Potential IIT Bombay CEP courses for TEQIP III colleges

Sr. No.	Intended for	Course Name and Duration of Programme	Faculty &Department	About Course
1.	*All Branches*	**Laboratory and Ergonomic Safety for Engineers** *5 days*	*Prof. A. Kunwar* *Bioscience and BioEngineering*	*This short term course is intended to create awareness of the potential hazards and risks involved amongfaculty as well as laboratory staff members of Engineering colleges who are involvedin laboratory activities. Course Contents include; Chemical Safety, Bio Safety, Fire Safety, Laser Safety, Radiation Safety, Gas Cylinder Safety, Electrical Safety, Machine safety, Cryogenicsafety and ErgonomicSafety.*
2	*All Branches*	**Analysis of Research Problems through Design of Experiments** *3 - 5 days*	*Prof. Suhas Joshi* *MechanicalEngg.*	*The course will provide a step-by-step learning of classical as well as modern designs for experimentation using Taguchi Methods followed by analysis of the results. Design of experiments, if adopted efficiently, would aid in performing experiments to the desired level of resolution thereby avoiding unnecessary investment in resources.*
3	*All Branches*	**Innovation Entrepreneurship and Incubators** *5 days*	*Prof.Milind Atrey* *Mechanical Engg.*	*The course on offer will share with the participants, in terms of teaching of Entrepreneurship, forming a venture around an idea, as well as creating an Incubation centre in the institute or university. The course will also expose the participants to the ecosystem or the enabling mechanisms on the IIT Bombay campus which motivate students to come out with innovative ideas*
4	*All Branches*	**Academic Leadership Development** *3 days*	*Prof. Pooja Purang* *Humanities & Social Sciences*	*This academic leadership programme will be a national level activity. The program shall focus on challenges faced by Indian institutions engaged inhigher education with changing times. The main objective of the course is :To develop skills for effective leadership and Development of strategies and practices to overcome current and future challenges in highereducation*
5	*All Branches*	**Innovative Teaching Methodology** *3 days*	*Prof.Kannan Moudgalya* *Chemical Engg.*	*The developments in Information and Communication Technologies (ICT) have revolutionized the way education is delivered. Industry free Research has shown that use of ICT in teaching enhances student learning. This course will give an overview of ICT based teaching methods, such as flipped method and clickers based live lectures. This workshop will also cover free and open source software, such as Moodle, Scilab, LaTeX, Open Modelica and R. Scilab provides a powerful numerical computing environment for engineering and scientific applications, and is an alternative to the expensive Matlab.*

6	*All Branches*	**Free and Open source software in teaching and learning** *2-3Days*	*Prof. KannanMoudgalya* *Chemical Engg.*	*The developments in Information and Communication Technologies (ICT) have revolutionized the way education is delivered. Industry free Research has shown that use of ICT in teaching enhances student learning. The aim of this two-day workshop is to give hands-on training to the participants onusing Free and Open Source Software (FOSS) such as Scilab, Open Modelica, LaTeXand R in teaching and learning. Scilab provides a powerful numerical computing environment for Engineering and Scientific applications, and is an alternative to the expensiveMatlab.*
7	*All Branches*	**ICT Based Teaching Methods** *3 days*	*Prof. KannanMoudgalya* *Chemical Engg.*	*Information and communication technologies can be used effectively in teaching and learning. These can help improve the quality of teaching. A large number of students can be trained effectively through ICT based training methods. Topics covered will be: New educational methodologies, Moodle, LaTeX, Scilab and OpenModelica*
8	*All Branches*	**Teaching through Moodle** *5 days*	*Prof. P.Sunthar* *Chemical Engg.*	*This course is for any teacher wishing to setup a course on moodle and use it as a supplement to the classroom lectures. Broad outline: course structure and capabilities, forums and discussions, assignments and online grading, automated evaluations and quizzes, workshops and peer evaluation*
9	*All Branches*	**Introductory Programming** *5 days*	*Prof. A.Ranade* *Computer Sci. & Engg.*	*Computer programming is a compulsory subject for all branches of engineering. Worldwide it is considered difficult to teach. Thepurpose of this TEQUIP course is to discuss how to teach theintroductory programming course, how to enthuse students aboutprogramming, how to design assignments and examinations for thiscourse.* *The course covers pedagogy of basic language constructs as well as strategies for teaching how to design programs. Teaching design isimportant because it is often found that students may know languagefeatures but may not be able to use them. The course also discussesprogramming applications such as root finding, polynomial arithmetic, function evaluation, sorting and searching, as well as issuses in designing medium sized programs such as simple editors and simulators.A rudimentary graphics system is used as a teaching tool; it provides excitement and helps in illustrating many ideas such as recursion.* *Instructional material such as slides, sample lab assignments and examinations, and the graphics library will be supplied.*
10	*All Branches*	**Basic Electronics** *5 days*	*Prof. M.B.Patil* *Electrical Engg.*	*Basic Electronics is a compulsory course in almost all branches of engineering. The purpose of this TEQIP course is to provide comprehensive instructional material as well as guidance to faculty members engaged in teaching basic electronics.* *The course covers (a) problem solving in several areas commonly covered in an electronics course, (b) use of circuit simulation in teaching, (c) use of an app for "active learning". The last part of the course, i.e., use of an app in a classroom situation, is expected to enrich the learning experience of the students.*

				The following topics will be covered: network theorems, diode circuits, common-emitter amplifier, op-amp linear circuits, Schmitt trigger, oscillator based on Schmitt trigger, logic gates, multiplexers, asynchronous and synchronous counters, phasors, RC/RL transients.
11	*All Branches*	**Mathematics fundamentals for Engineering Teachers** *5 days*	*Prof. SachinPatwardhan* *Chemical Engg.*	*Applied mathematics and computations have assumed a central position in Engineering research and design. In particular, it is important to teach applied mathematics with engineering flavour. As a consequence, applied mathematics has to be taught in a different approach The contents of this course are as follows:* *1.Transforms & their Engineering Applications: A vector space view of functions and signals, geometric interpretations of signal processing operations and signal theoretic concepts, how one can explain several linear system theoretic ideas by taking recourse to geometric interpretations, eigen functions of linear systems, the Fourier Transform, interpreting the frequency and time domains and duality, generalization in the form of the Laplace transform, operating in time and frequencysimultaneously,* *2. time-frequency methods, multiresolution analysis and the wavelet transform, engineering applications of these ideas. Matrix Computations: In this day and age, one is more or less completely dependent on computers for everything. As far as computing is concerned, however, not everything that the computer churns out may be exact. The existence of round-off errors and overflow/underflow errors are well known but the effects of these are quite often underestimated. It is therefore rather important to understand the extent of errors that actual computation can bring into a problem. These lectures are aimed at emphasizing this gap between actual theory of linear algebra and numerical linear algebra using some examples from matrixcomputations. Mathematical Modelling based on Multivariate Regression: A large variety of grey-box and black-box mathematical models are used in all engineering disciplines for capturing static/dynamic behaviour or engineered systems*

12	*All Branches*	**End to End Innovation** *3/5 days*	*Tata Centre for Technology and Design, IIT Bombay.*	*This is a course developed to help understand the challenges of designing and implementing technology solutions, using an end to end innovation approach. The 3-day course will be a unique combination of lectures, case studies, exercises and project experiences that highlights need identification, prototype building and eventually reaching the end product to the customer, in an interactive manner. With an additional lab component, this course can extend up to 5days.*
13	*All Branches*	**Analysis of Modern Manufacturing Process.** *5 days*	*Prof. Prashant P. Date* *Mechanical Engg.*	*Manufacturing is an intensely competitive activity. It is important to know of the recent developments and be able to consider several processing alternatives and choose the most economical one. Knowledge about the process is important for equipment selection & process capability assessments and for quality that can be expected from aprocess.*
14	*All Branches*	**Linear Algebra for Engineers** *5 days*	*Prof. INDER KUMAR RANA* *Mathematics*	*The course will have two parts: Part one will cover important aspects of Linear Algebra as needed in Engineering branches. The second part will cover applications of linear algebra. We will also discuss how it can be made interesting for students.*
15	*All Branches*	**Linear Algebra** *5 days*	*1.Prof.Debasattam Pal* *2.Prof.Harish Pillai* *3.Prof.Madhu Belur* *Electrical Engg.*	*1.Scalars, vectors, linear independence, spaces, basis,dimension* *2.Maps between vector spaces,matrices* *3.Rank of a matrix: square/non-square, row/column ranks, full row rank, full column rank* *4.Orthogonal matrices, symmetricmatrices* *5.SVD, rank, PCA, datacompression* *6.Eigenvalues,eigenvectors* *7.Solving Ax = b: existence, uniqueness of x, inverse ofA* *8.Different methods for solving Ax = b, exposure to accuracy,flops* *9.Notions/definition of other decompositions: QR,LU* *10.Innerproducts,innerproductspaces.Gram-Schmidtorthogonalization* *11.Orthogonalprojection,bestapproximation.Applicationtoestimationtheory* *12.Power method of computingeigenvalues/eigenvectors* *13.Google's page rank algorithm. Perron-FrobeniusTheorem*

16	*All Branches*	**Workshop on Outcome Based Education** *2 days*	*Prof. Sridhar Iyer and Prof. Shahna Murthy* *Educational Technology*	*1. Outcome Based Technology* *The 2-day course aims to introduce college teachers to the why, what and how of outcome based education (OBE). The course includes sessions on :* *1.writing valid learning objectives for modules/chapters in a course & mapping them to different cognitive levels of Revised Bloom's Taxonomy* *2. hands-on sessions where teachers are guided to follow a structured wayof writing measurable course outcomes from the learning objectivesframed* *3. hands-on sessions on writing assessment questions mapped to the course outcomes framed* *creating a blueprint of assessment questions along the three dimensions of course outcomes, Bloom's levels and type of questions* *4.introduction to student centric teaching-learning techniques that enhance student learning* *2. Course on pedagogy for effective student-centered teaching-learning with technology* *The 2-day course aims to introduce college teachers to the pedagogy of student-centered teaching-learning practices (active learning) with technology tools - tools that they commonly used as a teaching resource like videos, animations andsimulations. It includes:* *1.What, why and how of learning objectives* *2. Why active learning is needed* *3. What constitutes active learning* *4.How to do effective student-centered integration of technology in teaching (includes introduction to example active learning techniques)* *5. Hands-on sessions where teachers are guided to apply the techniques todesign active learning activities with technology and implement them effectively in flipped classroom modeas well as in in-class teachingmode.*
17	*All Branches*	**Manufacturing Processes** *5 days*	*Prof. Prashant P. Date* *Mechanical Engg.*	*The course will cover aspects on manufacturing processes like metal casting, forming, joining, PM and plastic injection moulding, plus a little exposure to machining if the participants so desire. A few lectures on Product design, TPM, TQM, FMEA, financial management are planned.*

18	*All Branches*	**Computational Techniques for Scientists and Engineers** *5 Days*	*Prof. PSV Nataraj* *Systems & Control*	*1. Introduction toMATLAB* *2. Cell & StructureArrays* *3. Functions andFiles* *4. Programming* *5. Advanced Plotting* *6. Model Building and Regression* *7. Linear Algebraic Equations* *8. Calculus & Differential Equations* *9. Linear and Nonlinear Optimization* *10. Simulation with Simulink* *11. Code Vectorization* *12. Parallel Computing with MATLAB – Multicore CPUs* *13. Parallel Computing with MATLAB – GPUs* *14. Connecting MATLAB and Simulink to Hardware* *The course is based heavily on solving problems via programming –* *It's a hands-on course. So, all participants must bring their own laptops loaded with MS-WindowsOperating system. Other software required for the course will be provided to the college course coordinator, well in advance of the course. Participants mustinstall these software and come to the course.*
19	*All Branches*	**Automation and Control Applications** *3 days*	*Prof. PSV Nataraj* *Systems & Control*	*The course provides the principles and techniques related to advances in automation and control systems. The course consists of* *• Lecture sessions; • Tutorial / hands-on training sessions;* *• Software demonstration / practice sessions; and* *• Open session for discussions.* *Rough Syllabus: Digital controller basics System Identification, Adaptation and tuning. Robust controller design Automation using PLC, SCADA, and Embedded Systems*
20	*All Branches*	**Introduction to Artificial Intelligence, Machine Learning, and Deep Learning- with hands-on applications to engineering systems** *3 days*	*Prof. PSV Nataraj* *Systems & Control*	*This course is designed to introduce you to the field of AI and its applications to Engineering Systems. Starting from basic algorithms like Linear Regression, we'll introduce start-of-art techniques in Machine learning, Deep Learning and Deep Reinforcement Learning (optional, if time permits). These techniques will be applied to various real-world engineering systems- including DC Motor, Single Board Heater System, Laboratory Boiler, Two-tank Process, and Gas Turbine Engine (simulator). MATLAB and its toolboxes are used throughout the course.* *Course contents: 1. Motivation for AI 2. Introduction to Machine Learning 1. Supervised learning 2. Unsupervised learning 3.*

				Reinforcement learning 3. Idea behind Gradient Descent method 4.Motivation for Feature Scaling 5. ML Regression and Classification examples in MATLAB 6. Evolution of Deep learning - Break through 7. Understanding the Artificial Neural Network 8. Regularization and Optimization Algorithms – for the user 9. Getting Started: Deep Learning Implementation 10. Hands-on experience with DC-motor kit for: a. DL Based Dynamic Modelling b. DL Based Predictive Analytics 11. Live Demo sessions: a. Single board Heating system b. Gas Turbine Engine Simulator c. Laboratory Process Boiler d. Hybrid Two-tank Process System 12. AI application in control using Reinforcement Learning (optional – if time permits) ***Day wise schedule (tentative): Day 1: Machine Learning Basics Morning: Theory 1. What is machine learning? 2. Types of ML using examples with simple datasets in MATLAB a) Supervised Learning b) Unsupervised Learning 3. Idea behind Gradient Descent using Animation 4. Motivation for feature Scaling with an example 5. ML Regression and Classification examples in MATLAB a) Decision boundary and cost function Afternoon: Hands-on Application of ML to DC Motors 1. ML Algorithms for Time series forecasting a) Access and load data from the system using MATLAB b) Derive features using pre-processing c) Apply regression to predict the motor rpm 2. ML Classifications of Low/Medium/High Speeds of DC motor a) Process Data to make classes b) Apply classification techniques and classify motor speeds Day 2: Deep Learning Basics Morning: Theory 1. Introduction to Neural Networks 2. Evolution of Deep learning 3. Elements of Deep Learning a) Artificial Neural Networks b) DL Optimizers – quick overview c) Common Activation functions in DL 4. Back Propagation – The heart of DL 5. Getting started with DL - Application to engineering systems Afternoon: DL for Modelling - Hands-on Application and Demos 1. Dynamic modeling Using DL 2. Develop DL Model with live script in MATLAB a) Access the data b) Pre-process/configure the data c) Configure the DNN d) Train the Network using Hypothesis 3. Live Demonstrations: Predictive modelling a) Single board heating system b) Hybrid Two tank system Day 3: Predictive Analytics using Deep Learning Morning: Theory 1. Introduction to Predictive Analytics 2. On-Board Anomaly Detection 3. Anomaly Detection schemes 4. Applications to Sensor/Actuator Fault diagnosis Afternoon: Predictive Analytics - Hands-on Application and Demos 1. Develop the Fault Diagnosis model a) Access the Abnormal data b) Automate Classifier***

				Training c) Develop a supervised learning model d) Apply the model for On-Board Anomaly Detection 2. Algorithm implementations on DC-Motor kit 3. Live Demonstrations: Sensor fault detection in Single Board Heater System Sensor and Actuator fault detection: Gas Turbine Engine Optional topic (time permitting) 4. AI application in control using Reinforcement Learning.
21	*All Branches*	**Institution Building Program** *3-5 days*	*Prof.Ashish Pandey* *School Of Management*	*This offering is based on whole system approach. We engage all the stakeholders of the institution or university for conversations based on possibilities and not on the constraints. This program has two components:* *1.Appreciative Inquiry* *2.Structured Inputs from Experts* *Appreciative Inquiry (AI) is based on the tenet that institution building is not the bundle of problems to be solved but a miracle to be embraced and cherished. AI by its very nature is application oriented, collaborative and provocativemethod of organization development*
22	*All Branches*	**Educational Leadership Program** *3-5 days*	*Prof. Ashish Pandey* *School Of Management*	*Educational leadership is the process of engaging, inspiring, guiding and channelizing the talents and energies of teachers, pupils and external stakeholders and partners toward achieving common educationalgoals.* *The Education Leadership Development Process (ELDP) equips institutions with a pipeline of highly engaged and inspired educators from within the existing talent-pool who can add value through teaching, consulting and research. It is a holistic perspective that looks at the Leadership Development process through the philosophy of AppreciativeInquiry.*
23	*All Branches*	**Expo creative Design Methods** *3 days*	*Prof. Ravi Poovaiah* *Industrial Design Centre*	*The course will inform the participants about the complete aspects of Design Process including Need Finding, Design Analysis, Problem Space Visualisation, Visual Affinity Mappings, Concept Diagrams, Prototyping Tools, User Testing and Feedback, Iterative Creative Concept Generation, Scenarios and Presentation Techniques. The workshop will also delve upon Design and Innovation, Information Visualisation, Product Form and Visual Elements, Designing for Products and Interactions,etc.*

24	*All Branches*	**Expo 'Designing for Computer Interactions'** *3 days*	*Prof. Ravi Poovaiah* *Industrial Design Centre*	*Methodology and process of designing interactive products, services and events with focus on physical, cognitive and social interactions. It includes design of tangible, gestural and expressive interfaces, products that enrich user experience encompassing design of integrated systems, products for future use, products for social interactions and devices used in public spaces.* *In addition, the course will cover user studies, affinity mappings, information theory, ordering of information, methods for structuring and visualization of Information, as well as introduction to Information Architecture.*
25	*All Branches*	**Deep Learning and Computer Vision** *6 days*	*Prof. Biplab Banerjee* *CSRE*	*Convolutional Networks, Recurrent Networks and LSTM/GRU, Auto-encoder, CNN for object recognition, detection and segmentation, Variational AE, GAN and variants, Optimization in deep learning, Several examples on image to image translation, Image Captioning, Video action recognition, VQA etc.*
26	*All Branches*	**Introduction to Human Factors Engineering and Advanced Cognitive Systems Design**(Cognitive Ergonomics/ Cognitive Systems Engineering) *5 days*	*Prof. Vivek Kant* *IDC School of Design*	*The aim of this course is to introduce the basics of Cognitive Ergonomics/ Cognitive Systems Engineering (CE/CSE). CE/CSE finds widespread application in the analysis and design of a variety of industrial applications. This course will introduce the basics of theory, methods and applications of these areas in a variety of technical artifacts and safety-critical systems. The coursewill cover the following topics: Human psychological systems (capabilities and limitations); Cognitive processes (perception, memory, attention,thinking and problem solving); Human factors methods (analysis methods, design guidance methods, evaluation methods); Applications in varioussectors.*
27	*All Branches*	**Fluid-Structure Interaction** *5 days*	*Prof.Rajneesh Bhardwaj* *Mechanical Engg.*	*This course addresses fundamentals of Fluid-Structure Interaction (FSI), with applications in several disciplines such as Mechanical, Aerospace, Civil, Chemical, Bioengineering etc. The following key concepts in FSI will be explained: Added fluid Stiffness, Added Mass, Added Damping, Memory Effect, Sloshing, Aero-elasticity approximation, Flow induced static instability, coupled mode flutter, Flow-induced Coriolis damping, Vortex-induced Vibrations (VIV), Lock-in, Characteristicsetc. Different Computational techniques used for FSI solvers will be discussed and compared. Finally, development of immersed boundary method will be covered in this course. The proposed topics are important from fundamental as well as applications point of view.*

28	*All Branches*	**Computational Fluid Dynamics: Development Application and Analysis** *5 days*	*1.Prof.Atul Sharma,* *2.Prof.Sandip KumarSaha,* *3.Prof.Shyamprasad Karagadde* *Mechanical Engg.*	*Computational Fluid Dynamics (CFD) is a methodology for computer simulation of fluid mechanics and heat transfer problems. The present course is structured for a module-by-module code- development of the two-dimensional numerical formulation; the codes are given for 2D heat conduction, advection and convection. The present subject involves learning to develop and effectively use a product -a CFD software.*
29	*All Branches*	**Design of Mechatronic systems** *5 days*	*Prof. Prasanna Gandhi* *Mechanical Engg.*	*Because of increasing demand on quality and productivity of products and services, the industrial dynamics is changing rapidly on several fronts including economics, research, technical knowledge and so on. To match these demands of increased quality at lower cost, automation is inevitable. Toward this goal, our engineers need to acquire the knowledge in the field of automation and mechatronics. With this motivatioin, the proposed course is designed to offer fundamental, theoretical and practical knowledge base in automation and mechatronics. The course will run for five days. It will comprise of lectures and hands on sessions. The participants will get unique hands-on and experimental exposure in the laboratory sessions. Topics covered in the course include: Importance of automation, Elements of mechatronic systems: sensors, actuators, and controller. Mathematical modeling/ representation of physical systems, real world examples. Use of Laplace transforms, transfer function and state space representations. Basic types of controllers P, PD, PID. Concept of stability, stability analysis, Linear domain tools for control analysis and synthesis: Use and application of Root locus method, frequency domain analysis, Bode plot. Introduction to Digital control systems. Fundamentals of microprocessors: architecture, memory, and interfacing peripherals. Concept of sampling, Implementation of digital control: using computer and microprocessor. Introduction to signal processing, filters, their importance. Introduction to PLCs: Ladder logic diagram, ARM based systems. Mechatronic systems design philosophy and approaches for various problems. Advanced control topics: nonlinear control fundamentals, handling nonlinearities inevitable in mechatronic systems such as friction, Control of robotic systems and general rigid body systems.*

30	*All Branches & Applied Science*	**Solar Photovoltaics : Fundamentals, Technologies andApplications** *3 days*	*Prof.Chetan S.Solanki* *Energy Science &Engg.*	*This course with the title "Solar Photovoltaics: Fundamentals, Technologies and Applications" is designed to provide introduction to various aspects of solar PV technologies. The course is designed in a manner that any Engineering and Science graduate without background in solar photovoltaic can attend and understand it.*
31	*All Branches & Applied Science*	**Community Driven Environmentally Sustainable Village** *5 days*	*Prof. Bakul Rao* *CTARA*	*The course "Community Driven Environmental Sustainable Village" is designed for TE-QIP/UBA/UMA colleges and CBO/NGO organizations and CSR division of companies to help plan, design and engage in overall sustainable development of villages. The course is intended to help build the concepts of sustainable development, sustainable villages, community engagement and participation. Tools for planning, designing, monitoring and evaluation would be taught using a case study approach. Through the course, the participants would also build their capacity to understand the existing and past programs of GOI and states for rural / Gram Panchayats*
32	*Aerospace Engg.*	**Incompressible Fluid Mechanics - A Refresher Course** *5 days*	*Prof.Aniruddha Sinha* *Aerospace Engineering*	*The subject is fundamental to Mechanical, Aerospace, Civil and Chemical Engineering. The course will serve to deepen understanding of the essential concepts, with suitable mathematical rigour of the derivations, along with an exposition of the underlying physics.* *Topics covered: Classification of flows, Hydrostatics, Governing equations in differential and integral form, Dimensional analysis, Potential flow theory, Exact flow solutions, Boundary layer theory, Introduction to turbulence*
33	*Aerospace Engg.*	**Acoustics and aero acoustics** *3-5 days*	*Prof.Aniruddha Sinha* *Aerospace Engineering*	*Most acoustics problems are essentially linearized fluid dynamics. We will take this perspective in this course to rigorously describe the fundamentals of acoustics. This will be a 3-day course.* *Depending on audience interest, a 5-day course may also be conducted to include Aero acoustics -- the study of sound generate by flow, in the absence or presence of solid walls. This will also include a discussion of computational aero acoustics (CAA).*
34	*Aerospace Engg*	**Aircraft Stealth Technology** *5 days*	*Prof. Shripad P. Mahulikar* *Aerospace Engineering*	• *Principles of Stealth & Target Identification – camouflage (merge with background), conceal (hide), deceive; Active vs. Passive detection; role of Electronic Warfare & Electronic Countermeasures;* • *Air-power, Air-superiority, Air-supremacy & role of Stealth Aircraft (with examples of warfare, including surgical strike with precision weapons);* • *Mission Attainment Measure, Aircraft*

				Survival rate, Measure of Mission • ***Success, & Mission Goal;*** • ***Survivability, Susceptibility, Vulnerability of Aircraft & Helicopter in Human-made Hostile Environment;*** • ***Precision Guided Weapons & Role of Stealth Aircraft;*** • ***Introduction to Aircraft Signatures – Radar, IR, Aural, Visual, etc.*** • ***Military radars - Radar Cross-Section – its computational prediction & reduction;*** • ***Introduction to Materials for Stealth*** ▪ ***Design synthesis & modeling of Radar Absorbing Materials (RAM) & Radar transparent composite materials;*** • ***Basics of high frequency RCS of aerospace & naval targets;*** • ***Acoustic signatures & aero-acoustic field modeling;*** • ***Principles of IR Signatures (2–3, 3-5, 8-12 μm) – basic laws (Planck's, Wien's Displacement, Kirchhoff's), Grey Body spectrum of Solid Surfaces vs. Line & Narrow Band Emission from Unsymmetrical Gases [e.g. CO_2, H_2O (vap.)];*** • ***Modelling of IR Signatures from Internal Sources – engine heated casing, engine exhaust plume, aerodynamic heating of air-frame in supersonic aircraft;*** • ***IR Signatures from External Sources – reflection of earth-shine (in 8-12 μm), sunshine (in 2–3 μm followed by 3-5 μm), & sky-shine (in 8-12 μm);*** • ***Role of Atmosphere – attenuation of IR-signature by intervening atmosphere & atmospheric background (sky-shine) radiance;*** • ***Relation between IR-Signature and Aircraft / Helicopter Susceptibility – lock-on envelope & lethal envelop for air-to-air combat in horizontal plane;*** • ***IR-Signature Suppression (& its Penalties) – optical blocking (effect of convergent nozzle exit area variation &effect of C-D nozzle on IR-signature), cooling of hot parts, emissivity optimization;*** • ***IR Countermeasures (IRCM) for point IR-detection – decoys / flares;*** • ***IRC^2M – imaging IR-detectors;*** • ***Stealth related to air-intakes, UCAVs, & MAVs;*** • ***Stealth aspects of LTA systems for military applications;*** • ***ELF (Extremely Low Freq.) signature of underwater vehicles.***

35	*Bioscience and BioEngineering*	**Biology for Engineers** *5 days*	*Prof. A.Kunwar* *Bioscience and BioEngineering*	*The first part of the course will be molecular biology which will bring forth the components building a cell. The second part of the course will be Physical Biology/Biophysics which shall illustrate how one can use Physics and Mathematics to understand various biological systems/phenomena. The last part shall use a few notable examples to illustrate the Engineering perspective with an emphasis on applications.*
36	*Bioscience and BioEngineering*	**Modern Biophysical Techniques** *5 days*	*Prof. A.Kunwar* *Bioscience and BioEngineering*	*The horizon of modern biosciences and bioengineering are rapidly expanding due to development of various new biophysical manipulation and measurement techniques. The course is intended for faculty members of Engineering colleges, engaged in teaching biology courses, who seek an introduction to modern biophysical experimental techniques. Due to the interdisciplinary nature of the course, basic knowledge of physics and mathematics is expected, but strong attempts will be made to give an intuitive understanding of the mathematics and physics involved. The topics covered in this course include fluorescence microscopy, confocal microscopy, NMR spectroscopy, Fluorescence Resonance Energy Transfer (FRET), Fluorescence-activated cell sorting (FACS), optical tweezers and bio-AFM*
37	*Bioscience and BioEngineering*	**Computer Simulation of Complex Biological Systems** *5 days*	*Prof. A. Kunwar* *Bioscience and BioEngineering*	*This short term course is intended to train the faculty members ofEngineering colleges for molecular dynamics and Monte-carlo simulations. The course content assumes that faculty members have an exposure to Physics and Mathematics at 10+2 level. This short term course aims to cover basics of Molecular Dynamics and Monte-Carlo Simulations along with several examples of itsapplications.*
38	*Chemical, Systems & control Engg.*	**Advances in ControlSystem** *3 days*	*Prof.Ravindra Gudi* *Chemical Engg.*	*The course is planned to provide academicians and practicing Engineers with the principles and techniques for better understanding of issues related to advances in control of process and manufacturingsystems.*
39	*Chemical Engg, Instrumentation Engg.*	**Data Analytics for Process Monitoring, Soft Sensing Controller Performance Assessment** *3 days*	*Prof. Ravindra Gudi* *Chemical Engg.*	*The course is oriented towards Data Analytics for Process Monitoring, Quality Prediction and Performance Assessment. This workshop will aim on introduction to the tools. These tools will be very useful in overall plant optimization. These methods promote operation excellence in the batch and continuous process industry through their ability to benchmark process operations with respect to performance limits and play an important role in detecting aberrant operation and initiating remedial measures so as to align the plant back along prior established superior benchmarks.*

40	*Chemical Engg, Instrumentation Engg.*	**Optimization for Engineering System Design and Operations** *3 days*	*Prof. Ravindra Gudi* *Chemical Engg.*	*This course will provide a tutorial introduction to the optimization based modelling tools and solution methods .It will also involve hands-on sessions on representative software platforms that showcase the technology advances in problem representation and solution methods and to provide practicing engineers with the principles and techniques for better understanding of issues related to process monitoring, performance assessment, soft sensing and control.*
41	*Chemical, Instrumentation , Control System Engg.*	**Digital Control from Scratch** *3 days*	*Prof. Kannan Moudgalya* *Chemical Engg.*	*Control of systems is getting extremely important for reasons of safety, and competitiveness in industry. It has a great role to play in home automation. All controllers implemented in modern times are digital. This is because digital devices are rugged, inexpensive, easy to use and noise tolerant. Most digital control courses assume a good knowledge of analog control. These courses mostly discretise the analog controllers to arrive at a digital form. At IIT Bombay, we have been teaching digital control more or less from scratch.*
42	*Chemical, Instrumentation & Control System Engg.*	**Advanced Multivariable Control** *3-5days*	*Prof. SachinPatwardhan* *Chemical Engg.*	*This course introduces fundamentals of control relevant model development and adaptive predictive control of multi- variable systems, introduction to Digital Control systems- sampling,model discretization, and open loopstability. Development of Predictive Control Relevant Linear Time Series Modelsusing System Identification- Output Error models, introduction to stochastic processes, development of ARX, ARMAXand Box-Jenkins models, model structure selection and issues in model development, state spacerealizations.* *Recursive on-line parameter estimation using RLS and extended least squares approaches Adaptive and ModelPredictive Control: Model based future prediction, constrained optimization based MPC formulation, quadratic programming and linear programming based reformulation, adaptive predictive controlformulations with on-line recursive parameter estimation, simulation studies using quadruple tank system and experimental studies using single board heater system.*

43	*Civil Engg.*	**Soft Computing Techniques at Basin Level Water Resources Assessment and Management** *5 days*	*Prof. Jothiprakash* *Civil Engg.*	*The short-term course aims to include the following themes with particular emphasis to water resources:* *1. Artificial NeuralNetworks* *2. GeneticAlgorithms* *3. OptimizationTechniques* *4. Remote SensingTechniques* *5. Geographic InformationSystems* *6. Advanced numericalmethods* *7. Hydroinformatics*
44	*Computer Engg.*	**Advanced Programming**	*Prof.Abhiram Ranade* *Computer Sci.&Engg*	*Computer programming has become a mandatory skill for all engineers.* *For all but the simplest tasks, the material discussed in introductoryprogramming courses is not enough. Proper use of data structures isnecessary. Understanding how the data structures are implemented is necessary to get high performance. In modern programming languages, data structures are provided as standard libraries; actual use oftenrequires some customization. Advanced programming language notions and strategies are also very useful.* *This TEQIP course aims to equip teachers in teaching such an advanced programming course. The topics covered will be:* ** Basic data structures such as search trees, priority queues, hash tables, and their implementation. Analysis strategies.* ** Standard libraries which implement above data structures.* ** Programming techniques. Recursion. Object oriented programming.* ** Applications* ** Representation and algorithms for graphs.* *Instructional material such as slides, sample lab assignments and examinations will be supplied. A graphics library developed at IIT Bombay has been found to be very useful in teaching this course, andit will also be supplied. Furthermore, the participants of the coursewill receive help and guidance in their teaching activities from IITBombay even after the course is over.*

45	*Electrical, Electronics & Telecommunication Engg.*	**Digital Signal Processing** *3 -5 days*	*Prof. V M Gadre* *Electrical Engg.*	*The aim of this course is to introduce the basic principles and developments that have taken place in this rich and evergreen subject while providing some expertise in DSP system design.* *Main Objectives of the course(s):* *1. To understand the requirementsfor, and implications of, working with a discretized independent variable: sampling theorems; correlating the analog and discretedomain.* *2. To build up the elements ofdiscrete systemtheory.* *3. To learn to specify requirementsfor discrete time systems and to design them.* *4. To translate these systems into realizations in hardware andsoftware.* *5. To explore practical applicationsof DSP.* *6. To gain some awareness in advanced DSP concepts with an exposure tocurrent developments.* *7.To deal with specific advancedtopics indetail.*
46	*Electrical & Electronics Engg.*	**Principles of Electromagnetics and Finite Element Method** *3-5 days*	*Prof.S.V.Kulkarni* *Electrical Engg.*	*Electromagnetic Fields is one of the foundation courses in both Electrical and Electronics Engineering Curricula. It is generally perceived to be a difficult-to-understand subject by the students and a difficult-to-teach subject by teachers. This course is aimed at providing a thorough understanding of important concepts.Use of Virtual Electromagnetics Laboratory being developed at EE Dept. of IIT Bombay will also be made to supplement discussions during the course. The second part of the course covers principles and applications of Finite Element Method (FEM) to Electrical and Electronics Engineering. The method has emerged as one of the most powerful numerical techniques for analysis of low- and high-frequency electromagnetic devices. It is widely used in academia and industries for research and development. Exposure to free FEM software and procedures to develop FEM codes will also be given duringthecourse.*

47	*Electrical & Electronics & Communication Engg.*	**Computational Electromagnetics** *3-5 days*	*Prof.S.V.Kulkarni* *Electrical Engg.*	*Understanding and computation of electromagnetics are essential pre-requisites for development, analysis and optimization of low-frequency devices (transformers, rotating machines...) and high-frequency devices (waveguides, antennas...). This course will cover basics of electromagnetics relevant to numerical computation of fields. The theory and applications of the following numerical techniques will then be elaborated: Finite Difference Method, Finite Difference Time Domain Method, Finite Element Method, Boundary Element Method, and Method of Moments. A few advanced research topics such as Coupled Field Computations, Meshless Methods, Vector Finite Elements, etc., will be discussed at the end.*
48	*Electrical & Electronics Engg.*	**RF and Microwave Design** *4-5 days*	*Prof. Girish Kumar* *Electrical Engg.*	*This short term course will cover 1.Passive Microwave Circuits* *a. Transmission Lines, ABCD andS- parameters* *b. Characteristics of MicrostripLines* *c. Microstrip LineDiscontinuities* *d. Coupled MicrostripLines* *e. Power Dividers andCouplers* *f. Filters* *g. Attenuators* *2.Active Microwave Circuits* *a. Amplifiers* *b. Oscillators* *c. Switches, Phase Shifters* *andMixers MicrowaveSystems*
49	*Electrical & Electronics Engg.*	**Microstrip Antennas** *3-5 days*	*Prof.Girish Kumar* *Electrical Engg.*	*This short term course will cover fundamentals of antennas, microstrip antennas (broadband, compact, multi- band, linear and circular polarizations), and microstrip antenna arrays*
50	*Electrical & Electronics Engg.*	**Advanced semiconductor devices lab** *5 days*	*Prof.Siddharth Tallur* *Electrical Engg.*	*The course will be offered as various modules. Each module will run for 1 day. Every module will be offered primarily as a lab component, with supplementary lecture class for conveying information on principle of operation of the device and overview of fabrication process flow, as necessary. The emphasis in the labs will be on device characterization and performance analysis. The experiments are designed such that they may be replicated in any adequately furnished undergraduate electronics lab. The following modules will be covered in this course: (i) Diodes: a. Day 1: pn junction, ohmic and Schottkymetal-semiconductor*

				contacts, LEDs (correlation of cut-in voltage to material bandgap) b. Day 2: Solar cell characterization (pn junction capacitance measurement and parameter extraction) c. Day 3: Effect of temperature on diode performance (LED and solar cell) (ii) MOS devices: a. Day 4: MOS capacitors (capacitance-voltage profiling) (iii) Organic semiconductors: a. Day 5: Organic LEDs (make and test in lab)
51	*Electrical, Mechanical, Chemical Engg.*	**Energy Efficiency and Management** *3 days*	*Prof.S.Bandyopadyay* *Energy Science &Engg.*	*Energy efficiency is the use of technology that requires less energy to perform the same function without compromise. The course will cover following topics: Overview of India's energy scenario; Fundamentals of energy engineering; Energy auditing; Energy economics; Energy management in thermal systems; Energy management in electrical systems.*
52	*Environmental Science and Engineering*	**Energy Recovery Options from Municipal Solid Waste** *3-5 days*	*Prof.MunishChandel and Prof.AnuragGarg* *Centre for Environmental Science and Engg.*	*The course will focus on the discussion of energy recovery opportunities from municipal solid waste (MSW). This course content includes the fundamentals and concepts of various biological and thermal treatment methods suggested for the generation of heat/ electricity from MSW. A brief background of waste characteristics and regulatory framework for MSW will be presented. Preparation methods for refuse derived fuel and its utilization as fuel in energy intensive industries will be discussed.* *Environmental pollution (air and liquid) from energy recovery processes and their control methods will also be discussed. An overview of life cycle analysis will be given. Some problems will be solved during the course duration and relevant case studies will be shared.*
53	*Environmental Science and Engineering*	**Introduction to Environmental Health & Safety** *4 days*	*Prof.Harish C. Phuleria* *Center for Environmental Science &Engg.*	*This course will provide an overview of the current legislation, standards and practices related to environmental health and safety in the workplaces.* *This will include topics on occupational health and safety regulations, hazardous materials management, biological, physical and chemical hazards identification and risk assessment, use of personal protective equipment, and industrial toxicology.* *Environmental exposure standards, human exposure and dose assessment, environmental monitoring of air, water, food, soil and microorganisms, and personal monitoring will be additionally examined. The concepts will be further strengthened through case studies from construction, chemical and oil-gasindustries.*

54	*Environmental Science and Engineering*	**Resource Recovery by Sustainable Sewage Sludge Management** *3 days*	*Prof.Anurag Garg* *Center for Environmental Science &Engg.*	*The course will include the following: Overview of sewage characteristics and treatment; Sludge generation and processing strategies; Resource recovery by anaerobic process, composting and incineration.*
55	*Environmental Science and Engieering*	**Wastewater Reclamation Technologies** 2-3 days	*Prof.AnuragGarg* *Center for Environmental Science &Engg.*	*The focus of the proposed course is on the methods by which wastewater can be recycled for various beneficial purposes. The major topics will include: Overview of wastewater characteristics and treatment; advanced wastewater treatment processes; possible reclamation methods and casestudies.*
56	*Environmental Science and Engieering*	**A course on Environmental Engg.**	*Prof.Amritanshu Shriwastav* *Center for Environmental Science & Engg*	*This is a pedagogy course for the environmental engineering education to all UG students in engineering colleges. The course is designed to provide an overview and introduction to all the relevant topics including the pollution and management of water, air, and solid waste. Further, some topics on environmental management tools, viz. life cycle assessment and environmental impact assessment will be covered. An introduction to the environmental modeling will also be provided.*
57	*Mechanical Engg.*	**3D Printing: A Disruptive Technology** *3 days*	*Prof. K P Karunakaran* *Mechanical Engg.*	*The goal in this course is to give an overview of the various RMtechnologies. After giving the necessary backgroundin CAD modeling and Reverse Engineering, various popular RP processes will be discussed in detail. These will include Fused Deposition Modeling (FDM), Selective Laser Sintering (SLS),Stereo- Lithography Apparatus (SLA), 3DPrinting and Laminated Object Manufacturing (LOM).*
58	*Mechanical Engg, Production Engg.*	**E-Mobilityand Innovations in Sheet MetalForming** *3- 5 days*	*Prof. Prashant P. Date* *MechanicalEngg.*	*Challenges of E-Mobility is demanding in terms of high power and energy density storage in batteries, fast charging, better management of heat generated and higher mileage per charge.* *Till a battery operated car reachesits peak development, and infrastructure necessary for that is developed, a hybrid engine concept is seen as an intermediatesolution.* *Such a hybrid engine would have an IC engine as well as a battery drive.* *Hence it is absolutely essential to think of light weighting an IC Engine. This programme focusses on current and future battery technology and hybrid engine concepts.*
59	*Mechanical Engg, Production Engg.*	**Sheet Metal Technology** *3-5 days*	*Prof. Prashant P. Date* *Mechanical Engg.*	*The course will cater to 7 areasnamely, materials, product design, Process design, Tool design, Equipment selection, Materials testing and Troubleshooting.*

60	*Mechanical Engg, Production Engg.*	**Metal Forming** *3 days*	*Prof. Prashant P. Date* *MechanicalEngg.*	*1. States of stress processes malts testing 2. Tensile testing andanalysis of data 3. Flow forming 4. Forging 5. Deformation mechanismmaps* *6. Equipment selection &specification* *7. Sheet metal formability concept 8. Formability evaluation* *9. Deepdrawing* *10. Hotforming* *11. Roll forming 12. Issues insheet metalassembly*
61	*Mechanical Engg, ProductionEngg*	**Analysis of Sheet Metal Forming Process.** *5 days*	*Prof. Prashant P. Date* *MechanicalEngg.*	*Sheet metal has traditionally been used in a number of sectors of the industry. Often, sheet metal forming is regarded by many, more as an art than any kindof science. Typical methods of manufacture involved the use of a die and a punchto shape the sheet into desired product shapes. Rule of thumb could be used to design the tools and expectations onthe dimensional accuracy and dimensional tolerances were very limited (were not very high). Modern day manufacturing with sheet metal involves plenty of science. This was necessitated by the need for light weighting of sheet metal components, development of new materials, development of newprocesses, means to handle the spring back for which sheet metal parts are so notorious, development of new shaping and joining techniques, both at room temperature and at high temperature,and above all, a number of FEM soft wares which are capable of predicting the outcome of a forming process with ahigh degree of accuracy. These soft waresare based on the theory of plasticity, and it is important to understand not only the process but also the theory to be able to use the soft wares effectively. Measurements of parameters, process control also improved over the times so that the final outcome (the product)can be expected to be closed to thedesigned geometry, properties andperformance.* *The proposed course attempts to bring to* *the participants the science involved in the development of several sheet metal technologies that we use. Industry delegates may bring along live cases which can be discussed during the brainstorming sessions during the course of the programme. Expression of interest to present a live problem should be made at the time of registration. One session of 15 minutes will be permitted per Company for presentation of the live case.*

62	*Mechanical Engg.*	**Fuels and Combustion** *5 days*	*Prof .Neeraj Kumbhakarna* *Mechanical Engg.*	*The phenomenon of combustion is ubiquitous in power producing devices such as engines and turbines. It isalso seen in various other engineering systems that accomplish useful tasks such as material processing in industries, waste disposal, space heating, etc. Hence it is essential for engineers to understand this phenomenon in detail. The knowledge of various aspects of combustion enables engineers to effectively control it and harness its potential to accomplish useful tasks. It also enables them in tackling various issues related to safety and pollutant emissions. This course introduces students to various aspects of the science of combustion from an engineering point of view whilecovering some necessary concepts of chemistry.It will also introduce thecharacterization of different fuels in terms of their composition and properties, both of which affect combustion. A few topicson fuel synthesis will help understand the reasons behind the heterogeneity in the composition of different liquidfuels.*
63	*Mechanical & Chemical Engg.*	**CFD using Open FOAM** *5 days*	*Prof. P.Sunthar* *Chemical Engg.*	*This course will introduce teaching CFD as a full course or as a lab course to undergraduate/postgraduate students.* *Potential teachers: Mechanical, Chemical Engineering:* *Syllabus outline: Fluid flow, Turbulence, Heat Transfer, Reaction, Multiphase, non-Newtonian flows.*
64	*Mechanical Engg.*	**Fundamentals of Micro-electro-mechanical-Systems Technology** *3-5 days*	*Prof. Pradeep Dixit* *Mechanical Engg.*	*Micro-electro-mechanical-Systems (MEMS) is an inter-disciplinary area, which is getting extremely popular due to the increasing usage of inertial sensors in daily life. Inertial sensors such as Accelerometers, Gyroscopes, Pressure sensors, tactile sensors, etc. are being used in air-bag deployment, Automatic screen rotation, and measuring pressure in various automobile applications.* *This three-to-five-day program aims at understanding the basic fundamentals of Micro-electro-mechanical-Systems (MEMS) technology, materials used in MEMS and various sensing/actuation principles (piezo resistive, piezoelectric, electrostatic, etc.). The program will specifically focus on the design and fabrication of smart sensors which are used currently in the industries.* *Various micro-fabrication techniques (Lithography, plasma etching, and thin film deposition) will be covered in this course, which will be helpful for researchers working in mechanical, electrical, Physics and material science domain.*

65	*Mechanical Engg.*	**Advance Heat Transfer** *5 days*	*Prof. SandipKumar Saha* *Mechanical Engg.*	*Instantaneous and continuous, Superposition theorem. Duhamel's theorem and applications for time varying boundary conditions.* *Radiation heat transfer: Introduction- intensity, emissive power, Planck spectral emissive power for black body.* *Real surfaces: Emissivity, Absorptivity and Reflectivity. Shape factor calculations using shape factor algebra.* *Radiation calculation using radiosity approach for grey diffuse surface, Network modelling and Radiosity method* *Gas radiation, Well stirred furnace model.* *Convective heat transfer:* *Derivation of governing equation for convection. 2D laminar Couette flow and nondimensional numbers. Concept of Adiabatic wall temperature. Flow over a flat plate. Boundary Layer theory Scale analysis, Falkner Skan similarity solution for momentum and thermal boundary layers. Integral solution. Internal flow Scale Analysis, Concept of developed temperature profile and solutions for constant wall flux and constant wall temperature boundary conditions. Solution of entry length problem for constant wall condition (Graetz Problem).Natural convection solutions- Scale Analysis, Integral solutions, Similarity solution.*

66	*MechanicalEngg*	**Computational Fluid Dynamics** *5 days*	*Prof. SandipKumar Saha* *Mechanical Engg.*	*Introduction to Computational Fluid Dynamics and Principles of Conservation: Continuity Equation, Navier Stokes Equation, Energy Equation and General Structure of Conservation Equations, classification of partial differential equations.* *Fundamentals of Discretization: Finite Difference, Finite Element and Finite Volume Method* *Finite Difference Method: Discretisation techniques using Taylor- Series, Consistency, Stability analysis and Convergence, Grid independence study* *Finite Element Method: Basics, discretization techniques for steady and unsteady problem.* *Finite Volume Method: Some Conceptual Basics and modelling of heat conduction, Boundary Condition Implementation.* *Discretization of Unsteady State Problems, convection-diffusion, and flow field using finite volume method (FVM), SIMPLE and SIMPLER algorithm* *Collocated Grid* *Unstructured Grid Formulation; Modelling of phase change problems; introduction to turbulence modelling*
67	*Mechanical Engg.*	**Fluid-Structure Interaction** **5 days**	*Prof. Rajneesh Bhardwaj* *Mechanical Engg.*	*Computational techniques used for FSI solvers will be discussed and compared. Finally, development of immersed boundary method will be covered in this course. The proposed topics are important from fundamental as well as applications point of view.*
68	*Mechanical & Chemical Engg.*	**Basics of Combustion and Modelling** *3 days*	*Prof.S.Sreedhara* *Mechanical Engg.*	*The phenomenon of combustion plays a major role in power producing devices such as engines, turbines and furnaces. This course introduces students to various aspects of the science of combustion from an Engineering point of view while covering some necessary concepts of chemistry.*

69	*MechanicalEngg.*	**Realizing Science and Applications of Micro- and Nano-machining** *3 - 5 days*	*Prof.Suhas Joshi* *Mechanical Engg.*	*New products and technological developments in the area of strategic, automotive, aerospace, electronics, and bio-medical industries require complex and micro-and nano-sized features, significant miniaturization and high precision. In order to address these demands, micro- and nano-manufacturing has been continuously evolving in the recent years. It is envisioned that the research and development activities in this domain will not only facilitatethe exponential growth in the global economy, but also aid in scientific understanding of materials processingat a fundamentallevel.* *This three-to-five-day program aims at understanding the role of micro- and nano-manufacturing in shaping thefuture needs in the context of Indian as well as global requirements. The program therefore will specifically focus on development of 'devices and processes' using micro- and nano-machining for automotive, aerospace, electronics and bio-medical domains. These aspects will be illustrated through lecture-cum- demonstration sessions. Concurrently, generating a new and in-depth understanding of mechanics pertaining micro- and nano-machining processes through numerical modelling and simulations has been the major topic of interest all over the world. The state of the art on this front will be realized through expert lectures and follow up discussions. In general, the topics which could include –Multi-scale science of micro- and nano-machining processes, Innovative applications of laser-based Micro-machining, Micro- textured surfaces design and fabrication, Microfluidic-based devices & developments,Micro-electric-discharge and associated processes and soon.*
70	*Metallurgy & Material Science*	**Surface Engineering - the need for better surface management** *2 days*	*Prof. A.S.Khanna* *MEMS*	*Domain of Surface - Properties, deterioration mechanism, possible ways of modification, characterization, performance evaluation*
71	*Systems and Control Engg.*	**Linear Systems Control** *5 days*	*Prof.S.Srikant* *Systems and Control*	*The course will cover State Space Representation of dynamical systems, solutions, properties of solutions such as stability, controllability and observability, finally an overview of state feedback control, and Linear Quadratic Regulator (LQR) control design will be expounded. Additionally some intermittent material on vector spaces will be introduced.*

72	*Systems and Control Engg.*	**Nonlinear Adaptive Control** *5 days*	*Prof.S.Srikant* *Systems and control*	*We begin with fundamentals of nonlinear state space systems, nature of solutions, stability notions and Lyapunov stability theorems, control design based on Lyapunov functions will be introduced, ideas of Back-stepping based control design will be developed, further adaptive control will be introduced based on certainty equivalence and non-certainty equivalence based methods, stability proofs constructed and update laws designed. Additional norms and properties of the same along with Barbalat's Lemma will be studied.*
73	*Systems and Control Engg.*	**Advanced Analytical Dynamics** *5 days*	*Prof.S.Srikant* *Systems and Control*	*The course covers modeling of mechanical systems - Newton's laws for collection of particles both translating and rotating, force momentum principles, vector representation in rotating and translating frames, Newton's laws for rigid bodies, Lagrange's equations of motion, conserved quantities, Hamilton's equations, Holonomic constrains in dynamicalsystems.*
74	*Systems and Control Engg.*	**Optimal Control and applications** *4 days*	*Prof. Ravi Banavar* *Systems and Control*	*This course will be beneficial to students and teachers in mathematics and engineering interested in learning about optimal control and its many applications. Basic ideas and tools of optimal control (with mathematical rigour), frequently encountered in engineering problems, in particular, electrical, mechanical, chemical and aerospace engineering will be introduced. A large part of the course will emphasize the following topics: calculus of variations and first order necessary conditions for an extremum; second order necessary conditions; control systems and a variational approach to a fixed-time, free-endpoint problem; statement of the Maximum Principle and a sketch of the proof; time-optimal control and linear-quadratic control problems. The textbook followed will be: Calculus of Variations and Optimal Control Theory: A Concise Introduction; by Daniel Liberzon; Princeton University Press,2012.*
75	*Systems and Control Engg.*	**Nonlinear Control Systems** *4 days*	*Prof. Ravi Banavar* *Systems and Control*	*The course will expose an individual with a background in linear control systems to the essential ideas and tools of nonlinear systems, both analysis and design. In specific, the course will cover the following topics: phase portraits of second-order systems; ordinary differential equations (ODEs), the Lipschitz condition and existence and uniqueness of the solution;affine-in- the-control nonlinear systems;*

				linearization and the Jacobian; flows, stability and invariant sets; Lyapunov theorem and LaSalle's invariance theorem; operations on vector fields - the gradient, the Lie derivative and the Lie bracket; distributions, feedback linearization, zero dynamics and controller design examples. The textbooks to be followed would be: 1.H. K. Khalil, Nonlinear Systems, Prentice Hall, 2002 2. J. LaSalle and S. Lefschetz, Stability by Liapunov's Direct Method, Academic Press, 1961 3. A. Isidori, Nonlinear Control Systems , Springer, 1989.