1. 本大題係為是非題，計含二十個子題，請按子題之敘述為真時請答（○），若敘述為偽時則請答（X），請將答案按子題號序列表書於試卷紙上，毋須抄寫題目，亦請切勿直接作答於試題紙上。每子題答對者得兩分，未答者不予計分，答錯者倒扣兩分，唯僅倒扣至本大題為零分時為止。

   a. If an open-loop system is unstable, applying feedback will always improve its stability.

   b. Mason's gain formula can be applied between any two nodes of a signal-flow graph.

   c. The roots of the auxiliary equation, $A(s)=0$, of Routh's tabulation of a characteristic equation must also be the roots of the latter.

   d. When a row of Routh's tabulation contains all zeros before the tabulation ends, this means that the equation has roots on the imaginary axis of the s-plane.

   e. For the second-order prototype system, when the undamped natural frequency ω_n increases, the maximum overshoot of the output stays the same.

   f. Increasing the undamped natural frequency will generally reduce the rise time of the step response.

   g. Adding a zero to the forward-path transfer function will generally improve the system damping, and thus will always reduce the maximum overshoot of the system.

   h. The location of the roots of the characteristic equation in the s-plane will give a definite indication on the maximum overshoot of the transient response of the system.

   i. The intersect of the asymptotes must always be on the real axis.

   j. The breakaway points of the root loci must always be on the real axis.

   k. Adding a zero to the loop transfer function will always increase the bandwidth of the closed-loop system.

   l. A closed-loop system with a pure time delay in the loop is usually less stable than one without a time delay.

   m. A Bode plot can be used for stability analysis for minimum- as well as nonminimum- phase transfer functions.

   n. Once the value of K_D of a PD controller is fixed, increasing the value of K_P will increase the phase margin monotonically.

   o. A system compensated with a PD controller is usually more robust than a system compensated with a PI controller.

   p. You can always express the input-output relationship as a transfer function for a discrete-data system.

   q. The characteristic equation of a discrete-data system, $F(z)= z^3 - z^2 + 0.1z + 0.5=0$, represents an unstable system since it contains a negative coefficient.

   r. When the characteristic-equation roots of a discrete-data system are found in the second and third quadrants inside the unit circle in the z-plane, the frequency of oscillation of the system will generally be higher than if the roots are in the first and fourth quadrants.

   s. Without modification, all the rules and properties for the construction of root loci in the s-plane can be applied to the construction of root loci of discrete-data system in the z-plane.

   t. A pole of $E(s)$ in the left half-plane transforms into a pole of $E(z)$ outside the unit circle.

2. Derive the transfer function of the fractional-order hold. (5 %)

3. Use the Jury test to determine the stability of the discrete-data system with a characteristic equation given by

$$z^3 - 1.9z^2 + 1.4z - 0.45 = 0$$

(5 %)

4. The loop transfer function $L(jw)$ of a stable feedback satisfies the following equation

$$\frac{|L(jw)|}{|1+L(jw)|} \leq 2$$

Find the gain margin and phase margin of the system. (15%)

5. The following state space realization has a zero at λ_o.

$$\frac{dx(t)}{dt} = Ax(t) + Bu(t)$$
$$y(t) = Cx(t)$$

Find a nonzero $u(t)$ and initial condition $x(0)$ such that the output $y(t)$ is zero for all time t. (10%)

6. Show that the controllability of a linear system in invariant under state feedback (10%)

7. A rigid body of unit mass is subject to an external force. Derive the transfer function from the force to the displacement. Suppose that the displacement is measurable, is it possible to design a proportional feedback controller (P-controller) so that the closed-loop system is asymptotically stable? Why? (15%)