1. (25%) Derive Laplace Transforms of the following functions u of time t:
   (a) (5%) $u(t)=\delta(t-\tau)$, $\tau>0$;
   (b) (5%) $u(t)=e^{st}1(t)$, s is a complex number;
   (c) (5%) $u(t)=\cos(\omega t-\tau)1(t-\tau)$, $\omega,\tau>0$;
   (d) (5%) $1(t)=u(t)+\int_0^t u(\tau)\,d\tau$, and
   (e) (5%) $u(t)=\int_{0^-}^t \sin(t-\tau)d\tau$, $\tau>0$.
   where δ and 1 denote the unit-pulse and unit-step function of time, respectively.

2. (25%) Consider the following dynamics G with the transfer function being

$$G(s)\equiv\frac{11s^2+11s+10}{(s+10)(s^2+s+1)}.$$

   (a) (5%) Is G asymptotically stable? Is it bounded-input-bounded-output stable? Is it exponentially stable?
   (b) (5%) What is the steady-state error of the unit-step response?
   (c) (5%) Estimate the rising time of the unit-step response.
   (d) (5%) Estimate the overshoot of the unit-step response.
   (e) (5%) Estimate the settling time of the unit-step response.

3. (25%) Given the unit-feedback system shown in Figure 1 with the open loop transfer function G(s) as:

$$G(s)=\frac{K}{s(s+2)(s+10)}$$

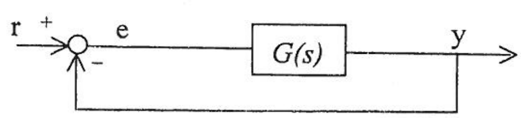

Figure 1

(a) (5%) Determine the closed loop transfer function

(b) (5%) Determine the range of K which makes the closed loop system stable

(c) (10%) Plot the root locus and determine the breakaway points and asymptotes.

(d) (5%) Find the locations at the $j\omega$ axis (imaginary axis) when the root locus cross the imaginary axis.

4. (25%) Consider the closed loop system as shown in Figure 2.

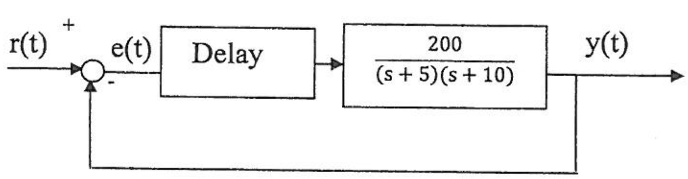

Figure 2

(a) (5%) Plot the Bode plot of open loop system in details when the time delay is equal to 0.

(b) (10%) Plot the Nyquist diagram of G(s), and determine the gain margin and phase margin of the system when the delay is equal to 0.

(c) (5%) For the time delay time equal to 0.1 second, determine the gain margin.

(d) (5%) Determine the range of the delay time approximately which makes the system become unstable. Explain the delay effect on the stability of the closed loop system.