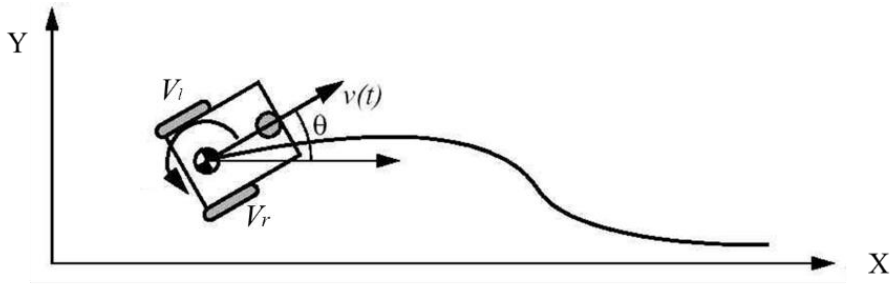
Lab 2 - Work on your C/C++ Programming

In this lab, you should write C/C++ code to implement the specified tasks.

Task 1. Your C/C++ programming in Ubuntu

The following figure describes a differentially driven robot in a 2D space. The robot position is (*x*, *y*) and its heading is *θ*.



The discrete form of its kinematic equations is shown below:

$$x(k+1) = x(k) + \frac{V_r + V_L}{2}\cos(\theta(k)) * \Delta t$$

$$y(k+1) = y(k) + \frac{V_r + V_L}{2}\sin(\theta(k)) * \Delta t$$

$$\theta(k+1) = \theta(k) + \frac{V_r - V_L}{W} * \Delta t$$

where *W* is the wheelbase of the robot, i.e., the distance between two rear wheels.

V_l and V_r are the velocities of the left and right wheels, respectively.

Δt is the cycle time.

Suppose you have been given the following parameters:

$V_l = 10cm/s;$ $V_r = 8cm/s;$ $W = 30\ cm;$ $\Delta t = 1;$

$x(0) = 30cm;$ $y(0) = 30cm;$ $\theta(0) = \pi/4$

Your task is to write C/C++ code to generate the robot trajectory (x_k, y_k) when k = 0,1,2,3,4,5,6,7…200. All the trajectory points should be saved into a file for plotting.

You should follow the following steps to do the programming and graph plotting.

Step 1 Open terminal.

Step 2 Type the commands to go to the folder ***Documents/programs***

$ cd Documents/programs

Step 3 Open the file using any editor

$ gedit odometry.cpp

and add the parameters given above to the code.

```
#include<math.h>
#include<iostream>
#include<fstream>

#define   PI   3.14159265
int wheelbase=30, delta_t=1;
const int SIZE=200;
double vl=10, vr=8;
double rob_x[SIZE]={30}, rob_y[SIZE]={30}, rob_theta[SIZE]={PI/4};

// To generate the robot trajectory using robot kinematic equations
int robot_kinematics(double left_vel, double right_vel)
{
    int i;
    for(i=0; i<SIZE; i++)
    {

        // Put your code for implementing kinematic equations here

    }
    return 0;
}


// You should write main function into the file.
FILE *fp;    // data file for saving the trajectory data
int main(int argc, char **argv)
{
    int i;
    fp = fopen ("trajectory1","w");
    robot_kinematics(vl, vr);
    fprintf(fp, "%d, %d  \n", 30, 30);
    for(i=1; i<SIZE; i++){
        fprintf(fp, "%f, %f  \n", rob_x[i], rob_y[i]);
    }
    fclose(fp);
    return 0;
}
```

Step 4 Save the file and exit.

Step 5 Type the following command to compile your odometry calculation code.

$ g++ odometry.cpp

Step 6 Run your code.

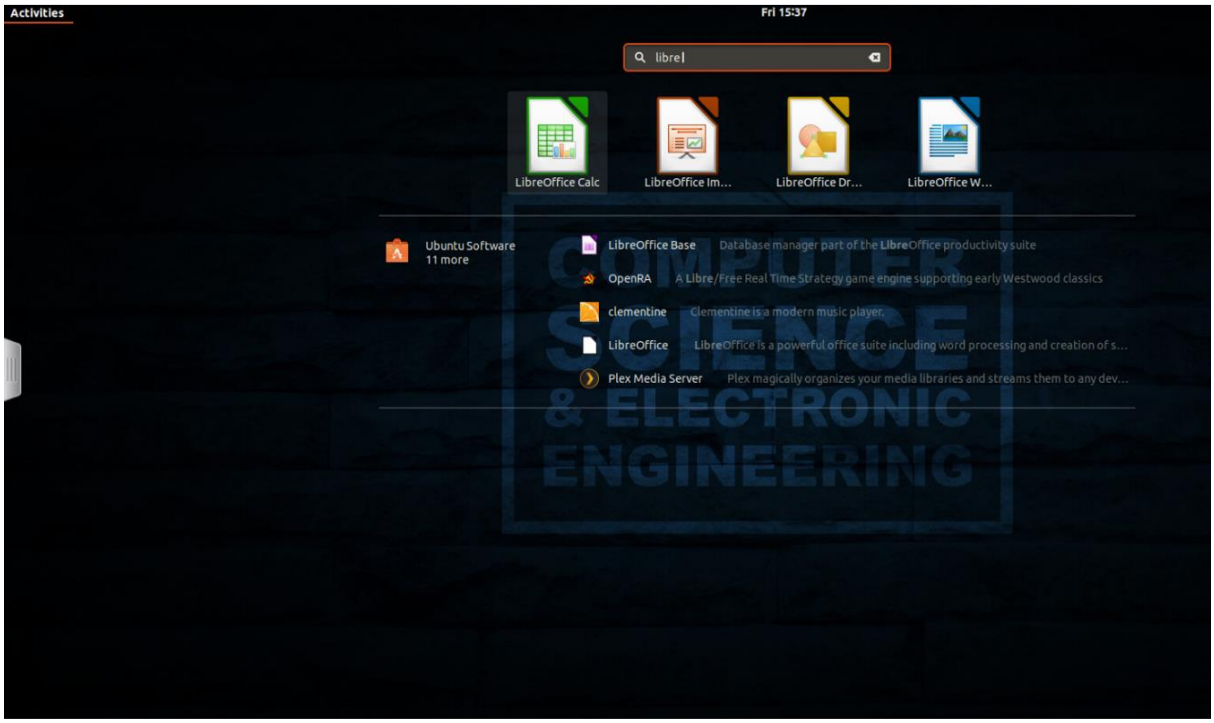
$ ./a.out

At this point, you should have a data file *trajectory1* file being generated in your M_drive.

Your next task is to plot it using LibreOffice Calc in Ubuntu.

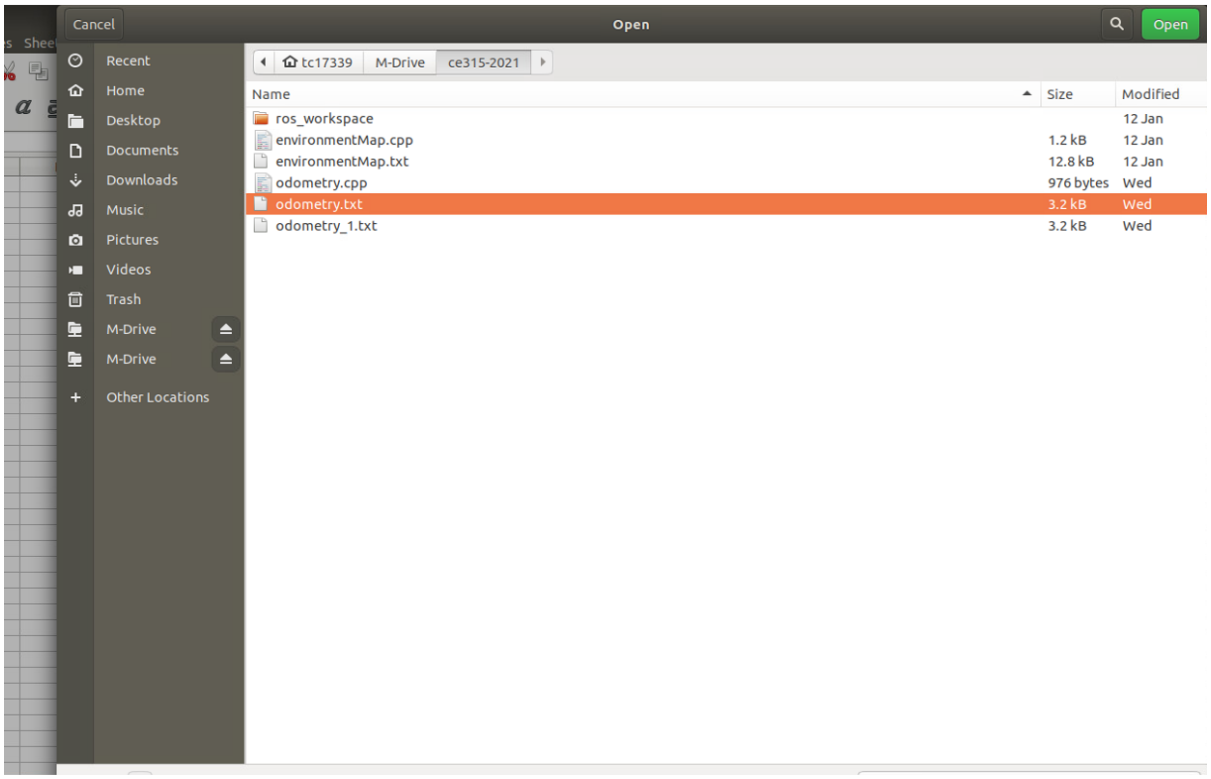
Plot your results using LibreOffice Calc in Ubuntu applications

Step 1 Search and select LibreOffice Cals from Activities in Ubuntu desktop.



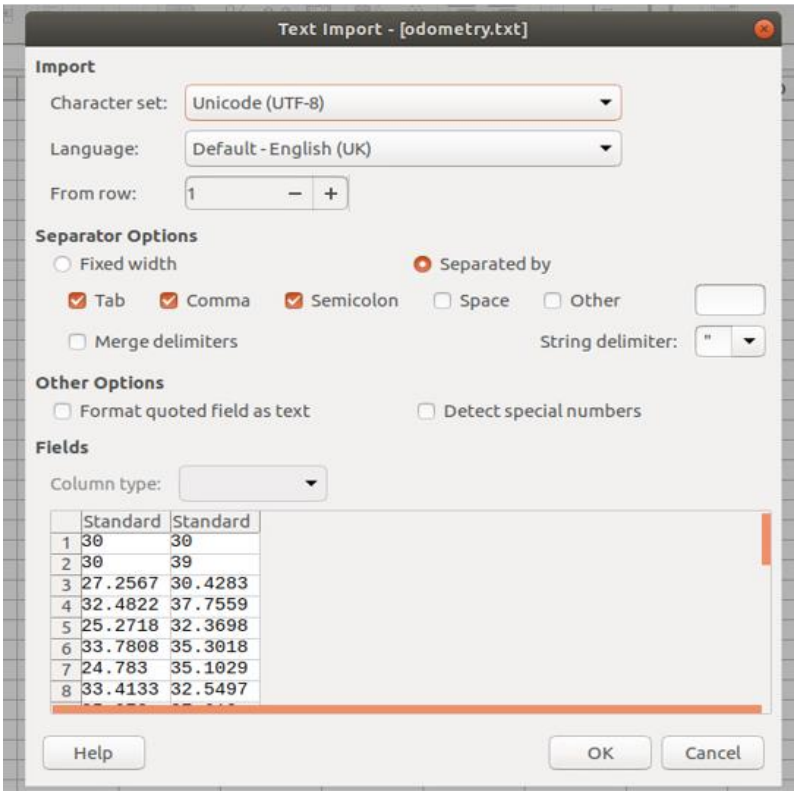
Step 2

Once you open the LibreOffice Cals, you should open your data file (e.g., odometry.txt in this case) from **File → Open.** In the pop-up window, go to your file location (e.g., ~/M-Drive/ce315-2021/odometry.txt in this case). You can select the file and then select **Open.**



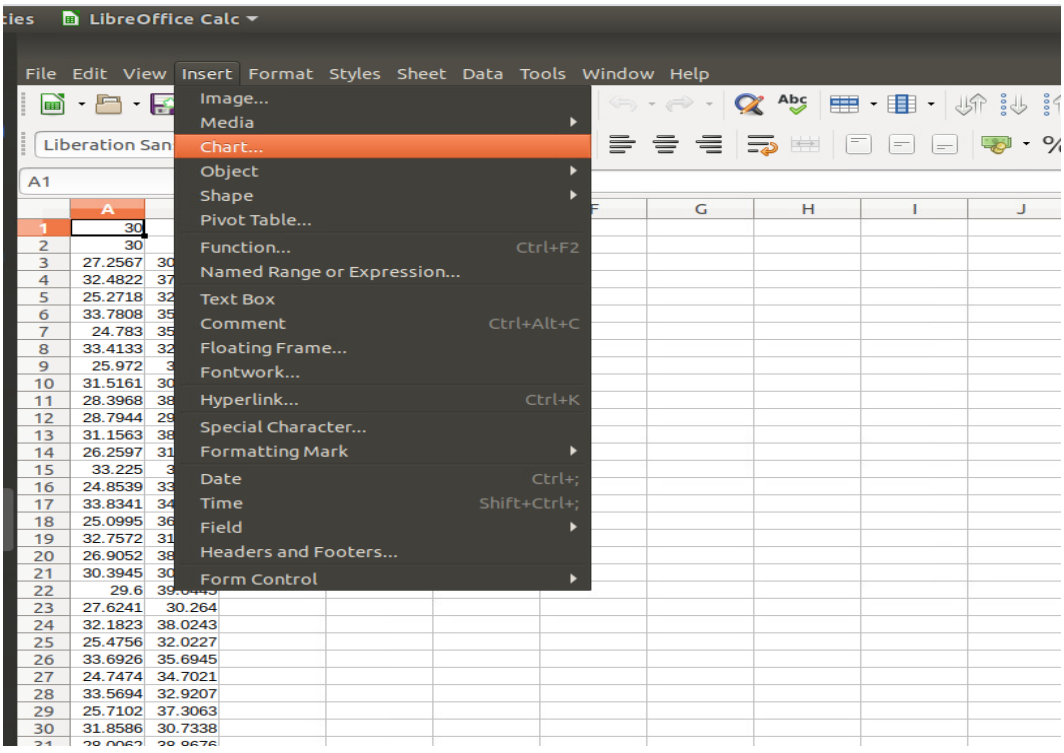
Step 3

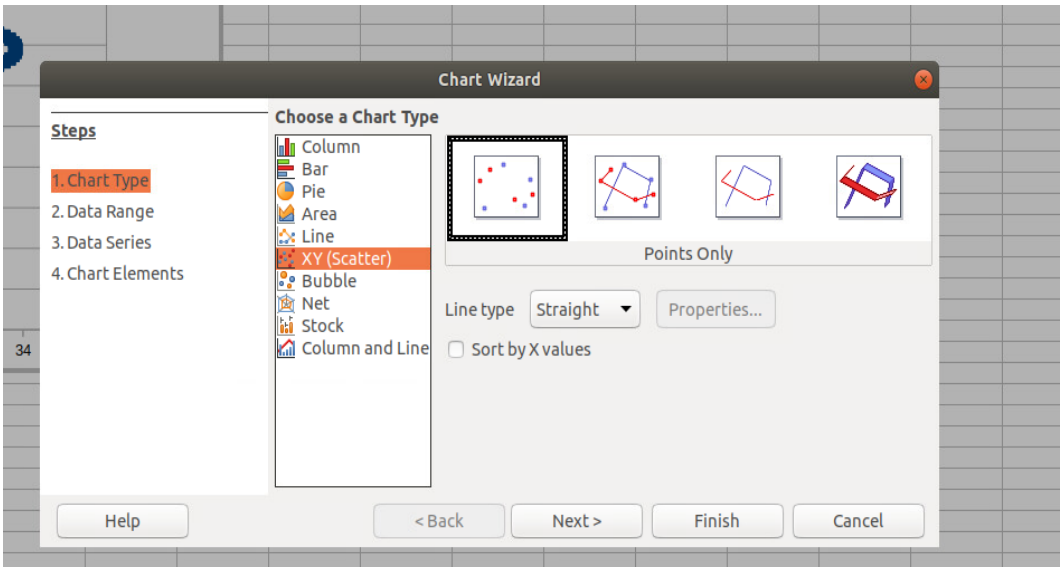
In the pop-up window, you may select one of Separators for your data (Tab, Comma, Semicolon) based on the separator used in your data. Then select Ok as the figure shown below.

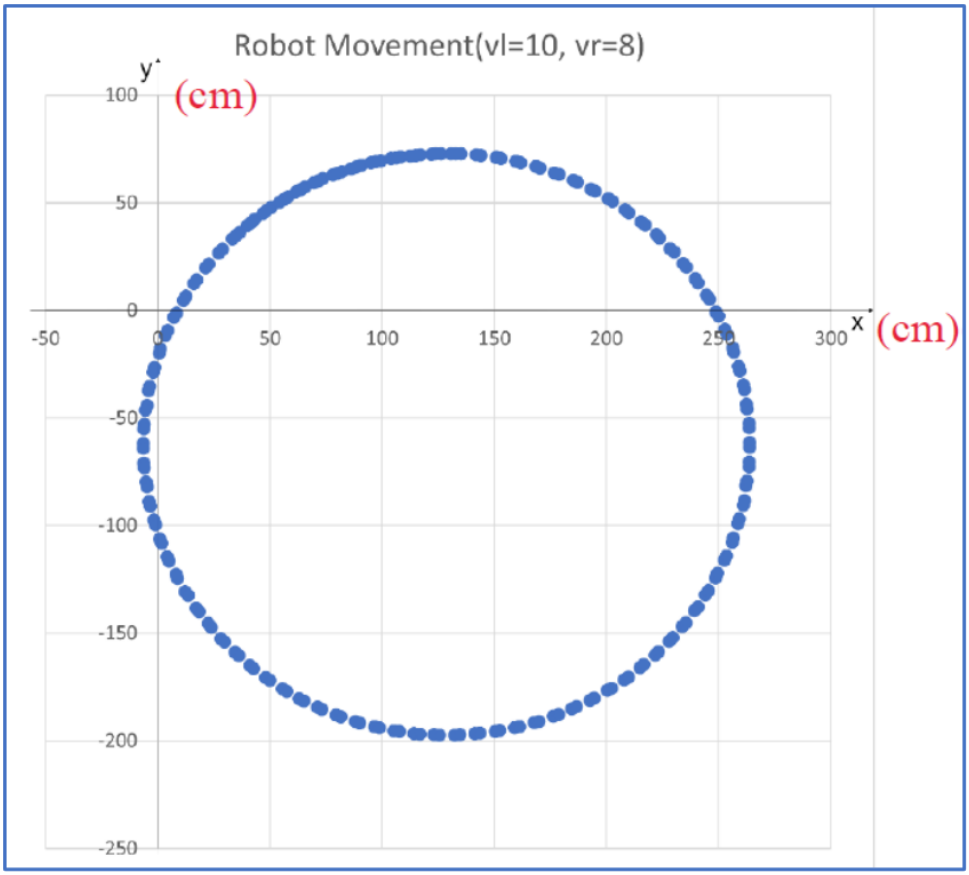


Step 4

Now you can go to Insert→Chart→Chart Type→XY (Scatter), choose left diagram (Points Only) and select Finish. Then, you can view the shape of your data.







Task 2: Improve your C/C++ programming skill

Suppose you have been given the following new parameters:

$V_l = 5cm/s;$ $V_r = 7cm/s;$ $W = 30\ cm;$ $\Delta t = 1;$

$x(0) = 30cm;$ $y(0) = 30cm;$ $\theta(0) = \pi/4$

You should use a module approach to revise your C/C++ code created in Task 1 so that it can generate two robot trajectories (x_k, y_k) at two pairs of different velocities. Note k = 0,1,2,3,4,5,6,7…200, and all the trajectory points should be saved into a file for plotting.