1. **Introduction:**

Webots is used to design and develop the software solution, the first problem is to develop a four-wheel inspection robotic vehicle which avoids collision during its motion. The robotic vehicle is designed with two distance sensors and is programmed using python programming language and simulated using the webots.

1. **Steps to design and develop the four-wheel inspection robot with distance sensors:**

Webots is opened by double-clicking on the icon. A new project directory is created by clicking on wizards on the menu. The name of the project directory is created as My\_four\_wheel\_robot by replacing it instead of my\_project and then the name of the world file is saved as My\_four\_wheel\_robot.wbt in the place of the given name empty.wbt. All the boxes mentioned are ticked except the rectangle arena which is not ticked by default, so enable the rectangle arena option and click the finish button.

The rectangle arena node option is clicked twice which is displayed on the scene tree and this will display the nodes and fields in it. The floor tile size is selected and the size is changed from 0.5 to 0.25. The changes are seen in the 3D view of the rectangle arena as soon as the values are given. The wall height field is selected and the value is changed from 0.1 to 0.05. The height of the wall in the rectangle arena is lowered.

To add a new node, the ‘+’ symbol is clicked and the base node displays a lot of options in that Robot is selected and added to the scene tree. When Robot is clicked on the scene tree many nodes are displayed in that Children is selected and the ‘+’ symbol is clicked to add the base node, and under the base nodes options shape is selected. Under shape, appearance null is selected and the base node is added as PBR Appearance, under PBR Appearance the base colour is selected and the values are changed to R=0, G=1, B=1simultaneously as the values are entered the colour of the robot changes.The roughness is given as 1 and the metalness values is changed to 0. Geometry Null is clicked and the base node is added as Box. Under geometry Box, size is clicked the dimensions of the size of the box is changed, x= 0 y=0.05 and z=0.2. Then, Shape is selected on the scene tree and the DEF name is created as Body. To add a bounding object, bounding object Null is clicked and Use is selected under Use Body(Shape) is added. Physics Null is clicked and the base node Physics is added.

For adding the wheels to the robot, under children the DEF Body shape is selected in the base nodes Hinge Joints is clicked and added. Now hinge joints is displayed on the scene tree and hinge joints null is clicked, the base node is selected as Hinge joint parameter and added. Under Device the base node is selected as rotational motor and added, a name is given to the motor as “wheel1”. In end point Null the base node is selected as solid and added. Under end point null solid, children is clicked and the base node is selected as shape and added. Under shape, appearance null is clicked and the base node is selected as PBR appearance and added. Geometry null is clicked and the base node is selected as cylinder and added. Under geometry cylinder the dimensions are changed, the height is changed as 0.02 instead of 0.1 and the radius is changed as 0.04 instead of 0.05. Under shape the def is given as Wheel, it changes as DEF Wheel shape. The bounding object null is clicked and under use the wheel shape is selected and added and Physics null is selected in the scene tree the base node is selected as Physics and added. In physics the name DEF is given as Physics\_wh. Now under end point solid, translation is clicked x=0.06, y=0, z=0.05 and then rotation is clicked x=0,y=0,z=1, angle=1.57. Hence the 1st wheel of the robot is designed, now to change the colour of the wheel under PBR appearance the base colour is selected and the values are entered R=1, G=0, B=0 and the colour of the wheel is changed to red. For implementing the next three wheels, the following steps mentioned above are to be followed the same way by clicking the hinge joint and the “+” symbol is to be clicked and by repeating the same procedure for creating the next three wheels. To make the wheels of the robot to move in the right direction the anchor value which is given under joint parameters is clicked and the values are given as x=0.045, y=0.025. This will help the robot to move properly in the right directions.

In the scene tree, under robot hinge joint is selected in the base nodes distance sensor is clicked and added. Under distance sensor children is clicked in the base nodes shape is added, in shape geometry null is selected and the base node box is added. Then the appearance null is clicked and the base node PBR appearance is selected and added. Under PBR appearance the base colour is changed as R=0, G=0, B=1 and the metalness is given as 0, Then translation is given as x=0.02, y=0, z=0.1 and the rotation is given as x=0, y=1, z=0, angle=-1.27. Under geometry box the size is changed as x=0.01. y=0.01, z=0.01. The name of the distance is sensor is given as ds\_left and the shape is given as DEF sensor. The bounding object null is selected and under use the sensor (shape) is added and physics null is clicked and the base node physics is added. To integrate another sensor to the right of the robot the same procedure is followed the first sensor created is copied and pasted and the same steps are followed the name of the second sensor is changed as ds\_right and the translation is given as x=-0.02, y=0, z=0.0, the rotation is given x=0, y=1, z=0, angle=-1.87. After doing these changes to the second sensor , both the sensors are created and integrated on the robot. Now to test whether the sensor are sensing the view option on the menu is clicked under view optional rendering is selected and show distance sensor rays option is selected, immediately the rays appear.

Select the Robot option in the scene tree and click the ‘+’ symbol on the menu. In the find search bar type box, many types of options will display in that select the wooden box and click add. Since the box seems to be very big, the dimensions of the box is changed by changing the size from 0.6 to 0. After doing this there will be immediate change in the size of the wooden box. The wooden box is placed in a desired position by moving it using the arrows.