زانکۆی پۆلیتەکنیکی هەولێر
ERBIL POLYTECHNIC UNIVERSITY

Kurdistan Region Government
Ministry of Higher Education
and Scientific Research
Erbil Polytechnic University

Module (Control Engineering) Catalogue

2022-2023

College/ Institute	Erbil Technical engineering college	
Department	Technical Mechanical and Energy Eng. Dept.	
Module Name	Control Engineering	
Module Code	COE805	
Degree	Technical Diploma ☐ Bachler ■ High Diploma ☐ Master ☐ PhD ☐	
Semester	8	
Qualification	PhD	
Scientific Title	Assistant Professor	
ECTS (Credits)	5	
Module type	Prerequisite ☐ Core ■ Assist. ☐	
Weekly hours	4	
Weekly hours (Theory)	(2)hr Class	( )Total hrs Workload
Weekly hours (Practical)	(2)hr Class	( )Total hrs Workload
Number of Weeks	20	
Lecturer (Theory)	Assist. Prof. Dr. Younis Khalid	
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Lecturer (Practical)	Assist. Prof. Dr. Younis Khalid	

E-Mail & Mobile NO.	
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Course Book

Course Description	Today's mechatronics, manufacturing, and heavy industries face increased demand, better quality, less environmental impact, and most importantly, much lower competitive cost. It is very difficult to achieve these conflicting requirements unless the systems and subsystems embedded in different applications and architectures are constantly monitored and intelligently controlled. This module allows the learner to develop their understanding of what is involved in designing, operating and monitoring such unmanned systems while adhering to strict and optimal performance specifications. Representative cases of these systems and subsystems range from smart sensors and actuators, smart home applications, biomedical applications, automotive technology, intelligent materials handling, advanced manufacturing and automation, manufacturing, HVAC systems, reverse osmosis, power plants and water treatment facilities. space technology, marine applications, the list is endless. Control engineering is important to achieve the next goal of industry - Industry. Control systems engineering is primarily concerned with the study of these interdisciplinary fields through mathematical modeling while studying and verifying the response of these models using appropriate control-command system simulation software packages. These analytical evaluations and simulations aim to develop integrated devices and intelligent controllers that will force these systems to act according to the most appropriate methodology. The fact that the cost of microprocessors and microcontrollers has dropped dramatically over the years has made

<table>
<tr><td></td><td colspan="5">them more attractive for electronically controlled controllers. This fact highlights the need for mechanical and manufacturing engineering learners to become familiar with these technologies and learn how to integrate microcontrollers into today's interdisciplinary fields.</td></tr>
<tr><td>Course objectives</td><td colspan="5">The objective of this unit is to introduce the learner to the integration of control systems in the interdisciplinary fields of dynamic engineering such as mechanics, electricity, thermal, flows, environment, biomedical, energy, etc., who seek to acquire their systems and subsystems. - The systems organize themselves automatically.</td></tr>
<tr><td>Student's obligation</td><td colspan="5">Class attendance, each student should practically participate in each lecturer.</td></tr>
<tr><td>Required Learning Materials</td><td colspan="5">Computer program: MATLAB with Simulink, Arduino</td></tr>
<tr><td rowspan="14">Evaluation</td><td colspan="2">Task</td><td>Weight (Marks)</td><td>Due Week</td><td>Relevant Learning Outcome</td></tr>
<tr><td colspan="2">Paper Review</td><td></td><td></td><td></td></tr>
<tr><td rowspan="6">Assignments</td><td>Homework</td><td>5%</td><td>4,6</td><td></td></tr>
<tr><td>Class Activity</td><td>2%</td><td></td><td></td></tr>
<tr><td>Report</td><td>5%</td><td></td><td></td></tr>
<tr><td>Seminar</td><td>5%</td><td>8</td><td></td></tr>
<tr><td>Essay</td><td></td><td></td><td></td></tr>
<tr><td>Project</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Quiz</td><td>8%</td><td>5,7</td><td></td></tr>
<tr><td colspan="2">Lab.</td><td>10%</td><td>3,5,7,9,11,13</td><td></td></tr>
<tr><td colspan="2">Midterm Exam</td><td>35%</td><td>10</td><td></td></tr>
<tr><td colspan="2">Final Exam</td><td>40%</td><td>16</td><td></td></tr>
<tr><td colspan="2">Total</td><td>100%</td><td>16</td><td></td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>Specific learning outcome:</td><td colspan="5">This course will develop your Technical Competence capability.
Upon successful completion of this course, you should:</td></tr>
</table>

	1. Review classical and modern control theories as applied in engineering systems 2. Examine mathematical models for control systems and subsystems 3. Study the stability of control systems 4. Analyses the use of microcontrollers in closed-loop control systems.
Course References:	▪ Key references: 1. Control Systems Engineering, Norman Nise. 2. Analysis and Design of Control Systems using Matlab Rao V. Dukkipati. 3. Modern Control Engineering, Katsuhiko Ogata. 4. Control Systems engineering, I. J. NAGARATH M. GOPAL. 5. Control Systems Engineering, S. K. Bhattacharya.

Course topics (Theory)	**Week**	**Learning Outcome**
Introduction and definitions - Basic definitions about the concepts of control **Mechanical system and Transfer Function** - Definition of transfer function - Deriving the transfer function for three basic parts of mechanical system	1	
Series and parallel connections in mechanical systems - Transfer function for mechanical system while connected it at series and parallel - Examples **Torsional system** - Deriving the transfer function for three basic parts of torsional System **Electrical system, series and parallel connections** - Deriving the transfer function for three basic parts of electrical system connected in parallel and series	2	
Thermal and fluid systems - Deriving the transfer function for thermal and fluid systems - Examples **Hydraulic system** - The basic concept of working the hydraulic system - Deriving the transfer function of the system **Hydraulic servomotor system** - Leverage system and deriving the transfer function for three cases of fixing - Method of connection with hydraulic system	3	

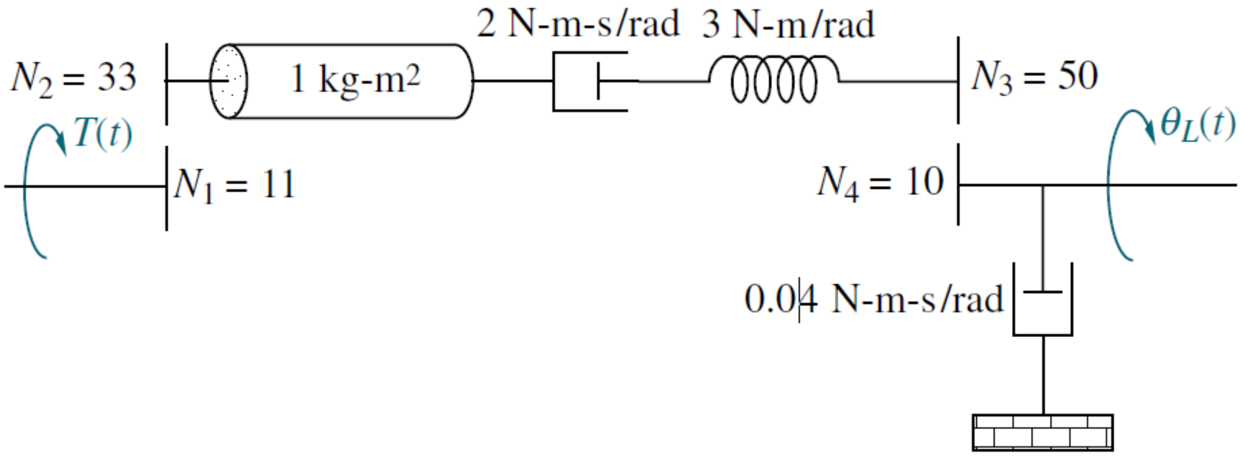
Pneumatic system - The basic concept of working the pneumatic system - Deriving the transfer function of the system **Block diagram** - The principles of block diagram - The basic nine rules for reduction the block diagram **Block diagram reduction** - Method of reduction of block diagrams of multi-input and output	4	
Types of control and Laplace transformations - Types of control methods and basic functions of Laplace transformation **Test signals** - The different types of test signals **Response of first order system** - Method of computing the response of first order system - Examples	5	
Response of second order system - Method of computing the response of second order system - Examples **Response specifications** - The specification of response which determine the stability of system **Steady state error** - Computing the steady state error by using Toyler method and normal method and compare between them	6	
Response improvement - The methods of response improvement - Examples **System stability** - The concept of system stability and its effect on control process **Routh criterion** - The Routh criterion for computing the stability of system	7	
Applications of Routh criterion - Some applications about Routh criterion - Examples **Root-locus method** - The root-locus method for computing system stability **Rules of Root-locus method** - Basic rules of root-locus method - Examples	8	
Polar-plot diagrams - The polar plot for computing system stability	9	
Principles of polar-plot diagrams - The method of polar plot diagram for computing the gain	10	

- Examples		
Logarithmic Scales and Bode Plots - Basic principles of logarithmic scale and Bode plots	11	
Construction of Bode Plots for Continuous-Time Systems - The method of construction of Bode plots - Examples	12	
Analysis of control system in state space - Principles and basic assumptions for state space method	13	
State space representation of transfer function of system - The state space representation - Examples	14	
Solving the time invariant state equations - The solution method of time invariant state equations	15	
Practical Topics	**Week**	**Learning Outcome**
1- Flow / level control demonstration	1	
2- Temperature control demonstration	2	
3- Pressure control demonstration	3	
4- Pump and valves and fitting test stand	4	
5- PLC Application: Mixing Process	5	
6- Experimental determination of dynamic properties and closed-loop response of a two-tank fluid level control system using valve control.	6	
7- Design of PID controller for hydraulic positioner system based on experimental frequency response data.	7	
8- Time response using MATLAB	8	
9- Stability and feedback control of linear system	9	
10- Arduino introduction of control system	10	
11- Arduino dynamic control system	11	

Questions Example Design

Q1:

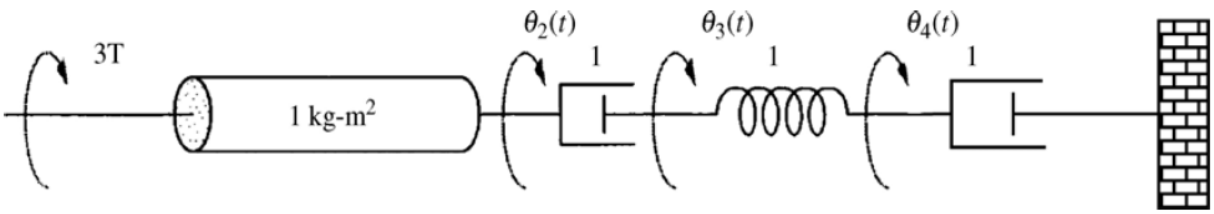
For the rotational system shown in Figure
find the transfer function, $G(s) = \theta_L(s)/T(s)$.



Solutions:

Reflecting impedances and applied torque to respective sides of the viscous damper yields the following

equivalent circuit:



Writing the equations of motion,

$$(s^2 + 2s)\theta_2(s) - 2s\theta_3(s) = 3T(s)$$
$$-2s\theta_2(s) + (2s+3)\theta_3(s) - 3\theta_4(s) = 0$$
$$-3\theta_3(s) + (s+3)\theta_4(s) = 0$$

Solving for $\theta_4(s)$,

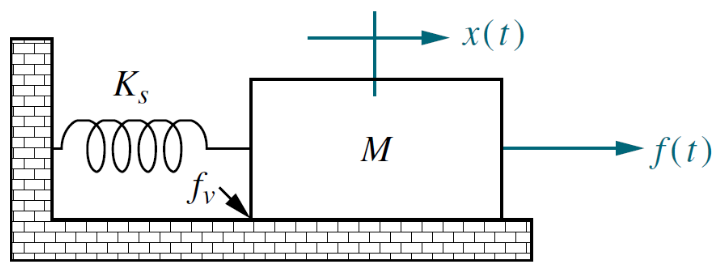
$$\theta_4(s)=\frac{\begin{vmatrix} s(s+2) & -2s & 3T(s) \\ -2s & (2s+3) & 0 \\ 0 & -3 & 0 \end{vmatrix}}{\begin{vmatrix} s(s+2) & -2s & 0 \\ -2s & (2s+3) & -3 \\ 0 & -3 & (s+3) \end{vmatrix}}=\frac{18T(s)}{s(2s^2+9s+6)}$$

But, $\theta_L(s)=5\theta_4(s)$. Hence,

$$\frac{\theta_4(s)}{T(s)}=\frac{90}{s(2s^2+9s+6)}$$

Q2: Solve for x(t) in the system shown in Figure 2 if f(t) is a unit step.

$M = 1$ kg
$K_s = 5$ N/m
$f_v = 1$ N-s/m
$f(t) = u(t)$ N



Solution:

The equation of motion is: $(Ms^2+f_vs+K_s)X(s) = F(s)$. Hence, $\frac{X(s)}{F(s)}=\frac{1}{Ms^2+f_vs+K_s}=\frac{1}{s^2+s+5}$.

The step response is now evaluated: $X(s)=\frac{1}{s(s^2+s+5)}=\frac{1/5}{s}-\frac{\frac{1}{5}s+\frac{1}{5}}{(s+\frac{1}{2})^2+\frac{19}{4}}=$

$$\frac{\frac{1}{5}(s+\frac{1}{2})+\frac{1}{5\sqrt{19}}\frac{\sqrt{19}}{2}}{(s+\frac{1}{2})^2+\frac{19}{4}}.$$

Taking the inverse Laplace transform, $x(t)=\frac{1}{5}-\frac{1}{5}e^{-0.5t}\left(\cos\frac{\sqrt{19}}{2}t+\frac{1}{\sqrt{19}}\sin\frac{\sqrt{19}}{2}t\right)$

$$=\frac{1}{5}\left[1-2\sqrt{\frac{5}{19}}\,e^{-0.5t}\cos\left(\frac{\sqrt{19}}{2}t-12.92^{o}\right)\right].$$

Extra notes:

External Evaluator

This Course Syllabus is well-structured, it was covered important topics on Control engineering science.

Dr. AbdulRahman B. Shakir
18-01-2023