16-311 Lab 01: Rube Goldberg

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Lab Objectives

start early!

- **TEAMWORK**

  Creating a healthy team environment with potentially unfamiliar teammates

- **CONSISTENCY**

  Create a robust and reliable machine.

- **SYSTEMS ENGINEERING**

  Use your team’s expertise to create subsystems that integrate into a final system

- **RESOURCE FAMILIARITY**

  Gain experience using resources in the REL and around campus

Introduction

start early!

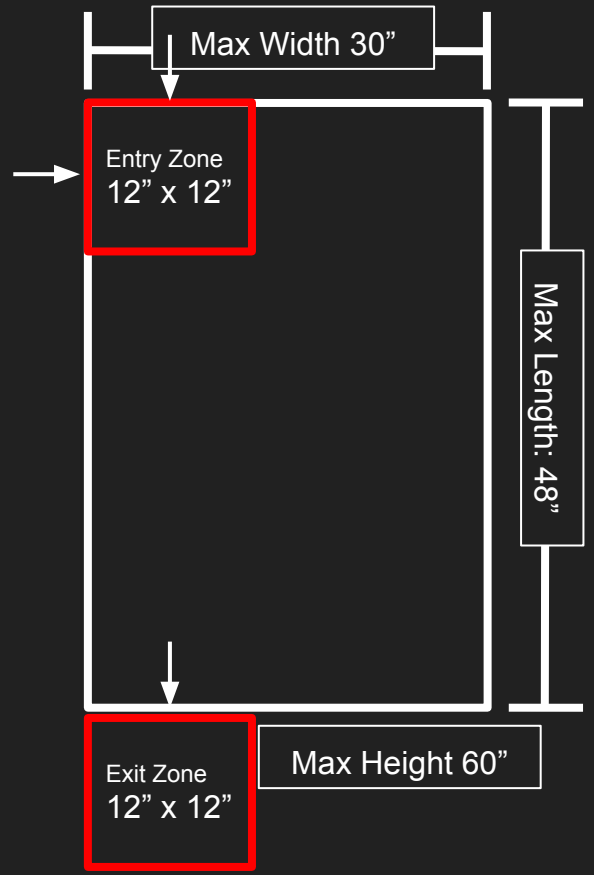
A **Rube Goldberg machine** is a contraption, invention, device, or apparatus that is deliberately over-engineered to perform a simple task in a complicated fashion, generally including a chain reaction. The expression is named after American cartoonist and inventor **Rube Goldberg** (1883–1970). (https://en.wikipedia.org/wiki/Rube_Goldberg_machine)

Requirements

Dimensions

start early!

- All parts of the machine (except the original golf ball) must, at all times, remain **within the dimensions** outlined in the diagram on the right.
- A golf ball will be **dropped from rest at a height of 42” into a 12”x12” entry zone (see diagram) in the top left corner of the machine**.
  - We may drop the ball at a randomly chosen location within this 12”x12” zone so ensure that all parts of the entry zone are capable of capturing the ball cleanly.
  - Max height of the entry zone is 40”
- The area directly above the entry zone must be clear.
- The same golf ball that enters must **leave the machine and land in a 12”x12” exit zone (see diagram) at a height of at exactly 42”.**
- If any component of the machine (excluding the original golf ball) ends up outside the bounding box on the right during the demo, it is considered a violation of dimensions.
- The height of the machine will be measured from the ground to the top of the machine



Energy Transfers (1)

start early!

- Any action in the machine that involves transferring energy from the one object to another object e.g.
  - Ball hitting dominos
  - Ball hitting another ball
  - Catapult launching ball
  - Many more…
- Must occur after the ball enters and before the ball leaves the machine.
- Transfers of like material (e.g. a series of dominoes) or transfers of like forms (e.g. a domino knocking over a chess piece) will only count as a single energy transfer.
- All energy transfers must be necessary for the machine to function (nonessential transfers will not be counted).
- All energy transfers must be unique.

Energy Transfers (2)

- All teams will be required to implement 4 transfers.
- You are encouraged to implement more energy transfers than required in order to build redundancies in your system in case one or more of them fail.
- NOTE: These energy transfers are in addition to a launch that brings the ball up to 62”

Launch start early!

- The Launch follows all rules of energy transfers
- At some point during your machine's operation, the original golf ball must be elevated to a height of 62".
- Note that the max. height of your machine is 60" i.e. you must launch the ball 2" above the top of your machine and catch it for full points
- This is usually the most challenging aspect of this lab, so start thinking about this early and don't be afraid to prototype.

Simultaneous Motion start early!

- At some point within the machine's operation, there must be at least 2 separate and necessary movements happening at the same time
  - E.g. ball rolls while dominos topple
  - E.g. two balls roll separately at the same time
- This simultaneous motion must occur for a reasonable amount of time
  - I.e. aim to have the simultaneous motion take place for at least a second
  - Any simultaneous motions that are not significant enough for us to observe will not count

Time start early!

- Your entire machine must run in between 10-25 seconds.
  - Ballpark number of 2-5 seconds per energy transfer
- A run is defined as the time between when the original golf ball enters your machine and when it leaves your machine.
  - The only exception is in the case of resets

Transport start early!

- Ensure that your machine can be transported short distances without breaking or requiring extensive recalibration.
- Machine must be durable enough to be transported short distances and demo multiple times.
- Keep weather conditions in mind if you will be transporting the machine outdoors!
- Sturdy bases
  - We will provide each team a base that matches the max dimensions
  - You will be required to return the base after the lab in as close to normal condition as possible. You must return the base by Wednesday at 4:30 pm
  - If you do not wish to return your base, you may optionally pay $5 for the base. If you alter the size or cannot return the base in good condition, you must choose this option.

Requirements Recap start early!

- Dimensions
  - Max. 30” x 48” x 60”
  - Entry/Exit zones must be located exactly where specified and of the correct dimensions.
- Launch
  - Ball must be elevated to a height of 62” and caught such that it remains within the machine.
- Energy Transfers
  - You must implement 4 necessary energy transfers.
- Simultaneous Motion
  - At some point within the machine’s operation, there must be at least 2 separate and necessary movements happening at the same time
- Time
  - The total run time of your machine must be 10-25s.
- Transport:
  - The machine must be able to withstand transportation over short distances.

Refer to earlier slides for more details on each section.

Your machine must meet ALL the dimension requirements outlined earlier in order to be able to demo.

No exceptions

Optional: Design Proposal start early!

You may (but are not required to) submit up to 2 design proposals for your machine to verify the validity of your energy transfers. For an energy transfer to be approved, your report must include a short description, a diagram, and the goal of the transfer. Please use the provided template below for your proposals. Only working transfers that were previously approved are guaranteed to be counted towards your grade.

- These proposals should be submitted via the following Google Form and will be reviewed within 24 hours.
  - https://goo.gl/forms/WMjuJV7ldjeGbI4j1
- All proposals must be submitted by Sunday, Jan. 20 at 11:59 AM
- Template Link: https://docs.google.com/document/d/1JtXSCM2z_4nMjLBTShDOqQOWLto6GGG6h-CxoM3DgkM/edit?usp=sharing

Mandatory Checkpoint Video (5 points) start early!

- Deadline: Saturday Jan 19th 11:59 pm
- Submit a video of your operating machine (in whatever state it is) using this Google Form: https://goo.gl/forms/pGuGM0mMf0i8cjml2
  - You will be required to submit a Youtube link to the video, not the video itself.
- It is okay if your machine is not finished. We want to see whatever progress you have made thus far.
  - You may take a video of the entire machine operating with the golf ball, or you may also show us individual energy transfers working with the ball.
- Do not spend a lot of time on this, an informal video will be fine.
- This will be worth 5 points out of a total 100 points for this lab.
- For this video only you will not be required to show dimensions or timing. Only your progress
- Also introduce each group member and state briefly their contribution to the machine

Demo (95 points) start early!

- You will be required to **demonstrate your machine three times**; your overall grade will be the **average of the three runs**.
- You will have 5 minutes before your sign-up time to set up your machine. You will then have only 15 minutes to demo three times. Anything not demo-ed during this time will not receive a grade. Be smart about this (ie. if you're signed up to demo at 4:30, make sure to be there no later than 4:25). You will then have 5 minutes to clear out of your demo spot or suffer a potential grade deduction.
- Please bring a **printed** grading sheet to the demo
- On demo day, you will be required to move your machine to multiple locations within NSH.
- Demo day can be very hectic, so please come prepared and try to be patient as the TAs try to get everything organized.
- Be sure to sign up for a demo slot when the sheet is released (you will be responsible for signing your team up for a time that works for everyone).
- **Warning**: **All team members must be present and on time for a non-zero score.**

Resets start early!

- If, during your demo, something goes wrong and your machine fails (e.g. ball falls out, energy transfer fails etc.), you are allowed to “reset” once per trial.
- A reset allows you to return the machine to a working state e.g.
  - Put ball back into machine
  - Manually perform an energy transfer
- Any energy transfers that are affected by a reset WILL NOT receive credit.
- You may only use a reset to skip an energy transfer if it caused the failure.
  - I.e. you cannot use a reset to skip a couple of energy transfers that you know won’t work.
  - You must let the machine fail, at which point you can use your reset to “skip” the failure point.
- If the machine fails again after a reset is used, it is considered the end of the trial and anything that happens after this point in the machine does not receive credit.

Optional Video Demo start early!

- You may submit a video of your machine working by Tuesday 3:00 pm as a backup for your demo: https://goo.gl/forms/WOn8X39S6FOxXQjj1
- The video must demonstrate whether or not ALL requirements of the lab are met, otherwise credit will not be given.
  - Use a ruler to show us the dimensions are within bounds, use a timer to time the run etc.
  - You MUST transport you machine through one doorway into a different room and them show your machine functioning after transport
  - Take time to be meticulous with your video demo. Use multiple camera angles if that is helpful in showing every aspect of your system. Video demos are hard to grade so please be meticulous in demonstrating the full capabilities of your machine.
  - Doing a walkthrough of your machine before the run is often helpful for the graders.
- The purpose of this video is to provide a backup in the event that something goes wrong with your machine on demo day.
- You will receive 65% of the points earned from the video demo if it is used.
- This is NOT the same as the mandatory checkpoint video.

Grading Sheet -

https://docs.google.com/document/d/1obaBHcMoLJNMGH5bewKB8akgCxw1YmzuQczxZiWlFcE/edit

Warning: All team members present and on time for a non-zero score.

Item	Points	Trial 1	Trial 2	Trial 3	Video
Checkpoint Video	5				
Dimensions Check	Yes/No				
Ball leaves machine into adjacent 12"x12" box at a height of 42"	10				
Energy Transfer 1	12				
Energy Transfer 2	12				
Energy Transfer 3	12				
Energy Transfer 4	12				
Ball reaches height of 60" at some point other than the handoff to next machine	5				
Ball reaches height of 62" at some point other than the handoff to next machine	10				
Ball is successfully caught by the machine after reaching a height of at least 60"	10				
Simultaneous motion	5				
Run time between 10-25s	7				
Trial Total	**100**				

Average of 3 trials: _____ / 100
Grade Video Instead? Yes / No

Final Score: _____ / 100

Deadlines Summary start early!

- Checkpoint Video - Saturday, Jan. 19th 11:59pm
- Last Optional Proposal - Sunday, Jan. 20th 11:59pm
- Optional Video Demo - Tuesday, Jan. 22nd 3:00 pm
- Demos Begin - Tuesday, Jan. 22nd 4:30pm
- Return Bases - Wednesday, Jan. 23rd 4:30 pm

FAQs

start early!

- Where can I find cardboard and other building materials?
  - CFA dumpster, CUC Package Pickup, Bookstore, Home Depot, Makerspace, iDeATe etc.
- Are we allowed to use multiple golf balls?
  - Yes, but the ball that enters the machine must be the same one that leaves the machine
- Are we allowed to use other moving objects?
  - Yes, you may use other items like ping-pong balls, marbles, magnets, dominos etc.
- Does _____ count as an energy transfer?
  - Submit a proposal, ask a Rube TA, come to Office Hours
- When is my group's demo time?
  - Demo time slots will be released a day or two before demo day
  - You are expected to make yourself available for the entirety of Tuesday's recitation time slot
- Can we use electricity, batteries, fire, chemicals, sharp objects, live animals etc. in our machine?
  - No. We strongly encourage creativity, but hazardous materials/forces will not be permitted.
- One of my teammates has dropped the class halfway through the lab - what do I do?
  - Contact the Rube TAs ASAP. We will do what we can to accommodate this so that you are still able to complete the lab successfully.

Tips

start early!

- Start early! It will take MANY hours to build a working, durable Rube Goldberg Machine.
- Submit proposals. Early. To the **lab's head TAs**.
- Cardboard and duct-tape **can** make surprisingly good building materials **if used well**.
- Invest in good quality duct-tape -- it makes a big difference in the quality of your construction.
- Getting the golf ball above 60 inches is particularly challenging.
- Build a robust machine. A flimsy machine is hard to debug and will most likely fail in the demo.
- Remember to leave room in your design for reinforcements and supports.
- Ensure that your machine is transportable.
- **Keep the REL clean** - many groups use it.
- There are also alternative locations on campus including Morewood Makerspace (now with workbenches!), IDeATe, Hammerslag Makerspace, Roboclub
- Come to TA Office Hours for help!
- Have fun!

Next Steps start early!

- START EARLY!!!
- Find time for a team meeting ASAP to come up with a plan for this lab
  - Teams will be announced at the end of this presentation
  - It is vital that you communicate effectively and share the load evenly within your team
- If you cannot stay past 5:50pm on demo-day (Tuesday), please inform the lab head TAs as soon as possible
- START EARLY!!!
- If you are participating in Build18, be aware that this lab will be another time-consuming project you will be working on this week
- Ensure that you have access to the REL
- Ensure that you have a space to work in for this lab
- START EARLY!!!

Feedback from past years

What was the most challenging part of the lab and why?

- “The launching mechanism for firing the ball 62 inches was exceedingly time-consuming.”
- “Getting everything to work consistently. Different small issues kept on coming up.”
- “To make every part work every time.”
- “Make sure the task is repeatable”
- “Figuring out how to get the ball up to 62” without too much force.”
- “The most challenging part was to schedule a time for people to work…”
- “Coming up with ideas. Being creative.”

What advice would you give to next year’s students?

- “Start Early.” (27)
- “Start as early as possible. Aim to finish by saturday”
- “Communicate well with teammates and plan early”
- Test early and often (5)
- “Start early and go to the CFA dumpsters”
- “To start very early and have a plan before starting to build”
- Have a good plan (11)
- “Start early and work diligently. Go in with a plan before blindly start cutting cardboard.”
- “Rube Goldberg machines are a series of SIMPLE machines. Do not do anything more complicated than it needs to be.”
- “You need to focus on making the machine durable. You will need to transport your machine across campus and if your project is fragile, it will not work on presentation day.”
- Use sturdy building materials (18)
- “Plan around the launch and the simplest way it can be done.”

Questions?

Contact the head TAs

start early!

Teams:
Will be made in class tomorrow

Update:
https://docs.google.com/spreadsheets/d/1JybBARJ6_ZaIEbV7kNcJSMcgys8aP8bahs1kinUjBDE/edit?usp=sharing