Academic Course Description

BHARATH UNIVERSITY
Faculty of Engineering and Technology
Department of Electrical and Electronics Engineering

BEE026 &Micro Electro Mechanical Systems
Eighth Semester,(Even Semester)

Course (catalog) description

The objective of this course is to present the state of the art in the areas of mechanical systemsto enable the control systems.

Compulsory/Elective course: Elective for EEE students

Credit & Contact hours : 3 and 45 hours

Course Coordinator : MS.S.DHIVYA

Instructors :MS.S.DHIVYA

Name of the instructor	Class handling	Office location	Office phone	Email (domain:@ bharathuniv.ac.in	Consultation
MS.S.DHIVYA	final year EEE	KS 303	**04422290125**	contactdhivyaeee@gmail.com	9.00-9.50 AM

Relationship to other courses:

Pre –requisites **:BEE501-control system**

Assumed knowledge : Basic knowledge in power electronics

Syllabus Contents

UNIT I INTRODUCTION 9

Intrinsic Characteristics of MEMS – Energy Domains and Transducers- Sensors and Actuators – Introduction to Micro fabrication – Silicon based MEMS processes – New Materials – Review of Electrical and Mechanical concepts in MEMS – Semiconductor devices – Stress and strain analysis – Flexural beam bending- Torsional deflection.

UNIT II SENSORS AND ACTUATORS-I 9

Electrostatic sensors – Parallel plate capacitors – Applications – Interdigitated Finger capacitor – Comb drive devices – Micro Grippers – Micro Motors – Thermal Sensing and Actuation – Thermal expansion – Thermal couples – Thermal resistors – Thermal Bimorph – Applications – Magnetic Actuators – Micromagnetic components – Case studies of MEMS in magnetic actuators- Actuation using Shape Memory Alloys.

UNIT III SENSORS AND ACTUATORS-II 9

Piezo resistive sensors – Piezo resistive sensor materials – Stress analysis of mechanical elements – Applications to Inertia, Pressure, Tactile and Flow sensors – Piezoelectric sensors and actuators – piezoelectric effects – piezoelectric materials – Applications to Inertia , Acoustic, Tactile and Flow sensors.

UNIT IV MICRO MACHINING 9

Silicon Anisotropic Etching – Anisotrophic Wet Etching – Dry Etching of Silicon – Plasma Etching – Deep Reaction Ion Etching (DRIE) – Isotropic Wet Etching – Gas Phase Etchants – Case studies – Basic surface micro machining processes – Structural and Sacrificial Materials – Acceleration of sacrificial Etch – Striction and Antistriction methods – LIGA Process – Assembly of 3D MEMS – Foundry process.

UNIT V POLYMER AND OPTICAL MEMS 9

Polymers in MEMS– Polimide – SU-8 – Liquid Crystal Polymer (LCP) – PDMS – PMMA – Parylene – Fluorocarbon – Application to Acceleration, Pressure, Flow and Tactile sensors- Optical MEMS – Lenses and Mirrors – Actuators for Active Optical MEMS

TEXT BOOKS:

1. Chang Liu, 'Foundations of MEMS', Pearson Education Inc., 2012.
2. Stephen D Senturia, 'Microsystem Design', Springer Publication, 2000.
3. Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture" Tata McGraw Hill, New Delhi, 2002.

REFERENCES:

1. NadimMaluf," An Introduction to Micro Electro Mechanical System Design", Artech House, 2000.
2. Mohamed Gad-el-Hak, editor, " The MEMS Handbook", CRC press Baco Raton, 2001.
3. Julian w. Gardner, Vijay K. Varadan, Osama O.Awadelkarim, Micro Sensors MEMS and Smart Devices, John Wiley & Son LTD, 2002.
4. James J.Allen, Micro Electro Mechanical System Design, CRC Press Publisher, 2005.
5. Thomas M.Adams and Richard A.Layton, "Introduction MEMS, Fabrication and Application," Springer, 2010.

Computer usage:

Professional component

General	-	0%
Basic Sciences	-	0%
Engineering sciences & Technical arts	-	0%
Professional subject	-	0%
Non major elective	-	100%

Broad area : Thermal Engineering,**Electronics**,Mechanical System Design

Test Schedule

S. No.	Test	Tentative Date	Portions	Duration
1	Cycle Test-1	August 1st week	Session 1 to 14	2 Periods
2	Cycle Test-2	September 2nd week	Session 15 to 28	2 Periods
3	Model Test	October 2nd week	Session 1 to 45	3 Hrs
4	University Examination	TBA	All sessions / Units	3 Hrs.

Mapping of Instructional Objectives with Program Outcome

The objective of this course is to present the state of the art in the areas of semiconductor device physics and materials technology to enable the Nano electronics.	Correlates to program outcome		
	H	**M**	**L**
1. To provide knowledge of semiconductors and solid mechanics to fabricate MEMS devices.	a,b,e	f,g	c,d,h,i,j,k,l
2. To educate on the rudiments of Micro fabrication techniques	a,b	e,f,g	c,d,h,i,j,k,l
3. To introduce various sensors and actuators	a,b,e	f,g	c,d,h,i,j,k,l
4. To introduce different materials used for MEMS	a,b,e	f,g	c,d,h,i,j,k,l
5. To educate on the applications of MEMS to disciplines beyond Electrical and mechanical engineering	a,b,e	f,g	c,d,h,i,j,k,l

H: high correlation, M: medium correlation, L: low correlation

Draft Lecture Schedule

S.NO	Topics	Problem solving (Yes/No)	Text / Chapter
UNIT I	**INTRODUCTION**		
1.	Intrinsic Characteristics of MEMS	NO	[T3],[R5],[T3]
2.	Energy Domains and Transducers	NO	
3.	Sensors and Actuators	NO	
4.	Introduction to Micro fabrication	NO	
5.	Silicon based MEMS processes	NO	
6.	New Materials	NO	
7.	Review of Electrical and Mechanical concepts in MEMS	NO	
8.	Semiconductor devices	NO	
9.	Stress and strain analysis	NO	
10.	Flexural beam bending,Torsional deflection	NO	
UNIT II	**SENSORS AND ACTUATORS-I**		
11.	Electrostatic sensors	NO	[T3],[R2],[R3]
12.	Parallel plate capacitors	NO	
13.	Interdigitated Finger capacitor	NO	
14.	Thermal Sensing and Actuation	NO	
15.	Magnetic Actuators	NO	
16.	Micromagnetic components	NO	
17.	Case studies of MEMS in magnetic actuators	NO	
18.	Actuation using Shape Memory Alloys	NO	
19.	Micro Motors		
UNIT III	**SENSORS AND ACTUATORS-II**		
20.	Piezo resistive sensors,Piezo resistive sensor materials	NO	[T2],[R3]
21.	Stress analysis of mechanical elements	NO	
22.	Applications to Inertia, Pressure, Tactile and Flow sensors	NO	
23.	Piezoelectric sensors and actuators	NO	
24.	piezoelectric effects	NO	
25.	piezoelectric materials	NO	

26.	Applications to Inertia	NO	
27.	Acoustic, Tactile and Flow sensors	NO	
UNIT IV MICRO MACHINING			
28.	Silicon Anisotropic Etching ,Anisotrophic Wet Etching	NO	[T2],[R4]
29.	Dry Etching of Silicon	NO	
30.	Plasma Etching – Deep Reaction Ion Etching (DRIE)	NO	
31.	Isotropic Wet Etching, Gas Phase Etchants	NO	
32.	Case studies ,Basic surface micro machining processes	NO	
33.	Structural and Sacrificial Materials , Acceleration of sacrificial Etch – Striction and Antistriction methods	NO	
34.	LIGA Process	NO	
35.	Assembly of 3D MEMS	NO	
36.	Foundry process	NO	
UNIT V POLYMER AND OPTICAL MEMS			
37.	Polymers in MEMS	NO	[T1],[R5],[R4]
38.	Polimide	NO	
39.	Liquid Crystal Polymer (LCP)	NO	
40.	PDMS,PMMA	NO	
41.	Parylene	NO	
42.	Fluorocarbon	NO	
45.	Application to Acceleration, Pressure, Flow and Tactile sensors	NO	

Teaching Strategies

The teaching in this course aims at establishing a good fundamental understanding of the areas covered using:

- Formal face-to-face lectures
- Tutorials, which allow for exercises in problem solving and allow time for students to resolve problems in understanding of lecture material.
- Laboratory sessions, which support the formal lecture material and also provide the student with practical construction, measurement and debugging skills.
- Small periodic quizzes, to enable you to assess your understanding of the concepts.

Evaluation Strategies

Cycle Test – I	-	5%
Cycle Test – II	-	5%
Model Test	-	10%
Assignment	-	5%
Attendance	-	5%
Final exam	-	70%

Prepared by:
MS.S.DHIVYA

Dated :

Addendum

ABET Outcomes expected of graduates of B.Tech / EEE / program by the time that they graduate:

a) An ability to apply knowledge of mathematics, science, and engineering fundamentals.

b) An ability to identify, formulate, and solve engineering problems.

c) An ability to design a system, component, or process to meet the desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

d) An ability to design and conduct experiments, as well as to analyze and interpret data.

e) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

f) An ability to apply reasoning informed by the knowledge of contemporary issues.

g) An ability to broaden the education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

h) An ability to understand professional and ethical responsibility and apply them in engineering practices.

i) An ability to function on multidisciplinary teams.

j) An ability to communicate effectively with the engineering community and with society at large.

k) An ability in understanding of the engineering and management principles and apply them in project and finance management as a leader and a member in a team.

l) An ability to recognize the need for,and an ability to engage in life-long learning.

Program Educational Objectives

PEO1: PREPARATION
Electrical Engineering Graduates are in position with the knowledge of Basic Sciences in general and Electrical Engineering in particular so as to impart the necessary skill to analyze and synthesize electrical circuits, algorithms and complex apparatus.

PEO2: CORE COMPETENCE
Electrical Engineering Graduates have competence to provide technical knowledge, skill and also to identify, comprehend and solve problems in industry, research and academics related to power, information and electronics hardware.

PEO3: PROFESSIONALISM
Electrical Engineering Graduates are successfully work in various Industrial and Government organizations, both at the National and International level, with professional competence and ethical administrative acumen so as to be able to handle critical situations and meet deadlines.

PEO4: SKILL
Electrical Engineering Graduates have better opportunity to become a future researchers/ scientists with good communication skills so that they may be both good team-members and leaders with innovative ideas for a sustainable development.

PEO5: ETHICS
Electrical Engineering Graduates are framed to improve their technical and intellectual capabilities through life-long learning process with ethical feeling so as to become good teachers, either in a class or to juniors in industry.

Course Teacher	Signature
MS.S.DHIVYA	

Course Coordinator **HOD/EEE**
(MS.S.DHIVYA) ()