Lesson 3: Coordinates

This lesson will cover how to move around in a Minecraft world with respect to the three-coordinate grid represented by (X Y Z) coordinates and the difference between relative position and world position. We'll also show you how to create a compass rose to help you find your way around and create a tool that allows you to copy and paste entire structures in the Minecraft world.

Why Learn Coordinates?
In Minecraft, it’s important to know where you are in the world, where your Agent is, and where all kinds of things from diamond mines, to woodland mansions, to underground spawners are. In Survival mode, it’s even more important to be able to get back to a safe place when the sun starts to go down, or to remember the location of points of interest so you can find them again if your inventory is full and you need to come back.

Even if you are already familiar with moving around in Minecraft, you may not have used coordinates, except perhaps to teleport. In order to use many of the MakeCode blocks effectively, you will need to understand Minecraft coordinates, which are also known as positions.

Coordinates in Minecraft
Minecraft uses a set of three coordinates (X, Y, and Z) to specify a position in a Minecraft world. MakeCode for Minecraft uses these coordinates in many of its blocks to specify where an action should take place.
Just like a 3-dimensional coordinate grid in math class, there is an origin point (0,0,0) where all 3 axes meet and the coordinates X, Y, and Z represent distances from this point.

- The X-coordinate represents a distance along the horizontal plane East to West, just like real world longitude values.
  - A distance East of the origin is represented by a positive X value, (+X).
  - A distance West of the origin is represented by a negative X value, (-X).
- The Y-coordinate represents a distance along the vertical plane Up to Down, just like real world altitude values.
  - A distance Up from the origin is represented by a positive Y value, (+Y).
  - A distance Down from the origin is represented by a negative Y value, (-Y).
- The Z-coordinate represents a distance North or South of the origin, just like real world latitude values.
  - A distance South of the origin is represented by a positive Z value, (+Z).
  - A distance North of the origin is represented by a negative Z value, (-Z).
To see where you are in Minecraft, use the function key F1. Your world position (X, Y, Z) coordinates will appear in the top left corner of your Minecraft window.

In the example above, your world position in this Minecraft world is currently (3, 98, 0). These numbers represent how far away you are from the world origin point (0, 0, 0).
- X = 3 means that you are 3 blocks east of the origin point
- Y = 98 means you are 98 blocks above the origin point
- Z = 0 means you are at the North-South origin

Try walking around in Minecraft and see how these values change. Press the spacebar to jump and notice that your altitude (Y value) changes, momentarily, by +1.

Absolute World Position versus Relative Player Position
There are two different kinds of positions in Minecraft:

- Absolute World Position
- Relative Player Position

**Absolute World Position**

An absolute world position is also made up of 3 numbers that represent the distance from the Minecraft world origin of (0, 0, 0). Just as in real life, the world positions are fixed and do NOT change, no matter where the player currently is in the Minecraft world.

For example, in real life:

- Earth’s geographical origin point, where latitude and longitude are both zero, is marked by a weather buoy off the coast of Africa, placed where the earth’s equator meets the Greenwich Prime Meridian.
- The Empire State Building has world coordinates of 40 degrees North and 73 degrees West of the origin point.
- Mount Everest has world coordinates of 27 North and 86 degrees East of the origin point.

No matter where you are, or where you move in the world, the world coordinates for the Earth’s geographical origin point, the Empire State Building, and Mount Everest don’t change.

Their position relative to you may change, but their world positions do not change.
**Relative Player Position**

A relative position is centered on the player’s current position, where the origin is the player’s current location in the game. Relative positions are denoted by a ‘~’ (tilde) symbol before each of the 3 numbers that make up the 3 coordinate (~X, ~Y, ~Z) position.

A position refers to the entire 1 x 1 x 1 space that a block occupies in a Minecraft world. Minecraft players are 2 blocks tall, so (~0 ~0 ~0) represents the player’s feet and (~0 ~1 ~0) represents the player’s head.

As a player moves around in Minecraft, so do the player’s feet, which means the relative position is NOT a fixed position – it changes as the player moves around in the game.

For example, wherever the player is in the Minecraft world:

- (~0, ~2, ~0) will always represent the location just above the player’s head
- (~5, ~0, ~0) will always represent the location 5 blocks East of the player’s current position
- (~0, ~3, ~-3) will always represent the block 2 blocks above the player’s head and 3 blocks North of the player’s current position

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**Unplugged activity: World Landmarks**

In this activity, you will learn and practice the difference between relative coordinates and absolute coordinates.

**Materials needed:**
- Globe or Map with longitude/latitude markers
- Or, a Mapping/GPS software
If you have access to a world map or a globe, you can find your own real-world position (where you are in the world, your latitude and longitude) as well as where different landmarks, like the Empire State Building, and the Great Pyramids of Giza, are relative to your current position in the world.

1. Find your own real-world position, the latitude and longitude of where you are right now.

   Notes:
   - Depending on your access to maps, globes, or GPS apps and the age and skills of the students, you may want to have the students use their country or state capitals for their world position. You can also adjust how precise you are in recording latitude and longitude. Here, we have used just the basic degrees without the more precise minutes and seconds.
   - Most mapping software like Bing Maps have a “My Location” feature which will give you your coordinates:

   ![My Location Feature](image)

   - On Earth, the latitude at the equator is 0 degrees and at the North Pole it is 90 degrees North. A degree of latitude covers about 70 miles or about 112 kilometers.

2. Choose a world landmark and look up the landmark’s real-world position, latitude and longitude.

3. Calculate the position of the landmark relative to your current location.

For example, if you were currently at the Space Needle in Seattle, Washington:

- Your world position would be 47 degrees North and 122 degrees West of the world origin point.
- You choose the Empire State Building as a landmark. The world coordinates of the Empire State Building are 40 degrees North and 73 degrees West of the world origin point.
- To calculate the position of the Empire State Building relative to your current position:
  - My Position (47, 122)
  - Empire State Building (40, 73)
  - Relative Position of Empire State Building to me (47-40=7, 122-73=49) or (~7, ~49)
7 degrees South of you and 49 degrees East of you. Remember that these relative position coordinates have a ‘~’ (tilde) before each of the numbers, whereas absolute world positions don’t have a tilde.

**Unplugged activity: Classroom Coordinates**

Practice the difference between relative coordinates and absolute coordinates in your own classroom. How general or detailed you choose to be with coordinates depends on the age and skills of your students.

**Materials needed:**
- Masking tape or Painter’s tape (optional)
- Index cards or labels
- Graph paper (optional)

**Set up:** Identify which direction or wall of your classroom represents each of the four cardinal directional points: North, South, East, and West and label them as such. If you can, place masking tape on the floor to represent the X and Z axes, creating a coordinate grid with the origin at the middle point of the room where these axes meet. This works especially well if you have a tiled floor. Remind the students that the Y-axis is the vertical Up/Down axis.

**Student Absolute World Positions:**
1. Imagine that your classroom is a Minecraft world of its own
2. Place at the origin point a sign indicating the classroom world position (0, 0, 0)
3. Stand on this origin point
4. Ask the students to write down on an index card or paper their classroom world position in the format (X, Y, Z). In other words, from the origin point, how would you need to travel along the X and Z axes to reach where they are? (If your floor is not tiled, use a step to represent one block.) For this exercise, have them leave the Y coordinate as zero (0).
5. Check a few students’ world positions by walking from the classroom world origin point to each student to make sure they are correct

Example: A student gives her or his classroom world coordinates as (4, 0, 2). If you walk 4 steps (or tiles) east and then 2 steps south from the classroom world origin point, you should end up where they are sitting.

**To discuss:**
- What determines an average step?
- What is the margin of error for short distances?
- What about large distances?
- Why isn’t this a problem in Minecraft itself?

**Object Absolute Positions:**
6. Pick an object in the room that has a permanent place
7. Ask the students to identify this object’s classroom world position and label it
8. If the object is off the floor, have the students give the Y coordinate as something other than zero. (You will want a consistent vertical measurement, say 1 foot = 1 block).

Repeat the previous steps with other objects that have a permanent place in the classroom – for example, the wall clock, the door to the classroom, or a window. Have the students label these objects with their respective world positions. When you feel the students have mastered the concept of absolute world position, move on to the next section.

**Student Relative Positions:**
1. Remind the students that when using a relative position, the origin (~0 ~0 ~0) is where they are
2. Point out an object in the classroom that was labeled with an absolute world position in the previous exercise
3. Ask students to write down on an index card or paper how far and in which of the cardinal direction(s) (N, S, E, W) they would need to travel from where they currently are in the classroom to reach the object. They should use the format (~X ~Y ~Z).

**Notes:**
- You may suggest that students ‘map’ out their classroom and location of themselves and objects on a piece of graph paper
- Check a few students’ relative positions by having them walk from where they are to the object, following what they wrote down as the object’s position relative to their current position.
- For example, a student might say that the object is (~2 ~0 ~5) relative to their current position. They would need to travel 2 tiles West and 5 tiles North to reach the object.

4. Have the students move to a different place in the room and then recalculate the object’s position relative to their new positions.
5. Repeat the previous step with other objects that have a permanent place in the classroom.
Point out the differences between an absolute classroom location and a relative position:

- The absolute position of an object with a permanent place does NOT change
- The position of an object relative to a student’s position changes as the student moves around the classroom

Additional Challenge: Relative position of moving objects
1. Have students work in pairs to calculate their partner’s position relative to their own position
2. Have both students then move around and re-calculate their positions relative to each other

**Activity: Create a Compass Rose**

Students will practice using coordinates in Minecraft to create a simple Compass Rose that points to the four cardinal directions within a Minecraft world. Students can then use this as the basis for creating more individualized and detailed compass roses.

1. Create a new MakeCode project called “Compass Rose”
2. Drag an On chat command block out of the Player Toolbox drawer, and change the command to “compassrose”

```
on chat command "compassrose"
```

3. Next, go to the Blocks Toolbox drawer, drag a Fill with block into the On chat command
4. Using the drop-down menu in the Fill with block, select a block with which to build your compass rose axis
5. Put the values (~10, ~0, ~0) in the from field and (~10, ~0, ~0) in the to field to print out a line of 20 blocks along the X axis.

```
fill with "compassrose"
```

In the Blocks Toolbox drawer, you will find the Print block. This block will print words with any block you choose along a given axis.
6. Drag out two of these Print blocks and drop them after the Fill with block in the On chat command.
7. Type a “W” in the first Print block, and a “E” in the second Print block to indicate West and East.
8. Using the drop-down menu in the Print block, select a block with which to print these letters.
9. In the first “W” Print block, enter the values (~-11, ~0, ~0).
10. In the second “E” Print block, enter the values (~11, ~0, ~0).

Repeat steps 3-10 above, but this time for the North-South axis of the compass rose:
11. From the Blocks Toolbox drawer, drag a Fill with block into the On chat command.
12. Using the drop-down menu in the Fill with block, select a block with which to build your compass rose axis.
13. Put the values (~0, ~0, ~-10) in the from field and (~0, ~0, ~10) in the to field to print out a line of 20 blocks along the Z axis.
14. Drag out two of the Print blocks and drop them after the Fill with block in the On chat command.
15. Type an “N” in the first Print block, and an “S” in the second Print block to indicate North and South.
16. Using the drop-down menu in the Print block, select a block with which to print these letters.
17. In the first “N” Print block, enter the values (~0, ~0, ~-11).
18. In the second “S” Print block, enter the values (~0, ~0, ~11).

Your complete program should look like this:
on chat command "compassrose"

fill with
from ~-10 ~0 ~0

to ~10 ~0 ~0

replace

print "W"
of

at ~-11 ~0 ~0

along West (negative X)

print "E"
of

at ~11 ~0 ~0

along West (negative X)

fill with
from ~0 ~0 ~-10

to ~0 ~0 ~10

replace

print "N"
of

at ~0 ~0 ~-11

along West (negative X)

print "S"
of

at ~0 ~0 ~11

along West (negative X)
```javascript
player.onChat("compassrose", function () {
    blocks.fill(
        blocks.block(Block.GrayWool),
        positions.create(-10, 0, 0),
        positions.create(10, 0, 0),
        FillOperation.Replace
    )
    blocks.print(
        "W",
        blocks.block(Block.LimeWool),
        positions.create(-11, 0, 0),
        CompassDirection.West
    )
    blocks.print(
        "E",
        blocks.block(Block.YellowWool),
        positions.create(11, 0, 0),
        CompassDirection.West
    )
    blocks.fill(
        blocks.block(Block.GrayWool),
        positions.create(0, 0, -10),
        positions.create(0, 0, 10),
        FillOperation.Replace
    )
    blocks.print(
        "N",
        blocks.block(Block.BlueWool),
        positions.create(0, 0, -11),
        CompassDirection.West
    )
    blocks.print(
        "S",
        blocks.block(Block.RedWool),
```
Go into a Flat World in Minecraft and type ‘compassrose’ in the chat command line. For best results, stand still while the letters are being drawn – remember, the positions are being calculated relative to you as the player, so if you move around, the letters will show up in different places!

Additional Mods/Challenges to the Compass Rose project:

- Add an Up and Down Y axis and labels
- Make your compass rose up in the sky, so you can look up and see it as you walk along
- Extend the axis of your compass rose to more than 20 blocks long
- Instead of using Fill and Print blocks, program your Agent to make the compass rose for you
- Use the Builder blocks to create your compass Rose
Other reference examples:
- Compass Example – [https://minecraft.makecode.com/examples/compass](https://minecraft.makecode.com/examples/compass)

**Activity: Minecraft Moving Company**

If you've ever built the perfect house in Minecraft but wished you had done it in a different location, now you can! You can use coordinates and some of the block operations in the Blocks Toolbox drawer to copy and paste entire portions of the Minecraft landscape. You can copy hillsides, lakes, and even entire buildings! Let’s create a way to specify an area of the world, then copy it somewhere else.

In this project, we will use three different **On chat commands:**
- “start”: This will set one corner of the area to be copied
- “stop”: This will set the opposite corner of the area to be copied
- “copy”: This creates an exact copy of everything between the start and stop points, at your current position

1. Create a new MakeCode project called “Move Me” or something similar
2. Next, drag three **On chat command** blocks into the coding Workspace
3. Change the name of these **On chat command** blocks to “start”, “stop”, and “copy”
Let’s create some variables that we’ll use to store the starting and stopping positions. We’ll talk more about variables in a subsequent chapter but for now just note that a single variable can represent the three separate coordinates that describe an absolute world position.

4. Open the Variables Toolbox drawer and click the Make a Variable button

5. Name the variable start, and click Ok

6. Click the Make a Variable button again

7. And name the second variable stop, and click Ok

Now, let’s set the value of these variables based on the Player’s current world position.

8. From the Variables Toolbox drawer, drag a Set variable block into the On chat command “start” block
9. Using the drop-down menu in the Set variable block, select the start variable

10. From the Player Toolbox drawer, drag a Player world position block into the Set start block, replacing the 0

![Set start block](image)

Let’s print out a status message that reports back the coordinates that were saved as the starting position.

11. From the Player Toolbox drawer, drag a Say block after the Set start block.

![Set start block](image)

12. Click on the Advanced tab in the Toolbox to expand the Toolbox categories

![Toolbox categories](image)

13. From the Text Toolbox drawer, drag a Join block into the Say block replacing “Hi!”

14. In the first slot of the Join block, type in “Starting Point Set: “

15. From the Variables Toolbox drawer, drag the Start variable block into the second slot of the Join block

![Join block](image)

We will follow the same steps 8-15, but for the stopping position. Hint, you can right-click on any block and select Duplicate to copy blocks. This is a good strategy to save some time when creating large blocks of similar code! Here are the steps again:

16. From the Variables Toolbox drawer, drag a Set variable block into the On chat command “stop” block
17. Using the drop-down menu in the Set variable block, select the stop variable
18. From the Player Toolbox drawer, drag a Player world position block into the Set stop block, replacing the 0
19. From the Player Toolbox drawer, drag a Say block after the Set stop block.
20. From the Text Toolbox drawer, drag a Join block into the Say block replacing “Hi!”
21. In the first slot of the Join block, type in “Stopping Point Set: ”
22. From the Variables Toolbox drawer, drag the Stop variable block into the second slot of the Join block

Now that we’ve set the starting and stopping points, let’s create the ability to copy the area in between these points.

23. From the Blocks Toolbox drawer, drag the first Clone block (the one with the mask property) into the On chat command “copy” block. This block clones, or copies, the area from the first set of coordinates to the second set of coordinates. And copies it into the third set of coordinates.

24. From the Variables Toolbox drawer, drag the Start variable block into the first set of from coordinates in the Clone block
25. From the Variables Toolbox drawer, drag the Stop variable block into the second set of to coordinates in the Clone block
Now, let’s test out our code.

26. Enter into a Minecraft world where you have a house or some other structure you want to copy
27. Move your Player to the bottom left corner of the structure, and in the chat window type the command “start”
28. Move your Player to the top right corner of the structure, and in the chat window type the command “stop”
29. Then move your Player to an open space in the world where you want to copy the structure, and in the chat window type the command “copy”

Did it copy your house or structure correctly?

Notes:
• The orientation of whatever you copy will always be the same. For example, if a building faces east, it is always going to face east.
• In the Clone block, for the mode property, if you choose move instead of normal, this will perform a cut and paste rather than a copy and paste. It will delete what was in between the old coordinates and paste a copy at the new coordinates.

Here is the complete code:
JavaScript:

```javascript
let stop: Position = null
let start: Position = null
player.onChat("start", function () {
    start = player.position()
    player.say("Starting Point Set: " + start)
})
player.onChat("copy", function () {
    blocks.clone(
        start,
        stop,
        positions.create(0, 0, 0),
        CloneMask.Replace,
        CloneMode.Normal
    )
})
player.onChat("stop", function () {
    stop = player.position()
    player.say("Stopping Point Set: " + stop)
})
```

Shared Program:  [https://makecode.com/_dHhhCoW85JAJ](https://makecode.com/_dHhhCoW85JAJ)
Copying the wagon from the Oregon Trail World –

Set the starting point at the bottom left

Set the stopping point at the top right
Independent Project

For your independent project, create one or more commands that alter the landscape in some way. Here are some ideas:

- Create an “instant swimming pool” filled with water
- Create a way to instantly tunnel through a mountain or portions of the nether
- Create a way to literally “move mountains”
- Improve the Minecraft Moving Company activity so that you can enter in a height for the upper coordinate rather than having to actually stand there yourself
- Experiment with the Mask and Mode menus on the Clone block

Your project should do the following:
- Use coordinates in some way
- Alter the landscape using code
- Be creative and original

Example:
This project allows you to create a section of paved road with streetlights
And then duplicate this section numerous times to create a new street of any length
Compose a diary entry addressing the following:

- How did you come up with this idea?
- What did you decide to alter in the landscape?
- What does your program do?
- Describe how your program alters the landscape
- Include at least one screenshot of the result of your program
- Share your project include the URL here

NOTE: If you decided to improve one of this lesson’s activities, please talk about the new code you wrote in addition to what was already provided in the lesson.

Assessment

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
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<tbody>
<tr>
<td><strong>Diary</strong></td>
<td>Minecraft Diary entry is missing 4 or more of the required prompts.</td>
<td>Minecraft Diary entry is missing 2 or 3 of the required prompts.</td>
<td>Minecraft Diary entry is missing 1 of the required prompts.</td>
</tr>
</tbody>
</table>
| **Project**              | Project lacks all of the required elements:  
  - Uses coordinates  
  - Alters landscape  
  - Creative/original | Project lacks 2 out of the 3 of the required elements:  
  - Uses coordinates  
  - Alters landscape  
  - Creative/original | Project lacks 1 out of the 3 the required elements:  
  - Uses coordinates  
  - Alters landscape  
  - Creative/original | Project alters the landscape in a creative and original way, efficiently and effectively using coordinates. |

CSTA Standards

- 3A-IC-26 Demonstrate ways a given algorithm applies to problems across disciplines
- 2-AP-13 Decompose problems and subproblems into parts to facilitate the design, implementation, and review of programs.
- 3B-AP-14 Construct solutions to problems using student-created components, such as procedures, modules and/or objects.
- CT.L2-12 Use abstraction to decompose a problem into sub problems
- CPP.L1:6-05 Construct a program as a set of step-by-step instructions to be acted out
- CPP.L1:6-06 Implement problem solutions using a block-based visual programming language