國立臺灣科技大學102學年度碩士班招生試題

系所組別： 電機工程系碩士班丁二組

科　　目： 控制系統

(總分為100分)

Problem 1: (20 points, 10 points each)

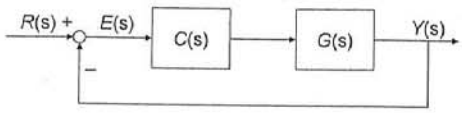
Let Laplace transform $F(s)=\dfrac{s+c}{(s+a)(s+b)}, a,b,c>0$,

(a) find the inverse Laplace transform $f(t)=L^{-1}\{F(s)\}, t\geq 0$; and

(b) find the z-transform $X(z)$ of sequence $x[k]=f(kT), k=0,1,2,\cdots$.

Problem 2: (15 Points)

For a negative unit-feedback control system, shown below, with plant $G(s)=\dfrac{1}{Js^2+Bs}, J,B>0$, design a phase lead/lag controller in the form of $C(s)=\dfrac{1+bs}{1+as}$ such that the loop transform function has the gain cross-over frequency ω_c and the phase margin PM.



Problem 3: (15 Points)

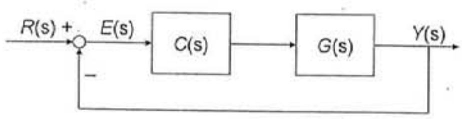
Given a continuous-time plant $G(s)=\dfrac{1}{s(s+1)}$, design a controller $C(s)$ as shown below such that the following specifications are satisfied:

the maximum overshoot of the unit step response $M_p=0\%$;

the 90% rise time of the unit step response $t_r\leq 0.1$ seconds; and

the steady-state error for the unit ramp input $e_{ss}\leq 0.05$.

Please also write down your final design specifications of maximum overshoot M_p, rise time t_r and the steady-state error e_{ss} for the unit ramp input.



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Problem 4: (18 points)

Consider the following linear time-invariant system:

$$dx(t)/dt = Ax(t) + Bu(t),\ y(t) = Cx(t) + Du(t) \tag{1}$$

where $x(t) \in \Re^n, u(t) \in \Re^m, y(t) \in \Re^k, A, B, C$ and D are appropriate matrices. After similarity transform $x(t) = Tz(t)$, where T is nonsingular, the transformed system is given as follows:

$$dz(t)/dt = \bar{A}z(t) + \bar{B}u(t),\ y(t) = \bar{C}z(t) + \bar{D}u(t). \tag{2}$$

Show that controllability and observability of system (1) are *invariant* under the similarity transform.

Problem 5: (32 points)

Consider the following magnetic levitation dynamic system:

$$M\,d^2x(t)/dt = Mg - ki^2(t)/x(t),\ \ v(t) = Ri(t) + L\,di(t)/dt \tag{3}$$

where $v(t)$ is the input voltage, $i(t)$ is the winding current, R, L are respectively the winding resistance and inductance, M is the ball mass, $x(t)$ is the ball position, g is the gravitational acceleration, and k is a proportional constant.

(a) Describe the system (3) using the state space equation with $x_1(t) = x(t), x_2(t) = dx(t)/dt$, and $x_3(t) = i(t)$, and its output equation $y(t) = x(t)$ (6 points); (b) Find its linearized equation with respect to the equilibrium point x_{10}, x_{20}, x_{30} and v_0; i.e., let $x_1(t) = x_{10} + \delta x_1(t)$, $x_2(t) = x_{20} + \delta x_2(t)$, $x_3(t) = x_{30} + \delta x_3(t)$, and $v(t) = v_0 + \delta v(t)$, find $\delta\dot{x}(t) = A\delta x(t) + B\delta v(t)$, and $y(t) = C\delta x(t) + D\delta v(t)$, where $\delta x(t) = [\delta x_1(t)\ \ \delta x_2(t)\ \ \delta x_3(t)]^T$. (10 points); (C)If $x_{10} = 0.5m$, $M = 1kg, g = 9.8m/\sec^2, k = 1$, $R = 1\Omega, L = 0.01H$, find its characteristic equation and eigenvalues. What system feature is obtained? (8 points); (d) Is the linearized system controllable or observable? (8 points)