Abbreviations used for ease:

Non-linear bicycle model: NLBM
Linear bicycle model: LBM
Kinetic bicycle model: KBM

Q1)

Ex sheet 2:-

Ex1)

a) Because at low speeds the forces F_x, F_y, F_z are small.

b) Because Coulomb friction doesn't incorporate elastic tire deformation.

c) $\alpha \to$ tire slip angle is the angle b/w wheel velocity & the centre line of the tire.
$\delta \to$ the vehicle slip angle is the diff b/w where the car is heading & where it is actually going.

The phenomenon of drifting occurs because the rear tire slip angle is greater than the front slip angle.

d) • Aspect ratio $= \frac{\text{width}}{\text{height}}$. so if Aspect ratio increases

it means height ↓ so a ↓ so cornering stiffness also decreases

• As C_α is independent of material properties so no impact of changing from iron to aluminium.

• rim size ↑ so C_α minor decrease

• Number of plies ↑ so C_α minor increase

• tire pressure ↑ so C_α major decrease

• tire temp ↑ so C_α minor decrease

• vertical load ↑ so C_α major increase

$X_2 = W = 4$ 15000

e) linear bicycle model → linear tire model

Dynamic bicycle " → non-linear tire model

2a, b)

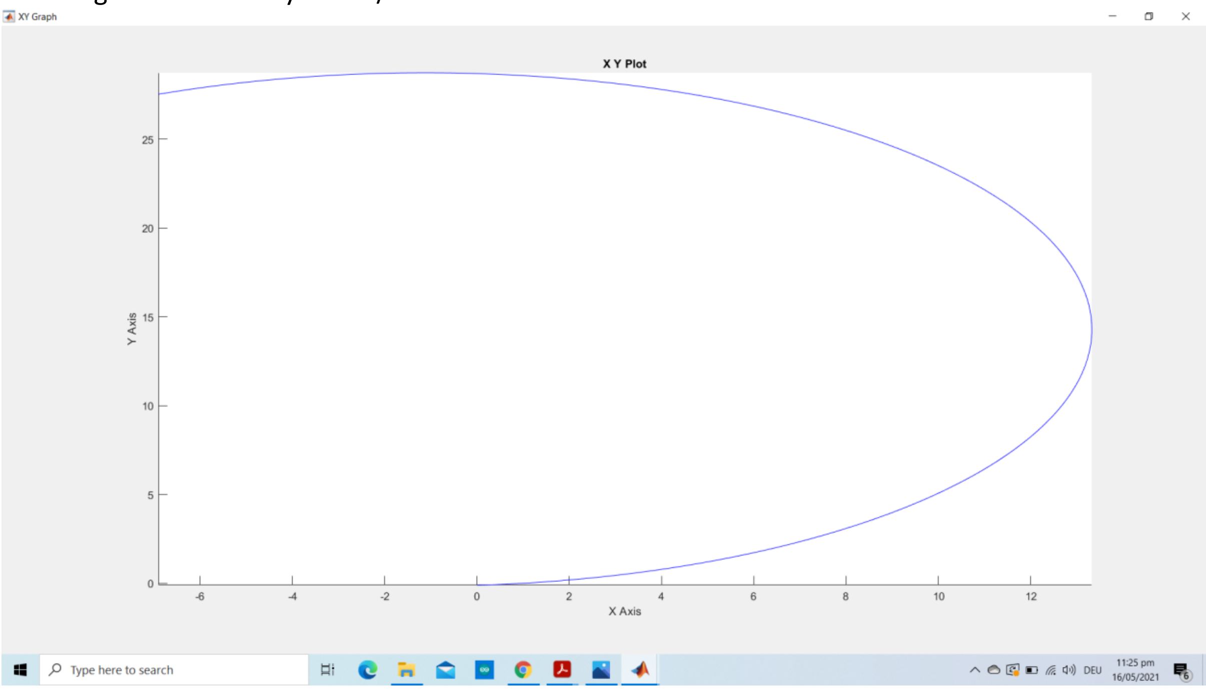
Linear bicycle model X-Y diagram with following inputs:

x0 = 0 ;

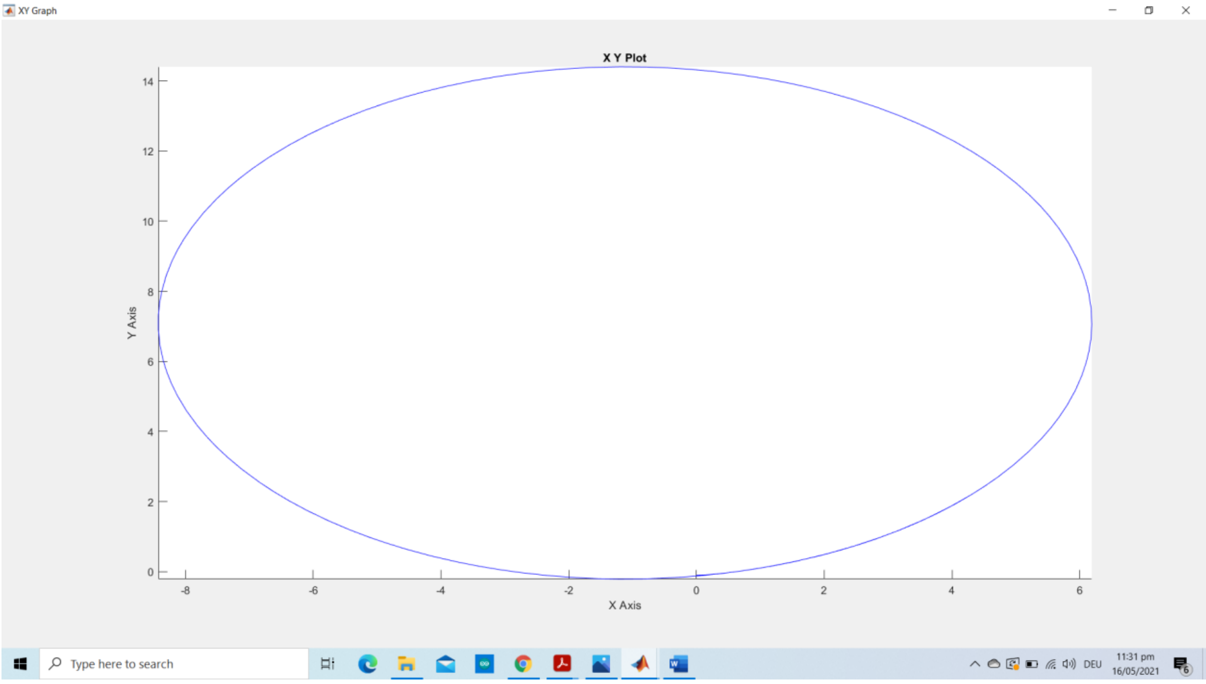
y0 = -0.1;

For angle = 10 degrees

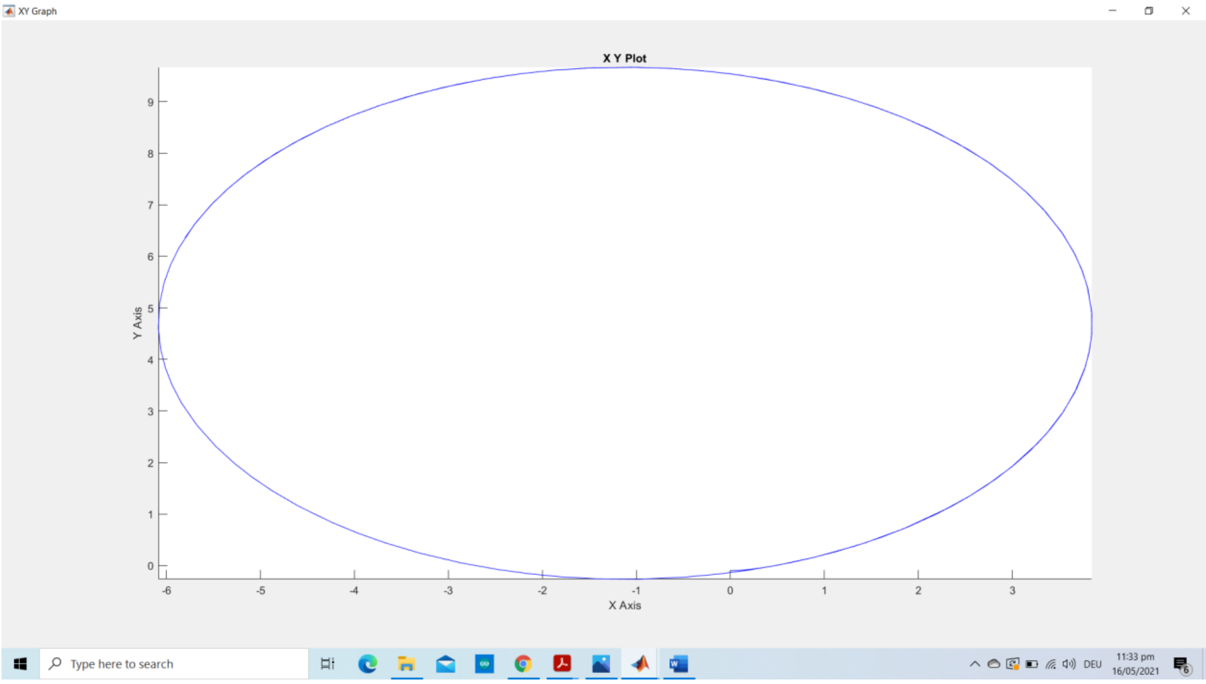
And longitudinal velocity = 5 m/s



For angle = 20 degres , longitudinal velocity = 5 m/s



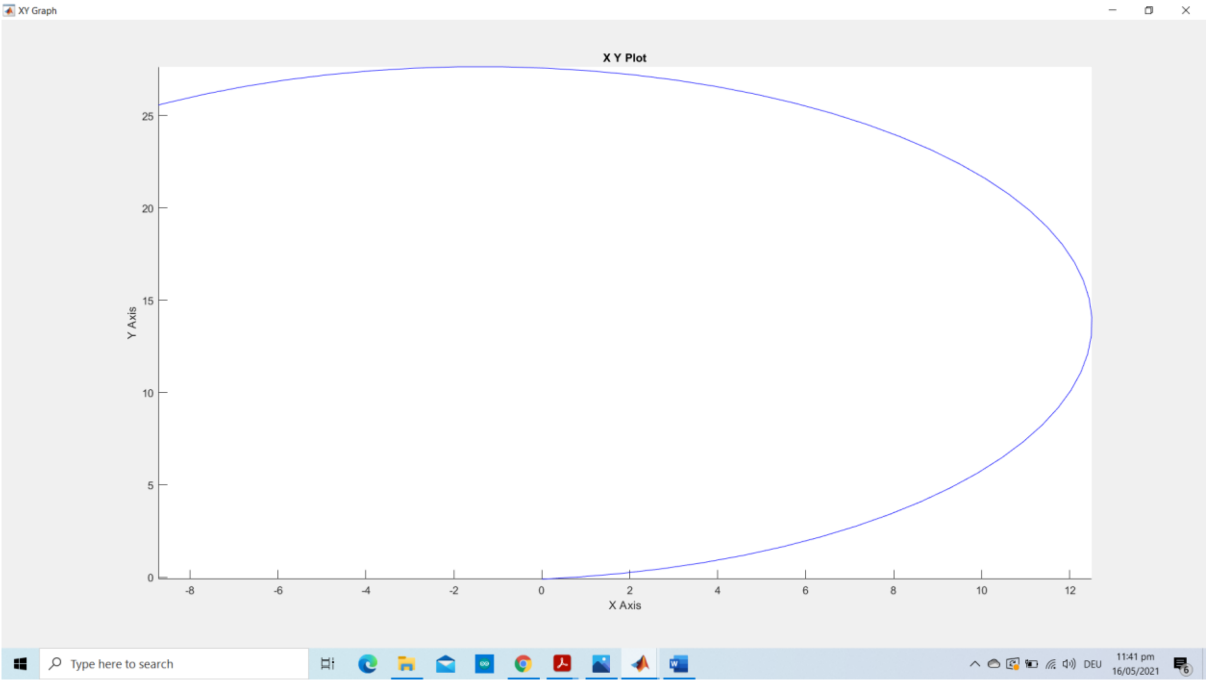
For angle = 30 degrees, longitudinal velocity = 5 m/s



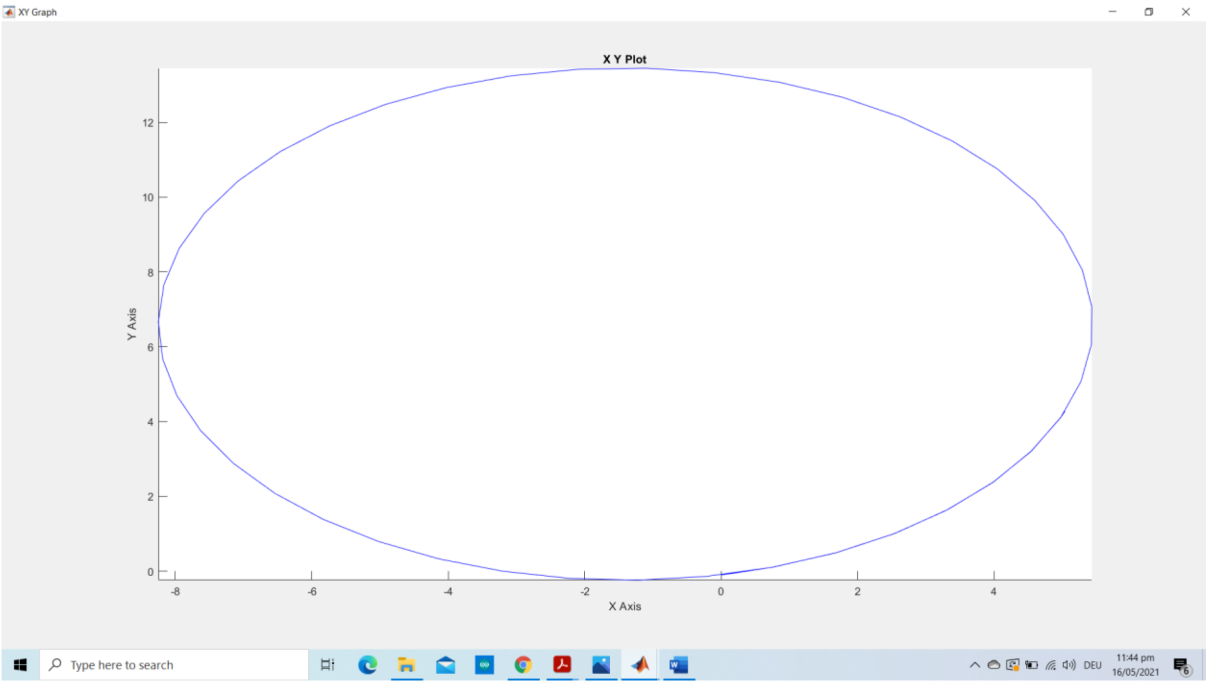
For the LBM, as the steering angle increases while keeping the longitudinal velocity constant the radius decreases.

For Kinematic Bicycle model with following inputs:
x0 = 0 ;
y0 = -0.1;

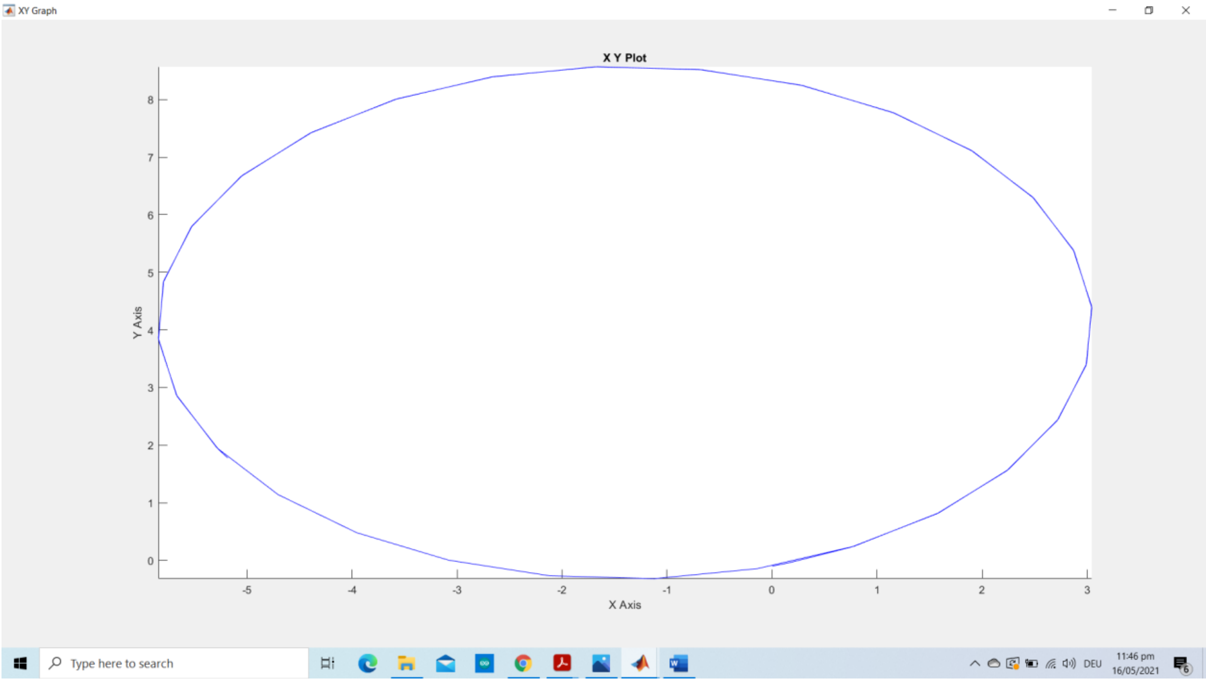
Angle = 10° , longitudinal_velocity = 5 m/s



Angle = 20° , longitudinal_velocity = 5 m/s

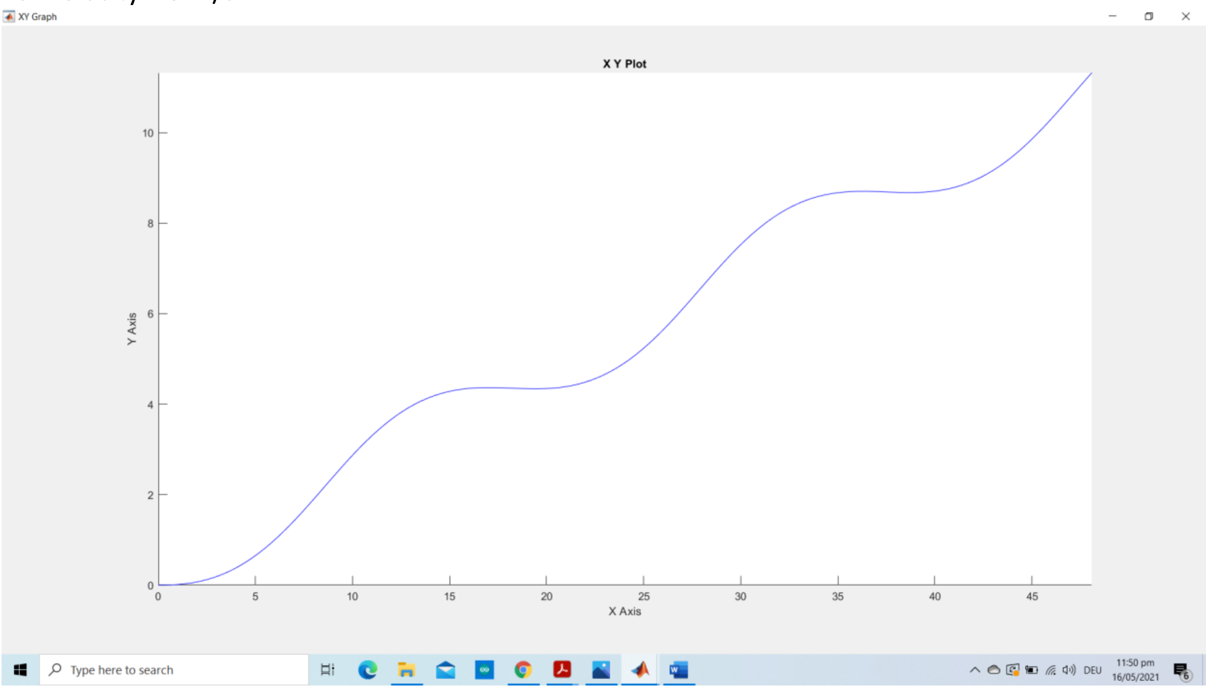


Angle = 30° , longitudinal_velocity = 5 m/s

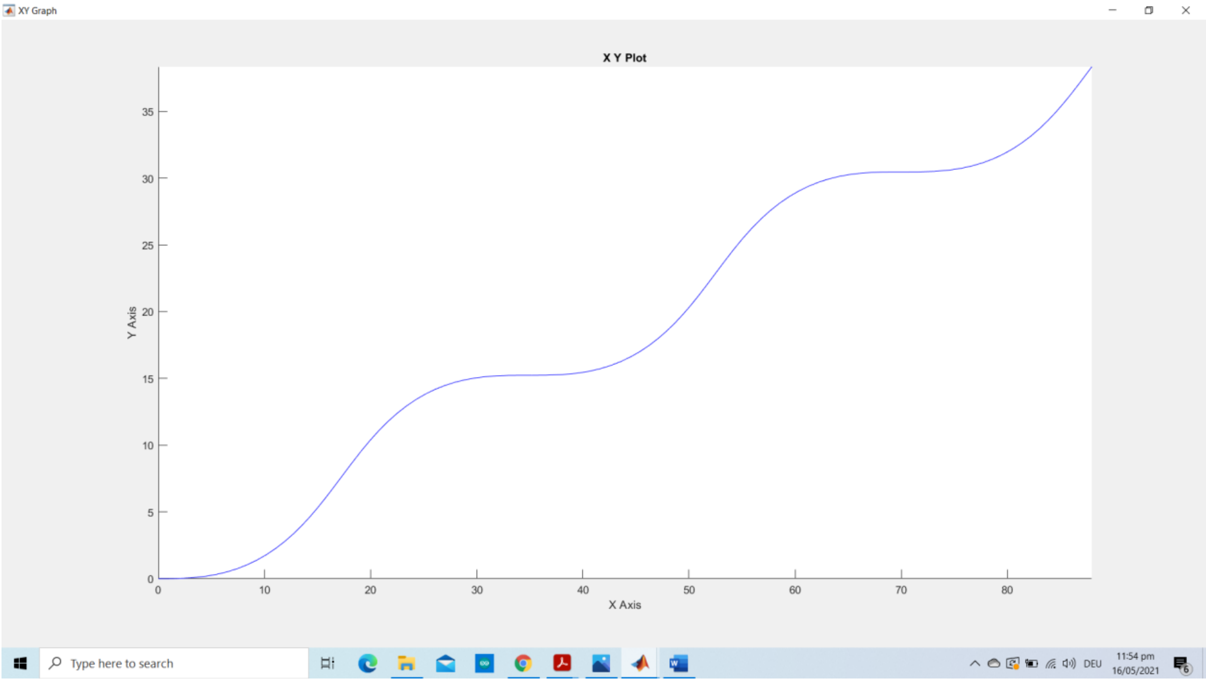


For the KBM as well, as the steering angle increases while keeping the longitudinal velocity constant the radius decreases.
The respective KBM and LBM x-y diagram almost seems to overlap each other for these cases.

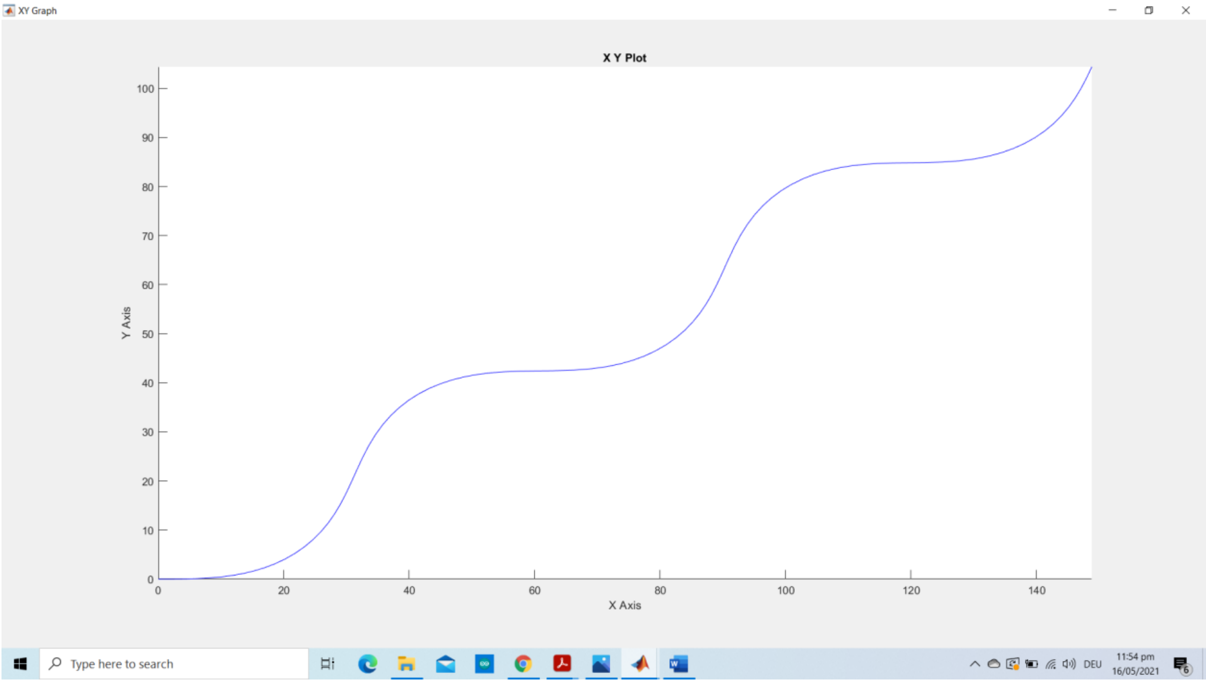
2c)
LBM:
For velocity = 5 m/s



For velocity = 10m/s



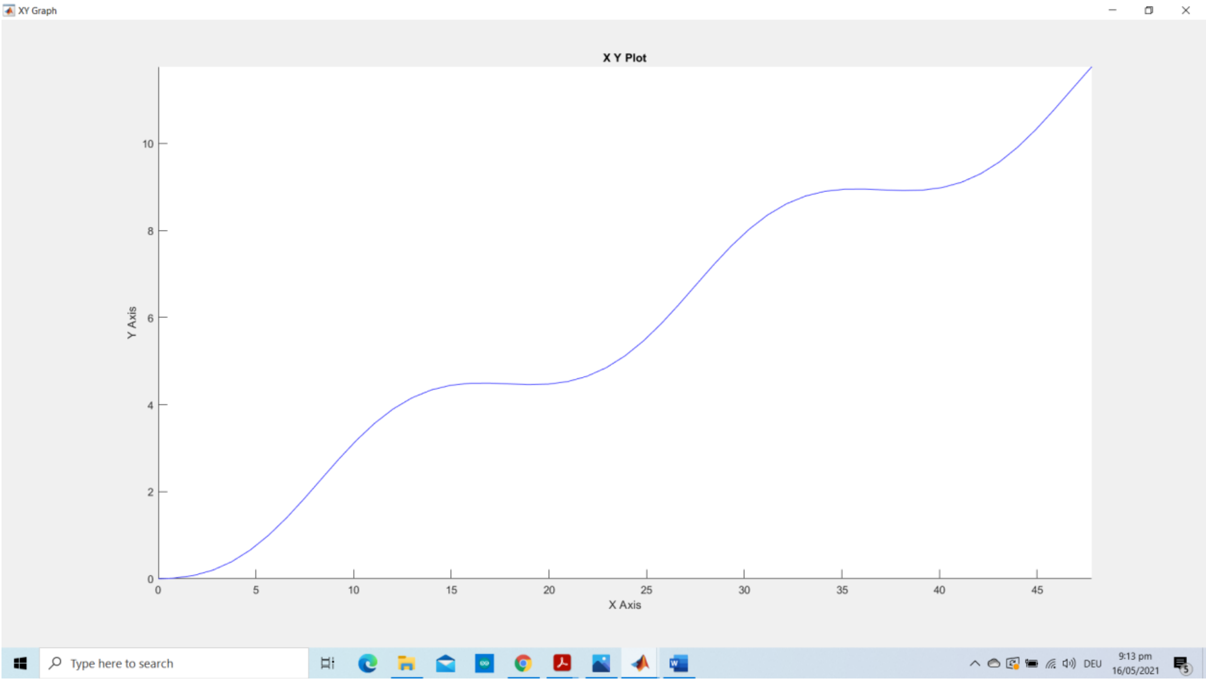
For velocity = 20 m/s



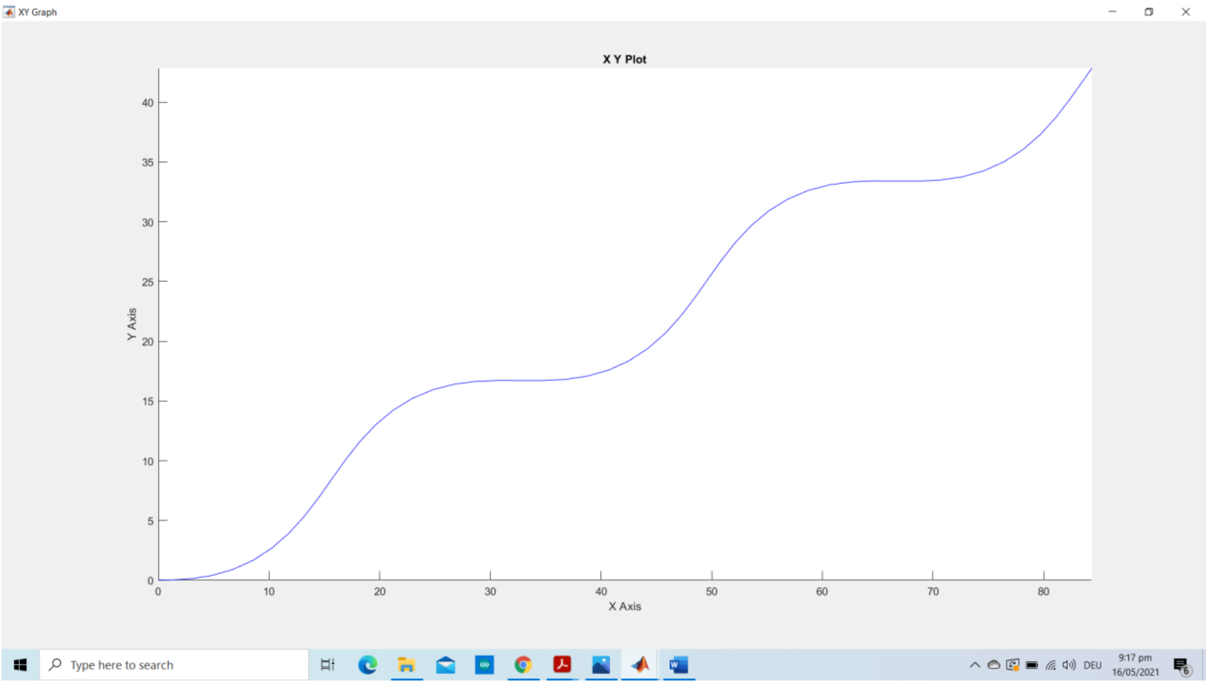
KBM:

V= 5m/s

Sameed Quais – 715861 Exercise Sheet 2 Solutions

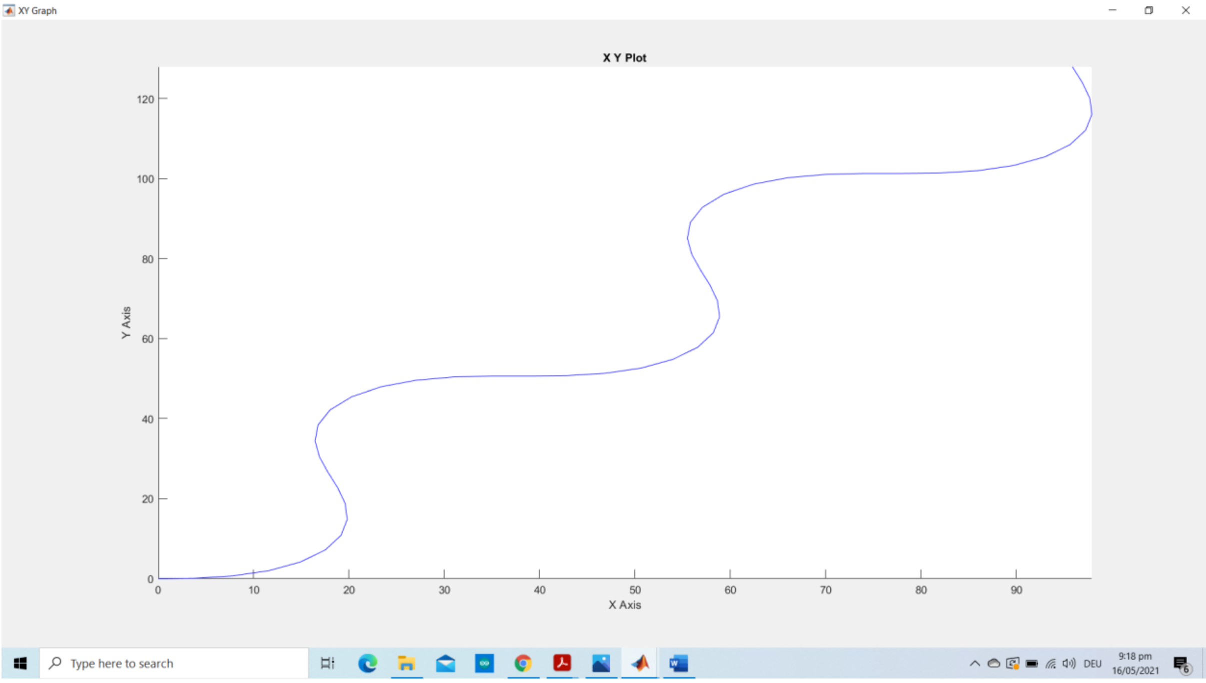


v = 10m/s



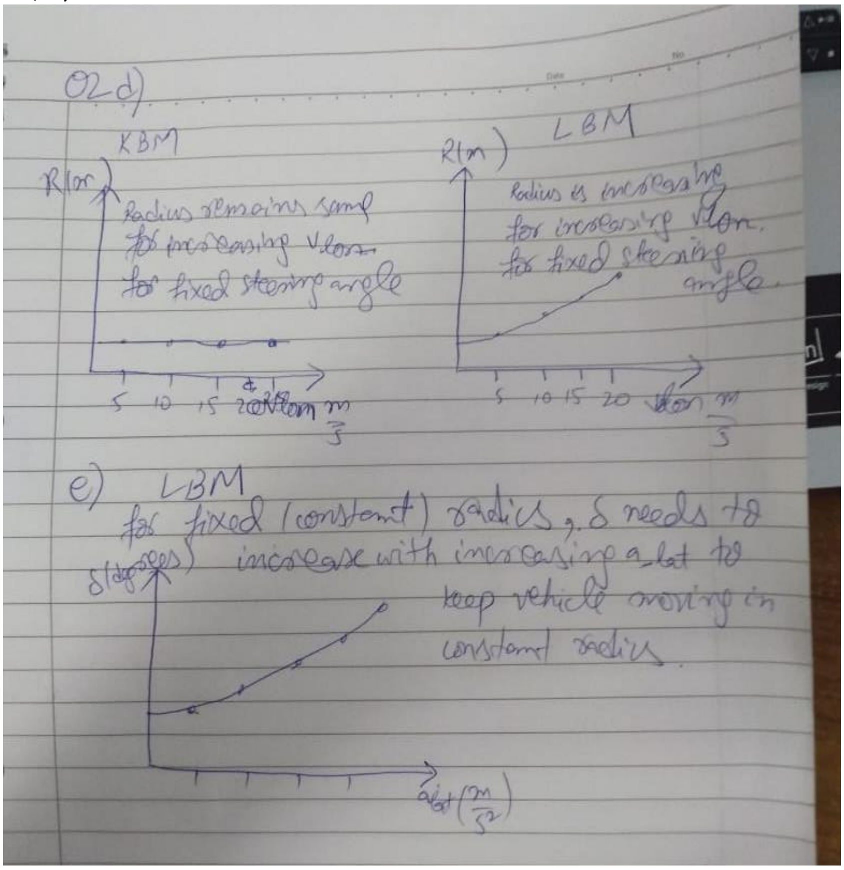
V = 20m/s

Sameed Quais – 715861 Exercise Sheet 2 Solutions



For high velocity LBM shows more deviation than KBM in X-Y diagram.

2d,e)



3a)

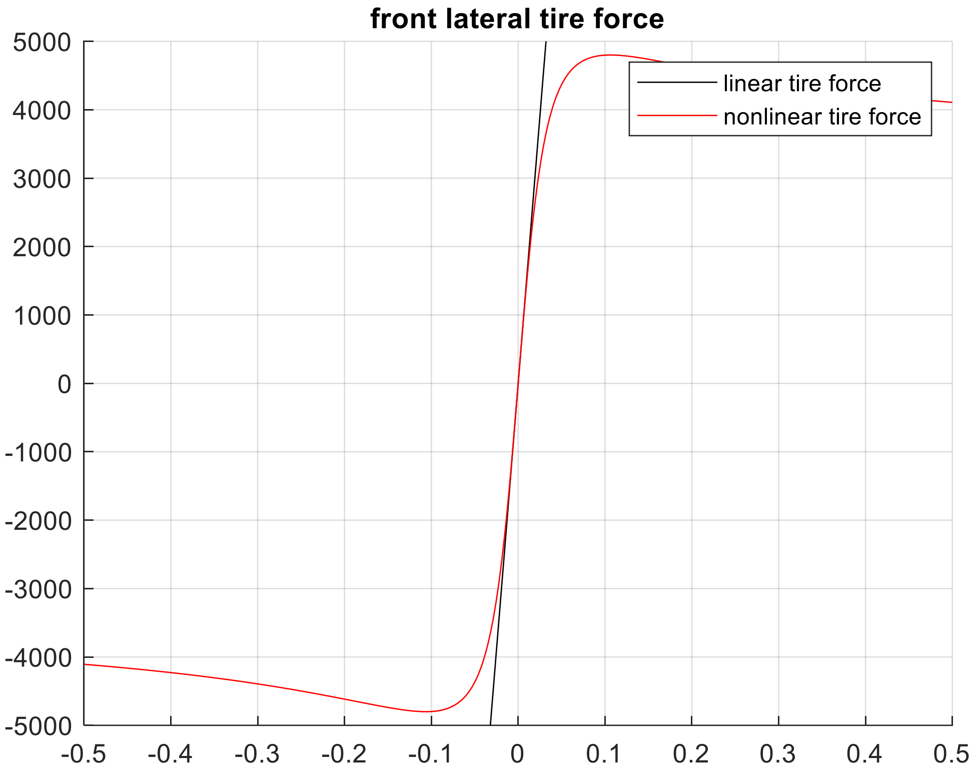


Figure 1: Linear and nonlinear tire force over the slip angle for front tire force

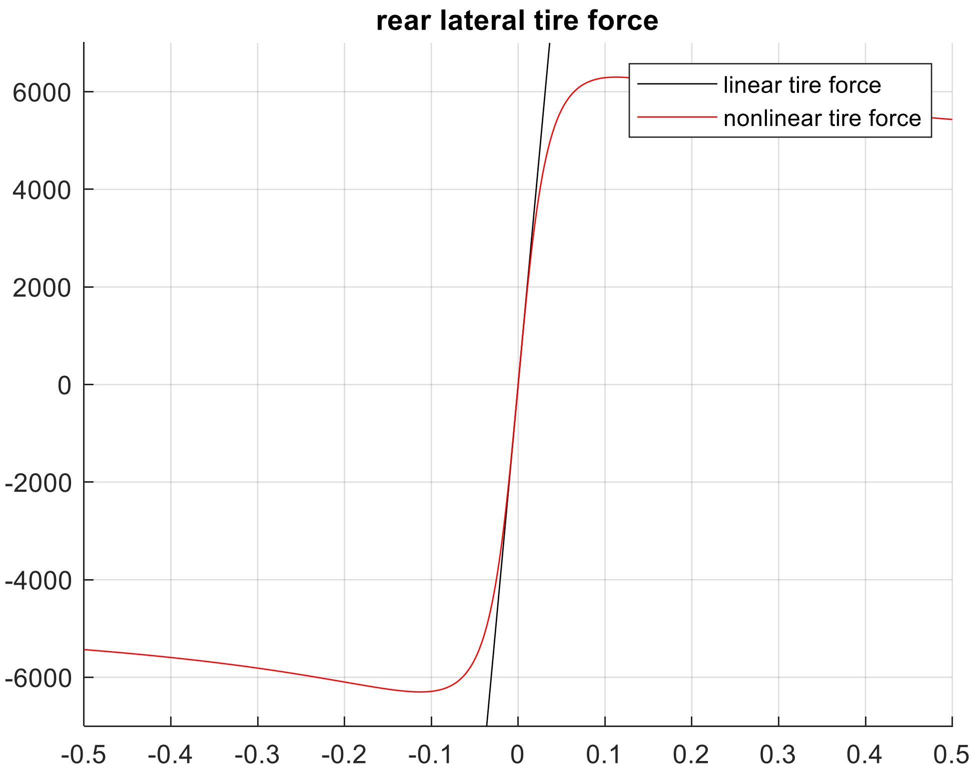


Figure 2: Linear and nonlinear tire force over the slip angle range for rear tire

3b)

Non-linear bicycle model in Simulink file. It's X_Y diagram is shown below:

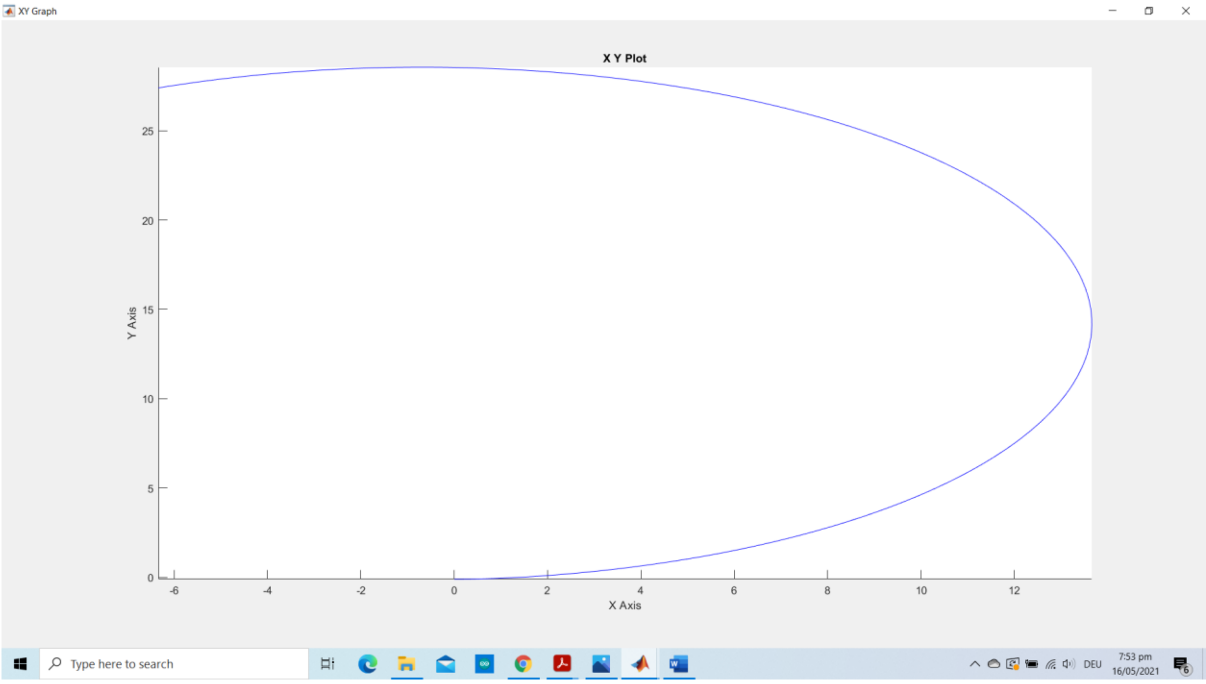


Figure 3: X-Y Diagram of Non-linear bicycle model

3c)

Sinusoidal with v_lon = 5 m/s

x0 = 0 ;

y0 = -0.1;

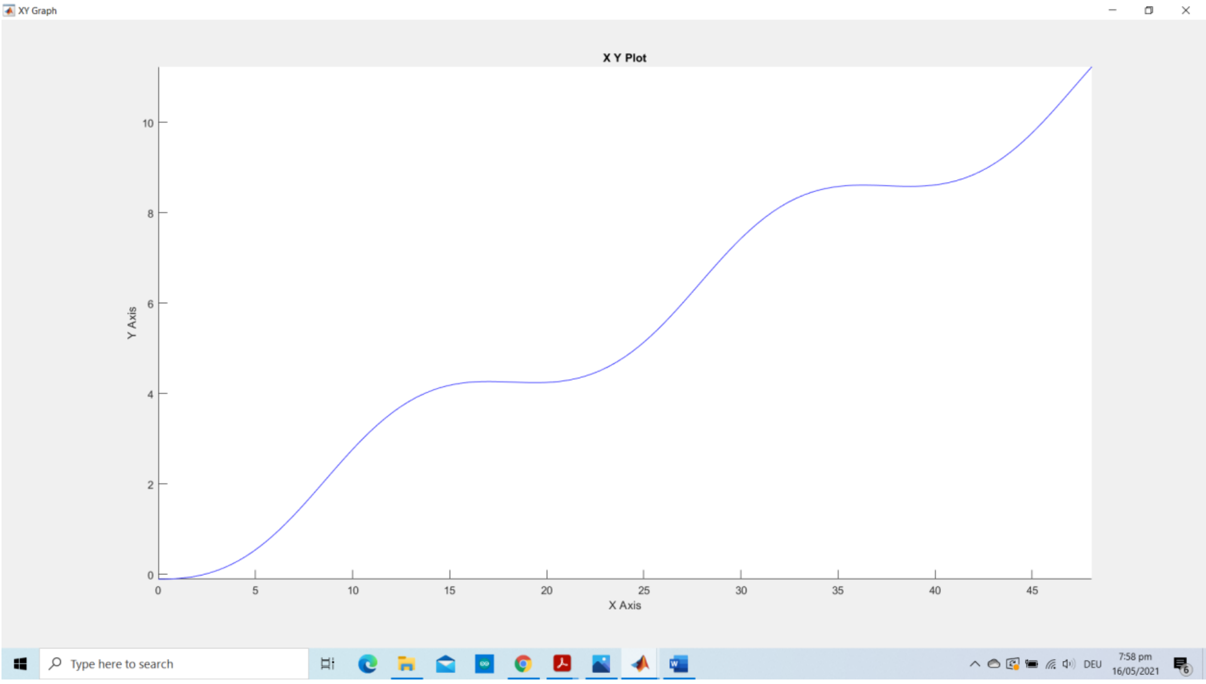


Figure 4: NLBM

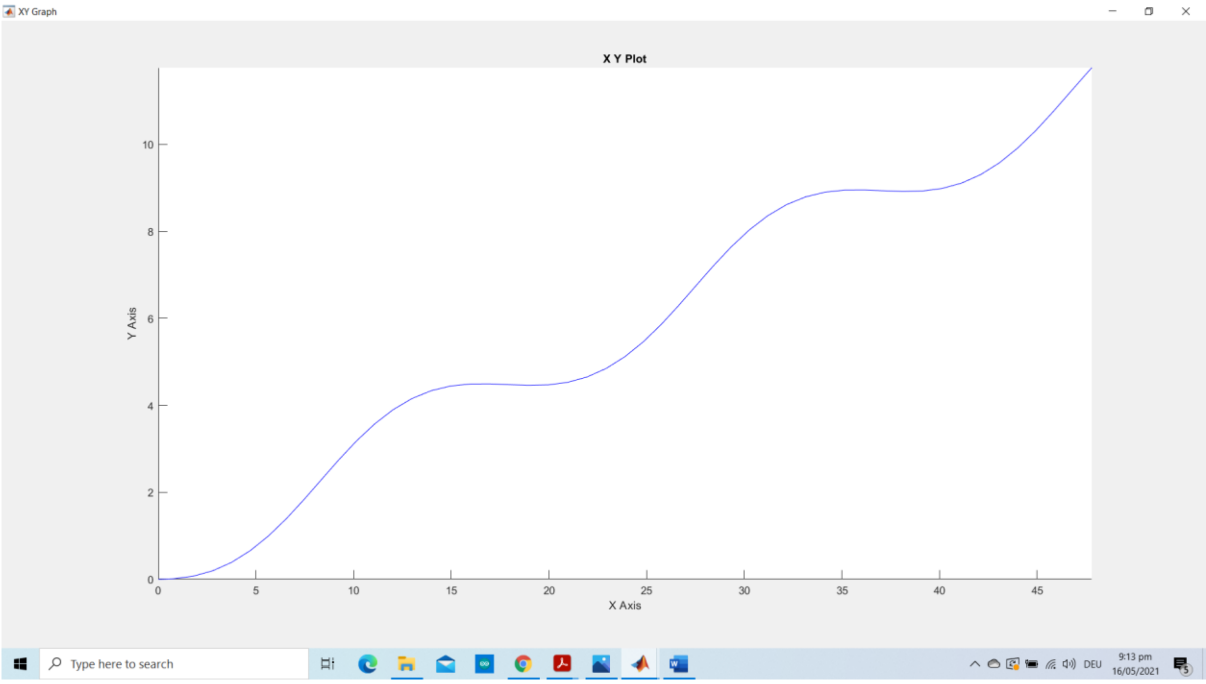


Figure 5: KBM

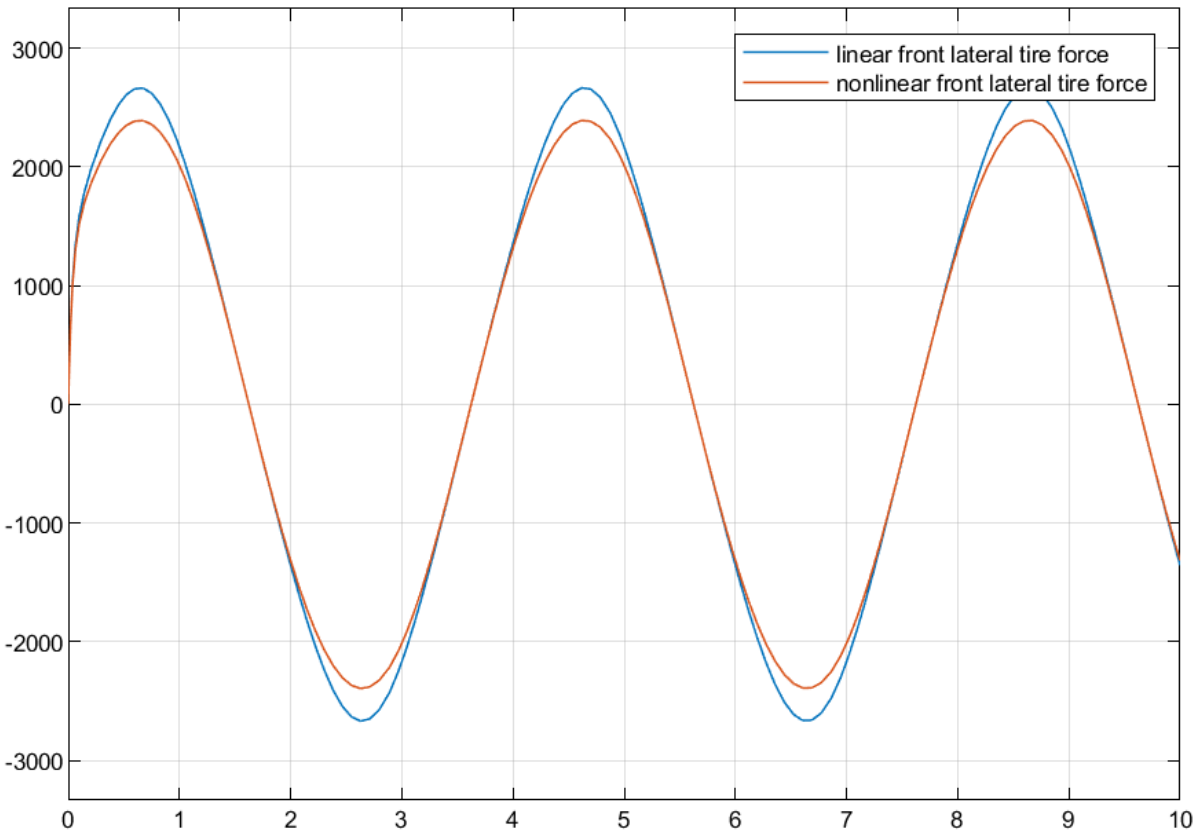


Figure 6: Comparison of LBM and NLBM forces

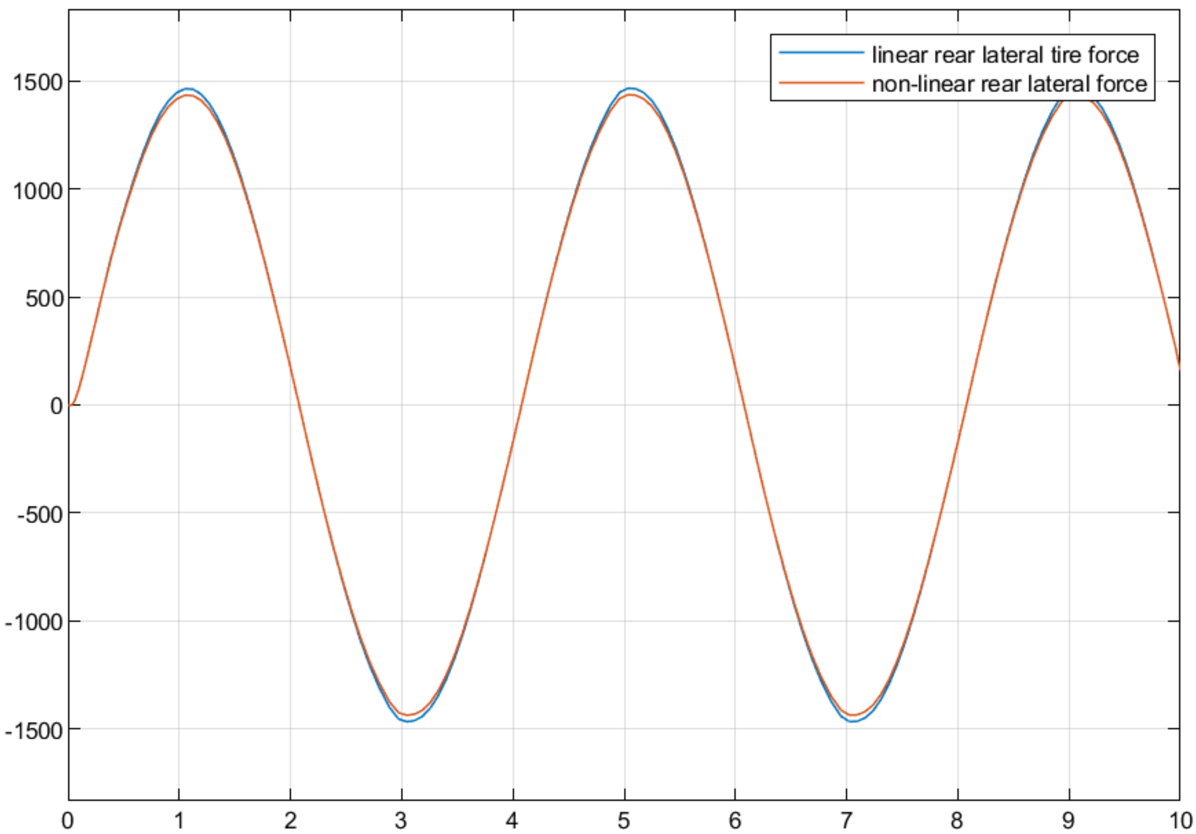


Figure 7: Comparison of LBM and NLBM forces

Sinusoidal with v_lon = 10 m/s

x0 = 0 ;

y0 = -0.1;

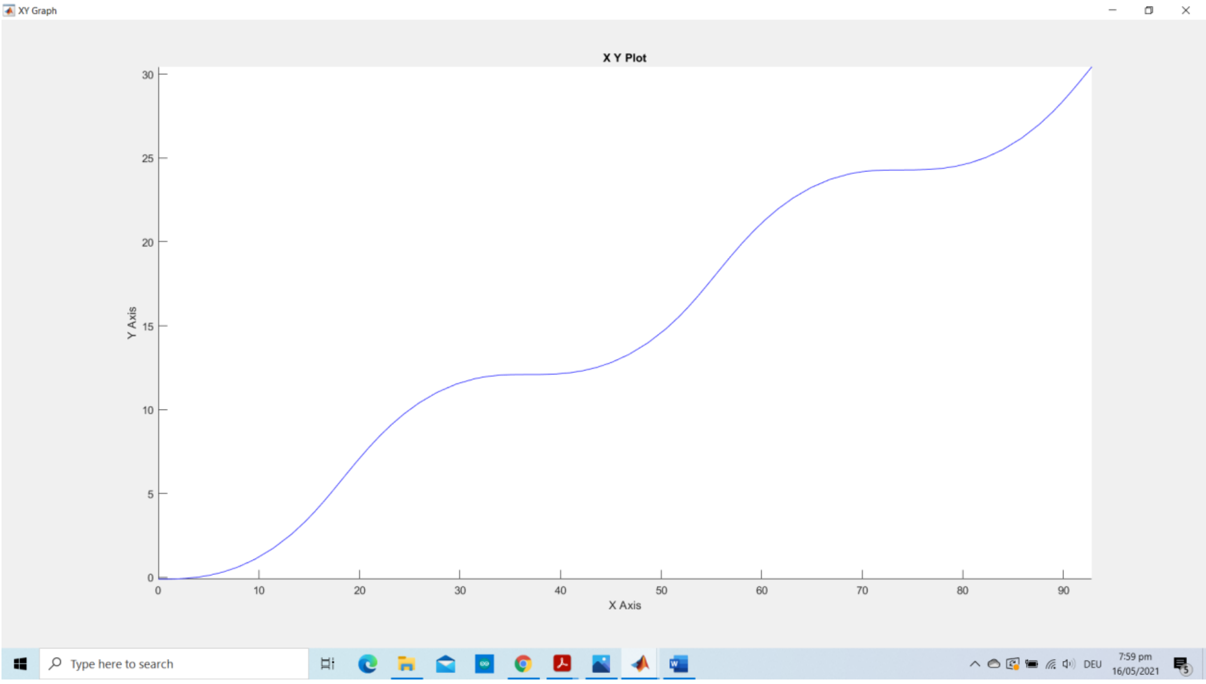


Figure 8: NLBM

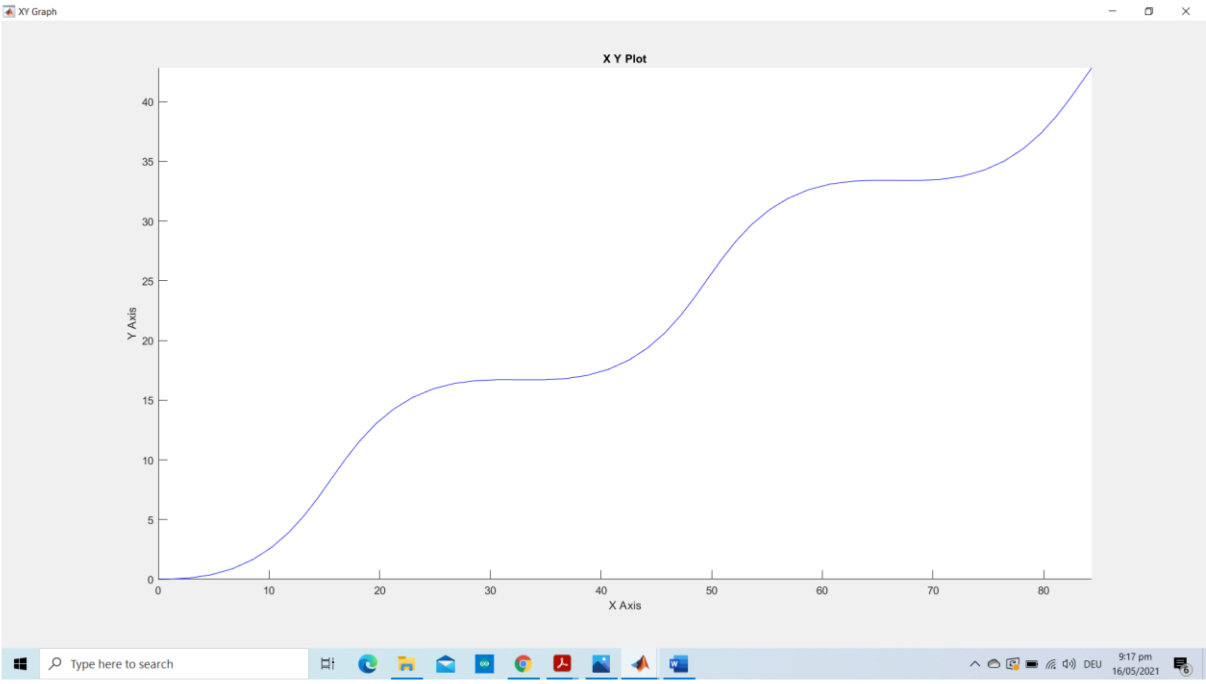


Figure 9: KBM

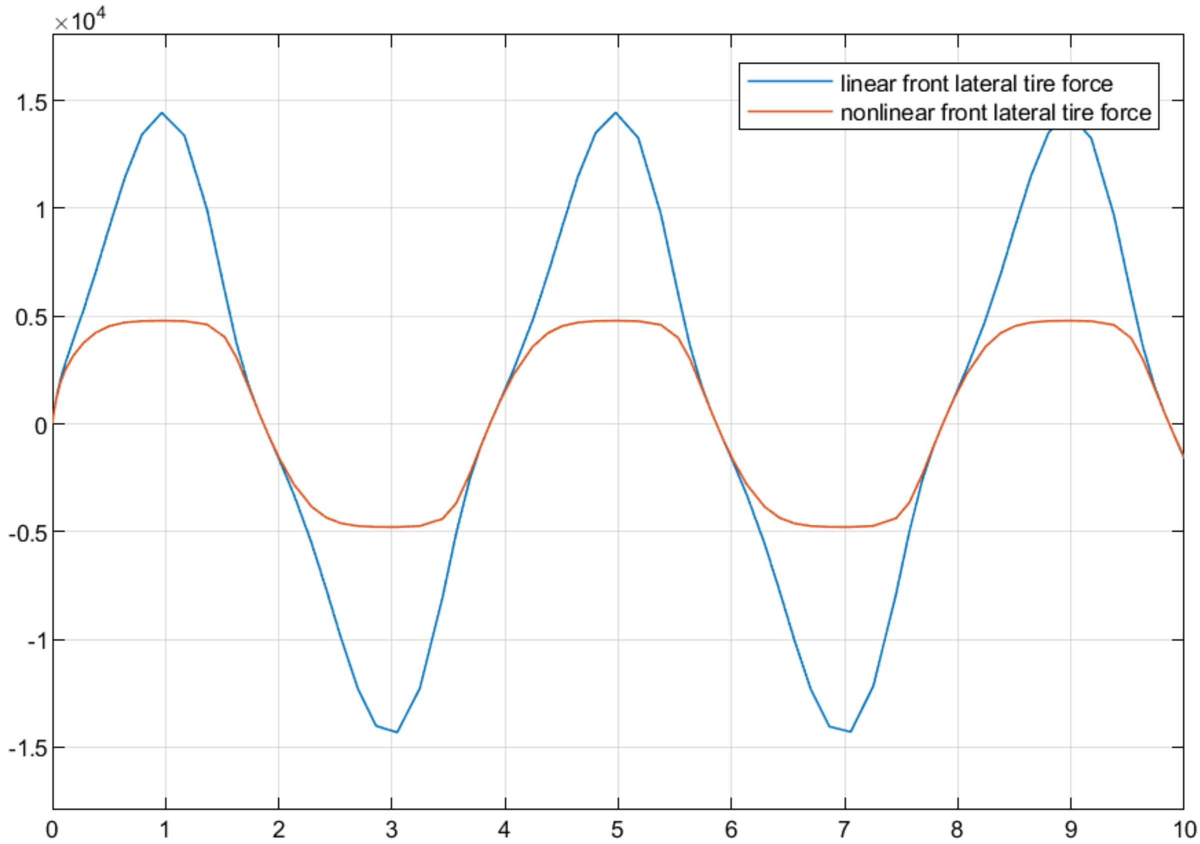


Figure 10: Comparison of LBM and NLBM forces

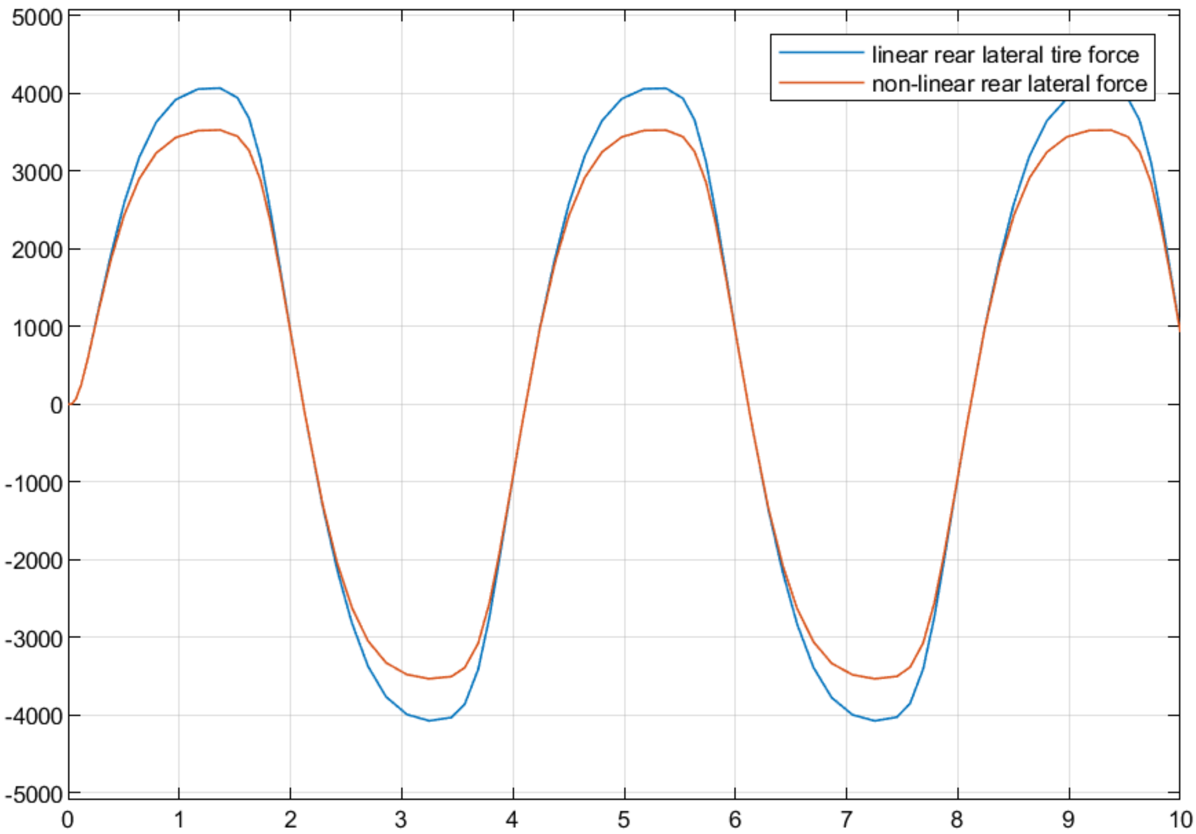


Figure 11: Comparison of LBM and NLBM forces

Sinusoidal with v_lon = 20 m/s

x0 = 0 ;

y0 = -0.1;

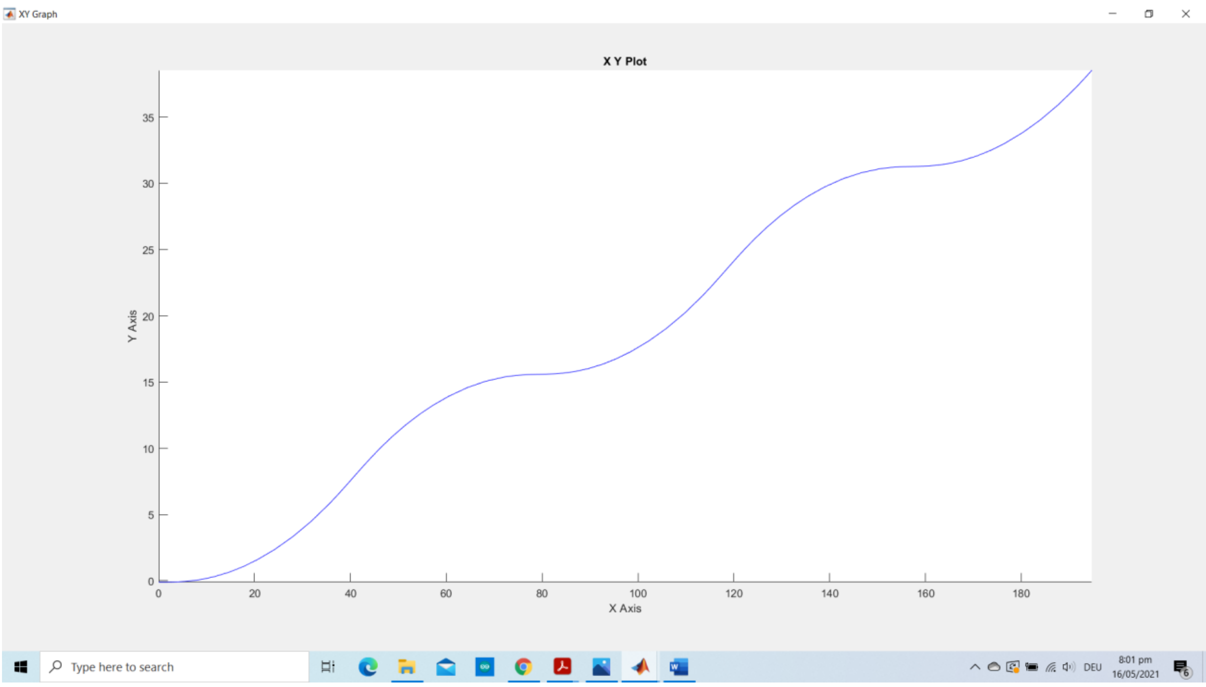


Figure 12:NLBM

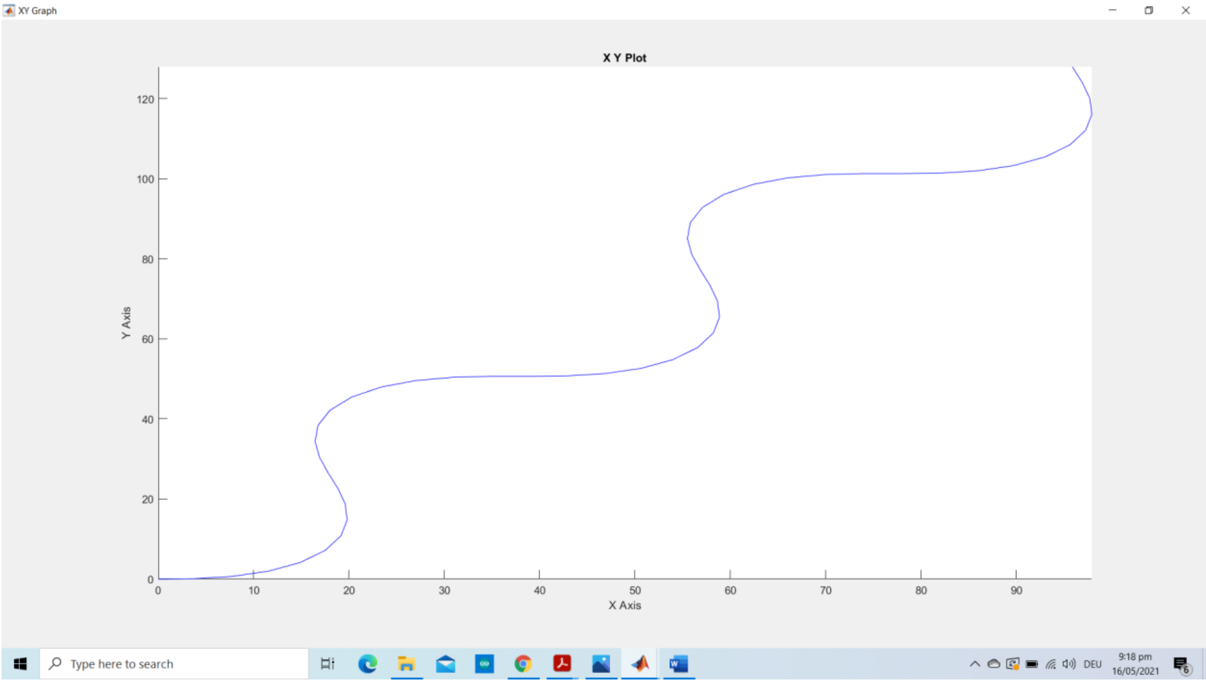


Figure 13: KBM

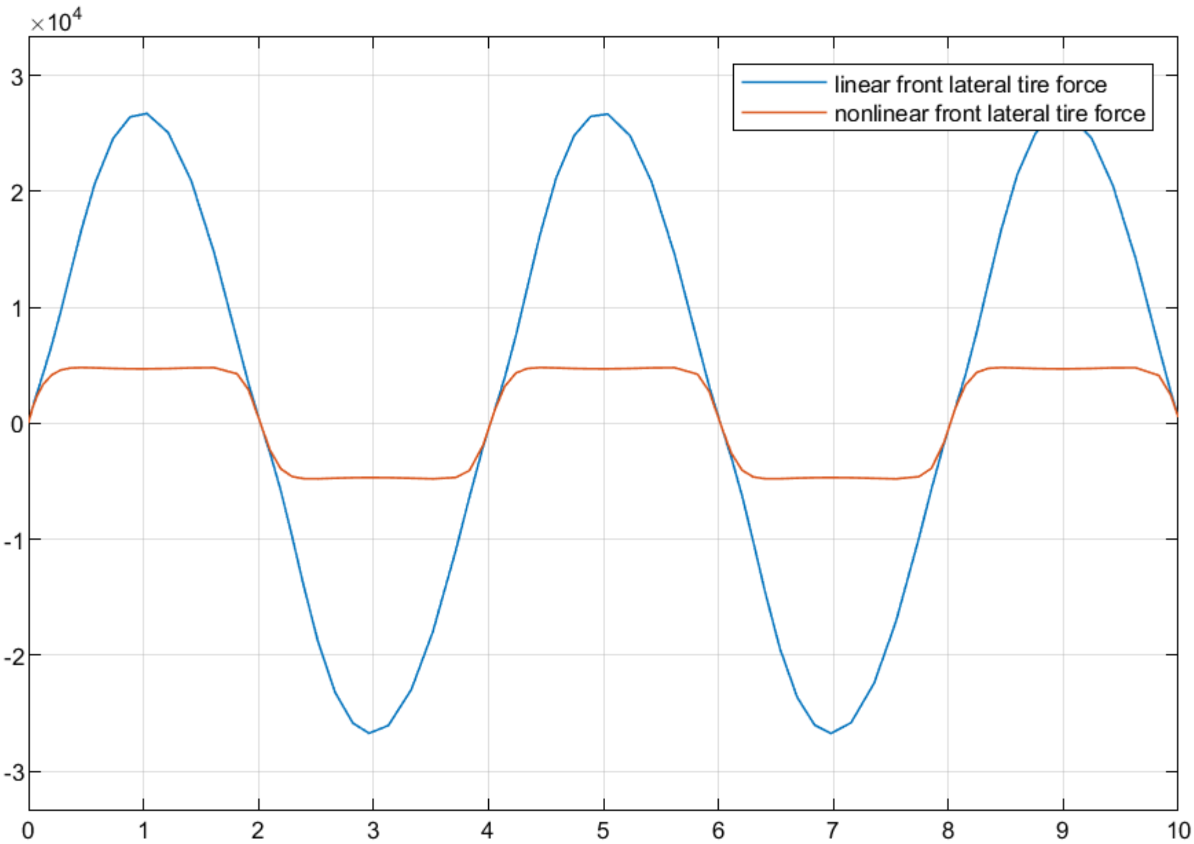


Figure 14: Comparison of LBM and NLBM forces

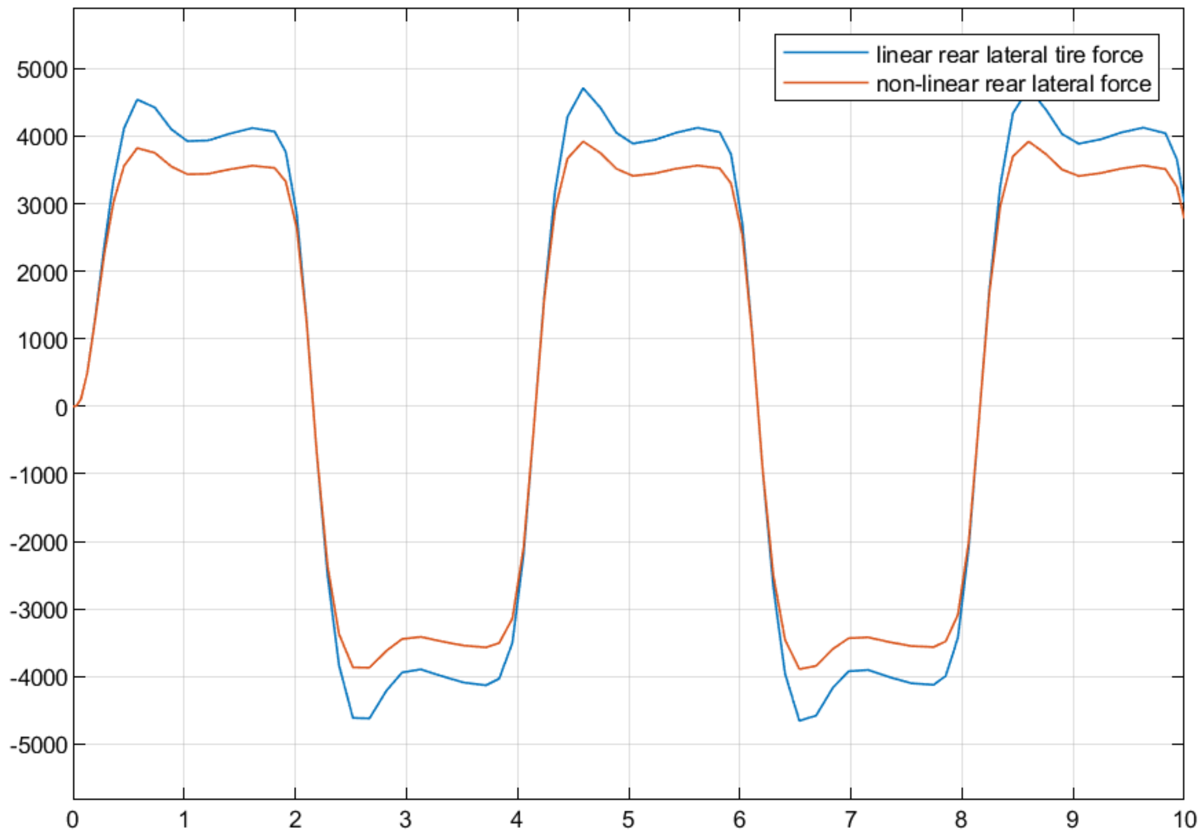


Figure 15: Comparison of LBM and NLBM forces

It can be concluded from X-Y graph in figure 4 & 5, 8 & 9 and 12 & 13 at high longitudinal velocities the non-linear bicycle model deviates from KBM.

From figure 6, 7, 10, 11, 14 and 15 that as the longitudinal velocity increases the difference in LBM and NLBM front tire lateral forces is larger as compared to the rear tire lateral forces.

3d)

V_lon = 5 m/s

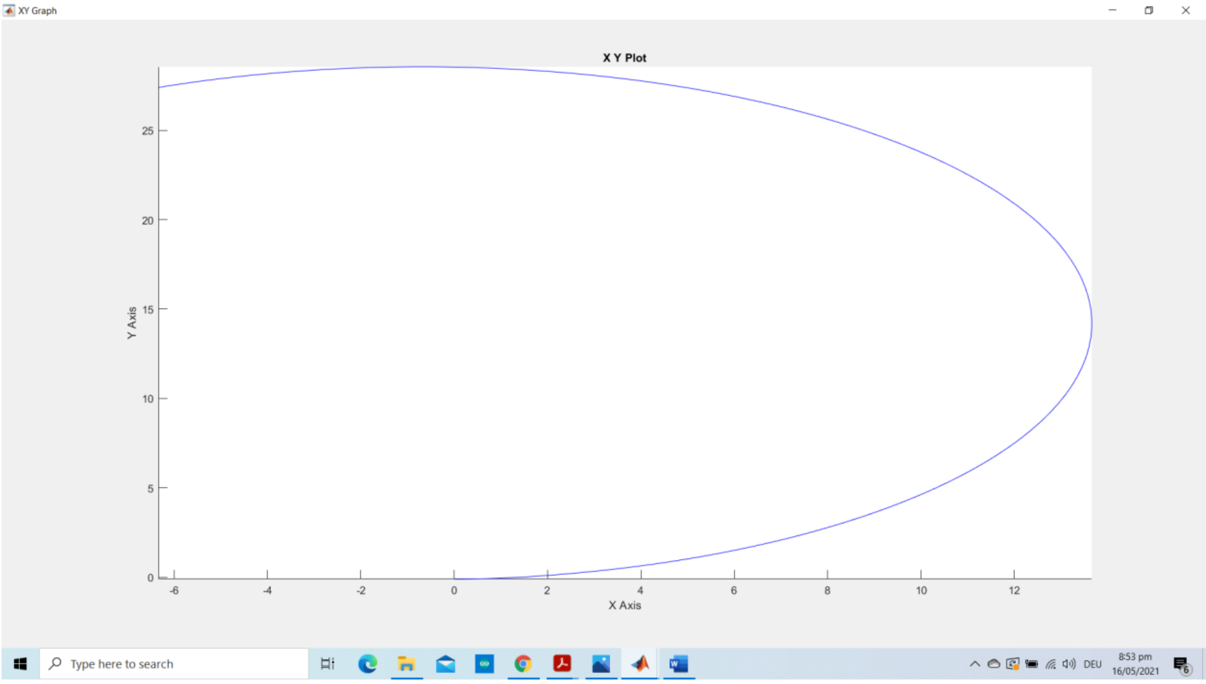


Figure 16: X-Y diagram at given v_lon.

V_lon = 15 m/s

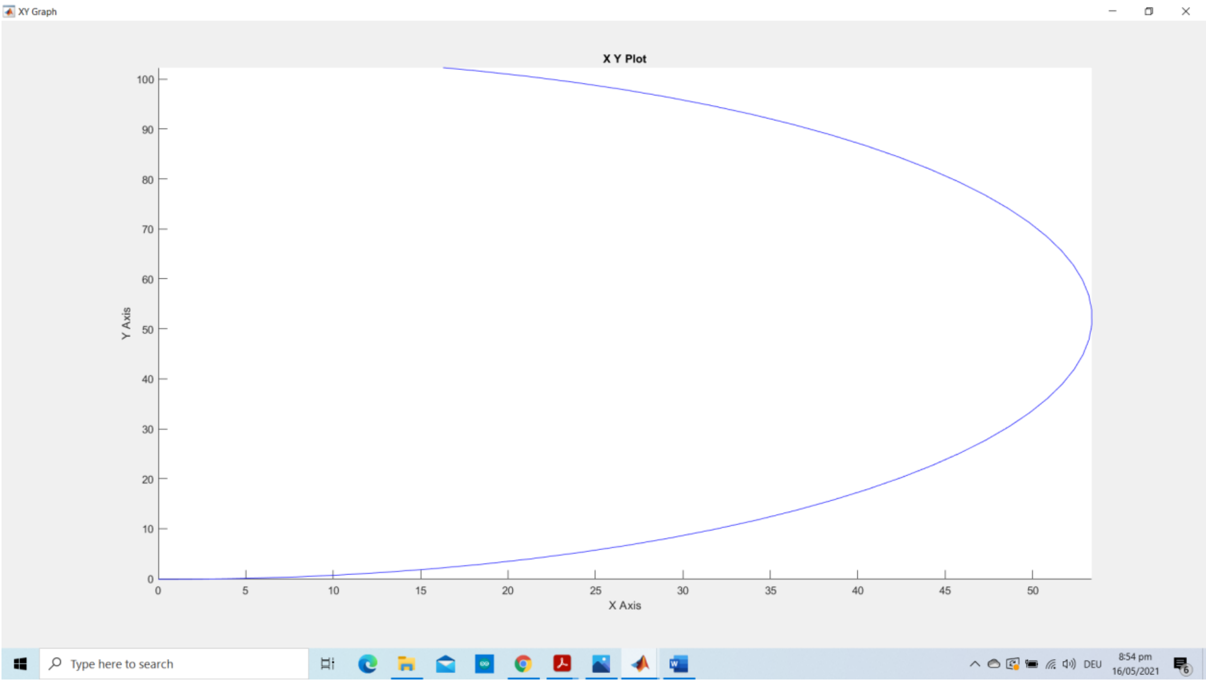


Figure 17: X-Y diagram at given v_lon.

V_lon = 30 m/s

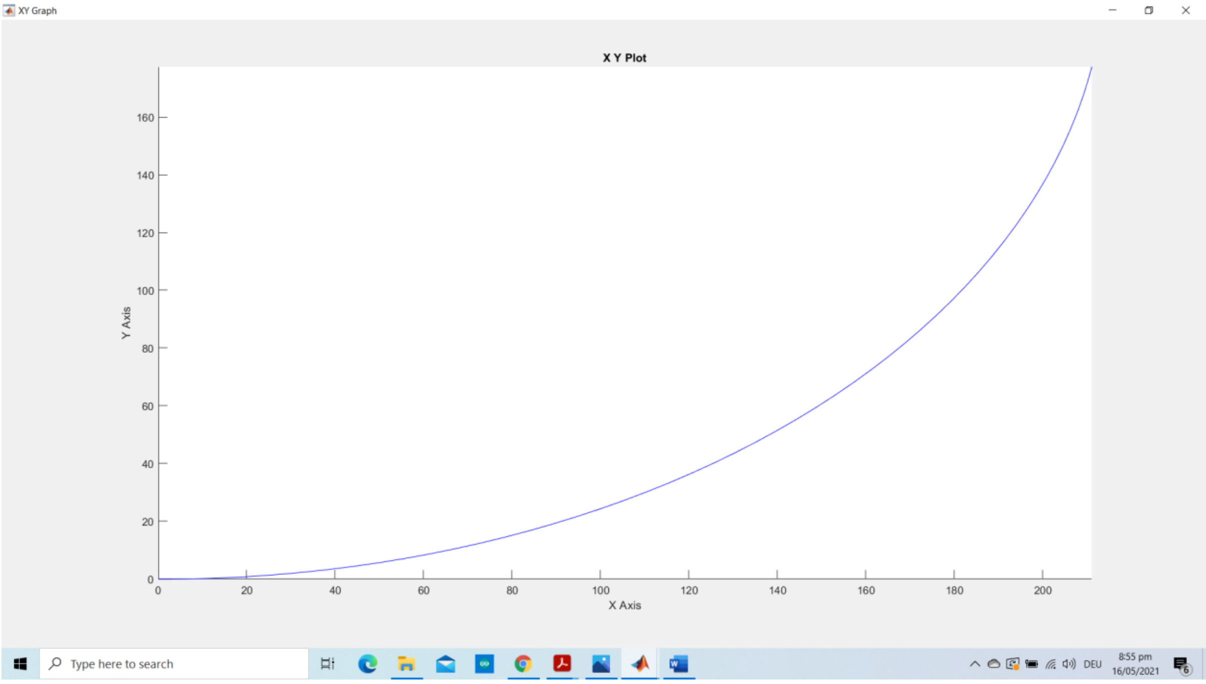


Figure 18: X-Y diagram at given v_lon

As we increase the value of longitudinal velocity the radius increases.

As compared to linear and kinematic bicycle model for same vale of delta, non-linear bicycle model requires larger radius.