Dairy Bike: Task 2.1

task-2

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TASK 2.1

Welcome everyone to Task2 of DairyBike (DB) theme!

Up until this task you have already installed software that are required for the theme and have a good understanding of the world of mathematical modeling along with Control Systems.

In this Task you'll design your own Dairy Bike with the help of certain existing models that we will provide. The bike will use a reaction wheel pendulum to balance itself on two wheels. We hope you have got a good introduction about CoppeliaSim until now. Now here we will be using CoppeliaSim extensively to design the DB.

Please go through this **user manual** before you start designing.

Designing Dairy Bike

Download the **task2_1.ttt** file from here. This .ttt file contains some preloaded elements using which you will create your own DB.
Each team will have to make their own DB using the pre-made models provided

Following is the list of elements provided and their uses:

Name	Component Name	Function
Front Motor	FrontMotor	This element acts as an actuator
Front Wheel	FrontWheel_Respondable	This element is real respondable front wheel
	FrontWheel_Visible	This element contains visual features only
Reaction Wheel Motor	ReactionWheelMotor	This element will provide required torque to balance
Reaction Wheel	Reaction Wheel	This element is real respondable reaction wheel
	Marker	This element will help identify direction of rotation
Rear Motor	RearMotor	This element will drive the bike
Rear Wheel	RearWheel_Respondable	This element is real respondable rear wheel
	RearWheel_Visible	This element contains visual features only

Table 1: List of elements in task2_1.ttt

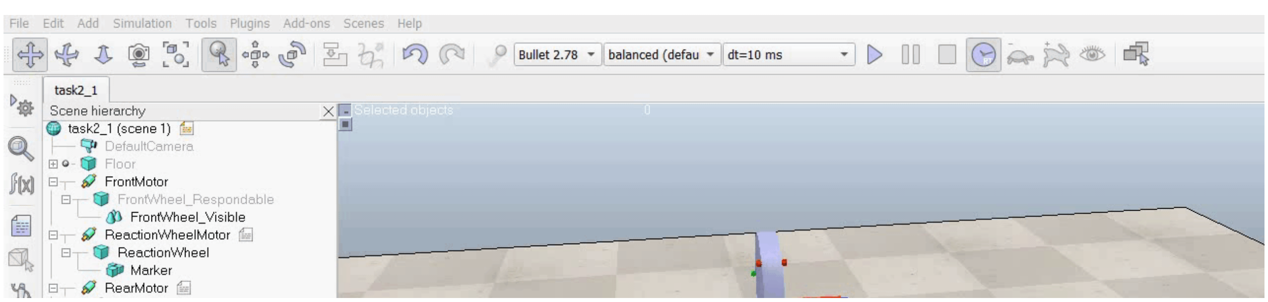


Figure 1: GIF of the components in task2_1.ttt file

Bot Design Restrictions:

- **Do not edit or change any properties of the elements mentioned in the table above.**
- The Dairy Bike that you will build should **only use Reaction wheel** based balancing.

Bounding Box

- Bounding box is a virtual cuboid which specifies the maximum permissible dimensions of the Bike.
- length x height x width **(1.2m x 1.0m x 0.6m)**

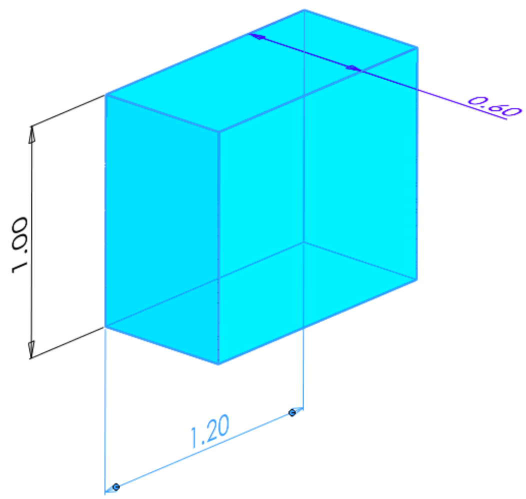


Figure 2: Bounding Box of Dairy Bike

- **Dairy Bike Weight Specifications**
  - The maximum permissible weight without payload is **20 kg**.
- **Minimum turning radius**
  - The minimum turning radius ~ 0.8-1m

CoppeliaSim via Autodesk Fusion360. Delivery mechanism (Understanding dummies in CSim)

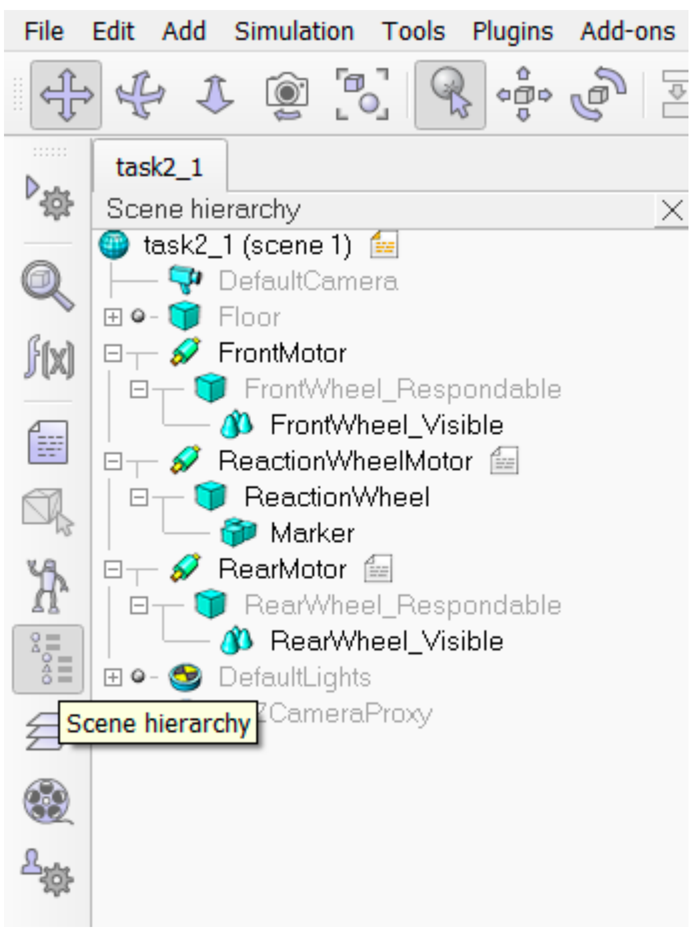
CoppeliaSim Hierarchy

- Inside CoppeliaSim on the left hand side you will find a block named Scene Hierarchy, on expanding the block you can look at the arrangement of components present, this arrangement defines the hierarchy or parent child relationship.

- **Important Note**- Make sure that this hierarchy is set up as it is, including the naming convention.

Hierarchy description:
(You can also refer to Figure 3)

- FrontMotor
  - FrontWheel_Respondable
    - FrontWheel_Visible
- RecationWheelMotor
  - ReactionWheel
    - Marker
- RearMotor
  - RearWheel_Respondable
    - RearWheel_Visible



- The main objective here is to design the chassis using primitive shapes in CoppeliaSim

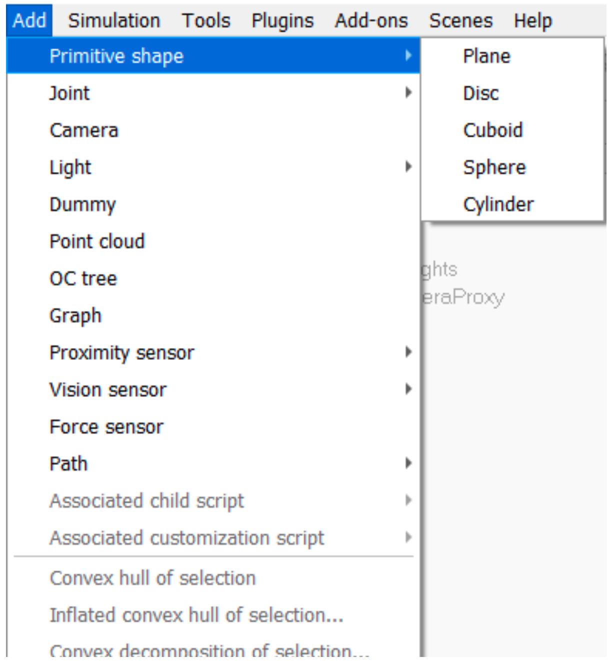
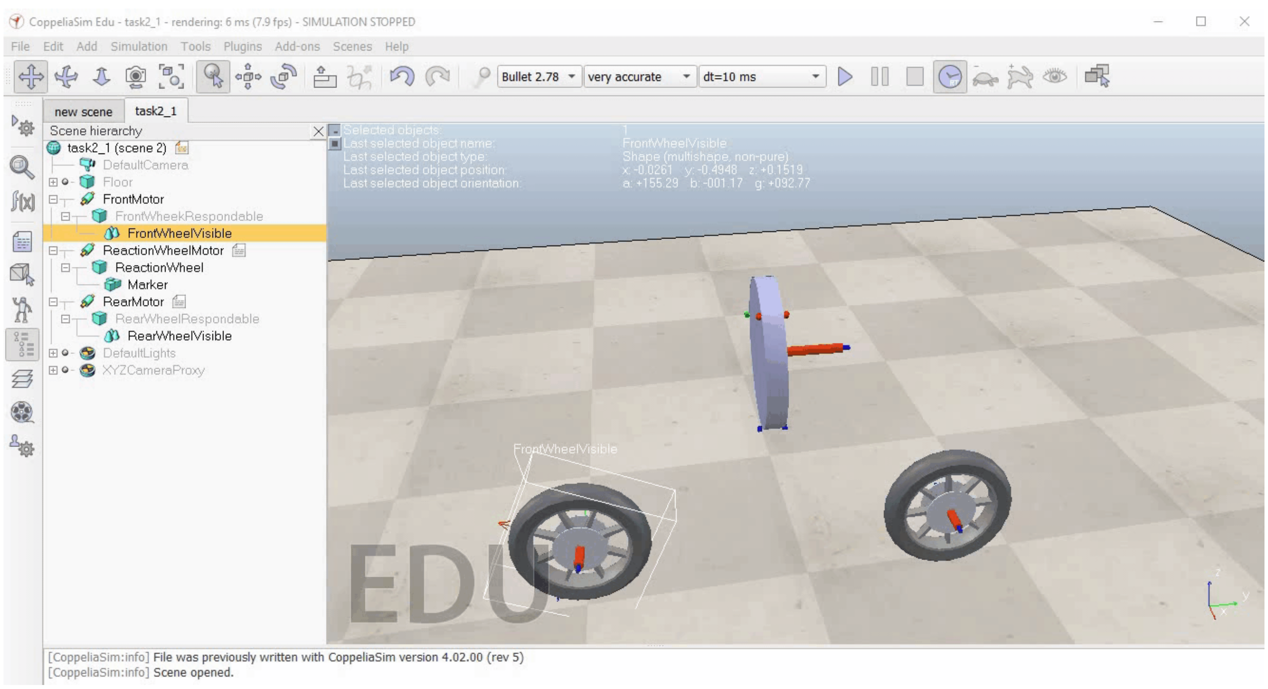


Figure 4: Primitive Shape menu in CoppeliaSim

- However you can design the visual aspects in Fusion 360.
- Important point to understand here is that Visual aspects will be added as **non-dynamic** and **non-respondable** objects so they won't affect your RTF (Real Time Factor)



- The bounding box of package is (10cm x 10cm x 10cm)

- Attached below are the 3 varieties of packages:
  - **Milk.ttm**
  - **Curd.ttm**
  - **Cheese.ttm**

- You can use “Plane” option that is available in Add >> Primitive shapes >> Plane, to create a holding structure for the packages.

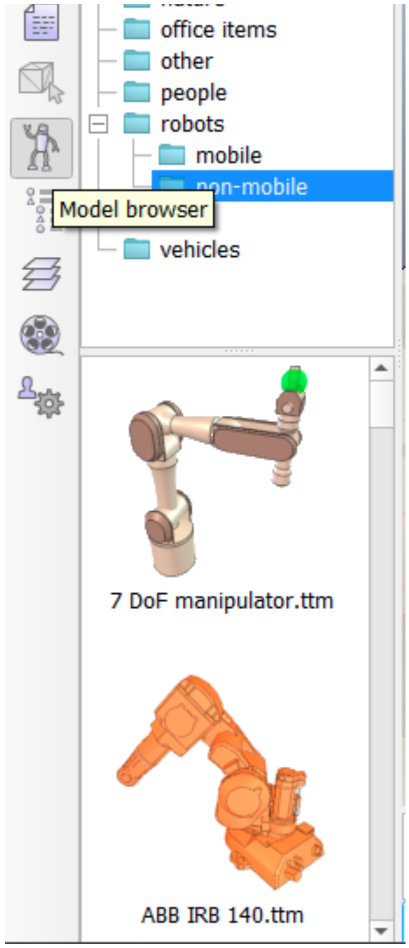
Note- CoppeliaSim principles to follow, do not add any non-dynamic body as a child script to a dynamic body

The making of complete Dairy Bike

- Now that you have skeleton components with you, and have learnt about adding dummies, you will have to make your own DB using these components and adding the required components to it.

- The main challenge here is to design a chassis for your DB, which will give it the feeling of a bike.

- The payload storage space can be on both sides of the DB and should be connected to chassis.


office items
other
people
robots
mobile
non-mobile
Model browser
vehicles
7 DoF manipulator.ttm
ABB IRB 140.ttm

Task 2.2 ››

Task Submission

Dairy Bike: Task 2.2

task-2

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TASK 2.2

Welcome to Task 2.2!

This Task is simple, now that you have designed your own DB in previous task here you'll derive the **Mathematical Model** for the same using the experience of Task1.

Q1. Import the labeled JPEG image of your Dairy Bike (DB) as designed in Task 2.1. Describe various parts of the DB and brief reasoning for the selection of your design. Describe the various components of DB with their masses and Moment of Inertia.

Q2. Find out the Kinetic Energy and Potential Energy of the overall system. Also specify the chosen states for your system.

Q3. Find out the Lagrangian function and write down the governing dynamical equations using Euler-Lagrange mechanics.

Q4. Find out all the equilibrium points and comment on the stability of each of them.

Q5. Find out the Jacobian Matrices around the unstable equilibrium point and specify the state matrix A and input matrix B for the robot designed.

Q6. Find the controllability matrix **[C]** and comment on the controllability of the designed system.

Q7. Convert your model from continuous time system to discrete time system and comment on the importance of this step.

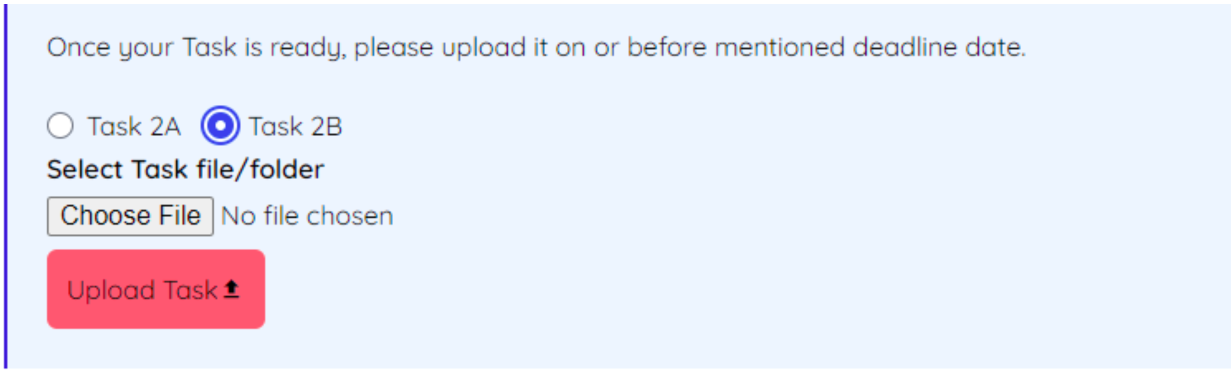
Q8. Find out the gain K for the system using LQR function in the octave and comment on the stability of the modified matrix.

$$\tilde{A} = (A - BK)$$

Make a .pdf file of your solutions to each question and upload it by following instructions in the Task Submission section below.

Task Submission

- For successful completion of **Task 2_2** , upload the **task2_2.pdf** file on the portal.
  - Now, open the portal and go to **Task 2** . In the **Task 2 Upload** section select **Task 2B** .
  - Now select **Choose file** button to upload the file. From the dialogue box, select the file and click **Open**



All the Best!!

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TASK 2.2

Task Submission