AS5570 Principles of Guidance of Autonomous Vehicles

Assignment 2 Part 1

Group 1

Question 7 Part 1 (PPN, Non-manoeuvring target)

Parameters

X_{P0} = (0, 0) m
θ_0 = 30°
R_0 = 7000 m
V_P = 400 m/s
nu = 1/0.6
α_T = 60°
N = 4

Simulation settings

ODE solving method: Euler
Time step: 0.001 s
Termination criteria: R < 0.5 m or t > 60 s

Tested initial conditions

α_{P0} = 10°, 85°
Non-manoeuvring target

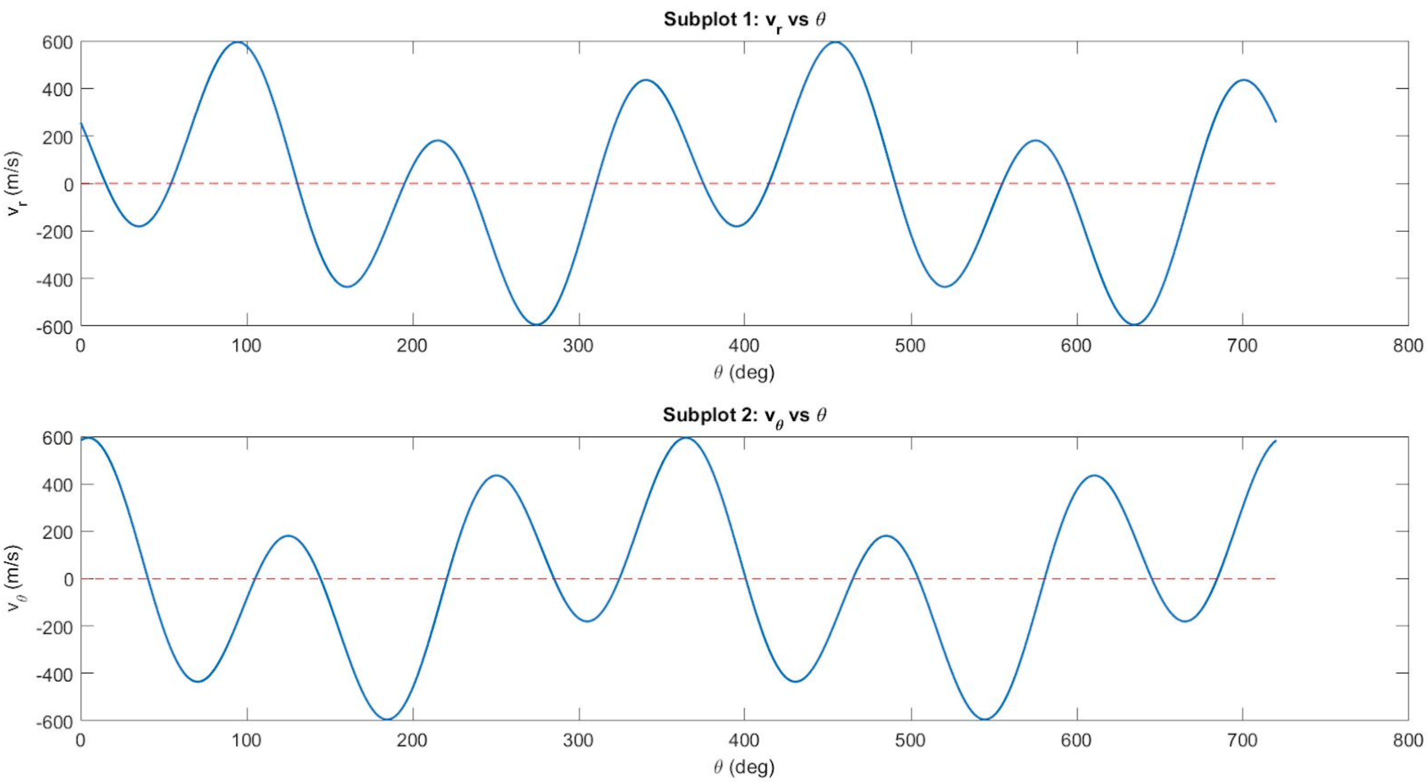
Observations

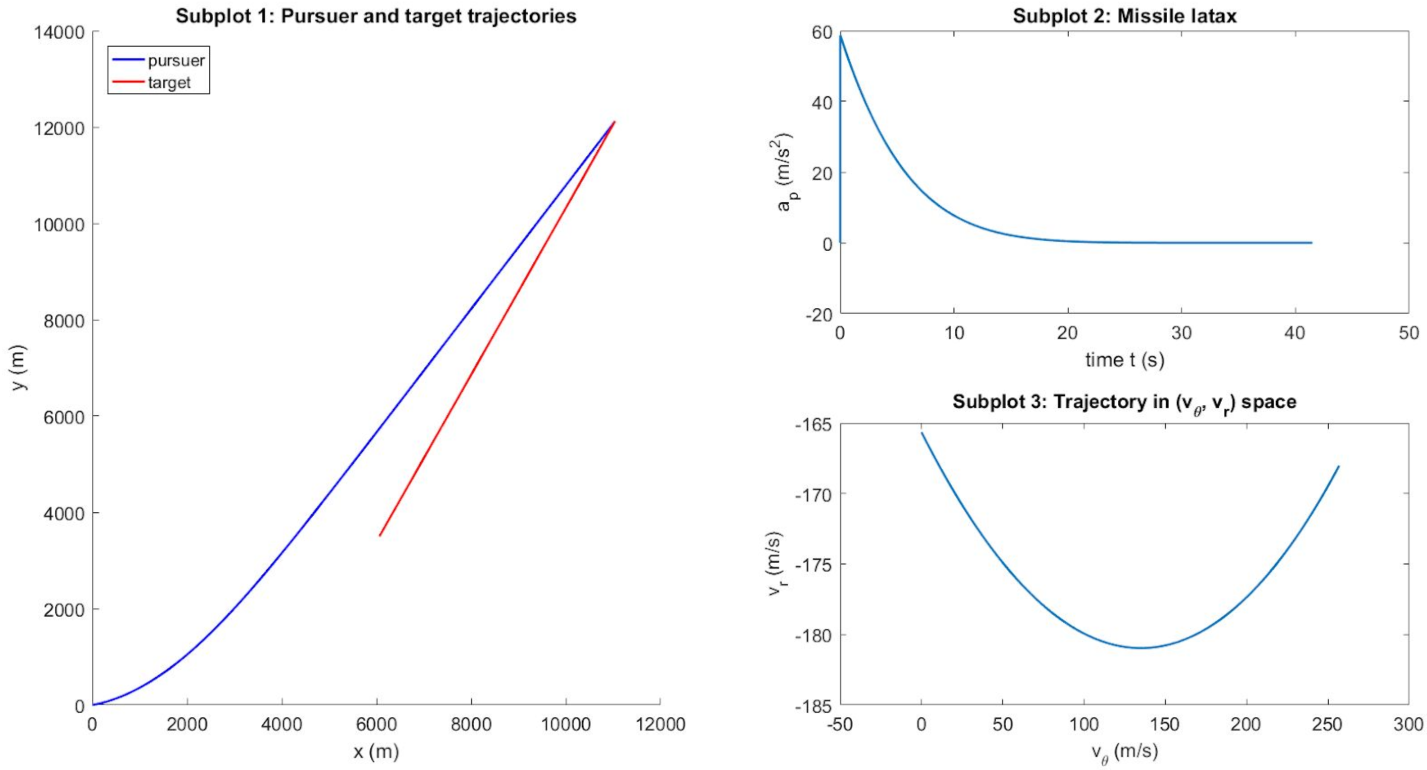
α_{P0} (°)	Interception occurs?	t_f (s)	Impact angle (°)
10	Yes	41.485	7.9401
85	Yes	41.731	17.6479

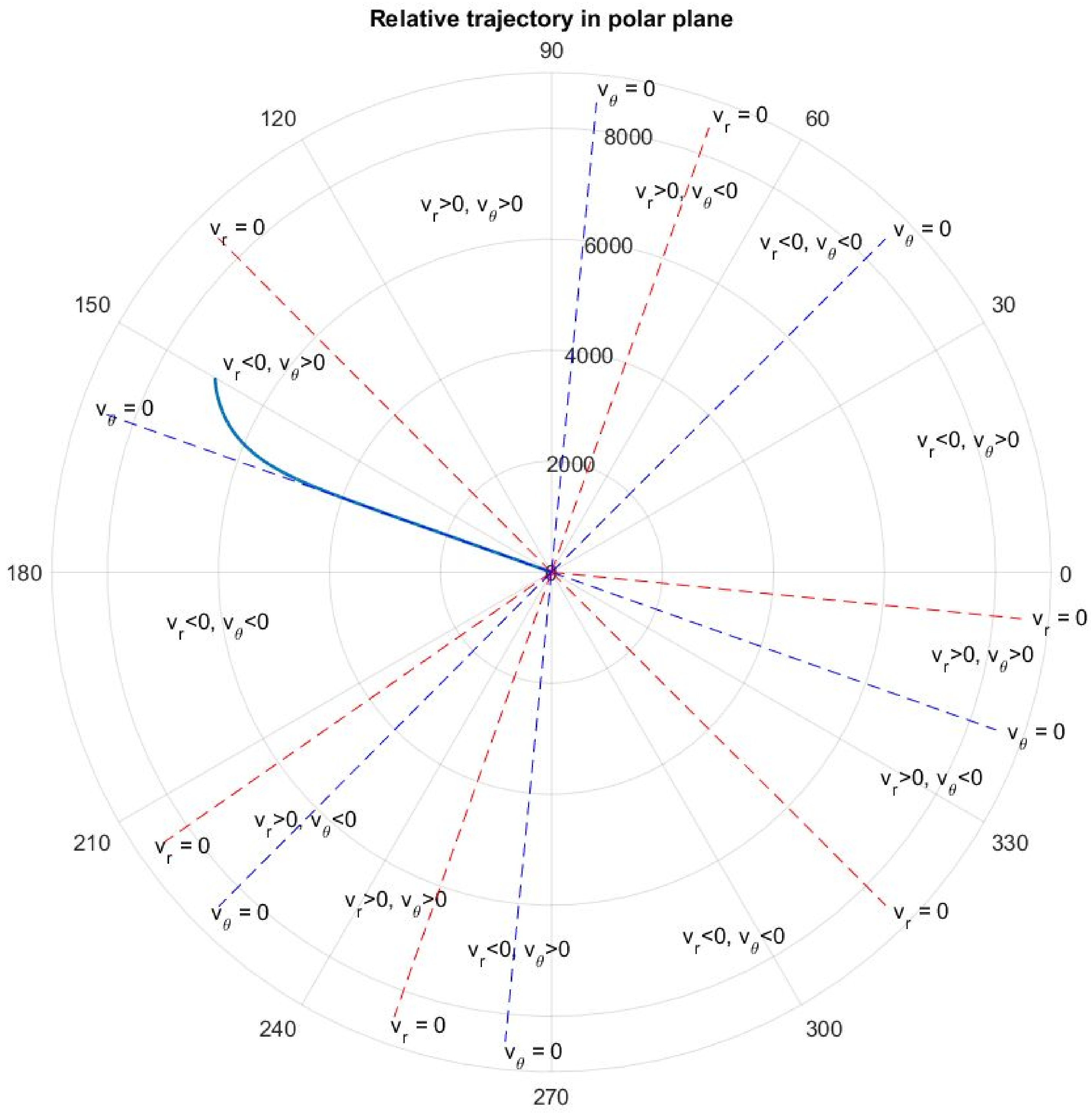
- Unlike the TPN and RTPN cases, the pursuer is able to intercept the target for α_{P0} = 85°.
- As observed from the plots of v_r and v_θ vs θ,
    - The roots θ_r and θ_θ are alternating and
    - $v_r(\theta_\theta) \cdot \frac{d\,v_\theta}{d\,\theta}(\theta_\theta) > 0$
- As observed from the polar plots of relative pursuer trajectory, for both cases of α_{P0}, the pursuer starts in a sector where $v_r < 0$ and $v_\theta > 0$. Hence, R decreases while θ increases until $\theta = \theta_\theta$ (where $v_\theta = 0$). The relative trajectory tends to lie along the $v_\theta = 0$ line since that line cannot be crossed.
- As observed from the rectilinear plot of the trajectories, for both cases of α_{P0}, the pursuer remains in one half-plane bounded by the target trajectory.

- In both cases of α_{P0}, missile latax is initially of high magnitude and decreases to 0 as time increases. For α_{P0} = 10°, a_P initially has a high positive value. For α_{P0} = 85°, a_P initially has a high negative value. This is because α_{P0} is respectively much lower than and much higher than the LOS angle and PPN guidance suitably changes a_P to correct the pursuer heading.
- For α_{P0} = 10°, the (v_θ, v_r) plot lies in the 4th quadrant. The signs of v_θ, v_r in this quadrant agree with those in the sector in which the trajectory lies. v_θ decreases, while v_r first decreases then increases.
- For α_{P0} = 85°, the (v_θ, v_r) plot lies in the 3rd quadrant. The signs of v_θ, v_r in this quadrant agree with those in the sector in which the trajectory lies. v_θ increases, while v_r decreases.

Plots (α_{P0} = 10°)

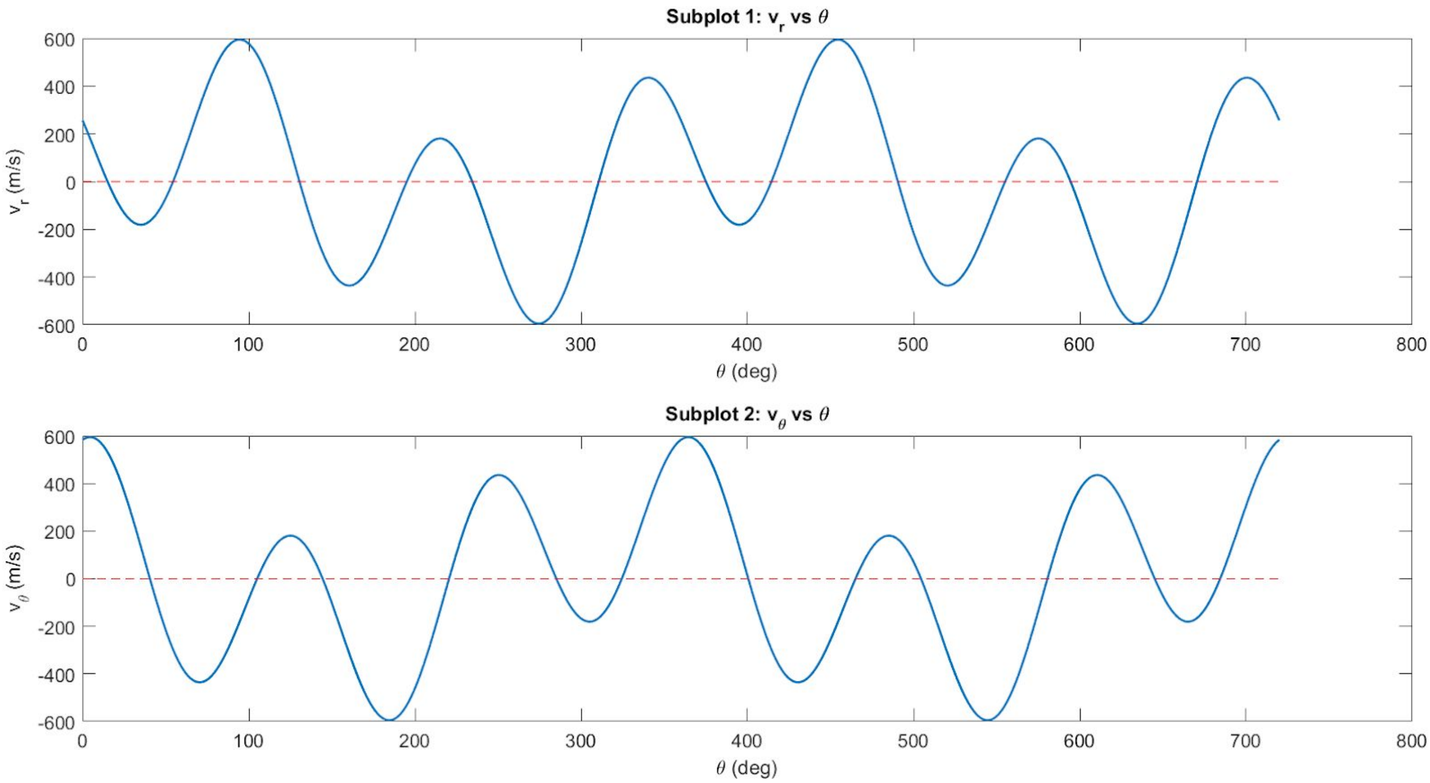


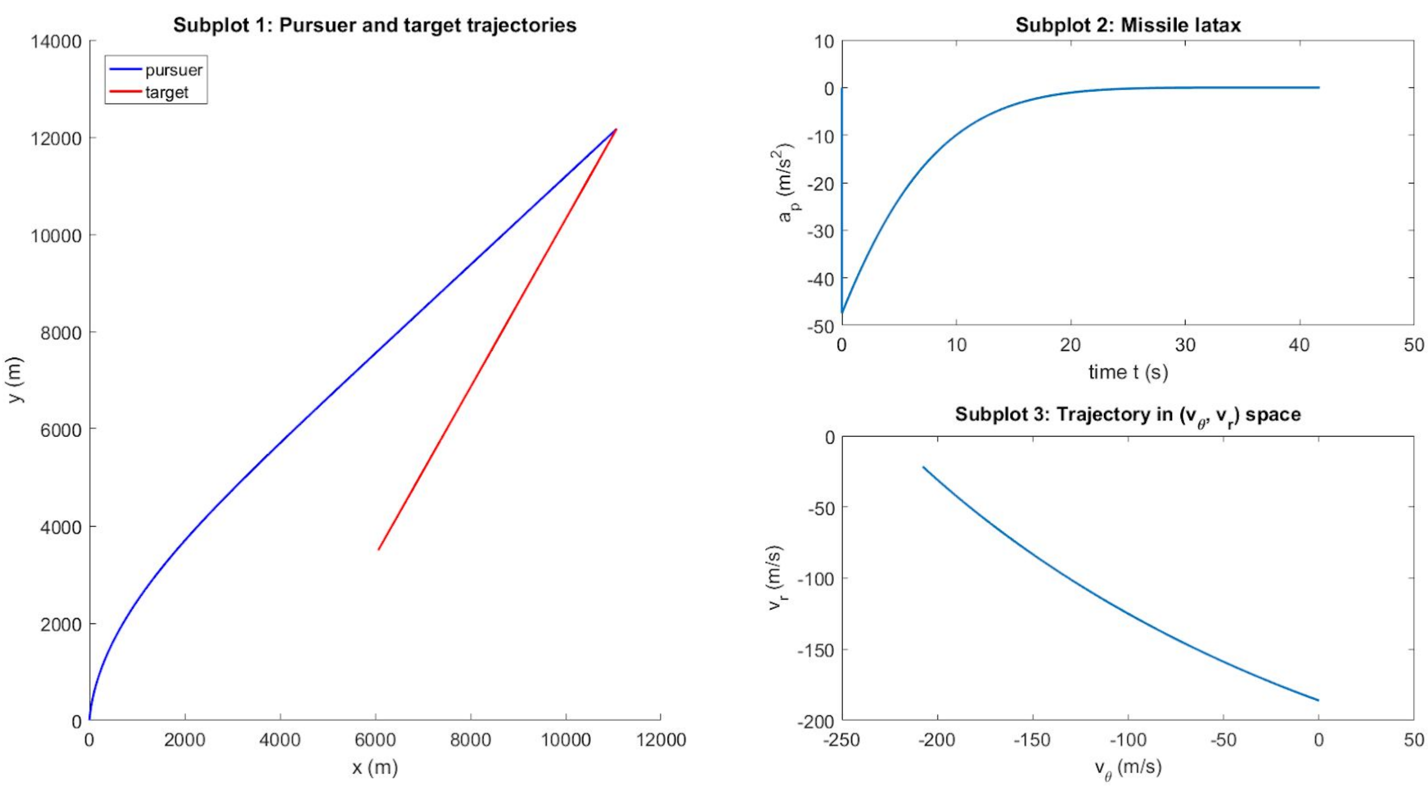

Subplot 1: Pursuer and target trajectories
pursuer
target
y (m)
x (m)
0
2000
4000
6000
8000
10000
12000
14000
Subplot 2: Missile latax
a_p (m/s^2)
time t (s)
-20
0
20
40
60
10
30
50
Subplot 3: Trajectory in (v_θ, v_r) space
v_r (m/s)
v_θ (m/s)
-165
-170
-175
-180
-185
-50
100
150
200
250
300



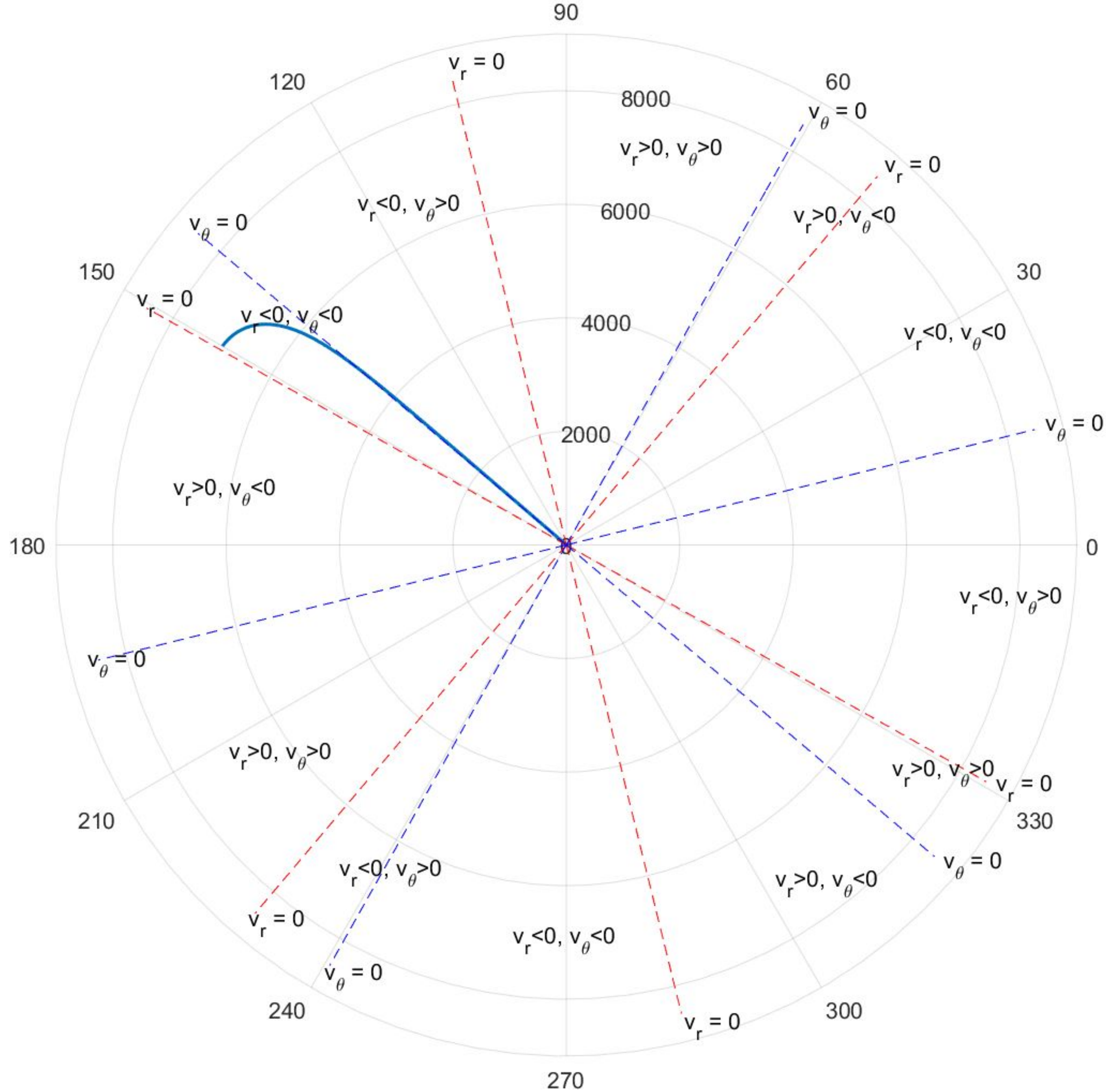
Relative trajectory in polar plane
90
120
60
150
30
180
0
210
330
240
300
270
2000
4000
6000
8000
$v_\theta = 0$
$v_r = 0$
$v_r>0,\ v_\theta>0$
$v_r>0,\ v_\theta<0$
$v_r<0,\ v_\theta<0$
$v_r<0,\ v_\theta>0$

Plots (α_{P0} = 85°)





Relative trajectory in polar plane



Question 7 Part 2 (PPN, Manoeuvring target)

Inputs

X_{P0} = (0, 0) m
θ_0 = 30°
R_0 = 7000 m
V_P = 400 m/s
nu = 1/0.6
α_{T0} = 0°
a_T = 30 m/s^2
N = 4

Simulation settings

ODE solving method: Euler
Time step: 0.001 s
Termination criteria: R < 0.5 m or t > 60 s

Tested initial conditions

α_{P0} = 10°, 85°
Manoeuvring target: α_{T0} = 0°, anti-clockwise manoeuvre

Part a) Yes, interception occurs and the impact angle ranges from 156.74° to 164.29° as N is varied from 3 to 6.

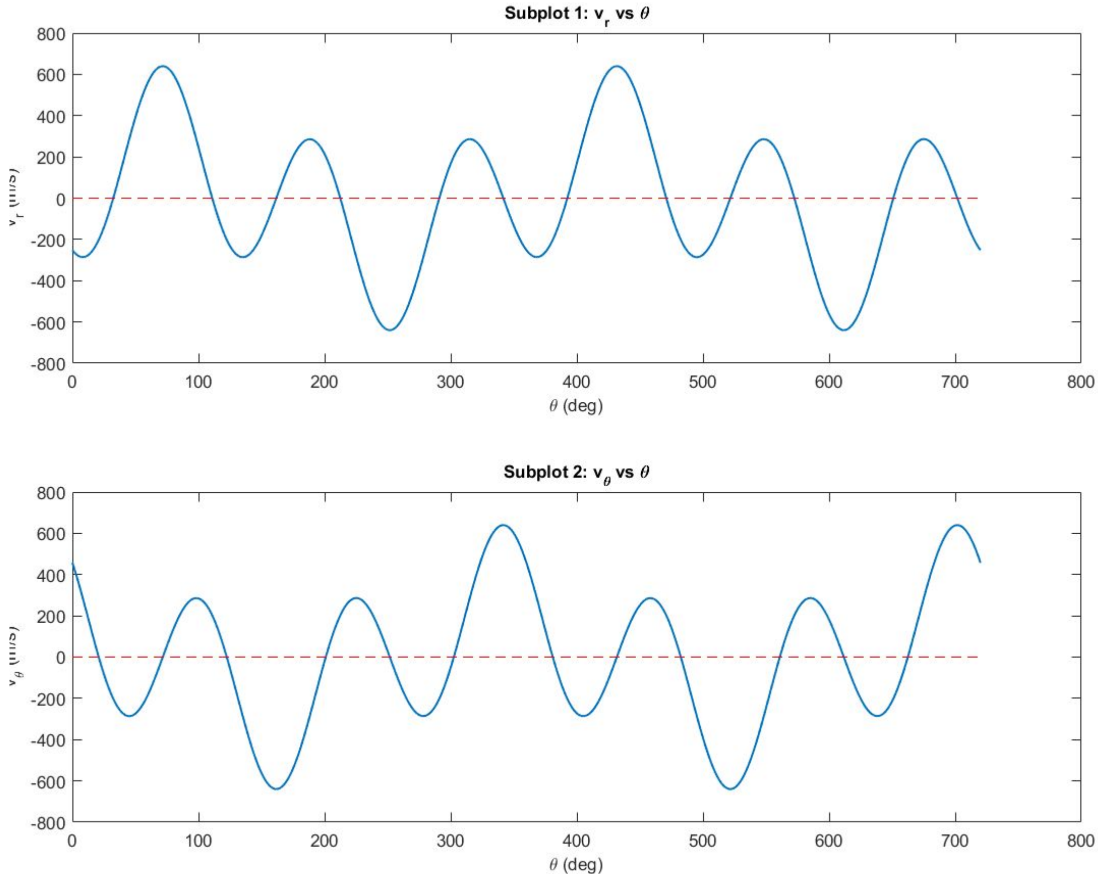
Observations

α_{P0} (°)	Interception occurs?	t_f (s)
10	Yes	24.94
85	Yes	24.39

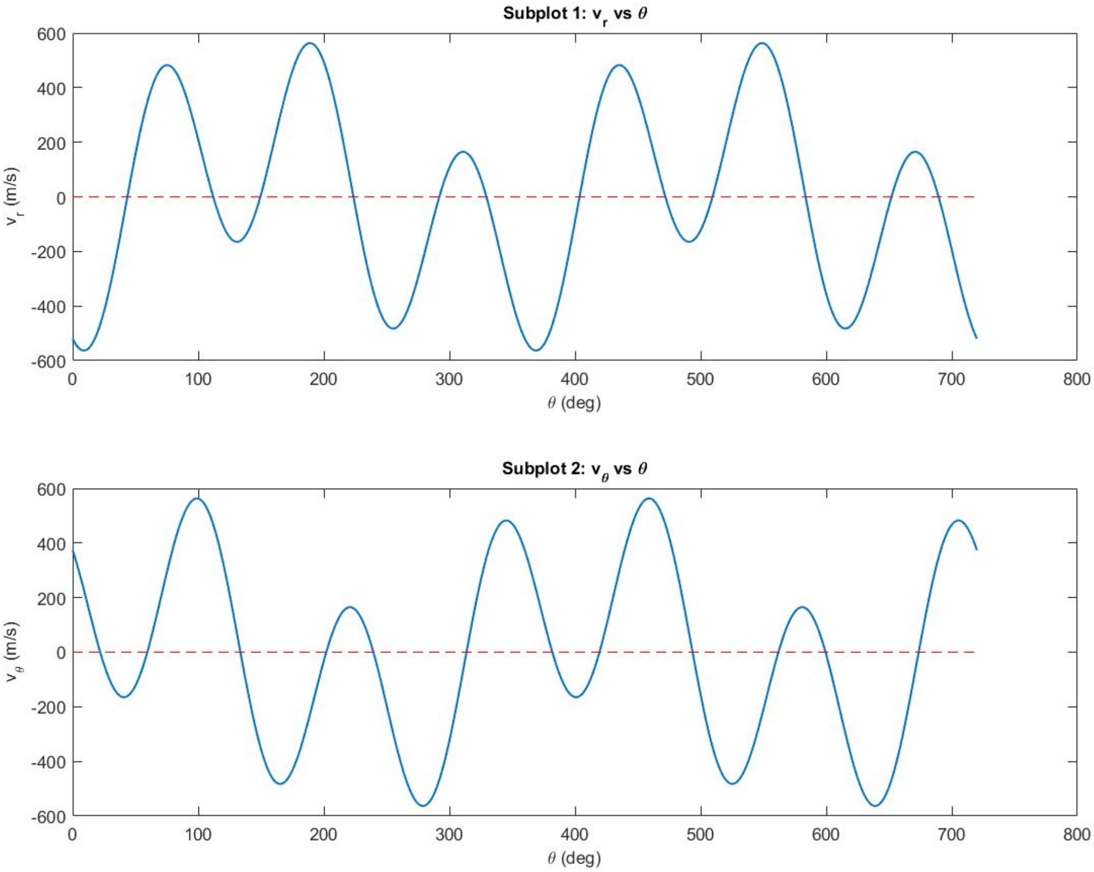
- Unlike the TPN and RTPN cases, the pursuer is able to intercept the target for α_{P0} = 85°.
- As observed from the plots of v_r and v_θ vs θ, for all t,
  - The roots θ_r and θ_θ are alternating and
  - $v_r(\theta_\theta) \cdot \frac{d v_\theta}{d \theta} (\theta_\theta) > 0$
- As observed from the (v_θ, v_r) plots and polar plots of relative pursuer trajectory, for both cases of α_{P0}, the trajectory tends to v_θ = 0.
- In both cases of α_{P0}, missile latax is initially of high magnitude, suddenly drops, increases until it peaks and then decreases steeply towards -infinity.
- For both values of α_{P0}, the (v_θ, v_r) plot lies in the 3rd and 4th quadrants.

Plots (α_{P0} = 10°)

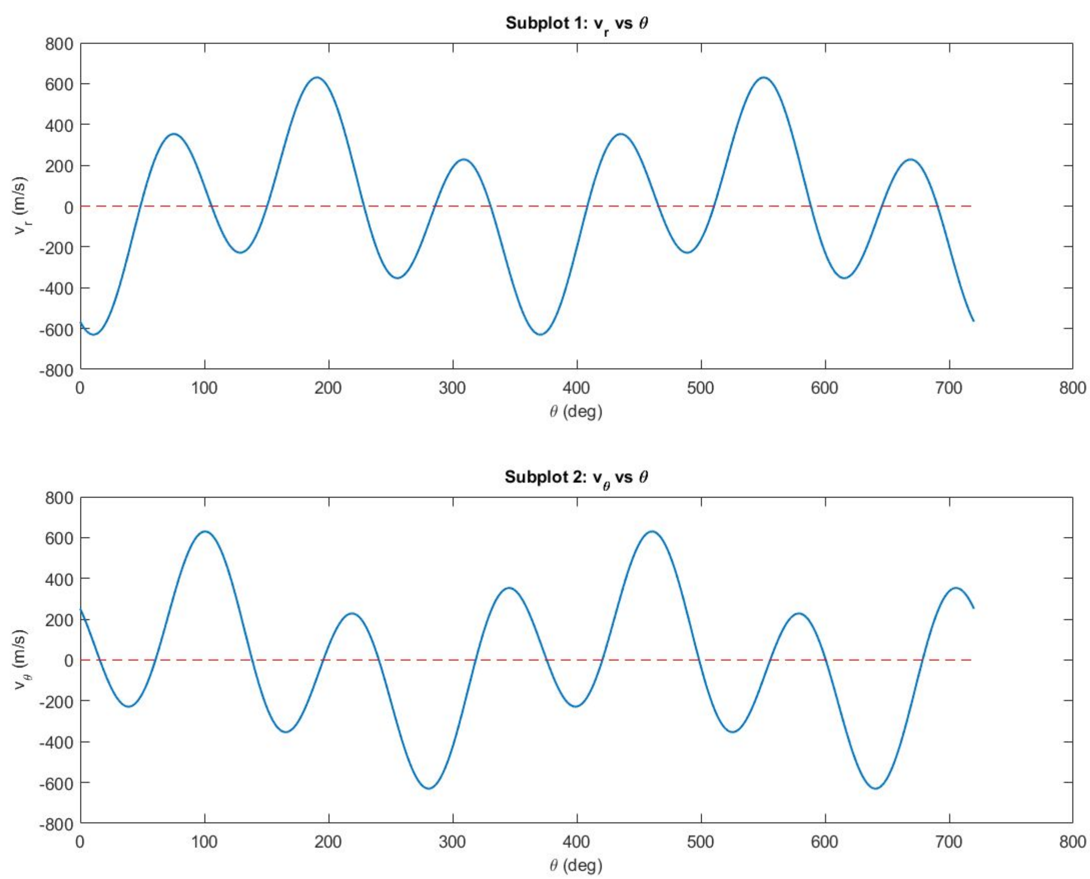
v_r , v_θ vs θ plot at t = 10 seconds

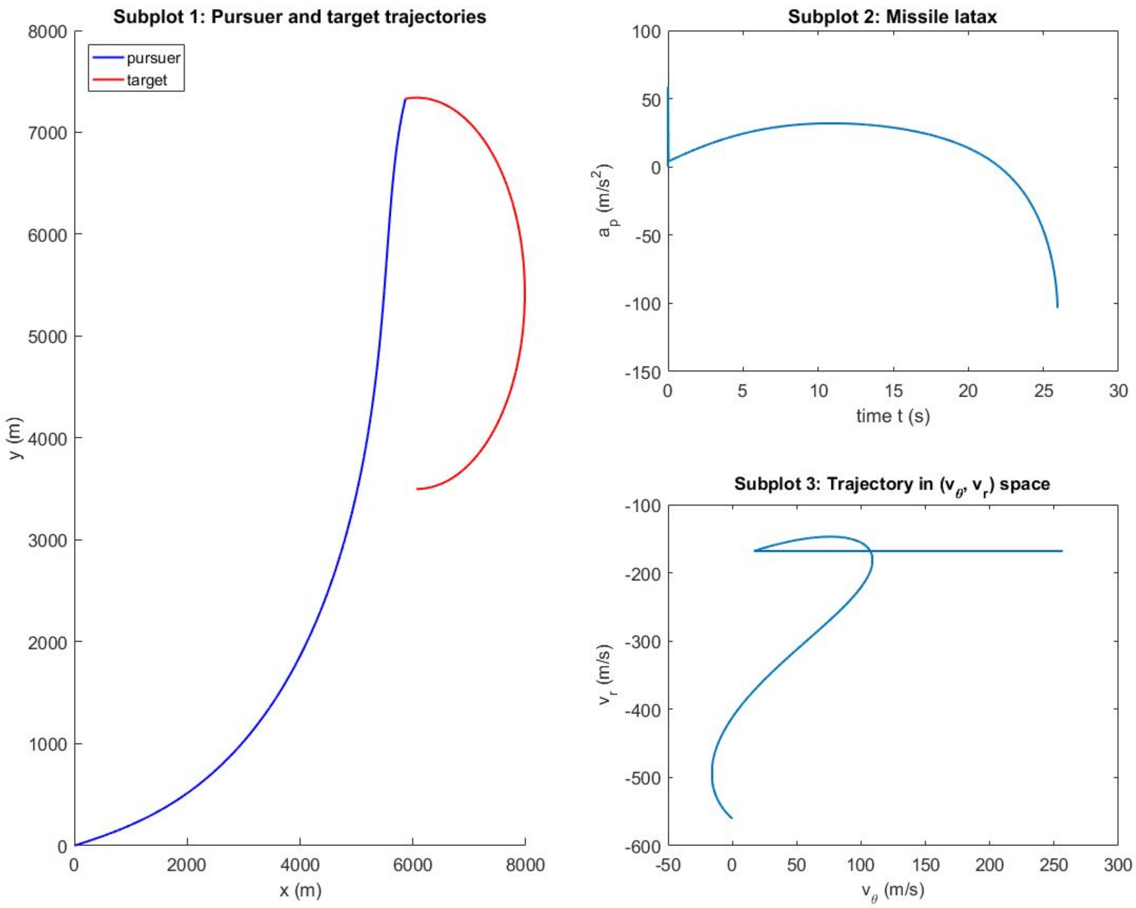


v_r , v_θ vs θ plot at t = 20 seconds



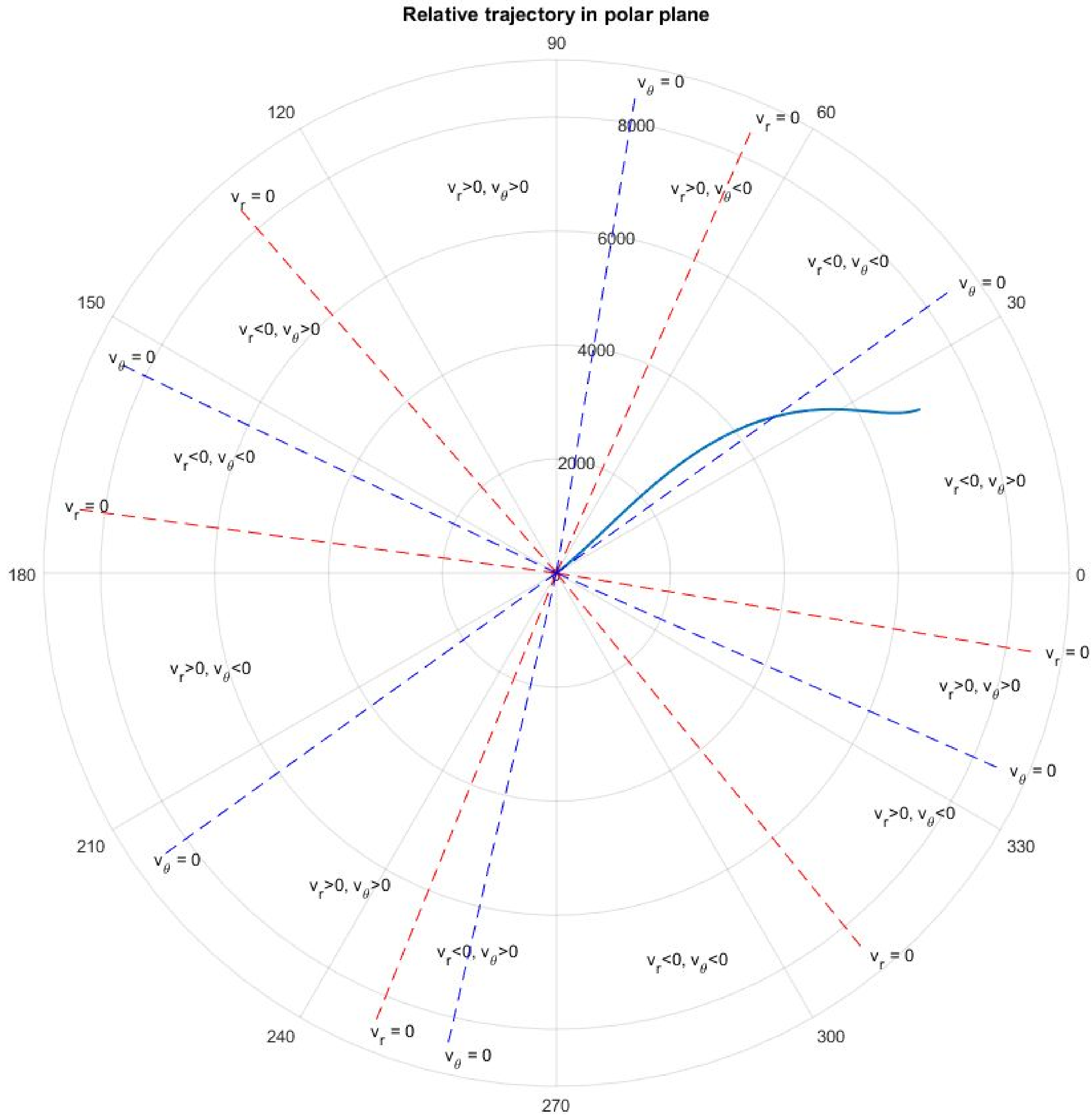
v_r , v_θ vs θ plot at t = t_f = 24.94 seconds



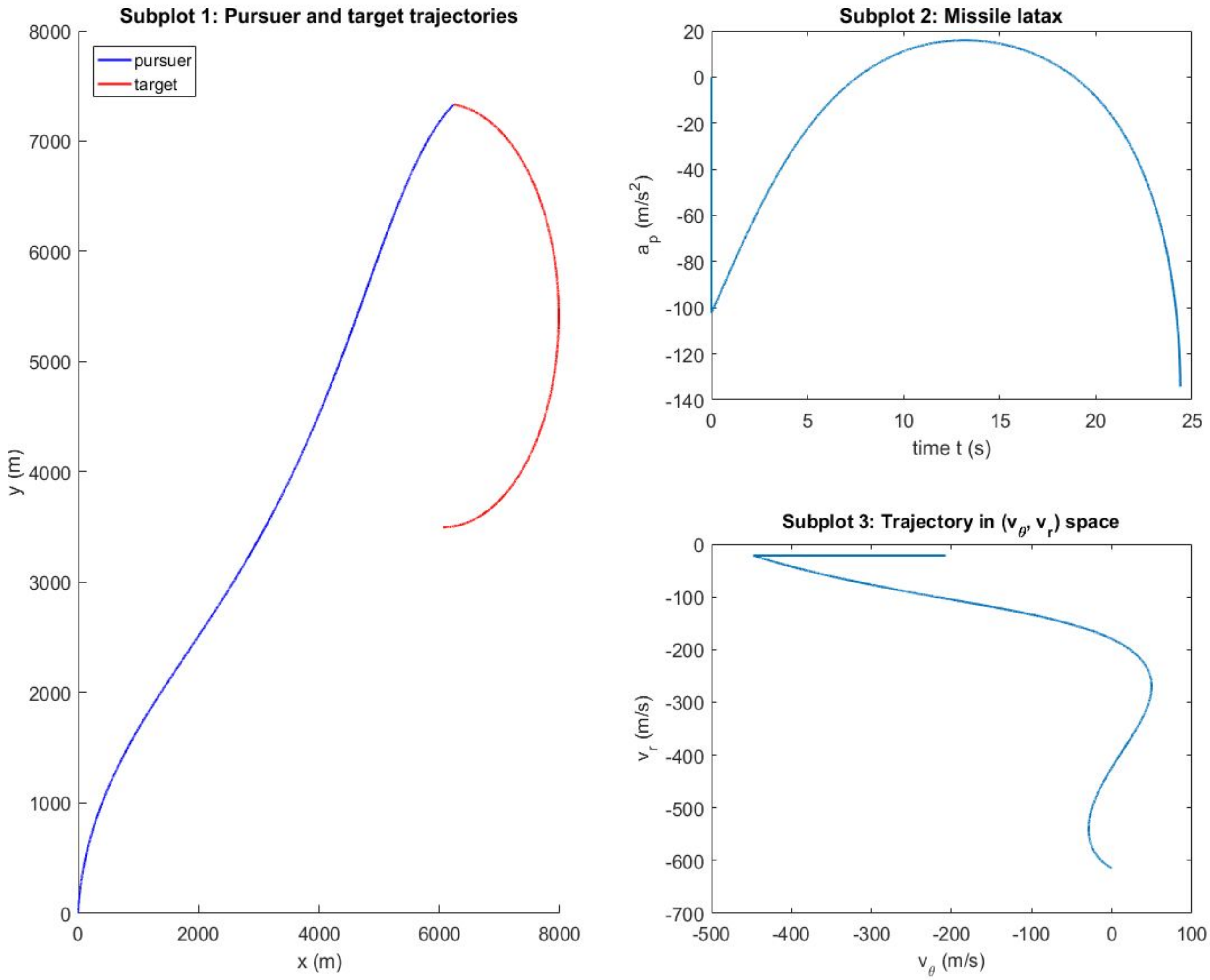


Subplot 1: Pursuer and target trajectories
pursuer
target
y (m)
x (m)
Subplot 2: Missile latax
a_p (m/s^2)
time t (s)
Subplot 3: Trajectory in (v_θ, v_r) space
v_r (m/s)
v_θ (m/s)

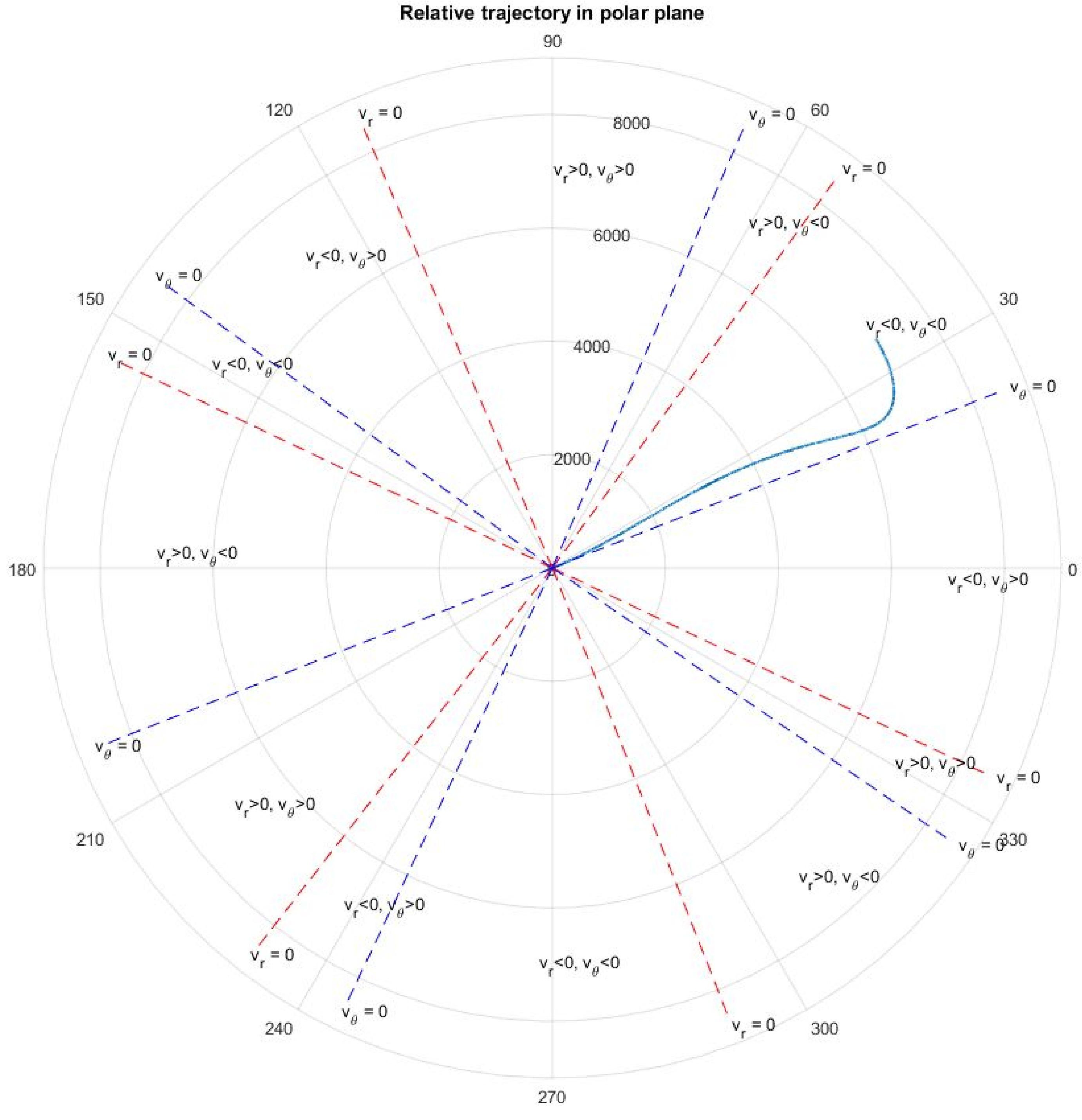
Note: The sectors depicted in this polar plot have been calculated from the v_r , v_θ vs θ plot at t = t_f.



Plots (α_{P0} = 85°)



Note: The sectors depicted in this polar plot have been calculated from the v_r , v_θ vs θ plot at $t = t_f$.



TPN Problem(pg-174 NPTEL)

1 Parameters :

- V_{P0} = 400m/s
- V_{P0} = 0.6*400 = 240 m/s
- α_{T0} = 60deg
- θ_0 = 30deg
- R_0 = 7000 m;
- X_{T0}= R0*cos(θ_0)
- Y_{T0}= R0*sin(θ_0)
- X_{P0}= 0
- Y_{P0} = 0

2 Simulation settings:

- Ode Solver:ode45(RK4 with Variable time step)
- Maximum Allowed time step = 0.05Secs
- Termination condition: R<R_tolerance or time > Max_allowed_time

3 Tested Initial conditions:

Simulation was done for 4 test cases

1. Maneuvering Target with $\alpha_{p0} = 10deg$
2. Maneuvering Target with $\alpha_{p0} = 85deg$
3. Non-Maneuvering Target with $\alpha_{p0} = 10deg$
4. Non-Maneuvering Target with $\alpha_{p0} = 85deg$

4 Range variation with time

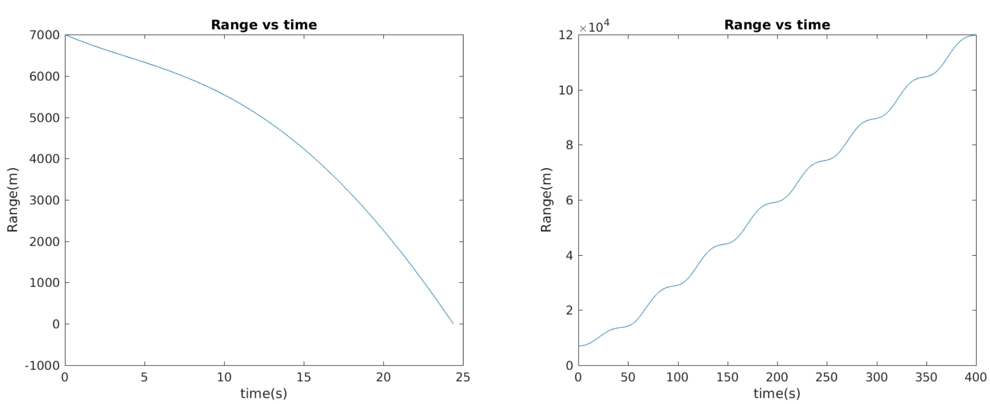


Figure 1: Maneuvering Target; $\alpha_{p0} = 10deg$(left);$\alpha_{p0} = 85deg$(right)

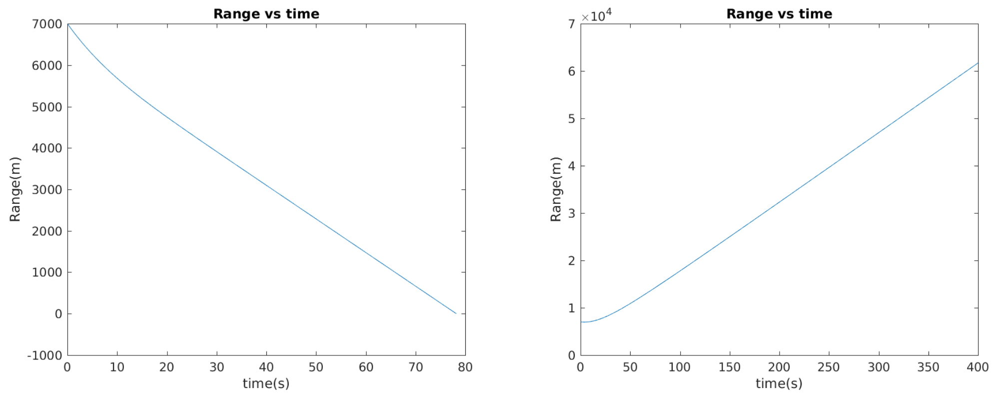


Figure 2: Non-Maneuvering Target; $\alpha_{p0} = 10deg$(left);$\alpha_{p0} = 85deg$(right)

5 Trajectories

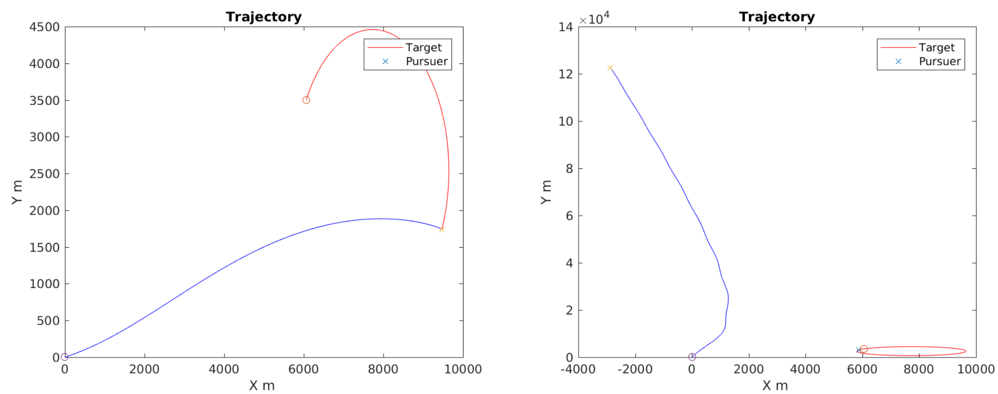


Figure 3: Maneuvering Target; $\alpha_{p0} = 10deg$(left);$\alpha_{p0} = 85deg$(right)

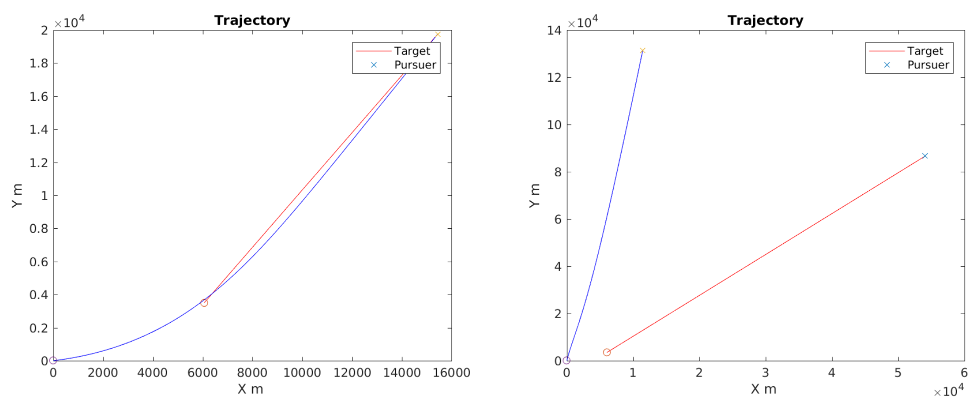


Figure 4: Non-Maneuvering Target; $\alpha_{p0} = 10deg$(left);$\alpha_{p0} = 85deg$(right)

6 Acceleration Required versus time

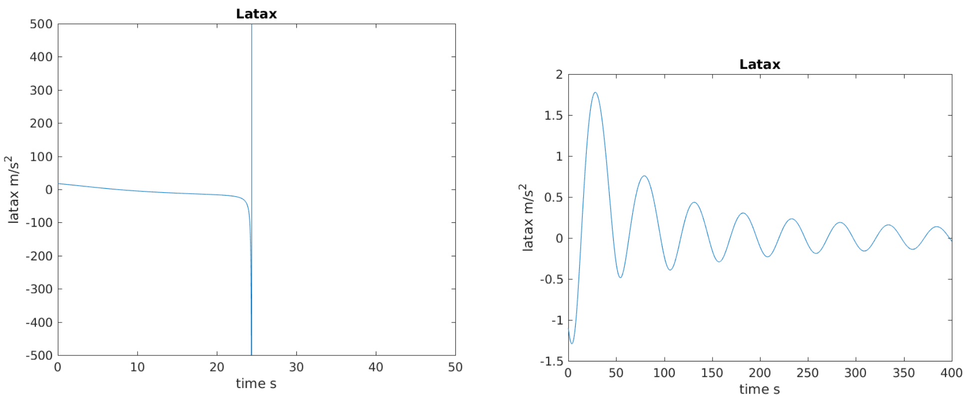


Figure 5: Maneuvering Target; $\alpha_{p0} = 10deg$(left);$\alpha_{p0} = 85deg$(right)

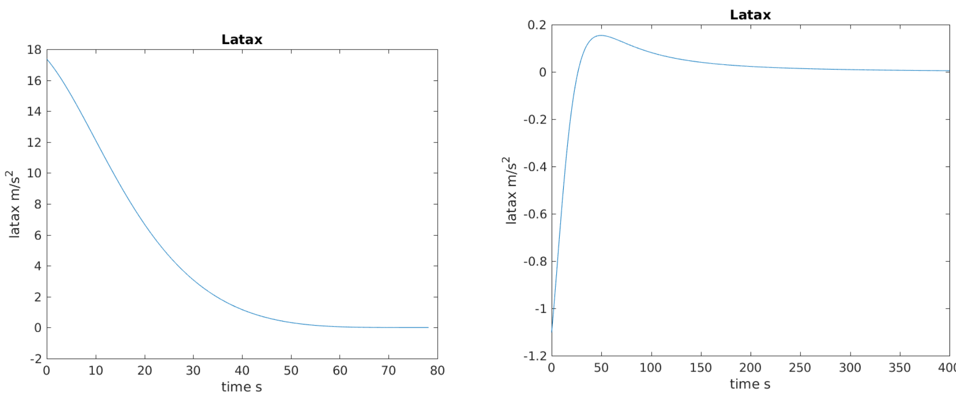


Figure 6: Non-Maneuvering Target; $\alpha_{p0} = 10deg$(left);$\alpha_{p0} = 85deg$(right)

7 V_R vs V_θ

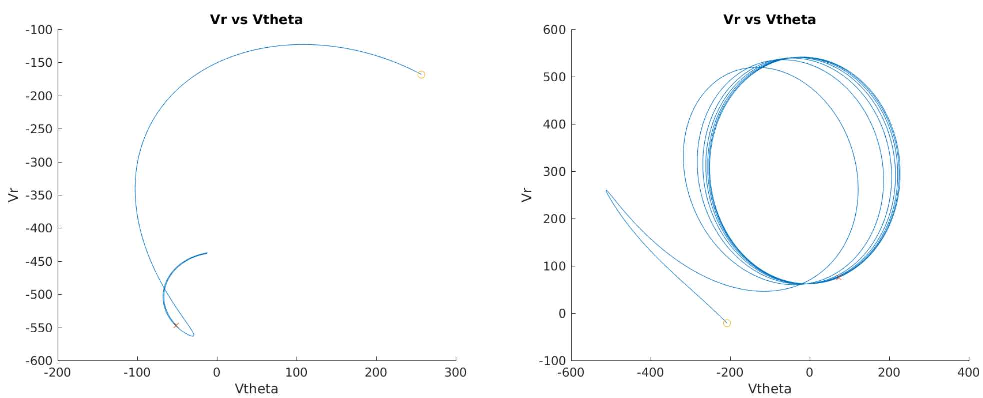


Figure 7: Maneuvering Target; $\alpha_{p0} = 10deg$(left);$\alpha_{p0} = 85deg$(right)

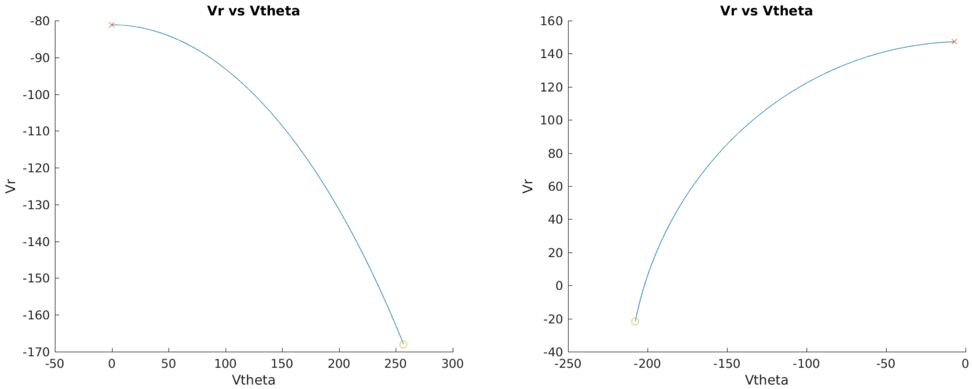


Figure 8: Non-Maneuvering Target; $\alpha_{p0} = 10deg$(left);$\alpha_{p0} = 85deg$(right)

RTPN(Realistic True Proportional Navigation)

November 6, 2018

1 Initial Conditions

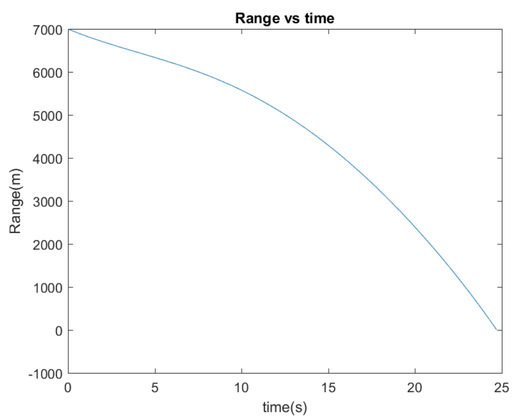
- $V_{P0} = 400m/s$
- $V_{T0} = 0.6 * 400 = 250m/s$
- $\alpha_{T0} = 60deg$
- $\theta_0 = 30deg$
- $R_0 = 7000m$
- $X_{T0} = R0 * Cos(\theta_0)$
- $Y_{T0} = R0 * Sin(\theta_0)$
- $X_{P0} = 0$
- $Y_{P0} = 0$

2 Simulation Setting

- ODE solver
- Time step 0.05

3 Graphs

3.1 Range Vs Time



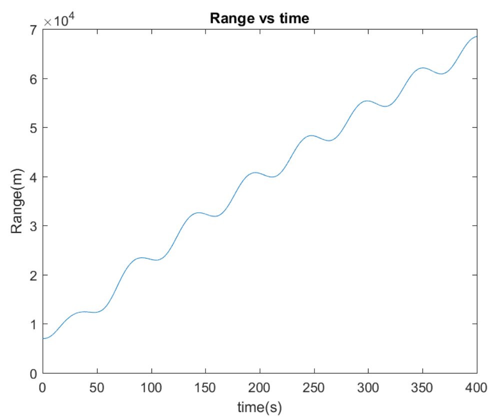


Figure 1: Manuevering Target $\alpha_{P0} = 10(left)$ and $\alpha_{P0} = 85(Right)$

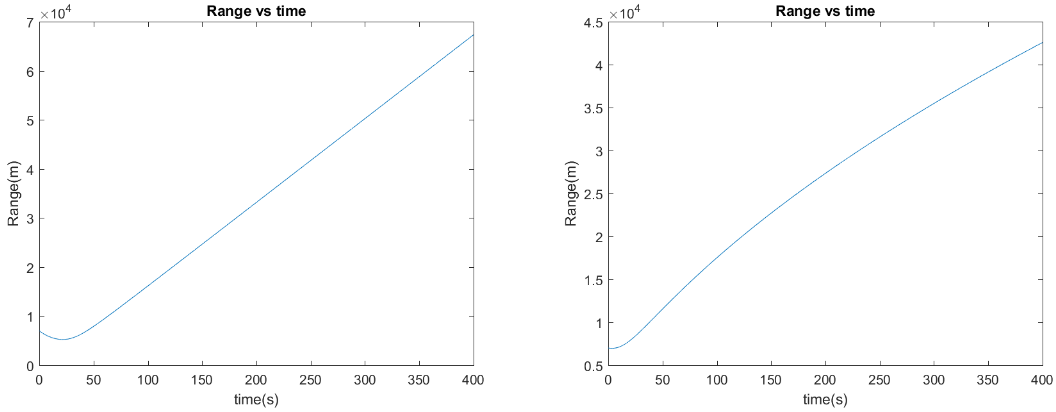


Figure 2: NonManuevering Target $\alpha_{P0} = 10(left)$ and $\alpha_{P0} = 85(Right)$

3.2 Trajectory

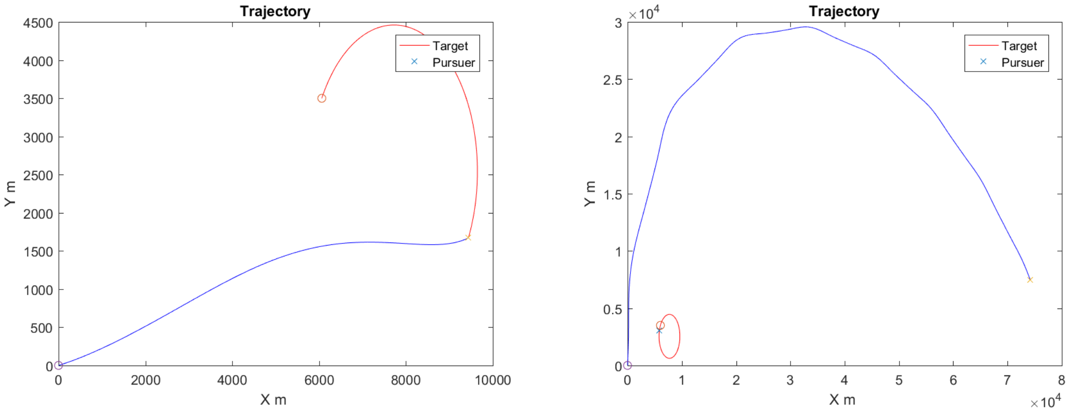


Figure 3: Manuevering Target $\alpha_{P0} = 10(left)$ and $\alpha_{P0} = 85(Right)$

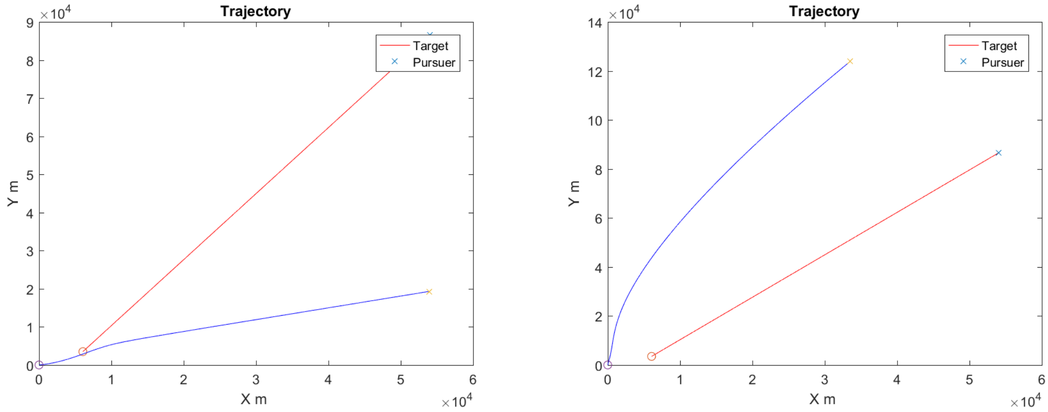


Figure 4: NonManuevering Target $\alpha_{P0} = 10(left)$ and $\alpha_{P0} = 85(Right)$

3.3 Latex

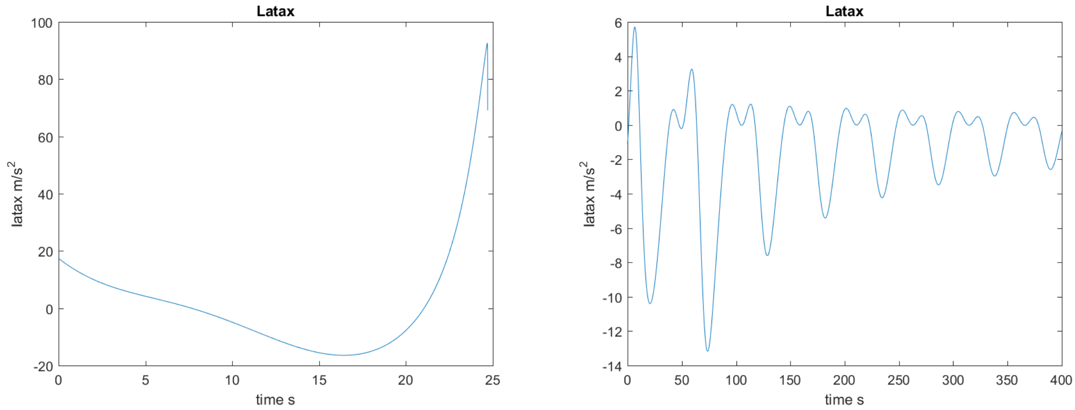


Figure 5: Manuevering Target $\alpha_{P0} = 10(left)$ and $\alpha_{P0} = 85(Right)$

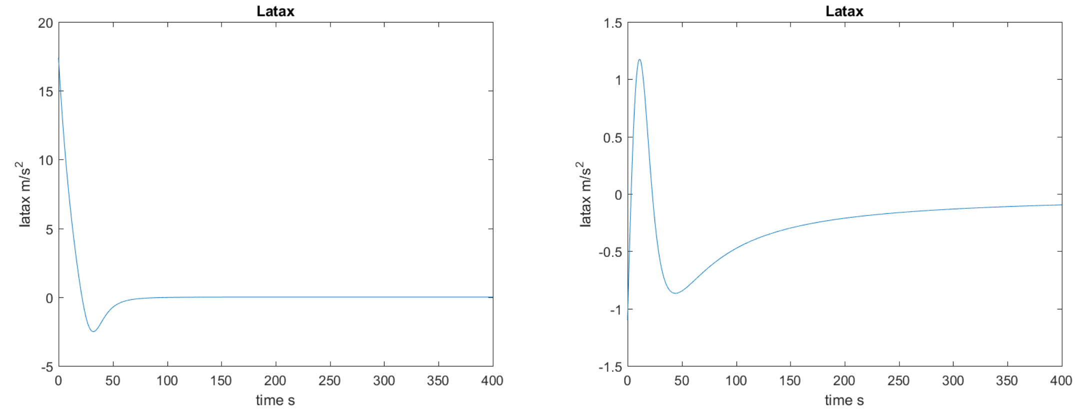


Figure 6: NonManuevering Target $\alpha_{P0} = 10(left)$ and $\alpha_{P0} = 85(Right)$

3.4 Vr vs Vtheta

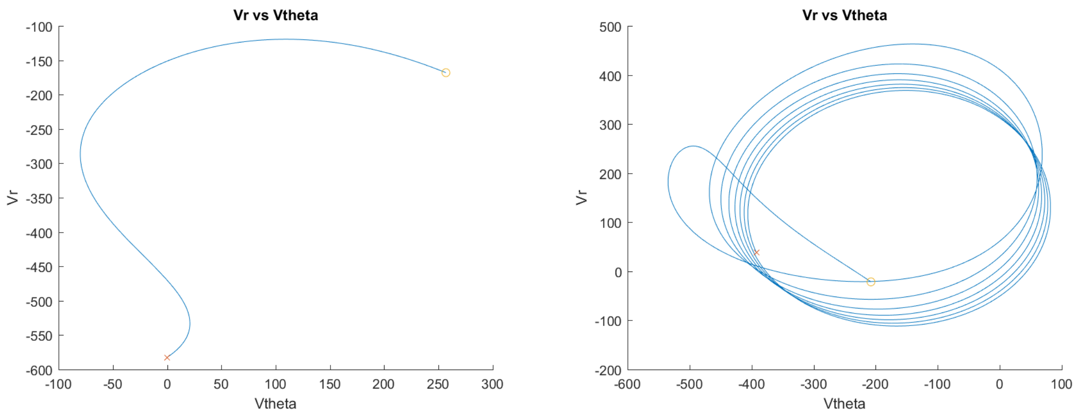


Figure 7: Manuevering Target $\alpha_{P0} = 10(left)$ and $\alpha_{P0} = 85(Right)$

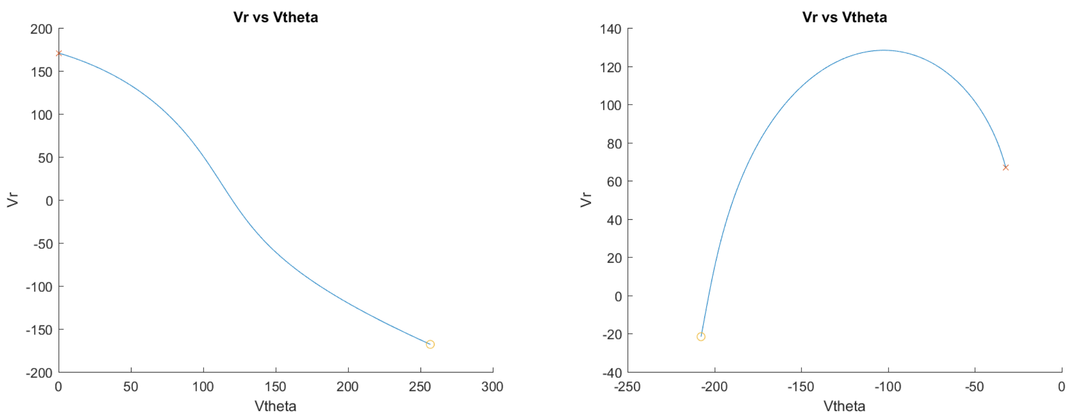


Figure 8: NonManuevering Target $\alpha_{P0} = 10(left)$ and $\alpha_{P0} = 85(Right)$