ME 210 Winter 2024: PARKOUR MADNESS
Final Project

Project Presentation on March 10 starting at 7:00 pm.
Revision 0: 2/12/24

Purpose:

The purpose of this project is to provide you with an opportunity to apply what you have learned so far in ME210 to solve an open-ended mechatronics design problem.

Background:

Congratulations! Your team has decided to compete your **TRACBOT** (robot) in the annual **d.JAM** (d.school Parkour Jam)! But before you start thinking about how your TRACBOT will be agile in performing flips! It wouldn't be an amazing d.JAM without a set of GOALS as well as some beef between competing TRACBOTs. During the d.JAM you will need to make sure you are the crowd favorite by completing all the tasks in the fastest possible way while ensuring that your TRACBOT has the most amount of swag.

Although your TRACBOT may perform a "flip" as well as other aesthetic acrobatic movements, these are not essential for the d.JAM as they are central to freerunning, a discipline derived from parkour but emphasising artistry rather than efficiency.

> FUN FACT - Parkour as a type of movement was later established by David Belle when he and others founded the Yamakasi in the 1990s and initially called it l'art du déplacement. It was popularized through various forms of media including the James Bond movie Casino Royale (2006).

The Task:

Design an autonomous robot that is able to perform all the tasks as mentioned in the d.JAM. The objective is to ensure that your TRACBOT completes the most tasks in the least amount of time. The leaderboard is sorted first on the basis of points and then on the basis of the completion time of each team's TRACBOT to decide the winner of the d.JAM.

Specifications

Your TRACBOT will start in its respective START ZONE. Here, you can manually pre-load 5x DARTs which are represented by 1.6in diameter balls. Each OCOURSE has the following objectives:

- Make contact with the CONTACT ZONE
- Deposit a ball in the SHOOTING GOAL
- Move up the CLIMBING RAMP (optional)

The Field:

- ☐ The field, shown in Figure 1, is constructed from wood and split into 2 sides: an 8 foot by 4 foot area for OCOURSE A and an 8 foot by 4 foot area for OCOURSE B. The two halves will be divided along the 8 foot side, with the CONTACT ZONE and SHOOTING GOAL in between.
- ☐ OCOURSE A will start in START ZONE A located on the top right corner of the field and will be scored on the SHOOTING GOAL to the left. OCOURSE B will start in START ZONE B located on the bottom right corner of the field. Each START ZONE will be 16 in by 16 in.
- ☐ The SHOOTING GOAL and CONTACT ZONE are both 8 in by 8 in. The opening for the SHOOTING GOAL will be level with the wall, and the CONTACT ZONE will extend 4 inches above the wall.
- ☐ There will be an IR beacon located near the SHOOTING GOAL, emitting at a height of 8 inches above the field, as illustrated in Figure 2. The beacon will pulse at a frequency of 3333 Hz.
- ☐ The CLIMBING RAMP end zone will be a 16 in by 16 in platform raised 8 in above the field. The CLIMBING RAMP itself will have a 20 in base, over which it will rise 8 in, as shown in Figure 2.
- ☐ Black tape will be placed on each half of the field going from the START ZONE to wall opening shown in Figure 1. Additional black tape will lead from the CONTACT ZONE to the start of the CLIMBINB RAMP.

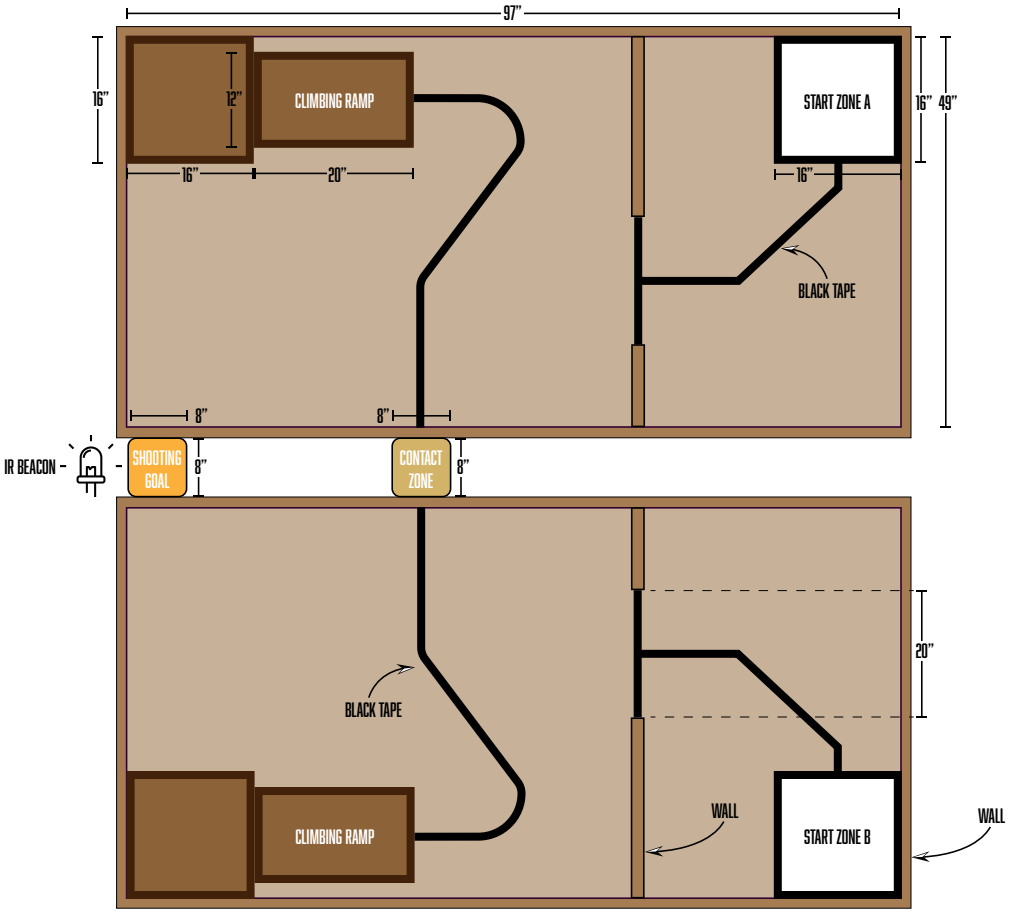

Figure 1: Top view of the field.

The Game:

The d.JAM is designed for timed trials to reach #1 in the leaderboard. Their objective is to complete the most tasks in the shortest time!

- ☐ Each TRACBOT will start in its own START ZONE in a randomly determined orientation.
- ☐ While your TRACBOT is in the **START ZONE**, you may only communicate with it via a button, a switch, or a potentiometer.
- ☐ Upon auditory start command, you may load DARTs into your TRACBOT and tell it to start. At this point, we will begin a 2 minutes and 10 seconds timer.
- ☐ You can **manually load a maximum of 5 DARTs** in the START ZONE at one time. You may only re-load DARTS in your START ZONE.
- ☐ **"Loading" means placing the DARTs in your TRACBOT, on your TRACBOT, or the floor within the START ZONE**. Your TRACBOT must be completely within the START ZONE (and have attempted to score the DARTs) in order to be re-loaded.
- ☐ You can only score into the **SHOOTING GOAL** once your robot is **entirely out of the START ZONE**.
- ☐ You may not enter the other team's half of the field.
- ☐ You may not play **'defense' against the other team's TRACBOT** or touch any aspect of the SHOOTING

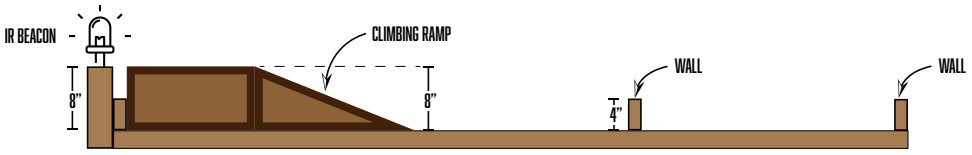

Figure 2: Side view of the field.

GOAL in hopes to sabotage.

- ☐ Your TRACBOT must make physical contact with the CONTACT ZONE in order to receive points – i.e. you may not use a projectile to make contact.
- ☐ Climbing the CLIMBING RAMP is optional, but does earn extra points.
- ☐ In order to indicate that your TRACBOT is finished performing tasks (and end your time early before 2 minutes and 10 seconds), it must perform some kind of celebration (consider flashing lights, waving servos, etc.).
- ☐ If your TRACBOT does not finish early, it must automatically stop at 2 minutes and 10 seconds on its own.
- ☐ The TRACBOT with the most points and the least time wins!

Scoring:

- ☐ Completion of each task by the TRACBOT will earn you 2 points.
- ☐ Climbing up the CLIMBING RAMP will earn you an additional 4 points.
- ☐ Each task may only be completed **ONCE**.
- ☐ Only the TRACBOT which reaches the CONTACT ZONE and interacts with it first will earn the 2 contact points.
- ☐ If your TRACBOT gets stuck, you may request to manually reset it in the home location for a 1-point penalty.
- ☐ Any fouls (eg. deliberately breaking rules such as playing defense) will result in a 2-point penalty.

$$P_{total} = \{(2 * \text{\# of tasks completed}) + (4 \text{ if reached top of CLIMBING RAMP})$$
$$-(\text{\# of manual resets}) - (2 * \text{ \# of Penalties})\}$$
$$t_{end} = \text{Time when large-scale motion of Robot } \textbf{ends}$$

The final ranking will be sorted first by number of points, and then by which TRACBOT acquired that many points in the least amount of time. An example ranking:

1. **ParkourBot**: 8 points in 1 minute and 33 seconds
2. **RoboKour**: 8 points in 2 minutes and 10 seconds
3. **JamBot**: 6 points in 1 minute and 45 seconds

Robot requirements:

- ☐ Each student team will be responsible for designing, building, and demonstrating an operational robot. The robot should be an autonomous machine which will compete according to the specifications and rules defined in this document.

- ☐ Each robot must be a stand-alone entity, capable of meeting all project specifications, and must operate completely untethered during grading and competition.
- ☐ Power for the robot must be supplied by batteries, which are carried on board of each robot. Each team will receive two 7.2V NiMH rechargeable battery packs. The use of circuit breakers is mandatory. We will provide one circuit breaker per team, which will allow you to start your motors (it accepts short current surges).
- ☐ The provided batteries are the only power sources that may be utilized.
- ☐ Each robot should incorporate an easily accessible toggle switch on its exterior, which will serve as an emergency stop switch. The switch must cut all power to the robot when toggled.
- ☐ At the beginning of each round, your robot must fit within a 12" x 12" x 12" cube. Your robot may be dismembered to conform to this specification :)
- ☐ The robot's control software should be executed from the flash memory of one or more Arduino UNO micro-controllers. Tethering of robots to computers during competition is strictly prohibited.
- ☐ Each robot must be constructed as part of ME 210 activities during the remainder of the quarter. It may not be based on a commercial or otherwise preexisting platform. Rulings from a member of the staff may be requested if there are questions about the content of your robot.
- ☐ Each team must adhere to an expenditure limit of **US $200** for the materials and parts used in the construction of the robot. The cost of the two provided NiMH battery packs, fuses/circuit breakers, and the lab kit components (including a single Arduino per team member) do not count towards this limit.
- ☐ Robots must be robust enough to deal with all normal game interactions including, but not limited to, collisions with any part of the field or debris.

Rules of Engagement:

- ☐ Rounds last for 2 minutes and 10 seconds. The robot that scores the most points wins in the least amount of time.
- ☐ Robots must automatically cease gameplay at the end of a round.
- ☐ The initial orientation will be randomly set by the staff. The side of your team will also be randomly assigned at the beginning of the round.
- ☐ An auditory start command will be issued by a member of the staff, at which time a member of each team will activate their robot, thereby initializing gameplay. This is the last human interaction with the robot allowed until the 2 minutes and 10 seconds have elapsed (with an exception being while the robot is in the START ZONE and resets approved by the teaching staff).
- ☐ Sideline coaching is strictly prohibited; no information may be passed to your robot during the match aside from the button, switch or potentiometer interactions aforementioned.
- ☐ Intentional destruction, damage, or alteration of any part of the field or other robots is expressly forbidden.
- ☐ Intentional jamming of your opponent's sensing abilities is prohibited.
- ☐ When robots intersect during normal gameplay, they are not required to yield to one another. The robots may be constructed such that an oncoming robot is diverted in this instance. However, strategies that intentionally create interaction with another robot, or upon interaction intentionally dismantle or disable the other robot (i.e. flipping or affecting sensing) are not permitted.
- ☐ Robots must show good sportsmanship: any celebratory actions or displays prior to the end of the game will be penalized and censured harshly by staff.
- ☐ All machines and devices must be safe to users, to the lab, and to any spectators.
- ☐ Staff reserves the right to require a team to reduce their robot's speed if said speed is considered unsafe.

- ☐ No part of the robot may become ballistic (shoot balls not metal!).
- ☐ The competition seed position will be determined by the order in which teams perform the graded check off (see performance requirements).
- ☐ Members of your team are not allowed to position themselves (that's you, the humans) in a way that will interfere with the activities of any opponent's robot. Polite, "G-rated" heckling is permitted, of course.

Essential Guidelines for Safety

- ☐ **All projects shall respect the spirit of the rules, as established in this specification and in the culture of ME210. If you are considering something that may violate official sanctions, you must first consult with a member of the staff. Interpretations and rulings are the sole domain of the teaching staff.**
- ☐ All machines and devices must be safe to users, to the lab, and to any spectators.
- ☐ High speed projectiles are not permitted. If your robot has appendages, they should remain tethered to your robot at all times.
- ☐ If your robot stores energy anywhere other than the batteries, you must justify by analysis and demonstration that the stored energy cannot become hazardous. There is no explicit restriction on the amount of energy that may be stored. Any such device must start the round with zero stored energy.
- ☐ The powers of the staff to protect ME210 and its participants are very substantial and shall not be questioned.
- ☐ Tolerances on the dimensions of the field are ± 1 inch unless otherwise specified. (double check this with our field, once it is built).
- ☐ Once the field is constructed, its dimensions may supersede the above tolerances.
- ☐ Although ungraded, teams are encouraged to use creative themes and aesthetics with their robots.
- ☐ Pyrotechnics and combustion of any kind are prohibited.
- ☐ A main circuit breaker/switch will be provided and must be used as a main power shut down. When the switch is in the off position, all power must be disabled, and no subsystems may remain energized.

Performance Requirements

- ☐ For the purposes of grading, the minimum requirement for each robot is to start in the START ZONE, orient, touch the CONTACT ZONE, put a DART into the SHOOTING ZONE, and "celebrate". We call this "beating the brick"; there will be no opponent during this checkoff.
- ☐ **Your robot must indicate that the game is afoot using some electro-mechanical mechanism.** For example: waving to the crowd when time starts, and then again at 2:10 when the game is over. Turning LEDs on and off will not be permitted for this requirement.
- ☐ Your team may check off at any time by declaring[1] your wish to check off to a staff member prior to the check off attempt. If disaster strikes ("Its never done THAT before!?!!"), and your robot fails to check off, your robot's check off requirement will henceforth be raised to two successive, successful check-offs. If either of these consecutive check-off attempts fails, you will be required to perform no more than three consecutive successful checkoffs. **Check-offs must be completed for all teams no later than 5:00 pm on 3/8/24.**
- ☐ It is important for everyone to remember that the minimum performance requirement is the goal for the class. Student teams are strongly encouraged to strive for demonstration of the minimum performance functionality as early as reasonably possible, so that the members of these teams may return to their regularly-scheduled lives.

[1] Note that you cannot just state your wish; you must declare it.

- ☐ The results of the tournament held at the public presentation session will not affect grading. The public presentation is purely an opportunity for you to enjoy the devices you've created, and to show your friends and families why you have disappeared for 3 weeks.

Project Advice

- ☐ Start early (now, start now).
- ☐ Spend a lot of time perfecting your state machine, hammering out your design, agreeing on your interfaces, and picking your components. These will be the foundation for your code, and programming your robot will go a lot faster if you do these things well.
- ☐ Get out of your comfort zone. If you don't have experience with a concept or device, working on it during the project will be a great learning opportunity. For example, if you are a CS major, do not spend all of your time coding; instead work on signal conditioning or mechanical design.
- ☐ Work together and communicate. It's tempting to divide and conquer, but your teammates can't help you if they don't understand what you're working on.
- ☐ Sleep. You think you'll get more done if you stay up for 48 hours straight beating your head against a stack of datasheets, but you're wrong.
- ☐ Know where to find emergency replacement parts. If you don't have time to wait for a shipment, then Jameco and Room 36 can save your project, for a price (be wary of, but receptive to, blood contracts).
- ☐ There are other lesser known resources on campus for Laser Cutting or 3D Printing, like Lab64 in Packard building. But accesses to these resources require prior training; so try to get that ahead of time. There are just one or two laser cutters and 3D printers in Lab64, but these can save the day when PRL is overflowing with people.

Milestones

Project Assigned:
February 15 (in class)

Finalize a four person team, and enter your info into the team spreadsheet.

First Checkpoint:
February 20 (in class)

2-4 minute in-class presentation. Show 3 design concepts with sketches, time schedules, a project plan, and personnel assignments.

Second Checkpoint:
February 23, 11:59 pm

Turn in physical documentation on Canvas, including schematics, state diagrams, design calculations, and any preliminary testing results.

Third Checkpoint:
March 1, 11:59 pm

Demonstration of all functional subsystems per block diagram: drive train, beacon sensing, tape sensing, navigation, etc. All components of your robot should be working individually.

Fourth Checkpoint:
March 8, 5:00 pm

All subsystems functional and integrated. Beat The Brick (your robot can move) check-off by teaching staff.

Public Presentation:
March 10, 7:00 pm

The RobOSCARs will take place on **3/10/24** at **7:00 pm** in the Atrium of Building 550. At this event, you can compete in the tournament with your finished, presentable, competition-ready machines. Guests are welcome and even encouraged!

Project Review:
March 12 (in class)

Brief in-class presentations from each team on project outcome and lessons learned. Bring your FILMs!

Project Report:
March 15, 5:00 pm

Report in HTML format, suitable for publishing on the ME210 website.

Evaluation

Performance Testing Procedures:

All robots will be tested by a demonstration, performed by a team member, that should show all of the possible user interactions.

Grading Criteria:

- ☐ **Concept (20 %)** The concept portion of your grade will be based on the technical merit of the design and programming for the machine. Included in this grade will be evaluation of the appropriateness of the solution, as well as innovative hardware and software and use of physical principles in the solution.
- ☐ **Implementation (25 %)** The implementation portion of your grade will be based on the machine displayed at the evaluation session. Included in this portion of the grade will be evaluation of the physical appearance of the machine and the quality of its construction. Aesthetics will not be judged, rather, craftsmanship and finished appearance are the focus of this portion.
- ☐ **Performance (25 %)** The performance portion of your grade will be based on the results of the performance during the check-off evaluation session. **To earn the performance points, you must demonstrate at least the core functionality.**
- ☐ **Coach Evaluations (15 %)** The coach evaluations portion of your grade will be based on the four project milestone reviews (see previous section).
- ☐ **Report (15 %)** The report portion of your grade will be based on an evaluation of the final report. It will be judged on clarity of explanations and on the completeness and appropriateness of the documentation. This report should be prepared in HTML format (as a website), and submitted as a compressed ZIP archive on Canvas ready for publication on the Internet. If your report is already hosted on the internet, please include a text file containing a link to the live webpage.

Resources

Websites:

SparkFun (www.sparkfun.com)	Seeed Studio (www.seeedstudio.com)	Jameco (www.jameco.com)
Mouser (www.mouser.com)	ServoCity (www.servocity.com)	Ponoko (www.ponoko.com)
Adafruit (www.adafruit.com)	Hackaday (www.hackaday.com)	DigiKey (www.digikey.com)
McMaster-Carr (www.mcmaster.com)	HobbyKing (www.hobbyking.com)	Newark (www.newark.com)

Local Stores:

Anchor Electronics in Santa Clara	J&M Hobby House in San Carlos
Jameco in Belmont	TAP Plastics in San Mateo

Revision History

Revision 0: Initial release (2/12/24)