YESHWANTRAO CHAVAN COLLEGE OF ENGINEERING
(An Autonomous Institution affiliated to R T M Nagpur University Nagpur)
Accredited by NAAC (1st Cycle) with 'A' Grade (Score 3.25 on 4 Point Scale)
Wanadongri, Hingna Road, Nagpur-441110

Department of Mechanical Engineering
(Honors in SAAM)

B.E. Honors in Subtractive and Additive Manufacturing
SoE & Syllabus 2021-22

B.E. Honor in Subtractive and Additive Manufacturing

Information Brochure of Honor Program

1. Title of Program: **Subtractive and Additive Manufacturing**
2. Type of Program **: Honor**
3. Department offering the program: **Mechanical Engineering**
4. Industry Collaboration: _ MTAB Engg. Pvt. Lt. Chennai, Altem Technologies Pvt. Ltd. Pune
5. Department/s eligible to opt for the program:

   (The program can be opted only by the students Mechanical Engineering Department.)
6. General information about courses in program:

   Additive and Subtractive manufacturing is a blended approach to explore industrial process and latest trends of subtractive manufacturing (CNC Machines) and additive manufacturing (3D Printing).Product complexity over the entire product mix of diversified industrial domains is changing rapidly ,more complex nonlinear designs are need of time . Traditional manufacturing system is unable to suffice the need, so more focused and optimized approach of manufacturing is required . Additive manufacturing (also known as 3D printing) is considered a disruptive technology for producing components with topologically optimized complex geometries as well as functionalities that are not achievable by traditional methods. Additive manufacturing technology now sees increased adoption beyond prototyping into end and spare part production because it offers complexity and performance advantages that are not possible with conventional methods, traditional machining, or molding processes. On the contrary, the advantages of computer numerical control (Subtractive Manufacturing) are that the machine provides smoother touches and more strength to the objects. Latest industrial trend and shifting scenario of industry 4.0 clearly hinting towards inculcation of advanced manufacturing system evolvement in the process of education .More qualified technocrats in this domain are in huge demand in the market. This course is designed to explore opportunities for new and innovative product development using subtractive and additive manufacturing.

7. Advance knowledge or research orientation of Program:

Understanding a manufacturing process's nuances empowers designers to optimize for that process's benefits during the early stages of product development. When it comes to precision and quality, design engineers consider subtractive manufacturing the first choice for industries such as automotive, aerospace, defense, and others. Subtractive manufacturing processes include milling and turning for fabricating parts with tight tolerances and complex geometries. Industries leverage their innovations to maintain their product standards and increase productivity. Subtractive manufacturing offers compatibility with a wide range of high-performance metals and plastics, among other materials. No matter the size of your production run, subtractive manufacturing can provide high-quality and precision. Multi-axis milling and turning, such as Siemens 828D controller provide controlled and complex prototyping services to produce tight tolerances, complex geometry, and excellent surface finishes. The Additive manufacturing technology has in recent years entered into applications such as medical, aerospace and automotive due to innovations in materials and processing technologies, yet there are still many technical challenges that must be overcome in order to achieve a higher market penetration. With regards to materials processing and printing technologies, these have been identified as:

- The need to increase dimensional accuracy and repeatability of parts potentially through in-situ metrology and combined model based approaches.
- Limited material options necessitating the need for new materials.
- Methods which enable cost reductions and increase build speed, and size, of parts.

Diversified research avenues and opportunities are open in the field of additive manufacturing system

8. Employability potential of program:

As additive manufacturing (AM) transforms the engineering and manufacturing industries, the broader manufacturing workforce is struggling to adapt to the rapid pace of change. An agile workforce planning process and training can help to bridge the AM talent gap. Because AM represents a paradigm shift in design and production, well-trained talent—engineers and

technicians—are critical to maximizing this technology. From the use of resins in vat polymerization to complex 3D laser cladding in directed energy deposition, AM innovations in materials and technologies demand new skills and capabilities, both technical and managerial. Yet many of these innovations have outpaced the ability of the broader manufacturing workforce to adapt: 9 out of 10 manufacturers are struggling to find the skilled workers needed—a shortage that is impacting production, quality, innovation, and growth. Engineers must learn and implement new design processes and technologies, adapt to new design programs, and gain familiarity with new materials beyond their traditional training and professional experience. Moreover, design engineers will have to work side by side with manufacturing engineers on the factory floor, and both will need to think about fabrication and modeling more imaginatively than they have historically. Aerospace, Medical, energy sector, consumer products, transportation are few major domains widely open for skilled engineers with subtractive and additive manufacturing knowledge.

9. Departmental Steering committee: For proper publicity / conduct of program

SN	Name of the Faculty Member	Post	Designation	e-mail ID	Contact Number
1	Dr. S. S. Chaudhari	Chairman	HOD	hod_me@ycce.edu	9545531727
2	Dr.J.P.Giri	Member	Associate Professor	jayantpgiri@gmail.com	9822929871
3	Prof.A.P.Edlabadkar	Member	Assistant Professor	ajinkyae@gmail.com	9764478622
4	Prof.A.R.Narkhede	Member	Assistant Professor	alok.narkhede@gmail.com	7666767483

10. Departmental coordinator

SN	Name of the Faculty Member	Post	Designation	e-mail ID	Contact Number
1	Prof.A.R.Narkhede	Member	Assistant Professor	alok.narkhede@gmail.com	7666767483

Scheme of Examinations

B.E. Honor in SUBTRACTIVE AND ADDITIVE MANUFACTURING
(Industry Aligned Course: MTAB Engg. Pvt. Lt. Chennai, Altem Technologies Pvt. Ltd. Pune)

SN	Sem	Sub. Code	Course Name	T/P	L	P	Hrs	Credits	MSEs	TA	ESE	ESE-Hr
1	5	MEH131	Computer Graphics and Solid Modeling	**T**	3	0	3	3	30	30	40	3
2	5	MEH132	Lab: Computer Graphics and Solid Modeling	**P**	0	2	2	1		60	40	3
3	5	MEH133	Computer Integrated Manufacturing	**T**	3	0	3	3	30	30	40	3
4	5	MEH134	Lab Computer Integrated Manufacturing	**P**	0	2	2	1		60	40	
5	6	MEH141	Industry 4.0	**T**	3	0	3	3	30	30	40	3
6	6	MEH142	Additive Manufacturing	**T**	3	0	3	3	30	30	40	3
7	6	MEH143	Lab: Additive Manufacturing	**P**	0	2	2	1	30	30	40	
8	7	MEH151	CNC and Robotics	**T**	3	0	3	3	30	30	40	3
9	7	MEH152	Lab: CNC and Robotics	**P**	0	2	2	1		60	40	
TOTAL					**15**	**8**	**23**	**19**				

MSEs* = Three MSEs of 15 Marks each will conducted and marks of better 2 of these 3 MSEs will be considered for Continuous Assessment

TA ** = for Theory : 20 marks on lecture quizzes, 8 marks on assignments, 2 marks on class performance

TA = for Practical : MSPA will be 15 marks each**

V Semester

MEH131	Computer Graphics and Solid Modeling			L=3	T=0	P=0	Credits= 3
Evaluation Scheme *Best Two out of three MSE's would be considered	MSE-I*	MSE-II*	MSE-III*	TA	ESE	Tota	ESE Duration
	15	15	15	30	40	100	3 Hrs.
Prerequisites							

Objective	Course Outcome
To educate the students on main concepts of computer aided design, representation of curves, surface and solids	

UNIT-I: CAD TOOLS

Definition of CAD Tools, Types of system CAD/CAM system evaluation Criteria, functional areas of CAD, Modeling and viewing, efficient use of CAD software.

Wire frame modeling -Types of mathematical representation of curves, wire frame models, wire frame entities, parametric representation of analytical and synthetic curves – Hermite cubic splines, Bezier curves, B- Splines, rational curves-NURBS.

UNIT-II: SURFACE MODELING

Mathematical representation of surfaces, Surface model, Surface entities, surface representation, parametric representation of surfaces, plane surface, ruled surface, surface of revolution, Tabulated surface.

UNIT-II: SURFACE MODELING

Mathematical representation of surfaces, Surface model, Surface entities, surface representation, parametric representation of surfaces, plane surface, ruled surface, surface of revolution, Tabulated surface.

UNIT-III: PARAMETRIC REPRESENTATION OF SYNTHETIC SURFACES

Hermite Bicubic surface, Bezier surface, B-Spline surface, COONs surface, Blending surface, Sculptured surface, Surface manipulation - Displaying, Segmentation, Trimming, Intersection, Transformations - 2D and 3D, Orthogonal and Perspective transformations.

UNIT-IV: SOLID MODELLING

Solid Representation - Boundary Representation (B-rep), Constructive Solid Geometry (CSG) and other methods, Design Applications: Introduction to Feature based and Assembly modelling.

UNIT V:ADVANCED MODELING CONCEPTS

Feature Based Modeling, Assembly Modeling, Behavioral Modeling, Conceptual Design & Top-down Design. Techniques for visual realism – hidden line – Surface removal – Algorithms for shading and Rendering. Parametric and variational modeling, Feature recognition, Design by features, Assembly and Tolerance Modeling, Tolerance representation – specification, analysis and synthesis, AI in Design

UNIT VI: CAD/CAM DATA EXCHANGE

Evaluation of data- exchange formats, IGES data representations and structure, STEP Architecture, implementation, ACIS & DXF.

Text books:				
1	CAD/CAM, Theory & Practice	1st Edition (2991)	Ibrahim Zeid	McGraw-Hill
2	Procedural elements for computer	st 1 Edition (2998)	D Rogers	WCB/McGraw-Hill
3	Introduction to Finite Elements in	2nd Edition (2002)	Chandrupatla&Belegundu A.D	Prentice Hall
4	Optimization for Engineering Design	1st Edition (2005)	Kalyanmoy Deb	Prentice Hall
5	P. N. Rao,	-	CAD/CAM	McGraw Hill
6	Martenson, E. Micheal	2995	Geometric Modelling	John Wiley & Sons
7	P. Radhakrishnan, S. Subramanyam		CAD/CAM/CIM	New Age International

Reference books:				
1	Computer Graphics	McGraw-Hill	Hearn D. & Baker M.P	Prentice Hall
2	Computer Graphics	2nd Edition (2987)	S. Harrington	Mcgraw-hill Professional
3	Mathematical Elements for	1st Edition (2990)	RoggersDravid F., Adams J. Alan	McGraw-Hill
4	Theory & Problems of Computer	1st Edition (2986)	Roy A. Plastock, Gordon	McGraw-Hill
5	V. Ramamurti	2992	Computer Aided Mechanical Design and Analysis	Tata Mc Graw Hill-

V Semester

MEH132	LAB : Computer Graphics and Solid Modeling			L= 0	T = 0	P = 1	Credits = 1
Evaluation Scheme *Best Two out of three MSE's would be considered	MSE-I*	MSE-II*	MSE-III*	TA	ESE	Total	ESE Duration
	--	--	--	60	40	100	3 Hrs
Prerequisites							

List of Practical

1) Introduction to CAD softwares.
2) Generation of at least two simple solid models showing geometric properties using any CAD software.
3) To generate at least two simple assembly model using any CAD software
4) Simulate assemble model using any CAD software
5) Programs on 2 D transformations – scaling, rotation, reflection, translation

V Semester

MEH133	Computer Integrated Manufacturing			L=3	T=0	P=0	Credits= 3
Evaluation Scheme *Best Two out of three MSE's would be considered	MSE-I*	MSE-II*	MSE-III*	TA	ESE	Tota	ESE Duration
	15	15	15	30	40	100	3 Hrs.
Prerequisites							

Objective	Course Outcome
To develop in the engineering students the ability to analyze any engineering problem in a simple and logical manner and to apply to its solution a few, well understood basic principles	**CO1 : The Students will have ability to design and evaluate experimentation on CNC machines.** **CO2: Designing of GT cell layouts for transforming into flexible manufacturing system.** **CO3: The students will be able to compose and transform robot programs various industrial applications.** **CO4: The students will have ability to justify CAPP and CAQC to design computer integrated manufacturing**

Unit 1 **[7 hrs]**
Concept and scope of CIM, components of CIM, benefits, limitations.Basics of computer graphics NC basics, NC words, Manual part programming (NC part programming) Punch Tape, Tape Format CNC , DNC, APT programming Adaptive control, application. Tooling for CNC machine.

Unit 2 **[7 hrs]**
Introduction to Group Technology, Limitations of traditional manufacturing systems, characteristics and design of groups, benefits of GT and issues in GT. Part families , classification and coding , Production flow analysis , Machine cell design , Benefits

Unit 3 **[8 hrs]**
Introduction & Components of FMS , Application work stations , Computer control and functions , Planning, scheduling and control of FMS , Scheduling , Knowledge based scheduling , Hierarchy of computer control , Supervisory computer Manufacturing data systems , data flow , CAD/CAM considerations , Planning FMS database

Unit 4 **[8 hrs]**
Industrial robotics Robot anatomy, Robot control, accuracy, repeatability, End Effectors Sensor, Introduction to robot programming, Robot application (Material handling processing assembly and inspection) introduction to robot Kinematics.

Unit 5 **[10 hrs]**

Process Planning in the Manufacturing cycle , Process Planning and Production Planning Process Planning and Concurrent Engineering, CAPP, Variant process planning , Generative approach , Forward and Backward planning, Input format, Logical Design of a Process Planning , Implementation considerations ,manufacturing system components, Automated material handling systems, AS/RS, general considerations , selection, evaluation and control . Inspection and Quality control, CAQC, CMM types, working, applications Expert process planning

Unit 6 **[5 hrs]**

Totally integrated process planning systems, Integration of CNC robotics for CIM, Agile manufacturing, Nano Manufacturing. Simulation

Reference books:

S.N.	Title of the book	Edition (Year of publication)	Author(s)	Publisher
1	Systems Approach to Computer Integrated Design and Manufacturing	1996	Nanua Singh	John Wiley & Sons, 1996.
2	Automation, Production Systems and Computer Integrated Manufacturing	2002	Groover M.P	Prentice-Hall of India Pvt. Ltd., New Delhi, 2002
3	Handbook of Flexible Manufacturing Systems	1991	Jha, N.K	Academic Press Inc., 1991
4	Group Technology in Engineering Industry	1979	Burbidge, J.L	Mechanical Engineering pub. London, 1979.
5	G.T Planning and Operation, in The automated factory-HandBook: Technology and Management	1991	Askin, R.G. and Vakharia, A.J	Cleland, D.I. and Bidananda, B (Eds), TAB Books, NY, 1991.
6	Cellular Manufacturing Systems		Irani, S.A	Hand Book
7	Planning, design and analysis of cellular manufacturing systems	1995	Kamrani, A.K, Parsaei, H.R and Liles, D.H. (Eds)	Elsevier

V Semester

MEH134	Lab: Computer Integrated Manufacturing			L= 0	T = 0	P = 1	Credits = 1
Evaluation Scheme *Best Two out of three MSE's would be considered	MSE-I*	MSE-II*	MSE-III*	TA	ESE	Total	ESE Duration
	--	--	--	60	40	100	3 Hrs
Prerequisites							

Objective	Course Outcome
To develop in the engineering students the ability to analyze any engineering problem in a simple and logical manner and to apply to its solution a few, well understood basic principles.	**CO1 : The Students will have ability to design and evaluate experimentation on CNC machines.** **CO2: Designing of GT cell layouts for transforming into flexible manufacturing system.** **CO3: The students will be able to compose and transform robot programs various industrial applications.** **CO4: The students will have ability to justify CAPP and CAQC to design computer integrated manufacturing**

List of Practical

1. Study of CIM.
2. Study of CAD systems
3. Numerical control – Fundamental & Application
4. CNC- Lathe – Features, Specification, & Part Program.
5. CNC- Milling – Features, Specification, & Part Program.
6. Group Technology.
7. FMS & CIM.

8. Computer Aided Process Planning.
9. Manual Part Programming.
10. APT Part Programming.
11. Robots Fundamental and Applications
12. AGVS- Fundamental and applications
13. CNC Lathe – Programming, Simulation & Actual Machining of Part.(Thread Cutting , Facing , Turning , Grooving etc.)
14. CNC Milling – Programming, Simulation & Actual Machining of Part. (Profile Cutting, Various Interpolation, Pocketing, Mirroring etc.)
15. Programming, Simulation of Robot.

VI Semester

MEH141	Industry 4.0			L=3	T=0	P=0	Credits= 3
Evaluation Scheme *Best Two out of three MSE's would be considered	MSE-I*	MSE-II*	MSE-III*	TA	ESE	Tota	ESE Duration
	15	15	15	30	40	100	3 Hrs.
Prerequisites							

Objective	Course Outcome
To develop understanding of students about transformation of industrial processes through Industry 4.0 .It primarily concerns about the integration of modern technologies such as sensors, communication, and computational processing. Different essential drivers such as data transformation ,machine learning ,Internet of things and cyber physical securities must be properly addressed .	

UnitI **5 hrs**

Globalization and Emerging Issues, The Fourth Revolution, LEAN Production Systems, Smart and Connected Business Perspective, Smart Factories

Unit II **9hrs**

Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artical Intelligence, Big Data and Advanced Analysis

Unit III :Related Disciplines, System, Technologies for enabling Industry 4.0 **9hrs**

Cyber physical Systems , Robotic Automation and Collaborative Robots , Support System for Industry 4.0 , Mobile Computing , Related Disciplines , Cyber Security, Basics of Industrial IoT

Unit IV: Role of data, information, knowledge and collaboration in future organizations8 hrs

Resource-based view of a firm , Data as a new resource for organizations , Harnessing and sharing knowledge in organizations , Cloud Computing Basics , Cloud Computing and Industry 4.0,Business Model and Referece Architecture for Industrial IoT

Unit 5: Industrial IoT **8 hrs**

Application Domains: Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management.

Unit 6: Business issues in Industry 4.0 **6hrs**

Opportunities and Challenges, Future of Works and Skills for Workers in the Industry 4.0 Era , Strategies for competing in an Industry 4.0 world

Reference :

1. Handbook of Industry 4.0 and SMART SystemsBy Diego GalarPascual, Pasquale Daponte, Uday Kumar : 2019 by CRC Press
2. The Concept Industry 4.0 An Empirical Analysis of Technologies and Applications in Production Logistics by Christoph Jan Bartodziej :2017,Springer Gabler
3. Sustainability in Manufacturing Enterprises: Concepts, Analyses and Assessments for Industry 4.0 by Ibrahim Garbie
4. Industry 4.0: The Industrial Internet of Things by Alasdair Gilchrist
5. The Fourth Industrial Revolution by Klaus Schwab

VI Semester

MEH142	Additive Manufacturing			L=3	T=0	P=0	Credits= 3
Evaluation Scheme *Best Two out of three MSE's would be considered	MSE-I*	MSE-II*	MSE-III*	TA	ESE	Tota	ESE Duration
	15	15	15	30	40	100	3 Hrs.
Prerequisites							

Objective	Course Outcome
The main objective of this course is to acquaint students with the concept of AM, various AM technologies, selection of materials for AM, modeling of AM processes, and their applications in various fields.	

Unit 1 Introduction to Additive Manufacturing (AM) **[7Hrs]**

General overview Introduction to reverse engineering Traditional manufacturing vis AM Computer aided design (CAD) and manufacturing (CAM) and AM Different AM processes and relevant process physics AM process chain Application level: Direct processes – Rapid Prototyping, Rapid Tooling. Rapid Manufacturing; Indirect Processes - Indirect Prototyping. Indirect Tooling, Indirect Manufacturing.

Unit 2 Materials science for AM **[7Hrs]**

Discussion on different materials used Use of multiple materials, multifunctional and graded materials in AM Role of solidification rate Evolution of non-equilibrium structure property relationship Grain structure and microstructure

Unit 3 AM technologies **[12Hrs]**

Powder-based AM processes involving sintering and melting (selective laser sintering, shaping, and electron beam melting. involvement). Printing processes (droplet based 3D Solid-based AM processes - extrusion based fused deposition modeling object Stereo lithography Micro- and Nano-additive

Unit4 Mathematical Model for AM **[13Hrs]**

Transport phenomena models: temperature, fluid flow and composition, buoyancy driven tension driven free surface flow pool) Case studies: Numerical Modeling of AM process, Powder bed melting based process, Droplet based printing process Residual stress, part fabrication time, cost, optimal orientation and optimal Defect in AM and role of transport Simulations (choice of parameter, Mo de! validation for different)

Unit5 Process selection, planning, control for AM **[7Hrs]** Selection of AM technologies using decision methods, Additive manufacturing process plan: strategies and post processing. Monitoring and control of defects, transformation
UNIT-6: **[8 hrs]** Powder Metallurgy: Powder manufacture and Conditioning, Production of Sintered Structural Components, Self-lubricating bearing, Cemented Carbides, Ceramics, Sintered Carbide cutting tools.

Text Book

1	Additive Manufacturing and 3D Printing Technology: Principles and Practice	CRC Press Taylor and Francis Group, A CHAPMAN and HALL BOOK	2020 G K Awari, C S Thorat, D P Kothari, V.V. Ambade	ISBN: 978-0-367-43622-3

VI Semester

MEH143	Lab: Additive Manufacturing			L= 0	T = 0	P = 1	Credits = 1
Evaluation Scheme *Best Two out of three MSE's would be considered	MSE-I*	MSE-II*	MSE-III*	TA	ESE	Total	ESE Duration
	--	--	--	60	40	100	3 Hrs
Prerequisites							

List of Experiments: -

- ARTEC Space Spider-Industrial 3D scanner. ARTEC Space Spider is a high-resolution 3D scanner based on blue light technology.
- MOJO 3D Printer. ...
- Creality Ender 3D Printer.
- Catia V5. ...
- ARTECH Studio. ...
- PTC Creo. ...
- AutoCAD. ...
- Some Project Experiment.

VII Semester

MEH151	CNC and Robotics			L=3	T=0	P=0	Credits= 3
Evaluation Scheme *Best Two out of three MSE's would be considered	MSE-I*	MSE-II*	MSE-III*	TA	ESE	Tota	ESE Duration
	15	15	15	30	40	100	3 Hrs.
Prerequisites							

Objective	Course Outcome
To understand the need and process of automation in industry. Study the Computer Numerically Controlled machines and Robots, their components, functions, functions, programming and applications.	

Unit 1 **[7 hrs]**

Concepts of NC, CNC, DNC. Classification of CNC machines, MCU architecture and functionality, Machine Configurations, Types of control, CNC controller's characteristics, Interpolators

Unit 2 **[8 hrs]**

Qualified, semi qualified and preset tooling, tooling system for Machining centre and Turning centre, work holding devices, of CNC Machines. Programming CNC machines, Part print analysis and Process planning, Advanced Programming features, canned cycles. APT part programming CAD/CAM, Parametric Programming.

Unit 3 **[8 hrs]**

Manual part programming for CNC turning, milling and machining center. Wire EDM machines. Computer assisted part programming techniques, Conversational and Graphics based software, Solid based part programming. Freeform surface machining. Simulation and Verification of CNC programs, Adaptive CNC control techniques. Integration of CNC machines for CIM.

Unit 4 **[7 hrs]**

Robotics, Basic concepts, Robot configurations, Basic robot motions, Types of drives, Applications Transformations and kinematics, Vector operations, Translational transformations and Rotational transformations, Properties of transformation matrices, Homogeneous transformations and Manipulator, Forward solution, Inverse solution, Introduction to robot dynamics. Controls, Control system concepts, Analysis, control of joints, Adaptive and optimal control.

Unit 5 **[8 hrs]**

End effectors, Classification, Mechanical, Magnetic, Vacuum, and Adhesive, Drive systems, Force analysis and Gripper design. Robot programming, Methods, Languages, Computer control and Robot Software – Programming Languages, Robot application (Assembly, inspection, material handling, processing)

Unit 6 **[7 hrs]**

Sensory devices, Non optical and optical position sensors, Velocity and Acceleration, Range, Proximity, touch, Slip, Force, Torque. Machine vision, Image components, Representation, Hardware, Picture coding, Object recognition and categorization Integration of Robots with CNC machines for CIM.

Text books:				
S.N.	**Title of the book**	**Edition (Year of publication)**	**Author(s)**	**Publisher**
1	Robot Engineering An Integrated approach	2004	Klafter R.D., Chmielewski T.A. and Negin M	Springer
Reference :				
1	CNC Technology and Programming	2003	Krar, S., and Gill	Industrial Press Inc
2	An Introduction to CNC Machining	1991	Gibbs, D.	Industrial Press
3	Computer Numerical Control Concepts and Programming	1991	Seames, W.S.	Thomson Learning EMEA, Limited
4	Computer Numerical Control for Machining	1993	Lynch, M	McGraw-Hill
5	Computer Control of Manufacturing Systems	2005	Koren Y	Tata McGraw-Hill Education
6	Robotics control, sensing, vision, and intelligence	2004	Fu K.S., Gonzalez R.C., and Lee C.S.G.	Tata McGraw-Hill Education
7	*Robotics Technology and Flexible Automation*	2001	*Deb S.R*	Tata McGraw-Hill Education
8	Introduction to Robotics Mechanics and Control	2008	Craig J.J	Pearson Education India

VII Semester

MEH152	Lab. : CNC and Robotics			L= 0	T = 0	P = 1	Credits = 1
Evaluation Scheme *Best Two out of three MSE's would be considered	MSE-I*	MSE-II*	MSE-III*	TA	ESE	Total	ESE Duration
	--	--	--	60	40	100	3 Hrs
Prerequisites							

List of practical

1) Demonstration on Automation through development in NC machines.
2) Numerical control – Fundamental & Application.
3) Manual Part Programming.
4) APT Part Programming.
5) CNC- Lathe – Features, Specification, & Part Program.
6) CNC Lathe – Programming, Simulation & Actual Machining of Part.
7) [a, b ,e ,i, j, k, l, m] (Thread Cutting, Facing, Turning, Grooving etc.)
8) CNC- Milling – Features, Specification, & Part Program.
9) CNC Milling – Programming, Simulation & Actual Machining of Part.
   (Profile Cutting, Various Interpolation, Pocketing, Mirroring etc.)
10) Robots Fundamental and configurations.
11) Robots Applications
12) Programming, Simulation of Robot.
13) Problems on Robot kinematics.