1) Given the following open-loop system:

\[ G_o(w) = \frac{10(1+w)}{w(1-\frac{w}{2})} \]

a) Sketch the root locus of

\[ G_{tot}(w) = \frac{k \cdot G_o(w)}{1 + k \cdot G_o(w)} \]

in the w-plane for positive values of k.

b) Sketch the Bode diagram of \( G_o(w) \) in the w variables.

c) Sketch the complete Nyquist diagram of \( G_o(w) \).

d) Assess the stability of \( G_{tot}(w) \).
2) Given the system:

\[ G(z) = \frac{10}{(z+0.5j)(z-0.5j)(z+2)(z-3)} \]

which is clearly unstable.

Find a functional observer that will place the poles of the closed-loop system at the origin (deadbeat control). The three observer poles are to be placed at

\[ \frac{3}{2} + 0.5, \pm 0.25j \]
3) Given the system:

\[ G(z) = \frac{(z + 0.2j)(z - 0.2j)}{z^3} \]

a) Find the discrete step response of this system.

b) Find the discrete ramp response of this system.

4) Given the system:

\[
\begin{bmatrix}
\dot{x}(k+1) \\
y(k)
\end{bmatrix} =
\begin{bmatrix}
\Phi & 1 \\
K & -\phi.5
\end{bmatrix}
\begin{bmatrix}
x(k) \\
x(k)
\end{bmatrix}
+ 
\begin{bmatrix}
0 \\
1
\end{bmatrix} u(k)
\]

\[ y(k) =
\begin{bmatrix}
2 & 3
\end{bmatrix}
x(k)
\]

a) For which range of \( K \) is this system stable?
b) For which values of $K$ does this system lose controllability?

c) For which values of $K$ does this system lose observability?

5) Given the system:
\(C_p = \text{center of pressure}\)
\(C_g = \text{center of gravity}\)
\(F_T = \text{engine thrust}\)
\(F_a = \text{normal component of aerodynamical force}\).
\(\delta = \text{engine angle}\)
\(\theta = \text{pitch angle}\).

The following control system describes this system:

\[ K_p = \text{analog rate feedback} \]
\[ K_p = \text{proportional feedback} \]
For a Saturn V rocket, the simplified rocket dynamics can be given as:

$$G_p(s) = \frac{0.9407}{s^2 - 0.0297}$$

The engine dynamics are neglected:

$$G_e(s) = 1$$

The sampling rate used by Saturn V is:

$$T = 0.444 \text{ sec}$$

Assume: $$K_p = 1$$. Find the range of stability of this system as a function of $$K_p$$. 