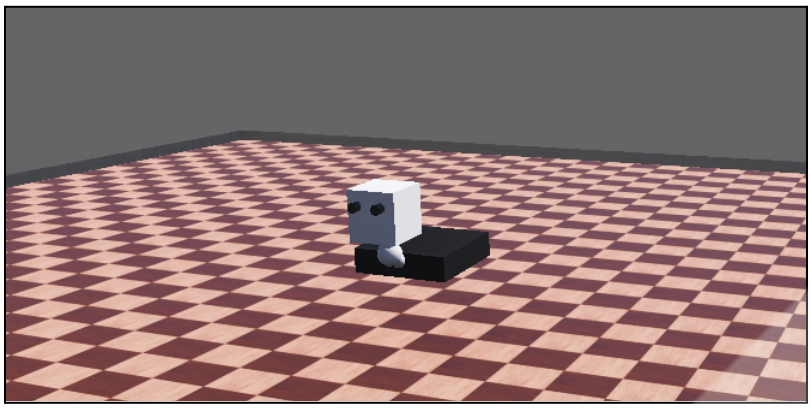
Topic	FOUR LEGGED ROBOT - I	
Class Description	**Students will construct a simple four legged robot. They will also learn how to build a limb joint for a robot which is inspired by an animal.**	
Class	**PRO C292**	
Class time	**50 mins**	
Goal	• Understanding the base structure of the robot • Building the limb joints • Adding physics to the robot	

Resources Required	• Teacher Resources:
	  ○ Laptop with internet connectivity
	  ○ Earphones with mic
	  ○ Notebook and pen
	  ○ Smartphone
	• Student Resources:
	  ○ Laptop with internet connectivity
	  ○ Earphones with mic
	  ○ Notebook and pen	

Class structure	**Warm-Up** **Teacher-Led Activity 1** **Student-Led Activity 1** **Wrap-Up**	**10 mins** **10 mins** **25 mins** **05 mins**
Credit & Permissions:	**This project uses Webots, an open-source mobile robot simulation software developed by Cyberbotics Ltd.** **License**	
WARM-UP SESSION - 10 mins		

Teacher Action	Student Action
Hey <student's name>. How are you? It's great to see you! Are you excited to learn something new today? **Following are the WARM-UP session deliverables:** • Greet the student. • Revision of previous class activities. • Quizzes.	**ESR**: Hi, thanks! Yes I am excited about it! Click on the slide show tab and present the slides
WARM-UP QUIZ Click on In-Class Quiz	
Activity Details **Following are the session deliverables:** • Appreciate the student. • Narrate the story by using hand gestures and voice modulation methods to bring in more interest in students.	
TEACHER-LED ACTIVITY - 10 mins	
Teacher Initiates Screen Share	
• **Building the torso of the robot**	
Teacher Action	**Student Action**
So what did we learn in our last class? *The teacher will clarify if there are any doubts!* So let's get started with today's class. In our last class, we completed our robotic arm project.	**ESR:** Varied!

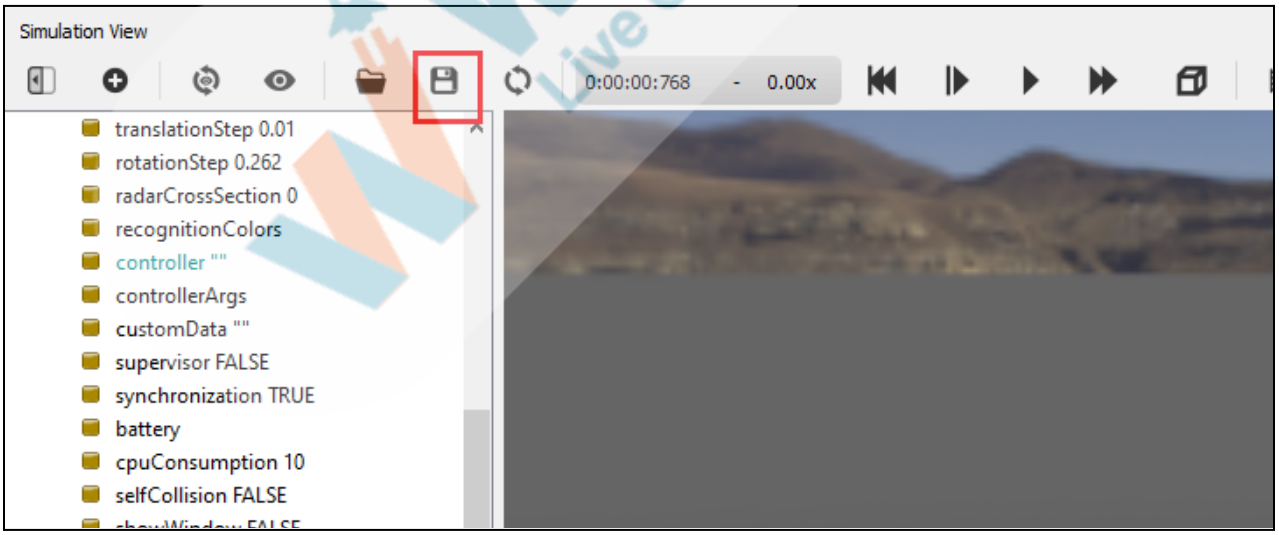
Today, we are going to start building a biomimetic robot. The word biomimetic refers to human-made devices or systems that imitate nature. A biomimetic robot is a robot which mimics a living creature. Today, we will build a robot which is inspired by a four-legged animal e.g. dog.	
Teacher downloads the boilerplate code from Teacher Activity 1.	
Open the file using Webot. 1. Open the **webots** 2. Go to the **Open World** 3. Upload the webots file from boilerplate code	
First let's think about the structure of the four legged robot. What do we need? How can we make a torso? What can we use to make the legs? But the legs also need to be able to move. How can we achieve that? Perfect! Let's get started.	**ESR:** We need a torso, head, and four legs etc. **ESR:** We can use basic shapes (e.g. box/cuboid) provided in webots. **ESR:** We can use cylinder shape to make the legs. **ESR:** We can use rotational motors to move the legs.
Teacher opens the boilerplate code on webots.	



If you see the structure is falling down, pause  *the simulation and reset*  *it.*

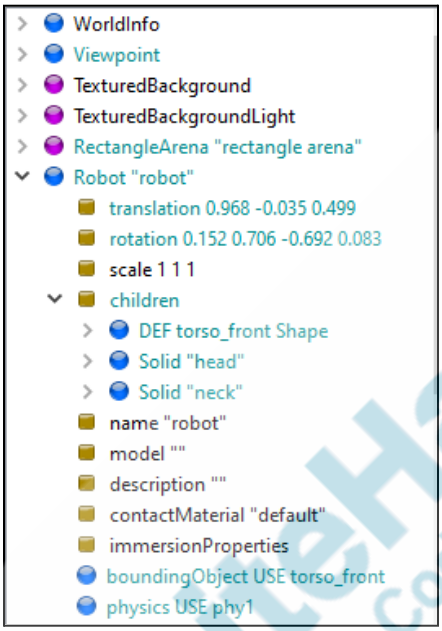
1. We can see that the head and the torso are already given.
2. We will add a hip structure to our robot.
3. We will also add four legs to the structure.

Make sure you save the project after every major step. Otherwise, you might lose your work.



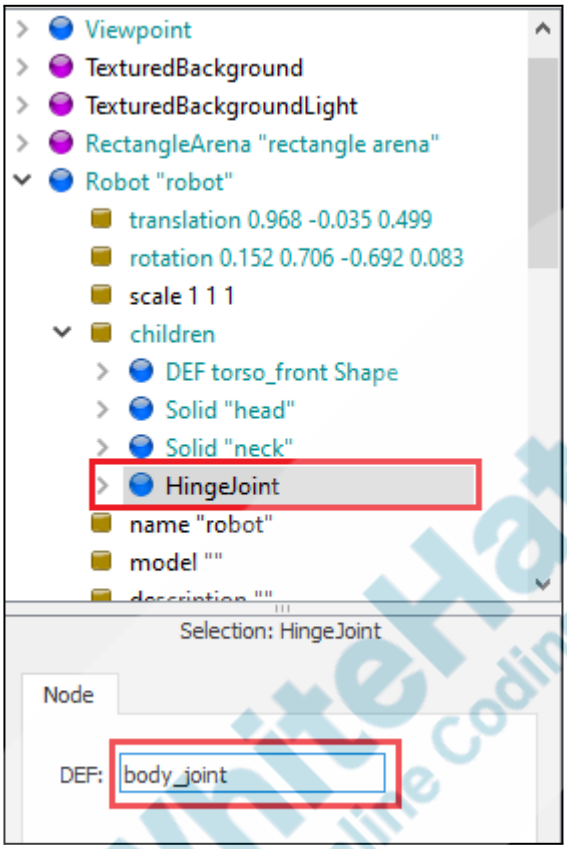
Let's add the hip structure first.

1. First, let's look at the structure of the robot in the **Scene tree**.



   In the **Scene tree**, we have a **robot**. Under the **children** of the **robot** node, we have a **shape** which is the torso, a **solid** node for the neck and a **solid** node for the **head**.
2. Now, we will add a **hingeJoint** to connect the front portion of the torso with a back portion which we will create later.

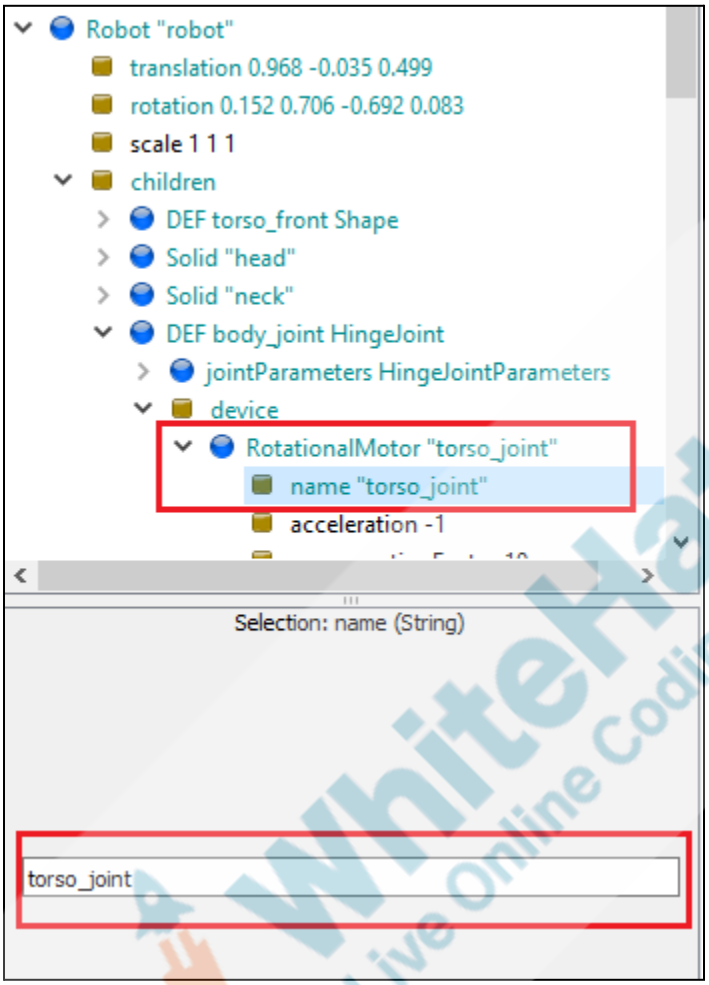
   a. Add a **hingeJoint** and click on the hingeJoint in the **Scene tree.** Change **DEF** property to **body_joint.**



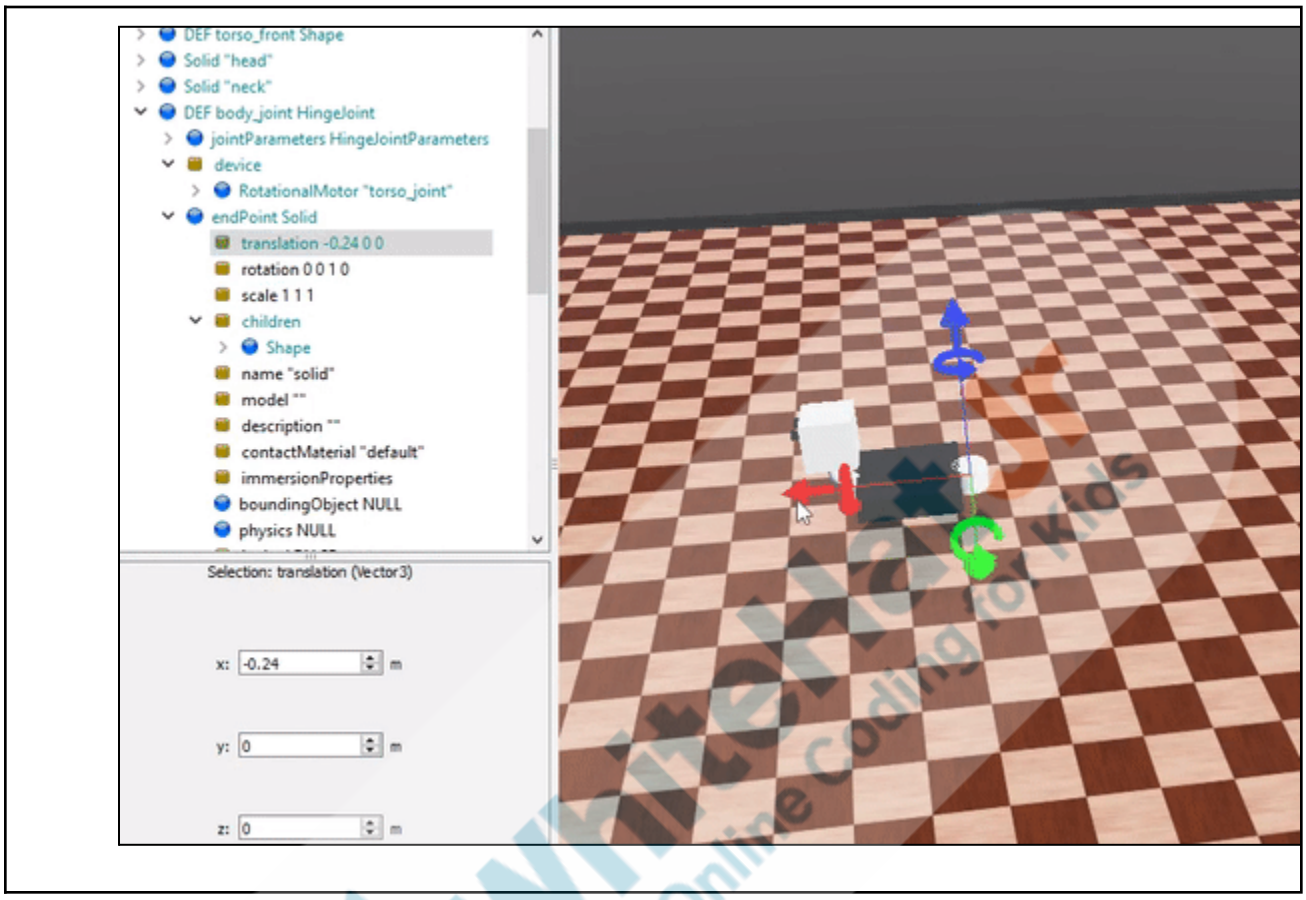
3. Now, we need to specify properties for this hingeJoint. First, expand the hingeJoint node in the **scene tree**. Now,

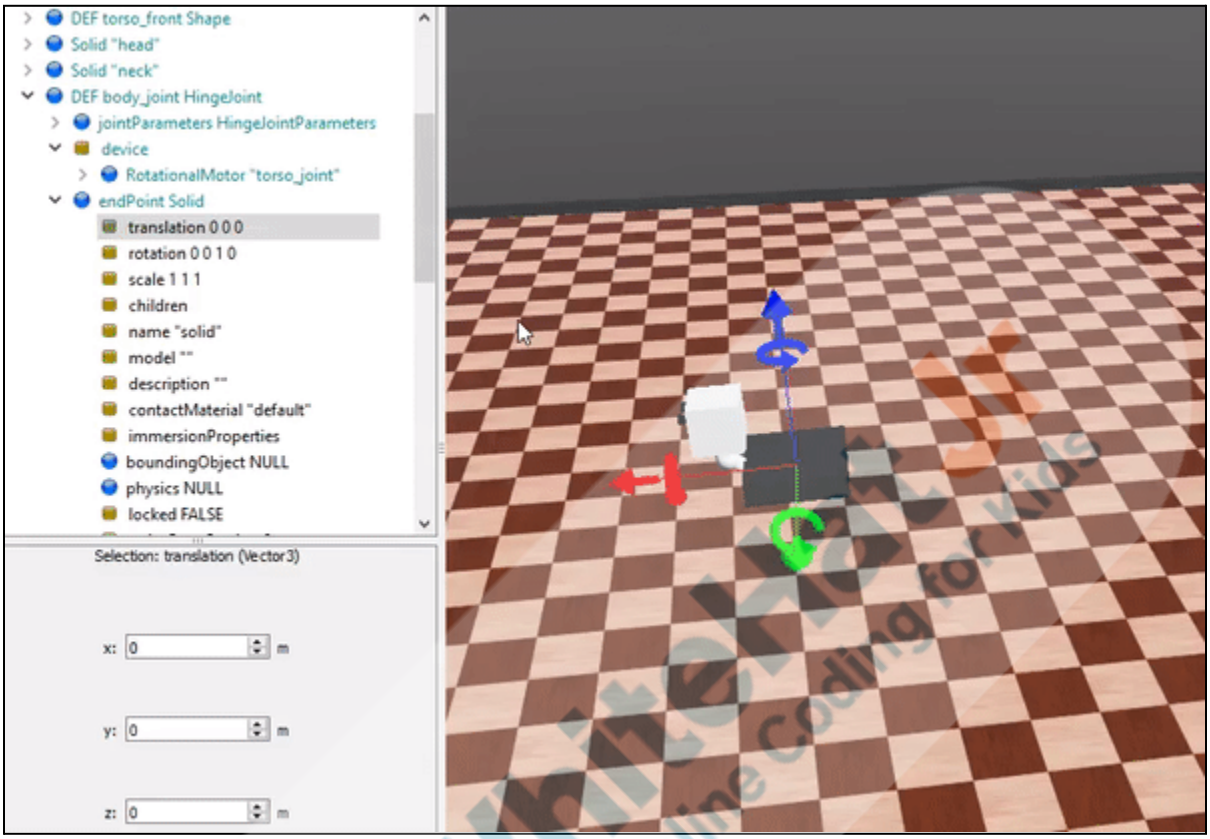
    a. Add **jointParameters** as **HingeJointParameters**.

    b. Add a **RotationalMotor** under the **device** option and name this motor as "**torso_joint**".



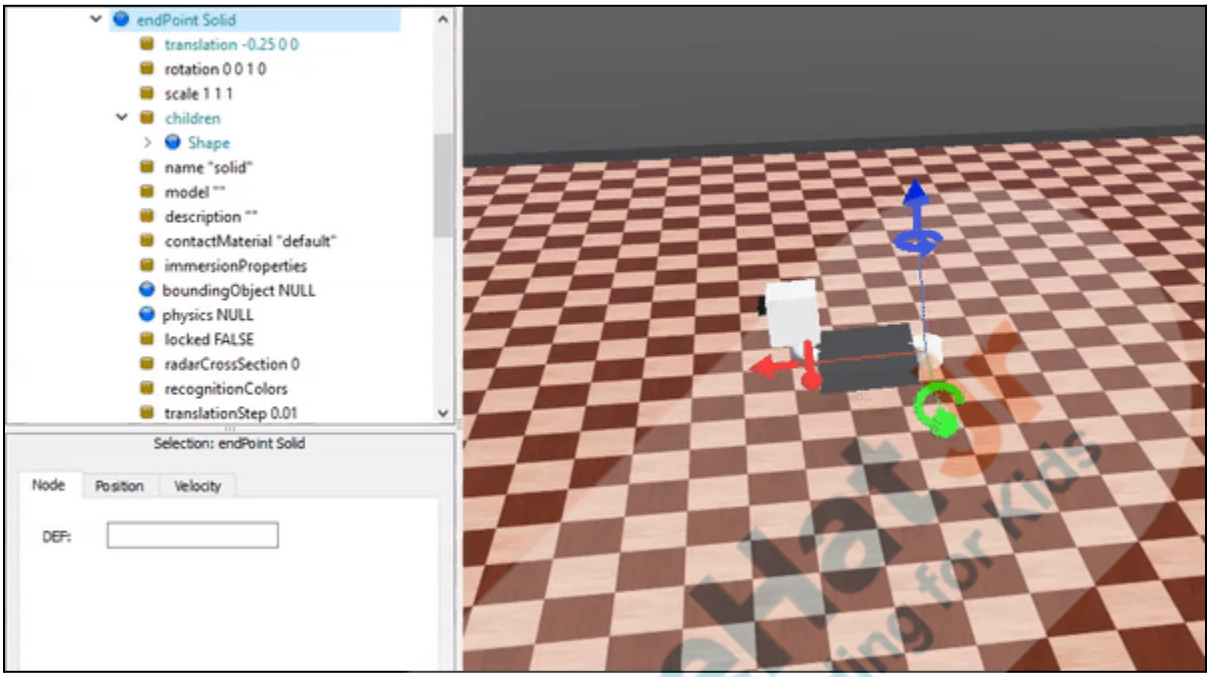
c. Now, add a **solid** node under the **endPoint** option of the **hingeJoint** we have added for the torso.
d. Add a **shape** node to the **children** of this **solid** node.
e. Add **appearance** as **PBRAappearance** and change **metalness** property to **0**.
f. Under geometry, add a **cylinder** shape. Change the **radius** to 0.07
g. Reposition this node at the back of the torso by dragging.





Click here to view the reference video.

h. Now, rename this shape to **torso_joint_shape** and add it to the **boundingObject**. Make sure that you add **physics** to it.



Click here to view the reference video.

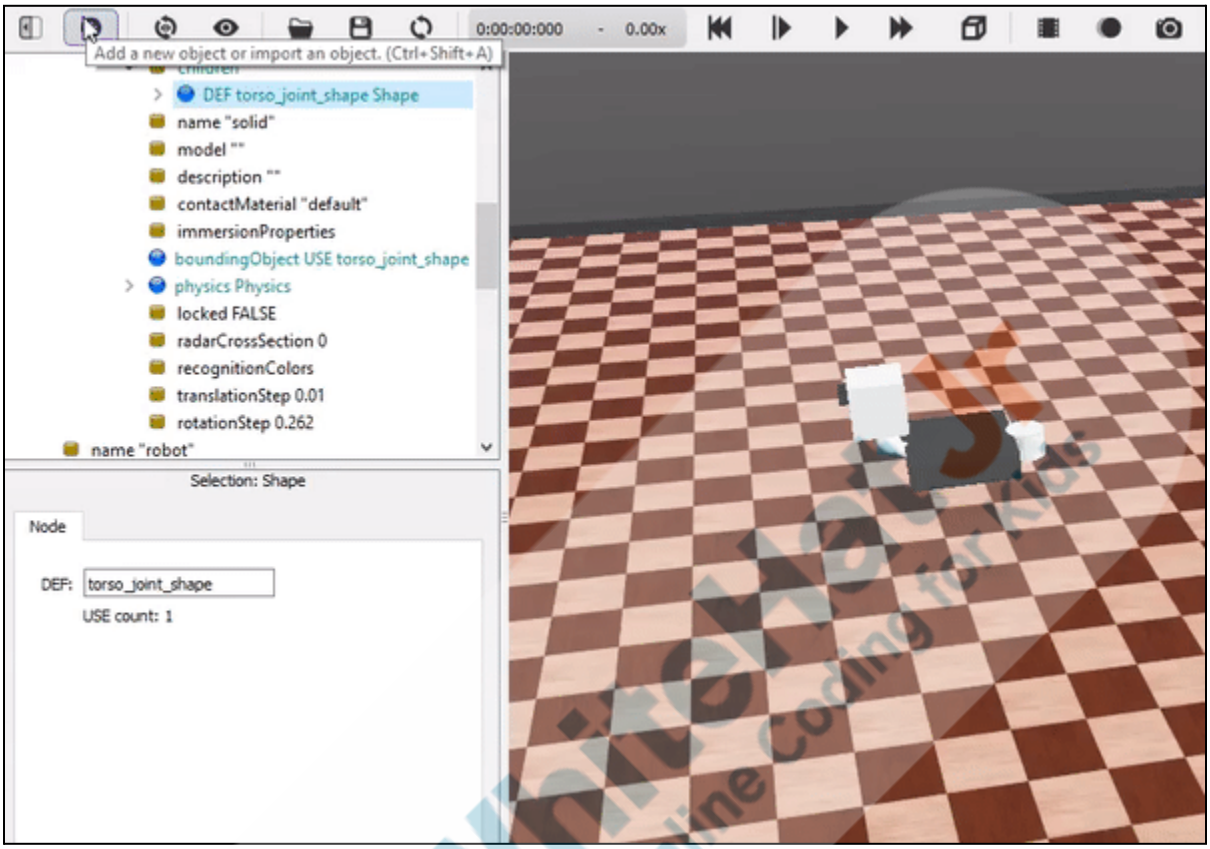
Now, we want to make another black box connected with this hinge joint. This will create the back portion of the robot.

a. Add a **solid** node under the children of the hinge joint's **endPoint** solid node.
b. Add a **shape** node to this **solid** node and change it to a box shape. This will create the back portion of the torso. The size of the **shape** node can be

   x: 0.2, y: 0.4, z: 0.1

   [we need each shape to be contained in a solid node because the shape node does not have a position property. So, we cannot reposition the shape node on its own. Also, we cannot apply physics properties to a shape node. That's why we make the shape node a child of a solid node to reposition it properly and to add physics.]

c. Reposition it by dragging the solid node.

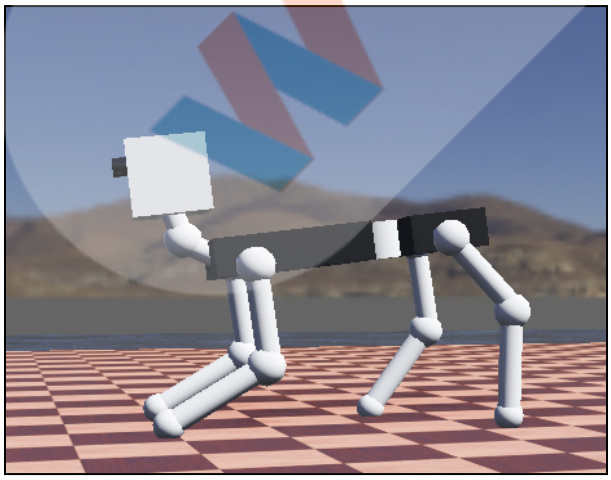


Click here to view the reference video.

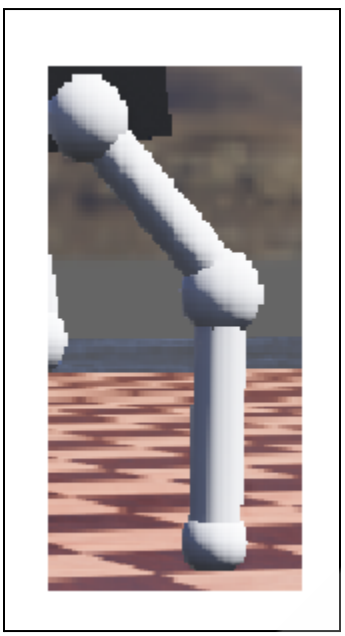
d. Add **torso_back** as the **boundingObject**. Make sure that you add **physics** to it.

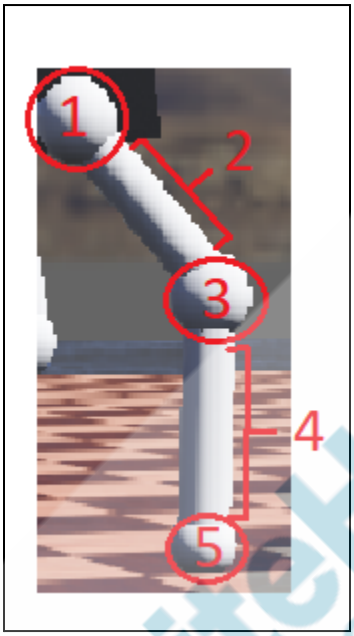
Looks good, isn't it? What's left? Yes. Let's add the legs. But it will be your task to add the legs. Are you ready?	 **ESR:** legs. **ESR:** Yes.

Teacher Stops Screen Share

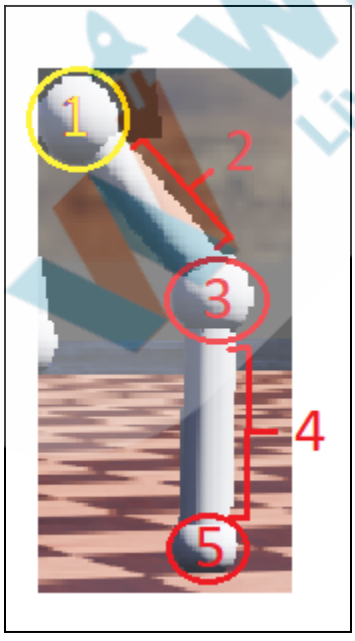
So now it's your turn. Please share your screen with me.	
We have one more class challenge for you. Can you solve it? Let's try. I will guide you through it.	
STUDENT-LED ACTIVITY - 25 mins	
• **Ask the student to press the ESC key to come back to the panel.** • **Guide the student to start Screen Share.** • **The teacher gets into Full Screen.**	
Student Initiates Screen Share	
ACTIVITY • **Learn to build the legs of the robot.**	
Teacher Action	**Student Action**
Student downloads the boilerplate code from Student Activity 1.	
Let's add the first leg. But first let's understand how do we want the legs to look like- 	

The leg will have the following structure which can be broken down into 5 sections.



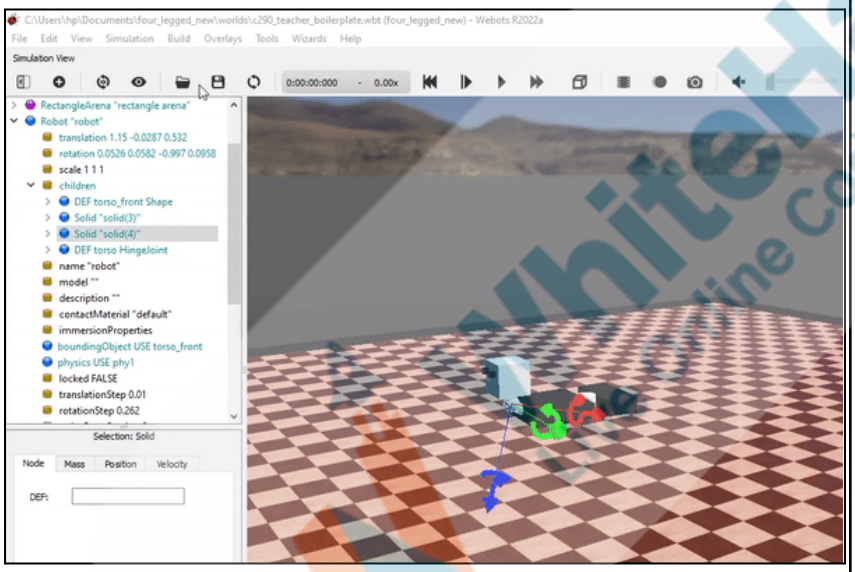


Section-1:



Again, we will add a hinge joint for our first leg.

1. Click on the children of the **Robot** node and add a hinge joint.
2. Click on the **hingeJoint** and change the **DEF** as **leg1_joint**
3. Expand to view the properties of the new hinge joint and add **HingeJointParameters** to the **jointParameters** property.
4. Add **RotationalMotor** to the **device** property.
5. Expand the device property, click on the **name** property and rename this rotational motor as **front_left.**
6. Add a **solid** node to the **endPoint** property.

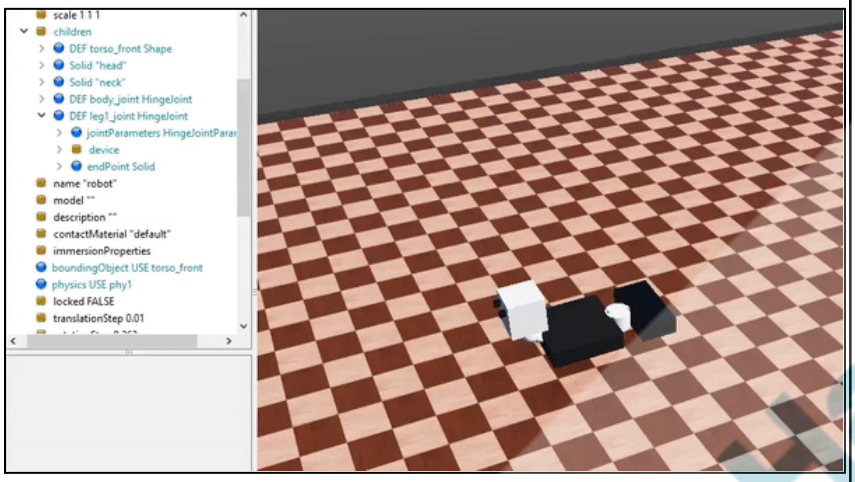


Click here to view the reference video.

7. Now, in the **endPoint** solid node's children, add a **shape** node. This will help us give the hinge joint a shape.
8. Click on the node and change the **DEF** property to **leg1**. This name will help us to add the **boundingObject** later.
9. Change the appearance to **PBRAappearance** and change the **metalness** to 0.
10. Change the **geometry** to Sphere and make the

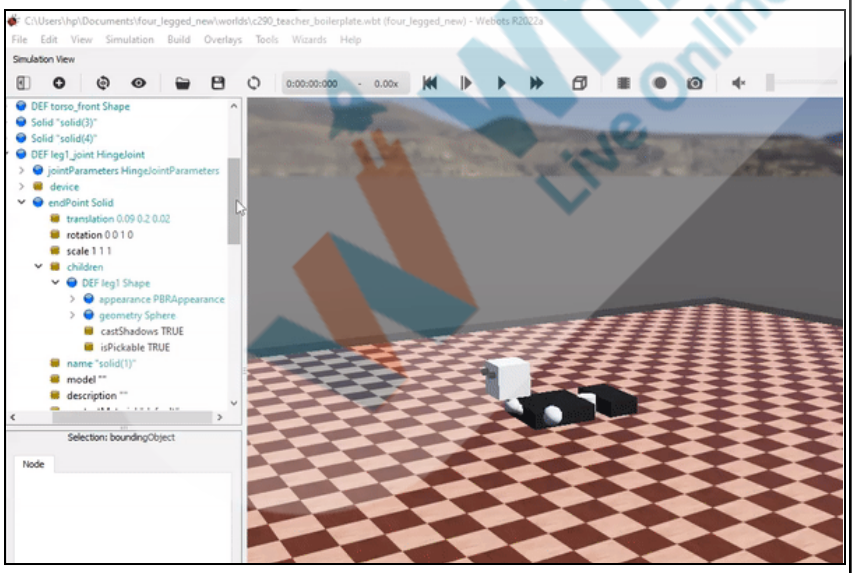
radius 0.06.

11. Reposition it by dragging. Suggested position: 0.09, 0.2, 0



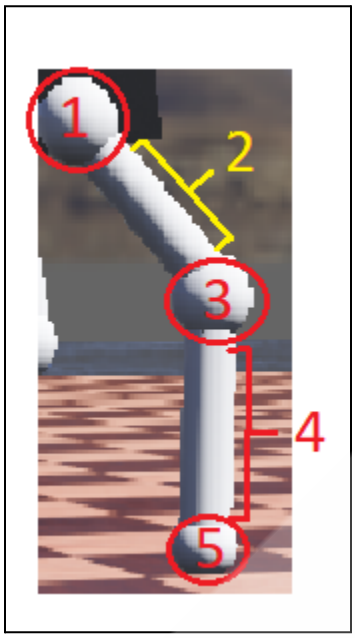
Click here to view the reference video.

12. Add physics to the **endPoint solid** node of the hinge joint.



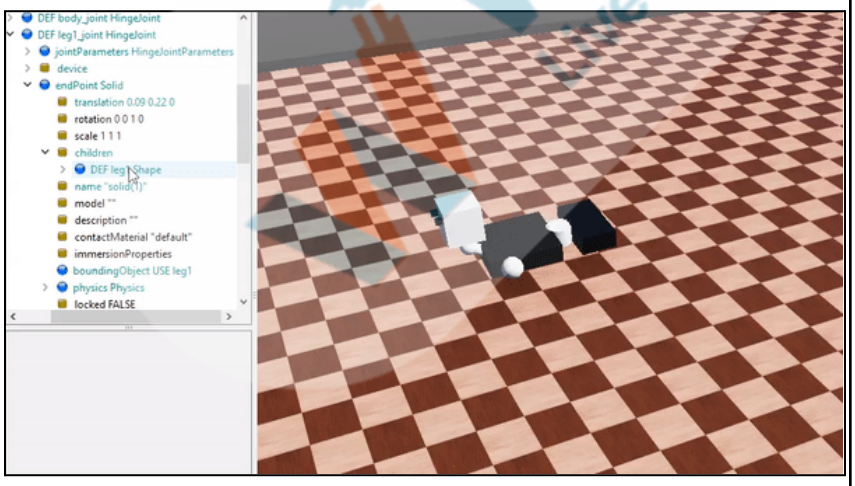
Click here to view the reference video.

Section-2:



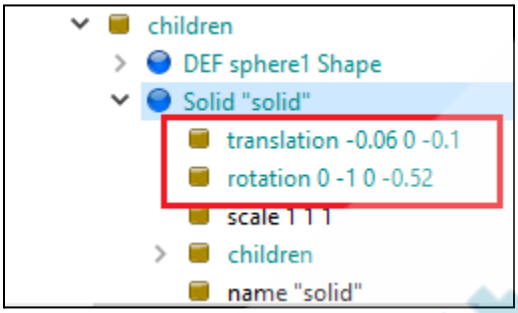
Let's add the next portion of the leg. This should be a cylindrical shape.

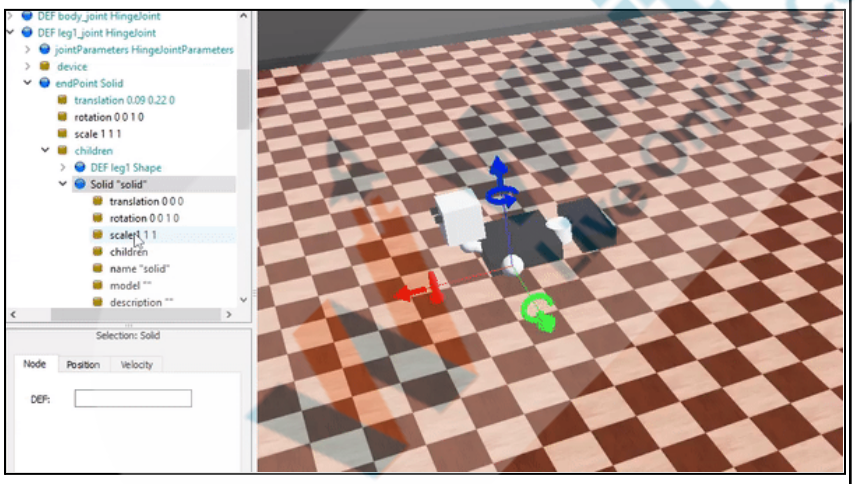
1. Go to the children of the **endPoint solid** node of the hingeJoint we had just created → add a **solid** node.



Click here to view the reference video.

2. Add the **shape** node to this newly created **solid** node.
3. Click on the node and change **DEF** to **cylinder1**.
4. Add appearance as PBRAappearance and change metalness property to 0.
5. Under geometry, add **cylinder** shape. Change the **height** to 0.25 and **radius** to 0.03
6. Change the rotation of the solid node to 0, -1, 0, -0.52
7. Change the position to -0.06, 0, -0.1

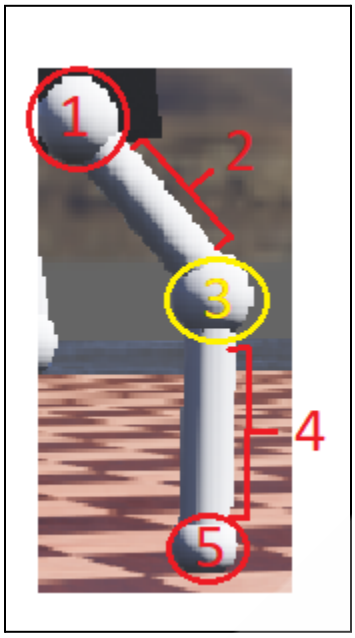




Click here to view the reference video.

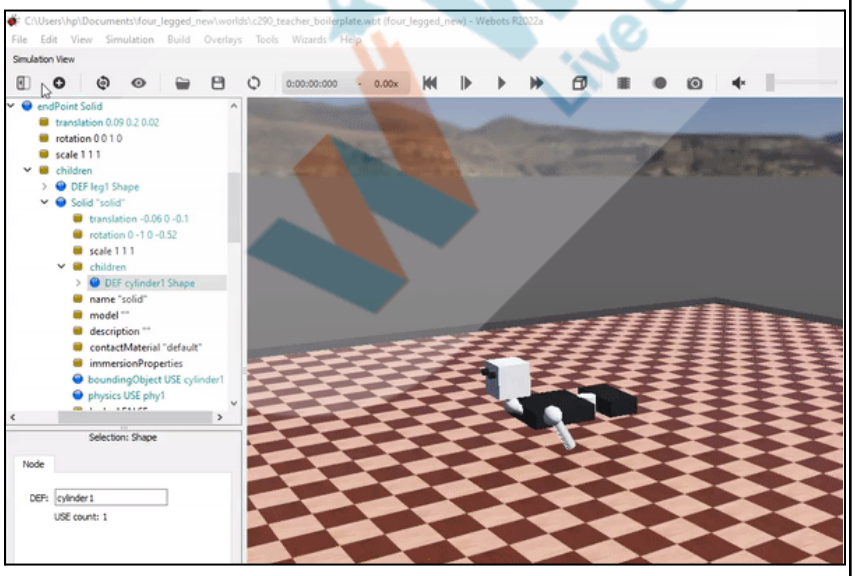
8. Add **bouldingObject** as **cylinder1** and add physics to this solid node.

Section-3:



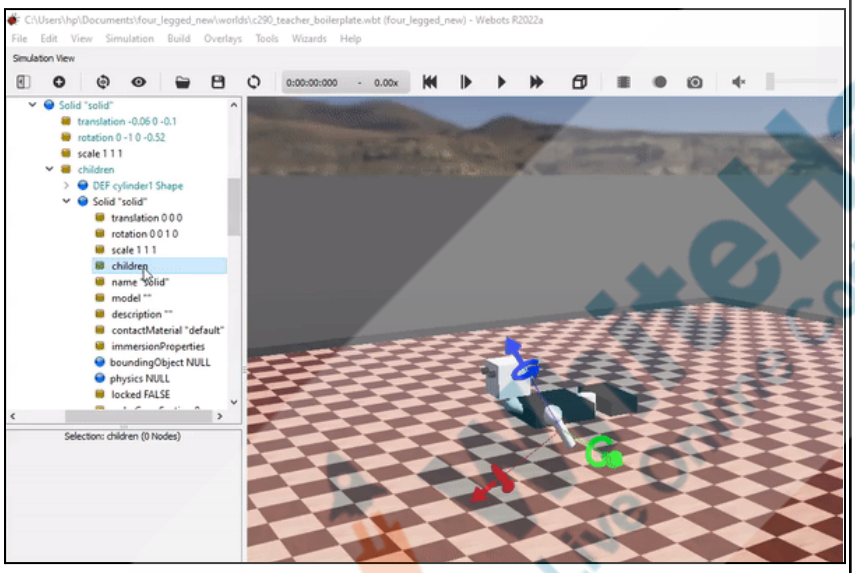
Let's add the next portion of the leg. This should be sphere-shaped.

1. Go to the **children** of the **solid** node which contains the cylinder1 we had just created → add a **solid** node.



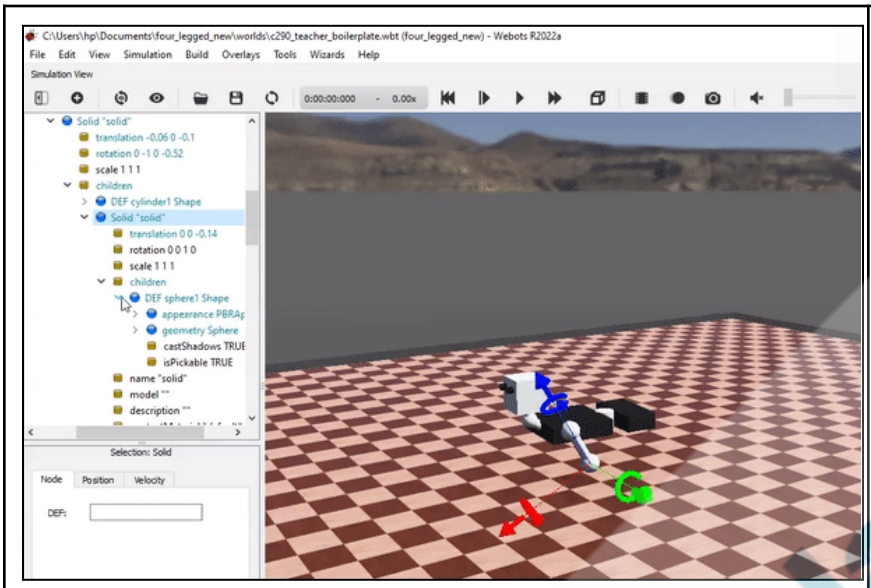
Click here to view the reference video.

2. To the children of this **solid** node, add a **shape** node.
3. Click on the node and change **DEF** to **sphere1**.
4. Add appearance as PBRAappearance and change metalness property to 0.
5. Under geometry, add a **sphere** shape. Change the **radius** to 0.06
6. Reposition this node at the bottom end of the cylinder node by dragging.



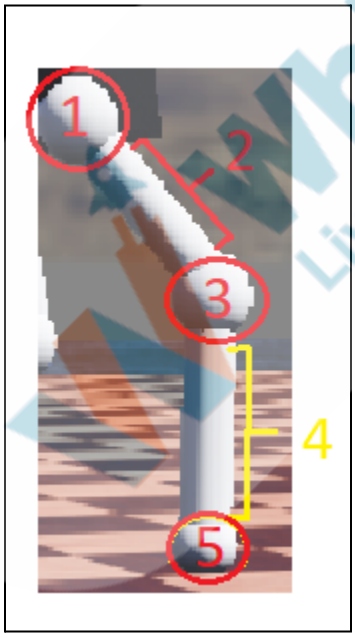
Click here to view the reference video.

7. Add **bouldingObject** as **sphere1** and add physics to this solid node.



[Click here](#) to view the reference video.

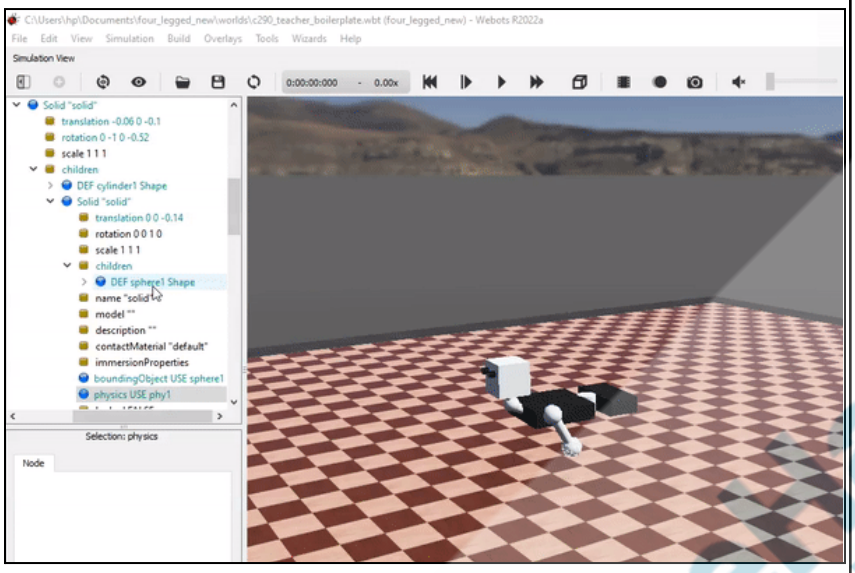
Section-4:



Let's add the next portion of the leg. This should be a cylindrical shape.

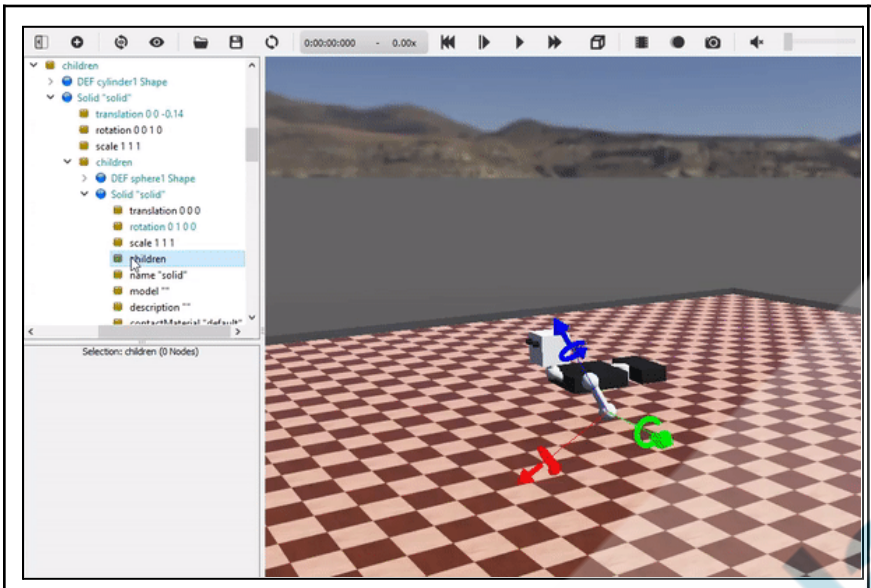
1. Go to the **children** of the **solid** node which contains

the sphere1 we had just created → add a **solid** node.



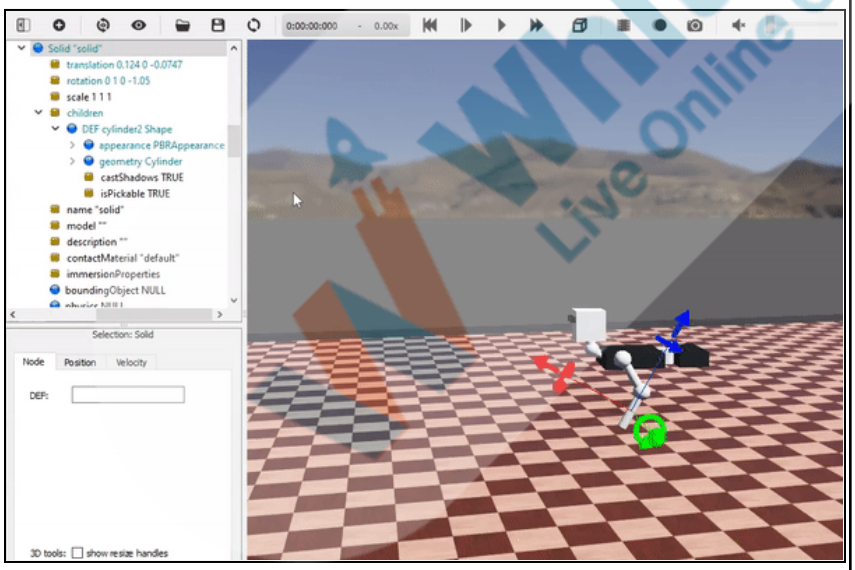
[Click here](#) to view the reference video.

2. To the children of this **solid** node, add a **shape** node.
3. Click on the node and change **DEF** to **cylinder2**.
4. Add appearance as PBRAappearance and change metalness property to 0.
5. Under geometry, add **cylinder** shape. Change the **height** to 0.25 and **radius** to 0.03
6. Change the rotation of the solid node and reposition it by dragging.



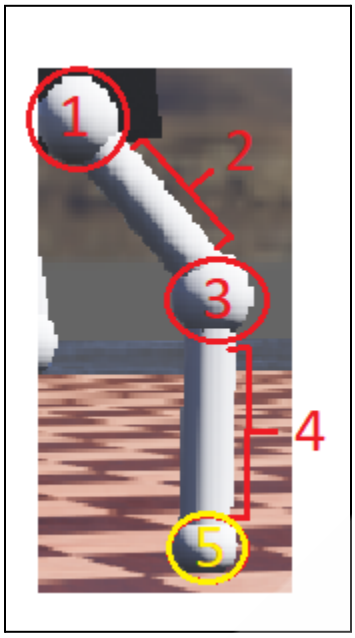
[Click here](#) to view the reference video.

7. Add **bouldingObject** as **cylinder2** and add physics to this solid node.



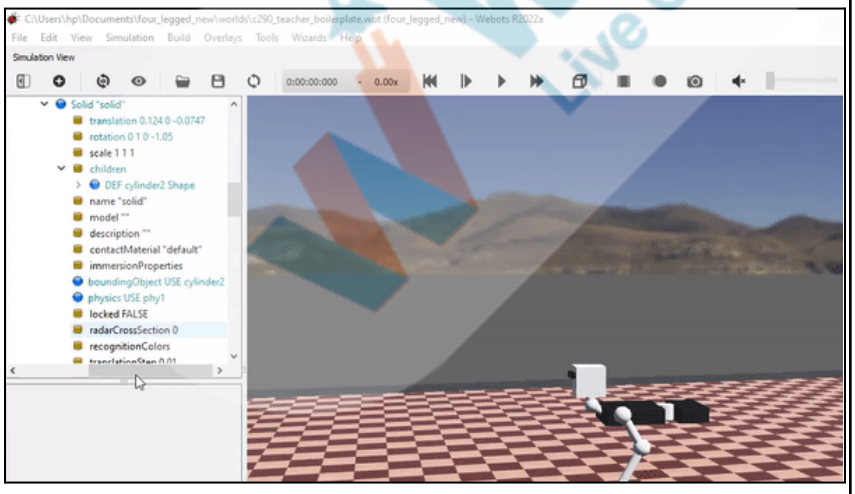
[Click here](#) to view the reference video.

Section-5:



Let's add the next portion of the leg. This should be sphere-shaped.

1. Go to the **children** of the **solid** node which contains the cylinder2 we had just created → add a **solid** node.

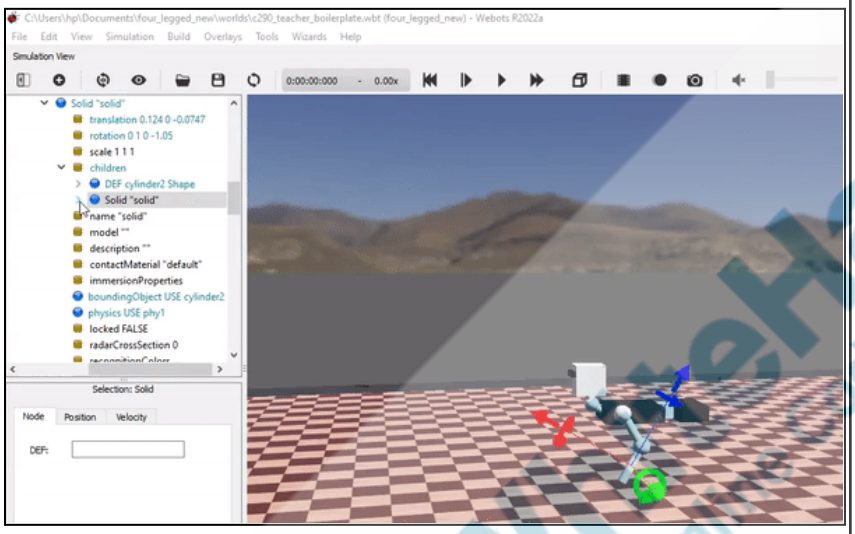


[Click here](#) to view the reference video.

2. To the children of this **solid** node, add a **shape**

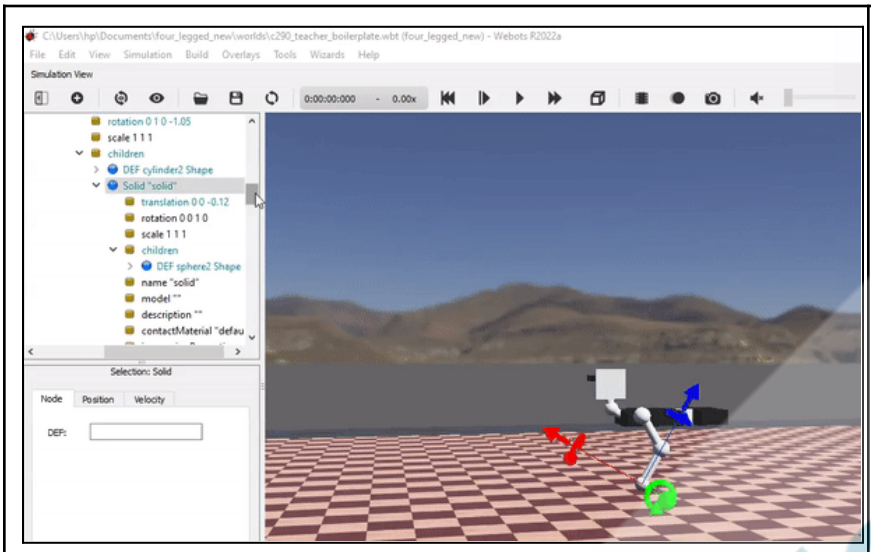
node.

3. Click on the node and change **DEF** to **sphere2**.
4. Add appearance as PBRAappearance and change metalness property to 0.
5. Under geometry, add a **sphere** shape. Change the **radius** to 0.05
6. Reposition this node at the bottom end of the cylinder node by dragging.



Click here to view the reference video.

7. Add **bouldingObject** as **sphere2** and add physics to this solid node.



[Click here](#) to view the reference video.

So, we have built one leg.

Let's save the project.

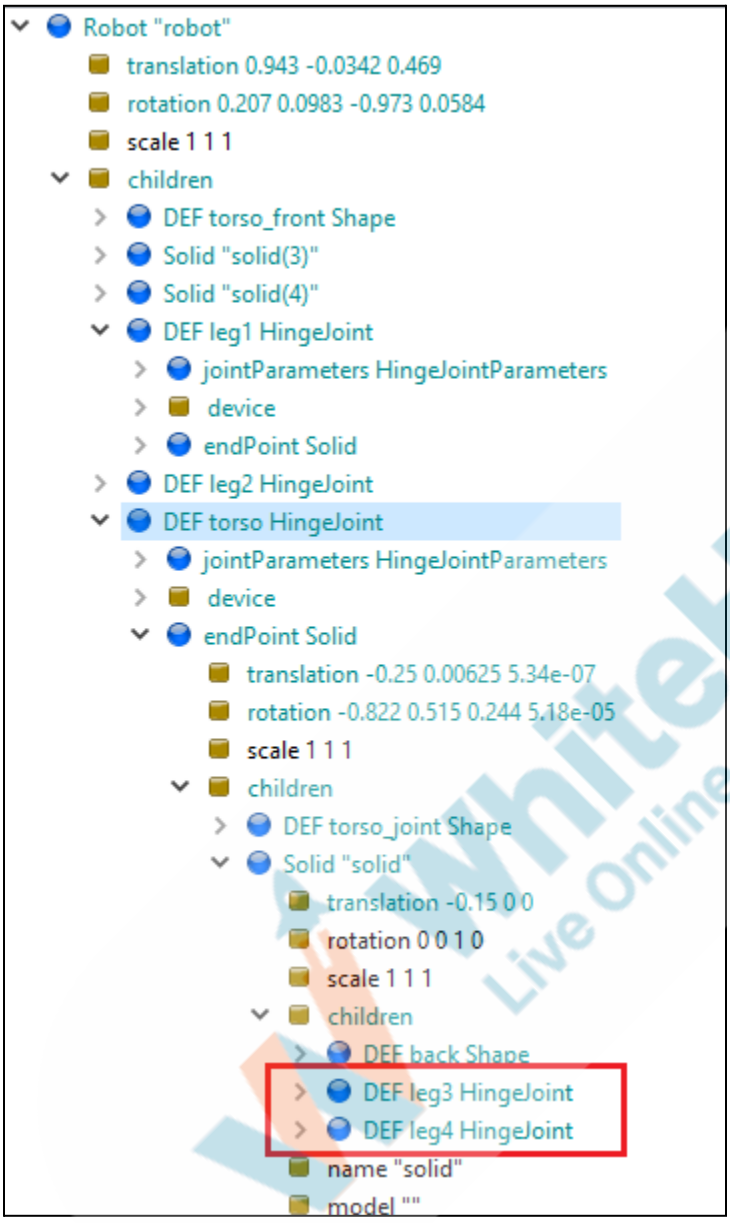
Once it is saved, try playing the simulation.

If the leg breaks down, reopen the project and try again.

If it still happens, check if the **boundingObjects** and **physics** is applied to all the solid nodes or not.

Now, we copy the leg1 and paste it again to create leg2, leg3 and leg4.

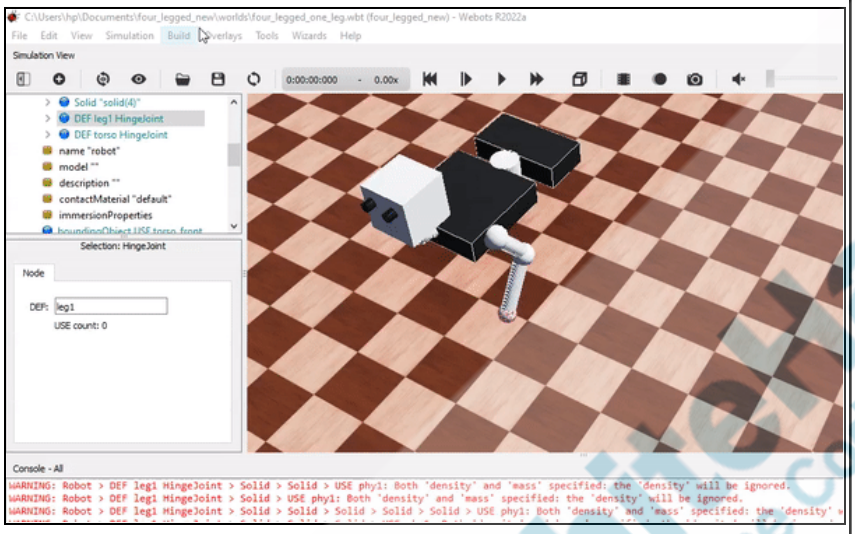
Note that leg3 and leg4 are part of the back torso and have to be pasted as shown:



Name	translation:x	translation:y	translation:z
leg1	0.09	0.2	0
leg2	0.09	-0.2	0
leg3	0	0.2	0

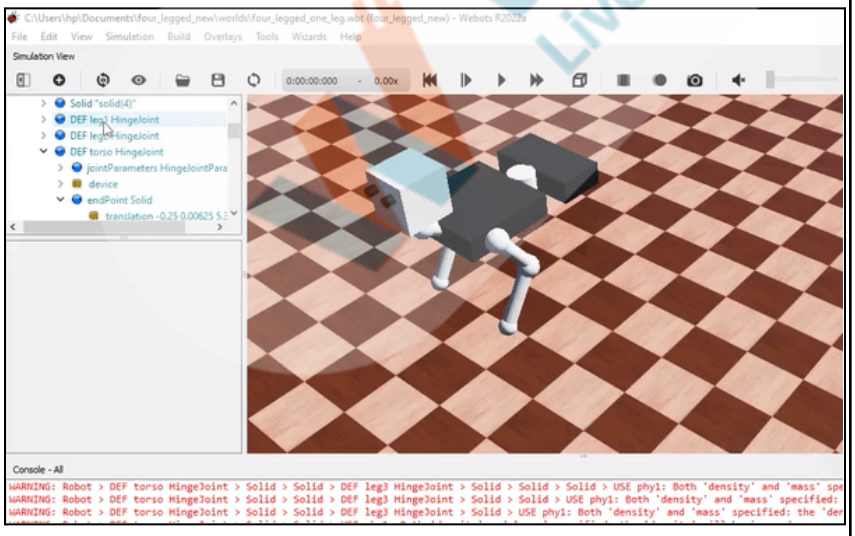
leg4	0	-0.2	0

leg2 reference :



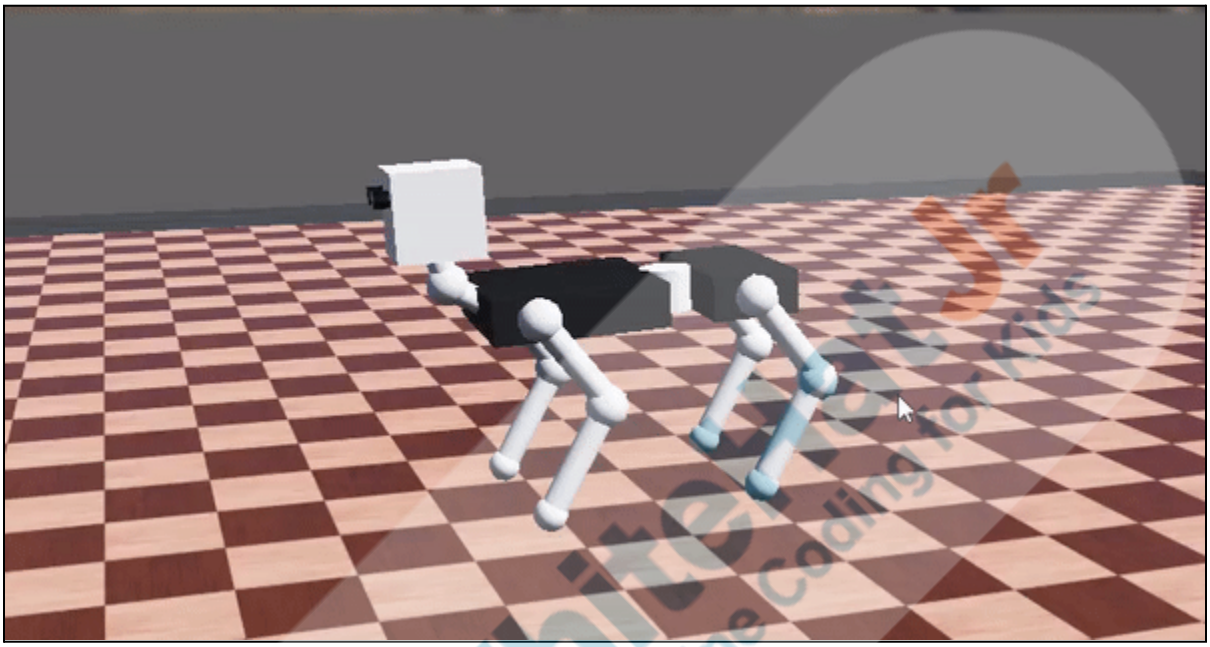
Click here to view the reference video.

leg3 and leg4 reference :



Click here to view the reference video.	

Reference Output:



Click here to view the output video.

Great work!	

Teacher Guides Student to Stop Screen Share

WRAP-UP SESSION - 05 mins

Activity details

Following are the WRAP-UP session deliverables:

- Appreciate the student.
- Revise the current class activities.
- Discuss the quizzes.

WRAP-UP QUIZ
Click on In-Class Quiz

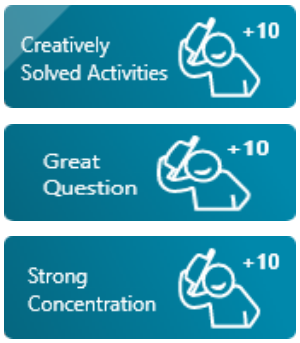
Activity Details

Following are the session deliverables:

- Explain the facts and trivia
- Next class challenge
- Project for the day
- Additional Activity (Optional)

FEEDBACK

- **Appreciate and compliment the student for trying to learn a difficult concept.**
- **Get to know how they are feeling after the session.**
- **Review and check their understanding.**

Teacher Action	Student Action
You get “hats-off” for your excellent work! In the next class, we will learn how to move this robot.	*Make sure you have given at least 2 hats-off during the class for:* 

PROJECT OVERVIEW DISCUSSION

Refer the document below in Activity Links Sections

Teacher Clicks ✖ End Class

ACTIVITY LINKS		
Activity Name	**Description**	**Links**
Teacher Activity 1	Teacher Boilerplate Code	https://github.com/procodingclass/PRO-C292-Teacher-Boilerplate
Teacher Activity 3	Reference Code	https://github.com/procodingclass/PRO-C292-Reference-Code
Teacher Reference 1	Project	https://s3-whjr-curriculum-uploads.whjr.online/e9fc1f60-06ec-47d2-b351-17f1c9b637ce.pdf
Teacher Reference 2	Project Solution	https://github.com/procodingclass/PRO-C292-Project-Solution
Teacher Reference 4	In-Class Quiz	https://s3-whjr-curriculum-uploads.whjr.online/5b2837c8-d818-4945-aed-f8bce954921a.pdf
Student Activity 1	Boilerplate Code	https://github.com/procodingclass/PRO-C292-Student-Boilerplate