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Control Systems Learning Element 1

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Task 1

b) Transfer functions derived from matlab

$$G_z(s) = \frac{33.33}{s^2 + 0.15s}$$

$$G_\Psi(s) = \frac{3.333\times10^{-4}}{s^2 + 15s}$$

Task 2

b) Jordan normal of A

J =

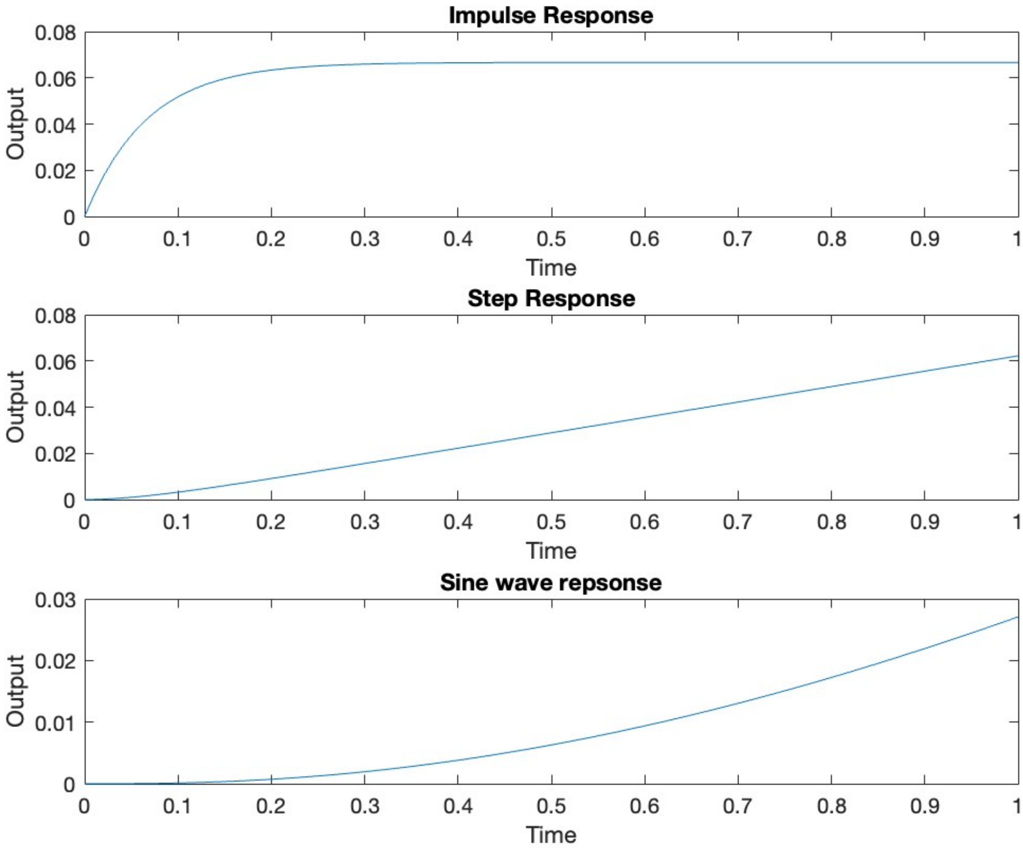
$$\begin{pmatrix}
0 & 1.0000 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & -30.0000 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & -0.1500 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1.0000 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & -30.0000 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & -0.1500 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -15.0000 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -0.1500 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{pmatrix}$$

c) Accessing stability

The system was originally thought to be stable since all eigenvalues were non-negative. However, since the Jordan for is not diagonal, then not all jordan blocks are of dimension 1x1. Therefore, the system is neither stable or asymptotically stable at the equilibrium point and is concluded to be unstable.

Task 3

b) Figure showing the heading trajectory vs time for all three control input cases.



c) Verification of steady state error value using final value theorem

From matlab we find the transfer function;

$$H(s) = \frac{33{,}333}{s(s+15)}$$

The laplace transform of $\delta(0)3 \times 10^{-5} = 3 \times 10^{-5}$

By the Final Value Theorem,

$$\lim_{t \to \infty} y(t) = \lim_{y \to 0} sY(s) = \lim_{y \to 0} sH(s)U(s) = \lim_{y \to 0} \frac{33{,}333(3 \times 10^{-5})}{s + 15} = \frac{1}{15} = 0.0667$$

Task 4

b) Figure of responses for different gain values