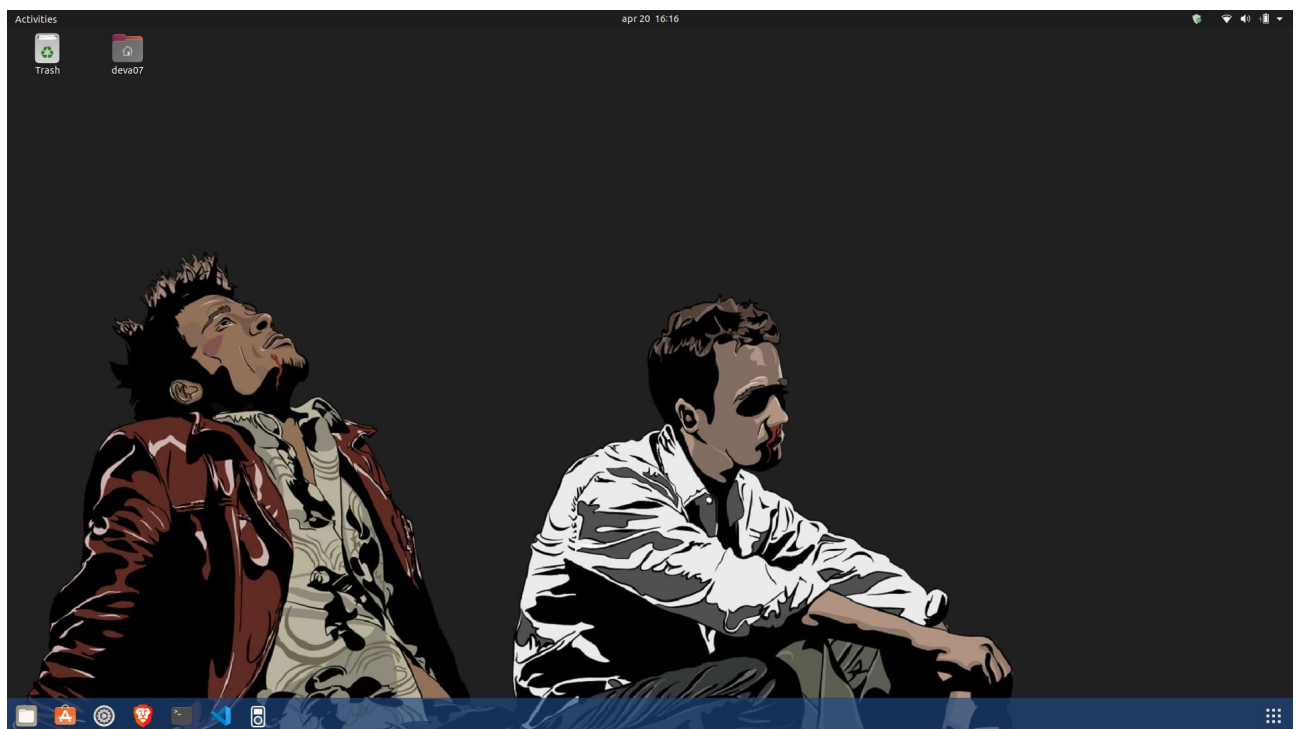I could not complete all the problems, as I did not have time to do so. I have listed down what further improvements/solutions to be done for each incomplete problem.

Section – A: Robot Operating System (ROS)

Task 1

Setup Ubuntu 20.04 on your computer. You will need to dual boot Linux or install a virtual machine. WSL is discouraged because it causes multiple issues.

Task 2

Create a catkin workspace after installing ROS Noetic. Do the following subtasks inside the workspace.

- "abhiyaan_app_ws" in the repo is the workspace

Write a subscriber node and a publisher node in the same package and launch both using a launch file.
Node1 : To publish the string "Team Abhiyaan rocks:" to the Topic: /team_abhiyaan Datatype: String
Node2 : To subscribe to the above publisher and print the message on the console Write a single launch file to run both nodes.

- Subscriber node path – abhiyaan_app_ws/src/task/scripts/subscriber.py
- Publisher Node apth – abhiyaan_app_ws/src/task/scripts/publisher.py
- Launch File – abhiyaan_app_ws/src/task/launch/comm.launch

Now write a node which subscribes to the above publisher and reverses each word in the string individually and publishes onto the Topic: /naayihba_maet Datatype: String i.e if "Team Abhiyaan Rocks" is being published to /team_abhiyaan, you need to publish "maeT naayihbA skcoR" to /naayihba_maet.

- I created a node that was able to subscribe to the above publisher. But I was not sure how to make it a publisher too.
- Python script - abhiyaan_app_ws/src/task/scripts/revSubPub.py

Possible Solution/Things to do:
- From rqt_graph, I understand the node is not publishing, possibly because rospy.spin() does not let the function end. I think I have to make a single function that can act as both publisher and subscriber instead of 2 separate functions and calling them separately
- I have to figure out how to store that received data from a publisher in a variable so as I can manipulate/perform operations on the data and publish it. Possibly an inbuilt function exists in ros, that can store it in a variable.

Open turtlesim. You will be welcomed by a turtle named 'turtle1' spawned at the center of the simulator. Kill this turtle using :
- running "rosrun turtlesim turtlesim_node" will spawn a turtle.

Simulate the classical two body problem considering the two turtles to be rigid bodies. The two body problem :
- After spawning the 2 turtles, I wanted to bring them to the coordinates (0,2) and (0,-1) assuming the centre of the turtlesim window to be (0,0) (which is not with respect to turtlesim. The bottom left corner is the origin). I was not sure how to do it in the python script, therefore for the time being I used the commands,
  "rosservice call /turtle2/teleport_absolute 5.5 4.5 0"
  "rosservice call /turtle1/teleport_absolute 5.5 7.5 3.1415"
  "rosservice call /clear"
- After this the launch file needs to be run. The 2 turtles move in 2 different orbit. I think it is not the solution to the 2 body problem.

What needs to be done further

- So I had trouble recalling the 2 body problem XD. So I think better understanding of the 2 body problem would help me set the parameters for the trajectory of the turtles
- Need to know how to draw ellipse in turtlesim.

- I think the turtles do not start at the same time, not sure though. There is some delay before the 2nd turtle start. Need to figure out a way such that they start together.
- Figure out a way to move the turtle in a python script

Section – B: Robot Operating System (ROS)

Section B.1: Programming

You are given a 2D matrix of dimensions m * n consisting of integers, and an integer k. Your task is to print "true" if the element k lies in the matrix and "false" otherwise. If the element exists then print the index in a new line. Each row and column is in sorted order, and the first element of a row is greater than the last element of the previous row

- secb1.py has the solution to the problem
- *Algorithm:*
    - o Find a row such that the first element of the row before is less than k and the first element of the row after is greater than k. This can be efficiently done by modified Binary search.
    - o Once we find the row, we employ binary search to find the element and its index efficiently.

Section B.2: Computer Vision

We want our vehicle to avoid obstacles and potholes on the road. Write a code to detect the simulated potholes in the video.

- python script to detect the potholes "openCV/read.py"
- Running the script, lot of other circular or close to circular Objects apart from the potholes also gets detected.
- And also once the potholes is detected , "the green circle" does not stay with the potholes, it quickly moves on to next. I understood the effects of each parameter of cv.Hough_Circles and I tried playing with it. I finally I settled with a set that captures the most potholes for maximum time.

Possible Improvements/Solutions

- I think we have to set the right parameters for the cv.Hough_Circles() method. This maybe can be done using Regression Learning (I have no idea how to implement it XD)

Section B.3: Literature Review and Theory

Question 1

What are the different sensors that are typically used to obtain the data which is fed into the navigation stack for autonomous systems?

The typically used sensors are
1) Camera
2) Radar
3) Lidar

What are the advantages and disadvantages associated with these sensors?

Camera

Advantages

- Equipping vehicles with cameras at different positions it is possible to maintain a 360o view of the external Environment
- 3D cameras are available for displaying highly detailed and realistic images

Disadvantages

- Poor weather conditions can restrict the sensing capabilities .In few circumstances or situations, the images from the Cameras are not good enough to make a good decisions.
    - Example: If the colors of the object are similar to the background, it would be hard for the computer to distinguish between them.

Radar Sensors (Radio Detection and Ranging)

Advantages

- No Trouble identifying during fog or rain

Disadvantage

- With the pedestrian recognition algorithm, today's vehicles can identify between 90% and 95% of pedestrians, which is not enough to ensure safety
- 2D Radars are being widely used today. These sensors are incapable of sensing accurately an object's height.
- Cannot see color

Lidar Sensors (Light Detection and Ranging)

Advantages

- Allows creating 3D images of the detected Objects
- Can be configured to create 360 degree map around the Vehicle rather than relying on a narrow field of view.

Disadvantage
- Expensive
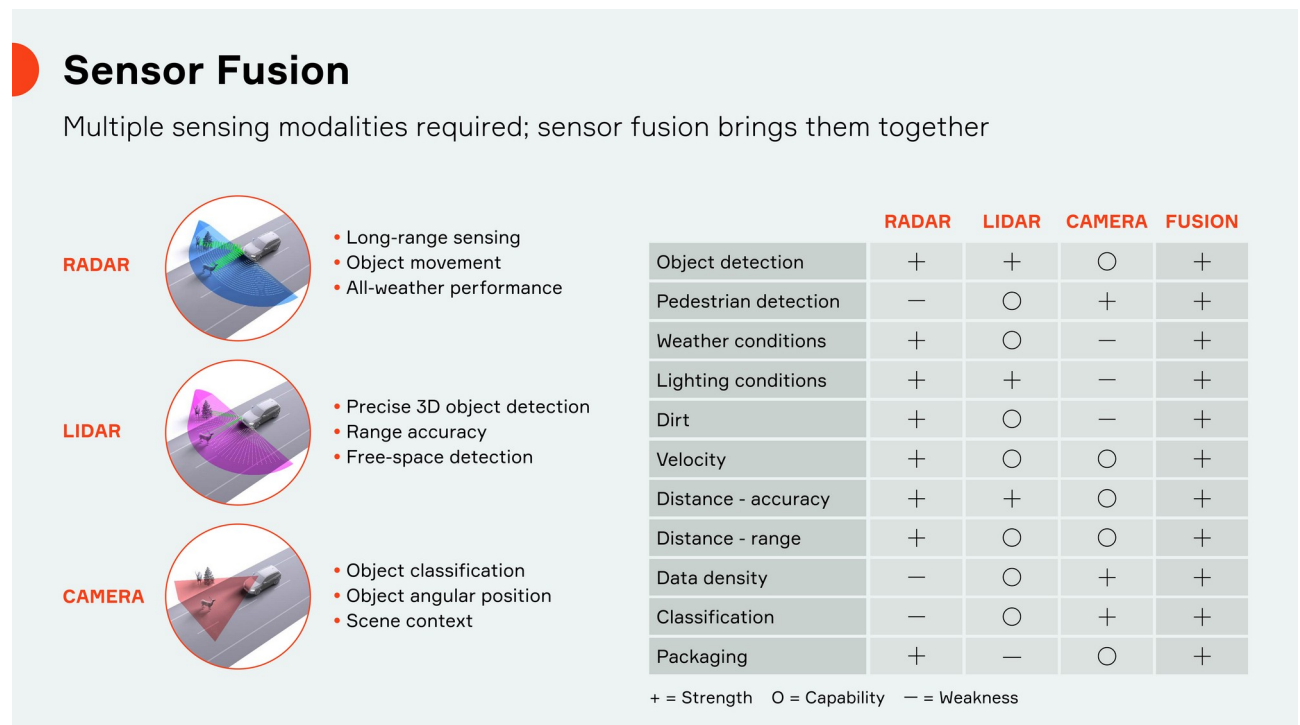- Snow or fog can limit its sensing capabilities.

When do we use which?

- From above advantages and disadvantages, Camera is better suited for environments with less weather hindrance and when there is a low budget.

- Radars are better when the weather conditions are bad and when there is a low budget.
- If there is no constraint on the budget, Lidar is a better choice for environments with less weather hindrance.

What about sensor fusion?

Sensor Fusion is bringing together the inputs of multiple sensors (radars, Cameras, Lidars) to form a single model of the environment. Since the model is fusion of 3 classes of Sensors, the disadvantages of each sensor is balanced by other classes of Sensor. The below image is good sum-up

Sensor Fusion

Multiple sensing modalities required; sensor fusion brings them together

RADAR
- Long-range sensing
- Object movement
- All-weather performance

LIDAR
- Precise 3D object detection
- Range accuracy
- Free-space detection

CAMERA
- Object classification
- Object angular position
- Scene context

	RADAR	LIDAR	CAMERA	FUSION
Object detection	+	+	O	+
Pedestrian detection	—	O	+	+
Weather conditions	+	O	—	+
Lighting conditions	+	+	—	+
Dirt	+	O	—	+
Velocity	+	O	O	+
Distance - accuracy	+	+	O	+
Distance - range	+	O	O	+
Data density	—	O	+	+
Classification	—	O	+	+
Packaging	+	—	O	+

+ = Strength   O = Capability   — = Weakness

Sources:
https://www.aptiv.com/en/insights/article/what-is-sensor-fusion#:~:text=Sensor%20fusion%20is%20the%20ability,strengths%20of%20the%20different%20sensors.
https://www.itransition.com/blog/autonomous-vehicle-sensors

Question 2

Make a brief documentation on your understanding of the above paper. The documentation can include insights, results, alternatives and any suggestions/improvements that you can think of. We essentially want you to explain the algorithm to us, discuss how well it will/won't work.

- The paper talks about an efficient method to predict T and + Intersections. Briefly, the process involves three steps,

- o Data Pre-Processing
- o Beam Model
- o Feature Classification
- At the big picture, from my understanding, I think the below is what is happening in the method explained by the paper,
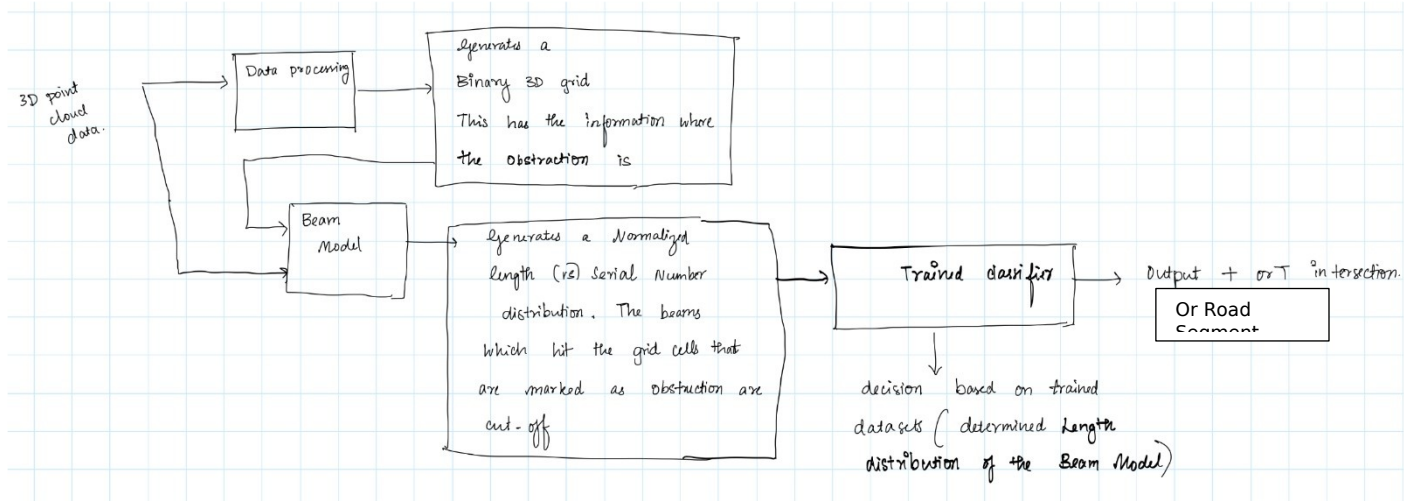
- Normalized Length vs. Serial Number of the Beam Distribution
- I tried to understand the paper better, but there were a few terms I could not understand. Since I had a time constraint, I didn't dig deeper. Below is how I approached the problem. The terms underlined in red are the ones I could not understand.
https://drive.google.com/file/d/1SveDQkcQUnlGIHhaEkJRi8d27iEmdCkP/view?usp=sharing

Bonus Questions

Question 2

Draft an email to a company/organization of your choice, inviting them to sponsor Team Abhiyaan.

Subject: Requesting for Sponsorship, Team Abhiyaan, IIT Madras.

Dear Concerned Authority,

We hope your esteemed establishment and your employees are doing well.

We, the Team Abhiyaan, are many enthusiastic students of IIT Madras who are driven to build autonomous, intelligent, robust, precise, and safe ground navigation systems. We foresee a future of Autonomous Vehicles becoming a norm, and we are passionate to contribute in achieving that dream at the earliest.

Why Autonomous Vehicles?

Every 3 minutes (almost the time taken to read this email), on an average, a person dies due to a car accident, and around 300 people are injured globally(Source: NSC Injury Facts). And almost 90% of the accidents are due to human error. With the rise and advancements of Autonomous vehicles, this number can be reduced, and many lives can be saved, and this is the motivating factor that pushes us to do phenomenal work.

Autonomous Vehicle is a booming industry. The global autonomous vehicle market was valued at $76.13 billion in 2020, and is projected to reach $2,161.79 billion by 2030, registering a CAGR of 40.1% from 2021 to 2030. (Source: Allied Market Research)

Our Team's primary goal is to win the Intelligent Ground Vehicle Competition at Oakland University. We believe a Global Level Competiton will give us a direction and international exposure in the pursuit of achieving our dream. Many eminent International Universities like Princeton University and Yale University participate every year. Below are the Achievements at the Global and National levels,

Our dreams are big, but it is achievable. We often are limited by our monetary resources. For instance, our Team performed exceptionally well in Indy Autonomous Challenge (One of the 6 Asian Teams to Qualify for Round 1). We could not participate in further rounds as we did not have enough funds for the transport and logistics.

We seek your acclaimed company for assistance. We would like you to be our Financial Sponsors for our Team in this wonderful expedition.

Why you Should consider being Our Sponsors,

1) International and National Recognition for Your Company

2) Associate with India's Best University

3) Our Team boasts a follower count of 1061 on Instagram

4) Collaboration with One of India's Biggest Student-Run Innovation Bodies (CFI - Centre for Innovation)

5) Team Abhiyaan achievements have been published in popular national dailies, television channels, magazines and Social Media.

6) Team Abhiyaan acts as an ambassador of your brand at Shaastra, India's only ISO certified student-run tech fest, which has a footfall of 40k.

Below are our plans for the upcoming years.
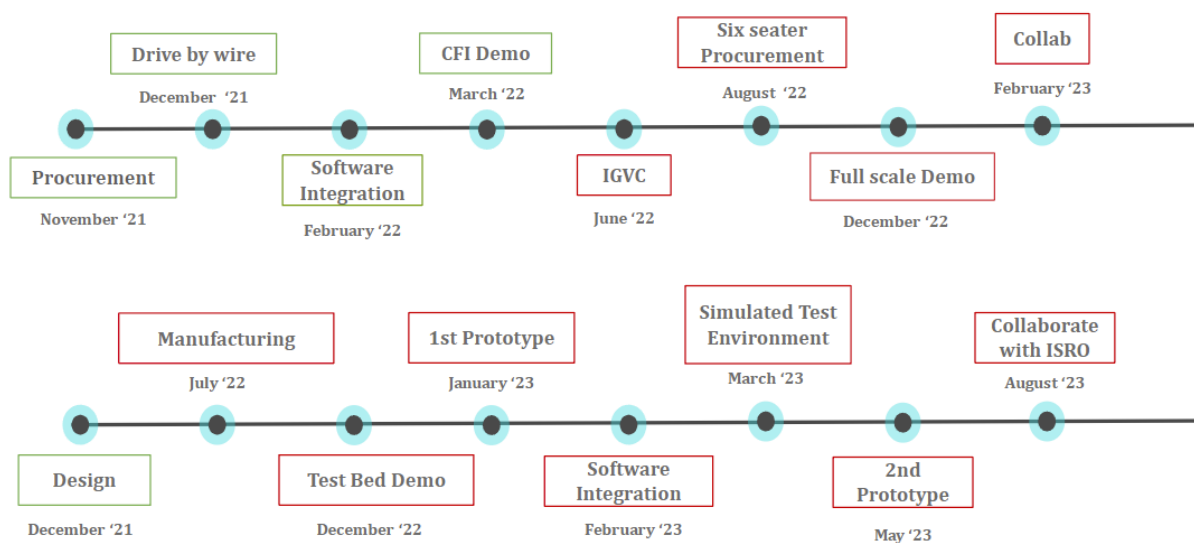
We hope you would consider our request. For any further clarifications or to discuss the sponsorship, please feel free to drop us a mail or contact us at +91 1234567890.

Warm Regards,

Team Abhiyaan

Be clear on what you expect from the sponsorship and how you would like the discussions, dealings, and agreements to go ahead.

The above email is generic that can be used for any company. I personally think **we should not mention our expectations from the Sponsor** at the first email, rather request them to make a proposal. There is a possibility that they might **offer us something that might be beyond what we had expected**. So therefore I did not mention it in the email.

Choose the company appropriately. Also, Mention why you feel that the company you have chosen is the right fit to become a sponsor of Team Abhiyaan.

Below are companies that can be potential Sponsors for Abhiyaan,

Company Name	Reason for Choosing	Type Of Sponsorship
DRDO		
ONGC	Sponsoring IITB AUV Teams	Financial
Teledyne Tech		

Question 3

Make an Instagram poster (.png/.jpg/.jpeg file) welcoming the sponsor of Team Abhiyaan.

Possible Improvements

- With a Transparent Abhiyaan logo, I think the poster would tad bit look better XD