1. (40%) Explain the following terms:
   (a) Transfer function of a system
   (b) Impulse response of a system
   (c) Bode plot
   (d) Phase-lead compensation
   (e) Phase-lag compensation
   (f) Steady-state error
   (g) Causal system
   (h) Time-invariant system

2. (30%) Consider the linear system

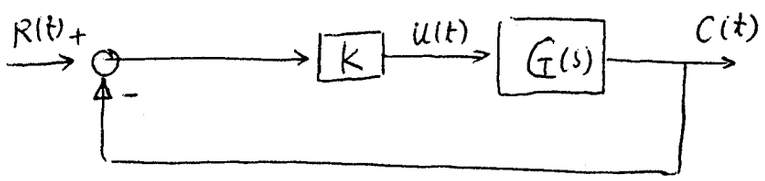
$$\dot{x}(t) = Ax(t) + Bu(t) \quad \text{where } A = \begin{bmatrix} 2 & 0 \\ 1 & 2 \end{bmatrix},\ B = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

$$y(t) = Cx(t) + Du(t) \quad \text{where } C=[1 \quad 1],\ D=[1]$$

   (a) Find the transfer function of the system. (5 points)
   (b) Find the impulse response of the system. (5 points)
   (c) Is this system stable? Controllable? Observable? (5 points)
   (d) Write down the input-output differential equation. (5 points)
   (e) Using state feedback to relocate the eigenvalues -1, -3. (10 points)

3 (30%) Given the following feedback control system, where the plant dynamics are described by the following differential equation:

$$\dddot{c}(t) + 7\ddot{c}(t) + 10\dot{c}(t) = \dot{u}(t) + u(t)$$



   (a) Find G(s)
   (b) Plot the locus of roots of the closed-loop system as K is varied from 0 to
   (c) Find the range of K for which the closed loop is stable.
   (d) If one of the closed-loop roots is at -10, for K=30, find the other two roots.
   (e) Using the dominant roots determined in part d, find the damping ration