**Rules for**

# "Polyathlon"

**Version 151021 Released**

**Object of the game:** What is a polyathlon?

Polyathlon is a series of contests or events similar to the athletic decathlon where robots compete to determine the best over all performers. Each contest will be scored based on performance and then the scores totaled to determine the over all winner. The number of contests in our polyathlon may change each year. Contests are designed and selected to have conflicting optimization parameters. For example finding and pushing targets favors a wide robot but avoiding obstacles favors a narrow robot.

Each contest is fairly simple so that everyone has a chance to compete. A robot need not compete in every contest but will get zero points for contests not entered.

All of the contests in polyathlon are individual events. That is to say individually timed and measured, as opposed to head to head matches.

## General rules

### I. Robots

1) Robot Size: Bots must initially fit inside a 12x12 inch square or 14 inch circle. . After starting, the robot may expand, but only to the extent the robot would fit in an 18 inch diameter circle. The robot's height will be limited at all times to 18 inches.
2) Weight limit – 20 lbs.
3) Swarm bots are or other multiple bots NOT permitted.
4) Bots may be deemed unsafe and subject to disqualification by judges before starting or during the event.
5) Bots may not deposit anything on any playing surface. Bots may not mark the playing surface with any substance such as ink or paint.

### II. Hardware and Software:

1) Robot hardware design is fixed and cannot be changed between contests. You may not add or subtract mechanical components. Robots may extend arms, shift sensor positions or change shape using actuators after starting. The robot hardware may also be adjusted manually in a 15 second window before starting. For example, manually shifting the position of a sensor or arm is OK if it takes less than 15 seconds and can be done at the starting position.
2) Software can be changed between contests. This may be done by switches, jumpers, changing memory modules or by downloading new software.
3) The robot's "brain" must be contained on the robot. Links to remote computers are only allowed for the downloading of new software before a contest and for telemetry from the robot.
4) Data may not be sent to the robot during a contest. Remote stop and start signals are permitted as they enhance safety.

## III. Sequencing of contests

1) The contests will be conducted one at a time. For example, all contestants will complete simple line following before starting advanced line following. The judges will determine the event sequence and announce it prior to the start of the Polyathlon.

2) Contestants will be allowed 2 or 3 attempts to complete a contest depending on time available. The best score will be used. Each contestant will do a single run. After everyone has completed his or her first run the second round will begin and then the 3rd if time is available.

   Sequence Example:

   Simple Line Following: Bot1, Bot2, Bot3, Bot1, Bot2, Bot3
   Advanced Line Following: Bot1, Bot2, Bot3, Bot1, Bot2, Bot3
   Etc.

3) The time between attempts cannot be determined in advance. It will depend on the number of competitors and the time they take to complete each contest run. The judges may set a minimum time and/or maximum time that a competitor has to prepare between runs. The judges have the right to assess penalties and/or assign a DNF for a round to competitors that are not ready to run in a timely manner.

IV. **Obstacles and Targets:** Some polyathlon contests use obstacles and or targets.

1) These objects will be constructed from 3" schedule 40 PVC drain pipe, cut to 3.5" long.

2) Bear in mind that 3" pipe has an actual diameter of 3.5" and schedule 40 denotes a wall thickness of 0.216". Drain pipe is cellular. (foamed core with smooth walls) (This is the most commonly available pipe in this size.)

3) Objects will have all edges deburred.

4) No attempt will be made to remove maker's marks/labels from the pipe

5) In the interest of promoting the use of various vision systems on robots, it shall be permitted for a contestant to provide colored covers for obstacles.

   A. The covers shall be at least 1/8" shorter than the obstacles.

   B. The covers shall be no thicker than 0.020"

   C. Any color may be used.

## V. Contests:

### 1) Basic Line Follower

A. **Goal:** Complete the course faster than your opponents.

B. **The course** will be a simple oval with turn radius no less than 6 inches. The "line" is 3/4 inch black electrical tape on a white surface. Lines will be at least 8 inches from the edge.

C. A time limit of 90 seconds will be imposed. Failure to complete the course within 90 seconds will result in a score of zero.

D. Human help is permitted in Basic Line Follower. A contestant or assistant may

help a wandering robot back to the line. The robot may not be manually advanced along the track. A 5 second penalty will be assessed for each assist.

E. If the course is short then the judges may elect to have the robots traverse 2 or more laps.

**2) Advanced Line Follower**

A. **Goal**: Complete the course faster than your opponents.

B. **The Course** will have intersecting lines and 90 degree turns. Non-intersecting lines will be spaced apart greater than 8 inches. Intersections will be 90 degrees. Intersections shall have at least 10" inches of straight run leading to and from the crossing.. The "line" is 3/4 inch black electrical tape on a white surface. Lines will be at least 8 inches from edge.

C. A time limit of 90 seconds will be imposed. Failure to complete the course within 90 seconds will result in a score of zero.

D. Human help is NOT permitted in Advanced Line Follower.

E. A Robot that loses the line and regains it may continue. A robot that reverses direction will be considered as not finishing.

3) **Beacon Killer**

A. **Goal**: Travel 10 feet to make contact with a beacon from a random start orientation in the least time.

B. **Beacon**: Contestant may use the club's Cube Quest polarized white light beacon. (See Autonomous Cube Quest Rules for details.) Alternately the contestant may supply his own beacon. Beacons shall fit in a 12" square. (Stands and holders excluded)

C. **The Arena**:

i. A Starting box 18" square.

ii. A beacon box 12" square shall be 10 feet distant (edge to edge)

iii. Overall size of the contest area will be determined by the judges. This will be based on the area available at the venue. There will be at least 3 feet of arena area beyond the beacon to allow robots to turn if needed. Also there will be at least 2 feet of arena area behind the Starting box. Thus a length of 17.5 feet is the minimum. It is permitted that the arena be bounded by a wall or walls

D. **Robot Starting Placement**: Robot will be placed 10 feet from beacon pointed in a starting direction set by the judges. The starting direction will be at least 70 degrees from the beacon direction. All contestants will be placed in the same direction for each attempt.

E. **Revealing of Start Direction**: The Judges will not reveal the Starting direction until all contestants are ready.

F. **Second and Third Rounds**: The judges will select a new start direction for each round of attempts.

G. **Changes to code or settings** are not allowed after the starting direction for any given round has been revealed.

H. **Timing:** Robots will have a 5 second delayed start. Time starts when robot starts moving and ends when it touches the beacon. Robots have a maximum of 60 seconds to complete this task. . Failure to complete the course within the allotted time will result in a score of zero.

**4) Beacon Killer with obstacles**

A. **Goal**: Travel 10 feet to make contact with a beacon from a random start orientation in the least time without moving obstacles (much). A time penalty will be imposed for each obstacle moved too far.

B. **Beacon**: - **The Arena - Robot Starting Placement**: - **Revealing of Start Direction - Changes to code or settings**: These rules are the same as above

C. **Second and Third Rounds**: The judges will select a new start direction for each round of attempts. Additionally the judges must relocate at least one obstacle for each round of attempts. It is the Judge's option to reveal or conceal obstacle locations prior to the start of a round.

D. **Obstacles:** Five to twenty objects will be placed in the arena between the robot and the beacon.

i. Obstacles will be at least 2 feet apart, edge to edge.

ii. Extra obstacles may or may not be placed behind the beacon.

iii. Obstacles will be placed no closer than 2 feet from the beacon location.

iv. The Obstacles will as described above.

v. The position of each object will be marked with a small marker such as tape. Markers will be designed to allow the judges to determine if and how far an obstacle has been moved.

E. **Timing and Scoring:**

i. Robots will have a 5 second delayed start. Time starts when robot starts moving and ends when it touches the beacon.

ii. A 10 second time penalty will be applied for every obstacle moved by the robot more than 1/4 inch.

iii. Robots have a maximum of 90 seconds to complete this task. Failure to complete the course within the allotted time will result in a score of zero.

**5) Navigation by dead reckoning**

A. **Goal**: Travel from a Start/Finish line to 3 waypoints in the appropriate order and return to the Start/Finish line in the minimum time. To succeed, the robot must accurately measure distance traveled and angle of turns and do so quickly.

B. **The Course**: (see diagram in Apendix.)

i. The committee shall provide the running surface. It shall be smooth and uniform. For example foam core panels.

ii. The running surface shall extend at least 16.5” outside the center of each waypoint and at least 18” behind the start finish line.

iii. The start / finish line is 10 inches wide, two pylons are located in line with the finish line

iv. A second pair of pylons are located 13 inches in front of the start finish line. They are also spaced at least 16" apart. (These are used for the timing system.)

v. The First waypoint is centered 2 feet in front of the start / finish line.

vi. The 3 waypoints are centered at the vertices of an equilateral triangle where each side of the triangle is 3 feet. The far side of the triangle shall be parallel to the start / finish line

vii. The waypoints are marked on the running surface in a light color such as a yellow marker.

C. **Robots:** In addition to the general rules above, it is prohibited to use external beacons or optical references such as fiducials for dead reckoning. It is prohibited to attempt to detect the markings on the floor. The use of an IMU is permitted including measurements of the Earth's magnetic field. The use of optical means to measure relative changes in the robots postion is permitted, provided the sensor only views the floor directly beneath the robot.

D. **Running:**

i. The robot must start behind the Start/Finish line. The time will begin as soon as any portion of the robot crosses the Start/Finish line. The robot then attempts to traverse the course.

ii. The robot must first proceed to the waypoint closest to the start line. The robot has reached a waypoint when any portion of the robot is located directly above any portion of the waypoint.

iii. The robot must next proceed to each of the far waypoints in any order.

iv. After navigating to each of the far waypoints, the robot must again pass over the waypoint closest to the Start/Finish line then proceed to the Start/Finish line.

v. The time is stopped once any portion of the robot crosses over any portion of the Start/Finish line without hitting the pylons.

**E. Scoring:** The robot which traverses all waypoints and returns to the finish line in the least time will prevail. The maximum time allowed to run the course shall be 90 seconds. A robot’s final score may exceed 90 seconds if penalties are assessed. A robot which hits a pylon or does not return to the finish line will not receive a score. A competitor who removes their robot from the course before the 90 seconds has completed will not receive a score. A penalty of 30 seconds will be assessed for each waypoint that the robot fails to reach. The judges will make the final determination whether a robot has reached a waypoint, crossed

the finish line, or contacted a pylon.

**6) Bulldozer**

A. **Goal**: Push 5 objects off of the playing surface in the least time without driving off the edge.

B. **The Playing Surface** will be a table approximately 38" X 72". Table height is between 4.5" and 5.5". The table is provided by AHRC. The table surface is "Thrifty White 32 sq. ft. Hardboard Panel Board" (available at Home Depot at this writing as Store SKU # 346428). There will be no lines added to mark the table edges. Robots must detect the drop-off to avoid falling off. Robots may use optical, mechanical, sonar or other sensors to detect the edge. A line that is 18 inches from the end of the table defines the starting zone. There will be markings on the table for the starting zone and for the target positions. The preferred marking tape is Tartan 5142 (available at Home Depot at this writing) If the preferred tape is not available a light colored substitute may be used.

C. The Target Objects will as described above.

D. Judges will determine the placement of the Target Objects. Target Objects will be placed standing on end. No Target Objects shall be in the starting zone. Locations shall be marked so that for a given round the target objects are placed the same for each contestant.

E. **Second and Third Rounds**: The judges must relocate at least one obstacle for each round of attempts. It is the Judge's option to reveal or conceal obstacle locations prior to the start of a round.

F. **Starting:** Robots may be placed anywhere in the starting zone. Robots must be oriented at least 90 degrees from the direction of the Target Zone.

G. **Scoring and Timing -** Time Starts when the robot crosses the starting line. Time stops when all objects are pushed off. Robots have a maximum of 90 seconds to complete this task. If a robot runs off the table before pushing off all objects the time defaults to 90 seconds. A time penalty of 10 seconds is imposed for each object left on the table after time expires or the robot falls off.

## VI. Rules Violations, Protests, Appeals and Judges Decisions:

1) The principles of good sportsmanship shall govern the conduct of all participants and officials.
2) Any contestant may protest an alleged violation of these rules by citing the specific line in the current released version of the rules. Any judge may make a determination on a protest.
3) A judgement is made against a contestant may be appealed to the head judge.
4) The determination of the head judge shall be final.

by Dale Heatherington

Individual events are scored on time and/or distance with some events adding time penalties for moving obstacles or missing goal objects. The scoring formulas are designed to equally weight all events and are normalized to the best score in each event. 100 points are awarded to the best performer in each event while the lesser performers will get a proportionally lower score. Failure to compete in an event yields a score of zero in that event. Failure to execute a task can also generate a zero score. For example, a line follower fails to complete a full lap.

If a bot is the only bot competing in an event it will receive a score of 100 if it properly executes the task. If the judges determine it failed to complete the task ( beacon finder completely misses the beacon) they may award zero points instead.

When all events are complete each contestants over all score is computed by totaling the event scores and dividing by the number of events.

**Here are the formulas for each event.**

“Fastest time” is the lowest time recorded for everyone competing in the event. ie: First place.

“Time” is the recorded time of the contestant.

**Basic line follower**
score = 100 * fastest time / time

**Advanced line follower**
score = 100 * fastest time / time

**Beacon Killer**
score = 100 * fastest time / time

**Beacon Killer plus obstacles**
time = time + penalties.
Penalty = 10 seconds per obstacle moved
Score = 100 * fastest time / time

**Navigation by dead reckoning**
Distance can be any units, inches, mm, cm etc.
Score = 100 * least distance / distance
(Time will be recorded to break ties)

**Bulldozer**
Penalty is 10 seconds for each target not pushed off before time expires.
Score = 100 * fastest time / time

---

**Examples**

Line follower.

Bot 1 = 7 seconds Score = 100 * 7 / 7 = 100
Bot 2 = 12 seconds Score = 100 * 7 / 12 = 58.3
Bot 3 = 14 seconds Score = 100 * 7 / 14 = 50

Beacon Killer plus obstacles.

Bot 1 = 4 seconds + 10s penalty = 14 Score = 100 * 14 / 14 = 100
Bot 2 = 15 seconds + 0 penalty = 15 Score = 100 * 14 / 15 = 93.33
Bot 3 = 12 seconds + 20s penalty = 32 Score = 100 * 14 / 32 = 43.75

Bulldozer

Bot 1 pushes off 3 targets then drives himself off after 20 seconds. Max time imposed, 90 sec.
Bot 2 pushes off all targets in 30 seconds
Bot 3 pushes off 4 targets before time expires at 90 seconds

Bot 1 = 90 seconds + 2x10 penalty(90+20=110) Score = 100 * 30 / 110 = 27.27
Bot 2 = 30 seconds Score = 100 * 30 / 30 = 100
Bot 3 = 90 seconds + 10 penalty (90 + 10 = 100) Score = 100 * 30 / 100 = 30

Final Scores

If these 3 events were all we had, the final scores could be computed.

| Bot Name | Line Follower | Beacon Killer | Bulldozer | Total | Average |
|---|---|---|---|---|---|
| Bot 1 | 100 | 100 | 27.27 | 227.27 | 75.75 |
| Bot 2 | 58.3 | 93.33 | 100 | 251.63 | 83.87 |
| Bot 3 | 50 | 43.75 | 30 | 123.75 | 41.25 |

---

**Procedures for Rules Revisions & Release:**

- For ease on maintenance using various system, Rules are to be maintained in *.doc form (not *.docx)
- A version heading shall be at the top of the rules in the format "Version YYMMDD Type" where Type is either Released or Draft
- After the Rules committee has approved the Draft rules they are published as "Released".
- Rules shall be published as a PDF (Various free programs such as PDF forge act as printer drivers to create PDF files.)
- Rules committee shall submit released rules to the club webmaster for publishing
- Revision notes indicating changes shall be kept as part of the rules (below)

Revision Notes:

- 141023 changed 5.f.1 and 5.f.2 Bulldozer playing surface.
- 150920 added Procedures for Rules Revisions & Release
- 151020 change outlining method. Added Protest Procedure. Changed Navigation rules

**Appendix:**