**Name:**

**Enrolment No:**

# UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

## End Semester Examination, December 2018

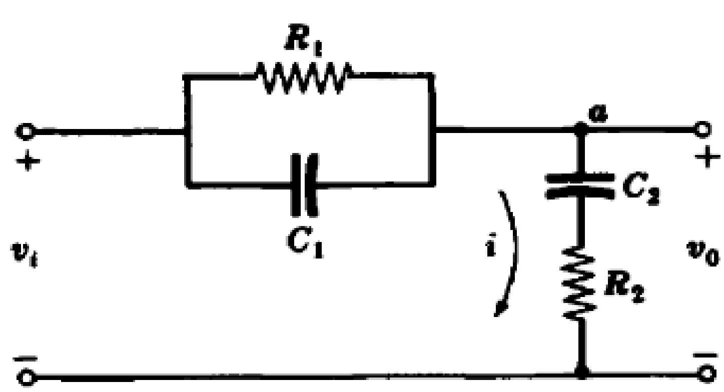
**Programme Name: B.Tech. EL –IOT** | **Semester : V**
**Course Name : Control System Design** | **Time : 03 hrs**
**Course Code : ICEG 321** | **Max. Marks : 100**
**Nos. of page(s) : 3**

**Instructions:** 1) Mention Roll No at the appropriate place in the question paper. 2) Answers should be brief and concise. 3) Assume any missing data 4.) Make sure you are provided with appropriate graph paper.

**SECTION A (20 marks)**
**All question of section A are compulsory**

| S. No. | | Marks | CO |
|---|---|---|---|
| Q 1 | Elucidate the block diagram of a closed loop control system. Explain the significance of various components. | **4** | **CO1** |
| Q 2 | What do you mean by control system compensation? Explain with the help of an example. | **4** | **CO1** |
| Q 3 | Elucidate the significance of linearization. Why linearization is needed? | **4** | **CO1** |
| Q 4 | Elucidate the significance of state space analysis. | **4** | **CO1** |
| Q 5 | Differentiate between lag and lead compensators. | **4** | **CO1** |

**SECTION B (40 marks)**

| | | | |
|---|---|---|---|
| Q 6 | Determine the transfer function of the R-C network mechanization of the lag-lead compensator shown in figure 1.   Figure 1 Lag-Lead Compensator | **10** | **CO2** |
| Q 7 | Obtain the state space representation for the system represented by following n[th] order differential equation: | **10** | **CO2** |

<table>
<tr><td></td><td>$\frac{d^n x(t)}{dt^n} + a_1 \frac{d^{n-1} x(t)}{dt^{n-1}} + a_n y = u(t)$</td><td></td><td></td></tr>
<tr><td>Q 8</td><td>Elucidate the mathematical equation of PID controller. What is the advantage of PI controller over PD controller?</td><td>10</td><td>CO2</td></tr>
<tr><td>Q 9</td><td>Obtain the state space representation for the following electrical network:

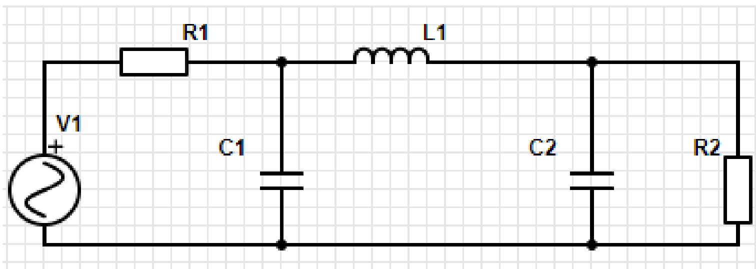



Figure 2 Electrical network</td><td>10</td><td>CO2</td></tr>
<tr><td colspan="4">SECTION-C (40 marks)<br>Question 11 carries an internal choice</td></tr>
<tr><td>Q 10</td><td>Devise a “Multiposition” (discontinuous) feedback control strategy for the control operation depicted in figure 3 with following specifications:

a. Control objective is to maintain water level in the vessel at “SET-POINT” (at 50% height)
b. Outlet pump can run at 5 preset speeds (0%, 25%, 50%, 75%, and 100%) as indicated in figure.
c. Outlet pump running condition depends on load from subsequent system (load variable).
d. Input valve can be manipulated as per controller requirement.
e. Minimum and maximum water levels are marked along the container.

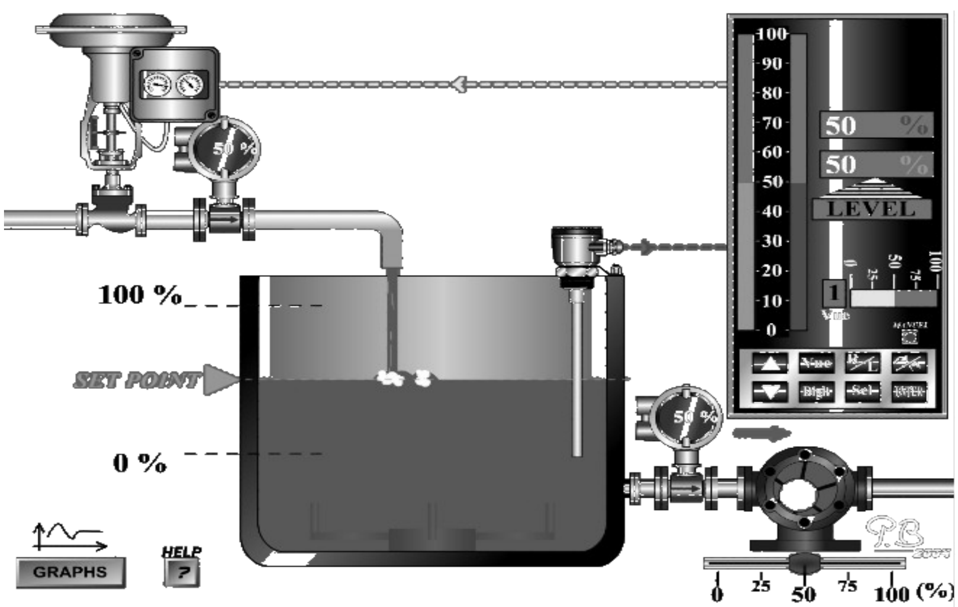
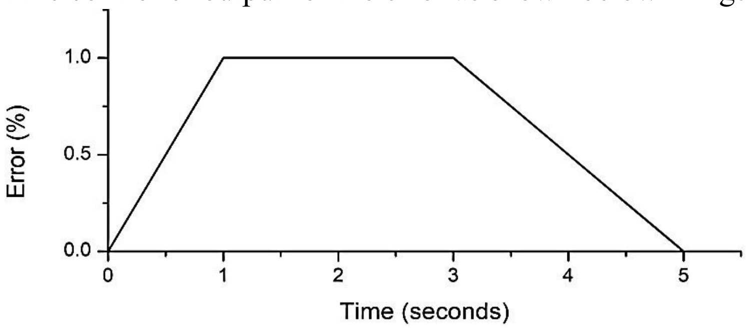



Figure 3 Screenshot of a simple Industrial Water Level Controller</td><td>20</td><td>CO5</td></tr>
</table>

| | | | |
|---|---|---|---|
| Q 11 | A PID controller has following configuration: $K_p=5$, $K_I=0.7\,s^{-1}$ $K_D=0.5\,s$ and $p_1=20\%$. Plot the controller output for the error as shown below in figure<br><br><br>Fig<br>OR<br>Design a lag compensator for a unity feedback system with an open-loop transfer function:<br>$G_f(s)=\frac{k}{s(s+1)(s+5)}$<br>The required parameters for system design are: $K_v \geq 8\,s^{-1}$ and $\varphi_{pm}=33°$ | **20** | **CO5** |

SET B

| Name: <br> Enrolment No: | UPES |
|---|---|

# UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

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**Nos. of page(s) : 2**

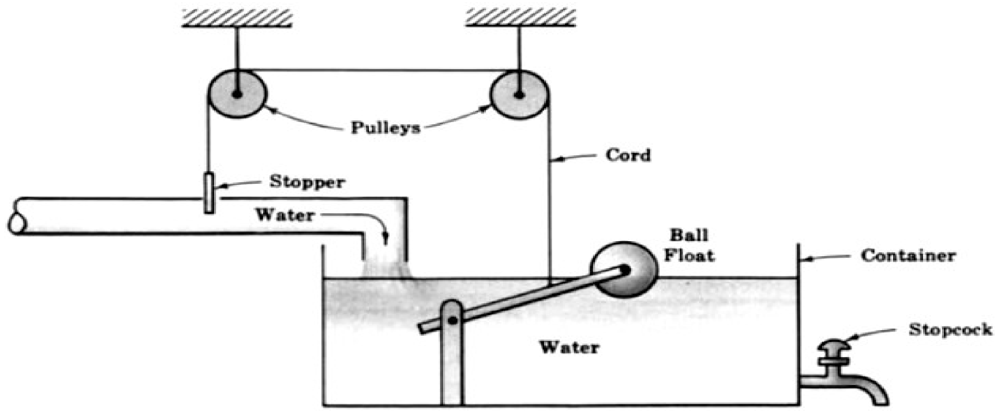
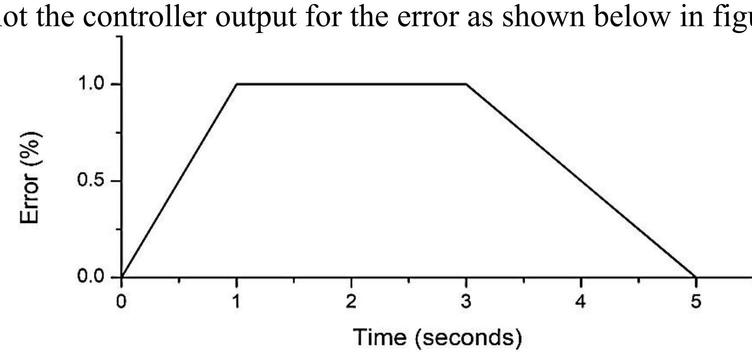
**Instructions:** 1) Mention Roll No at the appropriate place in the question paper. 2) Answers should be brief and concise. 3) Assume any missing data 4.) Make sure you are provided with appropriate graph paper.

**SECTION A (20 marks)**
**All question of section A are compulsory**

| S. No. | | Marks | CO |
|---|---|---|---|
| Q 1 | A system is described by the following differential equation: $\frac{d^3y}{dt^3}+5\frac{d^2y}{dt^2}+7\frac{dy}{dt}+y=\frac{d^3x}{dt^3}+6\frac{d^2x}{dt^2}+2\frac{dx}{dt}+8x$ Find the expression for the transfer function of the system, $Y(s)/X(s)$; assuming all initial conditions to be 0. | **4** | **CO1** |
| Q 2 | State three reasons for using feedback control systems and one reason for not using them. | **4** | **CO1** |
| Q 3 | Define the following terms commonly used in control systems: Plant, Actuator, Open-loop control system, Feedback control, Regulator system | **4** | **CO1** |
| Q 4 | What do you mean by the term Control System Compensation? | **4** | **CO1** |
| Q 5 | Which controller is also known as Anticipatory Controller? Explain briefly. | **4** | **CO 1** |

**SECTION B (40 marks)**
**Question 9 carries an internal choice**

| S. No. | | Marks | CO |
|---|---|---|---|
| Q 6 | Elucidate working of various discontinuous controller modes. What is the advantage of proportional control mode over discontinuous controller modes | **10** | **CO2** |
| Q 7 | Obtain the state space representation for the following transfer function: $\frac{C(s)}{R(s)}=\frac{1}{s^2+a_1s+a_2}$ | **10** | **CO2** |
| Q 8 | Enumerate the term offset error. Why do proportional controllers exhibit offset error. Justify your answer with corresponding derivation. | **10** | **CO2** |
| Q 9 | Explain the principle of linearization with the help of a suitable example. **OR** Figure 3 shows a simple automatic control system using mechanical components (for water level control); the objective of the system is to fill a container with water if it is emptied through a stopcock at the bottom, which is operated manually. The "ball float" floats on the water and as the ball gets closer to the top of the container, the | **10** | **CO2** |

| | | | |
|---|---|---|---|
| | stopper decreases the flow of water. When the container is filled completely, the stopper shuts off the flow of water. In this system identify (a) process, (b) set-point, (c) controller, (d) Actuator, and (e) the feedback element. Also draw the block diagram for the system.<br><br><br>Figure 1. Water level Control System | | |
| **SECTION-C (40 marks)**<br>**Question 11 carries an internal choice** | | | |
| Q 10 | For Phase Lag compensation you are given with the following data: $R_1$ = 1KΩ, C = 1 mF. Find the range of $R_2$ for the compensator such that the value of roots of the characteristic equation lies to the left of the line S = −3. | **20** | **CO5** |
| Q 11 | A PID controller has following configuration: $K_p = 5$, $K_I = 0.7\,s^{-1}$ $K_D = 0.5\,s$ and $p_1 = 20\%$. Plot the controller output for the error as shown below in figure<br><br><br>Figure 2. Error function for PID controller<br>OR<br>Design a lag-lead compensator for a unity feedback system with an open-loop transfer function:<br>$G_f(s) = \dfrac{k}{s(1+0.5s)(1+0.1s)}$<br>The required parameters for system design are: $K_v \geq 25\,s^{-1}$, $\omega_b = 10\,rad/s$, and $\varphi_s = 60°$ | **20** | **CO5** |