University of Sana'a
Faculty of Engineering
Department: Biomedical Engineering
Title of the Program: Biomedical Engineering

Course Specification of Analog Control Systems

Course Code (BE251)

I. Course Identification and General Information:						
1	**Course Title:**	Analog Control Systems				
2	**Course Code & Number:**	BE251				
3	**Credit hours:**	C.H				TOTAL
		Th.	Seminar	Pr	Tr.	
		2	--	2	2	4
4	**Study level/ semester at which this course is offered:**	3rd Level / 2nd Semester				
5	**Pre –requisite (if any):**	Engineering Physics (FR002), Electrical Circuits 1 (BEBE111),, Electrical Circuits 2 (BEBE112), General Biology (BE101), Electronics I (BE122).				
6	**Co –requisite (if any):**	Biomedical Signals Processing (BE225).				
7	**Program (s) in which the course is offered:**	Biomedical Engineering Program				
8	**Language of teaching the course:**	English				
9	**Location of Teaching the Course:**	Faculty of Engineering				
10	**Prepared by:**	Dr. Mohammed Al-Olofi				
11	**Reviewed by:**	Dr. Waleed Al-talabi				
12	**Date of Approval:**					

II. Course Description:

The Analog Control Systems course aims to give the student knowledge of the basic concepts and Theories of modeling, development, analysis, design and implement of analog control systems. This course includes mathematical modeling of control systems using transfer function and state variable models, block diagrams reduction and signal flow graphs, characteristics and performance of control systems, transient response analysis, stability analysis, Frequency response and Root-Locus method, logarithmic plots and Bode diagram method, and PID controllers. In addition, several design methods of control systems are introduced: series and compensation, state space design, controllability and observability, design of linear control systems, linear time varying state models and pole-placement design method. The practical part allows students to practice different control approaches studied in theoretical classes.

III. Course Intended learning outcomes (CILOs) of the course (maximum 8CILOs)		Referenced PILOs (Only write code number of referenced Program Intended learning outcomes)
Knowledge and Understanding: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
a1	Explain the concepts and mathematical modeling of physical systems in transfer function model and state variable model.	A1 Describe and explain the underlying mathematical methods and theories; life scientific-principles; and engineering core concepts related to the Biomedical Engineering context.
a2	Describe how different analysis techniques are used to determine the specifications of control systems, and common design methods for design analog controllers.	A4 Understand and give examples of design methods, knowledge tools, analytical skills, measurement techniques and methodologies for innovative and creative engineering solutions applied to healthcare problems and quality of life issues.
B. Cognitive/ Intellectual Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		

b1	Apply common conventional and modern engineering methods to model, analyze, and organize the analog biomedical systems.	B1 Apply engineering principles; basic of life-science; mathematical theories; and modern tools professionally in modelling, analyzing, designing, and constructing physical digital systems; devices and/or processes relevant to Biomedical Engineering fields.
b2	Analysis, and evaluate the biomedical engineering systems using the modern control engineering tools, then select the suitable analog controller for biomedical systems.	B2 Identify, formulate and solve the complex problems related to the Biomedical Engineering fields in a creative and innovative manner by using a systematic and analytical thinking methods.
b3	Design the analog controllers, and others components of the medical devices by using the control system design methods.	B3 Design the biomedical systems or processes within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
C. Professional and Practical Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
c1	Use the modern engineering tools, and analytical techniques to evaluate performance characteristics of different types of plant and process, and applying the knowledge to design, and implement an analog control systems.	C2 Use a wide range of analytical tools, techniques, IT, modern engineering tools, software packages and develop required computer programs to solve, modeling and analyzing Biomedical Engineering problems.
c2	Conduct appropriate	C3 Use computational facilities and techniques, measuring instruments, workshops and

	experimentation related to analog control systems, and Locate different type of analog controllers used in real medical equipment.	laboratory equipment to design and conduct experiments, collect, analyse and interpret data and present results in the biomedical systems practice.
D. Transferable Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
d1	Lead, and work productively as an individual and as a member of a team / multi-disciplinary team.	D1 Lead and motivate individuals, show capability to work in stressful environments and within constraints, collaborate effectively within multidisciplinary team.

(A) Alignment Course Intended Learning Outcomes of Knowledge and Understanding to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
a1 Explain the concepts and mathematical modeling of physical systems in transfer function model and state variable model.	• Interactive lectures & examples, • Tutorials, • Videos demonstrations, • Presentation/seminar, • Interactive class discussions, • Case studies, • Exercises and home works, • Computer laboratory-based sessions, • Directed self- study, • Problem based learning,	• Written tests (mid and final terms and quizzes), • Short reports, • Practical lab performance assessment, • Coursework activities assessment, • Home works and assignments, • Presentations.

a2 Describe how different analysis techniques are used to determine the specifications of control systems, and common design methods for design analog controllers.	• Interactive lectures & examples, • Tutorials, • Videos demonstrations, • Presentation/seminar, • Interactive class discussions, • Case studies, • Exercises and home works, • Laboratory/Practical experiments based session, • Computer laboratory-based sessions, • Workshops practices, • Directed self- study, • Problem based learning, • Mini/major project.	• Written tests (mid and final terms and quizzes), • Oral exams, • Short reports, • Lab\Project report • Practical lab performance assessment, • Coursework activities assessment, • Home works and assignments, • Presentations.

(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
b1 Apply common conventional and modern engineering methods to model, analyze, and organize the analog biomedical systems.	• Interactive lectures & examples, • Tutorials, • Videos demonstrations, • Presentation/seminar, • Interactive class discussions,	• Written tests (mid and final terms and quizzes), • Short reports, • Lab\Project report • Practical lab performance

	• Case studies, • Exercises and home works, • Laboratory/Practical experiments based session, • Workshops practices, • Directed self- study, • Problem based learning, • Mini/major project.	assessment, • Coursework activities assessment, • Home works and assignments, • Presentations.
b2 Analysis, and evaluate the biomedical engineering systems using the modern control engineering tools, then select the suitable analog controller for biomedical systems.	• Interactive lectures & examples, • Tutorials, • Videos demonstrations, • Presentation/seminar, • Interactive class discussions, • Case studies, • Exercises and home works, • Laboratory/Practical experiments based session, • Computer laboratory-based sessions, • Workshops practices, • Directed self- study, • Problem based learning, • Mini/major project.	• Written tests (mid and final terms and quizzes), • Short reports, • Lab\Project report • Practical lab performance assessment, • Coursework activities assessment, • Home works and assignments, • Presentations.
b3 Design the analog	• Interactive lectures & examples,	• Written tests (mid and final terms and

controllers, and others components of the medical devices by using the control system design methods.	• Tutorials, • Interactive class discussions, • Case studies, • Exercises and home works, • Laboratory/Practical experiments based session, • Computer laboratory-based sessions, • Workshops practices, • Directed self- study, • Problem based learning, • Team work (cooperative learning), • Field visits/training, • Mini/major project.	quizzes), • Oral exams, • Short reports, • Lab\Project report • Practical lab performance assessment, • Coursework activities assessment, • Home works and assignments, • Presentations.

(C) Alignment Course Intended Learning Outcomes of Professional and Practical Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
c1 Use the modern engineering tools, and analytical techniques to evaluate performance characteristics of different types of plant and process, and applying the knowledge to design, and implement an analog control systems.	• Interactive lectures & examples, • Tutorials, • Videos demonstrations, • Presentation/seminar, • Interactive class discussions, • Case studies, • Laboratory/Practical	• Written tests (mid and final terms and quizzes), • Short reports, • Lab\Project report • Practical lab performance assessment, • Coursework activities

	experiments based session, • Computer laboratory-based sessions, • Workshops practices, • Directed self- study, • Problem based learning, • Team work (cooperative learning), • Field visits/training, • Mini/major project.	assessment, • Home works and assignments, • Presentations.
c2 Conduct appropriate experimentation related to analog control systems, and Locate different type of analog controllers used in real medical equipment.	• Interactive lectures & examples, • Tutorials, • Videos demonstrations, • Presentation/seminar, • Interactive class discussions, • Case studies, • Laboratory/Practical experiments based session, • Computer laboratory-based sessions, • Workshops practices, • Directed self- study, • Problem based learning, • Team work (cooperative learning), • Field visits/training, • Mini/major project.	• Short reports, • Lab\Project report • Practical lab performance assessment, • Coursework activities assessment, • Home works and assignments, • Presentations.

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
d1 Lead, and work productively as an individual and as a member of a team / multi-disciplinary team.	• Videos demonstrations, • Presentation/seminar, • Interactive class discussions, • Case studies, • Laboratory/Practical experiments based session, • Computer laboratory-based sessions, • Workshops practices, • Problem based learning, • Team work (cooperative learning), • Field visits/training, • Mini/major project.	• Short reports, • Lab\Project report • Practical lab performance assessment, • Coursework activities assessment, • Presentations.

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	contact hours
1	**Introduction of control systems**	**a1, a2**	– Introduction of analog control systems, – types of analog control	**1**	**2**

			systems, – components of analog control systems, – steps to design analog control systems.		
2	**Mathematical models of systems.**	**a1, a2**	– Mathematical models of electrical, mechanical, thermal, fluid, hydraulic systems, – differential equation, – linear approximation of control systems, – Laplace transform and theorems – transfer function models,	**1**	**2**
3	**Mathematical models of systems.**	**a1, a2**	– s-plane analysis of analog control systems, – block diagram reduction, – signal flow graph	**1**	**2**
4	**State-variable models**	**a1, a2**	– State-variable model, – analysis in State-variable, – transform from State-variable model to transfer function model	**1**	**2**
5	**Feedback control system characteristics**	**a2, b1, b2, b3**	– Feedback control system characteristics, – error signal analysis, – sensitivity of feedback control system to parameters variation,	**1**	**2**

			– disturbance and noise signal rejection, – cost of feedback control system, – design examples.		
6	**Performance of the feedback control system**	**a2, b1, b2, b3**	– Performance of 2nd order feedback control system, – test input signals, – steady-state error of feedback control system, – performance index of feedback control systems, – design examples.	**1**	**2**
7	**The Stability of feedback control system**	**a2, b1, b2, b3**	– Stability analysis of feedback control system, – The Routh-Hurwitz Stability Criterion, – Relative stability, – Stability of State Variable Systems, – design examples.	**1**	**2**
8	**Mid-Term Theoretical Exam**	**a1, a2, b1, b2, b3**	– Previous Topics	**1**	**2**
9	**The Root Locus method**	**a2, b1, b2, b3, c1**	– Root locus concept, – root locus procedures,	**1**	**2**
10	**The Root Locus method**	**a2, b1, b2, b3, c1**	– Parameters design by the root locus, – PID controllers, – design examples	**1**	**2**

11	**Frequency Response methods**	**a2, b1, b2, b3, c1**	– Frequency response plots, – bode diagram, – Frequency response measurements, – performance specifications in Frequency response, – design example	**1**	**2**
12	**Design of feedback control systems**	**a2, b1, b2, b3, c1, c2, d1**	– Approaches to System Design, – Cascade Compensation Networks, – Phase-Lead Design Using the Bode Diagram and Root Locus,	**1**	**2**
13	**Design of feedback control systems**	**a2, b1, b2, b3, c1, c2, d1**	– System Design Using Integration Networks, – Phase-Lag Design Using the Bode Diagram and Root Locus, – Design on the Bode Diagram Using Analytical Methods, – Systems with a Pre-filter, Design for Dead beat Response, – design examples.	**1**	**2**
14	**Design of state variable feedback control systems**	**a2, b1, b2, b3, c1, c2, d1**	– Controllability and Observability, – Full-State Feedback Control Design,	**1**	**2**

			– Observer Design,		
15	**Design of state variable feedback control systems**	**a2, b1, b2, b3, c1, c2, d1**	– Integrated Full-State Feedback and observer, – Reference Inputs, – Internal Model Design, – design examples	**1**	**2**
16	**Final Theoretical Exam**	**a1, a2, b1, b2, b3, c1, c2**	– All Topics	**1**	**2**
Number of Weeks /and Units Per Semester				**16**	**32**

B - Practical Aspect: (if any)

Order	Tasks/ Experiments	Number of Weeks	contact hours	Learning Outcomes
1	**Introduction of analog control systems.**	**1**	**2**	a1, a2
2	**Introduction of matlab software.**	**1**	**2**	a1, a2, b1, b2
3	**Control Systems toolbox in matlab software.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
4	**Control Systems toolbox in matlab software.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
5	**Mathematical models of analog control system in matlab software.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
6	**Mathematical models of analog control system in matlab software.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
7	**Mid-Term Practical Exam** (if any)	**1**	**2**	a1, a2, b1, b2, b3, c1, c2

8	**Block diagram reduction in matlab software.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
9	**Midterm Practical Exam**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
10	**Analysis of analog control systems response and performance .**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
11	**Root locus method in matlab program.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
12	**Bode plot method in matlab program.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
13	**Analog controller design method in matlab program.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
14	**Analog controller design method in matlab program.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
15	**Final Practical Exam**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2
Number of Weeks /and Units Per Semester			**15**	**30**

V. Teaching Strategies of the Course:

- Interactive lectures & examples,
- Tutorials,
- Videos demonstrations,
- Presentation/seminar,
- Interactive class discussions,
- Case studies,
- Exercises and home works,
- Laboratory/Practical experiments based session,
- Computer laboratory-based sessions,
- Workshops practices,

V. Teaching Strategies of the Course:

- Directed self- study,
- Problem based learning,
- Team work (cooperative learning),
- Field visits/training,
- Mini/major project.

VI. Assessment Methods of the Course:

- Written tests (mid and final terms and quizzes),
- Oral exams,
- Short reports,
- Lab\Project report
- Practical lab performance assessment,
- Coursework activities assessment,
- Home works and assignments,
- Presentations.

VII. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1	Problems, and advance problems, and computer problems of the Chapter 2	a1, a2	2	3
2	Problems, and advance problems, and computer problems of the Chapter 3	a1, a2	3	3
3	Problems, and advance problems, and computer problems of the Chapter 4, 5	a1, a2, b1, b2, b3	5	3
4	Problems, and advance problems, and computer problems of the Chapter 6, 7	a1, a2, b1, b2, b3	9	3

5	Problems, and advance problems, and computer problems of the Chapter 8	a1, a2, b1, b2, b3, c1, c2	10	6
6	Problems, and advance problems, and computer problems of the Chapter 10	a1, a2, b1, b2, b3, c1, c2	13	6
7	Problems, and advance problems, and computer problems of the Chapter 11	a1, a2, b1, b2, b3, c1, c2	15	6
Total				30

VIII. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
1	**Assignments**	15	30	15%	a1, a2, b1, b2, b3, c1, c2
2	**Quiz 1**	6	10	5%	a1, a2, b1, b2, b3
3	**Midterm Theoretical Exam**	8	30	15%	a1, a2, b1, b2, b3
4	**Midterm Theoretical Exam**	9	20	10%	a1, a2, b1, b2, b3
5	**Quiz 2**	12	10	5%	a1, a2, b1, b2, b3, c1, c2
6	**Final Practical Exam**	15	30	15%	a1, a2, b1, b2, b3, c1, c2
7	**Final Theoretical Exam**	16	70	35%	a1, a2, b1, b2, b3, c1, c2
Total			200	100%	

IX. Learning Resources:

- *Written in the following order: (Author - Year of publication – Title – Edition – Place of publication – Publisher).*

1- Required Textbook(s) (maximum two).

1- Richard C. Dorf, Robert H. Bishop, 2013, **Modern Control Systems**, 12th Edition, Prentice Hall.

2- Katsuhiko Ogata, 2010, **Modern Control Engineering**, 5th Edition, Prentice Hall.

2- Essential References.

1- Norman S. Nise**,**2011**, CONTROL SYSTEMS ENGINEERING**, Sixth Edition, John Wiley & Sons, Inc.

2- FARIDGOLNARAGHI, BENJAMINC.KUO, 2010, **Automatic Control Systems**, ninth Edition, John Wiley & Sons, Inc.

3- Electronic Materials and Web Sites *etc*.

Websites:

1- The National Program on Technology Enhanced Learning (NPTEL), Automatic Control https://nptel.ac.in/courses/112/107/112107240/

Journals:

2- IEEE Transactions on control systems technology: Peer reviewed academic journal.. https://www.ieeexplore.ieee.org/xpl

3- International Journal of control, automation and systems: The leading peer reviewed academic journal . https://www.springer.com/Journal

Other Web Sources:

4- Analog Devices, a Head of What's Possible, https://www.analog.com/en/education/education-library/tutorials.html

X. Course Policies:	
1	**Class Attendance:** A student should attend not less than 75 % of total hours of the subject; otherwise he/she will not be able to take the exam and will be considered as exam failure. If the student is absent due to illness, he/she should bring a proof statement from university Clinic. If the absent is more than 25% of a course total contact hours, student will be required to retake the entire course again.
2	**Tardy:** For late in attending the class, the student will be initially notified. If he repeated lateness in attending class, he/she will be considered as absent.
3	**Exam Attendance/Punctuality:** A student should attend the exam on time. He/she is permitted to attend an exam half one hour from exam beginning, after that he/she will not be permitted to take the exam and he/she will be considered as absent in exam
4	**Assignments & Projects:** In general one assignment is given to the students after each chapter; the student has to submit all the assignments for checking on time, mostly one week after given the assignment.
5	**Cheating:** For cheating in exam, a student will be considered as fail. In case the cheating is repeated three times during his/her study the student will be disengaged from the Faculty.
6	**Plagiarism:** Plagiarism is the attending of a student the exam of a course instead of another student. If the examination committee proofed a plagiarism of a student, he/she will be disengaged from the Faculty. The final disengagement of the student from the Faculty should be confirmed from the Student Council Affair of the university or according to the university roles.

7	**Other policies**: - Mobile phones are not allowed to use during a class lecture. It must be closed; **otherwise** the student will be asked to leave the lecture room. - Mobile phones are not allowed in class during the examination. - Lecture notes and assignments might be given directly to students using soft or hard copy.

University of Sana'a
Faculty of Engineering
Department: Biomedical Engineering
Title of the Program: Biomedical Engineering

Template for Course Plan (Syllabus)

Analog Control Systems
BE251

I. Course Identification and General Information:					
1	**Course Title:**	Analog Control Systems			
2	**Course Code & Number:**	BE251			
3	**Credit Hours:**	**Credit Hours**	**Theory Hours**		**Lab. Hours**
			Lecture	**Exercise**	
		4	2	2	2
4	**Study Level/ Semester at which this Course is offered:**	3rd Level / 2nd Semester			
5	**Pre –Requisite (if any):**	Engineering Physics (FR002), Electrical Circuits 1 (BEBE111),, Electrical Circuits 2 (BEBE112), General Biology (BE101), Electronics I (BE122).			
6	**Co –Requisite (if any):**	Biomedical Signals Processing (BE225).			
7	**Program (s) in which the Course is Offered:**	Bachelor of Biomedical Engineering			
8	**Language of Teaching the Course:**	English			
9	**Location of Teaching the Course:**	Faculty of Engineering			
10	**Prepared by:**	Dr. Mohammed Al-Olofi			
11	**Reviewed by:**	Dr. Waleed Al-talabi			
12	**Date of Approval:**				

II. Course Description:

The Analog Control Systems course aims to give the student knowledge of the basic concepts and Theories of modeling, development, analysis, design and implement of analog control systems. This course includes mathematical modeling of control systems using transfer function and state variable models, block diagrams reduction and signal flow graphs, characteristics and performance of control systems, transient response analysis, stability analysis, Frequency response and Root-Locus method, logarithmic plots and Bode diagram method, and PID controllers. In addition, several design methods of control systems are introduced: series and compensation, state space design, controllability and observability, design of linear control systems, linear time varying state models and pole-placement design method. The practical part allows students to practice different control approaches studied in theoretical classes.

III. Course Intended Learning Outcomes (CILOs): (مخرجات تعلم المقرر)

A. Knowledge and Understanding: Upon successful completion of the course, students will be able to:	
a1	Explain the concepts and mathematical modeling of physical systems in transfer function model and state variable model.
a2	Describe how different analysis techniques are used to determine the specifications of control systems, and common design methods for design analog controllers.
B. Intellectual Skills: Upon successful completion of the course, students will be able to:	
b1	Apply common conventional and modern engineering methods to model, analyze, and organize the analog biomedical systems.
b2	Analysis, and evaluate the biomedical engineering systems using the modern control engineering tools, then select the suitable analog controller for biomedical systems.
b3	Design the analog controllers, and others components of the medical devices by using the control system design methods.
C. Professional and Practical Skills: Upon successful completion of the course, students will be able to:	

III. Course Intended Learning Outcomes (CILOs): (مخرجات تعلم المقرر)	
c1	Use the modern engineering tools, and analytical techniques to evaluate performance characteristics of different types of plant and process, and applying the knowledge to design, and implement an analog control systems.
c2	Conduct appropriate experimentation related to analog control systems, and Locate different type of analog controllers used in real medical equipment.
D. Transferable Skills: Upon successful completion of the course, students will be able to:	
d1	Lead, and work productively as an individual and as a member of a team / multi-disciplinary team

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
1	**Introduction of control systems**	– Introduction of analog control systems, – types of analog control systems, – components of analog control systems, – steps to design analog control systems.	1	2
2	**Mathematical models of systems.**	– Mathematical models of electrical, mechanical, thermal, fluid, hydraulic systems, – differential equation, – linear approximation of control systems, – Laplace transform and theorems	1	2

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		– transfer function models,		
3	**Mathematical models of systems.**	– s-plane analysis of analog control systems, – block diagram reduction, – signal flow graph	**1**	**2**
4	**State-variable models**	– State-variable model, – analysis in State-variable, – transform from State-variable model to transfer function model	**1**	**2**
5	**Feedback control system characteristics**	– Feedback control system characteristics, – error signal analysis, – sensitivity of feedback control system to parameters variation, – disturbance and noise signal rejection, – cost of feedback control system, – design examples.	**1**	**2**
6	**Performance of the feedback control system**	– Performance of 2nd order feedback control system, – test input signals, – steady-state error of feedback control system, – performance index of feedback control systems,	**1**	**2**

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		– design examples.		
7	**The Stability of feedback control system**	– Stability analysis of feedback control system, – The Routh-Hurwitz Stability Criterion, – Relative stability, – Stability of State Variable Systems, – design examples.	**1**	**2**
8	**Mid-Term Theoretical Exam**	– Previous Topics	**1**	**2**
9	**The Root Locus method**	– Root locus concept, – root locus procedures,	**1**	**2**
10	**The Root Locus method**	– Parameters design by the root locus, – PID controllers, – design examples	**1**	**2**
11	**Frequency Response methods**	– Frequency response plots, – bode diagram, – Frequency response measurements, – performance specifications in Frequency response, – design example	**1**	**2**
12	**Design of feedback control systems**	– Approaches to System Design,	**1**	**2**

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		– Cascade Compensation Networks, – Phase-Lead Design Using the Bode Diagram and Root Locus,		
13	**Design of feedback control systems**	– System Design Using Integration Networks, – Phase-Lag Design Using the Bode Diagram and Root Locus, – Design on the Bode Diagram Using Analytical Methods, – Systems with a Pre-filter, Design for Dead beat Response, – design examples.	**1**	**2**
14	**Design of state variable feedback control systems**	– Controllability and Observability, – Full-State Feedback Control Design, – Observer Design,	**1**	**2**
15	**Design of state variable feedback control systems**	– Integrated Full-State Feedback and observer, – Reference Inputs, – Internal Model Design, – design examples	**1**	**2**
16	**Final Theoretical Exam**	– All Topics	**1**	**2**
Number of Weeks /and Units Per Semester			**16**	**32**

B. Case Studies and Practical Aspect:			
No.	**Tasks/ Experiments**	**Number of Weeks**	**Contact Hours**
1	**Introduction of analog control systems.**	**1**	**2**
2	**Introduction of matlab software.**	**1**	**2**
3	**Control Systems toolbox in matlab software.**	**1**	**2**
4	**Control Systems toolbox in matlab software.**	**1**	**2**
5	**Mathematical models of analog control system in matlab software.**	**1**	**2**
6	**Mathematical models of analog control system in matlab software.**	**1**	**2**
7	**Mid-Term Practical Exam** (if any)	**1**	**2**
8	**Block diagram reduction in matlab software.**	**1**	**2**
9	**Midterm Practical Exam**	**1**	**2**
10	**Analysis of analog control systems response and performance .**	**1**	**2**
11	**Root locus method in matlab program.**	**1**	**2**
12	**Bode plot method in matlab program.**	**1**	**2**
13	**Analog controller design method in matlab program.**	**1**	**2**
14	**Analog controller design method in matlab program.**	**1**	**2**
15	**Final Practical Exam**	**1**	**2**
Number of Weeks /and Units Per Semester		**15**	**30**

V. Teaching Strategies of the Course:

- Interactive lectures & examples,
- Tutorials,
- Videos demonstrations,
- Presentation/seminar,
- Interactive class discussions,
- Case studies,
- Exercises and home works,
- Laboratory/Practical experiments based session,
- Computer laboratory-based sessions,
- Workshops practices,
- Directed self- study,
- Problem based learning,
- Team work (cooperative learning),
- Field visits/training,
- Mini/major project.

VI. Assessment Methods of the Course:

- Written tests (mid and final terms and quizzes),
- Oral exams,
- Short reports,
- Lab\Project report
- Practical lab performance assessment,
- Coursework activities assessment,
- Home works and assignments,
- Presentations.

VII. Assignments:

No.	Assignments	Week Due	Mark
1	Problems, and advance problems, and computer problems of the Chapter 2	2	3
2	Problems, and advance problems, and computer problems of the Chapter 3	3	3
3	Problems, and advance problems, and computer problems of the Chapter 4, 5	5	3
4	Problems, and advance problems, and computer problems of the Chapter 6, 7	9	3
5	Problems, and advance problems, and computer problems of the Chapter 8	10	6
6	Problems, and advance problems, and computer problems of the Chapter 10	13	6
7	Problems, and advance problems, and computer problems of the Chapter 11	15	6
Total			**30**

VIII. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment
1	**Assignments**	15	30	15%
2	**Quiz 1**	6	10	5%
3	**Midterm Theoretical Exam**	8	30	15%
4	**Midterm Theoretical Exam**	9	20	10%

VIII. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment
5	**Quiz 2**	12	10	5%
6	**Final Practical Exam**	15	30	15%
7	**Final Theoretical Exam**	16	70	35%
Total			**200**	**100%**

IX. Learning Resources:

- *Written in the following order:*

- *Written in the following order: (Author - Year of publication – Title – Edition – Place of publication – Publisher).*

1- Required Textbook(s) (maximum two):

1- Richard C. Dorf, Robert H. Bishop, 2013, **Modern Control Systems**, 12th Edition, Prentice Hall.

2- Katsuhiko Ogata, 2010, **Modern Control Engineering**, 5th Edition, Prentice Hall.

2- Essential References:

3- Norman S. Nise**,**2011**, CONTROL SYSTEMS ENGINEERING**, Sixth Edition, John Wiley & Sons, Inc.

4- FARIDGOLNARAGHI, BENJAMINC.KUO, 2010, **Automatic Control Systems**, ninth Edition, John Wiley & Sons, Inc.

3- Electronic Materials and Web Sites etc.:

Websites:

1- The National Program on Technology Enhanced Learning (NPTEL), Automatic Control
https://nptel.ac.in/courses/112/107/112107240/

Journals:

2- IEEE Transactions on control systems technology: Peer reviewed academic journal..
https://www.ieeexplore.ieee.org/xpl

IX. Learning Resources:

3- International Journal of control, automation and systems: The leading peer reviewed academic journal

. https://www.springer.com/Journal

Other Web Sources:

4- Analog Devices, a Head of What's Possible,

https://www.analog.com/en/education/education-library/tutorials.html

X. Course Policies:

1	**Class Attendance:** A student should attend not less than 75 % of total hours of the subject; otherwise he/she will not be able to take the exam and will be considered as exam failure. If the student is absent due to illness, he/she should bring a proof statement from university Clinic. If the absent is more than 25% of a course total contact hours, student will be required to retake the entire course again.
2	**Tardy:** For late in attending the class, the student will be initially notified. If he repeated lateness in attending class, he/she will be considered as absent.
3	**Exam Attendance/Punctuality:** A student should attend the exam on time. He/she is permitted to attend an exam half one hour from exam beginning, after that he/she will not be permitted to take the exam and he/she will be considered as absent in exam
4	**Assignments & Projects**: In general one assignment is given to the students after each chapter; the student has to submit all the assignments for checking on time, mostly one week after given the assignment.
5	**Cheating**:

	For cheating in exam, a student will be considered as fail. In case the cheating is repeated three times during his/her study the student will be disengaged from the Faculty.
6	**Plagiarism:** Plagiarism is the attending of a student the exam of a course instead of another student. If the examination committee proofed a plagiarism of a student, he/she will be disengaged from the Faculty. The final disengagement of the student from the Faculty should be confirmed from the Student Council Affair of the university or according to the university roles.
7	**Other policies:** - Mobile phones are not allowed to use during a class lecture. It must be closed; **otherwise** the student will be asked to leave the lecture room. - Mobile phones are not allowed in class during the examination. - Lecture notes and assignments might be given directly to students using soft or hard copy.