EE324, Control Systems Lab, Problem sheet 10
(Report submission date: 11th April 2021, viva on 12th April)

All examples below have only real numbers within A, and preferably (i.e. as far as possible) only integer values for A, B, C and D.
Notation: Matrix P is n X m means n-rows and m-columns. (i,j)-th entry of A means entry in the i-th row and j-th column.

Q1) Consider state space system $\frac{dX}{dt} = AX + BU$, and $y = CX + DU$

- Take any nonsingular 3 X 3 matrix T, and any 3 X 3 matrix A, B of size 3 X 1 and C of size 1 X 3 (and D : scalar: 1 X 1). Check that $G(s) = D + C(sI - A)^{-1}B$ is the same even if A, B, C are changed using $T: A \rightarrow T^{-1}AT,\ B \rightarrow T^{-1}B,\ C \rightarrow CT$
- Check that eigenvalues of A are the poles of G(s) (for the above example).
- Take G(s) : two examples: denominator of degree two: one which is proper, and one which is strictly proper. Obtain state space realizations for both. Comment about value of D in each of the two cases.

Q2) Obtain state space realization (any of the canonical forms) for $G(s) = \frac{(s+3)}{(s^2+5s+4)}$

- Then get state space realization for G(s), but with zero at -1 instead of -3: Get state space realization of size 2 X 2.

Q3) Choose a 3 X 3 diagonal matrix A, and B and C of appropriate size (with one column and one row respectively). Check that if corresponding entry of B is zero, then that diagonal entry of A is no longer a pole of G(s) (due to pole/zero cancellation). Same happens with C also.

Q4) Choose A to be upper-triangular, 3 X 3 matrix, and entry in (1,3) is zero. Check that if entries along the diagonal are repeated, then pole/zero cancellation can happen even if entries in B or C are nonzero (in continuation of question Q3).