INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTION FORM

Course Title	**Design For Manufacturing of MEMS and MICRO SYSTEMS**			
Course Code	BCC210			
Course Structure	Lectures	Tutorials	Practicals	Credits
	3	-	-	3
Course Coordinator	Mr. M. Sunil Kumar, Assistant Professor, Department of Mechanical Engineering			
Team of Instructors	Mr. M. Sunil Kumar, Assistant Professor, Department of Mechanical Engineering			

I. COURSE OVERVIEW

Microelectromechanical systems (MEMS) is the technology of microscope devices, particularly those moving with Parts. It merges at the nano-scale into nanoelectromechanical systems (NEMS) and nanotechnology. The fabrication of MEMS evolved from the process technology in semiconductor device fabrication, i.e. the basic techniques are deposition of material layers, patterning by photolithography and etching to produce the required shapes.

II. PREREQUISITE(S)

Level	Credits	Periods/ Week	Prerequisites
PG	3	3	Advanced Mechanics of Solids, Precision Engineering

III. MARKS DISTRIBUTION

Subject	SEE Examination	CIA Examination	Total Marks
Design for Manufacturing of MEMS and Microsystems	70 Marks	30 Marks	100 Marks

Semester End Examination 70 Marks All the Units (1, 2, 3, 4 and 5)	70 Marks (3 Hours)	5 questions to be answered. Each question carries 14 Marks

<table>
<tr><td rowspan="6">Average of two CIA Examinations</td><td colspan="4">Continuous Internal Assessment (CIA) - 1</td></tr>
<tr><td rowspan="3">30 Marks
(2 Hours)</td><td rowspan="3">Units
I, II and
III (half)</td><td rowspan="2">Continuous Internal Examination (CIE)
(2 hours)
[4 questions to be answered out of 5 questions from Part- A & B]</td><td>Part - A
5 questions to be answered out of 5 questions, each carries 1 mark.</td></tr>
<tr><td>Part - B
4 questions each carry 5 marks.</td></tr>
<tr><td>Technical Seminar and Term Paper</td><td>5 marks</td></tr>
<tr><td colspan="4">Continuous Internal Assessment (CIA) - 2</td></tr>
<tr><td rowspan="3">30 Marks
(2 Hours)</td><td rowspan="3">Units
III (half)
IV and V</td><td rowspan="2">Continuous Internal Examination (CIE)
(2 hours)
[4 questions to be answered out of 5 questions from Part- A & B]</td><td>Part – A
5 questions to be answered out of 5 questions, each</td></tr>
<tr><td>Part - B
4 questions each carry 5 marks.</td></tr>
<tr><td>Technical Seminar and Term Paper</td><td>5 marks</td></tr>
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IV. EVALUATION SCHEME

S. No	Component	Duration	Marks
1	CIE - I Examination	2 hour	25
2	Technical Seminar and Term Paper	10 minutes seminar and 1000 words document	05
TOTAL			30
3	CIE - II Examination	2 hour	25
4	Technical Seminar and Term Paper	10 minutes seminar and 1000 words document	05
TOTAL			30
CIA Examination marks to be considered as average of above two CIA's			
5	EXTERNAL Examination	3 hours	70
GRAND TOTAL			100

V. COURSE OBJECTIVES

The course should enable the students to:

I. Understand of modern trends in design and manufacturing using CAD/CAM.
II. Apply advanced aspects of enabling computer aided technologies used in design.
III. Enumerate fundamental theories and technologies in computer aided manufacturing.

VI. COURSE OUTCOMES

At the end of the course the students are able to:

1. Understand the operational theory of common MEMS sensors and MEMS.
2. Identify the situations where MEMS sensors and actuators would be ideal for applications to various products.
3. Apply the scaling-law to determine if MEMS devices would perform better than existing non-microscale devices.
4. Analyze the engineering science and physics of MEMS devices at the micro-scale including: Electrostatics, thermodynamics, piezoresistive, magnetism, microfluidics and optics.
5. Understand the fabrication methods used to build/construct MEMS.
6. Selection and sizing of tools and components for CNC.

VII. HOW PROGRAM OUTCOMES ARE ASSESSED

Program Outcomes		Level	Proficiency assessed by
PO1	**Engineering Knowledge:** Capability to apply knowledge of Mathematics, Science Engineering in the field of Mechanical Engineering	H	Technical Seminar
PO2	**Problem Analysis:** An ability to analyze complex engineering problems to arrive at relevant conclusion using knowledge of Mathematics, Science and Engineering.	H	Technical Seminar
PO3	**Design/ Development of solution:** Competence to design a system, component or process to meet societal needs within realistic	S	Guest Lectures
PO4	**Conduct investigation of complex problems:** To design and conduct research oriented experiments as well as to analyze and implement data using research methodologies.	S	Projects
PO5	**Modern Tool usage:** An ability to formulate solve complex engineering problems using modern engineering and information technology tools.	S	Projects
PO6	**The Engineer society:** To utilize the engineering practices, techniques, skills to meet needs of health, safety legal, cultural and societal issues.	N	--
PO7	**Environment and Sustainability:** To understand the impact of engineering solution in the societal context and demonstrate the knowledge for sustainable development.	N	--
PO8	**Ethics:** An understanding and implementation of professional and Ethical responsibilities.	N	--
PO9	**Individual Team work:** To function as an effective individual and as a member or leader in multi-disciplinary environment and adopt in diverse	N	Guest Lectures
PO10	**Communication:** An ability to assimilate, comprehends, communicate, give and receive instructions to present effectively with engineering community and society.	N	--
Program Outcomes		**Level**	**Proficiency assessed by**
PO11	**Project Management and Finance:** An ability to provide leadership in managing complex engineering project at multi-disciplinary environment and to become a professional engineer.	N	--
PO12	**Life-Long learning:** Recognition of the need and an ability to engage in lifelong learning to keep abreast with technological changes.	S	Projects

VIII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

Program Specific Outcomes		Level	Proficiency assessed by
PSO1	**Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical system including allied engineering streams.	H	Technical Seminars
PSO2	**Design/ Analysis:** An ability to adapt and integrate current technologies in the design and manufacturing domain to enhance the employability.	S	Projects
PSO3	**Successful Career and Entrepreneurship:** To build the nation by imparting technological inputs and managerial skills to become a Technocrats.	S	Guest Lectures

N - None S - Supportive H - Highly related

IX. SYLLABUS:

UNIT-I OVERVIEW AND WORKING PRICIPLES OF MEMS AND MICROSYSTEMS

Overview and working principles of mems and microsystems: MEMS and microsystems, evolution of micro fabrication, microsystems and microelectronics, microsystems and miniaturization, applications of MEMS in industries, micro sensors, micro actuation, MEMS with micro actuators micro accelerometers, micro fluidies.

UNIT – II ENGINEERING SCIENCE FOR MICROSYSTEMS DESIGN AND FABRICATION

Engineering science for microsystems design and fabrication: Atomic structure of matter, ions and ionization, molecular theory of mater and intermolecular force, doping of semiconductors, diffusion Process, plasma physics, electrochemistry, quantum physics.

UNIT – III ENGINEERING SCIENCE FOR MICROSYSTEMS DESIGN AND FABRICATION

Engineering mechanics for microsystems design: Static Bending of thin Plates, mechanical vibration. Thermo mechanics fracture mechanics, thin-film mechanics, overview of finite element stress analysis

UNIT – IV THERMO FLUID ENGINEERING AND MICROSYSTEMS DESIGN

Thermo fluid engineering and microsystems design: Overview of basics of fluid mechanics in macro and meso scales, basic equations in continuum fluid dynamics, laminar fluid flow in circular conduits, computational fluid dynamics, incompressible fluid flow in micro conduits, fluid flow in sub micrometer and nano scale, overview of heat conduction in solids, heat conduction in multilayered thin films and in solids in sub micrometer scale, design considerations, process design mechanical design, mechanical design using finite element method, design of a silicon die for a micro pressure sensor.

UNIT – V MATERIALS FOR MEMS, MICROSYSTEMS AND THEIR FABRICATION

Materials for mems and microsystems and their fabrication: Substrates and Wafers, Active substrate materials, Silicon as a substrate material, Silicon Compounds, Silicon Piezoresistors, Gallium Arsenide, Quartz, Piezoelectric Crystals and Polymers, Photolithography, Ion implantation, Diffusion and oxidation, chemical and physical vapor deposition, Etching, Bulk micro manufacturing, Surface Micromachining, The LIGA Process

TEXT BOOKS

1. Tai-Ran Hsu, “MEMs & Microsystems: Design & Manufacture”, Tata McGraw Hill, 1st Edition, 2002.
2. M. Maluf, “An Introduction to Microelectromechanical Systems Engineering”, Artech House, 1st Edition, 2000.
3. Trimmer, W.S.N, “Micro robots and Micromechanical Systems Sensors & Actuators”, 19th Edition, 1989

REFERENCE BOOKS

1. Madou, M, "Fundamentals of Microfabrication", CRC Press, 1st Edition, 1997.
2. Hsu, T.R, "The Finite Element Method in Thermomechanics", Alien & Unwin, London, 1stEdition,1986.

COURSE PLAN

At the end of the course, the students are able to achieve the following course learning outcomes.

Lecture No.	Course learning outcomes	Topics to be covered	Reference
1-3	**Understand** the overview of MEMS.	Unit-I OVERVIEW AND WORKING PRINCIPLES OF MEMS AND MICROSYSTEMS: MEMS and Microsystems, evolution of micro fabrication.	T1,T2
4-6	**Understand** the design of microsystems and miniaturization.	Microsystems and microelectronics, microsystems and miniaturization.	T1
7-9	**Understand** the applications of MEMS.	Applications of MEMS in industries.	T1
10-12	**Understand** the working of micro sensors and micro actuation.	Micro sensors, micro actuation,	T1
13-14	**Understand** the working of micro actuators	MEMS with micro actuators	T1,T2
15-17	**Understand** the applications of micro Accelerator.	Micro accelerometers	T1
18-20	**Understand** about micro fluidics	Micro fluidics.	T1
21-23	**Understand the** design of microsystems and fabrication	**Unit-II ENGINEERING SCIENCE FOR MICROSYSTEMS DESIGN AND FABRICATION**	T1
23-25	**Understand** the engineering science for micro system design.	Atomic structure of matter, ions and ionization,	T1,T2
26-28	**Understand** the engineering science for micro system design.	Molecular theory of mater and intermolecular force,	T1
29-30	**Understand** the engineering science for micro system design.	doping of semiconductors, diffusion Process.	T1
31-33	**Understand** the engineering science for micro system design.	Plasma physics.	T1
34-36	**Understand** the engineering science for micro system design.	Electrochemistry.	T1,T2
37-39	**Understand** the engineering science for micro system design.	Quantum physics.	T1
40-42	**Understand**	**UNIT-III ENGINEERING SCIENCE FOR MICROSYSTEMS DESIGN AND FABRICATION**	T1,R1
43-45	**Understand** the phenomenon of bending	Static Bending of thin Plates,	T2
46-48	**Understand** about the mechanical vibration.	Mechanical vibration.	T1,T2
49-51	**Analyze about** thermo mechanics frature mechanics.	Thermo mechanics fracture mechanics.	T1
52-54	**Understand** about the overview of finite element stress analysis.	thin-film mechanics, overview of finite element stress analysis.	T1
55-57	**Understand** about thermo fluid engineering and micro system design and fluid mechanics.	**UNIT-IV THERMO FLUID ENGINEERING AND MICRO SYSTEMS DESIGN**. Overview of	T1

		basics of fluid mechanics in macro and meso scales, basic equations in continuum fluid dynamics.	
58-60	**Understand** the phenomenon of fluid flow and flow in micro conduits.	laminar fluid flow in circular conduits, computational fluid dynamics, incompressible fluid flow in micro conduits, fluid flow in sub micrometer and nano scale.	T1,T2
61-63	**Understand** the overview of heat conduction in thin films and in sub micrometer scale.	overview of heat conduction in solids, heat conduction in multilayered thin films and in solids in sub micrometer scale.	T1,R1
64-65	**Understand** the design consideration, process design	design considerations, process design mechanical design, mechanical design using finite element method,	T1
66-68	**Illustrate** the design of micro pressure sensor.	design of a silicon die for a micro pressure sensor.	T1,R1
69-71	**Understand** the material for MEMS and microsystems.	**Unit- V MATERIALS FOR MEMS, MICROSYSTEMS AND THEIR FABRICATION** Substrates and Wafers, Active substrate materials, Silicon as a substrate material, Silicon Compounds, Silicon Piezoresistors,	
72-74	**Understand** the material for MEMS and microsystems.	Gallium Arsenide, Quartz, Piezoelectric Crystals and Polymers, Photolithography, Ion implantation, Diffusion and oxidation,	
74-76	**Illustrate** the various deposition and LIGA Process	chemical and physical vapor deposition, Etching, Bulk micro manufacturing, Surface Micromachining, The LIGA Process	

XI MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OFPROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Course Objectives	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
I	H	H										S	H	H	
II		H	S		S								S	H	
III	S	H	S										H		S

S - Supportive **H - Highly related**

XII MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES ANDPROGRAM SPECIFIC OUTCOMES

Course Objectives	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	H			S									H	S	
2	S	H	S									S	H		S
3	S	H			S								S		
4	H			S								S	S	S	
5	S	H	S		S							S			S
6	H	S		S											

S - Supportive **H - Highly related**

Prepared by:

Mr. M. Sunil Kumar, Assistant Professor

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