ME 348E/392Q: Advanced Mechatronics
Fall 2025

# Final Project : Bevo Madness Tournament

Competition Date : 12/9/2025, 10am-11am (live, in-person)
Report Due : Exam date per university schedule
*Adapted from Ed Carryer, instructor of ME210, Stanford University*

## I. Objective

During this final project, you will work on an open-ended mechatronics design problem. The task is to design an autonomous machine that could compete against an opponent in a game of head-to-head, one-on-one mechatronic basketball. This will be a fast-paced competition, with each game lasting 2 minutes. You may modify your code until competition day, 30 min before it opens to the public. You will not able to modify the code again during the competition, which will most likely be played in single-elimination bracket. *Students will work in a team with 2 or 3 additional students.*

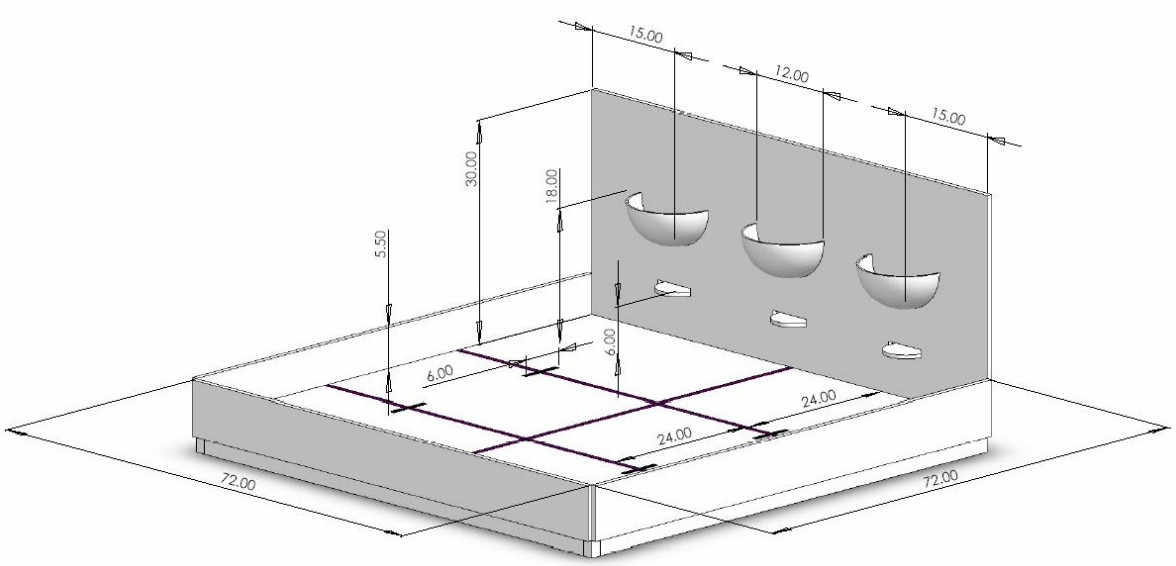


Figure 1: One Side of Competition Board

### A. Court Description

Court will be constructed from white melamine coated particle board. The court will be divided at the half-court line, and each half will have dimensions of 6' x 6'. The overall dimensions of the entire court will be 12' long by 6' wide. Along the centerline of the court, there will be three round baskets: one in the center, one with its centerline 15" from the left edge and one with its centerline 15" from the right edge, each with rims that have openings that are 12" in diameter, at a height of 18" from the courts playing surface. The baskets will be mounted in one large backboard that spans the width of the court, measuring 30 high by 6 wide, which also serves to divide the baskets into two halves down the half-court

line. A small circular infrared beacon will be placed directly below each basket, at a height of 6' above the court surface. Around the perimeter of the court, a protective border will be installed. This will serve to clearly demarcate the in-bounds area, and to ensure that Bots are not able to navigate off the edges of the court. The borders will be constructed of boards measuring 3/4" wide by 5 1/2" high. At no time during play may a Bot cross the half-court line. A length of non-reflective black tape will be placed down the central longitudinal axis of each side of the court. Perpendicular to these strips of tape, two additional lengths of tape will be added: the first will be 24" from the backboard at the center-court line, and the second will be 48" from the backboard. Both will span the width of the court. 6" lengths of tape will be located directly in front of the two side baskets on both perpendicular tape lines. The competition court board will be on display in the mechatronics laboratory, ETC 3.148, starting from the second week of class.

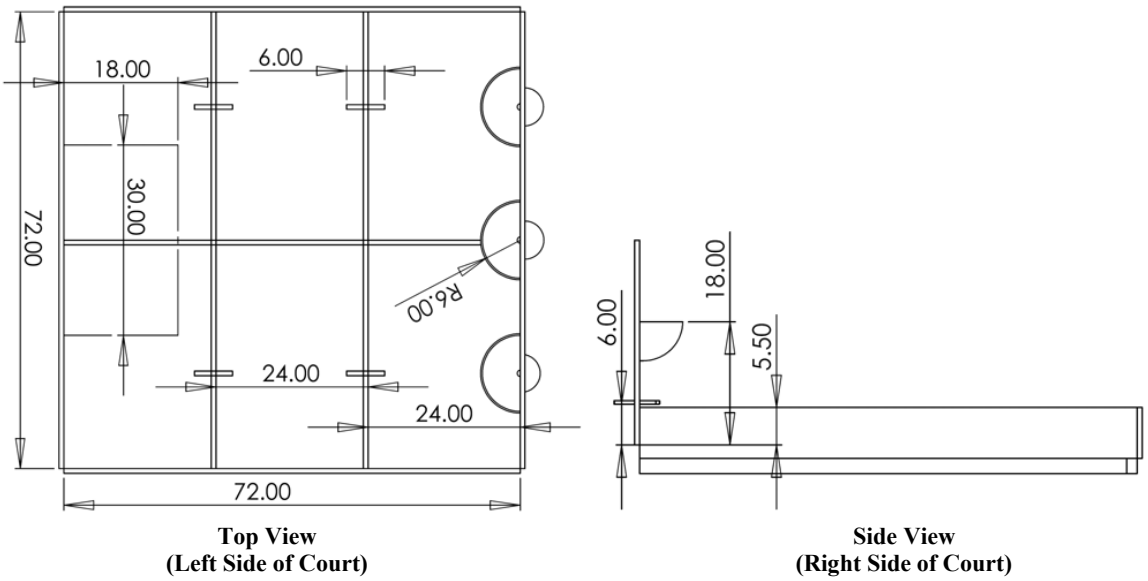


Figure 2: One Side of Competition Board

## II. Robot Requirements and Competition Specifications

Each Bot must be a stand-alone entity, capable of meeting all requirements.

- Each Bot must operate completely un-tethered during grading and competition. Power must be supplied by batteries, which are to be carried on-board each Bot. Each robot must consist of the basic robotic chassis (Romi), but students may request to build the entire robot from scratch (no other premade kits are allowed). There is a possibility of loaning out a limited supply of rechargeable battery packs and additional motors to students who request them. Beyond these items, majority of the robotic system and, in particular, the shooting mechanism, needs to be an original design from the student creating the robot (e.g., off the shelf robotic arms can not be used - the mechanism must be designed and built from scratch).

- At the beginning of each game, the Bots will be loaded with 10 foam balls. Each student may obtain 1-2 balls from the lab or will be provided with a link to purchase their own (golf-ball sized foam balls). Bots will be placed somewhere inside the boundaries of the Start Zones in a random orientation. Bots will be placed so that they are entirely inside the boundaries of the start zones. A start command will be issued, at which time the instructor facilitating the competition will initiate the activities of the Bots. This is the last human interaction allowed with the Bots.
- In a randomly-selected order and one at a time, a basket will become "Active," and will remain Active until a ball is successfully shot into it by either player. When a basket is Active, the beacon beneath it will be enabled, and will modulate infrared light at a frequency of 56 kHz. When Active, the beacons will be visible (to sensors capable of detecting IR light such as old digital cameras) from all points on both sides of the court. There will also be an indication of which basket is Active that will be visible to spectators. When a basket becomes Inactive, the beacon below it will stop modulating, and another basket will be randomly selected to become Active.
- Both Bots begin each game with an initial score of 0 points. Bots score 1 point by successfully shooting a ball into a basket that is Active. No points will be lost for missed shots. To constitute a valid shot, a ball must be completely released by a Bot and stay in the basket. The balls may not be modified in any way, aside from the normal deformations that result in handling and shooting. A Bots score is the sum of the points of all of their shots during a game. The game will end when the first Bot has shot the last of its 10 balls, or when 2 minutes have elapsed, whichever occurs first.
- Each Bot is required to occupy a volume not to exceed 13" x 13" in horizontal dimensions and 17" in height when initiated. Your machine must contain its complete supply of balls to be used during the game (no reloading). Bots may navigate anywhere on their half of the Bevo Madness Court (as determined by which Starting Zone they occupy at the beginning of a game). Bots may not navigate onto the other side of the court, and must never break the plane of the court centerline, as delineated by the backboard. Bots may touch the baskets during play; however, any Bot that touches a basket with enough force to visibly move or damage a basket or beacon will be disqualified.
- For the purposes of grading, the minimum requirement for each Bot is to be able to shoot a ball into each of the three baskets, when they are Active and not facing another opponent, on operational check-off day. The results of the tournament will not affect grading; however, only competition winners will receive a small prize.
- Once your robot has been activated, the operator may not touch it until the entire game is complete. During operation, the machine is required to stay within the boundaries of the Bevo Madness Court.
- A report describing the technical details of the machine will be required. The report should be of sufficient detail that a person skilled at the level of ME 348/392 could understand, reproduce, and modify the design.

- All robots must be safe to the user, lab, and spectators. Excessively high-velocity ball discharge is discouraged. No other projectiles may be used other than those provided. All projects must respect the spirit of the rules, as established by these requirements. If you are considering something that may violate them, you must consult with a member of the teaching staff.

## III. Deliverables

The project will compose 35% of your course grade and has the following major deliverables:

- *Project Concepts Video (10%)*
  Your team will submit a video outlining your proposed project in Week 3 (see syllabus for dates). The video should be no more than 10 min in length and should include: (1) a morphological chart showing required functions and features of your robot, and potential solutions, (2) in-depth description of three initial shooting mechanisms that you brainstormed - including hand drawings, list of motors and sensors needed for each, etc., (3) discussion of how these three options were evaluated (e.g., pros and cons) and which of the three options will be selected for the final design, (4) a timeline and list of milestones that need to be achieved to ensure project success must also be included *(identify how the work will be broken up between team members - don't just put one person in charge of hardware, software etc.)*. You must also include (5) a SWOT analysis anticipating any potential challenges for your team relative to your existing strengths. The document will be evaluated on content, the appropriateness of the solution, as well as innovative hardware and software and use of physical principles in the solution.
- *Critical Design Review Presentation (10%)*
  You will present your design in class during a Critical Design Review in Week 8 (see syllabus for dates). Presentations will be 8 min + 2 min questions (duration is tentative, will depend on final enrollment) and will be presented live during class. The design review must include: (1) a focused discussion on your shooting mechanism design, including CAD drawings, information about motors used and how they will be controlled as well as a high level state machine diagram, pseudocode, and a show-and-tell of the current state of the robotic system (2) a discussion of how elements of the design changed or any challenges that needed to be overcome, (3) a bill of materials and estimated cost, (4) a progress report on the timeline and milestones presented in the concept presentation, (5) an evaluation of what design elements are on a critical path and a discussion of any issues to date with implementation. The presentation will need to be created in powerpoint and will be graded on the quality of the presentation, the completeness and maturity of the design, and clarity of delivery.
- *Demonstration of Operation (25 %)*
  You will need to demonstrate operation of a completely functional robot, in lab, on or before the posted checkpoint date, during the open lab time. Additional checkpoints include: shooting mechanism (week 9), feeder mechanism (week 11), and navigation system (week 13). Grading will be based on operation, as outlined in the Canvas assignments for each checkpoint, as well as craftsmanship and

finished appearance of the robot. You must do a live demonstration for the instructor to also enable online discussion about any issues you are facing or potential concerns. If any team can't make the deliverable date, there might be a possibility to accept a video for full credit within 24 hours of the deadline.

- *Team Check-ins and Progress Presentation (15 %)*
  In Week 10 you will meet as a group with the teaching team after first submitting a reflection on your team's individual efforts and dynamics. Then in Week 12 your team will present to the class your current progress and updates.
- *Competition Day (10%)*
  You will need to compete your robot in the Bevo Madness Competition on **TBD in ETC (Time TBD as well)**. The competition will be live-streamed and open to the public. It will also evaluated by a group of impartial judges. Students with the winning robot will win a small prize. The grade for this deliverable will be based on attendance at the competition.
- *Final Report (30%)*
  You will need to submit a final report on Canvas by course final exam time. A guideline for the report format and a grading rubric will be provided. The report will be graded on completeness, clarity, correctness, and appearance.

## IV. Available Materials and Resources

- Romi Chassis, drive motors and wheels, line follower and bump sensors (must be returned after the competition).
- Raspberry Pi, A-Star Motor Controller, MyParts kits, 9V rechargeable batteries or a power bank, foam golf balls, DC and stepper motors, to sign out (Note: If you would like to solder a part to a perf board, you must let the instructor know in advance.)
- ETC 3.148 Advanced Mechatronics Lab - work benches, multimeters, oscilloscopes, storage options. Access possible during office hours and by appointment.
- Texas Inventionworks - see website for covid updates.
- Online Electronics Stores: Sparkfun, Adafruit, Digikey, Mouser, Newark, Allied Electronics

You will need to purchase any additional that components you would like for your project. All borrowed items must be returned in the original box for a course grade to be assigned.