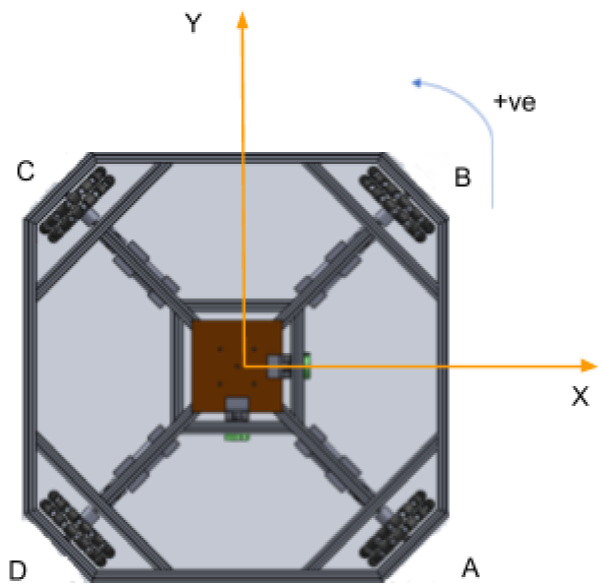
OMNIDRIVE

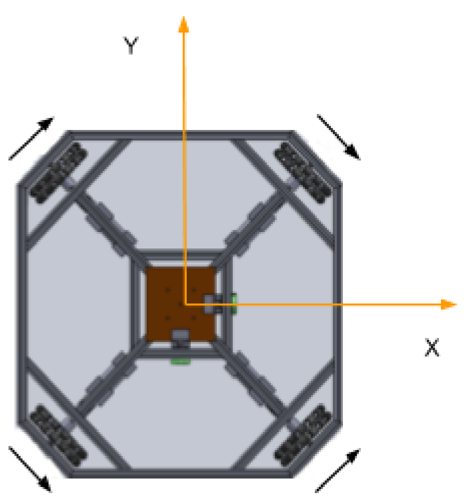
Conventions:



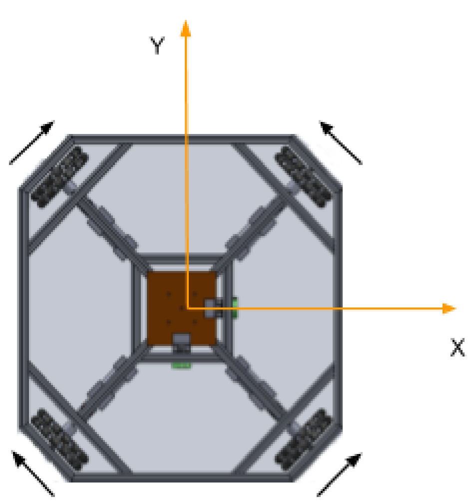
Anticlockwise +ve

Wheel	Angle
A	315°
B	45°
C	135°
D	225°

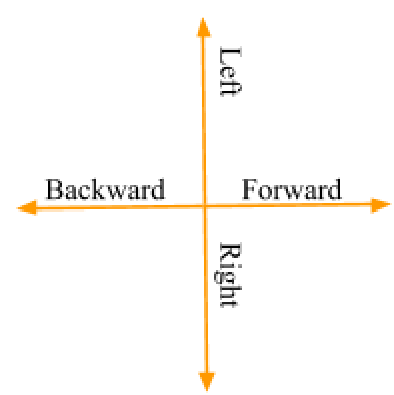
Side	Direction
AB	Forward
BC	Left
CD	Backward
DA	Right

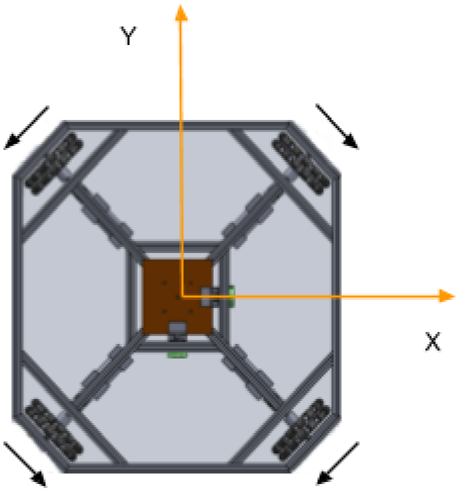


Forward

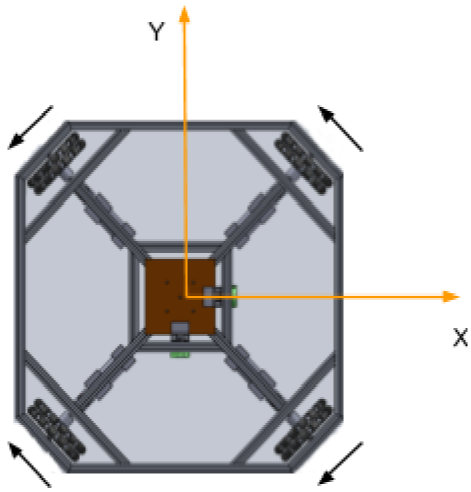


Left





Right



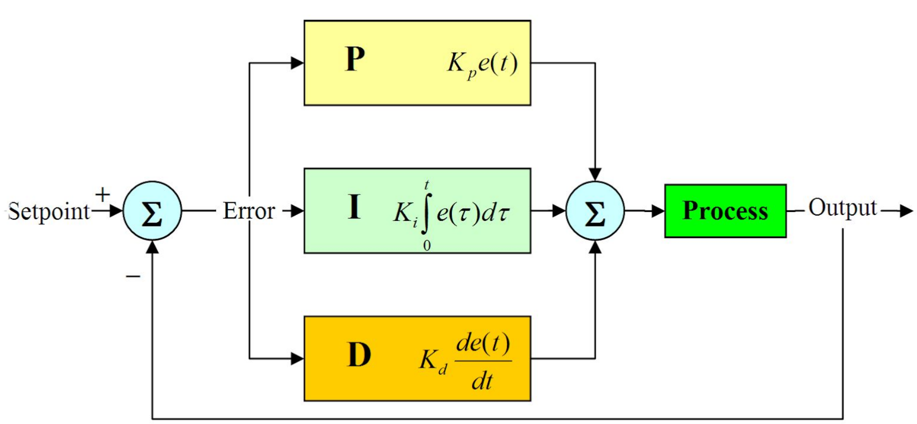
Backward

Lower Control:

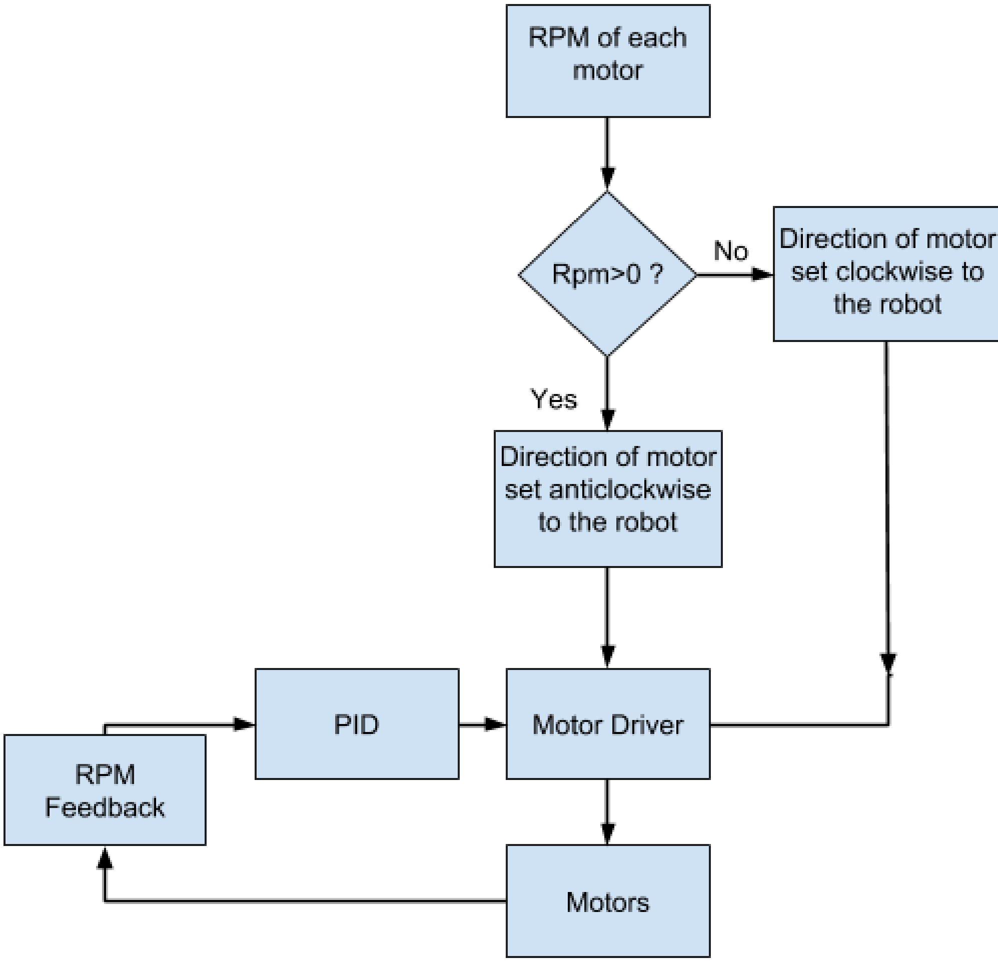
The desired velocity of each motor is attained and maintained by this subsystem. It consists of a control system PID(Proportional Integral Derivative). The control system is applied to the velocity of each motor.

★ PID Controller(Proportional Integral Derivative)-

- P-controller- it is directly proportional to the error. It always tends towards the required point.
- I-controller- it gives an offset when the p-controller is not enough to reach near the required point.
- D-controller- it decrease the setting time of the output.



General Flow:



- Firstly, the direction of the motors is decided depending on the sign of the required rpm.

- The rpm feedback from the encoders is fed into the control system PID and the output of the PID is scaled into PWM and fed into Motor Drivers.

ENCODERS

• Any transducer that generates a coded reading of a measurement can be termed an encoder.

•Shaft Encoders are digital transducers that are used for measuring angular displacements and velocities.

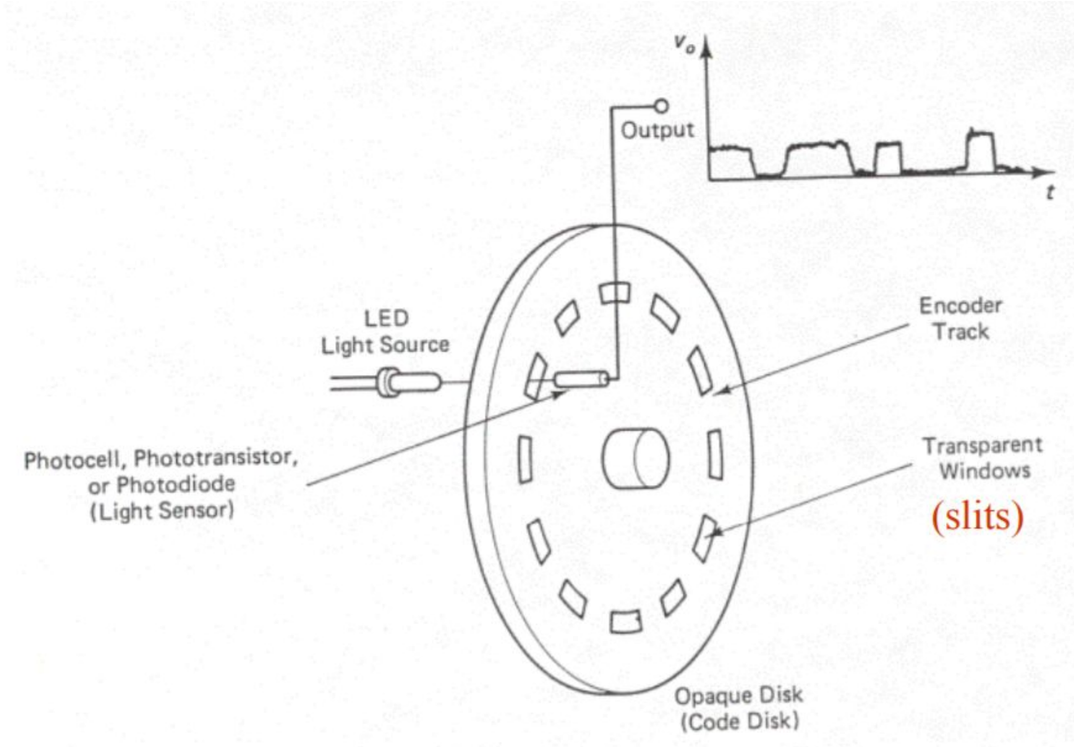
Shaft Encoders can be classified into two categories depending on the nature and method of interpretation of the output: –

1. Incremental Encoders

2. Absolute Encoders

• Incremental Encoders – Output is a pulse signal that is generated when the transducer disk rotates as a result of the motion that is being measured

By counting pulses or by timing the pulse width using a clock signal, both angular displacement and angular velocity can be determined. – Displacement, however, is obtained with respect to some reference point on the disk, as indicated by a reference pulse (index pulse) generated at that location on the disk. The index pulse count determines the number of full revolutions.



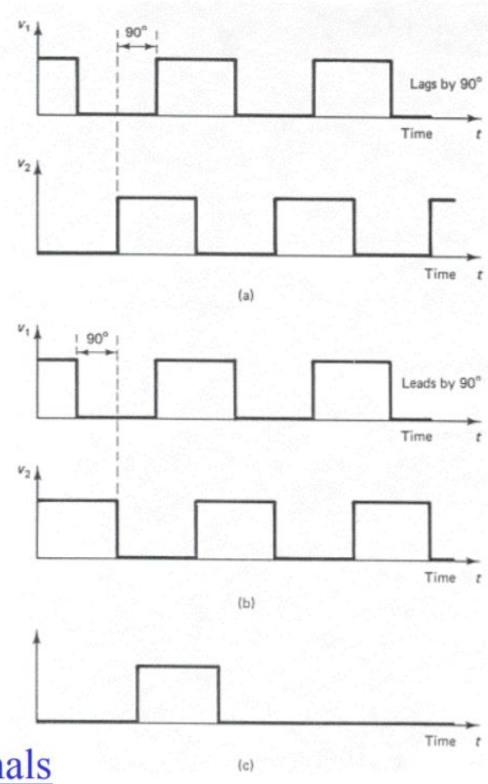
Schematic Representation of an Optical Encoder
One Track and One Pick-Off Sensor Shown

Elements of the Optical Encoder – The optical encoder uses an opaque disk (code disk) that has one or more circular tracks, with some arrangement of identical transparent windows (slits) in each track. – A parallel beam of light (e.g., from a set of light emitting diodes) is projected to all tracks from one side of the disk. – The transmitted light is picked off using a bank of photosensors on the other side of the disk that typically has one sensor for each track. – The light sensor could be a silicon photodiode, a phototransistor, or a photovoltaic cell.

– Since the light from the source is interrupted by the opaque areas of the track, the output signal from the probe is a series of voltage pulses. This signal can be interpreted to obtain the angular position and angular velocity of the disk.

– Note that an incremental encoder disk requires only one primary track that has equally spaced and identical window (pick-off) areas. The window area is equal to the area of the inter-window gap. Usually, a reference track that has just one window is also present in order to generate a pulse (known as the index pulse) to initiate pulse counting for angular position measurement and to detect complete revolutions.

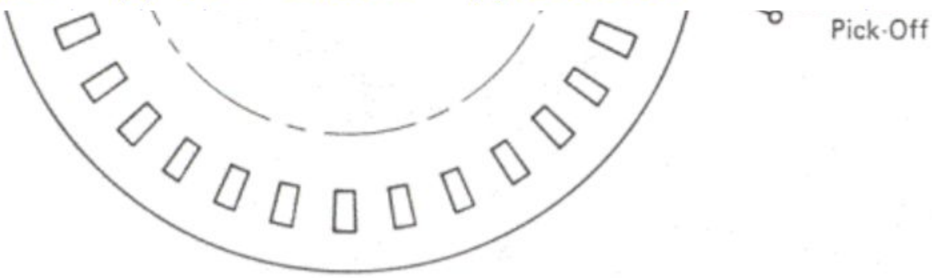
Clockwise (CW) rotation:
V_1 lags V_2 by a quarter of a cycle
(i.e., a phase lag of 90°)
Counterclockwise (CCW) rotation:
V_1 leads V_2 by a quarter of a cycle



Incremental Encoder Pulse Signals
(a) CW rotation (b) CCW rotation (c) reference

–

In



Incremental Optical Encoder Disk
Offset-Sensor Configuration

contrast, absolute encoder disks have several rows of tracks, equal in number to the bit size of the output data word. Furthermore, the track windows are not equally spaced but are arranged in a specific pattern on each track so as to obtain a binary code (or gray code) for the output data from the transducer.

– Some designs of incremental encoders have two identical tracks, one a quarter-pitch offset from the other, and the two pick-off sensors are placed radially without any circumferential offset, i.e., the offset track configuration. – A pick-off sensor for a reference pulse is also used.

• Signal interpretation depends on whether the particular optical encoder is an incremental device or an absolute device.

– We will focus on the incremental optical encoder.

– The output signals from either the offset sensor configuration or the offset track configuration are the same.

– Note that the pulse width and pulse-to-pulse period (encoder cycle) are constant in each sensor output when the disk rotates at constant angular velocity. When the disk accelerates, the pulse width decreases continuously; when the disk decelerates, the pulse width increases continuously. – The quarter-pitch offset in sensor location or track position is used to determine the direction of rotation of the disk. It is obtained by determining the phase difference of the two output signals, using phasedetection circuitry. One method for determining the phase difference is to time the pulses using a highfrequency clock signal.

<u>Errors in shaft encoder readings can come from several factors: –</u>
Quantization error (due to digital word size limitations)

– Assembly error (eccentricity, etc.) – Coupling error (gear backlash, belt slippage, loose fit, etc.)

– Structural limitations (disk deformation and shaft deformation due to loading) – Manufacturing tolerances (errors from inaccurately imprinted code patterns, inexact positioning of the pickoff sensors, limitations and irregularities in signal generation and sensing components, etc.)

– Ambient effects (vibration, temperature, light noise, humidity, dirt, smoke, etc.)

- These factors can result in erroneous displacement and velocity readings and inexact direction detection.

Calculations:

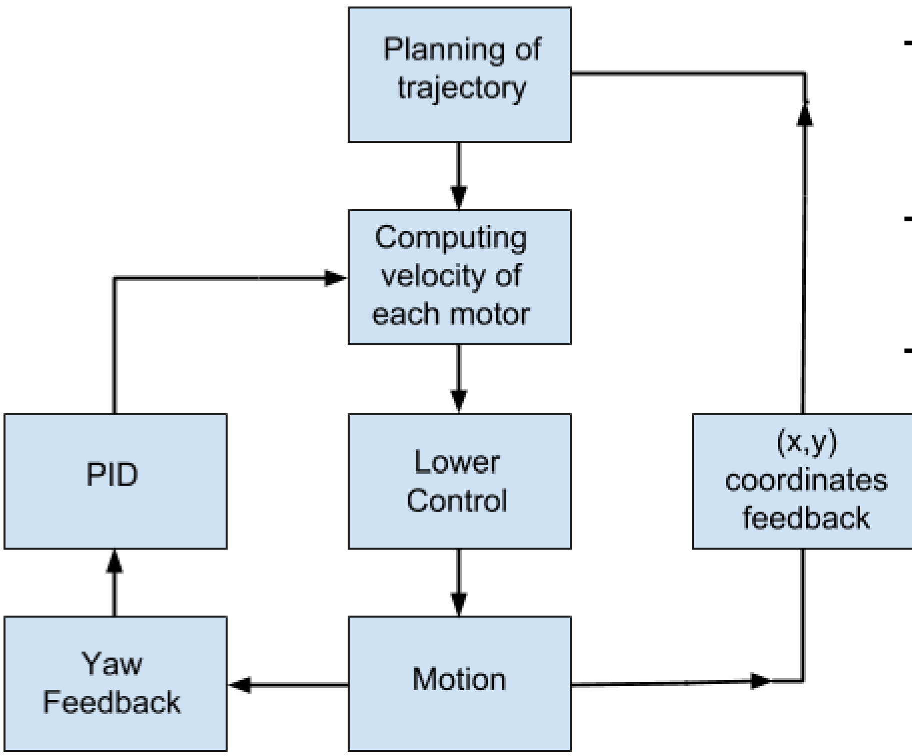
Angle=(Count)*360/PPR

Revolutions=Counts/PPR

Displacement=Revolutions*Circumference of wheel

Odometry(UpperControl): is the use of data from motion sensors to estimate the change in position and orientation of the robot in reference to a starting point.

General Flow:

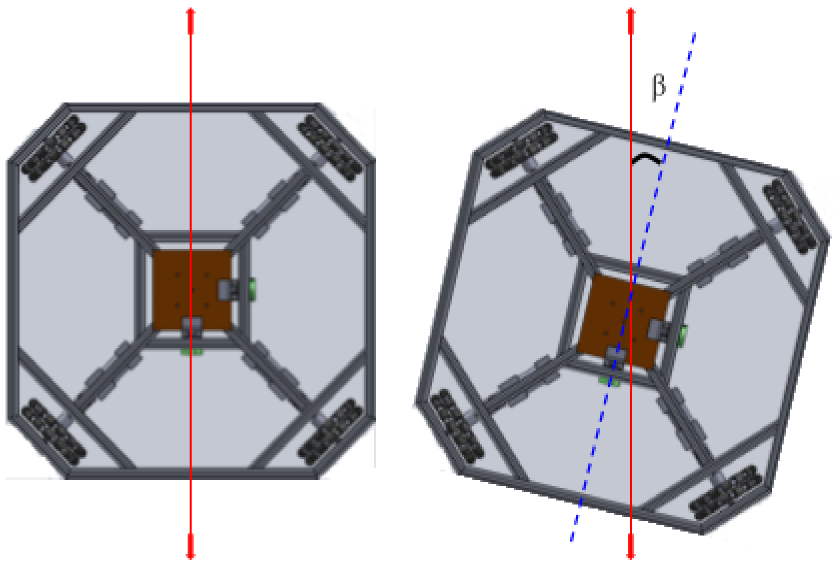


- ➔ The direction and speed of the robot are calculated using trajectory equations.
- ➔ The velocity of each motor is calculated.
- ➔ The calculated velocity of each motor is attained and maintained by the Lower Control.
- ➔ The (x,y) coordinates are fed into the trajectory equations.
- ➔ The Yaw is fed in a control system and the new velocity of motors is calculated.

★ Feedbacks:

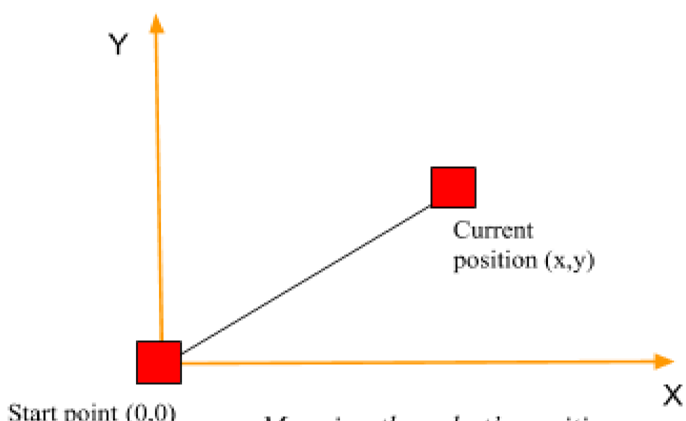
- ○ Yaw: The angle between the current orientation of the robot, with respect to the original orientation in the horizontal plane, is called Yaw.
    - ■ Inertial Mass Unit.

- HMC compass.



β- Yaw

- (X,Y) Coordinates: The y-displacement and x-displacement of the robot with respect to the starting point can be calculated using
    - Encoders
    - LiDAR

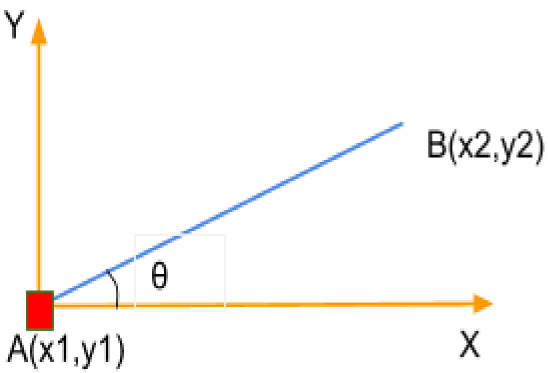


Mapping the robot's position with respect to start point

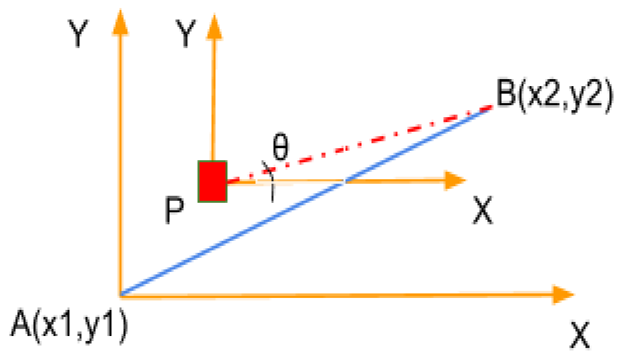
➔ Planning of Trajectory:

◆ Line: Task- Move from point A to point B with velocity ‘v’.

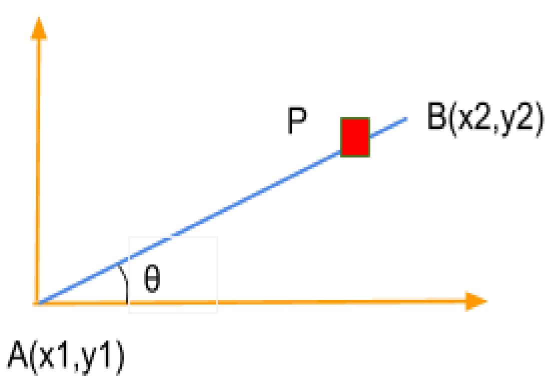
- Calculate angle and distance between the robot’s current position and final point.
- Move with velocity ‘v’ at the calculated angle.
- Calculate the angle between the robot’s current position and final point. If any deviation found, move with the new calculated angle.
- Stop the robot when the distance covered is less than some tolerance distance.



Required Angle(θ)=∠BAX
Velocity= ‘v’



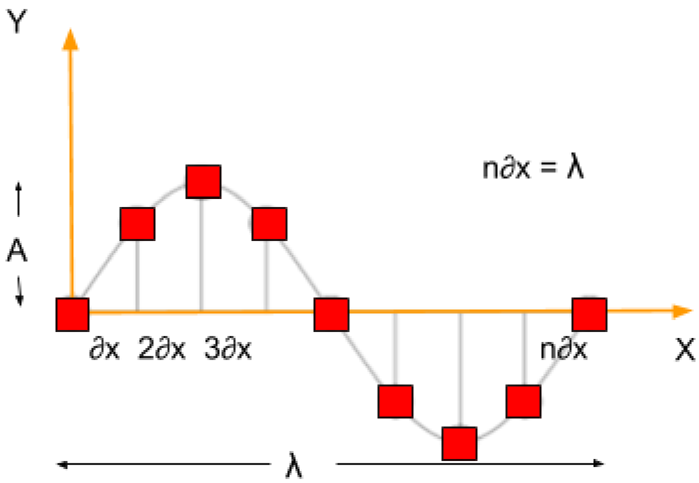
Deviation found
New Required Angle(θ)=∠BPX
Velocity= ‘v’



Required Angle(θ)=∠BPX
Velocity= 0
Tolerance distance= BP

◆ Sine: The relation between the y and x coordinate is simply, y=sin(x).

The sine path can be traced if we divide it into different lines as shown below.

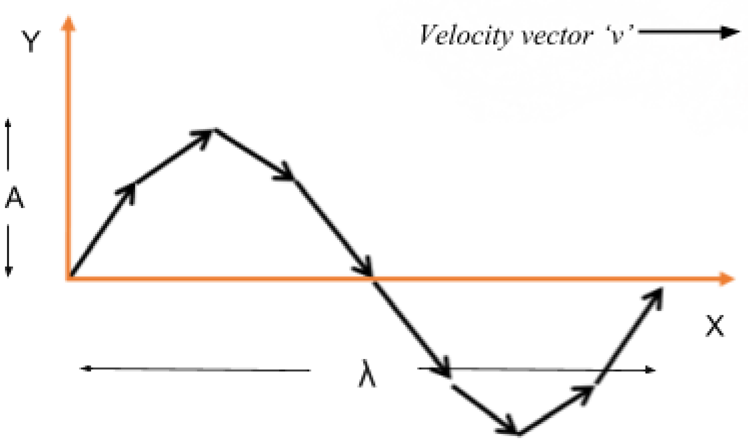


For the desired 'n' lines, sample the sine wave accordingly.

Scale the real world 'x' displacement in 'λ'.

Obtain 'n' lines by increasing ∂x and finding the corresponding 'y' from the equation(y=sinx).

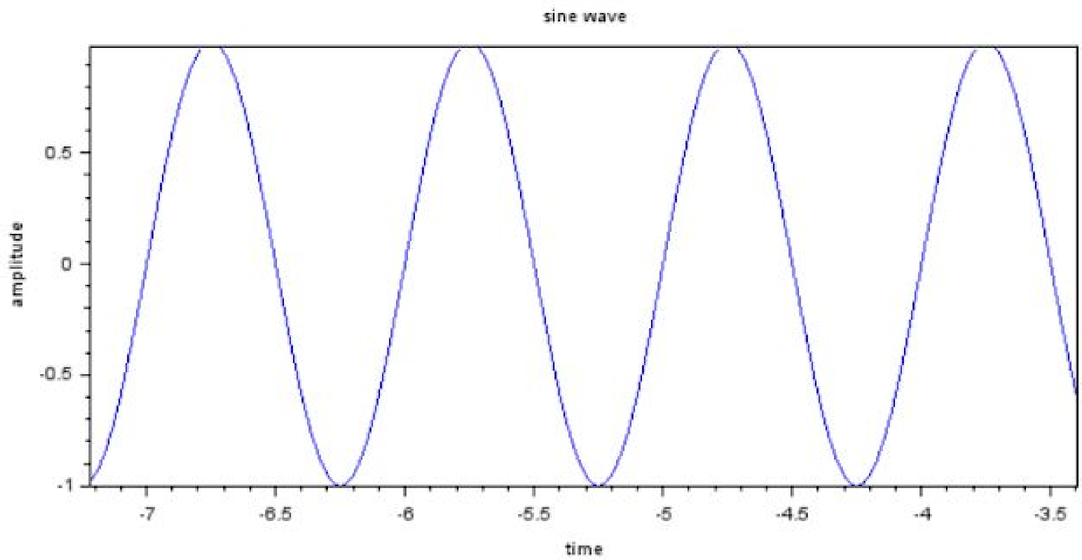
A- amplitude
∂x- small value of x
λ- wavelength



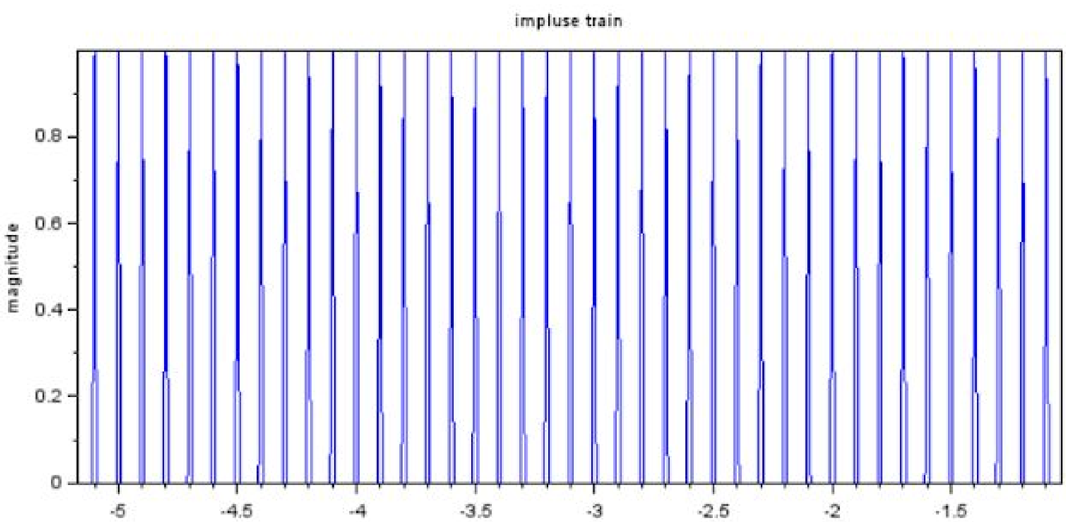
It is necessary to choose an appropriate ∂x because an abrupt change in direction of velocity can make the robot unstable.

Note- The minimum value of ∂x depends on the resolution of the feedbacks.

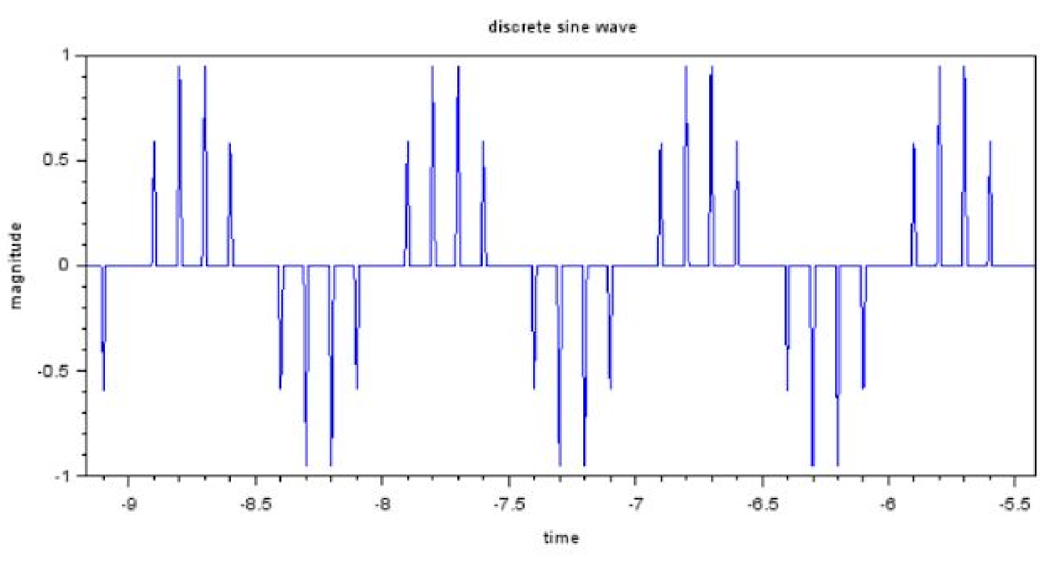
Sampling



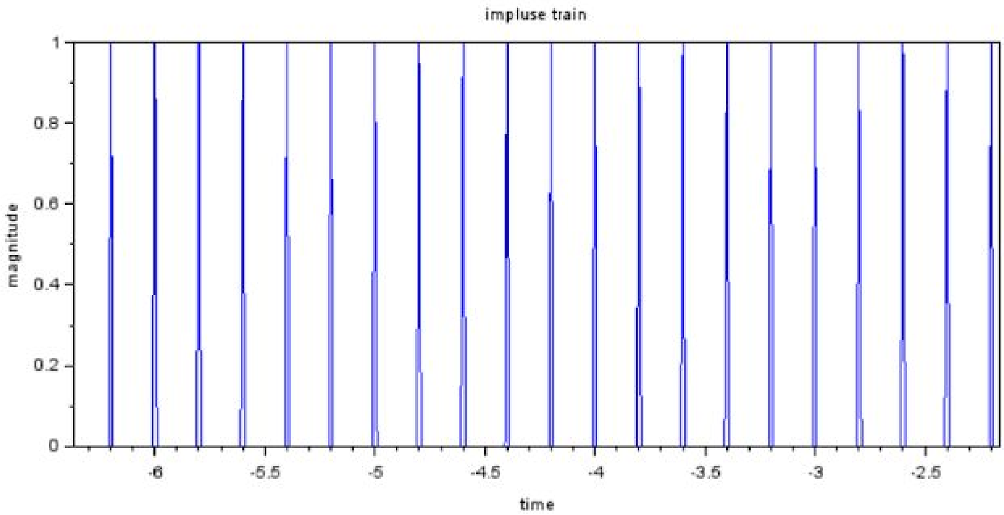
Sine wave
f= 1unit



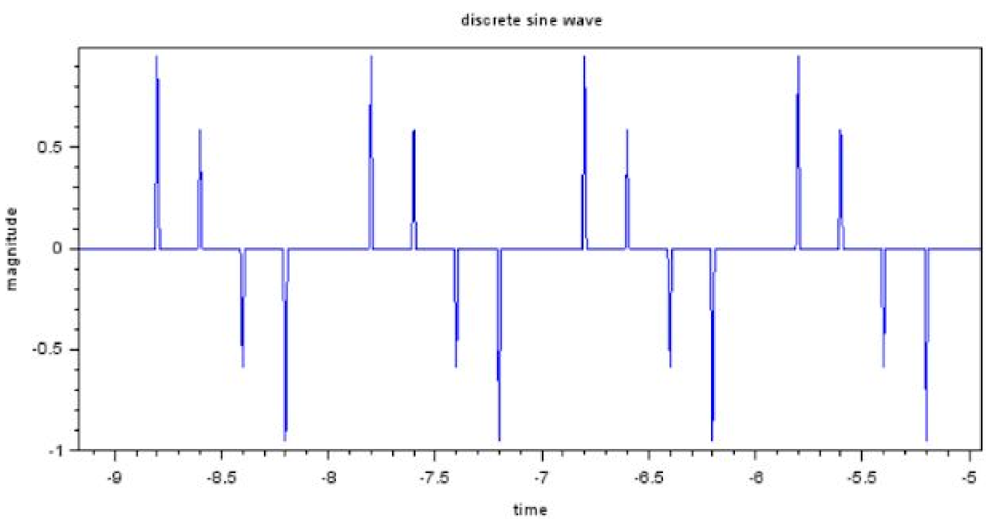
Impluse train
fs= 10units



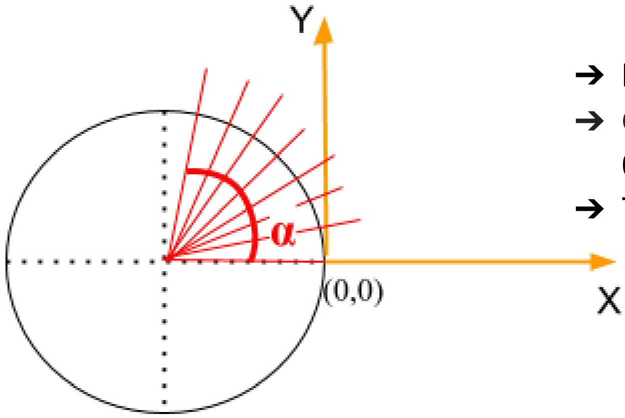
UnderSampling



fs= 1unit



◆ Arc/Circle: Task- Tracing arc anticlockwise from the forward side of the robot.
The arc can also be traced by dividing it into 'n' lines.



$$(x + radius)^2 + y^2 = (radius)^2$$

- ➔ Equation- $x = radius * (cos\theta - 1)$

  $y = radius * sin\theta$
- ➔ Divide angle **α** in ‘n’ parts.
- ➔ Obtain different (x,y) points by substituting θ=**0,α/n,α/2n,α/3n…..α.**
- ➔ Trace ‘n’ lines.

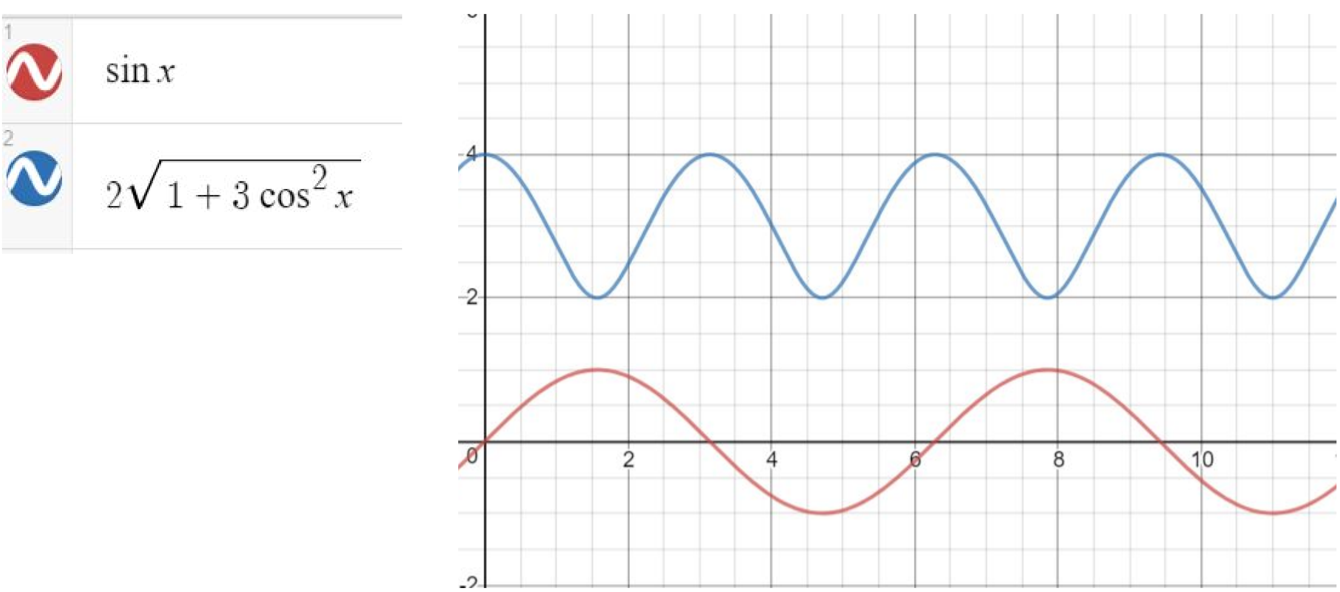
For circle **α=360°**

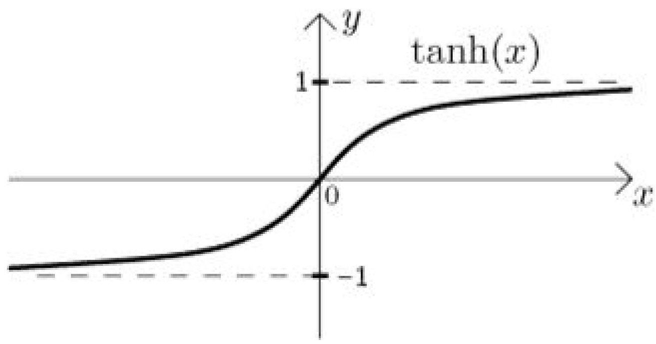
Velocity as a function of distance:

Relation between x-y coordinate=>

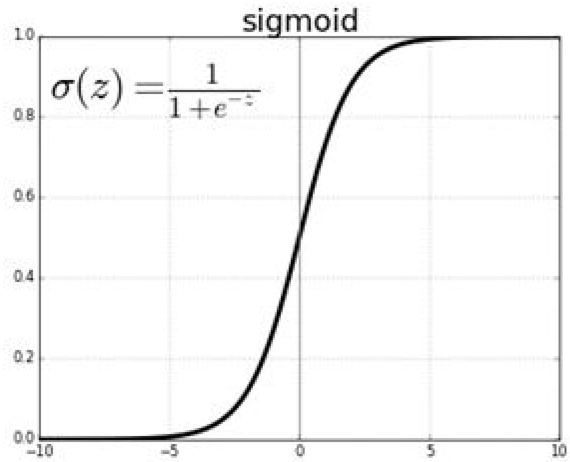
$$y = sinx$$

$$v(x) = (\frac{vmax}{2}).\sqrt{1 + 3cos^2x}$$

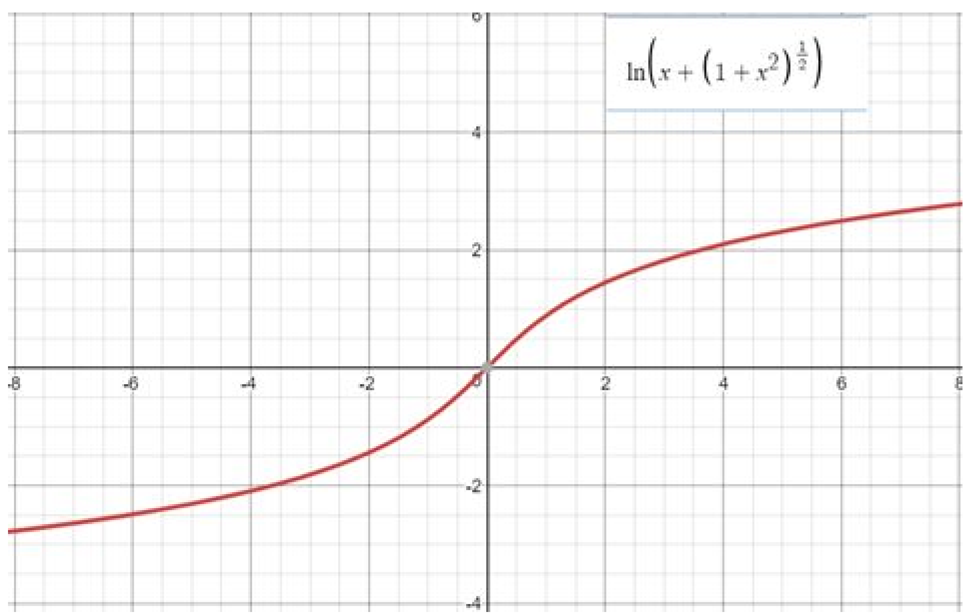




y
$\tanh(x)$
1
0
x
−1



sigmoid
$\sigma(z) = \frac{1}{1+e^{-z}}$
1.0
0.8
0.6
0.4
0.2
0.0
−10
−5
0
5
10



$\ln\left(x + \left(1 + x^2\right)^{\frac{1}{2}}\right)$
6
4
2
-2
-4
-8
-6
-4
-2
0
2
4
6
8