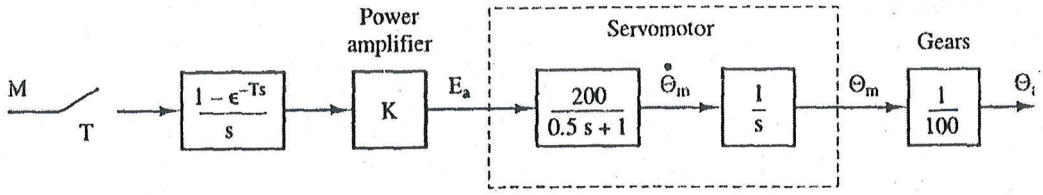
Ref. No.: **Ex/PG/ETCE/T/111C/2018**

M.E. ELECTRONICS AND TELE-COMMUNICATION ENGINEERING FIRST YEAR
FIRST SEMESTER - 2018

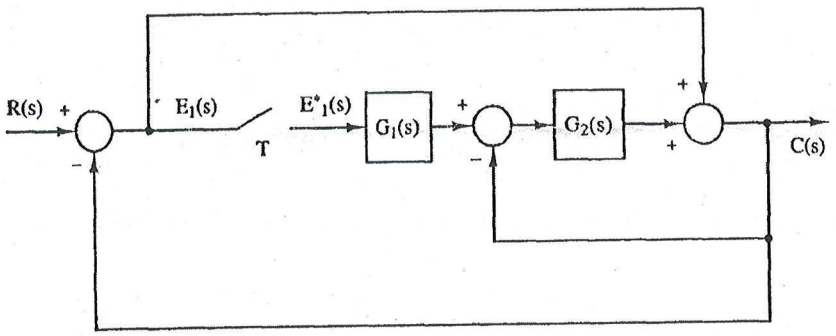
Subject: **DIGITAL CONTROL SYSTEM (CON)** Time: 3 Hours Full Marks: 100

Answer ANY FOUR.
All parts of the same question must be answered at one place only.

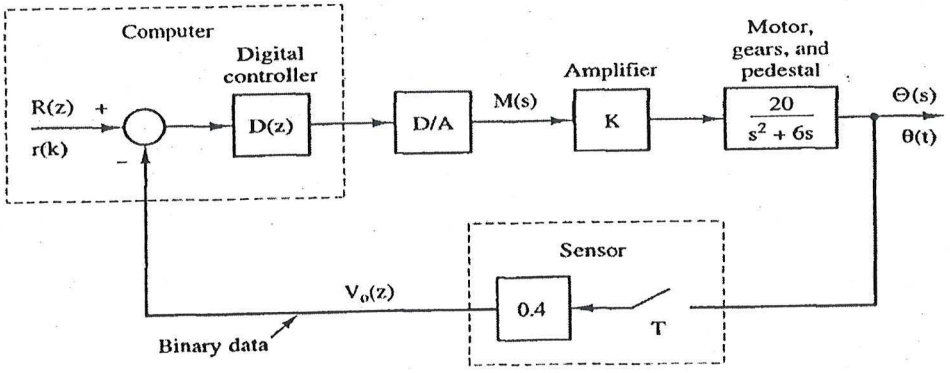
1. (a) Derive the open loop transfer function of the following control system of one joint of a robot with $K = 2.4$, $T = 0.1$ s, $E_a(s)$ as the servo motor input voltage, $\theta_m(s)$ as the motor shaft angle and $\theta_a(s)$ as the arm angle. 15



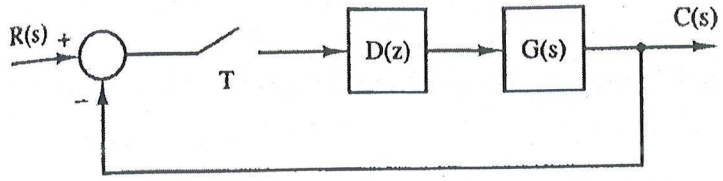
(b) Draw the signal flow diagram of the following system. Hence obtain $C(z)$. 10



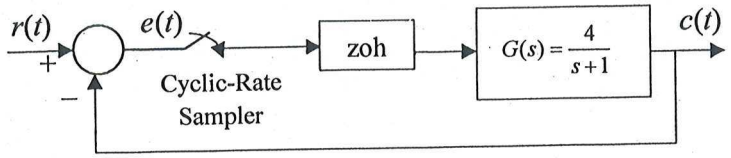
2. (a) Evaluate the closed loop transfer function of the following antenna control system with $D(z) = 1$, $T = 0.05$ s, $K = 20$. 17



(b) Design a digital controller $D(z)$ to attain a steady state error less than 0.01 for unit ramp input and to ensure stability of the entire system with $G(s)=\frac{1-\exp(-Ts)}{s(s+1)}$ and T=0.1 sec. 8



3. (a) Find the state equations of the following closed loop system with the cyclic sampler operating at kT, $kT + T_1$, where $T = 1$ s and $T_1 = 0.25$ s. 15

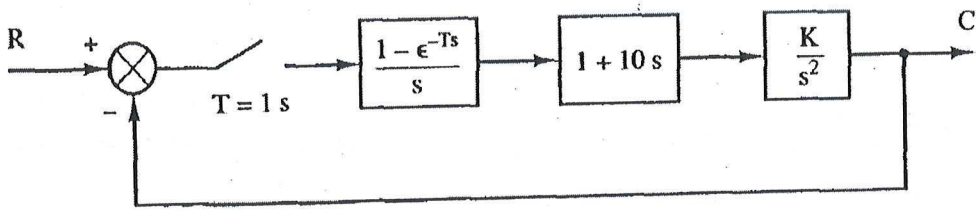


(b) Show that for the similarity transformation 5

$$\mathbf{C}[z\mathbf{I}-\mathbf{A}]^{-1}\mathbf{B}+\mathbf{D}=\mathbf{C}_w\left[z\mathbf{I}-\mathbf{A}_w\right]^{-1}\mathbf{B}_w+\mathbf{D}_w.$$

(c) What is bilinear transformation? 5

4. (a) Find the range of K for stability of the following system from its root locus. 10



(b) State and prove Nyquist stability criterion for digital control system. 8

(c) Using Nyquist stability criteria, comment on stability of a closed loop system with open loop transfer function 7

$$\overline{GH}(z)=\frac{0.01kz}{(z-1)(z-0.905)}.$$

5. (a) For a plant described by 15

$$\vec{x}(k+1)=\begin{bmatrix}1 & 0.0952\\ 0 & 0.905\end{bmatrix}\vec{x}(k)+\begin{bmatrix}0.00484\\ 0.0952\end{bmatrix}u(k)$$

find the gain matrix **K** required to realize the closed loop characteristic equation with zeros providing a damping ratio of 0.46 and a time constant of 0.5 s.

(b) Derive the dynamics and the transfer function of a reduced order state observer. 10

6. (a) State Lyapunov stability theorem for linear time-invariant discrete system. 5

(b) Consider a linear digital control system described by 10

$$\vec{x}(k+1)=\begin{bmatrix}0.5 & 0\\ 0 & 0.2\end{bmatrix}\vec{x}(k)+\begin{bmatrix}1\\ 1\end{bmatrix}u(k).$$

Find the optimal control $u^o(k)$ so that the Lyapunov function $V(\vec{x})=\vec{x}^T(k)\mathbf{P}\vec{x}(k)$ is minimized where **P** is a positive definite solution of $\mathbf{A}^T\mathbf{P}\mathbf{A}-\mathbf{P}=-\mathbf{I}$.

(c) Given a first order plant described by $x(k+1) = 0.9x(k) + 0.1u(k)$ with the cost function 10

$$J_3=\sum_{k=0}^{3}\left(x^2(k)+5u^2(k)\right)$$

calculate the optimal control required to minimize the cost function.

7. Write short notes on any TWO.

(a) State observer 12½

(b) Fast-slow sampler 12½

(c) Asynchronous sampling 12½