Sharif University of Technology
Institute of Aerospace

Homework #1

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Course: *Flight Dynamic II* – Professor: *Dr.Zare*
Due date: *March 28th, 2025*

Problem 1

(a) The Earth-center, Earth-fixed(ECEF) frame:

In specific time origins of ECEF fix to earth centered inertial(ECI) frame and we assume in 100 second they don't change too much so we neglect this change.

$u^i(t) = u_o^i + a_x^i t, \quad v^i(t) = a_y^i t, \quad w^i(t) = 0$

$u_o^i = 100ft/s, \quad a_x^i = 25ft/s^2, \quad a_y^i = 50ft/s^2$

$$u^i(t) = 100 + 25t, \quad v^i(t) = 50t, \quad w^i(t) = 0$$
$$x^i(t) = 100t + 25/2t^2, \quad v^i(t) = 50/2t^2, \quad w^i(t) = 0$$

Figures have plot in MATLAB and code(Q1_a) attached to home work file.

Figure 1: X location ECEF frame

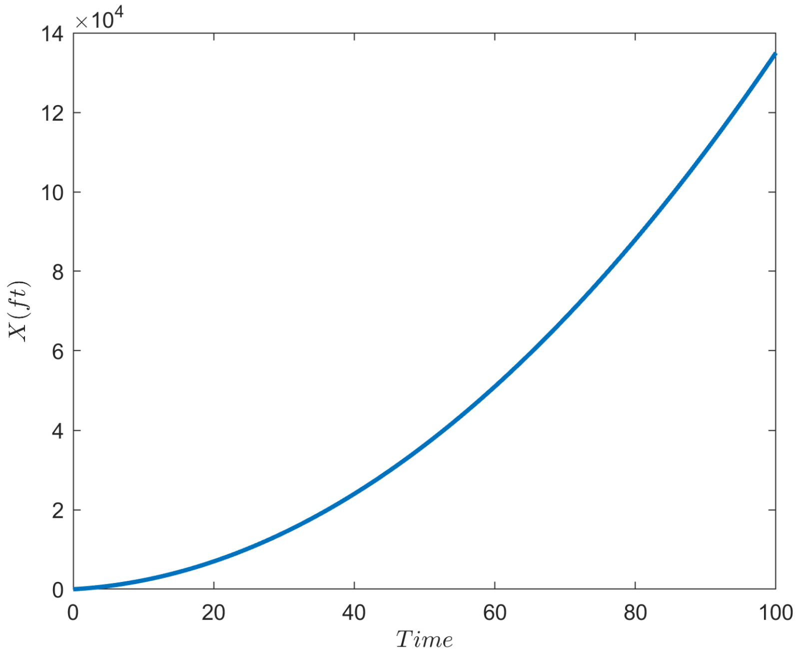


Figure 2: Y location ECEF frame

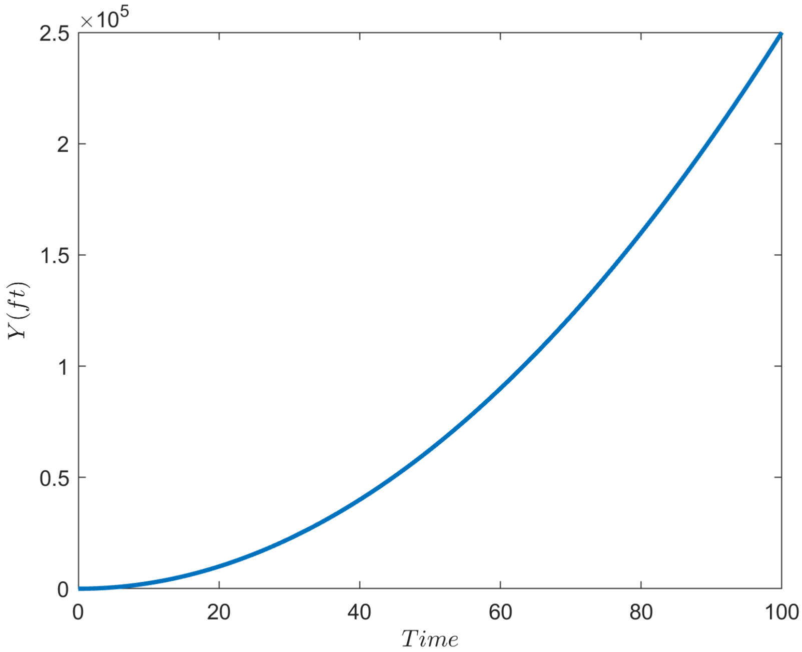


Figure 3: Z location ECEF frame

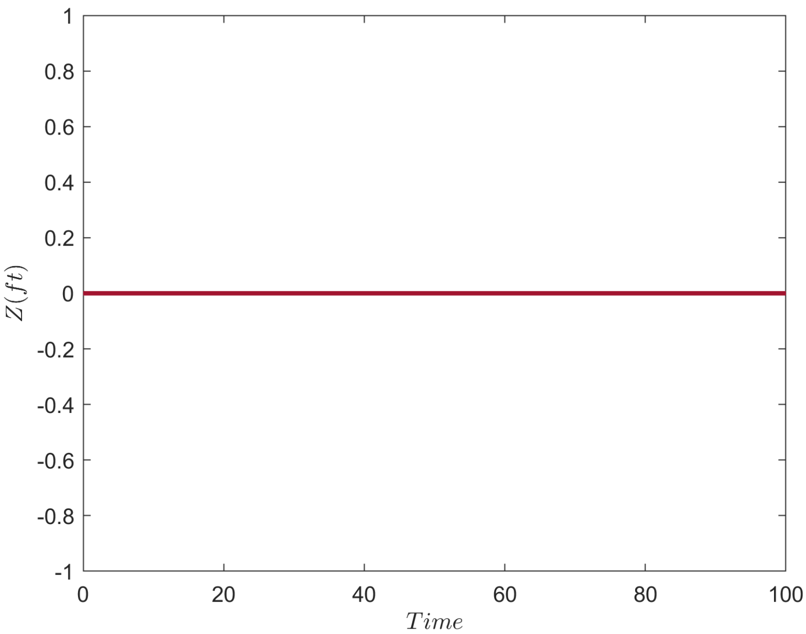


Figure 4: X direction velocity ECEF frame

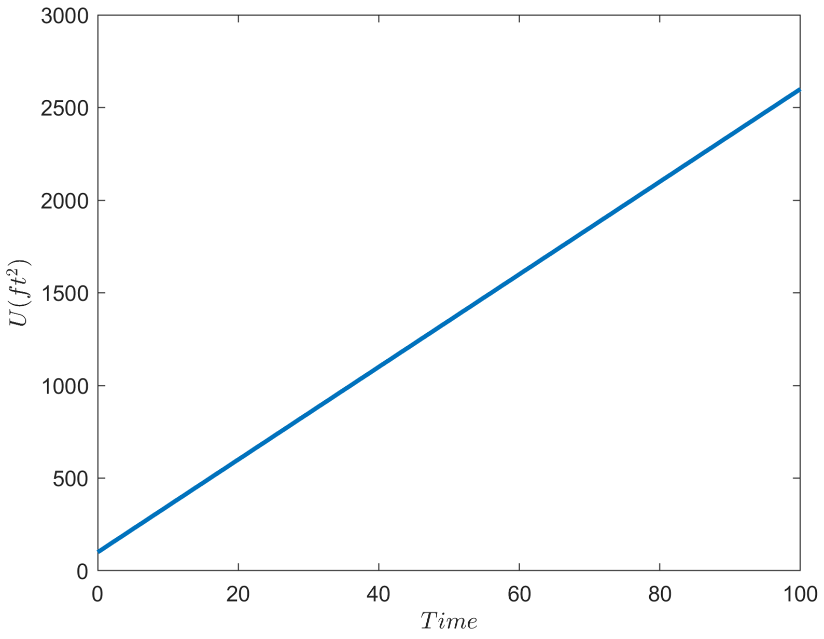


Figure 5: Y direction velocity ECEF frame

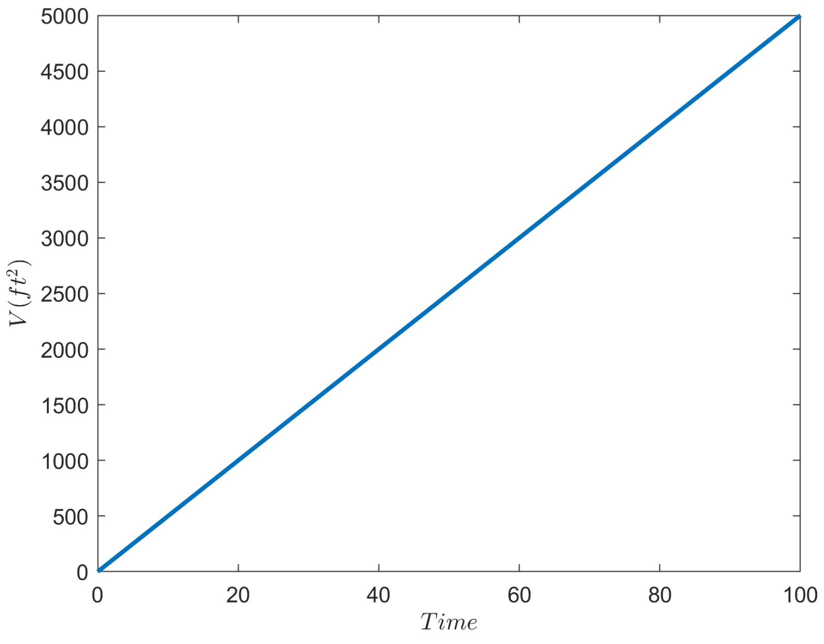
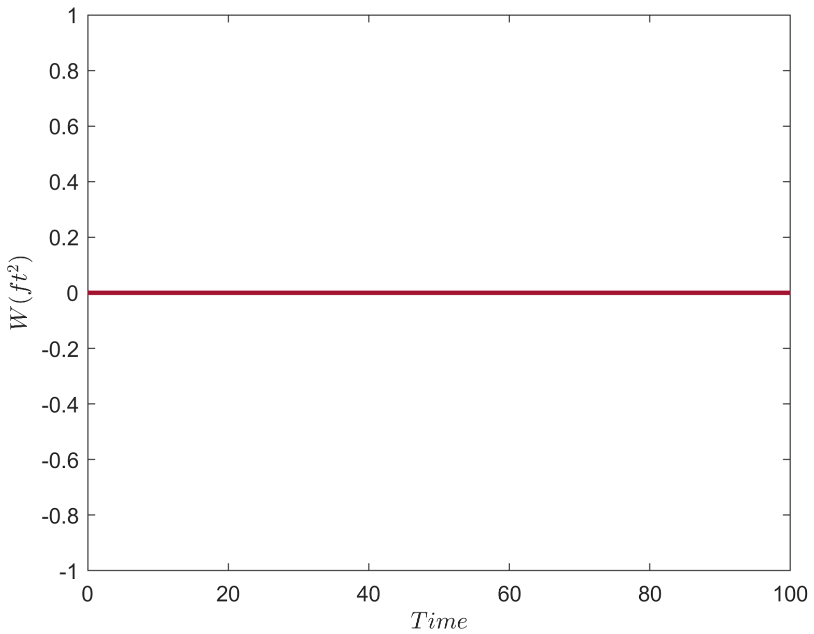


Figure 6: Z direction velocity ECEF frame



(b) kos

Problem 2

(a) Body to tunnel transformation matrix:
Angle of attack:

$$\theta = 20^\circ$$

Yaw angle:

$$\psi = 10^\circ$$

Bank angle:

$$\phi = 10^\circ$$

$$R_{body}^{tunnel} = \begin{bmatrix} \cos(-\psi) & -\sin(-\psi) & 0 \\ \sin(-\psi) & \cos(-\psi) & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} \cos(-\theta) & 0 & \sin(-\theta) \\ 0 & 1 & 0 \\ -\sin(-\theta) & 0 & \cos(-\theta) \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(-\phi) & -\sin(-\phi) \\ 0 & \sin(-\phi) & \cos(-\phi) \end{bmatrix}$$

$$R_{body}^{tunnel} = \begin{bmatrix} 0.9254 & 0.2295 & -0.3016 \\ -0.1632 & 0.9595 & 0.2295 \\ 0.3420 & -0.1632 & 0.9254 \end{bmatrix}$$

(b) Transfer from body to stability:

$$\begin{bmatrix} -D \\ Y \\ -L \end{bmatrix}^S = R_B^S \times \begin{bmatrix} F_X \\ F_Y \\ F_Z \end{bmatrix}^B$$

$$R_B^S = \begin{bmatrix} \cos(\theta) & 0 & \sin(\theta) \\ 0 & 1 & 0 \\ -\sin(\theta) & 0 & \cos\theta) \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(\phi) & -\sin(\phi) \\ 0 & \sin(\phi) & \cos(\phi) \end{bmatrix}$$

Transformation matrix:

$$R_B^S = \begin{bmatrix} 0.9397 & 0.0594 & 0.3368 \\ 0 & 0.9848 & -0.1736 \\ -0.3420 & 0.1632 & 0.9254 \end{bmatrix}$$

$$F^S = \begin{bmatrix} -12.2196 \\ -16.6967 \\ -97.0196 \end{bmatrix}$$

Problem 3

(a) Data for glider:

$C_D = 0.01 + 0.022C_l^2, \quad m = 454_{kg}, \quad S = 7.43_{m^2}$

$\rightarrow C_{D_0} = 0.01, \quad K = 0.022$

Glider is in $(\frac{L}{D})_{\max}$

$(\frac{L}{D})_{\max} = \frac{1}{\sqrt{4C_{D_0}K}} = \frac{1}{\sqrt{4 \times 0.01 \times 0.022}} = 33.7100$

In $(\frac{L}{D})_{\max}$:

$\frac{1}{(L/D)_{\max}} = \frac{C_{D_0}}{C_l} + KC_l = \frac{1}{33.71} = \frac{0.01}{C_l} + 0.022C_l$

Above equation Solved in MATLAB and code(Q3.m) attached.

From MATLAB solution:

$$C_l = 0.674 \rightarrow C_D = 0.02$$

Assume:

$\gamma = -\tan^{-1}(\frac{1}{(L/D)_{\max}}) \rightarrow \gamma = -0.0297_{rad}$

For equilibrium condition $\dot{\gamma} = 0 \rightarrow \frac{1}{2}C_l\rho V^2 S/m = g\cos(\gamma)$

$$\rightarrow V_{eq} = \sqrt{\frac{2mg\cos(\gamma_{eq})}{C_l\rho S}}$$

In MATLAB code we use ISA to plot V_{eq} for altitude 0 to 5000 ft. γ_{eq} is constant in every altitude.

$$\gamma_{eq} = -0.0297_{rad}$$

Figure 7: $V_{eq} in different altitude$