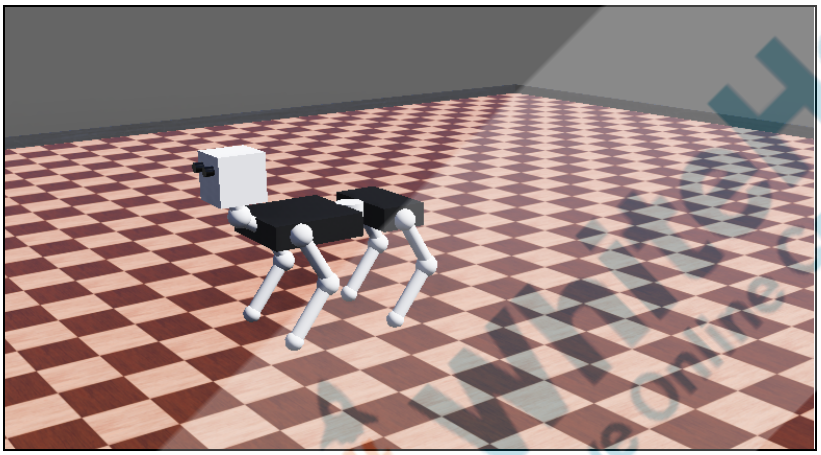
Topic	FOUR LEGGED ROBOT - II	
Class Description	**Students will move the robot. They will program the rotational motors in a way that the robot can simulate the walking motion.**	
Class	**PRO C293**	
Class time	**45 mins**	
Goal	• Understanding anchor and axis • Breaking down walking into substeps • Writing controller to simulate walking	

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** **20 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	
• **Setting up the anchor, axis for the hingeJoint** • **Assigning maxTorque for the rotational motor**	
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 have completed the structure of our four-legged robot. We learnt how to structure the legs of the robot.	**ESR:** Varied!

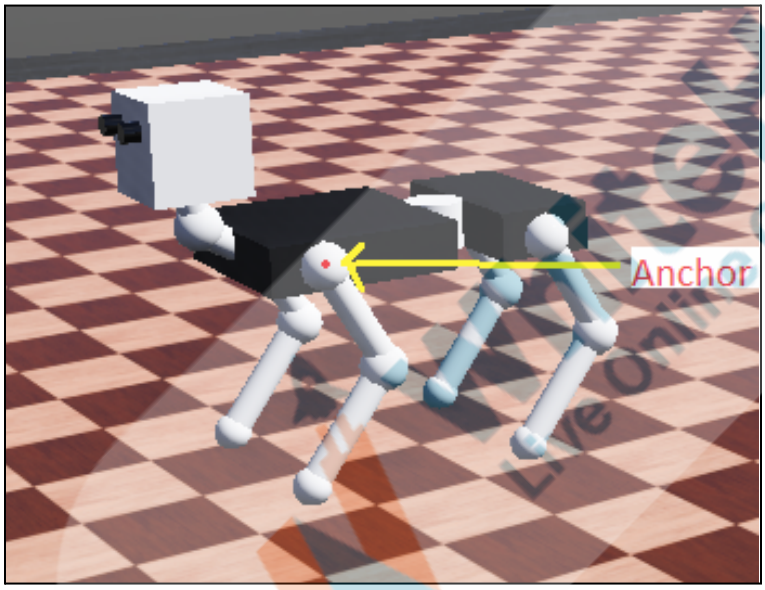
Today we will program it to walk.	
Teacher downloads the boilerplate code from Teacher Activity 1.	
Open the file using Webot. 1. Open the **webots** 2. Go to the **Open World** 3. Upload the webots file from boilerplate code	
Teacher opens the boilerplate code on webots.  *Pause* ⏸ *the simulation before you start coding it.* We had completed the leg structure of the four legged robot in the last class. Today, we want to move our robot. How do you think we can do that? Exactly! Let's do that. But before we start with code, we need to make sure that the leg's hinge joints are working properly. Let's start with that.	**ESR:** by adding a controller and writing the code for it.

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

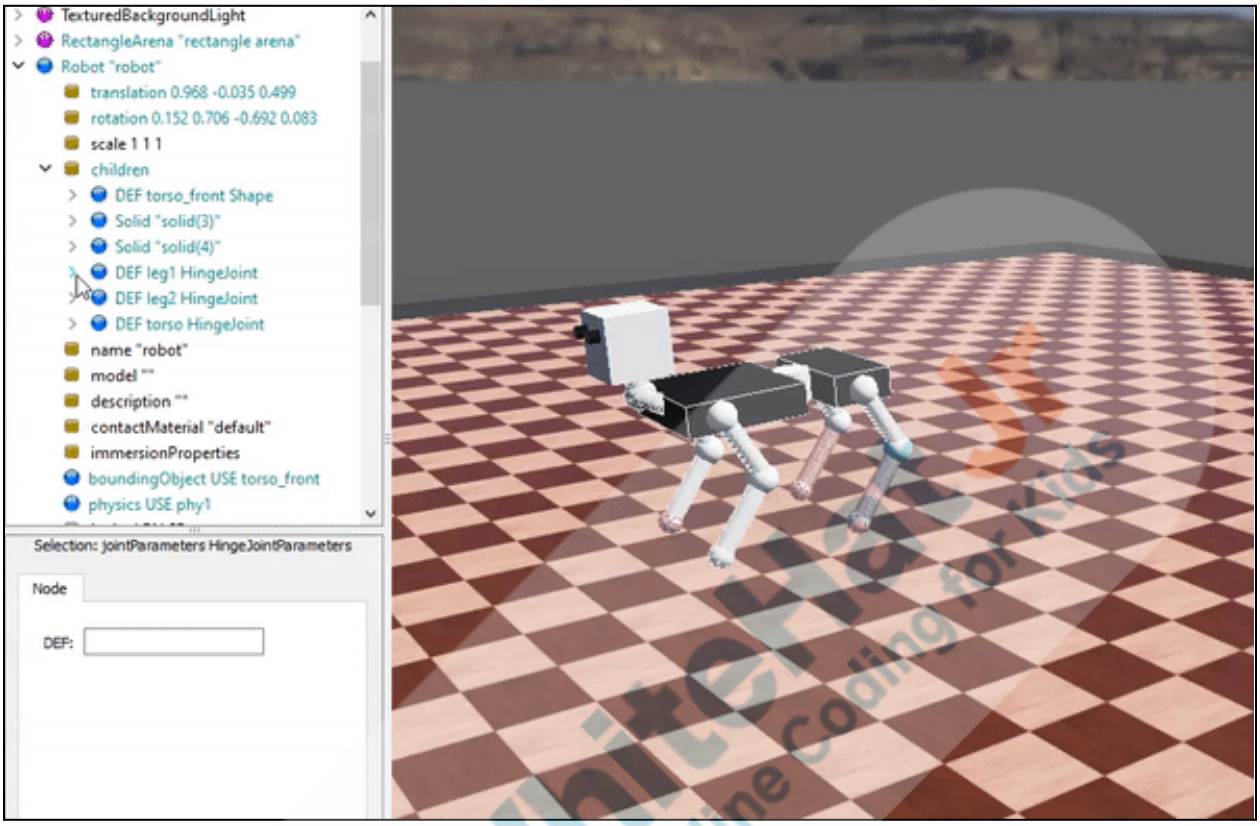
We know that our legs are connected to the body by a hinge joint. A hinge joint allows motion in one plane. It has a point around which the movement happens. This point is called the anchor point.

front_left leg (leg1):

If we focus on the front left leg only for now, we want the anchor point to be exactly where the center of the sphere for the joint is -



If we go to the **jointParameters**, the anchor is currently set to (0,0,0). We will change it and position it exactly where the **endPoint solid** node's position is.



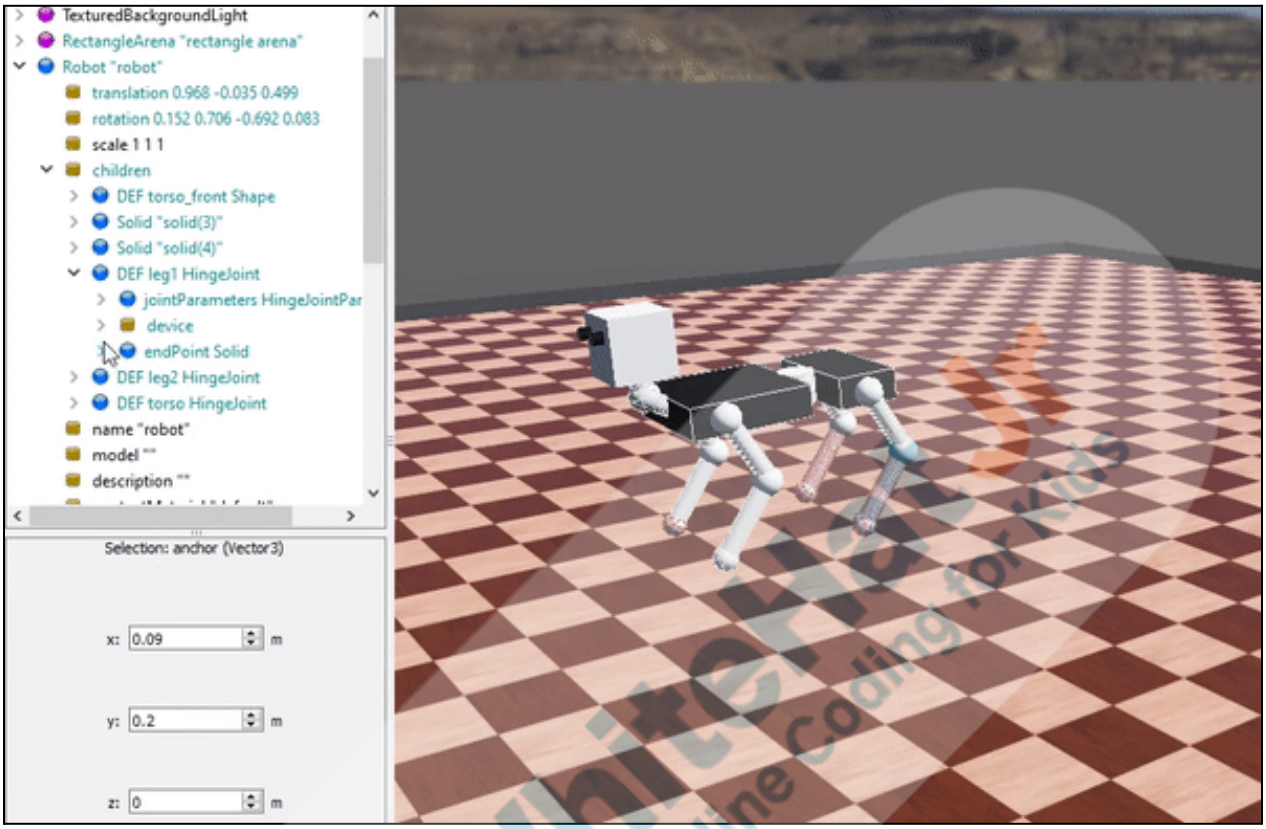
Click here to view the reference video.

Now, our anchor point is set. Next thing we need to decide is on which plane the leg should rotate around the anchor.

We need to change the **axis** property under **jointParameters** to set the axis.

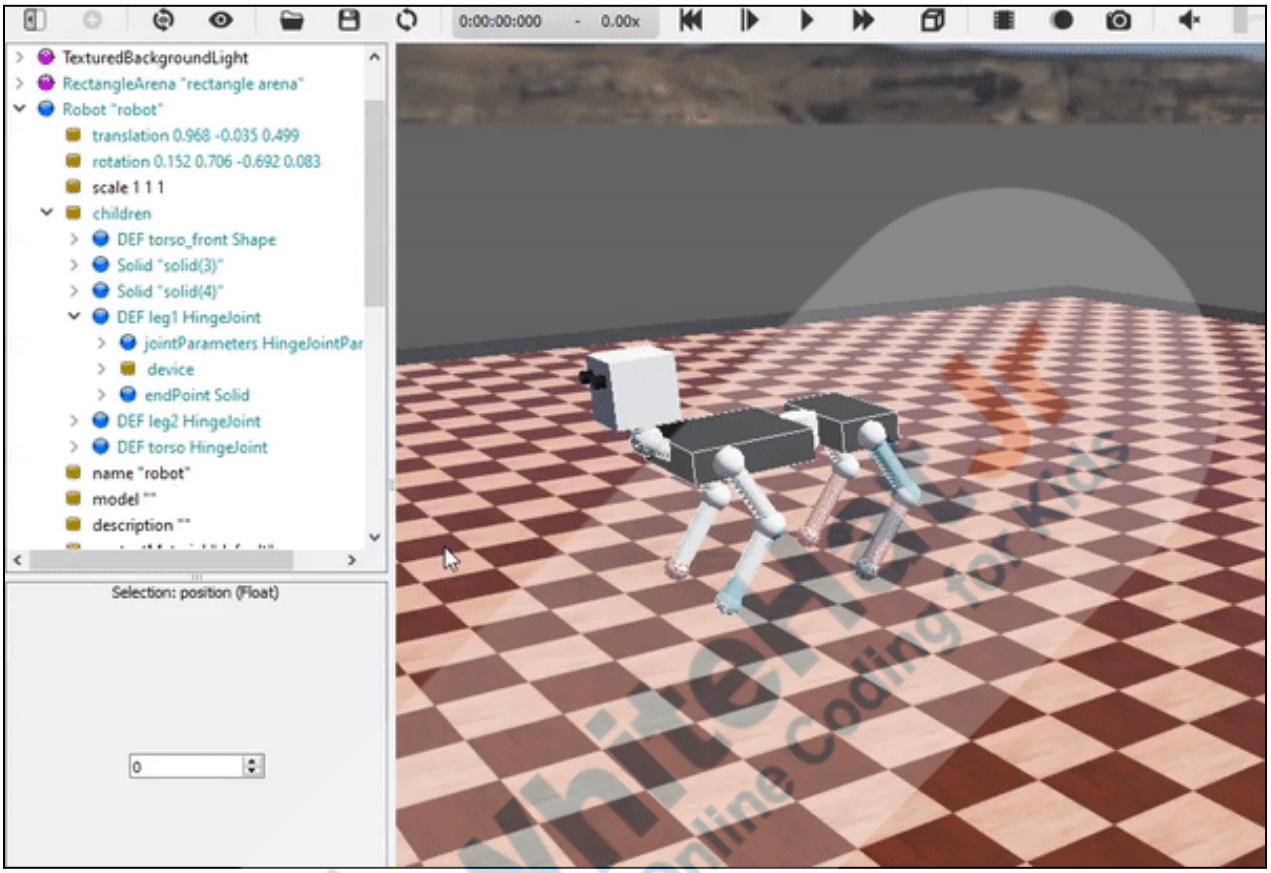
We can check if the **axis** we have chosen is correct or not in the following way. Change the **position** property continuously and check if it rotates in the correct direction. If not, then you should change the axis.

In our project, the axis was set as x initially i.e. (**x-1, y-0, z-0**). But when we tried changing the position, we noticed that it was moving in the wrong direction. So, we changed it to y i.e. (**x-0,y-1,z-0**) and tried again.



Click here to view the reference video.

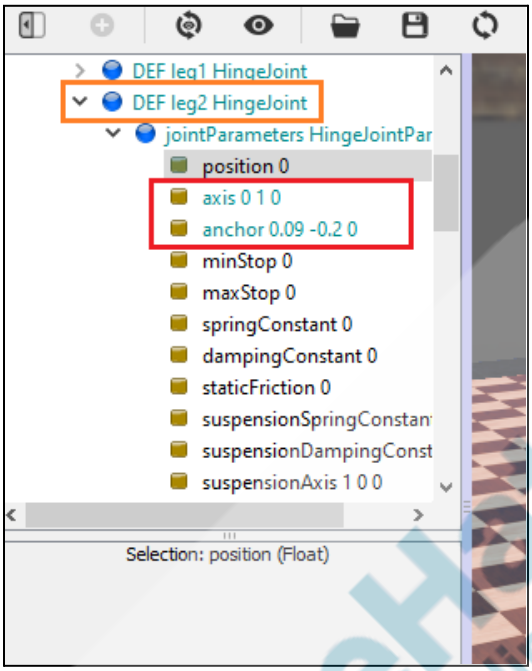
We also need to increase the torque of the rotational motor so that the legs would have enough power to move forward. We can increase it by clicking on the **DEF leg1 HingeJoint → device → rotational motor "front_left" → maxTorque.**	

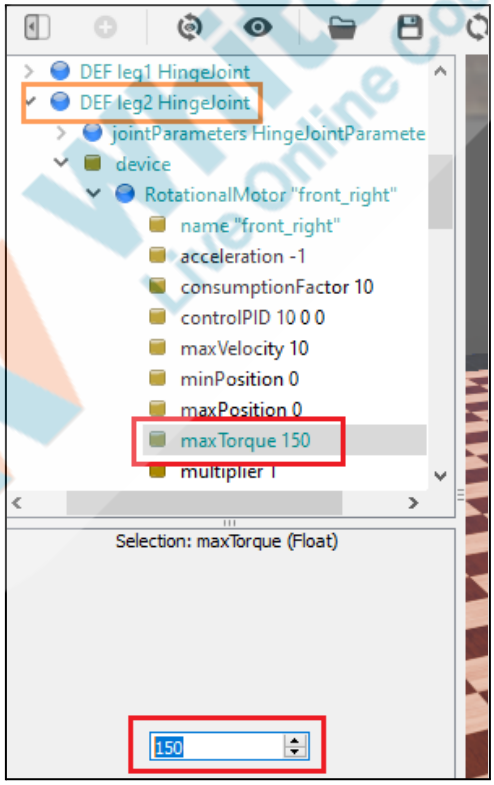


Click here to view the reference video.

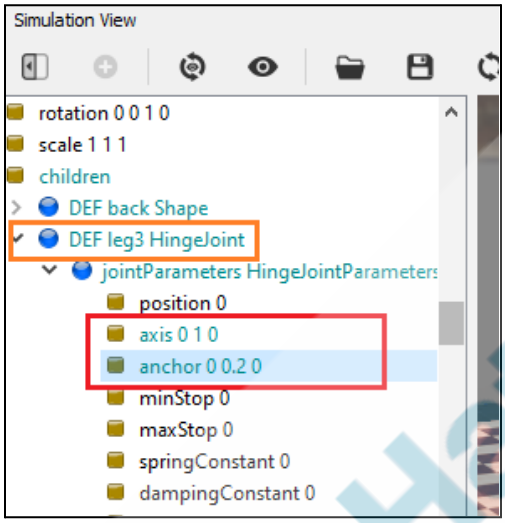
Looks good, isn't it? What's left? Yes. We need to do this for all four legs. So, let's do this for leg2, leg3 and leg4. Are you ready?	**ESR:** We need to do this for the other 3 legs also. **ESR:** Yes.
Teacher Stops Screen Share	
So now it's your turn.	

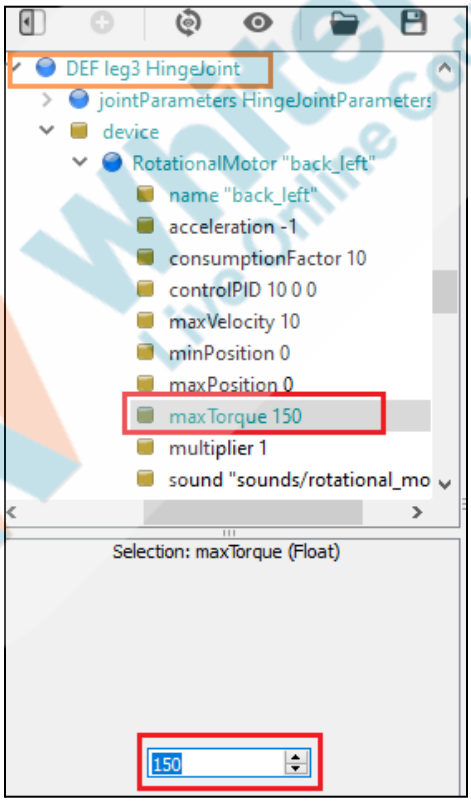
Please share your screen with me.	
We have one more class challenge for you. Can you solve it? Let's try. I will guide you through it.	
STUDENT-LED ACTIVITY - 20 mins	
• **Ask the student to press the ESC key to come back to the panel.** • **Guide the student to start Screen Share.** • **The teacher gets into Full Screen.**	
Student Initiates Screen Share	
ACTIVITY • **Adding controller to simulate walking motion**	
Teacher Action	**Student Action**
Student downloads the boilerplate code from Student Activity 1.	
front_right leg (leg2): Student changes the **anchor**, **axis** and **maxTorque** for leg2.	



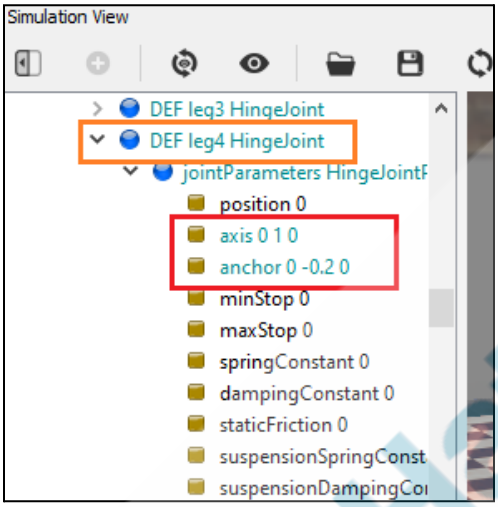


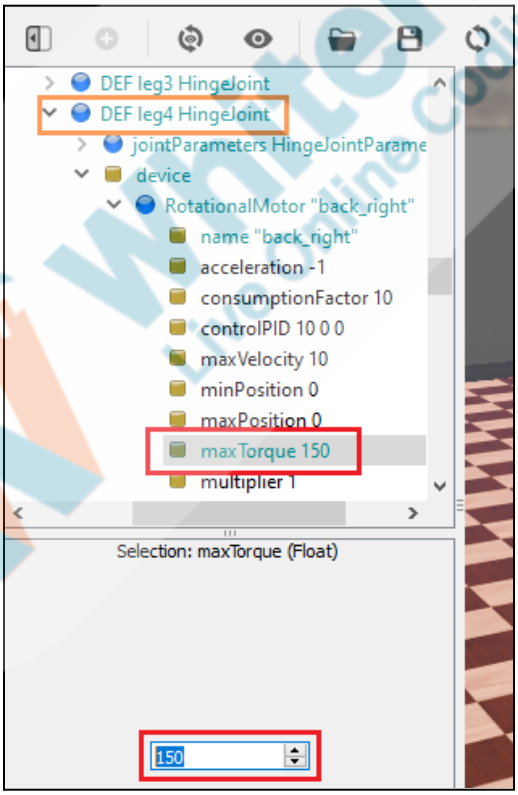
back_left leg (leg3):	





back_right leg (leg4):





Let's create a controller for the four-legged robot.

Go to wizards → New Robot Controller → create a new python controller.

Add the controller to the robot.

Go to Scene Panel → Click on "robot" → click on controller → select the new controller we have just made.

Let's write the code now-

1. Let's import the controller first.

   ```
   from controller import Robot
   ```

2. Initiate a robot object.

   ```
   robot=Robot()
   ```

3. Initiate timestep and flag variables. We will use the flag variable to control each leg separately.

   ```
   timestep=320
   flag= 0
   ```

4. Use the **getDevice()** method to create reference variables for each motor.

   ```
   leg1=robot.getDevice("front_left")
   leg2=robot.getDevice("front_right")
   leg3=robot.getDevice("back_left")
   leg4=robot.getDevice("back_right")
   ```

5. Add the main **while** loop which will perform simulation steps until Webots stops the controller.

   ```
   while (robot.step(timestep) !=-1):
   ```

6. We will divide the walking process into 5 smaller subdivisions.

   a. First, we will move the **leg1** forward.

```
if(flag%10==0):
    leg1.setPosition(-0.3)
```

b. Then, let's move the **leg2** forward.

```
elif(flag%10==2):
    leg2.setPosition(-0.3)
```

c. Move the **leg3** forward.

```
elif(flag%10==4):
    leg3.setPosition(-0.3)
```

d. Move the **leg4** forward.

```
elif(flag%10==6):
    leg4.setPosition(-0.3)
```

e. Now, we need to reposition all the hingeJoint back to 0.2. This will move the body forward with the leg

```
elif(flag%10==7):
    leg1.setPosition(0.2)
    leg2.setPosition(0.2)
    leg4.setPosition(0.2)
    leg3.setPosition(0.2)
```

f. Increase the flag by 1 for each loop

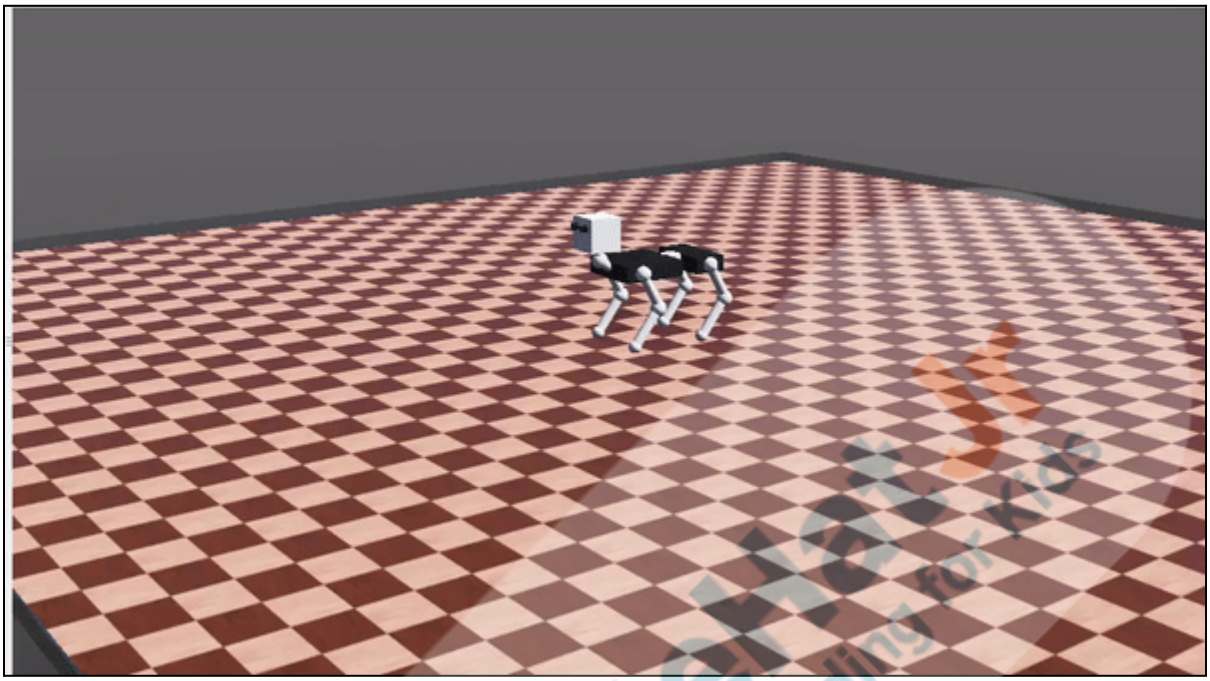
```
flag=flag+1
```

Reference code:

```
from controller import Robot

robot=Robot()

timestep=320

flag= 0

leg1=robot.getDevice("front_left")
```

```
leg2=robot.getDevice("front_right")
leg3=robot.getDevice("back_left")
leg4=robot.getDevice("back_right")

while (robot.step(timestep) !=-1):

    if(flag%10==0):
        leg1.setPosition(-0.3)

    elif(flag%10==2):
        leg2.setPosition(-0.3)

    elif(flag%10==4):
        leg3.setPosition(-0.3)

    elif(flag%10==6):
        leg4.setPosition(-0.3)

    elif(flag%10==7):
        leg1.setPosition(0.2)
        leg2.setPosition(0.2)
        leg4.setPosition(0.2)
        leg3.setPosition(0.2)

    flag=flag+1
```

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 about receiver and emitter devices. Using these devices, we will complete our four-legged 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-C293-Teacher-Boilerplate
Teacher Activity 3	Reference Code	https://github.com/procodingclass/PRO-C293-Reference-Code
Teacher Reference 1	Project	https://s3-whjr-curriculum-uploads.whjr.online/335e1a36-fb55-494c-a486-23dcbc63a8c7.pdf
Teacher Reference 2	Project Solution	https://github.com/procodingclass/PRO-C293-Project-Solution
Teacher Reference 4	In-Class Quiz	https://s3-whjr-curriculum-uploads.whjr.online/40f25624-72af-4de4-bfb0-77d4b956f05a.pdf
Student Activity 1	Boilerplate Code	https://github.com/procodingclass/PRO-C293-Student-Boilerplate