NEC NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE FILE

Academic year	: 2022-23
Department	: ME
Course Name	: B.Tech
Student's Batch	: 2022-23
Regulation	: R20
Year and Semester	: IV B.Tech I Semester
Name of the Subject	: mechatronics
Subject Code	: R20CC40E06
Faculty In charge	: CH.SEKHAR

Signature of Faculty

Head of the Department

NARASARAOPETA ENGINEERING COLLEGE

NEC

(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE FILE CONTENTS

NARASARAOPETA
ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

INSTITUTE VISION AND MISSION

NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

INSTITUTE VISION AND MISSION

VISION:

To emerge as a **Centre of excellence** in technical education with a blend of effective **student centric teaching learning** practices as well as **research** for the transformation of **lives and community**.

MISSION:

1. Provide the best class infrastructure to explore the field of engineering and research.
2. Build a passionate and a determined team of faculty with student centric teaching, imbibing experiential and innovative skills.
3. Imbibe lifelong learning skills, entrepreneurial skills and ethical values in students for addressing societal problems.

PRINCIPAL

NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

DEPARTMENT VISION AND MISSION

NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

DEPARTMENT VISION AND MISSION

VISION:

To strive for making competent **Mechanical Engineering Professionals** to cater the real time needs of Industry and **Research** Organizations of high repute with **Entrepreneurial Skills and Ethical Values.**

MISSION:

M1. To train the students with State of Art Infrastructure to make them industry ready professionals and to promote them for higher studies and research.

M2. To employ committed faculty for developing competent mechanical engineering graduates to deal with complex problems.

M3. To support the students in developing professionalism and make them socially committed mechanical engineers with morals and ethical values.

HOD-ME

NARASARAOPETA
ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

AND

PROGRAM SPECIFIC OUTCOMES (PSOs)

NARASARAOPETA
ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: Excel in profession with sound knowledge in mathematics and applied sciences

PEO 2: Demonstrate leadership qualities and team spirit in achieving goals

PEO 3: Pursue higher studies to ace in research and develop as entrepreneurs.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1. The students will be able to apply knowledge of modern tools in manufacturing enabling to conquer the challenges of Modern Industry.

PSO2. The students will be able to design various thermal engineering systems by applying the principles of thermal sciences.

PSO3. The students will be able to design different mechanisms and machine components of transmission of power and automation in modern industry.

HOD-ME

NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

PROGRAM OUTCOMES (POs)

NARASARAOPETA
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DEPARTMENT OF MECHANICAL ENGINEERING

PROGRAM OUTCOMES (POs):

Engineering Graduates will be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

HOD-ME

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BLOOM'S TAXONOMY LEVELS

REVISED Bloom's Taxonomy Action Verbs

Definitions	I. Remembering	II. Understanding	III. Applying	IV. Analyzing	V. Evaluating	VI. Creating
Bloom's Definition	Exhibit memory of previously learned material by recalling facts, terms, basic concepts, and answers.	Demonstrate understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions, and stating main ideas.	Solve problems to new situations by applying acquired knowledge, facts, techniques and rules in a different way.	Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support generalizations.	Present and defend opinions by making judgments about information, validity of ideas, or quality of work based on a set of criteria.	Compile information together in a different way by combining elements in a new pattern or proposing alternative solutions.
Verbs	• Choose • Define • Find • How • Label • List • Match • Name • Omit • Recall • Relate • Select • Show • Spell • Tell • What • When • Where • Which • Who • Why	• Classify • Compare • Contrast • Demonstrate • Explain • Extend • Illustrate • Infer • Interpret • Outline • Relate • Rephrase • Show • Summarize • Translate	• Apply • Build • Choose • Construct • Develop • Experiment with • Identify • Interview • Make use of • Model • Organize • Plan • Select • Solve • Utilize	• Analyze • Assume • Categorize • Classify • Compare • Conclusion • Contrast • Discover • Dissect • Distinguish • Divide • Examine • Function • Inference • Inspect • List • Motive • Relationships • Simplify • Survey • Take part in • Test for • Theme	• Agree • Appraise • Assess • Award • Choose • Compare • Conclude • Criteria • Criticize • Decide • Deduct • Defend • Determine • Disprove • Estimate • Evaluate • Explain • Importance • Influence • Interpret • Judge • Justify • Mark • Measure • Opinion • Perceive • Prioritize • Prove • Rate • Recommend • Rule on • Select • Support • Value	• Adapt • Build • Change • Choose • Combine • Compile • Compose • Construct • Create • Delete • Design • Develop • Discuss • Elaborate • Estimate • Formulate • Happen • Imagine • Improve • Invent • Make up • Maximize • Minimize • Modify • Original • Originate • Plan • Predict • Propose • Solution • Solve • Suppose • Test • Theory

derson, L. W., & Krathwohl, D. R. (2001). A taxonomy for learning, teaching, and assessing, Abridged Edition. Boston, MA: Allyn and Bacon.

NARASARAOPETA
NEC ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE OUTCOMES
(COs)

NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING
B.TECH – R20 REGULATION - COURSE OUTCOMES

Course Name: MECHATRONICS (Open Elective-IV)	Course Code: C415
CO	**After successful completion of this course, the students will be able to:**
C415.1	**Discuss** the elements of a microcontroller as well as the operating principles of motors, sensors, and circuits commonly used in mechatronic devices
C415.2	**Describe** the basics of Semiconductors used in mechatronics.
C415.3	**Analyze** the Sensors and Transducers for different applications.
C415.4	**Analyze** different logics ad logical controls.
C415.5	**Apply** the concepts of mechatronics for various applications.

NARASARAOPETA
ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE INFORMATION SHEET

	Narasaraopeta Engineering College (Autonomous) Yallmanda(Post), Narasaraopet- 522601 **Department of Mechanical Engineering**

COURSE INFORMATION SHEET

PROGRAME: B.Tech Mechanical Engineering	
COURSE: MECHATRONICS	Semester : **VII** CREDITS: **3**
COURSE CODE: **R20CC4OE06** REGULATION: **R20**	COURSE TYPE (CORE /ELECTIVE / BREADTH/ S&H): **ELECTIVE**
COURSE AREA/DOMAIN: **Industrial Engineering/Automation**	PERIODS: 6 Per Week.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
19BME6TH04	Dynamics of Machinery	Concepts of springs	**III-II**
19BCC2TH14	Elements of Electrical & Electronics Engineering	Knowledge of actuators	**I-II**

COURSE OUTCOMES:

SNO	Course Outcome Statement
CO1	**Discuss** the elements of a microcontroller as well as the operating principles of motors, sensors, and circuits commonly used in mechatronic devices.[K4]
CO2	**Describe** the basics of Semiconductors used in mechatronics. [K2]
CO3	**Analyze** the Sensors and Transducers for different applications.[K4]
CO4	**Analyze** different logics ad logical controls.[K4]
CO5	**Apply** the concepts of mechatronics for various applications.[K3]

SYLLABUS:

UNIT	DETAILS
I	**INTRODUCTION:** Multi-disciplinary Scenario, Origins, Evolution of Mechatronics, An overview of Mechatronics, Introduction to Manufacturing, Design. **System modelling:** Introduction, system modelling, mechanical system, translational mechanical system with spring, damper and mass, Rotational mechanical system with spring, damper and mass; electrical system, modelling electric motor, fluid system, thermal systems, modeling pneumatic actuator
II	**SEMICONDUCTORS AND ELECTRONICS** Semiconductors, PN junction diode-types, BJT, DIAC, TRIAC, LEDs, transistors, FET, MOSFET, SCR, IC, DC
III	**SENSORS AND TRANSDUCERS** Introduction and background, difference between transducer and sensor, transducers types, transduction principle, photoelectric transducers, thermistors, thermo devices, thermo couple, inductive transducers, capacitive transducers, pyro electric transducers, piezoelectric transducers, Hall-effect transducers, Fibre optic transducers.
IV	**DIGITAL LOGIC & PLC** Digital logic, number systems, logic gates, Boolean algebra, karnaugh maps, application of logic gates, sequential logic, Programmable logic controller (PLC), Digital controllers.
V	**APPLICATIONS IN MECHATRONICS**

	Sensors for condition monitoring, mechatronic control in automated manufacturing, artificial intelligence in mechatronics, Fuzzy logic applications in mechatronics, micro sensors in Mechatronics, and contemporary issues.

TEXT BOOKS	
T	**BOOK TITLE/AUTHORS/PUBLISHER**
T1	Mechatronics - Electronic Control Systems in Mechanical and Electrical Engineering (2010), W. Bolton, Pearson Education.
T2	Mechatronics system design by Devdas Shetty and Richard A. Kolk, PWS publishing company.
REFERENCE BOOKS	
R	**BOOK TITLE/AUTHORS/PUBLISHER**
R1	Mechatronics: Principles, concepts and applications by Nitaigour Premchand Mahalik, Tata – McGraw Hill Publishing Company Ltd.
R2	Mechatronics: Integrated Mechanical Electronic Systems by K.P. Ramchandran, G.K. Vijyaraghavan, M.S. Balasundaram, Willey Publication, 2008

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS:

SNO	DESCRIPTION	Associated PO & PSO
1	Microprocessor and sensors	PO3 & PSO3

WEB SOURCE REFERENCES:

1	https://nptel.ac.in/downloads/112101098/
2	https://nptel.ac.in/courses/112101098/download/lecture-1.pdf
3	https://www.youtube.com/watch?v=glUrzUxbepE&t=1026s
4	https://nptel.ac.in/courses/112101098/download/lecture-2.pdf
5	https://nptel.ac.in/courses/112101098/download/lecture-4.pdf
6	https://www.youtube.com/watch?v=zxYeJW9v6OU&list=PLwymdQ84KI-w5DwDzqO_4hWsB2Jc4_eBy
7	https://nptel.ac.in/courses/112101098/download/lecture-5.pdf
8	https://nptel.ac.in/courses/112101098/download/lecture-6.pdf
9	https://nptel.ac.in/courses/112101098/download/lecture-7.pdf
10	https://www.youtube.com/watch?v=gXTpOP9AtQ8&list=PLir19lgiavA0EKRRN3xdARy_z44hKhNQc
11	https://nptel.ac.in/courses/112101098/download/lecture-9.pdf
12	https://nptel.ac.in/courses/112101098/download/lecture-10.pdf
13	https://nptel.ac.in/courses/112101098/download/lecture-12.pdf

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

√ Chalk & Talk	√ PPT	☐Active Learning
√Web Resources	☐ Students Seminars	☐Case Study
☐Blended Learning	√ Quiz	☐Tutorials
☐Project based learning	√ NPTEL/MOOCS	☐ Simulation
☐Flipped Learning	☐Industrial Visit	☐Model Demonstration
☐Brain storming	☐Role Play	√ Virtual Labs

MAPPING CO'S WITH PO'S

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	2	-	-	-	-	-	-	-	-	-	-	-	3
CO2	3	1	1	-	-	-	-	-	-	-	-	-	-	-	3
CO3	3	1	2	-	-	-	-	-	-	-	-	-	-	-	3
CO4	2	2	3	-	2	-	-	-	-	-	-	-	-	-	3
CO5	3	2	1	-	-	--		-	-	-	-	-	-	-	3
CO6	2	2	2	-	2	-	-	-	-	-	-	-	-	-	3
Average	2.66	1.5	1.88	-	2	-	-	-	-	-	-	-	-	-	3

MAPPING COURSE WITH POs & PSOs

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C311	2.66	1.5	1.88	-	2	-	-	-	-	-	-	-	-	-	3.00

<table>
<tr><th colspan="3">Course Outcome Assessment Methods</th><th colspan="2">Weightages</th><th rowspan="6">Final Course Outcome (100%)</th></tr>
<tr><td rowspan="4">Direct Assessment</td><td rowspan="3">Cumulative Internal Examinations (CIE)</td><td>Descriptive Test</td><td rowspan="3">30%</td><td rowspan="4">90%</td></tr>
<tr><td>Objective Test</td></tr>
<tr><td>Assignment Test</td></tr>
<tr><td colspan="2">Semester End Examinations (SEE)</td><td>70%</td></tr>
<tr><td>Indirect Assessment</td><td colspan="3">Course End Survey</td><td>10%</td></tr>
</table>

Rubrics for overall attainment of course outcomes:
If 50% of the students crossed 50% of the marks: Attainment Level 1
If 60% of the students crossed 50% of the marks: Attainment Level 2
If 70% of the students crossed 50% of the marks: Attainment Level 3

Note: Percentages mentioned in above rubrics can be slightly changed depending upon the complexity of your respected subject.

Course Instructor **Course Coordinator** **Module Coordinator** **Head of the Department**

ANNEXURE I:

(A) PROGRAM OUTCOMES(POs) Engineering Graduates will be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

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11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

(B) PROGRAM SPECIFIC OUTCOMES (PSOs) :

PSO1.The students will be able to understand the modern tools of machining which gives them good expertise on advanced manufacturing methods.

PSO2.The students will be able to design different heat transfer devices with emphasis on combustion and power production.

PSO3.The students are able to design different mechanisms and machine components suitable to automation industry.

Cognitive levels as per Revised Blooms Taxonomy:

Cognitive Domain	LEVEL	Key words
Remember	K1	Defines, describes, identifies, knows, labels, lists, matches, names, outlines, recalls, recognizes, reproduces, selects, states.
Understand	K2	Comprehends, converts, defends, distinguishes, estimates, explains, extends, generalizes, gives an example, infers, interprets, paraphrases, predicts, rewrites, summarizes, translates.
Apply	K3	Applies, changes, computes, constructs, demonstrates, discovers, manipulates, modifies, operates, predicts, prepares, produces, relates, selects, shows, solves, uses.
Analyse	K4	Analyzes, breaks down, compares, contrasts, diagrams, deconstructs, differentiates, discriminates, distinguishes, identifies, illustrates, infers, outlines, relates, selects, separates.
Evaluate	K5	Appraises, compares, concludes, contrasts, criticizes, critiques, defends, describes, discriminates, evaluates, explains, interprets, justifies, relates, summarizes, supports
Create	K6	Categorizes, combines, compiles, composes, creates, devises, designs, explains, generates, modifies, organizes, plans, rearranges, reconstructs, relates, reorganizes, revises, rewrites, summarizes, tells, write

Unit wise Sample assessment questions

COURSE OUTCOMES: Students are able to

SNO	Course Outcome Statement
CO1	**Discuss** the elements of a microcontroller as well as the operating principles of motors, sensors, and circuits commonly used in mechatronic devices.[K4]
CO2	**Describe** the basics of Semiconductors used in mechatronics. [K2]
CO3	**Analyze** the Sensors and Transducers for different applications.[K4]
CO4	**Analyze** different logics ad logical controls.[K4]
CO5	**Apply** the concepts of mechatronics for various applications.[K3]

S NO	QUESTION	KNOWLEDGE LEVEL	CO
	UNIT I		
1	**Derive** mathematical modeling of spring, Damper and Mass for Mechanical Translation System.	Evaluating (K5)	**CO1**
2	**Explain** Open and closed loop control systems with neat sketch.	Applying (K3)	**CO1**
3	**Derive** mathematical modeling of spring, Damper and Mass for Mechanical Rotational systems.	Applying (K3)	**CO1**
4	**Explain** the basic components of mechatronics.	Applying (K3)	**CO1**
	UNIT 2		
1	**Explain** the PN Junction diode and its applications.	Applying (K3)	**CO2**
2	**Explain** the P- Type and N-Type semiconductors.	Applying (K3)	**CO2**
3	**Explain** the Bipolar Junction Transistor working principle and applications.	Applying (K3)	**CO2**
4	**Compare the** BJT, FET and MOSFET Transistor.	Applying (K3)	**CO2**
	UNIT 3		
1	Define Photoelectric transduces and **Explain** different types of Photoelectric Transducer.	Applying (K3)	**CO3**
2	**Explain** the working principle of thermocouple and also write the advantages and disadvantages.	Applying (K3)	**CO3**
3	**Explain** the working principle of Thermistors and also explain different types	Applying (K3)	**CO3**

	of Thermistors.		
4	**Explain** capacitive and inductive Transducers.		
	UNIT 4		
1	**What** are the number systems in digital logics? **Explain** them with examples.	Applying (K3)	**CO4**
2	**What** are the logic gates used in digital logic? **Write** truth table, circuit of Boolean operation for each gate.	Applying (K3)	**CO4**
3	**Prove** that a. $A+(B\bullet C)=(A+B)\bullet(A+C)$ b. $(A+B)\bullet\overline{c}+A\bullet C=A+B\bullet\overline{c}$	Applying (K3)	**CO4**
4	**Explain** the laws of Boolean algebra used in digital logic.	Applying (K3)	**CO4**
5	**Draw** Ladder diagram for the following; i. AND gate ii. OR gate iii. XOR gate iv. Latching	Applying (K3)	**CO4**
	UNIT 5		
1	**Define** Artificial intelligent and **Explain** its impact on mechatronics.	Applying (K3)	**CO5**
2	**What** are micro sensors & Describe the micro sensors used in mechatronics.	Applying (K3)	**CO5**
3	**Explain** Fuzzy logic applications on mechatronics with suitable examples.	Applying (K3)	**CO5**
4	**Explain** about sensor based conditioning monitoring with suitable examples?	Applying (K3)	**CO5**

Narasaraopeta Engineering College (Autonomous)

Kotappakonda Road, Yellamanda (P.O), Narasaraopet- 522601, Guntur District, AP.

Subject Code: R20CC4OE06

IV B.Tech I Semester Examinations,

MECHATRONICS

(ME)

Time: 3 hours **Max Marks: 70**

Note: Answer All **FIVE** Questions.
All Questions Carry Equal Marks (5X14=70M)

Q.No		Questions	KL	CO	Marks
		Unit - I			
1	a	**Explain** the basic components of mechatronics.	K3	01	[14M]
		OR			
	b	**Derive** mathematical modeling of spring, Damper and Mass for Mechanical, Rotational systems.	K5	01	[14M]
		Unit - II			
2	a	**Explain** the PN Junction diode and its applications.	K3	02	[14M]
		OR			
	b	**Compare the** BJT, FET and MOSFET Transistor.	K4	02	[14M]
		Unit - III			
3	a	**Explain** the working principle of thermocouple and also write the advantages and disadvantages.	K3	03	[14M]
		OR			
	b	**Explain** capacitive and inductive Transducers.	K3	03	[14M]
		Unit - IV			
4	a	What is a number system? **Explain** in detail about types of number systems	K3	04	[14M]
		OR			
	b	What is PLC? **Explain** the basic structure of PLC	K3	04	[14M]
		Unit - V			
5	a	**List** the applications of Mechatronics in condition monitoring and automated manufacturing industries?	K3	05	[14M]
		OR			
	b	**Explain** Fuzzy logic applications on mechatronics with suitable examples	K3	05	[14M]

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Subject Code: R20CC4OE06

IV B.Tech I Semester Examinations,

MECHATRONICS

(ME)

Time: 3 hours **Max Marks: 70**

Note: Answer All **FIVE** Questions.

All Questions Carry Equal Marks (5X14=70M)

Q.No		Questions	KL	CO	Marks
		Unit - I			
1	a	Define Mechatronics and **Explain** Evaluation of Mechatronics.	K3	01	[12M]
		OR			
	b	**Explain** translational and rotational mechanical system.	K3	01	[12M]
		Unit - II			
2	a	**Explain** the P- Type and N-Type semiconductors.	K3	02	[12M]
		OR			
	b	**Explain** the Bipolar Junction Transistor working principle and applications.	K3	02	[12M]
		Unit - III			
3	a	**Explain** the working principle of thermocouple and also write the advantages and disadvantages.	K5	03	[12M]
		OR			
	b	**Explain** the working principle of thermocouple and also write the advantages and disadvantages.	K3	03	[12M]
		Unit - IV			
4	a	What is a logic gate? **Explain** in detail about types of logic gates.	K3	04	[12M]
		OR			
	b	Simplify the following Boolean operations by the use of Karnaugh maps: i) $Q = \bar{A}.\bar{B}.C + \bar{A}.\bar{B}.\bar{C} + \bar{A}.B.\bar{C}$ ii) $Q = \bar{A}.B.\bar{C}.D + A.\bar{B}.\bar{C}.D + \bar{A}.\bar{B}.\bar{C}.D + A.B.\bar{C}.D + A.B.\bar{C}.\bar{D} + A.B.C.D$	K3	04	[12M]
		Unit - V			
5	a	**Explain** the applications of artificial intelligence and fuzzy logic in Mechatronics.	K3	05	[12M]

	OR				
	b	**Explain** Fuzzy logic applications on mechatronics with suitable examples	K3	05	[12M]

NEC NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

ACADEMIC CALENDAR

NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

ACADEMIC CALENDAR
(B.Tech. 2020 Admitted Batch, Academic Year 2023-24)

2020 Batch 4th Year 1st Semester

Description	From Date	To Date	Duration
Commencement of Class Work	05-06-2023		8 Weeks
1st Spell of Instructions	05-06-2023	29-07-2023	
Assignment Test-I	26-06-2023	01-07-2023	
I Mid examinations	31-07-2023	05-08-2023	1 Week
2nd Spell of Instructions	07-08-2023	30-09-2023	8 Weeks
Assignment Test-II	28-08-2023	02-09-2023	
II Mid examinations	02-10-2023	07-10-2023	1 Week
Preparation & Practicals	09-10-2023	14-10-2023	1Week
Semester End Examinations	16-10-2023	28-10-2023	2 Weeks

2020 Batch 4th Year 2nd Semester

Description	From Date	To Date	Duration
Commencement of Class Work	06-11-2023		
Abstract Submission	06-11-2023	11-11-2023	1 Week
Change of Title or Abstract	13-11-2023	18-11-2023	1 Week
1st Review	25-12-2023	-	5 Weeks
2nd Review	29-01-2024	-	5 Weeks
3rd Review	04-03-2024	-	5 Weeks
Thesis Submission	11-03-2024	23-03-2024	2 Weeks
Project Viva-Voce	25-03-2024	30-03-2024	1 Week

PRINCIPAL

NEC NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

TIME TABLE

NARASARAOPETA ENGINEERING COLLEGE: NARASARAOPET (AUTONOMOUS)
DEPARTMENT OF MECHANICAL ENGINEERING
IV B.TECH I SEM TIME TABLE
Section-A

ROOM NO: 1216

Wef: 05/06/2023

	1	2	BREAK	3	4		5	6	7
TIMINGS	9.10-10.00	10.00-10.50	10.50-11.00	11.00-11.50	11.50-12.40	12.40-1.30	1.30-2.20	2.20-3.10	3.10-4.00
MON	SM	E&HV		MECHATRONICS			FEM		DM
TUE	E&I			SM		L	Mechatronics & Simulation Lab		
WED	DM			FEM		U	E&HV	E&I	
THU	Mechatronics & Simulation Lab					N	MECHATRONICS	E&HV	
FRI	E&HV			SM	DM	C	E&I		MECHATRONICS
SAT	MECHATRONICS			FEM		H	DM		SM

CODE	SUBJECT	FACULTY
DM	Digital Manufacturing	Mrs.D.Raghavendra
FEM	Finite Element Methods	Dr.M.Venkanna Babu
E&HV	Electric & Hybrid Vehicle	Mrs.P.Sravani
SM	Services Marketing	Dr.B.Anki Reddy
MECHATRONICS	Mechatronics	Mr.CH.Sekhar
E&I	Entrepreneurship & Innovation	Dr.P.Suresh Babu
M&S LAB	Mechatronics & Simulation Lab	Mr.P.Kiran Kumar/MD.Taju/A.Pavan

Signature of HOD

Signature of Principal

NARASARAOPETA
NEC ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

SYLLABUS COPY

IV B.TECH I SEMESTER Open Elective-IV	L	T	P	INTERNAL MARKS	EXTERNAL MARKS	TOTAL MARKS	CREDITS
	3	0	0	30	70	100	3
Code: R20CC4OE06	MECHATRONICS						

COURSE OBJECTIVES: The course content enables students to:

- Understand key elements of Mechatronics system, representation into block diagram
- Understand the concept of PLC system and its ladder programming, and significance of PLC systems in industrial application

COURSE OUTCOMES:

After successful completion of this course, the students will be able to:

CO1: Discuss the elements of a microcontroller as well as the operating principles of motors, sensors, and circuits commonly used in mechatronic devices

CO2: Describe the basics of Semiconductors used in mechatronics.

CO3: Analyze the Sensors and Transducers for different applications.

CO4: Analyze different logics ad logical controls

CO5: Apply the concepts of mechatronics for various applications

UNIT 1:

INTRODUCTION TO MECHATRONICS Introduction: Multi-disciplinary Scenario, Origins, Evolution of Mechatronics, An overview of Mechatronics.

SYSTEM MODELLING: Introduction, system modelling, mechanical system, translational mechanical system with spring, damper and mass, Rotational mechanical system with spring, damper and mass; electrical system, modelling electric motor, fluid system, thermal systems, modeling pneumatic actuator

UNIT 2:

SEMICONDUCTORS AND ELECTRONICS

Semiconductors, PN junction diode-types, BJT, DIAC, TRIAC, LEDs, transistors, FET, MOSFET, SCR, IC, DC

UNIT 3:

SENSORS AND TRANSDUCERS: Introduction and background, difference between transducer and sensor, transducers types, transduction principle, photoelectric transducers, thermistors, thermo devices, thermo couple, inductive transducers, capacitive transducers, pyroelectric transducers, piezoelectric transducers, Hall-effect transducers, Fibre optic transducers.

UNIT 4:

DIGITAL LOGIC & PLC: Digital logic, number systems, logic gates, Boolean algebra, karnaugh maps, application of logic gates, sequential logic, Programmable logic controller (PLC), Digital controllers.

UNIT 5:

APPLICATIONS IN MECHATRONICS Sensors for condition monitoring, mechatronic control in automated manufacturing, artificial intelligence in mechatronics, Fuzzy logic applications in mechatronics, micro sensors in mechatronics, and contemporary issues.

TEXT BOOKS:

1. Mechatronics - Electronic Control Systems in Mechanical and Electrical Engineering (2010), W. Bolton, Pearson Education.
2. Mechatronics system design by Devdas Shetty and Richard A. Kolk, PWS publishing company.

REFERENCES:

1. Mechatronics: Principles, concepts and applications by Nitaigour Premchand Mahalik, Tata – McGraw Hill Publishing Company Ltd.
2. Mechatronics: Integrated Mechanical Electronic Systems by K.P. Ramchandran, G.K. Vijyaraghavan, M.S. Balasundaram, Willey Publication, 2008

WEB RESOURCES:

1. https://nptel.ac.in/courses/112/103/112103174/
2. https://ocw.mit.edu/courses/mechanical-engineering/2-737-mechatronics-fall-2014/
3. https://nptel.ac.in/downloads/112101098/

NEC NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

LESSON PLAN

	Narasaraopeta Engineering College (Autonomous) Yallmanda(Post), Narasaraopet- 522601
NEC	

DEPARTMENT OF MECHANICAL ENGINEERING
LESSON PLAN

Course Code	Course Title (Regulation)	Sem	Branch	Contact Periods/Week	Sections
R20CC4OE06	MECHATRONICS	VII	Mechanical Engineering	6	A & B

COURSE OUTCOMES: Students are able to

SNO	Course Outcome Statement
CO1	**Discuss** the elements of a microcontroller as well as the operating principles of motors, sensors, and circuits commonly used in mechatronic devices.[K4]
CO2	**Describe** the basics of Semiconductors used in mechatronics. [K2]
CO3	**Analyze** the Sensors and Transducers for different applications.[K4]
CO4	**Analyze** different logics ad logical controls.[K4]
CO5	**Apply** the concepts of mechatronics for various applications.[K3]

Unit No	Outcome		Topics/Activity	Ref Text book	Total Periods	Delivery Method
1	**CO1: Discuss** the elements of a microcontroller as well as the operating principles of motors, sensors, and circuits commonly used in mechatronic devices.[K4]		**UNIT– I : INTRODUCTION**			
		1.1	Multi-disciplinary Scenario, Origins, Evolution of Mechatronics	T1, T2, R1	2	Chalk & Talk, PPT
		1.2	An overview of Mechatronics, Introduction to Manufacturing, Design.	T1, T2, R1	2	Chalk & Talk, PPT
		1.3	System modelling: Introduction, system modelling, mechanical system, translational mechanical system with spring, damper and mass	T1, T2, R1	2	Chalk & Talk, PPT, NPTEL/MOOCS
		1.4	Rotational mechanical system with spring, damper and mass; electrical system, modelling electric motor	T1, T2, R1	2	Chalk & Talk, PPT
		1.5	fluid system, thermal systems, modeling pneumatic actuator	T1, T2, R1	2	Chalk & Talk, PPT
2	**CO2: Describe** the basics of Semiconductors used in mechatronics. [K2]		**UNIT-II: SEMICONDUCTORS AND ELECTRONICS**			
		2.1	Semiconductors	T1, T2, R2	1	Chalk & Talk, PPT
		2.2	PN junction diode-types, BJT, DIAC, TRIAC, LEDs	T1, T2, R2	3	Chalk & Talk, PPT
		2.3	Transistors, FET, MOSFET	T1, T2, R1	3	Chalk & Talk, PPT
		2.4	Transistors, SCR, IC, DC	T1, T2, R2	3	Chalk & Talk, PPT
3	**CO3:**		**UNIT-III: SENSORS AND TRANSDUCERS**			
		3.1	Introduction and background, difference between transducer and sensor	T1,R2	2	Chalk & Talk, PPT

	Analyze the Sensors and Transducers for different applications.[K4]	3.2	Transducers types, transduction principle	T1,R2	2	Chalk & Talk, PPT
		3.3	Photoelectric transducers, thermistors, thermo devices, thermo couple	T1, R2	2	Chalk & Talk, PPT
		3.4	Inductive transducers, capacitive transducers, pyro electric transducers	T1, R2	2	Chalk & Talk, PPT
		3.5	Piezoelectric transducers, Hall-effect transducers, Fibre optic transducers.	T1, R2	2	Chalk & Talk, PPT
4	**CO4:** **Analyze** different logics ad logical controls.[K4]	**UNIT-IV: DIGITAL LOGIC & PLC**				
		4.1	Digital logic	T1, T2,R2	2	Chalk & Talk, Virtual Lab
		4.2	Number systems, logic gates	T1, T2, R2	2	Chalk & Talk, Virtual Lab
		4.3	Boolean algebra, karnaugh maps	T1, T2, R2	2	Chalk & Talk, Virtual Lab
		4.4	Application of logic gates, sequential logic	T1, T2, R2	2	Chalk & Talk, Virtual Lab
		4.5	Programmable logic controller (PLC)	T1, T2, R2	2	Chalk & Talk, Virtual Lab
5	**CO5:** **Apply** the concepts of mechatronics for various applications.[K3]	**UNIT V: APPLICATIONS IN MECHATRONICS**				
		5.1	Sensors for condition monitoring,	T1, R2	3	Chalk & Talk, Web Resources
		5.2	Mechatronic control in automated manufacturing	T1, R2	2	Chalk & Talk, Web Resources
		5.3	Artificial intelligence in mechatronics	T1, R2	3	Chalk & Talk, Web Resources
		5.4	Fuzzy logic applications in mechatronics, micro sensors in mechatronics	T1, R2	2	Chalk & Talk, Web Resources
				Total	50	
END EXAMINATIONS						

Text Books:

T1 Mechatronics - Electronic Control Systems in Mechanical and Electrical Engineering (2010), W. Bolton, Pearson Education.

T2 Mechatronics system design by DevdasShetty and Richard A. Kolk, PWS publishing company

Reference Books:

R1 Mechatronics: Principles, concepts and applications by Nitaigour Premchand Mahalik, Tata – McGraw Hill Publishing Company Ltd.

R2 Mechatronics: Integrated Mechanical Electronic Systems by K.P. Ramchandran, G.K. Vijyaraghavan, M.S. Balasundaram, Willey Publication, 2008

Faculty **HOD** **Principal**

NARASARAOPETA
NEC ENGINEERING COLLEGE
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DEPARTMENT OF MECHANICAL ENGINEERING

CO-POs & CO-PSOs MAPPING (COURSE ARTICULATION MATRIX)

NEC NARASARAOPETA ENGINEERING COLLEGE
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DEPARTMENT OF MECHANICAL ENGINEERING
COURSE ARTICULATION MATRIX
R20-REGULATION

Explanation of Course Articulation Matrix Table to be ascertained:

- Course Articulation Matrix correlates the individual COs of a course with POs and PSOs.
- The Course Outcomes are mapped with POs and PSOs in the scale of 1 to 3.
- The strength of correlation is indicated as **3** for **Substantial (High)** correlation, **2** for **Moderate (Medium)** correlation, and 1 for **Slight (Low)** correlation.

Course Code: C415	**Course Name: MECHATRONICS (Open Elective-IV)**														
COs	**POs & PSOs**														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
C415.1	3	2	-	-	-	-	-	-	-	-	-	-	2	-	1
C415.2	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
C415.3	3	2	-	-	-	-	-	-	-	-	-	-	2	2	-
C415.4	3	3	2	-	-	-	-	-	-	-	-	-	2	-	2
C415.5	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
C415	3.00	2.20	2.00	-	-	-	-	-	-	-	-	-	2.00	2.00	1.50

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DEPARTMENT OF MECHANICAL ENGINEERING

WEB REFERENCES

NEC NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

MECHATRONICS

LIST OF E-RESOURCE

1 https://nptel.ac.in/downloads/112101098/
2 https://nptel.ac.in/courses/112101098/download/lecture-1.pdf
3 https://www.youtube.com/watch?v=glUrzUxbepE&t=1026s
4 https://nptel.ac.in/courses/112101098/download/lecture-2.pdf
5 https://nptel.ac.in/courses/112101098/download/lecture-4.pdf
6 https://www.youtube.com/watch?v=zxYeJW9v6OU&list=PLwymdQ84KI-w5DwDzqO_4hWsB2Jc4_eBy
7 https://nptel.ac.in/courses/112101098/download/lecture-5.pdf
8 https://nptel.ac.in/courses/112101098/download/lecture-6.pdf
9 https://nptel.ac.in/courses/112101098/download/lecture-7.pdf
10 https://www.youtube.com/watch?v=gXTpOP9AtQ8&list=PLir19lgiavA0EKRRN3xdARy_z44hKhNQc
11 https://nptel.ac.in/courses/112101098/download/lecture-9.pdf
12 https://nptel.ac.in/courses/112101098/download/lecture-10.pdf
13 https://nptel.ac.in/courses/112101098/download/lecture-12.pdf

NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

STUDENT'S ROLL LIST

NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

20 BATCH IV-I PROMOTION LIST

S.No	H.T.NO	Name of the Candidate
1	20471A0301	ALAVALA ADITHYA VARA PRASAD
2	20471A0302	BATTULA RAJESH
3	20471A0303	BHIMAVARAPU HEMANTH KUMAR
4	20471A0304	BONAM JAYA PRAKASH
5	20471A0305	BOYAPATI PAVAN KUMAR
6	20471A0306	DADDANALA VEERANJIREDDY
7	20471A0307	DERANGILA PARDHU GANESH
8	20471A0308	DOPPALAPUDI S S NAGA RAVITEJA
9	20471A0309	EEDARA MOHON SAI
10	20471A0310	GANESH SAI PAVAN
11	20471A0312	GERA KOTESWARA RAO
12	20471A0313	KARASALA PRASANTH
13	20471A0314	KARASANI PAVAN KUMAR REDDY
14	20471A0315	KATTA MAHESWAR
15	20471A0317	KESARI DHANUNJAYA REDDY
16	20471A0318	KOMARAGIRI SASIKUMAR
17	20471A0319	KOMERA SIVA NAGARAJU
18	20471A0320	KOTHA GOPI
19	20471A0321	KUNDURTHI NAVEEN
20	20471A0323	MADANU JOSEPH VINAY KUMAR
21	20471A0324	MADDUMALA RAMAKRISHNA
22	20471A0325	MAGANTI SASI PAVAN
23	20471A0326	MAKKENA SAMBASIVA RAO

24	20471A0327	MIRIYALA SASHANK
25	20471A0328	NALLA ABHIRAM CHOWDARY
26	20471A0329	NUTHAKKI RAKESH
27	20471A0330	ARAVAPALLI SAI SRINIVAS
28	20471A0331	PALETI JOHN HOSANNA
29	20471A0332	PERUMAALLA SRIKANTH
30	20471A0333	POLURI KRISHNA CHAITHANYA
31	20471A0334	PONNAGANTI CHANDU HARSHA VARDHAN
32	20471A0336	PATHAN MEERA VALI
33	20471A0337	POTTIMURTHI PURNA CHANDRA RAO
34	20471A0338	PRUDHVI DURGA BHARATH CHANDAN
35	20471A0339	RAMAVATHU BADDUNAIK
36	20471A0341	SHAIK APPAPURAM MAHABOOB SUBHANI
37	20471A0343	SHAIK GANGARAM ABDUL RAHAMAN
38	20471A0344	SHAIK GULLAPALLI NAGURVALI
39	20471A0345	SHAIK LAL AHAMAD BASHA
40	20471A0346	SHAIK MAHAMMAD FAREED
41	20471A0348	SHAIK MANISHA
42	20471A0349	SHAIK PARVEZ
43	20471A0350	SHAIK SADHIK
44	20471A0352	TIPPIREDDY AMARNATHREDDY
45	20471A0353	VADLAVALLI GANESH
46	20471A0354	VEERAGANDHAM VENKATA MANIKANTA
47	20471A0356	ADAKA GOPIRAJU
48	20471A0357	ATCHYUTHA PAVAN KUMAR
49	20471A0358	BALLE RAMANJANEYULU
50	20471A0359	BANDARU SAI GANESH
51	20471A0360	BERAM NARENDRA REDDY
52	20471A0361	CHEBROLU MANIKANTA SAI NITHIN
53	20471A0362	CHENNAMSETTY GOPI

54	20471A0363	GANGULA SUNNY
55	20471A0364	GANJI HANUMA KOTI GANESH
56	20471A0365	GANNNAVARAPU JAYA SRIKANTH
57	20471A0366	GUTTIKONDA AYYAPPA REDDY
58	20471A0367	MADDINENI AJAY
59	20471A0368	MANNEPALLI VEERA NARASIMHA
60	20471A0369	MARAGANI NAGA THIRUMALA RAO
61	20471A0370	PARELLA BALA GURAVAIAH
62	20471A0371	SETLAM RANENDRA VAMSHI
63	20471A0372	SHAIK GUTHIKONDA SALIM
64	20471A0373	SHAIK JAKIR
65	20471A0374	SHAIK MOHAMMAD TAHEER
66	20471A0375	THOTA SRIVAMSI NADH
67	20471A0376	YAKKANTI SAI KIRAN REDDY
68	21475A0301	PALLAPOTHU SAIKIRAN YADAV
69	21475A0302	SYED SARDAR VALI
70	21475A0303	DERANGULA GOPI KRISHNA
71	21475A0305	SHAIK ADIL
72	21475A0306	JANAPAREDDI PRASAD
73	21475A0307	REPALLE YASHWANTH
74	21475A0308	RAMAVATHU PAVAN KUMAR NAIK
75	21475A0309	NELAVALLI VIKAS
76	21475A0310	DUDDU JOSEPH
77	21475A0311	MUNIKOLA SANTHOSH KUMAR
78	21475A0312	MORAPAKULA CHARAN TEJA
79	21475A0313	GODA SANDEEP
80	21475A0314	MOGILI PRAKASH
81	21475A0315	SHAIK MABU SUBHANI
82	21475A0316	DAGGUPATI VENKATA PRADEEP
83	21475A0317	NAGASURENDRA CHARI UPPALAPATI

84	21475A0318	NALLURI NAVEEN
85	21475A0319	ORCHU VENKATA RAVINDRA
86	21475A0320	NELLURI YASWANTH
87	21475A0321	PENUMALA PAVAN KUMAR
88	21475A0322	BAANANA PRADEEP KUMAR
89	21475A0323	BOJANKI DEMUDU BABU
90	21475A0324	DATTI CHANDU
91	21475A0325	BORUGADDA NITHIN
92	21475A0326	VARIKUTI KARTHIK VENKATA RAM
93	21475A0327	GOLLA SUNDARA SAMRAJYA SUGNAN
94	21475A0328	CHATTA VENKATRAMAIAH
95	21475A0329	KSHATRIYA JITHENDRA SINGH
96	21475A0330	BOMMALI BALA SIVA YOGENDRA SAI NANDU
97	21475A0331	REVALLA SAI
98	21475A0332	BANDI SRINIVAS
99	21475A0333	GURRAM SIVA GANESH
100	21475A0334	EMANI LEELA SHANKAR
101	21475A0335	KUPPALA SRINU

PRINCIPAL

NEC NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

HAND WRITTEN/PRINTED LECTURE NOTES

MECHATRONICS

IVth Year – Ist Semester

UNIT – I:

INTRODUCTION: Multi-disciplinary Scenario, Origins, Evolution of Mechatronics, An overview of Mechatronics, Introduction to Manufacturing, Design.

System modelling: Introduction, system modelling, mechanical system, translational mechanical system with spring, damper and mass, Rotational mechanical system with spring, damper and mass; electrical system, modelling electric motor, fluid system, thermal systems, modeling pneumatic actuator.

UNIT 2: SEMICONDUCTORS AND ELECTRONICS

Semiconductors, PN junction diode-types, BJT, DIAC, TRIAC, LEDs,Transistors, FET, MOSFET Transistors, SCR, IC, DC

UNIT – III:

SENSORS AND TRANSDUCERS: Introduction and background, difference between transducer and sensor, transducers types, transduction principle, photoelectric transducers, thermistors, thermo devices, thermo couple, inductive transducers, capacitive transducers, pyroelectric transducers, piezoelectric transducers, Hall-effect transducers, Fibre optic transducers.

UNIT – IV:DIGITAL LOGIC & PLC

Digital logic, number systems, logic gates, Boolean algebra, karnaugh maps, application of logic gates, sequential logic, Programmable logic controller (PLC), Digital controllers.

UNIT – V: APPLICATIONS IN MECHATRONICS

Sensors for condition monitoring, mechatronic control in automated manufacturing, artificial intelligence in mechatronics, Fuzzy logic applications in mechatronics, micro sensors in mechatronics, and contemporary issues..

TEXT BOOK:

1. Mechatronics - Electronic Control Systems in Mechanical and Electrical Engineering (2010), W. Bolton, Pearson Education.
2. Mechatronics system design by Devdas Shetty and Richard A. Kolk, PWS publishing company.

UNIT – I:

INTRODUCTION: Multi-disciplinary Scenario, Origins, Evolution of Mechatronics, An overview of Mechatronics, Introduction to Manufacturing, Design.

System modelling: Introduction, system modelling, mechanical system, translational mechanical system with spring, damper and mass, Rotational mechanical system with spring, damper and mass; electrical system, modelling electric motor, fluid system, thermal systems, modeling pneumatic actuator.

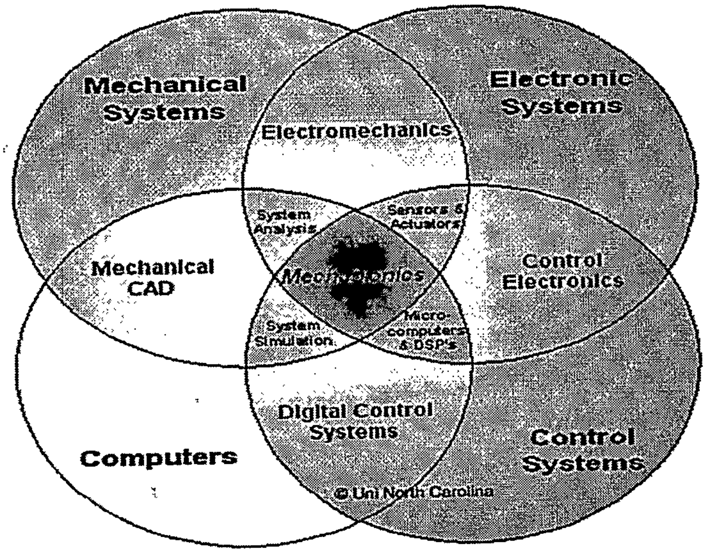
What is mechatronics?

The term mechatronics was 'invented' by a Japanese engineer in 1969, as a combination of 'mecha' from mechanisms and 'tronics' from electronics.

Definition : It is the field of study that implies the synergistic integration of Electronics Engineering, Electrical Engineering, Computer Technology with Mechanical Engineering for the Design, Manufacture, Analyse and Maintenance of a wide range of Engineering Products and Processes.

Example: automatic washing machine, digital fuel injection system, engine management system. Etc.,

MECHATRONICS



Multi-disciplinary scenario

- Mechatronics is the synergistic (Together) combination of mechanical engineering, electronic engineering, control engineering and systems thinking in the design of products and manufacturing processes".
- Multi-disciplinary products are not new; they have been successfully designed and used for many years. Most common is the electromechanical system.
- It employs a sequential design-by-discipline approach. For example in the design of electromechanical system three stages of design are adopted.
- They are design of mechanical system, design of microelectronic system and control system.
- Each design application follows the completion of the previous one.
- to overcome drawbacks Mechatronics uses concurrent engineering.

Origin of Mechatronic system

1. The word Mechatronics was coined by Japanese in the late 1960"s to describe the philosophy adopted in the design of subsystem of electromechanical systems.
2. The field of Mechatronics received the international recognitions only in the last few years.
3. The field has been derived by rapid progress in the field of microelectronics.
4. At R&D level the following areas have been recognized under Mechatronics discipline.

a) Motion control actuators and sensors
b) Micro devices and optoelectronics
c) Robotics
d) Automotive systems
e) Modeling and design
f) System integration
g) Manufacturing
h) Vibration and noise control

Evaluation of Mechatronics

The technology has evolved through several stages that are termed as levels. The evolution levels of Mechatronics are:

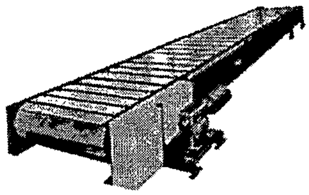
a. Primary level Mechatronics (first)
b. Secondary level Mechatronics (second)
c. Tertiary level Mechatronics (third)
d. Quaternary level Mechatronics (fourth)

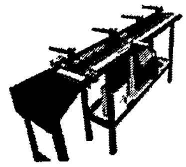
a. Primary level Mechatronics (first):

In the early days Mechatronics products were at primary level containing I/O devices such as sensors, and actuators that integrated electrical signals with mechanical action at the basic control level.

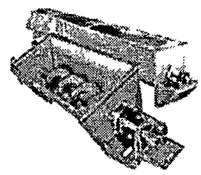
Examples: electrically controlled fluid valves and relays

The First Level





- conveyors,
- rotary tables,
- auxiliary manipulators

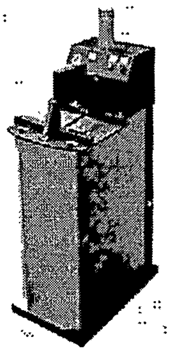


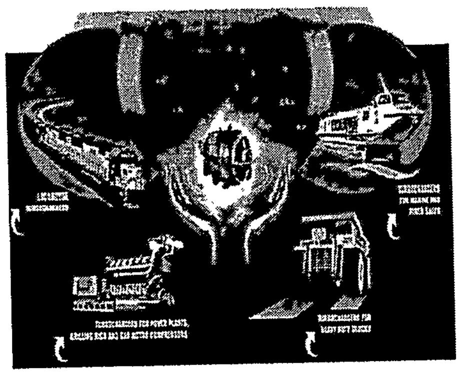
b. Secondary level Mechatronics (second):

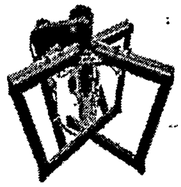
This level integrates microelectronics into electrically controlled devices.

Examples: cassette player.

The Second Level







- operated power machines (turbines and generators),
- machine tools and industrial robots with numerical program management

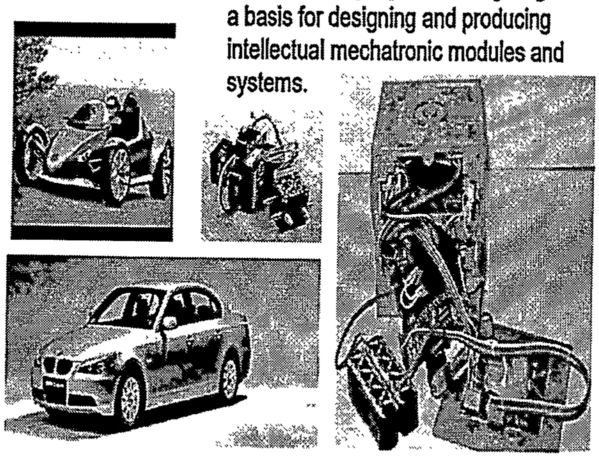
c. Tertiary level Mechatronics (third):

- This incorporates advances feedback functions into control strategy, thereby enhancing the quality in terms of sophistication.
- Mechatronics system at this level is called 'smart system'.
- The control strategy includes microelectronics, microprocessor and other „application specific integrated circuits" (ASIC).

Examples: DVD player, CD drives, automatic washing machine, CD drives, etc.

The Third Level

Synthesis of new precise, information and measuring high technologies gives a basis for designing and producing intellectual mechatronic modules and systems.



d. Quaternary level Mechatronics (fourth):

This level includes intelligent control in Mechatronics system. The level attempts to improve smartness a step ahead by introducing intelligence and fault detection and isolation (FDI) capability system.

Examples: artificial neural network and fuzzy logic technologies

Advantages of Mechatronics:

1. The products produced are cost effective and very good quality.
2. High degree of flexibility
3. Greater extent of machine utilization
4. Greater productivity
5. High life expected by proper maintenance.
6. The integration of sensor and control system in a complex system reduces capital expenses.

Disadvantages of Mechatronics :

1. Higher initial cost of the system.
2. Imperative to have Knowledge of different engineering fields for design and implementation.
3. It is expenses to incorporate Mechatronics approaches to existing/old systems.
4. Specific problem of various systems will have to be addressed separately and properly.

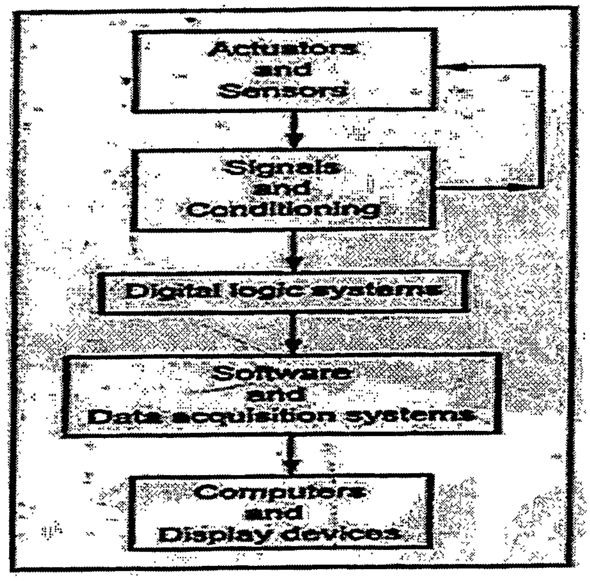
Characteristics of Mechatronic system:

1. High quality product.
2. Safe
3. Low cost.
4. Portable produced quickly
5. Serviceability, maintainability and upgradeability

Applications of Mechatronic systems:

1. Automotive machines.
2. Fax and photocopier mechanics
3. Dishwashers.
4. Automatic washing machine
5. Air conditioners, elevator controls.
6. Documents scanners
7. IC manufacturing systems.
8. Robotics employed in welding, nuclear inspection, painting etc.,
9. VCRs and CD Players.

Elements of mechatronics system:



Actuators: Solenoids, DC motors, Stepper motors, Servo motors, Hydraulics and Pneumatics.

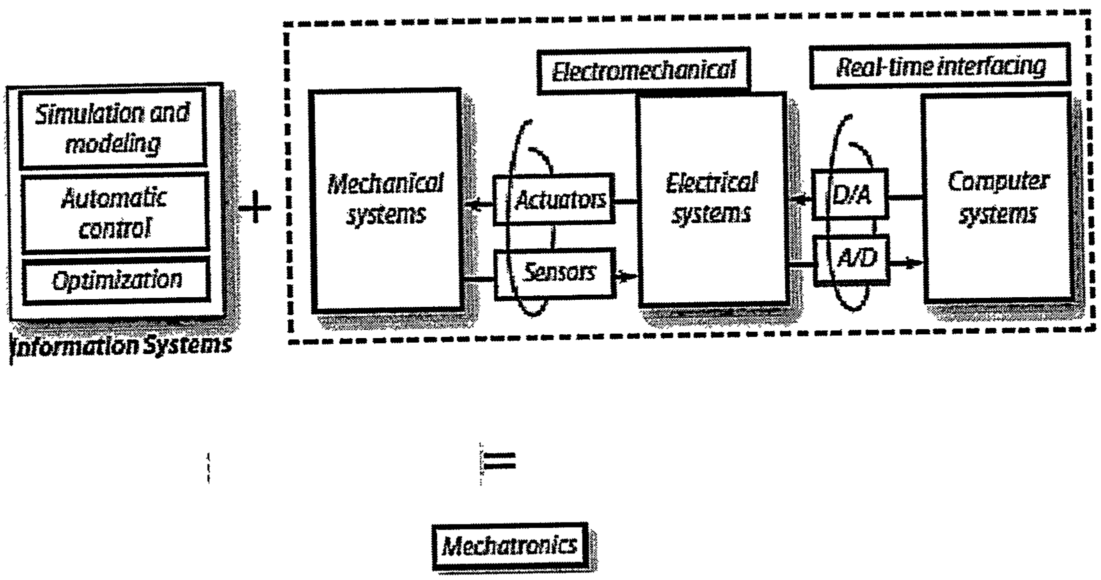
Sensors: Switches, Pots, Photoelectric, Encoders, Strain gauges, Thermocouples, Accelerometers etc..

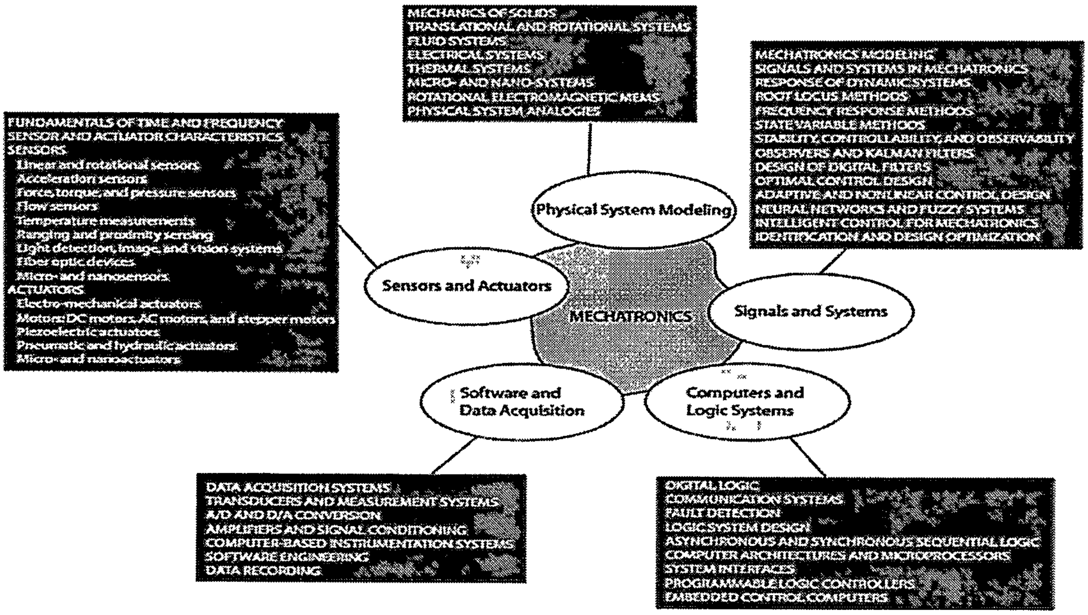
Input signal conditioning and Interfacing: Amplifiers, Filters, A/D and D/A.

Digital control architecture: Logic circuits, Microcontrollers, PLC, Sequencing and Timing, Communication, Control algorithms, Logic and Arithmetic algorithms.

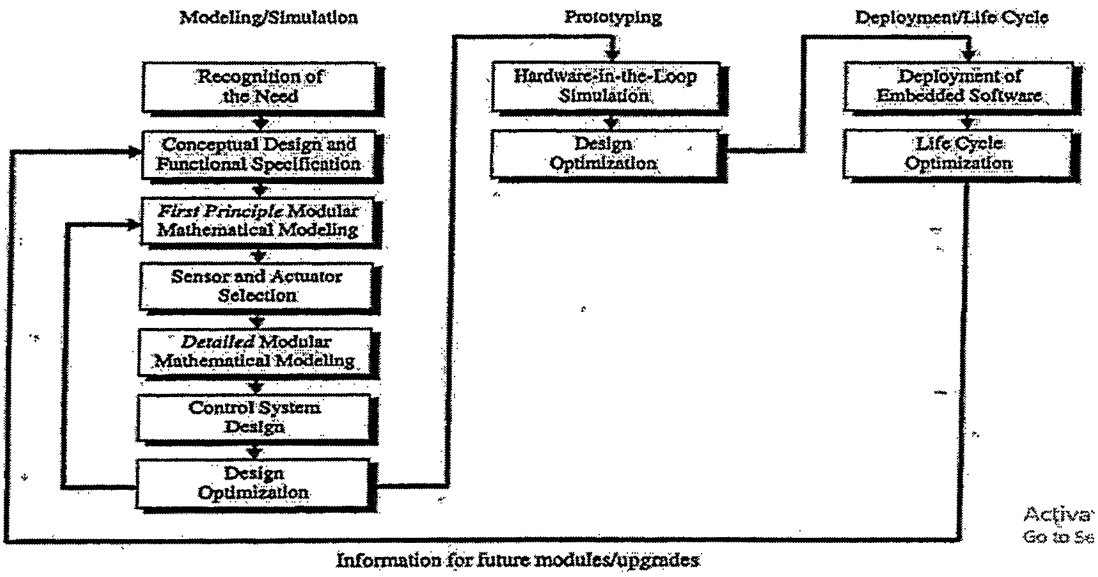
Output signal conditioning and Interfacing: D/A and A/D Converters, Amplifiers, PMC erc..

Graphical display: CRT, LCD, LED, CCD.





Mechatronic Design Process



Mechatronics design process:

- The Need
- Analysis of the Problem
- Preparation of a Specification
- Generation of Possible Solutions
- Selections of a Suitable Solutions
- Production of a detailed Design
- Production of Working Drawings

SYSTEM

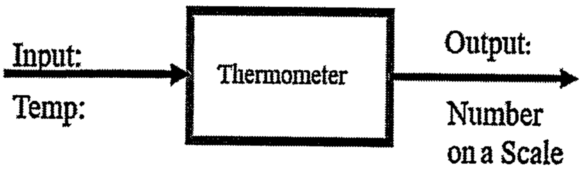
A system can be thought of as a box or block diagram which has an input and an output and where we do not consider what input but only the relationship between the output and input.

a motor may be thought of as a system which has as its input electric power and as output the rotation of a shaft.

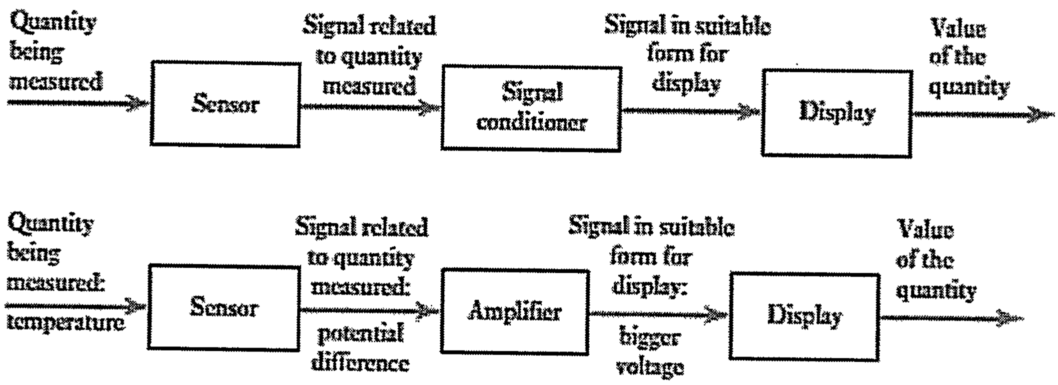
• Fig: An example of a system

Measurement System :

A measurement system is a system which is used for making measurements. It has as its input the quantity being measured and its output the value of that quantity. For example, a temperature measurement system, i.e. a thermometer, has an input of temperature and an output of a number on a scale



A measurement system and its constituent elements.



A digital thermometer system.

Basic Elements of Measurement Systems

1.A sensor which responds to the quantity being measured by giving as its output a signal which is related to the quantity. For example, a thermocouple is a temperature sensor.

2. A signal conditioner takes the signal from the sensor and manipulates it into a condition which is suitable for either display or in the case of a control system, for use to exercise control.

3. A display system where the output from the signal conditioner is displayed.

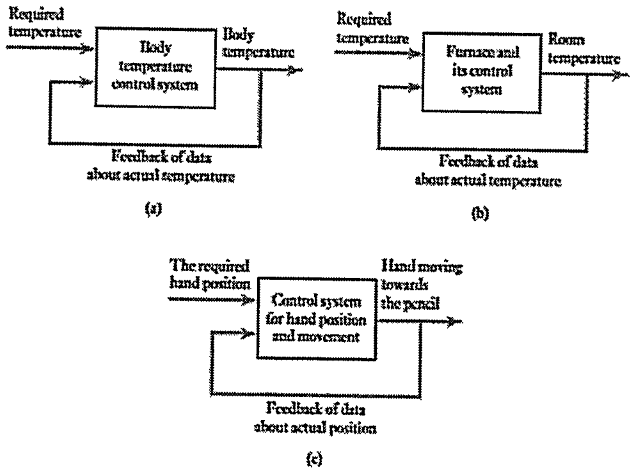
Control System

A control system can be thought of as a system which can be used to:

1. control some variable to some particular value, e.g. a central heating system where the temperature is controlled to a particular value;
2. control the sequence of events, e.g. a washing machine where when the dials are set to, say, 'white' and the machine is then controlled to a particular washing cycle, i.e. sequence of events, appropriate to that type of clothing;
3. control whether an event occurs or not, e.g. a safety lock on a machine where it cannot be operated until a guard is in position.

An example of a control system

Feedback control



Feedback control:
(a) human body temperature,
(b) room temperature with central heating,
(c) picking up a pencil.

Control systems may be classified as; 1.Open loop control system. 2. Closed loop or feedback control system.

Open- and closed-loop systems

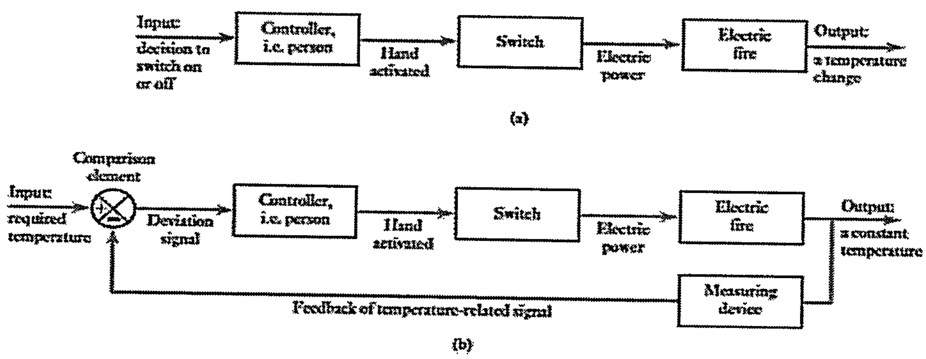


Figure 1.9 Heating a room: (a) an open-loop system, (b) a closed-loop system.

Basic elements of a closed-loop system

1.Comparison element 2.Contol element 3.Correction element

4.Process element 5.Measurement element

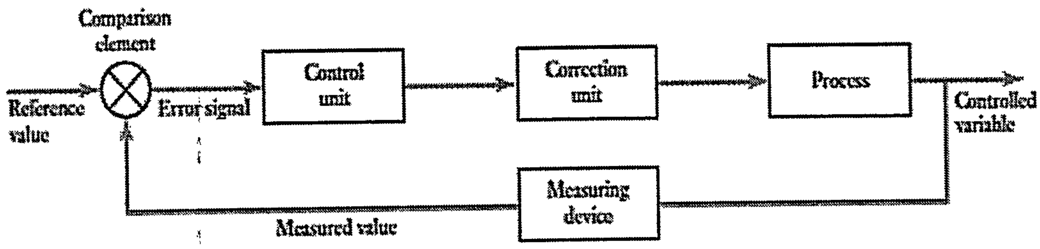
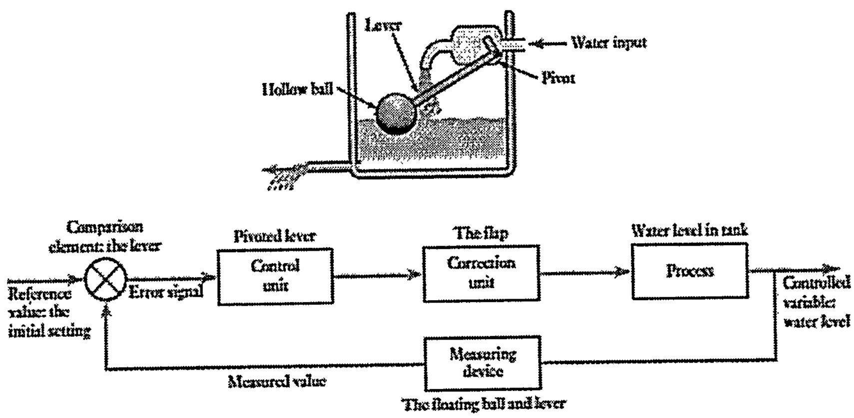
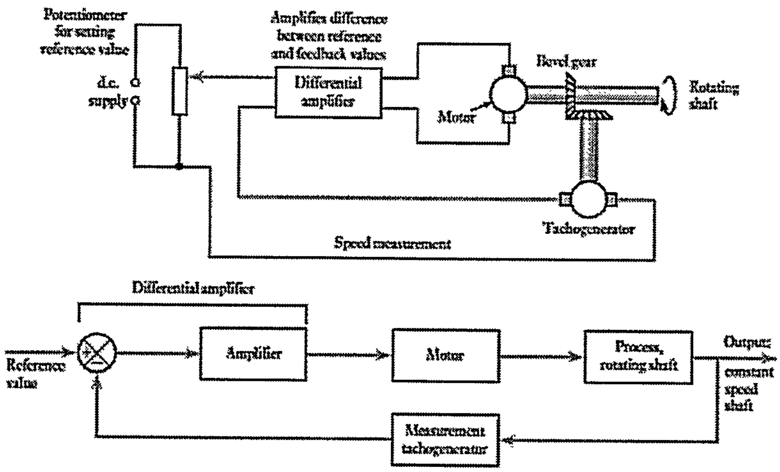


Figure 1 The elements of a closed-loop control system.

The automatic control of water level



Shaft speed control



MECHANICAL SYSTEMS

1.MECHANICAL TRANSLATIONAL SYSTEMS

2.MECHANICAL ROTATIONAL SYSTEMS

MECHANICAL TRANSLATIONAL SYSTEMS :

The model of mechanical translational systems can be obtained by using three basic elements Mass, Spring and Dash-Pot. These three elements represent three essential phenomena which occur in various ways in mechanical systems.

List of Symbols Used In Mechanical Translational System

x = Displacement, m.

v = $\frac{dx}{dt}$ Velocity, m/sec^2

$a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$ Acceleration, m/sec^2

f = Applied force, N (Newton's)

f_m = Opposing force offered by mass of the body, N

f_k = Opposing force offered by the elasticity of the body (spring), N

f_b = Opposing force offered by the friction of the body (dash – pot), N

M = Mass, kg

K = Stiffness of spring, N/m

B = Viscous friction co – efficient, N – sec/m

Note: Lower case letters are functions of time.

Mass

Consider an ideal mass element shown in figure1.3which has negligible friction and elasticity. Let a force be applied on it. The mass will offer an opposing force which is proportional to acceleration of the body.

Let f = Applied force

f_m= Opposing force due to mass

Here $f_m \alpha\, a$

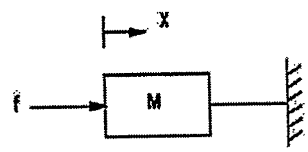


Figure 1.3

$$f_m \,\alpha \frac{d^2x}{dt^2} \text{ or } f_m = M\frac{d^2x}{dt^2}$$

By Newton's second law, $f = f_m = M\frac{d^2x}{dt^2}$............. (1)

Dash-Pot

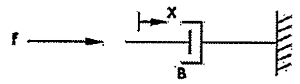


Figure 1.4

Consider an ideal frictional element dashpot shown in figure 1.4 which has negligible mass and elasticity. Let a force be applied on it. The dash-pot will offer an opposing force which is proportional to velocity of the body.

Let f = Applied force

f_b= Opposing force due to friction

Here, $f_b \alpha$ v

$f_b \alpha \frac{dx}{dt}$ or fb = B $\frac{dx}{dt}$

By Newton's second law, f = f_b = B$\frac{dx}{dt}$ .... (2)

When the dashpot has displacement at both ends as shown in figure 1.5 the opposing force is proportional to differential velocity.

$f_b\, \alpha \frac{d(x_1 - x_2)}{dt}$; f_b= B$\frac{d(x_1 - x_2)}{dt}$

$\therefore f = f_b = B\frac{d(x_1 - x_2)}{dt}$ .... (3)

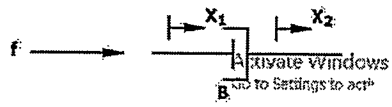


Figure 1.5

Spring

Consider an ideal elastic element spring shown in figure 1.6 which has negligible mass and friction. Let a force be applied on it. The spring will offer an opposing force which is proportional to displacement of the body.

Let f = Applied force

f_k= opposing force due to elasticity

Here $f_k \propto x or f_k = Kx$

By Newton's second law, f = $f_k = Kx$ .... (4)

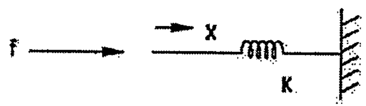


Figure 1.6

When the spring has displacement at both ends as shown in figure 1.7 the opposing force is proportional to differential displacement.

$$f_k \propto (x_1 - x_2)$$

$$f_k = K(x_1 - x_2)$$

$\therefore f = f_k = K(x_1 - x_2)$ ....(5)

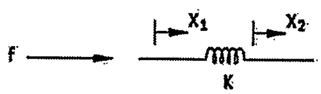


Figure 1.7

MECHANICAL ROTATIONAL SYSTEMS :

The model of rotational mechanical systems can be obtained by using three elements, moment inertia [J] of mass, das-pot with rotational frictional coefficient [B] and torsional spring with stiffness [K].

List of Symbols Used In Mechanical Rotational System

θ = Angular displacement, rad

$\frac{d\theta}{dt}$ = Angular velocity, rad/sec

$\frac{d^2\theta}{dt^2}$ = Angular acceleration, rad/sec^2

T = Applied torque, N-m

J = Moment of inertia, kg-m^2/rad

B = Rotational frictional coefficient, N-m / (rad/sec)

K = Stiffness of the spring, N-m/rad

Mass

Consider an ideal mass element shown figure 1.8which has negligible friction and elasticity. The opposing torque due to moment of inertia is proportional to the angular acceleration.

Let T = Applied torque

T_j = Opposing torque due to moment of inertia of the body.

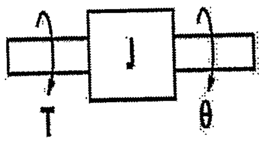


Figure 1.8

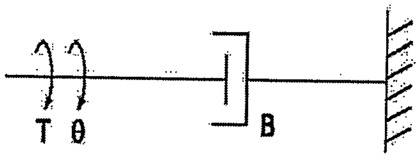
Here $T_j \propto \frac{d^2\theta}{d^t}$ or $T_j = J\frac{d^2\theta}{dt^2}$

By Newton's second law

$$T = T_j = J\frac{d^2\theta}{dt^2} \quad \text{.........(1)}$$

Dash pot

Consider an ideal frictional element dash pot shown in figure which has negligible moment of inertia and elasticity. Let a torque be applied on it. The dash pot will offer on opposing torque which is proportional to the angular velocity of the body.



Let T = Applied torque

T_b = Opposing torque due to friction

$$T_b \alpha \frac{d\theta}{dt} or T_b = B\frac{d\theta}{dt}$$

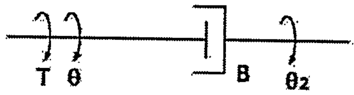
By Newton's second law

$T = T_b = B\frac{d\theta}{dt}$ .... (2)

When the dash point has angular displacement at both ends as shown in fig. the opposing torque is proportional to the differential angular velocity.

$T_b \alpha \frac{d}{dt}(\theta_1 - \theta_2)$ $\quad T_b = B\frac{d}{dt}\ (\theta_1 - \theta_2)$

$\therefore T = T_b = B\frac{d}{dt}(\theta_1 - \theta_2)$ .... (3)



Spring

Consider an ideal elastic element, torsional spring as shown in fig. which has negligible moment of inertia and friction. Let a torque be applied on it. The torsional spring will offer an opposing torque which is proportional to angular displacement of the body.

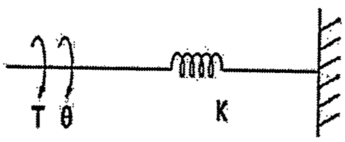
Let T = Applied torque.

T_k = Opposing torque due to elasticity

$T_k \alpha \theta \quad T_k = K\theta$

By Newton's second law

$T = T_k = K\theta$ .... (4)



When the spring has angular displacement at both ends shown in fig. the opposing torque is proportional to differential angular displacement.

$T_k \alpha(\theta_1 - \theta_2)$

$T_k = K(\theta_1 - \theta_2)$

$\therefore T = T_k = K(\theta_1 - \theta_2)$ .... (5)

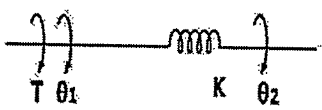
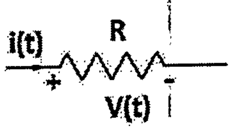
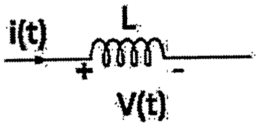
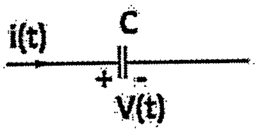


Figure 1.9

ELECTRICAL SYSTEMS

The models of electrical systems can be obtained by using resistor, capacitor and inductor. The current-voltage relation of resistor, inductor and capacitor are given in table 1.1. For modeling electrical network or equivalent circuit is formed by using R, L and voltage or current source. The differential equations governing the electrical systems can be formed by writing Kirchoff's current law equations by choosing various nodes in the network or Kirchoff's voltage law equations by choosing various closed path in the network. The transfer function can be obtained by taking Laplace transform of the differential equations and rearranging them as a ratio of output to input.

Table 1.1: Current-voltage relation of R, L and C

Element	Voltage across the element	Current through the element
	$v(t) = Ri(t)$	$i(t) = \frac{v(t)}{R}$
	$v(t) = L\frac{d}{dt}i(t)$	$i(t) = \frac{1}{L}\int v(t)dt$
	$vt = \frac{1}{c}\int i(t)dt$	$i(t) = C\frac{dv(t)}{dt}$

Thermal System

List of symbols used in thermal systems

q	=	Heat flow rate, Kcal/sec
θ_1	=	Absolute temperature of emitter, °K
θ_2	=	Absolute temperature of receiver, °K
$\Delta\theta$	=	Temperature difference, °C
A	=	Area normal to heat flow, m3
K	=	Conduction or convection coefficient, Kcal/sec-°C
Kr	=	Radiation coefficient, Kcal/sec-°C
H	=	K/A = Convection coefficient, Kcal/m-sec-°C
K	=	Thermal conductivity, Kcal/m-sec °C
ΔX	=	Thickness of conductor, m
R	=	Thermal resistance, °C-sec/Kcal
C	=	Thermal capacitance, Kcal/°C

Heat flow rate :Thermal systems are those that involve the transfer of heat from one substance to another. There are three different ways of heat flow from one substance to another. They are conduction, convection and radiation.

For conduction,

Heat flow rate, $q = K\Delta\theta = \frac{KA}{\Delta X}$ ....(1)

For convection,

Heat flow rate, $q = K\Delta\theta = HA\Delta\theta$ .... (2)

For radiation,

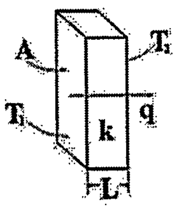
Heat flow rate, $q = Kf(\theta_1^4 - \theta_2^4)$

If $\theta_1 >> \theta_2$ then, $q = K_r\bar{\theta}^4$ .... (3)

Where $\bar{\theta}^4 = (\theta_1^4 - \theta_2^4)^{\frac{1}{4}}$

Note: $\bar{\theta}^4$ is called effective temperature difference of the emitter and receiver.

The value of the resistance depends on the mode of heat transfer.



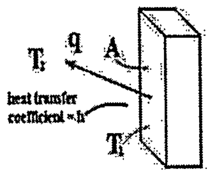
$q = kA\frac{T_2 - T_1}{L}$

Conduction Mode:

$$q = Ak\frac{T_2 - T_1}{L}$$

$$q = \frac{T_2 - T_1}{R}:$$

$$R = \frac{L}{kA}$$



$q = hA(T_1 - T_2)$

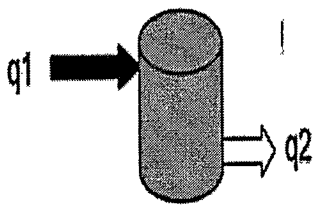
Convection Mode: in liquid and gasses

$$q = hA(T_1 - T_2)$$

$$q = \frac{T_2 - T_1}{R}:$$

$$R_{conv} = \frac{1}{hA}$$

Thermal capacitance: is a measure of the store of internal energy in a system



$(q_1 - q_2) / dt$ = rate of change of internal energy

m = is the mass

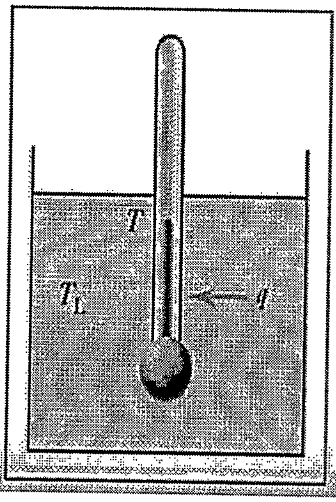
c = is the specific heat capacity

$(q_1 - q_2) / dt = m\,c\,dT/dt$

$C = m\,c$ is the thermal capacitance

$$q_1 - q_2 = C\frac{dT}{dt}$$

Consider a thermometer at a temperature T, which is just inserted in the liquid bath of Temp T_L , $T_L > T$ hence heat (q) flows towards thermometer



$$q = \frac{T_L - T}{R}$$

$$q_1 - q_2 = C\frac{dT}{dt};$$

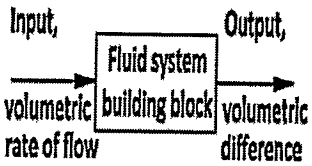
$$q = C\frac{dT}{dt}$$

$$C\frac{dT}{dt} = \frac{T_L - T}{R}$$

$$RC\frac{dT}{dt} + T = T_L$$

FLUID SYSTEM BUILDING BLOCKS

In fluid flow systems there are three basic building block which can be considered to be the equivalent of electrical resistance, capacitance and inductance. For such systems (figure 8.19) the input, the equivalent of the electrical current, is the volumetric rate of flow q, and the output, the equivalent of electrical potential difference, is pressure difference ($p_1 - p_2$). Fluid systems can be considered to fall into two categories: Hydraulic, where the fluid is a liquid and is dement to be incompressible; and pneumatic, where it is a gas which can be compressed and consequently shows a density changes.



- In fluid systems there are three basic building blocks: *Resistance*, *capacitance* and *inertance*
- Hydraulic: the fluid is liquid (assume to be incompressible)
- Fluid system can be divided into two types: hydraulic and pneumatic.

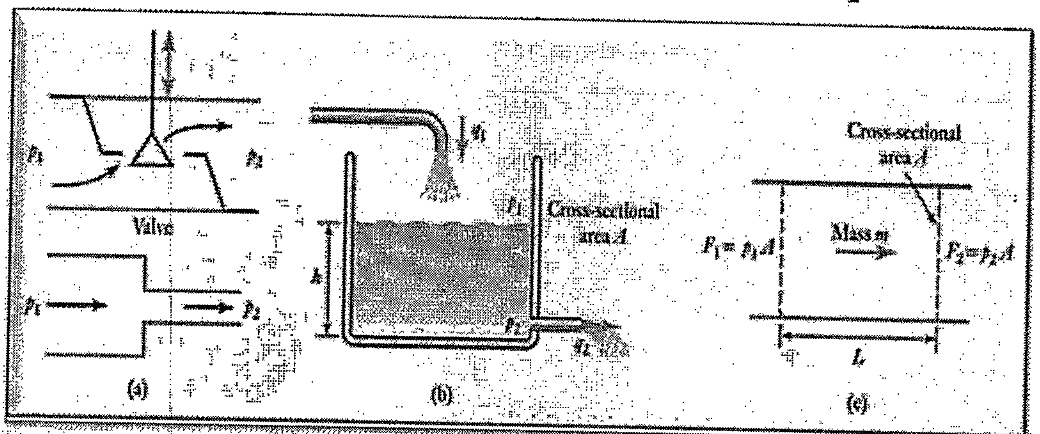
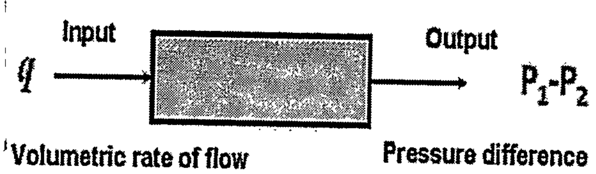


Fig : Hydraulic examples: (a) resistance, (b) capacitance, (c) inertance

The basic building blocks of fluid systems are : Volumetric rate of flow q

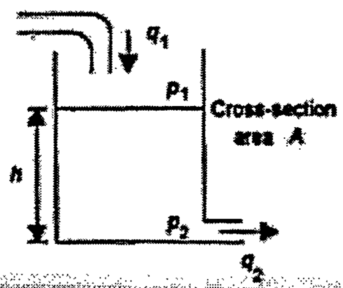
Pressure difference $P_1\text{-}P_2$



Hydraulic resistance (R) is the resistance to flow of liquid as the liquid flow through valves or changes in pipe diameter takes place.

$$P_1\text{-}P_2 = R\,q$$

Hydraulic capacitance :is the term used to describe energy storage with a liquid where it is stored in the form of potential energy.
A height of liquid in a container is one form of such a storage. For such capacitance, the rate of change of volume V in the container (*dV / dt*) is equal to the difference between the volumetric rate at which liquid enters the container q_1 and the rate at which it leaves q_2.



$$q_1 - q_2 = \frac{dV}{dt};\ V = Ah$$

$$q_1 - q_2 = \frac{d(Ah)}{dt} = A\frac{dh}{dt}$$

$$P = \rho g h$$

$$h = \frac{P}{\rho g}$$

$$\therefore q_1 - q_2 = A\frac{d\left(\frac{P}{\rho g}\right)}{dt}$$

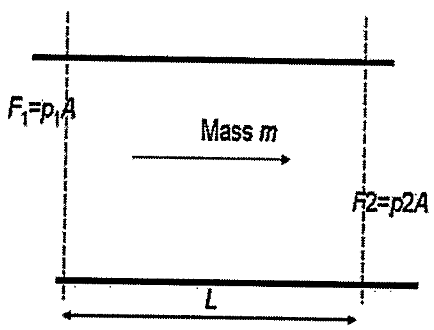
$$= \frac{A}{\rho g}\frac{dP}{dt}$$

$$= C\frac{dP}{dt}$$

$$q_1 - q_2 = C\frac{dp}{dt}$$

$where\ C = \frac{A}{\rho g}$ hydraulic capacitance

Hydraulic inertance is the equivalent of inductance in electrical systems or a spring in mechanical systems. To accelerate a fluid and so increase its velocity a force is required.



$$F_1 - F_2 = p_1A - p_2A = (p_1 - p_2)A$$

$$(p_1 - p_2)A = ma$$

$$(p_1 - p_2)A = m\frac{dv}{dt} = \rho AL\frac{dv}{dt}$$

$$\therefore (P_1 - P_2)A = L\rho\frac{dQ}{dt} \qquad (Q = A\,v)$$

$$P_1 - P_2 = \frac{L\rho}{A}\frac{dQ}{dt}$$

$$= I\frac{dQ}{dt}$$

$$I = \frac{L\rho}{A}$$

I = is the hydraulic inertanc

UNIT 2: SEMICONDUCTORS AND ELECTRONICS

Semiconductors, PN junction diode-types, BJT, DIAC, TRIAC, LEDs, Transistors, FET, MOSFET Transistors, SCR, IC, DC

Introduction to Semiconductors

- **Semiconductor** are materials whose electrical conductivity lies between **conductor** and an **insulator**.

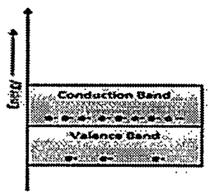
➢ Electrical Conductivity: Level to which a material conducts electricity.

➢ **Conductor:** allows the current to flow through it with the application of voltage like copper.

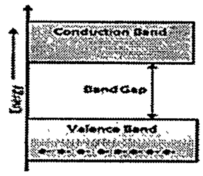
➢ **Insulator: Do not allows** the current to flow through it with the application of voltage like Glass.

Energy band diagram of materials

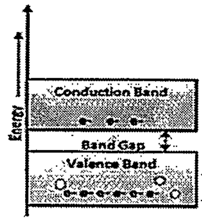
- **Conductor**: have a very small energy gap
  - ➢ Result: current flows easily



- **Insulator**: have a large energy gap
  - ➢ Result: no current flows



- **Semiconductor**: have a medium energy gap
  - ➢ Result: only a small amount of current can flow



Bands in Energy Diagram

- Valance Band: Outermost electron orbital of an atom of material that electrons actually occupy. This is lower band. From this band electrons can jump out of, moving into the higher energy level.
- Conduction Band: This band is generally empty and high in energy. When the electrons are in these band, they have enough energy to move freely in the material. This movement of electrons creates a current.
- Energy band gap: The gap between valance band and conduction band.

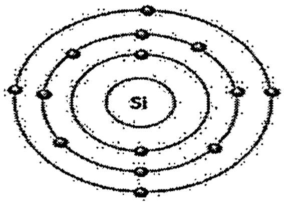
Materials having Semiconductor property

- Semiconductors are the materials which have 4 electrons in its outer most orbit and which forms crystalline structure.

➢ Silicon(Si): atomic number is 14

Number of Energy Levels: 3

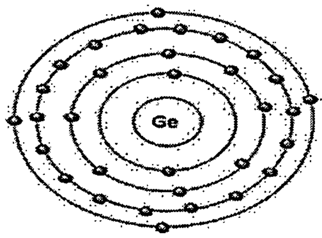
First Energy Level: 2
Second Energy Level: 8
Third Energy Level: 4



➢ Germanium(Ge): atomic number is 32

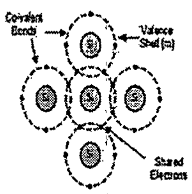
Number of Energy Levels: 4

First Energy Level: 2
Second Energy Level: 8
Third Energy Level: 18
Forth Energy Level: 4



Silicon Crystal Structure

- Silicon atoms form covalent bonds and can crystallize into a regular lattice.
- Silicon atom has four electrons in its outer most orbit which it can share in covalent bonds with its neighbors and form crystal lattice.



Properties of Semiconductor

- It has negative temperature coefficient of resistance, i.e., the resistance of semiconductor decreases with increase in temperature and vice versa
- The resistivity lies between insulator and conductor
- Doping increases conductivity of semiconductor
- At absolute zero, it behaves as perfect insulator
- At room temperature it behaves as conductor.

Types of Semiconductors

Semiconductors can be classified as:

1. Intrinsic Semiconductor.
2. Extrinsic Semiconductor.

Extrinsic Semiconductors are further classified as:

a. n-type Semiconductors.
b. p-type Semiconductors.

Types of Semiconductor
(i) Intrinsic Semiconductor : A semiconductor in its pure state is called intrinsic semiconductor.
(ii) Extrinsic Semiconductor : A semiconductor doped with suitable impurity to increase its impurity, is called extrinsic semiconductor.

On the basis of doped impurity extrinsic semiconductors are of two types
(i) n-type Semiconductor Extrinsic semiconductor doped with pentavalent impurity like As, Sb, Bi, etc in which negatively charged electrons works as charge carrier, is called n-type semiconductor.

Every pentavalent impurity atom donate one electron in the crystal, therefore it is called a doner atom
(ii) p -type Semiconductor: Extrinsic semiconductor doped with trivalent impurity like Al, B,etc, in which positively charged holes works as charge carriers, is called p-type semiconductor.

Comparison of semiconductors

Intrinsic Semiconductor	Extrinsic Semiconductor
1. It is in pure form.	1. It is formed by adding trivalent or pentavalent impurity to a pure semiconductor.
2. Holes and electrons are equal.	2. No. of holes are more in p-type and no. of electrons are more in n-type.
3. Fermi level lies in between valence and conduction Bands.	3. Fermi level lies near valence band in p-type and near conduction band in n-type.
4. Ratio of majority and minority carriers is unity.	4. Ratio of majority and minority carriers are equal.

1-5 N-type and P-type Semiconductors

Doping

- The process of creating *N* and *P* type materials
- By **adding impurity atoms to intrinsic Si or Ge to improve the conductivity of the semiconductor**
- **Two types of doping** – trivalent (3 valence e-) & pentavalent (5 valence e-)

***p*-type material – a semiconductor that has added trivalent impurities**

***n*-type material – a semiconductor that has added pentavalent impurities**

Trivalent Impurities:

- Aluminum (Al)
- Gallium (Ga)
- Boron (B)
- Indium (In)

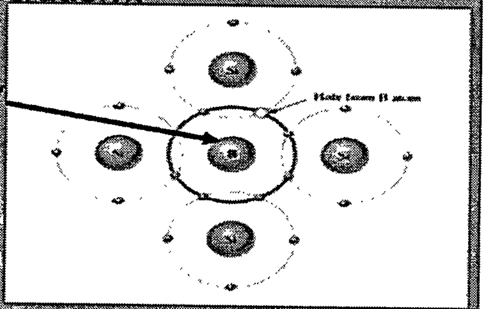
Pentavalent Impurites:

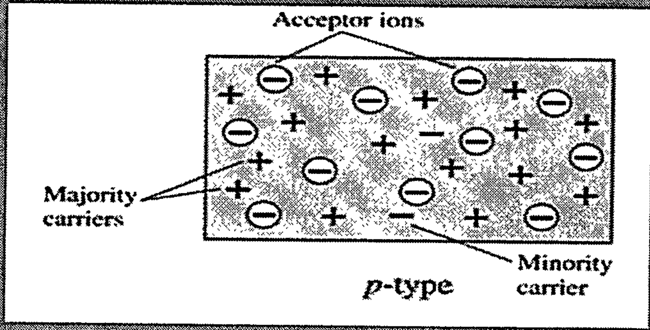
- Phosphorus (P)
- Arsenic (As)
- Antimony (Sb)
- Bismuth (Bi)

P-type semiconductor:

- Trivalent impurities are added to Si or Ge to increase number of holes.
- Boron, indium and gallium have 3 valence e- form covalent bond with 4 adjacent silicon atom. A hole created when each trivalent atom is added.
- The no. of holes can be controlled by the no. of trivalent impurity atoms
- The trivalent atom can take an electron- *acceptor atom*
- Current carries in p-type are holes – majority carries
- electrons – minority carries (created during electron-holes pairs generation).

B impurity atom



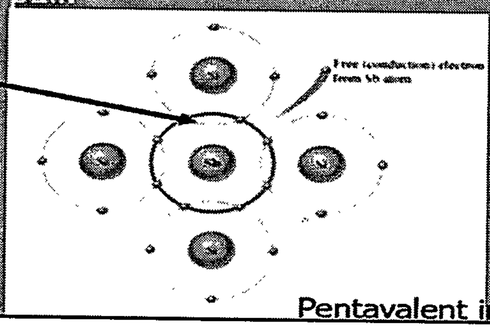


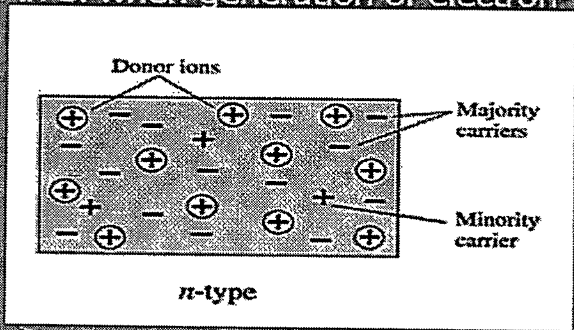
Trivalent impurity atom in a Si crystal

N-type semiconductor:

- ➢ Pentavalent impurities are added to Si or Ge, the result is an increase of free electrons
- ➢ 1 extra electrons becomes a conduction electrons because it is not attached to any atom
- ➢ No. of conduction electrons can be controlled by the no. of impurity atoms
- ➢ Pentavalent atom gives up an electron -call a *donor atom*
- ➢ Current carries in n-type are electrons – majority carriers
- ➢ Holes – minority carriers (holes created in Si when generation of electron-holes pair.

Sb impurity atom





Pentavalent impurity atom in a Si crystal

Comparison between n-type and p-type semiconductors

N-type

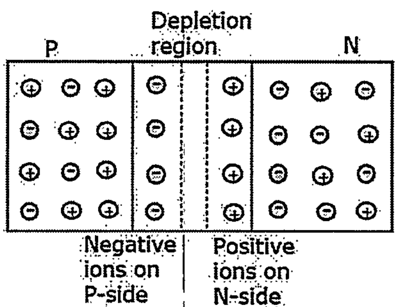
- Pentavalent impurities are added.
- Majority carriers are electrons.
- Minority carriers are holes.
- Fermi level is near the conduction band.

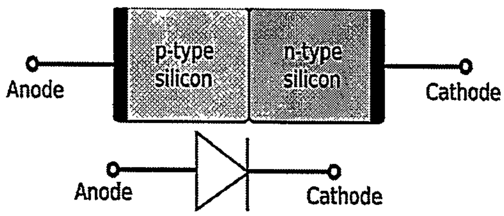
P-type

- Trivalent impurities are added.
- Majority carriers are holes.
- Minority carriers are electrons.
- Fermi level is near the valence band.

PN junction diode

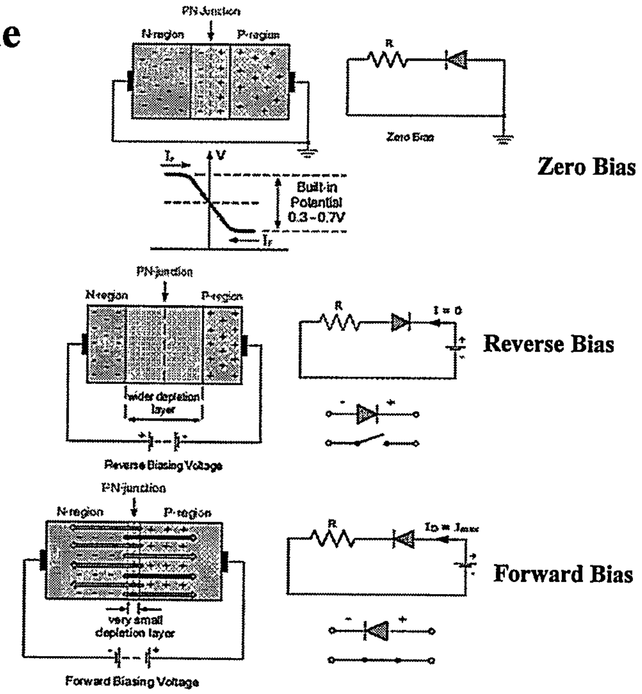
- A **p-n junction diode** is two-terminal or two-electrode semiconductor device, which allows the electric current in only one direction while blocks the electric current in opposite or reverse direction.
- p-n junctions are formed by joining p-type and n-type semiconductor materials.





Working of PN Junction diode

- There are two operating regions and three possible "biasing" conditions for the standard **Junction Diode** and these are:
- **Zero Bias** – No external voltage potential is applied to the PN junction diode.
- **Reverse Bias** – The voltage potential is connected negative, (-ve) to the P-type material and positive, (+ve) to the N-type material across the diode which has the effect of Increasing the PN junction diode's width.
- **Forward Bias** – The voltage potential is connected positive, (+ve) to the P-type material and negative, (-ve) to the N-type material across the diode which has the effect of Decreasing the PN junction diodes width.



Advantages of PN Junction Diode

Sr. No.	Factor	Explanation
1.	Low cost	PN junction diodes can be made easily, making them very cost-effective compared to other types.
2.	High efficiency	PN junction diodes have high efficiency and low forward voltage drops making them perfect for power conversion applications.
3.	Fast switching speed	PN junction diodes are fast in switching speed, making them ideal for high-frequency applications.
4.	Wide operating temperature range	PN junction diodes are able to operate at a wide temperature range making them suitable for harsh environments.
5.	High reliability	PN junction diodes can be used in critical applications because they are reliable and long-lasting.
6.	Versatility	PN junction diodes are versatile components that can be used for a wide range of purposes, such as rectification, voltage regulation and protection.
7.	Small size	PN junction diodes can be purchased in small packages making them ideal for compact designs.

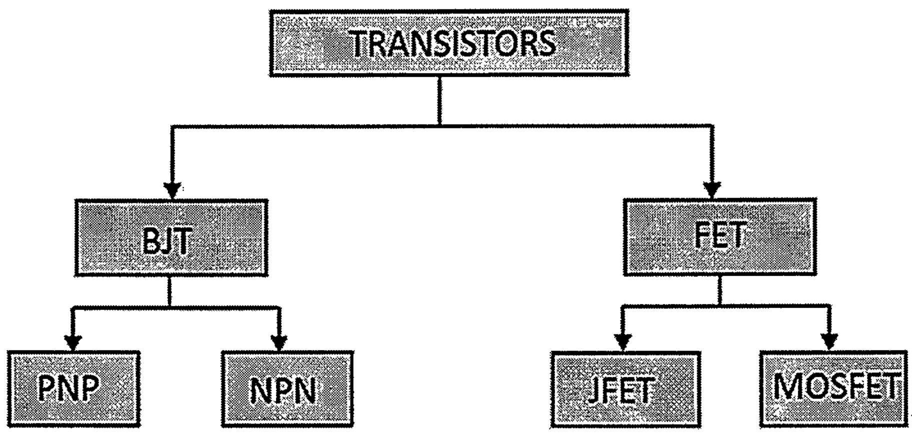
Disadvantages of PN Junction Diode

1. **Reverse voltage is limited:** PN junction diodes are not suitable for high-voltage applications due to their low reverse voltage rating.
2. **Non-linear characteristics in current-voltage:** The current-voltage properties of PN junction diodes can cause distortion in applications like rectification.
3. **High reverse leakage current:** PN Junction diodes have a large reverse leakage current. This can lead to power losses in reverse-biased situations.
4. **Low frequency response:** PN junctions diodes are not suitable for high-frequency applications due to their limited frequency response.
5. **Temperature Sensitivity:** PN junction diodes can be affected by temperature. This can cause their forward voltage drop or reverse leakage current to decrease.
6. **Reverse recovery time is limited:** PN junction diodes only have a short reverse recovery time. This can lead to high switching losses in fast-switching situations.
7. **Limitation on voltage blocking ability:** PN junction diodes are limited in their voltage blocking capabilities, which limits their use for high-voltage applications.

Application of PN junction diode

1. PN junction diode is used for **Rectification** of input and out signals.
2. Clipping and Clamping digital circuits.
3. PN junction is used for Voltage regulation.
4. In Switching.
5. Signal detection.
6. Power supply digital circuits.
7. Used for LED lighting.
8. Solar cell applications.
9. Voltage multipliers.

TRANSISTOR: A transistor is a semiconductor device commonly used to amplify or switch electronic signals.
The word transistor was derived from transfer resistor, as they transfer signals from low resistance to high resistance.



Bipolar Junction Transistor

A Bipolar Junction Transistor (BJT) is a three terminal circuit or device that amplifies flow of current. It is solid state device that flows current in two terminals, i.e., collector and emitter and controlled by third device known as terminal or base terminal. Unlike a normal p-n junction diode, this transistor has two p-n junctions. The basic symbols of BJT are *n-type* and *p-type*. Electronic current is conducted by both free electrons and holes in bipolar junction transistor.

Terminals of Bipolar Junction Transistors

There are three terminals in bipolar junction transistors are explained below.

- **Emitter** – It supplies charge carriers. It is highly doped so that it can inject a large number of charge carriers into the base. Emitter is always greater than base.
- **Base** – Base is middle layer in BJT which is thin compared to emitter and collector. Base is very lighted doped.
- **Collector** – It collects charge carriers. Its doped between emitter and base means moderately doped, but it is always greater than emitter and base in size.

Types of Bipolar Junction Transistors

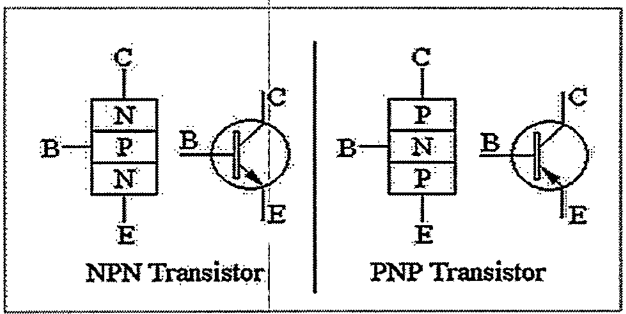
Since a semiconductor has less resistance to flow current in one direction and high resistance in another direction. The device mode of a semiconductor is transistor. There are two types of transistors, i.e., point contact and junction transistor in bipolar junction transistors. Junction transistor are used more than point type transistor. Junction transistor are also types based on their construction. These are:

NPN Junction Transistors

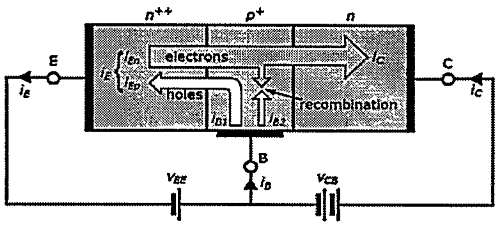
In this transistor, a single p-type semiconductor layer is sandwiched between two n-type semiconductor layers.

PNP Junction Transistors

In this transistor, a single n-type semiconductor layer is sandwiched between two p-type semiconductor layers.



Bipolar junction transistors are formed by sandwiching either n-type or p-type. The electrodes for each junction transistor are: emitter, base, and collector.

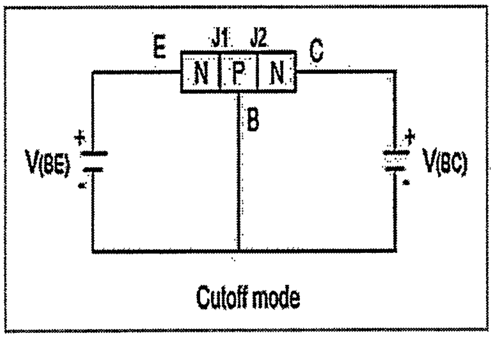


BJT operation modes

There are three modes: Cut-off mode, saturated mode, and active mode in bipolar transistor junction. We need supply DC voltage to NPN or PNP transistors in order to operate transistor in one of these regions. Transistor operates in any of these regions based on polarity of DC voltage. Applying dc voltage means biasing of transistor.

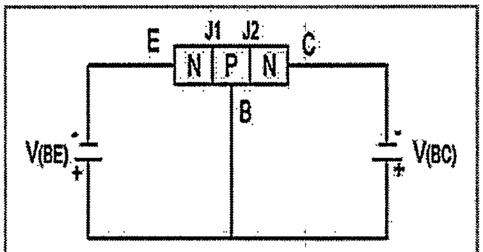
Cutoff mode

In this mode, both junctions are reversed biased so no current flows through the device. Hence, transistor is in off mode and acts like open switch. This mode is used for switch OFF application.



Saturated mode

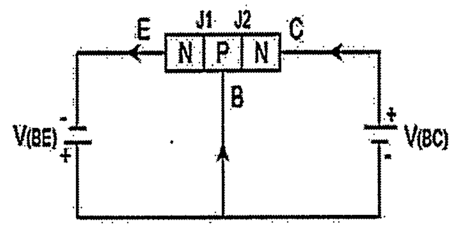
In this mode, both junctions are forward biased so current flows through the device. Hence, transistor is in on mode and acts like closed switch. This mode is used for switch ON application



Saturation mode

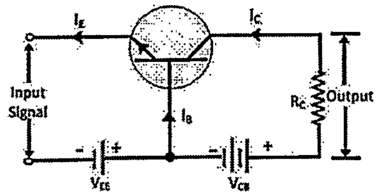
Active mode

In this mode, one junction (emitter to base) is forward biased and another junction (collector to base) is reverse biased. This mode is used for amplification of current.

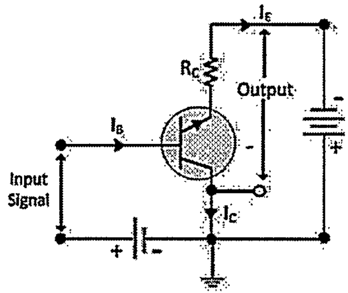


Active mode

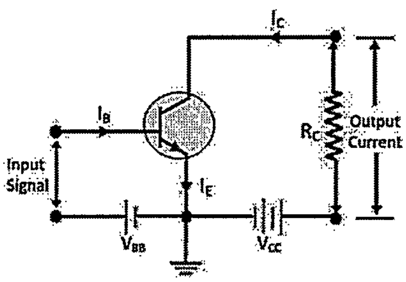
- BJT can be connected in three different configurations by keeping one terminal common and using the other two terminals for the input and output.
- **Common Base (CB):** voltage gain, but no current gain
- **Common Collector (CC):** current gain, but no voltage gain
- **Common Emitter (CE):** both current and voltage gain.



CB Connection of NPN Transistor



CC Connection of NPN Transistor



CE Connection of NPN Transistor

advantages of bipolar junction transistors:

- It has high frequency operation,
- It has high driving capability,
- It can be used as digital switch.

Applications of BJT

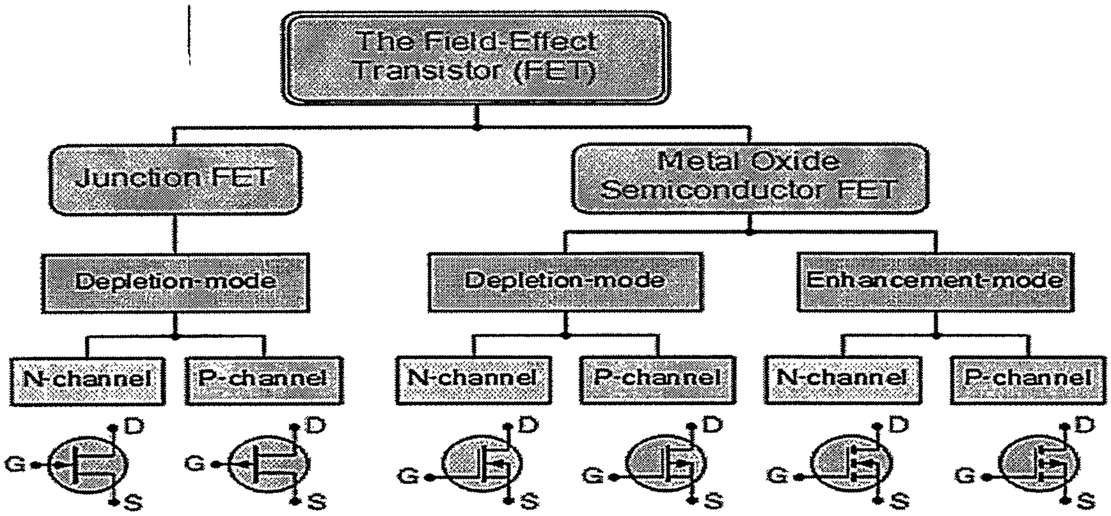
Bipolar junction transistors are mainly used in switching and amplification. Applications of BJT include:

- Radio transmitters
- Audio amplifiers
- Televisions
- Computers
- Mobile phones

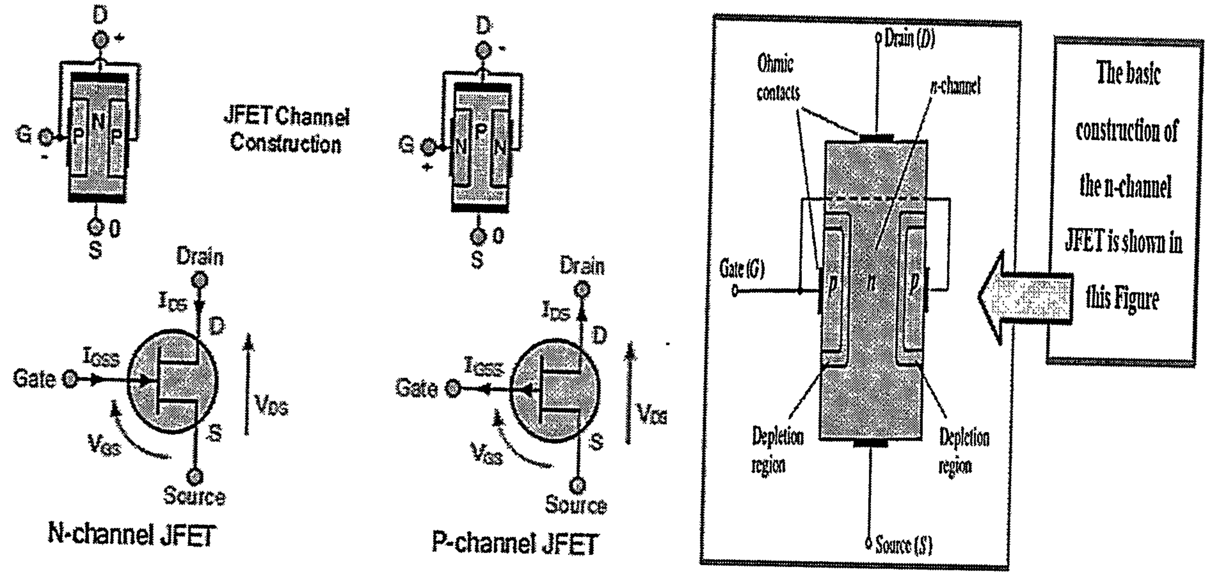
Disadvantages of bipolar junction transistors

- It is affects Radiation
- It generates more noise
- It has less thermal stability
- Base control of BJT is very complex
- Switching frequency is low & high complex control
- Switching time of BJT is low as compared with voltag & current with high alternating frequency.

FIELD-EFFECT TRANSISTOR (FET) : The FET transistors are voltage controlled devices, where as the BJT transistors are current controlled devices. The FET transistors have basically three terminals, such as Drain (D), Source (S) and Gate (G) which are equivalent to the collector, emitter and base terminals in the corresponding BJT transistor.



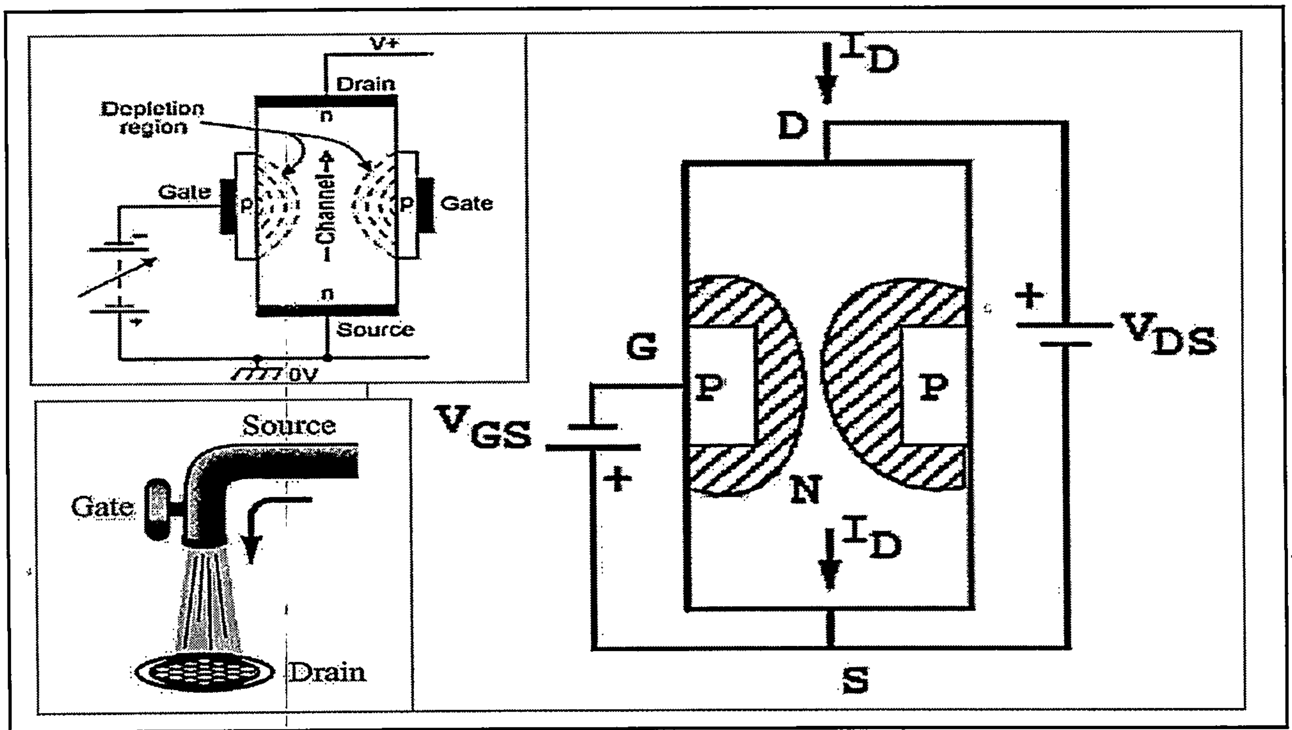
Junction Field Effect Transistor (JFET) Construction



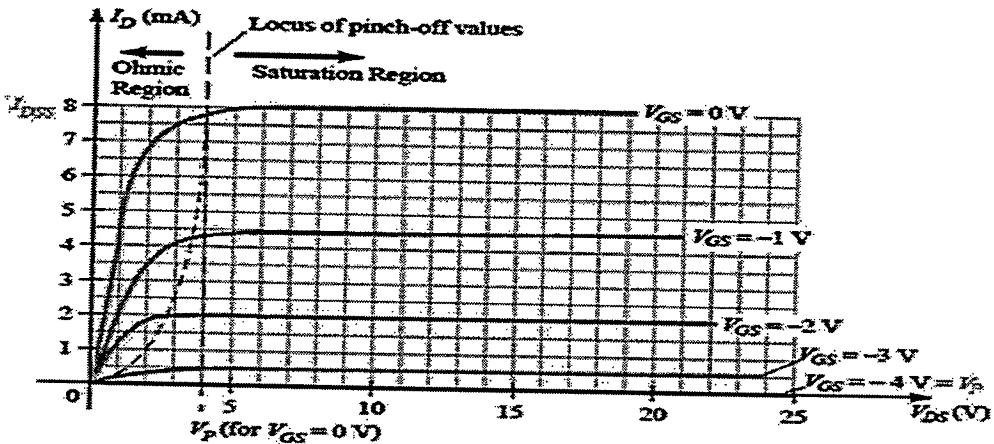
The junction field effect transistor (JFET) is a three-terminal device with one terminal capable of controlling the current between the other two. The JFET are of two types include n-channel JFET and p-channel JFET. The basic construction of n-channel (or p-channel) JFET is shown in Fig (2-2). Generally n-channel JFET is preferred, in an n-channel JFET consists of an n-type silicon bar with two islands of p-type semiconductors material diffused on the opposite sides of its middle part, thus forming two p-n junctions (forming diodes). The two (p-type) regions are connected with each other (externally or internally) and are named gate (G). The ohmic contacts are made at the two ends of the n-type semiconductor bar (silicon). One terminal is known as the source (S) through which the majority carriers (electrons in this case) enter the bar. The other terminal is known as the drain (D) through which these majority carriers leave the bar. In essence, therefore, the drain and the source are connected to the ends of the n-type channel and the gate to the two layers of p-type material. Thus, a junction field effect transistor (FET) has essentially three terminals called gate (G), source(S) and drain (D).
The silicon bar works like a resistor between its two terminals D and S. The gate terminal is similar to the base of an ordinary transistor. It is used to control the flow of current from source to drain. Thus source and drain terminals are similar to emitter and collector terminals respectively of a BJT.

Basic Operation and Characteristics of JFET

The circuit diagram of an n-channel JFET with normal polarities is shown in Fig. (2-3). When an absence of any applied potentials the JFET has two p-n junctions under no-bias conditions, the depletion regions around the p-n junctions are of equal thickness and symmetrical. In contrast, when a voltage VDS is applied across the drain and source terminals and voltage applied across the gate and source (VGS) is zero (i.e gate circuit is open), the two p-n junction form a very thin depletion layer. Thus, a large amount of electrons will flow from source to drain through a wide channel formed between the two depletion layers, and that means (ID = IDSS). Whereas, when a reverse VGS (-VGS: negative) is applied across the gate and source terminals, the width of the depletion layer is increased. This reduces the width of the conducting channel thus decreasing the conduction (flow of electrons) through it. Therefore, the current flowing from source to drain depends upon the width of the conducting channel, which depends upon the thickness of depletion layer form by the two p-n junctions depends upon the voltage applied across the gate source terminals. It is clear that the current from source to drain can be controlled by applies of potential (electric field) on the gate. That is why the device is called field effect transistor. It may be noted that a (p-channel) JFET also operates in the same method as an (n-channel) JFET except that the channel current carriers will be holes instead of electrons and all the polarities will be reversed.



Moreover, the JFET characteristics can be studied for both n-channel and p-channel. Where, the n-channel JFET characteristics or transconductance curve is showed in the Fig. (2-4) below. It is graphed between drain current (ID) and gate-source voltage (VGS). There are multiple regions in the transconductance curve and they are ohmic, saturation, cutoff, and breakdown regions.
Fig. (2-4): (I-V) Characteristics of n-channel JFET, where for the n-channel device the controlling voltage VGS is made more and more negative from its VGS = 0 V level. In other words, the gate terminal will be set at lower and lower potential levels as compared to the source.



Advantages of FET :

•FET has a high input impedance of several megaohms
•FET has less effect by radiation than BJT
•Temperature stable than BJT
•Less noise compare to BJT
•Can be fabricated with fewer processing
•Smaller in size
•Longer life
•High efficiency
•It can be used low frequency application
•Uni-polar device
•Voltage control device
•They have better thermal stability
•They have voltage control device

Disadvantages of FET :

•They are more costly than junction transistor
•Smaller gain bandwidth product compare to BJT
•Transconductance is low hence voltage gain is low
•It has lower switching time compare to BJT
•Special handling is required during installation
•When FET performance degrades as frequency increases. This due to the feedback by internal capacitance

Applications of FETs

- Amplifier
- Oscillator
- Analog Switch
- Integrated Circuits
- Buffer Amplifiers

Metal Oxide Semiconductor Field Effect (MOSFET)

The Metal Oxide Semiconductor Field Effect Transistor (MOSFET) is one type of FET transistor. MOSFET is further categorized into depletion and enhancement types. Usually, the (MOSFET) is a three terminal semiconductor device. There are three terminals include source (S), gate (G) and drain (D). Unlike a JFET, in this device the gate is electrically insulated from the current carrying channel therefore sometimes it is also known as insulated gate FET (IGFET).

The gate current is very small whether the gate is positive or negative. The metal oxide semiconductor field effect transistor (MOSFET) can be used in any of the circuits covered for the FET. In present days, the MOSFET transistors are mostly used in the electronic circuit applications instead of the JFET.

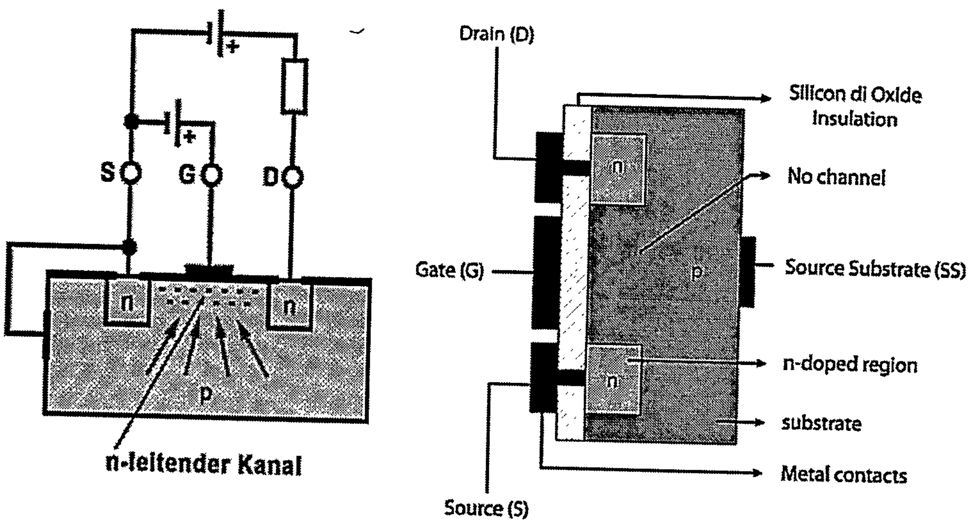


Fig. : Metal oxide semiconductor field effect transistor (MOSFET: n-channel).

Construction of MOSFET

As aforementioned, the MOSFET is basically classified into two forms they are depletion and enhancement types transistors. The MOSFET is also available in both types, n-channel (NMOS) and p-channel (PMOS) Fig. (2-6).

The basic structure of the MOSFET is shown in the Figures (2-5 and 2-6). The construction of the MOSFET is very different as compared to the construction of the JFET. In both enhancement and depletion modes of MOSFETs an electric
field is produced by gate voltage which changes the flow charge carriers, such as electrons for n-channel and holes for p-channel.
The simple side view of an n-channel MOSFET is shown in Fig. (2-6) left the figure shows its constructional details. The source (S) and drain (D) terminals are connected through metallic contacts to n-doped regions linked by an n-channel as shown in the Figures (2-5 and 2-6). The gate (G) is also connected to a metal contact surface but remains insulated from the n-channel by a very thin layer usually silicon dioxide SiO_2. The fact that the deposited SiO_2 layer is an insulating layer reveals that there is no direct electrical connection between the gate (G) terminal and the channel of a MOSFET. The input impedance of MOSFET is very high (of the order of 10^{10} to 10^{15} ohms).

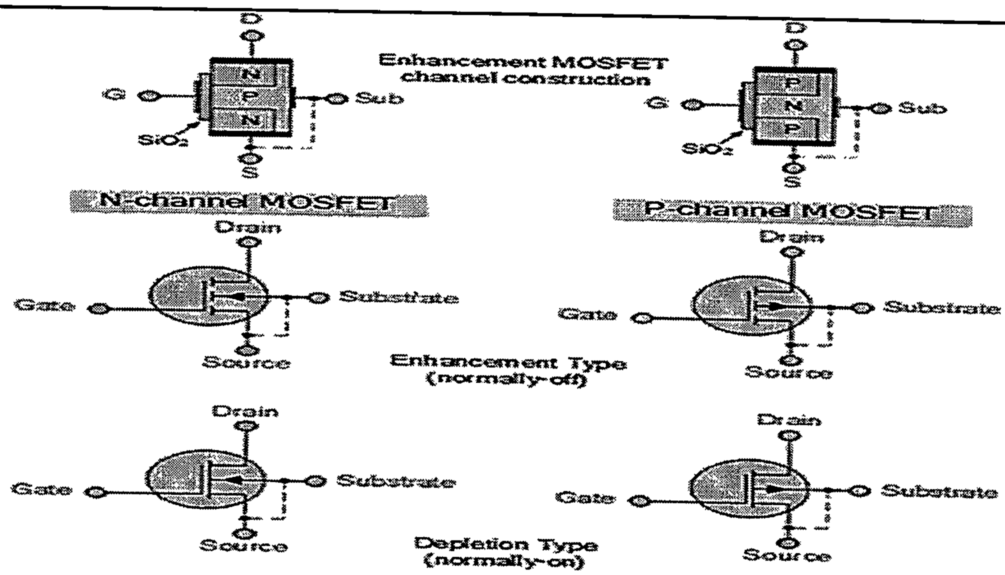
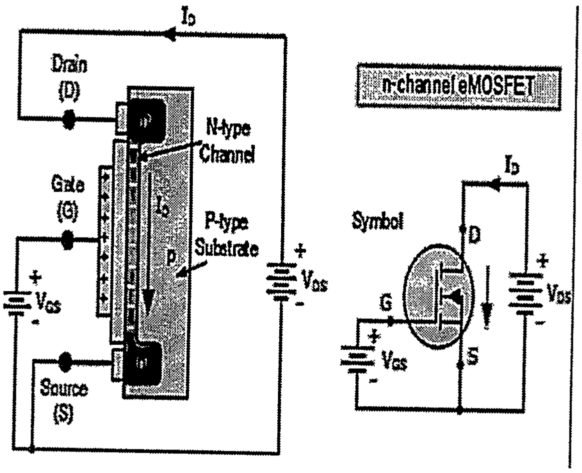


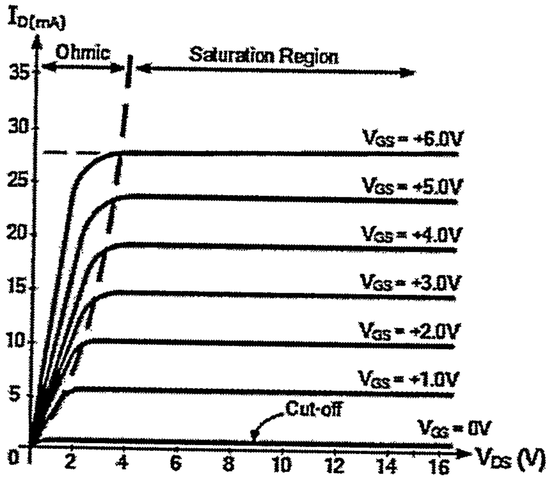
Fig.: Metal oxide semiconductor field effect transistor (MOSFET) types, n-channel (NMOS) and p-channel (PMOS)

Basic Operation and Characteristics of MOSFET

The Enhancement mode MOSFET is commonly used type of transistor. This type of MOSFET is equivalent to normally-open switch because it does not conduct when the gate (G) voltage is zero. The circuit diagram of an n-channel MOSFET (Enhancement mode, EMOSFET) with normal polarities is shown in the Figure (2-7). When negative voltage (-VGS) is applied to the gate (G), electrons accumulate on it. These electrons repel or (prevent) the conduction hand electrons in the n-channel. Therefore the number of conduction electrons available for current conduction through the channel will reduce. Thus, the greater the negative potential on the gate, the lesser is the current conduction from source to drain. In contrast, if the positive voltage (+VGS) is applied to the n-channel gate terminal, then the channel conducts and the drain current flows through the channel.
In this case if the gate is given positive voltage, more electrons are made available in the n-channel. Consequently, the current from source to drain is increased.
If this bias voltage increases to more positive voltage then channel width and drain current (ID) through the channel increased to some more. But if the bias voltage is zero or negative (-VGS) then the transistor may switch OFF and the channel is in non-conductive state. So now we can say that the gate voltage of enhancement mode MOSFET enhances the conduction channel.
The V-I characteristics of enhancement mode MOSFET are shown below which gives the relationship between the drain current (ID) and the drain-source voltage (VDS). From the below Figure (2-8) we observed the behavior of an
enhancement MOSFET in different regions, such as ohmic, saturation and cut-off regions.



Scheme of Basic Operation of n-channel MOSFET (enhancement mode)



Characteristics Curve of Enhancement Mode MOSFET.

Advantages of MOSFET :

- Ability to scale down in size
- It has low power consumption to allow more components per chip surface area
- MOSFET has no gate diode. This makes it is possible to operate with a positive or negative gate voltage
- It read directly with very thin active area
- They have high drain resistance due to lower resistance of a channel
- Physical size is less than 4 mm^2 when it is a package form
- It is widely used than JFET
- The enhancement type MOSFET find wide application in digital circuitry
- They support high speed operation compare to JFETs
- They have high input impedance compare to JFET
- It is easier to fabricate MOSFET than JFET
- They can easy to manufacture

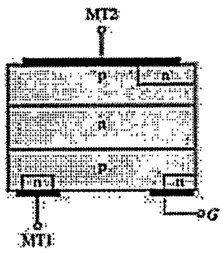
Disadvantages of MOSFET :

- Has a short life
- Required repeated calibration for accurate dose measurement
- They have very susceptible to overload voltage, hence due to installation special handling is to be required

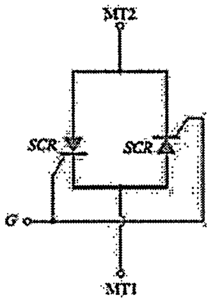
MOSFET applications

- Radiofrequency applications use MOSFET amplifiers extensively.
- MOSFET behaves as a passive circuit element.
- Power MOSFETs can be used to regulate DC motors.
- MOSFETs are used in the design of the chopper circuit.

Structure and Symbol of TRIAC



Basic Structure of Triac



SCR equivalent of Triac

Schematic Symbol of Triac

Construction

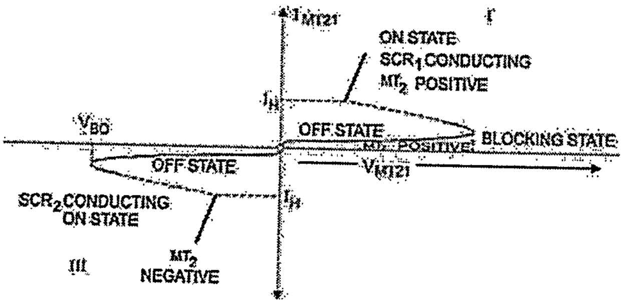
Two SCRs are connected in inverse parallel with gate terminal as common. Gate terminals is connected to both the N and P regions due to which gate signal may be applied which is irrespective of the polarity of the signal. Here, we do not have anode and cathode since it works for both the polarities which means that device is bilateral. It consists of three terminals namely, main terminal 1(MT_1), main terminal 2(MT_2), and gate terminal G.

- **Introduction**
- **Triac** is a three terminal AC switch which is different from the other silicon controlled rectifiers in the sense that it can conduct in both the directions that is whether the applied gate signal is positive or negative, it will conduct.
- Thus, this device can be used for AC systems as a switch.
- This is a three terminal, four layer, bi-directional semiconductor device that controls AC power.
- The triac of maximum rating of 16 kw is available in the market.

Operation of TRIAC

- The triac can be turned on by applying the gate voltage higher than break over voltage. However, without making the voltage high, it can be turned on by applying the gate pulse of 35 micro seconds to turn it on. When the voltage applied is less than the break over voltage, we use gate triggering method to turn it on. There are four different modes of operations, they are-
- When MT_2 and Gate being Positive with Respect to MT_1
  - When this happens, current flows through the path P_1-N_1-P_2-N_2. Here, P_1-N_1 and P_2-N_2 are forward biased but N_1-P_2 is reverse biased. The triac is said to be operated in positively biased region. Positive gate with respect to MT_1 forward biases P_2-N_2 and breakdown occurs.
- When MT_2 is Positive but Gate is Negative with Respect to MT_1
  - The current flows through the path P_1-N_1-P_2-N_2. But P_2-N_3 is forward biased and current carriers injected into P_2 on the triac.
- When MT_2 and Gate are Negative with Respect to MT_1
  - Current flows through the path P_2-N_1-P_1-N_4. Two junctions P_2-N_1 and P_1-N_4 are forward biased but the junction N1-P1 is reverse biased. The triac is said to be in the negatively biased region.
- When MT_2 is Negative but Gate is Positive with Respect to MT_1
  - P_2-N_2 is forward biased at that condition. Current carriers are injected so the triac turns on. This mode of operation has a disadvantage that it should not be used for high (di/dt) circuits. Sensitivity of triggering in mode 2 and 3 is high and if marginal triggering capability is required, negative gate pulses should be used. Triggering in mode 1 is more sensitive than mode 2 and mode 3.

Characteristics of a TRIAC



V-I Characteristic of a Triac

The **triac** characteristics is similar to SCR but it is applicable to both positive and negative triac voltages. The operation can be summarized as follows-

First Quadrant Operation of Triac

Voltage at terminal MT_2 is positive with respect to terminal MT_1 and gate voltage is also positive with respect to first terminal.

Second Quadrant Operation of Triac

Voltage at terminal 2 is positive with respect to terminal 1 and gate voltage is negative with respect to terminal 1.

Third Quadrant Operation of Triac

Voltage of terminal 1 is positive with respect to terminal 2 and the gate voltage is negative.

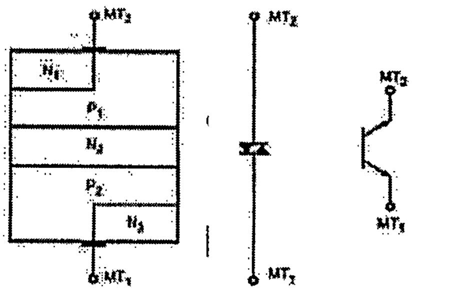
Fourth Quadrant Operation of Triac

Voltage of terminal 2 is negative with respect to terminal 1 and gate voltage is positive.

Advantages and Disadvantages of TRIAC

- **Advantages of Triac**
- It can be triggered with positive or negative polarity of gate pulses.
- It requires only a single heat sink of slightly larger size, whereas for SCR, two heat sinks should be required of smaller size.
- It requires single fuse for protection.
- A safe breakdown in either direction is possible but for SCR protection should be given with parallel diode.
- **Disadvantages of Triac**
- They are not much reliable compared to SCR.
- It has (dv/dt) rating lower than SCR.
- Lower ratings are available compared to SCR.
- We need to be careful about the triggering circuit as it can be triggered in either direction.
- **Uses of Triac**
- They are used in control circuits.
- It is used in High power lamp switching.
- It is used in AC power control.

Introduction of DIAC



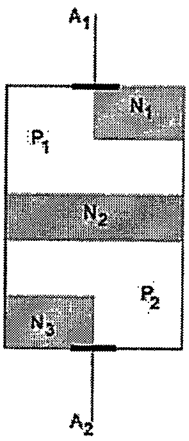
Basic Structure *Schematic Symbols*

Diac

Introduction

- **Diac** is a device which has two electrodes. It is a member of the thyristor family.
- It is mainly used in triggering of thyristor.
- The advantage of using this device is that it can be turned on or off simply by reducing the voltage level below its avalanche breakdown voltage.
- Also, it can be either turned on or off for both the polarity of voltages.
- This device works when avalanche breakdown occurs.

Construction of DIAC

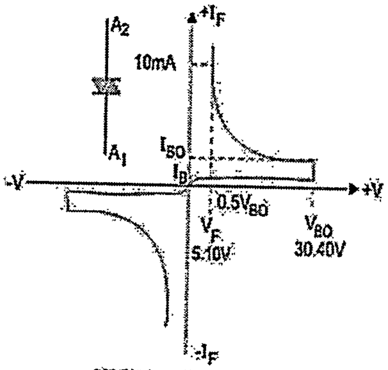


Construction of Diac

It is a device which consists of four layers and two terminals. The construction is almost same as that of the transistor. But there are certain points which deviate from the construction from the transistor. The differentiating points are-

- There is no base terminal in the diac.
- The three regions have almost the same level of doping.
- It gives symmetrical switching characteristics for either polarity of voltages.

Operation of DIAC



V-I Characteristics of the Diac

- From the figure, we see that it has two p-type material and three n-type materials. Also it does not have any gate terminal in it.
- The **diac** can be turned on for both the polarity of voltages. When A_2 is more positive with respect to A_1 then the current does not flows through the corresponding N-layer but flows from P_2-N_2-P_1-N_1.
- When A_1 is more positive A_2 then the current flows through P_1-N_2-P_2-N_3.
- The construction resembles the diode connected in series. When applied voltage is small in either polarity, a very small current flows which is known as leakage current because of drift of electrons and holes in the depletion region.
- Although a small current flows, but it is not sufficient enough to produce avalanche breakdown so the device remains in the non conducting state.
- When the applied voltage in either polarity exceeds the breakdown voltage, diac current rises and the device conducts in accordance with its V-I characteristics.

Advantages of DIAC

•The DIAC offer symmetrical switching characteristics.
•Symmetrical switching helps in reducing the harmonics in a system.
•It has low on-state voltage drop.
•The voltage drop increases with the voltage.
•It can be easily switches by increasing or decreasing the applied voltage.

Disadvantages

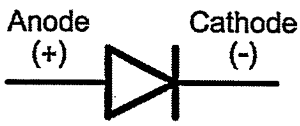
•It is a low power device
•It only conducts when voltage increases above 30 volts.
•It cannot block high voltages.

Applications of DIAC

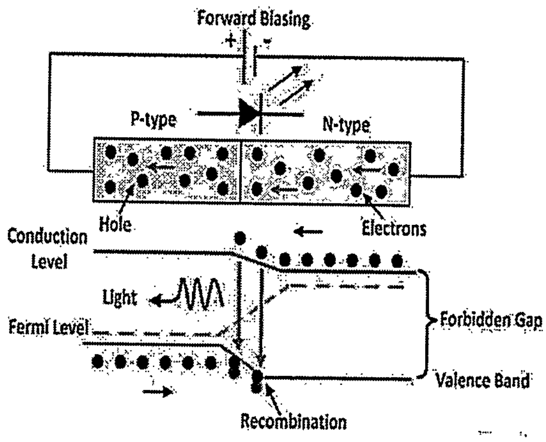
- It can be used mainly in the triac triggering circuit. The diac is connected in the gate terminal of the triac. When the voltage across the gate decreases below a predetermined value, the gate voltage will be zero and hence the triac will be turned off. The main applications are- It can be used in the lamp dimmer circuit.
- It is used in the heat control circuit.
- It is used in the speed control of a universal motor.
- It is used with triac in series combination for triggering. The gate of triac is connected with a terminal of the diac. When applied voltage across diac increases above the avalanche breakdown, then only it can conduct. However, when the voltage across diac decreases below its avalanche breakdown voltage it will be turned off and hence the triac will also remain in the off state.

LEDs

- The LED is a PN-junction diode which emits light when an electric current passes through it in the forward direction.
- In the LED, the recombination of charge carrier takes place.
- The electron from the N-side and the hole from the P-side are combined and gives the energy in the form of heat and light.
- The LED is made of semiconductor material which is colorless, and the light is radiated through the junction of the diode.



- The working of the LED depends on the quantum theory. The quantum theory states that when the energy of electrons decreases from the higher level to lower level, it emits energy in the form of photons. The energy of the photons is equal to the gap between the higher and lower level.
- The LED is connected in the forward biased, which allows the current to flows in the forward direction.
- The flow of current is because of the movement of electrons in the opposite direction.
- The recombination shows that the electrons move from the conduction band to valence band and they emits electromagnetic energy in the form of photons. The energy of photons is equal to the gap between the valence and the conduction band.



Advantages of LED :
The brightness of light emitted by LED is depends on the current flowing through the LED. Hence, the brightness of LED can be easily controlled by varying the current. This makes possible to operate LED displays under different ambient lighting conditions.
Light emitting diodes consume low energy.
LEDs are very cheap and readily available.
LEDs are light in weight. Smaller size.
LEDs have longer lifetime.
LEDs operates very fast. They can be turned on and off in very less time.
LEDs do not contain toxic material like mercury which is used in fluoro-lamps.
LEDs can emit different colors of light.
Disadvantages of LED :
LEDs need more power to operate than normal p-n junction diodes.
Luminous efficiency of LEDs is low.

Applications of LED

The various applications of LEDs are as follows

- Burglar alarms systems
- Calculators
- Picture phones
- Traffic signals
- Digital computers
- Multimeters
- Microprocessors
- Digital watches
- Automotive heat lamps
- Camera flashes Aviation lighting

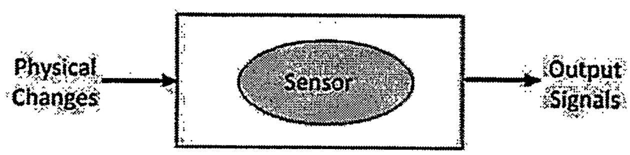
UNIT – III:

SENSORS AND TRANSDUCERS: Introduction and background, difference between transducer and sensor, transducers types, transduction principle, photoelectric transducers, thermistors, thermo devices, thermo couple, inductive transducers, capacitive transducers, pyroelectric transducers, piezoelectric transducers, Hall-effect transducers, Fibre optic transducers.

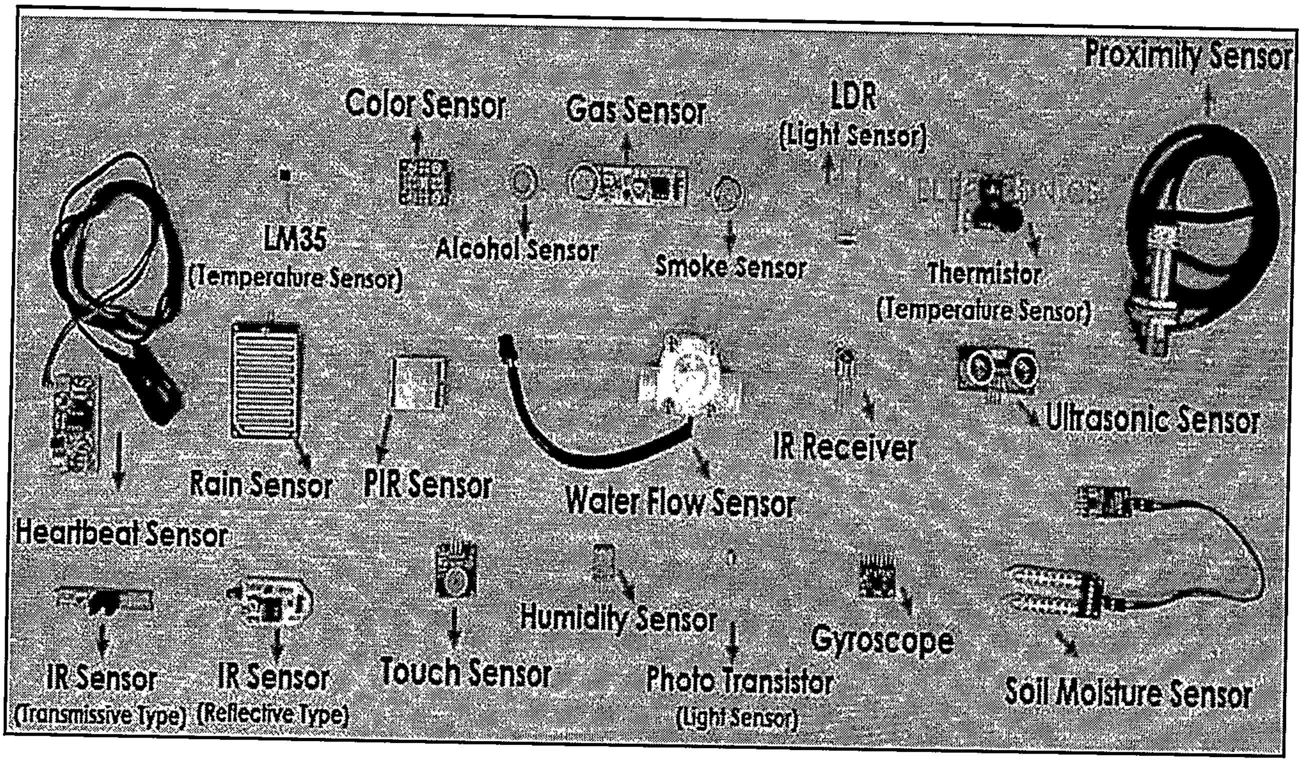
SENSOR:

1.Sensors are devices which produce a proportional output signal (mechanical, electrical, magnetic, etc.) when exposed to a physical phenomenon (pressure, temperature, displacement, force, etc.). Many devices require sensors for accurate measurement of pressure, position, speed, acceleration or volume.

2.Sensors are used as elements which produces a signal relating to the quantity being measured.

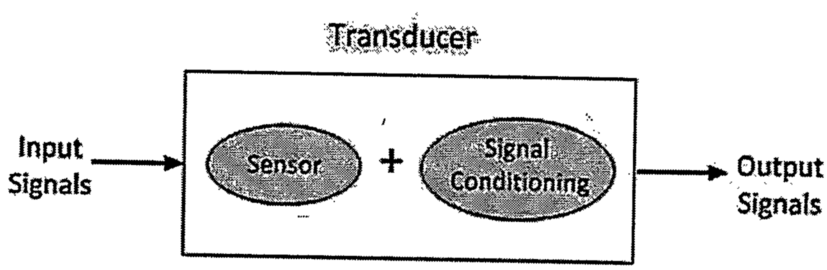


Sensor



TRANSDUCERS

Transducers are devices which converts an input of one form of energy into an output of another form of energy.



Difference between Sensor and Transducers

Basis For Comparison	Sensor	Transducer
Definition	Senses the physical changes occurs in the surrounding and converting it into a readable quantity.	The transducer is a device which, when actuates transforms the energy from one form to another.
Components	Sensor itself	Sensor and signal conditioning
Function	Detects the changes and induces the corresponding electrical signals.	Conversion of one form of energy into another.
Examples	Proximity sensor, Magnetic sensor, Accelerometer sensor, Light sensor, Barometer, Gyroscope etc.	Thermistor, Potentiometer, Thermocouple, etc.

Characteristics of Sensors

Sensor characteristics are of two types

➢ Static Characteristics: Static characteristics refer to the steady state relationship between sensor input and output.

➢ Dynamic Characteristics :Dynamic characteristics refer to the relationship between the sensor input and output when the measured quantity is varying rapidly.

Static Characteristics

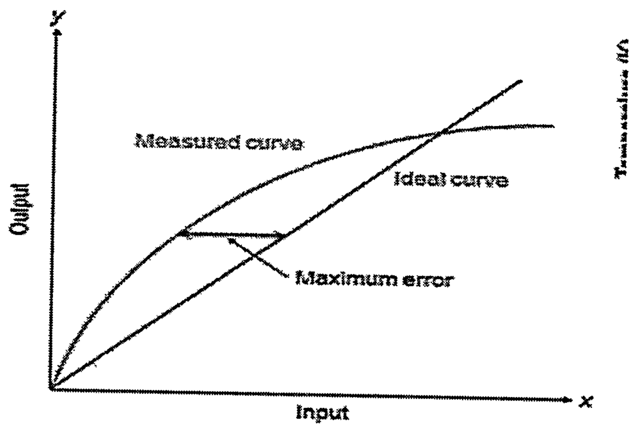
Range: The range of a sensor indicates the limits between which the input can vary. Example: a thermocouple for the measurement of temperature might have a range of 25-225 °C.

Span: Span is difference between the maximum and minimum values of the input. Thus, the above-mentioned thermocouple will have a span of 225-25=200 °C.

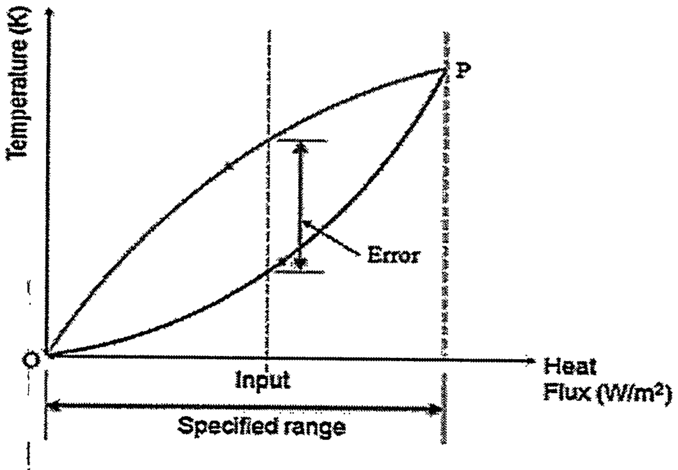
Error: Error is the difference between the measured value and the true value of the quantity. Example: A sensor might give a displacement reading of 29.8 mm, when the actual displacement had been 30 mm, then the error is 0.2 mm

Sensitivity: Sensitivity of a sensor is defined as the ratio of change in output value of a sensor per unit change in input value. For example, a temperature sensor may have a sensitivity of 10 mV/°C. If 1oC raise in temp results in 10mV

Non-Linearity: The nonlinearity indicates the maximum deviation of the actual measured curve of a sensor from the ideal curve. It is shown in fig



Hysteresis: The hysteresis is an error of a sensor, which is defined as the maximum difference in output at any measurement value within the sensor's specified range when approaching the point first with increasing and then with decreasing the input parameter. It is shown in fig.



Stability: Stability is the ability of a sensor device to give same output with a constant input over a period.

Dead band: The dead band or dead space of a sensor is the range of input values for which there is no output.

Repeatability: It specifies the ability of a sensor to give same output for repeated applications of same input value under same conditions.

Accuracy: This is the closeness to the actual value.

Precision: Precision is defined as the ability of sensor to reproduce a certain set of readings within given accuracy. Precision depends upon repeatability.

Output Impedance: It is the impedance measured at the output of sensor. It is necessary to know the output impedance of a sensor because the electrical output of sensor is interfaced with an electronic circuit.

Dynamic Characteristics

Response time: This is the time which elapsed by sensor to gives an output corresponding to some specified percentage (90-95%) of its steady value after a constant input, a step input, is applied.

Time constant: The time constant is a measure of the inertia of the sensor and so how it will react to changes in its input. This is the 63.2% response time.

Rise time: This is the time taken for the output to rise from 10% to 90 % of its steady value.

Settling time: This is the time taken for the output to settle to within some small percentage (2%) of steady state value

Classification of Transducer

a. Whether the device senses and converts or just converts physical phenomenon.
b. Method of conversion of energy.
c. Nature and Type of output signals.
d. Type of sensing element used.
e. Type and nature of measured to be used.
f. Whether they are self generating or externally powered.
g. Its purpose in the measurement system.

a. Whether the device senses and converts or just converts physical phenomenon.
They are

i. Primary transducer: These are detectors which sense a physical phenomenon and convert it into an analogous output. E. g: Thermocouple.

ii. Secondary transducer: These are those which convert the analogous output of the detector, which has sensed the E.g.: Measurement of compressive force with the help of load cell.

b. Method of conversion of energy: The energy or signal produced due to physical phenomenon or measured are converted into another form using mechanical linkages as in the case of simple dial gauge or the properties of material like resistance, conduction, expansion etc. E.g. Strain gauges are used to measure the mechanical strain of a member due to load or force. The change in resistance of the strain gauges is the measure of force.

c. Nature and Type of output signals:

i. Analog transducer: These are whose convert physical phenomenon into an analogous output which is a continuous function of time. Strain gauges, thermisters, LVDT, etc,are examples of analogue transducer.

ii. Digital transducer: These are whose convert physical phenomenon into an electrical output which is in the form of pulses. These are not many digital transducers available, although there importance is well recognized in modern microprocessor based control systems and instrumentation. Angular digital encoder and digital level transducers are examples are digital transducers.

d. Type of sensing element used:

i. Elastic elements: Most pressure measuring devices use a Bourdon tube, a bellow or a diaphragm. The action of these elements is based on elastic deformation brought about by the force resulting from pressure summation.

ii. Mass sensing elements: This is based on the inertia of a concentrated mass. Vibration pick up accelerometers, liquid manometers are examples of mass sensing element transducer.

iii. Thermal elements: these elements sense the heat of a system by indicating some change in the property of the material used, which varies with the heat.

iv. Hydro pneumatic elements: The two simple examples of hydro pneumatic elements are Float and hydrometer.

e. Whether they are self generating or externally powered:

I. Active transducers: These are those which develop their own power. They are also know as self generating transducers, the energy required for production of output signal form the physical phenomenon being measured. E.g.: Piezoelectric pick up, thermocouples photo voltaic cell etc.

ii. Passive transducers: These are those which required externals power of producing output signal. There also know externally power transducers. E. g. Resistance thermometer, thermostats, differential transformers etc.

f. Its purpose in the measurement system:

i.Input transducers: These transducers convert a non electric quality into an electric signal. E.g. Strain gauge, photovoltaic cell etc

ii. Output transducers: These transducers convert electrical signal back into non-electrical signal according to whether they make physical contact or not. They are contact and non-contact type

g. Its purpose in the measurement system:

Mechanical transducers for measuring quantities such as position, velocity, force, torque, displacement, pressure, vibration, strain mass etc.

Based on electrical Principle

Variable-resistance type

- Strain
- Pressure gauges
- Thermistors
- RTD
- Photoconductive cell

Variable-capacitance type

- Capacitor microphone
- Pressure gauge
- Dielectric gauge.

Voltage-generating type

- Thermocouple
- Piezoelectric pick-up
- Photovoltaic cell
- Rotational motion tachometer

Voltage-Divider type

- Pressure-actuated voltage divider.
- Potentiometer position sensor.

Variable-inductance type

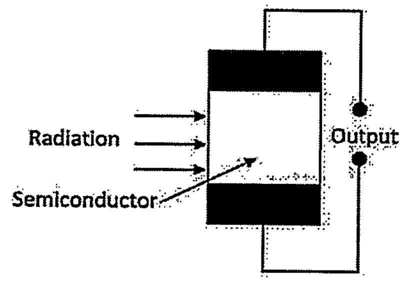
- LVDT
- Reluctance pick-up
- Eddy current gauge

Photoelectric Transducer

Definition: The photoelectric transducer converts the light energy into electrical energy. It is made of semiconductor material. The photoelectric transducer uses a photosensitive element, which ejects the electrons when the beam of light absorbs through it.

The discharges of electrons vary the property of the photosensitive element. Hence the current induces in the devices. The magnitude of the current is equal to the total light absorbed by the photosensitive element.

The photoelectric transducer absorbs the radiation of light which falls on their semiconductor material. The absorption of light energises the electrons of the material, and hence the electrons start moving. The mobility of electrons produces one of the three effects.



Photoelectric Transducer

1.The resistance of the material changes.

2.The output current of the semiconductor changes.

3.The output voltage of the semiconductor changes.

Classification of Photoelectric Transducers

1.Photoemissive Cell

2. Photoconductive Cell

3. Photo-voltaic cell

4. Photodiode

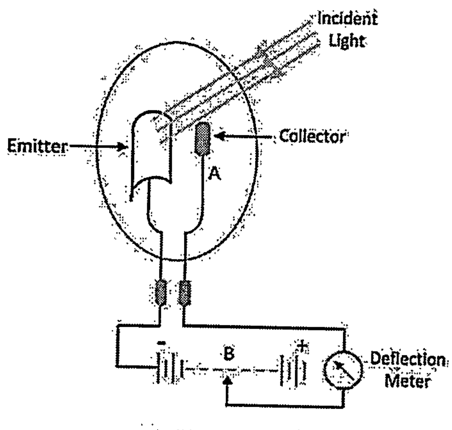
5. Phototransistor

1.Photoemissive Cell

The Photo emissive cell converts the photons into electric energy. It consists the anode rode and the cathode plate. The anode and cathode are coated with a Photo emissive material called caesium antimony.

When the radiation of light fall on cathode plates the electrons starts flowing from anode to cathode. Both the anode and the cathode are sealed in a closed, opaque evacuated tube. When the radiation of light fall on the sealed tube, the electrons starts emitting from the cathode and moves towards the anode.

The anode is kept to the positive potential. Thus, the photoelectric current starts flowing through the anode. The magnitude of the current is directly proportional to the intensity of light passes through it.

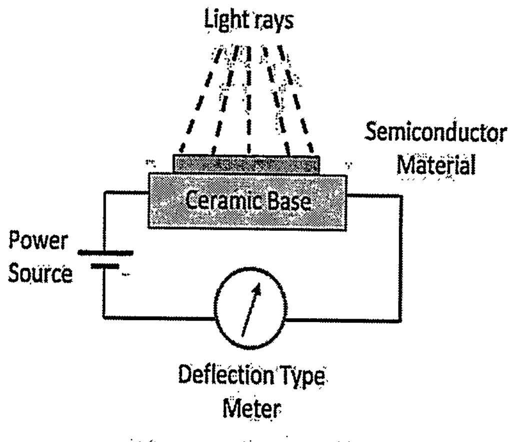


Photoemissive Cell

2.Photoconductive Cell

The photoconductive cell converts the light energy into an electric current. It uses the semiconductor material like cadmium selenide,

When the beam of light falls on the semiconductor material, their conductivity increases and the material works like a closed switch. The current starts flowing into the material and deflects the pointer of the meter.

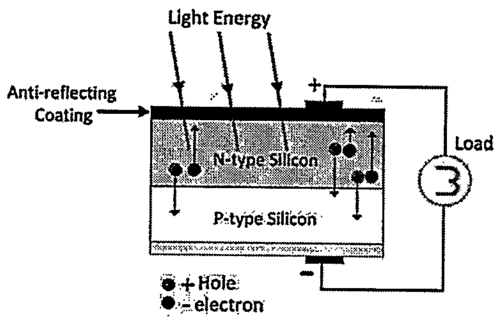


Photoconductive Cell

3.Photo-voltaic cell

The photovoltaic cell is the type of active transducer. The current starts flowing into the photovoltaic cell when the load is connected to it. The silicon and selenium are used as a semiconductor material. When the semiconductor material absorbs heat, the free electrons of the material starts moving. This phenomenon is known as the photovoltaic effect.

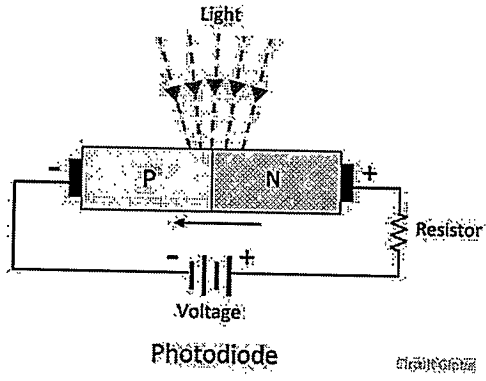
The movements of electrons develop the current in the cell, and the current is known as the photoelectric current.



Photovoltaic Cell

4.Photodiode

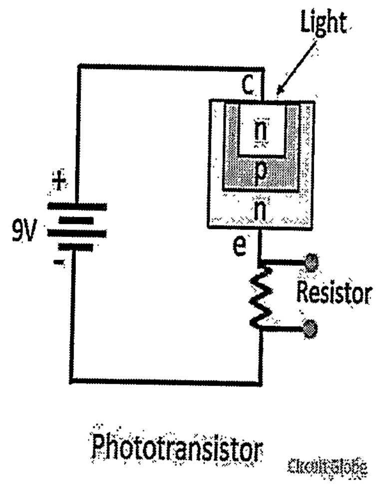
The photodiode is a semiconductor material which converts the light into the current. The electrons of the semiconductor material start moving when the photodiode absorbs the light energy. The response time of the photodiode is very less. It is designed for working in reverse bias.



5.Phototransistor

The phototransistor is a device that converts the light energy into electric energy. It produces both the curren and voltage.

The photovoltaic cell is a bipolar device which is made of semiconductor material. The semiconductor material is enclosed in an opaque container in which the light easily reaches to the photosensitive element. The element absorbs light, and the current starts flowing from base to emitter of the device. This current is converted into the voltages.



THERMISTORS

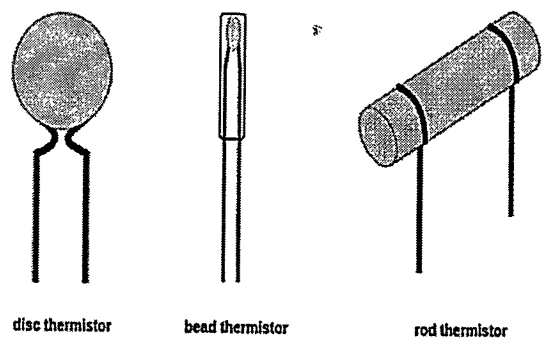
The Thermistor or simply **Thermally** Sensitive Res**istor** is a temperature sensor that works on the principle of varying resistance with temperature. They are made of semiconducting materials. The circuit symbol of the thermistor is shown in the figure.

Construction of Thermistor

A thermistor is made of oxides of metals such as Nickel, Manganese, Cobalt, Copper, Uranium etc. It is available in a variety of shapes and sizes. Commonly used for configurations are Disk type, Bead type and Rod type.

The disc type thermistor and rod type thermistor is used when greater power dissipation is required. The rod type thermistor has high power handling capacity.

The smallest thermistor in these configurations is the bead type thermistor. its diameter is low as 0.15 mm. The measurement element is typically encapsulated in a glass probe. It is commonly used for measuring the temperature of liquids.



Working Principle of Thermistors

The thermistor works on the simple principle of change in resistance due to a change in temperature. When the ambient temperature changes the thermistor starts self-heating its elements. its resistance value is changed with respect to this change in temperature. This change depends on the type of thermistor used. The resistance temperature characteristics of different types of thermistors are given in the following section.

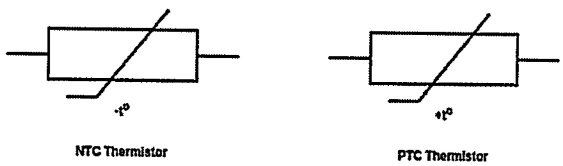
Types of Thermistors

The two basic types of thermistors available are the NTC and PTC types.

NTC Thermistor

NTC stands for Negative Temperature coefficient. They are ceramic semiconductors that have a high Negative Temperature Coefficient of resistance. The resistance of an NTC will decrease with increasing temperature in a non-linear manner.

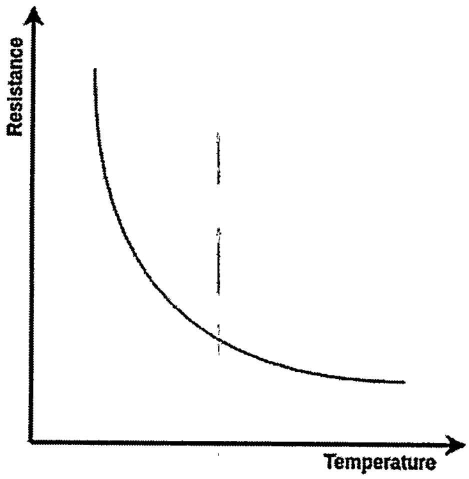
Circuit symbols of NTC and PTC thermistors are shown in the following figure



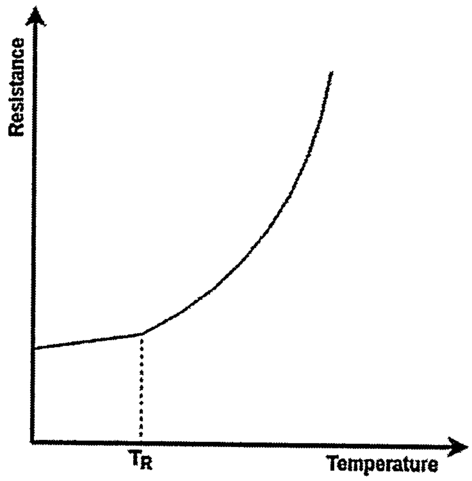
PTC Thermistor

PTC thermistors are Positive Temperature Coefficient resistors and are made of polycrystalline ceramic materials. The resistance of a PTC will increase with increasing temperature in a non-linear manner. The PTC thermistor shows only a small change of resistance with temperature until the switching point(TR) is reached.

The temperature resistance characteristics of an NTC and a PTC is shown in the following figure.



NTC Characteristics



PTC Characteristics

Advantages of thermistors

- Less expensive.
- More sensitive than other sensors.
- Fast response.
- Small in size.

Dis-advantages of thermistors

- Limited Temperature range.
- Resistance to temperature ratio correlation is non-linear.
- An inaccurate measurement may be obtained due to the self-heating effect.
- Fragile.

Applications of thermistors

NTC Thermistor Application

- Digital Thermostats.
- Thermometers.
- Battery pack temperature monitors.
- In-rush-current limiting devices

PTC Thermistor Application

- Over-current protection . In-rush-current protection

THERMO COUPLE

Basic Principle

The basic principle of thermocouple is: when two dissimilar metals are joined together an emf will exist between the two points A and B, which is primarily a function of the junction temperature. This principle is known as the *Seebeck effect.* Figure 2.104 illustrates Seebeck effect, where two metals A and B are used to close the loop connecting junctions at temperature T_1 and T_2. The emf produced is found to be almost linear in temperature and very repetitive for constant materials.

The emf produced by the thermocouple loop is approximately given by

$$\text{emf} = \alpha(T_2 - T_1)$$

where α is the constant in V/K; T_1 and T_2 are junction temperatures.

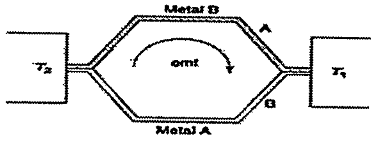


Figure Seebeck effect.

Construction

The thermocouple consists of one hot junction and one cold junction. The hot junction will be introduced into the place where temperature is measured. The other cold junction is maintained at a constant reference temperature. Also one voltage-measuring instrument is connected to the free end of the thermocouple.

Operation

In a thermocouple, the known temperature is called the *reference temperature.* The temperature which is to be measured is introduced in the thermocouple's hot junction. A common arrangement for establishing the reference temperature is an ice bath. The reference temperature is held constant at 0 °C.

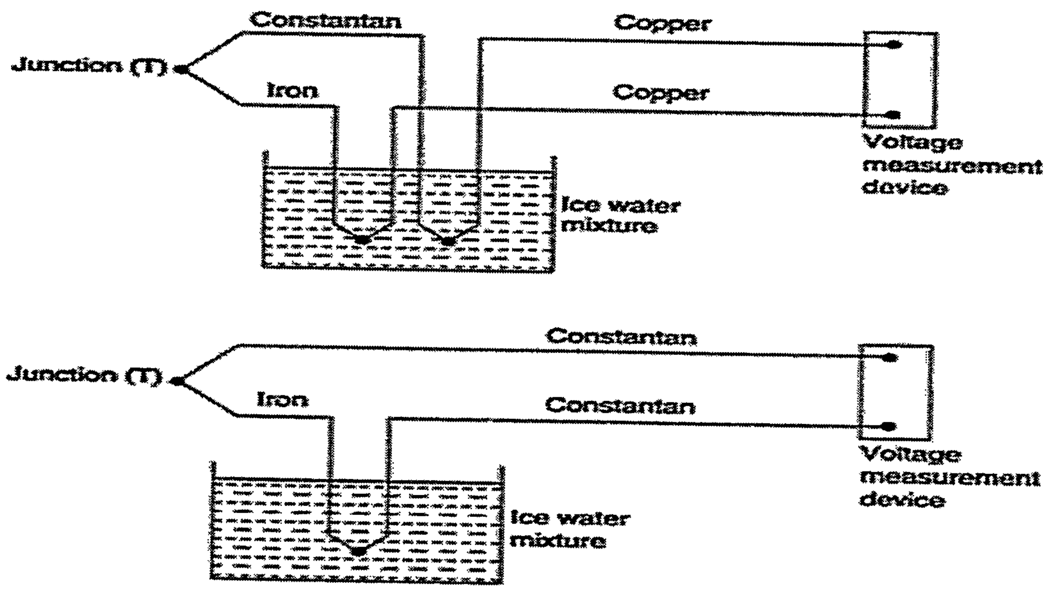


Figure : Construction of thermocouple.

TABLE STANDARD THERMOCOUPLE CHARACTERISTICS

Type	Material	Operating Range	Accuracy
K	Chromel/Alumel	−200 to 1350	+/− 3°C
J	Iron/Constantan	−200 to 800	+/− 3°C
E	Chromel/Constantan	−200 to 1000	+/− 1.5°C
R	Platinum/Platinum Rhodium (10%)	−50 to 1600	+/− 2°C
S	Platinum/Platinum Rhodium (13%)	−50 to 1600	+/− 2°C
T	Copper/Constantan	−200 to 400	+/− 2°C

Advantages:

1.Wide Range

2. Fast Response

3. Passive 4. Inexpensive 5. The calibration can be easily checked.6 The thermocouple offers good reproducibility.

Disadvantages:

1.Non-Linear

2.Accuracy - Often between 0.5 and 2.2°C, depending on TC type

3.Noise - Long leads can attract electrical signals - Already low signal from thermocouple

4.Thermal shunting -Heating of wire mass can affect measurements by absorbing energy

5.Corrosion - High alkali or water environments can modify calibration

Inductive Transducer

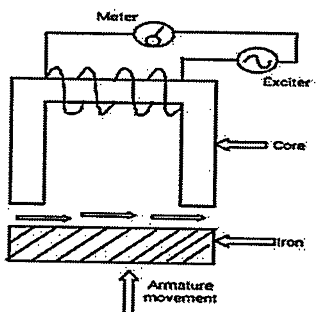
Definition: A transducer that works on the principle of electromagnetic induction or transduction mechanism is called an inductive transducer. A self-inductance or mutual inductance is varied to measure required physical quantities like displacement (rotary or linear), force, pressure, velocity, torque, acceleration, etc. These physical quantities are noted as measured. Linear Variable Differential Transducer(LVDT) is an example of an inductive transducer. Using LVDT, displacement is measured in terms of the voltage induced in the winding by moving the core in one direction

Types of the Inductive Transducer

Inductive transducers may be of passive-type or self-generating type. The tachometer is the example of a self-generating inductive transducer. LVDT is an example of a passive type inductive transducer. Inductive transducers are divided into two types. They are,

Simple Inductance Type

In this type of transducer, a single coil is used to measure the required parameter. The change in displacement changes the permeability of the flux produced in the circuit results in a change in the inductance of the coil and the output. The output can be calibrated in terms of the measurand, which is to be measured. The circuit of a simple inductance type is shown below. Single inductance type is again divided into two types.



Simple Inductance Type

Single Coil Inductance Type

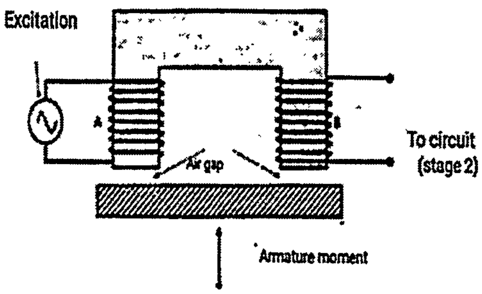
When the armature of the circuit is moved, the air gap between the magnetic materials and the permeability of the flux produced in the circuit changes. This results in a change of the inductance in the circuit. This type is used mainly in counting the no.of objects. The circuit of a single-coil inductance type is shown below.

Hallow Coil Inductive Type Circuit

The magnetic core can be moved inside the hallow material, which has a coil wound around the hallow magnetic material The output is proportional to the input and it can be calibrated in terms of the measurand. The air gap decides the change in the magnetic field of the coils and the flux linkage.

Mutual Inductance Transducers (two coils)

In this type, two coils are used for mutual induction. One for generating excitation and another for output. The voltage difference between the two coils depends on the movement of the armature. When the armature position is changed by connecting to the movable mechanical element, then the inductance changes. The air gap between the armature and the magnetic material and also voltage induced in the coil depends on the change in the armature position. This type is also called a differential mutual inductive transducer.



Mutual Inductance Transducer

Inductive Transducer Working Principle

Generally, inductive transducers works on the principle of change in self-inductance of one coil, change in mutual inductance of two-coils and eddy current production. The voltage difference and change in inductance results due to the change in flux in the coils (secondary or primary coils). The working principle of the inductive transducer is explained below.

Change in Self-inductance

Consider the self-inductance of the coil be,

L = N2/R

The expression for the reluctance of the coil is,

$$R = l/\mu A$$

$$L = N^2\mu A/l$$

$$L = N^2\mu G$$

Where 'N' represents no.of turns

'R' represents the magnetic circuit's reluctance

'μ' represents permeability of the coil (medium in and around the coil)

G= A/l = geometric form factor

'A' represents a cross-section area of the coil

'l' represents the length of the coil

From the above equations, we can observe that self-inductance can be varied or changed by changing the no.of turns, or geometric form factor or permeability of the coil.

The displacement can be measured directly in terms of inductance by changing any of the above parameters (turns, form factor, permeability). We can also calibrate the instrument against measurand.

Change in Mutual Inductance

Inductive transducers also on the principle of mutual inductance of multiple coils.We consider the two coils, which have self-inductance L1 and L2

The mutual inductance of the coils is given by,

$$M = K \sqrt{L1L2}$$

Where 'K' represents the coefficient of coupling.

Hence, the mutual inductance can be changed by varying the self-inductance of the individual coils or by changing the coefficient of coupling. The factor K depends on the distance and orientation of the coils.

To measure the displacement, one coil is fixed and the other coil is connected to a movable object. As the object moves, the factor K changes, which results in a change in mutual inductance in the coils. This change can be calibrated in terms of displacement for an instrument.

Eddy Current Production

The production of eddy current in the inductive transducer can be varied by changing the conductive plate placed near the coil. When the conductive plate is placed near the coil that carries alternating current, eddy currents are induced in the plate which has its own magnetic field acts against the coil. The conductive plate that carries circulating current is called eddy current.

When the conductive plate is brought near to the coil, then the eddy current is produced with its own magnetic flux, which reduces the magnetic flux of the coil and inductance. As the distance between the coil and the conductive plate is decreased, higher eddy currents are produced and more reduction in the inductance of the coil and vice versa. Hence the change in inductance can be measured by moving the conductive plate. This Change can be calibrated to measure the physical quantity called displacement in an instrument.

Advantages of Inductive Transducer

The advantages of the inductive transducer include the following.

- The inductive transducers can work in any environmental conditions like humidity and high temperatures. These can give high performance in the industrial environment also.
- These have high accuracy and stable operating range with good life-span
- These can be operated in high switching rates in industrial applications.
- These type transducers can be operated in wide ranges used in various applications

The disadvantages of the inductive transducer include the following.

- The working and operating range of inductive transducer depends on the construction and temperature conditions
- It depends on the magnetic field of the coil.

Applications of the Inductive Transducer

Inductive transducers are used in,

- Proximity sensors to measure position, dynamic motion, touchpads, etc.
- Detection of metals and missing parts
- Counting the no.of objects.
- Accelerometers
- Linear and Rotary Motor
- Galvanometers
- LVDT and RVDT
- Pressure and airflow sensors
- Electroactive polymers
- Potential meters
- Micro-electro-mechanical systems
- Powered generators etc.
- Sequential counters
- PB monitors, heart monitors, etc

Capacitive Transducer

Definition: The capacitive transducer is used for measuring the displacement, pressure and other physical quantities. It is a passive transducer that means it requires external power for operation. The capacitive transducer works on the principle of variable capacitance. The capacitance of the capacitive transducer changes because of many reasons like overlapping of plates, change in distance between the plates and dielectric constant.

The capacitive transducer contains two parallel metal plates. These plates are separated by the dielectric medium which is either air, material, gas or liquid. In the normal capacitor the distance between the plates are fixed, but in capacitive transducer the distance between them are varied.

The capacitive transducer uses the electrical quantity of capacitance for converting the mechanical movement into an electrical signal. The input quantity causes the change of the capacitance which is directly measured by the capacitive transducer.

The capacitors measure both the static and dynamic changes. The displacement is also measured directly by connecting the measurable devices to the movable plate of the capacitor. It works on with both the contacting and non-contacting modes.

Principle of Operation

The equations below express the capacitance between the plates of a capacitor

$$C = \varepsilon A/d$$

$$C = \varepsilon_r \varepsilon_0 A/d$$

Where A – overlapping area of plates in m^2

d – the distance between two plates in meter

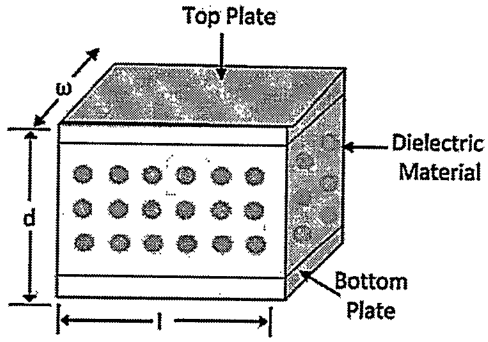
ε – permittivity of the medium in F/m

ε_r – relative permittivity

ε_0 – the permittivity of free space

The schematic diagram of a parallel plate capacitive transducer is shown in the figure below.

The change in capacitance occurs because of the physicals variables like displacement, force, pressure, etc. The capacitance of the transducer also changes by the variation in their dielectric constant which is usually because of the measurement of liquid or gas level



Parallel Plate Capacitive Transducer

The capacitance of the transducer is measured with the bridge circuit. The output impedance of transducer is given as $X_c = 1/2\pi f c$

Where, C – capacitance
f – frequency of excitation in Hz.

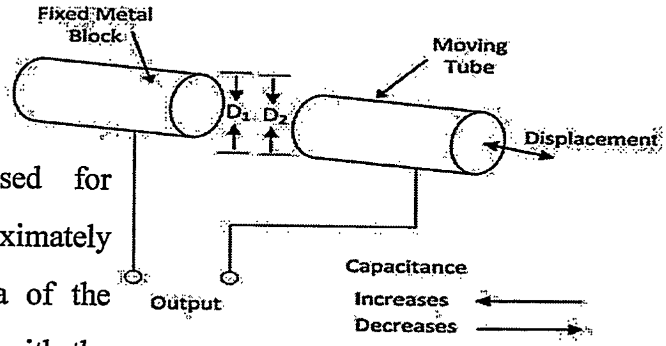
The capacitive transducer is mainly used for measurement of linear displacement. The capacitive transducer uses the following three effects.

1. Variation in capacitance of transducer is because of the overlapping of capacitor plates.
2. The change in capacitance is because of the change in distances between the plates.
3. The capacitance changes because of dielectric constant.

The following methods are used for the measuring displacement.

1. A transducer using the change in the Area of Plates – The equation below shows that the capacitance is directly proportional to the area of the plates. The capacitance changes correspondingly with the change in the position of the plates.

The capacitive transducers are used for measuring the large displacement approximately from 1mm to several cms. The area of the capacitive transducer changes linearly with the capacitance and the displacement. Initially, the nonlinearity occurs in the system because of the edges. Otherwise, it gives the linear response.



Capacitive Transducer

The capacitance of the parallel plates is given as

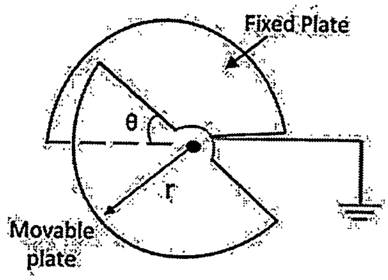
$$C = \frac{\varepsilon A}{d} = \frac{\varepsilon x \omega}{d} F$$

where x – the length of overlapping part of plates
ω – the width of overlapping part of plates.

The sensitivity of the displacement is constant, and therefore it gives the linear relation between the capacitance and displacement.

$$S = \frac{\partial C}{\partial x} = \varepsilon \frac{\omega}{d} F/m$$

The capacitive transducer is used for measuring the angular displacement. It is measured by the movable plates shown below. One of the plates of the transducer is fixed, and the other is movable.



The angular movement changes the capacitance of the transducers. The capacitance between them is maximum when these plates overlap each other. The maximum value of capacitance is expressed as

$$C_{max} = \frac{\varepsilon A}{d} = \frac{\pi \varepsilon r^2}{2d}$$

The capacitance at angle θ is given expressed as,

$$C = \frac{\varepsilon \theta r^2}{2d}$$

θ – angular displacement in radian.

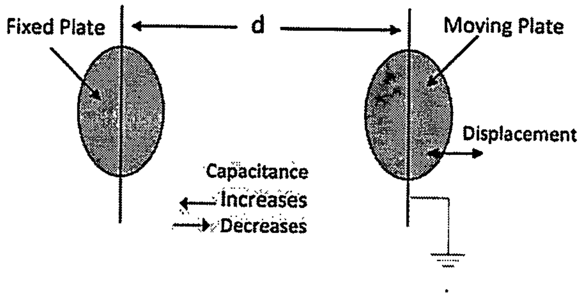
The sensitivity for the change in capacitance is given as

$$S = \frac{\partial C}{\partial \theta} = \frac{\varepsilon r^2}{2d}$$

The 180° is the maximum value of the angular displacement of the capacitor.

2. The transducer using the change in distance between the plates – The capacitance of the transducer is inversely proportional to the distance between the plates. The one plate of the transducer is fixed, and the other is movable. The displacement which is to be measured links to the movable plates.

The capacitance is inversely proportional to the distance because of which the capacitor shows the nonlinear response. Such type of transducer is used for measuring the small displacement.



Advantages of Capacitive Transducers.

1.It requires an external force for operation and hence very useful for small systems.

2.The capacitive transducer is very sensitive.

3.It gives good frequency response because of which it is used for the dynamic study.

4.The transducer has high input impedance hence they have a small loading effect.

5.It requires small output power for operation.

Disadvantages of Capacitive Transducers.

1.The metallic parts of the transducers require insulation.

2.The frame of the capacitor requires earthing for reducing the effect of the stray magnetic field.

3.Sometimes the transducer shows the nonlinear behaviors because of the edge effect which is controlled by using the guard ring.

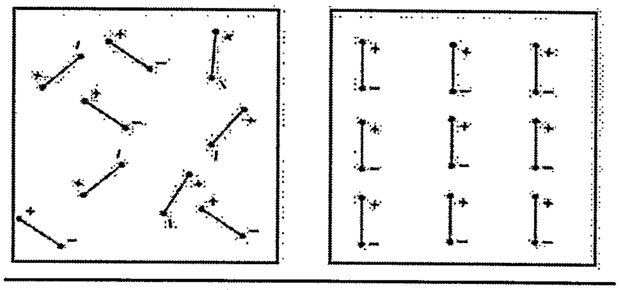
4.The cable connecting across the transducer causes an error.

Applications of capacitive transducers:-

1. Feed hopper level monitoring
2. Small vessel pump control
3. Grease level monitoring
4. Level control of liquids
5. Metrology applications 1. to measure shape errors in the part being produced 2. to analyze and optimize the rotation of spindles in various machine tools such as surface grinders, lathes, milling machines, and air bearing spindles by measuring errors in the machine tools themselves
6. Assembly line testing 1. To test assembled parts for uniformity, thickness or other design features 2. To detect the presence or absence of a certain component, such as glue etc

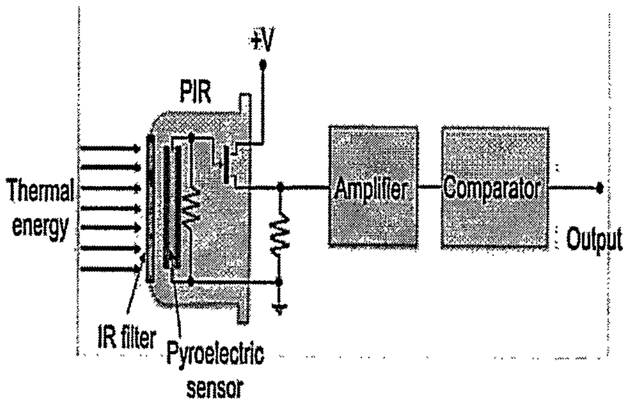
Pyroelectric sensors

These sensors work on the principle of pyro electricity, which states that a crystal material such as Lithium tantalite generates charge in response to heat flow. In presence of an electric field, when such a crystal material heats up, its electrical dipoles line up as shown in figure. This is called as polarization. On cooling, the material retains its polarization. In absence of electric field, when this polarized material is subjected to infrared irradiation, its polarization reduces. This phenomenon is the measure of detection of movement of an object



Principle of pyroelectricity

Pyroelectric sensor comprises of a thick element of polarized material coated with thin film electrodes on opposite faces as shown in figure . Initially the electrodes are in electrical equilibrium with the polarized material. On incident of infra red, the material heats up and reduces its polarization. This leads to charge imbalance at the interface of crystal and electrodes. To balance this disequilibrium, measurement circuit supplies the charge, which is calibrated against the detection of an object or its movement.



Construction and working a Pyroelectric sensor

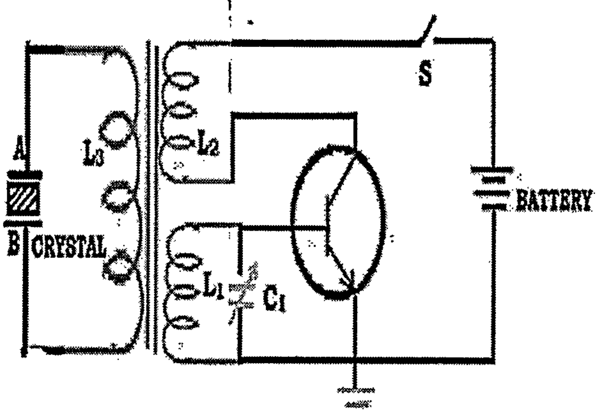
Applications of Pyroelectric sensors

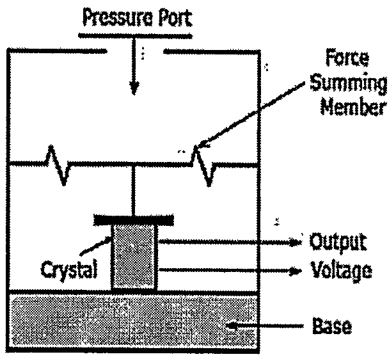
- Intrusion detector
- Optothermal detector
- Pollution detector
- Position sensor
- Solar cell studies
- Engine analysis

Piezo Electric Transducers

- A piezoelectric transducer (also known as a piezoelectric sensor) is a device that uses the piezoelectric effect to measure changes in acceleration, pressure, strain, temperature or force by converting this energy into an electrical charge.
- A transducer can be anything that converts one form of energy to another. The piezoelectric material is one kind of transducers.
- When we squeeze this piezoelectric material or apply any force or pressure, the transducer converts this energy into voltage. This voltage is a function of the force or pressure applied to it

- Piezoelectric transducers depend upon the characteristics of certain materials that are capable of generating electric voltage when they deform.
- Piezoelectric materials, when subjected to mechanical force or stress along specific planes, generate electric charge.
- The property of generating an electric charge when deformed makes piezoelectric materials useful as primary sensors in instrumentation.
- The best-known natural material is quartz crystal (SiO2). Rochelle salt is also considered a natural piezoelectric material. Artificial materials using ceramics and polymers, such as PZT (lead zirconium titanate), PVDF (polyvinylidene fluoride), BaTio3 (barium titanate), and LS (Lithium Sulfate) also exhibit the piezoelectric phenomenon





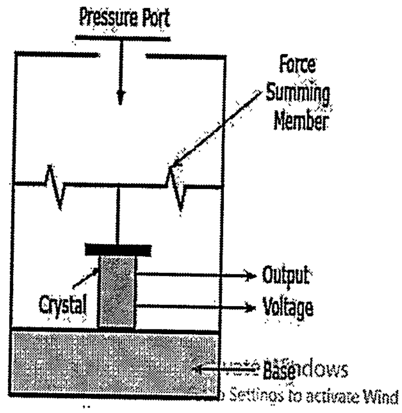
Piezo-Electric Transducer

CONSTRUCTION and WORKING

The figure shows a conventional piezoelectric transducer with a piezoelectric crystal inserted between a solid base and the force summing member.

- If a force is applied on the pressure port, the same force will fall on the force summing member.

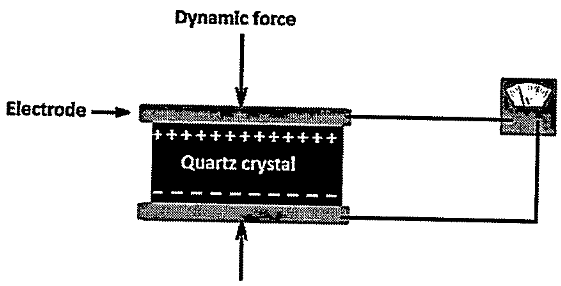
- Thus a potential difference will be generated on the crystal due to its property. The voltage produced will be proportional to the magnitude of the applied force.



Piezoelectric Transducer Working Principle

A quartz crystal exhibits a very important property known as the piezoelectric effect.

When some mechanical pressure is applied across faces of a quartz crystal, a voltage proportional to the applied mechanical pressure appears across the crystal. Conversely, when a voltage is applied across the crystal surfaces, the crystal is distorted by an amount proportional to the applied voltage.

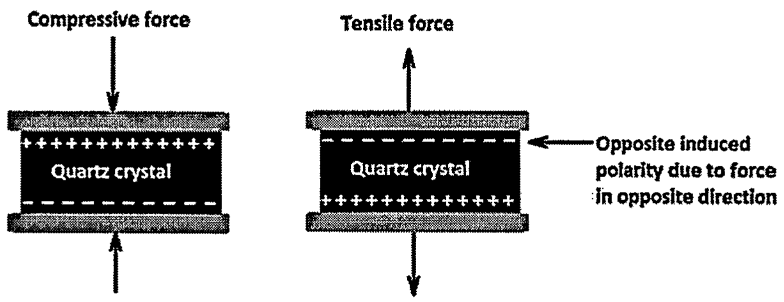


This phenomenon is known as the piezoelectric effect and the material that exhibits this property is known as a piezoelectric material.
All piezoelectric transducers work on the piezoelectric effect. In a piezoelectric transducer, a piezoelectric material is used as a sensing element which transforms input mechanical quantity into a proportional electrical signal. This is the basic piezoelectric transducer working principle.

Besides quartz, the other substances that exhibit the piezoelectric effect are Rochelle salt and tourmaline.
Rochelle salt exhibits the greatest piezoelectric effect, but its applications are limited to manufacture of microphones, headsets, and loudspeakers. It is because Rochelle salt is mechanically weakest and strongly affected by moisture and heat. Tourmaline is most rugged but shows least piezoelectric effect.
Quartz is a compromise between the piezoelectric effect of Rochelle salt and the mechanical strength of tourmaline. It is inexpensive and readily available in nature.

Piezoelectric Transducer Working

In a piezoelectric transducer, a piezoelectric material like quartz crystal is used as a sensing element. When a dynamic force or dynamic pressure is applied to a piezoelectric transducer a charge generates on the surface of the crystal. This charge appears as a potential difference across the electrodes fitted on opposite sides of the crystal.
The charge so generated is very small in magnitude. Therefore it has to amplify with the help of a charge amplifier to get a sufficient output. The output instrument is calibrated in terms of input measuring quantity.
If we apply a static force or static pressure, there will be no output voltage. Therefore, input measuring quantity should always be dynamic.
The magnitude of the output voltage is directly proportional to the applied force.



The polarity of the generated voltage depends upon the direction of the applied force. Therefore, the polarity of generated voltage for tensile force and compressive force will be opposite in polarity on the same piece of piezoelectric material.

Charge induced on a crystal is proportional to the applied force,

i.e. $Q \alpha F$

or $Q = dF$

or $d = Q/F$, is the charge sensitivity. Its unit is C/N.

Advantages of Piezoelectric Transducers

1.High frequency response: They offer very high frequency response that means the parameter changing at very high speeds can be sensed easily.

2.High transient response: The piezoelectric transducers can detect the events of microseconds and also give the linear output.

3.The piezoelectric transducers are small in size and have rugged construction.

Limitations of Piezoelectric Transducers

•Low Output: The output obtained from the piezoelectric transducers is low, so external electronic circuit has to be connected.

•High impedance: The piezoelectric crystals have high impedance so they have to be connected to the amplifier and the auxiliary circuit, which have the potential to cause errors in measurement. To reduce these errors amplifiers high input impedance and long cables should be used.

•Forming into shape: It is very difficult to give the desired shape to the crystals with sufficient strength.

Applications of the Piezoelectric Transducers

1) The piezoelectric transducers are more useful for the dynamic measurements, i.e. the parameters that are changing at the fast rate. This is because the potential developed under the static conditions is not held by the instrument. Thus piezoelectric crystals are primarily used measurement of quantities like surface roughness, and also in accelerometers and vibration pickups.
2) For the same reasons they can be used for studying high speed phenomenon like explosions and blast waves
3) Used along with the strain gauges for measurement of force, stress, vibrations, etc.
4) The automotive companies used piezoelectric transducers to detect detonations in the engine blocks.
5) Used in medical treatment, sonochemistry and industrial processing equipment's for monitoring the power
6) Used in Inkjet printers
7) Used in smartphone screens.
8) Used in lighters.

Hall Effect Transducer

Definition: The hall effect element is a type of transducer used for measuring the magnetic field by converting it into an emf. The direct measurement of the magnetic field is not possible. Thus the Hall Effect Transducer is used. The transducer converts the magnetic field into an electric quantity which is easily measured by the analogue and digital meters.

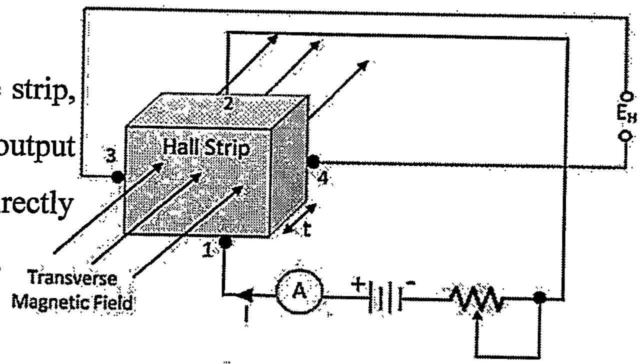
Principle of Hall Effect Transducer

The principle of hall effect transducer is that if the current carrying strip of the conductor is placed in a transverse magnetic field, then the EMF develops on the edge of the conductor. The magnitude of the develop voltage depends on the density of flux, and this property of a conductor is called the Hall effect. The Hall effect element is mainly used for magnetic measurement and for sensing the current.

The metal and the semiconductor has the property of hall effect which depends on the densities and the mobility of the electrons.

Consider the hall effect element shown in the figure below. The current supply through the lead 1 and 2 and the output is obtained from the strip 3 and 4. The lead 3 and 4 are at same potential when no field is applied across the strip.

When the magnetic field is applied to the strip, the output voltage develops across the output leads 3 and 4. The develops voltage is directly proportional to the strength of the material.



Hall Effect Element

The output voltage is

$$E_H = K_H IB/t$$

where, $K_H - Hall\ effect\ coefficient;\ \frac{V-m}{A-Wbm^{-2}}$

$t - thickness\ of\ Strip;m$

The I is the current in ampere and the B is the flux densities in Wb/m2

The current and magnetic field strength both can be measured with the help of the output voltages. The hall effect EMF is very small in conductors because of which it is difficult to measure. But semiconductors like germanium produces large EMF which is easily measured by the moving coil instrument.

ADVANTAGES OF HALL EFFECT TRANSDUCER

•High speed operation over 100 KHz possible. Whereas at high frequencies the inductive or capacitive sensor output begins to distort.

•Non contact operation so there is no wear and friction, hence unlimited number of operating cycles.

•When packed immune to dust, air, water where as capacitive sensor may get triggered by dust.

•It can measure zero speed.

•Highly repeatable operation.

•Capable of measuring large current.

DISADVANTAGES OF HALL EFFECT TRANSDUCER

1.It may be affected by external interfering magnetic field.

2.Large temperature drift.

3.Large offset voltage.

Applications of Hall Effect Transducers

1. It is used as magnetic to an electric transducer to measure the magnetic field.
2. It is used for the measurement of displacement.
3. It is used for the measurement of a.c. or d.c. current.
4. It is used for the measurement of power.
5. Open/close detection of laptop flip screen. Hence conserve power while switching laptop to sleep.
6. Variable speed drives
7. Used in Flowmeters
8. Used in Encoded switches
9. Used in Motor control protection/indicators
10. Used in Rotary encoders

UNIT – IV

DIGITAL LOGIC: Digital logic, number systems, logic gates, Boolean algebra, karnaugh maps, application of logic gates, sequential logic,PLC.

Digital logic is the representation of signals and sequences of a digital circuit through numbers. It is the basis for digital computing and provides a fundamental understanding on how circuits and hardware communicate within a computer. Digital logic is typically embedded into most electronic devices, including calculators, computers, video games, and watches. This field is utilized by many careers that work with computers and technology, such as engineers and repair technicians.

Digital logic is fundamental in creating electronic devices. It is used to create circuits and logic gates, as well as to check computer chips. Knowledge of digital logic lends itself to many different computer technology design and engineering professions.

Digital logic circuits ⇒ electronic circuits that handle information encoded in binary form (deal with signals that have only two values, **0** and **1**)

◆ ***Digital*** .... computers, watches, controllers, telephones, cameras, ...

logic gate is an elementary building block of a digital circuit. Most logic gates have two inputs and one output. At any given moment, every terminal is in one of the two binary conditions low (0) or high (1), represented by different voltage levels.

number systems

Number systems are the technique to represent numbers in the computer system architecture, every value that you are saving or getting into/from computer memory has a defined number system.

1.Binary number system
2.Octal number system
3.Decimal number system
4.Hexadecimal (hex) number system
5.Binary coded decimal systems

BINARY NUMBER SYSTEM

A Binary number system has only two digits that are 0 and 1. Every number (value) represents with 0 and 1 in this number system. The base of binary number system is 2, because it has only two digits

1 1 0 1 (base-2)

$1 \times 2^0 = 1$

$0 \times 2^1 = 0$

$1 \times 2^2 = 4$

$1 \times 2^3 = 8$

$8 + 4 + 0 + 1 = 13$

$1101_2 = 13_{10}$

OCTAL NUMBER SYSTEM

Octal number system has only eight (8) digits from 0 to 7. Every number (value) represents with 0,1,2,3,4,5,6 and 7 in this number system. The base of octal number system is 8, because it has only 8 digits.

5 2 1 7 (base-8)

$7 \times 8^0 = 7 \times 1 = 7$

$1 \times 8^1 = 1 \times 8 = 8$

$2 \times 8^2 = 2 \times 64 = 128$

$5 \times 8^3 = 5 \times 512 = 2560$

$2560 + 128 + 8 + 7 = 2703$

$5217_8 = 2703_{10}$

DECIMAL NUMBER SYSTEM

Decimal number system has only ten (10) digits from 0 to 9. Every number (value) represents with 0,1,2,3,4,5,6, 7,8 and 9 in this number system. The base of decimal number system is 10, because it has only 10 digits.

3 5 0 1 (base-10)

$1 \times 10^0 = 1$

$0 \times 10^1 = 0$

$5 \times 10^2 = 500$

$3 \times 10^3 = 3000$

$3000 + 500 + 0 + 1 = 3501$

HEXADECIMAL NUMBER SYSTEM

A Hexadecimal number system has sixteen (16) alphanumeric values from 0 to 9 and A to F. Every number (value) represents with 0,1,2,3,4,5,6, 7,8,9,A,B,C,D,E and F in this number system. The base of hexadecimal number system is 16, because it has 16 alphanumeric values. Here A is 10, B is 11, C is 12, D is 14, E is 15 and F is 16

1 A C F (base-16) [A = 10, B = 11, C = 12, D = 13, E = 14, F = 15]

F → $15 \times 16^0 = 15 \times 1 = \mathbf{15}$

C → $12 \times 16^1 = 12 \times 16 = \mathbf{192}$

A → $10 \times 16^2 = 10 \times 256 = \mathbf{2560}$

1 → $1 \times 16^3 = 5 \times 4096 = \mathbf{20480}$

$20480 + 2560 + 192 + 15 = 23247$

$1ACF_{16} = 23247_{10}$

Number system	Base(Radix)	Used digits	Example
Binary	2	0,1	$(11110000)_2$
Octal	8	0,1,2,3,4,5,6,7	$(360)_8$
Decimal	10	0,1,2,3,4,5,6,7,8,9	$(240)_{10}$
Hexadecimal	16	0,1,2,3,4,5,6,7,8,9, A,B,C,D,E,F	$(F0)_{16}$

Binary coded decimal systems

The binary-coded decimal (BCD) is an encoding for decimal numbers in which each digit is represented by its own binary sequence

Decimal:	0	1	2	3	4	5	6	7	8	9
BCD:	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001

Thus, the BCD encoding for the number 127 would be:

0001 0010 0111

Decimal Number Quantity (fractional number)

- . 5 8 1 (base-10)

$5 \times 10^{-1} = 5 \times 0.1 = \mathbf{0.5}$

$8 \times 10^{-2} = 8 \times 0.01 = \mathbf{0.08}$

$1 \times 10^{-3} = 1 \times 0.001 = \mathbf{0.001}$

$0.5 + 0.08 + 0.001 = 0.581$

Binary-to-Decimal Conversion

- . 1 0 1 (base-2)

$1 \times 2^{-1} = 1 \times 0.5 = \mathbf{0.5}$

$0 \times 2^{-2} = 0 \times 0.25 = \mathbf{0}$

$1 \times 2^{-3} = 1 \times 0.125 = \mathbf{0.125}$

$0.5 + 0 + 0.125 = 0.625$

$0.101_2 = 0.625_{10}$

Octal-to-Decimal Conversion

- . 2 5 (base-8)

$2 \times 8^{-1} = 2 \times 0.125 = \mathbf{0.25}$

$5 \times 8^{-2} = 5 \times 0.015625 = \mathbf{0.017825}$

$0.25 + 0.017825 = 0.267825$

$0.25_8 = 0.267825_{10}$

Hexadecimal-to-Decimal Conversion

- . F 5 (base-16)

F → $15 \times 16^{-1} = 15 \times 0.0625 =$ **0.9375**

5 → $5 \times 16^{-2} = 5 \times 0.00390625$ = **0.01953125**

$0.9375 + 0.01953125 = 0.95703125$

$0.F5_{16} = 0.95703125_{10}$

Exercise 1

Convert these binary system numbers to decimal system numbers

a) 100101101
b) 11100.1001
c)111111
d)100000.0111

b)
$1 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 0 \times 2^0 + 1 \times 2^{-1} + 0 \times 2^{-2} + 0 \times 2^{-3}$ 1+ 1×2^{-4}

$= 16 + 8 + 4 + 0 + 0 + 0.5 + 0 + 0 + 0.0625$
$= 28.5625$

Decimal-to-Binary Conversion (positional number)

- 2 5 0

$$250_{10} = 1\ 1\ 1\ 1\ 1\ 0\ 1\ 0_2$$

2	250		
2	125	Remainder	0
2	62	Remainder	1
2	31	Remainder	0
2	15	Remainder	1
2	7	Remainder	1
2	3	Remainder	1
	1	Remainder	1

Decimal-to-Octal Conversion

- 2 5 0

8	250		
8	31	Remainder	2
	3	Remainder	7

$$250_{10} = 372_8$$

Decimal-to-Hexadecimal Conversion

- 2 5 0

16 | 250

15 Remainder 10

$250_{10} = 15\ 10_{16}$?

$= FA_{16}$

Decimal-to-Binary Conversion (fractional number)

- 0 . 4375

0.4375 x 2	=	0.8750
0.8750 x 2	=	1.75
0.75 x 2	=	1.5
0.5 x 2	=	1.0

$0.4375_{10} = 0.0111_2$

Decimal-to-Octal Conversion

- 0.4375

0.4375 x 8	= 3.5	↓
0.5 x 8	= 4.0	

$0.4375_{10} = 0.34_8$

Decimal-to-Hexadecimal Conversion

- 0.4375

0.4375 x 16	= 7.0	↓

$0.4375_{10} = 0.7_{16}$

Case	A	+	B	Sum	Carry
1	0	+	0	0	0
2	0	+	1	1	0
3	1	+	0	1	0
4	1	+	1	0	1

In fourth case, a binary addition is creating a sum of (1 + 1 = 10) i.e. 0 is written in the given column and a carry of 1 over to the next column.

Example – Addition

0011010 + 001100 = 00100110

```
  11          carry
  0011010   = 26₁₀
 +0001100   = 12₁₀
 ---------
  0100110   = 38₁₀
```

Binary Subtraction

Basic Rules for Binary Subtraction

$0 - 0$	=	0	0 minus 0 equals 0
$1 - 1$	=	0	1 minus 1 equals 0
$1 - 0$	=	1	1 minus 0 equals 1
$10_2 - 1$	=	1	10_2 minus 1 equals 1

Subtract binary number 101 from 1011

```
(borrow)
0 1
 1 0 1 1
-  1 0 1
 -------
 0 1 1 0
```

Hexadecimal to binary

1. Split the hex number into individual values.
2. Convert each hex value into its decimal equivalent.
3. Next, convert each decimal digit into binary, making sure to write four digits for each value.
4. Combine all four digits to make one binary number.

Example - hex 28 to binary

2 = decimal 2 8 = decimal 8

2 = binary 0010 8 = binary 1000

Result - 00101000

Example - hex FC to binary

F = decimal 15 C = decimal 12

15 = binary 1111 12 = binary 1100

Result - 11111100

logic gate is an elementary building block of a digital circuit. Most logic gates have two inputs and one output. At any given moment, every terminal is in one of the two binary conditions low (0) or high (1), represented by different voltage levels.

Logic Gates

AND gate

OR gate

NOT gate

NAND gate

NOR gate

Ex-OR gate

Ex-NOR gate

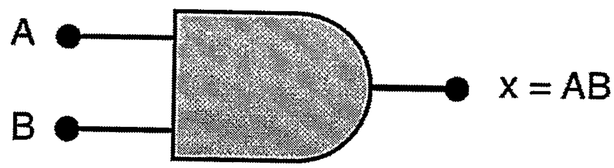
"AND" Logic Gate

- Two logic inputs, A and B, are combined using the AND operation (denoted by '.' symbol) to produce the output x (x, A, B are bits)
- The table shows that x is a logic 1 only when both A and B are at logic 1

AND

A	B	x = A • B
0	0	0
0	1	0
1	0	0
1	1	1

Truth Table



AND gate

Circuit Symbol

"AND" LOGIC GATE

- Example: **The bus goes to A and B.** The success (truth) of the bus going to both places can be represented by x; thus 'x' occurs **only when** the bus goes to **both A and B**
- The Boolean expression for the AND operation is **F = A . B**
- The **period (.) sign** is **not** the **multiplicative** function, but means AND in logic

F = A AND B

AND

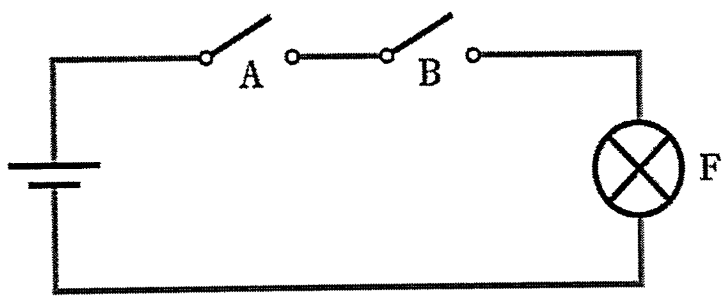
A	B	x = A·B
0	0	0
0	1	0
1	0	0
1	1	1

"AND" LOGIC GATE

In an electric circuit, **AND** operation is equivalent to **two switches in series**

The lamp **F lights** (i.e. F = 1) only when **both switches are closed** (closed switch is represented by logic level 1)

i.e. **F = A . B**



"OR" LOGIC GATE

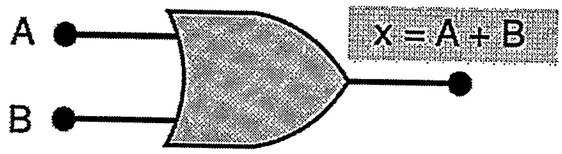
Two logic inputs, A and B, are combined using the OR operation (denoted by '+' symbol) to produce the output x (x, A, B are bits).

A **truth table** is a means for describing how a logic circuit's **output depends** on the logic levels present at the circuit's **inputs**

OR

A	B	x = A + B
0	0	0
0	1	1
1	0	1
1	1	1

Truth Table



OR Gate

Circuit Symbol

"OR" LOGIC GATE

Example: **The bus will go to A or B.** The success (truth) of the bus going to one or other can be represented by x; thus 'x' occurs when the bus goes to **either A or B or both** (it might travel through A to get to B or vice versa)

The Boolean expression for the OR operation is **x = A + B**

The **positive (+) sign** is **not** the **additive** function, but means OR in logic

x = A OR B

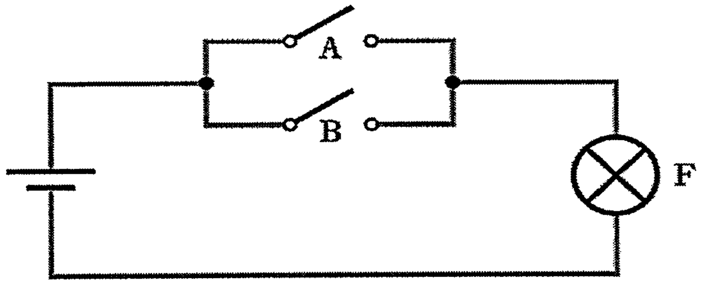
OR

A	B	x = A + B
0	0	0
0	1	1
1	0	1
1	1	1

"OR" LOGIC GATE

- In an electrical circuit, **OR** operation is equivalent to **two switches in parallel**
- The lamp F lights (F = 1) when either switch or both switches are closed (closed switch is represented by logic level 1)

i.e. F = A + B



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"NOT" LOGIC GATE

The **NOT** operation is unlike the OR and AND operations because it is performed on a **single input** variable

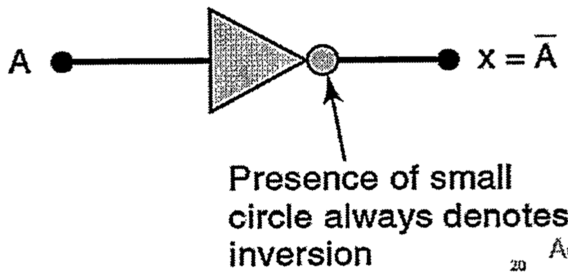
If the variable A is subjected to the NOT operation (also called inversion or complementation), the result x is expressed as $x = \bar{A}$ or x = A'

Truth Table

NOT

A	$x = \bar{A}$
0	1
1	0

NOT Circuit Symbol



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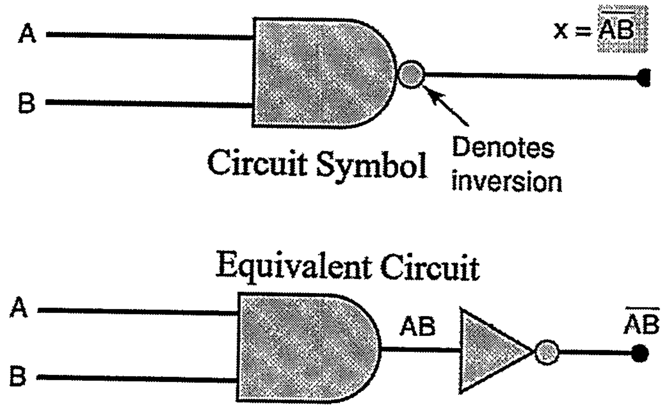
“NAND” Logic Gate

- NAND-gate operates like an AND-gate followed by an Inverter (NOT gate)
- The NAND-gate output ($x = \overline{A.B}$) is the exact inverse of the AND-gate



Truth Table

		AND	NAND
A	B	AB	$\overline{AB}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

Operator Precedence

- If an **expression contains both AND and OR operations,** the **AND** operations are **performed first,** unless there are parentheses in the expression, in which case the **operation inside the parentheses is to be performed first**

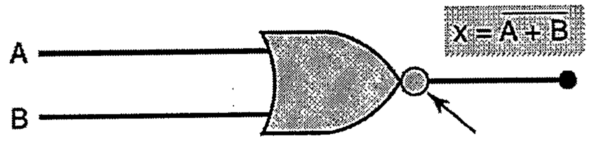
- Example: $F = A \, . \, B + C$

  First AND operation is performed between A and B

  The result of above operation is then ORed with C

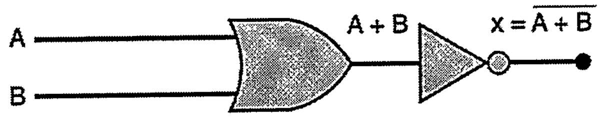
"NOR" LOGIC GATE

- NOR gate operates like an OR-gate followed by an Inverter (NOT gate)
- The NOR-gate output ($x = \overline{A + B}$) is the exact inverse of the OR-gate



Circuit Symbol

Equivalent Circuit

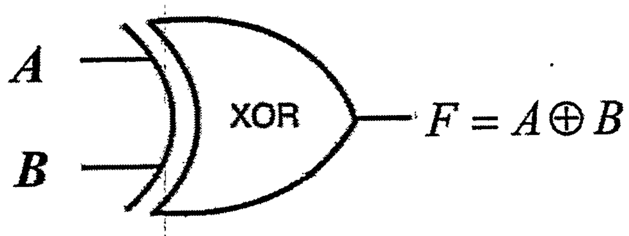


Truth Table

A	B	OR: $A + B$	NOR: $\overline{A + B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

"EX-OR/XOR" LOGIC GATE

- Two logic inputs, **A** and **B**, are combined using the Exclusive-OR (EX-OR or simply XOR) operation (denoted by symbol ⊕) to produce the output **F**
- The truth table shows that **F** is a logic 1 only when **A** and **B** are different



Circuit Symbol

Truth Table

A	B	F
0	0	0
0	1	1
1	0	1
1	1	0

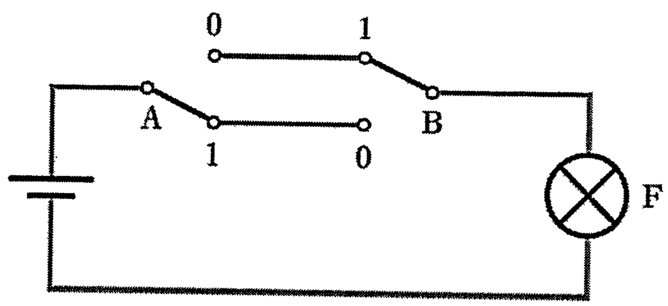
"EX-OR/XOR" LOGIC GATE

- Example: **The bus goes to either A or B but not to both.** The success (truth) of the bus going to one or other can be represented by F; thus 'F' occurs when the bus goes **only to A (and not B) or only to B (and not A)**
- The Boolean expression for the EX-OR operation is
  $F = A \oplus B = (A . \overline{B}) + (\overline{A} . B)$
  (in terms of the fundamental gates OR, AND, NOT)

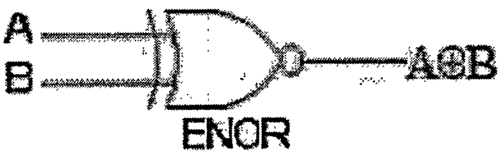
A	B	F
0	0	0
0	1	1
1	0	1
1	1	0

"EX-OR/XOR" LOGIC GATE

- The **XOR** operator is typically represented in an electric circuit by the **two-way switching** associated with a stair light
- The lamp **F lights** (i.e. F = 1) **only** when **one of the switches is ON** (1) AND **the other is OFF** (0) i.e. **$F = A \oplus B = (A . \overline{B}) + (\overline{A} . B)$**



EX-NOR gate



2 Input EXNOR gate		
A	B	$\overline{A \oplus B}$
0	0	1
0	1	0
1	0	0
1	1	1

The 'Exclusive-NOR' gate circuit does the opposite to the EOR gate. It will give a low output if either, but not both, of its two inputs are high. The symbol is an EXOR gate with a small circle on the output. The small circle represents inversion. The NAND and NOR gates are called universal functions since with either one the AND and OR functions and NOT can be generated.

Basic rules of Boolean algebra.

1. $A + 0 = A$
2. $A + 1 = 1$
3. $A \cdot 0 = 0$
4. $A \cdot 1 = A$
5. $A + A = A$
6. $A + \overline{A} = 1$
7. $A \cdot A = A$
8. $A \cdot \overline{A} = 0$
9. $\overline{\overline{A}} = A$
10. $A + AB = A$
11. $A + \overline{A}B = A + B$
12. $(A + B)(A + C) = A + BC$

A, B, or *C* can represent a single variable or a combination of variables.

Commutative Laws

- The commutative law allows change in position of AND or OR variables. There are two commutative laws.
  (*i*) $A + B = B + A$
  Thus, the order in which the variables are ORed is immaterial.
  (*ii*) $A \cdot B = B \cdot A$
  Thus, the order in which the variables are ANDed is immaterial.
- This law can be extended to any number of variables.

Associative Laws

- The associative law allows grouping of variables. There are two associative laws
  (*i*) $(A + B) + C = A + (B + C)$
  Thus, the way the variables are grouped and ORed is immaterial.
  (*ii*) $(A \cdot B) \cdot C = A \cdot (B \cdot C)$
  Thus, the way the variables are grouped and ANDed is immaterial.
- This law can be extended to any number of variables.

Distributive Laws

- The distributive law allows factoring or multiplying out of expressions. There are two distributive laws.
  (*i*) $A(B + C) = AB + AC$ (*ii*) $A + BC = (A + B)(A + C)$
- This law is applicable for single variable as well as a combination of variables.

Idempotence Laws

Idempotence means the same value. There are two Idempotence laws

(*i*) $A \cdot A = A$

i.e. ANDing of a variable with itself is equal to that variable only.

(*ii*) $A + A = A$

i.e. ORing of a variable with itself is equal to that variable only.

Absorption Laws

There are two absorption laws

(*i*) $A + AB = A(1 + B) = A$ (*ii*) $A(A + B) = A$

Involutionary Law

This law states that, for any variable 'A'

$$\overline{\overline{A}} = (A')' = A$$

Guide To The K-Map (Karnaugh Map)

In many digital circuits and practical problems we need to find expression with minimum variables. We can minimize Boolean expressions of 2, 3, or 4 variables very easily using the K-map without using any Boolean algebra theorems. The K-map can take two forms Sum of Product (SOP) and Product of Sum (POS) according to the needs of the problem. The K-map is table-like representation but it gives more information than TRUTH TABLE. We fill the grid of K-map with 0's and 1's then solve it by making groups.

Steps to solve expression using the K-map
1. Select K-map according to the number of variables.
2. Identify minterms or maxterms as given in the problem.
3. For SOP put 1's in blocks of K-map respective to the minterms (0's elsewhere).
4. For POS put 0's in blocks of K-map respective to the maxterms(1's elsewhere).
5. Make rectangular groups containing total terms in power of two like 2,4,8 ..(except 1) and try to cover as many elements as you can in one group.
6. From the groups made in step 5 find the product terms and sum them up for SOP form.

The K-map Fill Order

2 - Variable Map

A\B	0	1
0	0	1
1	2	3

3- Variable Map

A\BC	00	01	11	10
0	0	1	3	2
1	4	5	7	6

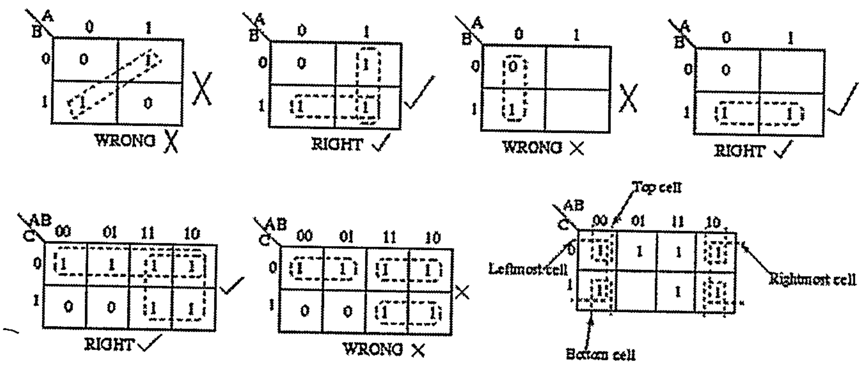
4 - Variable Map

AB\CD	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

Grouping Rules

The Karnaugh map uses the following rules for the simplification of expressions by grouping together adjacent cells containing ones

1. No zeros allowed.
2. No diagonals.
3. Only power of 2 number of cells in each group.
4. Groups should be as large as possible.
5. Everyone must be in at least one group.
6. Overlapping allowed.
7. Wrap around is allowed.
8. Get the fewest number of groups possible.



We perform the **Sum of minterm** also known as **Sum of products** (SOP).

- The **minterm** for each combination of the variables that produce a **1** in the function and then taking the **OR** of all those terms.

We perform the **Product of Maxterm** also known as **Product of sum** (POS).

- The **maxterm** for each combination of the variables that produce a **0** in the function and then taking the **AND** of all those terms.

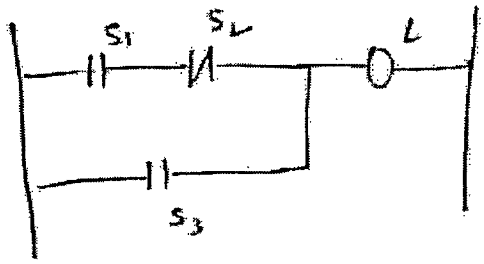
The grouping of 0's result in Product of Sum expression

the grouping of 1's result in Sum of Product expression.

* S_1 ON → L_1 ON

S_2 ON → L_1 OFF

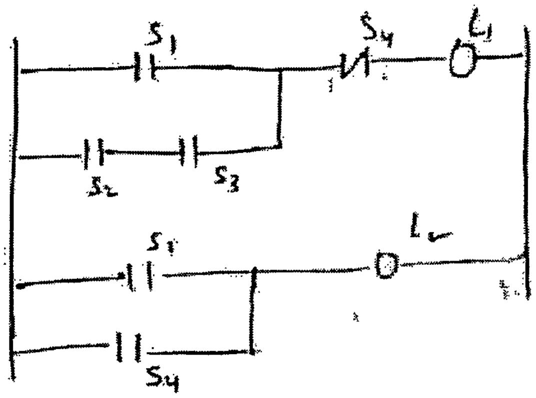
S_3 ON → L_1 ON



* S_1 ON → L_1 ON, L_2 ON

$[S_2$ & $S_3]_{ON}$ → L_1 ON

S_4 ON → L_2 ON, L_1 OF



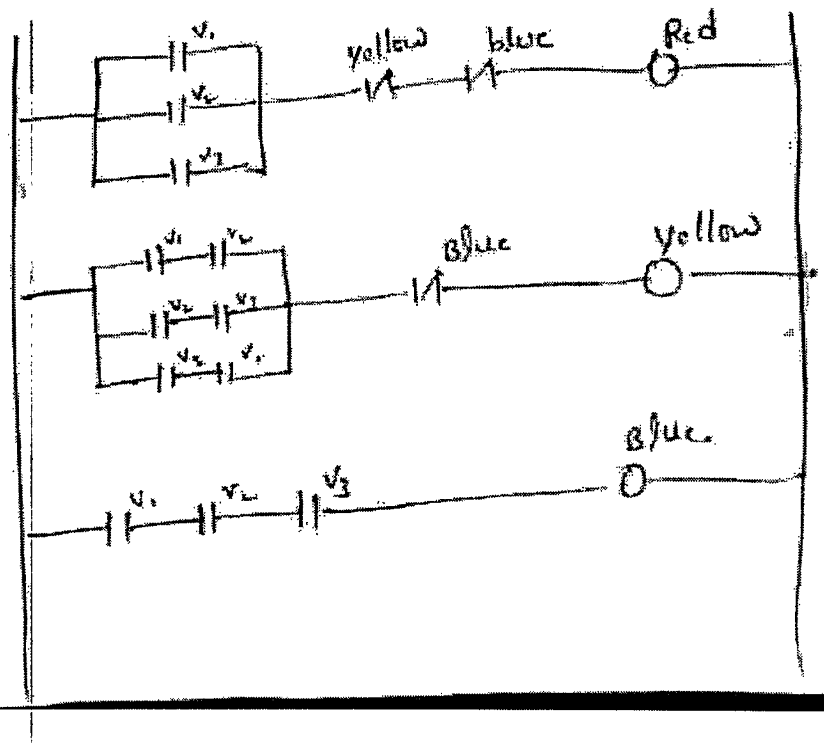
* practical problem :-

Consider 3 switches V_1, V_2, V_3 & 3 bulbs (Red, Yellow, Blue)

condition : 1 — If any one switch ON Red has to glow

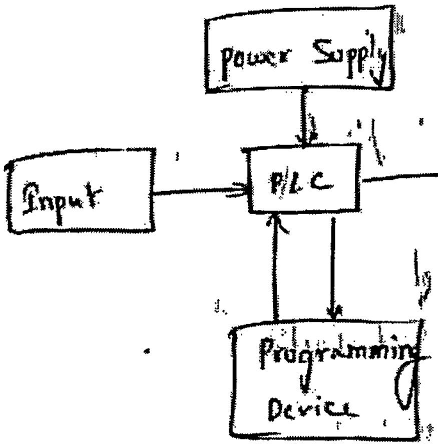
condition : 2 → If any two switches ON yellow has to glow

Condition : 3 — If three switches ON Blue has to glow.



PLC

* **PLC :-** PLC is a Solid State device which controlls the output device based on the inputs and user defined programs.



∵ Inputs — switches
Sensors
push buttons
Selector switches
limit switches
float switch
Toggle switch

∵ Output — EEP RO

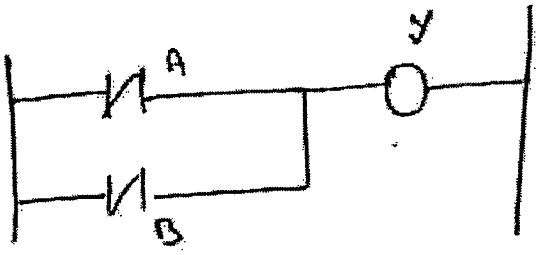
⇒ EEPROM = Electr Enabl progra read only mem

→ Sensors
- → Analog → proximity
  - → Resisti
  - → Induct
  - → Capaci
- → Digital

→ Memory
- → Applications → program, data
- → System operated → RAM, ROM,

* NOR Gate :-

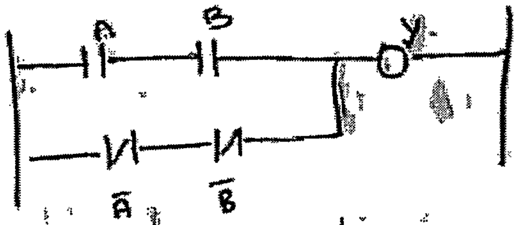
A	B	y
0	0	1
0	1	0
1	0	0
1	1	0



* X-NOR :-

A	B	y
0	0	1
0	1	0
1	0	0
1	1	1

$\because A \odot B = A \cdot B + \bar{A} \cdot \bar{B}$



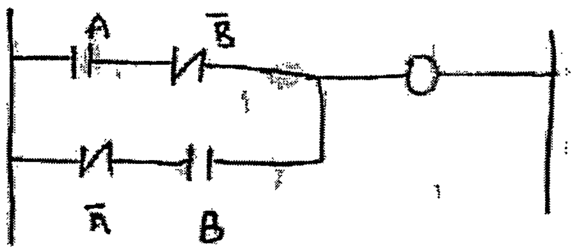
* X-OR :-

A	B	y
0	0	0
0	1	1
1	0	1
1	1	0

$\because A \oplus B = A\bar{B} + \bar{A} \cdot B$

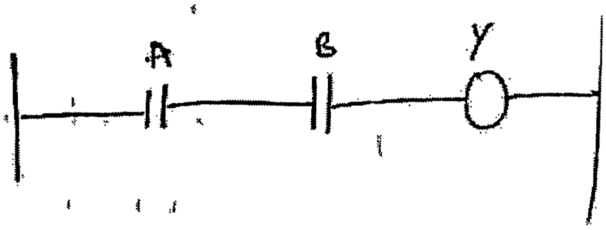
→ A = —| |—

$\bar{A}$ = —|/|—



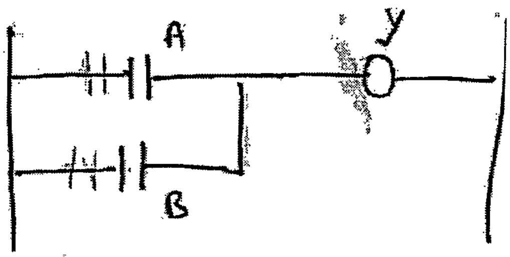
* AND GATE Ladder diagram :-

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1



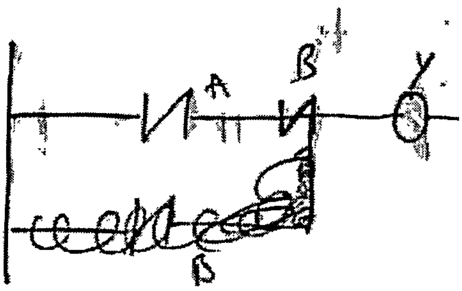
* OR Gate :-

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1



* NAND Gate :-

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

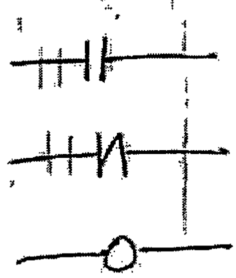


→ Input can be used "N" no:of times in a program while output can be used as only once in a program,

→ Output can be used as input where as input can't be used as output.

→ Lapping and overlapping is not allowed in ladder diagram.

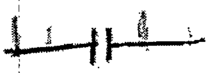
Basic Elements of Ladder diagrams



No } Inputs
Nc
Load → output

∴ No = Normally open
Nc = Normally closed.

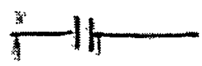
No

off state :  (It doesn't conduct)

ON state :  (It conducts)

Nc

OFF State : 

ON State : 

* Programming Languages :-

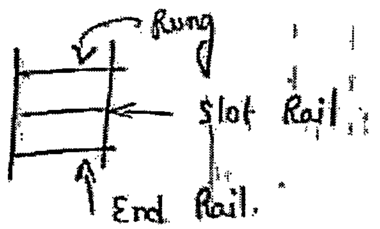
i) Ladder diagram (It consists of Rules & Rungs).

ii) Instruction unit

iii) Structure text (C, C++, Java).

iv) Sequential flow chart

v) functional block diagram



* Rules :-

→ Input must be connected at left most corner of the ladder diagram while output must be connected at the right most corner of ladder diagram.

→ Input can be connected both in series and parallel connection where as output can be connected only in parallel connection.

MICROCONTROLLER BASICS

A **Microcontroller** is a small and low-cost microcomputer, which is designed to perform the specific tasks of embedded systems like displaying microwave's information, receiving remote signals etc.

The general microcontroller consists of the processor, the memory (RAM, ROM, EPROM), Serial ports, peripherals (timers, counters) etc.

Types of Microcontrollers

Microcontrollers are divided into various categories based on memory, architecture, bits and instruction sets. Following is the list of their types

- **Bit** – Based on bit configuration, the microcontroller is further divided into three categories.
    - **8-bit microcontroller** – This type of microcontroller is used to execute arithmetic and logical operations like addition, subtraction, multiplication division, etc. For example, Intel 8031 and 8051 are 8-bit microcontroller.
    - **16-bit microcontroller** – This type of microcontroller is used to perform arithmetic and logical operations where higher accuracy and performance is required. For example, Intel 8096 is a 16-bit microcontroller.
    - **32-bit microcontroller** – This type of microcontroller is generally used in automatically controlled appliances like automatic operational machines, medical appliances, etc.
- **Memory** – Based on the memory configuration, the microcontroller is further divided into two categories.
    - **External memory microcontroller** – This type of microcontroller is designed in such a way that they do not have a program memory on the chip. Hence, it is named as external memory microcontroller. For example: Intel 8031 microcontroller.
    - **Embedded memory microcontroller** – This type of microcontroller is designed in such a way that the microcontroller has all programs and data memory, counters and timers, interrupts, I/O ports are embedded on the chip. For example: Intel 8051 microcontroller.
- **Instruction Set** – Based on the instruction set configuration, the microcontroller is further divided into two categories.
    - **CISC** – CISC stands for complex instruction set computer. It allows the user to insert a single instruction as an alternative to many simple instructions.
    - **RISC** – RISC stands for Reduced Instruction Set Computers. It reduces the operational time by shortening the clock cycle per instruction.

Applications of Microcontrollers

Microcontrollers are widely used in various different devices such as -

- Light sensing and controlling devices like LED.
- Temperature sensing and controlling devices like microwave oven, chimneys.
- Fire detection and safety devices like Fire alarm.
- Measuring devices like Volt Meter.

So as a summary, we can say that It is possible to integrate on a single chip all of the blocks that are needed in a microcomputer, except the I/O devices. Such a chip is termed a microcontroller. An example is Intel 8751. A few of the blocks on the 8751 are

- – 4K × 8 bits of EPROM;
- – 128 × 8 bits of RAM;
- – 4 numbers of 8 bit I/O ports.

It also has timers and facility for serial communication. Microcontrollers are used in a variety of instruments like washing machines, printer sharer, computer keyboards, etc. They are basically used in equipment where the size and cost are required to be very small compared to a microcomputer, and where lots of complex calculations are not needed.

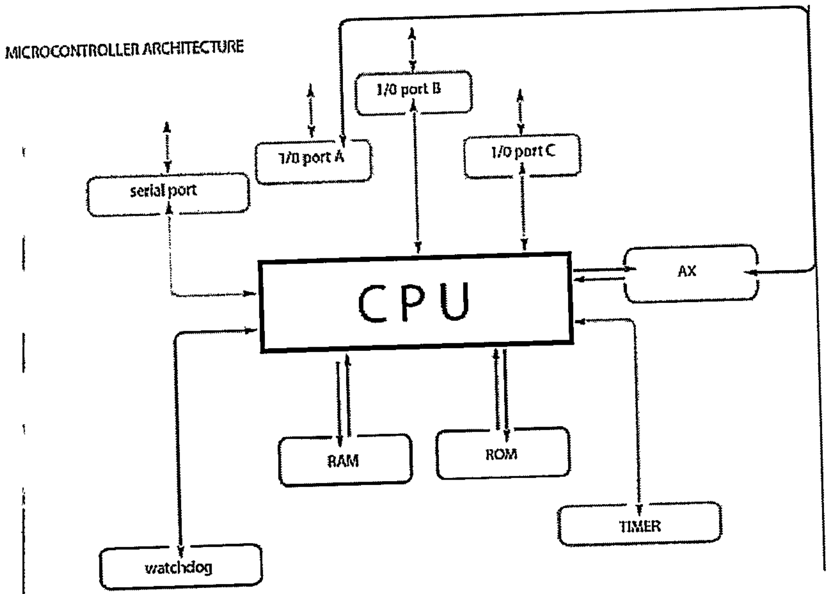
INTRODUCTION TO MICROCONTROLLER

A microcontroller is an electronic device belonging to the microcomputer family. These are fabricated using the VLSI technology on a single chip. There are microcontrollers available in the present market with different word length starting from 4 bit, 8 bit, 64 bit to 128 bit. This chapter is about microcontrollers, their architecture, and various features.

Microcontroller

In a broader sense, the components which constitute a microcontroller are the memory, peripherals and most crucially a processor. Microcontrollers are present in devices where the user has to exert a degree of control. They are designed and implemented to execute a specific function such as displaying integers or characters on an LCD display module of a home appliance. Application of microcontrollers is myriad. In simpler terms, any gadget or equipment which has to deal with the functions such as measuring, controlling, displaying and calculating the values consist of a microcontroller chip inside it. They are present in almost all the present day home appliances, toys, traffic lights, office instruments and various day-to-day appliances.

Microcontroller Architecture



The most important part of a microcontroller is a central processing unit with a word length ranging from 4-bit to 64-bit and in some modern microcontrollers the word length goes even beyond the limit of 64-bit. A timer is one other constituent of a microcontroller. There is a watchdog timer. Memory spaces such as RAM, ROM, EEPROM, EPROM are there to store data and programs. For data storage, volatile memory RAM is used while for the program and operating parameter storage ROM and other memory spaces are used.

CPU: Being regarded as the brain of the microcontroller, central processing unit fetches, decodes and executes the instructions. It coordinates various activities taking place in the microcontroller.

I/O ports: There are several parallel input/output ports in a microcontroller. They are used to interface various peripherals such as printers, external memories, LEDs and LCDs to the microcontroller. Apart from parallel ports, there are serial ports to interface serially connected peripherals with the microcontroller.

Memory: As in the case of a microprocessor, a microcontroller has spaces for memories such as RAM, ROM including EEROM and EPROM. It also allocates a certain amount of flash memory to store program source code.

Timers and counters: These are the fascinating constituent parts of a microcontroller. Timers and counters are used in operations which include modulation, clock functions, frequency generation and measuring and pulse generation.

Analog to digital converters (ADCs): Such converters are useful while converting the output of a sensor which would be in analog form.

Digital to analog converter (DAC): The working of a DAC is just the reverse of an analog to digital converter. As it is obvious, the output will be an analog signal which can be used to control the analog peripherals such a motor.

Features of a Microcontroller

- The main advantage of a CISC (complex instruction set computer) architecture, with which the modern microcontrollers are built, is the macro-type instructions. A macro instruction can be used in a program replacing a number of instructions.
- Latest microcontrollers are operated at lesser power consumption. Usually, they can support a working voltage of 1.8-5.5 V.
- Advanced memory is another feature of a microcontroller. Use of ROM memories like EEPROM and EPROM (flash memory) make it more reliable and user-friendly. While EEPROM is a relatively slow memory, EPROM is faster. Fact that it allows more erase/write cycles also makes it more usable.

Advantages

The main advantage of a microcontroller is that the low cost with all the integral parts mounted together on a single chip. The design makes it more compact and easy to use. The easiness of using a microcontroller and the relatively easy maintenance process also make it more reliable. Almost all the pins in a microcontroller are programmable and it makes the microcontroller a lot user-friendly. Simplicity while interfacing ROM, RAM, and I/O ports.

Easiness of troubleshooting and a minimal time requirement for various operations are other crucial advantages.

Disadvantages

Since it contains all the components on a single chip, microcontrollers are having relatively complex architecture. Microcontrollers are not suitable to interface high power devices directly and they can only perform the limited number of operations simultaneously.

Comparing Microcontroller with a Microprocessor

Microprocessor

- It has only the CPU inside; ie the processing powers such as Intel's Pentium 1,2,3,4 core 2 duos, i3, i5 etc.
- Don't have RAM, ROM and other peripheral on the chip. The system designer has to add them externally to make them functional.
- Application includes desktop PCs, laptops, notepads etc.
- Applications are where tasks are unspecific like developing software, games, websites, photo editing, creating documents etc.
- Since microprocessors cannot be used stand alone as it needs RAM, ROM and other peripherals the system that uses microprocessors is costlier than a microcontroller.
- The clock speed of the microprocessor is quite high as compared to the microcontroller. This can operate above 1 GHz as they perform complex tasks.

Microcontroller

- In a microcontroller CPU, RAM, ROM, and other peripherals are embedded on a single chip.
- At times it is termed a mini computer or a computer on a single chip.
- Some giants in the manufacturing business of microcontrollers are ATMEL, microchip, TI, Freescale, Philips, Motorola etc.
- Designed to perform specific tasks. ie, the relationship between the input and output is defined.
- Since the applications are very specific, they need small resources like RAM, ROM, I/O ports and hence can be embedded on a single chip.
- The clock speed of a microcontroller varies from a few MHz to 30-50 MHz.

Types of Microcontrollers

According to the architecture, memory and word size, it can process, microcontrollers are divided into several categories.

Categorization Based on Bit Size

There is an 8-bit microcontroller which executes basic functions such as arithmetic and logic operations. Intel 8051 is an 8-bit microcontroller. Example for a 16-bit microcontroller is Intel 8096. They are more accurate and provide better performance compared to the 8-bit microcontrollers. 32-bit microcontrollers are used to execute higher functions where precise automatic control is required. The best example of such a microcontroller application is implantable medical appliances.

Categorization Based on Memory

According to the memory space inside the microcontroller, the microcontrollers are classified as external memory microcontroller and embedded memory microcontroller.

External memory microcontroller: It does not have all the integral parts fabricated on a single chip, especially the memory. Intel 8031 is such a device which does not have the program memory on the chip.
Embedded memory: As the name indicates it has all the functioning bocks including the program and data memory fabricated on a single chip. 8051 is an example.

Based on memory architecture, microcontrollers are divided into two: Harvard memory architecture and Princeton memory architecture.

Categorization Based on Instruction Set

There are two classifications based on the instruction set. They are CISC and RISC. CISC is the abbreviated form for complex instruction set computer and RISC is the abbreviated form for reduced instruction set computer. CISC is based on macro instruction sets which mean a single instruction is used to replace a number of instructions. In reduced instruction architecture, the operation time is reduced by minimizing the clock cycle per instruction.

8051: It is the most universally used microcontroller and was introduced by Intel in the year of 1981. It has 40 kb internal ROM and 128 byte RAM. An additional 64 kb of external memory can be interfaced with the microcontroller. The four parallel 8-bit ports of this microcontroller can be easily programmed and addressed. There is a crystal oscillator interfaced to the microcontroller which generates a frequency of 12 MHz. Apart from these components, there is a serial port which is 8-bit sized and two 16-bit timers incorporated in the 8051 microcontrollers.

Various Manufacturers of Microcontrollers

1. Analog devices- 8051 microcontrollers with the 12-bit analog to digital converter.
2. Atmel- 8051, AT91, AVR, AVR32
3. Freescale semiconductor-family of microcontrollers ranging from 8-bit to 32-bit
4. Infineon technologies- 8-bit microcontrollers based on 8051 and 16-bit ROM and OTP microcontrollers
5. Maxim Integrated Products- 75 MHz single-cycle flash 8051 microcontrollers, some low power 16-bit microcontrollers
6. Microchip – wide array of 8-bit microcontroller families including PIC12, PIC16, PIC18, 16- bit PIC 24 microcontroller and PIC32 which is 32-bit microcontrollers.

HISTORY OF MICROCONTROLLERS

A microcontroller was developed in 1971 by Intel Corporation in the United States.

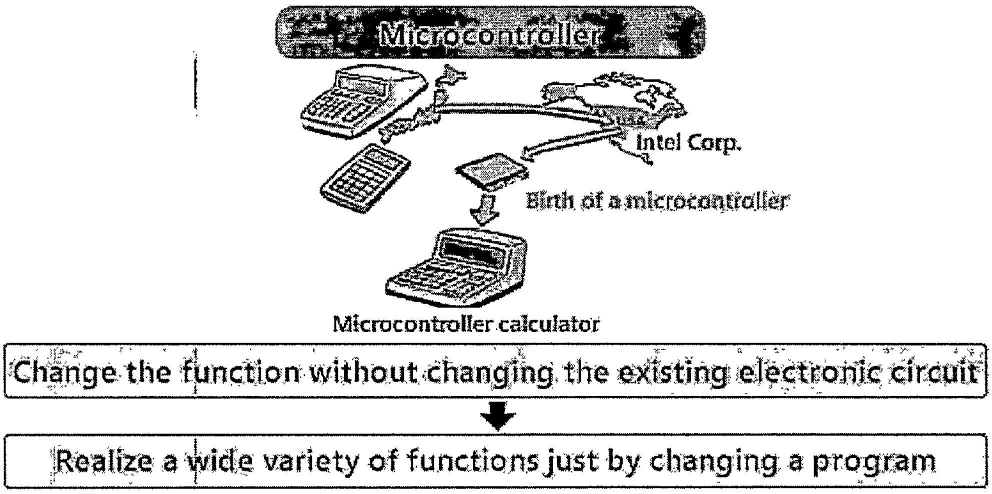
That is the 4 bit microcontroller called i4004.

It was ordered by a Japanese company BUSICOM for calculators.

Later, the contract was changed and it was sold as a general-purpose microcontroller with success.

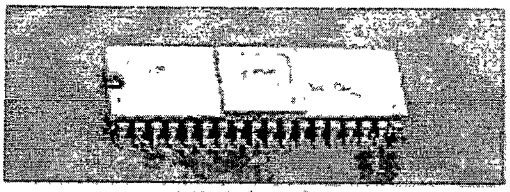
After that, Intel Corp. developed a 16 bit microcontroller '8086,' following the 8 bit microcontrollers such as 'i8008', 'i8080A,' and 'i8085.'

After developing several microcontrollers, they continue to develop the CPUs used in current personal computers.

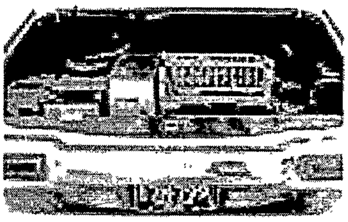


Birth and benefits of a microcontroller

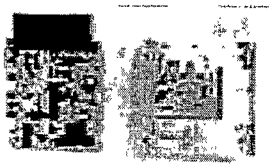
Toshiba developed a 12 bit microcontroller TLCS-12 in 1973.
At that time, the United States was considering electronic control units as a countermeasure of the exhaust gas regulation law.
Against this background, Toshiba's 12 bit microcontroller was developed as Ford's in-vehicle engine controller.
After that, Toshiba developed a wide range of high-level microcontrollers from 4 bit to 32 bit or higher.



TLCS-12



Ford's test car



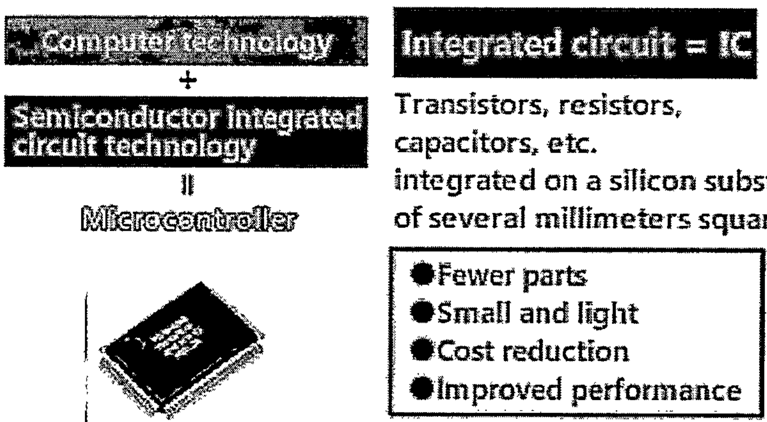
EEC-I Control module

Toshiba's original microcontroller

Integrated Circuits and Microcontrollers

Large scale integrated circuits generally mean semiconductor integrated circuits (IC) with 1000 or more elements.
They are also called LSIs (Large Scale Integrated circuit).

A microcontroller realizes functions of a computer using LSIs.



Features of an integrated circuit

Microcontrollers have gone through a silent evolution (invisible). The evolution can be rightly termed as silent as the impact or application of a microcontroller is not well known to a common user, although microcontroller technology has undergone significant change since early 1970's. Development of some popular microcontrollers is given as follows.

Intel 4004	4 bit (2300 PMOS trans, 108 kHz)	1971
Intel 8048	8 bit	1976
Intel 8031	8 bit (ROM-less) .	
Intel 8051	8 bit (Mask ROM)	1980
Microchip PIC16C64	8 bit	1985
Motorola 68HC11	8 bit (on chip ADC)	
Intel 80C196	16 bit	1982
Atmel AT89C51	8 bit (Flash memory)	
Microchip PIC 16F877	8 bit (Flash memory + ADC)	

Advantages of Microcontrollers

- The flexibility Embedded Operating System are specifying the processor chips that are due to the programmable nature.
- In fact, faster speed of execution is fully integrated into the processor such as a computer on a chip. These devices are operating at a faster speed to executing the instructions to the general purpose of microprocessors.
- Programming the logical controllers (PLCs) are subsets of the microcontrollers that will design the set of instructions for manufacturing the robots and also the industrial equipment planning for specific automated tasks.
- More than one task may perform the PLCs and microcontrollers are repetitive for human attention.
- The microcontrollers are controlling the read-only memory that is rather than the random access memory.

Applications of Microcontrollers

We know that microcontrollers are used for most of the household and industrial applications. The huge areas of applications are as follows.

- Evolution of Microcontrollers measuring the physical quality for example force, acceleration, stress, pressure, velocity an also strain.
- The microcontroller is based upon the laboratory instruments to measuring the voltage, phase angle, energy, frequency and also power.
- Traffic light controlling system
- Robot ARM positioning control
- As a matter of fact, both the stepper motor control and DC motor
- Angular speed measurement
- Household appliances for example light control, TV, washing machine, VCR, and video games.

Other Industrial applications

- Peripheral controller of a PC
- Robotics
- In bio-medical equipment
- In communication system
- In automobiles
- In fire detection devices
- In light and temperature sensing and controlling devices
- Process control and industrial automation devices
- In measuring devices such as volt and current meters

Future of Microcontrollers

The reconfigurable accelerator which it's directly accessing on-chip buses, I/O and also cache. It covers more than one needs, and customers will achieve higher performance.

Programmable I/O

Evolution of Microcontrollers are often into the lots of variations to the accommodate client requirements among the several combinations of a serial-like USART, SPI, UART and so on. Due to, the clients realize to using the eFPGA to manufacturing the program different from each SKU.

Reconfigurable Accelerators

Microcontrollers having the hardwired into the offload process to developing the performance. For example, the crypto engines consist of advanced encryption standard.

Particularly, it enables the microcontroller customized without adding the incremental accelerators using one mask.

NEW CHALLENGES FOR MICROCONTROLLERS

Hidden inside expensive systems and commodity appliances, microcontrollers (MCUs) continue to provide OEMs with quick, inexpensive solutions and semiconductor vendors with important sources of revenue. As defined by the Semiconductor Industry Association (SIA), an MCU is a chip that contains a processor core and nonvolatile memory such as ROM, one-time-programmable memory (OTP), EEPROM or flash memory. The MCU can and does contain other forms of on-chip memory, peripherals and even mixed signal data converters—A/D and D/A. Some MCUs can generate audio, drive LCD displays and connect to multiple bus standards. The MCU's low average selling price (ASP) and widespread use in digital electronics has prompted some semiconductor vendors to tag even processors without nonvolatile memory with the MCU name—thus sending the message of low price and high volume.

The MCU's scenario, however, is changing. There were fewer low-risk, fast time-to-market competing solutions. One could use a bare RISC processor augmented by the peripherals of an adequate microcontroller, and possibly add a small, low-development risk ASIC. Bare processors used to consume high power—an MCU could stay awake and turn on the high-performance (and high-power consumption) processor only when needed.

During the past four to five years, the ascent of IP business has changed the spectrum of options for OEM engineers; standard peripherals have become inexpensive or free of royalty. Multimedia applications require SOC designs that combine to deliver performance otherwise unavailable for a reasonable price from separate chips. A discipline of reuse has reduced risk and improved time-to-market. Peripheral-rich ASICs have become a tougher competitor to MCUs, as have the recently introduced inexpensive FPGAs. ASSPs combining powerful RISC and DSP engines and accelerators with standard and advanced peripherals are succeeding as they target applications in cellular telephony, wireless, smart phones, PDAs, multimedia and digital cameras.

The new workloads and available solutions tend to further reduce MCU ASPs already eroding because of competition among MCU vendors and lowered costs for manufacturing. Although MCUs are going to continue to increase in unit shipments, price erosion is expected to make revenue less exciting than before. Worldwide MCU unit shipments will experience an 11.32 percent CAGR from 2001 to 2006, according to In-Stat/MDR. MCUs showed a modest increase in unit shipments even between 1999 and 2001 and have been hurt by less than 15 percent between 2000 and 2001. However, while unit shipments are expected to increase, recovery for revenues is expected to be slowing as annual price erosion takes its toll.

To gain market share, MCU vendors must compete by tackling advanced technologies, IP cores and data conversion. All of this must be coupled with an ability to continue to offer the MCU's original benefits: an updated vast array of peripherals, nonvolatile memory and commodity volume prices. Hitachi, for example, is planning products that will guarantee 10,000 times rewriting of flash memory with data retention periods of 10 years.

And though new embedded system workloads and the progress made in recent years in high chip integration have reduced one of the MCU's main advantages—that of being able to deliver a plethora of peripherals at a very low price—MCUs continue to be indispensable for many end-use applications.

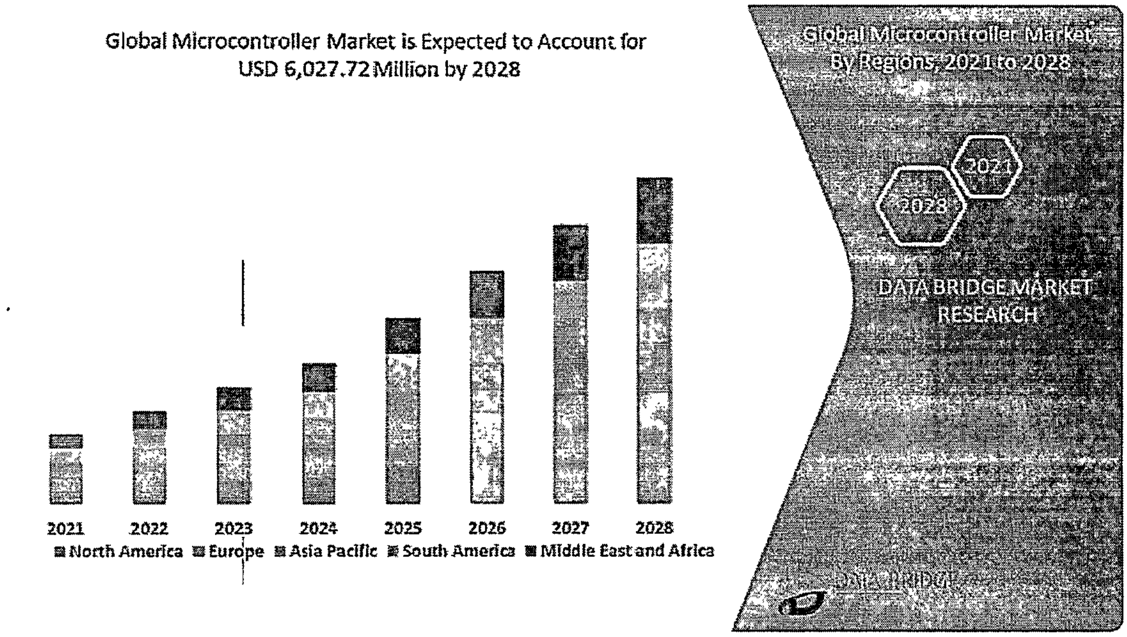
Example:

1. What is the need of communication within charger, battery pack, and motor drive?
2. Write a pseudo code for displaying speed on the digital dashboard as per below conditions; Update displayed speed every second, turn on high efficiency indicator between 50 to 60 kmph, Turn on safe drive indicator above 80 kmph.
3. What are the factors affecting the selection of microprocessor / microcontroller?
4. Differentiate between the embedded C programming and model based system approaches.

OPPORTUNITIES:

A **microcontroller market** is a small, self-sufficient and CPU processing chip that is used to provide security in cryptography solutions. The main role of the microcontrollers is used control some or all the functions of the consumer electronic devices.

Increasing demand for connected devices coupled with increased adoption of internet of things technology would imply growth in the microcontroller market value. Increasing adoption of external flash memory for microcontrollers will also create lucrative growth opportunities for the microcontroller market in the long run. Rising incorporation of microcontrollers in the medical devices and equipment is also fostering the microcontroller market growth. Growing and expansion of automotive and electronics industries will further induce growth in the demand for microcontrollers.



However, increasing macroeconomic conditions will pose a major challenge to the microcontroller market growth. Also, challenges associated with the operational failure in extreme climatic condition will act as market restraint for the microcontroller market. Intense competition among 16-bit, 32-bit and other microcontroller systems will further dampen the microcontroller market growth rate. Lack of standardisation and security and privacy concerns will also hamper the microcontroller market growth rate.

Microcontroller Market, By Product (8- Bit Microcontrollers, 16- Bit Microcontrollers, 32-Bit Microcontrollers and 64- Bit Microcontrollers), Architecture (Architecture, AVR Architecture, PIC Architecture, ARM Architecture and Others), Memory (Embedded Memory Microcontroller and External Memory Microcontroller), Application (Automotive, Consumer Electronics, Industrial, Medical devices, Military and Defence, Communication, Computer and Others), Country (U.S., Canada, Mexico, Brazil, Argentina, Rest of South America, Germany, Italy, U.K., France, Spain, Netherlands, Belgium, Switzerland, Turkey, Russia, Rest of Europe, Japan, China, India, South Korea, Australia, Singapore, Malaysia, Thailand, Indonesia, Philippines, Rest of Asia-Pacific, Saudi Arabia, U.A.E, South Africa, Egypt, Israel, Rest of Middle East and Africa) Industry Trends and Forecast to 2028.

NARASARAOPETA
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DEPARTMENT OF MECHANICAL ENGINEERING

MID & ASSIGNMENT EXAMINATION QUESTION PAPERS WITH SCHEME AND SOLUTIONS

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
IV B.TECH I - SEMESTER ASSIGNMENT TEST – II, September– 2023

SUBJECT: MECHATRONICS **DATE:** 02-09-2023

DURATION: 30 MIN **MAX MARKS:** 5

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	**Explain** the Piezo Electric Transducers.	3	Evaluating (K5)	5
2	**Explain** capacitive and inductive Transducers.	3	Evaluating (K5)	5
3	**Explain** pyroelectric transducer and Hall-effect transducers.	3	Evaluating (K5)	5
4	**Explain** the working principle of Thermistors and also explain different types of Thermistors.	3	Evaluating (K5)	5
5	**Explain** the working principle of thermocouple and also write the advantages and disadvantages.	3	Evaluating (K5))	5
6	**What** are the number systems in digital logics? **Explain** them with examples.	4	Evaluating (K5)	5
7	**Explain** the laws of Boolean algebra used in digital logic.	4	Evaluating (K5)	5
8	What are the logic gates used in digital logic? **Write** truth table, circuit of Boolean operation for each gate.	4	Applying (K3)	5
9	**Convert** the Hexadecimal number 233 into Binary system.	4	Applying (K3)	5
10	**Convert** the Octal number 1234 into Binary system.	4	Applying (K3)	5

Prepared

Verified **Approved**

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DEPARTMENT OF MECHANICAL ENGINEERING

Mechatronics Scheme of Evaluation

IV B. TECH I – SEMESTER ASSIGNMENT TEST–II, September– 2023

1. **Explain** the Piezo Electric Transducers.
   Diagram ------------------------------ 1 M
   Explanation -------------------------- 4 M
2. **Explain** capacitive and inductive Transducers.
   Capacitive Transducer----------------2.5 M
   Inductive Transducers --------------- 2.5 M
3. **Explain** pyroelectric transducer and Hall-effect transducers.
   pyroelectric transducer -------------------2.5 M
   Hall-effect transducers--- ---------------- 2.5 M
4. **Explain** the working principle of Thermistors and also explaindifferent types of Thermistors.
   Working Principle-----------1 M
   Types ------------------------- 4M
5. **Explain** the working principle of thermocouple and also writethe advantages and disadvantages.
   Working Principle ------------------------ 3 M
   advantages and disadvantages ----------2 M
6. What are the number systems in digital logics? Explain them with examples.
   Types of Number Systems -----2 M
   Explanation ------------------------3 M
7. **Explain** the laws of Boolean algebra used in digital logic.
   List----------- -----2 M
   Explanation -----3 M
8. What are the logic gates used in digital logic? **Write** truth table,circuit of Boolean operation for each gate.
   Types of Logic Gates -----2 M
   Explanation ---------------- 3 M
9. **Convert the Hexadecimal number 233 into Binary system.**
   Convert the Hexadecimal number 233 into Binary system-----5 M
10. **Convert** the Octal number 1234 into Binary system.
    Convert the Octal number 1234 into Binary system.--------------- 5 M

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
IV B.TECH I - SEMESTER MID – I, July– 2023

SUBJECT: MECHATRONICS **DATE:** 31-07-2023

DURATION: 90 MIN **MAX MARKS:** 25

Answer All Questions

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	a). Define Mechatronics and **Explain** Evaluation of Mechatronics..	1	Evaluating (K5)	5
	b). **Derive** mathematical modeling of spring, Damper and Mass for Mechanical Rotational systems.	1	Applying (K3)	5
2	a). **Explain** the working of PN Junction Diode and also write Advantages and Disadvantages.	2	Evaluating (K5)	5
	b)**Explain** the working of Bipolar junction transistor(BJT) and mention its merits , Demerits and applications of BJT	2	Applying (K3)	5
3	a).**Explain** the different types of photoelectric transducers.	3	Evaluating (K5)	5

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
IV B.TECH I - SEMESTER MID – I, July– 2023

SUBJECT: MECHATRONICS **DATE:** 31-07-2023

DURATION: 90 MIN **MAX MARKS:** 25

Answer All Questions

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	a). Define Mechatronics and **Explain** Evaluation of Mechatronics..	1	Evaluating (K5)	5
	b). **Derive** mathematical modeling of spring, Damper and Mass for Mechanical Rotational systems.	1	Applying (K3)	5
2	a). **Explain** the working of PN Junction Diode and also write Advantages and Disadvantages.	2	Evaluating (K5)	5
	b)**Explain** the working of Bipolar junction transistor(BJT) and mention its merits , Demerits and applications of BJT	2	Applying (K3)	5
3	a).**Explain** the different types of photoelectric transducers.	3	Evaluating (K5)	5

NARASARAOPETA
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DEPARTMENT OF MECHANICAL ENGINEERING

Mechatronics Scheme of Evaluation

IV B. TECH I – SEMESTER MID–I, July– 2023

1. a. Define Mechatronics and Explain Evaluation of Mechatronics.
   Definition ------------------------ 1 M
   Evaluation of Mechatronics----4 M
   b.**Derive** mathematical modelling of spring, Damper and Mass for Mechanical Translation System.
   Diagram ----------------------- 2 M
   Derivation--------------------------3 M
2. a.Define Microcontroller and Explain the Basic Structure of Microcontroller
   Definition ----------------------- 1 M
   Structure and Explanation ---4 M
   b. **Explain** the working of PN Junction Diode and also write Advantages and Disadvantages..
   Working of PN Junction Diode ---------3 M
   Advantages ------------------------------1 M
   Disadvantages----------------------------1 M
3. a). **Explain** the different types of photoelectric transducers.
   Types ---------------------- 1 M
   Explanation ----------------4 M

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
IV B.TECH I - SEMESTER ASSIGNMENT TEST – I, July– 2023

SUBJECT: MECHATRONICS
DURATION: 30 MIN

DATE: 03-07-2023
MAX MARKS: 5

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	**Explain** the basic components of mechatronics.	1	Evaluating (K5)	5
2	**List** the advantages and disadvantage of mechatronics.	1	Analyzing (K4)	5
3	**Explain** Mechatronic Design process.	1	Evaluating (K5)	5
4	**List** the applications of mechatronics.	1	Analyzing (K4)	5
5	**Derive** mathematical modeling of spring, Damper and Mass for Mechanical Translation System.	1	Evaluating (K5))	5
6	Define Mechatronics and **Explain** Evaluation of Mechatronics.	1	Evaluating (K5)	5
7	**Derive** mathematical modeling of spring, Damper and Mass for Mechanical Rotational systems.	1	Appling (K3)	5
8	**Explain** the measurement system and control systems in Mechatronics.	1	Evaluating (K5)	5
9	**Explain** the system modeling for electric systems.	1	Evaluating (K5)	5
10	**Explain** Open and closed loop control systems with neat sketch.	1	Evaluating (K5)	5

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DEPARTMENT OF MECHANICAL ENGINEERING

Mechatronics Scheme of Evaluation

IV B. TECH I – SEMESTER ASSIGNMENT TEST–I, July– 2023

1. **Explain** the basic components of mechatronics.
   List of Basic Components ------------ 2 M
   Explanation ----------------------------3 M
2. **List** the advantages and disadvantage of mechatronics.
   Advantages ----------------3 M
   Disadvantage ------------- 2 M
3. **Explain** Mechatronic Design process.
   Diagram -----------------2 M
   Explanation -------------- 3 M
4. **List** the applications of mechatronics.
   Applications of Mechatronics -------- 5M
5. **Derive** mathematical modelling of spring, Damper and Mass for Mechanical Translation System.
   Diagram ---------------------- 2 M
   Derivation------------------------3 M
6. Define Mechatronics and **Explain** Evaluation of Mechatronics.
   Definition ---------------------- 1 M
   Explanation --------------------4 M
7. **Derive** mathematical modelling of spring, Damper and Mass for Mechanical Rotational systems.
   Diagram ---------------------- 2 M
   Derivation----------------------3 M
8. **Explain** the measurement system and control systems in Mechatronics.
   Measurement Systems ------3 M
   Control Systems ------------2 M
9. **Explain** the system modelling for electric systems.
   Diagram ---------------------- 2 M
   Explanation ------------------3 M
10. **Explain** Open and closed loop control systems with neat sketch.
    Diagram -------------------- 2 M
    Explanation ----------------3 M

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
IV B.TECH I - SEMESTER MID – II, November – 2022

SUBJECT: MECHATRONICS **DATE:** 17-11-2022

DURATION: 90 MIN **MAX MARKS:** 25

Answer All Questions

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	**Distinguish** between AC and DC Motors.	3	Appling (K3)	5
2	**What** are the logic gates used in digital logic? **Write** truth table, circuit of Boolean operation for each gate.	4	Applying (K3)	5
	Draw Ladder diagram for the following; i. AND gate ii. OR gate iii. XOR gate iv. Latching	4	Applying (K3)	5
3	**List** the applications of mechatronics in automated manufacturing industry?	5	Analyzing (K4)	10

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
IV B.TECH I - SEMESTER MID – II, November – 2022

SUBJECT: MECHATRONICS **DATE:** 17-11-2022

DURATION: 90 MIN **MAX MARKS:** 25

Answer All Questions

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	**Distinguish** between AC and DC Motors.	3	Appling (K3)	5
2	**What** are the logic gates used in digital logic? **Write** truth table, circuit of Boolean operation for each gate.	4	Applying (K3)	5
	Draw Ladder diagram for the following; i. AND gate ii. OR gate iii. XOR gate iv. Latching	4	Applying (K3)	5
3	**List** the applications of mechatronics in automated manufacturing industry?	5	Analyzing (K4)	10

NARASARAOPETA ENGINEERING COLLEGE
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DEPARTMENT OF MECHANICAL ENGINEERING

Mechatronics Scheme of Evaluation

IV B. TECH I – SEMESTER MID–II, November – 2022

1. **Distinguish** between AC and DC Motors.
   Minimum five Difference --------------------5 M
2. **a.What** are the logic gates used in digital logic? **Write** truth table, circuit of Boolean operation for each gate.
   Logic Gates--------------2 M
   Truth Tables ------------2 M
   Boolean Operation-----1 M
   b. Draw Ladder diagram for the following;
   i. **AND gate----1 M**
   ii. **OR gate------1 M**
   iii. **XOR gate ---1 M**
   iv. **Latching ----2 M**
3. **List** the applications of mechatronics in automated manufacturing industry?
   List ---------------**5 M**
   Explanation -----**5 M**

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IV B.TECH I - SEMESTER ASSIGNMENT TEST – IV, October– 2022

SUBJECT: MECHATRONICS **DATE:** 24-10-2022
DURATION: 30 MIN **MAX MARKS:** 10

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	Simplify the following Boolean operations by the use of Karnaugh maps: i) $Q = \bar{A} . \bar{B} . C + \bar{A} . \bar{B} . \bar{C} + \bar{A} . B . \bar{C}$ ii) $Q = \bar{A} . B . \bar{C} . D + A . \bar{B} . \bar{C} . D + \bar{A} . \bar{B} . \bar{C} . D + A . B . \bar{C} . D + A . B . \bar{C} . \bar{D} + A . B . C . D$	4	Applying (K3)	5
2	**Explain** the laws of Boolean algebra used in digital logic.	4	Evaluating (K5)	5
3	**Prove** that i. A+(B•C)=(A+B)•(A+C) ii. $(A+B)\cdot \bar{C}+A\cdot C=A+B\cdot \bar{C}$	4	Evaluating (K5)	5
4	**Draw** Ladder diagram for the following; i. AND gate ii. OR gate iii. XOR gate iv. Latching	4	Applying (K3)	5
5	**Explain** about sensor based conditioning monitoring with suitable examples?	5	Evaluating (K5)	5
6	**List** the applications of mechatronics in automated manufacturing industry?	5	Analyzing (K4)	5

NARASARAOPETA ENGINEERING COLLEGE
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DEPARTMENT OF MECHANICAL ENGINEERING

Mechatronics Scheme of Evaluation

IV B. TECH I – SEMESTER ASSIGNMENT TEST–IV, October– 2022

1. Simplify the following Boolean operations by the use of Karnaugh maps:
   i) $Q = \bar{A}\,.\,\bar{B}\,.\,C + \bar{A}\,.\bar{B}\,.\bar{C} + \bar{A}.B.\,\bar{C}$ ----------**2.5 M**
   ii) $Q = \bar{A}\,.B.\,\bar{C}\,.\,D + A.\,\bar{B}\,.\,\bar{C}\,.\,D + \bar{A}\,.\,\bar{B}\,.\,\bar{C}\,.\,D + A\,.B.\,\bar{C}\,.D + A\,.\,B.\,\bar{C}\,.\,\bar{D} + A\,.\,B.\,C.\,D$ ------**2.5 M**
2. **Explain** the laws of Boolean algebra used in digital logic.
   Laws ------------------3 M
   Explanation -------- 3 M
3. Prove that
   i. $A+(B\cdot C)=(A+B)\cdot(A+C)$ -------- **2.5 M**
   ii. $(A+B)\cdot \bar{C}+A\cdot C=A+B\cdot \bar{C}$ ----**2.5 M**
4. Draw Ladder diagram for the following;
   AND gate ---- **1 M**
   OR gate --------**1 M**
   XOR gate -----**1 M**
   Latching -------**2 M**
5. Explain about sensor based conditioning monitoring with suitable examples?
   Explanation -------3 M
   Example -----------2 M
6. **List** the applications of mechatronics in automated manufacturing industry?
   Applications ------- 5 M

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
IV B.TECH I - SEMESTER ASSIGNMENT TEST – III, October– 2022

SUBJECT: MECHATRONICS **DATE:** 10-10-2022

DURATION: 30 MIN **MAX MARKS:** 10

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	**Distinguish** between AC and DC Motors.	3	Appling (K3)	5
2	**Explain** the working principle of Pneumatic Actuator.	3	Evaluating (K5)	5
3	**Distinguish** between Hydraulic, Pneumatic and Electrical Actuators.	3	Appling (K3)	5
4	**What** are the number systems in digital logics? **Explain** them with examples.	4	Evaluating (K5)	5
5	**Convert** the following; a. Hexadecimal number 233 into Binary system. b. Octal number 1234 into Binary system.	4	Applying (K3)	5
6	**Explain** different logic gates used in digital logics.	4	Evaluating (K5)	5

NARASARAOPETA ENGINEERING COLLEGE
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DEPARTMENT OF MECHANICAL ENGINEERING

Mechatronics Scheme of Evaluation

IV B. TECH I – SEMESTER ASSIGNMENT TEST–III, October– 2022

1. **Distinguish** between AC and DC Motors.
   Minimum five Difference -------------------5 M
2. **Explain** the working principle of Pneumatic Actuator.
   Diagram ------------------2 M
   Working Principle------ 3 M
3. **Distinguish** between Hydraulic, Pneumatic and Electrical Actuators.
   Minimum five Difference -------------------5 M
4. What are the number systems in digital logics? **Explain** them with examples
   Types of Number Systems -----2 M
   Explanation -----------------------3 M
5. Convert the following;
   a. Hexadecimal number 233 into Binary system ------- **2.5 M**
   b. Octal number 1234 into Binary system **---------------2.5 M**
6. **Explain** different logic gates used in digital logics.
   Types of Logic Gates -----2 M
   Explanation ---------------- 3 M

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
IV B.TECH I - SEMESTER MID – I, September– 2022

SUBJECT: MECHATRONICS **DATE:** 13-09-2022

DURATION: 90 MIN **MAX MARKS:** 25

Answer All Questions

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	a).**Explain** the basic components of mechatronics.	1	Evaluating (K5)	5
	b). **Derive** mathematical modeling of spring, Damper and Mass for Mechanical Translation systems.	1	Appling (K3)	5
2	a). Define Microcontroller and **Explain** the Basic Structure of Microcontroller.	2	Evaluating (K5)	5
	b).**Explain** the difference between microprocessor and microcontrollers.	2	Appling (K3)	5
3	a).**Explain** the working principle of Hydraulic Actuator.	3	Evaluating (K5)	5

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
IV B.TECH I - SEMESTER MID – I, September– 2022

SUBJECT: MECHATRONICS **DATE:** 13-09-2022

DURATION: 90 MIN **MAX MARKS:** 25

Answer All Questions

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	a).**Explain** the basic components of mechatronics.	1	Evaluating (K5)	5
	b). **Derive** mathematical modeling of spring, Damper and Mass for Mechanical Translation systems.	1	Appling (K3)	5
2	a). Define Microcontroller and **Explain** the Basic Structure of Microcontroller.	2	Evaluating (K5)	5
	b).**Explain** the difference between microprocessor and microcontrollers.	2	Appling (K3)	5
3	a).**Explain** the working principle of Hydraulic Actuator.	3	Evaluating (K5)	5

NARASARAOPETA ENGINEERING COLLEGE
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DEPARTMENT OF MECHANICAL ENGINEERING

Mechatronics Scheme of Evaluation

IV B. TECH I – SEMESTER MID–I, September– 2022

1. **a.Explain** the basic components of mechatronics.
   List of Basic Components ------------- 2 M
   Explanation ------------------------------3 M
   b.Derive mathematical modelling of spring, Damper and Mass for Mechanical Translation System.
   Diagram ------------------------- 2 M
   Derivation-------------------------3 M
2. a.Define Microcontroller and Explain the Basic Structure of Microcontroller
   Definition ----------------------- 1 M
   Structure and Explanation ---4 M
   b.**Explain** the difference between microprocessor and microcontrollers.
   Minimum five Difference -------------------5 M
3. a).**Explain** the working principle of Hydraulic Actuator.
   Diagram ----------------------- 2 M
   Working Principle-------------3 M

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
IV B.TECH I - SEMESTER ASSIGNMENT TEST – II, September– 2022

SUBJECT: MECHATRONICS **DATE:** 06-09-2022

DURATION: 30 MIN **MAX MARKS:** 10

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	**Explain** the basic components of microcontrollers.	2	Evaluating (K5)	5
2	**List** the advantages and disadvantages of microcontrollers.	2	Analyzing (K4)	5
3	**Explain** the difference between microprocessor and microcontrollers.	2	Evaluating (K5)	5
4	**List** the applications of Microcontrollers	2	Analyzing (K4)	5
5	**Explain** the different types of microcontrollers.	2	Evaluating (K5))	5
6	Define Microcontroller and **Explain** the Basic Structure of Microcontroller	2	Evaluating (K5)	5

NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

Mechatronics Scheme of Evaluation

IV B. TECH I – SEMESTER ASSIGNMENT TEST–II, September– 2022

1. **Explain** the basic components of microcontrollers.
   List of Basic Components ------------- 2 M
   Explanation -------------------------------3 M
2. **List** the advantages and disadvantages of microcontrollers
   Advantages ------------------3 M
   Disadvantage --------------- 2 M
3. **Explain** the difference between microprocessor and microcontrollers.
   Minimum five Difference -------------------5 M
4. **List** the applications of Microcontrollers
   Applications of Mechatronics -------- 5M
5. **Explain** the different types of microcontrollers.
   Types ----------------------- 2 M
   Explanation ---------------3 M
6. Define Microcontroller and Explain the Basic Structure of Microcontroller
   Definition ----------------------- 1 M
   Structure and Explanation ---4 M

NARASARAOPET ENGINEERING COLLEGE (AUTONOMOUS): NARASARAOPET
DEPARTMENT OF MECHANICAL ENGINEERING
IV B.TECH I - SEMESTER ASSIGNMENT TEST – I, August– 2022

SUBJECT: MECHATRONICS **DATE:** 29-08-2022

DURATION: 30 MIN **MAX MARKS:** 10

Q. No	Questions	Course Outcome (CO)	Knowledge Level as Per Bloom's Taxonomy	Marks
1	**Explain** the basic components of mechatronics.	1	Evaluating (K5)	5
2	**List** the advantages and disadvantage of mechatronics.	1	Analyzing (K4)	5
3	**Explain** Mechatronic Design process.	1	Evaluating (K5)	5
4	**List** the applications of mechatronics.	1	Analyzing (K4)	5
5	**Derive** mathematical modeling of spring, Damper and Mass for Mechanical Translation System.	1	Evaluating (K5))	5
6	Define Mechatronics and **Explain** Evaluation of Mechatronics.	1	Evaluating (K5)	5
7	**Derive** mathematical modeling of spring, Damper and Mass for Mechanical Rotational systems.	1	Appling (K3)	5
8	**Explain** the measurement system and control systems in Mechatronics.	1	Evaluating (K5)	5
9	**Explain** the system modeling for electric systems.	1	Evaluating (K5)	5
10	**Explain** Open and closed loop control systems with neat sketch.	1	Evaluating (K5)	5

NARASARAOPETA
NEC ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

Mechatronics Scheme of Evaluation

IV B. TECH I – SEMESTER ASSIGNMENT TEST–I, August– 2022

1. **Explain** the basic components of mechatronics.
   List of Basic Components ------------- 2 M
   Explanation -----------------------------3 M
2. **List** the advantages and disadvantage of mechatronics.
   Advantages -----------------3 M
   Disadvantage --------------- 2 M
3. **Explain** Mechatronic Design process.
   Diagram -------------------2 M
   Explanation --------------- 3 M
4. **List** the applications of mechatronics.
   Applications of Mechatronics -------- 5M
5. **Derive** mathematical modelling of spring, Damper and Mass for Mechanical Translation System.
   Diagram ------------------------ 2 M
   Derivation--------------------------3 M
6. Define Mechatronics and **Explain** Evaluation of Mechatronics.
   Definition ------------------------ 1 M
   Explanation ---------------------4 M
7. **Derive** mathematical modelling of spring, Damper and Mass for Mechanical Rotational systems.
   Diagram ------------------------ 2 M
   Derivation------------------------3 M
8. **Explain** the measurement system and control systems in Mechatronics.
   Measurement Systems ------3 M
   Control Systems ------------2 M
9. **Explain** the system modelling for electric systems.
   Diagram ------------------------ 2 M
   Explanation --------------------3 M
10. **Explain** Open and closed loop control systems with neat sketch.
    Diagram ----------------------- 2 M
    Explanation -------------------3 M

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH IV B.TECH I SEM II MID & QUIZ MARKS - AWARD LIST November -2022

Branch : ME-A

Subject: Mechatronics

Date:17-11-2022

Sl. No.	H.T.NO.	CO No.	1	2	2	3	Total Marks (25M)	Reduced To (20M)	Quiz (10M)
		Max.Marks	5	5	5	10			
		Q.No.	1 (a)	2 (a)	2 (b)	3			
1	19471A0301		5	0	5	7	17	14	9
2	19471A0302						A	A	A
3	19471A0303		5	4	5	7	21	17	8
4	19471A0304		5			7	12	10	5
5	19471A0305		5	5	5	9	24	20	10
6	19471A0306		5	5	5		15	12	6
7	19471A0307		5	5	5	7	22	18	10
8	19471A0308		5	5	5	6	21	17	9
9	19471A0309		5	4.5	4.5	5	19	16	9
10	19471A0310						A	A	10
11	19471A0311		5	4	5	5	19	16	7
12	19471A0312		5	5	5	9	24	20	10
13	19471A0313		5	5	5	7	22	18	10
14	19471A0315		5	4	4		13	11	10
15	19471A0316		5	5	5	8	23	19	10
16	19471A0317			1			1	1	3
17	19471A0318		5	3	5	7	20	16	8
18	19471A0319		5	5	5	8	23	19	9
19	19471A0320		5	5	5	9	24	20	10
20	19471A0321		5	1	5	4	15	12	9
21	19471A0322		4		5		9	8	10
22	19471A0323		5		4	5	14	12	3
23	19471A0324						A	A	A
24	19471A0326		5	5	5	9	24	20	10
25	19471A0327		5	5	5	7	22	18	8
26	19471A0328		5	5	5	2	17	14	10
27	19471A0329		5	5	5	7	22	18	10

28	19471A0330		5		4		9	8	10
29	19471A0331		4	5	5		14	12	10
30	19471A0333		5	5	5	7	22	18	9
31	19471A0335		5	5	5	5	20	16	10
32	19471A0336		5	4	5	5	19	16	8
33	19471A0337		5	5	5	5	20	16	10
34	19471A0338		5	5	5	8	23	19	10
35	19471A0339		5	5	5	4	19	16	9
36	19471A0340		5	5		9	19	16	9
37	19471A0341		4	5	5	5	19	16	8
38	19471A0342						A	A	A
39	19471A0343		5	5	5	7	22	18	9
40	19471A0344		5	5	5	8	23	19	7
41	20475A0354		5	5	5	5	20	16	7
42	20475A0355		5	5	5	5	20	16	10
43	20475A0356		5	5	5	6	21	17	10
44	20475A0357		5	5	5	6	21	17	10
45	20475A0358		5	5	5	7	22	18	9
46	20475A0359		5	5	5	5	20	16	10
47	20475A0360		5	5	5	5	20	16	10
48	20475A0361		5	5	5	5	20	16	10
49	20475A0362		5	5	5	5	20	16	7
50	20475A0363		5	5	5	5	20	16	2
51	20475A0364		5	5	5	7	22	18	9
52	20475A0365		5	5	5	7	22	18	9
53	20475A0366		5	5	5	5	20	16	10

Name of the Staff Member: CH. JGICHAL

Signature of the Staff Member

Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH IV B.TECH I SEM IV-ASSIGNMENT TEST MARKS - AWARD LIST october -2022

Branch : ME-A Subject: Mechatronics Date:25-10-2022

SNO.	H.T.NO.	Q.NO.	CO	MARKS	Q.NO.	CO	MARKS	TOTAL MARKS (10M)
1	19471A0301	1	4	5	2	4	2	7
2	19471A0302	4	4	4	5	5	5	9
3	19471A0303	3	4	5	4	4	5	10
4	19471A0304	6	5	5				5
5	19471A0305	3	4	5	4	4	5	10
6	19471A0306	3	4	5	4	4	5	10
7	19471A0307							A
8	19471A0308	2	4	5	3	4	5	10
9	19471A0309	6	5	5				5
10	19471A0310							A
11	19471A0311	5	5	5	6	5	5	10
12	19471A0312	4	4	5	5	5	5	10
13	19471A0313	4	4	5	5	5	5	10
14	19471A0315	4	4	5	5	5	2	7
15	19471A0316	3	4	5	4	4	5	10
16	19471A0317							A
17	19471A0318	1	4	5	2	4	5	10
18	19471A0319	2	4	5	3	4	5	10
19	19471A0320	5	5	5	6	5	5	10
20	19471A0321	1	4	5	2	4	5	10
21	19471A0322							A
22	19471A0323	1	4	5	3	4	5	10
23	19471A0324							A
24	19471A0326	4	4	5	5	5	5	10
25	19471A0327	2	4	5	3	4	5	10
26	19471A0328	3	4	5	4	4	5	10
27	19471A0329	3	4	5	4	4	5	10
28	19471A0330							A
29	19471A0331	3	4	5	4	4	5	10

30	19471A0333	1	4	5	2	4	5	10
31	19471A0335							A
32	19471A0336	3	4	5	4	4	5	10
33	19471A0337	3	4	5	4	4	5	10
34	19471A0338	4	4	5	5	5	5	10
35	19471A0339	5	5	5	6	5	5	10
36	19471A0340	1	4	5	2	4	5	10
37	19471A0341							A
38	19471A0342	4	4	5	5	5	5	10
39	19471A0343	4	4	5	5	5	4	9
40	19471A0344	2	4	5	3	4	5	10
41	20475A0354	2	4	5	3	4	5	10
42	20475A0355	3	4	5	4	5	5	10
43	20475A0356	2	4	5	3	4	5	10
44	20475A0357	1	4	5	2	4	5	10
45	20475A0358	3	4	5	4	4	5	10
46	20475A0359							A
47	20475A0360	4	4	5	5	5	5	10
48	20475A0361	3	4	5	4	4	5	10
49	20475A0362							A
50	20475A0363	5	5	5	6	5	5	10
51	20475A0364	2	4	5	3	4	5	10
52	20475A0365	2	4	5	3	4	5	10
53	20475A0366	5	5	5	6	5	5	10

Name of the Staff Member

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Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH IV B.TECH I SEM III-ASSIGNMENT TEST MARKS - AWARD LIST OCT -2022

Branch : ME-A Subject: Mechatronics Date:10-10-2022

SNO.	H.T.NO.	Q.NO.	CO	MARKS	Q.NO.	CO	MARKS	TOTAL MARKS (10M)
1	19471A0301	1	3	5	2	3	3	8
2	19471A0302	2	3	3	3	3	5	8
3	19471A0303	3	3	5	4	4	5	10
4	19471A0304	1	3	5	2	3	3	8
5	19471A0305	3	3	5	4	4	5	10
6	19471A0306							AB
7	19471A0307	1	3	5	2	3	4	9
8	19471A0308	5	4	3	6	4	5	8
9	19471A0309	5	4	3	6	4	5	8
10	19471A0310	1	3	5	2	3	3	8
11	19471A0311							AB
12	19471A0312	2	3	5	3	3	5	10
13	19471A0313	1	3	5	2	3	4	9
14	19471A0315	1	3	5	2	3	3	8
15	19471A0316							AB
16	19471A0317	3	3	5	4	4	3	8
17	19471A0318	3	3	5	4	4	5	10
18	19471A0319	2	3	5	3	3	4	9
19	19471A0320	2	3	5	3	3	5	10
20	19471A0321	4	4	5	5	4	2	7
21	19471A0322							AB
22	19471A0323							AB
23	19471A0324	5	4	3	6	4	5	8
24	19471A0326							AB
25	19471A0327							AB
26	19471A0328	1	3	5	2	3	3	8
27	19471A0329							AB
28	19471A0330							AB

29	19471A0331	4	4	5	5	4	3	8
30	19471A0333	1	3	5	2	3	5	10
31	19471A0335							AB
32	19471A0336	1	3	5	2	3	5	10
33	19471A0337	3	3	3	4	4	5	8
34	19471A0338	1	3	5	2	3	5	10
35	19471A0339	4	4	5	5	4	3	8
36	19471A0340	2	3	4	3	3	5	9
37	19471A0341	2	3	5	3	3	5	10
38	19471A0342	4	4	5	5	4	3	8
39	19471A0343	5	4	3	6	4	5	8
40	19471A0344	4	4	5	5	4	3	8
41	20475A0354	5	4	3	6	4	5	8
42	20475A0355							AB
43	20475A0356							AB
44	20475A0357	2	3	5	3	3	5	10
45	20475A0358	3	3	5	4	4	5	10
46	20475A0359	1	3	5	2	3	4	9
47	20475A0360							AB
48	20475A0361	3	3	5	4	4	5	10
49	20475A0362	3	3	5	4	4	5	10
50	20475A0363							AB
51	20475A0364							AB
52	20475A0365	4	4	5	5	4	3	8
53	20475A0366							AB

Name of the Staff Member CH. SEKHAR

Signature of the Staff Member

Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH IV B.TECH I SEM I-ASSIGNMENT TEST MARKS - AWARD LIST -2022

Branch : ME-A Subject: Mechatronics Date:29-08-22

SNO.	H.T.NO.	Q.NO.	CO	MARKS	Q.NO.	CO	MARKS	TOTAL MARKS (10M)
1	19471A0301	7	1	4	8	1	4	8
2	19471A0302							AB
3	19471A0303	9	1	4	10	1	5	9
4	19471A0304	7	1	5	8	1	5	10
5	19471A0305	1	1	5	2	1	5	10
6	19471A0306							AB
7	19471A0307	7	1	5	8	1	5	10
8	19471A0308	1	1	5	2	1	5	10
9	19471A0309							AB
10	19471A0310							AB
11	19471A0311	5	1	4	6	1	5	9
12	19471A0312	3	1	5	4	1	5	10
13	19471A0313	9	1	4	10	1	5	9
14	19471A0315	5	1	5	6	1	5	10
15	19471A0316	3	1	5	4	1	5	10
16	19471A0317	1	1	5	2	1	5	10
17	19471A0318	9	1	4	10	1	4	8
18	19471A0319	3	1	5	4	1	4	9
19	19471A0320	3	1	5	4	1	5	10
20	19471A0321	1	1	4	2	1	5	9
21	19471A0322	1	1	4	2	1	5	9
22	19471A0323	1	1	5	2	1	5	10
23	19471A0324							AB
24	19471A0326	9	1	5	10	1	5	10
25	19471A0327	9	1	4	10	1	4	8
26	19471A0328	5	1	5	6	1	5	10
27	19471A0329	9	1	4	10	1	4	8
28	19471A0330	1	1	4	2	1	5	9

29	19471A0331	3	1	5	4	1	4	9
30	19471A0333	1	1	5	2	1	5	10
31	19471A0335	3	1	5	4	1	5	10
32	19471A0336							AB
33	19471A0337							AB
34	19471A0338	3	1	5	4	1	5	10
35	19471A0339	7	1	5	8	1	5	10
36	19471A0340	1	1	5	2	1	5	10
37	19471A0341	7	1	5	8	1	5	10
38	19471A0342	7	1	5	8	1	5	10
39	19471A0343	9	1	4	10	1	4	8
40	19471A0344	9	1	4	10	1	4	8
41	20475A0354							AB
42	20475A0355							AB
43	20475A0356	1	1	5	2	1	5	10
44	20475A0357	5	1	5	6	1	5	10
45	20475A0358							AB
46	20475A0359	5	1	5	6	1	5	10
47	20475A0360							AB
48	20475A0361							AB
49	20475A0362							AB
50	20475A0363							AB
51	20475A0364	3	1	5	4	1	5	10
52	20475A0365	1	1	5	2	1	5	10
53	20475A0366							AB

Name of the Staff Member CH.SEKHAR **Signature of the Staff Member** ch.s

Signature of the HOD

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS) : : NARASARAOPET

(R19) 2019 BATCH IV B.TECH I SEM II-ASSIGNMENT TEST MARKS - AWARD LIST -2022

Branch : ME-A Subject: Mechatronics Date: 06-09-2022

SNO.	H.T.NO.	Q.NO.	CO	MARKS	Q.NO.	CO	MARKS	TOTAL MARKS (10M)
1	19471A0301	4	2	5	6	2	5	10
2	19471A0302							AB
3	19471A0303	3	2	5	4	2	5	10
4	19471A0304	2	2	5	5	2	5	10
5	19471A0305	5	2	5	6	2	5	10
6	19471A0306							AB
7	19471A0307	2	2	5	5	2	5	10
8	19471A0308	5	2	5	6	2	5	10
9	19471A0309							AB
10	19471A0310							AB
11	19471A0311	2	2	5	5	2	5	10
12	19471A0312	3	2	5	4	2	5	10
13	19471A0313	1	2	5	2	2	5	10
14	19471A0315	6	2	4	6	2	5	9
15	19471A0316	3	2	5	4	2	5	10
16	19471A0317	1	2	5	2	2	3	8
17	19471A0318	3	2	5	4	2	5	10
18	19471A0319	1	2	5	2	2	5	10
19	19471A0320	3	2	5	4	2	5	10
20	19471A0321	5	2	5	6	2	5	10
21	19471A0322							AB
22	19471A0323							AB
23	19471A0324	1	2	5	2	2	5	10
24	19471A0326	4	2	5	6	2	4	9
25	19471A0327							AB
26	19471A0328	3	2	4	4	2	4	8

27	19471A0329	5	2	5	6	2	5	10
28	19471A0330							AB
29	19471A0331	2	2	5	5	2	5	10
30	19471A0333	5	2	5	6	2	4	9
31	19471A0335							AB
32	19471A0336							AB
33	19471A0337	5	2	5	6	2	5	10
34	19471A0338	3	2	5	4	2	5	10
35	19471A0339	4	2	4	6	2	4	8
36	19471A0340	4	2	4	5	2	5	9
37	19471A0341	2	2	4	5	2	4	8
38	19471A0342	4	2	5	6	2	5	9
39	19471A0343	4	2	5	6	2	5	10
40	19471A0344	4	2	5	6	2	5	10
41	20475A0354							AB
42	20475A0355							AB
43	20475A0356	4	2	5	6	2	4	9
44	20475A0357	2	2	5	5	2	5	10
45	20475A0358	1	2	5	2	2	5	10
46	20475A0359	4	2	5	6	2	4	9
47	20475A0360	1	2	5	2	2	5	10
48	20475A0361							AB
49	20475A0362							AB
50	20475A0363	3	2	5	4	2	5	10
51	20475A0364	5	2	5	6	2	5	10
52	20475A0365	5	2	5	6	2	5	10
53	20475A0366							AB

Name of the Staff Member CH. SEKHAR

Signature of the Staff Member

Signature of the HOD

NARASARAOPETA
NEC ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

UNIT WISE IMPORTANT QUESTIONS

NEC NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

MECHATRONICS

UNIT WISE SAMPLE QUESTIONS

S NO	QUESTION	KNOWLEDGE LEVEL	CO
	UNIT I		
1	**Derive** mathematical modeling of spring, Damper and Mass for Mechanical Translation System.	Evaluating (K5)	CO1
2	**Explain** Open and closed loop control systems with neat sketch.	Applying (K3)	CO1
3	**Derive** mathematical modeling of spring, Damper and Mass for Mechanical Rotational systems.	Applying (K3)	CO1
4	**Explain** the basic components of mechatronics.	Applying (K3)	CO1
	UNIT 2		
1	**Explain** the PN Junction diode and its applications.	Applying (K3)	CO2
2	**Explain** the P- Type and N-Type semiconductors.	Applying (K3)	CO2
3	**Explain** the Bipolar Junction Transistor working principle and applications.	Applying (K3)	CO2
4	**Compare the** BJT, FET and MOSFET Transistor.	Applying (K3)	CO2
	UNIT 3		
1	Define Photoelectric transduces and **Explain** different types of Photoelectric Transducer.	Applying (K3)	CO3
2	**Explain** the working principle of thermocouple and also write the advantages and disadvantages.	Applyin g (K3)	CO3
3	**Explain** the working principle of Thermistors and also explain different types of Thermistors.	Applying (K3)	CO3
4	**Explain** capacitive and inductive Transducers.		
	UNIT 4		
1	**What** are the number systems in digital logics? **Explain** them with examples.	Applying (K3)	CO4
2	**What** are the logic gates used in digital logic? **Write** truth table, circuit of Boolean operation for each gate.	Applying (K3)	CO4

3	**Prove** that a. $A+(B\cdot C)=(A+B)\cdot(A+C)$ b. $(A+B)\cdot\overline{c}+A\cdot C=A+B\cdot\overline{c}$	Applying (K3)	**CO4**
4	**Explain** the laws of Boolean algebra used in digital logic.	Applying (K3)	**CO4**
5	**Draw** Ladder diagram for the following; i. AND gate ii. OR gate iii. XOR gate iv. Latching	Applying (K3)	**CO4**
	UNIT 5		
1	**Define** Artificial intelligent and **Explain** its impact on mechatronics.	Applying (K3)	**CO5**
2	**What** are micro sensors & Describe the micro sensors used in mechatronics.	Applying (K3)	**CO5**
3	**Explain** Fuzzy logic applications on mechatronics with suitable examples.	Applying (K3)	**CO5**
4	**Explain** about sensor based conditioning monitoring with suitable examples?	Applying (K3)	**CO5**

NEC NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

PREVIOUS QUESTION PAPERS

Narasaraopeta Engineering College (Autonomous)

Kotappakonda Road, Yellamanda (P.O), Narasaraopet- 522601, Guntur District, AP.

Subject Code: R20CC4OE06

IV B.Tech I Semester (Regular/supple) Examinations, (Month, Year)

MECHATRONICS

(ME)

Time: 3 hours **Max Marks: 70**

Note: Answer All **FIVE** Questions.
All Questions Carry Equal Marks (5X14=70M)

Q.No		Questions	KL	CO	Marks
		Unit - I			
1	a	Define Mechatronics and **Explain** Evaluation of Mechatronics.	K3	01	[12M]
		OR			
	b	**Explain** translational and rotational mechanical system.	K3	01	[12M]
		Unit - II			
2	a	**Explain** the P- Type and N-Type semiconductors.	K3	02	[12M]
		OR			
	b	**Explain** the Bipolar Junction Transistor working principle and applications.	K3	02	[12M]
		Unit - III			
3	a	Define Photoelectric transduces and **Explain** different types of Photoelectric Transducer.	K5	03	[12M]
		OR			
	b	**Explain** the working principle of Thermistors and also explain different types of Thermistors	K3	03	[12M]
		Unit - IV			
4	a	What is a logic gate? **Explain** in detail about types of logic gates.	K3	04	[12M]
		OR			
	b	Simplify the following Boolean operations by the use of Karnaugh maps:	K3	04	[12M]
		Unit - V			
5	a	**Explain** the applications of artificial intelligence and fuzzy logic in Mechatronics.	K3	05	[12M]
		OR			
	b	**Explain** Fuzzy logic applications on mechatronics with suitable examples	K3	05	[12M]

Narasaraopeta Engineering College (Autonomous)

Kotappakonda Road, Yellamanda (P.O), Narasaraopet- 522601, Guntur District, AP.

Subject Code: R20CC4OE06

IV B.Tech I Semester (Regular/supple) Examinations, (Month, Year)

MECHATRONICS

(ME)

Time: 3 hours **Max Marks: 70**

Note: Answer All **FIVE** Questions.
All Questions Carry Equal Marks (5X14=70M)

Q.No		Questions	KL	CO	Marks
		Unit - I			
1	a	**Explain** the basic components of mechatronics.	K3	01	[14M]
		OR			
	b	**Derive** mathematical modeling of spring, Damper and Mass for Mechanical Rotational systems.	K5	01	[14M]
		Unit - II			
2	a	**Explain** the PN Junction diode and its applications.	K3	02	[14M]
		OR			
	b	**Compare the** BJT, FET and MOSFET Transistor.	K4	02	[14M]
		Unit - III			
3	a	**Explain** the working principle of thermocouple and also write the advantages and disadvantages.	K3	03	[14M]
		OR			
	b	**Explain** capacitive and inductive Transducers.	K3	03	[14M]
		Unit - IV			
4	a	What is a number system? **Explain** in detail about types of number systems	K3	04	[14M]
		OR			
	b	What is PLC? **Explain** the basic structure of PLC	K3	04	[14M]
		Unit - V			
5	a	**List** the applications of Mechatronics in condition monitoring and automated manufacturing industries?	K3	05	[14M]
		OR			
	b	**Explain** Fuzzy logic applications on mechatronics with suitable examples	K3	05	[14M]

Narasaraopeta Engineering College (Autonomous)
Kotappakonda Road, Yellamanda (P.O), Narasaraopet- 522601, Guntur District, AP.

Subject Code: R16ME4201

IV B.Tech II Semester Supple Examinations, April-2023

MECHATRONICS

(ME)

Time: 3 hours **Max Marks: 60**

Question Paper Consists of **Part-A** and **Part-B.**

Answering the question in **Part-A** is Compulsory & Four Questions should be answered from Part-B

All questions carry equal marks of 12.

PART-A

1. (a) What is translational mechanical system?
   (b) What is a sensor? Give an example.
   (c) List the advantages of Electro-Mechanical Linear Actuator.
   (d) Write any two applications of logical gates.
   (e) What is micro sensor application in Mechatronics.
   (f) Define the term Transient and steady state response.

[2+2+2+2+2+2]

PART-B

4 X 12 = 48

2. (a) What is the difference between inductive and capacitive sensors? (6m)
   (b) What are the components of a Mechatronic system? Explain their role in automation. (6m)

3. (a) Discuss about Fluid power actuators and piezoelectric actuators taking one example for each. (12m)

4. (a) Explain any two types of Mechanical actuation systems. (8m)
   (b) Write short notes on solid state switches and solenoids (6m)

5. (a) What is a number system? Explain about any two types of number systems (8m)
   (b) Discuss about sequential logic circuit. (4m)

6. (a) What are the fuzzy logic applications in mechatronics. (6m)
   (b) What are the applications of Mechatronics in condition monitoring? (6m)

7. (a) Differentiate Transient and steady state response systems. (4m)
   (b) What are the stages in designing a mechatronics system? (8m)

***

NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

IV B.Tech I Semester Regular Examinations, November-2022

Sub Code: 19BME7TH0I

MECHATRONICS

Time: 3 hours

(ME)

Max. Marks: 60

Note: Answer All **FIVE** Questions.

All Questions Carry Equal Marks (5 X 12 = 60M)

Q.No		Questions	KL	CO	M
		Unit-I			
1	a	What are the components of Mechatronic system? Explain their importance in detail.	K1	01	12M
		OR			
	b	Explain the working of translational mechanical system with spring, damper and mass.	K3	01	12M
		Unit-II			
2	a	Discuss about the microcontroller Technology.List out the advantages and disadvantages of microcontrollers.	K2	02	12M
		OR			
	b	List out the applications, opportunities and challenges of Microcontrollers.	K2	02	12M
		Unit-III			
3	a	Explain any two types of Mechanical actuation system with neat sketches.	K3	03	12M
		OR			
	b	Explain in brief about the following 1. DC motors, 2. AC motors, 3. stepped motor.	K3	03	12M
		Unit-IV			
4	a	What are Logic gates? Explain about any 3 types of logic gates with examples.	K3	04	12M
		OR			
	b	What is a Programmable logic controller (PLC). Discuss the advantages and drawbacks of using the PLC's.	K2	04	12M
		Unit-V			
5	a	Explain the importance of mechatronics in automation and how is it useful for industrial automation.	K3	05	12M
		OR			
	b	Explain Fuzzy logic applications on mechatronics with suitable examples	K3	05	12M

KL: Blooms Taxonomy Knowledge Level CO: Course Outcome M:Marks

***

NEC NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

IV B.Tech I Semester Regular Examinations, November-2022

Sub Code: 19BME7TH01
Time: 3 hours

MECHATRONICS
(ME)

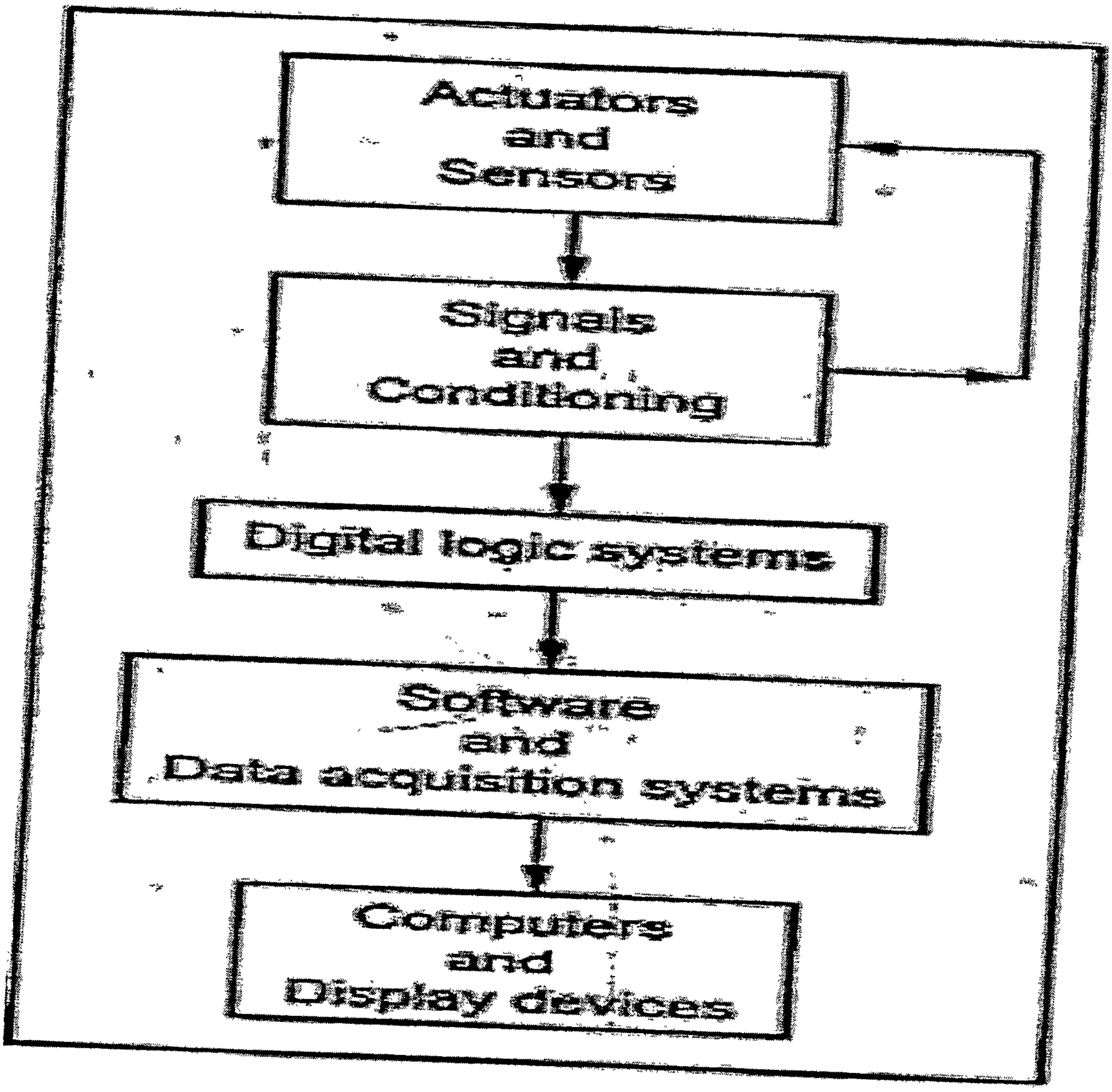
Max. Marks: 60

Note: Answer All FIVE Questions.
All Questions Carry Equal Marks (5 X 12 = 60M)

Q.No		Questions	KL	CO	M
		Unit-I			
1	a	What are the components of Mechatronic system? Explain their importance in detail.	K1	01	12M
		OR			
	b	Explain the working of translational mechanical system with spring, damper and mass.	K3	01	12M
		Unit-II			
2	a	Discuss about the microcontroller Technology.List out the advantages and disadvantages of microcontrollers.	K2	02	12M
		OR			
	b	List out the applications, opportunities and challenges of Microcontrollers.	K2	02	12M
		Unit-III			
3	a	Explain any two types of Mechanical actuation system with neat sketches.	K3	03	12M
		OR			
	b	Explain in brief about the following 1. DC motors, 2. AC motors, 3. stepped motor.	K3	03	12M
		Unit-IV			
4	a	What are Logic gates? Explain about any 3 types of logic gates with examples.	K3	04	12M
		OR			
	b	What is a Programmable logic controller (PLC). Discuss the advantages and drawbacks of using the PLC's.	K2	04	12M
		Unit-V			
5	a	Explain the importance of mechatronics in automation and how is it useful for industrial automation.	K3	05	12M
		OR			
	b	Explain Fuzzy logic applications on mechatronics with suitable examples	K3	05	12M

KL: Blooms Taxonomy Knowledge Level CO: Course Outcome M:Marks

1.a) **Components of mechatronic Systems:**



Actuators: Solenoids, DC motors, Stepper motors, Servo motors, Hydraulics and Pneumatics.

Sensors: Switches, Pots, Photoelectric, Encoders, Strain gauges, Thermocouples, Accelerometers etc..

Input signal conditioning and Interfacing: Amplifiers, Filters, A/D and D/A.

Digital control architecture: Logic circuits, Microcontrollers, PLC, Sequencing and Timing, Communication, Control algorithms, Logic and Arithmetic algorithms.

Output signal conditioning and Interfacing: D/A and A/D Converters, Amplifiers, PMC erc..

Graphical display: CRT, LCD, LED, CCD.

1.b) MECHANICAL TRANSLATIONAL SYSTEMS :

The model of mechanical translational systems can be obtained by using three basic elements Mass, spring and Dash-Pot. These three elements represent three essential phenomena which occur in various ways in mechanical systems.

List of Symbols Used In Mechanical Translational System

x = Displacement, m.

v = $\frac{dx}{dt}$ Velocity, m/sec^2

a= $\frac{dv}{dt}=\frac{d^2x}{dt^2}$ Acceleration, m/sec^2

f = Applied force, N (Newton's)

f_m = Opposing force offered by mass of the body, N

f_k = Opposing force offered by the elasticity of the body (spring), N

f_b = Opposing force offered by the friction of the body (dash – pot), N

M = Mass, kg

K = Stiffness of spring, N/m

B = Viscous friction co – efficient, N – sec/m

Note: Lower case letters are functions of time.

Mass

Consider an ideal mass element shown in figure1.3which has negligible friction and elasticity. Let a force be applied on it. The mass will offer an opposing force which is proportional to acceleration of the body.

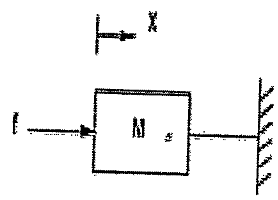


Figure 1.3

Let f = Applied force

f_m= Opposing force due to mass

Here $f_m \alpha$ a

$$f_m \alpha \frac{d^2x}{dt^2} \text{ or } f_m = M\frac{d^2x}{dt^2}$$

By Newton's second law, $f = f_m = M\frac{d^2x}{dt^2}$ .... (1)

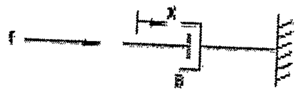


Figure 1.4

Dash-Pot

Consider an ideal frictional element dashpot shown in figure 1.4 which has negligible mass and elasticity. Let a force be applied on it. The dash-pot will offer an opposing force which is proportional to velocity of the body.

Let f = Applied force

f_b = Opposing force due to friction

Here, $f_b \propto v$

$f_b \propto \frac{dx}{dt}$ or $f_b = B\frac{dx}{dt}$

By Newton's second law, $f = f_b = B\frac{dx}{dt}$ .... (2)

When the dashpot has displacement at both ends as shown in figure 1.5 the opposing force is proportional to differential velocity.

$f_b \propto \frac{d(x_1-x_2)}{dt}$; $f_b = B\frac{d(x_1-x_2)}{dt}$

$\therefore f = f_b = B\frac{d(x_1-x_2)}{dt}$ .... (3)

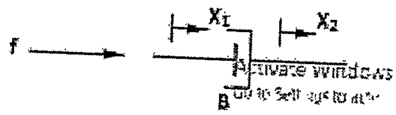


Figure 1.5

Spring

Consider an ideal elastic element spring shown in figure 1.6 which has negligible mass and friction. Let a force be applied on it. The spring will offer an opposing force which is proportional to displacement of the body.

Let f = Applied force

f_k = opposing force due to elasticity

Here $f_k \propto x$ or $f_k = Kx$

By Newton's second law, $f = f_k = Kx$ .... (4)

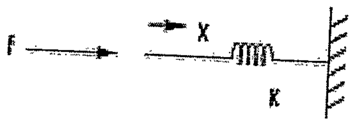


Figure 1.6

When the spring has displacement at both ends as shown in figure 1.7 the opposing force is proportional to differential displacement.

$$f_k \propto (x_1 - x_2)$$

$$f_k = K(x_1 - x_2)$$

$$\therefore f = f_k = K(x_1 - x_2)$$ ....(5)

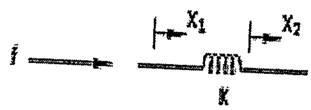


Figure 1.7

2.a) A **Microcontroller** is a VLSI (Very Large Scale Integration) Integrated Circuit (IC) that contains electronic computing unit and logic unit (combinedly known as CPU), Memory (Program Memory and Data Memory), I/O Ports (Input / Output Ports) and few other components integrated on a single chip.

A **Microcontroller** is a small and low-cost microcomputer, which is designed to perform the specific tasks of embedded systems like displaying microwave's information, receiving remote signals etc.

Basically, a Microcontroller consists of the following components.

- Central Processing Unit (CPU)
- Program Memory (ROM – Read Only Memory)
- Data Memory (RAM – Random Access Memory)
- Timers and Counters
- I/O Ports (I/O – Input/Output)
- Serial Communication Interface
- Clock Circuit (Oscillator Circuit)
- Interrupt Mechanism

Most modern Microcontrollers might contain even more peripherals like SPI (Serial Peripheral Interface), I2C (Inter Integrated Circuit), ADC (Analog to Digital Converter), DAC (Digital to Analog Converter), CAN (Controlled Area Network), USB (Universal Serial Bus), and many more.

Advantages of Microcontrollers

1. A Microcontroller is a true device that fits the computer-on-a-chip idea.

2. No need for any external interfacing of basic components like Memory, I/O Ports, etc.

3. Microcontrollers doesn't require complex operating systems as all the instructions must be written and stored in the memory. (RTOS is an exception).

4. All the Input/Output Ports are programmable.

5. Integration of all the essential components reduces the cost, design time and area of the product (or application).

Disadvantages of Microcontrollers

1. Microcontrollers are not known for their computation power.

2. The amount of memory limits the instructions that a microcontroller can execute.

3. No Operating System and hence, all the instruction must be written.

2.b) Applications of Microcontrollers

There are huge number of applications of Microcontrollers. In fact, the entire embedded systems industry is dependent on Microcontrollers. The following are few applications of Microcontrollers.

- Front Panel Controls in devices like Oven, washing Machine etc.
- Function Generators
- Smoke and Fire Alarms
- Home Automation Systems
- Automatic Headlamp ON in Cars
- Speed Sensed Door Locking System

NEW CHALLENGES FOR MICROCONTROLLERS

Hidden inside expensive systems and commodity appliances, microcontrollers (MCUs) continue to provide OEMs with quick, inexpensive solutions and semiconductor vendors with important sources of revenue. As defined by the Semiconductor Industry Association (SIA), an MCU is a chip that contains a processor core and nonvolatile memory such as ROM, one-time-programmable memory (OTP), EEPROM or flash memory. The MCU can and does contain other forms of on-chip memory, peripherals and even mixed signal data converters—A/D and D/A. Some MCUs can generate audio, drive LCD displays and connect to multiple bus standards. The MCU's low average selling price (ASP) and widespread use in digital electronics has prompted some semiconductor vendors to tag even processors without nonvolatile memory with the MCU name—thus sending the message of low price and high volume.

The MCU's scenario, however, is changing. There were fewer low-risk, fast time-to-market competing solutions. One could use a bare RISC processor augmented by the peripherals of an adequate microcontroller, and possibly add a small, low-development risk ASIC. Bare processors used to consume high power—an MCU could stay awake and turn on the high-performance (and high-power consumption) processor only when needed.

During the past four to five years, the ascent of IP business has changed the spectrum of options for OEM engineers; standard peripherals have become inexpensive or free of royalty. Multimedia applications require SOC designs that combine to deliver performance otherwise unavailable for a reasonable price from separate chips. A discipline of reuse has reduced risk and improved time-to-market. Peripheral-rich ASICs have become a tougher competitor to MCUs, as have the recently introduced inexpensive FPGAs. ASSPs combining powerful RISC and DSP engines and accelerators with standard and advanced peripherals are succeeding as they target applications in cellular telephony, wireless, smart phones, PDAs, multimedia and digital cameras.

The new workloads and available solutions tend to further reduce MCU ASPs already eroding because of competition among MCU vendors and lowered costs for manufacturing. Although MCUs are going to continue to increase in unit shipments, price erosion is expected to make revenue less exciting than before. Worldwide MCU unit shipments will experience an 11.32 percent CAGR from 2001 to 2006, according to In-Stat/MDR. MCUs showed a modest increase in unit shipments even between 1999 and 2001 and have been hurt by less than 15 percent between 2000 and 2001. However, while unit shipments are expected to increase, recovery for revenues is expected to be slowing as annual price erosion takes its toll.

To gain market share, MCU vendors must compete by tackling advanced technologies, IP cores and data conversion. All of this must be coupled with an ability to continue to offer the MCU's original benefits: an updated vast array of peripherals, nonvolatile memory and commodity volume prices. Hitachi, for example, is planning products that will guarantee 10,000 times rewriting of flash memory with data retention periods of 10 years.

And though new embedded system workloads and the progress made in recent years in high chip integration have reduced one of the MCU's main advantages—that of being able to deliver a plethora of peripherals at a very low price—MCUs continue to be indispensable for many end-use applications.

OPPORTUNITIES:

A **microcontroller market** is a small, self-sufficient and CPU processing chip that is used to provide security in cryptography solutions. The main role of the microcontrollers is used control some or all the functions of the consumer electronic devices.

Increasing demand for connected devices coupled with increased adoption of internet of things technology would imply growth in the microcontroller market value. Increasing adoption of external flash memory for microcontrollers will also create lucrative growth opportunities for the microcontroller market in the long run. Rising incorporation of microcontrollers in the medical devices and equipment is also fostering the microcontroller market growth. Growing and expansion of automotive and electronics industries will further induce growth in the demand for microcontrollers.

3.a) **Mechanical Acuators:**

CAMS

A cam is a body which rotates or oscillate and in doing so, imparts a reciprocating or oscillatory motion to a second body called the follower , with which it is in contact

As the cam rotates so the follower is made to rise, dwell and fall; the length of times spent at each of these positions depends on the shape of the cam
The rise section: is the one that drives the follower upwards,
The fall section: is the one that lowers the follower . The dwell section is the one that allows the follower to remain at the same level for a significant period of time. It is circular with a radius that does not change

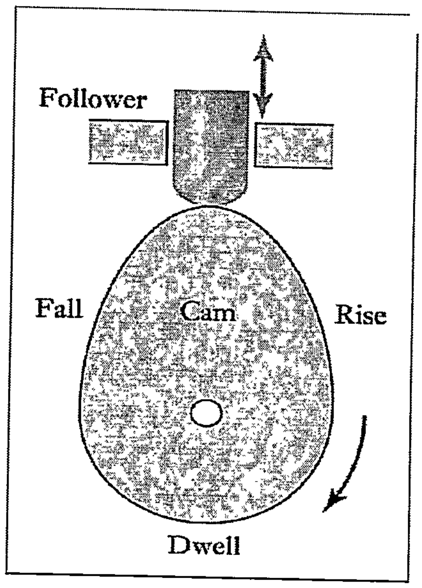
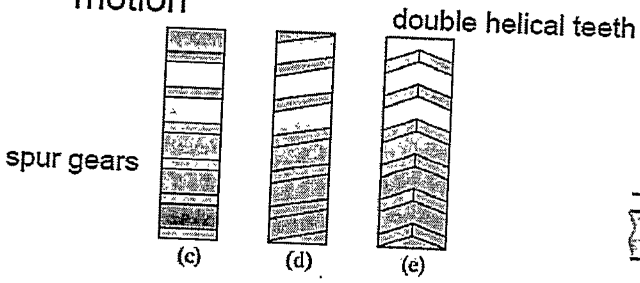


Figure Cam and cam follower

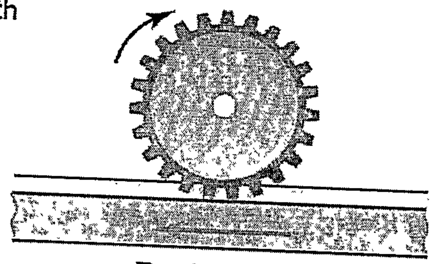
Gears

Forms of gears:

- parallel shaft gears:
- spur gears: have axial teeth with the teeth cut along axial lines parallel to the axis of the shaft
- helical gears: helical teeth with teeth being cut on helix
  helical gears have the advantage of smoother drive and prolonged life of gears, however, the inclination of the teeth results in an axial force component on the shaft bearing which can be overcome by using double helical teeth.
- Rack and pinion : are used to transfer linear to rotary motion



helical gears

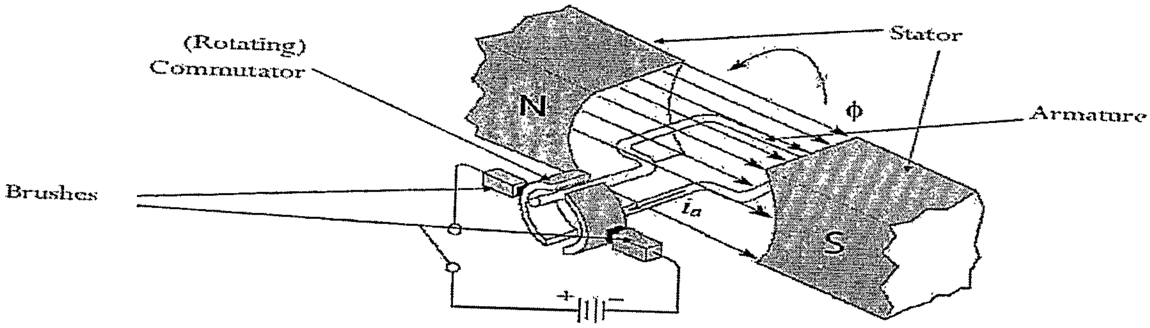

Rack and pinion

3.b)

- **DC Motors:**
- DC motors are very common in industry and have been used for a long time. In DC motors, the stator is a set of fixed permanent magnets, creating a fixed magnetic field, while the rotor carries a current. Through brushes and commutators, the direction of current is changed continuously, causing the rotor to rotate continuously.
- **AC Motors:**
- Electric AC motors are similar DC motors except that the rotor is permanent magnet, the stator houses the windings, and all commutators and brushes are eliminated.
- **Servo Motors:**
- A Servomotor is a DC,AC, brushless, or even stepper motor with feedback that can be controlled to move at a desired speed (and consequently, torque), for a desired angle of rotation. To do this, a feedback device sends signals to the controller circuit of the servomotor reporting its angular position and velocity. If as a result of higher loads, the velocity is larger than desired set value, the current is increased until the speed is equal to the desired value. If the speed signal shows that the velocity is larger than the desired, the current is reduced accordingly. If position feedback is used as well, the position signal is used to shut off the motor as the rotor approaches the desired angular position.

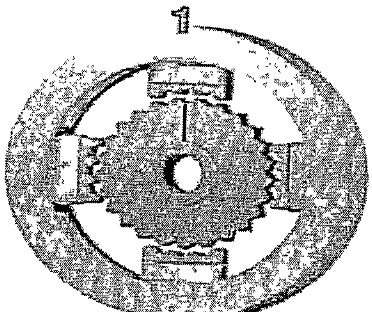
Components of a DC Electric Motor

- The principle components of an electric motor are:
  - North and south **magnetic poles** to provide a strong magnetic field. Being made of bulky ferrous material they traditionally form the outer casing of the motor and collectively form the **stator**
  - An **armature**, which is a cylindrical ferrous core rotating within the stator and carries a large number of windings made from one or more conductors
- A **commutator**, which rotates with the armature and consists of copper contacts attached to the end of the windings
- **Brushes** in fixed positions and in contact with the rotating commutator contacts. They carry direct current to the coils, resulting in the required motion

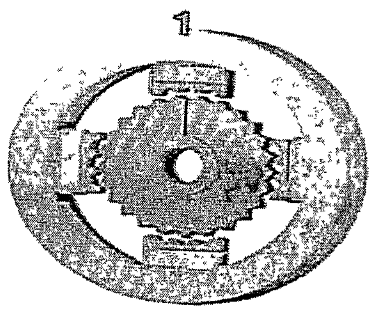


Stepper Motors

- When incremental rotary motion is required in a robot, it is possible to use **stepper motors**
- A stepper motor possesses the ability to move a specified number of revolutions or fraction of a revolution in order to achieve a fixed and consistent angular movement
- This is achieved by increasing the numbers of poles on both rotor and stator
- Additionally, soft magnetic material with many teeth on the rotor and stator cheaply multiplies the number of poles (reluctance motor)



- This figure illustrates the design of a stepper motor, arranged with four magnetic poles arranged around a central rotor
- Note that the teeth on the rotor have a slightly tighter spacing to those on the stator, this ensures that the two sets of teeth are close to each other but not quite aligned throughout



- Movement is achieved when power is applied for short periods to successive magnets
- Where pairs of teeth are least offset, the electromagnetic pulse causes alignment and a small rotation is achieved, typically 1-2°

4.a) **logic gate** is an elementary building block of a digital circuit. Most logic gates have two inputs and one output. At any given moment, every terminal is in one of the two binary conditions low (0) or high (1), represented by different voltage levels.

Logic Gates

AND gate

OR gate

NOT gate

NAND gate

NOR gate

Ex-OR gate

Ex-NOR gate

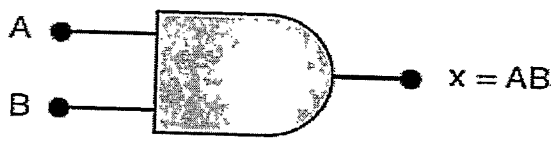
"AND" LOGIC GATE

- Two logic inputs, A and B, are combined using the AND operation (denoted by '.' symbol) to produce the output x (x, A, B are bits)
- The table shows that x is a logic 1 only when both A and B are at logic 1

AND

A	B	$x = A \cdot B$
0	0	0
0	1	0
1	0	0
1	1	1

Truth Table



AND gate

Circuit Symbol

"AND" LOGIC GATE

- Example: **The bus goes to A and B.** The success (truth) of the bus going to both places can be represented by x; thus 'x' occurs **only when** the bus goes to **both A and B**
- The Boolean expression for the AND operation is **F = A . B**
- The **period (.) sign** is not the **multiplicative** function, but means AND in logic

F = A AND B

AND

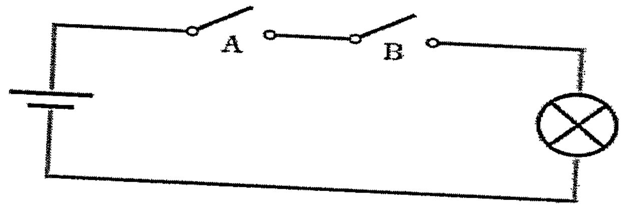
A	B	$x = A \cdot B$
0	0	0
0	1	0
1	0	0
1	1	1

"AND" LOGIC GATE

In an electric circuit, **AND** operation is equivalent to **two switches in series**

The lamp **F lights** (i.e. F = 1) only when **both switches are closed** (closed switch is represented by logic level 1)

i.e. **F = A . B**



"OR" LOGIC GATE

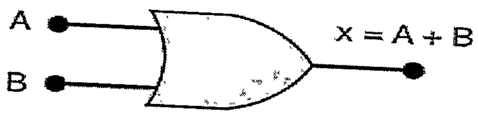
Two logic inputs, A and B, are combined using the OR operation (denoted by '+' symbol) to produce the output x (x, A, B are bits).

A truth table is a means for describing how a logic circuit's **output depends** on the logic levels present at the circuit's **inputs**

OR

A	B	x = A + B
0	0	0
0	1	1
1	0	1
1	1	1

Truth Table



OR Gate

Circuit Symbol

"OR" LOGIC GATE

Example: **The bus will go to A or B.** The success (truth) of the bus going to one or other can be represented by x; thus 'x' occurs when the bus goes to **either A or B or both** (it might travel through A to get to B or vice versa)

The Boolean expression for the OR operation is **x = A + B**

The **positive (+) sign** is **not** the **additive** function, but means OR in logic

x = A OR B

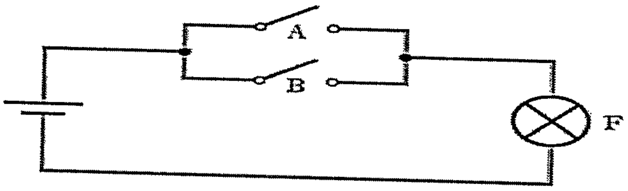
OR

A	B	x = A + B
0	0	0
0	1	1
1	0	1
1	1	1

"OR" Logic Gate

- In an electrical circuit, **OR** operation is equivalent to **two switches in parallel**
- The lamp F lights (F = 1) when either switch or both switches are closed (closed switch is represented by logic level 1)

i.e. $F = A + B$



"NOT" Logic Gate

The **NOT** operation is unlike the OR and AND operations because it is performed on a **single input** variable

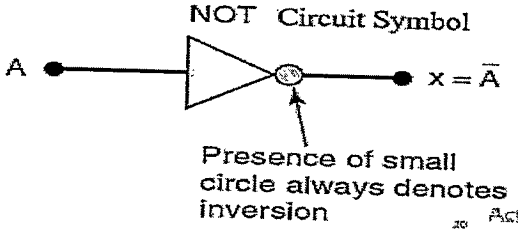
If the variable A is subjected to the NOT operation (also called inversion or complementation), the result x is expressed as $x = \bar{A}$ or $x = A'$

Truth Table

NOT

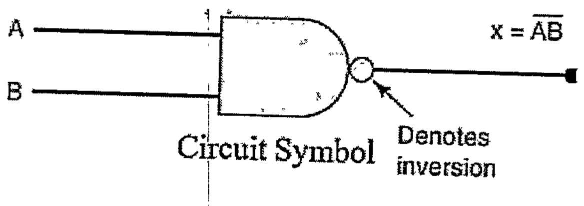
A	$x = \bar{A}$
0	1
1	0

NOT Circuit Symbol



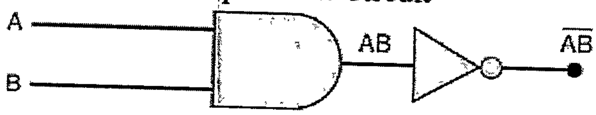
"NAND" Logic Gate

- NAND-gate operates like an AND-gate followed by an Inverter (NOT gate)
- The NAND-gate output ($x = \overline{A.B}$) is the exact inverse of the AND-gate



Circuit Symbol

Equivalent Circuit



Truth Table

		AND	NAND
A	B	AB	$\overline{AB}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

4. b) **Programmable Logic Controller:**

A programmable logic controller (PLC) is a specialized Programmable device which is used to control machines and processes.
It uses a programmable memory to store instructions and execute specific functions that include on/off control, timing, counting, sequencing, arithmetic, and data handling.

Advantages:

I. Increased Reliability
ii. More Flexibility
iii. Lower Cost
iv. Communications Capability
v. Faster Response Time
Vi. Easier to Troubleshoot

Disadvantages:

i. Requires training
ii. Fixed circuit operation
iii. Maintenance
iv. Cost
v. Propitiatory

5.a)

- Today's customers are demanding more variety and higher levels of flexibility in the products. Due to these demands and competition in the market, manufacturers are thriving to launch new/modified products to survive. It is reducing the product life as well as lead-time to manufacture a product. It is therefore essential to automate the manufacturing and assembly operations of a product. There are various activities involved in the product manufacturing process.
- Mechatronics concurrently employs the disciplines of mechanical, electrical, control and computer engineering at the stage of design itself. Mechanical discipline is employed in terms of various machines and mechanisms, where as electrical engineering as various electric prime movers viz. AC/DC, servo motors and other systems is used. Control engineering helps in the development of various electronics-based control systems to enhance or replace the mechanics of the mechanical systems. Computers are widely used to write various softwares to control the control systems; product design and development activities; materials and manufacturing resource planning, record keeping, market survey, and other sales related activities.

5.b) **Applications of Fuzzy logic control**

1. Vehicle primary suspensions
2. Passive damping
3. Active damping

4. Semi active damping
5. Modeling of quarter car model
6. Fuzzy logic controller for rotary crane system automation
7. Modeling of the rotary crane
8. Controller design
9. Fuzzy lozic controller for point to point position control

NARASARAOPETA ENGINEERING COLLEGE (AUTONOMOUS)

IV B.Tech I Semester Regular Examinations, November-2022

Sub Code: 19BME7TH0I

Time: 3 hours

MECHATRONICS

(ME)

Max. Marks: 60

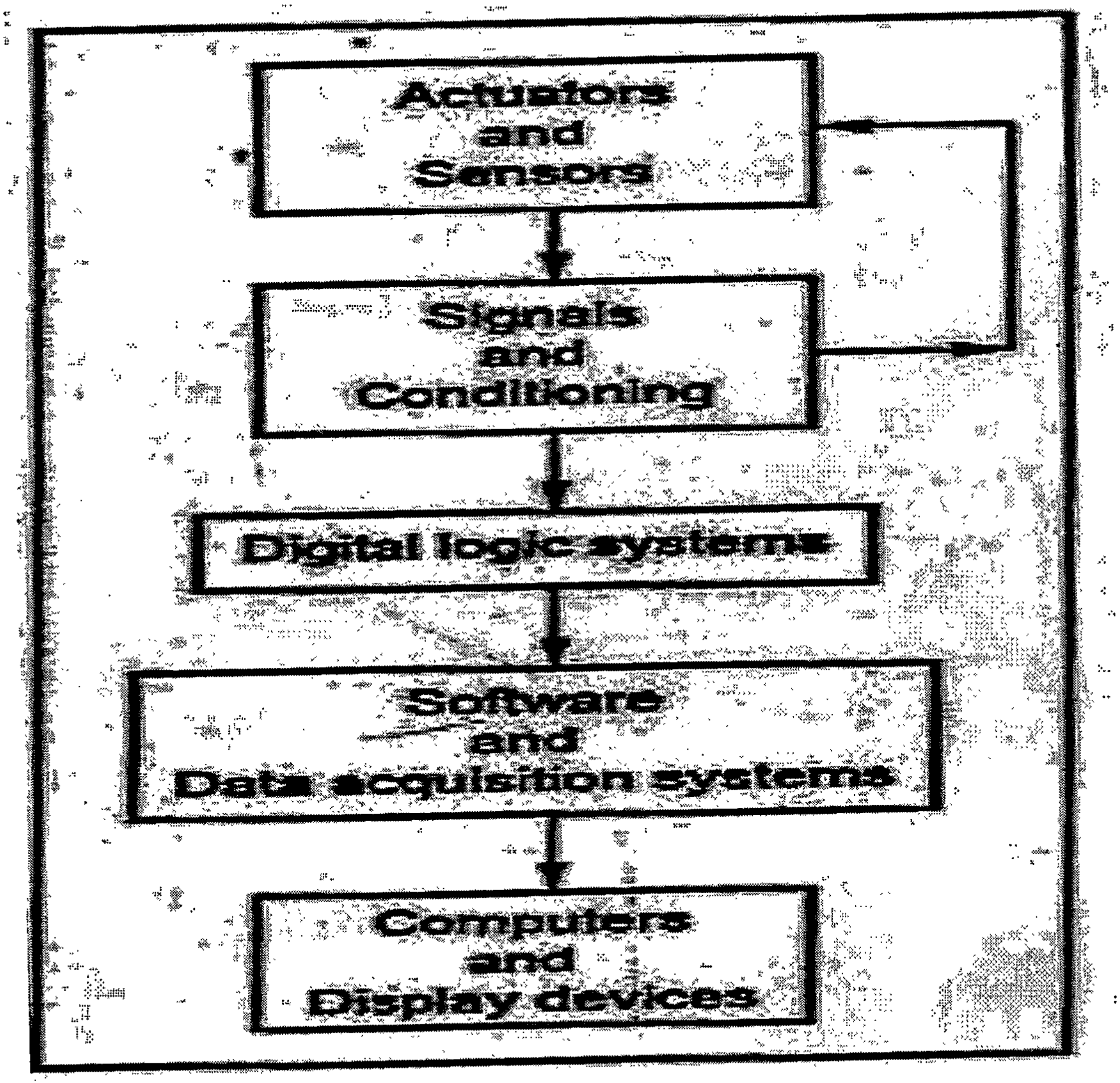
Note: Answer All FIVE Questions.

All Questions Carry Equal Marks (5 X 12 = 60M)

Q.No		Questions	KL	CO	M
		Unit-I			
1	a	What are the components of Mechatronic system? Explain their importance in detail.	K1	01	12M
		OR			
	b	Explain the working of translational mechanical system with spring, damper and mass.	K3	01	12M
		Unit-II			
2	a	Discuss about the microcontroller Technology.List out the advantages and disadvantages of microcontrollers.	K2	02	12M
		OR			
	b	List out the applications, opportunities and challenges of Microcontrollers.	K2	02	12M
		Unit-III			
3	a	Explain any two types of Mechanical actuation system with neat sketches.	K3	03	12M
		OR			
	b	Explain in brief about the following 1. DC motors, 2. AC motors, 3. stepped motor.	K3	03	12M
		Unit-IV			
4	a	What are Logic gates? Explain about any 3 types of logic gates with examples.	K3	04	12M
		OR			
	b	What is a Programmable logic controller (PLC). Discuss the advantages and drawbacks of using the PLC's.	K2	04	12M
		Unit-V			
5	a	Explain the importance of mechatronics in automation and how is it useful for industrial automation.	K3	05	12M
		OR			
	b	Explain Fuzzy logic applications on mechatronics with suitable examples	K3	05	12M

KL: Blooms Taxonomy Knowledge Level CO: Course Outcome M:Marks

1.a) **Components of mechatronic Systems:**



Actuators: Solenoids, DC motors, Stepper motors, Servo motors, Hydraulics and Pneumatics.

Sensors: Switches, Pots, Photoelectric, Encoders, Strain gauges, Thermocouples, Accelerometers etc..

Input signal conditioning and Interfacing: Amplifiers, Filters, A/D and D/A.

Digital control architecture: Logic circuits, Microcontrollers, PLC, Sequencing and Timing, Communication, Control algorithms, Logic and Arithmetic algorithms.

Output signal conditioning and Interfacing: D/A and A/D Converters, 'Amplifiers, PMC erc..

Graphical display: CRT, LCD, LED, CCD.

1.b) MECHANICAL TRANSLATIONAL SYSTEMS :

The model of mechanical translational systems can be obtained by using three basic elements Mass, spring and Dash-Pot. These three elements represent three essential phenomena which occur in various ways in mechanical systems.

List of Symbols Used In Mechanical Translational System

x = Displacement, m.

v = $\frac{dx}{dt}$ Velocity, m/sec^2

a= $\frac{dv}{dt}=\frac{d^2x}{dt^2}$ Acceleration, m/sec^2

f = Applied force, N (Newton's)

f_m = Opposing force offered by mass of the body, N

f_k = Opposing force offered by the elasticity of the body (spring), N

f_b = Opposing force offered by the friction of the body (dash – pot), N

M = Mass, kg

K = Stiffness of spring, N/m

B = Viscous friction co – efficient, N – sec/m

Note: Lower case letters are functions of time.

Mass

Consider an ideal mass element shown in figure1.3which has negligible friction and elasticity. Let a force be applied on it. The mass will offer an opposing force which is proportional to acceleration of the body.

Let f = Applied force

f_m= Opposing force due to mass

Here $f_m \alpha$ a

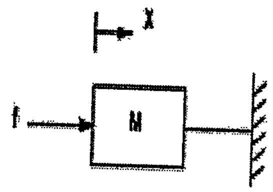


Figure 1.3

$$f_m \,\alpha\, \frac{d^2x}{dt^2} \text{ or } f_m = M\frac{d^2x}{dt^2}$$

By Newton's second law, $f = f_m = M\frac{d^2x}{dt^2}$ .... (1)

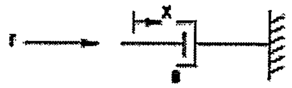


Figure 1.4

Dash-Pot

Consider an ideal frictional element dashpot shown in figure 1.4 which has negligible mass and elasticity. Let a force be applied on it. The dash-pot will offer an opposing force which is proportional to velocity of the body.

Let f = Applied force

f_b= Opposing force due to friction

Here, $f_b \alpha v$

$f_b \alpha \frac{dx}{dt}$ or $fb = B\frac{dx}{dt}$

By Newton's second law, $f = f_b = B\frac{dx}{dt}$ ...... (2)

When the dashpot has displacement at both ends as shown in figure 1.5 the opposing force is proportional to differential velocity.

$f_b \alpha \frac{d(x_1-x_2)}{dt}$; $f_b = B\frac{d(x_1-x_2)}{dt}$

$\therefore f = f_b = B\frac{d(x_1-x_2)}{dt}$ ...... (3)

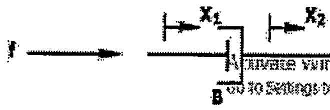


Figure 1.5

Spring

Consider an ideal elastic element spring shown in figure 1.6 which has negligible mass and friction. Let a force be applied on it. The spring will offer an opposing force which is proportional to displacement of the body.

Let f = Applied force

f_k= opposing force due to elasticity

Here $f_k \propto x$ or $f_k = Kx$

By Newton's second law, $f = f_k = Kx$ ...... (4)

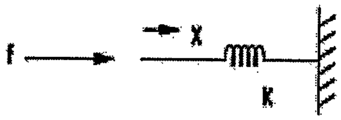


Figure 1.6

When the spring has displacement at both ends as shown in figure 1.7 the opposing force is proportional to differential displacement.

$$f_k \propto (x_1 - x_2)$$

$$f_k = K(x_1 - x_2)$$

$$\therefore f = f_k = K(x_1 - x_2) \quad ......(5)$$

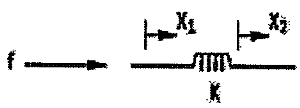


Figure 1.7

2.a) A **Microcontroller** is a VLSI (Very Large Scale Integration) Integrated Circuit (IC) that contains electronic computing unit and logic unit (combinedly known as CPU), Memory (Program Memory and Data Memory), I/O Ports (Input / Output Ports) and few other components integrated on a single chip.

A **Microcontroller** is a small and low-cost microcomputer, which is designed to perform the specific tasks of embedded systems like displaying microwave's information, receiving remote signals etc.

Basically, a Microcontroller consists of the following components.

- Central Processing Unit (CPU)
- Program Memory (ROM – Read Only Memory)
- Data Memory (RAM – Random Access Memory)
- Timers and Counters
- I/O Ports (I/O – Input/Output)
- Serial Communication Interface
- Clock Circuit (Oscillator Circuit)
- Interrupt Mechanism

Most modern Microcontrollers might contain even more peripherals like SPI (Serial Peripheral Interface), I2C (Inter Integrated Circuit), ADC (Analog to Digital Converter), DAC (Digital to Analog Converter), CAN (Controlled Area Network), USB (Universal Serial Bus), and many more.

Advantages of Microcontrollers

1. A Microcontroller is a true device that fits the computer-on-a-chip idea.

2. No need for any external interfacing of basic components like Memory, I/O Ports, etc.

3. Microcontrollers doesn't require complex operating systems as all the instructions must be written and stored in the memory. (RTOS is an exception).

4. All the Input/Output Ports are programmable.

5. Integration of all the essential components reduces the cost, design time and area of the product (or application).

Disadvantages of Microcontrollers

1. Microcontrollers are not known for their computation power.

2. The amount of memory limits the instructions that a microcontroller can execute.

3. No Operating System and hence, all the instruction must be written.

2.b) **Applications of Microcontrollers**

There are huge number of applications of Microcontrollers. In fact, the entire embedded systems industry is dependent on Microcontrollers. The following are few applications of Microcontrollers.

- Front Panel Controls in devices like Oven, washing Machine etc.
- Function Generators
- Smoke and Fire Alarms
- Home Automation Systems
- Automatic Headlamp ON in Cars
- Speed Sensed Door Locking System

NEW CHALLENGES FOR MICROCONTROLLERS

Hidden inside expensive systems and commodity appliances, microcontrollers (MCUs) continue to provide OEMs with quick, inexpensive solutions and semiconductor vendors with important sources of revenue. As defined by the Semiconductor Industry Association (SIA), an MCU is a chip that contains a processor core and nonvolatile memory such as ROM, one-time-programmable memory (OTP), EEPROM or flash memory. The MCU can and does contain other forms of on-chip memory, peripherals and even mixed signal data converters—A/D and D/A. Some MCUs can generate audio, drive LCD displays and connect to multiple bus standards. The MCU's low average selling price (ASP) and widespread use in digital electronics has prompted some semiconductor vendors to tag even processors without nonvolatile memory with the MCU name—thus sending the message of low price and high volume.

The MCU's scenario, however, is changing. There were fewer low-risk, fast time-to-market competing solutions. One could use a bare RISC processor augmented by the peripherals of an adequate microcontroller, and possibly add a small, low-development risk ASIC. Bare processors used to consume high power—an MCU could stay awake and turn on the high-performance (and high-power consumption) processor only when needed.

During the past four to five years, the ascent of IP business has changed the spectrum of options for OEM engineers; standard peripherals have become inexpensive or free of royalty. Multimedia applications require SOC designs that combine to deliver performance otherwise unavailable for a reasonable price from separate chips. A discipline of reuse has reduced risk and improved time-to-market. Peripheral-rich ASICs have become a tougher competitor to MCUs, as have the recently introduced inexpensive FPGAs. ASSPs combining powerful RISC and DSP engines and accelerators with standard and advanced peripherals are succeeding as they target applications in cellular telephony, wireless, smart phones, PDAs, multimedia and digital cameras.

The new workloads and available solutions tend to further reduce MCU ASPs already eroding because of competition among MCU vendors and lowered costs for manufacturing. Although MCUs are going to continue to increase in unit shipments, price erosion is expected to make revenue less exciting than before. Worldwide MCU unit shipments will experience an 11.32 percent CAGR from 2001 to 2006, according to In-Stat/MDR. MCUs showed a modest increase in unit shipments even between 1999 and 2001 and have been hurt by less than 15 percent between 2000 and 2001. However, while unit shipments are expected to increase, recovery for revenues is expected to be slowing as annual price erosion takes its toll.

To gain market share, MCU vendors must compete by tackling advanced technologies, IP cores and data conversion. All of this must be coupled with an ability to continue to offer the MCU's original benefits: an updated vast array of peripherals, nonvolatile memory and commodity volume prices. Hitachi, for example, is planning products that will guarantee 10,000 times rewriting of flash memory with data retention periods of 10 years.

And though new embedded system workloads and the progress made in recent years in high chip integration have reduced one of the MCU's main advantages—that of being able to deliver a plethora of peripherals at a very low price—MCUs continue to be indispensable for many end-use applications.

OPPORTUNITIES:

A **microcontroller market** is a small, self-sufficient and CPU processing chip that is used to provide security in cryptography solutions. The main role of the microcontrollers is used control some or all the functions of the consumer electronic devices.

Increasing demand for connected devices coupled with increased adoption of internet of things technology would imply growth in the microcontroller market value. Increasing adoption of external flash memory for microcontrollers will also create lucrative growth opportunities for the microcontroller market in the long run. Rising incorporation of microcontrollers in the medical devices and equipment is also fostering the microcontroller market growth. Growing and expansion of automotive and electronics industries will further induce growth in the demand for microcontrollers.

3.a) **Mechanical Acuators:**

CAMS

A cam is a body which rotates or oscillate and in doing so, imparts a reciprocating or oscillatory motion to a second body called the follower , with which it is in contact

As the cam rotates so the follower Is made to rise, dwell and fall; the length of times spent at each of these positions depends on the shape of the cam
The rise section: is the one that drives the follower upwards,
The fall section: Is the one that lowers the follower . The dwell section is the one that allows the follower to remain at the same level for a significant period of time. It is circular with a radius that does not change

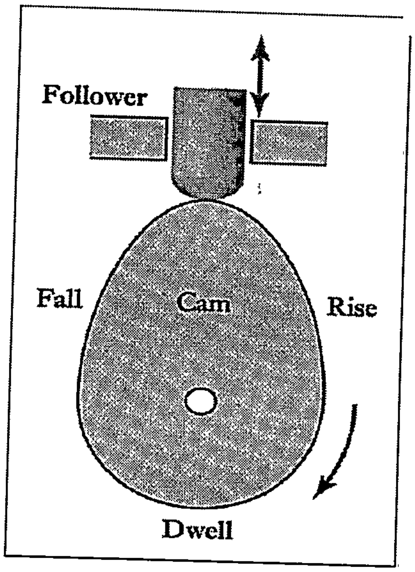
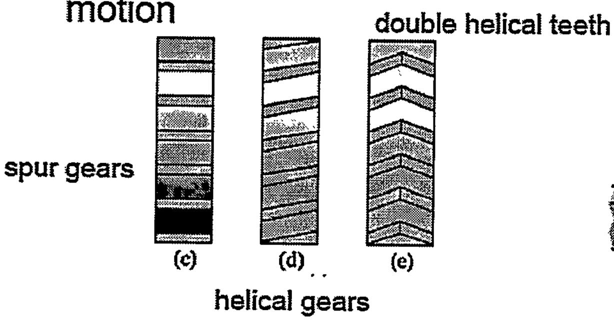


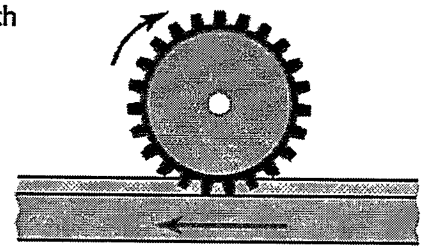
Figure Cam and cam follower

Gears

Forms of gears:

- parallel shaft gears:
- spur gears: have axial teeth with the teeth cut along axial lines parallel to the axis of the shaft
- helical gears: helical teeth with teeth being cut on helix
  helical gears have the advantage of smoother drive and prolonged life of gears, however, the inclination of the teeth results in an axial force component on the shaft bearing which can be overcome by using double helical teeth.
- Rack and pinion : are used to transfer linear to rotary motion





Rack and pinion

3.b)

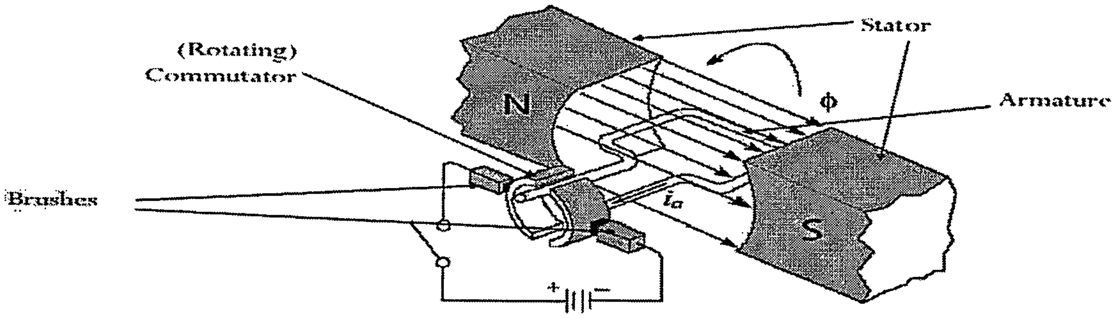
- **DC Motors:**
- DC motors are very common in industry and have been used for a long time. In DC motors, the stator is a set of fixed permanent magnets, creating a fixed magnetic field, while the rotor carries a current. Through brushes and commutators, the direction of current is changed continuously, causing the rotor to rotate continuously.
- **AC Motors:**
- Electric AC motors are similar DC motors except that the rotor is permanent magnet, the stator houses the windings, and all commutators and brushes are eliminated.
-

Servo Motors:

- A Servomotor is a DC,AC, brushless, or even stepper motor with feedback that can be controlled to move at a desired speed (and consequently, torque), for a desired angle of rotation. To do this, a feedback device sends signals to the controller circuit of the servomotor reporting its angular position and velocity. If as a result of higher loads, the velocity is larger than desired set value, the current is increased until the speed is equal to the desired value. If the speed signal shows that the velocity is larger than the desired, the current is reduced accordingly. If position feedback is used as well, the position signal is used to shut off the motor as the rotor approaches the desired angular position.

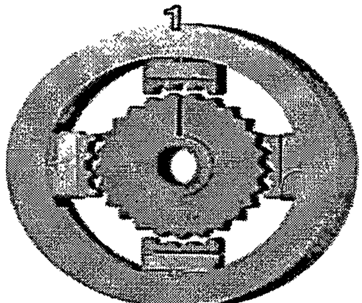
Components of a DC Electric Motor

- The principle components of an electric motor are:
  - North and south **magnetic poles** to provide a strong magnetic field. Being made of bulky ferrous material they traditionally form the outer casing of the motor and collectively form the **stator**
  - An **armature**, which is a cylindrical ferrous core rotating within the stator and carries a large number of windings made from one or more conductors
- A **commutator**, which rotates with the armature and consists of copper contacts attached to the end of the windings
- **Brushes** in fixed positions and in contact with the rotating commutator contacts. They carry direct current to the coils, resulting in the required motion

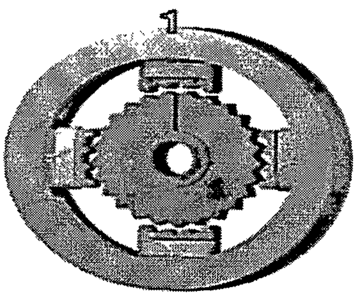


Stepper Motors

- When incremental rotary motion is required in a robot, it is possible to use **stepper motors**
- A stepper motor possesses the ability to move a specified number of revolutions or fraction of a revolution in order to achieve a fixed and consistent angular movement
- This is achieved by increasing the numbers of poles on both rotor and stator
- Additionally, soft magnetic material with many teeth on the rotor and stator cheaply multiplies the number of poles (reluctance motor)



- This figure illustrates the design of a stepper motor, arranged with four magnetic poles arranged around a central rotor
- Note that the teeth on the rotor have a slightly tighter spacing to those on the stator, this ensures that the two sets of teeth are close to each other but not quite aligned throughout



- Movement is achieved when power is applied for short periods to successive magnets
- Where pairs of teeth are least offset, the electromagnetic pulse causes alignment and a small rotation is achieved, typically 1–2°

4.a) **logic gate** is an elementary building block of a digital circuit. Most logic gates have two inputs and one output. At any given moment, every terminal is in one of the two binary conditions low (0) or high (1), represented by different voltage levels.

Logic Gates

AND gate

OR gate

NOT gate

NAND gate

NOR gate

Ex-OR gate

Ex-NOR gate

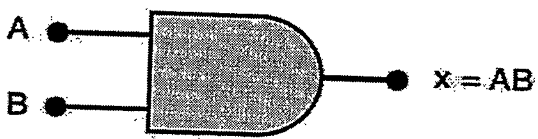
"AND" LOGIC GATE

- Two logic inputs, A and B, are combined using the AND operation (denoted by '.' symbol) to produce the output x (x, A, B are bits)
- The table shows that x is a logic 1 only when both A and B are at logic 1

AND

A	B	x = A • B
0	0	0
0	1	0
1	0	0
1	1	1

Truth Table



AND gate

Circuit Symbol

"AND" LOGIC GATE

- Example: **The bus goes to A and B.** The success (truth) of the bus going to both places can be represented by x; thus 'x' occurs **only when** the bus goes to **both A and B**
- The Boolean expression for the AND operation is **F = A . B**
- **The period (.) sign is not the multiplicative function,** but means AND in logic

F = A AND B

AND

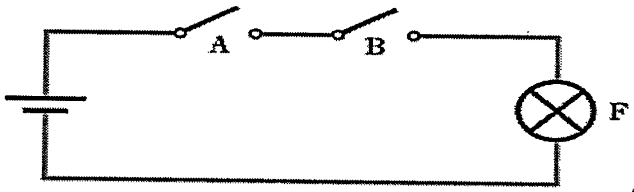
A	B	x = A • B
0	0	0
0	1	0
1	0	0
1	1	1

"AND" Logic Gate

In an electric circuit, **AND** operation is equivalent to **two switches in series**

The lamp **F lights** (i.e. F = 1) only when **both switches are closed** (closed switch is represented by logic level 1)

i.e. **F = A . B**



"OR" Logic Gate

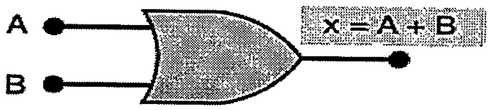
Two logic inputs, A and B, are combined using the OR operation (denoted by '+' symbol) to produce the output x (x, A, B are bits).

A truth table is a means for describing how a logic circuit's **output depends** on the logic levels present at the circuit's **inputs**

OR

A	B	x = A + B
0	0	0
0	1	1
1	0	1
1	1	1

Truth Table



OR Gate
Circuit Symbol

"OR" Logic Gate

Example: **The bus will go to A or B.** The success (truth) of the bus going to one or other can be represented by x; thus 'x' occurs when the bus goes to **either A or B or both** (it might travel through A to get to B or vice versa)

The Boolean expression for the OR operation is **x = A + B**

The positive (+) sign is not the additive function, but means OR in logic

x = A OR B

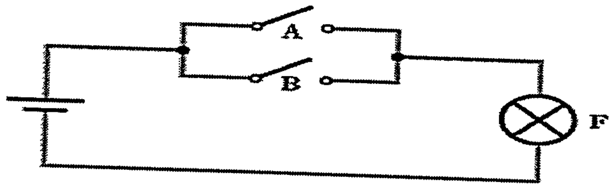
OR

A	B	x = A + B
0	0	0
0	1	1
1	0	1
1	1	1

“OR” LOGIC GATE

- In an electrical circuit, **OR** operation is equivalent to **two switches in parallel**
- The lamp F lights (F = 1) when either switch or both switches are closed (closed switch is represented by logic level 1)

i.e. F = A + B



“NOT” LOGIC GATE

The **NOT** operation is unlike the OR and AND operations because it is performed on a **single input** variable

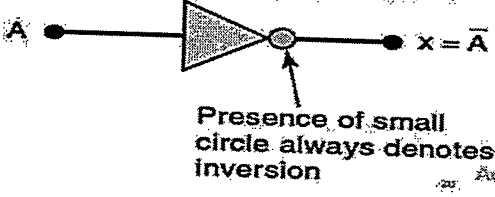
If the variable A is subjected to the NOT operation (also called inversion or complementation), the result x is expressed as $x = \bar{A}$ or $x = A'$

Truth Table

NOT

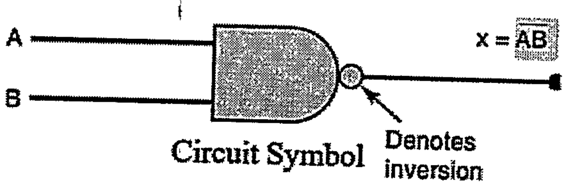
A	$x = \bar{A}$
0	1
1	0

NOT Circuit Symbol



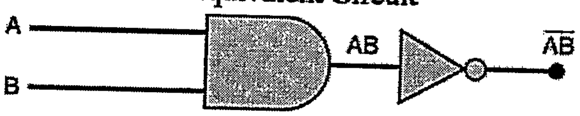
“NAND” LOGIC GATE

- NAND-gate operates like an AND-gate followed by an Inverter (NOT gate)
- The NAND-gate output ($x = \overline{A.B}$) is the exact inverse of the AND-gate



Circuit Symbol

Equivalent Circuit



Truth Table

A	B	AND: AB	NAND: $\overline{AB}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

4. b) **Programmable Logic Controller:**

A programmable logic controller (PLC) is a specialized Programmable device which is used to control machines and processes.
It uses a programmable memory to store instructions and execute specific functions that include on/off control, timing, counting, sequencing, arithmetic, and data handling.

Advantages:

I. Increased Reliability
ii. More Flexibility
iii. Lower Cost
iv. Communications Capability
v. Faster Response Time
Vi. Easier to Troubleshoot

Disadvantages:

i. Requires training
ii. Fixed circuit operation
iii. Maintenance
iv. Cost
v. Propitiatory

5.a)

- Today's customers are demanding more variety and higher levels of flexibility in the products. Due to these demands and competition in the market, manufacturers are thriving to launch new/modified products to survive. It is reducing the product life as well as lead-time to manufacture a product. It is therefore essential to automate the manufacturing and assembly operations of a product. There are various activities involved in the product manufacturing process.
- Mechatronics concurrently employs the disciplines of mechanical, electrical, control and computer engineering at the stage of design itself. [illegible] engineering helps in the development of various electronics based control systems to enhance or replace the mechanics of the mechanical systems. Computers are widely used to write various softwares to control the control systems; product design and development activities; materials and manufacturing resource planning, record keeping, market survey, and other sales related activities.

5.b) **Applications of Fuzzy logic control**

1. Vehicle primary suspensions
2. Passive damping
3. Active damping

4. Semi active damping

5. Modeling of quarter car model

6. Fuzzy logic controller for rotary crane system automation

7. Modeling of the rotary crane

8. Controller design

9. Fuzzy lozic controller for point to point position control

Narasaraopeta Engineering College (Autonomous)
Kotappakonda Road, Yellamanda (P.O), Narasaraopet- 522601, Guntur District, AP.

Subject Code: R16ME4201

IV B.Tech II Semester Regular & Supple Examinations, June-2022

MECHATRONICS

(ME)

Time: 3 hours Max Marks: 60

Question Paper Consists of Part-A and Part-B.

Answering the question in Part-A is Compulsory & Four Questions should be answered from Part-B

All questions carry equal marks of 12.

PART-A

1 a) Brief evolution of mechatronics. [CO1,K1,2M]
b) State the transduction principle. [CO2,K1,2M]
c) List out the different types of actuators. [CO3,K1,2M]
d) What is Hexa decimal system? [CO4,K1,2M]
e) Explain the principle of sensor. [CO5,K1,2M]
f) State the role of Digital Controller in mechatronics system. [CO6,K1,2M]

[2+2+2+2+2+2]

PART-B

4 X 12 = 48

2 a) List the various measurement systems in mechatronics. [CO1,K1,4M]
b) Explain the working of any one pneumatic actuator and state its advantages. [CO1,K2,8M]

3 a) Explain the working of any one capacitive transducer and state its advantages. [CO2,K2,6M]
b) Sketch and explain hall effect transducer.[CO2,K2,6M]

4 a) What is meant by Electrical actuation system? Explain the devices used in such systems. [CO3,K2,6M]
b) Explain the working principle in piezoelectric actuators.[CO3,K2,6M]

5 a) Explain the following logic gates [CO4,K2,8M]
i) AND ii) OR iii) NOT iv) NAND
b) Enlist applications of logic gates. [CO4,K2,4M]

6 a) Explain the different micro sensors used in mechatronics. [CO3,K2,6M]
b) What is significance role of artificial intelligence in mechatronics?[CO3,K1,6M]

7 a) Classify the different types of Process Controllers? Distinguish them in detail. [CO6,K2,8M]
b) Explain the basic standard symbols used in ladder diagram for programming PLC.[CO6,K2,4M]

***

PART-A

1. a) **Evaluation of Mechatronics**

The technology has evolved through several stages that are termed as levels. The evolution levels of Mechatronics are:

1. Primary level Mechatronics (first) 2. Secondary level Mechatronics (second)
3. Tertiary level Mechatronics (third) 4. Quaternary level Mechatronics (fourth)

b. Transducer Principles

Basic principle of the transducer is to use a current source (or voltage source and a voltage regulator) and an amplifier generates a voltage signal (V out) as outlined in. It Convert on form of singnal to another form of signal.

c. Different Types of Actuators

1. Hydraulic Actuators. 2. Pneumatic Actuators. 3. Electric Actuators

d. hexadecimal number system

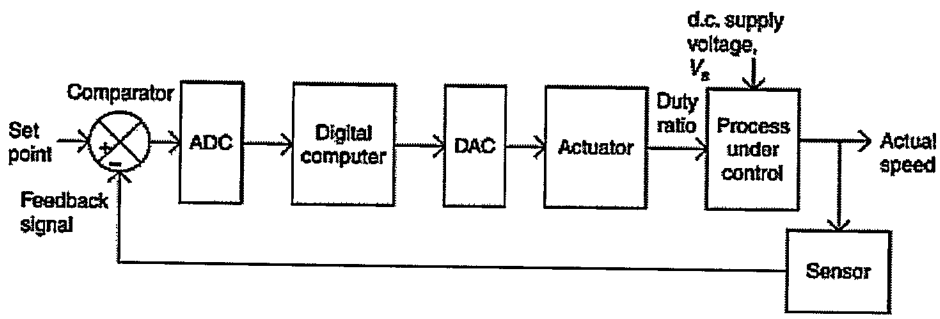
The hexadecimal number system is a type of number system, that has a base value equal to 16. It is also pronounced sometimes as 'hex'. Hexadecimal numbers are represented by only 16 symbols. These symbols or values are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E and F. Each digit represents a decimal value. For example, D is equal to base-10 13.

e. Sensor Principle.

Sensor produces a usable output in response to a specified quantity. it uses the sensing principle, that is it senses or detects a physical phenomenon.

f. digital controller

A digital controller is a system used for controlling closed-loop feedback systems as shown in Figure. The controller implements algebraic algorithms such as filters and compensatory to regulate, correct, or change the behaviour of the controlled system.



PART-B

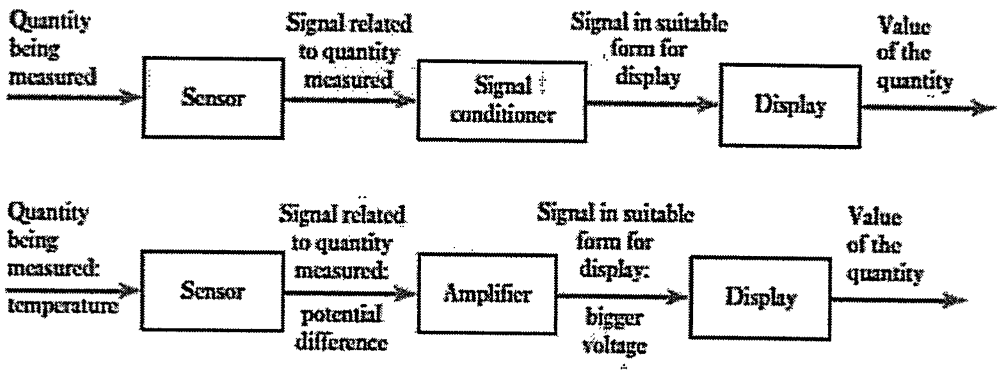
2.a)

1. A sensor which responds to the quantity being measured by giving as its output a signal which is related to the quantity. For example, a thermocouple is a temperature sensor.

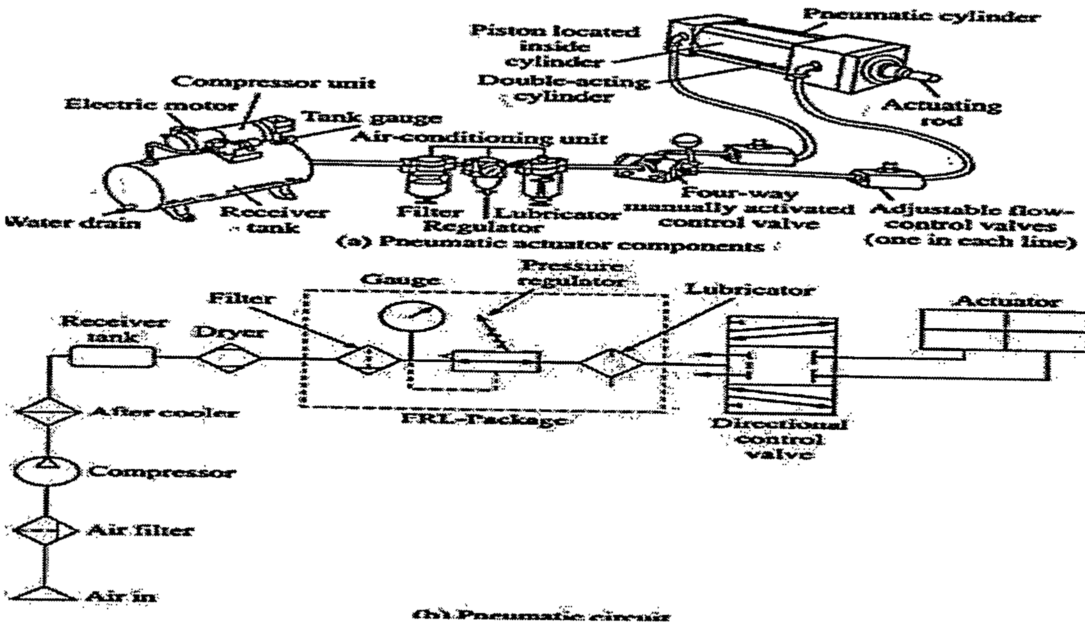
2. A signal conditioner takes the signal from the sensor and manipulates it into a condition which is suitable for either display or in the case of a control system, for use to exercise control.

3. A display system where the output from the signal conditioner is displayed.

A measurement system and its constituent elements.



2. b)



The structure is similar to that of hydraulic actuator

• Use air pressure to drive the pneumatic cylinder

Advantages: – clean and small. – cheap

Disadvantage: –

difficult to control position precisely

• Mainly used in opening control of robot grippers.

3.a) Capacitive Transducer

Definition: The capacitive transducer is used for measuring the displacement, pressure and other physical quantities. It is a passive transducer that means it requires external power for operation. The capacitive transducer works on the principle of variable capacitance. The capacitance of the capacitive transducer changes because of many reasons like overlapping of plates, change in distance between the plates and dielectric constant.

The capacitive transducer contains two parallel metal plates. These plates are separated by the dielectric medium which is either air, material, gas or liquid. In the normal capacitor the distance between the plates are fixed, but in capacitive transducer the distance between them are varied.

The capacitive transducer uses the electrical quantity of capacitance for converting the mechanical movement into an electrical signal. The input quantity causes the change of the capacitance which is directly measured by the capacitive transducer.

The capacitors measure both the static and dynamic changes. The displacement is also measured directly by connecting the measurable devices to the movable plate of the capacitor. It works on with both the contacting and non-contacting modes.

Principle of Operation

The equations below express the capacitance between the plates of a capacitor

$$C = \varepsilon A/d$$

$$C = \varepsilon_r \varepsilon_0 A/d$$

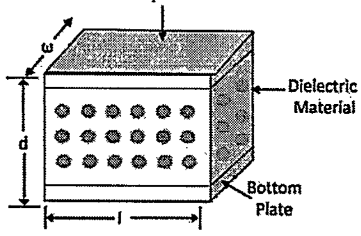
Where A – overlapping area of plates in m2
d – the distance between two plates in meter
ε – permittivity of the medium in F/m
εr – relative permittivity
ε0 – the permittivity of free space
The schematic diagram of a parallel plate capacitive transducer is shown in the figure below. The change in capacitance occurs because of the physicals variables like displacement, force, pressure, etc. The capacitance of the transducer also changes by the variation in their dielectric constant which is usually because of the measurement of liquid or gas level
The capacitance of the transducer is measured with the bridge circuit. The output impedance of transducer is given as

$$X_c = 1/2\pi f c$$

Where, C – capacitance
f – frequency of excitation in Hz.

The capacitive transducer is mainly used for measurement of linear displacement. The capacitive transducer uses the following three effects.

1. Variation in capacitance of transducer is because of the overlapping of capacitor plates.
2. The change in capacitance is because of the change in distances between the plates.
3. The capacitance changes because of dielectric constant.



Parallel Plate Capacitive Transducer

Advantages of Capacitive Transducers.

1. It requires an external force for operation and hence very useful for small systems.
2. The capacitive transducer is very sensitive.
3. It gives good frequency response because of which it is used for the dynamic study.
4. The transducer has high input impedance hence they have a small loading effect.
5. It requires small output power for operation.

3.b) Hall Effect Transducer

Definition: The Hall Effect element is a type of transducer used for measuring the magnetic field by converting it into an emf. The direct measurement of the magnetic field is not possible. Thus the Hall Effect Transducer is used. The transducer converts the magnetic field into an electric quantity which is easily measured by the analogue and digital meters.

Principle of Hall Effect Transducer

The principle of Hall Effect transducer is that if the current carrying strip of the conductor is placed in a transverse magnetic field, then the EMF develops on the edge of the conductor. The magnitude of the develop voltage depends on the density of flux, and this property of a conductor is called the Hall Effect. The Hall Effect element is mainly used for magnetic measurement and for sensing the current.

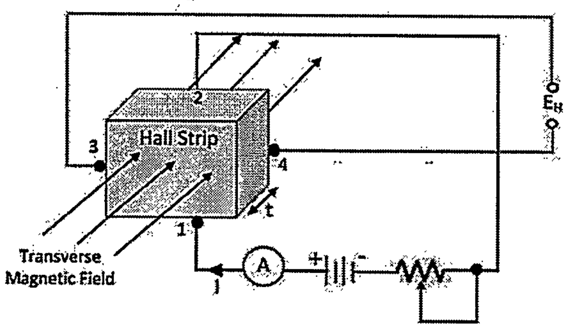
The metal and the semiconductor has the property of hall effect which depends on the densities and the mobility of the electrons. Consider the hall effect element shown in the figure below. The current supply through the lead 1 and 2 and the output is obtained from the strip 3 and 4. The lead 3 and 4 are at same potential when no field is applied across the strip.

When the magnetic field is applied to the strip, the output voltage develops across the output leads 3 and 4. The develops voltage is directly proportional to the strength of the material.

The output voltage is

$$E_H = K_H I B / t$$

where,



Hall Effect Element

$$K_H - Hall\ effect\ coefficient;\ \frac{V-m}{A-Wbm^{-2}}$$

$$t - thickness\ of\ Strip;m$$

The I is the current in ampere and the B is the flux densities in Wb/m2

The current and magnetic field strength both can be measured with the help of the output voltages. The hall effect EMF is very small in conductors because of which it is difficult to measure. But semiconductors like germanium produces large EMF which is easily measured by the moving coil instrument.

4.a) It is one of the cleanest and readily available forms of actuating system as it does not involve oil; as there is no need to compress air, hence no extra machinery. Electrical energy is always available on ship. The electrical energy is used to actuate a mechanical system using magnetic field i.e. EMF. Basic example are electrical motor operated valve and magnetic valve actuator or solenoid valve. An electric actuator is powered by a motor that converts electrical energy into mechanical torque. The electrical energy is used to actuate equipment such as multi-turn valves. Additionally, a brake is typically installed above the motor to prevent the media from opening valve. If no brake is installed, the actuator will uncover the opened valve and rotate it back to its closed position. If this continues to happen, the motor and actuator will eventually become damaged.[6] It is one of the cleanest and most readily available forms of actuator because it does not directly involve oil or other fossil fuels

1. **Switching devices** – mechanical switches, eg. relay and solid state switches, eg diodes, thyristors and transistors app – switch on or off electrical devices
2. **Solenoid** – type devices used to actuate valves of hydraulic and pneumatic systems. (flow control)
3. **Drive systems** – DC motor, AC motor and stepper motor.

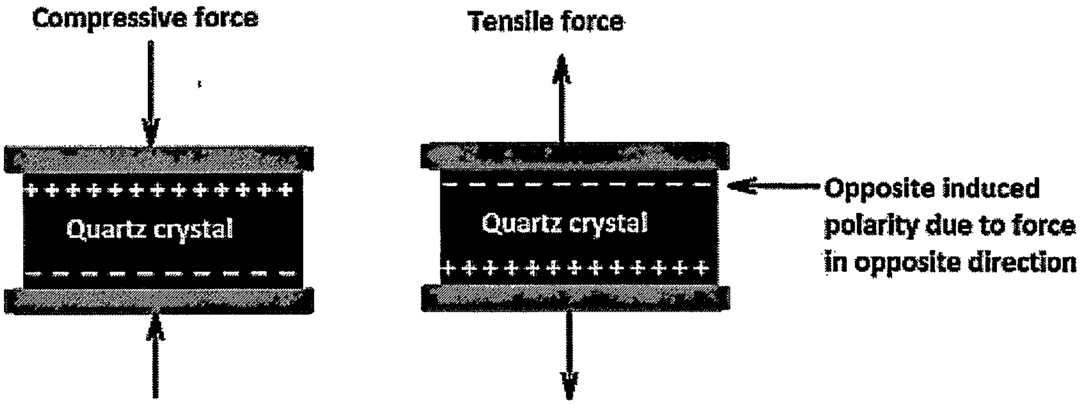
4.b) Piezoelectric Transducer Working

In a piezoelectric transducer, a piezoelectric material like quartz crystal is used as a sensing element. When a dynamic force or dynamic pressure is applied to a piezoelectric transducer a charge generates on the surface of the crystal. This charge appears as a potential difference across the electrodes fitted on opposite sides of the crystal.

The charge so generated is very small in magnitude. Therefore it has to amplify with the help of a charge amplifier to get a sufficient output. The output instrument is calibrated in terms of input measuring quantity.

If we apply a static force or static pressure, there will be no output voltage. Therefore, input measuring quantity should always be dynamic.

The magnitude of the output voltage is directly proportional to the applied force.



The polarity of the generated voltage depends upon the direction of the applied force. Therefore, the polarity of generated voltage for tensile force and compressive force will be opposite in polarity on the same piece of piezoelectric material.

Charge induced on a crystal is proportional to the applied force,

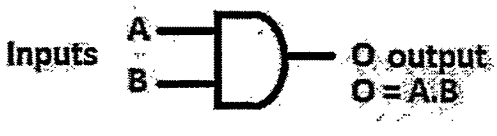
i.e. $Q \alpha F$

or $Q = dF$

or $d = Q/F$, is the charge sensitivity. Its unit is C/N.

5.a) AND Gate

The AND gate is a digital logic gate with 'n' i/ps one o/p, which performs logical conjunction based on the combinations of its inputs. The output of this gate is true only when all the inputs are true. When one or more inputs of the AND gate's i/ps are false, then only the output of the AND gate is false. The symbol and truth table of an AND gate with two inputs is shown below.



Symbol

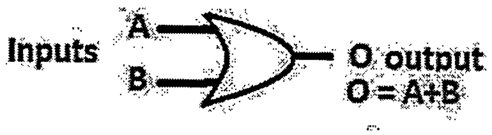
Inputs		Output
A	B	O
0	0	0
0	1	0
1	0	0
1	1	1

Truth table

AND Gate and its Truth Table

OR Gate

The OR gate is a digital logic gate with 'n' i/ps and one o/p, that performs logical conjunction based on the combinations of its inputs. The output of the OR gate is true only when one or more inputs are true. If all the i/ps of the gate are false, then only the output of the OR gate is false. The symbol and truth table of an OR gate with two inputs is shown below.



Symbol

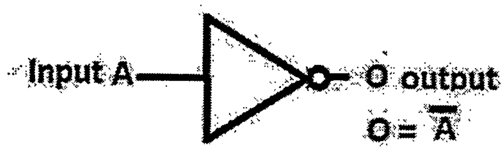
Inputs		Output
A	B	O
0	0	0
0	1	1
1	0	1
1	1	1

Truth table

OR Gate and its Truth Table

NOT Gate

The NOT gate is a digital logic gate with one input and one output that operates an inverter operation of the input. The output of the NOT gate is the reverse of the input. When the input of the NOT gate is true then the output will be false and vice versa. The symbol and truth table of a NOT gate with one input is shown below. By using this gate, we can implement NOR and NAND gates



Symbol

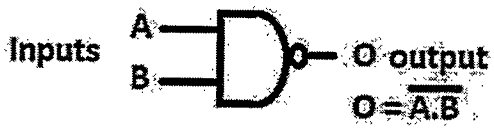
Inputs	Output
A	O
0	1
1	0

Truth table

NOT Gate and Its Truth Table

NAND Gate

The NAND gate is a digital logic gate with 'n' i/ps and one o/p, that performs the operation of the AND gate followed by the operation of the NOT gate.NAND gate is designed by combining the AND and NOT gates. If the input of the NAND gate high, then the output of the gate will be low.The symbol and truth table of the NAND gate with two inputs is shown below.



Symbol

Inputs		Output
A	B	O
0	0	1
0	1	1
1	0	1
1	1	0

Truth table

NAND Gate and its Truth Table

5.b) he applications of Logic Gates are:

- NAND Gates are used in Burglar alarms and buzzers.

- They are basically used in circuits involving computation and processing.
- They are also used in push button switches. E.g. Door Bell.
- They are used in the functioning of street lights.
- AND Gates are used to enable/inhibit the data transfer function.
- They are also used in TTL (Transistor Transistor Logic) and CMOS circuitry.

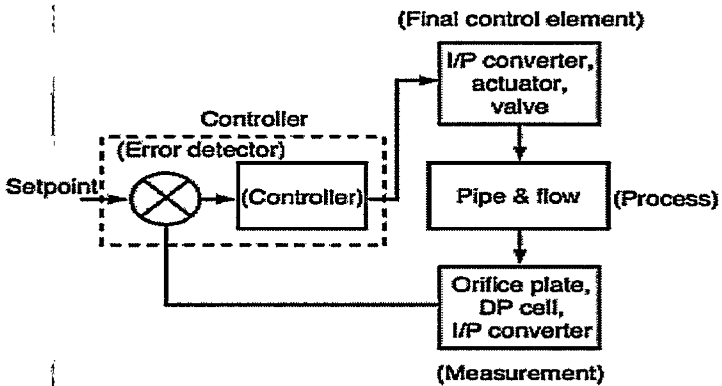
6.a) micro-sensor converts measured mechanical to an electrical signal

Form of signal	Measurands
Thermal	Temperature, heat, heat flow, entropy, heat capacity etc.
Radiation	Gamma rays, X-rays, ultra-violet, visible and infrared light, micro-waves, radio waves etc.
Mechanical	Displacement, velocity, acceleration, force, pressure, mass flow, acoustic wavelength and amplitude etc.
Magnetic	Magnetic field, flux, magnetic moment, magnetisation, magnetic permeability etc.
Chemical	Humidity, pH level and ions, gas concentration, toxic and flammable materials, concentration of vapours and odours, pollutants etc.
Biological	Sugars, proteins, hormones, antigens etc.

6.b) **AI** allows organizations to make better decisions, improving core business processes by increasing both the speed and accuracy of strategic decision-making processes.

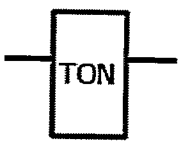
Artificial Intelligence (AI) is a branch of Science which deals with helping machines find solutions to complex problems in a more human-like fashion.

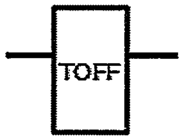
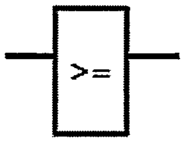
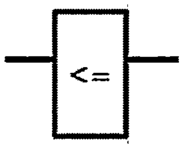
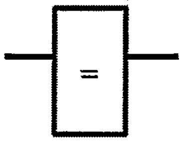
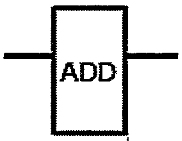
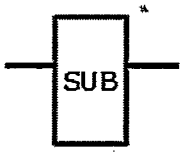
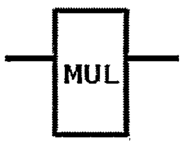
7.a)

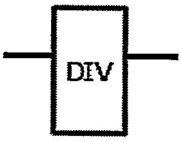
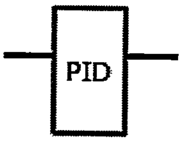
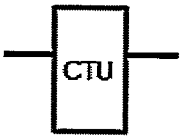
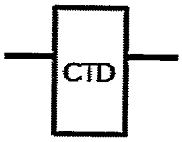


(b) Block diagram of the process-control loop

7.b)

Symbol	Name	Description
	Normally Open Contact (NO) Symbol	Its operation is very simple. When the condition is true then the contact is closed and output logic flow is enabled. When the condition is FALSE then the contact is OPEN and output logic flow is blocked.
	Normally Closed Contact (NC) Symbol	When the condition is true then the contact is OPEN and output logic flow is blocked. And when the condition is FALSE then the contact is CLOSED and output logic flow is enabled. The NC contact symbol operation is nothing but just the opposite to the NO contact symbol.
	Output Coil Symbol	When the input condition is true then the output is ON. And when the input condition is false then the output is OFF.
	One Shot Symbol– Positive Edge Detection	When the input condition transitions from FALSE to TRUE then the output is ON, for the time taken to do one PLC scan.
	Set Coil Symbol	When the input condition transitions from false to true then the output is set ON and once the output is set ON, it stays ON, even if the input condition goes FALSE.
	Reset Coil Symbol	When the input condition is true then the output is reset to OFF. And when the input condition is false it has no effect on the output. The SET and RESET coils can share the same variable address and therefore work hand in hand.
	Timer Delay on Symbol	When the input condition is true then the timer begins. And when the present time set point has been reached the output turns ON. If the input condition goes FALSE, at any stage, the timer stops and the output turns OFF as well.

	Timer Delay off Symbol	When the input condition is true then the output turns ON. Then if the input condition goes false the timer begins and when the preset time set point has been reached the output turns OFF. If the input condition goes TRUE, at any stage, the timer stops and the output turns ON as well.
	Greater than or Equal to	When the two inputs comparison is true then output is true otherwise false.
	Less than or Equal to	When the two inputs comparison is true then output is true otherwise false.
	Equal to	When two inputs are equal then output are true.
	Adder	Adder is used to add two or more inputs.
	Subtractor	Subtractor is used to subtract one value from the other one.
	Multiplication	Multiplication block is used to multiply two or more values.

	Division	Division block is used to divide two values.
	PID Controller	PID Controller is used to control the process value. The process variable is measured from the primary element (Input) and the output is manipulated to maintain the process variable value at the set point input value. The Proportional, Integral and Derivative input values are tune to increase the performance of controlling. Which is done according to process requirements.
	Counter Up	When input is True from False then counter increases 1 value from the last stored value. When this stored value reaches the preset value, the output will go True and the stored value is set again to 0.
	Counter Down	When input is True from False then counter decreases 1 value from the last stored value. When this stored value reaches 0 value, the output will go True and the stored value is set again to preset value.

Narasaraopeta Engineering College (Autonomous)

NEC Kotappakonda Road, Yellamanda (P.O), Narasaraopet- 522601, Guntur District, AP.

Subject Code: R16ME4201

IV B.Tech II Semester Regular & Supple Examinations, July-2021

MECHTRONICS (ME)

Max Marks: 60 Question Paper Consists of Part-A and Part-B.

Answering the question in Part-A is Compulsory & Four Questions should be answered from Part-B
All questions carry equal marks of 12.

PART-A

[2+2+2+2+2+21

1. a) Name the few emerging areas of mechatronics.
   b) Write any two applications of hall-effect sensor.
   c) Describe the function of stepper motor.
   d) Explain the general rules to write a ladder logic diagram.
   e) State the use of micro sensors in mechatronics.
   f) State the reason, why PLC is more useful?

PART-B

4x 12 = 48

2. a) Explain the social justification for the development of mechatronics.
   b) Discuss the rotational mechanical system with spring, damper and mass.

3. a) Formulate the factors to be considered for the selection of sensor? Explain in detail with any two examples.
   b) Explain pyroelectric and piezoelectric transducers in detail.

4. a) Explain the characteristics of electrical actuators. List out their advantages when compared with mechanical actuators.
   b) List out the specifications of stepper motor.
5. a) Write a brief note on sequential logic.
   b) Simplify the following Boolean expressions:
   $(AB + C)$ $AB\overline{C} + A$
6. a) Explain the concepts of fuzzy logic in mechatronics.
   b) Write a short note on mechatronic control in automated manufacturing.

7. a) Explain about ladder diagram for various logic functions.
   b) Describe the future trends of mechatronic systems.

S.No		Marks
1.a.	• Advanced smart automation technologies in mechatronics • MEMS dynamics and control • Sensor design and data collection approaches • Model-based mechatronic system design • Mechatronics and smart manufacturing systems • Computational intelligence in mechatronic systems • Artificial intelligence in mechatronic systems • Mechanism synthesis, analysis, and design • Modelling, control, and optimization of complex mechatronic systems • Novel robotic systems • Intelligent health monitoring and supervisory control of mechatronic systems • Medical mechatronics for healthcare and so on **Any 4 emerging areas**	**2 Marks**
1.b.	• Automotive and Automotive Safety • Appliances and Consumer Goods • Fluid Monitoring • Automatic toilet flushing mechanism • Automatic sinks • Automatic hand dryers • Building and door security systems • Elevators • Personal electronics and so on **Any two potential applications**	**2 Marks**
1.c.	A stepper motor is an electromechanical device it converts electrical power into mechanical power. Also, it is a brushless, synchronous electric motor that can divide a full rotation into an expansive number of steps.	**2 Marks**
1.d.	6 Rules for PLC Ladder Diagram Programming 1. Inputs can be used in Series as well as Parallel to form a connection 2. Outputs (or coil) can be used only in Parallel 3. One Input can be used in multiple times in one program 4. One Output cannot be used multiple times in one program, except in Set/Reset and Latch/ Unlatch functions 5. Input Address cannot be used as an Output Address 6. Outputs Address can be used as Inputs Address **State all the rules**	**2 Marks**
1.e.	Microsensors are currently used most commonly for measuring pressure, acceleration, torque, and chemical parameters. They are used in particularly large numbers in the automotive industry, where unit prices can be very low. Typical applications are in air bag actuation and vehicle stability control. Microsensors are also widely used in medical applications, particularly for blood pressure measurement.	**2 Marks**
1.f.	Programmable Logic Controller is the system that makes machinery and systems work automatically. It incorporates three basic features of input, process, and output	**2 Marks**

	where everything has to go along well and harmoniously. The input or data should go along with the suitable operation or process in order to produce the intended result or output. It's a quite complicated process to make all machineries become automatic. PLCs are the preferred method of controlling, measuring, and carrying out tasks in complex manufacturing and industrial applications because they play nicely with other systems. This system is responsible for all the growth in industry, manufacturing process, and even entertainment.	
2. a.	Mechatronics began as an A to Z kind of engineering for a new technological age. It has caught on with students who want to learn all of the skill sets required to build a whole machine by themselves. When well thought about the items at our homes that move and are powered by electricity: one will realize washing machine, ceiling fan, food processor, power drill are built on mechatronics platform. Designing and building all of the moving parts in a washing machine required mechanical know-how, someone who could make the parts spin just right. But to power the device, that engineer also had to have electrical skills too. If one needs to build a mechanical thing that is controlled by electrical components that needs software to make it work, then it is necessary that one need mechatronics as a platform to build a desired system and work smoothly. Mechatronics programs integrate electrical and mechanical engineering with computer science, the capability to build, innovate, and maintain products that span a wide range of things that we see in everyday life. The new social-cyber-physical systems development are based on transdisciplinary approaches in science and education. Scientific fundamentals regarding information links and the integration-interfacing process study based on mechatronic platforms capabilities will contribute to define mechatronics as environment for transdisciplinarity learning and integral education.	5 Marks
2.b.	Constitutive Equations for Rotating Mechanical Elements **Spring:** $\tau = K_r\theta$ **Friction:** $\tau = B_r\dot{\theta} = B_r\omega$ **Inertia:** $\tau = J\ddot{\theta} = J\alpha$	5 Marks

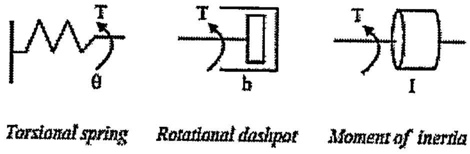


Figure 2.8 Rotational mechanical system components

A *rotational spring* is similar to a translational spring, but here the spring is twisted. The relationship between the applied torque, T, and the angle θ rotated by the spring is given by

$$T = k\theta, \tag{2.30}$$

where θ is known as the rotational *stiffness* constant. In our modelling we are assuming that the mass of the spring is negligible and the spring is linear.

The energy stored in a torsional spring when twisted by an angle θ is given by

$$E = \frac{1}{2}k\theta^2. \tag{2.31}$$

A *rotary damper* element creates damping as it rotates. For example, when a disk rotates in a fluid we get a rotary damping effect. The relationship between the applied torque, T, and the angular velocity of the rotary damper is given by

$$T = c\omega = c\frac{d\theta}{dt}. \tag{2.32}$$

In our modelling the mass of the rotary damper will be neglected, or will be assumed to be negligible. A rotary damper does not store energy.

Moment of inertia refers to a rotating body with a mass. When a torque is applied to a body with a moment of inertia we get an angular acceleration, and this acceleration rotates the body. The relationship between the applied torque, T, angular acceleration, a, and the moment of inertia, I, I is given by

$$T = Ia = I\frac{d\omega}{dt} \tag{2.33}$$

or, since $\omega = d\theta/dt$,

$$T = I\frac{d^2\theta}{dt^2}. \tag{2.34}$$

The energy stored in a mass rotating with an angular velocity ω is given by

$$E = \frac{1}{2}I\omega^2. \tag{2.35}$$

Rotating Systems	
Quantity	**Unit**
Moment of Inertia - J	kg-m²
Torque - τ	N-m
Angle - θ	rad
Angular velocity - $\dot{\theta} = \omega$	rad/sec
Angular acceleration - $\ddot{\theta} = \alpha$	rad/sec²
Spring Constant - K_r	N-m/rad
Friction Coefficient - B_r	N-m-s/rad

3.a.	What are the selection criteria for Sensors?	5 Marks

What are the selection criteria for Sensors?

➢There are certain features which have to be considered when we choose a sensor. They are as given below:

➢ Accuracy – should be High

➢Stability - maintain under abnormal condition

➢Environmental condition - usually has limits for temperature & humidity

➢Range - Measurement limit of sensor

➢Calibration - Essential for most of the measuring devices as the readings changes with time

➢Resolution - Smallest increment detected by the sensor

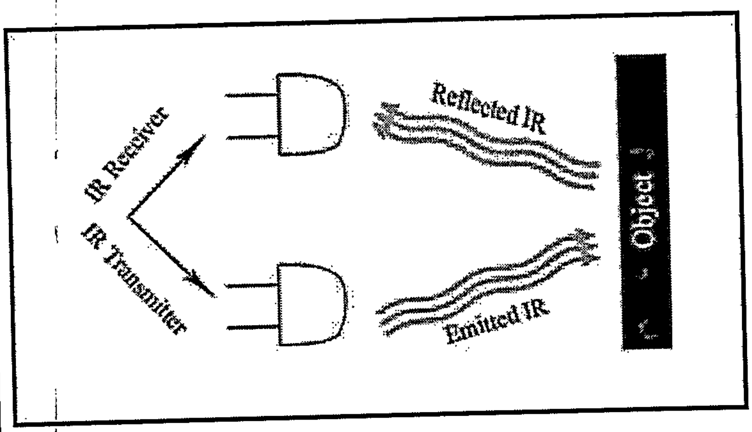
➢Cost - Should be Low

➢Power Consumptions - Low

➢Repeatability - The reading that varies is repeatedly measured under the same environment

IR sensors

The basic idea is to make use of IR LEDs to send the infrared waves to the object. Another IR diode of the same type is to be used to detect the reflected wave from the object. The diagram is shown below.



Simple Diagram Explaining Working Of IR Led Sensor

When IR receiver is subjected to infrared light, a voltage difference is produced across the leads. Less voltage which is produced can be hardly detected and hence operational amplifiers (**Op-amps**) are used to detect the low voltages accurately.

Measuring the distance of the object from the receiver sensor: The electrical property of IR sensor components can be used to measure the distance of an object. The fact when IR receiver is subjected to light, a potential difference is produced across the leads.

UV sensor:

Principle

Different definitions are approved to distinguish sensors and transducers. Sensors can be defined as an element that senses in one form of energy to

produce a variant in same or another form of energy. Transducer converts the measurand into the desired output using the transduction principle.
Based on the signals that are obtained and created, the principle can be categorized into following groups namely, Electrical, Mechanical, Thermal, Chemical, Radiant, and Magnetic.
Let's take the example of an ultrasonic sensor.
An ultrasonic sensor is used to detect the presence of an object. It achieves this by emitting ultrasonic waves from the device head and then receiving the reflected ultrasonic signal from the concerned object. This helps in detecting the position, presence and movement of objects.

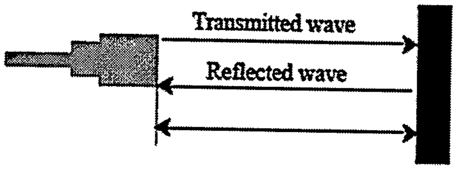
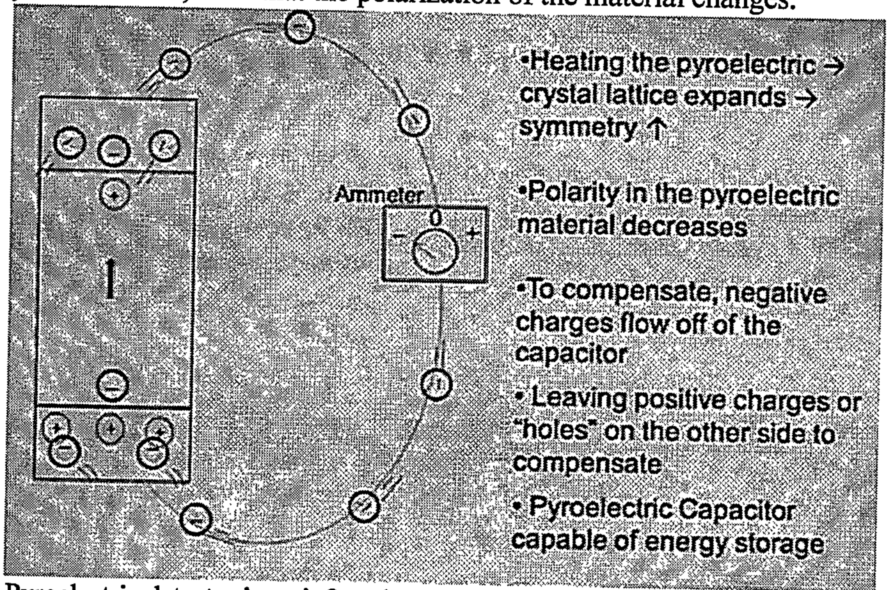


Figure Explaining Principle Of Ultrasonic Sensor

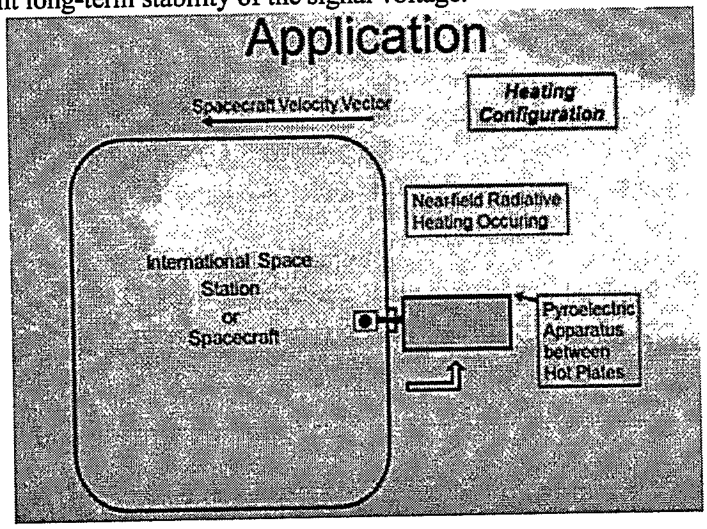
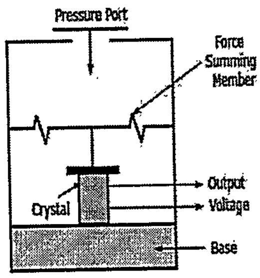
Since ultrasonic sensors rely on sound rather than light for detection, it is widely used to measure water-levels, medical scanning procedures and in the automobile industry. Ultrasonic waves can detect transparent objects such as transparent films, glass bottles, plastic bottles, and plate glass, using its Reflective Sensors.

3.b. **Pyro Electric Transducers** **5 Marks**

Pyro means heating / cooling effect. In certain materials when heated up or cooled down, there generates some potential which can be sensed by these type of sensors. Pyro electricity can be described as the ability of certain materials to generate a temporary voltage when they are heated or cooled. The change in temperature modifies the positions of the atoms slightly within the crystal structure, such that the polarization of the material changes.



A Pyroelectric detector is an infrared sensitive optoelectronic component which are specifically used for detecting electromagnetic radiation in a wavelength range from 2 to 14 µm. • A receiver chip of a pyroelectric infrared detector consists of singlecrystalline lithium tantalate. • Because of its very high curie temperature of

	620 °C lithium tantalate guarantees an extremely low temperature coefficient with an excellent long-term stability of the signal voltage.  **Piezoelectric transducer:** A **piezoelectric transducer** (also known as a piezoelectric sensor) is a device that uses the piezoelectric effect to measure changes in acceleration, pressure, strain, temperature or force by converting this energy into an electrical charge. A transducer can be anything that converts one form of energy to another. The piezoelectric material is one kind of transducers. When we squeeze this piezoelectric material or apply any force or pressure, the transducer converts this energy into voltage. This voltage is a function of the force or pressure applied to it. The electric voltage produced by a piezoelectric transducer can be easily measured by the voltage measuring instruments. Since this voltage will be a function of the force or pressure applied to it, we can infer what the force/pressure was by the voltage reading. In this way, physical quantities like mechanical stress or force can be measured directly by using a piezoelectric transducer. **CONSTRUCTION and WORKING** The figure shows a conventional piezoelectric transducer with a piezoelectric crystal inserted between a solid base and the force summing member. •If a force is applied on the pressure port, the same force will fall on the force summing member. •Thus a potential difference will be generated on the crystal due to its property. The voltage produced will be proportional to the magnitude of the applied force.  Piezo-Electric Transducer	
4.a.	<u>Characteristics of an electric actuator</u>: Continuous power output—The maximum force/torque attainable continuously without exceeding the temperature limits Range of motion—The range of linear/rotary motion	5 Marks

	Resolution—The minimum increment of force/torque attainable Accuracy—Linearity of the relationship between the input and output Peak force/torque—The force/torque at which the actuator stalls Heat dissipation—Maximum wattage of heat dissipation in continuous operation Speed characteristics—Force/torque versus speed relationship No load speed—Typical operating speed/velocity with no external load Frequency response—The range of frequency over which the output follows the input faithfully, applicable to linear actuators Power requirement—Type of power (AC or DC), number of phases, voltage level, and current capacity Electric activators work on alternating current that energizes an electric motor. Electric energy converts into torque which drives the actuator. Electric actuators use mechanical components like lead screws and gears to open and close their applications. The difference between pneumatic and electric actuators is that the electric motor is part of the actuator assembly rather than separate. The below are the advantages of electrical actuators when compared to mechanical: • Electric actuators are directly driven. As such, they have excellent response times that make them fast performers. For quick and light work, electric actuators are great. • Electric actuators are precise devices. Whereas hydraulic and pneumatic actuators have tolerances like slack, backlash and flex inherent in their design, which is not an issue with electrics. • Electricity is a clean energy source, meaning, there is no potential risk for leakage.	
4.b.	The stepper motor parameters mainly include step angle, steps for each revolution, steps for each second, and RPM. **Step Angle** The step angle of the stepper motor can be defined as the angle at which the motor's rotor turns once a single pulse is given to the stator's input. The resolution of the motor can be defined as the number of steps of the motor and the number of revolutions of the rotor. **Resolution = Number of Steps/Number of Revolution of the Rotor** The motor's arrangement can be decided through the step-angle & it is expressed within degrees. The resolution of a motor (the step number) is the no. of steps which make within a single revolution of the rotor. When the step-angle of the motor is small then the resolution is high for the arrangement of this motor. The exactness of the arrangements of the objects through this motor mainly depends on the resolution. Once the resolution is high then the accuracy will be low. Some accuracy motors can create 1000 steps within a single revolution including 0.36 degrees of step-angle. A typical motor includes 1.8 degrees of step angle with 200 steps for each revolution. The different step angles such	**5 Marks**

as 15 degrees, 45 degrees, and 90 degrees are very common in normal motors. The number of angles can change from two to six and a small step angle can be attained through slotted pole parts.

Steps for Each Revolution

The steps for each resolution can be defined as the number of step angles necessary for a total revolution. The formula for this is 360°/Step Angle.

Steps for Each Second

This kind of parameter is mainly used for measuring the number of steps covered within each second.

Revolution per Minute

The RPM is the revolution per minute. It is used to measure the frequency of revolution. So by using this parameter, we can calculate the number of revolutions in a single minute. The main relation between the parameters of the stepper motor is like the following.

Steps for Each Second = Revolution per Minute x Steps per Revolution / 60

Normal selection Criteria:

1. Determining the drive mechanism component

Determine the mechanism and required specifications. First, determine certain features of the design, such as mechanism, rough dimensions, distances moved, and positioning period.

2. Calculate the required resolution

Find the resolution the motor requires. From the required resolution, determine whether a motor only or a geared motor is to be used. However, by using the microstepping technology, meeting the required resolution becomes very easy.

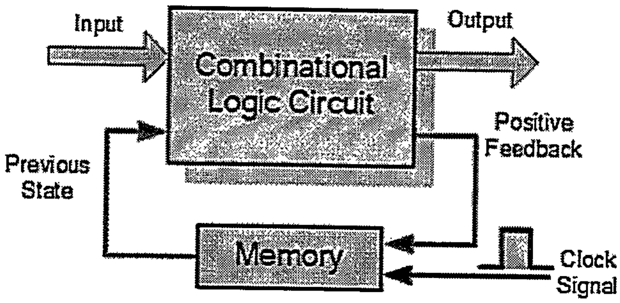
3. Determine the operating pattern

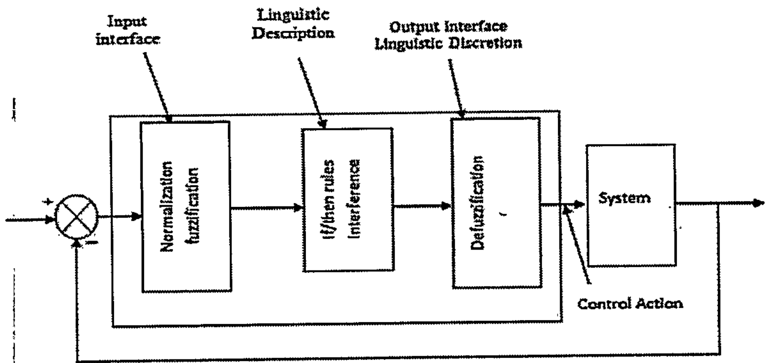
Determine the operating pattern that fulfills the required specifications. Find the acceleration (deceleration) period and operating pulse speed in order to calculate the acceleration torque.

4. Calculate the required torque

Calculate the load torque and acceleration torque and find the required torque demanded by the motor.

5. Select the motor

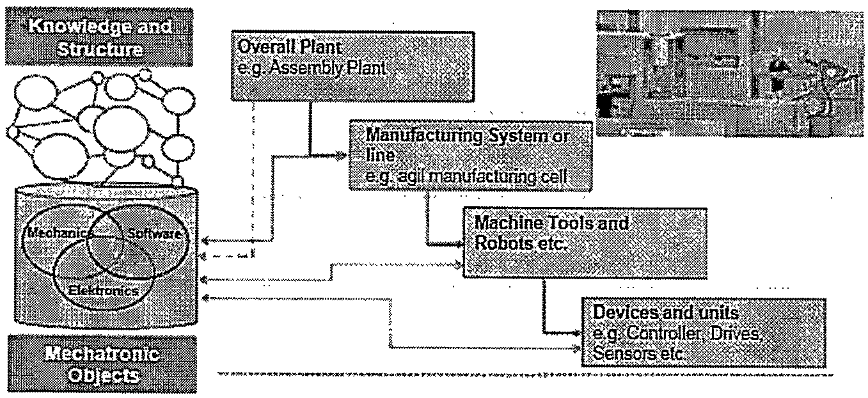
	Make a provisional selection of a motor based on the required torque. Determine the motor to be used from the speed-torque characteristics. **6. Check the selected motor** Confirm the acceleration/deceleration rate and inertia ratio.	
5.a.	The word "Sequential" means that things happen in a "sequence", one after another and in Sequential Logic circuits, the actual clock signal determines when things will happen next. Simple sequential logic circuits can be constructed from standard Bistable circuits such as: Flipflops, Latches and Counters and which themselves can be made by simply connecting together universal NAND Gates and/or NOR Gates in a particular combinational way to produce the required sequential circuit. Sequential Logic Circuits use flip-flops as memory elements and in which their output is dependent on the input state.  Sequential Logic circuits have some form of inherent "Memory" built in. Sequential logic circuits are able to take into account their previous input state as well as those actually present, a sort of "before" and "after" effect is involved with sequential circuits. The output state of a "sequential logic circuit" is a function of the following three states, the "present input", the "past input" and/or the "past output". Sequential Logic circuits remember these conditions and stay fixed in their current state until the next clock signal changes one of the states, giving sequential logic circuits "Memory". Sequential logic circuits are generally termed as two state or Bistable devices which can have their output or outputs set in one of two basic states, a logic level "1" or a logic level "0" and will remain "latched" (hence the name latch) indefinitely in this current state or condition until some other input trigger pulse or signal is applied which will cause the bistable to change its state once again.	**5 Marks**
5.b.	A.B+C = (A+C)(B+C) This is Boolean addition which is distributive over Boolean multiplication A.B+C = A.B+C.1 = C(C+A)+B(C+A) = (A+C)(B+C)	
6.a.	A fuzzy systemis a system that forms the output function, that the upper limit of the difference between the original function and the output is less than or equal to some arbitrary constant.	**5 Marks**

	A control system is an arrangement of physical components designed to alter another physical system so that this system exhibits certain desired characteristics. Following are some reasons of using Fuzzy Logic in Control Systems – • While applying traditional control, one needs to know about the model and the objective function formulated in precise terms. This makes it very difficult to apply in many cases. • By applying fuzzy logic for control we can utilize the human expertise and experience for designing a controller. • The fuzzy control rules, basically the IF-THEN rules, can be best utilized in designing a controller.  A fuzzy logic controller is composed of three basic parts; (i) input signal fuzzyfication, (ii) a fuzzy engine that handles rule inference and (iii) defuzzification that generates a continuous signal for actuators such as control valves. The fuzzification block transforms the continuous input signal into linguistic fuzzy variables such as small, medium, and large. The fuzzy engine carries out rule inference where human experience can easily be injected through linguistic rules. The defuzzification block converts the inferred control action back to a continuous signal that interpolates between simultaneously fired rules. **If provided example with explaination like suspension systems: 5 marks**	
6.b.	Mechatronics concurrently employs the disciplines of mechanical, electrical, control and computer engineering at the stage of design itself. Mechanical discipline is employed in terms of various machines and mechanisms, where as electrical engineering as various electric prime movers viz. AC/DC, servo motors and other systems is used. Control engineering helps in the development of various electronicsbased control systems to enhance or replace the mechanics of the mechanical systems. Computers are widely used to write various softwares to control the control systems; product design and development activities; materials and manufacturing resource planning, record keeping, market survey, and other sales related activities. Mechatronics based automated systems such as automatic inspection and quality assurance, automatic packaging, record making, and automatic dispatch help toexpedite the entire manufacturing operation. These systems certainly ensure a supplybetter quality, well packed and reliable products in	

the market. Automation in the machine tools has reduced the human intervention in the machining operation and improved the process efficiency and product quality. Therefore it is important to study the principles of mechatronics and to learn how to apply them in the automation of a manufacturing system.

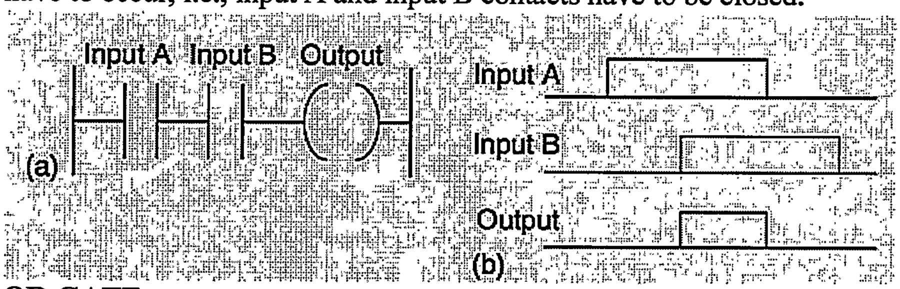
Mechatronics has a variety of applications as products and systems in the area of 'manufacturing automation'. Some of these applications are as follows:

1. Computer numerical control (CNC) machines
2. Tool monitoring systems
3. Advanced manufacturing systems
   a. Flexible manufacturing system (FMS)
   b. Computer integrated manufacturing (CIM)
4. Industrial robots
5. Automatic inspection systems: machine vision systems
6. Automatic packaging systems



7.a. **AND GATE:** 5 Marks

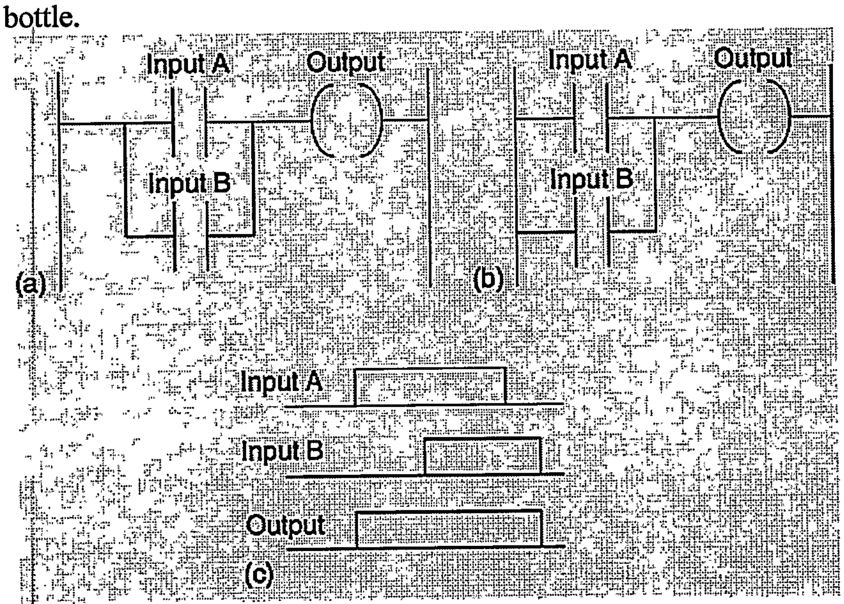
The ladder diagram starts with | |, a normally open set of contacts labeled input A, to represent switch A and in series with it | |, another normally open set of contacts labeled input B, to represent switch B. The line then terminates with O to represent the output. For there to be an output, both input A and input B have to occur, i.e., input A and input B contacts have to be closed.



OR GATE:

The ladder diagram starts with | |, normally open contacts labeled input A, to represent switch A and in parallel with it | |, normally open contacts labeled input B, to represent switch B. Either input A or input B have to be closed for the output to be energized. The line then terminates with O to represent the output.

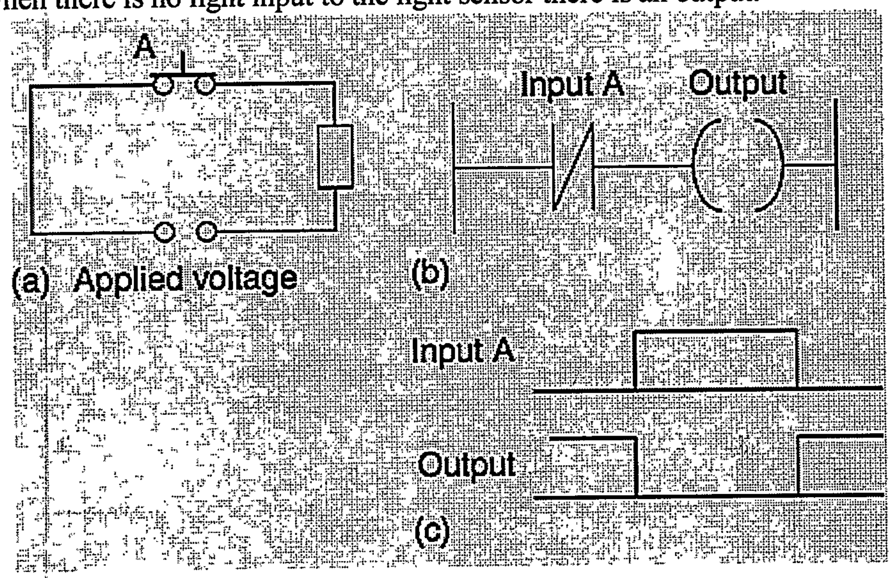
OR gate control system is a conveyor belt transporting bottled products to packaging where a deflector plate is activated to deflect bottles into a reject bin if either the weight is not within certain tolerances or there is no cap on the bottle.



NOT GATE:

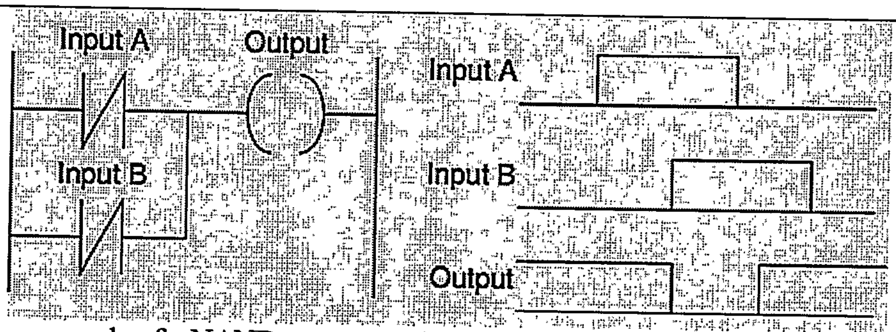
NOT gate system on a ladder diagram. The input A contacts are shown as being normally closed. This is in series with the output ( ). With no input to input A, the contacts are closed and so there is an output. When there is an input to input A, it opens and there is then no output.

An example of a NOT gate control system is a when it becomes dark, i.e., when there is no light input to the light sensor there is an output.



NAND

Both the inputs A and B have to be 0 for there to be a 1 output. There is an output when input A and input B are not 1. The combination of these gates is termed a NAND gate.

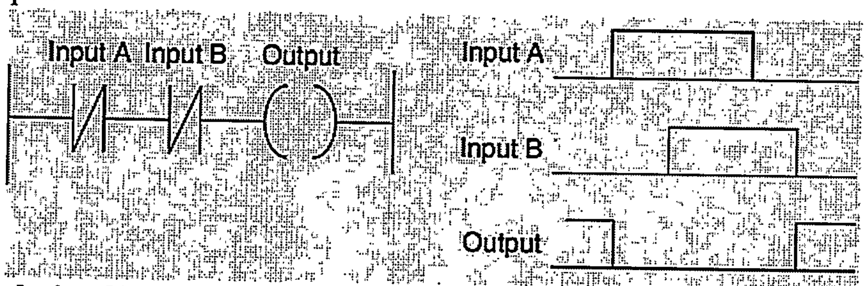


An example of a NAND gate control system is a warning light that comes on if, with a machine tool, the safety guard switch has not been activated and the limit switch signalling the presence of the workpiece has not been activated.

NOR GATE:

The combination of OR and NOT gates is termed a NOR gate. There is an output when neither input A or input B is 1.

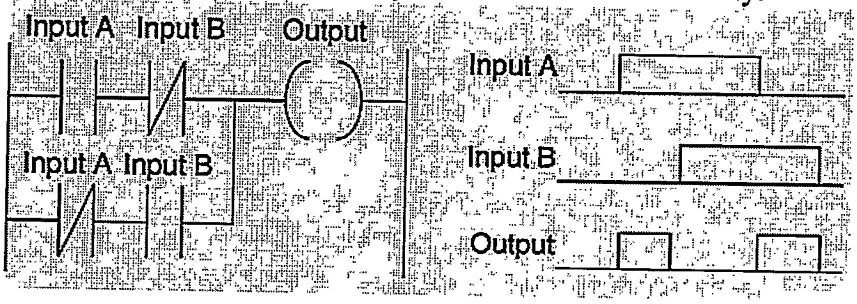
A ladder diagram of a NOR system. When input A and input B are both not activated, there is a 1 output. When either X400 or X401 are 1 there is a 0 output.



Exclusive OR (XOR)

When input A and input B are not activated then there is 0 output. When just input A is activated, then the upper branch results in the output being 1. When just input B is activated, then the lower branch results in the output being 1. When both input A and input B are activated, there is no output.

In this example of a logic gate, input A and input B have two sets of contacts in the circuits, one set being normally open and the other normally closed. With , each input may have as many sets of contacts as necessary.



Any FIVE gates with ladder diagram – 5 Marks

7.b.	After figuring out how to harvest, store and use electricity, engineers were able to bring mechanics to life; and as computer science rose in usefulness, mechatronic engineers started to use their field to create smart and complex machines that are designed to make life more secure and efficient. As these machines become more intricate and capable, the future of mechatronics will continue to grow and look for ways we can use energy and mechanics to help	**5 Marks**

	accomplish difficult or time consuming tasks, as well as continue to connect the world and increase our understanding of life. Potential Future trends: • Advanced smart automation technologies in mechatronics • MEMS dynamics and control • Sensor design and data collection approaches • Model-based mechatronic system design • Mechatronics and smart manufacturing systems • Computational intelligence in mechatronic systems • Artificial intelligence in mechatronic systems • Mechanism synthesis, analysis, and design • Modelling, control, and optimization of complex mechatronic systems • Novel robotic systems • Intelligent health monitoring and supervisory control of mechatronic systems • Medical mechatronics for healthcare	

NEC NARASARAOPETA ENGINEERING COLLEGE
(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

CO-POs & CO-PSOs ATTAINMENT

Course Code: C421	Course Name: MECHATRONICS	Year/Sem: IV/II

External Examination Assessment

S.No	Q.No	1						2		3		4		5		6		7	
		a	b	c	d	e	f	a	b	a	b	a	b	a	b	a	b	a	b
	COs	I	II	III	IV	V	VI	I	I	II	II	III	III	IV	IV	V	V	VI	VI
	Max. Marks	2	2	2	2	2	2	4	8	6	6	6	6	8	4	6	6	8	4
1		1	1	1	2	2	1	2	2	4	4	3	3	7	3	2			
2		1	1	1	1	1	1	2	3			3	3	7	3	3	3		
3		2	1	1	1	1	1			2	5	3	4	7	2	2			
4		1	1	1	1	1	1	2	3		3	3	3	6	2	3	1	3	3
5		1	1	1	1	1	1		2	4	2			4	2			3	
6		1	1	1	1	1	1	2		2	2		2	6	3			2	3
7		1	1	1	1	1	1	1	2					6	0	2	3		3
8		1	1	1	1	1	1	2	5	5	5	5	3	7	3	2	2	2	2
9		2	2	2	2	1	1	2	3	5	5	5	5	7	3				
10		2	1	1	2	2	2	2	3	4	4		1	7	3	3	4	4	4
11		0	0	0	0	0	0	2	3	5	5			7	3			2	2
12		2	2	2	2	2	2	3	6	5	5	5	5	7	3				
13		1		1	1	1	1			4	4	2	1	7	3			3	3
14		1	1	1	1	1	1			3	4	4	2	7	0		2	3	3
15												1	1	7	0	1	1	2	3
16		0	0	0	0	0		1	1			1	1	6	3			1	2
17		1	1	1	1	1	1			5	5	5	3	7	3	2	2		
18		2	1	1	2	2	1		2	3		2		7	3		2		
19		2	1	2	2	1	1	0	0	4	4	4	2	7	3			0	
20		1	1	1	1	1	1					2	2	7	3	2	2		3
21		1	1	2	2	1	1		5	5	5			7	3	2	2		
22		1	0	0	0	1	0	1	1			0	1	2	3	2	2	1	2
23		1	1	1	2	2	1					2	2	7	3	3	3	3	3
24		1	1	1	2	1	1	2	5	5	5	2		7	3	4	4		
25		2	2	2	2	1	1	5	5	5	3			7	3			3	3
26		2	2	1	1	1	2			2	2			7	3	2	2	3	3
27		2	2	2	2	2	2	3	6	6	5	6	6	8	3				
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29		2	2	1	1	1	2			5	5	5	5	7	3	4	4	2	2
30		1	1	1	1	1	1	2	0					7	3	2	2	3	3
31		2	2	2	2	2	2	2	1			2	2	7	3	3	3	3	3
32		1	1	0	0	0	0			1	1	1	1	6	2	1	1		
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34		2	1	1	1	1	1	2	5	3	3	5	5	7	3				
35		1	1	1	1	1	1	2	3			2	2	7	3	3	3		
36		2	2	2	2	2	2	3	3	4	4			5	2	2	2	3	3
37		2	1	2	2	2	1	2	5	5	5	5	5	5	3				3
38		2	2	2	2	2			4	5	5	3	3	7	3				
39		2	2	2	2	2	1	2	4	4	4	4	4	7	3	1	1	3	3
40		2	1	1	2	2	1	2	4					7	3	3	3	4	4
41		2	1	1	1	1	1			2	2	3		7	3	0	3	3	3
42		2	1	2	2	1	1	4	5	5	5	2	5	7	3				3
43		2	2	2	1	1	1		3	4	4			7	3	4	4		

44		1	1	1	0	0	0	1	1	1	2	1	1	2	2				
45		1	1	1	1	1	1	2		2	2			2	2	2	2	2	1
46		1	1	1	1	1	0	2	2	2	2	2	2	2	2	2	2		
47								2	2			2	2	0	0				
48		1	1	1	1	1	1	2	5	3	3			7	3			4	4
49		1	1	1	0	0	0	1	2	2	2	1	1			2	2		
50		2	2	1	2	2	1		2	5	5	5	5	7	3				2
51		2	1	1	2	2	2	3	6	5	5	5	5	7	3				
52		2	2	2	1	1	1			3	3		5	7	3	4			
53		1	2	2	2	2	1			5	5	5	5	7	3	3			3
54		2	2	2	2	1	1	2	6	5	5	4	4	7	3			5	3
55		1	2	2	2	2	0		4				5	4	3		2		3
56		2	2	2	2	1	1	1	6	5	5	4	4	7	3	3	3		4
57		1	1	1	0		1		3			3	3	7	3	3	3		3
58			1	1	2						2	2	2	7	3	2			
59		1		2				3	3			5	5	7	3		3		3
60			1	1	1	1	1				1	4	1	7	3	2			
61		2	2	2	2	1	1			2	4	2	4	7	3	2	2		
62		1	0	2	2	2	1			4	4	3	3	7	3	2	2		
63		1	1	1	1	1	1	2	4	3	3	3	3	4	3		0		
64		1	1	1	1	1	1		2	2	2	2	2	4	3				
65		1	1	1	1	1	1	2	3	2	2			7	3	2	1		
66		2	2	2	2	1	1		5	5	5	5	5	7	3				3
67		1	1	1	1	1	1	2	2					7	3	3	3	5	3
68		2	2	2	2	1	1			3	3	4	4	7	3			3	3
69		2	2	2	2	1	1			3	3	4	3	7	3				3
70		1	1	1	1	1	1	2	1			1	1	4	3	2	2	2	2
71		1	1	1	1	1	1			3	3	4	4	7	3			2	3
72		2	2	2	2	1	1	2	2	5	5	5	5	8	3	0	3		
73		2		2	2		1	2	4			5	5	7	3				
74		2	1	2	2	2	1	2	5	3	3	5	5	5	3				
75		1	1	1	1	1	1	2	3	4		2	3	3	3				
76		2	2	1	1	2	2			5	5	5	5	8	3			4	4
77		2	2	1	1	2	2			5	5			8	3	4	4	6	4
78		1	1	1	1	1	1			3	3	4	4	7	2	3	3		
79		1	1	2	2	2	1					4	4	3	3		3		
80		2	2	2	2	1	0		5	5	5	5	5	7	3				
81		2	2	2	2	2	2			5	5	5	5	8	3	5	3		
82		1		1	1	1	1	3	6					7	3	4		4	
83		2	2	2	2	1	1	2	4			5	5	7	3			4	4
84		2	2	2	2	2	2			5	5	5	5	7	3	5	5	6	4
85		1	1	1	1		1	1	2	2	3			5		2	3		
86		1	1	2	2	1		2	3	3	3	3	2	6					
87		2		2	2	2	2	2	2	3	6	5	5	7	3				
88		1	1	1	1	1	1	1	1	5	5	4	4	7	3	4	4	2	2
89		2	2	2	2	2				5	5		5	7	3				4
90		2	2	2	2	2	2	4	7	5	4	6	4	7	3				
91		1	2	2	1	2	1	2	5			3	4			3	3	4	4
92		1	2	2	2	2	2	3	7	5	5	4	5	8	3				
93		2	2	2	2	1	2	4	6	5	4	4	4	7	4				
94		2	1	2	2	1	2		2	5	4	5	5	7	4				
95		1	1	2	1	1	1	2	7	5	5	5	5	7	4	1	3		

96		2	1	2	2	1	2	3	5	5	5	4	6	7	3				
97		2	2	2	2	2	2	3	5	5	5			7	4	3			4
98		1	2	2	2	1	0	2	4	4	4		3	1	3	2	2		4
99		2	2	2	2	2	2	3	7	5	6	5		7	3		1		1
100		2	2	2	2	2	2	4	4	5	5	3	5	7	3		1		
101		1	1	1	1	1	1	3		4	4	2	4	7	3				
102		2	2	2	2	2	2	4	7	4	3	5	5	8	3			6	4
103		2	1	2	2	2	1	3	7			5	5	7	3		2	3	3
104		2	1	2	1	2	1	3	4			4	4	7	3	2	1		
105		2	2	2	2	2	2	4	7			3	3	8	4	5	4		
106		2	2	2	2	2	2	2	5					7	3		3	4	4
107		2	2	2	2	2	2	3	6	3	3	3	3	6	3				
108		2	1	1	2	1	1	1	1					7	3	2	3	2	3
109		2	1	2	2	2	1	2	2	3	3			8	3	2		5	
110		1	1	2	2	2	1	1	3	3	2	2	2	7	3				
111		2	1	2	2	2	1					3	2	7	3	3	3	3	3
112		1	1	2	2	2	1	1	5	5		3	5	7	3	3	3		
113		1	1	2	1	1	2	2	4	5	5	3	4	7	3				4
114		2	2	2	2	2	2		7	5	5		5	7	4				4
115		2	2	2	2	2	2		7	6	6		6	8	3	5		4	
116		2	2	2	2	2	2	3	5	5	5	5	5	8	3				
117		2	2	2	2	2	2				6	5	5	7	3	2	2		
118		1	1	1	1	1	1			4	5	2		3	3	2			
119		2	2	2	2	2	1	2	7	5	5	5	5	8	3				
120		1	2	1	2	1	1			4	5		5	7	3	4	4		4
121		1	1	1	1	1	1		5	4	4			7	3	4	3		3
122		1	1	2	1	1	1	3	4			2	4	7	3	5	5		
123		2	1	2	2	2	1			4	4	5	5	7	3	4	4		
124		1	1	1	1	1	1	2	4	4	4	3	3	7	3			3	3
125		2		2	2	2	1		5	5	5	5	5	7	3		2		
126		2	2	1	2	2	2	2	6	5	5			7	3	4	4		
127		2	1	1	1	1	2	2	4			4	4	7	3	3	2	1	3
128		2	2	2	2	1	1	3	6	5	5			7	3	3	3		
No. of Students answered		124	120	126	125	121	120	79	92	93	94	95	99	126	124	68	68	47	62
50% of Max.Marks		1	1	1	1	1	1	2	4	3	3	3	3	4	2	3	3	4	2
No. of Students crossed 50% of Max Marks		122	116	122	118	116	111	67	53	80	80	68	73	117	120	34	36	15	60
% of Students crossed 50% of Max Marks		98	97	97	94	96	93	85	58	86	85	72	74	93	97	50	53	32	97
Attainment Level		3	3	3	3	3	3	3	1	3	3	3	3	3	3	1	1	0	3

	3	3	3	3	3	3
Attainment Level	**2**	**3**	**3**	**3**	**2**	**2**
CO	**I**	**II**	**III**	**IV**	**V**	**VI**

Rubrics:

If 50% of the students crossed 50% of the marks: Attainment Level 1

If 60% of the students crossed 50% of the marks: Attainment Level 2

If 70% of the students crossed 50% of the marks:Attainment Level 3

Internal Examination Assessment

S.No	Roll. No	Test	Mid1				Assignment		Assignment		Quiz	Mid2		Assignment			Quiz 2	CO I	CO II	CO III	CO IV	CO V	CO VI
			1.a	1.b	2.a	2.b	3.a	3.b			1	1.a	2.a	3.a				Max. Marks	Max. Marks	Max. Marks	Max. Marks	Max. Marks	Max. Marks
		COs	I	I	II	II	III	III	I	II		IV	V	VI	IV	V							
		Max. Marks	5	5	5	5	5	5	10	10	10	10	10	10	10	10	10	30	30	20	30	30	20
1	18471A0302		5	5	5	5	5	5	9	10	5	9	9	9	10		9	24	25	15	28	18	18
2	18471A0303		4	2	5	4	4	5	10		4	9	9	9	0	9	5	20	13	13	14	23	14
3	18471A0304		4	5	4	4	4	4	9		6	9	10	8	10		10	24	14	14	29	20	18
4	18471A0305								10	8	5	10	8	9	10	9	9	15	13	5	29	26	18
5	18471A0306		4	4	3	3	4		8	8	5	10	9	8		8	7	21	19	9	17	24	15
6	18471A0307		4	5	4	4	3	5	9		3	10	10	5	10	8	10	21	11	11	30	28	15
7	18471A0308		3	5	3	4		5	8	8	10	10	10	7	9	8	9	26	25	15	28	27	16
8	18471A0309		5	5	5	4	5	5	10	10	10	10	10	7	10	10	10	30	29	20	30	30	17
9	18471A0310		4	5	5	5	4	5	9	10	10	10	7	10	10	10	10	28	30	19	30	27	20
10	18471A0311		5	5	5	2	5	5	10	10	9	8	8	8	9	2	9	29	26	19	26	19	17
11	18471A0312		4	5	5	5		5	8		2	8	8	8		10	7	19	12	7	15	25	15
12	18471A0313		3	5		4	5	1	8	9	10	9	9	7	10	9	10	26	23	16	29	28	17
13	18471A0315		5	5	5	4	5	5	9	9	8	9	9	9	10	9	8	27	26	18	27	26	17
14	18471A0316		5	4	5	5	2	5	10		8	9	9	9		10	10	27	18	15	19	29	19
15	18471A0317		5	5	4	4	5	5	8	10	10	8	8	8	10	8	10	28	28	20	28	26	18
16	18471A0318		4		4	3	2	5	10	6	4	8	8	6	10	9	9	18	17	11	27	26	15
17	18471A0319		4	5	5	4		5		10	7	9	9	9	9	9	9	16	26	12	27	27	18
18	18471A0320		4	3	4	3		4	10	9	6	10	8		10	8	9	23	22	10	29	25	9
19	18471A0321		3	2	3	4	5	5		9	5	9	9	9	10	9	9	10	21	15	28	27	18
20	18471A0322		5	5	3	3	2	5	9	8	10	9	9	9	10		9	29	24	17	28	18	18
21	18471A0323		5	5	5	4	4	5		8	1	8	8	8	10	9	7	11	18	10	25	24	15
22	18471A0324		5	5	4	4	4	5	9	8	9	8	9	9	10	9	4	28	25	18	22	22	13
23	18471A0325		4	5	5	4	5	5	10	7	10	9	9	9	10	9	8	29	26	20	27	26	17
24	18471A0326		4	5	4	4	4	5	9	9	10	10	10	8	10	6	10	28	27	19	30	26	18
25	18471A0327		5		5	4	3	5	9	8	10	9	9	9	6	9	9	24	27	18	24	27	18
26	18471A0328		5	5	4	4	3	5	10	9	5	9	9	9	10	9	9	25	22	13	28	27	18
27	18471A0329			5	3	4	4	4	10	10	7	9	9	9		9	10	22	24	15	19	28	19
28	18471A0330		5	4			3	5	9	9	4	9	9	9	6	6	10	22	13	12	25	25	19
29	18471A0331		4	5	5	4	4	4	10	8	10	8	8	9	10	7	9	29	27	18	27	24	18
30	18471A0332		5	5	5	5	4	5	9		3	9	10	8		8	10	22	13	12	19	28	18
31	18471A0333		5	5	5	4	4	5	10		8	10	10	8	10		9	28	17	17	29	19	17

32	18471A0334		3	2	4	4	4	4	9	9	10	9	9	9	9	9	10	24	27	18	28	28	19
33	18471A0335			4	3	3	3	3	8	9	10	8	8	8	4	8	8	22	25	16	20	24	16
34	18471A0336								9	9								9	9	0	0	0	0
35	18471A0337		5	5	5	5	5	5	9	10	9	9	9	9	10	7	10	28	29	19	29	26	19
36	18471A0338		4	5	4	3	4				9	9	9	9	10		9	18	16	13	28	18	18
37	18471A0339			5	5	3	5	5	9	9	2	7	7	7		6	6	16	19	12	13	19	13
38	18471A0340		4	5	2	3	3	4		8	8	8	10	10		9	9	17	21	15	17	28	19
39	18471A0341		3	5	2	5	4	5	10	9	8	7	7	7	10	7	10	26	24	17	27	24	17
40	18471A0342		5	5	5	5	4	5	10	10	10	8	8	8	10	8	10	30	30	19	28	26	18
41	18471A0343		5	5	5	5	4	4		10	8	9	9	9	10	6	7	18	28	16	26	22	16
42	18471A0344		4	5	4		4	4	10	6	9	10	9		10	9	2	28	19	17	22	20	2
43	18471A0345		5	5	3	3	2	4	10	8	9	9	9	9		8	9	29	23	15	18	26	18
44	18471A0346		5	5	4	3	4	5	8		10	10	9	8	10	10	9	28	17	19	29	28	17
45	18471A0347		4	5	4	5	4	5	9		10	7	7	7	10		10	28	19	19	27	17	17
46	18471A0348		5	5	5	4	5	4	9		5	10	10	8		7	10	24	14	14	20	27	18
47	18471A0349		4	5	2	4	4	4	10	9	4	10	8		10	10	3	23	19	12	23	21	3
48	18471A0350		4	5	2		4	4	3	10	3	9	9	9	4	7	2	15	15	11	15	18	11
49	18471A0351		5	2	4	5	5	5	8	10	9	9	9	9	7	6	7	24	28	19	23	22	16
50	18471A0352		5	5	5	3	5	5	9	9	10	8	10	10	10	10	10	29	27	20	28	30	20
51	18471A0353		4	5	4		3	4		8	9	8	8	8	5	7	5	18	21	16	18	20	13
52	18471A0354		4	5	3	4		4	8	9	9	10	5		10	8	1	26	25	13	21	14	1
53	18471A0355		4	5	3	4	4	5		10	3				0		10	12	20	12	10	10	10
54	19475A0301		4		2	2	5	4	8	8	4	9	9	9	10	7	9	16	16	13	28	25	18
55	19475A0302		5	5	4	4	4	4	10	9		9	9	9	10	8	6	20	17	8	25	23	15
56	19475A0304		4	5	4	3	3	5	10	8	10	8	10	7	10	9	10	29	25	18	28	29	17
57	19475A0305											9	9	9	8	10	9	0	0	0	26	28	18
58	19475A0307		4	3	5	5	5	5	10	10	10	10	10	8		10	10	27	30	20	20	30	18
59	19475A0308		4	5			3	5	10		3	9	9	9	10	10	9	22	3	11	28	28	18
60	19475A0309		5		4			5	9	10	10	8	8	10	10	10	10	24	24	15	28	28	20
61	19475A0310		5		5	4	5	5	10	5	10	10	10	9	10	10	9	25	24	20	29	29	18
62	19475A0311		5	5	5	5	5	5	10	7	10	9	9	9	10	10	8	30	27	20	27	27	17
63	19475A0312		5	5	5	5	5	4	10		9	10	9	9	10		8	29	19	18	28	17	17
64	19475A0313		5	5	4	4	5	5	10		6	10	9	9	10		9	26	14	16	29	18	18
65	19475A0314		4	5	4	4	2	5	10		9	9	9	7	10		9	28	17	16	28	18	16
66	19475A0315		5	5	4	5	2	5	10		10	8	8	8	10		10	30	19	17	28	18	18
67	19475A0316		4	5	4	4	4	5	10	8	9	10	10	9	10		9	28	25	18	29	19	18
68	19475A0317		5	5	5	5	3	5	10	10	10	8	8	8	10	7	10	30	30	18	28	25	18

69	19475A0318		5	5	5	5	5	5	10	10	9	9	10	10	10	10	10	29	29	19	29	30	20
70	19475A0319		5	5	3	4	3	5		10	9	9	9	9	10	9	10	19	26	17	29	28	19
71	19475A0320											7	7	7	10		7	0	0	0	24	14	14
72	19475A0321		4		4	4	3	5	10		10	10	9	9		10	9	24	18	18	19	28	18
73	19475A0322		4	4	4	4	3	4	10	10	8	9	9	9	10		10	26	26	15	29	19	19
74	19475A0323		4	5	4	4	3	5	10	10	10	9	9	9		10	10	29	28	18	19	29	19
75	19475A0324		3	4	4	4	4	5	10	10	10	10	10	8	10	9	9	27	28	19	29	28	17
76	19475A0325		4	5	5	5	4	5	10		8	8	8	8	10		9	27	18	17	27	17	17
77	19475A0326		4	5	4	5	3	5	10		9	9	9	9	10		10	28	18	17	29	19	19
78	19475A0327		4	3	3	4	3	4	10		8	9	9	9	10		10	25	15	15	29	19	19
79	19475A0328		4	5	3	3	2	5	10	7	8	9	9	9	10	10	10	27	21	15	29	29	19
80	19475A0329		3		4	4	1	4	10		9	9	9	9	10		9	22	17	14	28	18	18
81	19475A0330		4	1	5	4	3	5	10		10	7	7	7	10	9	9	25	19	18	26	25	16
82	19475A0331		4	5	3	4	4	5		10	10	8	8	9	10		9	19	27	19	27	17	18
83	19475A0332			3	3		4	5		10	10	8	8	8		10	10	13	23	19	18	28	18
84	19475A0333			3	4		4	5	5	10	8	9	9	9		10	9	16	22	17	18	28	18
85	19475A0334		3	5	4	4	4	4	10	10	10	9	9	7	10		10	28	28	18	29	19	17
86	19475A0335		4	4	4	4	4	4	10	10	10	9	9	7	10		10	28	28	18	29	19	17
87	19475A0336		4	4	4	4	2	4	10	9	9	7	7	7	10		5	27	26	15	22	12	12
88	19475A0337		3	5	4		3	5	10	9	10	8	8	6	10		4	28	23	18	22	12	10
89	19475A0338		4	4	4	2	4	4		10	10	8	8	8	10		10	18	26	18	28	18	18
90	19475A0339		4	5	4	4	4	5	10	10	9	9	9	7	10	7	10	28	27	18	29	26	17
91	19475A0340		3	2	3	3	2	5	10	8	10	8	8	8	10		7	25	24	17	25	15	15
92	19475A0341		4	5	5	4	4	4	10		9	8	8	8	10	8	10	28	18	17	28	26	18
93	19475A0342		2	5	5	4	3	5		10	9	8	8	9	10		9	16	28	17	27	17	18
94	19475A0343		2	5	5	5	2	5		9	9	10	9	9	10		9	16	28	16	29	18	18
95	19475A0344		3	5	3	3	3	5		10	10	8	8	8	10		10	18	26	18	28	18	18
96	19475A0345		4	5	4	4	4	5	10		10	9	9	9	10		10	29	18	19	29	19	19
97	19475A0347		3	4	3	3	2	4	10		9	9	9	9	10		10	26	15	15	29	19	19
98	19475A0348		3	5	5	3	3	4		10	9	10	8	7		10	10	17	27	16	20	28	17
99	19475A0349		3	3	3	3		2	10	9	9	9	9	7	10	10	10	25	24	11	29	29	17
100	19475A0350		4	4	5	5	4	5		10	9	9	9	9			8	17	29	18	17	17	17
101	19475A0351				4.5		4.5	5		10	2	8	8	9		10	8	2	16.5	11.5	16	26	17
102	19475A0352		4	5	4	4	3	5	5	7	9	9	9	9		10	10	23	24	17	19	29	19
103	19475A0353		4	4	4	4	4	5	10		10	10	9	9	10		10	28	18	19	30	19	19
104	19475A0354		4	4	4	3	3	4	10		9	8	8	8	A	10	10	27	16	16	18	28	18
105	19475A0355		3		4	4	4	5	10		8	8	8	8	10	8	4	21	16	17	22	20	12

106	19475A0356		0		4	4	3	5	10		9	8	8	8		10	10	19	17	17	18	28	18
107	19475A0357		4	1	4	4	4	4	10	9	10	8	8	8	10		10	25	27	18	28	18	18
108	19475A0358				4	2	3	4	10	10	9	8	8	8	10		10	19	25	16	28	18	18
109	19475A0359		4	4	3	2	3	4		9	8	8	8	8		10	9	16	22	15	17	27	17
110	19475A0360		3			4	3	1	9		8	9	9	7		10	10	20	12	12	19	29	17
111	19475A0361			2	3	4	1	4	10	10	10	8	8	8		10	10	22	27	15	18	28	18
112	19475A0362		4	5	2	4		4	10		9	8	8	8	10		10	28	15	13	28	18	18
113	19475A0363			2	4	5	4	4	10	10	9	9	9	9	10		10	21	28	17	29	19	19
114	19475A0364		3		3	4	3	2	10	10	9	9	9	7		10	10	22	26	14	19	29	17
115	19475A0365		3.5	2.5	3.5	3.5	3.5	3.5	10	9	10	9	9	9	10	10	9	26	26	17	28	28	18
116	19475A0366		2	5	3	4		4	10		10	8	8	8	10		10	27	17	14	28	18	18
117	19475A0367		3	2				3	10		9	8	8	8		10	10	24	9	12	18	28	18
118	19475A0368		2			3	2	3		10	7	8	8	6		10	9	9	20	12	17	27	15
119	19475A0369		4		3	1	2	4		9	9	8	8	8		10	10	13	22	15	18	28	18
120	19475A0370		2		4		3	5		7	9	10	9	9	10		10	11	20	17	30	19	19
121	19475A0371				4	3	4	5	9	10	10	8	8	8	10		10	19	27	19	28	18	18
122	19475A0372		4	2	4	5	4	4	10		10	8	8	8	10		10	26	19	18	28	18	18
123	19475A0373		2	2	3	2	2	3		9	8	10	8		10	8	10	12	22	13	30	26	10
124	19475A0374		3	3				3	10		0	8	8	9	10	2	10	16	0	3	28	20	19
125	19475A0376		3	1	3		3	5	10		10	7	7	8	10		10	24	13	18	27	17	18
126	19475A0377				4			5		9	9	7	7	7	A	7	10	9	22	14	17	24	17
127	19475A0378		2	2	3	3	3	3		9	10	7	7	7	A	10	9	14	25	16	16	26	16
128	19475A0379		2		4	3	2	4	10		10	8	8	8	10	A	9	22	17	16	27	17	17
50% of maximum marks																		15	15	10	15	15	10
No. of Students crossed 50% of max. marks																		114	111	120	124	122	123
% of students crossed 50% of max. marks																		89	87	94	97	95	96
Attainment Level																		3	3	3	3	3	3

Course Code: C421	Course Name: MECHATRONICS				Year/Sem: IV/II
CO Attainment					
C421.1	3	2	2.30	2.45	2.32
C421.2	3	3	3.00	2.45	2.95
C421.3	3	3	3.00	2.41	2.94
C421.4	3	3	3.00	2.48	2.95
C421.5	3	2	2.30	2.46	2.32
C421.6	3	2	2.30	2.45	2.32
C421					2.63

1. Copy the Direct CO Attaiment Level (Internal) and Diect CO Attaiment Level (External) from the previous sheets and then find the Direct CO Attainment Level.
2. Find Direct CO attainment level using the formula:
   CO Attainment Level (Internal) * 30% + CO Attainment Level (External) * 70%
3. Copy Indirect CO Attainment Level.
4. Find the CO attainment level using the formula:
   Direct CO Attainment Level *90% + Indirect CO Attainment Level * 10%

Course Code: C421	Course Name: MECHATRONICS	Year/Sem: IV/II

CO-PO & CO-PSO Mapping

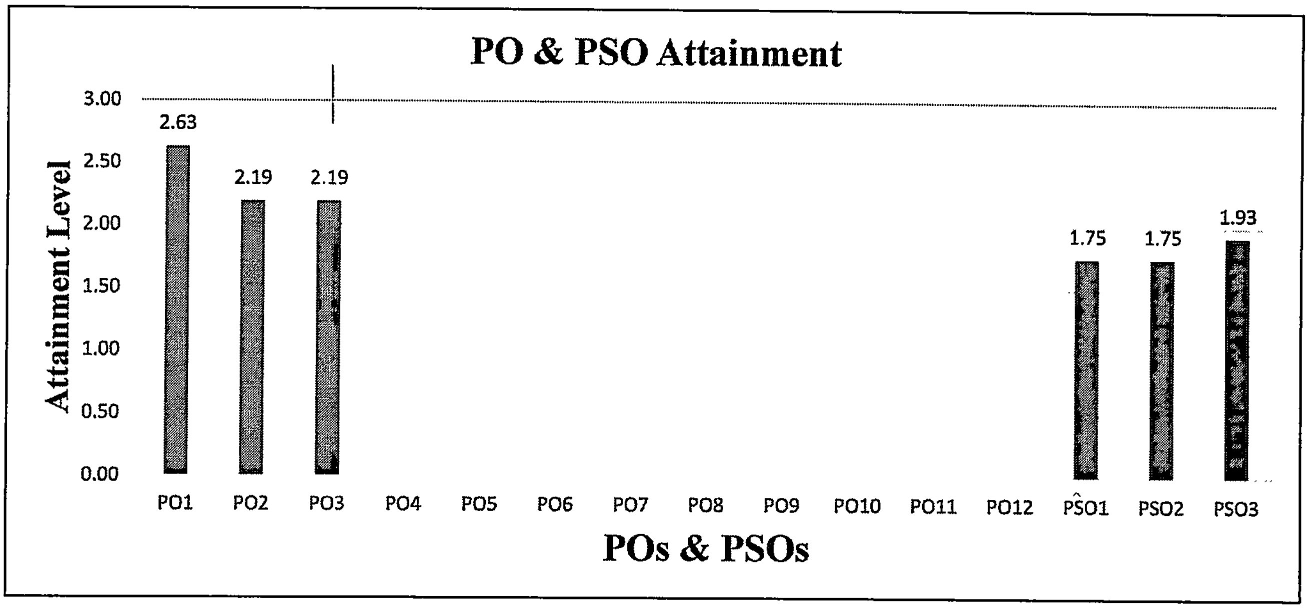
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C421.1	3	2	2	-	-	-	-	-	-	-	-	-	2	2	2
C421.2	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-
C421.3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	2
C421.4	3	3	-	-	-	-	-	-	-	-	-	-	-	-	2
C421.5	3	3	-	-	-	-	-	-	-	-	-	-	2	-	2
C421.6	3	3	3	-	-	-	-	-	-	-	-	-	-	-	3
C421	3.00	2.50	2.50	-	-	-	-	-	-	-	-	-	2.00	2.00	2.20

Total CO Attainment through Direct & Indirect Assessment

CO Attainment	2.63

PO & PSO Attainment

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PO Attainment	2.63	2.19	2.19	-	-	-	-	-	-	-	-	-	1.75	1.75	1.93



1. Copy CO - PO matrix and CO attainment matrix from previous pages and find PO attainment.
2. PO attainment is calculated as per the following formula:

   POi * Total CO attainment Level / 3   where 'i' ranges from 1 to 12

1. Copy CO - PSO matrix and CO attainment matrix from previous pages and find PSO attainment.
2. PSO attainment is calculated as per the following formula:

   PSOi * Total CO attainment Level / 3   where 'i' ranges from 1 to 3