※ 考生請注意：本試題不可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. Plot root-locus of a second-order linear time-invariant (LTI) system with damping ratio and natural frequency as a varying parameter, respectively. (25%)

2. Use a third-order LTI system which is type 1 as a forward plant to describe the objectives, procedure, and mathematical analysis in designing a unity feedback regulator. (25%)

3. Consider an LTI negative feedback control system whose root locus with the variation of control gain K is shown in Figure 1, find the following: (35%)
   (a) The range of gain to yield stability, and verify your results by Routh-Hurwitz criterion.
   (b) The value of gain so that the system is underdamped with the real part of complex poles equal to -1.
   (c) Whether the result in part (b) can be approximated by a second-order LTI system? Explain.
   (d) If this is a unit-feedback system, the steady-state error with unit-step input.
   (e) How to keep the same transient response for the system in part (b) but eliminate steady-state error with unit-step input.

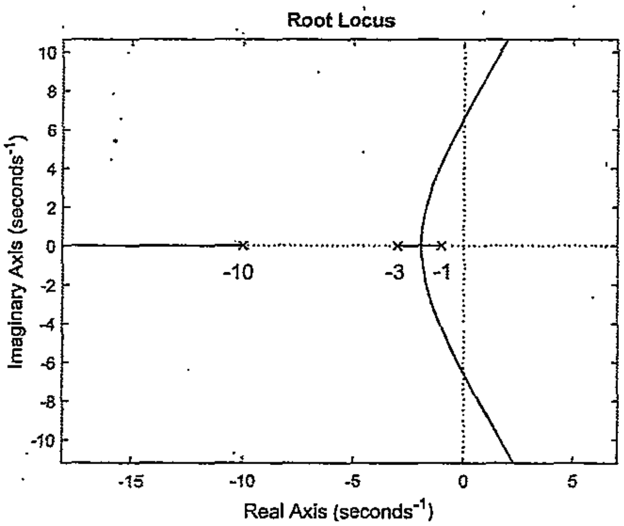

Figure 1. Root locus of the LTI system considered in Problem 3.

4. Consider a negative feedback system with the transfer functions

$$G(s)=\frac{K(s^2-4s+13)}{(s+2)(s+4)} \quad \text{and} \quad H(s)=\frac{1}{s}$$

find the following: (15%)
   (a) Using Nyquist criterion to find the range of K for stability of the system.
   (b) Gain and phase margins of the system.