# EIE3105
# Integrated Project (Part II)

Dr. Lawrence Cheung

Semester 2, 2021/22

# Objectives

- To provide students with the concepts and techniques in designing embedded software and hardware interfaces.

# Teaching Staff

- Lecturer: Dr. Lawrence Cheung
  - Office: DE628
  - Tel.: 2766-6131
  - Email address: encccl@polyu.edu.hk
  - Consultation Hours:
    - Monday: 2 p.m. – 5 p.m.

# Teaching Staff

- Tutor: Mr. Shu-yuen Lam
  - Office: DE618
  - Tel.: 2766-6239
  - Email address: shuyuen.lam@polyu.edu.hk

# Course Schedule and Material

- Lecture
  - Week 1 to 3: 9:30 a.m. – 11:20 a.m., Tuesday, FJ301
- Laboratory
  - Week 1 to 5: 8:30 a.m. – 11:20 a.m., CF105 and CF005, Monday
  - Week 6 to 13: 9:30 a.m. – 11:20 a.m., CF005, Monday

# Course Schedule and Material

- The arrangement of laboratory sessions
  - Most of practical works can be done in CF005, CF502 and CF503.
  - CF105 will be available from Week 1 to 5 for you to do the laboratory exercises.
  - CF005 will be available from Week 1 to 13.
    - Starting from Week 6, the laboratory sessions will become consultation sessions.
    - Mr. Lam will be there to help you to solve the hardware problem.

# Course Outline

| Week | Lecture |
|---|---|
| 1 – 3 | Course Information, De-bouncing Buttons, SP2, Ultrasonic Sensor, Analog-to-Digital Converter (AVR and ARM) |

# Course Outline

| Week | Laboratory |
|---|---|
| 1, 3 | Group A* – Demonstration 1: Robot Car and Ultrasonic Sensor Development (Hardware, CF005, 1.5 hours)<br>Group B – Lab (PWM, Input Capture and ADC, CF105, 1.5 hours) |
| 2, 4 | Group C – Demonstration 1: Robot Car and Ultrasonic Sensor Development (Hardware, CF005, 1.5 hours)<br>Group D – Lab (PWM, Input Capture and ADC, CF105, 1.5 hours) |

*: The group list can be found in Blackboard.

# Course Outline

| Week | Laboratory |
|---|---|
| 5 – 6 | Demonstration 1: Robot Car and Ultrasonic Sensor Development (Software)<br>Demonstration 4A: Ball Hitting (Group) |
| 7 – 9 | Demonstration 2: Line Tracking |
| 10 – 11 | Demonstration 3: Car Parking |
| 12 – 13 | Demonstration 4B: Relay Race (Group) |

# Continuous Assessment

| Component | % Weighting |
|---|---|
| Project Demonstration | 40 |
| Project Report and Presentation | 10 |
| Project Logbook | 8 |
| Test (AVR and ARM) | 4 |
| Lab | 2 |
| TOTAL | 64 |

# Continuous Assessment

- Continuous assessment in Semester 1

| Component | % Weighting |
|---|---|
| 6 Lab Exercises (AVR and ARM) | 10 |
| 3 Quizzes (AVR) and Final Test | 26 |
| TOTAL | 36 |

- Overall
  - Semester 1: 36%
  - Semester 2: 64%

# Continuous Assessment

- Logbook (8%)
  - Starting from Week 1 or 2, you need to submit your logbook every week to Blackboard.
  - You can stop writing your logbook when you finish all your works.
  - Write a short essay (less than 100 words) to show your progress
    - What did you do? What will you do?
  - The deadline is the end of each week (***11:59 p.m., Saturday***).

# Continuous Assessment

- Lab: AVR and ARM Interfacing (2%)
  - PWM, Input Capture and ADC
  - Deadline for submission: **5 p.m., 11 February 2022 (Friday)**
  - Submit demonstration videos and projects (program files) to Blackboard.
- Test: AVR and ARM Interfacing (4%)
  - Laboratory session, Week 5
  - CF105 / CF005, **60 minutes**, two questions

# Continuous Assessment

- Demonstrations (40%)
  - Demonstration 1: Robot Car and Ultrasonic Sensor Development (10%)
  - Demonstration 2: Line Tracking (10%)
  - Demonstration 3: Car Parking (10%)
  - Demonstration 4: Ball Hitting (Group, 5%) and Relay Race (Group, 5%)

# Continuous Assessment

- Report and Presentation (10%)
  - Write a short report (less than 5 pages) to describe your work in Demonstrations 1, 2, 3 and 4.
    - Show your design
    - Tell the difficulties you have and how to overcome them
  - Give a 5-minute presentation video with demonstration videos for all demonstrations.
  - Submission deadline: **5 p.m., 15 April 2022 (Friday)**

# Demonstrations

- Demonstration 1: Robot Car and Ultrasonic Sensor Development (10%)
  - Hardware development (4%): PCB soldering for your robot car and ultrasonic sensor
    - At the end, show your soldering to Mr. Lam for grading.
    - Four marks for the performance of your soldering
      - 4 marks: Perfect
      - 3 marks: Very good
      - 2 mark: OK
      - 1 marks: A room to improve

# Demonstrations

- Software development (6%):
  - We use STM32F103C8T6 ARM microcontroller.
  - The size is smaller.
  - We use STM32 Flash to download the hex file to the microcontroller.
  - Free software: https://www.st.com/en/development-tools/flasher-stm32.html

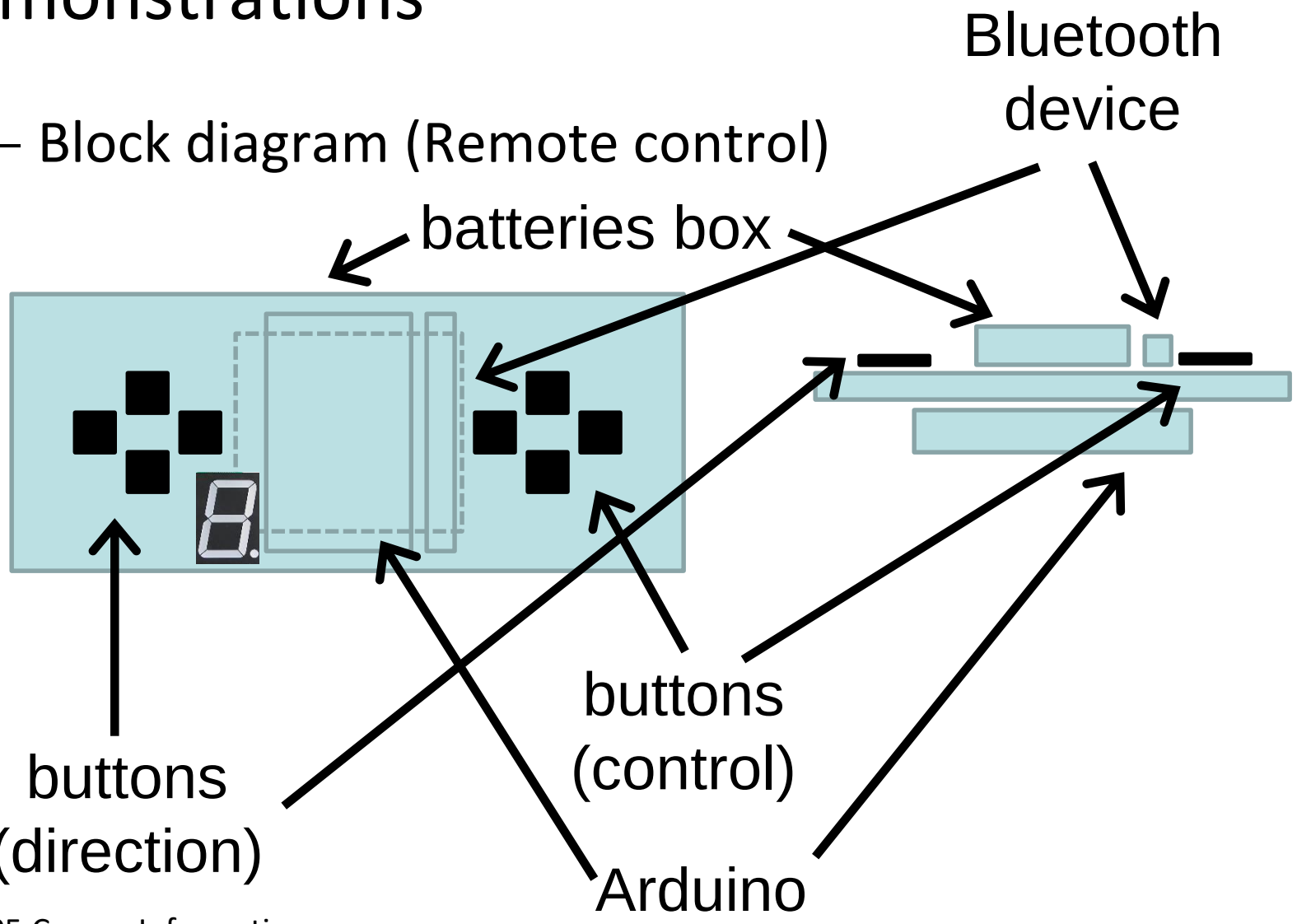
# Demonstrations

- Write a program for the remote control to send a command remotely to your robot car.
- Write a program to control the movement of the car according to the command from the remote control.
- Write a program to get the reading from your ultrasonic sensor.
- You will find that the following web site can help:

https://ensylam.blogspot.com/

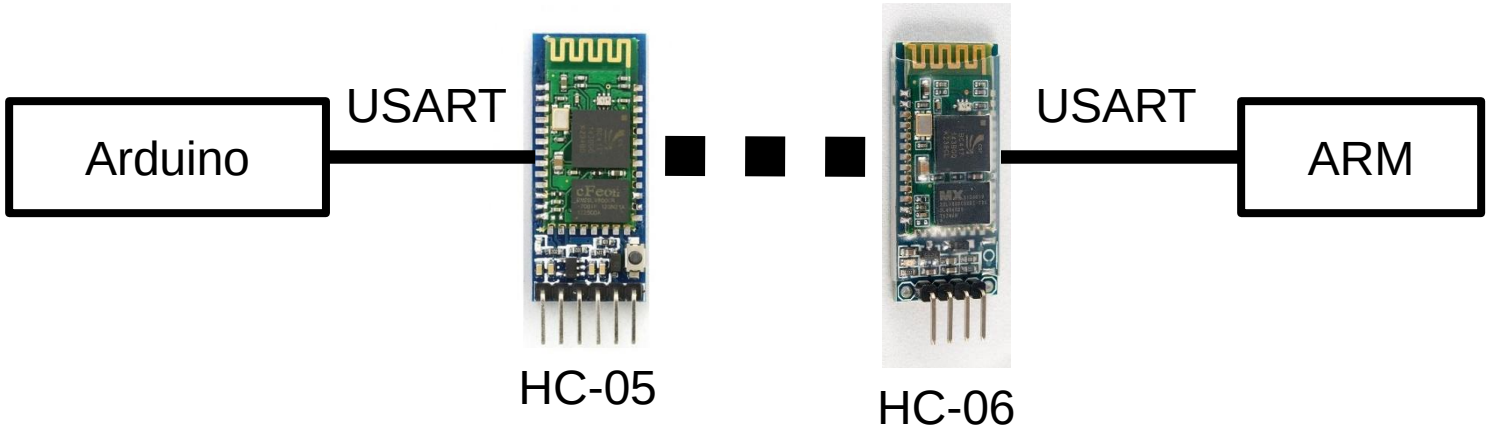
# Demonstrations

– Block diagram (Remote control)



# Demonstrations

- Block diagram (Communication)



# Demonstrations

– Block diagram (PWM control)

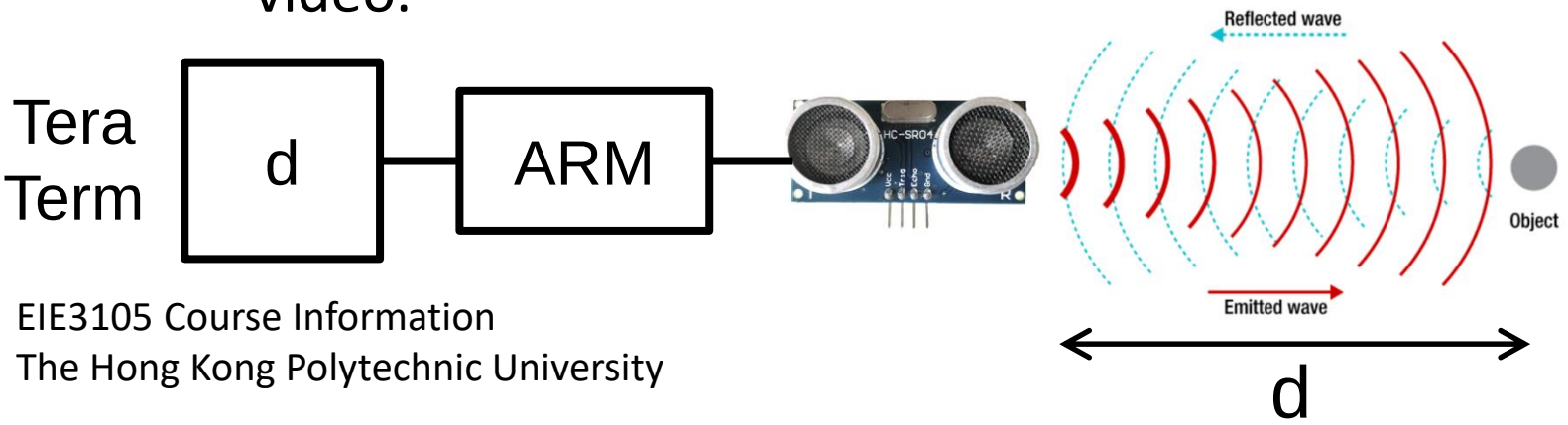
| Function | Device | Pin |
|---|---|---|
| Left wheel (Forward) | TIM1_CH1 | PA8 |
| Left wheel (Backward) | TIM1_CH1N | PB13 |
| Right wheel (Forward) | TIM1_CH2N | PB14 |
| Right wheel (Backward) | TIM1_CH2 | PA9 |
| Counter (Left wheel) | TIM4_CH2 | PB7 |
| Counter (Right wheel) | TIM2_CH2 | PA1 |

# Demonstrations

- Product 1: Program code and a demonstration video to show that you can remotely control the movement of your car.
  - Press a button to move the car forward within one second.
  - Press a button to move the car backward within one second.
  - Press a button to turn the car left and move forward within one second.
  - Press a button to turn the car right and forward within one second.

# Demonstrations

- Product 2: Program code and a demonstration video to show that you can get a reading from the ultrasonic sensor when you put an object in front it and show the distance to Tera Term.
  - Repeat it three times for three different distances.
  - The reading can be the time taken or distance.
  - Use a ruler to measure the distance and show it in the video.

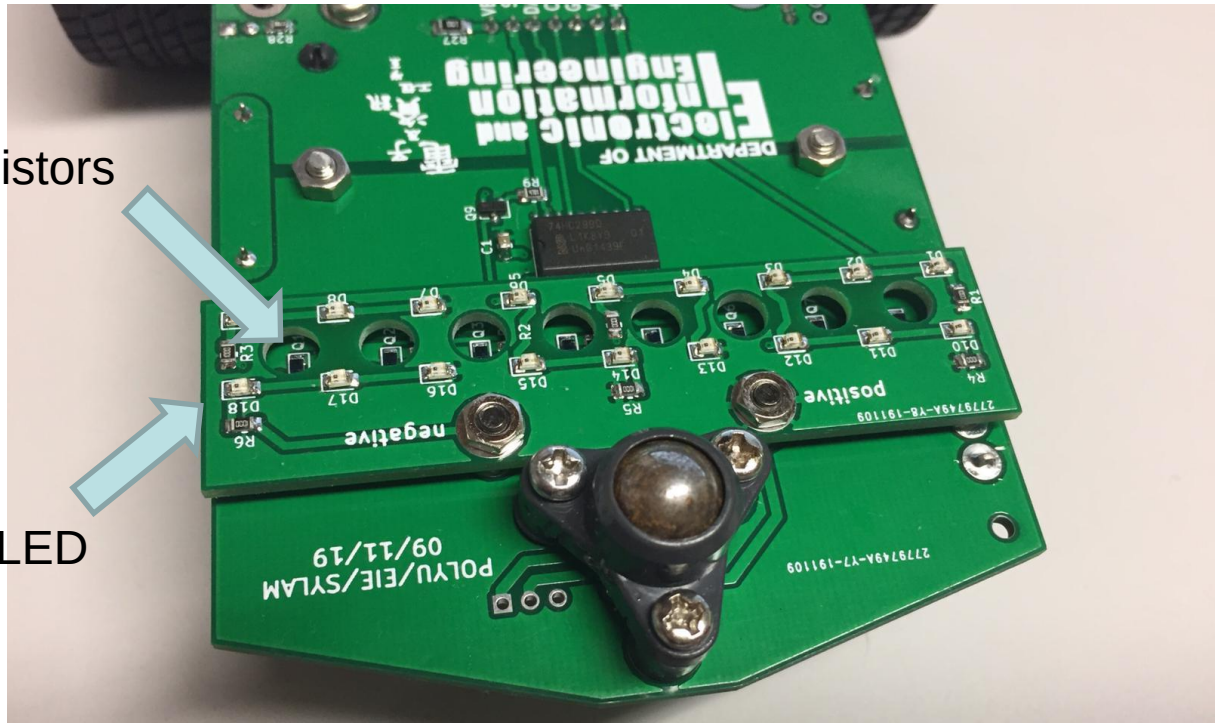


# Demonstrations

- Zip them into one single file and submit it to Blackboard.
- Submission deadline: **5 p.m., 25 Feb 2022 (FRI)**

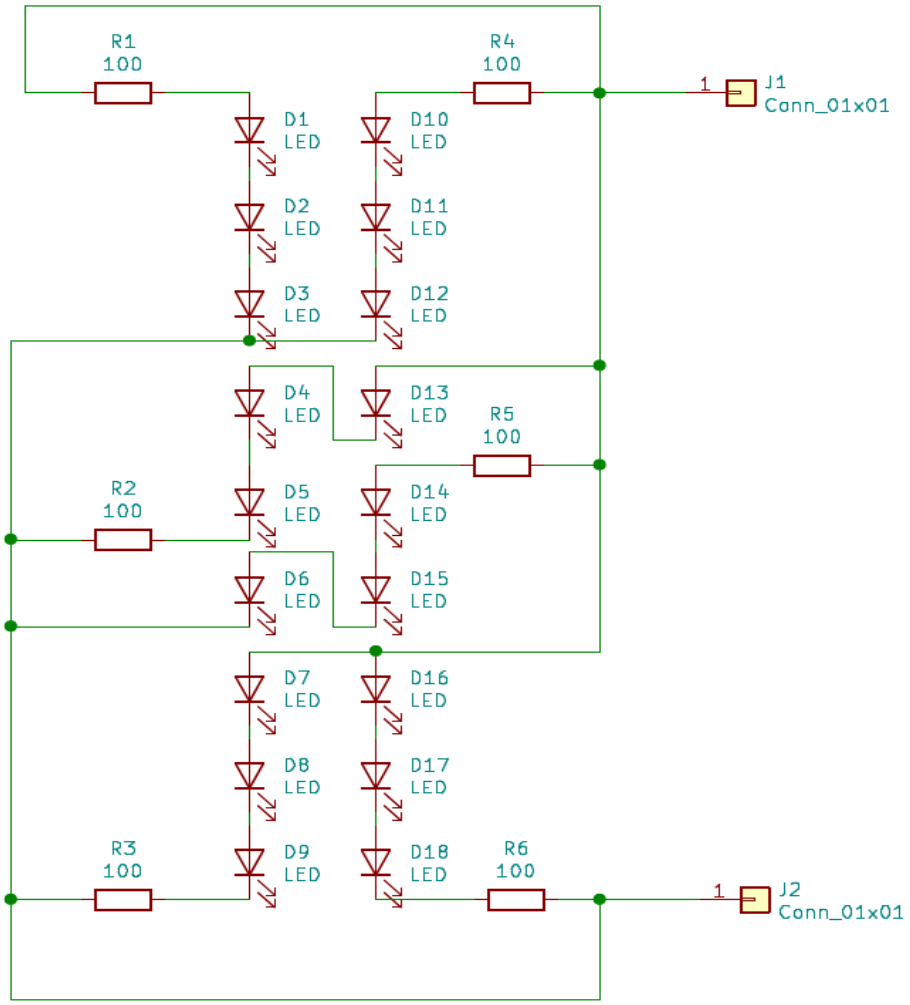
# Demonstrations

- Demonstration 2: Line Tracking (10%)
  - Infra-red LEDs and phototransistors



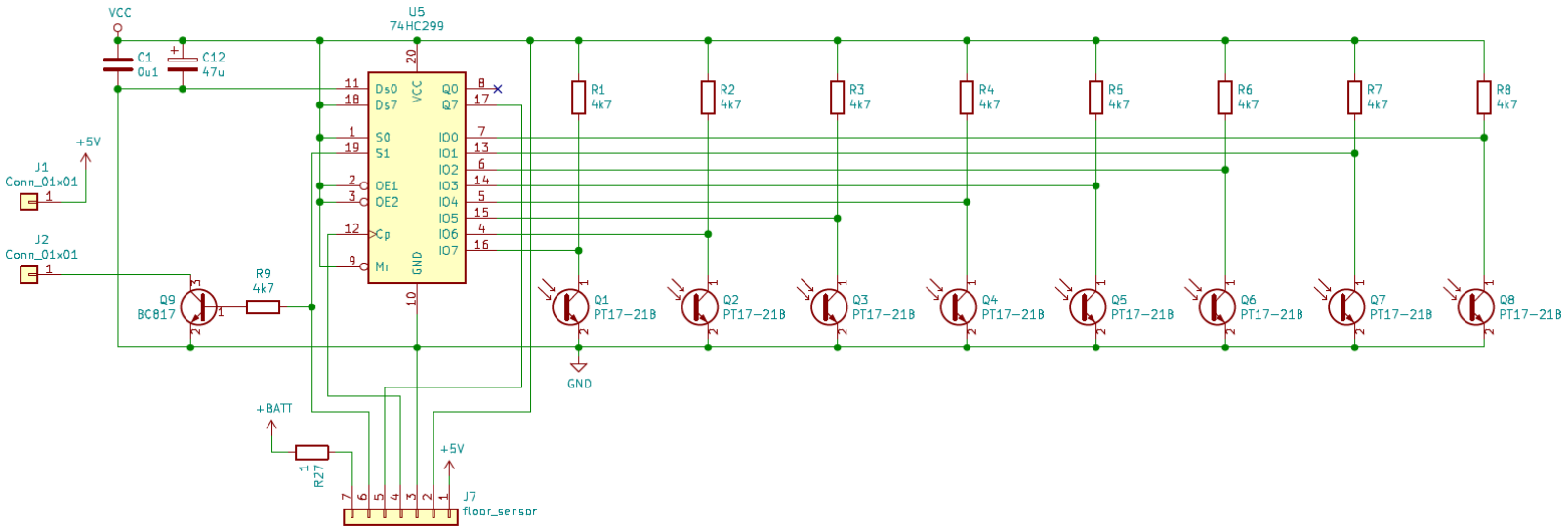
# Demonstrations

– Infrared LED circuit schematic



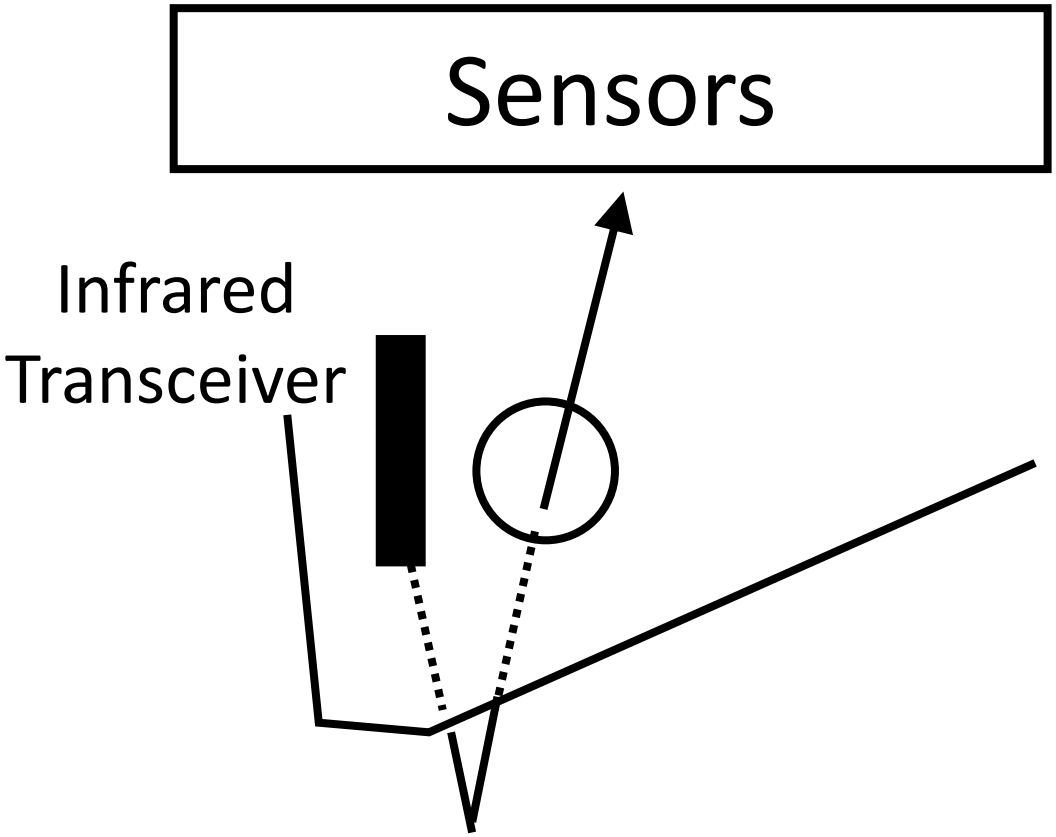
# Demonstrations

– Phototransistor circuit schematic



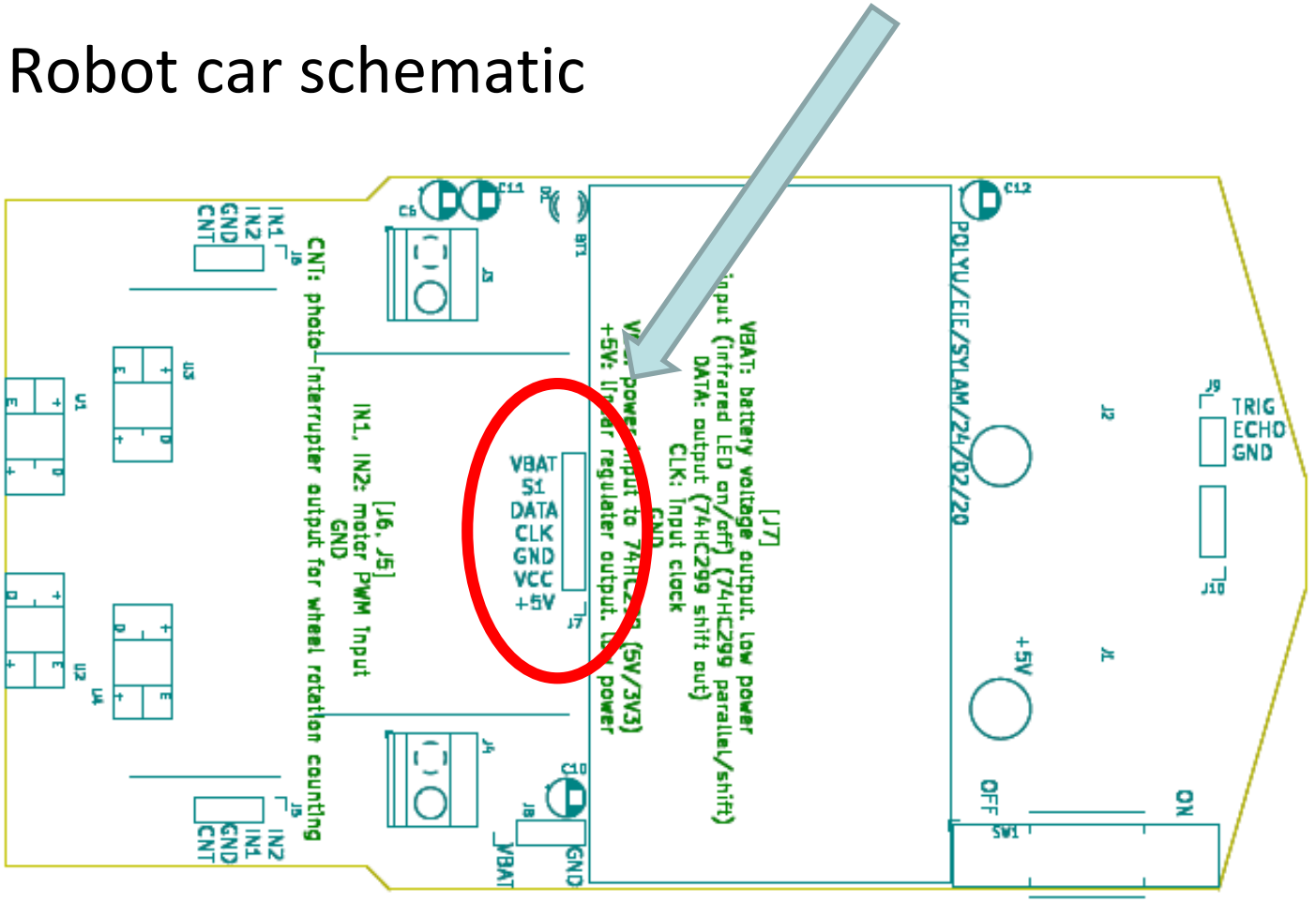
# Demonstrations

– How to track a line?



# Demonstrations

– Robot car schematic

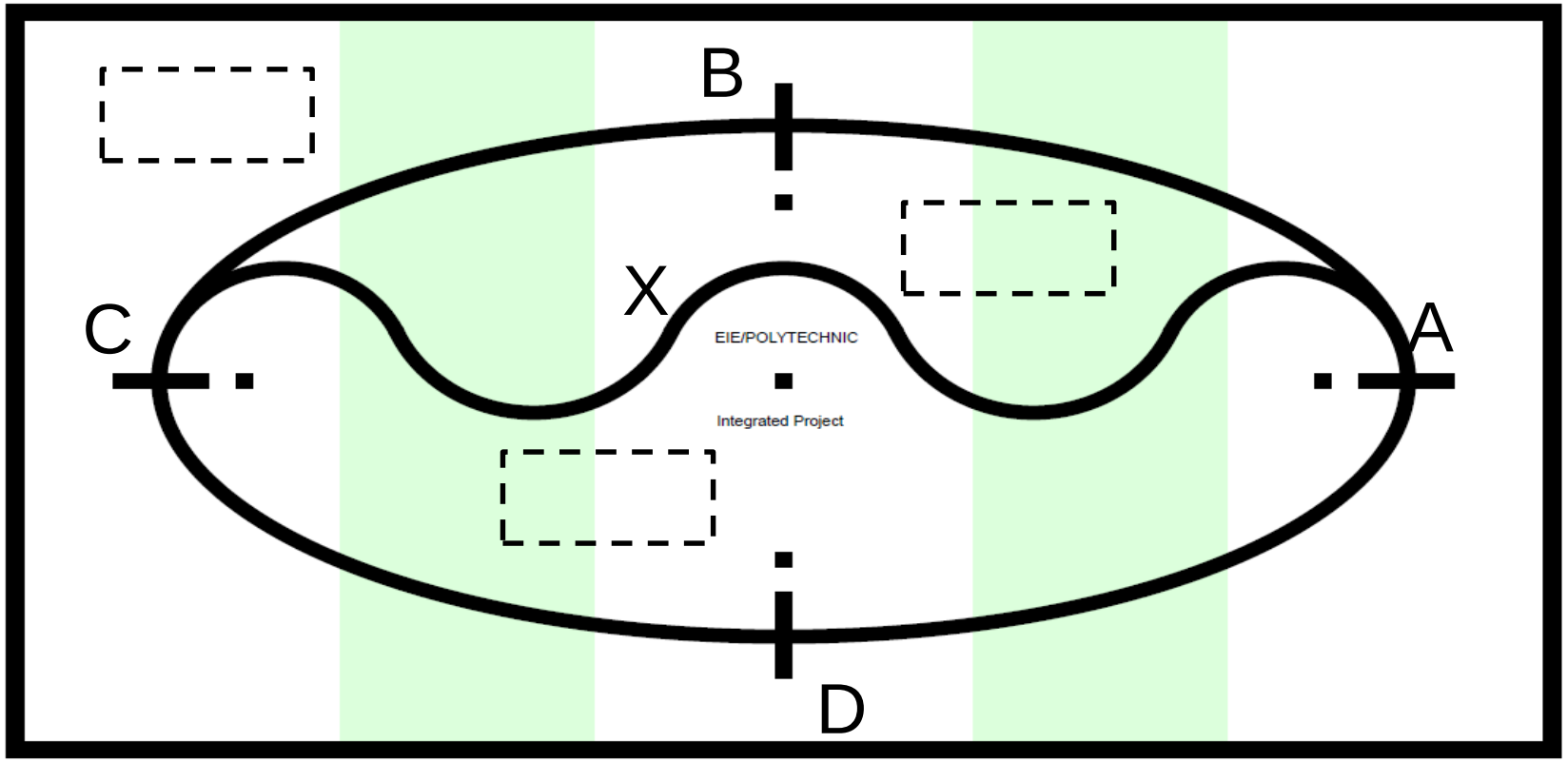


# Demonstrations

- Region A: To control the communication between the microcontroller and 74HC299
  - 74HC299: 8-bit universal shift register
  - Use SPI to communicate
- Follow “SPI2.c” to get the readings from the phototransistors.
- Convert the readings to ASCII characters and send them to Tera Term for checking.

# Demonstrations

– Follow the track



# Demonstrations

- Sequence: A ➔ B ➔ C ➔ D ➔ A ➔ X ➔ C ➔ D ➔ A ➔ B ➔ C ➔ X ➔ A
- It is acceptable if your car sometimes does not follow the track but the duration must be short (not more than **ONE** second).

# Demonstrations

- Marking criteria
  - Score 50% of total if your car can finish it within 60 seconds.
  - 50% of the total is proportional to the time taken to follow the track.
    - Top 30%: 50% (full marks)
    - Top 31% to 50%: 30%
    - Top 51% to 75%: 10%
    - Last 25%: 0%

# Demonstrations

- Product: Make a demonstration video.
  - Zip your program code and demonstration video into a single file.
  - Submit to Blackboard.
- Important reminder: No editing is allowed. You will score ***NO marks*** if the demonstration video is edited.
- Submission deadline: **5 p.m., 18 Mar 2022 (FRI)**

# Demonstrations

- Advices
  - If your car is too fast, it cannot detect the line properly and thus it cannot follow the track.
  - If your car is too slow, you cannot score high marks.
  - Your car should be sometimes fast (e.g., when your car is not turning) and sometimes slow (e.g., when it switches from one line to another line).

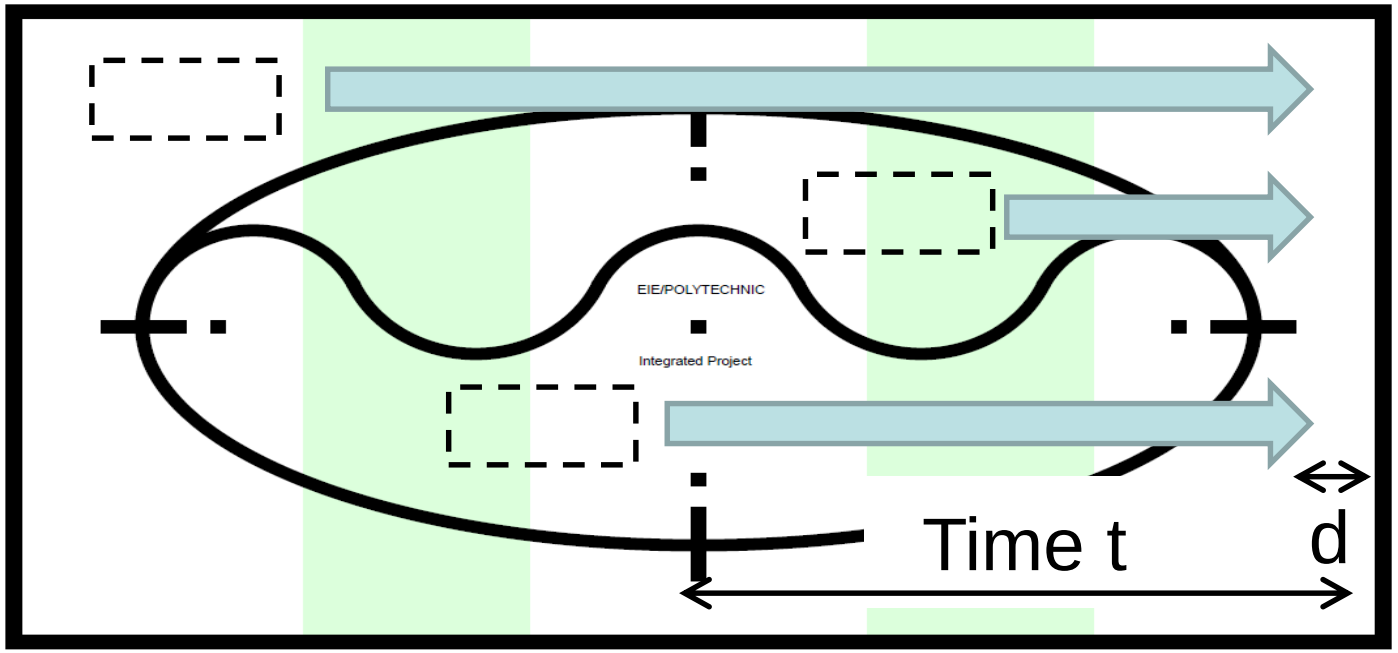
# Demonstrations

- Event lookup table

| Previous State | Event (Reading) | Actions to be taken (PWM values) | Next State |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

# Demonstrations

- Demonstration 3: Car Parking (10%)
  - Your car can get close to the wall closely but not hit the wall.



# Demonstrations

- The positions of the car (three positions) and the wall can be found in the arena.
- You need to build the wall by yourself, e.g. few boxes of lemon tea on the line.


- Marking criteria
  - Score 50% of total if your car can get close to the wall from the three specified positions and each time the distance between the car and the wall is less than 10 cm.

# Demonstrations

- 50% of the total marks is proportional to the total time taken (t) of the car to finish the parking from the three specified positions (25%) and the total distance (d) between the car and the wall from the specified positions (25%).
  - Top 30%: 50% (full marks)
  - Top 30% to 60%: 30%
  - Top 60% to 80%: 10%
  - Last 20%: 0%

# Demonstrations

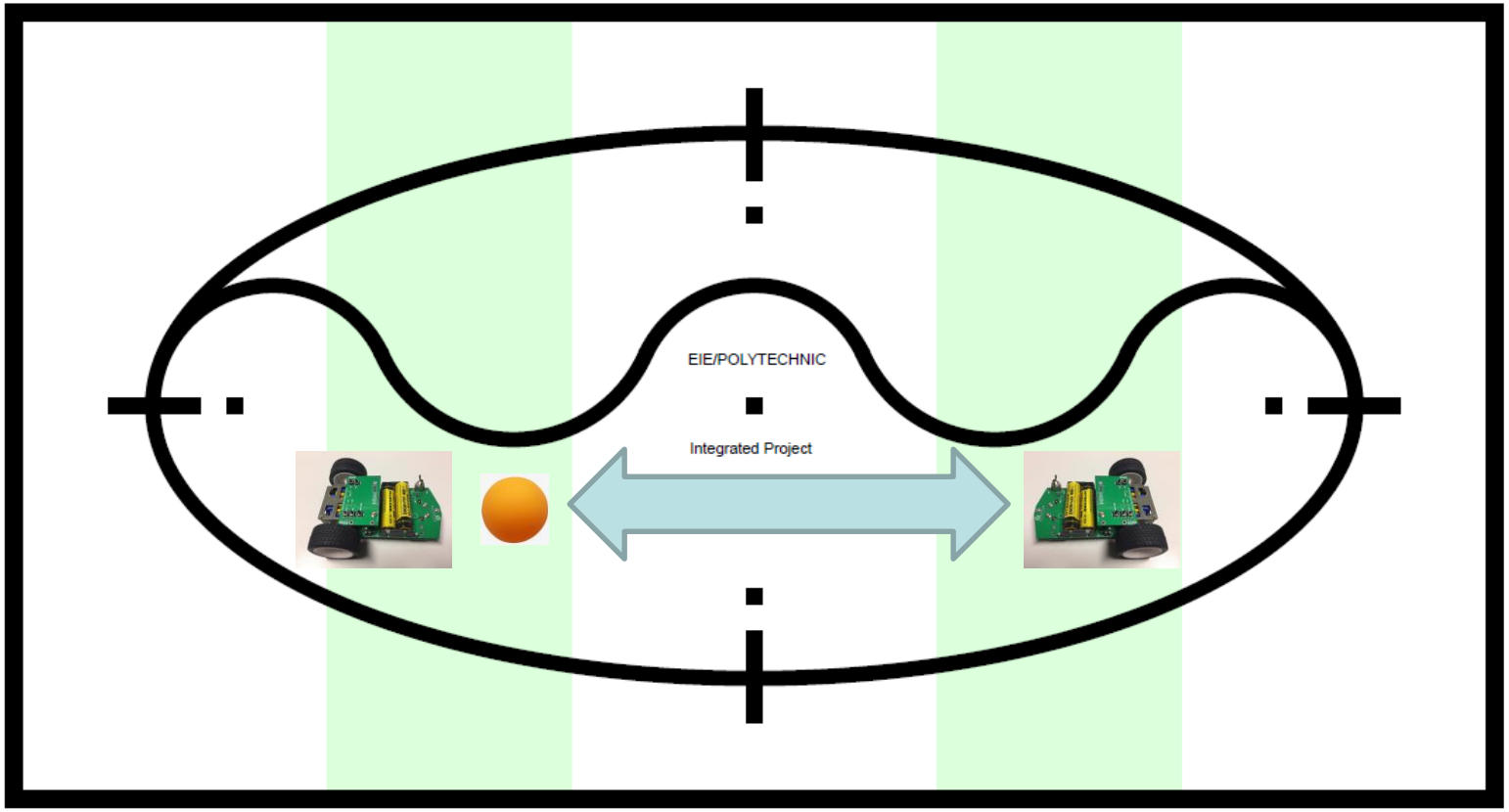
- Product: Make a demonstration video.
  - Before putting your car into a specified position, you should power off and then power on the robot car. Then put the car to the position and press the on-board button to start moving.
  - The above procedure should be repeated three times in three different specified positions.
  - Zip your program code and demonstration video into a single file.
  - Submit to Blackboard.

# Demonstrations

- Important reminder: No editing is allowed. You will score ***NO marks*** if the demonstration video is edited.
- Submission deadline: **5 p.m., 1 Apr 2022 (FRI)**

# Demonstrations

- Demonstration 4A: Ball Hitting (Group) (5%)



# Demonstrations

- Requirement: Hit the table tennis ball **SIX** times so that the ball can be passed from one car to another car.
  - Use a remote control to control the movement of a car.
  - Both cars cannot go into the central white region.
  - Each car hits the ball three times (total six times for two cars).
  - The ball must be hit by two cars alternatively.
  - If you cannot find a partner, let me know and I will help.

# Demonstrations

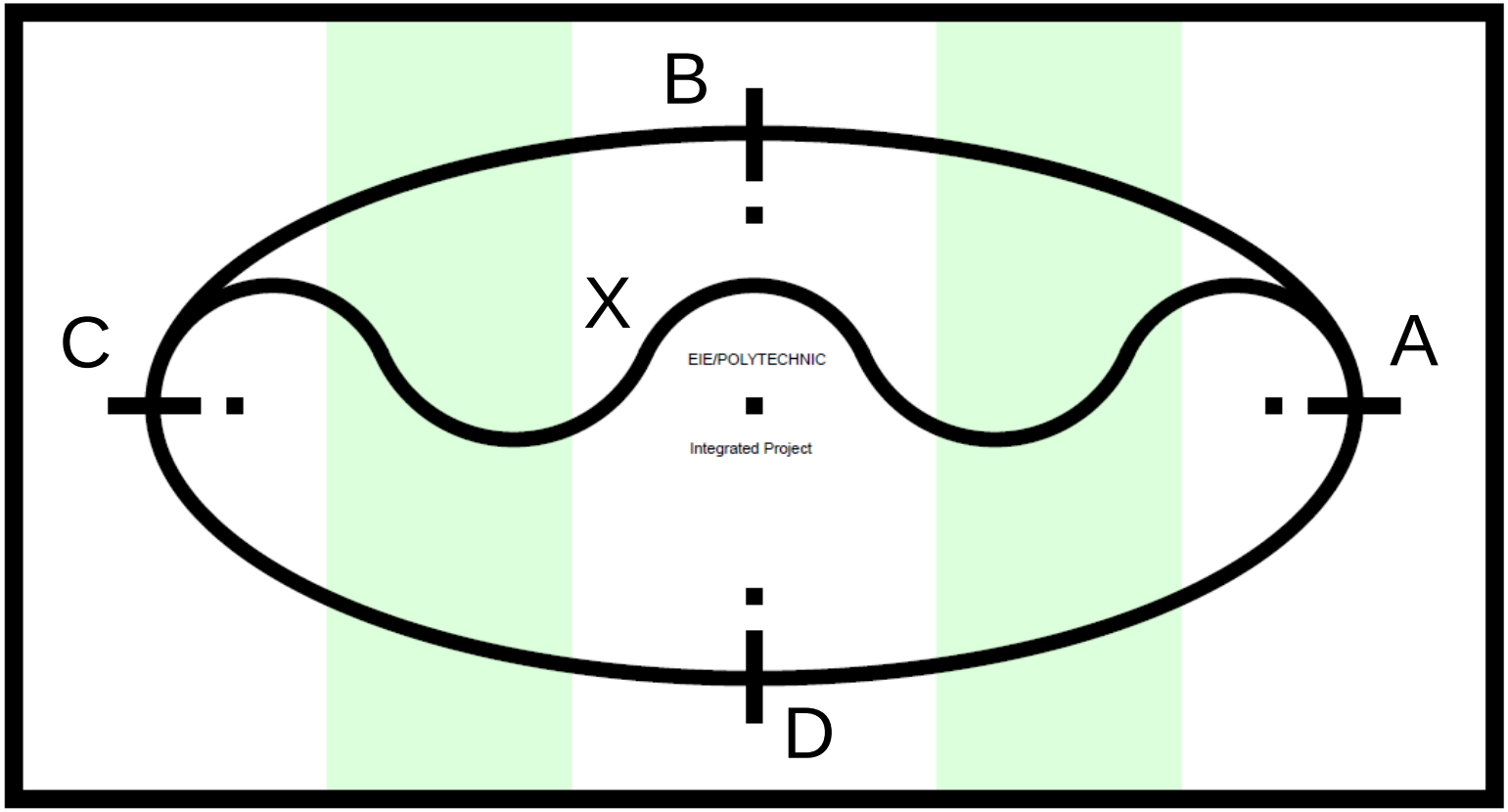
- Marking criteria
  - Score 50% of total if your car can finish it within 90 seconds.
  - 50% of the total marks is proportional to the time taken to finish the whole process.
    - Top 30%: 50% (full marks)
    - Top 30% to 60%: 30%
    - Top 60% to 80%: 10%
    - Last 20%: 0%

# Demonstrations

- Product: Make a demonstration video.
  - Zip your program code and demonstration video into a single file.
  - Submit to Blackboard.
- Important reminder: No editing is allowed. You will score ***NO marks*** if the demonstration video is edited.
- Submission deadline: **5 p.m., 25 Feb 2022 (FRI)**

# Demonstrations

- Demonstration 4B: Relay Race (Group) (5%)



# Demonstrations

- Requirement:
  - Car 1 (at A): A ➔ B ➔ C
  - Car 2 (at C): C ➔ D ➔ A ➔ B ➔ C
  - Car 1 (at C): C ➔ D ➔ A
  - Automation
  - Two cars are not allowed to be hit.
  - Two videos
    - Student A's car = Car 1, Student B's car = Car 2
    - Student A's car = Car 2, Student B's car = Car 1

# Demonstrations

- Marking criteria
  - Score 50% of total if your car can finish it within 90 seconds.
  - 50% of the total marks is proportional to the total time taken to finish the whole process.
    - Top 30%: 50% (full marks)
    - Top 30% to 60%: 30%
    - Top 60% to 80%: 10%
    - Last 20%: 0%

# Demonstrations

- Product: Make a demonstration video.
  - Zip your program code and demonstration video into a single file.
  - Submit to Blackboard.
- Important reminder: No editing is allowed. You will score ***NO marks*** if the demonstration video is edited.
- Submission deadline: **5 p.m., 15 Apr 2022 (FRI)**

# Advices

- Do **NOT** start working on a demonstration **TWO** days before the deadline.
  - You will find that you do not have enough time to finish it.
- It is time consuming to work on each demonstration. Thus, **time management** is very important.

# Advices

- In your demonstration video, you need to show the label of your car before showing your demonstration.
  - It is very important for you to work out all demonstrations by your car but not your classmate's car.

# Summary of Deadlines

- Lab: 5 p.m., 11 Feb 2022 (FRI)
- Test: 9:45 a.m. – 10:45 a.m., 14 Feb 2022 (MON)
- Logbook: 11:59 p.m., Saturday, Week 1 to 13
- Demonstration 1: 5 p.m., 25 Feb 2022 (FRI)
- Demonstration 2: 5 p.m., 18 Mar 2022 (FRI)
- Demonstration 3: 5 p.m., 1 Apr 2022 (FRI)
- Demonstration 4A: 5 p.m., 25 Feb 2022 (FRI)
- Demonstration 4B: 5 p.m., 15 Apr 2022 (FRI)
- Report and Presentation: 5 p.m., 15 Apr 2022 (FRI)

End