

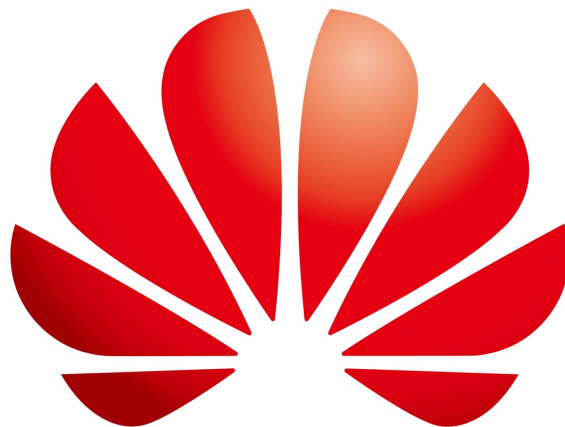


SENIOR DESIGN
COMPETITOR'S PACKAGE

University of Toronto Engineering Kompetition
Jan 11, 2020 – Jan 12, 2020

Directors: Sherry Chen and Jason Zhou

UTEK 2020 Sponsors:



HUAWEI

Welcome to UTEK 2020!

Thank you for participating in the UTEK 2020 Senior Design Competition. The Senior Design competition is open to third and fourth-year students and the engineering principles used in this competition are based on senior level knowledge.

In this competition, you will be given a design challenge and limited materials. On the first day of the competition, your team will need to use basic engineering knowledge to solve the problem, provide a best-fit solution with a prototype in **6 (six) hours**, and test your prototype in the testing field provided by UTEK. At the end of the 6 (six) hours, your team will also need to submit the presentation slides you will be using for your presentation. On the second day of the competition, **5 (five) teams** will present solutions to the client using the presentation slides you submitted on the first day.

Please follow all the rules of this competition. One of the most important rules is that the use of any materials not provided by UTEK is prohibited. If a team breaks any of the competition rules, the team will be disqualified from the competition.

Problem Statement

Tim Hortons is Canada's largest coffee chain, and it is a prominent feature of Canadian life. Tim Hortons has paid you, a team of aspiring student engineers, to design a Timmies delivery robot that delivers Timbits™ door to door. Your goal is to build a prototype of automated mobile robot that traverses through the road, stops in front of the houses, and delivers the orders.

In this competition, you can assume there's only one path to follow, which is marked by a black electric tape with a width of 2 cm and a total length of 3 m. You will be designing and implementing a feedback controller using IR reflective sensor to closely follow the line.

To simplify your task, you can assume that there are only 5 Timbits to be delivered. Each Timbit is perfectly ball-shaped with a diameter of 1.5 cm. Your robot should have a mounted reservoir to store the Timbits. A total of 5 Timbits will be loaded to the robot's reservoir by judges prior to the operation.

You can assume that all of the houses that the robot is delivering to are only located on the right side of the path. Each house is located 15 cm away from the path, and has a vertical size of roughly 8.5 cm x 10 cm facing the path. Any two adjacent houses are at least 20 cm apart. Your robot must be able to detect the houses, and stop in front of the houses along the line, then dispense the correct number of Timbits in front of each house in an accurate and timely manner.

Your robot should be fully autonomous and penalties will be applied for any external assistance. The robot will have a time limit of 3 minutes to complete the task. Your demonstration will be cut off should you go over this limit.

Q&A during the competition: Any question related to the competition can be raised through a discord channel <https://discord.gg/MG7zmt>. The competition director(s) will address those questions raised and make necessary announcements pertaining to the competition.

Simulation Logistics and Details

Competitors will be given two testing environments; each has a different road trajectory indicated by black electric tape, along which stands five houses(see the sample road trajectory and problem set up below). Each team will be given a unique delivery order from the judges prior to the demonstration. The delivery order specifies the number of Timbits you should deliver to each house.

For example, the delivery order will be similar to the following format:

house A: 1
house B: 2
house C: 0
house D: 0
house E: 2

This means that you should deliver 1 Timbit to house A, 2 Timbits to house B, no Timbit to house C or D, and deliver the rest 2 Timbits to house E. Since you will not be able to know the delivery sequence until the demonstration, you should make your code modular and flexible enough to accept different inputs, and test your code under all possible scenarios.

The team is free to choose any initial pose to start. Competitors will not be told prior to the final testing which simulation environment has been selected for competition. The time of each trial is limited to 3 minutes. Penalty is applied as the testing time progresses. The finish time of the run is counted when the robot finishes dispensing Timbits to the last house and lights up an LED.

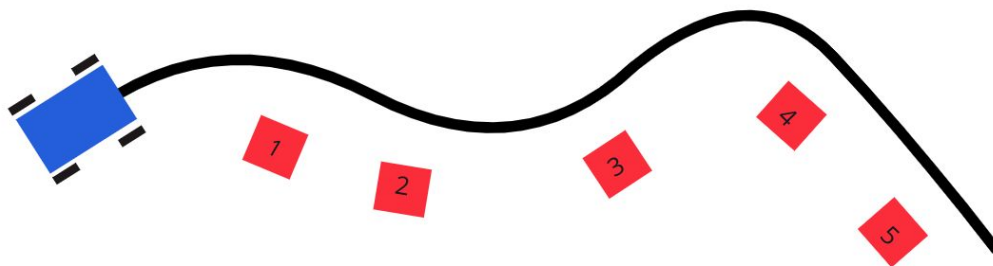


Figure 1 Sample Road Trajectory

Operation Procedures:

1. The judge loads 5 beads (as Timbits) to the mounted reservoir on the robot.
2. The robot starts at the starting position of the path.
3. The robot follows the trajectory of the path which is marked by the black electrical tape.

4. The robot stops in front of each house along the path for at least three seconds (including the houses with 0 timbits delivery order).
5. The robot dispenses the correct number of beads in front of the house.
6. After delivering to the last house, the robot comes to a full stop and lights up the LED to indicate the end of operation.

Competition Rules

The following rules detail the execution of the building, testing and judged prototype demonstrating. Failure to uphold all of these rules will result in loss of points and likely disqualification. Note that competitors are not allowed to watch other teams compete in the judged portion of the competition and that the layout of testing is standardized to ensure a fair competition. **Infraction of a rule tagged with an asterisk (*) results in automatic disqualification.**

General Rules

1. The design and build stage is 6 hours in duration.*
2. The use of the Internet is permitted in this competition.
3. The design must be built with the materials provided by UTEK.*
4. All information used by competitors must be referenced (included in the last slide in the presentation). Competitors are not permitted to submit work completed by anyone other than the members of their team.*

Design Rules and Requirements

1. Prototypes are not allowed to leave the competition premises unless they have been submitted to the competition staff.*
2. Teams may only use materials that they purchase from the shop or in the provided package.*
3. Provided tools may only be used to construct the prototype and may not be used as part of the prototype.*
4. Failure to submit prototype **prior to 5:00 pm**, presentation slides **by 6:00 pm**, will result in **immediate disqualification from the competition.***
5. Teams must not trade building materials. Violation of this rule will result in immediate disqualification of both teams involved.*

Testing Rules

1. The size of the robot must not exceed 25cm x 25cm x 25cm.
2. Teams may choose the initial pose of the robot prior to the operation.
3. Must follow the trajectory of the path.
4. Must stop in front of the house for a minimum of 3 seconds.
5. Must dispense the correct number of beads (Timbits) in front of the house.
6. Must flash LED light at the destination to indicate the end of operation.
7. A successful maneuver is within 3 minutes, otherwise the demonstration will be cut off at this limit.

8. Once the testing has begun, the prototype ideally should be entirely automated. However, In case of overshooting while doing the line following, a maximum of 3 manual intervenes are permitted with cost of penalty.

Shop Rules

1. Each team is given a budget of \$100 (UTEK bucks) in the beginning of the competition. You can spend it at the shops for additional materials and sensors.
2. Once given permission by the shop staff, competitors will collect the items of their choosing and then have their quantities verified by shop staff to maintain a record prior to leaving.
3. The shop will close at 4:30 pm.
4. All sales are final. No refunds.

Materials

The following materials will be provided to each team in the starter kit:

- 1 x Arduino Uno and USB cable
- 1 x breadboard
- 40 x jumper wires (FF, FM, MM)
- 1x 220 Ω resistors
- 1 x 0.1 μ C capacitor
- 2 x DC motors with wheels
- 1 x 9V battery with cap
- 1 x HC-SR04 ultrasonic sensor
- 1 x IR sensor (MH-series)
- 2 x 9g servo motors
- 1 x LED
- 1 x micro switch
- 5 x round beads (Timbits)
- 10 x popsicle sticks
- 1 x foam board
- 4 x zip ties
- 1 x xacto knife

The following tools will be shared commonly in a designated tool station:

- Glue guns & glue sticks
- Soldering iron & solders
- Scissors and other tools

The shop provides the following materials (with prices) in limited supply:

- Arduino UNO + cable (\$50)
- 9V battery (\$20)
- HC-SR04 ultrasonic sensor (\$30)
- IR sensor (MH-series) (\$20)
- 9g servo motor (\$20 each)
- Jumper wires (free on demand)
- DC motor (\$50)
- Wheel (\$50)
- Foam board (\$20)
- Popsicle stick (\$10)

Deliverables & Submission

Your deliverables include:

- A physical prototype
- Arduino Code
- Presentation slides

Physical Prototype

Your prototype must be submitted to a designated area (TBA) before **5:00 pm** for it to be considered for demonstration and evaluation. Please have your team number and names indicated on the robot.

Code and Presentation Slides

Your presentation slides and all code must be sent together to seniordesign@utek.skule.ca by **6:00 pm**. Include all files in a zip file. Only those submitted before the deadline will be considered. If you submit multiple times, then your most recent submission will be considered. Use the following subject line: “**UTEK SD: Team XX**”, where XX is your team number. See the “Presentation” section below for guidelines on how to prepare your presentation.

Evaluation

There will be 2 rounds of evaluation: a demonstration and a presentation. After the demonstration on the first day (Jan 11), the top performing 5 (five) teams will be selected to present their designs before a panel of judges on the second day (Jan 12) of the competition.

Performance Demonstration

The demonstration period is where the teams showcase the functionality of their prototypes. Each team will have 3 (three) minutes to deliver Timbits to all the houses along the path. Your prototypes will be evaluated primarily based on the demonstrated functionality, such as accuracy and speed. Please see the marking scheme for details.

Again, there will be 2 (two) stations available for demonstration and set up as mentioned before. Timing will begin when START on the robot is activated and no additional assistance (other than a maximum of 3 manual intervenes with penalties in the line following part) may occur after that. The robot can initially be chosen by each team to be at any position and pose along the demonstration setup.

Demonstration Marking Scheme

Your prototype will be evaluated based on the following criteria :

- **Line Following** - the smoother the control mechanism operates, the better
- **Stop in front of the houses** - (boolean) the robot should stop in front of each house
- **Delivery Accuracy** - number of Timbits in correct colour delivered to the designated area over the required number of delivery to that location
- **LED finish indicator** - required feature to indicate delivery done at the last house
- **Total Time Used** - the less time used from the START to the Light up from the finish indicator LED, the better
- **Bonus features** - robust and smooth line following mechanism

| Metric | Points | Comments |
|---|--|---|
| Line Following | Base: +5 as it reaches each house; +10 for reaching the destination Bonus: maximum of +15 will be given for smoothness and robustness | -10 for each human interference (maximum 3 times allowed) |
| Stop in front of the houses | +6 points for stopping at each house (5 houses in total) | |
| Delivery Accuracy | + 6 points for successfully delivering to one house accurately | -3 if misses by ± 1 timbit |
| Penalties | | |
| Finish Light Indicator | +10 points if present | LED on if and only if the robot has finished delivery to the last house |
| Total Time Used | - (20 * time used / 3 minutes) points | Maximum -15 -20 points penalty |
| Bonus features | | |
| Robustness and Smoothness of Line Following | +15 points (maximum) | No overshoot, minimum settling time, no continuous oscillation |

Presentation

5 (Five) teams that advance to Day 2 of the competition based on their scoring will be required to present their **10-minute presentation** highlighting their prototype's concept, design, function, and operation. The results from testing will be sent to the judges though teams may wish to highlight results from testing. Presentations longer than 10 minutes will be cut off. Following the presentation will be a **5-minute Q&A** session with the judges. You may wish to take evidence of your prototype's performance for the presentation (photos or video). For the presentation, you will be evaluated on clarity of expression, organization of ideas, evidence of mature judgment, effective participation of all team members, professionalism and responses to the judges' questions. Emails with the 5 (five) teams progressing to the next day will be sent out Saturday evening after the directors have finished all of the judging. Top 3 (three) finalists will be selected based on their Sunday presentation and the winner will be selected by an additional presentation in combination to their testing score.

Please see the last page for the presentation marking scheme.

Marking Scheme

This serves as the official marking scheme for the testing and presentation portions of the competition. In order to score high in the testing phase, the design and algorithm should be fast, consistent, and scalable.

| <u>PROTOTYPE</u> | Exceeds Expectation | Meets Expectation | Below Expectation | Little/No Value | Score |
|--|--------------------------------|---|------------------------------|----------------------------|--------------|
| Creativity/Uniqueness (circle one) | 10 - 9 - 8 | 7 - 6 | 5 - 4 - 3 | 2 - 1 | _____ |
| Scalability of Solution (circle one) | 10 - 9 - 8 | 7 - 6 | 5 - 4 - 3 | 2 - 1 | _____ |
| Reusability (circle one) | 10 - 9 - 8 | 7 - 6 | 5 - 4 - 3 | 2 - 1 | _____ |
| Operational Feasibility (circle one) | 10 - 9 - 8 | 7 - 6 | 5 - 4 - 3 | 2 - 1 | _____ |
| Speed (total time in seconds) | _____ | Score = Time / 540 s * 10 points | | | _____ |
| Trial 1 | _____ | | | | |
| Trial 2 | _____ | | | | |
| Trial 3 | _____ | | | | |
| Consistency (successful runs) | 10 (3/3) | 6 (2/3) | 3 (1/3) | 0 (0/3) | _____ |

PENALTIES

| | |
|--|-------------|
| Damage to the testing environment | - 10 |
|--|-------------|

| <u>PRESENTATION</u> | Exceeds Expectation | Meets Expectation | Below Expectation | Little/No Value | Score |
|--|--------------------------------|------------------------------|------------------------------|----------------------------|--------------|
| Clarity of expression (circle one) | 8 - 7 | 6 - 5 | 4 - 3 | 2 - 1 | _____ |
| Organization of ideas (circle one) | 8 - 7 | 6 - 5 | 4 - 3 | 2 - 1 | _____ |
| Showed evidence of mature judgment (circle one) | 8 - 7 | 6 - 5 | 4 - 3 | 2 - 1 | _____ |
| Effective participation of all team members (circle one) | 8 - 7 | 6 - 5 | 4 - 3 | 2 - 1 | _____ |
| Overall impression and responses to the judges' questions (circle one) | 8 - 7 | 6 - 5 | 4 - 3 | 2 - 1 | _____ |

Comments:

Explanation of Marking Scheme

| Objective | Little/No Value | Below Expectation | Meets Expectation | Exceeds Expectation |
|--------------------------------|--|---|---|---|
| PROTOTYPE | | | | |
| Creativity/ Uniqueness | Design and solution shows no evidence of originality. | Design and solution shows little evidence of originality. | Design and solution shows some evidence of originality either in the approach or build. Few other teams have similar solutions. | Design shows a great deal of originality in both the approach and build. No other team has a similar solution. |
| Scalability of Solution | No aspects of the design is scalable for use in a real scenario. | Very little of the design is scalable and the design is unlikely to be used in a real Scenario. | Some aspects of the design is scalable for use in a real scenario. | Many aspects of the design is scalable and would likely be used in a real scenario. |
| Reusability | The solution can only be used once. | The solution can be used again given sufficient time for the team to setup | The solution can easily be reset to be used again. | The solution is always ready to be re-used without assistance from the team |
| Operational Feasibility | The design is unusable by an operator and suffered a multitude of errors and is only used by physical means. | Design is difficult to operate, needs a high degree of physical assistance and is not operated by mechanical means. | Design requires several "helping" touches and corrections and was operated by a combination of mechanical and physical means. | Design requires several "helping" touches and corrections and was operated by a combination of mechanical and physical means. |
| PRESENTATION | | | | |
| All categories | Some major flaw has been noted | The information presented does | The information is presented well. | The information is presented |

| | | | | |
|--|---|--|---|---|
| | that damages the effectiveness of the presentation (this may be a major omission, a serious misstatement or any other major flaw) or that the information presented is of no value (does not help the presentation at all). | not meet minimum standards of acceptability. | Though there may be a few minor problems or omissions, they are not significant. Creativity, however, is not shown to any great degree. | effectively and creatively; nothing more could be expected. |
|--|---|--|---|---|

Senior Design Marking Scheme

This serves as the official marking scheme for the testing and presentation portions of the competition. In order to score high in the testing phase, the design and algorithm should be fast, consistent, and scalable.

| <u>PROTOTYPE</u> | Exceeds Expectation | Meets Expectation | Below Expectation | Little/No Value | Score |
|--|--------------------------------|------------------------------|------------------------------|----------------------------|--------------|
| Creativity/Uniqueness (circle one) | 10 - 9 - 8 | 7 - 6 | 5 - 4 - 3 | 2 - 1 | _____ |
| Scalability of Solution (circle one) | 10 - 9 - 8 | 7 - 6 | 5 - 4 - 3 | 2 - 1 | _____ |
| Reusability (circle one) | 10 - 9 - 8 | 7 - 6 | 5 - 4 - 3 | 2 - 1 | _____ |
| Operational Feasibility (circle one) | 10 - 9 - 8 | 7 - 6 | 5 - 4 - 3 | 2 - 1 | _____ |
| Day 1 Testing Score | _____ | | | | |

| <u>PRESENTATION</u> | Exceeds Expectation | Meets Expectation | Below Expectation | Little/No Value | Score |
|--|--------------------------------|------------------------------|------------------------------|----------------------------|--------------|
| Clarity of expression (circle one) | 8 - 7 | 6 - 5 | 4 - 3 | 2 - 1 | _____ |
| Organization of ideas (circle one) | 8 - 7 | 6 - 5 | 4 - 3 | 2 - 1 | _____ |
| Showed evidence of mature judgment (circle one) | 8 - 7 | 6 - 5 | 4 - 3 | 2 - 1 | _____ |
| Effective participation of all team members (circle one) | 8 - 7 | 6 - 5 | 4 - 3 | 2 - 1 | _____ |
| Overall impression and responses to the judges' questions (circle one) | 8 - 7 | 6 - 5 | 4 - 3 | 2 - 1 | _____ |

Comments:

Explanation of Marking Scheme

| Objective | Little/No Value | Below Expectation | Meets Expectation | Exceeds Expectation |
|-----------------------|--|---|--|--|
| PRESENTATION | | | | |
| All categories | Some major flaw has been noted that damages the effectiveness of the presentation (this may be a major omission, a serious misstatement or any other major flaw) or that the information presented is of no value (does not help the presentation at all). | The information presented does not meet minimum standards of acceptability. | The information is presented well. Though there may be a few minor problems or omissions, they are not significant. Creativity, however, is not shown to any great degree. | The information is presented effectively and creatively; nothing more could be expected. |