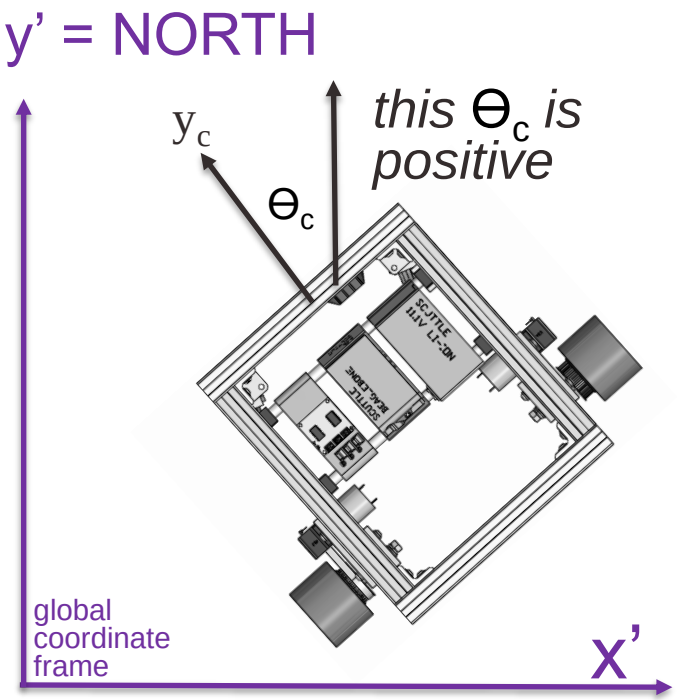
Absolute Orientation and Magnetometer rev1.1

revised 2019.09.23

Absolute Orientation

- SCUTTLE has a compass for orientation
  - The compass is nothing but a 3-axis magnetometer
  - Encoders can provide *relative* orientation
  - Compass is required for *global* orientation
- The compass is embedded in the IMU (MPU-9250)
  - It has 3 sensors oriented in the indicated directions
  - L1_mpu.py accesses the magnetometer
  - Each magnetometer requires calibration

Θ_c *is the angle between the north and the robot heading angle*

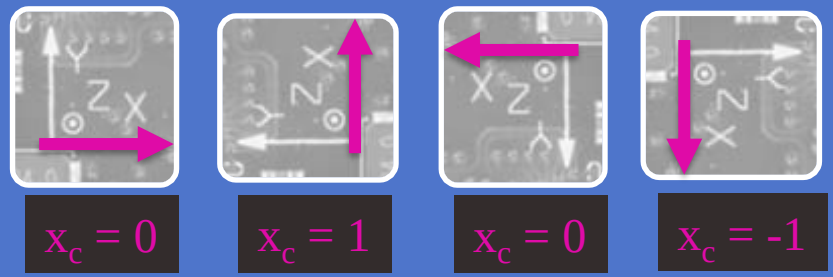


Magnetometer Behavior

- An axis is at its MAXIMUM when it is **aligned** NORTH
- The axis is at its MINIMUM when it is **opposing** NORTH
- After calibration, we can achieve the behavior below

Values Desired by Direction

Using x_c axis for example:



$x_c = 0$ | $x_c = 1$ | $x_c = 0$ | $x_c = -1$

(magnetic north)

1) Discover the maximum and minimum values by rotating sensor in a full circle.

Permanent magnets influence the sensor, so calibration must be done on the robot, in position near the motors.

Before Calibration	Min (microtesla)	max (microtesla)
x_c	-15	38
y_c	-22	20

2) Using the following equation, re-scale each axis

$$x_{c\,\text{scaled}} = \frac{2(x_c - x_{min})}{(x_{max} - x_{min})} - (1)$$

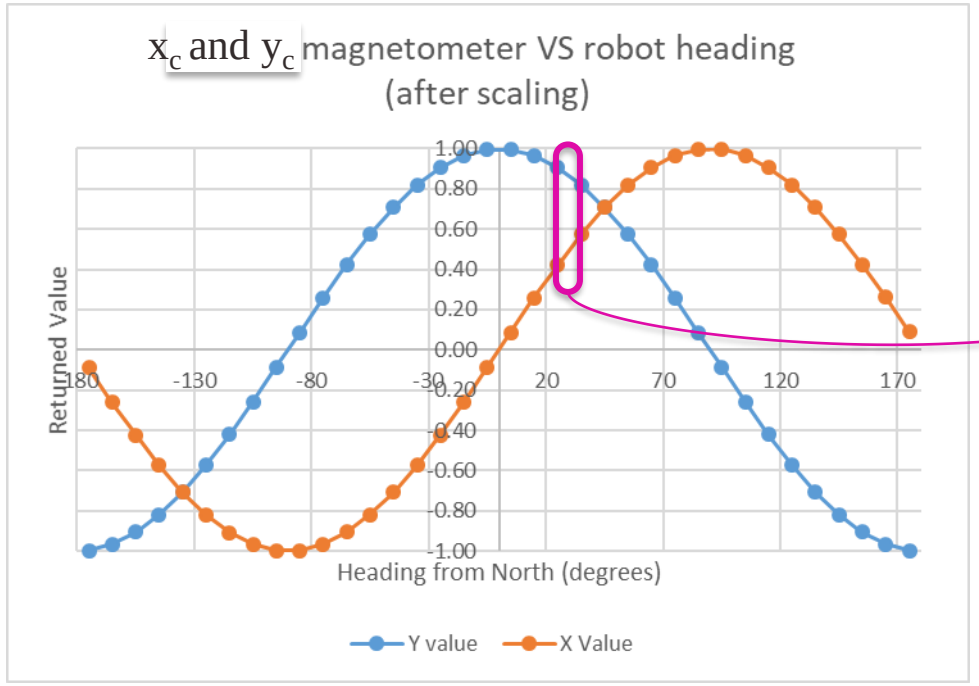
AfterCalibration	Min (ratio to max)	max (ratio to max)
x_c	-1	1
y_c	-1	1

Determining Absolute Orientation

- X_c and Y_c (scaled) axes are sufficient information to give heading.
  - Z_c axis returns zero if scuttle sits flat
- Θ_c is defined as rotation of SCUTTLE from the global coordinate frame, or y-prime
  - positive Θ_c means SCUTTLE is turned left from north
  - We can define NORTH as the y'-axis of the global coordinate frame

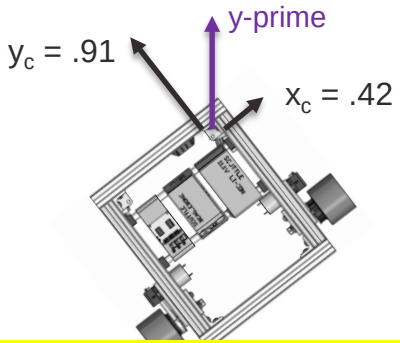
Θ_c is positive when scuttle points west
Θ_c is negative when scuttle points east

Use arctan2(x_c, y_c) to return a heading
arctan2 is the "element-wise arc tangent of x/y choosing the quadrant correctly."



Example:

ATAN2(0.42, 0.91) returns 25 degrees



y_c is pointed strongly north
X_c is pointed slightly north
both axes return positive values

Important Note: All x_c and y_c referred on this page are scaled values after Compass Calibration.