by Scoring Points</td>
<td>Design Team</td>
<td>Team</td>
</tr>
<tr>
<td>Geometry:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D: Shortening Length: Maximum 23 inches</td>
<td>Design Team</td>
<td>ME2110 Spec</td>
</tr>
<tr>
<td>D: Shortening Width: Maximum 11 inches</td>
<td>Design Team</td>
<td>ME2110 Spec</td>
</tr>
<tr>
<td>D: Shortening Height: Maximum 17 inches</td>
<td>Design Team</td>
<td>ME2110 Spec</td>
</tr>
<tr>
<td>Forces:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W: Weight: 30 lbs</td>
<td>Design Team</td>
<td>Team</td>
</tr>
<tr>
<td>Maintenance:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W: Hand-Time: Maximum 4 minutes</td>
<td>Design Team</td>
<td>Standard</td>
</tr>
</tbody>
</table>

### Function Tree

1. **Generate Power**
2. **Transmit Power**
3. **Hit Target**
4. **Brake on Target**
5. **Move to Target**
6. **Navigate to Target**

### Concept Generation

- Morphological Chart

### Concept Selection

- **Evaluation Matrices**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Importance</th>
<th>Design 1 Rating</th>
<th>Design 1 Weighted Total</th>
<th>Design 2 Rating</th>
<th>Design 2 Weighted Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
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<td></td>
<td></td>
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<tr>
<td>B</td>
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<td>C</td>
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<td>Total</td>
<td>Relative</td>
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<tr>
<td>Total</td>
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</tbody>
</table>
Week 6 – brainstorming session

Activity 1
• 20-minute discussion
• Brainstorm customer needs and engineering requirements
• 5-minute report out

Activity 2
• 20-minute discussion
• Brainstorm specifications for supporting engineering requirements
• 5-minute report out

Activity 3
• 30-minute discussion
• Brainstorm functions and mechanisms, use of power sources and triggering, as well as sensors for control
• 5-minute report out
Final design project

Specification*: ME2110 website

Primary Tasks
- Launch
- Pass
- Jumpshot
- Dunk

*Specification document and corresponding FAQ supercede information in this presentation
## Task points

<table>
<thead>
<tr>
<th>Task</th>
<th>Competition Point Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch</td>
<td>1 (successful deployment)</td>
</tr>
<tr>
<td>Pass</td>
<td>3 points/item (hits target zone)</td>
</tr>
<tr>
<td></td>
<td>1 points/item (leaves starting zone)</td>
</tr>
<tr>
<td>Jumpshot</td>
<td>8 points/item (lands in target zone)</td>
</tr>
<tr>
<td></td>
<td>3 points/item (hit target zone but not in target zone)</td>
</tr>
<tr>
<td></td>
<td>1 points/item (leaves starting zone)</td>
</tr>
<tr>
<td>Dunk</td>
<td>6 points/item (green zone)</td>
</tr>
<tr>
<td></td>
<td>5 points/item (yellow zone)</td>
</tr>
<tr>
<td></td>
<td>4 points/item (orange zone)</td>
</tr>
<tr>
<td></td>
<td>3 points/item (red zone)</td>
</tr>
<tr>
<td></td>
<td>1 point/item (not in a zone but off of PVC stand)</td>
</tr>
<tr>
<td></td>
<td>Money balls count 2x points per zone</td>
</tr>
</tbody>
</table>

**Competition items**

- 1 jumpshot item per trial
- 1 pass item per trial
- 2 moneyball items and 1 dunk item per trial

### Competition arena (jumpshot/pass)

**Top view**

- 4’
- 20”
- Target Zone 1 (jumpshot/pass)
- Stock items

**Side view**

### Competition arena (dunk)

**Top view**

- 20”
- 4’
- Target Zone 2 (dunk)
- Stock items

**Side view**

$X$ is a random variable from 1.5” to 2.5”

1/8” thick board
Scoring rules*

*Rules subject to clarification, updates by instructional team

Disqualification rules

• Disqualifications result in zero points for a trial, which is 1 run of team’s device
• Before the start of a round in the competition, your device must be set in a condition such that it is: (1) static, (2) is fully within the starting zone and (3) below 18” height
• System must be able to be setup by a maximum of 2 team members
• System must be setup and ready to go within 3 minutes
• System must be initiated by push button switch and autonomously operated after start
• Each button start push will count as a trial, no retrials are allowed
• System must be deactivated and static at the end of the 1-min round
• Power sources limited to five mousetraps, controller box, the mechatronics kit components, 5 rubber bands, and gravity
• System/team cannot damage arena or competition items
• Limited to $100 final bill of material cost

Launch task

• Teams can load start zone stock items and position system in starting zone before start
• System must have a perceptible motion from an actuator after button start to score
Scoring rules*  *Rules subject to clarification, updates by instructional team

Launch task
- Teams can load stock items labeled in the starting zone in Figure 1 and position system in starting zone before start
- System must have a perceptible motion from an actuator after button start to score

Pass task
- Crossing foul line (any intersection of line with system) results in no points scored
- Items hitting the target zone will score maximum points
- Items completely leaving the starting zone but not hitting the target zone or resting in it will score minimal points

Shooting task
- Crossing foul line (any intersection of line with system) results in no points scored
- Items resting in the target zone container scores maximum points
- Items hitting the target zone but not resting in it will score intermediate points
- Items completely leaving the starting zone but not hitting the target zone or resting in it will score minimal points

Dunk task
- Money balls must be picked up by system autonomously
- Items resting in a container score points for associated container color
- Items resting on container top lip score points for lower scoring container color
- Items that are removed from the PVC stands will count for minimal points
Competition scoring

Design Sprint 1
- All tasks
- Grading will be based on the average performance in 3 monitored trials
- Maximum trial score:
  - Launch: launching the system (1 point)
  - Pass: hitting target zone 1 with a pass (2 points)
  - Jumpshot: hitting target zone 1 with a stock item (3 points)
  - Dunk: placing 1 regular stock item in a red container (3 points)
- Maximum grade is 9 points/trial

Design Sprint 2
- All tasks
- Grading based on the average performance in 3 monitored trials
- Max trial score:
  - Launch: launching the system (1 point)
  - Pass: hitting target zone 1 with a pass (2 points)
  - Jumpshot: landing a stock item in target zone 1 (8 points)
  - Dunk: placing 1 regular stock item in an orange container (4 points)
  - Dunk: placing 1 moneyball stock item in a red container (6 points)
- Maximum grade is 21 points/trial
# Reports/presentations

<table>
<thead>
<tr>
<th>Report/Presentation</th>
<th>Week</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept Design</td>
<td>7</td>
<td>Week of Feb. 22</td>
</tr>
<tr>
<td>Sprint 1</td>
<td>8</td>
<td>Week of Mar. 1</td>
</tr>
<tr>
<td>Sprint 2</td>
<td>11</td>
<td>Week of Mar. 22</td>
</tr>
<tr>
<td>Design Review</td>
<td>13</td>
<td>Apr. 16 at 430-830PM</td>
</tr>
<tr>
<td>Final</td>
<td>14</td>
<td>Week of Apr. 19</td>
</tr>
</tbody>
</table>

### Mid-term breaks
- Tues. March 16 (A1-A4)
- Wed. March 24 (A5, A11)

### Design (10% final grade)
- 90% report, 10% presentation
- 3-page report, HOQ to morphological chart
- 10 minute presentation

### Sprint 1 grading (10% final grade)
- 75% report, 5% presentation, 20% performance
- 3-page report, 4-5 designs, evaluation, fabrication/test
- 10 minute presentation

### Sprint 2 grading (10% final grade)
- 70% summary, 30% performance
- 1-page summary/quad chart, prior results, fabrication/test

### Final report grading (15% final grade)
- 65% report, 5% presentation, 30% performance
- 5-page report, complete report
- 10 minute presentation

*All report descriptions are provided on the ME2110 website: [http://2110.me.gatech.edu/studios](http://2110.me.gatech.edu/studios)*
Virtual design review

• Save the date: 430-6PM on Friday April 16 2021
• Attendance: all students must attend and participate
• Format: virtual event with corporate partners, faculty, staff, friends and family
• Grading: accounts for 5% of overall course grade
• Presentation items: system design, fabrication, operation, performance
• Evaluators: corporate sponsors, faculty, graduate students
• Evaluation categories:
  • Design ingenuity (design creativity, design approach, design performance)
  • Fabrication (methods, cost, material utilization)
  • Presentation (oral communication, visual communication, presentation style)
Limited final competition

- **Save the date**: 6-8:30PM on Friday April 16th 2020
- **Attendance**: Limited participation in person, remainder of team virtual
- **Location**: GTMI Atrium
- **Details (full details to follow)**:
  - Same scoring rules for Sprint 2
  - Each team will compete in at least 3 trials
  - Any tiebreaks will be determined by key design variables including, but not limited to, overall system cost and overall system weight
  - Competition will be broadcast on same platform as design review
On in-laboratory work

Laser Cutter

- Utilize CAD-based design for manufacturing (potentially quicker design revisions)
- Maximize your utilization available for these equipment by preparing job files ahead of time, do not waste time in Inkscape and Cura when using your budget allotment!
IDEA laboratory guidelines

GTPD video-monitored / TA-staffed space

**Reservation-required outside of your studio sections**

Capacity-limited operation

**Follow GT return to campus guidelines (quarantine rules)**

Masks required for all users/staff

6-ft distancing

Forehead temperature check at entrance

Face shields made available

Safety glasses required for all users

Safety glasses can be sterilized with UV cabinet

Physical barriers between workstations – tables, 3DPs, TA stations

Large monitors for displays

Open tool checkout (power tools, batteries)
IDEA laboratory SUMS guidelines

IDEA Laboratory Access Requirements

Follow laboratory guidelines

Completed fabrication training

SUMS reservation for IDEA Laboratory resource (e.g., 28 workstations, 1 laser cutter, 5 3D printers)

Active login to SUMS

Team budget in open studio (self-tracked)

- 26.8 hours/week – workstations (max 3h/slot)
- 55 min/week – laser cutter
- 4.8 hours/week – 3D printers

Team budget during dedicated studio timings

- 2.75 hours/week – workstations
- 40 min/week – laser cutter
- 2.75 hours/week – 3D printers

Reservation and Use Process (for open studio)

Follow flowchart on next slide

- Goto http://sums.gatech.edu/ to reserve time, mark your section and team number in ‘description’ field
- Login to resource at studio using SUMS kiosk
- Enter IDEA, wait for TA temperature check at entrance
- Sanitize resource, use resource, clean up after yourself
- Logout using QR code or SUMS kiosk before reservation time expires (auto expires at end of reservation)

Cancel reservation ahead of time if you cannot make it

Penalty for arriving 15 mins late to reservation (stewardship grade), reservation voided after 15 mins

You should leave at least 10-15 mins at the beginning and end of the reservation for setup and teardown of equipment (e.g., 3D printer, laser cutter)

Notify your studio TA or head TAs if you have issues accessing SUMS
IDEA laboratory SUMS flowchart

1. Reserve IDEA resource on http://sums.gatech.edu/
2. Goto IDEA Laboratory
3. Login to resource at IDEA Laboratory using SUMS kiosk or resource QR code
4. Use resource/workstation
5. Sanitize resource/workstation
6. Enter IDEA Laboratory, receive temperature check
7. Clean-up after use
8. Logout using QR code on resource or at SUMS kiosk before time expires
9. Leave IDEA Laboratory
IDEA laboratory studio hours

Studio is closed on Saturdays
Dedicated studio timings – marked in grey
Open studio – any times not marked in black
Robot/tool storage and demerits

Shelves can be used for robot storage

Mechatronics kits should be stored in cabinets at front of laboratory

Demerits (e.g., stewardship grade) will be issued if materials are stored unsafely

Materials cannot overhang past team tray boundary
Project thoughts

Communication is key, develop a strategy, stick to it

Build early, constant vs ramped effort

Learn from others

Reliability and repeatablity

• Mechanisms – careful with springs, alignment
• Triggering – careful with strings
• Setup – make this easy as possible
• Setup procedure – have a list, physical guides
• Teamwork
Final design project

Learning Objectives:
• Apply structured design process in a team environment
• Apply basic fabrication to produce a physical design to functional spec
• Simulate, build and test designs to accomplish a physical task
• Communicate design outcomes (writing, presentation)

Helpful Materials:
• Past competition pictures / video: ME Flickr, ME Youtube
• Youtube: past designs, ideas
• Material sources: Home Depot / Ace Hardware / McMaster-Carr / Amazon
• Invention studio: laser cutters, 3D printers, etc.
• Mechatronics CAD files: ME2110 website (resources tab)
Appendix – Communication/Teamwork
Notes on teamwork/communication

Due to our schedules, we struggled to meet as consistently as we would have liked.

Earlier deliverables were not our strongest work because we all left it for the last minute due to our other assignments so it was stressful having to coordinate the report and presentation the couple days before hand, especially since we were not together and had to coordinate the assignment via group messages and emails. However, the final report worked out much better because we instead meet up and sat down together to work out all aspects.

We still had communication problems, namely not responding to messages in a timely fashion so we ended up having to rush a lot of the work and stress even though we allocated roles for each person. I think we should have met more in person versus just allocating roles so that everything would flow more, not be as rushed, and it wouldn’t be up to one person to edit everything the morning before class.

Synchronizing when the work gets done. Doesn't really depend on the individuals, sometimes others have lots of stuff to do while others don’t have as much.

Lack of communication and equal input was definitely prevalent amongst some members.

We may have been able to communicate better so that individual work goes well together with each other’s and it can then be seamlessly integrated into a single report. Sometimes the work a person did was not what someone was expecting which delayed things a bit.

As a whole, there was a little too much procrastination than what I am used to.

We tend to split hairs a lot and overthink design aspects, failing to address other aspects. We don’t come to a consensus quickly enough which is limiting the amount of time to do other things.
Everyone did their deliverables well and on time without much reminding. We met to discuss the status of everyone’s work and if anyone needed help but everyone appeared/and did have their work under control!

Our team communicated well and got the work done in an adequate amount of time. No one person made all of the decisions and everyone listened to the suggestions of other and didn’t shy away from asking for help when needed. This made our meetings run smoothly and helped us stay on track with what we were working on.

We were able to effectively delegate tasks to each person and accomplish our goals on time.

We were always in constant communication with each other every step of the project. We always met the deadlines we set for ourselves. We all worked hard enough to make the overall quality of our project as good as we wanted it to be.

We implemented a better form of communication. Our group met multiple times before deadlines and we divided up segments of the work to allow for more efficiency. We exchanged ideas and collaboratively discussed ways to make our deliverables more thorough.

Our group worked very well. We exploited each other’s strengths to allocate work and finish up in time.

All of us were willing take on equal parts of work. We all showed up on agreed meeting dates and times. Everyone’s opinions were heard.

Although specific parts of assignments were delegated to individual group members, each member did a good job of asking for feedback from his teammates. Likewise, the teammates were proactive in reviewing each other’s work to give quality feedback.

Frequent meetings have helped us keep a close track of what is not started, in progress, and completed. This is accomplished either in person or online. We have also split up tasks and brought them together to review/edit.

The group works really well on communicating our progress and we utilize Google Drive so we can easily help each other whether it be checking others’ work or offering assistance.
Notes on teamwork/communication

We tend to not work ahead. (Last minute)

When certain members do not respond on GroupMe or show up to outside meetings it makes it hard to complete assignments. It is also hard to coordinate things when they do not meet with the rest of the team after lecture.

Not all group members completed the work they said they would before attending meetings.

In terms of cooperation and communication, there weren’t really any difficulties. However, when we were assigned work due next meeting, some of us did not have it completely done, which delayed our completion and decreased our efficiency of the group meeting when we got together. But in general, we worked cohesively and cooperatively.

Finding time to meet up (especially with the whole team) was difficult, particularly with some of the team living off campus. Time management was also challenging, as we definitely underestimated the amount of work certain assignments would entail.

We spent less time reviewing our work than we should have. We worked quickly and didn’t leave enough time at the end to go over very much.

The only thing to work on is starting the project earlier in order to better space out the work load.

The only thing I would say about this group is that we are all busy, so it was hard to schedule time to meet. However, we all could make it work and get everything done.

The only major problem came with trying to find a time to meet up since each of us had various other extracurricular activities. As a result, some people missed sections of some of the meetings.

We accomplished our task on time and performed well, it was just stressful to be working up until the last minute. Time management is a skill we will need to work on in the future.

Communication about task delegation was poor at times. The team left a good portion of work for the night before due dates.

Trying to manage schedules was very difficult. GroupMe and Google Docs definitely helped, but each member seemed to be busy when others were free.
Notes on teamwork/communication

Google drive works well as well as actually meeting in person. We are more efficient when working together

The group continued to have solid communication. We maintained a divide and conquer mentality when approaching all parts of this project, and it worked perfectly. Everyone successfully completed their respective individual assignments and contributed to all group discussions. We completed everything with time and even requested feedback multiple times from the instructor to further improve our deliverables.

We divided work effectively and everyone contributed. Our group completed some work early and were able to take the pressure off later assignments.

The communication between the groups was very well organized. When we set a time for a group meeting, the group was prompt on time ready to work. In terms of cooperation, although some parts were individually divided, the overall work was reviewed by all of the group members and thus was cohesive.

Utilizing tools like GroupMe and Google Drive to organize our communication and documentation. Creating task lists to break up the workload also helped us take individual efforts and turn them into collaborative deliverables.

We maintained communication outside of class/studio very well. There was never real need for delegation because everyone would volunteer or jump at a task. Everyone did something and gave valuable input. We began working early on; not much procrastinating at all.

The google drive that was set up allowed us all to work on things in our own time, so that worked well. The quality of our deliverables was also satisfactory because of each individual group members strive to do the best they can.

We all did a great job of cooperating and communicating when we would be available to work together on the Project. We recognized that at times it is best to work separately and then come together to discuss work we had accomplished and then combine thoughts and ideas.

We also made great use of everyone’s individual strengths such as technical writing, creating a presentation, or modeling in Solidworks.

Meeting earlier in the week and multiple times for shorter sessions made meetings more productive