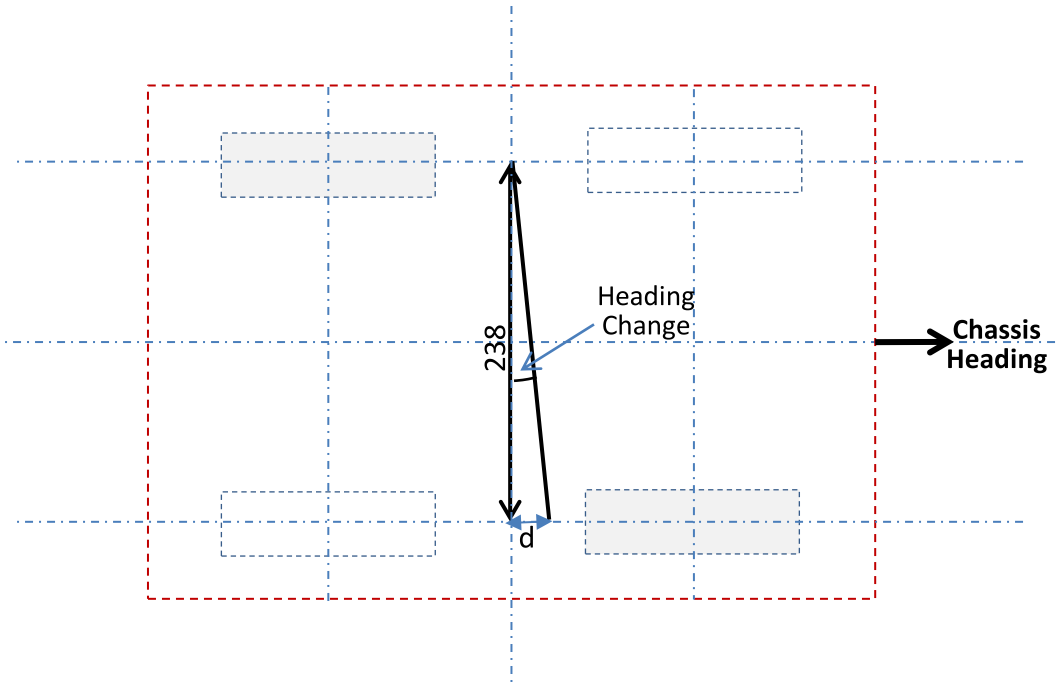
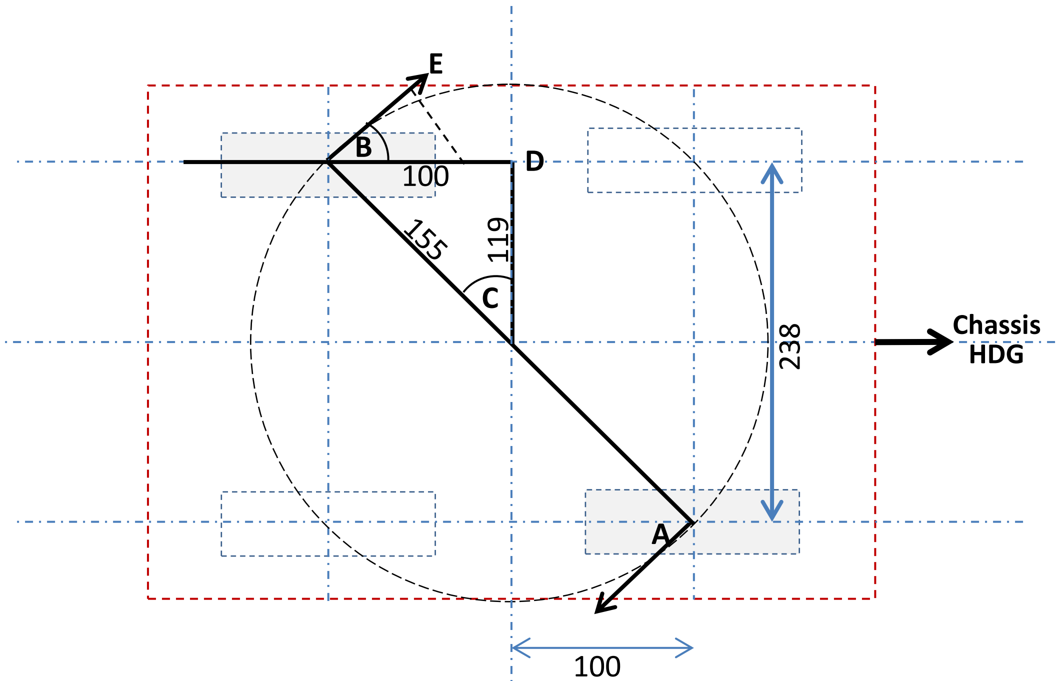
Odometer Derived Heading : Case A: Heading in Straight Line



The wheel track across chasses is 238mm (measured).
The Odometers measure the distance travelled by each motor drive wheel in a straight line.
If the two motors do not provide exactly the same rotational force (torque) then one wheel will travel further than the other (by distance d) and the Chariot chassis heading will change.
d = difference in distance travelled by each drive wheel (odometer readings).
For small angles, the heading change in radians = difference in distance /wheel track
There are pi radians in 180 degrees
Therefore Heading change in degrees = difference in distance/wheel track * 180/pi
= Difference in distance *0.24 deg

Odometer Derived Heading : Case B: Turn on the Spot



C is the centre of the Chassis. and B is centre of one wheel
The wheel track across chasses is 238mm (measured). The longitudinal distance between wheels = 200mm (measured). Therefore using Pythagoras, the diagonal wheel track is $\sqrt{(200^2 + 238^2)}$ = 310mm
The drive wheels are turning at the same speed, but in opposite directions. The in-line component of force (B-D) is balanced by the opposite in-line component of force from the other drive wheel, so the wheels have to drive and skid outwards (B-E) at a tangent to the turning circle.

The Odometer reads the distance travelled by the tyre in the direction (B-D) and we calculate the **Turning Component** of this distance in the direction (B-E) (Round the circumference of the turning circle)
Angle B = Angle C = Cos^{-1} (119/155) = 40deg. (note Cos^{-1} is called ArcCos in Python Math)
Therefore **Turning Component** (B-E) = Odometer DistanceB * Cos B = **Odometer Distance * 0.77**

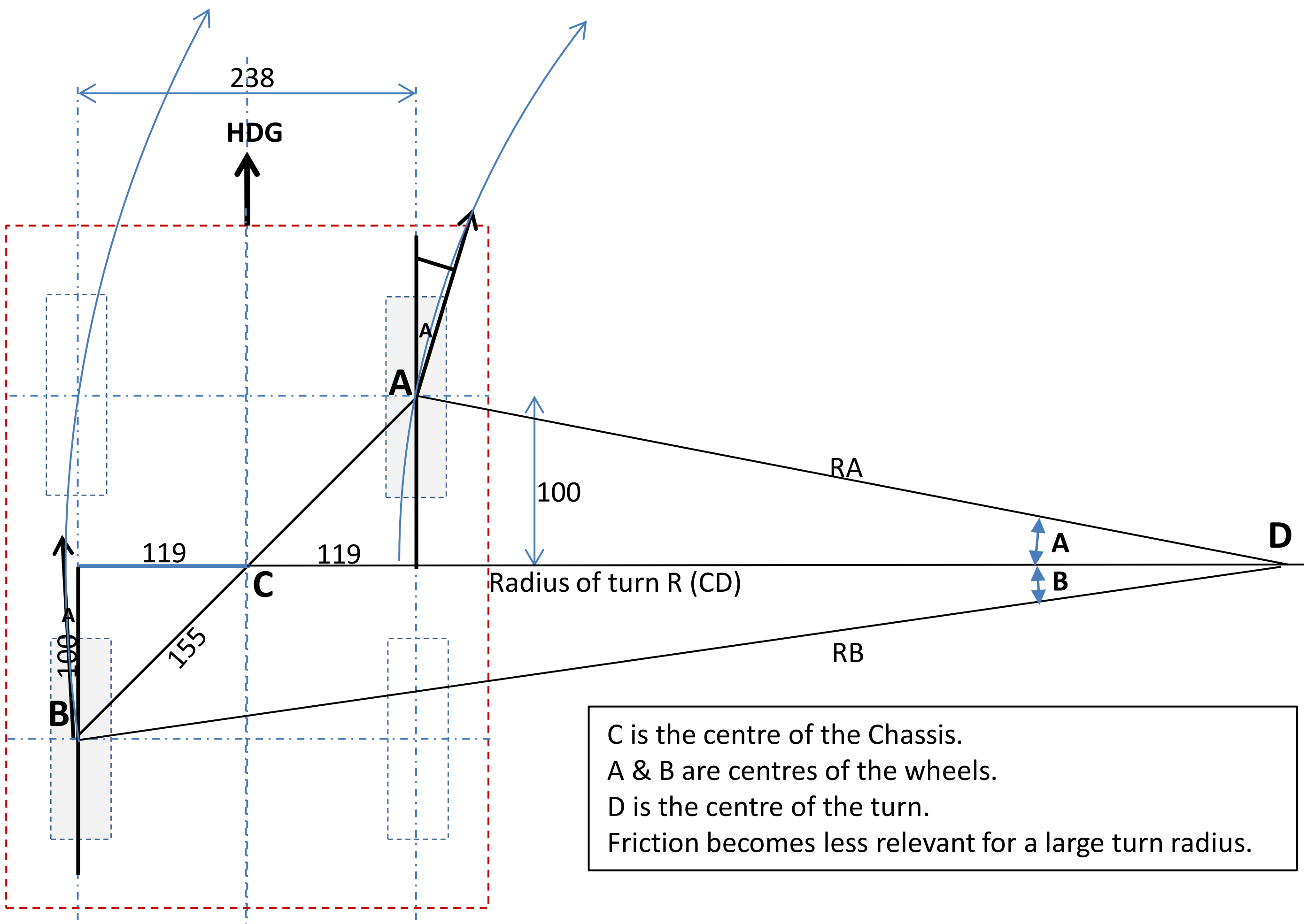
There will also be a small drag from the balancing wheel that is touching the floor depending on the weight being supported by this wheel and the coefficient of dynamic friction between tyre and floor. This varies and can be obtained by experimentation.

Heading in a Turn on the Spot

For a **Straight line** we can assume the turning circle diameter is the wheel track of 238mm. For a **Turn on the Spot** the wheels travel round a circle of diameter 310mm (the diagonal distance between the wheels) Therefore, for a 360 degree turn the distance travelled by the wheels is increased from π*238 to π*310.
The wheels and odometers therefore have to travel further than if they were mounted at each side (on the same axle) by a factor of 310/238 = 1.3
Therefore Heading change in degrees = Difference in distance of wheels *0.24 * 0.77 / 1.3
Difference in distance of wheels *0.14

When we calibrate the robots turn-on-the-spot movement we will use an additional calibration factor that we will call 'friction':
Therefore Heading change in degrees = Difference in distance of wheels *0.14 * friction.

Odometer Derived Heading : Case C: Arc of radius CD



C is the centre of the Chassis.
A & B are centres of the wheels.
D is the centre of the turn.
Friction becomes less relevant for a large turn radius.

The Turning Component depends on the radius of turn,

$RA = \surd(100^2 + (R\text{-}119)^2)$ Cos A = (R-119)/RA $= (R\text{-}119)/ \surd(100^2 + (R\text{-}119)^2)$

$RB = \surd(100^2 + (R\text{+}119)^2)$ Cos A = (R+119)/RA $= (R\text{+}119)/ \surd(100^2 + (R\text{+}119)^2)$

Turning component of wheel A round circumference of turning circle of wheelA = OdometerDistA * Cos A

= OdometerDistA * $(R\text{-}119)/ \surd(100^2 + (R\text{-}119)^2)$

Turning component of wheel B round circumference of turning circle of wheelB = OdometerDistB * Cos B

= OdometerDistB * $(R\text{+}119)/ \surd(100^2 + (R\text{+}119)^2)$

Note: If R=0 (turn on the spot) the Turning Components =

OdometerDistA*-0.77 $(-119)/\surd(100^2 + (-119)^2)$

OdometerDistB*0.77 $(+119)/ \surd(100^2 + (119)^2)$

Heading in an Arc

For a 360 degree Arc the distance travelled by wheelA is = 2*π*RA and by wheelB = 2*pi*RB

wheelA distance = 2*π* $\surd(100^2 + (R\text{-}119)^2)$

wheelB distance = 2*π* $\surd(100^2 + (R\text{+}119)^2)$

If R is less than 119 then wheelA distance is negative and wheelB distance is positive.

The wheels and odometers therefore have to travel further than if they were mounted at each side (on the same axle) by a factor of wheel distances/238

Therefore Heading change in degrees = Difference in distance of wheels *0.24 * 0.77 / wheel distances/238

We have to apply a correction to heading for both the turning component and the radius of turn component.

∴ Turn Heading = Heading * wheel factors* friction