# POLLINATOR BEE

## Table of Contents

## List of Abbreviations

| | |
|---|---|
| **ROS** | **R**obot **O**perating **S**ystem |
| **P** | **Plant** |
| **RD** | **R**ed **D**aylily |
| **GC** | **G**reen **C**arnation |
| **BD** | **B**lue **D**elphinium |
| **PL** | **Plant L**ocation |

## 1. Introduction:

In order for Plants to develop fruits that carry seeds, fertilization is important. Fertilization in Plants occurs when pollen from stamens - the male reproductive organ of the flower - is rubbed off onto the stigma, or tip of the pistil - the female reproductive organ of the flower. This is the process of pollination. Bees are one of the major causes of pollination across Plants. Moving from Plant to Plant, collecting nectar and pollen, is a task that is routine yet extremely challenging, and the proficiency of bees at this is worth not only marveling but also emulating. It is due to the industriousness of bees that the world has adequate food.

In this technological era, robots can not only be used as a machine to reduce human work but may also be used for imitating the behavior of animals, insects and birds. Inspired by this, e-Yantra Robotics Competition (eYRC-2018) introduces "Pollinator Bee".

Contestants are given a drone to imitate a bee. The drone performs a task routinely performed by bees, namely going through the process of pollinating flowers, and it is henceforth referred to as the "**Pollinator Bee**". Through this theme, we help you learn control system design and controlling a drone using the Robot Operating System (ROS).

Each flower is a platform with an incomplete circuit and exposed wires. The Pollinator Bee must hover over the flower and complete the circuit. A bee stinger made of conductive material attached below the Pollinator Bee completes the circuit by causing contact between exposed terminals. LEDs on the flower light up when the contact is successful and the circuit is complete.

The challenge is to complete this task in the shortest time possible. The team that performs the task best in accordance with the rules set for this task will be declared the **WINNER**!

## 2. Theme Description:

The arena consists of the following:

- **Bee: Bee** is a drone which pollinates the flowers with a conductive material carried below it and has a WhyCon Marker on it for localization.
- **Plants (P):** These are platforms with an **open circuit and exposed terminals**. They are of 3 types:
    - **Red Daylily (RD):** This is represented by Red LED cluster in the arena.
    - **Green Carnation (GC):** This is represented by Green LED cluster in the arena.
    - **Blue Delphinium (BD):** This is represented by Blue LED cluster in the arena.
- **Plant Stem:** Plant Stem represents the height of the Plant. Plant Stem are of 3 fixed heights: 40cm, 65cm and 90cm
- **Beehive:** Starting position of the **Bee**
- The arena is a grid. Rows are referenced using Roman digits I through VII and columns are referenced using English alphabets A through G. An intersection on the grid is called Node. An example Node IIIF is shown in Figure 1.

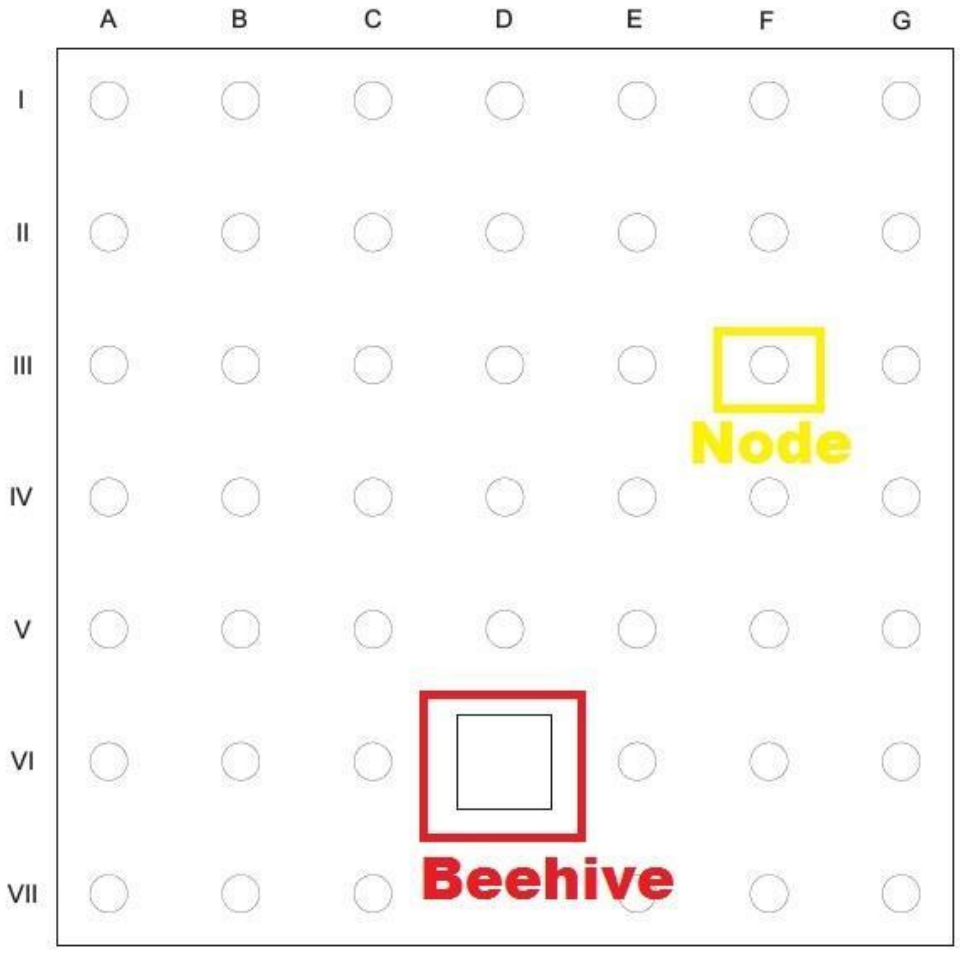


**Figure 1: Arena Design**

**A. Inputs:** The following inputs are provided:

- **Configuration Table**: This table refers to the Nodes on which Plants of specified Plant Stem will be placed on the arena.

Table 1: Configuration Table

| Node | Plant | Plant Stem |
|---|---|---|
| VIB | RD | 90cm |
| IID | RD | 40cm |
| IIF | GC | 65cm |
| IVF | BD | 65cm |

- **Array Input - Plant_location[]** : This array contains the locations of the Plants in terms of WhyCon Coordinates on the arena. Team is supposed to put the WhyCon Marker on each Plant one by one as given in the Configuration Table and store the these WhyCon Coordinates in **Plant_location[]** array.
  After storing the location of each Plant remove the WhyCon Marker from Plant.

Example: *Plant_location[] = [location of VIB, location of IID, location of IIF, location of IVF]* wherein location of VIB refers to WhyCon Coordinates of VIB and so on.

**Explanation of the given example:** The **Bee** starts at **Beehive** and visits each **Plant** as given in **Plant_location[]** in no specific order. The conductive material below the **Bee** must come in contact with the exposed terminals of the **Plant**. By doing so, the open circuit of the **Plant** is now complete and the LED cluster lights up. Using image processing the lit LED cluster will be detected and the **Bee** can move on to the next **Plant**. When all **Plants** are pollinated the **Bee** can return to the **Beehive**.

**Note:** Any Plant can be placed on any Node during the finals. All teams will receive the same configuration.

**B. Output:**

The team should show their output on the terminal after the Bee finishes pollinating all Plants in the arena by printing the following:

**Pollination Done! Pollinated 2 Red Daylily, 1 Green Carnation and 1 Blue Delphinium**

**In summary**, the following tasks have to be done:

1. Arena is set up using the Configuration Table.
2. After setting up the arena, analyze the location of the Plants in the arena by putting WhyCon markers on them. Store the WhyCon Coordinates in the **Plant_location[]** and remove the markers from the Plants.
3. The run starts as soon as the Pollinator Bee takes off. The Pollinator Bee must visit all the *n* waypoints fed into the code before the run.
4. Once the LEDs light up at a Plant by having the Pollinator Bee touch and complete the circuit, the Bee can move to the next Plant. If the Bee touches the circuit and moves to the next waypoint but the LED cluster fails to light up, pollination will **NOT** be counted.
5. Once all the Plants are visited, message as shown in the Output section above should be printed on the terminal window.

## 3. Arena:

The complete arena with the above mentioned details for this theme is depicted in Figure 1. The arena for this theme is a simplified abstraction of a garden with a Beehive and Plants placed on it. Each team has to prepare their arena. Preparing the arena consists of 6 major steps:

**A. Printing the Arena Design on a Flex Sheet:**

The arena design to be printed on a flex sheet is shown in Figure 2. A PDF file containing the arena design was already provided in Task 2. Each team should have already printed the flex design according to the directions given in the **Read Me** file given with Task 2.

**Details of arena design (Refer to Figure 2):**

- Dimensions of arena are **213 cm x 244 cm**.
- Team is not allowed to make changes in the arena design. Any team making any modification whatsoever will be disqualified from the competition.
- The arena consists of a Beehive and circles of **0.1mm** thickness representing intersecting nodes of diameter **8cm**.

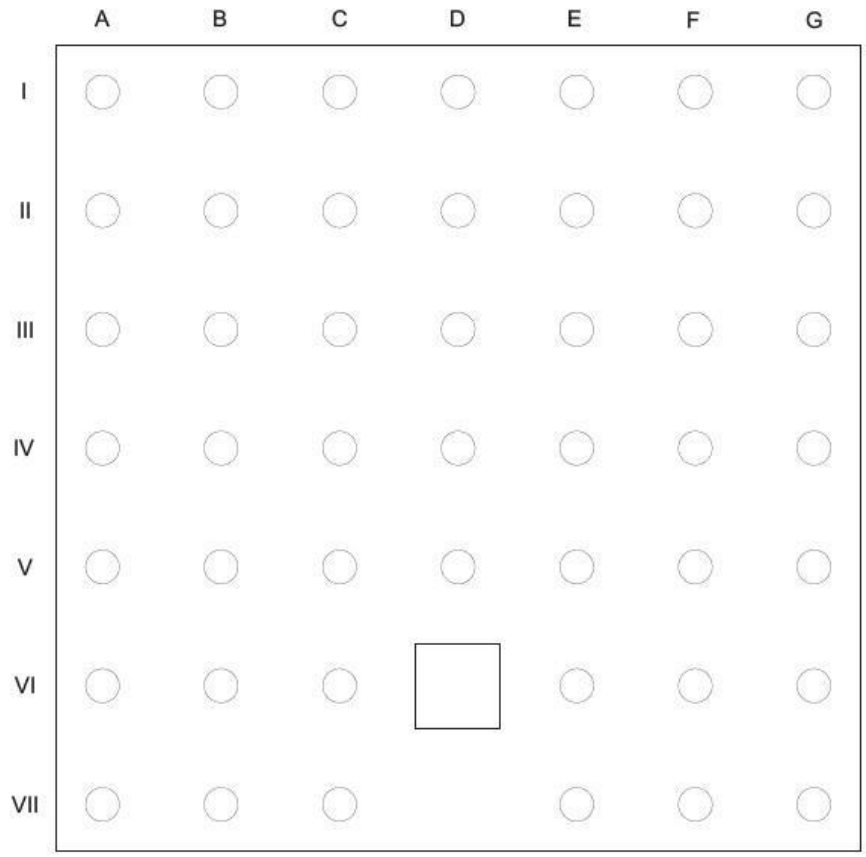


**Figure 2: Arena**

**B. Preparing the Plant:** Plant is made of Flower and Plant Stem.

**a. Preparing the Flower:** Team has to prepare 6 Flowers in total. All Flowers should fit inside dimensions of 15cm x 15cm x 15cm (length x breadth x height). Team is allowed to design their Flowers within this space. Flower consists of Flower Base and Petals. Refer Figure 3 for more information.

**b. Preparing the Flower Base:**

- Flower Base consists of a flat sun board upon which LED cluster is placed and exposed terminals or Petals will be housed.
- Flower Base must be 15cm x 15cm (length x width).

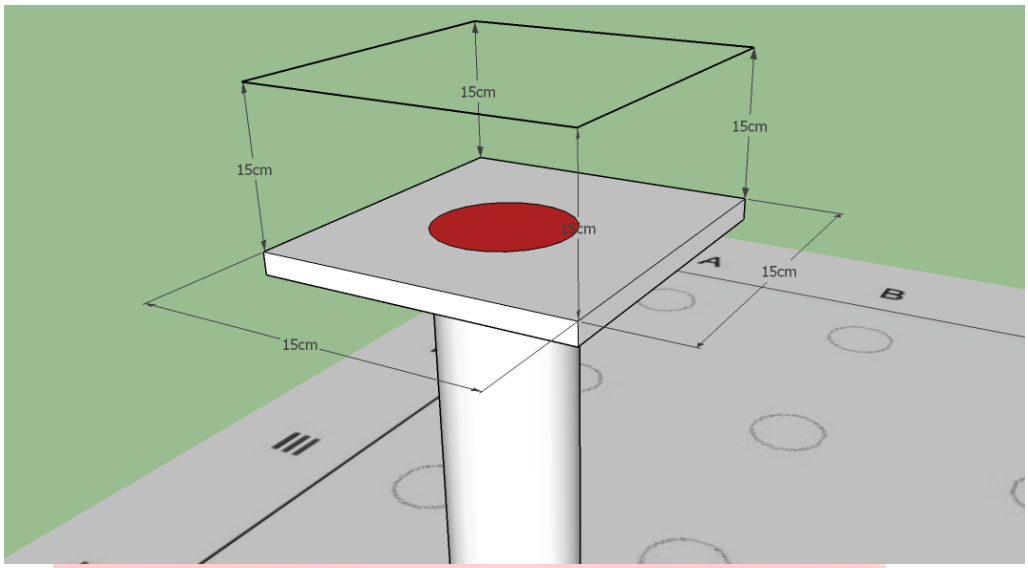


**Figure 3: Flower Dimensions**

**c. Preparing the Petals:**

- Petals are the exposed terminals of the open circuit.
- Team is allowed to use their creativity to design the Petals provided they adhere to the Plant rules (mentioned below) while designing.
- The open circuit must be fixed on the bottom face of the Flower Base. The LED cluster and the exposed terminals should be above the Flower Base.
- Creativity bonus for design will be awarded by the judges in the finals.
- Team must design their Petals so that they fit inside the dimensions of the bounding box (15cm x 15cm x 15cm).

**NOTE: The Colors on the Plant are used just for the representation purpose**

**TIP:** Team can design the Petals (exposed terminals) using aluminum foil. Added advantage of aluminum foil is that it provides extra reflection of the LED cluster when it lights up making it comparatively easier for team to detect it via Image Processing. However, this is only a suggestion; team has the option to design their Petals (exposed terminals) using any other appropriate material they deem fit.

**d. Preparing the Plant Stem:**

- The Plant Stem is made of PVC pipes of inner diameter 7.5 – 8.5 cm.
- Plant Stems are of 3 fixed heights – 40cm, 65cm and 90cm. Refer Figure 4.
- Prepare 4 stems of each height specified above.
- Any Flower may be placed on any Plant Stem.

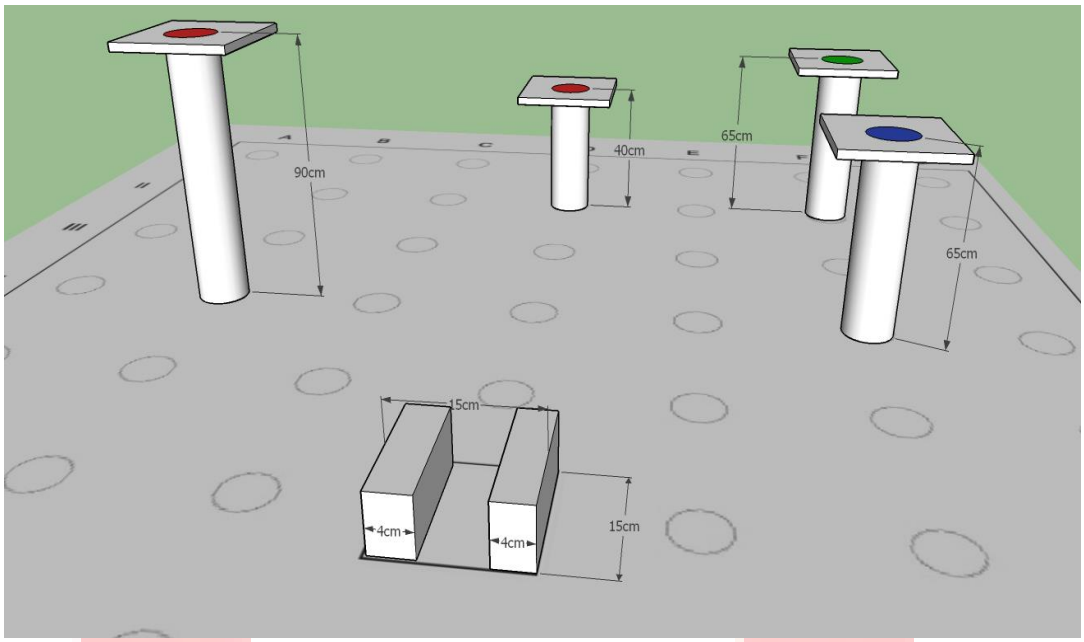


**Figure 4: Plant Stem**

**C. Preparing the Bee Stinger:**

- The Bee Stinger must be attached below the Bee.
- The maximum height of the Bee Stinger is 15 cm from the top of the Bee (i.e. from the top of the WhyCon marker on the drone). The Bee Stinger must fit inside this dimension.
- The Bee Stinger can be made of any conductive material.
- There should be at least a small layer of insulation between the Bee and the Bee Stinger so as to prevent any current going to the Bee and damaging it.
- Team is allowed to use their creativity and is given creative independence to design the Petals as they find best, provided they adhere to Bee Stinger rules (mentioned below) in mind while designing.
- Creativity bonus may be awarded in the finals for good and innovative designs by the judges.
- Team must design a Bee Stinger so that it fits inside the given dimensions.

**D. Preparing the Beehive:**

- Beehive is the starting position of the Bee.
- Beehive must fit within a dimension of 15 cm x 15 cm (length x width).
- Beehive has a minimum height of 15 cm and maximum height of 25 cm. Refer Figure 5.
- Bee takes-off from the Beehive. To this end, team must design a slot in the Beehive big enough to house the Bee Stinger assembly below the Bee.

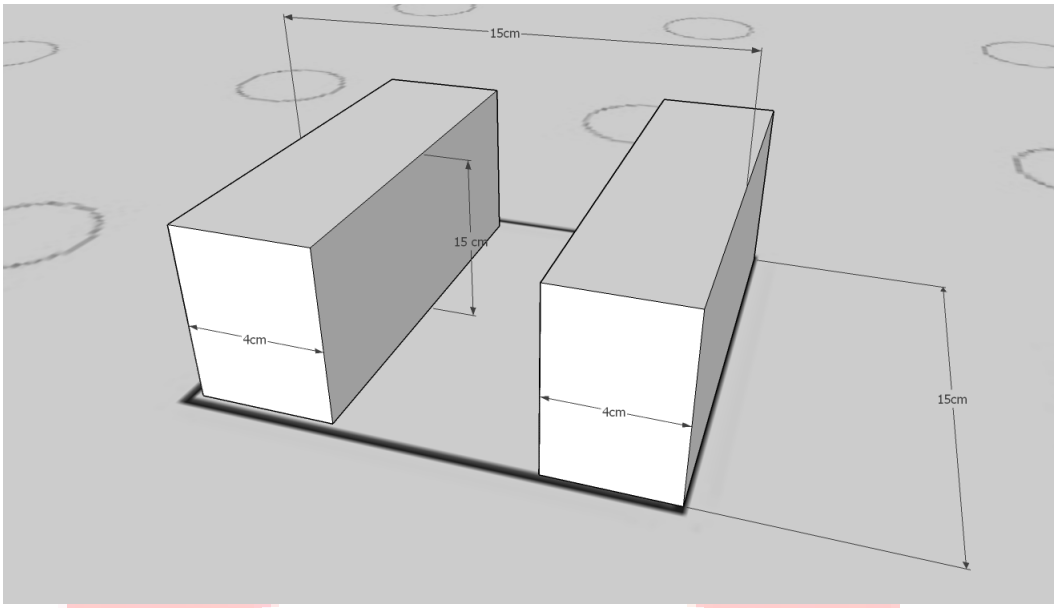


**Figure 5. Beehive Dimensions**

## E. Mounting the Camera:

- Team is provided with a USB camera and USB extension cable in the kit.
- The camera given to the team should be mounted such that it has a complete top view of the arena. Camera should be above the center of the arena at a height of approximately 10 feet (300 cm).
- Team can design any arrangement using their creativity to mount the camera, for example, hanging from ceiling, constructing a frame etc. An example setup is shown in Figure 6.
- USB extension cable is very useful to connect the camera to the PC/Laptop.

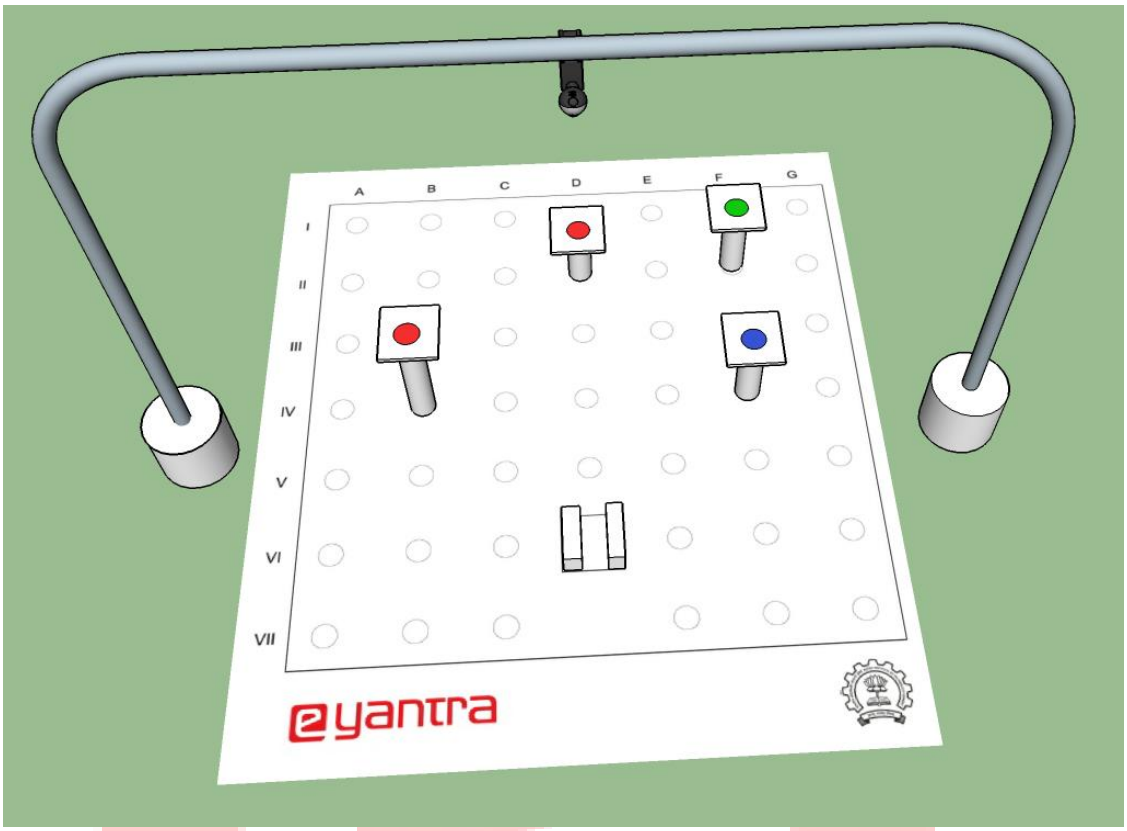


**Figure 6: Camera Setup Example**

**F. Setting up the Arena:**

As shown in Figure 6, place all the Plants in the arena according to Configuration Table and mount the camera.

**Note: If the arena is found damaged or in a condition that makes evaluation difficult, e-Yantra has the right to disqualify a team. The final decision is at the discretion of the reviewer.**

**Warning: Please be careful while handling the flex sheet – avoid folding. One way of "flattening" flex if it has been compromised is to hang it for a few hours in the sub – it tends to straighten out. Never attempt ironing it or applying heat of any kind – it may be a fire hazard.**

## 4. Hardware Specification:

### A. Use of Components:

- Team must use only the components which were sent to them in the kit. Only one set of components given in the kit is allowed per team.
- The Pollinator Bee and the Plant should be completely autonomous. The team is not allowed to use any wireless remote for manual control of the Pollinator Bee or the Plant. Additionally, there cannot be any communication of any form between the Plant and the computer. The computer can only detect when the Plant lights up using image processing.
- Team is allowed to create any type of mount for mounting camera above the arena.
- Team is allowed to create any type of conductive Bee Stinger for completing the circuit on the Plant.
- Team is allowed to create any type of exposed terminal on the Plant.

### B. Power supply:

- The Plant must be powered by 9V Duracell Alkaline batteries.
- The team cannot use any other power source for powering the Plant.
- The team can use a different power source for powering the Plant during testing but the final demonstration should only be made using the battery mentioned above.

**Note:** No other expansion and/or microcontroller-based boards shall be attached to the Pollinator Bee or the Plant.

## 5. Software Specification:

- e-Yantra has provided all teams with an e-Yantra version of the WhyCon package that has been already given to the teams in Task-0. This library is tailored to be used for the theme. **Use only this library.**
- The team must use Python to write their code.
- You are allowed to use only inbuilt Python libraries. Use of any other external libraries is not allowed and may result in disqualification of the team from the competition.
- As per e-Yantra policy, all your code and documents are open-source and may be published on the e-Yantra website.

## 6. Theme Rules:

- The maximum time allotted to complete the task is 10 minutes. A maximum of two runs will be given to a team (the better score from the two runs will be considered as the team's score). A maximum of two re-position requests in a run (explained below) will be allowed.
- Team has to note down the WhyCon coordinates of the Plant before the run starts and enter it into the **Plant_location[]**.
- Team has to keep the Bee at **Beehive** and **SWITCH ON** the Bee.
- The team must initiate the Bee script when instructed by the reviewer. This will be the start of a run. The timer will start at the same time.

- Once the run starts, human intervention is NOT allowed. If any intervention is made, it will be treated as request for re-position (Re-position Rules are discussed below).
- Pollination of Plant can be done in any order.
- Team can call end of run at any time once the run begins. Timer stops when the team calls for end of run.

**A. Bee Rules:**

- The Bee starts from the BEEHIVE position.
- The Bee must visit each Plant.
- The Bee Stinger below the Bee must come in contact with the exposed open circuit at each Plant.
- Only when the LEDs light up at a Plant, pollination will be counted.
- The Bee can pollinate each Plant only once. Visiting and pollinating the same platform repeatedly will NOT earn additional points to the team.
- Crashing into the Plant and/or dropping it will incur a penalty.

**B. Bee Stinger Rules:**

- The Bee Stinger must be made of a conductive material.
- The Bee Stinger must be of specified dimensions only as stated in preparing the Stinger section.
- The Bee Stinger must not be powered by a battery.

**Note**: Make sure that the conductive material of the Bee Stinger does not come in contact with the drone's PCB.

**C. Plant Rules:**

- The Plant must be of specified dimensions only as specified in Preparing the Plant.
- The Plant must have the LED cluster at its center and exposed terminals of the open circuit above the Plant Base. The circuit must be below the Plant Base.
- The LED cluster and the exposed terminals are only permitted to be above the Plant Base
- Due to any reason whatsoever, if the Plant is pollinated (lights up) without any intervention by the Bee, points will **NOT** be awarded. If the Bee pollinates the Plant after it is already lit up, marks will **NOT** be awarded.
- There must not be direct communication between Plant and PC/Laptop.

**D. Re-positioning of Runner:**

Suppose during the run, the Bee crashes into the Plant and falls down or the Bee flies out of the camera frame and does not return or the Bee stops flying and falls down for any reason whatsoever, a member of e-Yantra team who will be monitoring the task will place the Bee back at the Beehive. This is termed as a **Reposition.** Note that the timer used for measuring the task completion time in the competition will be continuously running. Bee is given **only two repositions** per run. If the Bee has been repositioned twice and requires a third reposition, **the run will be ended and the maximum time for the Task will be considered for that run.**

## 7. Judging and Scoring System:

**Total score: (600 - T) + (TP * 500) + LB + (CBS * 10) + (CBF * 10) - (P * 30) + B**

- T is the total time in seconds to complete the task.
- TP is the total number of flowers pollinated successfully.
- LB is the landing bonus of 50 points awarded:
  - When the Bee lands back at Beehive.
- CBS is creativity bonus, from 1 to 10, awarded to team with most creative Bee Stinger at judges' discretion.
- CBF is creativity bonus, from 1 to 10, awarded to team with most creative Flower Platform at judges' discretion.
- P is a penalty applied:
  - For each reposition,
  - For each Plant that the Bee collides against or displaces during the run,
  - For each time the Bee goes out of the camera frame.
- B is a bonus of 100 points awarded:
  - when the task is completed within 10 minutes,
  - No penalty is incurred.
- If no Plant is pollinated during the run then, T will be taken to be the maximum time i.e. 600 seconds.

***"Float like a butterfly and sting like a bee"***

**-Muhammad Ali**

**ALL THE BEST!**