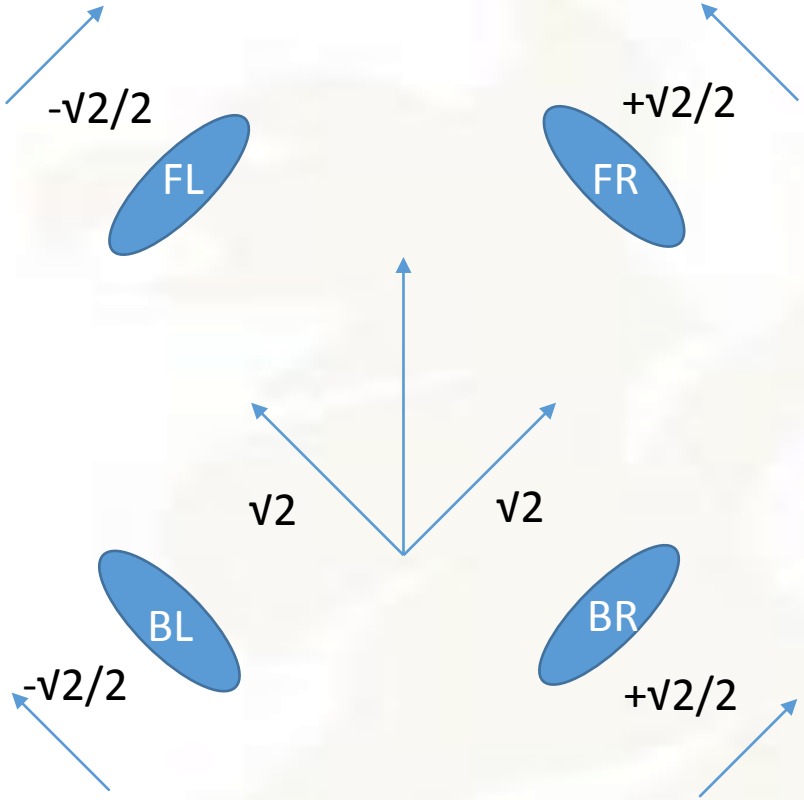
Force Analysis Of Holonomic Wheels

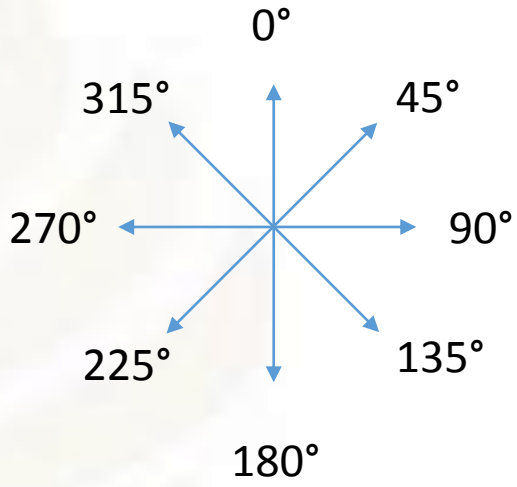
Nex+Gen Griffin Robotics FTC Team 7582

Cameron Pase

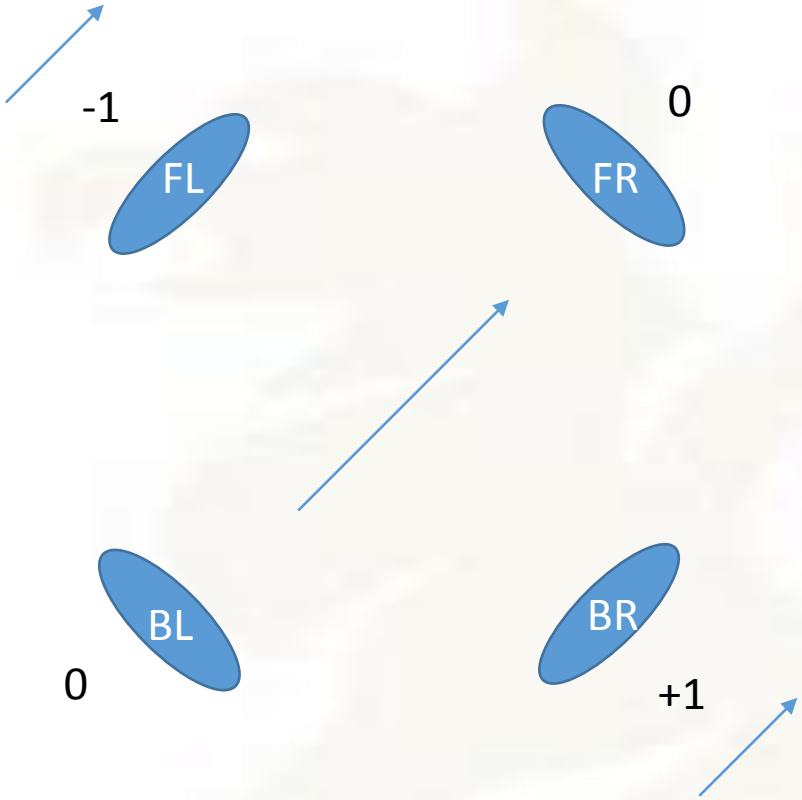
Douglas Pase, dmpase@gmail.com

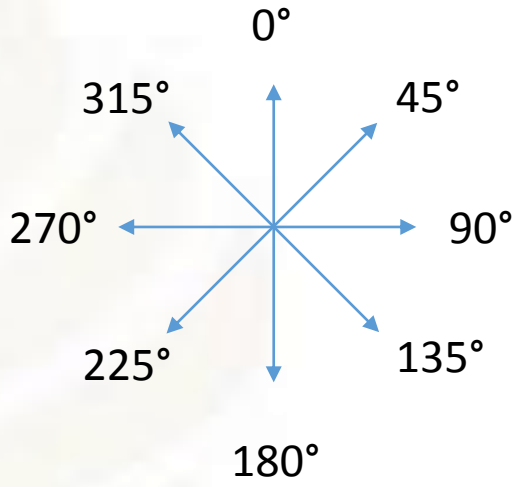
Bearing 0°
velocity 2
FL: -√2/2
FR: +√2/2
BR: +√2/2
BL: -√2/2



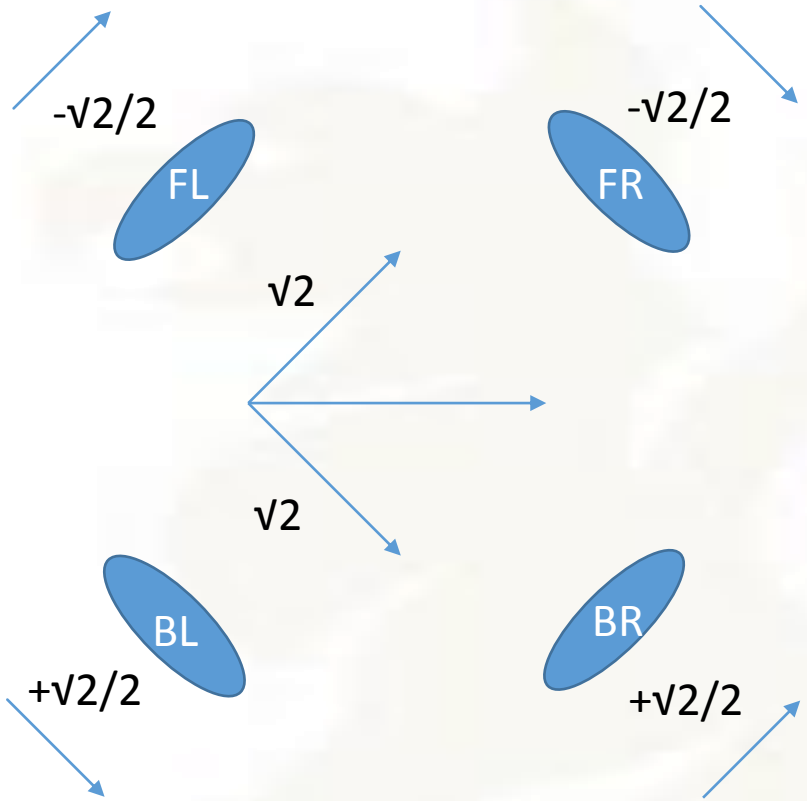


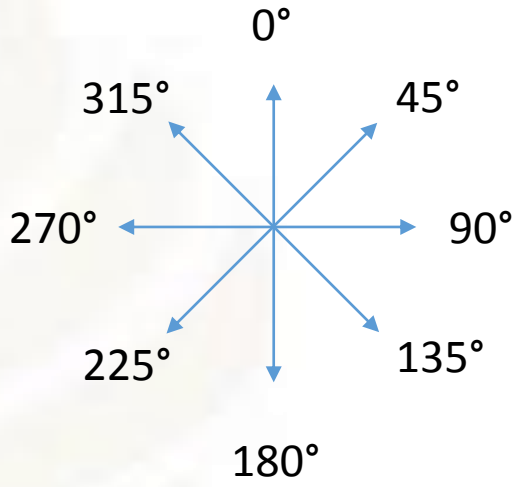
Bearing 45°
velocity 2
FL: -1
FR: 0
BR: +1
BL: 0



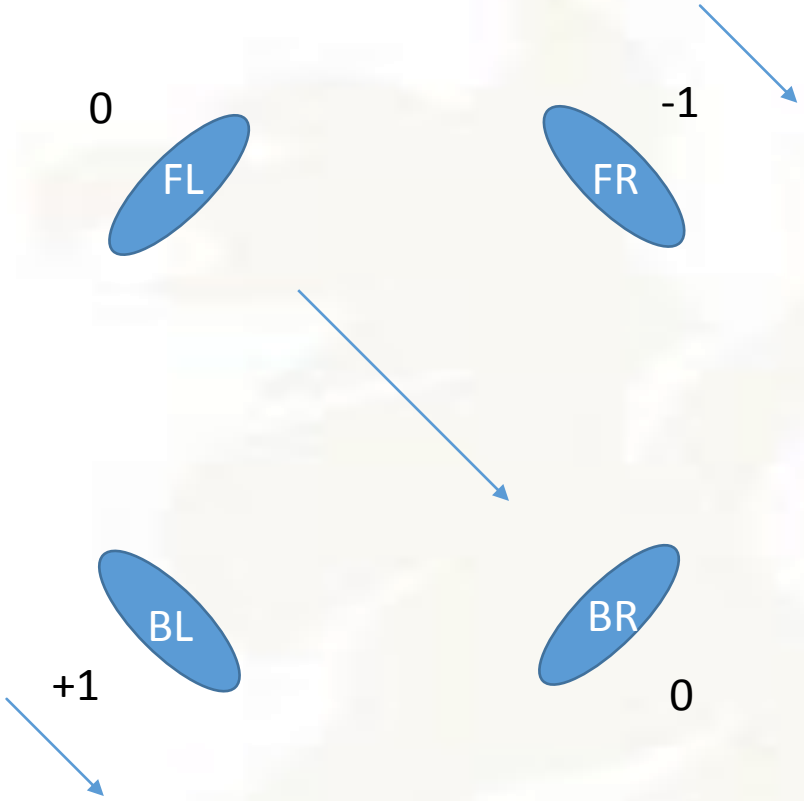


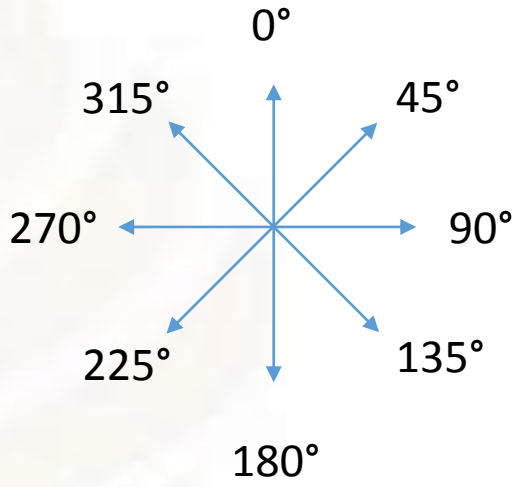
Bearing 90°
velocity 2
FL: -√2/2
FR: -√2/2
BR: +√2/2
BL: +√2/2



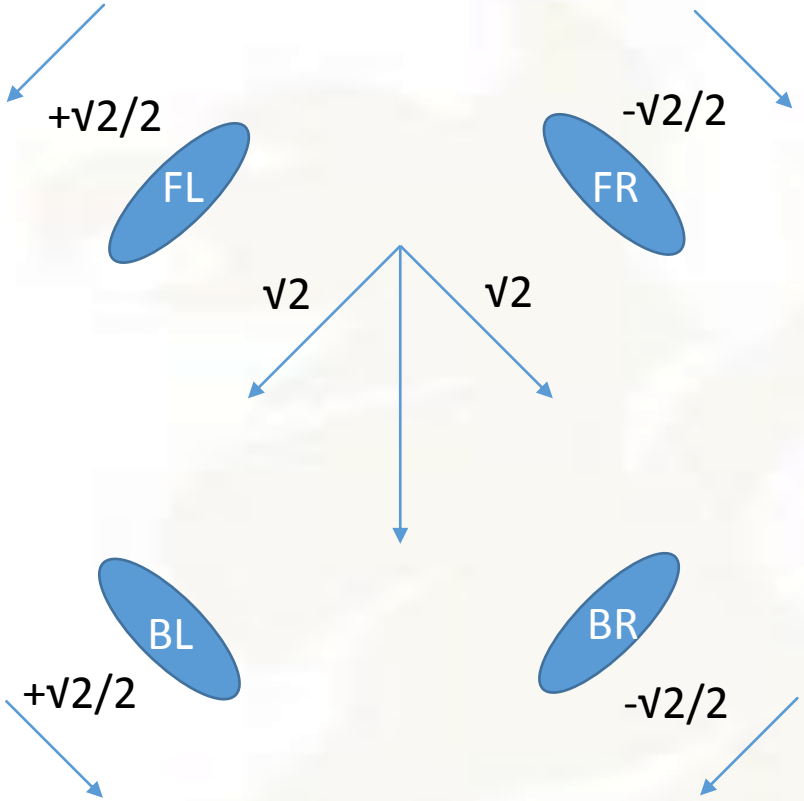


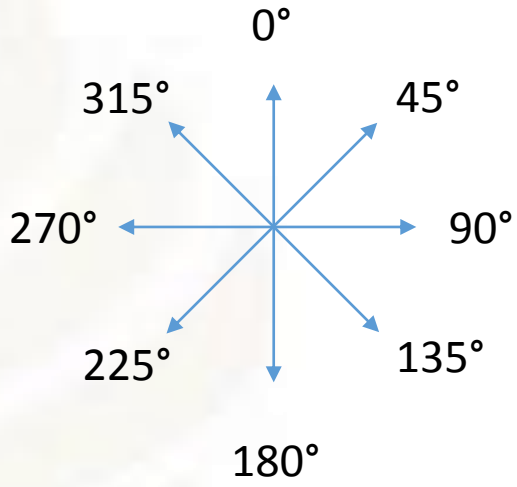
Bearing 135°
velocity 2
FL: 0
FR: -1
BR: 0
BL: +1



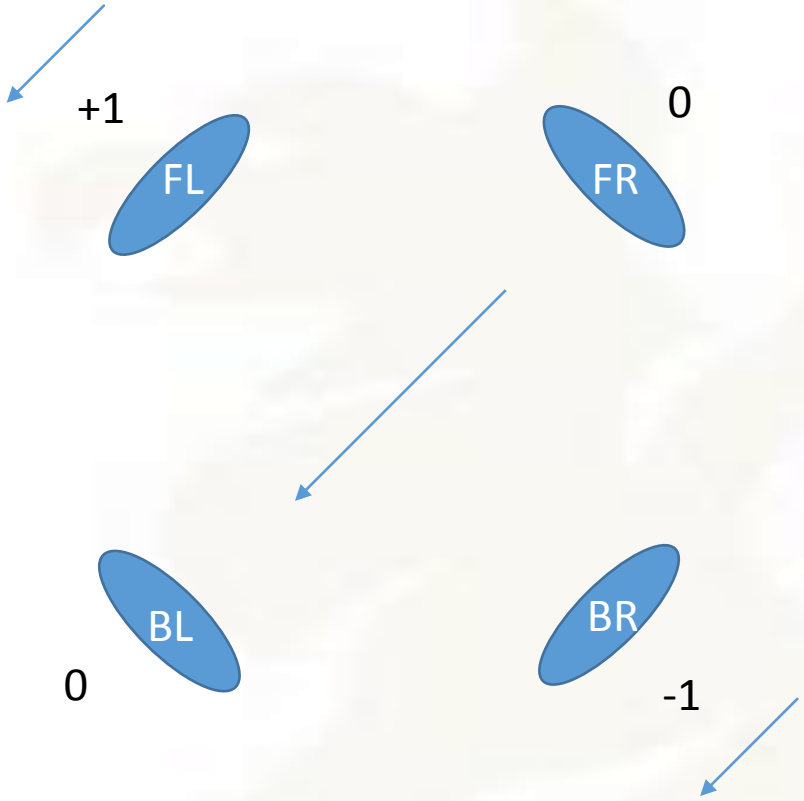


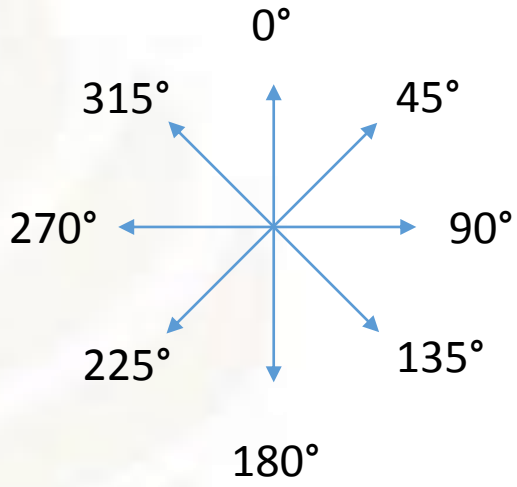
Bearing 180°
velocity 2
FL: +√2/2
FR: -√2/2
BR: -√2/2
BL: +√2/2



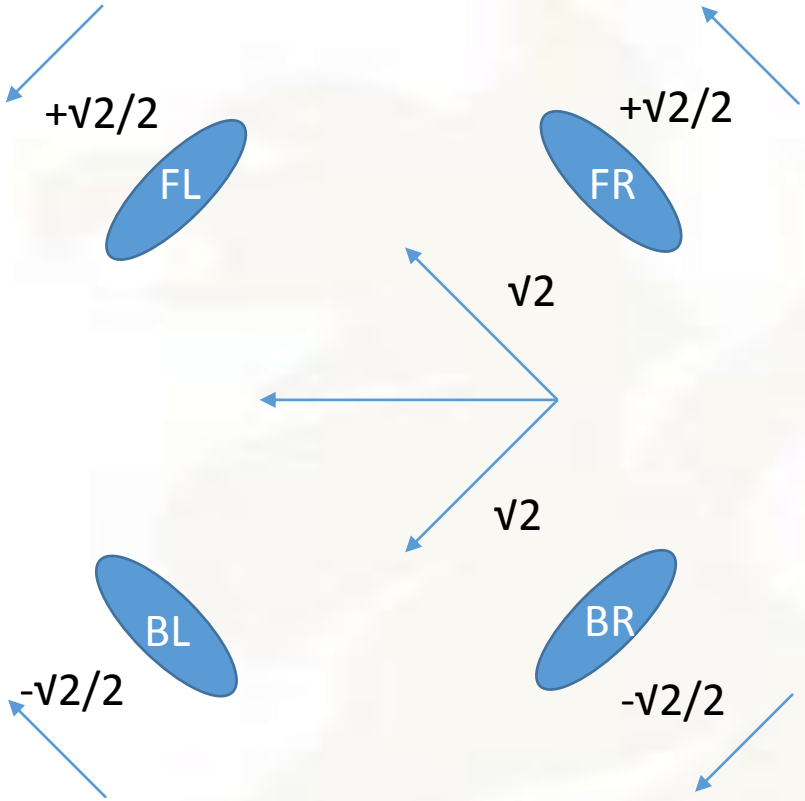


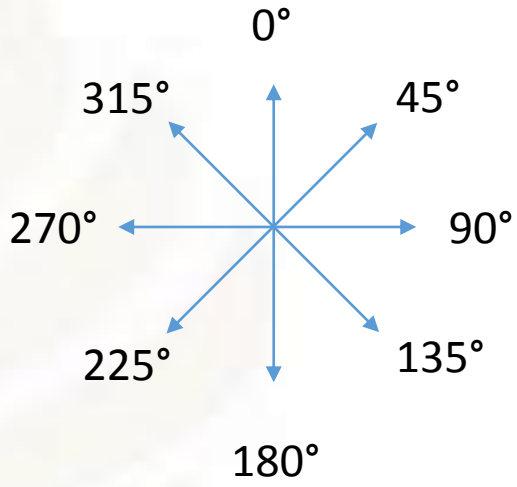
Bearing 225°
velocity 2
FL: +1
FR: 0
BR: -1
BL: 0



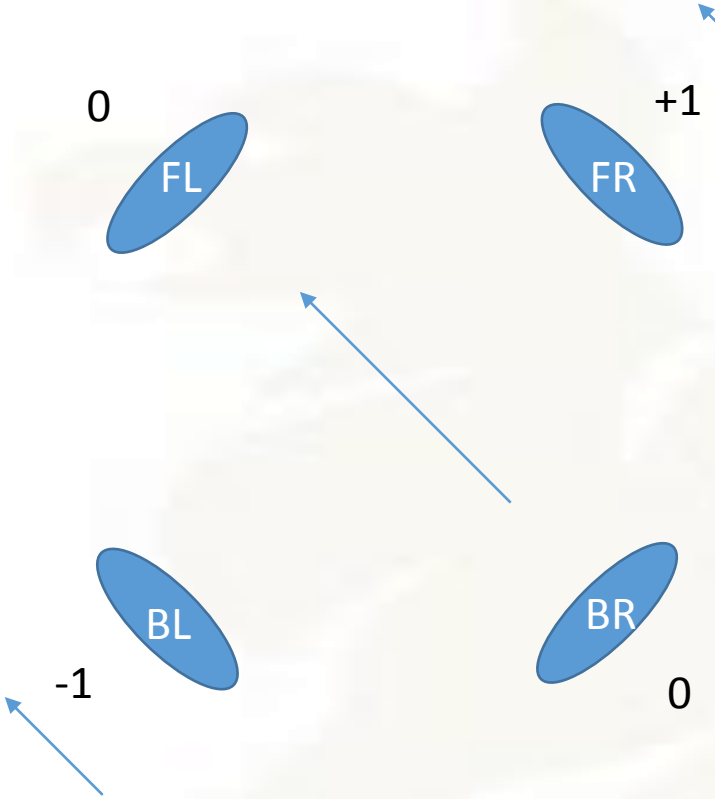


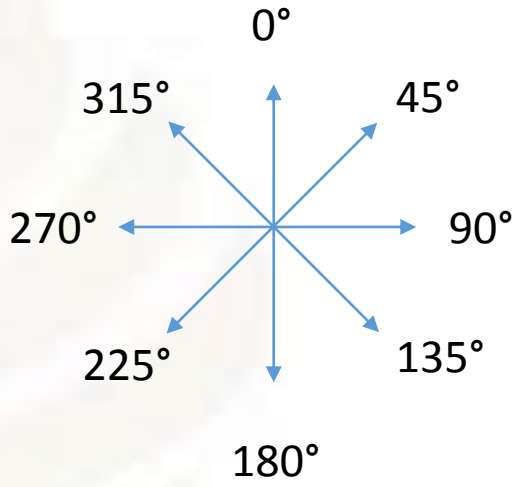
Bearing 270°
velocity 2
FL: +√2/2
FR: +√2/2
BR: -√2/2
BL: -√2/2





Bearing 315°
velocity 2
FL: 0
FR: +1
BR: 0
BL: -1



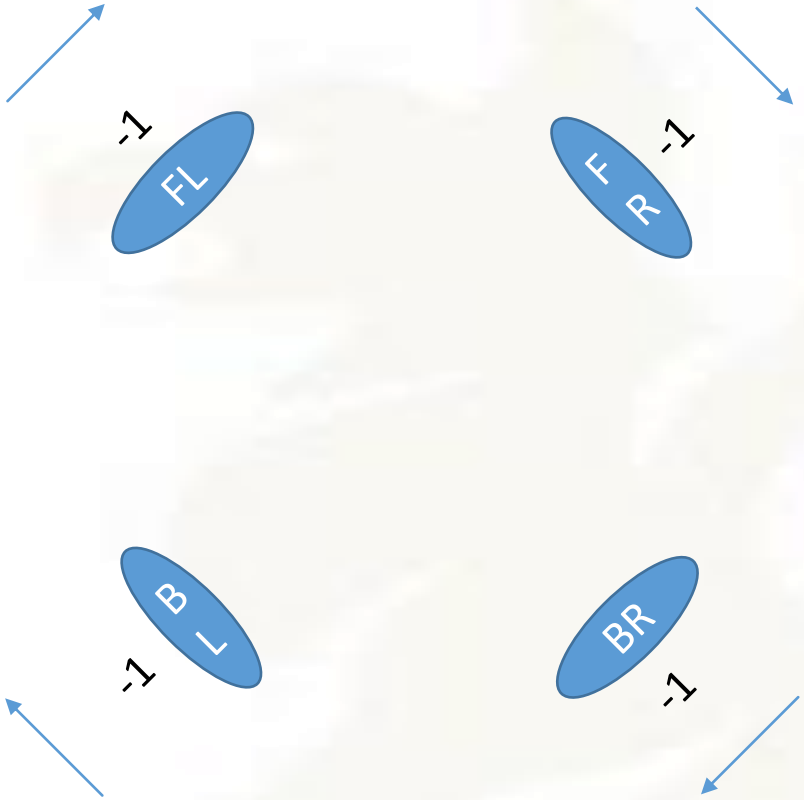


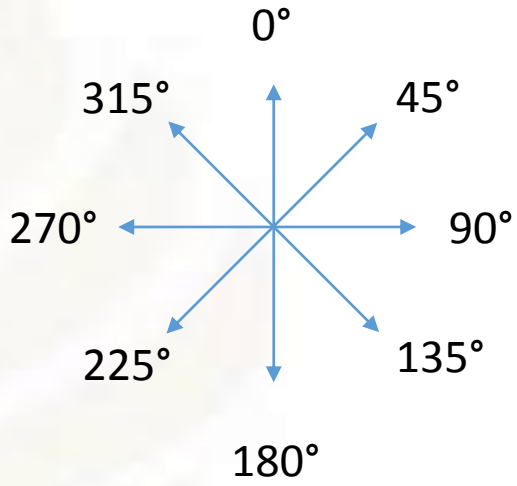
Computing Motor Power From A Bearing

Bearing	0°	45°	90°	135°	180°	225°	270°	315°	Power
Front Left	-√2/2	-1	-√2/2	0	+√2/2	+1	+√2/2	0	-sin(b+45°)
Front Right	+√2/2	0	-√2/2	-1	-√2/2	0	+√2/2	+1	cos(b+45°)
Back Right	+√2/2	+1	+√2/2	0	-√2/2	-1	-√2/2	0	sin(b+45°)
Back Left	-√2/2	0	+√2/2	+1	+√2/2	0	-√2/2	-1	-cos(b+45°)
sin(b+45°)	+√2/2	+1	+√2/2	0	-√2/2	-1	-√2/2	0	
cos(b+45°)	+√2/2	0	-√2/2	-1	-√2/2	0	+√2/2	+1	

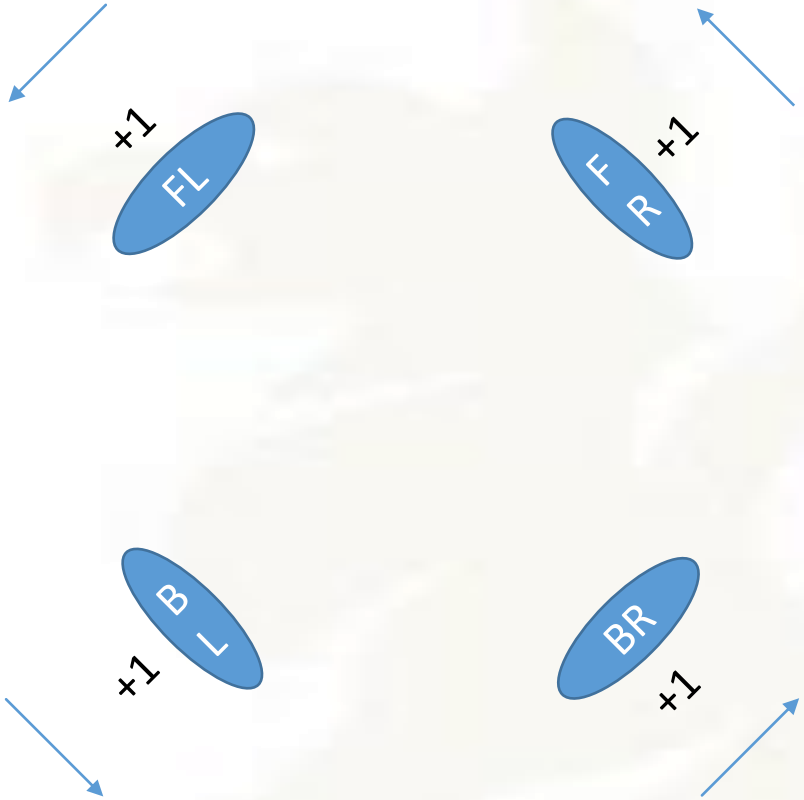
Rotation

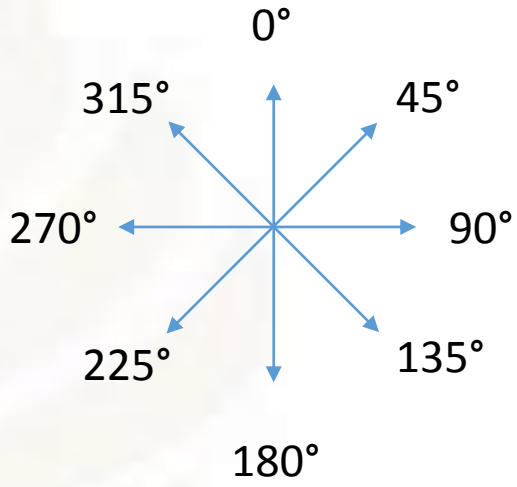
Rotate Right
velocity 2
FL: -1
FR: -1
BR: -1
BL: -1





Rotate Left
velocity 2
FL: +1
FR: +1
BR: +1
BL: +1





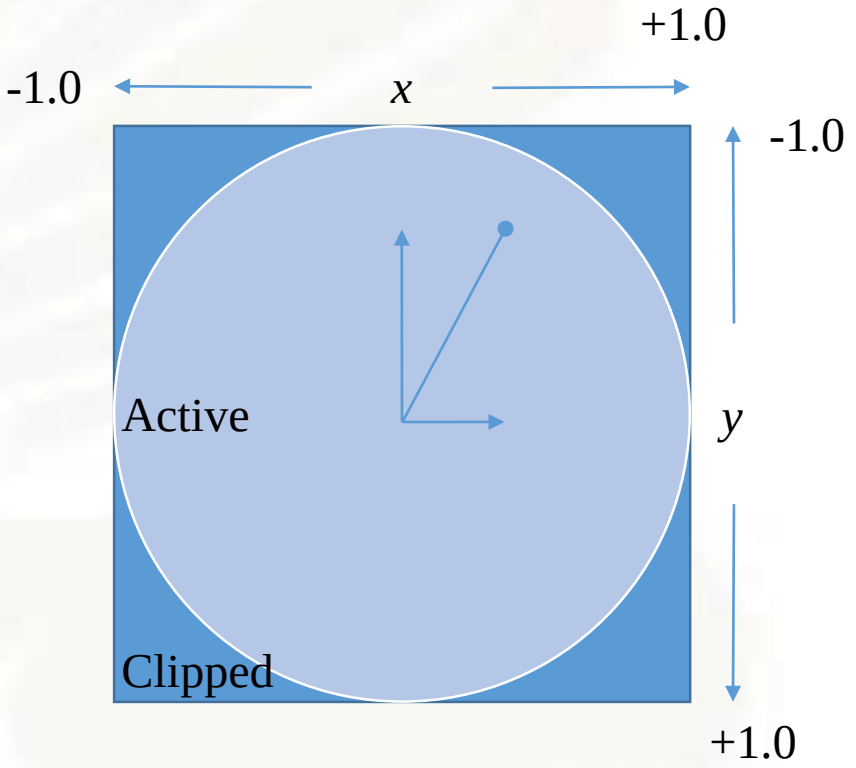
Joystick Calculations

The Gamepad Joysticks

- Each gamepad has two joysticks, *left* and *right*
- Joysticks have two axes, x and y
- Each axis is given a name that reflects the gamepad, joystick and axis
  - double gamepad1.left_stick_x
  - double gamepad1.left_stick_y
  - double gamepad2.right_stick_x
  - …
- We can read each axis value individually using that name

Joystick Conventions

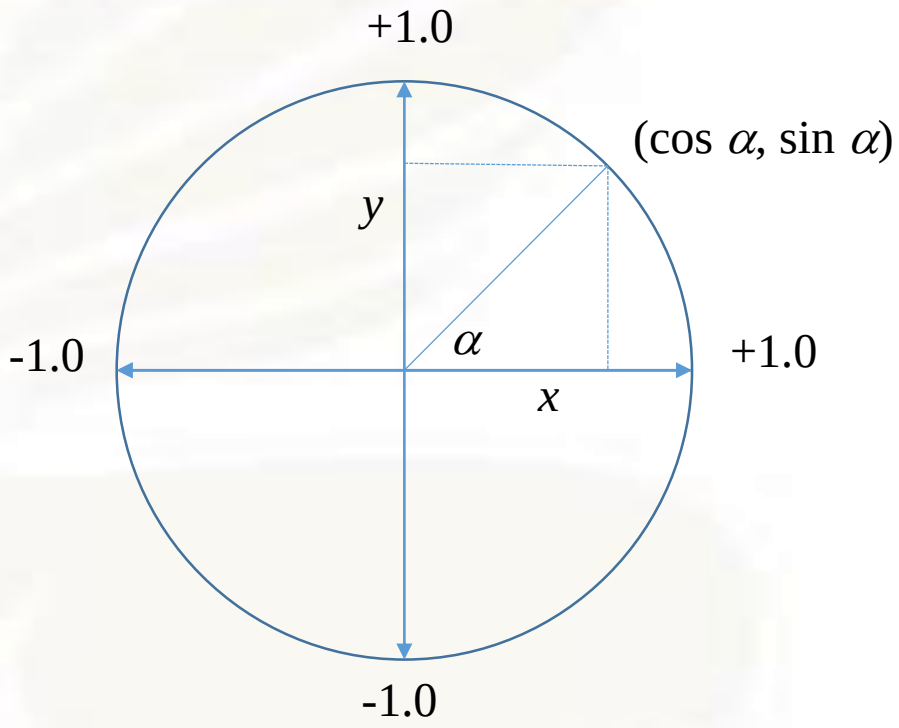
- Joysticks follow the conventions of computer graphics displays
- The *x* axis increases from left to right, like in mathematics
- But the *y* axis is upside down, it increases from top to bottom, which is the opposite of math
- The joystick *x* and *y* have a range of -1.0 to +1.0
- We can use the values of *x* and *y* to compute the direction the driver is telling the robot to go



Trigonometry Review

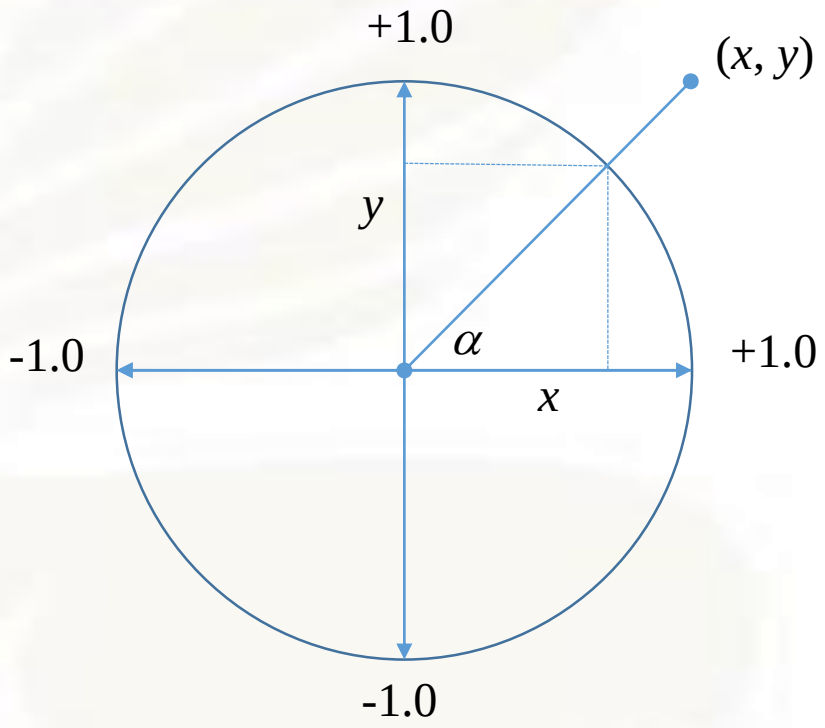
- Start with a unit circle (radius=1)
- For some angle α …
- $x = \cos \alpha$
- $y = \sin \alpha$
- $\tan \alpha = \frac{\sin \alpha}{\cos \alpha}$
- Pythagorean theorem says,

$$x^2 + y^2 = (\cos \alpha)^2 + (\sin \alpha)^2 = 1$$

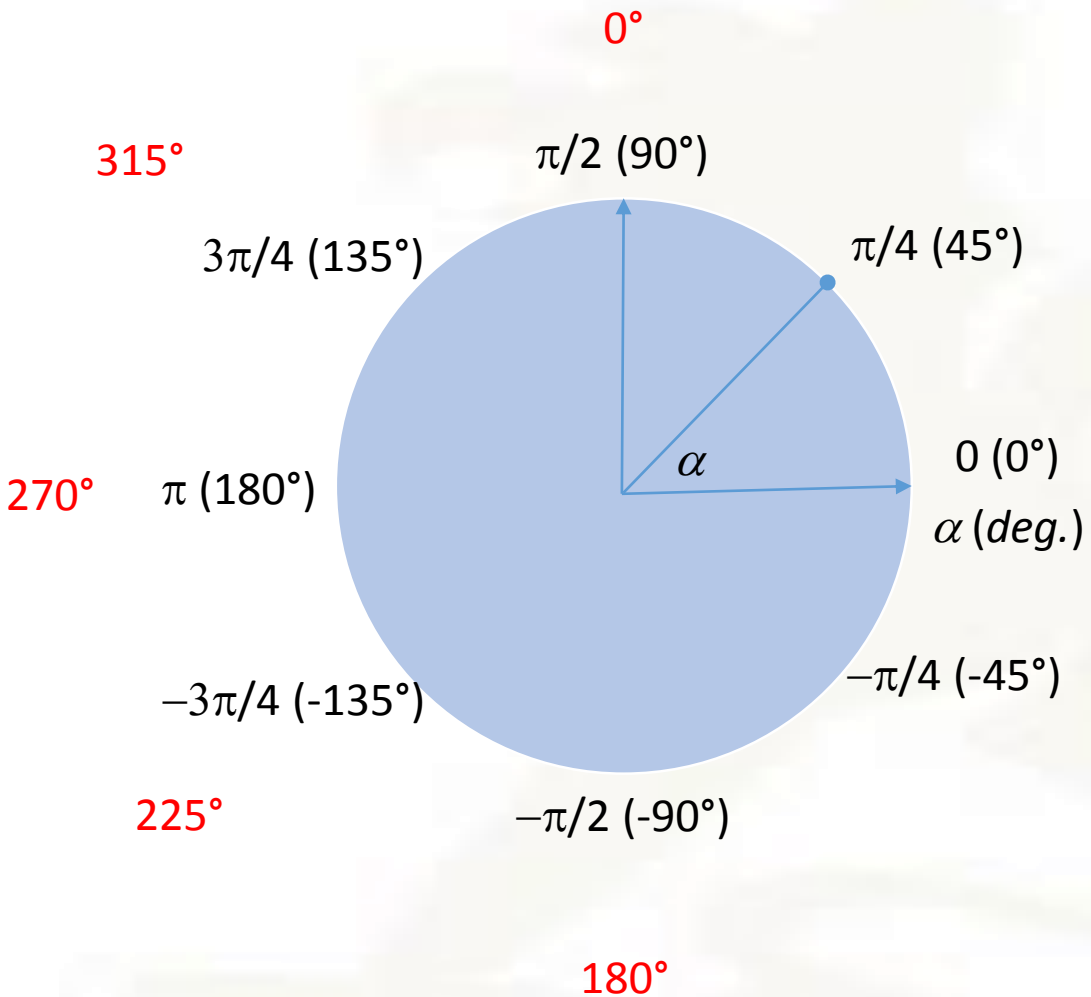


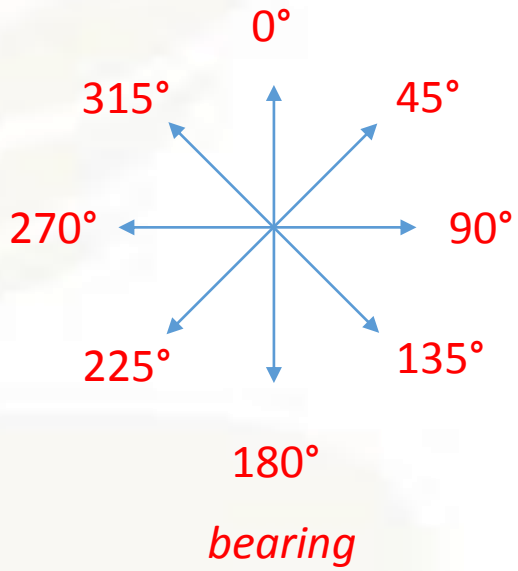
The Math.atan2(y, x) function

- If you know a point (x, y) on the line, you can find the angle α to the x-axis
- α = Math.atan2(y, x)
- Notice α is the angle from the x-axis to the line, in radians
- We can use this to find the direction the joystick is pointing, but we have to convert α to a bearing, in degrees



Comparing α to a Bearing





Comparing α to a Bearing

α

- α is in radians
- α is an angle from the x-axis
- α increases in a counterclockwise direction

Bearing

- bearing is in degrees
- bearing is an angle from the y-axis
- bearing increases in a clockwise direction

Converting Between α and a Bearing

x = gamepad1.left_stick_x

y = - gamepad1.left_stick_y

α= Math.atan2(y, x)

- To get the bearing in degrees

bearing = 90° – 180° * α / π

- Math.sin() and Math.cos() need the bearing in radians

radians = π * bearing / 180°

The Final Step

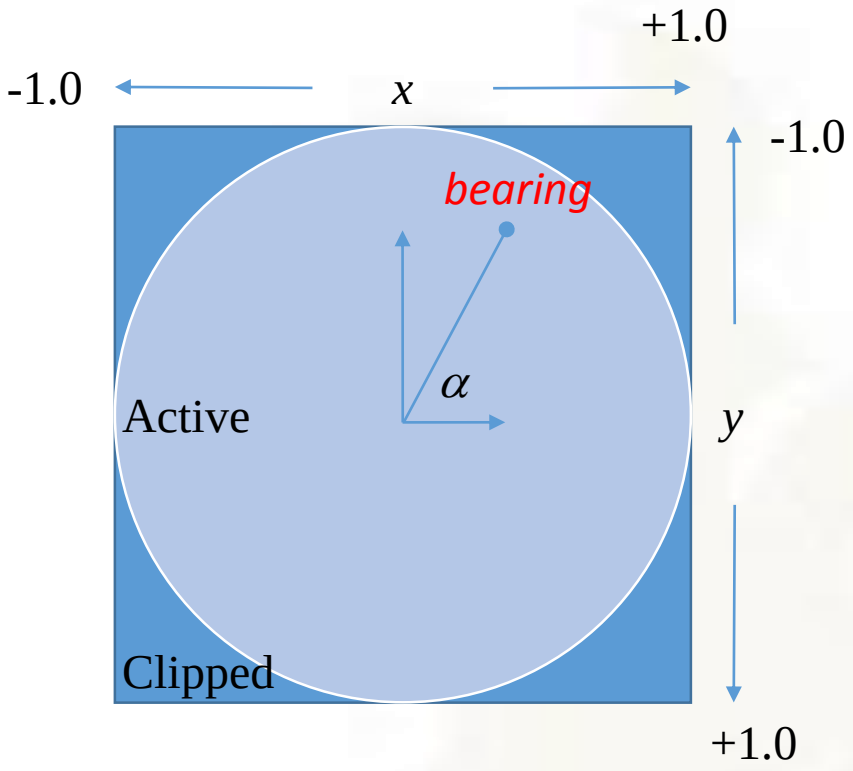
- Motor output should be proportional to how far the joystick is moved
  - All the way forward means as fast as possible
  - A little push means a little speed
- The length (distance from the center to the joystick position) can be calculated from x and y using the Pythagorean Theorem

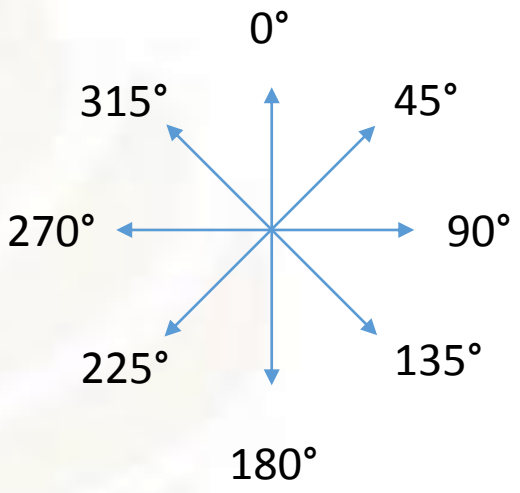
  length = $\sqrt{x^2 + y^2}$ = Math.sqrt(x*x+y*y)
- The length should never be greater than +1.0 or the motors will throw an exception

  length = Math.min(length, 1.0)

315° 0° 45°

3π/4 (135°) π/2 (90°) π/4 (45°)





270° π (180°) 0 (0°) 90°

α (deg.) bearing

x = gamepad1.left_stick_x

y = -gamepad1.left_stick_y

$\alpha = \text{Math.atan2}(y, x)$

$bearing = 90° - \alpha * 180°/\pi$

$length = \sqrt{(x^2+y^2)}$

$speed = min(\ length, 1.0\ )$

−3π/4 (-135°) −π/2 (-90°) −π/4 (-45°)

225° 180° 135°

Questions?