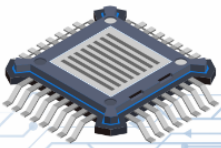
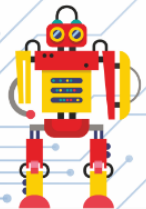
Table of Contents









Embedded Systems Course

Project 2: Solar Tracker

Let us assume you are part of a solar powered school that is focused on running the school in an eco-friendly and sustainable manner. You are proud to be part of such as school and have seen the benefits of how the solar power is fulfilling the power requirements of various machines and equipments in the school such as computers, projects, smart boards in addition to meeting the electricity requirements of the classrooms and various labs. While you have seen the benefits of solar power in the school, you have also observed that the supply of power in some classrooms located in certain corners of your school is not sufficient and therefore your school is not able to conduct classes in those classrooms. This is a major issue for your school as the annual academic schedule is very tight and the school needs to ensure all the classes are functioning effectively and regularly. On discussing this issue with your school authorities and analysing the problem you have found that the solar panels installed in your school is not generating sufficient power. You have further identified that the existing setup and direction of the solar panels is not allowing it to receive sufficient solar energy that can be converted into electricity. You have decided to help your school solve this problem by building a mechanism that can enable the solar panel system to produce energy efficiently and responsibly.

In this project, you will learn to build a simulation model of a single-axis solar tracker for your school to address the above problem.

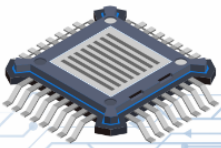
Let's get started!

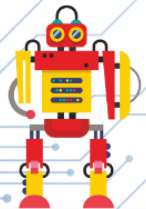
Solar tracking system:

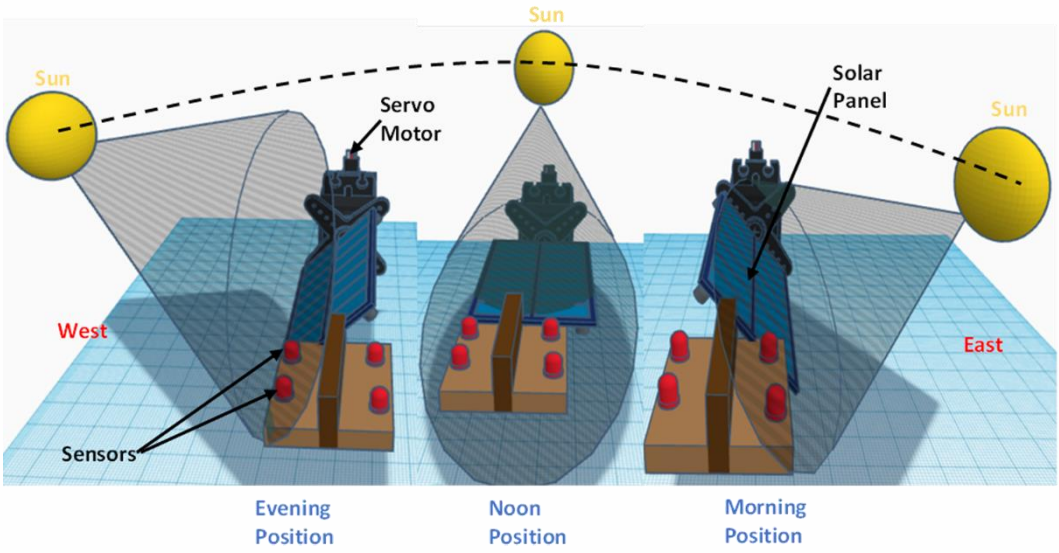
This project is designed to implement a single axis solar tracker system. Every panel you see in your day-to-day life is in a fixed position, most likely facing south at a 45-degree angle. In order to maximize energy generation from sun, it is necessary to introduce solar tracking systems into solar power systems. A single-axis tracker can increase energy by tracking sun rays by rotating the solar panel in various directions. This way the solar panel can rotate anywhere from east to west and the resultant energy can be produced efficiently and responsibly.











Prerequisite:

Ensure that you have gone through all the videos of the course Embedded Systems on Planetcode.in portal. These videos will help you to learn about the important terms and concepts as well as the equip you with the tools needed for this project. If you have already completed watching all the videos, well done! You are also set to begin the project.

If you have not completed the videos, please go to the platform https://planetcode.in/ to complete them before you proceed.

1. Platforms / Tools Needed

Tinkercad: https://www.tinkercad.com/

2. Major Steps to be performed in the Project

a) Setting up the basic circuit connections between Arduino and the Breadboard and connecting the Photoresistor sensors to the circuit.

b) Setting up the LED and LCD indicators' circuit connections and the servo motor connections.

c) Initial programming setup.

d) Reading Photoresistor sensor values and programming for the 5 different conditions.

e) Testing the Simulation and noting down the results.

Components Used:

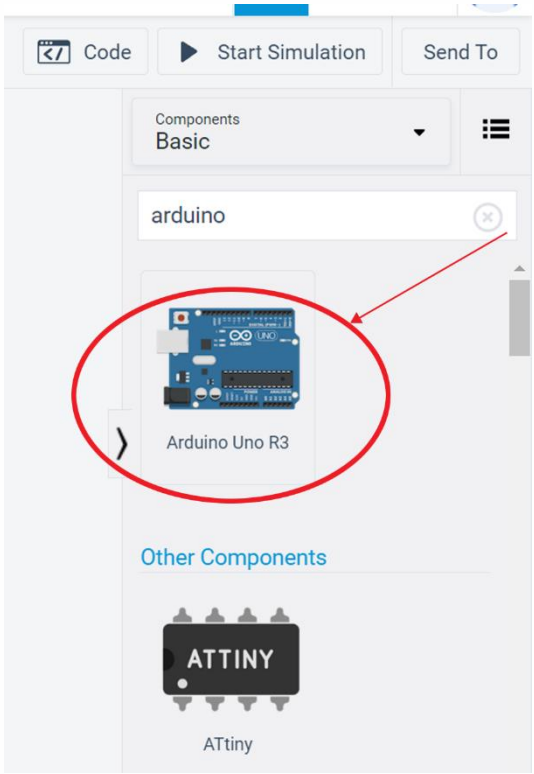
STEP by STEP Instructions

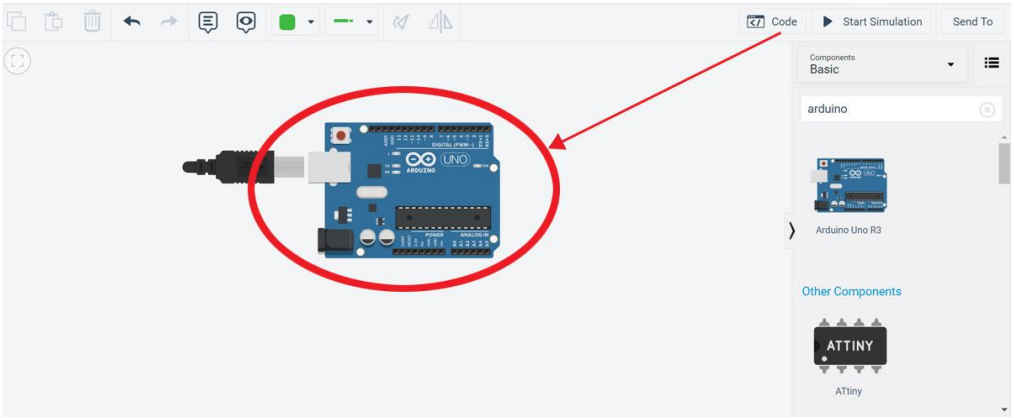
Part 1: Setting up the basic circuit connections between Arduino and the Breadboard and connecting the Photoresistor sensors to the circuit.

Step 1

Search for 'Arduino'.

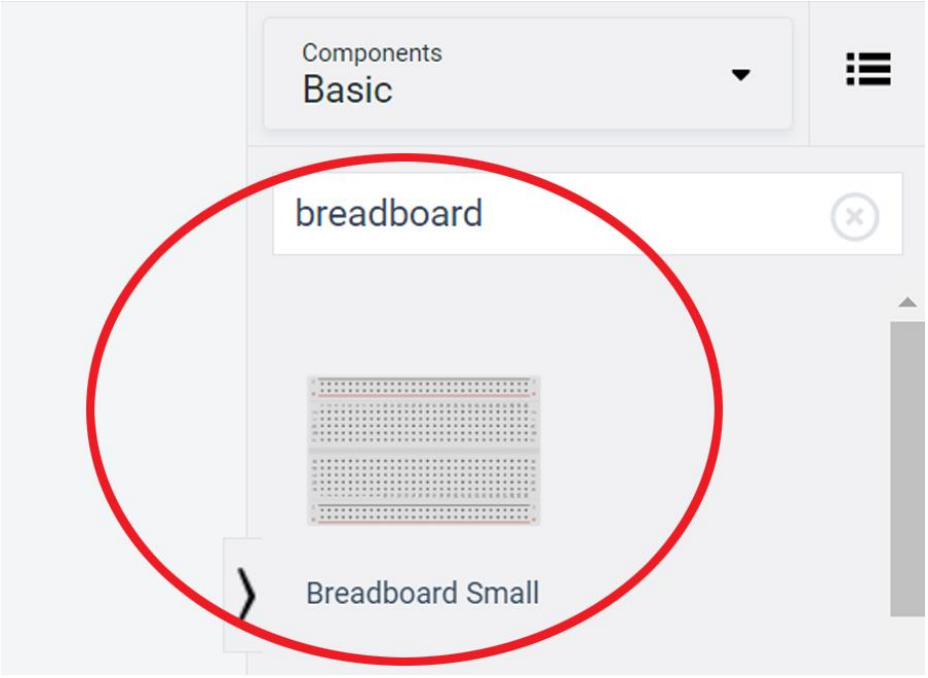
Drag and drop it in the circuit area, as shown.

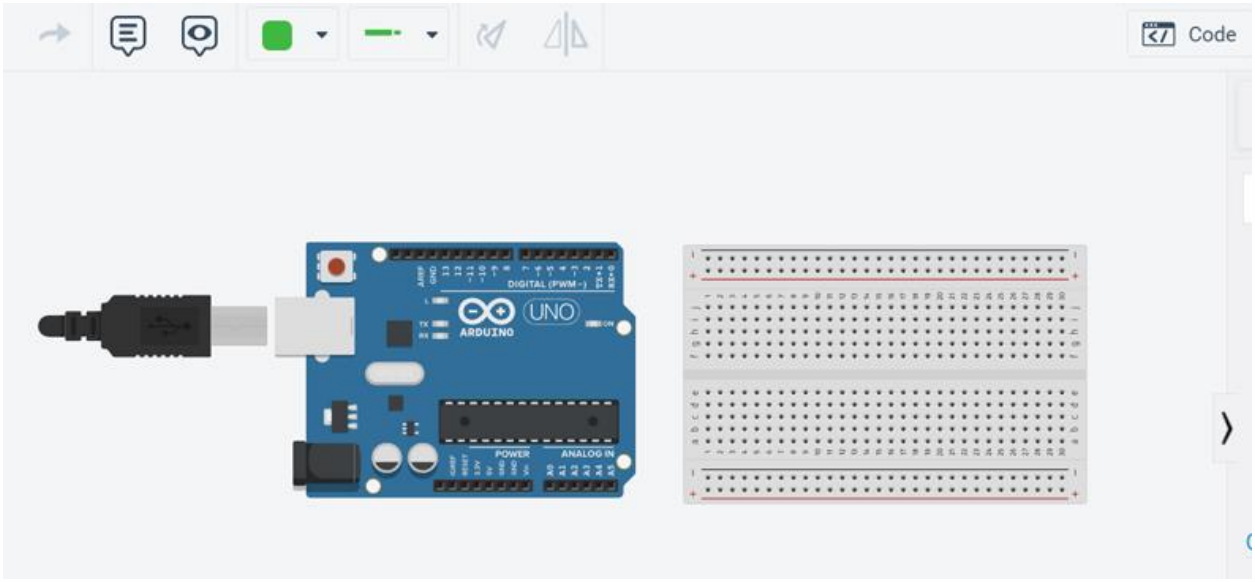




Step 2

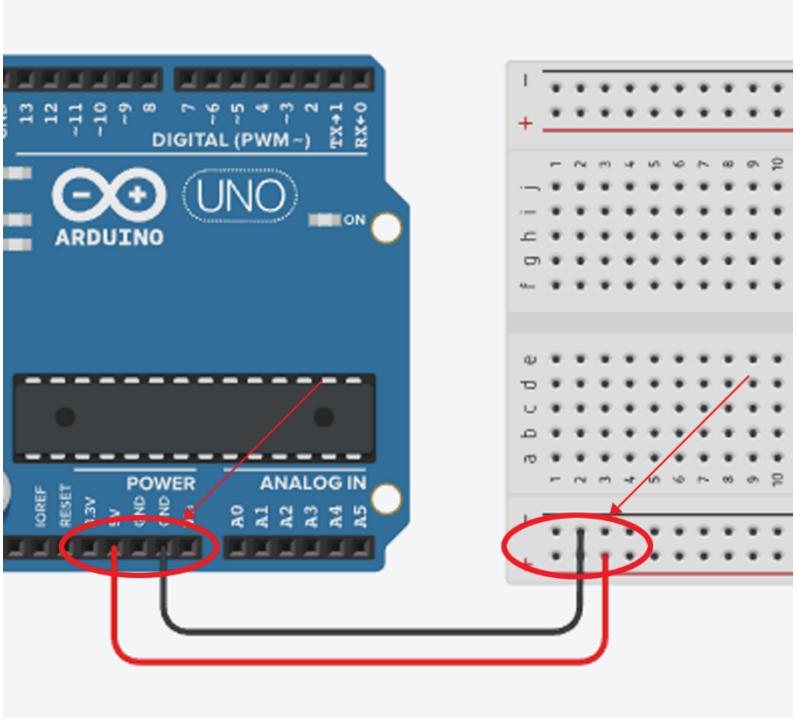
Now search and place the **small breadboard** in the same manner.





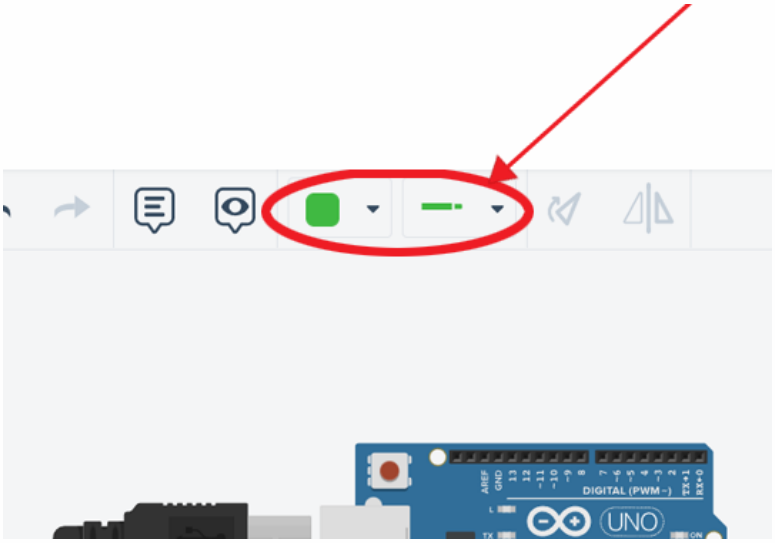
Step 3:

- Find +5v pin in the Arduino and connect it to the +Row of the breadboard.
- Find GND (Ground) pin in the Arduino and connect it to the -Row of the breadboard as shown in the image.



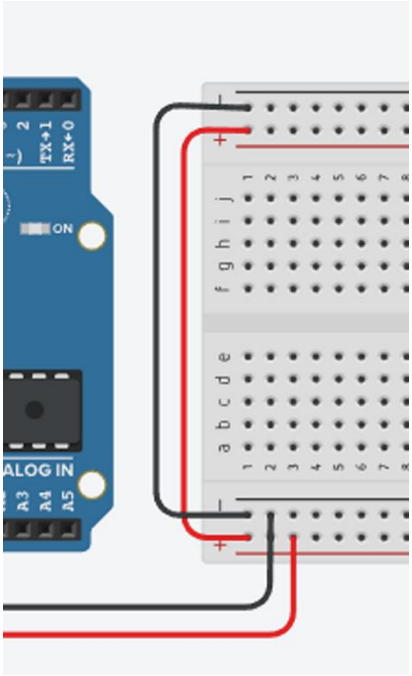
Step 4

Change the wire colour for easy identification of the connections.



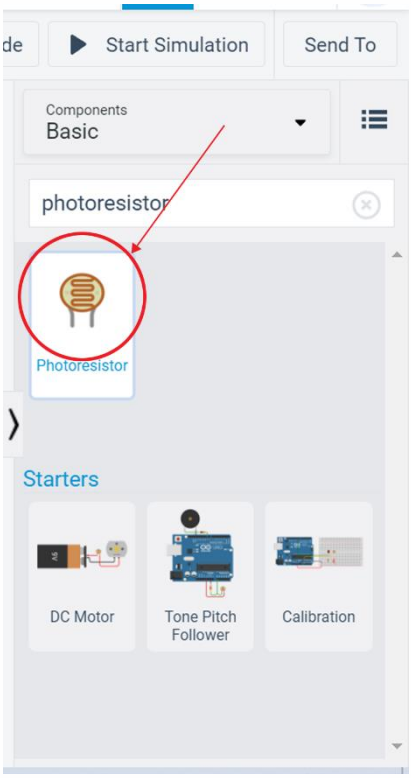
Step 5

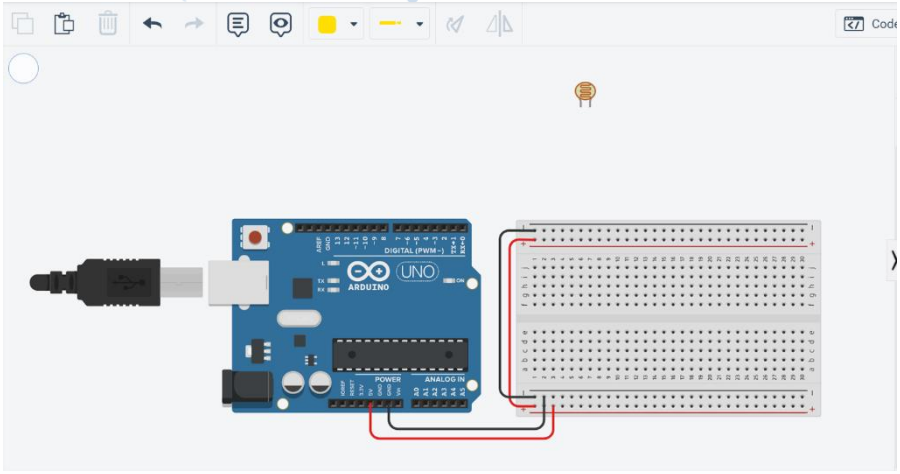
Connect the breadboard's lower power rail to upper power rail.



Step 6

Search and place the **Photoresistor** in the circuit area.

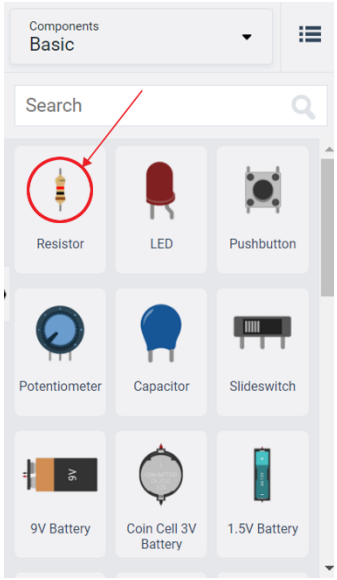


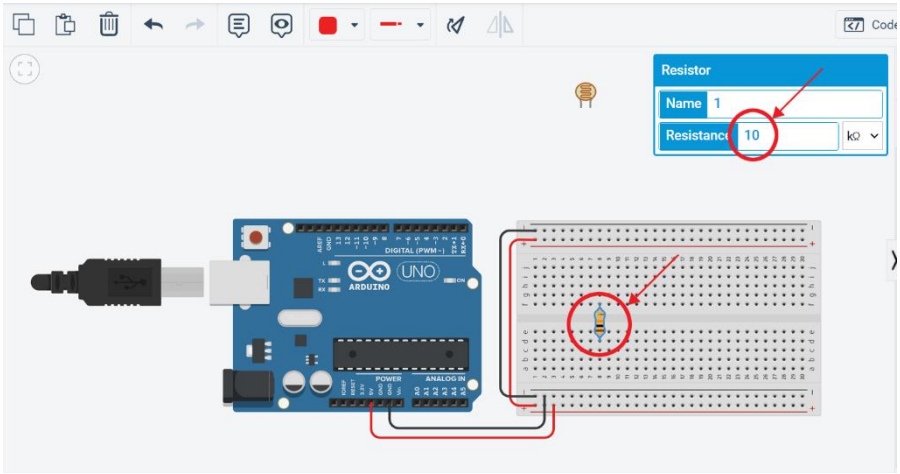


Step 7

Search and place the resistor in the breadboard as shown.

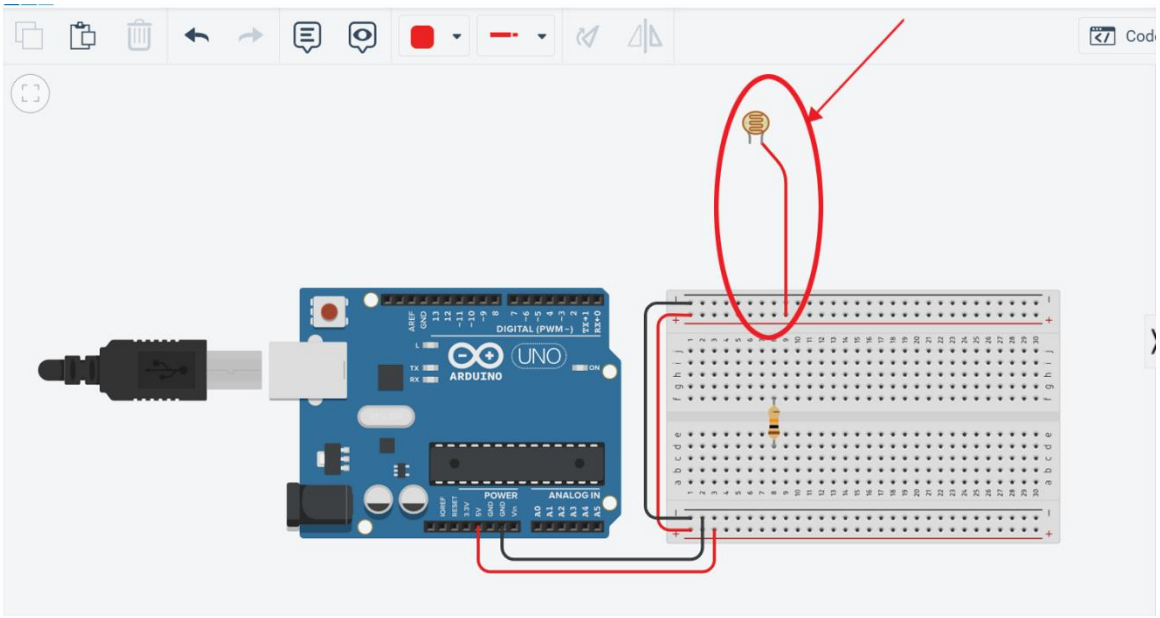
Change the resistor value to 10kohm.





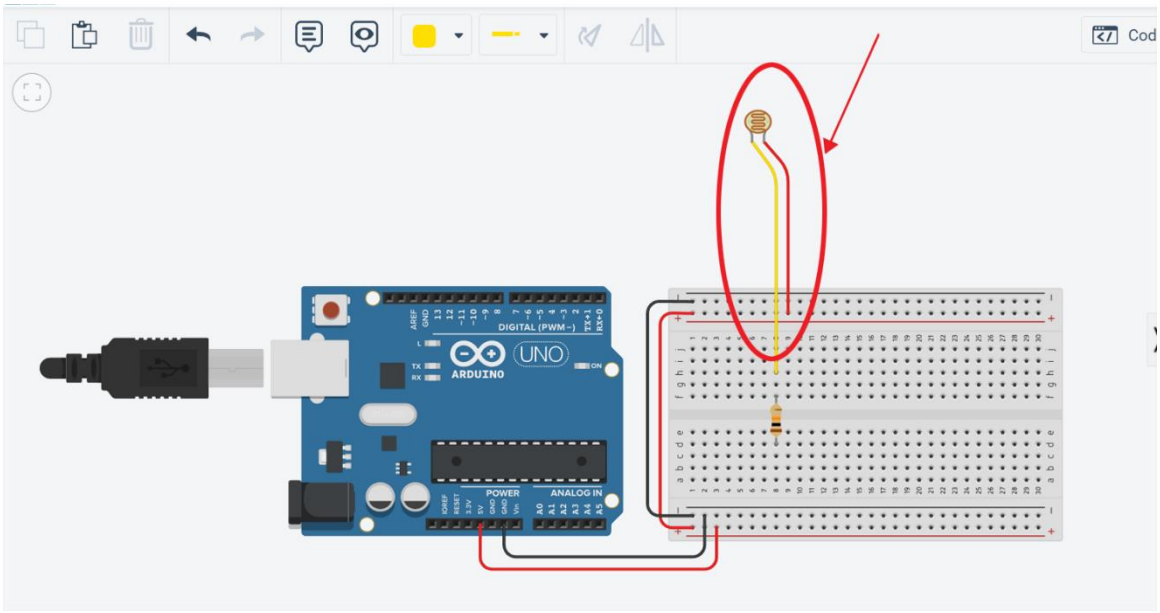
Step 8

Connect terminal 2 of the photoresistor to the + row in the breadboard as shown.



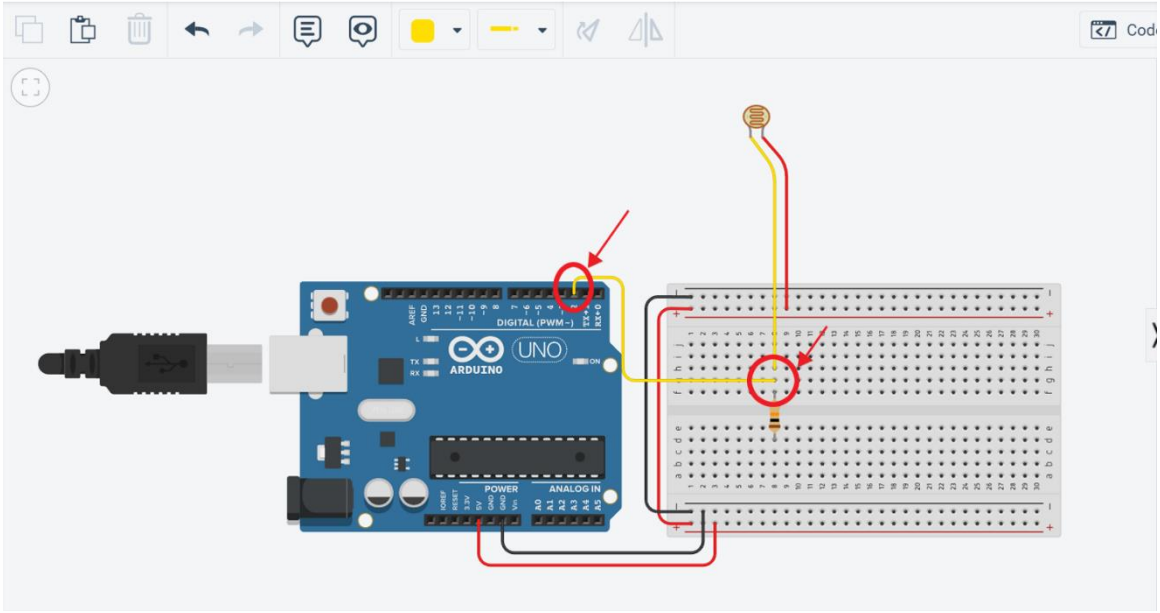
Step 9

Connect terminal 1 of the photoresistor to the breadboard as shown in the picture.



Step 10

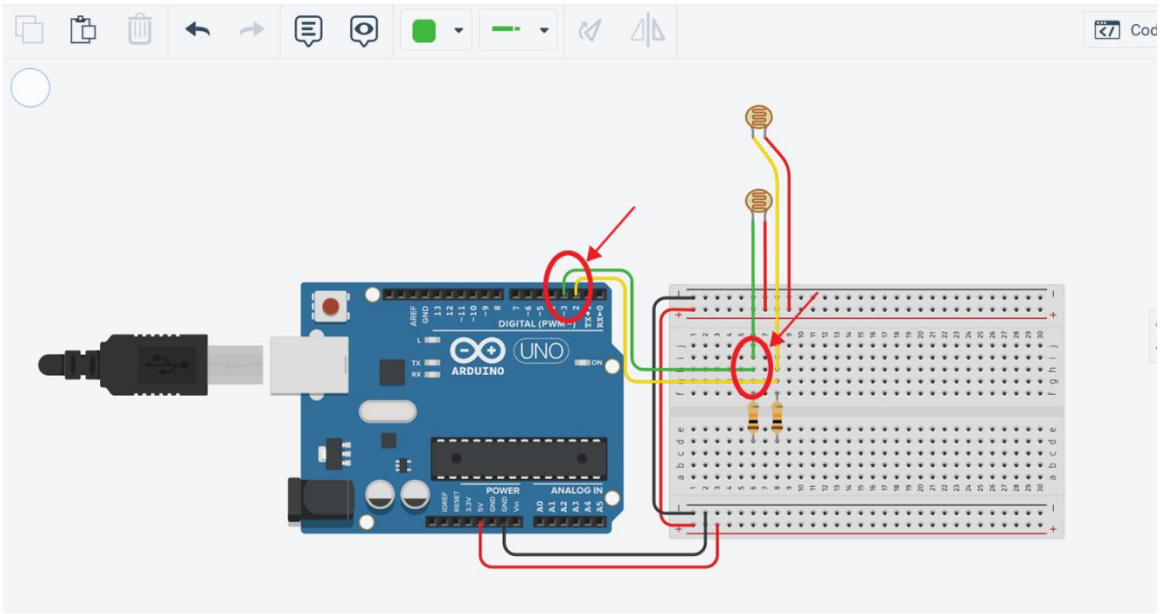
Connect Arduino pin 2 to the breadboard as shown in the picture.



Step 11

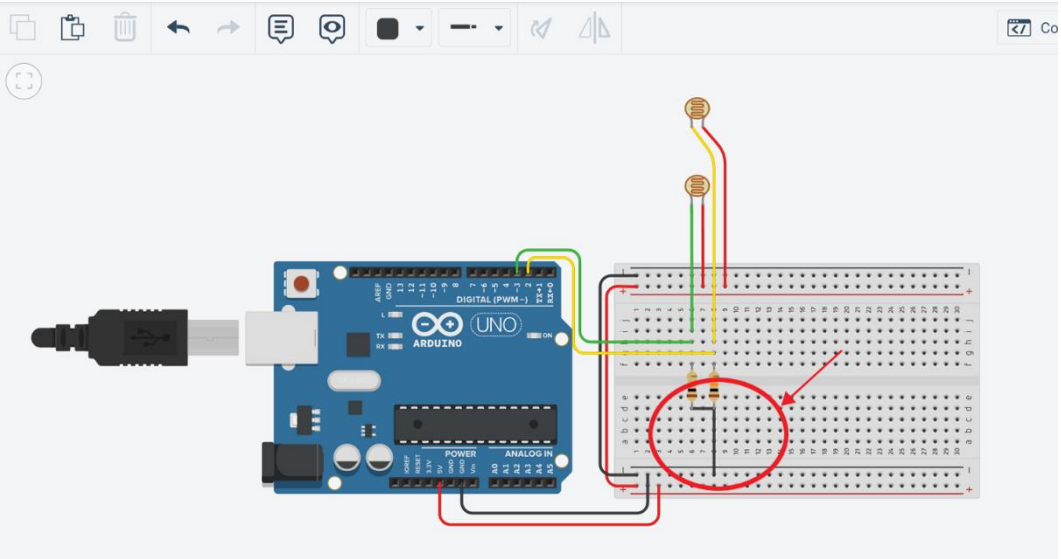
Place another Photoresistor and 10kohm resistor.

Connect Arduino pin 3 to the second photoresistor's terminal 1 as shown.



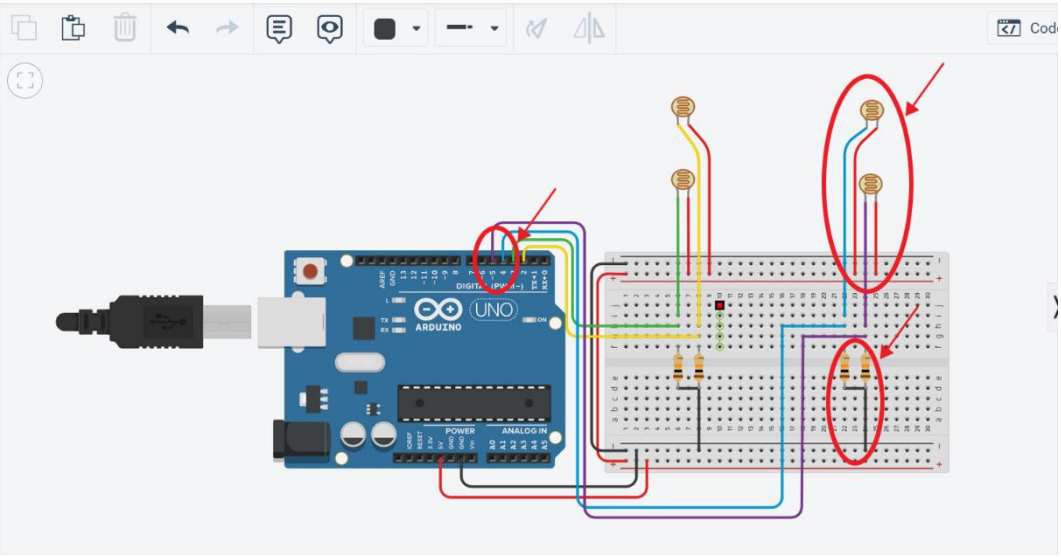
Step 12

Connect the other terminal of the resistors to the ground.



Step 13

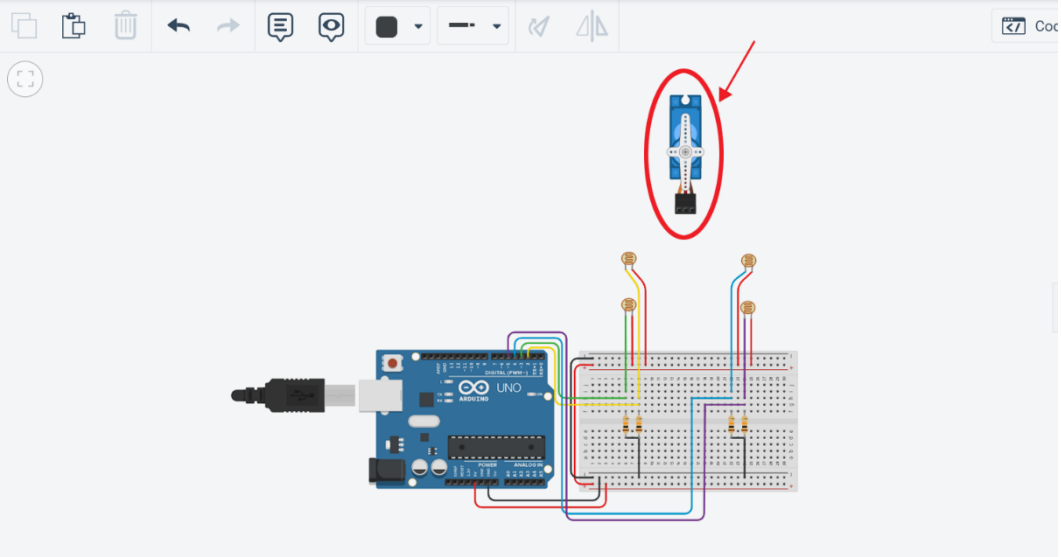
Just like you did in step 11 and 12 connect another two photoresistors with 10kohms resistors to the Arduino pin 4 and 5 as shown in the image.



Part 2: Setting up the LED and LCD indicators' circuit connections and the servo motor connections.

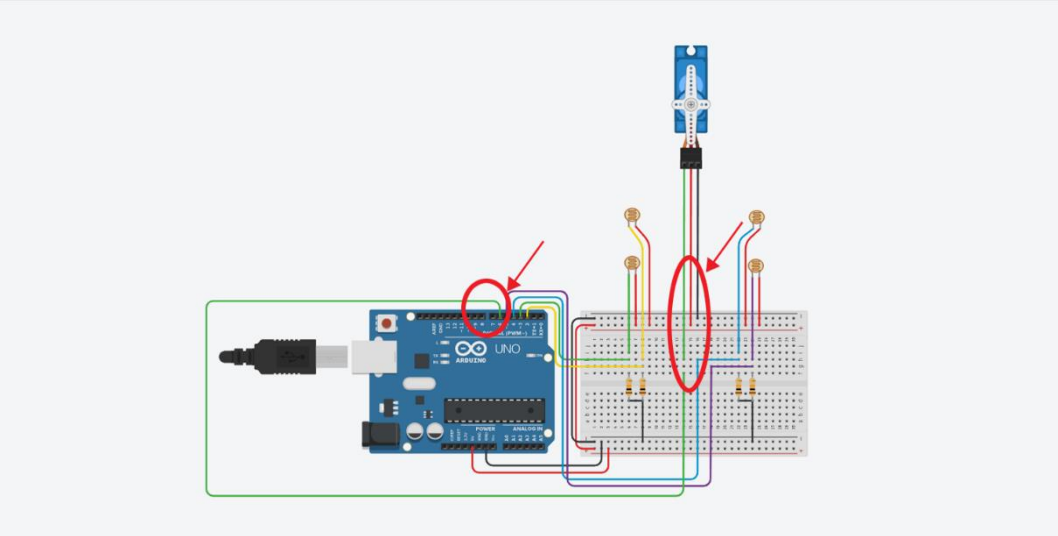
Step 14

- Search and place the servo motor.
- Rotate the servo motor and place it as shown.



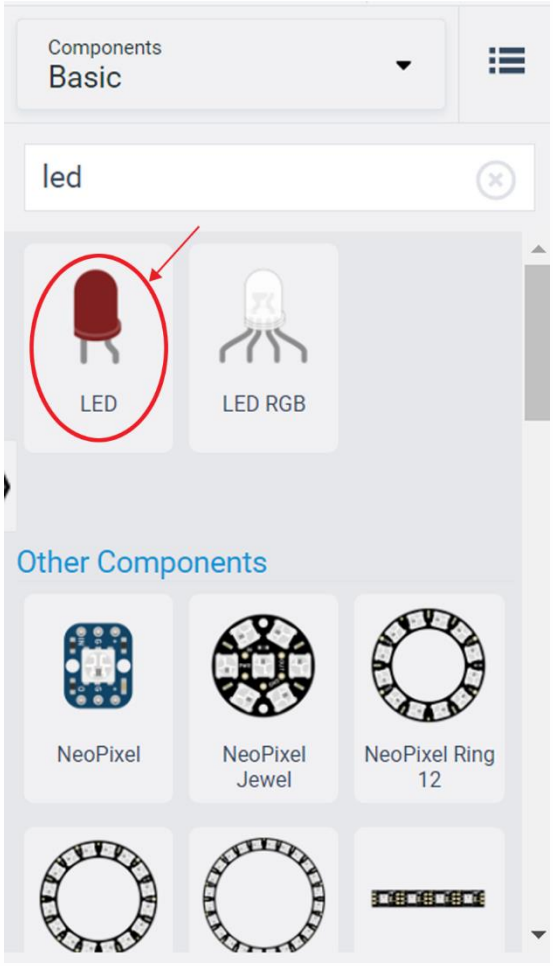
Step 15

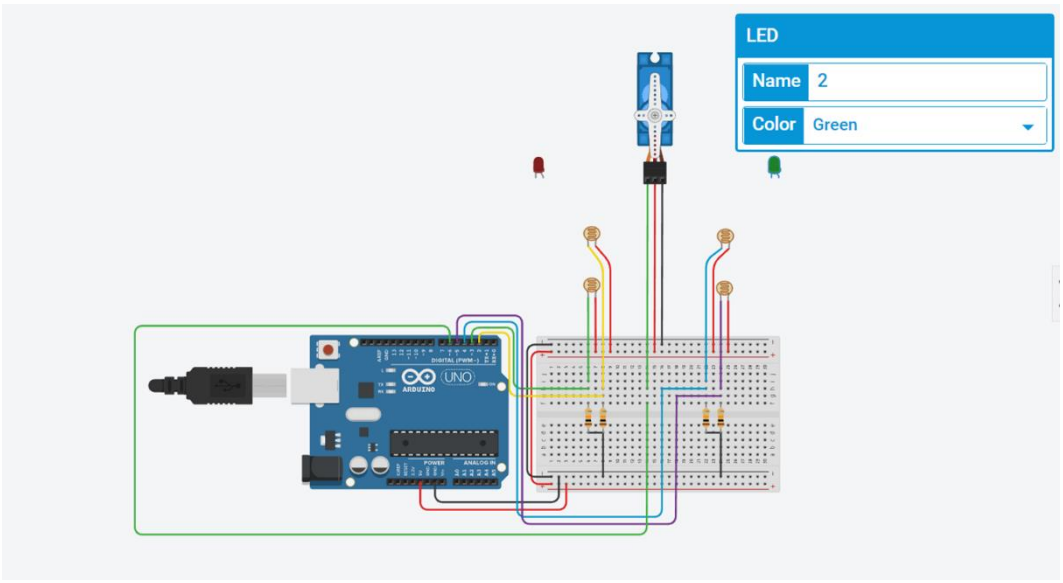
- Connect servo ground pin to breadboard's - power rail.
- Connect servo power pin to breadboard + power rail.
- Connect servo signal pin to Arduino pin6 as shown.



Step 16

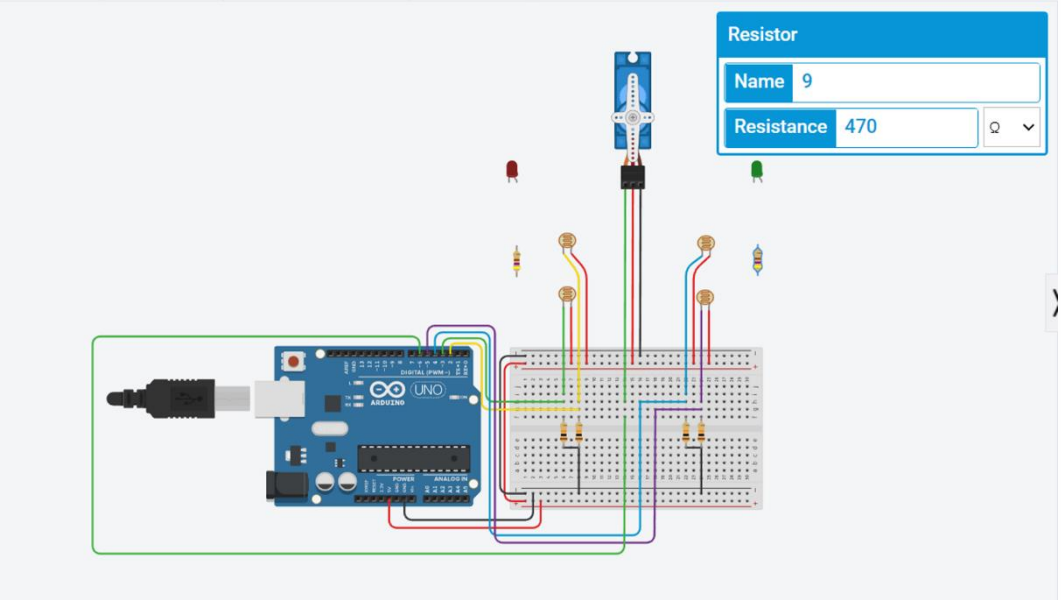
Search and place two LEDs and change colour of the right side led to green.





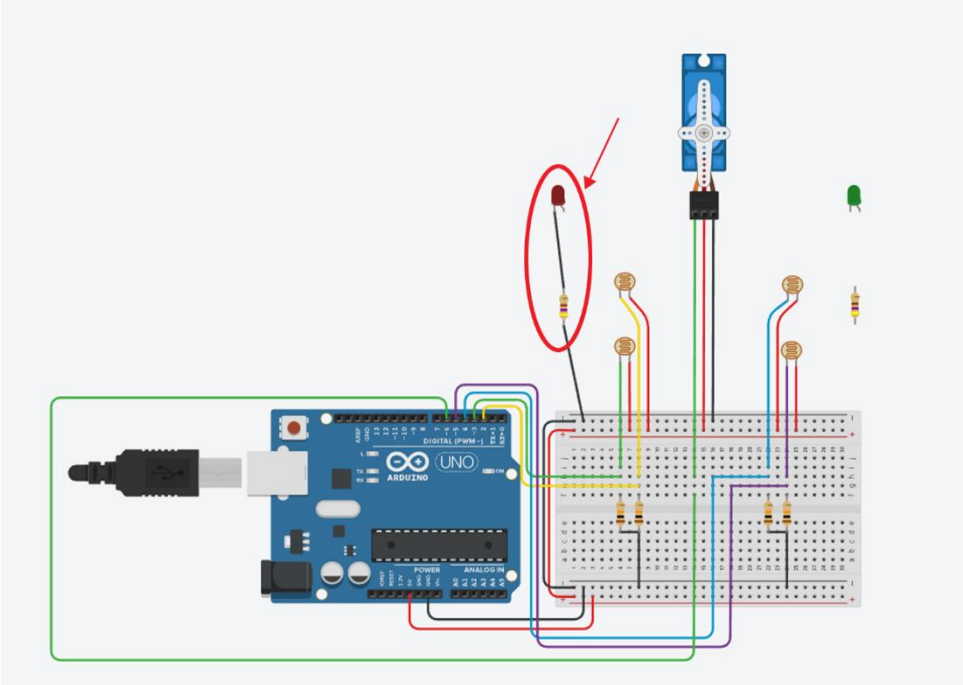
Step 17

Search and place 2 resistors and change its value to 470ohms as shown.



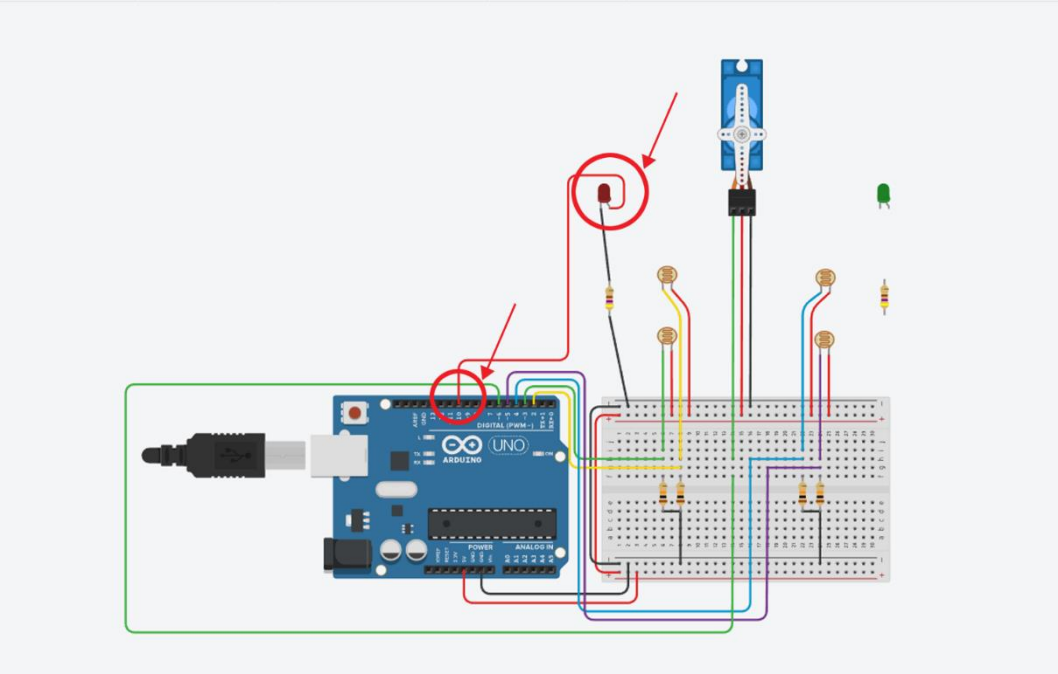
Step 18

- Connect the cathode of red LED to one end of the resistor.
- Connect another end of the resistor to the ground in breadboard as shown.



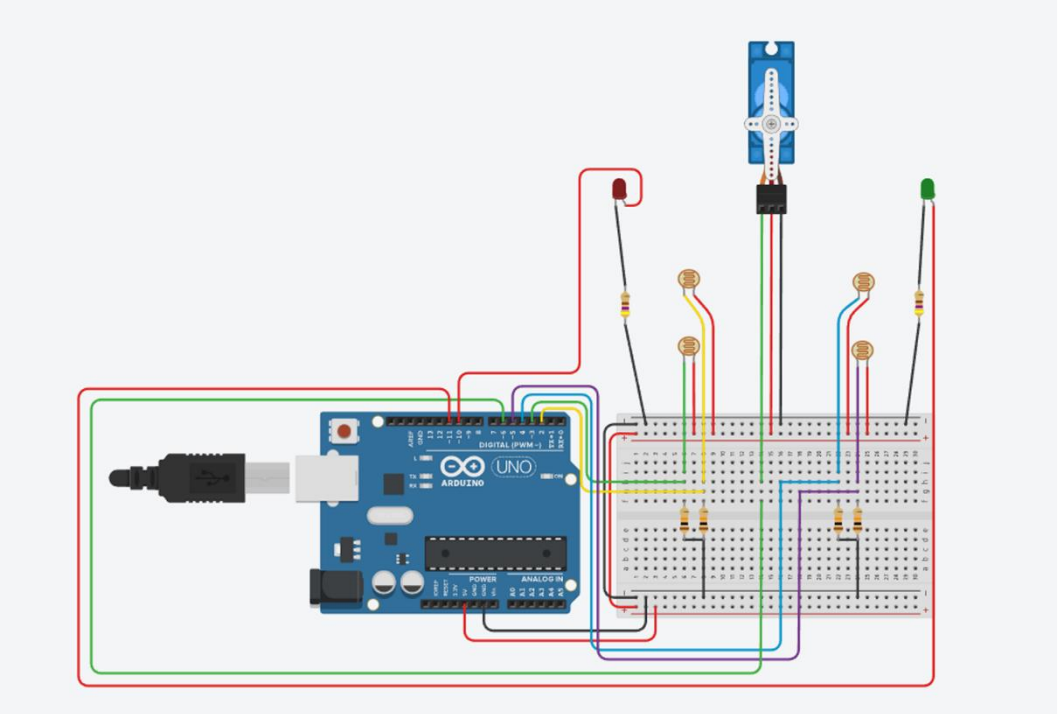
Step 19

Connect the anode of the red LED to Arduino pin10.



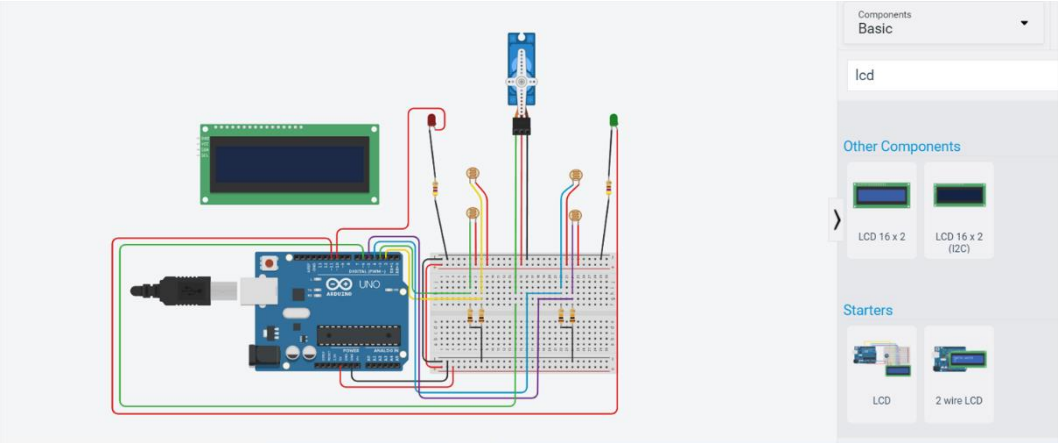
Step 20

Just like you did in step 19 and 20 connect the green LED, as shown.



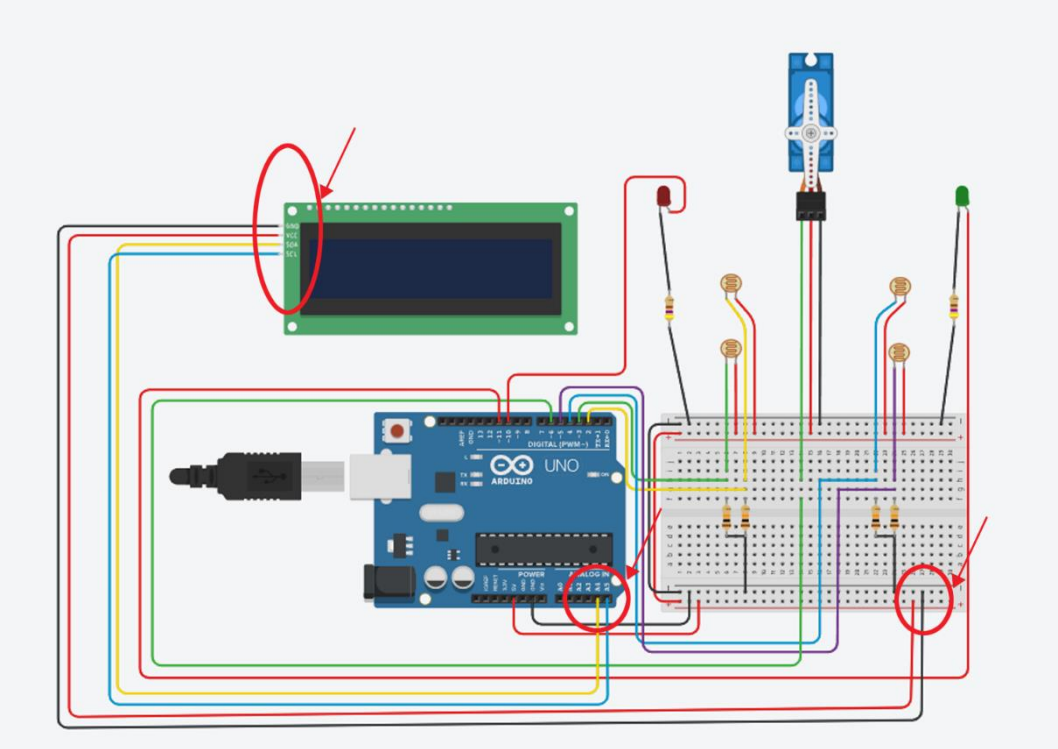
Step 21

Search and place LCD 16 x 2(I2C) in the circuit area as shown.



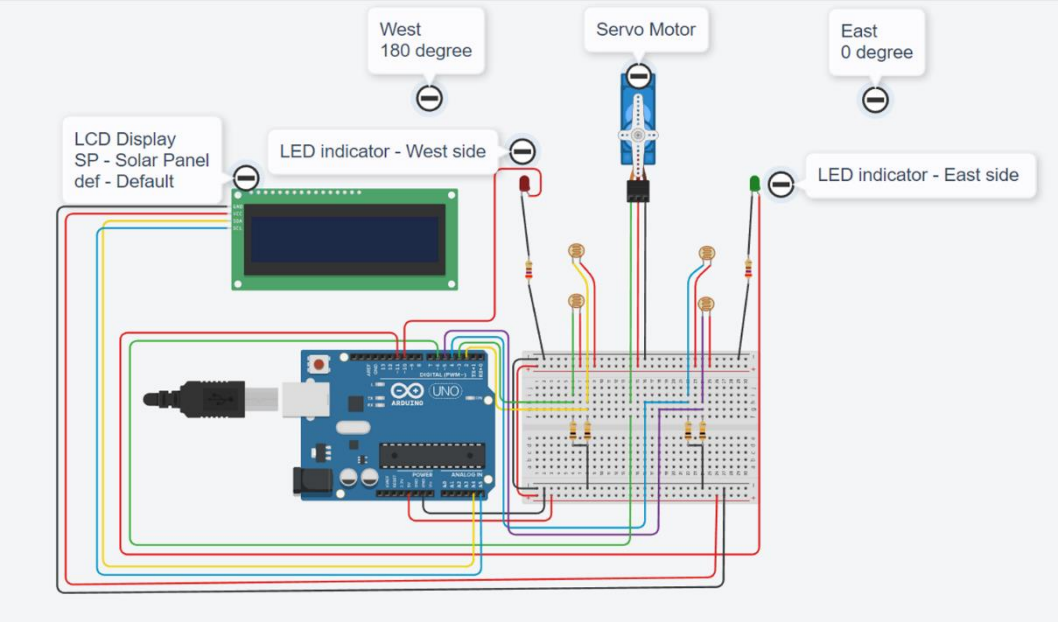
Step 22

- Connect LCD power pin to + rail in breadboard.
- Connect LCD Ground Pin to - rail in breadboard.
- Connect SDA pin of the LCD to the Arduino Pin A4.
- Connect SCL pin of the LCD to the Arduino pin A5.



Step 23

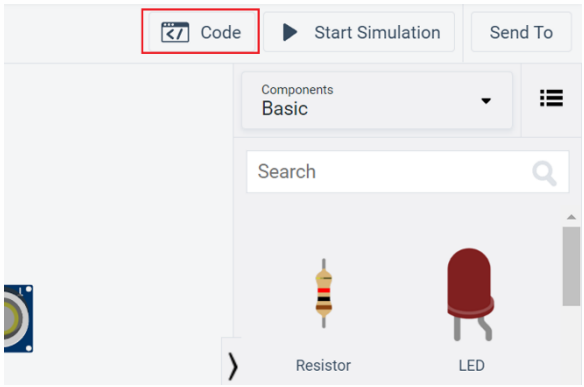
Name the components using Notes tool to obtain the outcome shown in the image.

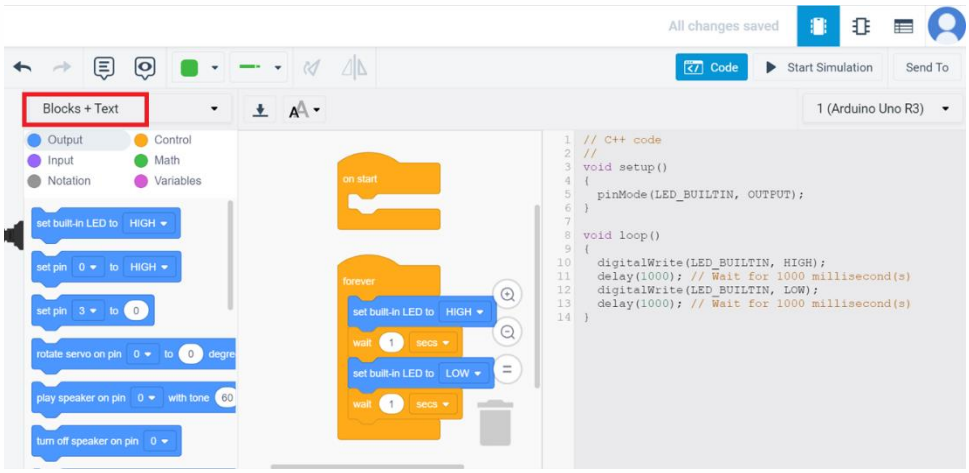


PART 3: Initial programming setup

Step 24

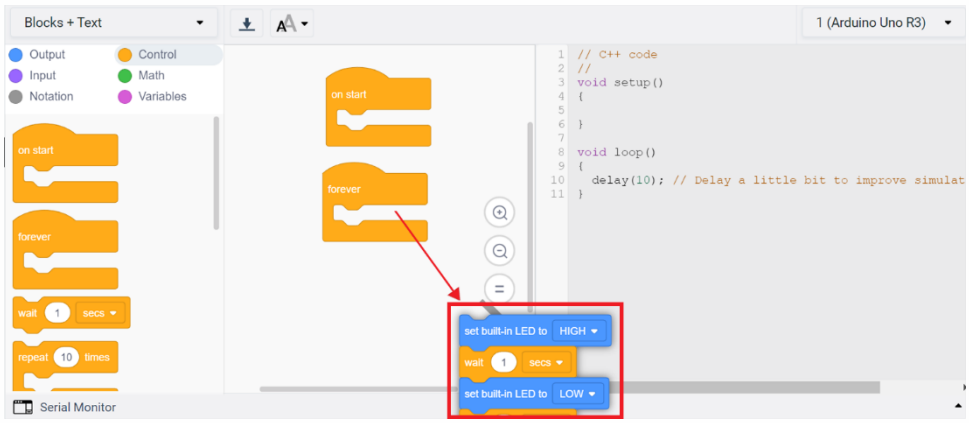
- Click '**code**' to open the code editor.
- Change the edit mode to '**Blocks+Text**' mode.





Step 25

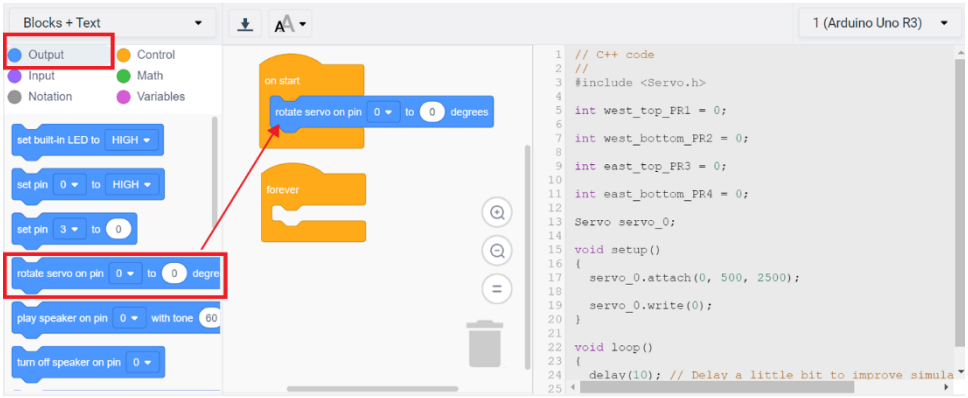
Delete the default blocks inside the forever loop by dragging them out to the recycle bin at the bottom right corner, as shown.



Step 26

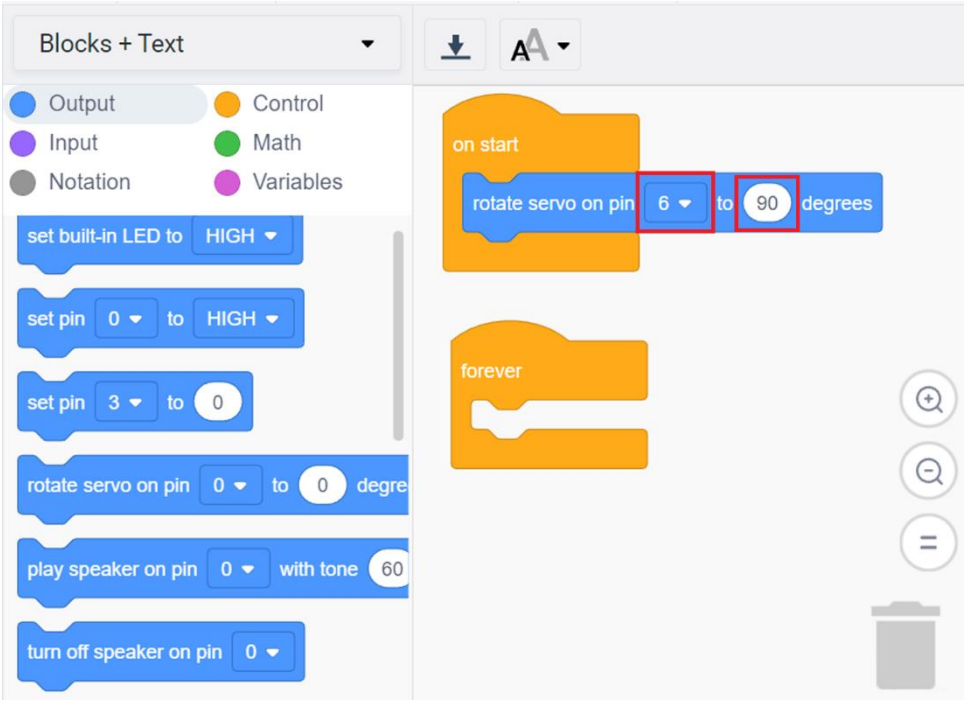
Initially, Servo Motor or SM should be set to 90 degree which will be its default position.

- Select '**Output**' menu.
- Drag and drop the '**rotate servo on pin**' block inside '**on start**' block in the program area.



Step 27

- Change the pin number to 6 as the servo signal pin is connected to the Arduino pin no 6 using the dropdown.
- Enter the angle as 90 degrees.

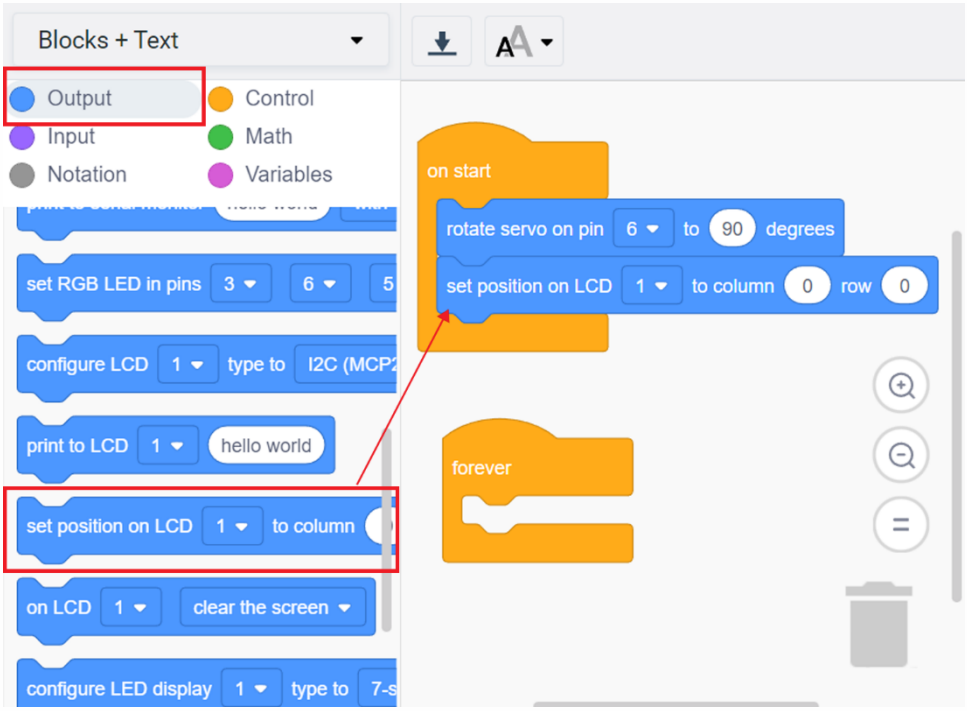


Now you will configure the LCD to display the Servo Motor's position.

Step 28

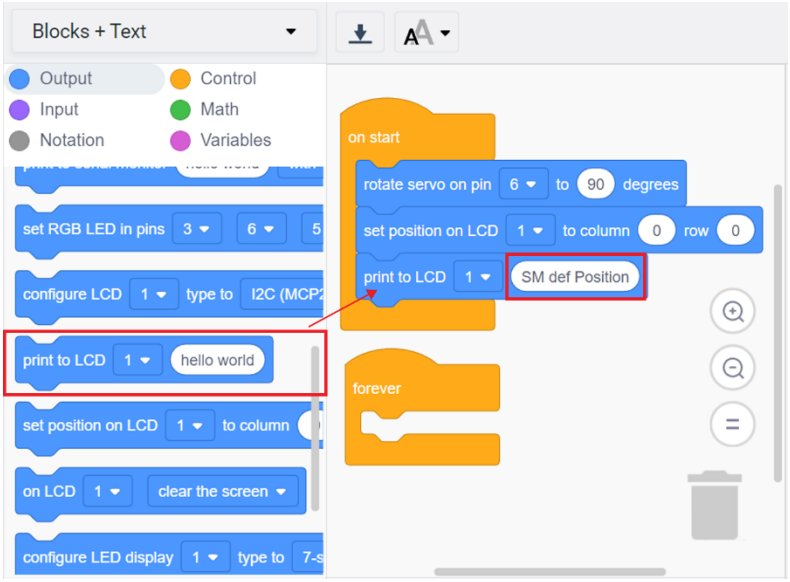
From the output menu, drag and place the 'Set the cursor position of the LCD 1 to column 0 row 0' as shown.

Row 0 points to 1st row of the LCD.



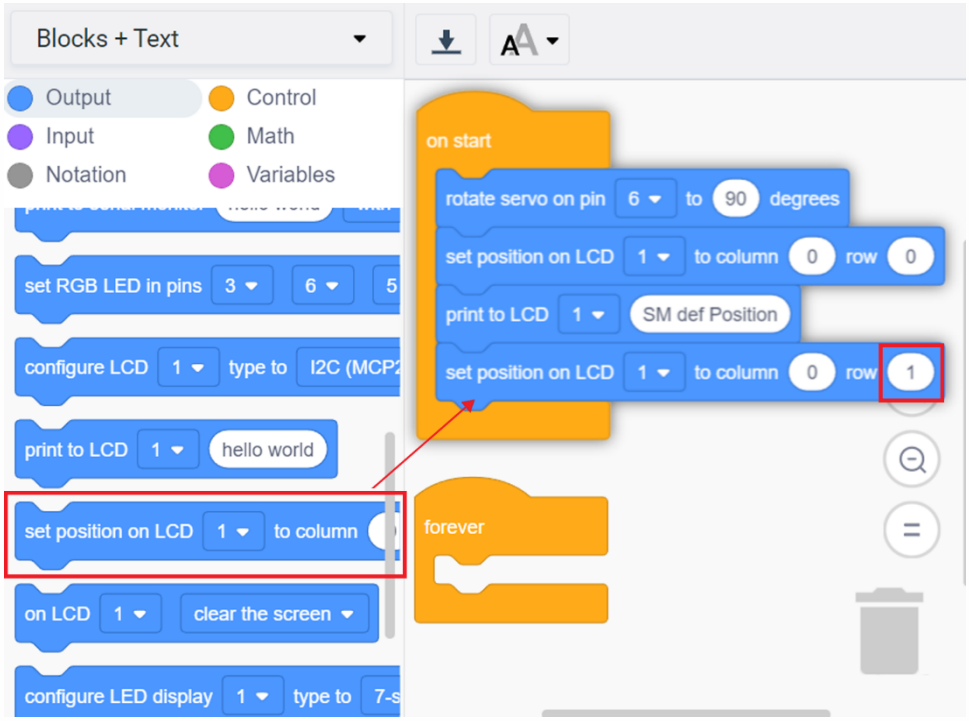
Step 29

- Select '**print to LCD 1 hello world**' block and place it inside the '**on start**' block.
- Change the text to '**SM def Position**' which denotes the Servo Motor default Position.



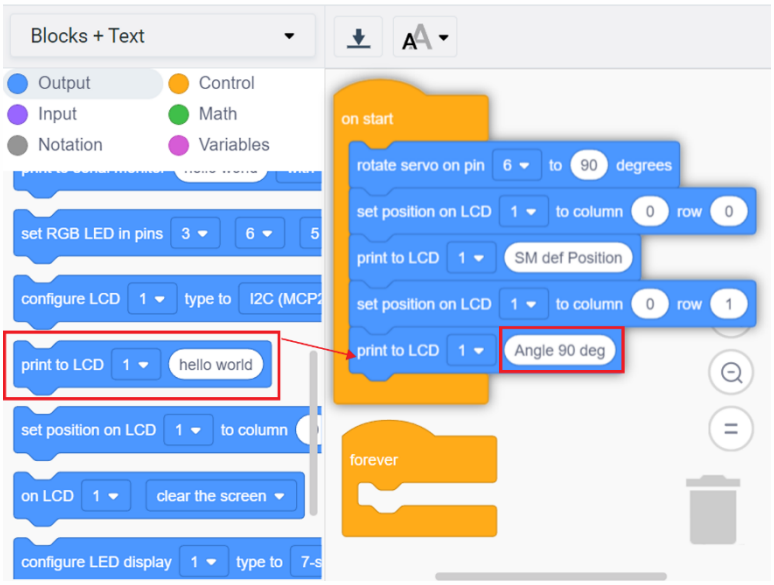
Step 30

- Select '**Set position on LCD 1 to column and row 0**' block and place it inside the '**on start**' block.
- Change the Row value to '**1**' as row 1 points to the 2nd row of the LCD.



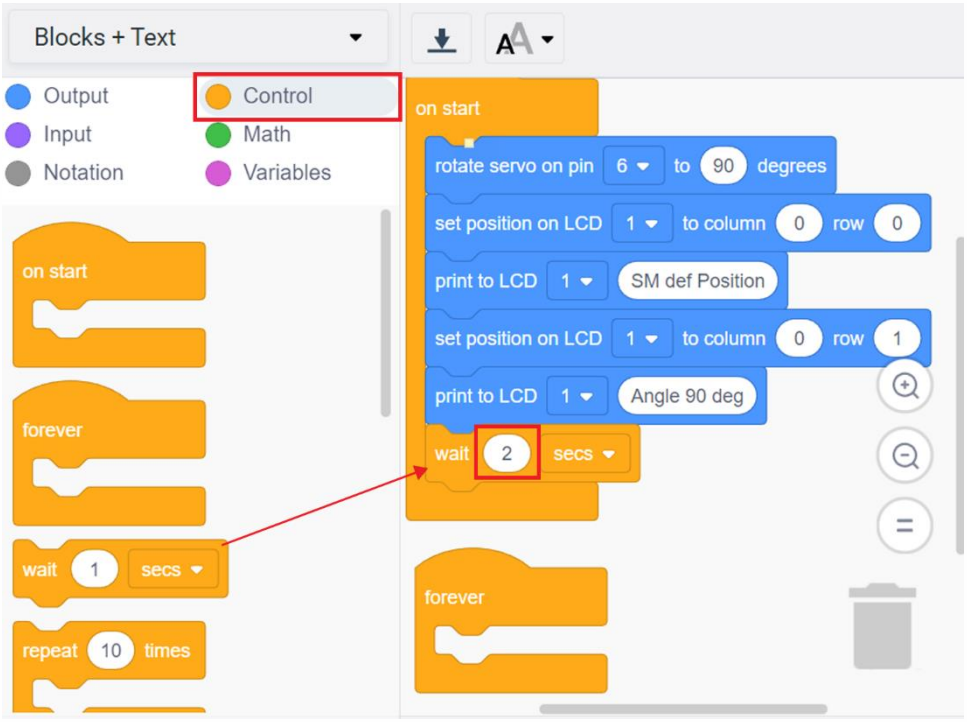
Step 31

- Select '**print to LCD**' block, and place it inside the '**on start**' block.
- Change the text of block to '**Angle 90 deg**'.



Step 32

- From Control menu, select '**wait 1 secs**' block.
- Place it inside the '**on start**' block.
- Change the value in the wait block to '**2**'.



Part 4: Reading Photoresistor sensor values and programming for the 5 different conditions.

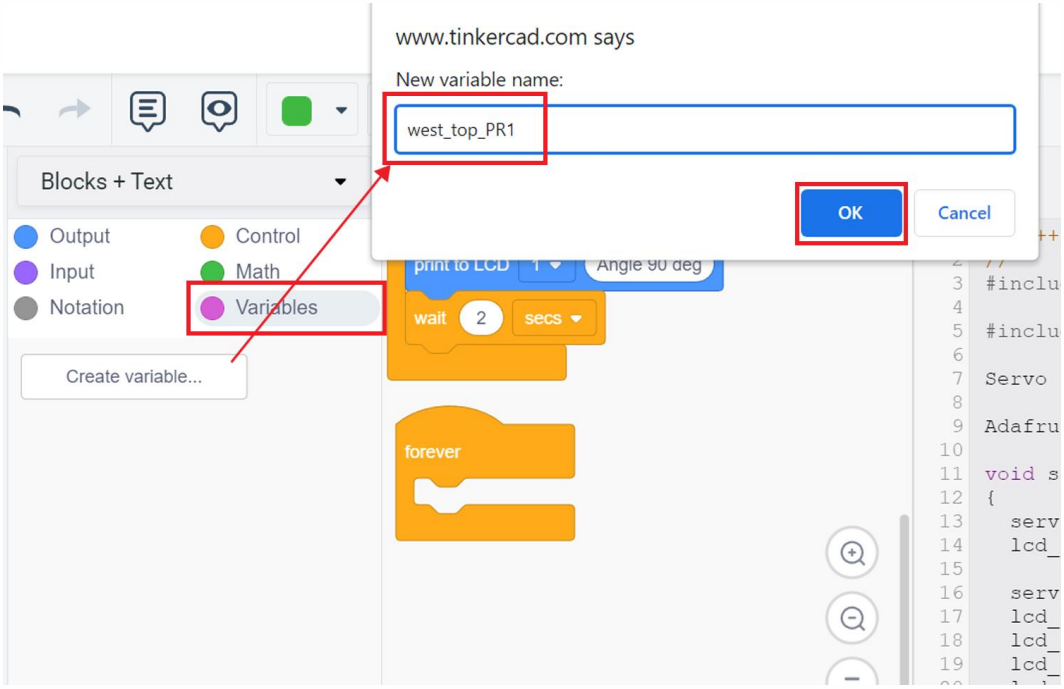
Now you will set the blocks to read the sensors' values and store the them in corresponding variables.

Sensor	Variable to be created
West Top Photoresistor Sensor	west_top_PR1
West Botton Photoresistor Sensor	west_bottom_PR2
East Top Photoresistor Sensor	east_top_PR3
East Bottom Photoresistor Sensor	east_bottom_PR4

First create a Variable in the name of 'west_top_PR1' to store the value given by the west top photoresistor sensor.

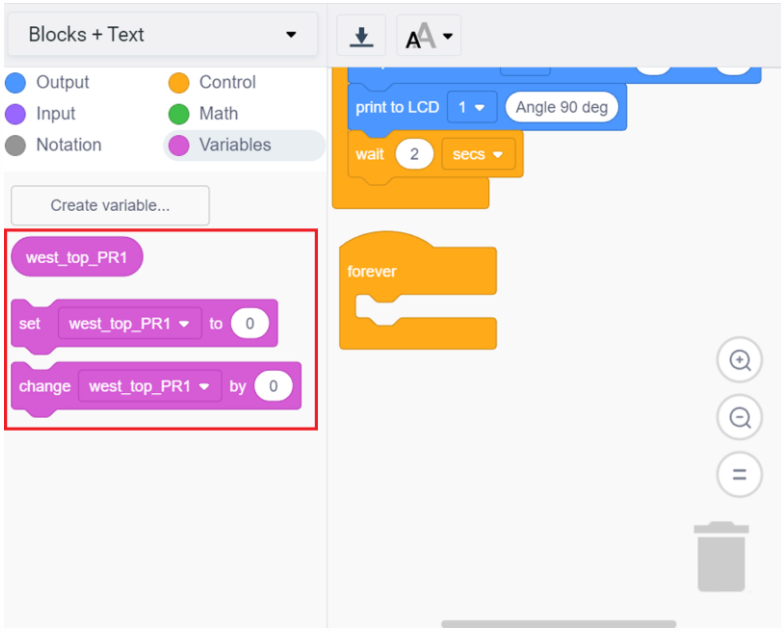
Step 33

- Click the variables menu, then select the create variable option.
- Type the variable name 'west_top_PR1' in the New variable name textbox.
- Click ok.



Step 34

Now the blocks related to the newly created variable and its options will appear here as shown in the image.



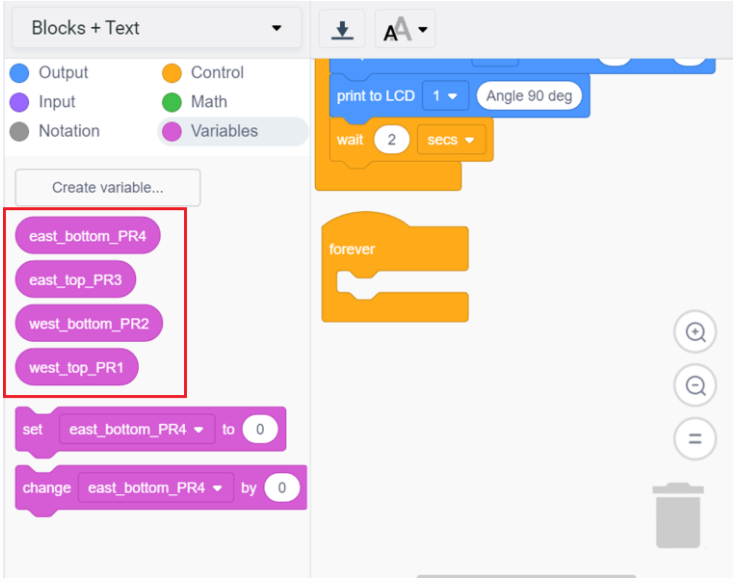
Step 35

Following the previous steps create the remaining 3 variables below:

west_bottom_PR2,

east_top_PR3,

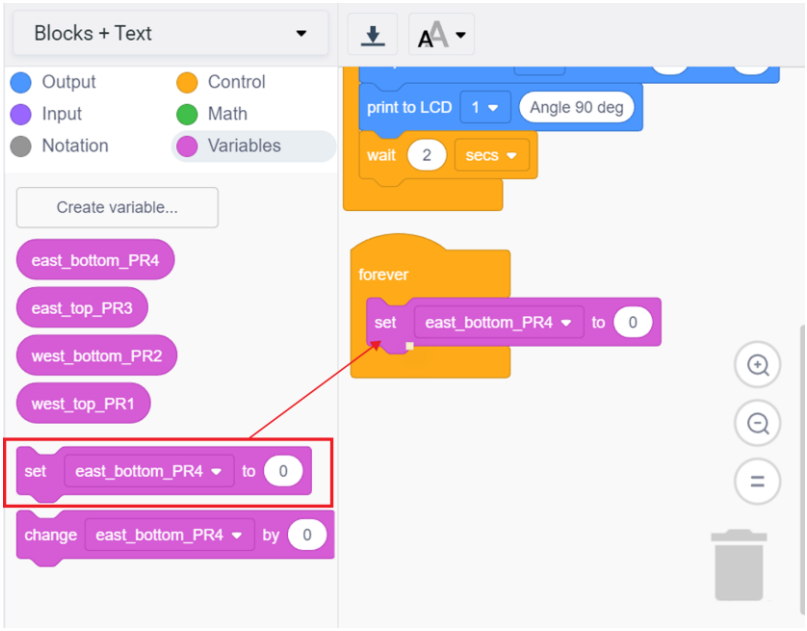
east_bottom_PR4.



Now you will store the value of the west top photoresistor sensor in the variable west_top_PR1.

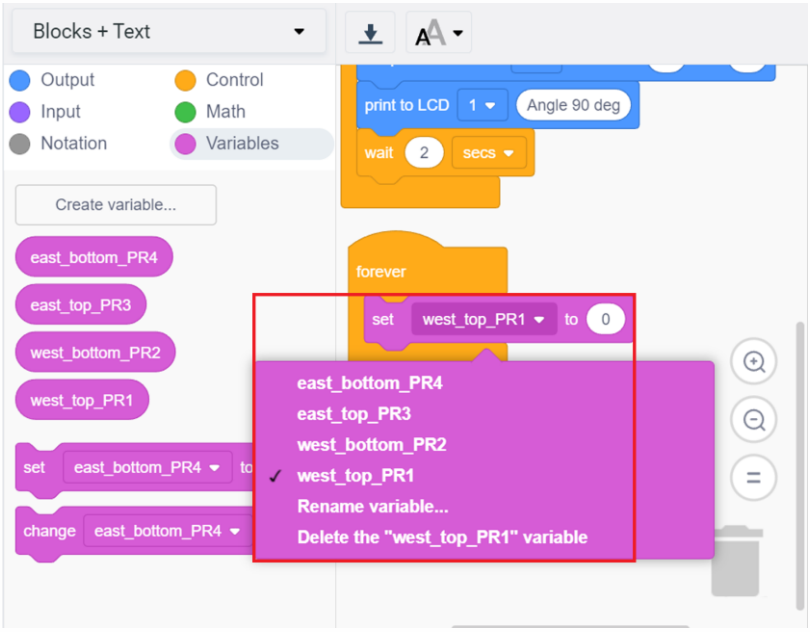
Step 36

- Select '**set east_bottom_PR4**' block.
- Place it inside the '**forever**' block.



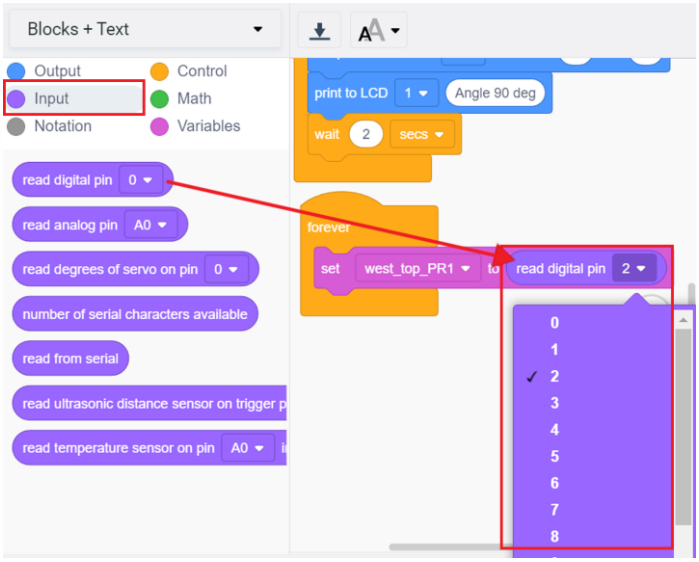
Step 37

Change '**east_bottom_PR4**' to '**west_top_PR1**' from the dropdown list.



Step 38

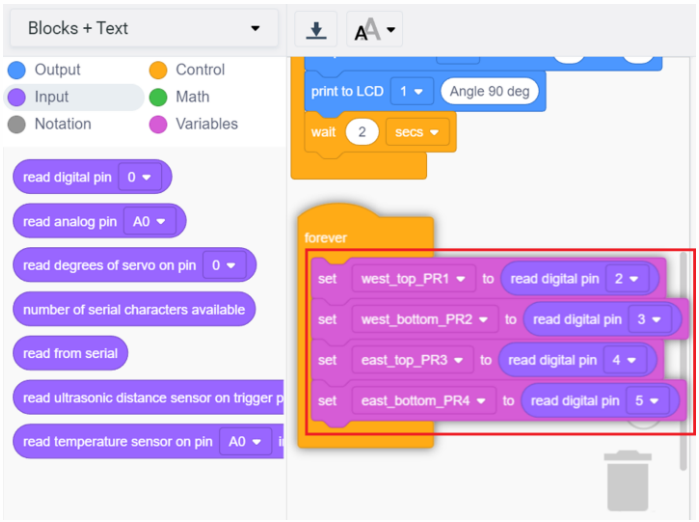
- From input menu, select '**read digital pin 0**'.
- Place it in the '**set west_top_PR1**' block.
- Change the pin number to '**2**' from the dropdown list, as west top photoresistor sensor is connected to Arduino pin 2.



Step 39

Same as you did previously, set other 3 variables, as shown.

- Set west_bottom_PR2 to digital read pin 3.
- Set east_top_PR3 to digital read pin 4.
- Set east_bottom_PR4 to digital read pin 5.



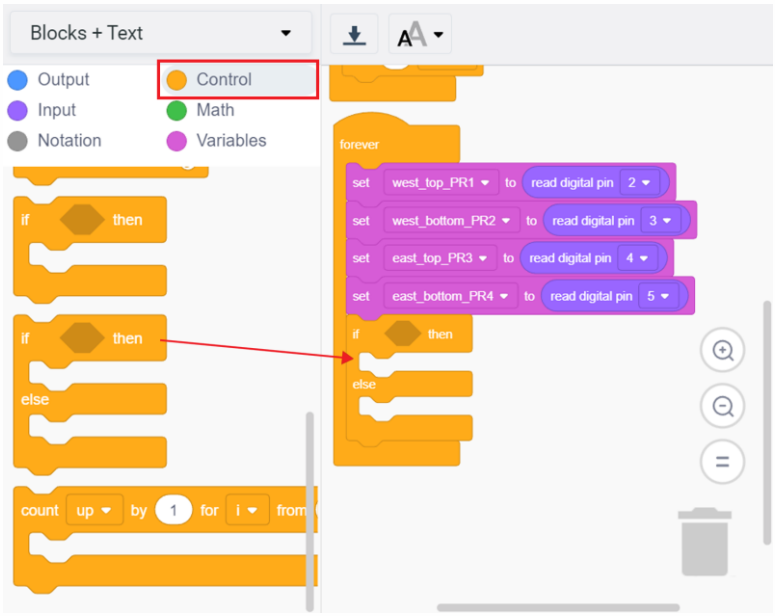
Now you will check for the 5 states:

State 1: At noon time, all the sensors will receive sunlight and hence the value of the 4 sensors' variables will be equal to 1.

To check this state,

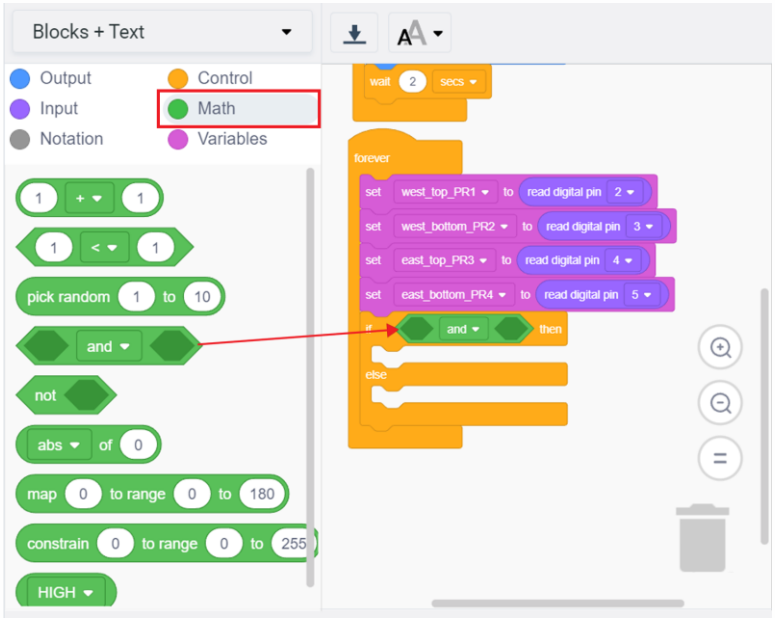
Step 40

From the control menu, select 'if else' block and place it inside the 'forever' loop.



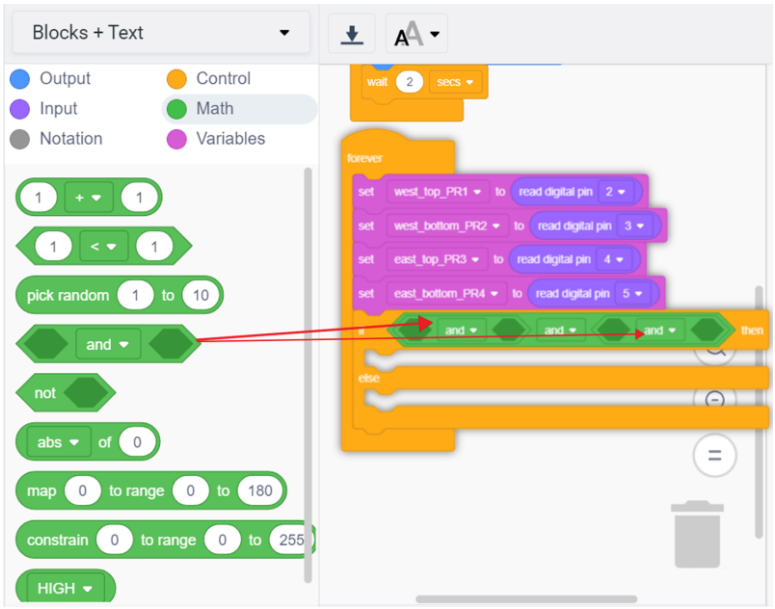
Step 41

From math menu, select the 'and' block and place it inside the if block, as shown.



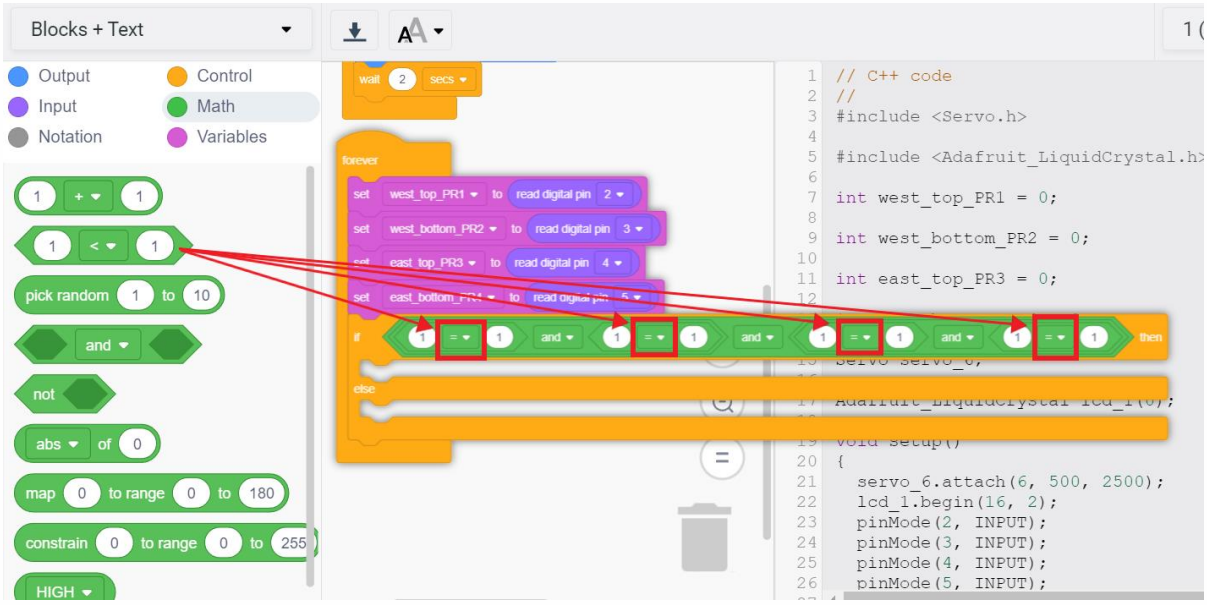
Step 42

- Select two more '**and**' blocks.
- Place it inside the previously placed '**and**' block.



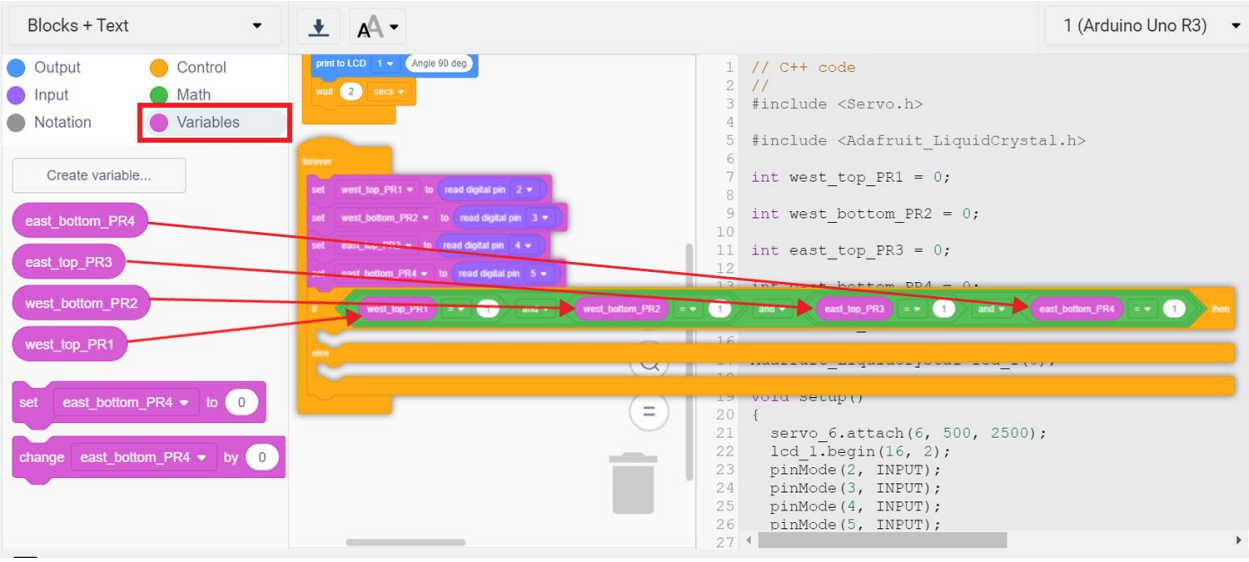
Step 43

- Place a '**<**' block inside each of the '**and**' blocks as shown.
- Change the '**<**' to '**=**' from the dropdown list.



Step 44

From variables menu, drag and place the variables in the '**=**' block as shown.



You have now checked for the 1st State. If the 1st state is true, then it means that the sun is in the noon position.

In that case, the servo motors need to be moved to the 90-degree noon (default) position angle so that the solar panels get the maximum sunlight.

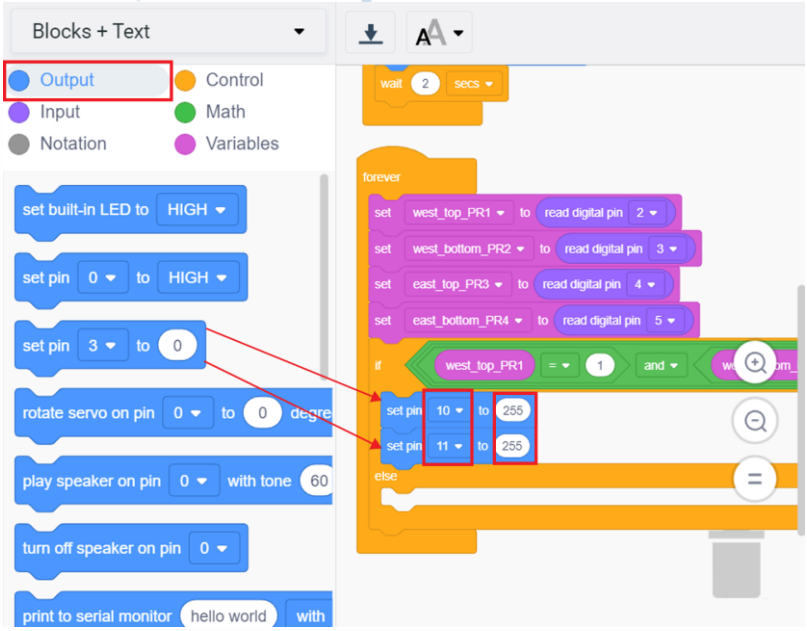
In addition to that, both the LEDs should be turned ON to indicate that both west and east side photoresistors are receiving sunlight.

The same is indicated using LCD by displaying 'SP def Position'.

Step 45

Set blocks for the LED indicator

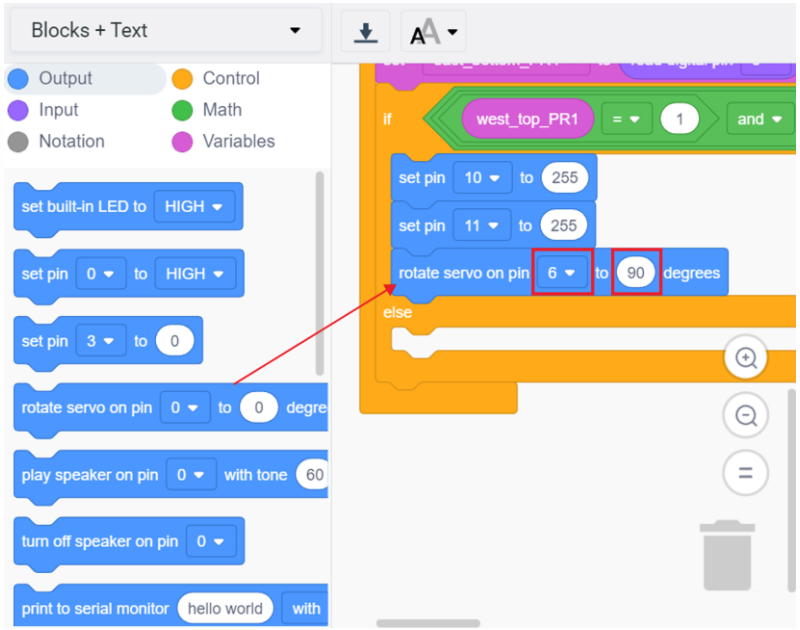
- From output menu, '**select set pin 3 to 10**'. As the west side LED is connected to the Arduino Pin 10.
- Place it inside the '**if**' block.
- Change the pin to 10 and value to 255. (Refer Table 1 from Appendix Section)
- Do the same for pin 11 to 255. As east side LED is connected to the Arduino pin 11.



Step 46

You will now set the servo motor angle to 90 degrees.

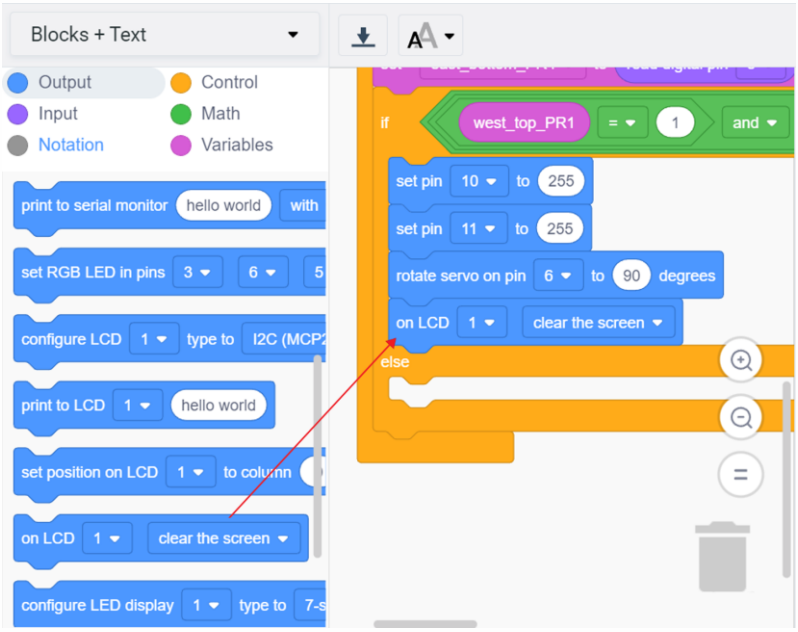
- Select 'rotate servo on pin 0 to '**90**' degrees.
- Place it inside the **'if'** block.
- Change the servo pin to 6 and value to '**90**'.



Step 47

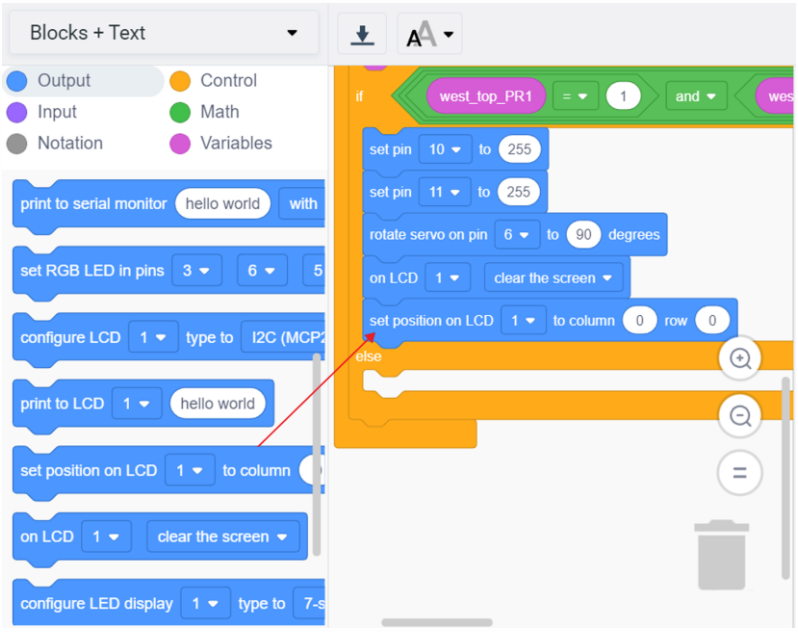
Blocks for LCD should display '**Save Energy**' in the first row and '**SP def position**' in the second row, where SP stands for solar panel.

- Select '**on LCD 1 clear screen**' block place it inside the '**if**' block.



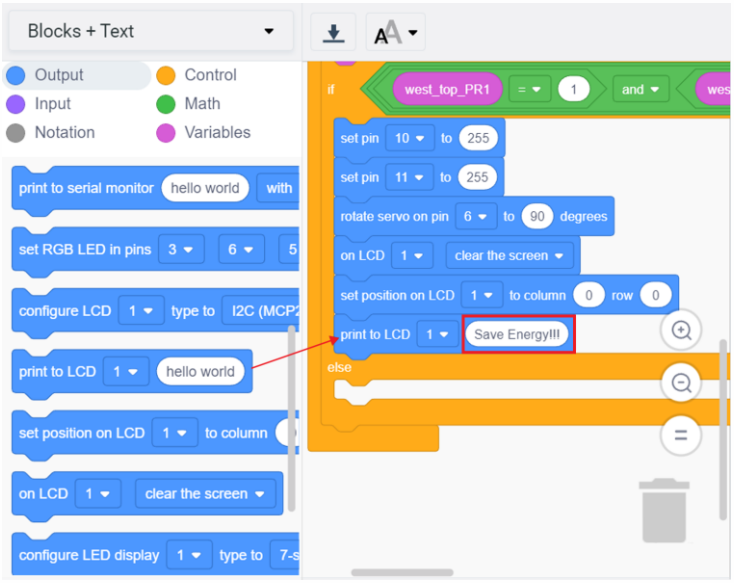
Step 48

- Select '**set position on LCD 1 to column 0 row 0**' block.
- Place it inside the **'if'** block.



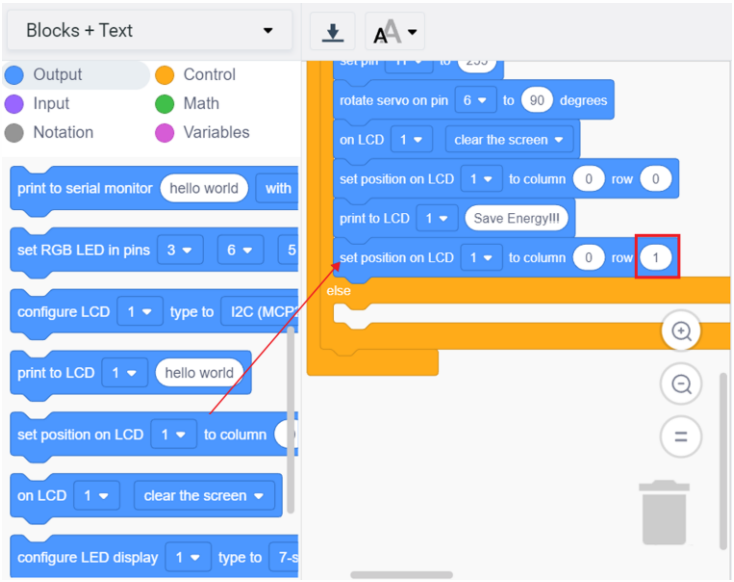
Step 49

- Select '**print to LCD 1 hello world**' block.
- Place it inside the '**if**' block.
- Change the text to '**Save Energy!!!**'.



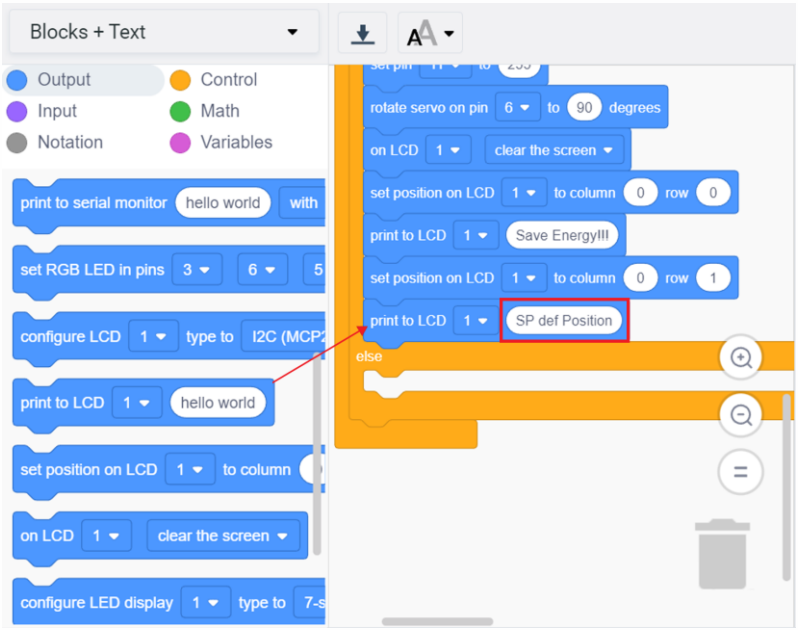
Step 50

- Select '**set position on LCD 1 to column 0 row 0**' block.
- Place it inside the '**if**' block.
- Change the row value to 1 (to set the second row of LCD).



Step 51

- Select '**print to LCD 1 hello world**'.
- Place it inside the '**if**' block.
- Change the text to be displayed to '**SP def Position**'.



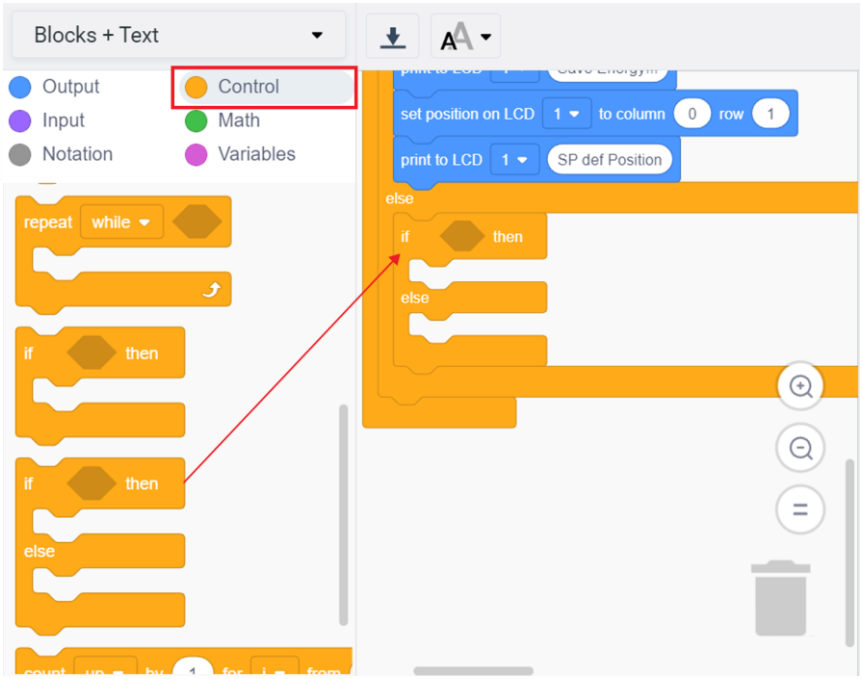
State 2: During the evenings, both the top and bottom sensors of the west side will receive sunlight. If sensors on the west side namely west_top_PR1 and west_bottom_PR2 have values are equal to 1, then,

- Set the servo motor to 180-degree angle to set the SP or-solar panel to west side.
- Turn on the west side LED.
- Turn off the East side LED.
- Display the notification that the solar panel is facing west side in the LCD.

Step 52

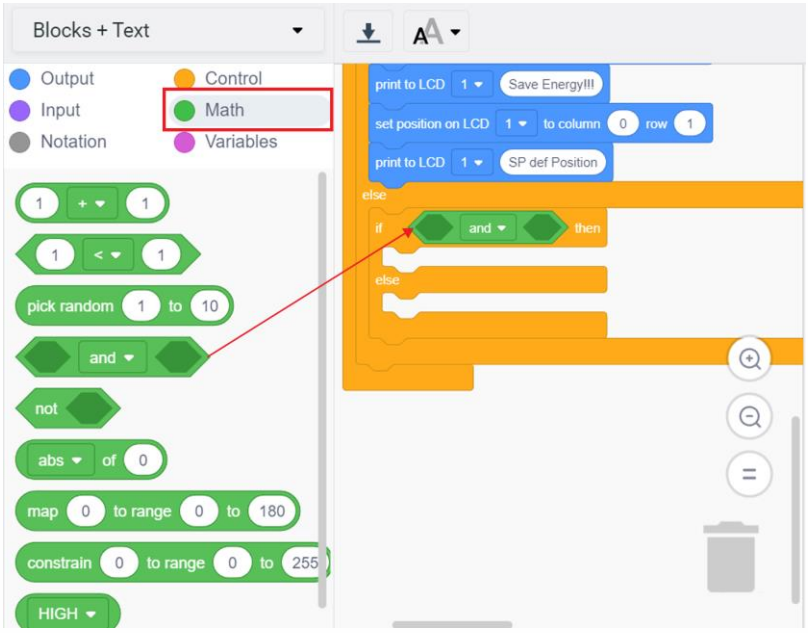
To check this condition,

- From control menu, select the 'if else' block.
- Place it inside the else of previous 'if else' block.



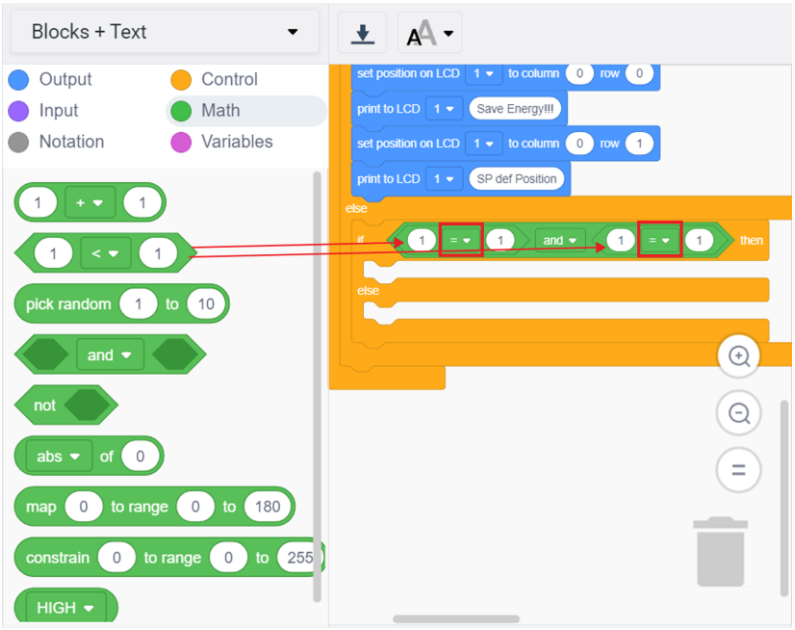
Step 53

From math menu, select '**and**' block, place it in the '**if**' block, as shown.



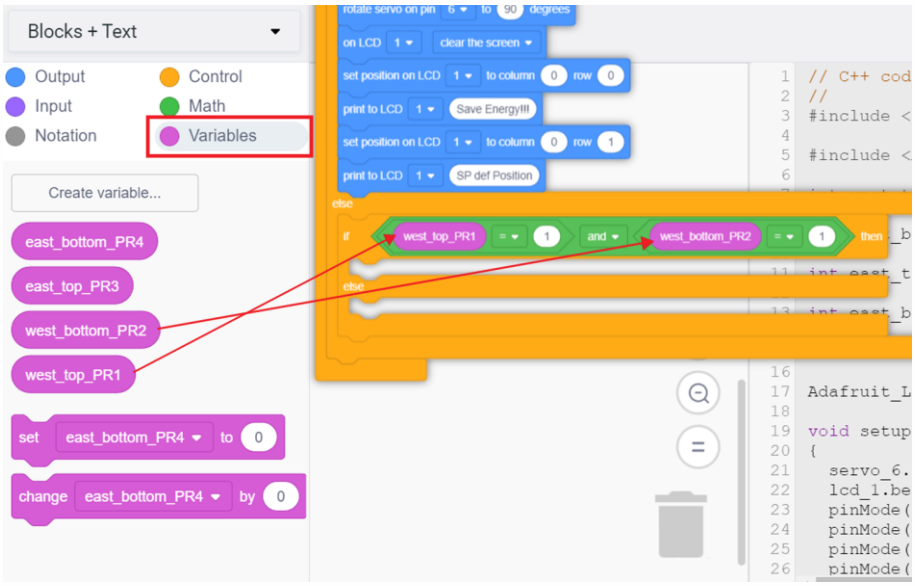
Step 54

- Select '**<**' block, place it in the first place of '**and**' block.
- Select one more '**<**' block, place it in the second place of '**and**' block.
- Change '**<**' to '**=**' from the dropdown list of the both '**<**' blocks.



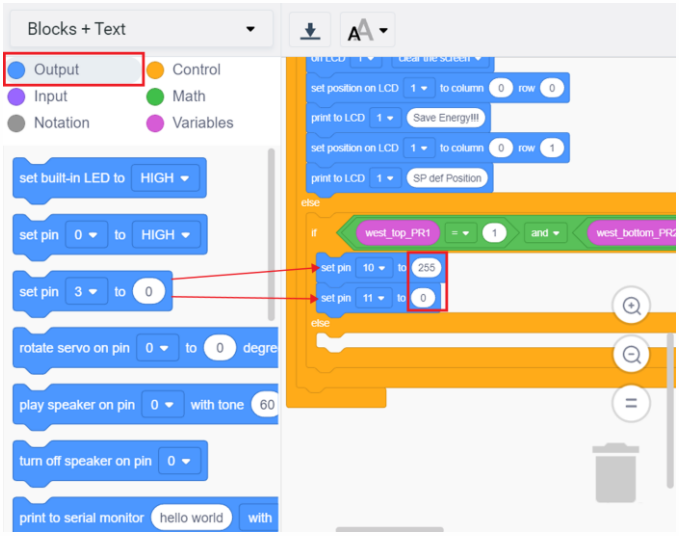
Step 55

- From variables menu, select '**west_top_PR1**' block, place it in the first '**=**' block.
- Select and place the '**west_bottom_PR2**' block, inside the second '**=**' block.



Step 56

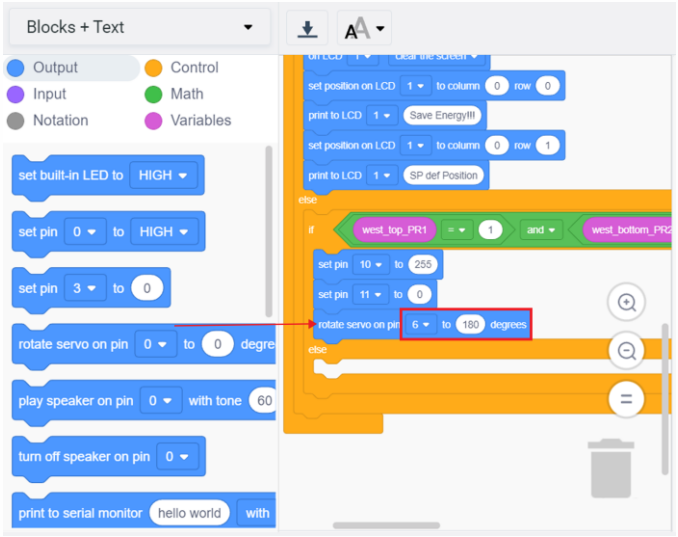
- From output menu, '**select set 3 to 0**' block, place it inside the '**if**' block, as shown.
- Change the pin to 10 and the text to 255. (refer Table 1 in Appendix section)
- Place another '**set pin 3 to 0**' block.
- Change pin to 11 and leave the value as 0.



Set servo motor angle to 180 degrees to face towards the west direction completely.

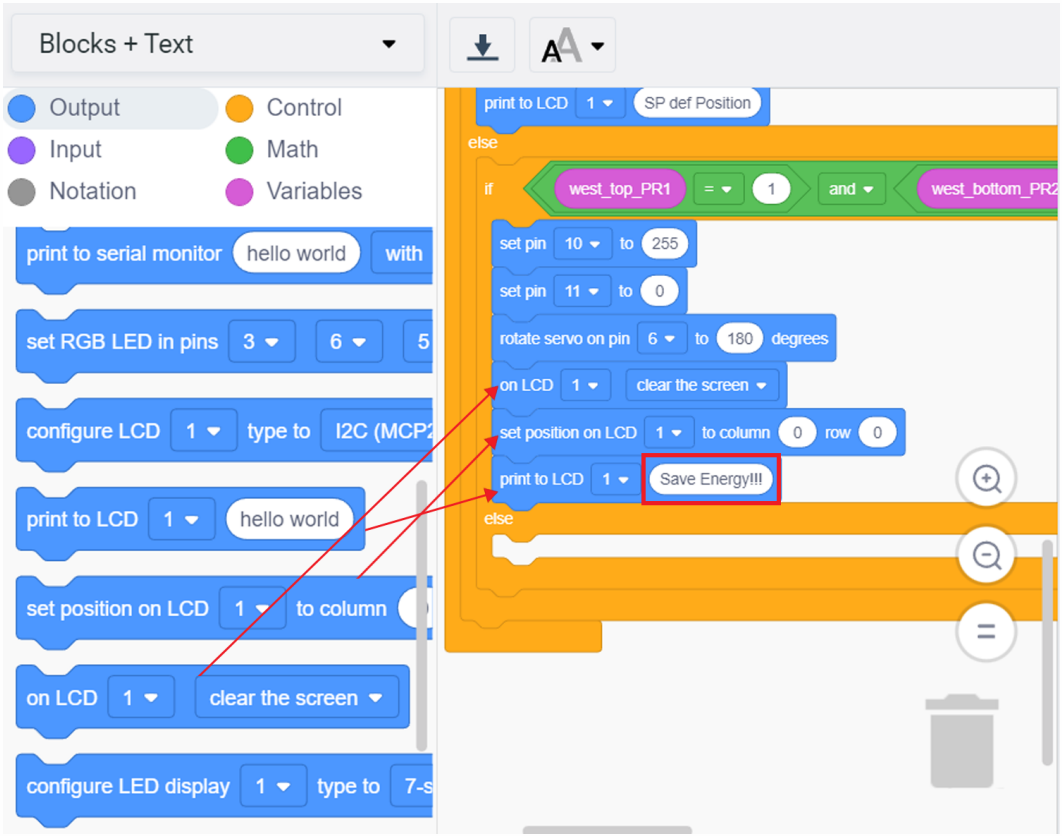
Step 57

- Select '**rotate servo on pin 0 to 0 degrees**' block.
- Place it inside the '**if**' block.
- Change the pin to 6 and value to 180.



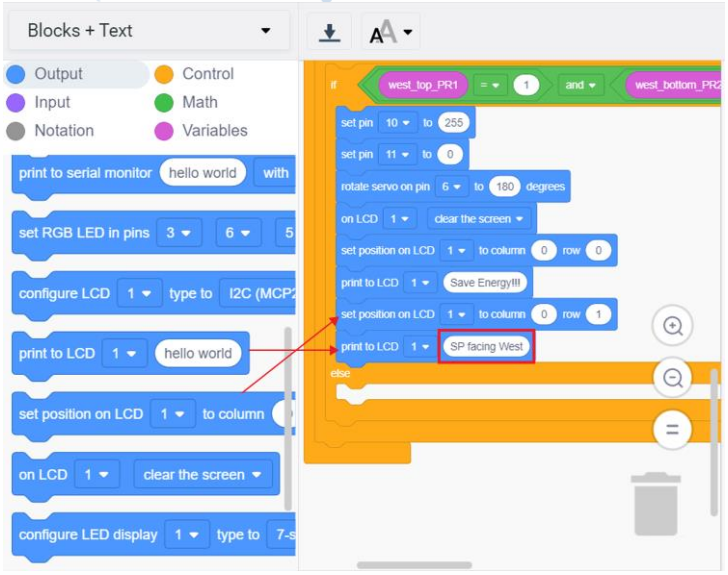
Step 58

- Select '**on LCD 1 clear the Screen**' block, place it inside the '**if**' block.
- Select '**set position on LCD 1 to column 0 row 0**', place it inside the '**if**' block.
- Select '**print to LCD hello world**' block, place it inside the '**if'** block.
- Change the text to '**Save Energy**' of '**print to LCD**' block.



Step 59

- Select '**set position on LCD 1 to column 0 row 0**' block.
- Place it inside the '**if**' block.
- Change the row text to 1.
- Select '**print to LCD 1 hello world**' block, place it inside the '**if**' block.
- Change the text to '**SP facing West**'.

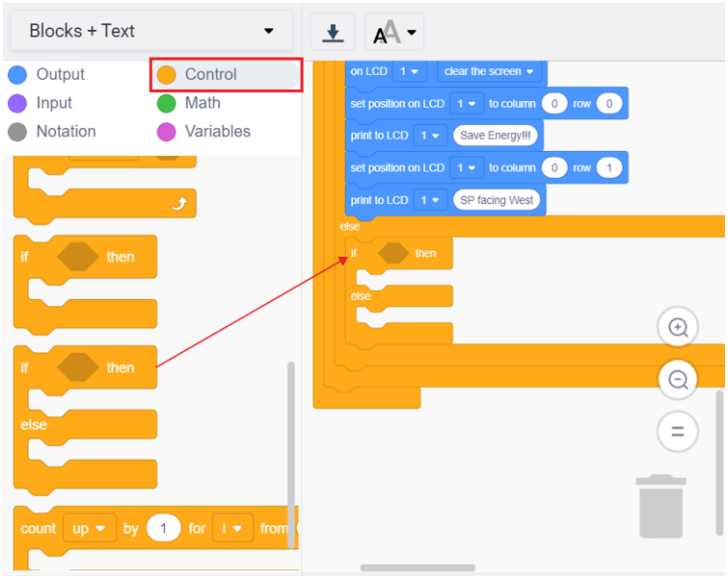


State 3: During late evenings, due to reduced sunlight being insufficient for both the photoresistors one of the west side sensor values will be HIGH and the other will be LOW. So,

- Set the servo motor to 135 degrees angle.
- Turn ON west side LED with light having low brightness and turn the east side LED OFF.
- Display the text 'panel is facing west' in the LCD.

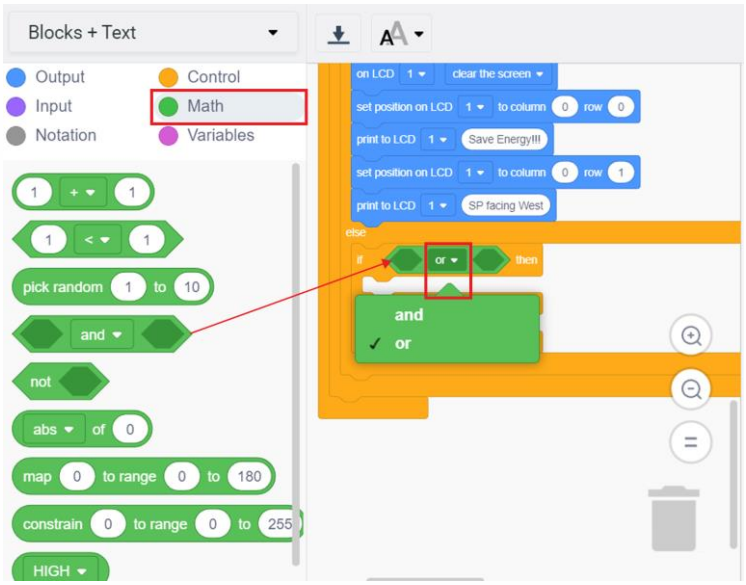
Step 60

To check condition, from control menu, place the 'if else' block inside the previous else block, as shown.



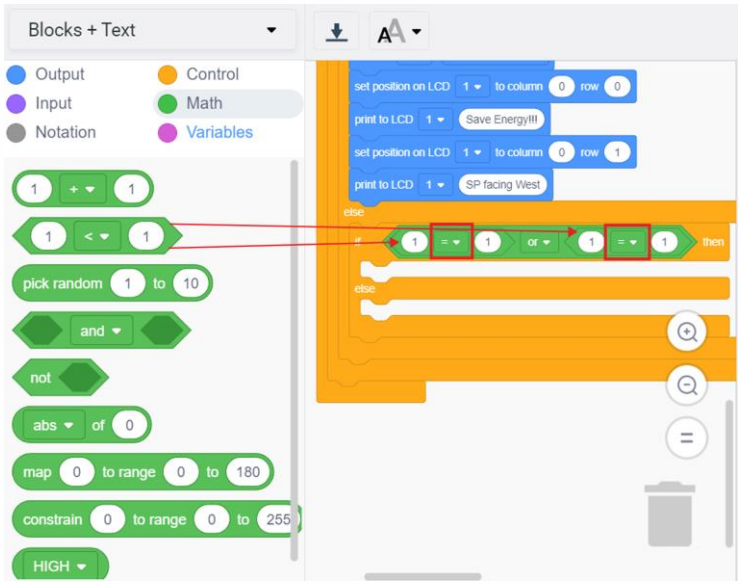
Step 61

- From maths menu, select '**and**' block, place it inside the '**if**' block.
- Change '**and**' to '**or**' from the dropdown list as shown.



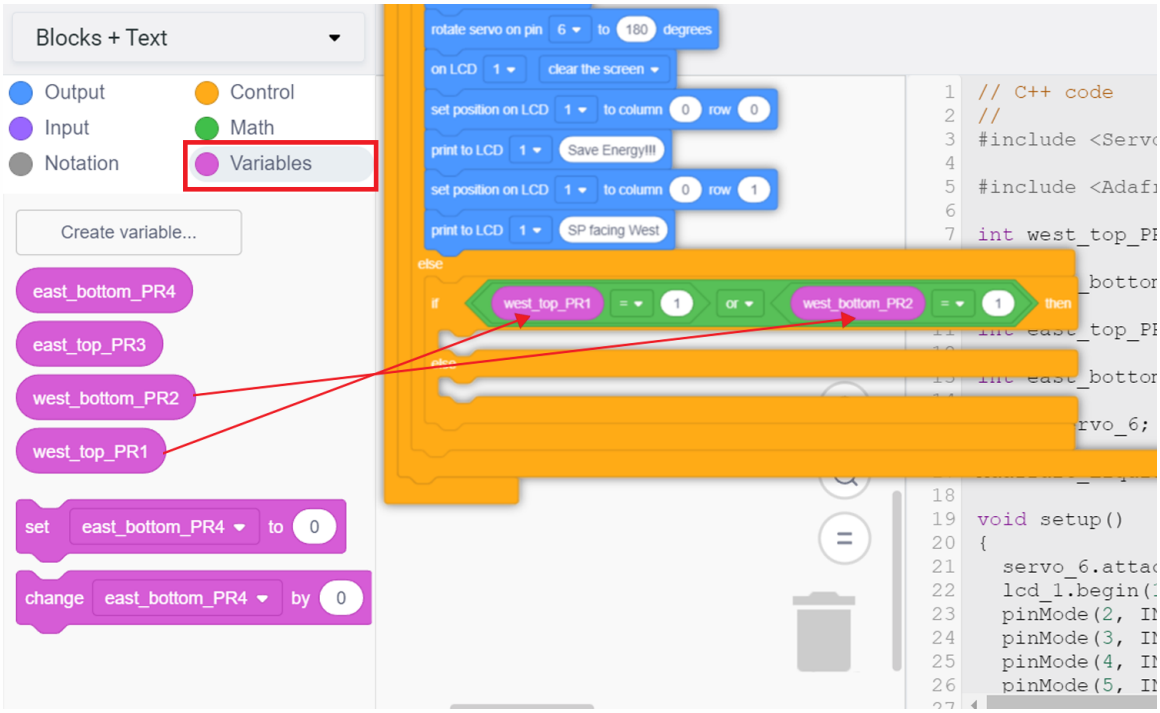
Step 62

- Select '**<**' block, place it in the first place of '**or**' block.
- Change '**<**' to '**=**' from the dropdown list.
- Select one more '**<**' block, place it in the second place of '**or**' block as shown in the image.
- Change '**<**' to '**=**' from the dropdown list.



Step 63

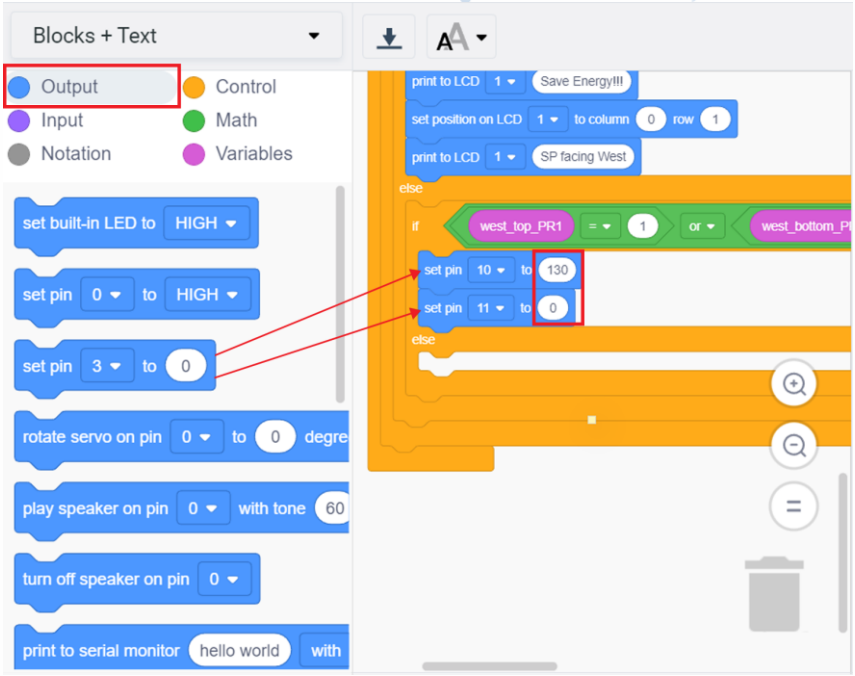
- From variables menu, select '**west_top_PR1**' block.
- Place it inside the first '**=**' block.
- Select '**west_bottom_PR2**' block.
- Place it inside the second '**=**' block as shown in the image.



Set the LED on the west side to glow in low brightness and turn off the LED on the east side. Refer to the below table for what each value signifies.

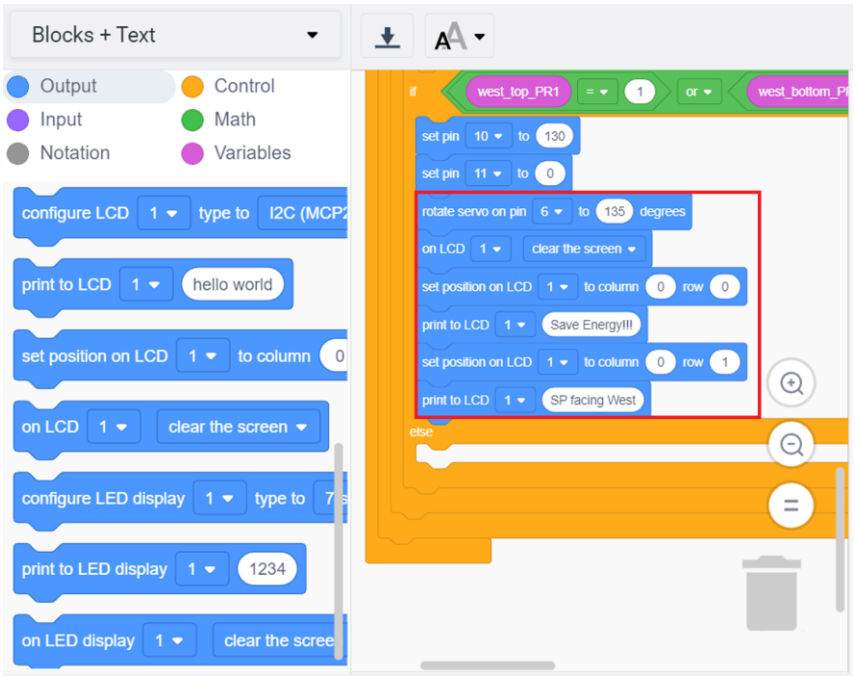
Step 64

- From output menu, select and place the '**set pin 3 to 0**' inside the '**if**' block.
- Change the pin to 10 and the value to 130. (Refer Table 1 in appendix section)
- Select another '**set pin 3 to 0**' block, place it inside the '**if**' block.
- Change the pin to 11.



Step 65

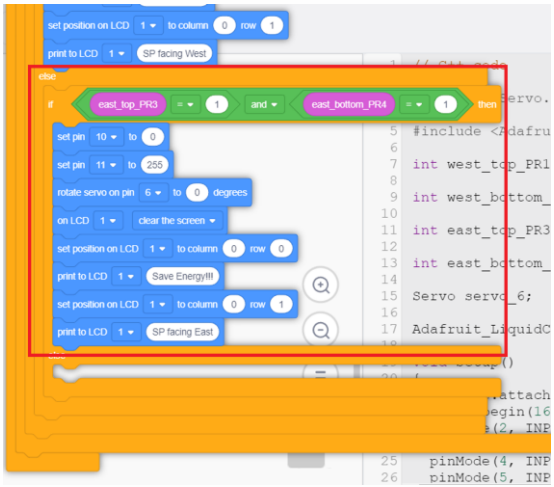
- Set servo angle to 135 degrees
- Set blocks for LCD to display '**Save Energy!!!**' in the first row and '**SP facing West**' in the second row.



Step 66

State 4: During mornings, both the top and bottom sensors of the east side will receive sunlight. If east side sensors east_top_PR3 and east_bottom_PR4 are equal to 1, then do the following:

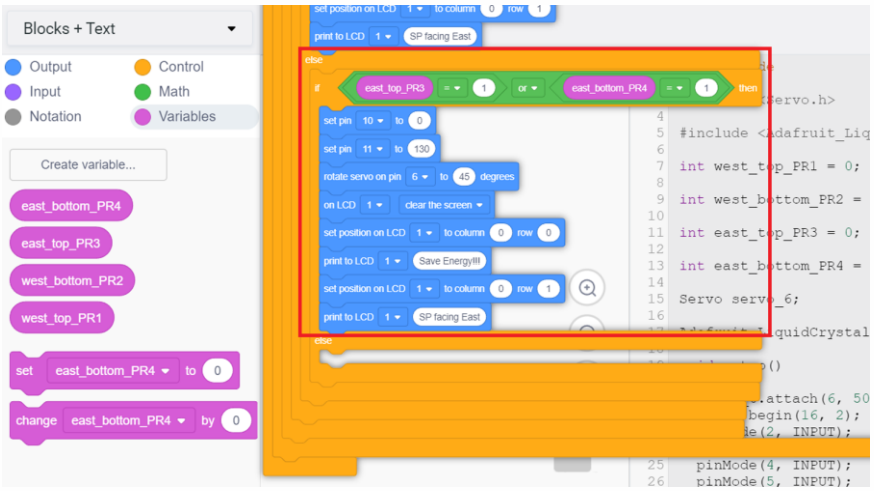
- Set the servo motor to 0 degree angle.
- Turn on the east side LED and Turn off the west side LED.
- Display that solar panel is facing east side as shown in the figure.



Step 67

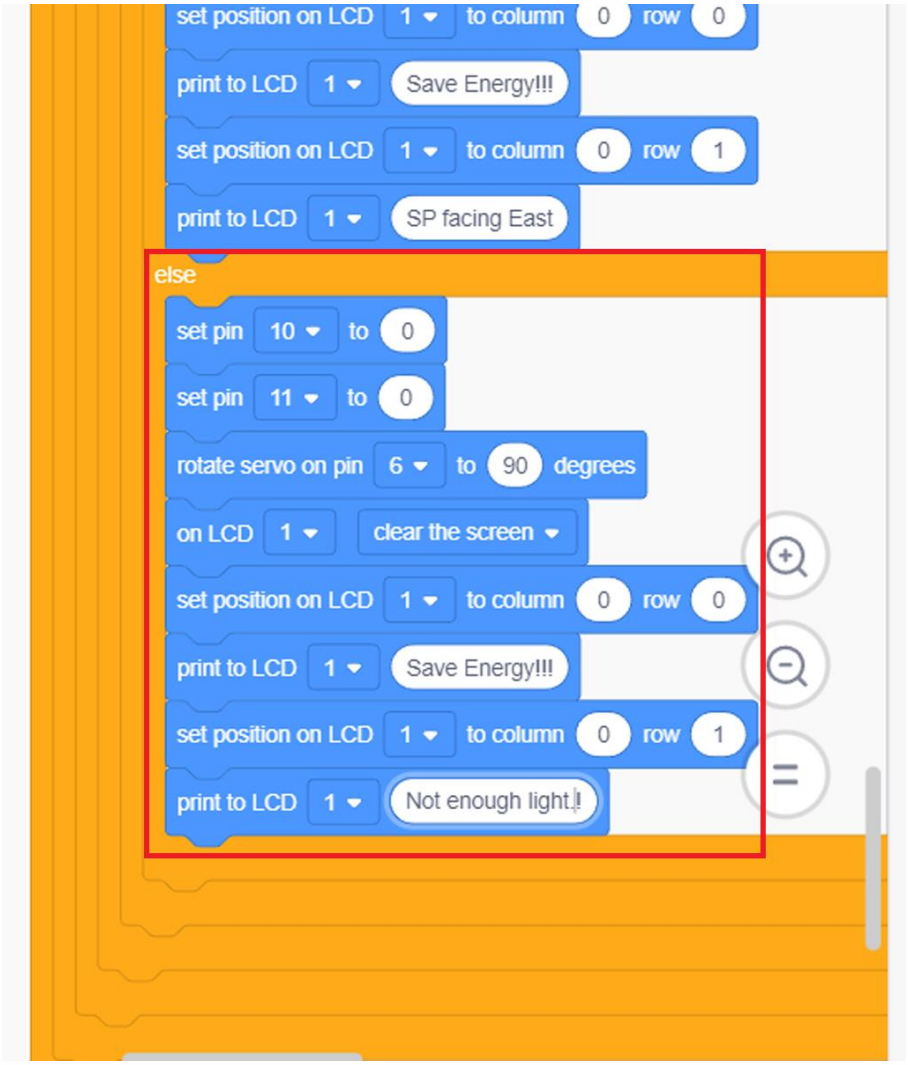
State 5: If one of the east side sensor values is equal to 1, then

- Set the servo motor to 45 degree angle.
- Turn on the east side LED with low brightness and turn off the west side LED.
- Display that solar panel is facing east side in LCD.



Step 68

In case none of the photoresistors receive enough sunlight, set the blocks inside the last else as shown in the image.

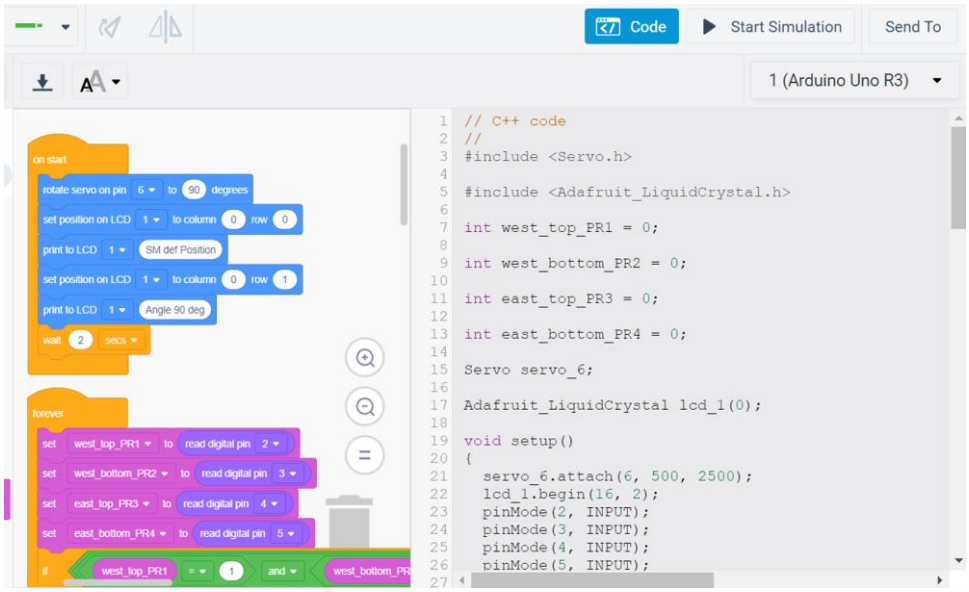


Part 5: Testing the Simulation and noting down the results.

Now you will proceed with the simulation.

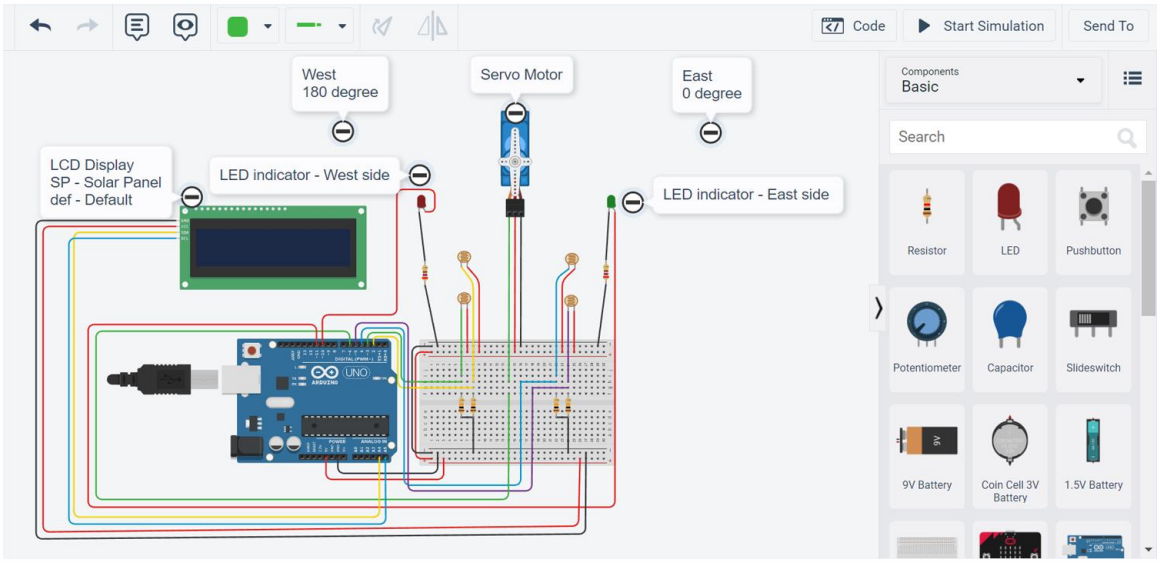
Step 69

Click '**Code**' button to enter into the circuit screen.



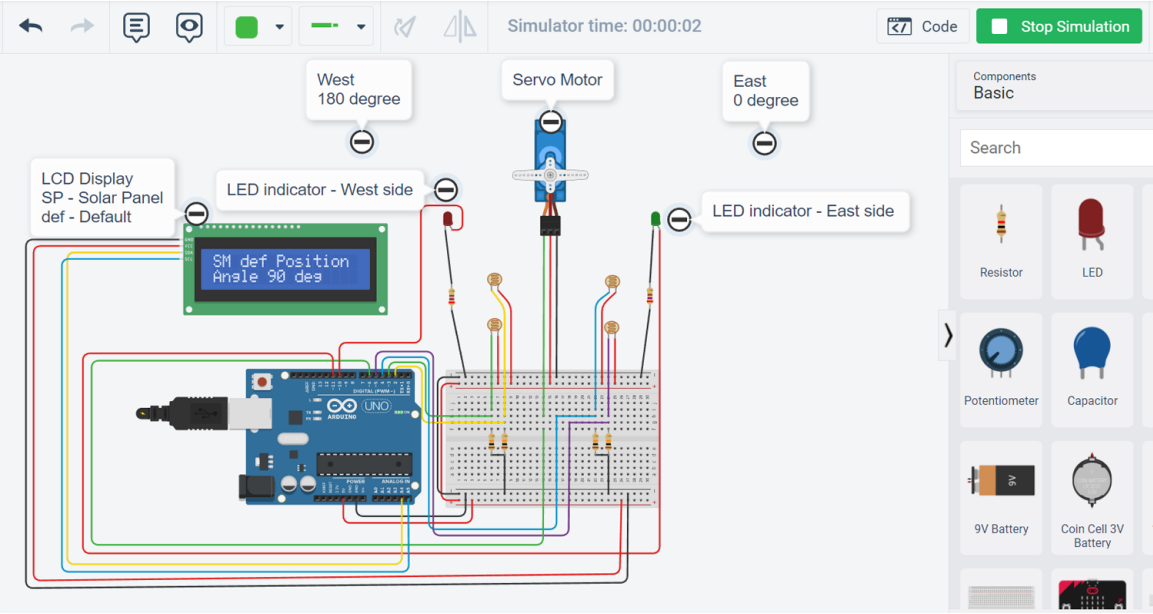
Step 70

Now click the '**Start Simulation**' button.



Step 71

As you begin the simulation, the Servo motor will be set to its default position. The LCD will display indicating the same.



As this is a simulation process, you will trigger the photoresistors manually to check each state and note the change in the servo motor position, the LCD and LED indicators.

Refer table 2 in Appendix section.

Step 72

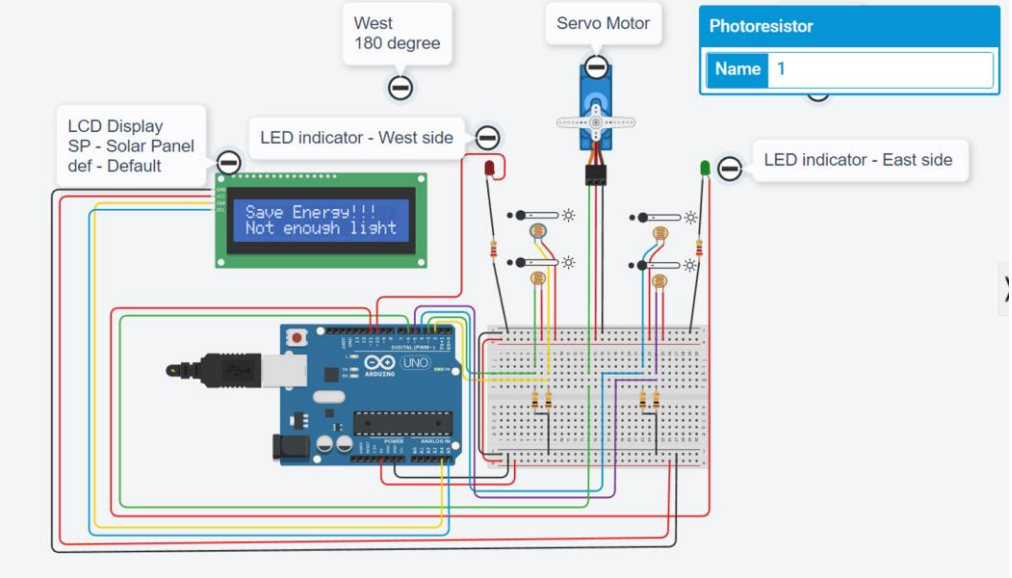
Click on the photoresistors to change their values as shown in the image.

INPUT: All photoresistors are low by default, in other words not getting enough sunlight

OUTPUT:

- Servo motor is in its default position, 90 degrees.
- Both the LEDs are turned off.
- LCD indicates that there is not enough sunlight.

initially

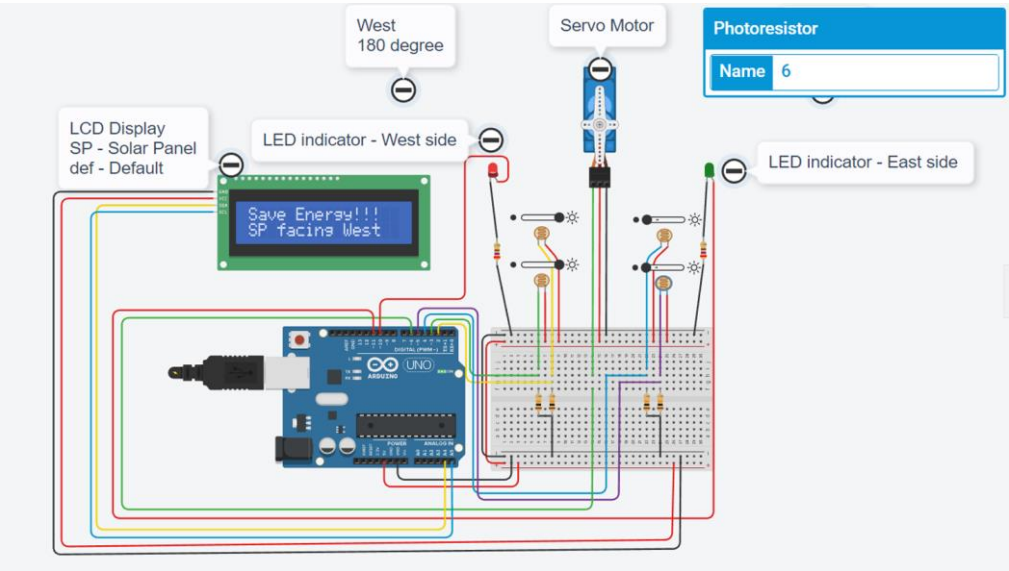


Step 73

INPUT: Set the value of west side photoresistors to HIGH.

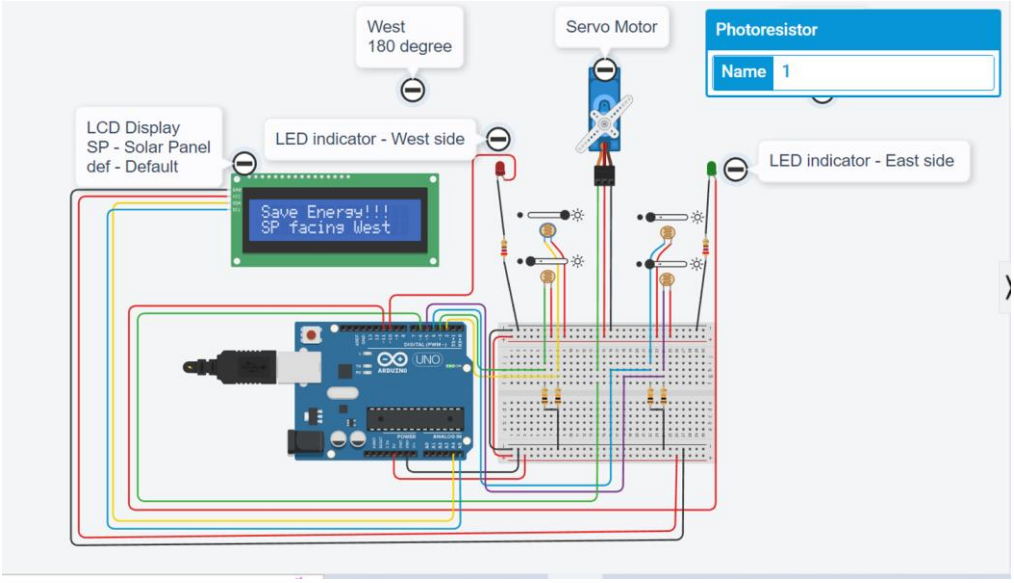
OUTPUT:

- Servo motor is in 180 degrees. This means that the solar panel is facing the west direction.
- West side LED is turned on. East side LED is turned off.
- LCD indicates that the solar panel is facing westwards.



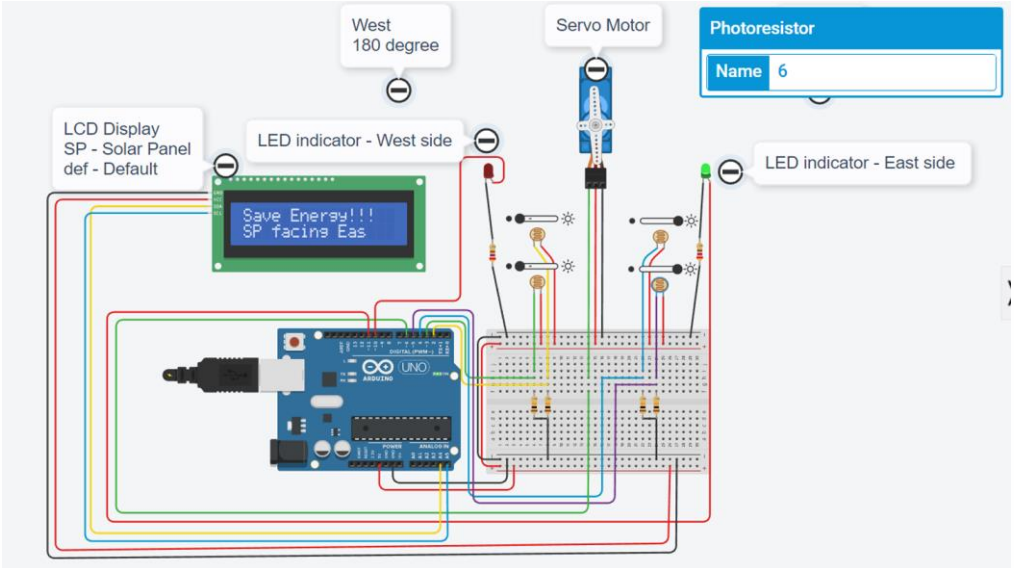
Step 74

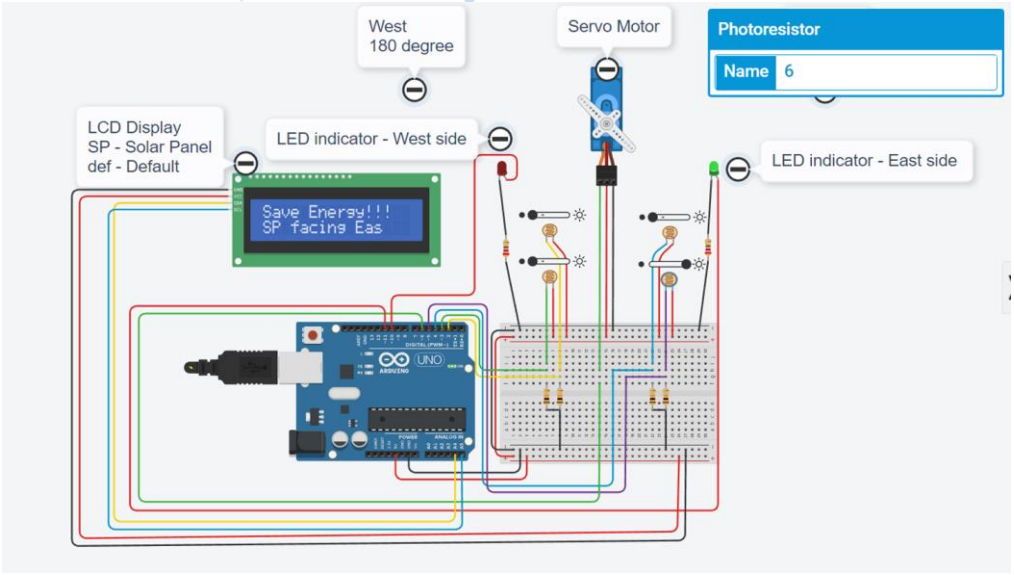
Change one of west side photoresistor to HIGH and check the output.



Step 75

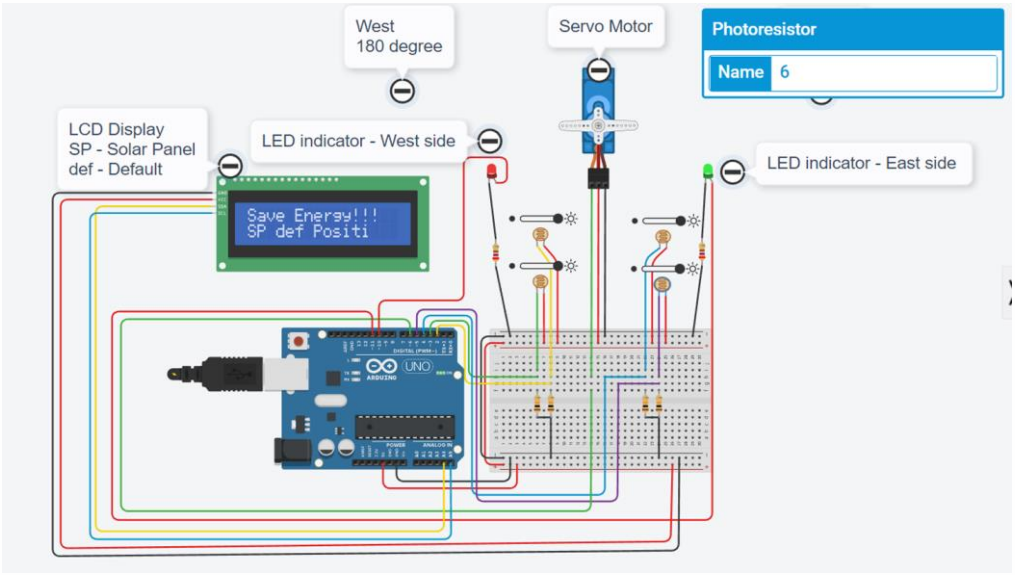
Now check with the same settings on the east side photoresistors.





Step 76

Set all the Photoresistors HIGH and check the output.



Congratulations! Your simulation model for single axis solar tracker is working perfectly well. You can now gather the same physical components and set up the solar tracker in real time.

Appendix:

Table 1

Value	LED ON/OFF	Brightness
0	OFF	-
130	ON	Low
255	ON	High

Table 2

(West) PR1	(West)PR2	(East) PR3	(East) PR4	Sun position	Servo motor position	Solar Panel facing towards	West LED	East LED	LCD Display
LOW	LOW	LOW	LOW	-	90 degree (Default position)	-	OFF	OFF	Not enough light
HIGH	HIGH	LOW	LOW	West	180 degree	West	ON (full brightness)	OFF	SP facing west
HIGH	LOW	LOW	LOW	West	135 degree	West	ON (low brightness)	OFF	SP facing west
LOW	HIGH	LOW	LOW	West	135 degree	West	ON (low brightness)	OFF	SP facing west
LOW	LOW	HIGH	HIGH	East	0 degree	East	OFF	ON (Full brightness)	SP facing east
LOW	LOW	HIGH	LOW	East	45 degree	East	OFF	ON (Low brightness)	SP facing east
LOW	LOW	LOW	HIGH	East	45 degree	East	OFF	ON (Low brightness)	SP facing east
HIGH	HIGH	HIGH	HIGH	Noon/ Overhead	90 degree	Noon / Overhead	ON (Full brightness)	ON (Full brightness)	SP def position