國立嘉義大學九十五學年度
生物機電工程學系碩士班招生考試（乙組）試題

科目：自動控制

1. A unity-feedback control system is characterized by the open-loop transfer function:

$$G(s) = \frac{14}{s(s^2 + 9s + 16)}$$

   (a) Determine the steady-state errors to unit step, unit ramp, and unit parabolic inputs. (9%)
   (b) Determine the peak overshoot and settling time of the system's unit step response. (16%) (Hint: Use the concept of dominant poles?)

2. The open-loop transfer function of a unit feedback control system is

$$G(s)H(s) = \frac{K}{s(s^2 + s + 1)(s + 4)}$$

   (a) Find the closed-loop transfer function. (3%)
   (b) Determine the range of K such that the system is stable. (6%)
   (c) Find the gain K that results in a marginally stable system and determine the corresponding oscillatory frequency. (6%)
   (d) If K equals to 3, convert the transfer function model to a state variable model. (Either signal flow graph or state diagram shall be presented.) (10%)

3. The convolution operation relates the general input to a system, $u(t)$, via the impulse response of the system, $g(t)$, to the output, $x(t)$. Show that for a linear, time-invariant (LTI) system, the system response is the 'convolution integral' of the function $g(t)$ and the input $u(t)$: (18%)

$$\begin{aligned} x(t) &= g(t) * u(t) \\ &= \int_0^t g(t-\tau)u(\tau)d\tau \end{aligned}$$

   The response of a first order system to a unit impulse input is given by

$$g(t) = e^{-at}$$

   Using the convolution equation to determine the response to a ramp input $u(t) = bt$. (7%)

4. A system consists of a controller, $C(s)$ = K/(s+4) and a process, $G(s)$ = 1/(s(s+2)), and unity feedback. Draw the root locus in details on the s-plane (10%) and solve the following questions with assistance of the locus plot:
   (a) What are the allowable values of K that the system is stable? (3%)
   (b) Determine the purely oscillatory frequency. (3%)
   (c) Determine the poles at where the system is marginally stable. (3%)
   (d) Determine the value of K such that the dominant pair of complex poles of the system has a damping ratio of $\sqrt{2}/2$. (6%)