MTECH in Integrated Sensor Systems (ISS) - Interdisciplinary Program

Background:

Since 2020, IIT Hyderabad has started an interdisciplinary MTech degree program in Integrated Sensor Systems (ISS). Candidates admitted into the program will require to do 52 credits which included 28 credits for course work and 24 credits for thesis work. The course work will provide all necessary basic and applied skills for design, fabrication and testing of integrated sensor system in all area of importance by using the concept of interdisciplinary science and technology. During the course work, candidates may take courses in Basic Concepts of Smart Materials and Devices, Physics of Low Dimensions Devices, Computational Modelling Techniques, Micro and Nanofabrication Technologies, Circuit and Packaging, Embedded Programming (Design and Lab), Intelligent Signal Processing using AI/IoT, and elective courses in other allied fields. Additionally, in thesis project, a candidate is required to design, analysis, fabricate, and characterize a device to achieve excellent thesis grade which will enable him/her to get confidence and skills in Integrated Sensor Systems. Most of the projects will be based on industry oriented problems. The program will help the candidates to get excellent industrial as well as academic career. The program also includes Industry lectures and a course in English communication. The overall program will develop manpower and technopreneurs in the area of sensors technology.

Duration: Two Years/Project Sponsored Three Years

Eligibility:

BE / B Tech or equivalent degree in any discipline with GATE paper in AE, BT, BM, CE, CH, EE, EC, IN, ME, MT, PH, XE OR M Sc or equivalent degree in Electronics, Physics, Chemistry with GATE paper in CY, EC, IN, PH.

Selection Procedure:

The MHRD supported candidates will be selected based on **GATE ranking**. Self-Sponsored and Industry sponsored candidates will be selected based on **written exam and/or interview**.

2 Yrs. MTECH (ISS-Integrated Sensor Systems)

Total Credit: 52 (28 Theory + 24 Thesis)

Course Code	**Semester 1**	
IS5010	Smart Material and Transducers	2
IS5013	Fabrication Technology and Characterization (Theory+Lab)	3
IS5020	Physics of low dimensional systems and quantum devices	3
IS5030	Computational modelling techniques	2
ISXXXX	Elective –I (Fundamental/Generic)	2 (or 3)*
LAXXXX	English Communication	1
IS5050	Industry Lecture Series	1
	Total	14

	Semester 2	
IS5023	Circuits and Packaging	3
ISXXXX	Elective – II (Circuit &Signal specific)	2 (or 3)*
ISXXXX	Elective – III (Device specific)	2 (or 3)*

ISXXXX	Elective – IV (Technology Specific)	2 (or 3)*
IS5033	Embedded Programming (Design+ Lab)	3
IS5040†	Intelligent Signal Processing using AI/IoT	2
	Total	14

†IS5040 to be offered along with EE6410; Other substitute: EE5158/EE5147/EE5611

*** Total elective credits (I+II+III+IV) should not exceed 8.**

	Semester 3	
IS5015	Thesis stage -1	12

	Semester 4	
IS5025	Thesis stage -2	12

3 Yrs MTECH (ISS-Integrated Sensor Systems) - Interdisciplinary Department

Total Credit: 52 (28 Theory + 24 Thesis)

Course Code	**Semester 1**	
IS5010	Smart Material and Transducers	2
IS5013	Fabrication Technology and Characterization (Theory+Lab)	3
IS5020	Physics of low dimensional systems and quantum devices	3
IS5030	Computational modelling techniques	2
ISXXXX	Elective –I (Fundamental/Generic)	2 (or 3)*
LAXXXX	English Communication	1
IS5050	Industry Lecture Series	1
	Total	14

	Semester 2	
IS5023	Circuits and Packaging	3
ISXXXX	Elective – II (Circuit &Signal specific)	2 (or 3)*
ISXXXX	Elective – III (Device specific)	2 (or 3)*
ISXXXX	Elective – IV (Technology Specific)	2 (or 3)*
IS5033	Embedded Programming (Design+ Lab)	3
IS5040†	Intelligent Signal Processing using AI/IoT	2
	Total	14

†IS5040 to be offered along with EE6410; Other substitutes: EE5158/EE5147/EE5611

*** Total elective credits (I+II+III+IV) should not exceed 8.**

	Semester 3	
IS5035	Thesis stage -1	Variable**

	Semester 4	
IS5045	Thesis stage -2	Variable**

	Semester 5	
IS5055	Thesis stage -3	Variable**

	Semester 6	
IS5065	Thesis stage -4	Variable**

****Total thesis credit = 24 and the distribution per semester to be decided by Guide.**

Guidelines for Guide and Elective Selection

1) Guide selection at the end of 1st Semester.
2) For project sponsored student, guide to be assigned at the start of first semester
3) Each student will be guided by 2 associated faculty members from different department except for project sponsored student who is guided by PI and/or CoPIs.
4) Elective I should be taken in consultation with MTech Convener or PI.
5) Electives II, III, and/or IV should be taken in consultation with the guide or PI.
6) Electives I, II, III, and/or IV can be selected from the other departments mentioned previously or any other courses only with the approval of Guide/PI/MTech Convener.
7) Total elective grades (I+II+III+IV) should not exceed 8 credits.
8) Course and thesis credits allocation per semester to be decided with the approval of Guide/PI's for 3 Year MTech.
9) Emphasis can be given on development of sensors or actuators for the thesis work. However, guides/PIs are free to allot the topic of thesis relevant to Integrated Sensors System.

Electives:

I. List of electives under different baskets

Course Code	**Electives I**	
CH5390	Microfluidic Platform for Cell Culture & Diagnostics (3D Printer)	1
BM4190	Biofabrication (3D Printed device)	2
MS5010	Properties of Materials	3
CY7230	Nanochemistry and Applications	3
EE6150	Nanophotonics and Metamaterials	3
MS5030	Materials Synthesis and Characterization	3

Course Code	**Electives II**	
EE5139	Power Management Integrated Circuit Design	2
EE7120	CMOS Sensors	2
PH6168	Spintronics	2
EE6160	Mesoscopic Carrier Transport	2

Course Code	**Electives III**	
CH5290	Introduction to Microfluidics and Micro reactors (3D printer)	2
PH6438	Fundamentals of Semiconductors Physics and Devices	2
EE5107	Semiconductor Physical Electronics	2
EE6140	Introduction to Biosensor Technology	3
EE6180	Biomedical IC Design	3
EE6410	Biomedical IC Design	3

Course Code	**Electives IV**	
EE5170	Thin-film Transistors	3
PH7013	Advanced Optical Instrumentation	3
PH6448	Microfabrication Techniques	2

CY7040	Organic Electronics and Photonics	3
MS5270	2d Materials: Synthesis, Characterization and Applications	3
PH6198	Organic Electronics	2
BM6110	Nano medicine	2

II. Complete Lists of Electives:

With the permission of Guide/MTech co-ordinator, a student can select alternate elective from the below mentioned list or any other suitable course from other department.

Course Code	Courses from other departments	Credits
BM4190	Biofabrication	2
BM6110	Nano medicine	2
CH6730	Nature Inspired materials engineering	2
CH6720	Basics of Nanosciences and Nanotechnology	2
PB5220	Advanced Fabrionics	2
CH5390	Microfluidic Platform for Cell Culture & Diagnostics	1
CH6840	Biomaterials Science and Engineering	2
CH6770	Introduction to Applied Statistical Mechanics	2
CH5290	Introduction to Microfluidics and Micro reactors	2
CY7040	Organic Electronics and Photonics	3
CY7230	Nanochemistry and Applications	3
CY8998	Applications of 3d Printing in Chemistry	3
CY5230	Statistical Thermodynamics and Surface Science	3
CY5220	Solid State Chemistry	3
CY8938	Modern Molecular Simulation Methods	3
EE6140	Introduction to Biosensor Technology	3
EE7120	CMOS Sensors	2
EE6150	Nanophotonics and Metamaterials	3
EE5611	Machine Learning Applications for Wireless Communications	2
EE5607	ML – Hardware Implementation	1
EE5170	Thin-film Transistors	3
EE5167	Embedded System Hardware and Design	2
EE5168	Embedded Systems: Hardware Languages	1
EE5147	Digital IC Design	2
EE5148	Digital IC Design Lab	1
EE5127	Analog IC Design	2
EE5128	Analog IC Design Lab	1
EE5158	Advanced Digital IC Design	2
EE5159	Microfabrication and Device Simulation Laboratory	2
EE5110	Semiconductor Device Modeling	3
EE5139	Power Management Integrated Circuit Design	2
EE5300	Digital Signal Processing	3
EE6120	Nanoelectronics: Principles and Devices	3
EE6160	Mesoscopic Carrier Transport	2
EE6180	Biomedical IC Design	3
EE6410	Biomedical IC Design	3
EE7110	More Than Moore Electronics	3
ME5010	Mathematical Methods for Engineers	3
ME5130	Finite Element Method	3
ME5080	Scaling Laws and Multi-scale Manufacturing	1.5
ME5660	Applied Micro and Nanomechanics in Engineering	3
MS5010	Properties of Materials	3
MS5030	Materials Synthesis and Characterization	3

MS5080	Thin Films Technology	3
MS5140	Introduction to Computational Methods in Materials Science	3
MS5270	2d Materials: Synthesis, Characterization and Applications	3
MS5290	Plasmonics: Fundamentals to Advanced Applications	3
PH4268	Solid State Physics	2
PH6168	Spintronics	2
PH6198	Organic Electronics	2
PH6317	Physics and Applications of Functional Materials	1
PH6438	Fundamentals of Semiconductors Physics and Devices	2
PH6448	Microfabrication Techniques	2
PH7013	Advanced Optical Instrumentation	3
CS6230	Optimization Methods in Machine Learning	3
CS6510	Applied Machine Learning	3

NEW Course Proposal:

IS5010: Smart Material and Transducers (Credit 2)

Introduction to functional materials, Ferroelectricity, Piezoelectricity, Magnetoresistance; Nature inspired material engineering for applications in environment, energy, healthcare. Energy harvester, biosensor and gap between natural and nature inspired material. MEMS based sensors and actuators: accelerometer, gyroscope.

References:

1. K.Uchino "Advanced Piezoelectric materials science and technology" Woodhead publishing
2. J.F. Nye "Physical properties of Crystals, Oxford Science publishers
3. S. D. Senturia, "Microsystem Design", Springer, NewYork, USA.
4. Alberto Corigliano, Raffaele Ardito, Claudia Comi, Attilio Frangi, Aldo Ghisi, Stefano Mariani "Mechanics of Microsystems", John Wiley & Sons, 20-Nov-2017.
5. Harmeet Bhugra, Gianluca Piazza, "Piezoelectric MEMS Resonators", Springer, 09-Jan-2017.

IS5013: Fabrication Technology and Characterization (Credit 3)

Fabrication methods for MEMS: Microstereolithography, Lithography, Galvanoformung, Abformung (LIGA), Micromachining, etc., Surface micromachining, Bulk micromachining, Dry bulk micromachining, Deep reactive Ion Etching (DRIE), Wet chemical-based micromachining. Thin film, 3-D ICs Fabrication, Modelling challenges, Material, Mechanical and Electrical characterization.

References

1. M. Gad-el-Hak, "The MEMS Handbook". 2nd edition. CRC Press.
2. M. Tilli. T. Motooka, V. M. Airaksinen, S. Franssila, M. P. Krockel, V. Lindroos, "Handbook of Silicon Based MEMS Materials and Technologies", William Andrew
3. P. Pal, and K. Sato, "Silicon wet bulk micromachining for MEMS". CRC Press.
4. M. Elwenspoek, H. Jansen, "Silicon Micromachining". Cambridge University Press, UK.
5. T. R. Hsu, "MEMS & Microsystems: Design and Manufacture", Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
6. Marc Madou, "Fundamental of microfabrications: the science of miniaturization", 2nd Edition, CRC Press, New York.

IS5050: Industry Lecture Series (Credit 1)

There will be 12 to 14 lecture series by different industry experts.

IS5020: Physics of Low Dimensional Devices and Quantum Devices (Credit 3)

Phonons and lattice dynamics, Free electron theory and Band theory of solids, Density of states, 1D, 2D and 3D, Effective mass tensors in low dimensions Heterostructure concepts and low dimensional systems such as quantum wells, nanowires and quantum dots. Quantum physics applied to such systems. Optical properties of low dimensional systems (transition rules, polarization etc). Transport properties of 2D and 1D systems. Quantized conductance with Landauer-formalism. Scattering phenomena in 1D. Devices based on quantum phenomena and Coulomb blockade. Magnetic nanowires, Domain wall motion devices, Magnetic nanoparticles and applications to data storage, the dielectric function and optical absorption • Excitons and plasmonics, Raman scattering and photoluminescence.

References

1. Davies, J H, "The Physics of Low-dimensional Semiconductors: An Introduction", Cambridge University Press 1997. ISBN: 052148491X
2. Kittel, Charles, "Introduction To Solid State Physics" 8Th Ed
3. Martin T. Dove, "Structure and dynamics", Oxford University press, 2002
4. John Singleton, "Band Theory and Electronic Properties of Solids", Oxford University press, 2001.
5. Stephen Blundell, "Magnetism in condensed matter", Oxford University press, 2001.
6. F.Iacomi, "Spectroscopia vibrațională a materialelor zeolitice," Ed. Stef, Iasi, 2007
7. L.David, C.Craciun, O.Cozar, V.Chis, Rezonanta "Electronica de Spin. Principii. Metode. Aplicatii". Presa Universitara Clujeana, Cluj-Napoca, 2001
8. S. E. Lyshevski, "Nano and Molecular Electronics", CRC Press Taylor & Francis Group 2007

IS5030: Computational modelling techniques (Credit 2)

Review of computational linear algebra, numerical methods for ordinary and partial differential equations, concepts of modeling across length and time scales, thermodynamic and kinetic models, Basic electronic structure methods - applications in thermodynamics of phase transitions, determination of physical properties Atomistic simulations: Molecular Dynamics and Monte Carlo methods and their applications in materials modelling; Mesoscale methods: phase-field models and their applications in process-structure-property relations, Concepts of scale bridging; Applications of Finite Element Method in Multiphysics Modeling Multiphysics Simulations of Micro/Nano Devices

References:

1. Richard Lesar, "Introduction to Computational Materials Science", Materials Research Society, Publisher: Cambridge English; First South Asian Edition edition (2016).
2. Daan Frenkel and Berend Smit, "Understanding Molecular Simulation: From Algorithms to Applications", 2nd Edition -, Academic Press.
3. J N Reddy, "An Introduction to the Finite Element Method", J N Reddy, McGraw Hill Education, July 2017.
4. Attilio Frangi, "Advances in Multiphysics Simulation and Experimental Testing of MEMS", World Scientific, 2008
5. John A. Pelesko, David H. Bernstein, "Modeling MEMS and NEMS", CRC Press, 25-Nov-2002.

IS5023: Circuits and Packaging (Credit 3)

RLC circuits, Amplifier, OPAMP/OTA, Comparator, Data Converter, Clock generation. MOSFET Fundamentals, CMOS logic Circuits, Memory, RTL coding, Die-bonding, Chip Packaging, SiP/SoP

References

1. Behzad Razhavi, "Fundamentals of Microelectronics", Wiley 2013
2. Bob Dobkin, Jim Williams, "Analog Circuit Design: A Tutorial Guide to Applications and Solutions" Newnes; 1 edition (January 9, 2013)
3. William J. Greig, "Integrated Circuit Packaging, Assembly and Interconnections", Springer, Boston, MA, 2003

4. John P. Uyemura, “CMOS Logic Circuit Design”, Kluwer Academic Publishers, New York, 2002.

IS5033: **Embedded Programming (Design +Lab) (Credit 3)**

Introduction to Embedded Systems, Architectures of embedded processors, Memory hierarchy and its management Basics of Microcontrollers –timers, interrupts, analogy to digital conversion, bootloaders Interaction with devices -buses, memory management, device drivers and wireless comm., Interfacing sensors, actuators and peripherals. Real-time principles - multi-tasking, scheduling, synchronization Building low-power high-performance systems – code profiling and optimization Architecture, Case Studies of Real time. Microcontrollers/Microprocessor: Arduino, Raspberry-pi, ARM, FPGA, ESP32, RL78etc)

References

1. Hennessy & Patterson "Computer architecture a quantitative approach", Morgan Kaufmann; 5 edition (25 October 2011).
2. Randal E. Bryant & David R. O'Hallaron "Computer Systems: A Programmer's Perspective” Pearson; 2 edition (4 February 2010).
3. https://github.com/gadepall/IOT
4. https://github.com/gadepall/arm-embedded
5. https://github.com/gadepall/arduino
6. https://github.com/gadepall/FPGA

IS5040: Intelligent Signal Processing using AI/IoT (Credit 2)

Algorithms, IC Design Perspective. Different types of signal processing techniques, Traditional Signal Processing algorithms vs. Practical Constraints; Need of an holistic view of Algorithm and VLSI Architecture, Hardware complexity analysis of resource constrained system; Computational Delay analysis of resource constrained system; Trade-off analysis : Arithmetic complexity vs Signal parameters; Wireless Sensor Networks, Network characteristics, Network Design and Challenges, Wireless Sensor Node Architecture and Design, Wireless Sensor Network Architecture, Data Aggregation, Sensor Data storage, Data Management and Processing, Time Synchronisation, Wireless Sensor and Actuator Networks, Network design, Control on Sensor Networks. Role of AI and ML in overall data aggregation, management and processing.

References:

1. Morris Mano “Digital Design-With an Introduction to the Verilog HDL”, Pearson, Prentice Hall, New Jersey.
2. Hennessey and Patterson, Morgan Kaufmann “Computer Architecture Computer Architecture: A Quantitative Approach” 5 edition (September 30, 2011).
3. Israel Koren, A K Peters, “Computer Arithmetic Algorithms”, CRC Press; 2 edition (November 30, 2001).
4. Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic “Digital Integrated Circuits: A design perspective”, Pearson Education India; Second edition (25 May 2016).
5. Hyeji Kim, Yihan Jiang, Ranvir Rana, Sreeram Kannan, Sewoong Oh, Pramod Viswanath. “Communication Algorithms via Deep Learning”, https://arxiv.org/abs/1805.09317
6. Hyeji Kim, Yihan Jiang, Sreeram Kannan, Sewoong Oh, Pramod Viswanath, “Deepcode: Feedback Codes via Deep Learning”. https://arxiv.org/abs/1807.00801
7. Timothy J. O'Shea, Jakob Hoydis, “An Introduction to Deep Learning for the Physical Layer”, https://arxiv.org/pdf/1702.00832.pdf
8. Timothy J. O'Shea, Tugba Erpek, T. Charles Clancy, “Deep Learning Based MIMO Communications”, https://arxiv.org/pdf/1707.07980.pdf
9. Fayçal Ait Aoudia, Jakob Hoydis, “End-to-End Learning of Communications Systems Without a Channel Model”, https://arxiv.org/pdf/1804.02276.pdf