Problem 1: Given the LTI system:

$$A = \begin{bmatrix} -1 & 1.5 \\ 1 & -2 \end{bmatrix}, \quad B = \begin{bmatrix} 1 \\ 0 \end{bmatrix}, \quad \mathbf{x}(0) = \begin{bmatrix} -0.5 \\ -1 \end{bmatrix}$$
$$C = \begin{bmatrix} 1 & 0 \end{bmatrix}, \quad D = 0$$

$$Input = u(t) * (-1)^{floor(t)}, \qquad t > 0$$

a. Check the observability of the system.
b. Design an open loop state estimator and:
    i. Write out the combined state equation.
    ii. Specify each state matrix and the initial condition of the combined state equation. (Assume your own estimator initial condition that is different from the system one.)
c. Design a closed loop state estimator and:
    i. Find the L that shifts the pole to [-3 -4].
    ii. Write out the combined state equation in system-observer configuration.
    iii. Write out the combined state equation in system-error configuration.
    iv. Specify each state matrix and the initial condition of both combined state equations above. (Assume your own estimator initial condition that is different from the system one.)
d. Use Matlab to simulate the system with open loop observer. Plot the states of the system and observer. Also plot the errors.
e. Use Matlab to simulate the system with close loop observer. Plot the states of the system and observer. Also plot the errors.
f. Explain the difference you see in the plots between both estimators.

Problem 2: Using the same system from problem 1:

a. Check the controllability of the system.
b. Check the stability of the system.
c. Design a state feedback controller that has the poles located at [-5 -6]. Specify your vector K.
d. Check the observability of the close loop system.
e. Design a closed loop observer to estimate the states of the system. Use the same estimator initial condition and poles used in problem 1.
f. Combine the full-state control law design of part c with the observer design of part e to obtain the output feedback control design. Provide the complete state space model for the output feedback system.
g. Use Matlab to simulate the system with output feedback controller. Plot the states of the closed loop system and the controller. Also plot the errors.