IEEE Ottawa Robotics Competition
Compétition de robotique d'Ottawa d'IEEE

Green Arm Challenge

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Disclaimer

It is your responsibility to read and understand this document on a regular basis because we may update it from time to time.

If you have questions, please contact our Arduino Team at orcarduino@gmail.com.

Green Arm Challenge

We only have one Earth and much of the waste in our world is the result of our never-ending production of goods. There will likely be a day where we have no place to store our garbage.

Recycling helps give the materials a second life. Thus, instead of drawing up on limited resources from our environment, we should focus on reducing, reusing, and recycling. However, sometimes it is hard to do so because we don’t know how to properly recycle.

Your task in the Green Arm Challenge is to program an arm that will quickly and accurately sort recyclable materials from a pile of garbage.

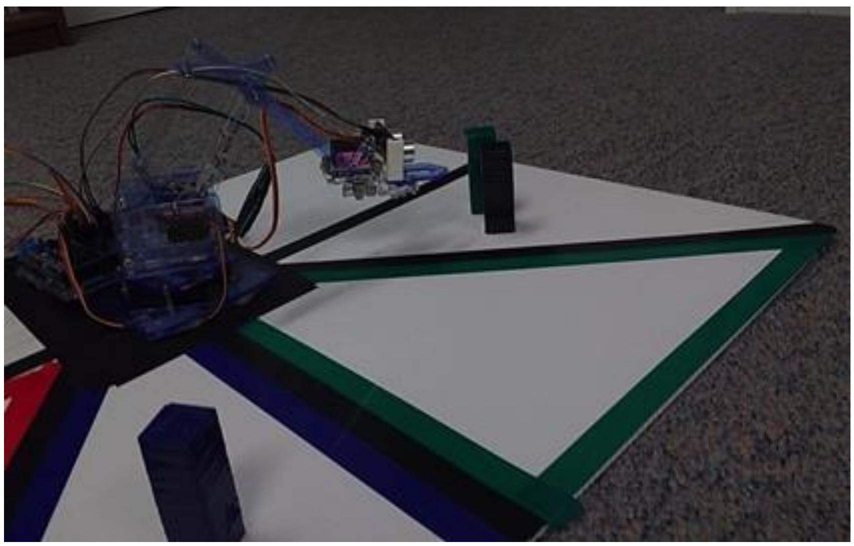


Figure 1 : Green Arm in Operation

Challenge Rules

Trucks deliver 4 types of material to the loading dock in bins: garbage (black), plastic (blue), paper (green) and metal (red). Once delivered, you need to sort the recyclables on to the matching conveyor belt. The black bins will remain the loading dock. Judges will ensure no bins are placed behind the unmoving black bins; however, other bins may be placed behind each other.

The bins will be one inch by one inch and four inches tall. They will be covered with multicoloured electrical tape of the respective bin colour. The top of the bin will be covered with the bonus objective symbol (in black and white), even for teams not attempting the bonus objective.

The conveyors are arranged in a semicircle around the robot and each conveyor (including the loading dock) is 45 degrees. The robot will be positioned so it can reach each conveyor.

1. You must submit a fully-costed BOM to orcarduino@gmail.com by **11:59 pm on May 17th**. Your arm will be inspected on competition day.

2. Your robot will be placed in an area where it can reach all the conveyors.

3. Time will start when the team captain starts the robot.

4. Time will stop when all the recyclables have been placed.

5. After the robot starts, it cannot be touched. Touching the robot will stop the test and the maximum time plus applicable penalties will be recorded.

6. The bins must be moved to the matching colour area.

7. The garbage must stay in the loading dock.

8. Time penalties apply if any bins get knocked over, are misplaced, or are placed on multiple conveyors. If any part of a bin is touching a conveyor, it is counted as in that conveyor.

9. If a bin is knocked over in the wrong conveyor, the knocking over a bin penalty will apply to all conveyors the bin is touching, and the wrong conveyor penalty will apply to all the conveyors the bin is touching that are the wrong colour.

10. You may have to move garbage bins in the loading dock to be able to reach all the recyclables.

11. There will be a maximum of 10 bins on the field.

12. The robot must come to a stop after all bins have been sorted.

13. Seventy percent (70%) of your final score for the challenge will be based on the average time it takes for your robot to sort the recyclables. Judges will also interview teams (30% of the final score).

Robot Arm

Mechanical Assembly

The selection and construction of the robot arm are the responsibility of the contestants. For the arm, we are recommending the low cost MeArm kit, as it is relatively low cost.

Figure 2 : MeArm

There are alternative arms that can be selected, such as the ROT2U.

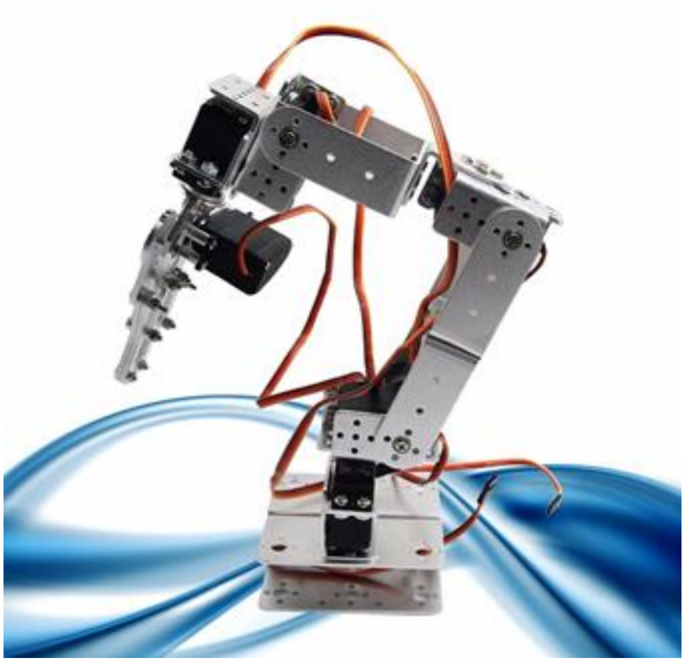


Figure 3 : ROT2U

Any robot arm that meets the specifications given in Table 1 is acceptable, including arms that are designed and built yourself. Whatever arm is selected will require modifications in order to mount the sensors. If students are familiar with CAD tools, we recommend that they design a small part with mounting holes for the sensor and the robot. For example, Figure 4 shows an ultrasonic sensor holder for a MeArm which was designed and 3D printed. Free 3D printing is available at the uOttawa Richard L'Abbé Makerspace. They also offer workshops on CAD tools and how to 3D print. Alternatively, the sensor can be glued or taped onto the arm.

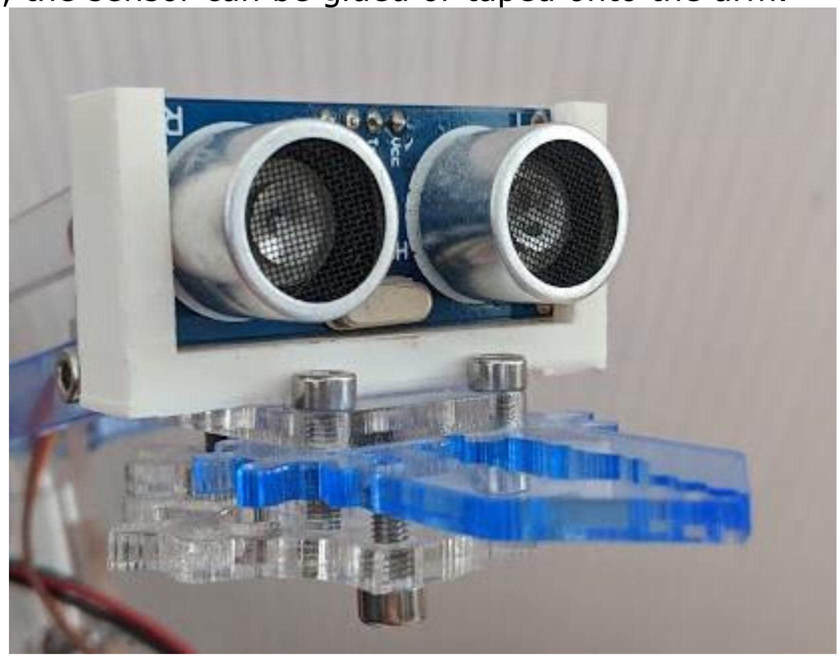


Figure 4 : Ultrasonic Sensor holder for MeArm

Suggested Purchase Locations

For the robotic arm kits, we recommend teams to order them from Banggood and/or Gearbest. For sensors and Arduinos, we recommend A2D Electronics. Students can also purchase parts from RobotShop or Ebay. Note: Purchases from Ebay can take several months to arrive but may allow you to get all the parts you need for this competition for about $50.

Sensors

From there, several sensors need to be added. A range sensor to find the blocks, and a colour sensor. Any colour sensor is acceptable, but for the range finding sensor we strongly recommend a time of flight sensor such as the VL53L0X. Other sensors such as Ultrasonic or IR Rangefinders can work but have a large detection cone that will make them harder to program.

Robotic Arm Restrictions

Table 1 : Robotic arm restrictions

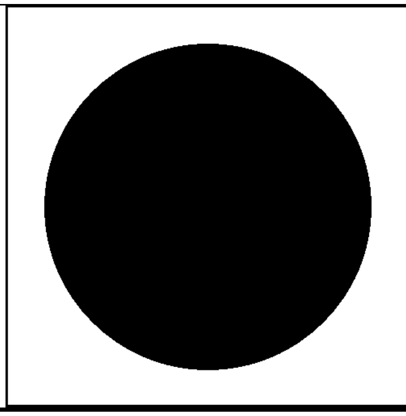
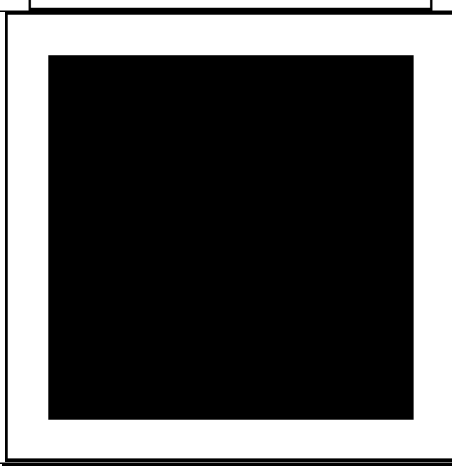
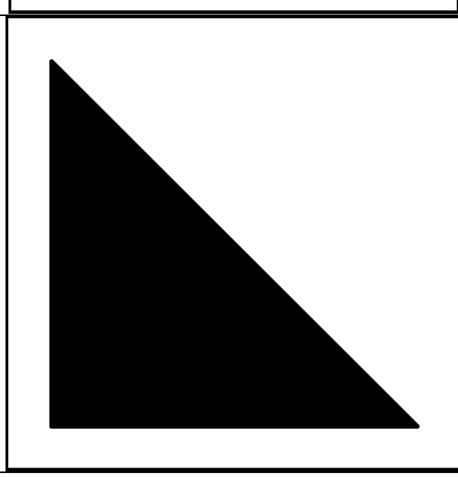
Requirement	Specification
Footprint Size	The arm's base must fit within a 150 mm by 200 mm box (overhang is allowed)
Allowed Sensors	Only sensors explicitly given in this table are allowed
Range Finding Sensor	Up to two range finding sensors of any kind are allowed. These sensors must be 1D (i.e. any kind of scanning sensor, like a LiDAR, is not allowed). Thus, these sensors will need to be mounted to a moving part of the robot.
Colour Sensor	One sensor is allowed for detecting the colour of the blocks
Bonus Objective - Camera	When performing the bonus objective, one camera is allowed to detect the symbol. The camera can also be used during the bonus round for colour detection or even finding the blocks. However, the camera will have to be remove during the normal round.
Total BOM Cost	The total cost of this arm (not excluding external items like test apparatus) must be less then $200 (CAD), including shipping. **Note:** Items must be included in the BOM, even if they were not specifically purchased for this competition.
Bonus Objective BOM Cost	Teams competing in the bonus objective may spend another $50 on parts, but they must specifically be noted as being used for the bonus objective and removed during the regular round.
Self Powered	The arm must contain batteries as no extremal cables are allowed
No wireless communication	The arm must not perform any wireless communications

Robotic arm solutions are not permitted to communicate wirelessly, and ideally the electronics should not contain any wireless devices. However, we recognize that many people (especially those performing the bonus objective) will be using a Raspberry Pi, which has a built in Wi-Fi chip. Judges will be observing the robotic arms for behaviour that looks like it is being controlled in real time, and may demand to see code or have access to your system at any time.

Bonus Objectives

The optional bonus objective will be to use a camera to recognize symbols on the top of the bin. Then, instead of sorting by colour, you will sort by symbol. All symbols will be black on a white background. The table below lists the symbols and the corresponding area they should go in.

Table 2 : Bonus objective symbols

Symbol	Area to Drop Bin in
	Green
	Blue
	Red

If you wish, you can also use the camera (or another) to locate the bins in the field. It is recommended to use either a raspberry Pi or beagle bone using the OpenCV library. A dimensioned drawing for all symbols is given in the appendix.

Contestants are expected to also have a solution for the regular challenge without a camera. The bonus and regular challenges will be judged separately.

Judging & Scoring

1. The starting placement of the bins for each round will be preselected (but not shared). Each team will have bins in the same locations per round.

2. All teams will gather at the competition area and remain there for the remainder of the round.

3. Judges will time and score your run.

4. If after 2 minutes there are still bins that need to be sorted, the robot will be stopped, and any recyclables left in the loading dock or in the robot gripper will be counted as in the wrong conveyor with penalties applied as appropriate.

5. The time penalties applied are as follows:
    a. Knocking a bin over: 10 seconds
    b. Placing a bin on the wrong conveyor: 5 seconds

6. The number of rounds will be decided on competition day based upon the available time and number of teams competing.

7. Completion time will be recorded for each round, including penalties.

8. The round that took the longest will be discarded and not considered for judging. This is to prevent a single bad run involving the accidental knocking over of several bins from disproportionately affecting your team's score.

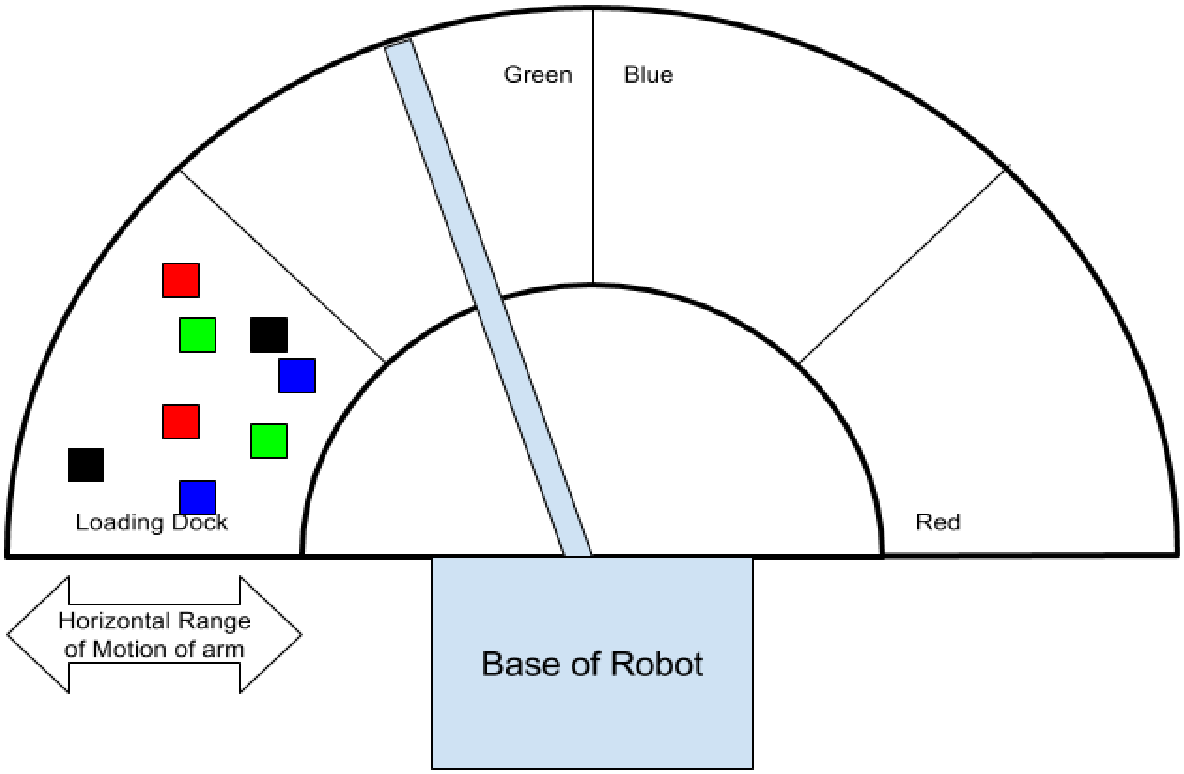
9. The winner of the Challenge will be determined by your robot's average completion time and the mark you receive during your interview. The team with the highest combined score will be the winner of the Challenge.

10. Decisions of the judges are final.

Appendix

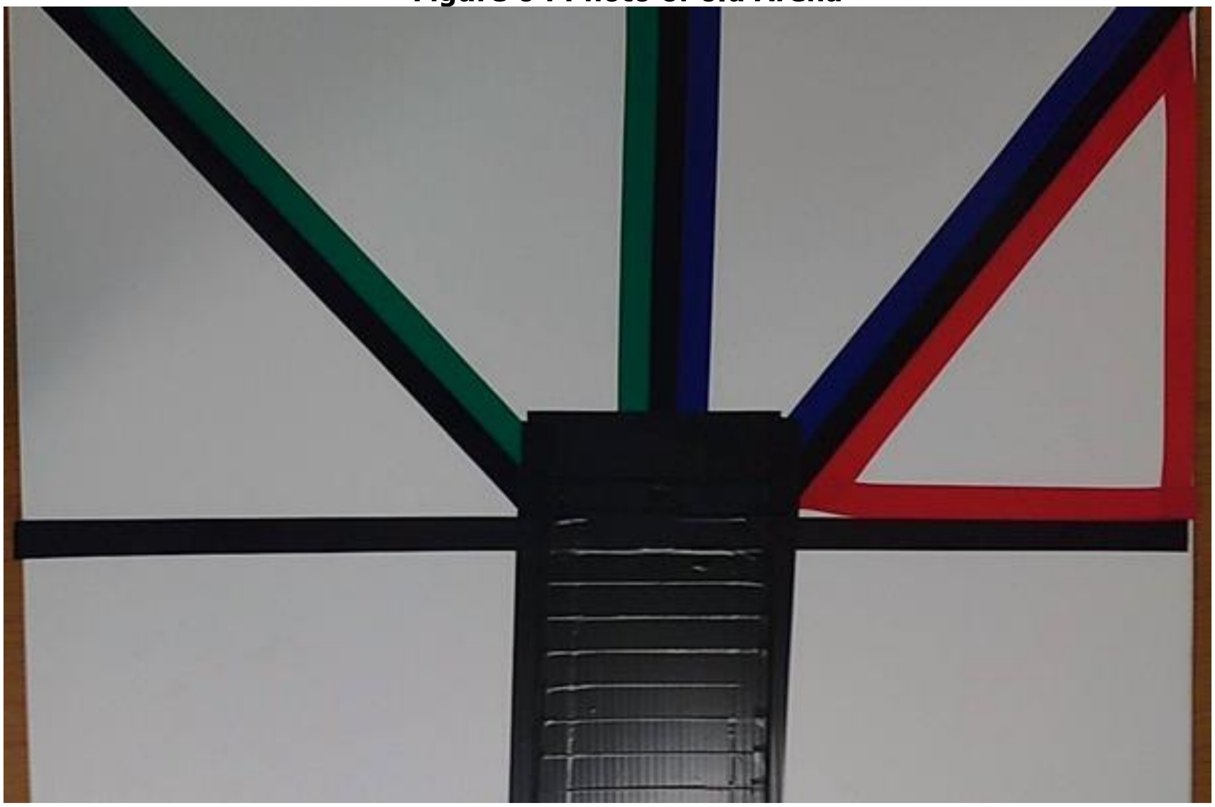
Arena Diagram

Figure 5 : Diagram of Arena



Arena Photo

Figure 6 : Photo of old Arena

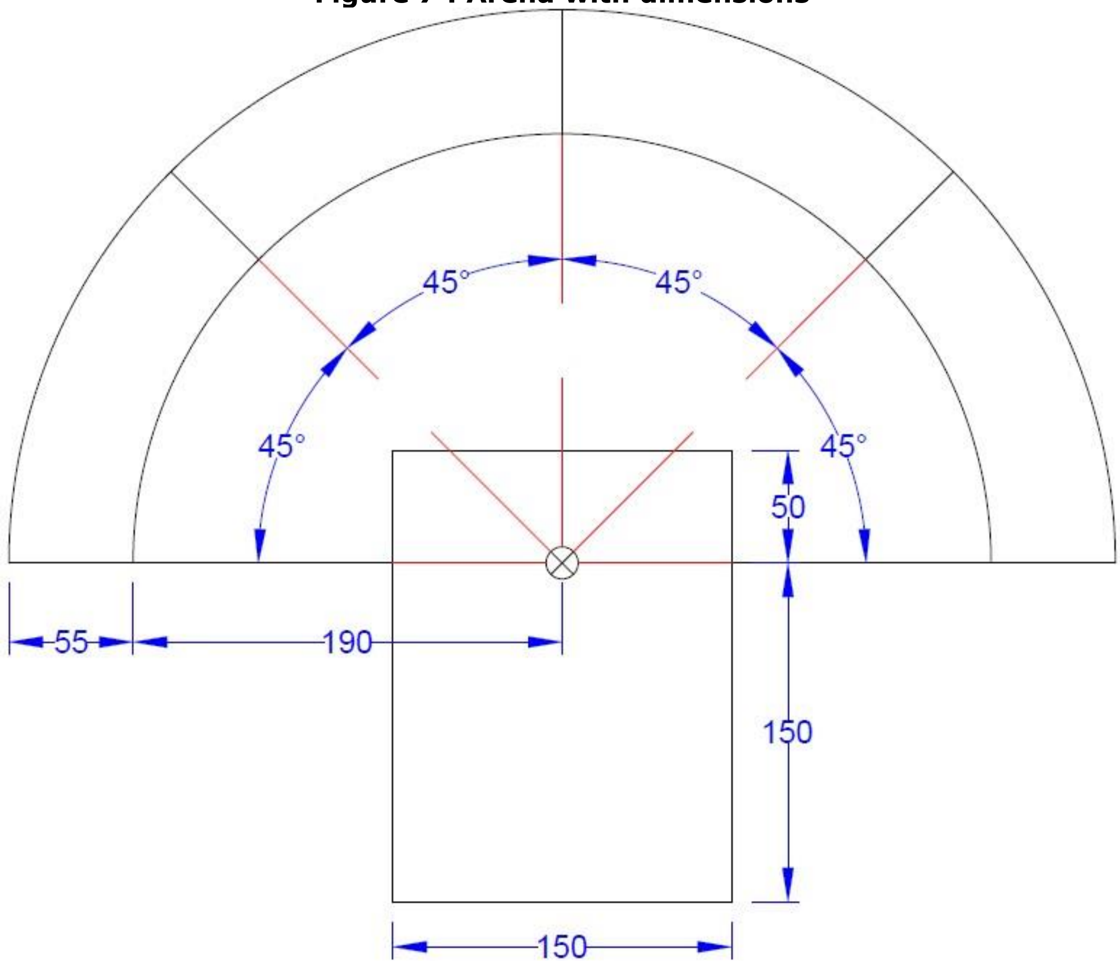


This is a photo of the old area for the green arm challenge. The main change this year will be explicit bands where the bins will be placed, and slightly revamped dimensions for more flexibility in arm selection. A video of an old challenge can be found here.

Arena Dimensioned Drawing

All units are in millimetres

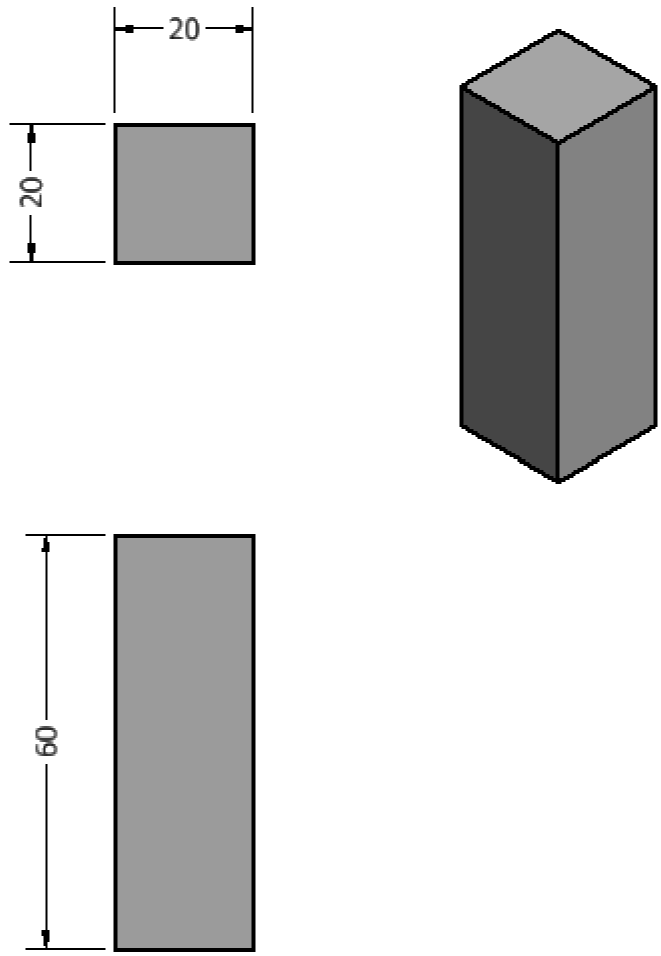
Figure 7 : Arena with dimensions



Recycling Bin Dimensioned Drawing

All units are in millimetres

Figure 8 : Recycling Bin Drawing



The bins are 3D printed and colour by using multi-colour electrical tape. It is difficult to specify the colour beyond green, blue and red so your solution should work over a reusable range of those colours. You should make it easy to adjust the thresholds, as time will be provided in the morning of competition day to adjust your robot to our exact bins in the actual lighting conditions.

The top of the bin will be covered with the black, bonus objective symbol, even for teams not competing in the bonus objective. Keep this in mind when positioning your colour sensor.

Bonus Objective Symbol Drawings

Symbols are placed on top face of bin and are a 20 mm by 20 mm printed piece of paper. This rectangle and the symbol inside will be black on a white background. All symbols are centered on the face and all units are in millimetres. Please note that dashed red lines are for dimension reference only and will not actually be printed.

Figure 9 : Bonus Objective - Circle

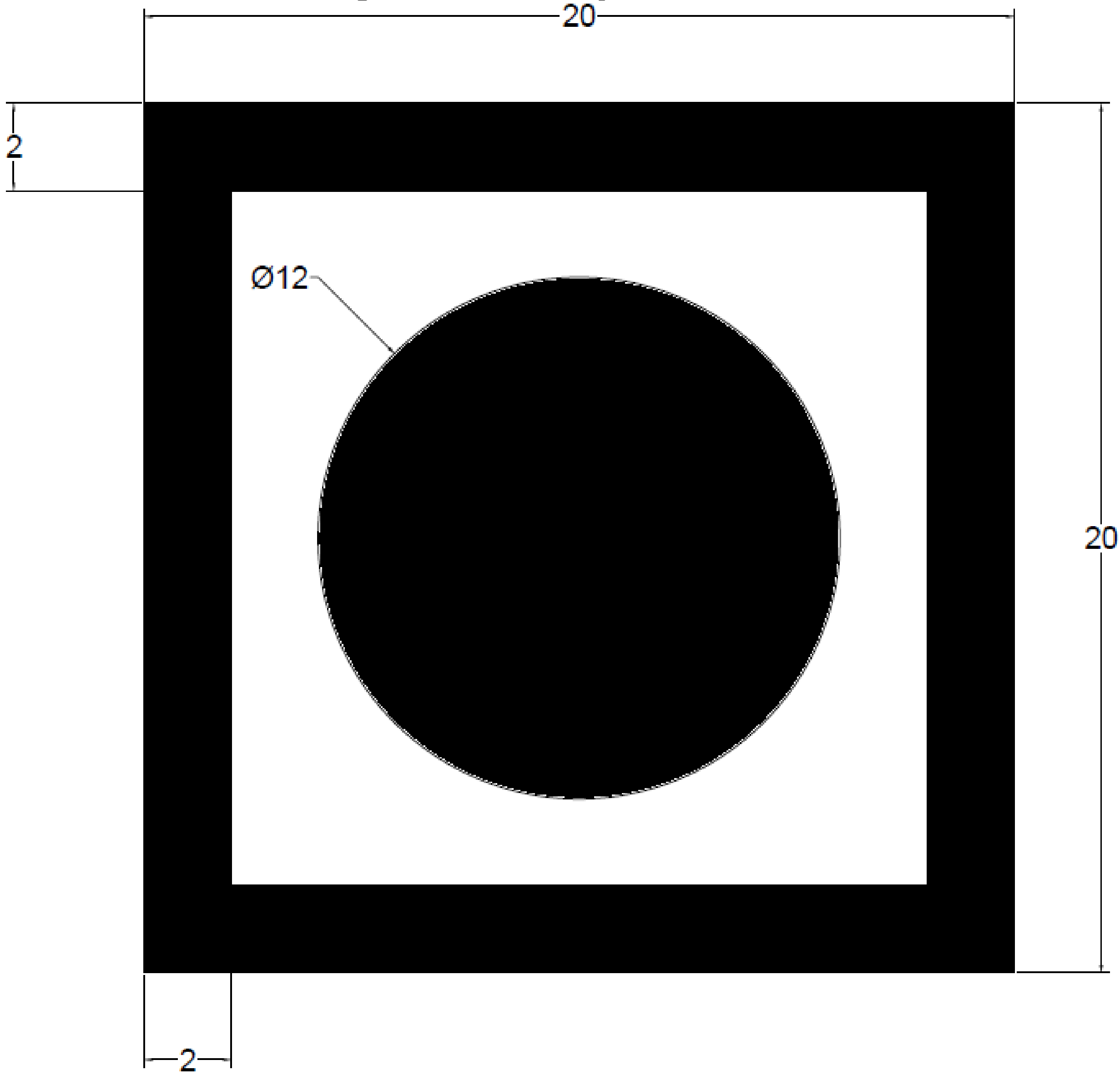


Figure 10 : Bonus Objective - Rectangle

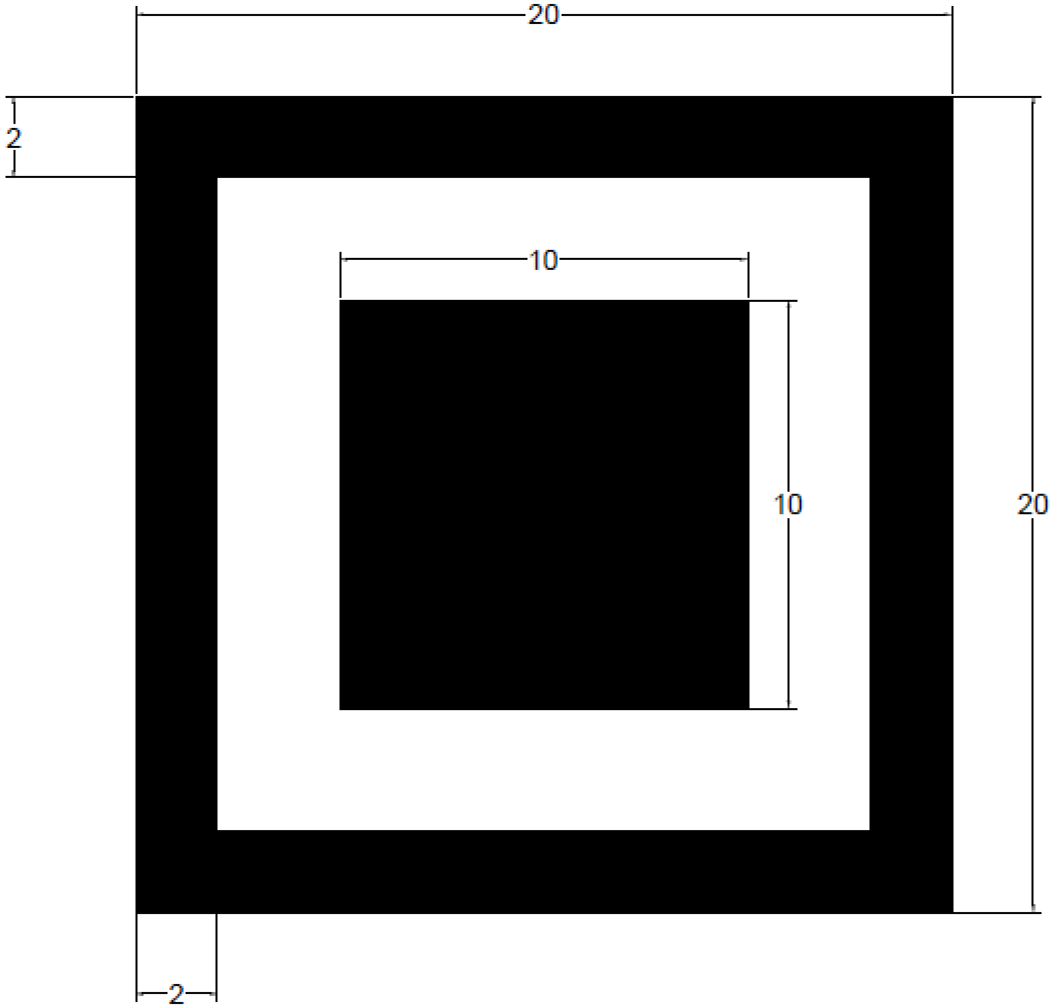


Figure 11 : Bonus Objective - Triangle