MINUTES

Minutes of the Fifty-sixth (56th) meeting of the Senate held on November 21, 2016 (Monday) at 03:30 p.m. in the Conference Room of the Institute.

Following members of the Senate attended the meeting:

1.	Prof. Rajeev Tripathi, Director	-	Chairman
2.	Prof. R. K. Srivastava	-	Member
3.	Prof. M. M. Gore	-	Member
4.	Prof. K. K. Shukla	-	Member
5.	Prof. Rakesh Narain	-	Member
6.	Prof. Anuj Jain	-	Member
7.	Prof. Geetika	-	Member
8.	Prof. R. K. Singh	-	Member
9.	Prof. H. Kar	-	Member
10.	Prof. Vinod Yadava	-	Member
11.	Prof. P. K. Dutta	-	Member
12.	Prof. P. P. Sahay	-	Member
13.	Prof. A. K. Singh	-	Member
14.	Prof. A. D. Bhatt	-	Member
15.	Prof. Sanjay Chaubey	-	Member
16.	Prof. Ramesh Kumar Tripathi	-	Member
17.	Prof. R. C. Vaishya	-	Member
18.	Prof. R. S. Yadav	-	Member
19.	Prof. V. K. Srivastava	-	Member
20.	Prof. R. P. Singh	-	Member
21.	Prof. P. K. Mehta	-	Member
22.	Prof. S. S. Narvi	-	Member
23.	Prof. Vijaya Bhadauria	-	Member
24.	Prof. R. K. Nagaria	-	Member
25.	Prof. Shiv Datt Kumar	-	Member
26.	Prof. H. S. Goyal	-	Member
27.	Prof. Ravi Prakash	-	Member

28.	Prof. K. N. Pandey	-	Member
29.	Dr. R. P. Tewari, Head Department of Applied Mechanics	-	Special Invitee
30.	Dr. Ambalika Sinha, Head Department of Humanities and Social Sciences	-	Special Invitee
31.	Dr. Pankaj Srivastava, Head Department of Mathematics	-	Special Invitee
32.	Mr. Rajesh Tripathi, Head (Oftg.) Department of Computer Science and Engineering	-	Special Invitee
33.	Dr. Paulson Samuel, Head (Oftg.) Department of Electrical Engineering	-	Special Invitee
34.	Dr. Shivesh Sharma Registrar (Oftg.) & Head, Department of Biotechnology	-	Secretary

The following members could not attend the meeting:

1.	Prof. I. K. Bhat	-	Member
2.	Prof. S. K. Duggal	-	Member
3.	Prof. Vineeta Agarwal	-	Member
4.	Prof. Suneeta Agarwal	-	Member
5.	Prof. R. P. Tiwari	-	Member
6.	Prof. A. K. Sachan	-	Member
7.	Prof. R. D. Gupta	-	Member
8.	Prof. Niroj Banerji	-	Member
9.	Prof. Neeraj Tyagi	-	Member
10.	Prof. Amit Dhawan	-	Member
11.	Prof. Shubhi Purwar	-	Member
12.	Prof. Sumathi Rao	-	Member (External)
13.	Prof. Partha Basu	-	Member (External)
14.	Head, Department of Chemistry	-	Special Invitee
15.	Head, Department of Physics	-	Special Invitee
16.	Head, School of Management Studies	-	Special Invitee

Following member was granted leave of absence:

1.	Prof. S. N. Singh	-	Member (External)

The Member Secretary, Senate extended warm welcome to the Chairman, Senate on behalf of the Senate members.

The Chairman, Senate extended warm welcome to the members and thanked them for taking their time out to attend the meeting.

Agenda item-wise proceedings are as under:

Item No. 56.01 : **To confirm the minutes of the Fifty-fifth (55th) meeting of the Senate held on 16.08.2016.**

Resolution : The Senate confirmed the minutes of its Fifty-fifth (55th) meeting held on 16.08.2016 with following observations:

(i) The name of Department of Biotechnology omitted in recommendations of DUGC and SUGC for offering elective subjects at Item No. 55.04 (iv) has been incorporated.

(ii) The name of Course Coordinator for the Course "Industrial Training (CA3691)" has been replaced from Dr. D. S. Kushwaha, CSED to Dr. D. K. Yadav, CSED at Item No. 55.06 (b) (2).

Item No. 56.02 : **To consider the action taken on the decisions taken in the Fifty-fifth (55th) meeting of the Senate held on 16.08.2016.**

Resolution : The Senate noted action taken on the decisions taken in its Fifty-fifth (55th) meeting held on 16.08.2016

Item No. 56.03 : **To consider the recommendations of the Chairman, SUGC.**

Resolution : The recommendations of the Chairman, SUGC on the request of the following students of Bachelor of Technology programme for granting semester leave were put up before the Senate and the Senate resolved to allow the same.

Sl. No.	Registration No.	Name of the Student	Department
1.	20155023	Ms. Anushri Ganguly	ECED
2.	20144154	Mr. Rohith Nayak Rathula	CSED
3.	20158009	Mr. Mohd. Omar Alam	CSED (ITY)
4.	20122048	Mr. Ashwini Kumar Prabhakar	EED
5.	20155142	Mr. Karan Kukreja	ECED
6.	20142081	Ms. Vishakha	EED
7.	20098049	Mr. Ravi Kant	EED

Item No. 56.04 : **To consider the recommendations of the Chairman, SMPC.**

Resolution : The recommendations of the Chairman, SMPC on the request of following students of Masters' programme were put up before the Senate by the Chairman, SMPC for case to case consideration. The Senate resolved as below:

(i) The Senate considered the recommendations of SMPC regarding absence of Mr. Ashish Gautam (2016CL07) from 19.09.2016 to 13.10.2016 (25 days) due to typhoid fever. He had taken treatment from Institute Health Centre and after that informed the Department also. The Senate resolved to allow the maximum admissible 07 (Seven) days leave as per Ordinance clause No. 5.1 with stipend and remaining leave period without stipend.

(ii) The Senate considered the recommendations of SMPC regarding semester leave of Mr. Rahul Chandra (2015PE01) as he got selected in DMRC and he has to join there. The Senate resolved to allow him for grant of one Semester leave (for Odd Semester of academic session 2016-17). However, the candidate has to produce 'No Objection Certificate' from his employer and fulfill the residential requirement for the programme as per Ordinances.

(iii) The Senate considered the case of Mr. Raju Kumar Maurya (2015PE02) regarding his absence from 25.07.2016 to 21.08.2016 (28 days) due to typhoid fever. The Senate resolved to allow him admissible leave of seven (07) days for the semester with stipend and remaining leave period without stipend.

(iv) The Senate considered the recommendations of SMPC regarding semester leave of Ms. Versha Singh (2015PE09) as she got selected in LMRC and she had to join there on August 23, 2016. The Senate resolved to allow her for grant of one Semester leave (for Odd Semester of academic session 2016-17). However, the candidate has to produce 'No Objection Certificate' from her employer and fulfill the residential requirement for the programme as per Ordinances.

(v) The Senate considered the recommendations of SMPC regarding re-conduct of Mid Semester Examination of subject Computer Aided Design (ME-2101/2125) for Mr. Meiyazhagan N (2016PD09) as his father expired on 24.09.2016 and the candidate was not able to appear

in the examination. The candidate informed the department on September 28, 2016 through E-mail. The Senate resolved to allow him for the same.

(vi) The Senate considered the recommendations of SMPC regarding semester leave of Mr. Anurag Dixit (2015PD17) as he got selected in NPCIL. The Senate resolved to allow him for grant of one Semester leave (for Odd Semester of academic session 2016-17). However, the candidate has to produce 'No Objection Certificate' from his employer and fulfill the residential requirement for the programme as per Ordinances.

(vii) The Senate considered the recommendations of SMPC regarding semester leave of Mr. Raghavendra Kumar Patel (2015PD16) as he got selected in Indian Railway. The Senate resolved to allow him for grant of one Semester leave (for Odd Semester of academic session 2016-17). However, the candidate has to produce 'No Objection Certificate' from his employer and fulfill the residential requirement for the programme as per Ordinances.

(viii) The Senate considered the recommendation of SMPC regarding modified course structure, scheme of evaluation and syllabi of all the four M.Tech. programmes of the Department of Applied Mechanics. The name of M.Tech. (Applied Mechanics) is changed to M.Tech. (Engineering Mechanics and Design). The Senate resolved that the detailed syllabus be circulated through e-mail to all Senate members of the Institute with a request to provide observations within one week time. The Course Structure, Scheme of Evaluation and Syllabi proposed by Department of Applied Mechanics are enclosed at **ANNEXURE-1**.

(ix) The Senate also considered the case of Mr. Deepak Singh (2015PE22) regarding his absence from 17.10.2016 to 12.11.2016 (27 days) due to jaundice. Senate resolved to allow him admissible leave of seven (07) days for the semester with scholarship and rest without scholarship.

Item No. 56.05 : **To consider the recommendations of the Chairman, SDPC.**

Resolution : The recommendations of the Chairman, SDPC on the request of following students of Doctoral programme were put up before the Senate by the Chairman, SDPC for case to case consideration. The Senate resolved as

below:

(i) The Senate considered the request of Mr. Bheem Sonkar (Reg. No. 2014REE52) regarding leave from 24.08.2016 to 23.09.2016 and resolved to allow him admissible leave in a Semester for 15 days with stipend and remaining leave period without stipend.

(ii) The Senate considered the request of following research scholars of Department of Computer Science and Engineering regarding grant of extension of one year from the even semester session 2016-17.

Sl. No.	Registration No.	Name of the Student
1.	2009RCS53	Mr. Sansar Singh Chauhan
2.	2009RCS55	Mr. Sanjeev Kumar Pippal
3.	2010RCS53	Mr. Rohit
4.	2008RCS05	Mr. Awadhesh Kumar
5.	2009RCS57	Mr. Jokhu Lal

The Senate resolved to allow them for extension of one year from the even semester session 2016-17.

(iii) The Senate considered the request Ms. Debjani Ghosh (Reg. No. 2010RCS03) regarding extension of one year starting from Odd Semester session 2016-17 and resolved to allow her for the same.

(iv) The Senate considered the recommendation of SDPC regarding rejection of two new courses [Research Methodology (MA601X) and Programming Languages (MA6102)] as proposed by Department of Mathematics. The Senate resolved that the Department of Mathematics may review the proposed courses after considering the similar courses already offered by other Departments and also taking feedback from other engineering and sciences Departments.

(v) The Senate considered recommendations of SDPC on the request of Ms. Shashibala Gautam (Reg. No. 2014RCL51) regarding maternity leave from 26.07.2016 to 25.12.2016 and resolved to allow her for the same.

(vi) The Senate considered recommendations of SDPC on the request of Mr. Ajay Kumar Verma (Reg. No. 2015RCE06) regarding grant of semester leave for 2016-17 (odd semester) and resolved to allow him for the same.

(vii) The Senate considered recommendations of SDPC on the requests of Mr. Dheerendra Kumar (Reg. No. 2016REE04), Mr. Praveen Kumar Singh (Reg. No. 2016REE05) and Mr. Dinesh Chaurasia (Reg. No. 2016REE09) regarding re-conduct of Mid Semester examination for the subject Digital Control System (EE-2102), as per recommendation of SDPC, the Senate resolved to allow for the same.

(viii) The Senate considered recommendations of SDPC on the request of Mr. Birendra Singh Yadav (Reg. No. 2013RBT02) regarding permission to proceed for the academic Institute as non–degree student and resolved to allow him for the same, as per clause 6 of Ordinances for Doctoral Programme.

(ix) The Senate considered recommendations of SDPC on the case of Mr. Adhir Tandon (Reg. No. 2009RME57) regarding conditional acceptance of new proposed supervisor Dr. Manoj Kumar Gupta. The Senate resolved that Mr. Adhir Tondon (Reg. No. 2009RME57) is granted an extension of two years to complete his thesis as a special case. Further, looking at the availability of expertise of willing Supervisor, he may be allowed to work on a modified topic and submit the required forms (DP-12 and DP-13) without any further delay.

Item No. 56.06 : **To consider the list of degree recipients for B.Tech., M.Tech., MBA, MCA, M.Sc., MSW and Ph.D. for the Thirteenth Annual Convocation-2016 of the Institute.**

Resolution : The Senate considered the list of degree recipients of B.Tech., M.Tech., MBA, MCA, M.Sc., MSW and Ph.D. programmes to be conferred in the Thirteenth (13th) Annual Convocation-2016 of the Institute, and resolved to recommend the same to the Board of Governors for approval. Summary of number of degree recipients for each programme is placed at **ANNEXURE-2**.

Item No. 56.07 : **To consider the List of medal recipients of B.Tech., M.Tech., MBA, MCA, M.Sc. and MSW programme for the Thirteenth Annual Convocation-2016 of the Institute.**

Resolution : The Senate noted and ratified the approval accorded by the Chairman, Senate on the list of medal recipients of B.Tech., M.Tech., MBA, MCA, M.Sc. and MSW programmes in Thirteenth (13th) Annual Convocation-2016 of the Institute. The list of medal recipients as approved by Chairman, Senate is placed at **ANNEXURE-3**.

Item No. 56.08 : **To note and ratify the approval accorded by the Chairman, Senate on the following matters.**

(a) Recommendations of the Ph.D. Oral Boards of different departments.

(b) Recommendations of the Minutes of Standing Committee.

Resolution : **(a)** The Senate noted and ratified the approval accorded by the Chairman, Senate on the recommendations of Ph.D. Oral Boards of the following students of the Institute.

Sl. No.	Registration No.	Name of the Student	Department
1.	2011REE03	Ms. Rehana Perveen	EED
2.	2010RMA52	Ms. Garima Mishra	Math.
3.	2010REE03	Mr. Abhishek Vikram	EED
4.	2013REL52	Ms. Aditi Srivastava	ECED
5.	2010RCS05	Mr. Hari Mohan Singh	CSED
6.	2010RMA07	Mr. Anand Shukla	Math.
7.	2011RME01	Mr. Saurabh Kumar Gupta	MED
8.	2008RMS04	Mr. Ashish Kumar Srivastava	SMS
9.	2010RCE51	Mr. Brij Kishor	CED
10.	2010RME09	Mr. Ajay Suryavanshi	MED
11.	2010RCH06	Ms. Subia Ambreen	CHY
12.	2013REL06	Ms. Pushpa Giri	ECED
13.	2012RGI53	Mr. Ramji Dwivedi	GISC
14.	2010REL54	Mr. Vadthiya Narendar	ECED
15.	2009RCY03	Ms. Nivedita Sinha	CHY
16.	2012RCS02	Mr. Shivendra Shivani	CSED
17.	2011REE04	Mr. Pradeep Kumar	EED
18.	2008RCS13	Mr. Avinash Gupta	CSED
19.	2013REL01	Mr. Anurag Upadhyay	ECED
20.	2013RPH01	Mr. Snehasis Bhunia	PHY
21.	2010RME06	Mr. Sandarbh Shukla	MED
22.	2009RCY53	Mr. Dilip Kumar Tiwari	CHY
23.	2010REE53	Mr. Anil Kumar Pandey	EED
24.	2012RCS55	Mr. Divya Kumar	CSED
25.	2010RCH05	Mr. Hridyesh Kumar	CHY

26.	2010RME11	Mr. Anand Shivanappa Reddy	MED
27.	2009RPH03	Mr. Aashish Jha	PHY
28.	2013REL05	Mr. Nishu Gupta	ECED
29.	2012RBT05	Mr. Ashish Tiwari	BOT
30.	2010REL53	Mr. Pawan Kumar Verma	ECED
31.	2013REL09	Mr. Krishan Kumar	ECED
32.	2009RCL51	Mr. Abhishek Kumar Chandra	CHEM.
33.	2010RCL51	Mr. Shyamsunder Bholanath Mishra	CHEM.
34.	2012RBT04	Mr. Shivraj Singh Gangoliya	BOT

Further, in view of the upcoming convocation – 2016, Senate resolved to allow the award of Ph.D. degree for all the candidates whose Oral Examination is held on or before November 30, 2016 and approved by the Chairman, Senate. Senate authorized the Chairman, Senate to allow for the award of degree to such candidates in 13th Convocation.

(b) The Senate noted and ratified the approval accorded by the Chairman, Senate on the recommendations of Standing Committee meetings held on 07.09.2016 and 23.09.2016. The minutes of the Standing Committee are annexed at **ANNEXURE-4**.

Item No. 56.09 : Any other matter with permission of the Chair.

Resolution : (i) The Senate considered the list of following eligible students who could not be considered for award of degree in earlier convocations due to unavoidable circumstances and resolved to award them degree for respective sessions.

Sl. No.	Registration No.	Name of the student	Programme / Branch	Year of Passing
1.	20101003	Mr. Prashant Shishodia	B.Tech. (Mech. Engg.)	2014
2.	2009PTSW02	Mr. Naveen Trivedi	M.Tech. (PT) (Soft. Engg.)	2013
3.	2009PTSW19	Mr. Harendra Singh	M.Tech. (PT) (Soft. Engg.)	2013

(ii) The Senate considered the request of following students who were not

able to appear in the Mid (Odd) Semester Examination 2016-17, due to medical reasons and resolved to allow the same in the same way as approved by Chairman, Senate on similar grounds of the recommendations of Standing Committee meeting dated 23.09.2016.

Sl. No.	Registration No.	Name of the student	Programme / Branch
1.	20164129	Ms. Krithika Venkatanath	B.Tech., CSE
2.	20121083	Mr. Siddhartha Rajpoot	B.Tech., CIV

(iii) The Senate considered the case of following students whose result for the subject mentioned could not be prepared, due to change in curriculum.

Sl. No.	Registration No.	Name of the student	Programme / Branch	Course Code	Course Name
1.	20111029	Mr. Mohd. Tufail	B.Tech., CIV	MC201	Engineering Graphics
2.	20112049	Mr. Kishan Kumar	B.Tech., ELE	MC201	Engineering Graphics

The Senate resolved that marks earned by these students in the two components of Civil and Mechanical may be combined together and treated as Teachers Assessment component for preparation of result of MC201-Engineering Graphics.

Looking at the urgency of implementation in view of the Convocation-2016, the Senate resolved to approve item No. 56.06, 56.07, 56.08 (a) and 56.09 (i).

The meeting concluded with the vote of thanks to the Chair.

04.01.2017

(Asheesh K. Singh)
Registrar (Oftg.) / Secretary

Approved

04/01/17.

(Rajeev Tripathi)
Director / Chairman

ANNEXURE – 1

Master of Technology

in

BIOMEDICAL ENGINEERING

Course Structure, Scheme of Evaluation and Syllabi

(*Effective from July 2017*)

Department of Applied Mechanics

Motilal Nehru National Institute of Technology Allahabad
Allahabad, U.P. -211004, INDIA

Course Structure

I Semester (Total credit = 20)

Course code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM2104	Biomechanics	4	0	0	4	20	20	60
AM2101	Applied Mathematics & Computation	4	0	0	4	20	20	60
AM21XX	**Elective-I**	4	0	0	4	20	20	60
AM21XX	**Elective-II**	4	0	0	4	20	20	60
AM21XX	**Elective-III**	4	0	0	4	20	20	60

List of Electives (Semester I):

Elective-I:		**Elective-III:**	
AM2130	Anatomy & Physiology for Biomedical Engineers	**AM2132**	Biomedical Instrumentation
AM2131	Effects of Radiation and Biomedical Application of Radiation	**AM2133**	Biomedical Signal and Image Processing
ME2118	Ergonomics	**AM2134**	Biological System Analysis and Control
Elective-II:		**AM2135**	Introduction to Biomedical Design
AM2111	Finite Element Methods		
AM2125	Non-Destructive Testing		
AM2149	Bio-fluid Dynamics		
ME2125	Computer Aided Design		

II Semester (Total credit= 20)

Course code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM2253	Biomedical Engineering Laboratory	4	0	0	4	20	20	60
AM2203	Biomaterials	4	0	0	4	20	20	60
AM22XX	**Elective-IV**	4	0	0	4	20	20	60
AM22XX	**Elective-V**	4	0	0	4	20	20	60
AM22XX	**Elective-VI**	4	0	0	4	20	20	60

List of Electives (Semester II):

Elective-IV:		**Elective-VI:**	
AM2230	Advanced Biomechanics	**AM2235**	Rehabilitation Engineering and Assistive Technology
BT2234:	Bioethics, Biosafety and IPR	**AM2236**	Medical Imaging
AM2232	Electro Physiological signal Analysis	**AM2237**	Artificial Intelligence in Biomedical Engineering
Elective-V:		**AM2202**	Characterization of Materials
AM2233	Tissue Engineering		
AM2234	Electro Diagnostics, Therapy and Electrical Safety		
AM2224	MEMS and Bio-MEMS		

III Semester (Total credit= 20)

Course code	Subject Name	Credits
AM2397	Special Study/Term Project/State of the Art/Colloquium/ Industrial/ Research Training	4
AM2398	Thesis/ Project	16

IV Semester (Total credit= 20)

Course code	Subject Name	Credits
AM2498	Thesis/ Project	20

Note: The distribution of thesis evaluation marks will be as follows:

1. Supervisor(s) evaluation component: 60%.
2. Oral Board evaluation component: 40%.

Semester-I

AM2104 Biomechanics		
Designation	:	Compulsory
Pre-requisites	:	Basics of engineering mechanics, and Anatomy of human body.
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Application of Statics to Biomechanics:

Basics concepts of Force Moments and Torque Equilibrium, analysis of systems in equilibrium. Skeletal joints, Skeletal muscle. Mechanics of the elbow, shoulder, Spinal column, Hip, Knee and ankle. Basic assumptions and limitations.

Deformable body Mechanics:

Applied forces and Deformations, internal forces and moments, Stress and Strain, Basic loading configurations, Uniaxial tension test, Load- elongation diagrams, Hooke's Law, Work and Strain Energy, Properties based on Stress-strain Diagrams, Idealized model for material behavior and Mechanical properties of materials.

Multi axial Deformation and stress analysis:

Poisson's ratio, Biaxial and tri axial stresses, Failure theories, allowable stress and factor of safety, Fatigue and endurance, Torsion, Bending and combined loading.

Mechanical Properties of Bone and Soft Tissues

Mechanics of bone, Composition of bone, Mechanical properties of bone, Bone fractures and Bone Remodeling, Biomechanics of Tendon and Ligaments. Biomechanics of Skeletal Muscles. Biomechanics of Articular cartilage.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

Text books and References

1. Fung Y.C., Biomechanics, Springer Verlag.
2. Winter.D.A., Biomechanics and Motor Control of Human Movement.
3. Frankel V.H.&Nordin Margareta ,Basic Biomechanics of the Skeletal System, LEA &FEBIGER.
4. Nihat Ozkaya and Margareta Nordin Fundamentals of Biomechanics, 3rd Edition. VNR, New York.

AM2101 Applied Mathematics and Computation		
Designation	:	Compulsory
Pre-requisites	:	Engineering Mathematics &Computer Programming
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Review of Elementary Engineering Mathematics: Solution of homogeneous and non-homogeneous equations; Power series; Laplace transform and its applications; Fourier series and Fourier transform

Linear Algebra: Matrices and Linear Transformations, Operational Fundamentals of Linear Algebra, Systems of Linear Equations, Gauss Elimination Family of Methods, Special Systems and Special Methods, Numerical Aspects in Linear Systems, Eigenvalues and Eigenvectors, Diagonalization and Similarity Transformations, Jacobi and Givens Rotation Methods, Tri-diagonal Matrices, QR Decomposition Method, Eigenvalue Problem of General Matrices, Singular Value Decomposition, Direct and Iterative solvers.

Ordinary Differential Equations: Introduction to ordinary differential equations, homogeneous linear equations of second order, non-homogeneous linear equations of second order, free and forced oscillation problems, problems with variable coefficients, system of equations.

Partial Differential Equations (PDEs): Existence and uniqueness of differential equations, nature of solution, Hyperbolic, Parabolic and Elliptic PDEs, nonlinear PDEs.

Nonlinear Equations: Motivation, Open and braketing method, Bisection, Fixed point, Newton's method, Secant and False position method, Rate of convergence, Merits and demerits of methods.

Numerical Integration: Motivation, Newton-Kotes method, Trapezoidal rule, Simpson's rule, Rhomberg integration, Gauss Quadrature.

Initial Value Problem: Motivation, Euler's method, Modified Euler method, Runge-Kutta methods, Adaptive integrations and multistep methods.

Boundary-value and Eigen-value Problem: Methods and Applications in Mechanics.

Text books and References

1. Numerical Methods in Engineering: M. Salvadori.
2. Applied Numerical Methods: B. Carnahan.
3. Applied Numerical Analysis: C.F. Gerald and P.O. Wheatley.
4. Numerical Mathematics & Computing: W. Cheney and D. Kincaid.
5. Applied Partial Differential Equations: Paul DuChateau and David Zachmann.
6. Partial Differential Equations for Scientists and Engineers: Stanley J. Farlow.
7. Numerical Methods for Partial Differential Equations: William F. Ames.
8. Numerical Methods for Elliptic and Parabolic Partial Differential Equations: John R Levison, Peter Knabner, Lutz Angermann.

AM2130 Anatomy & Physiology for Biomedical Engineers		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Introduction to Human Body: Human as Biological Organism, levels of the organization of human body, homeostasis, Anatomical position and terminology, Body regions and Body cavities.

Cell Structure and Function: Cells and Their Structure, Replication, Transcription and Translation, Mitosis and meiosis, Cellular Communication. Nature of cancer cells, Transport of ions through cell membrane, Resting and action potentials.

Tissues: Epithelial tissue, Connective Tissue, Muscle Tissue, Nervous Tissue.

Integumentary System: Function of the Integumentary System, Structure of the Skin, Physiology of the Skin.

Skeletal System: Structure and Function of Bone, Bone formation, Bones of the axial skeleton, Bone of the appendicular skeleton, Articulations.

Muscle Tissues mode of contraction: Microscopic and macroscopic structure of muscle, mode of muscle contraction.

Muscular System: Muscle terminology, muscle of axial and appendicular skeleton.

Nervous System: Anatomy of Central Nervous System, Peripheral and Autonomic Nervous system, Neuron, Physiology of Nerve conduction, Synapse and Synaptic Transmission. Brain, Blood brain barrier, neurotransmitter and Spinal cord. Cranial nerves, spinal nerves and Reflex arc.

Sensory Organs: Taste, smell, Structure and Function of Eye, structure and Function of ear.

Endocrine System: Hormones, Negative and Positive Feedback Endocrine gland and their secretions.

Cardiovascular System: Function and Composition of Blood, structure of Heart, blood flow thorough heart, Fetal circulation, coronary circulation, conduction system and innervation, cardiac cycle and electrocardiogram, Vessels, arteries, capillaries and veins, Principle systemic arteries and veins, Blood pressure.

Lymphatic System: Lymphatic structure, Nonspecific defense, antibody and cell mediated immunity, transfusion and rejection reactions.

Respiratory System: Respiration, Components of respiratory system, Mechanics of Breathing, Lung Volumes, Gas transport, Regulation of respiration.

Digestive System: digestive processes, Peritoneum, structure and Function of GI track.

Urinary System: Components of urinary system, Structure of nephron and its function, Urine concentration, Acid base balance.

Metabolism and temperature regulatory System, Water balance and electrolyte.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. Elaine. N. Marieb, 'Essentials of Human Anatomy and Physiology', 8th edition, Pearson Education, New Delhi.
2. Richard S Snell, *Clinical Anatomy by Regions*: Lippincott Williams & Wilkins, 8th edition.
3. Charles E. Tobin, Basic human Anatomy.
4. Guyton and Hall, "Textbook of Medical Physiology", Elsevier.
5. William F. Ganong, 'Review of Medical Physiology', 22nd edition, McGraw Hill, New Delhi.

AM2131 Effects of Radiation and Biomedical Application of Radiation		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Basic concept, types, source and characteristics of Electromagnetic radiations and its influence human health. Biological Effects and biomedical application of X-Rays, Gamma Rays, Microwave, Ultrasound etc. Introduction to Radio isotopes and its Biomedical Applications.

Laser, its Classification, Basic concept, types and their biomedical applications, Laser use in surgery, diagnosis and in promotion of healing, Safety with Biomedical Laser.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. A Sorenson and Phelps, Physics of Nuclear Medicine, W.B. Saunders Co.
2. J. R. Cameron and J.G. Skofronick, Medical Physics.
3. Christenson, Physics of Diagnostic Radiology, John Wiley.

ME2118 Ergonomics		
Designation	:	Elective
Pre-requisites	:	Solid mechanics, Linear Algebra, Differential Equations, etc.
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Introduction to Ergonomics; Elements of Anthropometry; Physiology, Anatomy; Biomechanics. Kinesiology; Workspace Design, Seating Design; Cumulative Trauma Disorders (CTDs); Manual. Material Handling; Hand Tool Design; Human Information Processing; Cognitive ergonomics; Manmachine system interface, Displays and Controls, Principles of graphic user interface design; Compatibility environmental factors; Human errors, product safety, product liability.

The Elemental Resource Model for Human Performance, Measurement of Neuromuscular Performance Capacities, Measurement of Sensory-Motor Control Performance Capacities: Tracking Tasks, Measurement of Information-Processing Subsystem Performance Capacities, High-Level Task Analysis: Cognitive Components, Task Analysis and Decomposition: Physical Components, Human–Computer Interaction Design, Applications of Human Performance Measurements to Clinical Trials to Determine Therapy Effectiveness and Safety, Applications of Quantitative Assessment of Human Performance in Occupational Medicine, Human Performance Engineering Design and Analysis Tools, Human Performance Engineering: Challenges and Prospects for the Future.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. J. D. Branzino, Handbook of Biomedical Engineering: Fundamentals of Biomedical Engineering, CRC Press.
2. Shrawan Kumar, Biomechanics in Ergonomics, CRC Press.

AM2111 Finite Element Methods		
Designation	:	Elective
Pre-requisites	:	Linear Algebra with Matrix Operations, Differential Equations, Mechanics of Materials, Theory of Elasticity.
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Introduction: Course objectives, History of FEM, Application Areas, Concept of Discretization and Interpolation, Different Steps in Finite Element Analysis, Demonstration through FE Analysis of Axially Loaded Bar.

Variational Methods & Energy Principles: Brief Introduction to Variational Calculus, Energy Principles – Principle of Virtual Work and Complementary Virtual Work, Principle of Minimum Potential Energy and Complementary Potential Energy, Mixed Principles.

Detailed FE Formulation for Solid Mechanics: Finite element discretization – Piecewise Interpolation & Shape Functions, C0 and C1 Interpolation, Conventional 1D, 2D & 3D Elements, Special Elements, Sub Parametric, Super Parametric &Isoparametric elements. FE Formulation Using Variational Methods & Energy Principles. Coordinate transformation & Jacobian, Numerical Integration & Calculation of Element Matrices.

Classical Finite Element Methods: Ritz Method, Method of Weighted Residuals, Galerkin method, Strong & Weak formulation. One & Two dimensional structural & non-structural boundary value problems involving scalar and vector valued dependent variables.

Dynamic Problems and Other Topics (in brief): Dynamic Equations from Hamilton's Principle, Mass (Consistent & Diagonal) and Damping Matrices, Free Vibration Analysis – Eigen value problem, Time-History analysis in Forced Vibration – Direct (Explicit & Implicit) Integration Methods.
Nonlinear & Stability problems, Error & Error estimation, Conforming &Non conforming Elements, Patch test.

Application through Computer Programming& Commercial Software:

- Input for Geometric & Material Configuration, Loading and Boundary Conditions.
- Automatic Mesh Generation, Nodal Coordinate and Nodal Connectivity.
- Calculation of Element Matrices (Stiffness & Mass Matrices, Load Vector).
- Assembly of Element Matrices to Global Matrices, Imposing Boundary Conditions.
- Solution (Gauss Elimination & other methods), Post Processing.

Text books and References

1. Energy and Finite Element Methods in Structural Mechanics: I. H. Shames and C. L. Dym.
2. Concepts and Applications of Finite Element Analysis: R. D. Cook, D. S. Malkus and M. E. Plesha.
3. The Finite Element Method Vol. I-II: O.C. Zienkiwiczand R.L. Taylor.
4. Finite Element Procedures: K. J. Bathe.
5. An Introduction to Finite Element Methods: J.N. Reddy.
6. Finite Element Methods in Engineering: S.S. Rao.

AM2125 Non-Destructive Testing		
Designation	:	Elective
Pre-requisites	:	Basic Material Science and Engineering
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Overview of NDT: NDT Versus Mechanical testing, Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterization. Relative merits and limitations, Various physical characteristics of materials and their applications in NDT, Visual inspection Unaided and aided.

Surface NDE methods: Liquid Penetrant Testing – Principles, Types and properties of liquid penetrants, Developers, Advantages and limitations of various methods, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, Inspection materials Magnetisation methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.

Thermography and eddy current testing (ET): Thermography- Principles, Contact and non contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation – infrared radiation and infrared detectors, Instrumentations and methods, applications. Eddy Current Testing- generation of eddy currents, properties of eddy currents, eddy current sensing elements, probes, instrumentation, types of arrangement, applications, advantages, limitations, interpretation/evaluation.

Ultrasonic testing (UT) and acoustic emission (AE): Ultrasonic Testing-Principle, Transducers, Transmission and pulse-echo method, Straight beam and angle beam, Instrumentation, Data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique, AE parameters, Applications

Radiography (RT): Principle, Interaction of X-Ray with matter, Imaging, film and film less techniques, Types and use of filters and screens, Geometric factors, Inverse square law, Characteristics of films – graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy- Xero-Radiography, Computed Radiography, Computed Tomography.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

[1] Practical Non-Destructive Testing: Baldev Raj, T.Jayakumar, M.Thavasimuthu

[2] Non-Destructive Testing Techniques: Ravi Prakash

[3] ASM Metals Handbook, Non-Destructive Evaluation and Quality Control, American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.

[4] Introduction to Non-destructive testing: a training guide: Paul E Mix

[5] Handbook of Nondestructive evaluation: Charles J. Hellier

[6] ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook,Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing

AM2149 Bio-fluid Dynamics		
Designation	:	Elective
Pre-requisites	:	Engineering Fluid Mechanics, Elementary Biology
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Introduction to Fluid Mechanics: Fluid properties, basic laws governing conservation of mass momentum and energy; Laminar flow, Couette flow and Hagen-Poiseuille equation, turbulent flow.

Bio-fluid Dynamics: Blood system network and physiology, blood rheology, Vessel structure and mechanical properties Lymphatic system; Body fluids and their motions; Flow of Newtonian and non-Newtonian fluids in rigid tubes, flexible tubes and collapsible tubes.

Cardio-vascular system: Heart and pumping process, Blood flow in body, Flow dynamical study of circulatory system, heart and blood vessels, anatomy and physiological considerations; Components and functions of arterial and venous systems: Blood flow through arteries and veins; Kinetic energy, flow, pressure-flow relations in vascular beds; Cardiac cycle; Cardiac valve dysfunctions; Blood pressure, regulation and controlling factors; Coronary circulation, heart failure.

Human Respiratory system: Physiology, Weibel's lung model, realistic lung model, studies of flow behavior in upper and lower human respiratory system during different breathing conditions, studies of wall shear stress and its implications, Dispersion and deposition of aerosols/inhaled particles in respiratory system, critical airways, tumorous airways.

Text books and References

1. "Bio-fluid Mechanics", J.N. Mazumdar, World Scientific, 1992.
2. "Biomechanics: Motion", Flow, Stress, and Growth", Y.C. Fung, Springer-Verlag, 1990.
3. "Cardiovascular Physiology", R.M. Berne, M.N. Levy, 8th Edition, Mosby, 2001.
4. "Bio-fluid Dynamics", C. Klienstreuer, Taylor & Francis.

ME2125 Computer Aided Design		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Introduction: Historical Development, Explicit and Implicit Equations, Intrinsic Equations, Parametric Equations, Coordinate Systems.

Curves: Fundamental of Curve Design, Parametric Space of a Curve, Reparametrization, Space Curves: Spline Curves, Bezier Curves, B-Spline Curve,Rational Polynomials, Rational curves, NURBS.

Surfaces: Fundamental of Surface Design, Parametric Space of a Surface, Reparametrization of a Surface patch, Sixteen point form, Four Curve Form, Plane, Cylindrical and Ruled Surfaces, Surfaces of Revolutions, Bezier Surface, B-Spline Surface.

Solids: Fundamental of Solid Design, Parametric Space of a Solids; Continuity and composite Solids, Surface and Curves in a Solid.

Solid Modeling: Topology and Geometry, Settheory, Euler Operators, Regularized Boolean Operators, Construction Criteria, Graph Based Models, Instances and Parameterized Shapes, Cell-decomposition and Spatial Occupancy Enumeration, Sweep representation, CGS, BRep, Wireframe Analytical properties, Relational properties and Intersection. Applications in Biomedical Engineering Design.

Laboratory:- Students will be introduced to basic design elements in making 2D sketches, leading up to more complex features with 3D parts and assemblies. Students will also gain practical experience in engineering design and 3D printing fabrication using the Pro/ENGINEER and other available Softwares.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. Posinasetti Nageswara Rao CAD/CAM: Principles and Applications, Tata McGraw-Hill Education.
2. Groover, CAD/CAM: Computer-Aided Design and Manufacturing, Pearson Education India.

AM2132 Biomedical Instrumentation		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Basic concepts of Medical Instrumentation: Generalized medical Instrumentation System, Medical Measurement constraints, Classification of Biomedical Instruments, Generalized static and dynamic characteristics, Design criteria, Commercial Medical Instrumentation Development process, Regulation of Medical Devices.

Theory, Analysis and design of biomedical transducers: optical, photo-electric, electrochemical, electrical, mechanical, electromechanical and thermoelectric, Applications to biomedical systems, Transducer characteristics sensors for physical measurands, sensors for measurement of chemicals. Medical measurands sensor characteristics and design for measurement of medical parameters like ECG, arterial blood pressure heart sounds, bio-potential amplifiers, Various types of electrodes used in ECG, EEG and EMG, Measurement of EEG, EMG and their diagnostic applications in Medicine, Flow and pressure measuring instruments in biomedical engineering, Development of non-invasive diagnostic instruments for tissue abnormalities, Medical Ultrasonography, Latest biomedical Instruments, Electro surgical unit, Pulse Oximeter, Defibrillators, Foetal ECG.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. Khandpur R.S., Hand book of Biomedical instrumentation,TMH.
2. Tompkins, Biomedical Digital Signal Processing.
3. Cormwell L. et al., Bio medical Instrumentation & Measurements, PHI.
4. Carr & Brown, Introduction to Biomedical Equipment, PHI.
5. Webster JG, *Medical Instrumentation: Application and Design,* 4th ed., John Wiley & Sons: New York.

AM2133 Biomedical Signal and Image Processing		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Biosignals and their Characteristics –Origin of Biomedical Signals, Classification of Biosignals, Stochastic Signals, Signal Sampling and conditioning, DFT properties-Frequency Domain Analysis of Signals, FFT Algorithms, Digital Filter Design.

Time Domain Modeling- AR modeling, Spectral Estimation, Data Compression Techniques- Wavelet Transformation, Vector Quantization, Linear and Non Linear prediction of Bio signals, Waveform detection and Pattern Recognition.

Digital Image representation, Elements of digital Image Processing System. Image Transforms- Discrete Fourier Transform and properties, Separable Image Transforms, Image Enhancement, Image Restoration, Image segmentation, Image Reconstructions from projections, Data compression-DPCM, Vector quantization, JPEG, MPEG, Wavelet Transforms, Brief description of CT,MRI, Ultrasound, PET and SPECT images.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. Cohen, Biomedical Signal Processing, Vol 1&2, CRC Press.
2. Tompkins W.J., Biomedical Digital signal Processing, Prentice Hall.
3. Jain A.K., Digital Image Processing, PHI.
4. Hicho Z. et. al., Fundamentals of Medical Imaging, John Wiley.

AM2134 Biological System Analysis and Control		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Introduction to linear control system, mathematical modeling, transfer functions, signal flow graphs, feedback control and its characteristics, Time domain and frequency domain analysis, stability analysis, Routh Hurwitz criteria, root locus plot, Bode plot, Nyquist Plot and Nichols plot, introduction to digital control, optimal, adaptive and Non-linear control.

Introduction mathematical modeling and control. Biological receptors, thermoregulatory systems, Human limbs, semicircular canal, musculoskeletal system, Respiratory system, pupil control system, neuromuscular reflex motion.

Application of control theory to physiological systems, Time domain and frequency domain analysis, stability analysis, Biological performance criteria and adaptive control, Simulation and implementation.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. Michael C. K. Khoo, Physiological Control Systems: Analysis, Simulation, and Estimation (IEEE Press Series on Biomedical Engineering).
2. John H. Milsum, Biological control systems analysis, McGraw-Hill.

AM2135 Introduction to Biomedical Design		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Principles of Implant Design, Clinical Problems Requiring Implants for Solution, Principles of Implant Design / Design Parameters: Permanent versus Absorbable Devices, the Missing Organ and its Replacement, Criteria for Materials Selection, Tissue Engineering: Scaffolds, Cells and Regulators, Case Study of Organ Regeneration, Design Parameters, Design Specifications: Biomaterials ,Biocompatibility: Local and Systemic Effects, Design Specifications: Tissue Bonding and Modulus Matching, Degradation of Devices: Natural and Synthetic Polymers, Biocompatibility: Scar Formation and Contraction, Degradation of Devices: Corrosion and Wear, Regulation of medical Devices, Scaffolds for Cartilage Repair, Implants for Bone, Implants for Plastic Surgery, Cardiovascular Prostheses: Heart Valves and Blood Vessels, Devices for Nerve Regeneration, Musculoskeletal Soft Tissues: Meniscus, Intervertebral Disk, Dental and Ear Implants, Other Devices: Spinal Cord, Heart Lung.

Design and application of electromechanical biomedical devices, Concept of prototype development and testing of medical instrument. Techniques for designing electronic circuits as part of complete sensor systems, basic electronics circuits, principles of accuracy, op amp circuits, analog signal conditioning, power supplies, microprocessors, wireless communications, sensors, and sensor interface circuits, practical printed circuit board (PCB) design including component selection, PCB layout, assembly.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. E. J. Mccormick, Human factors in Engineering and Design, TMH.
2. O. P. Astrand and R. Kaare, Textbook of Work Physiology, McGraw Hill.
3. Yannas, I. V. *Tissue and Organ Regeneration in Adults*. New York, NY: Springer-Verlag, 2001.
4. Ayyana M. Chakravartula, Lisa A. Pruitt Mechanics of Biomaterials: Fundamental Principles for Implant Design (Cambridge Texts in Biomedical Engineering).
5. Webster J. G., *Medical Instrumentation: Application and Design,* 4th ed., John Wiley & Sons: New York.
6. J. D. Branzino, Handbook of Biomedical Engineering: Fundamentals of Biomedical Engineering, CRC Press.

Semester-II

AM2253 Biomedical Engineering Laboratory		
Designation	:	Compulsory
Pre-requisites	:	Biomechanics, Biomaterials and Biomedical Instrumentation.
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

1. To perform the tensile test on biomedical implant using universal testing machine. To draw stress strain curve and to find out the followings: (1) Yield stress, (2) Ultimate Stress, (3) Breaking Stress, (4) Percentage Elongation, (5) Percent Reduction in Area, and (6) the Modulus of Elasticity.
2. To determine the impact strength of biomaterial using (a) Charpy test (b) Izod test for biomedical implants.
3. To determine the value of modulus of elasticity of an implant by measurement of slope and deflection of a beam using beam-bending apparatus. Draw load-deflection diagram.
4. To perform torsion test on the given biomedical implant. To draw toque –twist curve and to find out the following. To determine the hardness of the given material by (1) Brinell Method (2) Rockwell Method.
5. Measurement of Blood Pressure using different methods.
6. Recording and analysis of electrocardiogram.
7. Recording and analysis of electroencephalogram.
8. Recording and analysis of electromyogram.
9. Preparation of composite using Hand layup method.
10. 3-point bending test of composite.
11. Project-1.
12. Project-2.
13. Project-3.
14. Project-4.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

Lab Manuals.

AM2203 Biomaterials		
Designation	:	Compulsory
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Classes of biomaterials, Bulk Properties of Materials, Surface properties and surface characterization of materials, Properties of biomaterials: Physical, thermal, electrical and optical properties of bio-materials. Biocompatibility, Bio-functionality, Mechanical and Biological Testing of Biomaterials.

Metallic Implant Materials: Stainless steels, Co-based alloys, Ti and Ti-based alloys and Other metals. Corrosion of metallic implants.

Ceramic Implant Materials: Aluminum oxides, Calcium Phosphate, Glass Ceramics and Carbons. Medical applications of Ceramic Materials.

Polymeric implant: Polymerization, Polymeric implant materials, Degradable Polymers used for Biomedical Applications. Silicone used for Biomaterials, Hydrogels, Smart Polymers as biomaterials, Polymers used for drug delivery and Tissue Engineering Applications. Natural polymers found in human body, Composites as Biomaterials.

Cardiovascular Biomaterials, Orthopedic Biomaterials, Ophthalmological Biomaterials, Biomaterials for soft tissue applications and hard tissue application. Biomaterials used for artificial skin, artificial hair implantation etc.

Novel Biomaterials and Uses in Engineering and Tissue Engineering.

Recent advances in the field of Biomaterials.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons Biomaterials Science, Second Edition: Wiley Science.
2. Jef A., Helsen H., Jürgen Breme, Metals as Biomaterials Wiley.
3. Kinam Park and Randall J. Mrsny Controlled Drug Delivery Designing Technology for the future American chemical society Publication.
4. Park .J.B. & Lakes R.S, Biomaterials: An Introduction, Plenum Press, New York.
5. Silver F .H, Biomaterials, Medical Devices &Tissue Engineering: An Integrated approach, Chapman & Hall.

AM2230 Advanced Biomechanics		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Applications of Principles of Biomechanics in Two and three dimensional kinematics.

Kinematics: Body segment parameters: Method of measuring and estimating body segment parameters, two dimensional and three dimensional computational methods.

Two dimensional inverse dynamics: Planar motion analysis, numerical formulations, Human joint kinetics.

Three dimensional Kinetics: Data required for Three dimensional analysis, anthropometry and three dimensional kinetics calculations.

Electromyographic Kinesiology: Physiology of the EMG Signals, Acquisition, interpretation and Analysis of EMG Signals. Applications of EMG Techniques in Biomechanics related problems.

Computer simulation of Human Movement: Mathematical formulations, free body diagrams, Lagrange's equation of motion, numerical solution techniques, control theory, advantages and limitation of computer models.

Elastic Behavior of Biological Materials: Strain and stress relationship, Plastic deformation, Biological material properties based on strain and stress diagram.

Viscoelastic Behavior of Soft Tissues:

Viscoelasticity, Analogies based on Spring and dashpots, Empirical models of Viscoelasticity, Time-dependent material response, Bio viscoelastic solids, Structure of Skeletal Muscle, Sliding element theory of muscle action, Hill's Equation for skeletal muscle, Modified Hill equation, Hypothesis of Cross Bridge Theory . Other recent muscle models.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. Nihat Ozkaya and Margareta Nordin Fundamentals of Biomechanics:, 3rd Edition. VNR, New York.
2. David A. Winter Biomechanics and motor control of Human Movements:, 3rd Edition, John Wiley & Sons, Inc.
3. D. Gordon, E. Robertson, Graham E. Caldwell, Joseph Hamill Research Methods in Biomechanics:. Human Kinetics.
4. Mark L. Latash Neurophysiological Basis of Movement:, Human Kinetics.
5. Fung, Y.C.: Biomechanics: Mechanical Properties of Living Tissues, Springer, 1993.

BT2234: Bioethics, Biosafety and IPR		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Different ethical issues related to biotechnology, Importance and application of bioethics. International guidelines on bio-safety and bioethics and current legal issues.

Different standard practices (GLP, GMP, GCP, etc.). Social and international challenges for modern medicine, GM food, stem cell therapy.

Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, trade secrets, Geographical Indications. Precautions while patenting disclosure/non-disclosure. Patent infringement- meaning, scope, litigation, case studies.

Applications, international guidelines, and importance of biosafety, biosafety guidelines of biotechnology laboratories, important factors and safety guidelines to start-up of a biotechnology based company.

Role of different organizational level in bio-business set-up. Transition of an idea from biotechnology based R&D to business units, fund generation and resource creation for bio business startup.

Different bio-product based industries, their history, products and establishments. Different national and international organizations their functioning.

Text books and References

1. Eric Grace Biotechnology unzipped: Promises and realities.Wash. DC: Joseph Henry Press. 1997.
2. Arthur Kornberg. Sausalito, CA The golden helix: University Science Books. 1995.
3. Richard Oliver The coming biotech age: The business of biomaterials. NY: McGraw Hill. 2000.
4. Ruth Ellen Bulger et al., The ethical dimensions of the biological sciences. NY: Cambridge University Press. 1993.
5. David F. Betsch, Principles of Biotechnology.

AM2232 Electro Physiological Signal Analysis		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Introduction to bioelectric phenomenon, generation, transmission and interaction of signals in nervous systems. Discussion of initiation and propagation of action potential along the nerve fibers. Voltage clamp experiments, synaptic transmission and transduction process and receptors. Frequency modulation of the electrical signals. Use of mathematical models particularly electrical circuits models and describing behavior of cell membrane. Neural control mechanism, genesis and characteristics of EEG, ECG, EMG and Evoked potentials.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. Cynthia Furse, Douglas A. Christensen, Carl H. Durney Basic Introduction to Bioelectromagnetics, Second Edition, CRC Press.
2. J. Malvino & R. Plonsey Bioelectromagnatism.
3. Webster J G, *Medical Instrumentation: Application and Design,* 4th ed., John Wiley & Sons: New York.

AM2233 Tissue Engineering		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Introduction to Tissue Engineering, Fundamentals of Stem Cell Tissue Engineering, Growth Factors and Morphogens: Signals for Tissue Engineering, Extracellular Matrix: Structure, Function, and Applications to Tissue Engineering, Mechanical Forces on Cells, Cell Adhesion, Cell Migration, Inflammatory and Immune Responses to Tissue Engineered Devices, Polymeric Scaffolds for Tissue Engineering Applications, Calcium Phosphate Ceramics for Bone Tissue Engineering, Biomimetic Materials, Nanocomposite Scaffolds for Tissue Engineering, Roles of Thermodynamic State and Molecular Mobility in Bio-preservation, Drug Delivery Gene Therapy, Tissue Engineering Bioreactors, Animal Models for Evaluation of Tissue-Engineered Orthopedic Implants, Bioengineering of Human Skin Substitutes, Gene Therapy and Tissue Engineering Based on Muscle-Derived Stem Cells: Potential for Musculoskeletal Tissue Regeneration and Repair, Tissue Engineering application in Bone, cartilage, Vascular graft, Heart valves, Tissue Engineering, Stem Cells and Cloning for the Regeneration of Urologic Organs, The Bioengineering of Dental Tissues and recent advances.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. Patrick, Mikos and McIntire. Frontiers in Tissue Engineering, Pergamon Press.
2. Lanza, Labnger and Vacanti. Principles of Tissue Engineering, Academic Press.
3. Morgan and Yarmush, Tissue Engineering Methods and Protocols, Humana Press.

AM2234 Electro Diagnostics, Therapy and Electrical Safety		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Bio-potential Electrodes: Electrode- electrolyte interface, Polarizable and Non- Polarizable electrodes, Electrode behavior and circuit models, Body surface recording electrodes, internal electrodes, electrode array, microelectrodes and electrode for electric stimulation of Tissue. Practical considerations for optimum performance.

Diagnostic Equipment's: Recording of ECG, Different Lead Systems, Vector cardiography, Diagnostic Applications of ECG, Recording of EEG, different montage for EEG recording, Application of EEG for diagnosis of epilepsy, Surface EMG and its diagnostic applications.

Therapeutic Equipment: Cardiac Pacemakers, different types of pacemakers, pacing system analyzer, recent developments in implantable cardiac pacemaker. Cardiac defibrillators, Surgical Diathermy, Electro Surgical units and safety. Diagnostic application of LASERs, High frequency heat therapy, Short wave diathermy, microwave diathermy, Pain relief through electrical stimulation, Bladder Stimulator and cerebral stimulators. Hemodialysis, Ventilators, Anesthesia machines, Automatic Drug delivery Systems.

Electrical Safety: Physiological effect of electricity, Microshock and Macroshock Hazards, Electrical safety codes and standards, Basic approaches to protection against shock, grounding, Electrical safety analyzers, testing the electrical systems and electric appliances.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. Khandpur R. S., Hand book of Biomedical instrumentation, TMH.
2. Carr & Brown, Introduction to Biomedical Equipment, PHI.
3. Webester J. G., Medical Instrumentation, 3rd Edition, John Wiley.

AM2223 MEMS & Bio-MEMS		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Introduction: MEMS, microsystem, sensor, actuator, history, market, applications, etc.

Review of Essential Mechanical, Electrical Concepts: Mechanical: stress, strain, beam, cantilever, plates, bending, thermal stress, torsion of beam, fracture, vibration etc, Electrical: Conductor, insulator, semiconductor.

Scaling Laws in Miniaturization: Scaling in geometry, force, electricity, fluid, heat transfer, etc.

Material for MEMS: Review of crystal structure, miller indices, material for MEMS, substrate, device, packaging, silicon, silicon compound, gallium arsenide, piezoelectric martial, quartz, polymer, biomaterials and biocompatibility issues etc.

Micro Total Analysis System (μTAS): Fluid control components, μ-TAS: sample handling, μ-TAS: separation components, μ-TAS: detection, cell handling and characterization systems, systems for biotechnology and PCR, polynucleotide arrays and genetic screening.

Sensing and Actuation: Electrostatic sensing and actuation, thermal sensing and actuation, piezoelectric and piezoresistive sensing and actuation, magnetic sensing and actuation, miniature biosensors, biosensors arrays and implantable devices, neural interfaces, microsurgical tools, micro needles, and drug delivery, Microsystems for tissue engineering, tissue scaffolds, optical biosensors, etc.

Fabrication of MEMS: Bulk micromachining, surface micromachining, lithography, LIGA, SLIGA, etc.

MEMS Packaging: MEMS metrology, Overview of packaging of microelectronics, packaging design, technique, material, etc.

MEMS Design and Software: Design methodologies for MEMS, study of following softwares based on availability: Ansys multiphysics, COMSOL multiphysics, MatLab, Intellisuite, AutoCAD, SolidWorks, Spice, Ledit, etc.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. Foundations of MEMS, Chang Liu, Pearson Education International.
2. MEMS and MICROSYSTEM Design and Manufacture, Tai-Ran Hsu, Tata Mcgraw-Hill Publishing Company Ltd., New Delhi.
3. Microsystem Design, S. D. Senturia, Kluwer Academic Publishers.
4. Fundamentals of Microfabrication, Marc Madou, CRC Press, NY.
5. Microsystem Technology in Chemistry and Life Sciences, A. Manz and H. Becker, Eds. Springer-Verlag, New York.

Fundamentals of Micro Fabrication, the Science of Miniaturization, M. Madou, Nanogen Corporation, USA, CRC Press.

AM2235 Rehabilitation Engineering and Assistive Technology		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Introduction to Rehabilitation:

Definition, Concept of Rehabilitation, Concept of disability, Socio-vocational Rehabilitation, Medical, Psychological and social issues influencing the rehabilitation, Rehabilitation team, Therapeutic exercises and treatment techniques used in rehabilitation process, Socio-legal aspect of rehabilitation.

Orthotics & Prosthetics in Rehabilitation:

Concept of orthotics and prosthetics, material and fabrication for orthotics and prosthetics, Types of orthotics and prosthetics, Intelligent prosthetic Knee, Prosthetic Hand, Advance and automated prosthetics and orthosis, externally powered and Controlled orthotics & prosthetics,-FES system, Restoration of Hand function, Restoration of standing and walking, Myo-electric Hand. Engineering concepts in motor rehabilitation, applications. Computer Aided Engineering in Customized Component Design for orthotics and prosthetics.

Computer Application in Rehabilitation Engineering:

Interface in compensation for visual perception, Improvement of orientation and Mobility.

Engineering concepts in sensory rehabilitation Engineering; Sensory augmentation and substitution:

Visual system, Classification of Visual Impairments, Prevention and cure of visual impairments, Visual Augmentation, Tactile vision substitution, auditory substitution and augmentation, tactile auditory substitution, Assistive devices for the visual impaired, Hearing aids, cochlear implantation. Materials used for wheel chairs, Type of Wheel Chairs, design of wheel Chair, Tricycle, Walkers, Crutches.

Rehabilitation Aids for Mentally Impaired:

Walking Aids, Seating Aids and Postural Aids.

Applied Rehabilitative conditions:

Rehabilitation of people with spinal cord injury, stroke, cerebral palsy, traumatic brain injury, Hemiplegic, Spasticity, Myopathy, Cerebral injury and limb amputation. Rehabilitation engineering for the restoration of variety of human activities for disabilities that include sensory, motor of cognitive losses.

Artificial organs: Kidney, heart, pancreas, liver, etc.

Burn injury Rehabilitation

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. Smith, Raymond V. & John H. Leslie, "Rehabilitation Engineering". CRC Press.
2. Mann, William C. and Joseph P. Pane, "Assistive Technology for Persons with Disabilities" The American Occupation Therapy Association Inc.
3. Webster, John G. et al, "Electronic Devices for Rehabilitation" John Wiley & Sons.
4. Cooper Rory A, Ohnabe Hisaichi, Hobson Douglas A. "An Introduction to Rehabilitation Engineering (Series in Medical Physics and Biomedical Engineering)", CRC Press.
5. Cooper Rory A, Rehabilitation Engineering Applied to Mobility and Manipulation (Series in Medical Physics and Biomedical Engineering), CRC Press.

AM2236 Medical Imaging		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Introduction to medical imaging and different medical Imaging modalities. Review of Signals and system, Fourier transform, Transfer functions, Hankel transform, Sampling theorem.

Image Quality: Contrast, Modulation transfer function, resolution, Noise, Signal to noise ratio, accuracy, etc.

Radiography: Atomic structure (review), Ionization, forms of Ionizing radiation and their properties, Radiation dosimetry.

Projection Radiography: X-Ray production, X-ray interaction with biological matters, Instrumentation for medical X-ray system, Filters, contrast agents, X- Films and intensifiers, Image formation, Noise and artifacts.

X-Ray Computed Tomography: CT Instrumentation, Different generations of CT Scanner, Imaging principle, Image formation, Redon transform, Back Projection Theorem, Helical CT Reconstruction, Cone Beam CT, Image quality in CT.

Application of Projection radiography: Mammography, Fluoroscopy, Angiography, etc.

Nuclear Medical Imaging: Radio Active Decay, Modes of decay, Radio traces, Instrumentation for planer scintigraphy, Image Formation and Image quality. Instrumentation for PET and SPECT, Image Quality in PET and SPECT.

Ultrasound Imaging: Physics of Ultrasound, interaction of ultrasound with biological matter, Ultrasound beam patterns and focusing. Instrumentation for ultrasound imaging system, ultrasound transducer and probes, pulse echo imaging, A Mode, B Mode and M Mode imaging. Doppler ultrasound imaging.

Magnetic Resonance Imaging:

Instrumentation for MRI System, Concept of MRI Imaging, Magnetization, RF excitation, relaxation, Pulse echo sequences and contrast mechanism. MRI data acquisition, Image Reconstruction and Image quality.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. William R. Hendee, E. Russell Ritenour, Medical Imaging Physics.
2. Jerry L. Prince, Jonathan M., Medical Imaging Signals And Systems. Pearson Education.
3. Andrew G. Webb, Introduction to Biomedical Imaging, IEEE Press.

AM2237 Artificial Intelligence in Biomedical Engineering		
Designation	:	Elective
Pre-requisites	:	Basic knowledge of Computers, Linear algebra, etc.
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Basics of Artificial Neural Networks: Introduction, Pattern and data, methods for pattern recognition tasks, Artificial neural networks: Terminology, Models of neurons, Topology. Activation and synaptic dynamics: Activation dynamic models, synaptic dynamic models, learning methods. Functional units of ANN for pattern recognition tasks: Pattern recognition problems, basic functional units, Feed forward neural networks: Analysis of pattern association networks, analysis of pattern classification networks, Feedback neural networks: Analysis of linear associative, FF Networks. Competitive learning neural networks: Components of competitive learning network, analysis of pattern clustering network, Biomedical applications of ANN: Modeling and diagnosing the cardiovascular system, Pattern recognizing of pathology images, ultrasound and magnetic resonance medical images textures analysis using ANN.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. D. L. Hudson and M. E. Cohen, "Neural Networks and Artificial Intelligence for Biomedical Engineering", Prentice Hall.
2. Vojislav Kecman, "Learning and soft computing", Pearson Education (Asia) Pte. Ltd.
3. S. Haykin, "Neural networks: A Comprehensive Foundation"' Pearson Education (Asia) Pte. Ltd/Prentice Hall of India.
4. M. T. Hagan, H. B. Demuth and M. Beale, "Neural Network.

AM2202 Characterization of Materials		
Designation	:	
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).

Syllabus

Crystallography: Overviews in bonding, Bravais lattices, Miller indices, imperfections in crystals, crystal structures of common metal, ceramics, polymers. symmetries in crystals, point groups, space groups, reciprocal lattice, morphology

X-ray Diffraction Techniques: Production of X-rays, its properties and hazards, photon scattering, X-ray diffraction and Bragg's law, intensities calculations, Laue techniques, Debye-Scherrer techniques. modern diffractometers, diffractometer measurements, determination of crystal structure of powder sample, small angle scattering, line broadening, particle size, crystallite size, residual stress measurement, plane indexing, precise parameter measurement, phase identification, phase quantification, phase diagram determination, stereographic projection, pole figure, preferred orientation (texture analysis) and chemical analysis, profile fitting and Rietveld analysis.

Optical Microscopy: Principles and operations of microscopy, resolution, magnification, numerical aperture, depth of field, viewing area, contrast, geometry of optical microscopes, application of microscopy in metallurgical studies (qualitative and quantitative), morphology and symmetry, grain boundaries and dislocations, phase contrast microscopy, polarized light microscopy, hot-stage microscopy, sample preparation.

Electron Microscopy: Electron sources, electron diffraction, principles and operation of scanning electron microscope. Construction of electron microscopes, specimen handling and preparation, secondary electron image, backscattered electron image, image processing, analysis of electron micro-graphs and fractography studies, transmission electron microscopy (TEM).

Scanning Probe Microscopy: Principles and operation of scanning probe microscopes, scanning tunneling microscope, atomic force microscope, magnetic force microscopy, topography studies, nano-indentation and its probing.

Thermal Analysis: Thermo gravimetric analysis, differential thermal analysis, differential scanning calorimetery, thermo-mechanical analysis and their applications.

Solid State and Surface Spectroscopies: Electron Energy Loss Spectroscopy (EELS), Reflection Absorption Infra-red Spectroscopy (RAIRS), Transmission IR, Raman, Photoelectron Spectroscopy (PES), Auger Electron Spectroscopy (AES), X-ray Fluorescence (XRF), Nuclear Magnetic Resonance (NMR), Extended X-ray Absorption Fine Structure (EXAFS).

Term Paper: On recent advances based on literature survey and/or lab/industry visit

Text books and References

1. Crystals and Crystal structures, R.J.D. Tilley, John Wiley and Sons, 2006
2. Elements of X-ray Diffraction, Cullity B. D., Addison-Wesley Publishing Co.
3. Electron Microscopy and Analysis, P.J. Goodhew, F.J. Humphreys, Taylor & francis, Second edition.
4. Solid state chemistry and its Applications, Antony R. West, Wiley Student Edition.
5. Fundamentals of Molecular spectroscopy, Colin N. Banwell and Elaine M. McCash, Tat McGraw-Hill Publishing Co. Ltd., Fourth edition.

Materials Characterization :Introduction to Microscopic and Spectroscopic, Yang Leng, John Wiley&Sons.

Master of Technology

in

ENGINEERING MECHANICS AND DESIGN

Course Structure, Scheme of Evaluation and Syllabi

(*Effective from July 2017*)

Department of Applied Mechanics

Motilal Nehru National Institute of Technology Allahabad
Allahabad, U.P. -211004, INDIA

Course Structure and Evaluation Scheme

(Master of Technology in *Engineering Mechanics and Design*)

I Semester (Total Credits = 20):

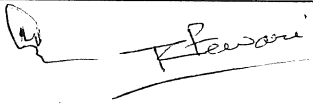
Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM2101	Applied Mathematics and Computation	4	0	0	4	20	20	60
AM2102	Continuum Mechanics	4	0	0	4	20	20	60
AM21XX	**Elective-I**	4	0	0	4	20	20	60
AM21XX	**Elective-II**	4	0	0	4	20	20	60
AM21XX	**Elective-III**	4	0	0	4	20	20	60

List of Electives (Semester I):

Elective-I:		**Elective-III:**	
AM2104	Biomechanics	**AM2114**	Dynamics of Structures
AM2110	Applied Elasticity	**AM2115**	Structural Reliability
AM2140	Advanced Fluid Mechanics	**AM2116**	Design of Thin Walled Structures
		ME2125	Computer Aided Design
Elective-II:			
AM2111	Finite Element Methods		
AM2112	Optimization Techniques		
AM2113	Computational Solid Mechanics		
AM2125	Non-Destructive Testing		

II Semester (Total Credits = 20):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM2201	Analysis and Design of Plates and Shells	4	0	0	4	20	20	60
AM2251	Experiments in Solid Mechanics	0	0	6	4	50	-	50
AM22XX	**Elective-IV**	4	0	0	4	20	20	60
AM22XX	**Elective-V**	4	0	0	4	20	20	60
AM22XX	**Elective-VI**	4	0	0	4	20	20	60



List of Electives (Semester II):

Elective-IV:		**Elective-VI:**	
AM2210	Wave Propagation in Solids	**AM2216**	Applied Plasticity
AM2212	Theory of Stability	**AM2217**	Fracture Mechanics
AM2224	Electro-acoustic Transducers	**AM2218**	Continuum Damage Mechanics
AM2206	Computational Fluid Dynamics	**AM2219**	Analysis and Design of Composite Structures
Elective-V:			
AM2213	Mechanics of Composite Materials		
AM2214	Multi-Functional Materials and Structures		
AM2215	Multiscale Modeling of Advanced Materials		

III Semester (Total Credits = 20):

S. No.	**Subject Name**	**Credits**
AM2391	**Special Study/Term Project/State of the Art/Colloquium/Industrial/Research Training (Proposed)**	4
AM2392	**Thesis/Project**	16

IV Semester (Total Credits = 20):

S. No.	**Subject Name**	**Credits**
AM2492	**Thesis/Project**	20

Note: The distribution of thesis evaluation marks will be as follows:

1. Supervisor(s) evaluation component: 60%
2. Oral Board evaluation component: 40%

AM2101Applied Mathematics and Computation		
Designation	:	Compulsory
Pre-requisites	:	*Engineering Mathematics &Computer Programming*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Review of Elementary Engineering Mathematics: Solution of homogeneous and non-homogeneous equations; Power series; Laplace transform and its applications; Fourier series and Fourier transform
Linear Algebra: Matrices and Linear Transformations, Operational Fundamentals of Linear Algebra, Systems of Linear Equations, Gauss Elimination Family of Methods, Special Systems and Special Methods, Numerical Aspects in Linear Systems, Eigenvalues and Eigenvectors, Diagonalization and Similarity Transformations, Jacobi and Givens Rotation Methods, Tri-diagonal Matrices, QR Decomposition Method, Eigenvalue Problem of General Matrices, Singular Value Decomposition, Direct and Iterative solvers.
Ordinary Differential Equations: Introduction to ordinary differential equations, homogeneous linear equations of second order, non-homogeneous linear equations of second order, free and forced oscillation problems, problems with variable coefficients, system of equations.
Partial Differential Equations (PDEs): Existence and uniqueness of differential equations, nature of solution, Hyperbolic, Parabolic and Elliptic PDEs, nonlinear PDEs.
Nonlinear Equations: Motivation, Open and braketing method, Bisection, Fixed point, Newton's method, Secant and False position method, Rate of convergence, Merits and demerits of methods.
Numerical Integration: Motivation, Newton-Kotes method, Trapezoidal rule, Simpson's rule, Rhomberg integration, Gauss Quadrature.
Initial Value Problem: Motivation, Euler's method, Modified Euler method, Runge-Kutta methods, Adaptive integrations and multistep methods.
Boundary-value and Eigen-value Problem: Methods and Applications in Mechanics.

Reference Books

1. Numerical Methods in Engineering: M. Salvadori.
2. Applied Numerical Methods: B. Carnahan.
3. Applied Numerical Analysis: C.F. Gerald and P.O. Wheatley.
4. Numerical Mathematics & Computing: W. Cheney and D. Kincaid.
5. Applied Partial Differential Equations: Paul DuChateau and David Zachmann.
6. Partial Differential Equations for Scientists and Engineers: Stanley J. Farlow.
7. Numerical Methods for Partial Differential Equations: William F. Ames.
8. Numerical Methods for Elliptic and Parabolic Partial Differential Equations: John R Levison, Peter Knabner, Lutz Angermann.

AM2102 Continuum Mechanics		
Designation	:	Compulsory
Pre-requisites	:	*Basic Engineering Mathematics, Linear Algebra*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Mathematical Preliminaries and Introduction: Index notation, range and summation convention, free and dummy indices, Kronecker delta, Levi-Civita symbol, co-ordinate transformations, Cartesian tensor, properties of tensors, tensors as linear operators, invariants of tensor, eigen values and Eigen vectors, polar decomposition, scalar, vector and tensor functions, comma notation, gradient of a scalar, gradient of a vector, divergence and curl of a tensor, integral theorems of vectors and tensors. Notion of a continuum, configuration, mass and density, descriptions of motion, material and spatial coordinates.

Kinematics of Deformation and Motion: Deformation gradient tensor, stretch and rotation, right and left Cauchy-Green deformation tensors, Eulerian and Lagrangian strain tensors, strain-displacement relations, infinitesimal strain tensor, infinitesimal stretch and rotation, compatibility conditions, principal strains and strain deviator, material and local time derivatives, stretching and vorticity, path lines, stream lines, vortex lines, Reynolds transport theorem, circulation and vorticity.

Forces and Stresses: Body and surface forces, Cauchy Stress Tensor, First and Second Piola-Kirchhoff Stress Tensor, Deviatoric and Pressure Components, Principal Stress.

Fundamental Balance Laws of Continuum Mechanics: Balance of Mass – Continuity Equation; Balance of Linear Momentum – Equations of Motion / Equilibrium Equations; Moments of Momentum (Angular Momentum); Balance of Energy - First Law of Thermodynamics, Energy Equation; Equations of State – Entropy, Second Law of Thermodynamics; Clausius-Duhem Inequality, Dissipation Functions

Constitutive Relations and Material Models: Constitutive Assumptions; Ideal Fluids; Elastic Fluids, Hyperelastic Material; Notion of Isotropy; Isothermal Elasticity - Thermodynamic Restrictions, Material Frame Indifference, Material Symmetry; Hooke's law, Stokes problem and Newtonian fluids.

Reference Books

1. Introduction to the Mechanics of a Continuous Medium: Lawrence E. Malvern.
2. An Introduction to Continuum Mechanics: Morton M. Gurtin.
3. Introduction to Continuum Mechanics for Engineers: Ray M. Bowen.
4. Continuum mechanics for engineers: G. Thomas Mase and George E. Mase.
5. Theory and Problems of Continuum Mechanics: George E. Mase.
6. Nonlinear Continuum Mechanics for Finite Element Analysis: J. Bonet and R. D. Wood.
7. Continuum mechanics and plasticity: Han Chin Wu.

AM2104 Biomechanics		
Designation	:	Elective
Pre-requisites	:	Basics of engineering mechanics, and Anatomy of human body
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Application of Statics to Biomechanics:
Basics concepts of Force Moments and Torque Equilibrium, analysis of systems in equilibrium. Skeletal joints, Skeletal muscle. Mechanics of the elbow, shoulder, Spinal column, Hip, Knee and ankle. Basic assumptions and limitations.

Deformable body Mechanics:
Applied forces and Deformations, internal forces and moments, Stress and Strain, Basic loading configurations, Uniaxial tension test, Load- elongation diagrams, Hooke's Law, Work and Strain Energy, Properties based on Stress-strain Diagrams, Idealized model for material behavior and Mechanical properties of materials.

Multi axial Deformation and stress analysis:
Poisson's ratio, Biaxial and tri axial stresses, Failure theories, allowable stress and factor of safety, Fatigue and endurance, Torsion, Bending and combined loading.

Mechanical Properties of Bone and Soft Tissues
Mechanics of bone, Composition of bone, Mechanical properties of bone, Bone fractures and Bone Remodeling, Biomechanics of Tendon and Ligaments. Biomechanics of Skeletal Muscles. Biomechanics of Articular cartilage.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

Reference Books

1. Biomechanics: Fung Y.C.
2. Biomechanics and Motor Control of Human Movement: Winter D.A.
3. Basic Biomechanics of the Skeletal System: Frankel V.H. and Nordin Margareta.
4. Fundamentals of Biomechanics: NihatOzkaya and Margareta Nordin.

AM2110Applied Elasticity		
Designation	:	Elective
Pre-requisites	:	Mechanics of Materials
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Analysis of Stress: Concept of Stress, Stress Components, Equilibrium Equations, Stress on a General Plane (Direction Cosines, Axis Transformation, Stress on Oblique Plane through a point, Stress Transformation), Principal Stresses, Stress Invariants, Deviatoric Stresses, Octahedral Stresses, Plane Stress, Stress Boundary Condition Problem.

Analysis of Strain: Deformations (Lagrangian Description, Eulerian Description), Concept of Strain, Strain Components (Geometrical Interpretation), Compatibility Equations, Strain transformation, Principal Strains, Strain Invariants, Deviatoric Strains, Octahedral Strains, Plane Strain, Strain Rates.

Stress-Strain Relations: Introduction, One-Dimensional Stress-Strain Relations (Idealized Time independent and Time–dependent stress-strain laws), Linear Elasticity (Generalized Hooke's Law), Stress-Strain Relationships for Isotropic and Anisotropic Materials (Plane stress and Plane Strain)

Basic Equations of Elasticity for Solids: Introduction, Stresses in Terms of displacements, Equilibrium Equations in terms of displacements, Compatibility equations in Terms of Stresses, Special cases of Elasticity equations (Plane Stress, Plane strain, Polar Co-ordinates), Principle of Superposition, Uniqueness of Solution, Principle of virtual work, Potential and Complementary energy, Variational Principles, St. Venant's Principle, Methods of analysis for Elastic Solutions, Elastic solutions by Displacement and stress Functions, Airy's Stress Function (Plane stress, Plane strain, Polar Co-ordinates).

Torsion: Introduction, Circular shaft, Torsion of non-circular cross-section, St. Venant's theory, Warping function, Prandtl's stress function, Shafts of other cross-sections, Torsion of bars with thin walled sections.

Viscoelasticity: Introduction, Viscoelastic models (Maxwell, Kelvin-Voigt, Generalized Maxwell and Kelvin models), Viscoelastic stress-strain relationships.

Reference Books

1. Mathematical Theory of Elasticity: I. S. Sokolnikoff
2. Advanced Mechanics of Materials: Boresi
3. Theoretical Elasticity: A. E. Green and W. Zerna
4. Theory of Elasticity: Timoshenko and Gere
5. Advanced Strength and Applied Elasticity: A. C. Ugural and S. K. Fenster
6. Applied Elasticity: R.T.Fenner
7. Advanced Strength of Materials: L. S. Srinath

AM2140 Advanced Fluid Mechanics		
Designation	:	Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Thermodynamics*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Basic Conservation & Governing Laws: Statistical & continuum methods, Eulerian&Lagrangian coordinates, material derivatives, control volumes, Reynolds' transport theorem (RTT), conservation of mass, momentum and energy, constitutive equations, Navier-Stokes equations- differential & integral approach, energy equations, governing equations for Newtonian fluids, boundary conditions.

Potential Flows: Stokes stream functions, solution of potential equation, flow in a sector, flow around a sharp edge, flow near a blunt nose, force and moment on a circular cylinder and sphere, conformal transformations, Joukowski transformations.

Viscous Incompressible Flows: Exact solutions for Couette flow, Poiseuille flow, flow between rotating cylinders, Stokes' first problem, Stokes' second problem, pulsating flow between parallel surfaces, stagnation-point flow, flow in convergent and divergent channels, flow over porous wall. Stokes approximation, rotating sphere in a fluid, uniform flow past a sphere and cylinder, Ossen's approximation, Hele-Shaw flow.

Introduction to Boundary Layer: Derivation of boundary layer equation, How potential flow complements B.L. equation, Integral solution of B.L., Laminar and turbulent boundarylayers, transition; B.L. separation and control.

Introduction to Compressible Flow: Velocity of sound and its importance, physical difference between incompressible, subsonic and supersonic flows, Mach number and its significance. Isentropic flow through nozzles, shocks and expansion waves, Rayleigh and Fanno Flow.

Reference Books

1. Fundamental Mechanics of Fluids: I.G. Currie
2. Foundations of Fluid Mechanics: S.W. Yuan
3. Advanced Fluid Mechanics: K. Muralidhar and G. Biswas
4. Boundary Layer Theory: H. Schlichting
5. Modern Compressible Flow with Historical Perspective: John D. Anderson
6. Fundamentals of Aerodynamics: J.D. Anderson
7. Fundamentals of Fluid Mechanics: B.R. Munson, D.F. Young and T.H. Okiishi
8. Introduction to Fluid Mechanics: R.W. Fox and A.T. McDonald
9. Viscous Fluid Flow: F.M. White

AM2111Finite Element Methods		
Designation	:	Elective
Pre-requisites	:	Linear Algebra with Matrix Operations, Differential Equations, Mechanics of Materials, Theory of Elasticity.
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction: Course objectives, History of FEM, Application Areas, Concept of Discretization and Interpolation, Different Steps in Finite Element Analysis, Demonstration through FE Analysis of Axially Loaded Bar.

Variational Methods & Energy Principles: Brief Introduction to Variational Calculus, Energy Principles – Principle of Virtual Work and Complementary Virtual Work, Principle of Minimum Potential Energy and Complementary Potential Energy, Mixed Principles.

Detailed FE Formulation for Solid Mechanics: Finite element discretization – Piecewise Interpolation & Shape Functions, C^0 and C^1 Interpolation, Conventional 1D, 2D & 3D Elements, Special Elements, Sub Parametric, Super Parametric &Isoparametric elements. FE Formulation Using Variational Methods & Energy Principles. Coordinate transformation & Jacobian, Numerical Integration & Calculation of Element Matrices.

Classical Finite Element Methods: Ritz Method, Method of Weighted Residuals, Galerkin method, Strong & Weak formulation. One & Two dimensional structural & non-structural boundary value problems involving scalar and vector valued dependent variables.

Dynamic Problems and Other Topics (in brief): Dynamic Equations from Hamilton's Principle, Mass (Consistent & Diagonal) and Damping Matrices, Free Vibration Analysis – Eigen value problem, Time-History analysis in Forced Vibration – Direct (Explicit & Implicit) Integration Methods.

Nonlinear & Stability problems, Error & Error estimation, Conforming &Non conforming Elements, Patch test.

Application through Computer Programming& Commercial Software:

- Input for Geometric & Material Configuration, Loading and Boundary Conditions.
- Automatic Mesh Generation, Nodal Coordinate and Nodal Connectivity.
- Calculation of Element Matrices (Stiffness & Mass Matrices, Load Vector).
- Assembly of Element Matrices to Global Matrices, Imposing Boundary Conditions.
- Solution (Gauss Elimination & other methods), Post Processing.

Reference Books

1. Energy and Finite Element Methods in Structural Mechanics: I. H. Shames and C. L. Dym.
2. Concepts and Applications of Finite Element Analysis: R. D. Cook, D. S. Malkus and M. E. Plesha.
3. The Finite Element Method Vol. I-II: O.C. Zienkiwiczand R.L. Taylor.
4. Finite Element Procedures: K. J. Bathe.
5. An Introduction to Finite Element Methods: J.N. Reddy.
6. Finite Element Methods in Engineering: S.S. Rao.

AM2112Optimization Techniques		
Designation	:	Elective
Pre-requisites	:	*Differential Calculus & Computer Programming*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction to Optimization: Design variables, Design constraints, Objective function Design space, feasible region, Problem statement, Local and Global optima, Classification of optimization problems, Solution by calculus and numerical methods.
Linear Programming: Simplex method, Geometric Programming: Application to simple problems.
Non-Linear Programming: Method of approximation programming, Kelly's Cutting Plane method.
Gradient Methods: Steepest descent and Side step method. Conjugate Gradient method, Rosin's Gradient Projection Method, Zotendik's method of feasible directions, Unconstrained minimization, and penalty function technique search procedures.
Genetic Algorithm: Artificial Neural Network, Dynamic programming
Application to Process Equipments, Structural Mechanics, Development of computer programmes.

Reference Books

1. Engineering Optimzation, Theory and Practice: S. S. Rao
2. Optimization of Structural and Mechanical Systems: J. S. Arora
3. Elements of Structural Optimization: R. T. Haftka and Z. Gürdal
4. Cost Optimization of Structures: Fuzzy Logic, Genetic Algorithm and Parallel Computing: H. Adeli and K. C. Sarma
5. An Introduction to Optimization: Edwin K. P. Chong and Stanislaw H. Żak
6. Nonlinear Optimization- Theory and Algorithms: L.C.W. Dixon
7. Linear Programming Vol.I: G. Hadley
8. Nonlinear and Dynamic Programming, Vol.II: G. Hadley

AM2113 Computational Solid Mechanics		
Designation	:	Elective
Pre-requisites	:	*Engineering and Numerical Mathematics, Computer Programming, Advanced Solid Mechanics / Continuum Solid Mechanics, Finite Element Method (basic).*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction and Review of Mathematical Preliminaries: Vector and Tensor Analysis, Elements of Linear Algebra, Multivariable Calculus, Linearization of Nonlinear PDE's, Different numerical methods for Computational Solid Mechanics, Programming Languages and Softwares for Computational Solid Mechanics.

Review of Continuum Solid Mechanics and FEM: Kinematics and Deformation Gradient, Material and Spatial Description, Stress and Strain Tensor, Compatibility Equations, Constitutive relations, Elasticity Tensor and Generalized Hooke's law, Different Material Models, Balance Laws and Equilibrium equations, Transformation of Coordinates, Energy Principles based Variational Formulation of Finite Element Equations for General Solid Mechanics Problem.

Elements of Computer Programming (Through programming in FORTRAN/C++): Brief history and evolution of Computers and Programming Languages, Constants and variables, Character variables, Numerical variables – integers and floating point, Variable type declaration, Intrinsic functions, Input-Output formats and statements, Assignment statements, Arithmetic expressions, logical calculations and repetitive calculations through looping, Arrays - of Rank *1*, *2* and *n* - dimension, Dynamic allocation and de-allocation, Procedures and structured programming – Subroutines and Module procedures etc, Pointers and dynamic data structures, Control structures and program design.

Programming for Solution of Linear Problems in One Dimension: Energy Principles and FE formulation for boundary value problems in structural mechanics – Bars, Beams, Shafts etc., Final discretized system of equations and solution techniques for linear problems, Basic structure of a standard FE analysis program, Implementation to the structural mechanics and heat conduction problems, Comparison with results obtained from Softwares like ANSYS, MATLAB etc (depending upon availability).

Programming for Solution of Nonlinear Problems in One Dimension: Mathematical problem formulation, linearization and basic numerical solution procedure, geometric nonlinear elastic problem, elasto-plastic and inelastic problems, Structure of computer program for the solution of nonlinear problems, Comparison with results obtained from Softwares.

Programming for Solution of Linear Problems in Two and Three Dimension: Mathematical problem formulation for – Plates and/or Shells, 3D problems, Final discretized system of equations, Implementation through computer programming, Comparison with results obtained from Softwares.

Project / Term Paper: On a real-life computational solid mechanics problem, as would be assigned to students.

Reference Books

1. Fortran 95/2003 for Scientists and Engineers: Stephen J. Chapman
2. Modern Fortran Explained: Michael Metcalf, John Reid and Malcolm Cohen
3. Computer Programming in Fortran 90 and 95: V. Rajaraman
4. Finite Elements in Plasticity: D. R. J. Owen and E. Hinton
5. Computational Inelasticity: J.C. Simo and T. J. R. Hughes
6. Computational Continuum Mechanics: Ahmed A. Shabana
7. An Introduction to Computational Micromechanics: Tarek I. Zohdi and Peter Wriggers
8. Classical and Computational Solid Mechanics: Y.C. Fung and Pin Ton

9.Computational Solid Mechanics: Variational Formulation and High Order Approximation: Marco L. Bittencourt

10.Handbook of Computational Solid Mechanics: Survey and Comparison of Contemporary Methods : Michal Kleiber

AM2125 Non-Destructive Testing		
Designation	:	Elective
Pre-requisites	:	*Basic Material Science and Engineering*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials, Term paper).

Syllabus

Overview of NDT: NDT Versus Mechanical testing, Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterization. Relative merits and limitations, Various physical characteristics of materials and their applications in NDT, Visual inspection Unaided and aided.

Surface NDE methods: Liquid Penetrant Testing – Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, inspection materials Magnetisation methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.

Thermography and eddy current testing (ET): Thermography- Principles, Contact and non contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation – infrared radiation and infrared detectors, Instrumentations and methods, applications.Eddy Current Testing-Generation of eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, Types of arrangement, Applications, advantages, Limitations, Interpretation/Evaluation.

Ultrasonic testing (UT) and acoustic emission (AE): Ultrasonic Testing-Principle, Transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique, AE parameters, Applications.

Radiography (RT): Principle, interaction of X-Ray with matter, imaging, film and film less techniques, types and use of filters and screens, geometric factors, Inverse square, law, characteristics of films – graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy- Xero-Radiography, Computed Radiography, Computed Tomography.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Reference Books

1. Practical Non-Destructive Testing: Baldev Raj, T.Jayakumar, M.Thavasimuthu
2. Non-Destructive Testing Techniques: Ravi Prakash
3. ASM Metals Handbook, Non-Destructive Evaluation and Quality Control, American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
4. Introduction to Non-destructive testing: a training guide: Paul E Mix
5. Handbook of Nondestructive evaluation: Charles J. Hellier
6. ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook,Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing

AM2114Dynamicsof Structures		
Designation	:	Elective
Pre-requisites	:	Engineering Mechanics, Mechanics of Materials, Engineering Mathematics including Differential Equations, Linear Algebra
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Tests, Class Tutorialsetc).

Syllabus

Introduction: Objectives, Types of Loadings, Essential Characteristics of Dynamic Problems, Discrete & Continuous systems, Rigid body dynamics vs. Vibration.

Fundamental Concepts: Formulation of the Equation of Motion, Newton's laws &D'Alembert's Principle, Lagrange's Equation, Functionals and Energy Principles, VariationalFormulations,Hamilton'sPrinciple,Formulation of Vibration Problems: Taught String, Axial Vibration of Bar,Torsional Vibration of Shaft, Flexural Vibration of Beam,Membrane,Thin&Thickplates,3DSolid etc.

Discrete Single-Degree-of–Freedom Systems: Analysis of Free and Forced Vibrations, Response to Harmonic,Periodic&ImpulsiveLoadings, Duhamel's Convolution Integral,VibrationIsolation,Complex-StiffnessDamping, Responseto GeneralDynamicLoading, Fourier Analysis.

Discrete Multi-Degree-of-Freedom Systems: Formulation ofMDOFEquationofMotion,Evaluation of Structural Property Matrices, Reduction of dynamic matrices, Analysis ofDynamic Response-Superposition method, Iteration method,Direct time integration of linear systems – Explicit & Implicit methods.

Continuous Systems: Eigen Value Problems and Orthogonality of Natural Modes, Rayleigh's Method, Rayleigh-Ritz Method, Coupled natural modes, Numerical methods of Discretization, Dynamics matrix for flexural, axial & torsional effects, Solution methods - Newmark's, Wilson's, Houbolt's Method, Introduction to Nonlinear Vibration and Random Vibration.

Reference Books

1. Structural Dynamics: Theory and Computation: Mario Paz.
2. Elements of Vibration Analysis: Leonhard Meirovitch.
3. Mechanical Vibrations: Geradin and Rixen.
4. Dynamics of Structures: Clough and Penzien.
5. Theory of Vibration with Applications: William T. Thomson.
6. Dynamics of Structures: J L Humar
7. Dynamics of Structures: W C Hurty and M F Rubinstein
8. Structural Dynamics: M. Mukhopadhyay
9. Dynamic loading and design of structures: A. J. Kappos

AM2115Structural Reliability		
Designation	:	Elective
Pre-requisites	:	Probability Theory, Mechanics of Solids and Structures, Finite Element Methods (basic).
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme): 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction: Course Overview, Basic Statistics, Theory of Probability, Probability Distributions (Continuous & Discrete), Random Variables

Analytical Methods Reliability Analysis: Failure Surface & Definition of Reliability in Normal Space (Cornell's Reliability Index), First Order Reliability Method (FORM), Hasofer-Lind's Definition of Reliability, Rackwitz-Fiessler Algorithm, Asymptotic Integral, Second Order Reliability Method (SORM)

Simulation Methods: Monte-Carlo Methods Latin Hypercube Sampling, Variance Reduction Technique, Importance Sampling and Adaptive Sampling, Subset Simulation

Stochastic Analysis: Implicit Performance Function, Polynomial Response Surface Method (RSM), Stochastic Response Surface Method (SRSM), Stochastic Models of Loads, Code Calibration, Partial Safety Factors, LRFD Format, System Reliability, Time Varying Reliability Analysis

Applications: Reliability Based Optimization, Introduction to Stochastic FEM, Case Studies, Term Project.

Reference Books

1. Probability, Statistics and Reliability for Engineers and Scientists: Ayyub B. M, McCuen R. H.
2. Probability, Random Variables and Stochastic Processes: Papoulis A.
3. Structural Reliability Analysis and Design: Ranganathan R.
4. Structural Reliability: Analysis and Prediction: Melchers R E.
5. Methods of Structural Safety: Madsen H O, Krenk S. and Lind N. C.
6. Reliability Based Structural Design: Choi S. K, Grandhi R. V. and Canfield R A.
7. Reliability and Optimization of Structural Systems: Rackwitz R., Augusti G. and Borri A.
8. Structural Reliability Using Finite Element Methods: Waarts P. H.,
9. Reliability Assessment Using Stochastic Finite Element Analysis: Haldar A. and Mahadevan S.
10. Computational Analysis of Randomness in Structural Mechanics: Bucher C.

AM2116 Design of Thin Walled Structures		
Designation	:	Elective
Pre-requisites	:	Mechanics of Materials, Differential Equations, Linear Algebra
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction: Line and surface structures; Internal/induced forces- Axial/Membrane, Bending/Flexure, Shear and Torsion; Thin and thick structures, Sandwich constructions.

Thin walled Beams: Introduction to Beam Theories, Bending, Torsion, Lateral Buckling, Flexural Torsional Buckling of Columns.

Design of Pressure Vessels and Piping: Design of pressure vessels- Introduction, Design of different kind of vessels, Openings and nozzles; Design of pipings- Introduction, Design of different piping systems, Branch connections, Pipe flanges

Reference Books

1. Introduction to the Theory of Thin Walled Structures: N W Murray
2. Stability Analysis and Design of Structures: M L Gambhir
3. Fundamental of heat exchanger and pressure vessel technology: J P Gupta
4. Pressure Vessel Design: Concepts and principles: J Spence and A S Tooth
5. Pressure vessels design and practice: S Chattopadhyay
6. Handbook of piping Design: G K Sahu

ME2125 Computer Aided Design		
Designation	:	Elective
Pre-requisites	:	Engineering Mathematics
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignments based on software and programming, Surprise Tests, Quizzes, and Tutorials etc)

Syllabus

Introduction: Historical Development, Explicit and Implicit Equations, Intrinsic Equations, Parametric Equations, Coordinate Systems.
Curves: Fundamental of Curve Design, Parametric Space of a Curve, Reparametrization, Space Curves: Spline Curves, Bezier Curves, B-Spline Curve, Rational Polynomials, Rational curves, NURBS.
Surfaces: Fundamental of Surface Design, Parametric Space of a Surface, Reparametrization of a Surface patch, Sixteen point form, Four Curve Form, Plane, Cylindrical and Ruled Surfaces, Surfaces of Revolutions, Bezier Surface, B-Spline Surface.
Solids: Fundamental of Solid Design, Parametric Space of a Solids; Continuity and composite Solids, Surface and Curves in a Solid.
Solid Modeling: Topology and Geometry, Set theory, Euler Operators, Regularized Boolean Operators, Construction Criteria, Graph Based Models, Instances and Parameterized Shapes, Cell-decomposition and Spatial Occupancy Enumeration, Sweep representation, CGS, BRep, Wireframe Analytical properties, Relational properties and Intersection. Applications in Biomedical Engineering Design.

Reference Books

1. CAD/CAM-Principles and Applications: PosinasettiNageswaraRao.
2. CAD/CAM-Computer-Aided Design and Manufacturing: M P Groover.

AM2201 Analysis and Design of Plates and Shells		
Designation	:	Compulsory
Pre-requisites	:	Mechanics of Materials
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction: Line and surface structures, Membrane, Thin and thick plates.

Pure Bending of Plates: Slope and curvature of slightly bent plates. Relations between moments and curvatures.
Small Deflection theory of Laterally Loaded Plates: Governing differential equation and boundary conditions. Bending of Rectangular Plates. Simply supported rectangular plates. Naviers' solution, Rectangular plates with various loading and edge conditions, levy's solution.
Bending of Circular plates: Governing equation, Axisymmetric loading, Various types of circular plates, Design of Circular Plates, Plate on elastic
Shells: Classification of shells, Engineering use of shell structures.
Membrane Theory: Cylindrical shells and shell of revolution, Axisymmetric and unsymmetrical loading. Solution for stress resultants and displacements. Cylindrical, spherical and conical shells supported at isolated points. Analysis for wind and periodic loads.
Bending Theory of Cylindrical Shell: Governing equations for stresses and displacements for symmetric and general conditions. Flugge and Donnel theories. Cylindrical shells with uniform and Non-uniform thickness.
Design of Plates & Shells: Design Considerations, Design load and other criterions, Design of Rectangular Plates, Design of Shells of Revolution, Design of Cylindrical Shells, Indian Codes of Practice, Other Design Codes, Design of Thin-Walled Industrial Structures.

Reference Books

1. Theory of Plates and Shells: S.Timoshenko and W.Krieger
2. Analysis of Plates: Szilard
3. Plates and Shells: Turner
4. Analysis of Plates: T.K.Vardan and K.Bhaskar.
5. Design of Plate and Shell Structures: Maan H. Jawad

AM2251 Experiments in Solid Mechanics		
Designation	:	Compulsory
Pre-requisites	:	*Engineering Mathematics, Theoretical Solid Mechanics*
Credit and Contact hours	:	0(L) - 0(T) – 6(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks
		Internal Assessment: (Scheme) 50 marks (10 marks for attendance + 40 marks for sessional assessment based on regular performance on Practical and Virtual Experimentation, Demonstration of knowledge and skill development through Surprise / Quiz Tests, Viva etc. andAssignments &Report Writing.

Syllabus

Part-A: Formal Concepts on Experimentation

Introduction to Experimentation: Basic Concepts, Definition of Terms, Calibration, Standards, Dimensions and Units, Measurement Systems - Sensors, Load cells and Electrical Resistance Strain Gages, System Response, Distortion, Experiment Planning, Analysis of Experimental Data.

Experimental Methods in Solid Mechanics: Displacement and Dimensional Measurements, Pressure Measurement, Force, Torque and Strain Measurements, Motion and Vibration Measurement, Data Acquisition and Processing, Report Writing and Presentations, Introduction to Design of Experiments.

Mid Term Project Submission: Design of an Experiment / Fabrication of an Experimental Specimen or Setup (as assigned).

Part-B: Practical Performance of Experimentation

Mechanical Experiments: Review of Undergraduate Experiments in Mechanics of Solids, Shear Centre of Thin-Walled Sections, Combined Bending and Torsion, Tensile / Buckling Tests on Composite Plates / Laminates, Torsion of Composite Tube, Dynamic / Viscoelastic Beam Experiment.

Strain Measurements using Electrical Strain Gage / Strain Rosette, in: Beams, Truss, Composite Laminate, and Pressure Vessel

Part-C: Virtual Experimentation / Simulation and Computer Programming for Analysis of Experimental Data:

Analysis of Obtained Experimental Data Using Computer Programming: Statistical Analysis of Experimental Data, Regression Analysis, Graphical Analysis and Curve Fitting.

Simulation Using Commercial Software: Computational Modeling / Simulation and Validation of Problems Performed through Experiments, subjected to different loading and boundary conditions.

End Semester Project Submission: Practical Experimentation, Computational Modeling and Validation, as well as Statistical / Regression Analysis of Designed / Fabricated Experiment or of Other Problem (as assigned).

Reference Books

1. Experimental Methods for Engineers: Jack P. Holman.
2. Experimental Stress Analysis: James W. Dally and William F. Riley
3. Design &Analysis of Experiments: D. C. Montgomery
4. Design of experiments for Engineers & Scientists: J. Antony
5.Measurement Systems- Applications and Design: E.O. Doebelin
6. Mechanical Measurement: T.G. Beckwith
7. Mechanical Measurements: D.S. Kumar
8. Fortran 95/2003 for Scientists & Engineers: Stephen J. Chapman

AM2210 Wave Propagation in Solids		
Designation	:	Elective
Pre-requisites	:	Engineering Mathematics including Differential and Integral Calculus, Advanced Solid Mechanics / Continuum Mechanics.
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme): 20 marks (5 marks for attendance + 15 marks for Take-home assignments and Class Tutorials).

Syllabus

Introduction, Elements of Continuum Mechanics and Linear Elastodynamics: Purpose and overview of the course, **Examples** of wave propagation in forced and free vibration of Solids / structures, **Review of Continuum Mechanics**, Problem statement in **Linear Elastodynamics**, The dynamic reciprocal identity, Reduction to wave equation using Helmholtz decomposition of Displacement field into Scalar and vector potentials.

Waves Propagation in One Dimension: Wave Propagation in general one dimensional elastic continuum, Wave equation for transverse displacement of freely vibrating **Taut String**, Solution by separation of variables, Travelling and Standing wave interpretation and mode shapes; **Axial wave in Bars**, D'Alembert solution for the wave equation, Strain waves and stress waves, Particle velocity vs. wave velocity, Acoustic Impedance, Reflection and transmission at Interface of two materials, Power and energy transport in axial wave, **Flexural waves in Beams**, Solution, Dispersion of Flexural waves, Phase velocity and Group velocity, Power and energy in flexural wave.

Waves Propagation in Two and Three Dimension: General time-harmonic elastic waves in plane, Polar and axial symmetry, Propagation of wavefront, Expansions behind wavefront, General solution approach, Reflection and transmission at interface, Free waves in infinite space, Reflection from a plane boundary, P and SV waves, SH wave, Scattering by a circular cavity, Diffraction of by a long crack, **Axial and flexural wave equations in Plate**, Solution methods, Generalization to **waves in three dimension**, Eigenvalues and Eigen vectors of Wave euqations.

Waveguides and Guided Waves: Overview on waveguides, **Rayleigh waves** – Governing equations and solution, Wave speed & Particle motion, **SH Plate waves** - Symmetric and Antisymmetric modes, Dispersion, Cut-off frequencies, **Lamb Waves** –Group velocity dispersion curves, Guided waves in Isotropic and **Composite Plates**, Dispersion curves for guided waves in composite plates, Guided waves in cylindrical shells, Conclusion.

Application of Wave Propagation for NDE and SHM (Partial self study, as assigned): Overview, *Nondestructive Evaluation* (NDE) techniques for *Structural Health Monitoring* (SHM), Electroactive and Magnetoactive Materials for SHM, Ultrasonic systems for industrial NDE, Guided waves for Inspection of Plates, Application of Waveguides, Laser-Ultrasonic techniques, Electromagnetic Acoustic Transducers, Acoustic Microscopy, *Piezoelectric Wafer Active Sensors* (PWAS), Coupled-field analysis of PWAS Resonators, PWAS Ultrasonic Transducers, Wave propagation and In-situ SHM using PWAS, Signal Processing and pattern recognition for PWAS based SHM, Practical issues with PWAS, Scopes and conclusion.

Reference Books

1. Wave Propagation in Elastic Solids: J. D. Achenbach.
2. Structural Health Monitoring with Piezoelectric Wafer Active Sensors: Victor Giurgiutiu.
3. Ultrasonic Nondestructive Evaluation - Engineering and Biological Material Characterization: TribikramKundu.
4. Wave Propagation: Chiang Mei, Rodolfo R. Rosales and TriantaphyllosAkylas.
5. Wave Motion in Elastic Solids: Karl F. Graff.
6. Fundamentals of Shock Wave Propagation in Solids: Lee Davison.
7. Structural Health Monitoring: F. K. Chang.

AM2212Theory of Stability		
Designation	:	Elective
Pre-requisites	:	Differential Equations, Engineering Mechanics, Mechanics of Solids, Theory of Elasticity.
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme): 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction and Buckling of Columns: Concepts of Stability, Equilibrium path, Stability criteria, Method of Neutral Equilibrium; Recapitulation of Critical Load for Euler Column, Columns with Different Boundary Conditions, Effective-length concept and design curve, Effects of Imperfections / Initial curvature, Eccentricity of loading etc.; Inelastic buckling of columns, Double and Tangent Modulus theory, Shanley's theory.

Beam-columns and Frames: Governing equation for Beam-columns, Displacement solution and stability for single concentrated transverse load, Beam-Columns with other transverse loading and boundary conditions, Semi-analytic / Series solution based on Energy Principles, Post-buckling behavior;

Introduction to buckling of **Frames**, Modes of Buckling, Critical Load of a Frame by Slope-Deflection Equations and Matrix Analysis, Effect of Initial Bending, Framed Columns.

Torsional and Lateral Stability: Stability of Thin-walled open sections, buckling by torsion and torsion-flexure; Lateral stability of beams with various loadings and end conditions.

Stability of Plates and Shells: Differential Equations of plate Buckling linear theory, stability of Rectangular plates under axial compression and shear, Effect of imperfections, Post-buckling behavior of plates;

Stability of cylindrical **Shells** under uniform axial pressure and torsion, Effect of imperfections.

Approximate Methods of Analysis: Energy Principles and Variational Calculus, Rayleigh-Ritz and Galerkin method, Finite Difference and Finite Element Method.

Reference Books

1. Theory of elastic Stability: S. P. Timoshenko and J. M. Gere
2. Principle of Structural Stability Theory: A.Chazes
3. Stability of Theory of Structures: AshwaniKumar
4. Background to Buckling: H.G. Allen and P.S. Bulson
5. Structural Stability of Columns and Plates: N.G.R. Iyengar

AM2224 Electroacoustic Transducers		
Designation	:	Elective
Pre-requisites	:	*Basic Electrical/Electronics Engineering, Wave Propagation*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction to Acoustics: Acoustic variables & basic relations, plane & spherical waves, reflection & transmission, radiation & reception of acoustic waves, absorption and attenuation of sound.

Electro-Mechano-Acoustical Analogy: Introduction, basic equations and impedances, transformer and gyrator, simple harmonic oscillator, Helmholtz resonator, loop analysis, circuit elements, Lagrange equation.

Acoustical Elements: Basic acoustic elements, specific acoustic impedance, mechanical impedance, electrical impedance, acoustic radiation impedance, duct impedance, equivalent circuit model, various acoustical examples, frequency and wavelength, dB scale, sound pressure level.

Basic Theory and Modeling of Microphone: Introduction, types, response, sensitivity, specifications, directivity pattern, microphone array, microphone equation, electret condenser microphone (ECM), ECM model for various types of microphone.

Basic Theory and Modeling of Moving Coil Transducer: Introduction, types, reciprocal and anti-reciprocal system, TS parameters, speaker non-linearities, equivalent circuit representation, loudspeaker enclosure, types of loudspeaker enclosure and corresponding circuits, total harmonic distortion, intermodulation distortion, miniature loudspeaker.

Theory and Analysis of Piezoelectric Transducer: Brief introduction to piezoelectricity, piezoelectric materials, piezoelectric devices, polarization, equivalent circuit, piezoelectric accelerometer, piezoelectric speaker, piezoelectric microphone.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Reference Books

1. Acoustics: L. L. Beranek.
2. Introduction to Electro acoustics and Amplifier Design: W. M. Leach.
3. Acoustics-An Introduction: H. Kuttruff.
4. Fundamentals of Acoustics: Kinsler, Frey, Coppens, and Sanders.
5. Audio Engineer's Reference Book: Michael Talbot-Smith(Editor).

AM2206 Computational Fluid Dynamics		
Designation	:	Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Heat Transfer, Engineering Mathematics, CAD, Computer programming.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorialsetc).

Syllabus

Basic ideas of CFD: Introduction to CFD, role of CFD and its applications, future of CFD.
Governing equations (GE's) of Fluid dynamics: Modeling of flow, control volume concept, substantial derivative, physical meaning of the divergence of velocity. Continuity equation, momentum equation, energy equation and its conservation form. Equations for viscous flow (Navier-Stokes equations), equations for inviscid flow (Euler equation). Different forms of GE's, initial and boundary conditions.
FVM for Diffusion Problems: FVM for 1D steady state diffusion, 2D steady state diffusion, 3d steady state diffusion. Solution of discretised equations- TDMA scheme for 2D and 3D flows.
FVM for Convection-Diffusion Problems: FVM for 1D steady state convection-diffusion, Central differencing scheme, Conservativeness, Boundedness, Transportiveness, Upward differencing scheme, Hybrid differencing scheme for 2D and 3D convection-diffusion, Power-law scheme, QUICK scheme.
Solution Algorithm for Pressure-velocity Coupling in Steady Flows: Concept of staggered grid, SIMPLE, SIMPLER, SIMPLEC, PISO algorithm.
FVM for Unsteady Flows: 1D unsteady heat conduction (Explicit, Crank-Nicolson, fully implicit schemes), Implicit mecthods for 2D and 3D problems, Discretization of transient convection-diffusion problems, solution procedure for transient unsteady flow calculations (transient SIMPLE, transient PISO algorithms).
Grid Generation: General transformation of the equations. Metices and Jacobians. Types of grids- structured and unstructured grids, grid generation methods- algebraic, differential and hybrid methods. Coordinate stretching, boundary-fitted coordinate systems. Elliptic and hyperbolic grid generation methods, orthogonal grid generation for Navier-Stokes equations, Multi-block grid generation.
Latest development in CFD techniques and newer applications.

Reference Books

1. "An Introduction to Computational Fluid Dynamics: the Finite Volume Method", H.K. Versteeg and W. Malalasekara, 2nd edition, Pearson Education, England, 2007.
2. "Computational Fluid Dynamics for Engineers" B. Andersson& others, 1st edition, Cambridge University Press, U.K., 2012.
3. "Computational Fluid Flow and Heat Transfer" (2nd edition), K. Muralidhar and T. Sundararajan, Narosa Publishing, 2004.
4. "Numerical Heat Transfer and Fluid Flow", S.V. Patankar, McGraw-Hill, New York, 1980.
5. "Principles of Computational Fluid Dynamics", P. Wesseling, Springer-Verlag.
6. "Computational Techniques for Fluid Dynamics Volume I & II" (2nd edition), C.A.J. Fletcher, Springer-Verlag, 1991.
7. "Computational Fluid Mechanics and Heat Transfer" (2nd edition), J.C. Tannehill, D.A. Anderson and R.H. Pletcher, Taylor and Francis, 1997.
8. "Numerical Computation of Internal and External Flows" (Vols. I & II), C. Hirsch, Wiley International, 1988.
9. "Computational Fluid Dynamics for Engineers" (Vols. I & II), K. Hoffmann and S. T. Chiang, Engineering Education System, 1993.

AM2213 Mechanics of Composite Materials		
Designation	:	Elective
Pre-requisites	:	*Continuum Mechanics / Solid Mechanics, Basic Engineering Mathematics, Linear Algebra, Differential Equations*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction: Classification and characteristics of composites, Conventional vs. Composite materials, Advantages and limitations, Salient applications in various fields, Fabrication technologies, Properties of matrix and reinforcement materials

Micromechanics: Fiber volume fraction, micro-mechanical relations, determination of strength and stiffness, Environmental effects-Hygro-thermal behavior.

Macromechanics: Basic stress-strain relationships for anisotropic materials, engineering constants for orthotropic materials, stress-strain relations for a lamina of arbitrary orientation, effective moduli, invariant properties of anorthotropic lamina, special cases of laminate stiffness, laminate strength analysis, concept of inter-laminar stresses and delamination

Failure theories and Damage mechanics: Failure mechanisms, maximum stress theory, maximum strain theory, Tsai-Hill theory, Tensor polynomial failure criterion, first ply failure theory, Introduction to damage theory based on continuum damage mechanics.

Reference Books

1. Mechanics of fibrous composites: Carl T. Herakovich
2. Principles of Composite Material Mechanics: R. F. Gibson
3. Mechanics of Composite Materials: R. M. Jones
4. Introduction to Composite Material: Stephen W.Tsai and H. Thomas Hahn
5. Composite Materials and their use in Structures: J. R. Vinson and T.W. Chou

AM2214 Multi-Functional Materials and Structures		
Designation	:	Elective
Pre-requisites	:	Engineering Mathematics, Basic Materials Science, Advanced Solid Mechanics.
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme): 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction and Mathematical Preliminaries: History of advanced material developments, Basic ideas, Demand and applications of multifunctional materials in industry, Tensor analysis, PDEs.

Elementary Anisotropic Elasticity: Deformation, Stress and Strain Tensor, Strain-Displacement and Compatibility Equations, Constitutive relations, Elasticity Tensor and Generalized Hooke's law, Balance Laws and Equilibrium equations, Constitutive relations for Orthotropic, transversely isotropic and isotropic materials.

FRP Reinforced Laminated Composites: Effective lamina properties from fiber-matrix micro mechanics, material and reference axis system, Transformed stiffness of lamina, Stiffness of a laminate, Multidirectional FRP Reinforced Laminated Composites, Hygro-thermal effects.

CNT Reinforced Composites: Basics and categories of CNTs, Effective mechanical properties of CNTs – MD simulation and other methods, Effective properties of CNT reinforced composites.

Functionally Graded Materials (FGMs): Basic idea based on Lessons from Nature, Graded microstructure - Characteristic dimensions and spatial variations, Volume Fraction, rules of mixture and effective field parameters; Characterization of properties of FGM, Macrostructuralthermomechanical properties, Effective material properties for ceramic-metal FGMs, Basic mathematical modeling.

Smart Materials and Composites: Piezoelectric materials, Shape Memory Alloys and Super-elastic Materials, Numerical Modeling of Smart Materials, Aerospace and Biomedical Applications of Smart Materials.

Analysis of Structures (beams and plates) of Functional Materials: Basic beam and plate theory, Analysis of FRP / CNT reinforced laminated composite structures, Analysis of Functionally graded structures, Smart structures with electromechanical loading, Failure criterion and design philosophies.

Reference Books

1. Structural Analysis of Polymeric Composite Materials: Tuttle, Mark E.
2. Shape Memory Alloys: Modeling and Engineering Applications: Lagoudas, Dimitris C. (Ed.)
3. Smart Materials and Structures: M.V. Gandhi and B.S. Thompson
4. Functionally Graded Materials - Nonlinear Analysis of Plates and Shells: Hui-ShenShen

AM2215 Multiscale Modeling of Advanced Materials		
Designation	:	Elective
Pre-requisites	:	Engineering Mathematics, Basic Materials Science, Advanced Solid Mechanics.
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme): 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction: Examples and motivation for exploring multiscale behaviour of materials, Relevant material properties at different scales.
Review of Preliminaries: Prerequisite mathematics, Fundamentals of Thermodynamics and statistical mechanics.
Molecular Dynamics and Related Issues: Particle-based methods, EAM/MEAM potentials: bridging from QM, Atomistic Plasticity, Damage & Fatigue, Molecular Dynamic Simulation Methods
Meso-scale methods: Overview and need, Quasi-continuum methods, Density Functional method.
Homogenization and Bridging: Multi-scale homogenization and stochastic homogenization, Inter-scale exchange and Scale bridging.
Computational Application: Variationalmultiscale methods, Numerical resolution and asymptotic behaviour of stochastic PDEs, Enriched continuum models and design.

Reference Books

1. Nano Mechanics and Materials: Theory, Multiscale Methods and Applications: Liu, Wing Kam, Karpov, Eduard G., and Park. Harold S.
2. An Introduction to Thermal Physics: Schroeder, Daniel V.
3. A First Course in Finite Elements: Fish, Jacob and Belytschko, Ted.
4. Nonlinear Finite Elements for Continua and Structures: Belytschko, Ted, Liu, Wing Kam, and Moran, Brian.

AM2216Applied Plasticity		
Designation	:	Elective
Pre-requisites	:	*Continuum Mechanics/Applied Elasticity*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Crystal plasticity: Resolved shear stress & strain, Lattice slip systems, Hardening, Yield surface, Flow rule, Micro to Macro plasticity.

Stresses and Strains: The Stress–Strain Behaviour, Analysis of Stress, Mohr's Representation of Stress, Velocity gradient and rate of deformation, Kinematics of large deformation, The Criterion of Yielding, Yielding of materials under complex stress state, Choice of yield function.

Non-Hardening & Elastic-Perfect Plasticity: Classical theories and its application to uniform & non uniform stress states, Hencky vs. Prandtl-Reuss, Elastic–Plastic Torsion and Bending of Beams, Thick walled cylinders.

Theory of the Slipline Field: Formulation of the Plane Strain Problem, Properties of Slipline Fields and Hodographs, Stress Discontinuities in Plane Strain, Construction of Slipline Fields and Hodographs, Analytical and Matrix Methods of Solution, Explicit Solutions for Direct Problems, Some Mixed Boundary-Value Problems, Superposition of Slipline Fields.

Limit Analysis: Collapse of Beams & Structures, Transverse loading of circular plates.

The Flow Curve: Uniaxial tests, Torsion tests, Compression tests, Bulge test, Equations to flow curve, Strain & work hardening hypothesis.

Plasticity with Hardening: Isotropic hardening, Non associated flow rules, Prandtl-Reuss flow theory, Kinematic hardening.

Plastic Instability: Inelastic buckling of struts, Buckling of plates, Tensile instability, Circular bulge instability, Plate stretching.

Reference Books

1. Theory of Plasticity: J. Chakrabarty.
2. Plasticity Theory: Jacob Lubliner.
3. Basic Engineering Plasticity: DWA Rees.
4. The Mathematical theory of plasticity: R.Hill.
5. Finite Elements in Plasticity- Theory & Practice: D. R. J. Owen and E. Hinton.
6. Continuum Theory of Plasticity: S. Huang.
7. Fundamentals of the Theory of Plasticity: L.M. Kachanov.
8. Plasticity for Engineers: Theory and Applications: C. R. Calladine.

AM2217Fracture Mechanics		
Designation	:	Elective
Pre-requisites	:	*Continuum Mechanics/Applied Elasticity*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction: Modes of loading, Crack growth and fracture mechanisms, Need for fracture mechanics, Linear elastic fracture mechanics and elastic plastic fracture mechanics.

Energy Release Rate: Surface Energy, Resistance, Griffith Theory of fracture, Extension of Griffith Theory by Irwin and Orowan, R-Curve, Pop-in phenomena, Crack branching. Necessary and sufficient conditions for fracture.

Crack-Tip Stress and Displacement Fields: Airy's stress function, Westergaard's approach, Generalized Westergaard's approach, William's Eigen function approach, Multi-parameter stress field equations, Influence of the *T*-stress and higher order terms, Role of photoelasticity on the development of stress field equations in fracture mechanics.

Stress Intensity Factor: Equivalence between SIF and *G*, Various methods for evaluating Stress Intensity Factors.

Crack Tip Plastic Zone: Modeling plastic zone at the crack-tip, Irwin and Dugdale models.

Fracture Toughness Testing: Qualitative toughness testing, K_{IC} testing, K-R curve testing, J_{IC} measurements, J-R curve testing, CTOD testing.

Micromechanics of Fracture: Cohesive strength of solids, Cleavage fracture, Intergranular fracture, Ductile fracture, Crack detection methods.

Reference Books

1. Elementary Engineering Fracture Mechanics: D. Broek.
2. Elements of Fracture Mechanics: Prashant Kumar.
3. Fracture Mechanics - Fundamentals and Applications: T. L. Anderson.
4. Introduction to Fracture Mechanics: KareHellan.
5. Fracture Mechanics- With an Introduction to Micromechanics: Dietmar Gross and Thomas Seelig.
6. Fracture Mechanics- An Introduction: E.E. Gdoutos.

AM2218 Continuum Damage Mechanics		
Designation	:	Elective
Pre-requisites	:	*Continuum Mechanics, Linear Algebra, Differential Equations*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Essentials of Continuum mechanics: Tensorial notation, stress, strain, invariants, equilibrium equations, Domain and validity of continuum damage mechanics, concept of representative volume element.

Phenomenological aspects of damage: Damage, measurement of damage, modeling of damage through effective area reduction, void volume fraction and stiffness reduction, representation of damage through different orders of tensors, concept of effective stress, hypothesis of strain equivalence, strain energy equivalence, and complementary strain energy equivalence.

Thermodynamics of damage: State variables, damage as state variables, first and second law of thermodynamics, thermodynamics potentials, dissipation potentials, constitutive equations, evolution equations.

Kinetic Laws of Damage Evolution: Unified formulation of damage laws, damage laws for brittle, quasi-brittle, ductile, creep, low cycle and high cycle fatigue.

Damage Analysis of Structures: Implementation of isotropic damage theory, case studies from literature.

Reference Books

1. A Course on damage mechanics: Jean Lemaitre.
2. Continuum damage mechanics: S. Murakami.
3. Mechanics of solid materials: Jean Lemaitre and J. L. Chaboche.
4. An Introduction to damage mechanics: L. M. Kachanov.
5. Damage mechanics with finite elements: P. I. Kattan and G. Z. Voyiadjis.
6. Damage mechanics: DusanKrajcinovic.
7. Damage mechanics: George Z. Voyiadjis and Peter I. Kattan.

AM2219 Analysis and Design of Composite Structures		
Designation	:	Elective
Pre-requisites	:	*Continuum Mechanics / Solid Mechanics, Basic Engineering Mathematics, Linear Algebra, Differential Equations*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction: Anisotropic elasticity, Virtual Work Principles, Variational Methods, Transformation of Stresses & Strains,

Analysis of Composite Structures: Classical lamination theory, shear deformation theories, Bending, Buckling and Vibration of Beams, Plates and Shells, Damage Mechanisms and Failure Theories.

Characterization and Testing: Characterization of fiber &matrix, Mechanical Testing:Tension, Compression, Shear, Flexure, Fracture Toughness, Impact and Compression After Impact (CAI).

Introduction to Composite Design: Framework for Composite Design, Ply Orientation and arrangement, Use of Failure Criterion, Sizing of the Laminates.

Reference Books

1. Mechanics of fibrous composites: Carl T. Herakovich.
2. Introduction to Composite Material: Stephen W. Tsai and H. Thomas Hahn.
3. Composite Materials and their use in Structures: J. R. Vinson and T.W. Chou.
4. Composite Structures-Testing, Analysis and Design: J. N. Reddy and A.V. Krishna Moorty.
5. Composite Materials - Design and Applications: D. Gay, S. V. Hoa, S. W. Tsai.
6. Introduction to Composite Materials Design: E J. Barbero.

Master of Technology

in

FLUIDS ENGINEERING

Course Structure, Scheme of Evaluation and Syllabi

(*Effective from July 2017*)

Department of Applied Mechanics

Motilal Nehru National Institute of Technology Allahabad
Allahabad, U.P. -211004, INDIA

Course Structure

I Semester (Total Credits = 20):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM2101	Applied Mathematics & Computation	4	0	0	4	20	20	60
AM2140	Advanced Fluid Mechanics	4	0	0	4	20	20	60
AM2206	Computational Fluid Dynamics	4	0	0	4	20	20	60
AM21XX	**Elective-I**	4	0	0	4	20	20	60
AM21XX	**Elective-II**	4	0	0	4	20	20	60

List of Electives (Semester I):

Elective-I:		**Elective-II:**	
AM2143	Aerodynamics.	**AM2146**	Multiphase Flow.
AM2144	Wind Engineering.	**AM2147**	Design of Experiments.
AM2145	Research Methodology.	**AM2142**	Convective Heat Transfer.
AM2110	Applied Elasticity	**ME2148**	Gas Turbine and Jet Propulsion.
AM2141	Bio-Fluid Dynamics.		

II Semester (Total Credits = 20):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM2240	Turbulence	4	0	0	4	20	20	60
AM2253	Advanced Fluid Mechanics Laboratory	0	0	6	4	20	20	60
AM22XX	**Elective-III**	4	0	0	4	20	20	60
AM22XX	**Elective-IV**	4	0	0	4	20	20	60
AM22XX	**Elective-V**	4	0	0	4	20	20	60

List of Electives (Semester II):

Elective-III:			**Elective-IV:**	**Elective-V:**	
AM2249	Advanced Computational Fluid Dynamics	**ME2243**	Thermo-Fluid Dynamics.	**ME2235**	Advanced Gas Dynamics.
AM2211	Fluid-Structure Interaction.	**AM2243**	Design of Heat Exchangers.	**AM2246**	Industrial Aerodynamics.
AM2241	Boundary Layer Theory.	**AM2244**	Design of Hydraulic Turbines.	**AM2247**	Design of Impeller Pumps.
AM2242	Design of Pipe Networks.	**AM2245**	River Engineering.	**AM2248**	Condition Monitoring, Diagnosis and Predictive Maintenance of Pumps.

III Semester (Total Credits = 20):

S. No.	Subject Name	Credits
AM2395	Special Study/Term Project/State of the Art/Colloquium Industrial/Research Training	4
AM2396	Thesis/Project	16

IV Semester (Total Credits = 20):

S. No.	Subject Name	Credits
AM2496	Thesis/Project	20

Note: The distribution of thesis evaluation marks will be as follows:

1. Supervisor(s) evaluation component: 60%
2. Oral Board evaluation component: 40%

Semester-I

AM2101 Applied Mathematics and Computation		
Designation	:	Compulsory
Pre-requisites	:	Engineering Mathematics and computer programming
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for Assignment submission, Surprise tests, Term paper, Quiz tests, etc.)

Syllabus

Review of Elementary Engineering Mathematics: Solution of homogeneous and non-homogeneous equations; Power series; Laplace transform and its applications; Fourier series and Fourier transform

Linear Algebra: Matrices and Linear Transformations, Operational Fundamentals of Linear Algebra, Systems of Linear Equations, Gauss Elimination Family of Methods, Special Systems and Special Methods, Numerical Aspects in Linear Systems, Eigenvalues and Eigenvectors, Diagonalization and Similarity Transformations, Jacobi and Givens Rotation Methods, Tri-diagonal Matrices, QR Decomposition Method, Eigenvalue Problem of General Matrices, Singular Value Decomposition, Direct and Iterative solvers.

Ordinary Differential Equations: Introduction to ordinary differential equations, homogeneous linear equations of second order, non-homogeneous linear equations of second order, free and forced oscillation problems, problems with variable coefficients, system of equations.

Partial Differential Equations (PDEs): Existence and uniqueness of differential equations, nature of solution, Hyperbolic, Parabolic and Elliptic PDEs, nonlinear PDEs.

Nonlinear Equations: Motivation, Open and braketing method, Bisection, Fixed point, Newton's method, Secant and False position method, Rate of convergence, Merits and demerits of methods.

Numerical Integration: Motivation, Newton-Kotes method, Trapezoidal rule, Simpson's rule, Rhomberg integration, Gauss Quadrature.

Initial Value Problem: Motivation, Euler's method, Modified Euler method, Runge-Kutta methods, Adaptive integrations and multistep methods.

Boundary-value and Eigen-value Problem: Methods and Applications in Mechanics.

References books

1. "Numerical Methods in Engineering", M. Salvadori, Prentice Hall International, 1961.
2. "Applied Numerical Methods", B. Carnahan, Krieger Pub, 1990.
3. "Applied Numerical Analysis", C.F. Gerald and P.O. Wheatley, 5th edition, Addison-Wesley, 1998.
4. "Numerical Mathematics & Computing", W. Cheney and D. Kincaid, 5th edition, Brooks/Cole, 2004.
5. "Applied Partial Differential Equations", Paul DuChateau and David Zachmann.
6. "Partial Differential Equations for Scientists and Engineers", Stanley J. Farlow.
7. "Numerical Methods for Partial Differential Equations", William F. Ames.
8. "Numerical Methods for Elliptic and Parabolic Partial Differential Equations", John R Levison, Peter Knabner, Lutz Angermann.

AM2140 Advanced Fluid Mechanics		
Designation	:	Compulsory
Pre-requisites	:	*Engineering Fluid Mechanics, Thermodynamics.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Basic Conservation & Governing Laws: Statistical & continuum methods, Eulerian & Lagrangian coordinates, material derivatives, control volumes, Reynolds' transport theorem (RTT), conservation of mass, momentum and energy, constitutive equations, Navier-Stokes equations- differential & intergral approach, energy equations, governing equations for Newtonian fluids, boundary conditions.

Potential Flows: Stokes stream functions, solution of potential equation, flow in a sector, flow around a sharp edge, flow near a blunt nose force and moment on a circular cylinder and sphere, conformal transformations, Joukowski transformations.

Viscous Incompressible Flows: Exact solutions for Couette flow, Poiseuille flow, flow between rotating cylinders, Stokes' first problem, Stokes' second problem, pulsating flow between parallel surfaces, stagnation-point flow, flow in convergent and divergent channels, flow over porous wall. Stokes approximation, rotating sphere in a fluid, uniform flow past a sphere and cylinder, Ossen's approximation, Hele-Shaw flow.

Introduction to Boundary Layer: Derivation of boundary layer equation, How potential flow complements B.L. equation, Integral solution of B.L., Laminar and turbulent boundary layers; transition; B.L. separation and control.

Introduction to Compressible Flow: Velocity of sound and its importance, physical difference between incompressible, subsonic and supersonic flows, Mach number and its significance. Isentropic flow through nozzles, shocks and expansion waves, Rayleigh and Fanno Flow.

References books

1. "Fundamental Mechanics of Fluids", I. G. Currie.
2. "Foundations of Fluid Mechanics", S.W. Yuan, Prentice-Hall India Pvt. Ltd, New Delhi.
3. "Advanced Fluid Mechanics", K. Muralidhar & G. Biswas, Narosa Publishing, 2005.
4. "Boundary Layer Theory", H. Schlichting, 6th Edition, McGraw-Hill Inc., 1986.
5. "Modern Compressible Flow with Historical Perspective", John D. Anderson, McGraw Hill.
7. "Fundamentals of Aerodynamics" (2nd ed), J. D. Anderson, McGraw Hill.
8. "Fundamentals of Fluid Mechanics", B.R. Munson, D.F. Young & T.H. Okiishi, 2nd Ed., John Wiley.
9. "Introduction to Fluid Mechanics", R.W. Fox & A.T. McDonald, 5th Edition, John Wiley,2001.
10. "Viscous Fluid Flow", F. M. White, 2nd Edition, McGraw-Hill, 1991.

AM2206 Computational Fluid Dynamics		
Designation	:	Compulsory
Pre-requisites	:	*Engineering Fluid Mechanics, Heat Transfer, Engineering Mathematics, CAD, Computer programming.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Basic ideas of CFD: Introduction to CFD, role of CFD and its applications, future of CFD.

Governing equations (GE's) of Fluid dynamics: Modeling of flow, control volume concept, substantial derivative, physical meaning of the divergence of velocity. Continuity equation, momentum equation, energy equation and its conservation form. Equations for viscous flow (Navier-Stokes equations), equations for inviscid flow (Euler equation). Different forms of GE's, initial and boundary conditions.

FVM for Diffusion Problems: FVM for 1D steady state diffusion, 2D steady state diffusion, 3d steady state diffusion. Solution of discretised equations- TDMA scheme for 2D and 3D flows.

FVM for Convection-Diffusion Problems: FVM for 1D steady state convection-diffusion, Central differencing scheme, Conservativeness, Boundedness, Transportiveness, Upward differencing scheme, Hybrid differencing scheme for 2D and 3D convection-diffusion, Power-law scheme, QUICK scheme.

Solution Algorithm for Pressure-velocity Coupling in Steady Flows: Concept of staggered grid, SIMPLE, SIMPLER, SIMPLEC, PISO algorithm.

FVM for Unsteady Flows: 1D unsteady heat conduction (Explicit, Crank-Nicolson, fully implicit schemes), Implicit mecthods for 2D and 3D problems, Discretization of transient convection-diffusion problems, solution procedure for transient unsteady flow calculations (transient SIMPLE, transient PISO algorithms).

Grid Generation: General transformation of the equations. Metices and Jacobians. Types of grids- structured and unstructured grids, grid generation methods- algebraic, differential and hybrid methods. Coordinate stretching, boundary-fitted coordinate systems. Elliptic and hyperbolic grid generation methods, orthogonal grid generation for Navier-Stokes equations, Multi-block grid generation.

Latest development in CFD techniques and newer applications.

References books

1. "An Introduction to Computational Fluid Dynamics: the Finite Volume Method", H.K. Versteeg and W. Malalasekara, 2nd edition, Pearson Education, England, 2007.
2. "Computational Fluid Dynamics for Engineers" B. Andersson & others, 1st edition, Cambridge University Press, U.K., 2012.
3. "Computational Fluid Flow and Heat Transfer" (2nd edition), K. Muralidhar and T. Sundararajan, Narosa Publishing, 2004.
4. "Numerical Heat Transfer and Fluid Flow", S.V. Patankar, McGraw-Hill, New York, 1980.
5. "Principles of Computational Fluid Dynamics", P. Wesseling, Springer-Verlag.
6. "Computational Techniques for Fluid Dynamics Volume I & II" (2nd edition), C.A.J. Fletcher, Springer-Verlag, 1991.
7. "Computational Fluid Mechanics and Heat Transfer" (2nd edition), J.C. Tannehill, D.A. Anderson and R.H. Pletcher, Taylor and Francis, 1997.
8. "Numerical Computation of Internal and External Flows" (Vols. I & II), C. Hirsch, Wiley International, 1988.
9. "Computational Fluid Dynamics for Engineers" (Vols. I & II), K. Hoffmann and S. T. Chiang, Engineering Education System, 1993.

AM2143 Aerodynamics		
Designation	:	Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Thermodynamics.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction to Aerodynamics: Hot air balloon and aircrafts, Various types of airplanes, Wings and airfoils, lift and Drag, Centre of pressure and aerodynamic centre, Coefficient of pressure, moment coefficient, Application of potential flow in aerodynamic problems.

Incompressible Flow Theory: Design of airfoils using conformal transformation, Kutta condition, Karman – Trefftz profiles, Thin aerofoil Theory and its applications. Vortex line, Horse shoe vortex, Biot - Savart law, Prandtl lifting line theory, Panel methods.

Compressible Flow Theory: Potential equation for compressible flow, small perturbation theory, Prandtl-Glauert Rule, Linearised supersonic flow, Method of characteristics.

Airfoils, Wings and Airplane configuration in High Speed Flows: Critical Mach number, Drag divergence Mach number, Shock stall, super critical airfoils, Transonic area rule, Swept wings (ASW and FSW), supersonic airfoils, wave drag, delta wings, Design considerations for supersonic airplanes.

Viscous Flow Measurements: Types of wind tunnels – Flow visualization processes – Measurement of force and moments in wind tunnels. Measurement of pressure, velocity and wall shear stress, Flow visualizations.

Latest developments and trends in Aerodynamics: UAV, MAV.

References books

1. L.J. Clancey, Aerodynamics, Indian Edition 2006, Sterling Book House, Mumbai.
2. J.D. Anderson, "Fundamentals of Aerodynamics", McGraw-Hill Book Co., New York, 1985. Rathakrishnan.E., Gas Dynamics, Prentice Hall of India, 1995.
3. Shapiro, A.H., Dynamics & Thermodynamics of Compressible Fluid Flow, Ronald Press, 1982.
4. E.L. Houghton and N.B. Caruthers, Aerodynamics for Engineering Students, Edward Arnold Publishers Ltd., London (First Indian Edition), 1988
5. Zucrow, M.J., and Anderson, J.D., Elements of gas dynamics McGraw-Hill Book Co., New York, 1989.
6. W.H. Rae and A. Pope, "Low speed Wind Tunnel Testing", John Wiley Publications, 1984.

AM2144 Wind Engineering		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction to Wind engineering: Wind climates and wind-induced phenomena, extreme wind climatology. Atmospheric boundary layer: Governing equations, mean velocity profiles, power law, logarithmic law wind speeds, atmospheric turbulence profiles, general characteristics of atmospheric turbulence, spatio-temporal expressions of wind fluctuations, spatio-temporal scales of fluctuations, spectral density function, length scale of turbulence, roughness parameters.

Bluff body aerodynamics: flow around bluff bodies and pressure distributions, governing equations, boundary layers and flow separations, wake and vortex formation, Strouhal number, Reynolds number, flow separation and reattachments, oscillatory flow patterns, vortex shedding, flow switching– Time varying forces to wind velocity in turbulent flow and its three-dimensional structures. Static wind forces and dynamic wind forces, quasi-steady assumption and fluctuating wind pressures, motion-induced forces and aerodynamic damping, wind force correlation and wind force combination.

Structural dynamics: human comfort and habitability of buildings to vibrations, damping in buildings and sophisticated evaluation techniques, suppression of wind-induced vibrations.

Aeroelastic phenomena: Vortex shedding and lock in phenomena in turbulent flows, across wind galloping, wake galloping - Torsional divergence, along wind galloping of circular cables, cross wind galloping of circular cables, wind loads and their effects on tall structures.

Wind loading: Introduction, analysis and synthesis loading coefficients, local & global coefficients, pressure shear stress coefficients, force and moment coefficients. Assessment methods, quasi steady method, peak factor method, extreme value method.

Wind tunnel and its full-scale testing, simulation techniques in wind tunnels.

Tornado wind and its effects on structures, microburst and its effects on structures, ASCE7 standard provisions.

Aerodynamics of wind turbines, wind-induced cable vibration.

References books

1. Wind Effects on Structures: Fundamentals and Applications to Design" by Simiu and Scanlan, , 3rd Ed. John Wiley and Sons, Inc., 1996.
2. "Building Aerodynamics" by Tom Lawson, Imperial College Press, London, 2001.
3. "Aerodynamics and drag mechanisms of bluff bodies and road vehicles", M.Sovran (Ed), Plenum press, New York, 1978.
4. "Winds forces in engineering" by P. Sachs, Pergamon Press, 1978.
5. "Flow induced vibrations" by R.D. Blevins, Van Nostrand, 1990.
6. "Wind Power Principles" by N.G. Calvent, Charles Griffin & Co., London, 1979.
7. "Car Aerodynamics" by Hucho.
8. "Design Guides to wind loading of buildings structures (Part I & II)" by N J Cook, Butterworths, London, 1985.
9. ASCE/SEI 7-10 Minimum Design Loads for Buildings and Other Structures.
10. IS: 875 (1987) Part III Wind loads, Indian Standards for Building codes.

AM2145 Research Methodology		
Designation	:	Elective
Pre-requisites	:	*Engineering Mathematics & Computer Programming*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction: A quick glance on research, Conceptualizing a research design Reviewing the literature.
Formulating a Research Problem: Identifying variables, Constructing hypotheses, Establishing the validity and reliability, Constructing an instrument for data collection, Measurement and Scaling Techniques, Sampling Fundamentals, Methods of Data Collection, Defining the Research Problem.
Developing a research plan and writing and presenting a research proposal (Mid-sem Exam).
Experimentation:
Processing data: Analysing Data, Analysis of Variance and Covariance,Testing of Hypotheses, Multivariate Analysis Techniques, Chisquare Test, Displaying data.
Research methodology and practice evaluation.
Writing and presentation of a research report (End Sem Exam).

References books

1. Research Methodology: Methods and Techniques, C R Kothari.

AM2110 Applied Elasticity		
Designation	:	Elective
Pre-requisites	:	Mechanics of Materials
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Analysis of Stress: Concept of Stress, Stress Components, Equilibrium Equations, Stress on a General Plane (Direction Cosines, Axis Transformation, Stress on Oblique Plane through a point, Stress Transformation), Principal Stresses, Stress Invariants, Deviatoric Stresses, Octahedral Stresses, Plane Stress, Stress Boundary Condition Problem.

Analysis of Strain: Deformations (Lagrangian Description, Eulerian Description), Concept of Strain, Strain Components (Geometrical Interpretation), Compatibility Equations, Strain transformation, Principal Strains, Strain Invariants, Deviatoric Strains, Octahedral Strains, Plane Strain, Strain Rates.

Stress-Strain Relations: Introduction, One-Dimensional Stress-Strain Relations (Idealized Time independent and Time–dependent stress-strain laws), Linear Elasticity (Generalized Hooke's Law), Stress-Strain Relationships for Isotropic and Anisotropic Materials (Plane stress and Plane Strain)

Basic Equations of Elasticity for Solids: Introduction, Stresses in Terms of displacements, Equilibrium Equations in terms of displacements, Compatibility equations in Terms of Stresses, Special cases of Elasticity equations (Plane Stress, Plane strain, Polar Co-ordinates), Principle of Superposition, Uniqueness of Solution, Principle of virtual work, Potential and Complementary energy, Variational Principles, St. Venant's Principle, Methods of analysis for Elastic Solutions, Elastic solutions by Displacement and stress Functions, Airy's Stress Function (Plane stress, Plane strain, Polar Co-ordinates).

Torsion: Introduction, Circular shaft, Torsion of non-circular cross-section, St. Venant's theory, Warping function, Prandtl's stress function, Shafts of other cross-sections, Torsion of bars with thin walled sections.

Viscoelasticity: Introduction, Viscoelastic models (Maxwell, Kelvin-Voigt, Generalized Maxwell and Kelvin models), Viscoelastic stress-strain relationships.

References books

1. Mathematical Theory of Elasticity: I. S. Sokolnikoff
2. Advanced Mechanics of Materials: Boresi
3. Theoretical Elasticity: A. E. Green and W. Zerna
4. Theory of Elasticity: Timoshenko and Gere
5. Advanced Strength and Applied Elasticity: A. C. Ugural and S. K. Fenster
6. Applied Elasticity: R.T.Fenner
7. Advanced Strength of Materials: L. S. Srinath

AM2141 Bio-Fluid Dynamics		
Designation	:	Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Elementary Biology.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction to Fluid Mechanics: Fluid properties, basic laws governing conservation of mass momentum and energy; Laminar flow, Couette flow and Hagen-Poiseuille equation, turbulent flow.

Bio-fluid Dynamics: Blood system network and physiology, blood rheology, Vessel structure and mechanical properties Lymphatic system; Body fluids and their motions; Flow of Newtonian and non-Newtonian fluids in rigid tubes, flexible tubes and collapsible tubes.

Cardio-vascular system: Heart and pumping process, Blood flow in body, Flow dynamical study of circulatory system, heart and blood vessels, anatomy and physiological considerations; Components and functions of arterial and venous systems: Blood flow through arteries and veins; Kinetic energy, flow, pressure-flow relations in vascular beds; Cardiac cycle; Cardiac valve dysfunctions; Blood pressure, regulation and controlling factors; Coronary circulation, heart failure.

Human Respiratory system: Physiology, Weibel's lung model, realistic lung model, studies of flow behavior in upper and lower human respiratory system during different breathing conditions, studies of wall shear stress and its implications, Dispersion and deposition of aerosols/inhaled particles in respiratory system, critical airways, tumorous airways.

References books

1. "Bio-fluid Mechanics", J.N. Mazumdar, World Scientific, 1992.
2. "Biomechanics: Motion", Flow, Stress, and Growth", Y.C. Fung, Springer-Verlag, 1990.
3. "Cardiovascular Physiology", R.M. Berne, M.N. Levy, 8th Edition, Mosby, 2001.
4. "Bio-fluid Dynamics", C. Klienstreuer, Taylor & Francis.

AM2146 Multiphase Flow		
Designation	:	Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Fluid Machinery.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction to Multiphase Flow: Introduction, Estimation of flow patterns, Classification and characteristics of complex Mixture, The Flow Properties of Fluid, Basic concept of flow of Newtonian and Non-Newtonian fluids.

Fundamental Concept of the Flow of Multiphase Mixtures: mechanics of transportation, Description of general two phase systems, Continuity equation, Momentum equation, Mechanical energy equation, Slip and Hold up effect.

Flow of Gas-Liquid and Liquid–Liquid Mixture in Pipes: Flow patterns, Holdup, Empirical overall correlations, Pressure gradient, Bubble flow pattern, Slug flow, Stratified flow, Wave flow and Annular-mist flow.

Flow of Gas-Solid and Liquid–Solid Mixture in Pipes: Flow patterns, Holdup, General correlations.

Freight Pipelines: Slurry transportation System, Pneumatic transportation System, Capsule transportation System, Measurement techniques.

Modeling Multiphase Flows: Introduction, General Multiphase Model, Volume of Fluid (VOF) Model Theory, Mixture Model Theory, Eulerian Model Theory, Wet Steam Model Theory, Modeling Mass Transfer in Multiphase Flows, Modeling Species Transport in Multiphase Flows, Solution Strategies for Multiphase Modeling.

References books

1. "The Flow of Complex Mixtures in Pipes", G.W. Govier & K. Aziz, Van Nostrand Reinhold Co., NY, 1972.
2. "Multiphase Fluid Flow Theory & Practice", F.G. Hammitt, McGraw-Hill Inc., NY, 1980.
3. "Computational Methods for Multiphase Flow" A. Prosperetti, G. Tryggvason, Cambridge University Press, 2009.

AM2147 Design of Experiments		
Designation	:	Elective
Pre-requisites	:	*Engineering Mathematics & Computer Programming*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction to Design of Experiments: Strategy of Experimentation, applications of Experimental Design, Basic Principles, Guidelines for DoE.

Basic Statistical Methods: Sampling and Sampling Distributions, Randomized Designs, Paired Comparison Designs, Inferences About the mean and Variances of Normal Distributions.

Analysis of Variance: The Analysis of Variance, Analysis of the Fixed Effects Model, Model Adequacy Checking, Practical Interpretation of Results, Determining Sample Size, The Random Effects Model, The Regression Approach to the Analysis of Variance, Nonparametric Methods in the Analysis of Variance.

Experiments with Blocking Factors: The Randomized Complete Block Design, The Latin Square Design, The Graeco-Latin Square Design, Balanced Incomplete Block Designs.

Factorial Experiments: Basic Definitions and Principles, The Advantage of Factorials, The Two-Factor Factorial Design, The General Factorial Design, Fitting Response Curves and Surfaces, Blocking in a Factorial Design.

Two-Level Factorial Designs: The 2^2 Design, The 2^3 Design, The General 2^k Design, A Single Replicate of the 2^k Design, Unreplicated 2^k Design, Addition of Center Points to the 2^k Design.

Blocking and Confounding Systems for Two-Level Factorials: Blocking a Replicated 2^k Factorial Design, Confounding in the 2^k Factorial Design, Confounding the 2^k, Factorial Design in Two Blocks.

Two-Level Fractional Factorial Designs: The One-Half Fraction of the 2^k Design, The One-Quarter Fraction of the 2^k Design, The General 2^{k-p} Fractional Factorial Design.

Regression Modeling: Linear Regression Models, Estimation of the Parameters in Linear Regression Models, Hypothesis Testing in Multiple Regression, Confidence Intervals in Multiple Regression, Prediction of New Response Observations, Regression Model Diagnostics, Testing for Lack of Fit.

Response Surface Methodology: Introduction to Response Surface Methodology, The Method of Steepest Ascent, Analysis of a Second-Order Response Surface, Experimental Designs for Fitting Response Surfaces, Experiments with Computer Models.

Random Effects Models: Random Effects Models, The Two-Factor Factorial with Random Factors, The Two-Factor Mixed Model, Sample Size Determination with Random Effects, Rules for Expected Mean Squares, Approximate *F* Tests.

Other Topics: Non-normal Responses and Transformations, Unbalanced Data in a Factorial Design, The Analysis of Covariance, Repeated Measures.

References books

1. Design and Analysis of Experiments, Douglas C. Montgomery, 8th Edition, Wiley.
2. Design and Analysis of Experiments (Springer Texts in Statistics), Angela M. Dean, Daniel Voss.
3. Experiments: Planning, Analysis, and Optimization (Wiley Series in Probability and Statistics) C. F. Jeff Wu, Michael S. Hamada.
4. Statistical Design and Analysis of Experiments, with Applications to Engineering and Science, Robert L. Mason, Richard F. Gunst, James L. Hess.
5. Statistical Design and Analysis of Experiments (Classics in Applied Mathematics No 22.) Peter W. M. John.
6. Statistics for Experimenters: Design, Innovation, and Discovery , George Box.
7. Designing Experiments and Analyzing Data: A Model Comparison Perspective, Second Edition by Maxwell and Delaney.
8. The Design of Experiments Sir Ronald Aylmer Fisher.
9. Design of Experiments for Engineers and Scientists, Jiju Antony.

AM2142 Convective Heat Transfer		
Designation	:	Elective
Pre-requisites	:	*Engineering Heat Transfer, Fluid Mechanics, Thermodynamics.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction: Physical origins and rate equations, Governing equations, units and dimensions, concepts of thermal boundary layer, displacement thickness, momentum thickness and energy thickness.

Laminar External flow and heat transfer: Blasius Solution, Temperature distribution over a flat plate boundary layer, Falkner-Skan and Eckert solutions, flow with transpiration, solutions for flow over an isothermal flat plate, flat plate with constant heat flux and with varying surface temperature, flows with pressure gradient.

Laminar internal flow and heat transfer: Exact solutions to Navier–Stokes Equations, Fully developed forced convection in pipes, Forced convection in the thermal entrance region of ducts and channels, heat transfer in the combined entrance region, Integral method for internal flows with different wall boundary conditions.

Natural Convection heat transfer: Governing equations for natural convection, Boussinesq approximation, Dimensional Analysis, Similarity solutions for Laminar flow past a vertical, Integral method for natural convection flow past vertical plate, effects of inclination, Natural convection in enclosures, mixed convection heat transfer past vertical plate and in enclosures.

Turbulent convection: Governing equations, Turbulence Models, Turbulent flow and heat transfer across flat plate and circular tube, Turbulent natural convection heat transfer, Empirical correlations for different configurations.

Latest development and state-of-art in convective heat transfer and its applications.

References books

1. Incropera F P and Dewitt D, "Fundamentals of Heat and Mass Transfer", John Wiley.
2. Kays W M and Crawford M E, "Convective Heat and Mass Transfer",McGraw Hill.
3. Bejan A, "Convection Heat Transfer", John Wiley
4. Schlichting H., " Boundary Layer Theory ", Sixth edition, McGraw Hill.

ME2148 Gas Turbines and Jet Propulsion		
Designation	:	Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Thermodynamics.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Review of Gas Dynamics: Physical difference between incompressible, subsonic and supersonic flows, three reference speeds, dimensionless velocity, concepts of static and stagnation parameters. Pressure waves, finite, shock and detonation waves, compound waves, Analysis of piston excited waves, shock tubes, one-dimensional isentropic flow, normal shocks, Rayleigh flow, Fanno flow.

Gas Turbine Outline: Review of Thermodynamic principles, Gas turbine cycles, main components of Gas turbine power plants, performance characteristics, typical Gas Turbine Plants. Methods of improving efficiency and power output of gas turbine plants.

Design considerations of Centrifugal and axial flow compressors.

Types of Gas turbine plants and their theory of operation, design consideration of gas turbine plants. Detailed study of main systems of gas turbine plants.

Selection of materials of Gas turbine components. Trouble shooting, maintenance and actual performance evaluation of gas turbine plants. Recent development of gas turbine plants.

Jet Propulsion Outline: Basic theory of Jet & rocket propulsion devices and historical development. Types of various jet propulsion plants like air screw, turboprop, turbojet, Ram jet, pulse jet, rocket propulsion, etc. and their comparative study.

Performance study of various jet propulsion devices from ideal and practical consideration.

Study and design considerations of main components of jet propulsion plants. Thrust augmentation devices and their thermodynamic analysis.

Combustion performance, products of combustion and their properties. Recent advances in jet propulsion and Rocket propulsion devices.

Latest trends and advancement in Gas Turbine and Jet Propulsion.

References books

1. "Gas Dynamics", E. Rathakrishnan, Prentice-Hall of India, New Delhi, 2002.
2. "Compressible Fluid Flow", M.A. Saad, Prentice-Hall, New Jersey, 1985.
3. "The Dynamics and Thermodynamics of Compressible Fluid Flow" (2 volumes), A. H. Shapiro, The Ronald Press, New York, 1953.
4. "Gas Turbine Fundamentals", Cohen, Rogers and Saravanamutto, Pearson Education.
5. "Jet Propulsion", Jack D. Mattingly, McGraw Hill Inc.
6. "Gas Turbines", V. Ganeshan, Tata-McGraw-Hill, New Delhi.
7. "Gas Turbines", R. Yadav.

Semester-II

AM2240 Turbulence		
Designation	:	Compulsory
Pre-requisites	:	*Engineering Fluid Mechanics, Thermodynamics, Engineering mathematics, Statistical methods.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction: Flow instability and transition to turbulence, Nature of Turbulence, Indicial notation for tensors, Fourier transforms and Parseval's theorem.

Governing Equations of Turbulence:

Eulerian, Lagrangian and Fourier descriptions of turbulence:

Statistical description of turbulence: Reynolds Averaged Navier-Stokes equations, Reynolds stress evolution equations.

Kolmogorov's Hypothesis: Diffusivity of turbulence and turbulence length scale.

Filtered Description of Turbulence: Bridging methods and large eddy simulation (LES).

Turbulent Free Shear Flows: Free Shear Flows- jet flows including heat transfer- 2D flows, wall jet and plane jets, its structure; turbulent jets, turbulent mixing layer and buoyancy effects- its structure; turbulent wake flows, wake of self propelled bodies; wall-bounded shear flows- its structure; boundary layer flows; thermal plume.

Wall Bounded Turbulent Flows: Turbulent flows in pipes, channels and boundary layers, Law-of-the-wall, Effects of surface roughness on turbulence.

Development of Turbulent closure models: Boussinesq approximation, Reynolds stress evolution closures.

Rapid Distortion Theory (RDT) of Turbulence:

Dynamics of Turbulence: Linear Instability Theory, Nonlinear Stability Analysis, Dynamical Systems, Introduction to Chaos. Vorticity dynamics- Reynolds stress and vorticity, vortex stretching, mean vorticity equation, kinetics energy and mean flow, kinetic energy of fluctuations, energy cascade, dissipation, material element deformation, mixing Navier-Stoke's equation for turbulent flow, turbulent energy dissipation equation.

Turbulence modeling: General comments on turbulence models; Method of solving turbulent equations- Direct numerical simulation (DNS), Large-eddy simulation (LES), Reynolds averaged Navier-Stokes equation (RANS), k-ε models. Turbulence models: Eddy viscosity models -zero equation models (constant eddy viscosity and mixing length models), one equation models, two equation models; Reynolds stress transport models (RSM). Wall treatments.

References books

1. "Turbulent Flows", S.B. Pope, Cambridge University Press, 2000.
2. "Turbulence Modeling for CFD" David C. Wilcox, DCW Industries, 3rd Edition, 2006.
3. "Viscous Fluid Flow", F.M. White, Tata McGraw Hill, 2011.
4. "A First Course in Turbulence", H. Tennekes and J.L. Lumley, The MIT Press, 1972.
5. "Turbulence", O. Hinze, McGraw Hill Inc.
6. "Turbulent Flow: Analysis, measurement and Prediction", Bernard, P.S., A.D. Wallace, J.M., John Wiley & Sons Inc., New Jersey, 2002.
7. "Turbulent Flows", Biswas, G. and Eswaran, V. Narosa Publishing, 2002.
8. "Turbulent Flows" (3rd ed.), Garde, New Age International, New Delhi.

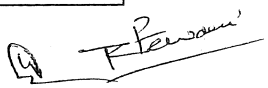
AM2253 Advanced Fluid Mechanics Laboratory		
Designation	:	Compulsory
Pre-requisites	:	*Basic knowledge of Fluid Mechanics and Engineering Mathematics, Computer Programming, CFD.*
Credit and Contact hours	:	0(L) - 0(T) – 6(P) – 4(Cr)
Assessment Methods	:	**Practical Examination: (Scheme)** End-Semester Exam: 50 marks.
		Internal Assessment: (Scheme) 50 marks (10 marks for attendance + 40 marks for sessional assessment and/or Term paper based on regular performance on Practical and Experimentation, Demonstration of knowledge and skill development through Surprise / Quiz Tests, Viva etc. and Assignments & Report Writing..

Syllabus

Experiment 1: Study of the pressure distribution over smooth and rough cylinder.
Experiment 2: Study of the Pressure distribution over symmetric airfoil.
Experiment 3: Study of the Pressure distribution over cambered airfoil& thin airfoils.
Experiment 4:Study of the characteristics of three dimensional airfoils involving measurement of lift, drag, pitching moment.
Experiment 5: Performance of an aerofoil with flap, influence of flap angle on lift, drag and stall.
Experiment 6: Flow visualization studies in low speed flow over airfoil with different angle of Incidence.
Experiment 7: Pressure distribution around a two- dimensional model in supersonic flow conditions, at different angles of attack.
Experiment 8: Lift coefficient for aerodynamic models in supersonic flow.
Experiment 9: Shock waves and expansion patterns around a two-dimensional model in supersonic flow conditions. (Flow visualization with Schlieren Apparatus.)
Experiment 10: Measurement of the Velocity profile in laminar and turbulent boundary layers.
Experiment 11: Measurement of the Velocity profile in the boundary layer at on rough and smooth plates.
Experiment 12: Measurement of the Velocity profile in the boundary layer at various distances from the leading edge of the plate.
Experiment 13: Measurement of Performance of a Centrifugal Pump and its Vibration Analysis.

References books

1. "Instrumentation, Measurements & Experiments Fluids", E. Rathakrishnan, CRC Press, NY, 2007.
2. "Low-Speed Wind Tunnel Testing", A. Pope and J.J. Harper, John Wiley & Sons Inc., NY, 1966.
3. "Experimental Methods for Engineers", J.P. Holman, McGraw-Hill Inc., NY, 2001.
4. "Design & Analysis of Experiments", D.C. Montgomery, Wiley, 7th ed., 2009.



AM2249 Advanced Computational Fluid Dynamics		
Designation	:	Elective
Pre-requisites	:	*Computational Fluid Dynamics..*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Multiphase Flow Modeling: Volume of Fluid (VoF) Method for Multiphase flow: Volume fraction equation, Advection of volume fraction, Geometrical Interface Reconstruction methods: Piecewise Line Interface Calculation (PLIC). Moment of Fluid (MOF), High Resolution Differencing schemes - Compressive Interface Capturing Scheme for Arbitrary Meshes (CICSAM) and Coupling with N-S solver. Level Set Method for Multi-Phase Flow. Level Set based Immersed Boundary Method for Moving Boundary Problems. Mixture model, Eulerian model, Wet steam model.

Finite Volume Method for Complex Geometry: Body-fitted coordinate grids for complex geometries, Cartesian vs. curvilinear grids, difficulties of curvilinear grids, Block-structured grids, unstructured grids and its discretization, discretization of diffusion and convective terms, treatment of source terms, assembly of discretized equations, Pressure-velocity coupling in unstructured meshes, staggered vs. co-located grid arrangements, extension of face velocity interpolation method to unstructured meshes.

Particle based simulation techniques: Molecular Dynamics (MD), Direct Simulation Monte Carlo (DSMC), Lattice Boltzmann Method (LBM). Application to LBM to bluff-body wake, microflow, and other fluid flow problems.

Introduction and basics of OpenFOAM: solver structure, setting up and running different examples, data visualization and analysis. Intermediate and Advance concepts in OpenFOAM: Programming in OpenFOAM, implementing a new solver and new boundary conditions.

Computer Architecture and Parallelization in CFD: Introduction to HPC and HPC Concepts. Parallel Programming: OpenMP, MPI and GPGPU programming.

References books

1. "An Introduction to Computational Fluid Dynamics: the Finite Volume Method", H.K. Versteeg and W. Malalasekara, 2nd edition, Pearson Education, England, 2007.
2. "Computational Fluid Dynamics for Engineers" B. Andersson & others, 1st edition, Cambridge University Press, U.K., 2012.
3. "Computational Fluid Flow and Heat Transfer" (2nd edition), K. Muralidhar and T. Sundararajan, Narosa Publishing, 2004.
4. "Numerical Heat Transfer and Fluid Flow", S.V. Patankar, McGraw-Hill, New York, 1980.
5. "Principles of Computational Fluid Dynamics", P. Wesseling, Springer-Verlag.
6. "Computational Techniques for Fluid Dynamics Volume I & II" (2nd edition), C.A.J. Fletcher, Springer-Verlag, 1991.
7. "Computational Fluid Mechanics and Heat Transfer" (2nd edition), J.C. Tannehill, D.A. Anderson and R.H. Pletcher, Taylor and Francis, 1997.
8. "Numerical Computation of Internal and External Flows" (Vols. I & II), C. Hirsch, Wiley International, 1988.
9. "Computational Fluid Dynamics for Engineers" (Vols. I & II), K. Hoffmann and S. T. Chiang, Engineering Education System, 1993.

AM2211 Fluid-Structure Interaction		
Designation	:	Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Strength of materials.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction to Fluid-structure interaction: Concept of fluid-structure interaction, brief history of fluid-structure interaction, dimensional analysis, concept of the hydrodynamic mass (added mass), hydrodynamic mass matrix.

Mathematical formulation of a simple fluid-structure interaction problem: Fluid domains, solid domains, coupling of the equations for fluid and structure.

Analysis Methods for Fluid-structure interaction problems: One-way separate analysis method (Hydrodynamics mass and damping method), Two-way coupled analysis method.

Vortex induced Vibration: Vortex wake of a stationery cylinder, Strouhal number, effects of cylinder motion on wake, analysis of vortex-induced vibration and its reduction.

Galloping and Flutter: Introduction to galloping, galloping instability, galloping response, vortex shedding, turbulence and galloping, flutter, prevention of galloping and flutter.

Instability of tube and cylinder arrays: Description of elastic instability, theory of fluid elastic instability, vibration of pairs of cylinders.

Vibration induced by Oscillatory flow: Inline forces and their maximum, inline motion, fluid force coefficients, transverse force and response, reduction of vibration induced by oscillating flow, ship motion in a seaway.

Vibration induced by turbulence and sound: Elements of the theory of random vibrations, sound and turbulence-induced vibration of panels, turbulence-induced vibration of tubes and rods, wind-induced vibration, response of aircraft to gusts, reduction of vibration induced by turbulence.

Fluid Coupling: Concentric cylinders with open ends of fluid filled annular gap, concentric cylinders with closed ends of fluid annular gap.

Damping of structures: Elements of damping, Definitions of damping coefficient and damping ratio, total damping, fluid (hydrodynamic) damping, structural (or support) damping, damping of bridges, towers, buildings, piping and aircraft structures.

Sound induced by Vortex shedding: Sound from single and vibrating cylinders, sound from multiple tubes and heat exchangers, sound from flow over cavities.

Examples of Fluid-structure interaction analyses: One-way separate analysis of fluid-induced vibration of steam generator tubes, two-way coupled analysis of flow-induced vibration of two tubes. Latest development in Fluid-Structure interaction.

References books

1. Robert D. Belvins (2001), Flow-induced Vibration, 2nd ed., 477 pp., Krieger Publishing Company, Malabar, Florida, USA.
2. J. Ballmann (ed.) (2003), Flow Modulation and Fluid-Structure Interaction at Airplane Wings, Springer.
3. N.G. Barton and J. Periaux (eds.) (2003), Coupling of Fluids, Structures and Waves in Aeronautics, Springer.

AM2241 Boundary Layer Theory		
Designation	:	Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Heat Transfer.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Incompressible Laminar Boundary Layers: Exact solutions of the Navier-Stokes equation exhibiting boundary layer at low viscosity. The boundary-layer equations in the spirit of Prandtl. Scaling, non-dimensionalisation and Reynolds number. Limitations of potential flow past a cylinder. Prandtl's boundary-layer equations in two dimensions deduced by order-of-magnitude arguments. Blasius solution: displacement thickness, skin friction, drag.

Transition and Incompressible Turbulent Boundary Layers: Concept of stability; basis of boundary layer stability analysis; physics of transition to turbulence. Reynolds stresses, mean velocity and shear stress in a turbulent boundary layer; the log law and power law profiles. Turbulent boundary layers in zero and non-zero pressure gradients. Separation in adverse pressure gradients. Concept of and occurrence in steady flows, and at rear stagnation point of impulsively started cylinder.

Boundary Layer Separation & Flow Control: Causes of boundary layer separation and its consequences, active and passive flow control, various different flow control techniques and their applications.

Introduction to Perturbation Theory: Regular and singular perturbations. Examples from algebraic equations and ordinary differential equations. The classical boundary-layer equations of Prandtl as the leading term in a matched asymptotic expansion. Exact solutions of the classical boundary-layer equations like Flow past a wedge: Falkner Skan. Far wake of a flat plate. Two-dimensional jet. Lock's mixing layer. Prandtl transformation. Prandtl-Glauert law for subsonic flow; Ackeret's law and applications. Axisymmetric flows: Mangler's transformation. Split disc Ekman layer problems: Stewartson layers. Glauert wall jet.

Thermal Boundary Layer: Introduction to thermal boundary layer, heat transfer in boundary layer, convective heat transfer, importance of non dimensional numbers, Prandtl number, Nusselt number, Lewis number etc.

References books

1. "Boundary Layer Theory", Schlichting, H., McGraw Hill Inc.
2. "The Laminar Boundary-Layer Equations", Curle, N., Oxford University Press.
3. "Laminar Boundary Layers", Rosenhead, L. (Edited), Oxford University Press.
4. "An Introduction to Fluid Mechanics", Batchelor, G. K., Oxford University Press.
5. "Separation of Flow", C.T. Chung, McGraw Hill Inc.

AM2242 Design of Pipe Networks		
Designation	:	Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Computer Programming*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction: uses, requirements, flow and pressure, Layout, PIPE GRAPHICS, Main sizing, Storage and pumping, Pipe valve fittings, Water meter, installation and testing

Basic Principles of Pipe Flow, Head Loss Equations.

Pipe Network Analysis Methods, Loop flow correction method, linear method. **Cost Considerations.**

General Principles of Pipe Network Synthesis: Water Transmission Lines, Water Distribution Mains, Single Input Source Branched Systems, Single Input Source Looped Systems,
Multi Input Source Branched Systems, Multi Input Source Looped Systems, Decomposition of a Large Water System and Optimal Zone Size, Reorganization of Water Distribution Systems.

Optimal design of branched pipe networks by linear programming problems (LPP): Dynamic and nonlinear programming for looped networks.

Reliability of distribution system

Fluid transients: water hammer: theory, boundary conditions, water column separation unsteady flow analysis by rigid column method graphical water hammer analysis air in pipeline .

Operation and maintenance of Pipe networks.

Term Paper: Development of program for Analysis and optimization of pipe network.

References books

1. Introduction to Urban Water Distribution: Unesco-IHE Lecture Note Series: by NemanjaT rifunovic.
2. Pipe Network Analysis, Eds. Lambert M Surhone, Mariam T Tennoe, Susan F Henssonow
3. Liquid Pipeline Hydraulics, E. ShashiMenon
4. Water distribution systems: simulation and sizing, Thomas M. Walski, Johannes Gessler, John W. Sjostrom
5. Analysis of flow in pipe networks, Roland W. Jeppson
6. Water distribution modeling, Volume 1, Thomas M. Walski, Donald V. Chase, DraganSavic
7. Analysis of Water Distribution Systems, Thomas M. Walski
8. Modeling, analysis, and design of water distribution systems, Lee Cesario, American Water Works Association
9. Advanced water distribution modeling and management, Volume 1, Thomas M. Walski
10. Simulation and analysis of gas networks, AndrzejOsiadacz
11. Hydraulic analysis of unsteady flow in pipe networks, J. A. Fox
12. Solving the Pipe Network Analysis Problem Using Optimization Techniques, School of Engineering and Applied Science, Southern Methodist University Nonlinear programs
13. Optimal design of water distribution networks, P.R. Bhave
14. Reliability analysis of water distribution systems, Larry W. May.
15. Performance in water distribution: a systems approach, SérgioTeixeira Coelho
16. Improving Efficiency and Reliability in Water Distribution Systems, Enrique Cabrera, Antonio F. Vela
17. Computer modeling of water distribution systems, American Water Works Association
18. Computer Applications in Water Supply: Systems optimization and control, Bryan Coulbeck
19. Integrated computer applications in water supply: Applications and implementations for systems operation and management. Vol. 2
20. Water transmission and distribution, American Water Works Association

AM2243 Thermo-Fluid Dynamics		
Designation	:	Elective
Pre-requisites	:	*Engineering Mathematics & Computer Programming*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Thermodynamic State Equations: Perfect and real gases, state equation of perfect gas, Amagat's isothermals, Detailed study of Van der Waal, Dieterio, Berthelot, Redlich and Kwong and other state equations for real gases, compressibility factor and compressibility chart, generalized chart.

Review of Thermodynamic Laws and Entropy: Reversibility and irreversibility, statements of second law and their discussion Equivalence of Kelvin-Planck and Clausius statements, Carnot engine and Carnot refrigeration, Thermodynamic temperature scale and absolute zero temperature, Clausius theorem and Clausius inequality, concept and characteristics of entropy Principle of increase of entropy and entropy of universe.

Availability and Irreversibility: Available energy lost work and degradation of energy, Maximum work, Availability – in a closed system and in a steady flow system, Gibbs function, Helmholtz function, Irreversibility and its measurement.

General Thermodynamic Relations: General relations from energy equations, specific heat relations, relations for internal energy, enthalpy and entropy, Joule-Thomson coefficient, Applications of general thermodynamic relations to ideal gas, Van der Waal and other state equations.

Review of Basic Equations and Steady State Conduction: General three-dimensional heat conduction equation, Steady one-dimensional heat conduction through simple and composite planes, cylindrical and spherical walls without heat generation, Effect of variable thermal conductivity, Critical thickness of insulation. Steady one-dimensional heat conduction through plane wall, hollow cylinder, solid cylinder and solid sphere with uniform heat generation, Heat transfer from finned surfaces, general equation, efficiency and effectiveness of fins, conduction in cooling of turbine balding, optimum dimensions, comparison of fin materials. Two-dimensional steady state heat conduction, Numerical and graphical methods, Analogical solution.

Unsteady State Heat Conduction: Heating and Cooling with negligible internal resistance, Temperature-time response of thermocouple, Heating and cooling with negligible surface resistance, Transient heat conduction in semi-infinite solids, Laplace's equation, Separation of Variables, Lumped capacitance methods, Heating and Cooling of infinite plate with finite internal and surface resistance, Numerical and graphical analysis.

Convection: Laminar and turbulent flow, hydrodynamic and thermal boundary layer. Dimensional analysis and dimensionless numbers for free and forced convection. Empirical relations and practical solution of free and forced convection in pipes, over plates and across cylinders and spheres, combined free and forced convection, combined free convection and radiation heat transfer.

References books

1. Introduction to Thermodynamics, Classical and Statistical, Third Edition, Sonntag, R.E., and Van Wylen, G, John Wiley and Sons, 1991.
2. Advanced Engineering Thermodynamics, Bejan, A., John Wiley and Sons, 1988.
3. Advanced Thermodynamics for Engineers, Kenneth Wark Jr., McGraw-Hill Inc., 1995.
4. Fundamentals of Heat & Mass Transfer, Incropera F.P. and DeWitt. D.P., John Wiley & Sons, 1996.
5. Analysis of Heat and Mass Transfer, Ozisik. M.N., McGraw Hill Co., 1980.
6. Heat Transfer - Basic Approach, Eckert. E.R.G., and Drake.R.M., McGraw-Hill Co., 1985.
7. Convection Heat Transfer, Bejan. A., John Wiley and Sons, 1984.

AM2243 Design of Heat Exchangers		
Designation	:	Elective
Pre-requisites	:	*Engineering Mathematics & Computer Programming*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction, classification and selection; heat exchanger thermo-hydraulic fundamentals;
heat exchanger design; compact heat exchangers; shell and tube heat exchanger design; regenerators; plate heat exchangers and spiral plate heat exchangers; Boilers, Re-boilers, condensers, Air cooled Heat exchangers,
Heat exchanger network design, Targeting and super targeting, Pinch design method, Network optimization,
heat-transfer augmentation; fouling; corrosion;
flow-induced vibration of shell and tube heat exchangers; mechanical design of shell and tube heat exchangers;
material selection and fabrication; quality control and quality assurance and nondestructive testing.
Latest advancement in Heat exchangers.

References books

1. Process Heat Transfer by DQ Kern.
2. Heat exchangers: Thermal-hydraulic fundamentals and design SadıkKakaç, A. E. Bergles, F. Mayinger.
3. Heat Exchanger Design Handbook Series:Dekker Mechanical Engineering, 2000, CRC Press.

AM2244 Design of Hydraulic Turbines		
Designation	:	Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Thermodynamics and Fluid Machineries.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Hydropower plants: Types, main components. Plant load factor, load duration curve, installed capacity, firm power, secondary power, and load prediction.

Penstocks and Water Hammer: Types of penstocks and their design criteria, Economical diameter of penstock, Valves, Bends, Manifolds, Effect of Water-hammer in penstock, Surge tanks.

Introduction to Hydraulic Turbines: Definition of head, discharge, power and efficiency of hydraulic turbines and hydro-unit. Classification based on head, specific speed, degree of reaction and direction of flow. Energy losses in turbines. Euler's energy equation, blade surface equation.

Impulse Turbines: Energy conversion in Pelton turbine, design parameters, design of turbine runner, nozzle, spear.

Reaction(Francis)Turbines: Classification, flow in runner, design parameters, determination of meridional flow, one-dimensional method of designing runner blades, relationship between the shape of blades and two-dimensional flow within runners. Blade designing in potential and rotational meridional flow. Draft tube- design and application. Deriaz turbine.

Reaction (Axial Flow) Turbines: Major definitions and relations concerning the flow within a runner, design parameters, flow upstream and downstream of the runner, determination of velocity triangles at inlet and outlet of the runner. Airfoil method of blade designing –cascade analysis and its performance, loss mechanism, blade profiles, forces acting on blades.

Cavitation in Hydraulic Turbine: Condition, types, consequences, remedy. Turbine cavitation coefficient, NPSH. Similarity laws in cavitating flows. Method of cavitation investigation in hydraulic turbines at laboratories and hydropower plants.

Turbine Performance Characteristics: Main characteristics and operating characteristics, iso-efficiency characteristics, Determination of major prototype turbine parameters on the basis of model characteristic curves. Derivation of the complete characteristics of prototype turbine. Distorted model, scale effect and efficiency.

Latest Trends and Development in Hydraulic Turbines: State-of-art for last few decades, latest design trends, newer applications in micro and pico-hydel power stations.

References books

1. "Water Power Engineering", H.K. Barrows, McGraw-Hill Book Co., New York.
2. "Hydropower Structures", R.S. Varshney, Nemchand & Brothers, Roorkee (U.P.), 1992.
3. "Hydraulic Turbines" (Volume I and II), V. V. Barlit, MACT- Bhapal, 1969.
4. "Hydraulic Machines", Jagdish Lal, Metropolitan Book Co., Delhi.
5. "Fluid Mechanics and Thermodynamics of Turbomachinery", 4th Edition,, S.L.Dixon, Butterworth and Heinemann, 1998.
6. "Hydraulic Turbine", M. Nechleba, McGraw-Hill Inc., New York, 1957.

AM2245 River Engineering		
Designation	:	Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Mathematics.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Characteristics of River.
Classification of flow, uniform flow, Gradually varied flow, Rapidly varied flow, unsteady flow.
Channelization, sediment transport, canalization and flood routing.
Interlinking of Rivers, River confluences and river network.
Bank erosion, River restoration, draught and flood management.
Latest advancement in river engineering and development of new techniques.

References books

1. River Mechanics. P Y Julien
2. Principles of river engineering: the non-tidal alluvial river. editorial board, P. Ph. Jansen.
3. Fluvial Processes in River Engineering: Howard H. Chang
4. Open-Channel Flow: M. Hanif Chaudhry.

ME2235 Advanced Gas Dynamics		
Designation	:	Elective
Pre-requisites	:	Fluid Mechanics, Thermodynamics
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
	:	**Internal Assessment (Scheme):**20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction: Glimpses of classical thermodynamics, statistical thermodynamics; Non-dimensionalization of Navier-Stokes and Energy equation with role of Mach number highlighted; stagnation quantities.

Normal Shocks: Governing equations, Rankine – Huguenot, Prandtl and other relations, weak shocks, thickness of shocks, normal shocks in ducts, performance of convergent-divergent nozzle with shocks, moving shock waves, shock problems in one dimensional supersonic diffuser, supersonic pitot tube.

Flow in Constant Area Duct with Friction: Governing equations, working formulas and tables, choking due to friction, performance of long ducts, Isothermal flow in long ducts.

Flow in Constant Area Duct with Heating and Cooling: Governing equations, working formula and tables, choice of end states, choking effects, shock waves with changes in stagnation temperature.

Generalized One-Dimensional Flow: Working equations, general method of solution, example of combined friction and area change, Example of combined friction and heat transfer.

Oblique shock: governing physical equations and general relations, shock polar diagram and auxiliary diagrams, strong and weak shocks, detached shock, interaction and reflection of shocks.

Method of characteristics: general principle of integration using method of characteristics, application to one dimensional isentropic progressive waves, application to steady two dimensional irrotational isentropic supersonic flows, Prandtl-Meyer expansion.

Boundary layer flow with Prandtl number unity and arbitrary Prandtl number, Integral equations of Laminar boundary layer, Differential and integral equations of Boundary layer, flow past a flat plate with turbulent Prandtl number of Unity. Elementary idea of boundary layer in tubes and in the presence of shock waves. Study of various flow visualization techniques. Study of different types of wind tunnels, their design criteria.

References books

1. "Gas Dynamics", E. Rathakrishnan, Prentice-Hall of India, New Delhi, 2002.
2. "Compressible Fluid Flow", M.A. Saad, Prentice-Hall, New Jersey, 1985.
3. "The Dynamics and Thermodynamics of Compressible Fluid Flow" (2 volumes), A. H. Shapiro, The Ronald Press, New York, 1953.
4. "Low-Speed Wind Tunnel Testing", A. Pope and J.J. Harper, John Wiley & Sons Inc., NY, 1966.
5. "Viscous Flow", F.M. White.

AM2246 Industrial Aerodynamics		
Designation	:	Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Aerodynamics.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Atmosphere: Types of winds, Causes of variation of winds, Atmospheric boundary layer, Effect of terrain on gradient height, Structure of turbulent flows.

Wind energy collectors: Horizontal axis and vertical axis machines, power coefficient, Betz coefficient by momentum theory.

Vehicle Aerodynamics: Power requirements and drag coefficients of automobiles, effects of cut back angle, aerodynamics of road vehicles, trains and hovercraft.

Building Aerodynamics: Pressure distribution on low rise buildings, wind forces on buildings. Environmental winds in city blocks, special problems of tall buildings. Building codes, building ventilation and architectural aerodynamics.

Flow induced vibrations: Effects of Reynolds number on wake formation of bluff shapes, vortex induced vibrations. Galloping and stall flutter.

References books

1. "Wind Effects on Structures: Fundamentals and Applications to Design" by Simiu and Scanlan, , 3rd Ed. John Wiley and Sons, Inc., 1996.
2. "Building Aerodynamics" by Tom Lawson, Imperial College Press, London, 2001.
3. "Aerodynamics and drag mechanisms of bluff bodies and road vehicles", M.Sovran (Ed), Plenum press, New York, 1978.
4. "Winds forces in engineering", P. Sachs, Pergamon Press, 1978.
5. "Car Aerodynamics", Hucho,
6. "Design Guides to wind loading of buildings structures (Part I & II)" by N J Cook, Butterworths, London, 1985.
7. ASCE/SEI 7-10 Minimum Design Loads for Buildings and Other Structures.
8. IS: 875 (1987) Part III Wind loads, Indian Standards for Building codes.

AM2247 Design of Impeller Pumps		
Designation	:	Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Fluid machinery.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction: Classification of pumps, layout of rotodynamic pumps, head, discharge, power and efficiencies. Dimensional analysis, non-dimensional parameters, condition of similarity, specific speed and its significance. Elements of pumps- impeller, casings, diffusers etc.

Centrifugal Pumps: Classification, single stage and multi-stage pumps, components, priming, pressure rise in pumps, cavitation, NPSH, Thomas cavitation factor, axial thrust.

Flow through Impeller: Euler's fundamental equations, theoretical head for an infinite number of blades, influence of a finite number of blades, pressure and velocity distribution in impeller passages, influence of circulation in impeller passages, influence of pre-whirl on head, choice of blade outlet angle, stalling and surging.

Axial & Mixed Flow Pumps: Geometry of the axial flow impeller vanes, experimental design factors- impeller hub ratio, chord spacing ratio, number of vanes, vane curvature and thickness. Airfoil theory of vanes. Helical pumps and diagonal pumps.

Impeller Design: Geometrical velocity fields, evolution of impeller shapes, impellers with blades of single and double curvature, design calculation of the impeller- principal dimensions. Blade design- blade surface area, blade shape and blade angles, method of determining blade angle for centrifugal and axial impellers. Relation between overall efficiency and specific speed.

Pump Casing: Flow at the outlet of the impeller, volute casing, volute design for optimum efficiency, circular volutes. Crossover, diffusion casing and diffusion rings, axial diffusers.

Pump Characteristics: Classification of characteristics, non-dimensional characteristics, pump operation at off-design conditions, affinity of characteristic curves, iso-efficiency curves, flow conditions corresponding to the optimum efficiency, influence of flow conditions on pump operation,. Pump in series and parallel. Matching of pumps to system characteristics; multi-stage pumps. Losses in pumps, total head-discharge curves.

Pump for special duties: Deepwell pump– submersible pump and vertical turbine pump. Storage pump, turbine pump, boiler-feed pump, circulating pump, condensate pump, non-clog pump, marine pump, self-priming pump.

References books

1. "Impeller Pumps", Stephen Lazarkiewicz and A.T. Troskolanski, Pergamon Press, Warsaw, 1965.
2. "Centrifugal and Axial Flow Pumps- Theory, Design and Applications", A. J. Stepanoff, John-Wiley & Sons, 1967.
3. "Pumps, Fans and Compressors", A. de Kovats and G. Desmur, Blackie & Son Ltd., Glasgow, 1958.
4. "Rotodynamic Pump Design" by R.K. Turton,
5. Centrigfugal Pumps & Blowers" by A. Church and Jagdish Lal, Metropolitan Book Co., Delhi.
6. "Pump Handbook", I.J. Karassic, Tata McGraw Hills Ltd. New Delhi.
7. "Critical Aspects in Rotodynamic Pumps and systems", R.K. Srivastava, Techo Economic Research Institution, New Delhi.
8. "Fluid Mechanics and Thermodynamics of Turbomachinery", 4th Edition, S.L.Dixon, Butterworth and Heinemann, 1998.

AM2248 Condition Monitoring, Diagnosis and Predictive Maintenance of Pumps		
Designation	:	Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Fluid machinery.*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Syllabus

Introduction: Diagnosis of machine condition and faults, Need and benefits of Condition Monitoring, Machine life cycle, Maintenance Management in Industry, Condition Monitoring and diagnostics of Hydraulic and Electro-pneumatic systems.

Performance analysis and testing of pumps for condition monitoring: Visual Inspection, Measurement of Temperature, Pressure, Flow, Speed and Power. Head Power Characteristics, Shutoff Head method, Balance leak-off flow method for monitoring of pumps.

Acoustic and Vibration Monitoring: Setting band levels for monitoring, Measurement of vibration, General severity assessment, Analyzing and Using the vibration spectrum, Vibration phase angle, Resonance, Specific vibration severity standards for pumps, advanced methods of vibration analysis of pumps, Control of vibration.

Wear Monitoring: Rate of wear, Effects of internal wear on pump performance and its efficiency.

Other monitoring: Corrosion Monitoring, Condition monitoring of shaft seals, Monitoring of seal-less pumps, Non-Destructive Testing, Analysis of wear debris in lubricants.

Monitoring of Positive displacement pumps: Performance characteristics, Condition monitoring by vibration analysis, Condition monitoring by performance analysis, Condition monitoring by analysis of wear particles in liquid pumped.

Performance Improvement Program and Predictive Maintenance: Basic types of maintenance, Application and Benefits of Cost Effective Maintenance, Performance analysis and its application to optimize time for overhaul using shut-off head test results, Knowledge Based Systems for Maintenance Management, Reliability centric maintenance, Modern Maintenance Management Systems.

Expert System: Application of Genetic Algorithm, Artificial Neural Networks and Fuzzy logic for Condition Monitoring, diagnosis and prediction of service life and maintenance management.

Standards, Patents and current research relevant to Condition Monitoring, Diagnosis and Maintenance Management.

Case studies and Term Paper: in detected performance shortfall and in condition monitoring of pumps.

References books

1. Predictive maintenance of pumps using condition monitoring: Ray S. Beebe
2. An Introduction to Predictive Maintenance: R. Keith Mobley
3. Engineering condition monitoring: practice, methods and applications: Ron Barron
4. Handbook of condition monitoring: BKN Rao
5. Handbook of Condition Monitoring: Techniques and Methodology: A. Davies
6. Pump User's Handbook: Life Extension, Heinz P. Bloch, Allan R. Budris
7. Intelligent condition monitoring and diagnosis systems: a computational intelligence approach: Kesheng Wang
8. CMS 110 R – Condition Monitoring Standards– Pump Vacuum Nash
9. CMS 111 R – Condition Monitoring Standards– Pump – Vertical –Multistage
10. CMS 153 R - Condition Monitoring Standards– Pump – Progressive Cavity
11. Modern Pumps: A Comprehensive Survey of Modern Pumping Equipment and Practice, Edward Mollo
12. Know and Understand Centrifugal Pumps L. Bachus, A Custodio.

Master of Technology

in

MATERIAL SCIENCE AND ENGINEERING

Course Structure, Scheme of Evaluation and Syllabi

(Effective from July 2017)

Department of Applied Mechanics

Motilal Nehru National Institute of Technology Allahabad
Allahabad, U.P. -211004, INDIA

Course Structure

I Semester (Total Credits = 20):

I Semester (Total Credits = 20):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM2101	Applied Mathematics and Computation	4	0	0	4	20	20	60
AM2103	Advanced Material Science and Engineering	4	0	0	4	20	20	60
AM21XX	**Elective-I**	4	0	0	4	20	20	60
AM21XX	**Elective-II**	4	0	0	4	20	20	60
AM21XX	**Elective-III**	4	0	0	4	20	20	60

List of Electives (Semester I):

Elective-I		Elective-II		Elective-III	
AM2120	Thermodynamics & Kinetics of Materials	AM2123	Mechanical Behaviour of Materials	AM2124	Ceramic Technology
AM2121	Electrical, Electronic, Magnetic and Optical Materials	AM2110	Applied Elasticity	AM2125	Non-Destructive Testing
AM2122	Polymer Science & Engineering	AM2102	Continuum Mechanics	AM2126	Nanomaterials

II Semester (Total Credits = 20):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM2202	Characterization of Materials	4	0	0	4	20	20	60
AM2252	Material Synthesis and Characterization Laboratory	0	0	6	4	50	-	50
AM22XX	**Elective-IV**	4	0	0	4	20	20	60
AM22XX	**Elective-V**	4	0	0	4	20	20	60
AM22XX	**Elective-VI**	4	0	0	4	20	20	60

List of Electives (Semester II):

Elective-IV		Elective-V		Elective-VI	
AM2203	Bio-Materials	AM2222	Carbon Nanotube and Carbon Nanostructures	AM2225	Materials in Service
AM2220	Computational Material Science	AM2223	MEMS and Bio-MEMS	AM2213	Mechanics of Composite Materials
AM2221	Energy Materials	AM2224	Electroacoustic Transducers	AM2218	Continuum Damage Mechanics

III Semester (Total Credits = 20):

S. No.	Subject Name	Credits
AM2393	Special Study/Term Project/State of the Art/Colloquium/Industrial/Research Training	4
AM2394	Thesis/Project	16

IV Semester (Total Credits = 20):

S. No.	Subject Name	Credits
AM2494	Thesis/Project	20

Note: The distribution of thesis evaluation marks will be as follows:

1. Supervisor(s) evaluation component: 60%
2. Oral Board evaluation component: 40%

Semester-I

AM2101 Applied Mathematics and Computation		
Designation	:	Compulsory
Pre-requisites	:	Engineering Mathematics and computer programming
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for Assignment submission, Surprise tests, Term paper, Quiz tests, etc.)

Syllabus

Review of Elementary Engineering Mathematics: Solution of homogeneous and non-homogeneous equations; Power series; Laplace transform and its applications; Fourier series and Fourier transform

Linear Algebra: Matrices and Linear Transformations, Operational Fundamentals of Linear Algebra, Systems of Linear Equations, Gauss Elimination Family of Methods, Special Systems and Special Methods, Numerical Aspects in Linear Systems, Eigenvalues and Eigenvectors, Diagonalization and Similarity Transformations, Jacobi and Givens Rotation Methods, Tri-diagonal Matrices, QR Decomposition Method, Eigenvalue Problem of General Matrices, Singular Value Decomposition, Direct and Iterative solvers.

Ordinary Differential Equations: Introduction to ordinary differential equations, homogeneous linear equations of second order, non-homogeneous linear equations of second order, free and forced oscillation problems, problems with variable coefficients, system of equations.

Partial Differential Equations (PDEs): Existence and uniqueness of differential equations, nature of solution, Hyperbolic, Parabolic and Elliptic PDEs, nonlinear PDEs.

Nonlinear Equations: Motivation, Open and braketing method, Bisection, Fixed point, Newton's method, Secant and False position method, Rate of convergence, Merits and demerits of methods.

Numerical Integration: Motivation, Newton-Kotes method, Trapezoidal rule, Simpson's rule, Rhomberg integration, Gauss Quadrature.

Initial Value Problem: Motivation, Euler's method, Modified Euler method, Runge-Kutta methods, Adaptive integrations and multistep methods.

Boundary-value and Eigen-value Problem: Methods and Applications in Mechanics.

References books

1. "Numerical Methods in Engineering", M. Salvadori, Prentice Hall International, 1961.
2. "Applied Numerical Methods", B. Carnahan, Krieger Pub, 1990.
3. "Applied Numerical Analysis", C.F. Gerald and P.O. Wheatley, 5th edition, Addison-Wesley, 1998.
4. "Numerical Mathematics & Computing", W. Cheney and D. Kincaid, 5th edition, Brooks/Cole, 2004.
5. "Applied Partial Differential Equations", Paul DuChateau and David Zachmann.
6. "Partial Differential Equations for Scientists and Engineers", Stanley J. Farlow.
7. "Numerical Methods for Partial Differential Equations", William F. Ames.
8. "Numerical Methods for Elliptic and Parabolic Partial Differential Equations", John R Levison, Peter Knabner, Lutz Angermann.

AM2102 Continuum Mechanics		
Designation	:	Elective
Pre-requisites	:	Basic Engineering Mathematics, Linear Algebra
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Mathematical Preliminaries and Introduction: Index notation, range and summation convention, free and dummy indices, Kronecker delta, Levi-Civita symbol, co-ordinate transformations, Cartesian tensor, properties of tensors, tensors as linear operators, invariants of tensor, eigen values and Eigen vectors, polar decomposition, scalar, vector and tensor functions, comma notation, gradient of a scalar, gradient of a vector, divergence and curl of a tensor, integral theorems of vectors and tensors. Notion of a continuum, configuration, mass and density, descriptions of motion, material and spatial coordinates.

Kinematics of Deformation and Motion: Deformation gradient tensor, stretch and rotation, right and left Cauchy-Green deformation tensors, Eulerian and Lagrangian strain tensors, strain-displacement relations, infinitesimal strain tensor, infinitesimal stretch and rotation, compatibility conditions, principal strains and strain deviator, material and local time derivatives, stretching and vorticity, path lines, stream lines, vortex lines, Reynolds transport theorem, circulation and vorticity.

Forces and Stresses: Body and surface forces, Cauchy Stress Tensor, First and Second Piola-Kirchhoff Stress Tensor, Deviatoric and Pressure Components, Principal Stress.

Fundamental Balance Laws of Continuum Mechanics: Balance of Mass – Continuity Equation; Balance of Linear Momentum – Equations of Motion / Equilibrium Equations; Moments of Momentum (Angular Momentum); Balance of Energy - First Law of Thermodynamics, Energy Equation; Equations of State – Entropy, Second Law of Thermodynamics; Clausius-Duhem Inequality, Dissipation Functions

Constitutive Relations and Material Models: Constitutive Assumptions; Ideal Fluids; Elastic Fluids, Hyperelastic Material; Notion of Isotropy; Isothermal Elasticity - Thermodynamic Restrictions, Material Frame Indifference, Material Symmetry; Hooke's law, Stokes problem and Newtonian fluids.

References books

1. Lawrence E. Malvern, Introduction to the Mechanics of a Continuous Medium, Prentice Hall Inc.
2. An Introduction to Continuum Mechanics: Morton M. Gurtin, Academic Press.
3. Introduction to Continuum Mechanics for Engineers: Ray M. Bowen, Plenum Press.
4. G. Thomas Mase and George E. Mase, Continuum mechanics for engineers, CRC Press.
5. Theory and Problems of Continuum Mechanics: George E. Mase, Schaum's Outline Series-McGraw-Hill.
6. Nonlinear Continuum Mechanics for Finite Element Analysis: J. Bonet & R.D. Wood, Cambridge Uni. Press.
7. Han Chin Wu, Continuum mechanics and plasticity, Chapman and Hall.

AM2103 Advanced Material Science and Engineering		
Designation	:	Compulsory
Pre-requisites	:	Basic Materials Science and Engineering, Chemistry
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Crystal Structure: Types of bonding, crystal structures of metals and alloys, imperfections in crystals, structure, and properties relationships in engineering materials.

Equilibrium Diagrams: Phase rule. binary equilibrium diagrams, micro-structural changes during cooling; the iron carbon equilibrium diagram; principles and effect of alloying elements on transformation characteristics, Copper-Zinc equilibrium diagram, ternary equilibrium diagrams, experimental determination of equilibrium diagrams.

Phase Changes: Types of phase changes, diffusion in solids, nucleation and growth kinetics, solidification, T-T-T-diagrams, C-C-T diagrams; effect of heat treatment on properties, precipitation and age hardening; recovery, recrystallization and grain growth.

Processing of Metals: Solidification of metals, casting, extrusion, drawing, forging and rolling; powder metallurgy techniques, fabrication through welding, influence of processing and heat treatment on microstructure. quantitative survey of processing,

Engineering Alloys and Applications: Introduction to steel and alloy specifications; important alloy steels and non-ferrous alloys; cast irons– types, high temperature alloys, light alloys: aluminium and its alloys copper and its alloys, bearing alloys, shape memory alloy.

Advanced Materials and Materials Engineering: Smart materials exhibiting ferroelectric, piezoelectric, optoelectric, semiconducting behavior, lasers and optical fibers, photoconductivity and superconductivity, nanomaterials: synthesis, properties and applications; biomaterials, superalloys, shape memory alloys; superhard cutting tool materials and superhard coatings. Ultra light Materials and Metallic Foams: Definition and processing, characterization of cellular metals, properties; various materials and coatings for implants; Coatings and high temperature materials.

Fundamentals of Molecular Self-Assembly: Nanoscale and colloidal systems, fundamentals of surface and interfacial chemistry, surface tension and wettability, insoluble monolayers, surface chemistry and monolayers, electrostatic interactions in self assembling systems, self-assemble of amphiphiles monolayers, micelles and microemulsions, structure and properties of micelles.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

References books

1. Material Science for Engineers: An Introduction, W. D. Callister, Jr, John Wily and Sons, Inc.
2. The Science and Engg. of Materials, Donald R. Askeland, Pradeep P. Fulay, Wendelin J. Wright, Global Engg.
3. Introduction to Physical Metallurgy, Avner S. H., 2nd ed., McGraw Hill.
4. Physical Metallurgy, Raghavan V., Prentice Hall of India.
5. Principles of Thermal Analysis and Calorimetry, Peter J. Haines, Royal Society of Chemistry.
6. Modern Physical Metallurgy and Materials Engineering, R. E. Smallman, R. J. Bishop, Butterworth-Heinemann.
7. Phase Transformations in Metals and Alloys, David A. Porter, Kenneth E. Easterling, 2nd Ed., Nelson Thornes Ltd. (Chapman & Hall).
8. Structure of Metals, Barrett C. S. & Massalski T. B., McGraw Hill, New York.

AM2110 Applied Elasticity		
Designation	:	Elective
Pre-requisites	:	Mechanics of Materials
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Analysis of Stress: Concept of Stress, Stress Components, Equilibrium Equations, Stress on a General Plane (Direction Cosines, Axis Transformation, Stress on Oblique Plane through a point, Stress Transformation), Principal Stresses, Stress Invariants, Deviatoric Stresses, Octahedral Stresses, Plane Stress, Stress Boundary Condition Problem.

Analysis of Strain: Deformations (Lagrangian Description, Eulerian Description), Concept of Strain, Strain Components (Geometrical Interpretation), Compatibility Equations, Strain transformation, Principal Strains, Strain Invariants, Deviatoric Strains, Octahedral Strains, Plane Strain, Strain Rates.

Stress-Strain Relations: Introduction, One-Dimensional Stress-Strain Relations (Idealized Time independent and Time–dependent stress-strain laws), Linear Elasticity (Generalized Hooke's Law), Stress-Strain Relationships for Isotropic and Anisotropic Materials (Plane stress and Plane Strain)

Basic Equations of Elasticity for Solids: Introduction, Stresses in Terms of displacements, Equilibrium Equations in terms of displacements, Compatibility equations in Terms of Stresses, Special cases of Elasticity equations (Plane Stress, Plane strain, Polar Co-ordinates), Principle of Superposition, Uniqueness of Solution, Principle of virtual work, Potential and Complementary energy, Variational Principles, St. Venant's Principle, Methods of analysis for Elastic Solutions, Elastic solutions by Displacement and stress Functions, Airy's Stress Function (Plane stress, Plane strain, Polar Co-ordinates).

Torsion: Introduction, Circular shaft, Torsion of non-circular cross-section, St. Venant's theory, Warping function, Prandtl's stress function, Shafts of other cross-sections, Torsion of bars with thin walled sections.

Viscoelasticity: Introduction, Viscoelastic models (Maxwell, Kelvin-Voigt, Generalized Maxwell and Kelvin models), Viscoelastic stress-strain relationships.

References books

1. Mathematical Theory of Elasticity" by I. S. Sokolnikoff.
2. "Advanced Mechanics of Materials" by Boresi.
3. "Theoretical Elasticity" by A. E. Green and W. Zerna.
4. "Theory of Elasticity" by Timoshenko.
5. "Advanced Strength and Applied Elasticity" by A. C. Ugural and S. K. Fenster.
6. "Applied Elasticity" by R.T.Fenner.
7. "Advanced Strength of Materials" by L. S. Srinath.

AM2120 Thermodynamics & Kinetics of Materials		
Designation	:	Elective
Pre-requisites	:	Thermodynamics
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction: Review of thermodynamic functions, laws of thermodynamics, enthalpy, heat capacity, internal entropy, configurational entropy, free energy functions and their relationships, Gibbs-Helmholtz relations, Maxwell relations, Clausius-Clapeyron equation, importance of thermodynamics in materials science-illustrations and examples; applications in areas of materials technology, industrial and process metallurgy, related calculation.

Thermodynamic Reactions and Rate of Processes: Thermally activated processes in materials, stability of materials, activation energy, potential barrier, Arrhenius equation, rate of reactions- first order, second order, etc, introduction to solutions, mixing functions, ideal and non-ideal solutions, related calculations, thermodynamics involved with rate of loading (anelastic behaviour / adiabatic loading.

Thermal Properties of Materials: Specific heat - Debye and other models, heat capacity, thermal expansion, thermal conduction, thermal stress and shock, melting point.

Phase Equilibria: Thermodynamics of solutions, equilibrium stability of phases, single phase system, Evolution of phase diagrams – construction, interpolation and thermodynamic evaluation, Hume-Rothery rules, phase rule, free-energy, composition diagrams, solidus–liquidus lines; retrograde solidus, binary, ternary and quaternary phase diagrams, pseudo-binary and pseudo-ternary systems with examples, calculations in phase thermodynamics.

Crystal Growth: Formation of crystals, theories of crystal growth, homogeneous and heterogeneous nucleation/crystal growth; criteria for equilibria in crystal growth; solid solubility; kinetics of growth - nucleation, diffusion and surface migration, dislocation; motion of dislocation, dislocation density; super-cooling; growth of single crystal of high perfection, whiskers and whiskers growth.

Phase Transformations: Classification of phase transformations, order of transformation, Gibbs rule and applications, rapid solidification and its methods, glass transformation, alloy solidification – cellular, dendritic, eutectic, peritectic, eutectoid; boundary transformations; recrystallization, grain growth; effect of alloying elements; strengthening mechanisms, shape memory effects/alloys, thermodynamics and metallography / polymorphism.

Thermodynamics of Multi-Component System: Gibbs-Duhem equation for ternary and multi-components systems, kinetics of solidification and melting, thermodynamics of melts.

Thermodynamics of Defects / Dislocations: Thermodynamics of lattice defects. enthalpy of formation of vacancy, interstitial and substitutional impurity, Frenkel's defects, calculations on all these topics, thermal energy required to minimize the dislocations.

Thermodynamics of Ceramics, Polymers and Composites: Phase changes in Ceramics, glass transition, glasses, phase changes in polymers and amorphous materials, phase changes in composites, metallic glasses.

Thermodynamics of Surfaces and Interfaces: Surface energy, surface tension, absorption kinetics of diffusion in solids. rate controlling mechanism of interface reactions, energy, shape, segregation at external and internal interfaces, theory of interface stability.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

References books

1. Gaskell David R, 'Introduction to Metallurgical Thermodynamics', McGraw Hill, Latest edition.
2. Jere H. Brophy, Robert M. Rose and John Wulff, 'The Structure and Properties of Materials, Vol II; Thermodynamics of structure', Wiley Eastern Pvt. Ltd., New Delhi, Latest edition.
3. Tupkary R. H., 'Introduction to Metallurgical Thermodynamics', Latest edition., Tu Publishers, Nagpur, 1995 onwards edition.
4. Upadhyaya G. S. and R. K. Dube, 'Problems in Metallurgical Thermodynamics and kinetics', Latest edition Pergamon Press, 1977 onwards.
5. Kenneth M. Ralls, Thomas H. Courtney and John Wulff, 'Introduction to Materials Science and Engineering', Wiley Eastern Ltd., Latest edition.
6. W. Kurz and D. J. Fisher, 'Fundamentals of Solidification', Trans. Tech. Publication, Switzerland.
7. R. W. Balluffi, S. M. Allen and W. C. Carter, 'Kinetics of Materials', John Wiley.
8. G. Khachaturyan, 'Theory of Structural Transformation in Solids', Wiley Interscience Publishers.
9. M. Alper, 'Phase Diagrams: Material Science and Technology', Vol 6, Academic Press.
10. Alok Gupta and Chatterjee, 'Thermodynamics and Phase Equilibrium'

AM2121 Electrical, Electronic, Magnetic and Optical Materials		
Designation	:	Elective
Pre-requisites	:	None
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction: Classification of materials on the basis of energy gap, conductors, semiconductors, dielectrics, superconductors, ferroelectrics, pyroelectrics, piezoelectrics, perovskites (titanates, zirconates, hafnates) etc.

Electrical Properties and Conducting Materials: Mechanism of electrical conduction, electron theories of solids, free electron theory, factors affecting electrical conductivity, Wiedemana-franz law, Lorentz number, thermoelectric properties, characteristics, properties and examples of high voltage conducting materials, high and low resistance materials, contact fuse and fuse materials. conductors, cable & wire materials, solder, sheathing, and sealing materials, electrical properties of these materials, related calculations.

Electronic Properties and Semiconducting Materials: Energy band theory, Brillouin zone theory, Fermi energy level, effective mass, concept of doping, energy diagrams, types of semiconductors, semiconductor compounds and alloys and their properties. structures of semiconductors, amorphous semiconductor, materials for different devices, related calculations.

Superconductivity and Superconducting Materials: Concept of superconductivity, Phenomenon, properties of superconductors, Meissner effect, critical magnetic field & critical temperature, types of superconducting materials, Type I & II superconductors, Silsbee rule, mechanism of superconduction. BCS theory, Debye temperature. London's & Glag theories, high temperature ceramic superconductors, applications: NMR, maglev, MHD etc., recent advances, related calculations.

Dielectric Properties and Insulating Materials: Dielectric constant, dielectric strength and dielectric loss, polarizability, mechanism of polarization, factors affecting polarization, polarization curve and hysteresis loop, types of dielectric materials-solid, liquid and gaseous types; natural and synthetic types, characteristic, properties, and applications of different types of mica, transformation oil, vacuum etc., ferroelectrics, piezoelectric, pyroelectrics, electrostriction effect, Clausius -Mosotti equation, related calculations.

Magnetic Properties and Magnetic Materials: Origin of magnetism, basic terms and properties, types of magnetic materials, introduction to dia, para, ferro, antiferro and ferrimagnetic materials, Curie temperature, laws of magnetic materials, domain theory, domain growth and domain wall rotation, magnetic anisotropy, magnetostriction & its mechanism, ferrites, spinels & garnets, ferromagnetic domains, magnetic hystersis. magnetoplumbite, hexaferrite, magnetic hysteresis loop, hysteresis loss, hard and soft magnetic materials, magnetic tape, magnetic bubble, magnetic glasses, high energy hard magnetic materials, commercial magnetic materials such as supermalloy, alnico, cunife, cunico etc., conventional and non-conventional applications, characterisation of magnetic materials, recent developments, related calculations.

Optical and Optoelectronic Materials: Optical properties, solar cell, principles of photoconductivity, effect of impurities, principles of luminescence, types; semiconductor lasers; LED materials, photoelectronic materials, effect of composition on band gap, LCD materials, photo detectors, application of photoelectronic materials, introduction to optical fibers, light propagation, electro-optic effect, Kerr effect.

Recent Advances. Developments and Researches: Spintronics: materials and devices, diamond semiconductors, ferromagnetic semiconductors, giant magneto- resistance (GMR), left handed materials, left and right handed (LH & RH) composite materials, diluted magnetic semiconductor etc.

Fabrication of Electronic and Opto-electronic Devices: Methods of crystal growth, zone refining.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Electrical Properties of Materials, L. Solymar, D. Walsh, Oxford University Press, USA.
2. Introduction to the Electronic Properties of Materials, David C. Jiles, Taylor and Francis.
3. Introduction to Magnetism and Magnetic Materials, D.C. Jiles, Springer.
4. Optoelectronic Materials and Device Concepts, Manijeh Razeghi, SPIE-International Society for Optical Engine.
5. Structure and Properties of Materials Volume IV, Rose R. M., Shepard L. A., Wulff J.
6. Electrical and Electronics Engineering Materials, 4th Edition, K.M. Gupta,Umesh Publication, Delhi.
7. Introduction to Magnetic Materials, B. D. Cullity, Addison-Wesley Publishing Company, California, London, 1972.

8. Modem Ferrite Technology, A. Goldman, Van Nostrand, New York, 1990.
9. Magnetism and Magnetic Materials, J. P. Jakubovics, Institute of Materials, London, 1994.
10. Physics of Dielectric Materials, Tareev B.,MIR, 1975.
11. Electronic Properties of Materials, Rolf E. Hummel, Springer, 2004.
12. Principles of Electronic Materials and Devices, Safa O. Kasap, McGraw-Hili, 2005.
13. Electronic Materials Science, Irene, Wiley-Interscience, 2006.
14. Smart Electronic Materials: Fundamentals and Applications, Jasprit Singh, Cambridge University Press, 2005.
15. Principles and Applications of Ferroelectrics and Related Materials, M. E. Lines, A. M. Glass, Oxford University Press, USA, 2001.
16. Solid State Physics, Dekker A. J. Macmillan India, 1995.
17. Modem Magnetic Materials: Principles and Applications, Robert C., O' Handley, Wiley-Interscience, 1999.

AM2122 Polymer Science & Engineering		
Designation	:	Elective
Pre-requisites	:	Chemistry
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Chemistry of Polymers: Monomers, functionality, degree of polymerizations, classification of polymers, criteria for rubberiness, polymerization methods: addition and condensation; their kinetics, copolymerization, monomer reactivity ratios and its significance, different copolymers, random, alternating, azeotropic copolymerization, block and graft copolymers, techniques for copolymerization-bulk, solution, suspension, emulsion. molecular weight and size of polymers, glass transition temperature and associated properties for polymers, kinetics of polymerization, crystalinity in polymers.

Polymer Characterization: Solubility and swelling, concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights, polymer crystallinity, analysis of polymers using IR, XRD, thermal (DSC, DMTA, TGA), microscopic (optical and electronic) techniques.

Synthesis and Properties: Commodity and general purpose thermoplastics: PE, PP, PS, PVC, Polyesters, Acrylic, PU polymers. Engineering Plastics: Nylon, PC, PBT, PSU, PPO, ABS, Fluoropolymers Thermosetting polymers: PF, MF, UF, Epoxy, Unsaturated polyester, Alkyds. Natural and synthetic rubbers: Recovery of NR hydrocarbon from latex, SBR, Nitrile, CR, CSM, EPDM, IIR, BR, Silicone, TPE.

Polymer Blends and Composites: Difference between blends and composites their significance, choice of polymers for blending, blend miscibility-miscible and immiscible blends, thermodynamics, phase morphology, polymer alloys, polymer eutectics, plastic-plastic, rubber-plastic and rubber-rubber blends, FRP, particulate, long and short fibre reinforced composites. Polymer Technology: Polymer compounding-need and significance, different compounding ingredients for rubber and plastics, cross-linking and vulcanization, vulcanization kinetics.

Polymer Rheology: Flow of Newtonian and non-Newtonian fluids, different flow equations, dependence of shear modulus on temperature, molecular/segmental deformations at different zones and transitions, measurements of rheological parameters by capillary rotating, parallel plate, cone-plate rheometer, viscoelasticity-creep and stress relaxations, mechanical models, control of rheological characteristics through compounding, rubber curing in parallel plate viscometer, ODR and MDR.

Polymer Processing: Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, extrusion, pultrusion, calendaring, rotational molding, thermoforming, rubber processing in two-roll mill, internal mixer.

Polymer Testing: Mechanical-static and dynamic tensile, flexural, compressive, abrasion, endurance, fatigue, hardness, tear, resilience, impact, toughness. Conductivity-thermal and electrical, dielectric constant, dissipation factor, power factor, electric resistance, surface resistivity, volume resistivity, swelling, ageing resistance, environmental stress cracking resistance. ASTM codes for polymer testing.

Degradation of Polymers: Effects of vapours and solvents on polymeric materials, oxidation, mechanical, photodegradation and thermal degradation of polymers, compatibility, solubility, permeability, radiation damage and chemical resistance of polymers.

Processing of polymers: Flow properties of polymers, extrusion, injection and blow moulding, calendering, vacuum and pressure forming and warm forging, casting of fibres and filaments, assembly by adhesion, thermal and mechanical bonding, control of properties like chain length, molecular weight distribution etc.

Heat Treatment: Standard heat treatment procedures for polymers.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Polymer Science, Vasant R. Gowariker, N. V. Viswanathan & Jayadev Sreedhar.
2. Encyclopedia of Polymer Science and Technology, Herman F. Mark.
3. Essentials of Polymer Science and Engineering, Paul C. Painter and Michael M. Coleman.
4. Physical Properties of Polymers, James Mark, Kia Ngai, William Graessley, Leo Mandelkern, Edward Samulski, Jack Koenig, George Wignall.
5. Plastics Engineering, R. J. Crawford, Pergamon Press.
6. Text Book of Polymer Science, Billmeyer, John Wiley & Sons.
7. Polymer Physics, Ulf W. Gedde, Chapman & Hall

AM2123 Mechanical Behavior of Materials		
Designation	:	Elective
Pre-requisites	:	Strength of Materials, linear Algebra
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Overview: Different responses of material to loading, material properties, macroscopic experiments and its relevance, physical mechanisms controlling the behavior.

Elasticity: Atomic structure and bonding, Atomic interaction, physical origin of elastic modulus, Generalized Hooke's law, orientation dependence of elastic modulus.

Plasticity: Theoretical shear strength of crystals, Point, line and volume defects, edge and screw dislocations, Burgers circuit and Burgers vector, force between dislocations, movement and interactions of dislocations, slip planes, twinning, strengthening mechanisms, work hardening, grain boundary strengthening and solid solution strengthening, true stress-strain curve, necking phenomenon, yield criteria, plastic stress- strain relationships.

Viscoelasticity and viscoplasticity: Responses of viscoelastic materials under different loading, creep and relaxation, Maxwell and Kelvin models.

Creep and Fracture: Primary, secondary and tertiary creep, creep mechanisms, dislocation creep, diffusion creep and grain boundary creep, creep laws, Analysis and Applications in Design. Brittle, ductile and fatigue fracture, fracture surfaces, Griffith's theory, modes of fracture, energy release rate, stress intensity factor, crack tip plasticity, J-integral and Crack Tip Opening Displacement

Fatigue: Cyclic loads, constant amplitude and variable amplitude loads, cycle counting techniques, infinite life, safe-life, fail-safe, damage-tolerant design philosophies, Low cycle and high cycle fatigue, Stress-Life approach, Strain-Life approach and Fracture mechanics approach, Cumulative damage theories.

Mechanical Characterization of Materials: Mechanical testing for material Characterization, Measurement techniques in experimental solid mechanics, Non destructive testing

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Norman E. Dowling, Mechanical behavior of materials : Engineering Methods for Deformation, Fracture and Fatigue, Prentice Hall.
2. Marc Meyers and Krishnan K. Chawla, Mechanical behavior of materials, Cambridge University Press.
3. William F. Hosford, Mechanical behavior of materials, Cambridge University Press.
4. Thomas H. Courtney, Mechanical behavior of materials, Overseas Press.
5. Joachim Roesler, Harald Harders, and Martin Baeker, Mechanical Behavior of Engineering Materials, Springer.
6. Prashant Kumar, Elements of fracture mechanics, Tata McGraw Hill.
7. S. Suresh, Fatigue of Materials, Cambridge University Press
8. RW Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, John Wiley & Sons.
9. D. Hull, DA Bacon, Introduction to dislocations, Pergamon.
10. G. E. Dieter, Mechanical Metallurgy, McGraw Hill.

AM2124 Ceramic Technology		
Designation	:	Elective
Pre-requisites	:	Basic Material Science and Engineering
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction: Introduction, history, types and nature, conventional ceramics, applications, bonding, crystallography, etc.

Structure of Ceramics: Lattice points, directions, and planes, basic structures, silicates, silica, glass, ceramic oxides, perovskite structure, etc.

Defects in Ceramics: Point defects, linear defects, planar (surface) defects, interfaces, and non-equilibrium structure.

Properties of Ceramics: Mechanical properties, thermal properties, electrical properties, optical properties, magnetic properties, failure modes in ceramics, property structure relationship.

Ceramic Phase Diagrams and Phase Equilibrium: Law of partial pressures, determination of phase diagrams, uniary (carbon, SiO_2), binary (NiO/CoO, MgO/CaO, $MgO/MgAl_2O_4/Al_2O_3$, BeO/Al_2O_3, MgO/TiO_2), ternary ($MgO/Al_2O_3/SiO_2$, $CaO/Al_2O_3/SiO_2$, $Na_2O/CaO/SiO_2$), and quaternary (SiO_2–Al_2O_3–AlN–Si_3N_4) systems.

Processing: Powder synthesis and sintering, glass forming processes, drawing, hot & cold pressing, fibre forming, blowing, powder crushing, slip casting, hydro plastic forming, extrusion, centring, jiggering, sol-gel processing, anvil technologies, ceramic coating, fusion casting, dyeing and firing, gas phase, liquid phase, solid phase ceramic fabrication processes, CVD, directed metal oxidation, reaction bonding, polymerisation, metal casting, ceramic-composite processing, etc.

Bioceramics: Introduction, history, and uses, biological properties, processing of bioceramics, etc.

Ceramics Environmental Impact: Life cycle assessment of ceramics, emissions and consumptions, case studies.

Advanced Ceramics and their Applications: Toughened ceramics, cermets, functionally graded materials, piezoelectric ceramics, ceramic magnets, high temperature super-conducting magnets, glass ceramic composites, chemically bonded ceramics, ceramics in electrical applications, electro ceramics, etc.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

References books

1. Introduction to ceramics, W. D. Kingery, Harvey Kent Bowen, Donald Robert Uhlmann.
2. Ceramic Materials: Science and Engineering, C. Barry Carter, M. Grant Norton, Springer.
3. Handbook of Advanced Ceramics Vol II, Processing and their Applications, Shigeyuki Somiya, Elsevier Acadmic Press.
4. Mechanical Properties of Ceramics, Watchman J. B., John Wiley, New York.
5. Series in Materials Science and Engineering – Fundamentals of Ceramics, Michel W. Barsoum, Institute of Physics Publishing, Bristol and Philadelphia.
6. Phase Equilibria and Crystallography of Ceramic Oxides, Journal of Research of the National Institute of Standards and Technology, Volume 106, Number 6, November–December 2001.
7. Electronic Ceramics, IEEE transactions.
8. Ceramic Processing and Sintering, M. N. Rahman, Marcel Dekker, Inc./CRC Press.

AM2125 Non-Destructive Testing		
Designation	:	Elective
Pre-requisites	:	Physics
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc).

Syllabus

Overview of NDT: NDT Versus Mechanical testing, Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterization. Relative merits and limitations, Various physical characteristics of materials and their applications in NDT, Visual inspection Unaided and aided.

Surface NDE methods: Liquid Penetrant Testing – Principles, Types and properties of liquid penetrants, Developers, Advantages and limitations of various methods, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, Inspection materials Magnetisation methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.

Thermography and eddy current testing (ET): Thermography- Principles, Contact and non contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation – infrared radiation and infrared detectors, Instrumentations and methods, applications. Eddy Current Testing- generation of eddy currents, properties of eddy currents, eddy current sensing elements, probes, instrumentation, types of arrangement, applications, advantages, limitations, interpretation/evaluation.

Ultrasonic testing (UT) and acoustic emission (AE): Ultrasonic Testing-Principle, Transducers, Transmission and pulse-echo method, Straight beam and angle beam, Instrumentation, Data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique, AE parameters, Applications

Radiography (RT): Principle, Interaction of X-Ray with matter, Imaging, film and film less techniques, Types and use of filters and screens, Geometric factors, Inverse square law, Characteristics of films – graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy- Xero-Radiography, Computed Radiography, Computed Tomography.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

References books

1. Baldev Raj, T.Jayakumar, M.Thavasimuthu, 'Practical Non-Destructive Testing', Narosa Publishing House, 2009.
2. Ravi Prakash, 'Non-Destructive Testing Techniques', 1st revised edition, New Age International Publishers, 2010.
3. 'ASM Metals Handbook, Non-Destructive Evaluation and Quality Control', American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
4. Paul E Mix, 'Introduction to Non-destructive testing: a training guide', Wiley, 2nd Edition New Jersey, 2005.
5. Charles, J. Hellier, 'Handbook of Nondestructive evaluation', McGraw Hill, New York 2001.
6. ASNT, American Society for Non Destructive Testing, Columbus, Ohio, 'NDT Handbook Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing'.

Tewari

AM2126 Nanomaterials		
Designation	:	Elective
Pre-requisites	:	Chemistry
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction to Nanotechnology: Nano technology, nano science, MEMS, CNT, fullerene, nano machines, semiconductor technology etc.

Solid State Physics: Introduction, structure (physics of solid state), FCC nanoparticle, semiconductor structures lattice vibration, energy band, reciprocal space, fermi surfaces, localized particles, mobility, exciton, etc.

Methods of Measuring Properties: Measurement methods, structure – atomic, crystallography, particle size, mass spectroscopy, LEED, RHEED, surface structures, microscopy – TEM, SEM, FIM, AFM etc.

Properties of Nanoparticles: Properties of nano-particles, metal nano-clusters, semi conducting nano-particles, semi conducting nano-particles, rare gas & molecular clusters, methods of synthesis.

Carbon Nanostructures: Carbon nano-structures, carbon-molecule, carbon clusters, C_{60}, $C_{20}H_{20}$, C_8H_8, CNT, applications.

Bulk Nanostructured Materials: Solid disordered nanostructures: synthesis, failure, mechanical properties, multilayers, electrical properties, other properties, composite glasses, porous silicon, nanostructured crystals: natural crystals, array in zeolites, metal nanoparticles, photonic crystals.

Nanostructured Ferromagnetism: Basic, para, ferro, ferri, antiferro-magnetism, effect of bilk nanostructuring on magnetic properties, dynamics of nanomagnets, nanopore containment, nanocarbon ferromagnets, giant and colossal magnetoresistance, ferrofluids.

Quantum Nanostructure, Self Assembly and Deposition: Quantum wells, wires and dots, preparation, size effect, single electron tunneling, etc., monolayer, multiplayer, LB film deposition, CVD, PVD, sputtering etc.

Homework: Report on history & current status of nanotechnology, nanomanufacuring, nanomachines, etc.

Project: Small research project summarized in a four-page write-up on the nano-fabrication, nanodevice (abstract style). One presentation based on the research work of any paper of your choice in the field of nanoscience and nanotechnology, visits to various labs.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Introduction to Nanotechnology, C. P. Poole Jr. and F. J. Owens, Wiley Inter Science.
2. Nano Structures and Nano Materials: Synthesis, Properties and Applications, Guozhong Cao- Imperial College Press.
3. Nanomaterials, A. K. Bandyopadhyay, Newage International (p) Limited.
4. Nanostructured Materials Processing, Properties and Applications, Carl C Koch, Jaico Publishing House.
5. Nanotechnology, William Illsey Atkinson, Jaico Publishing House.

Semester-II

AM2202 Characterization of Materials		
Designation	:	Compulsory
Pre-requisites	:	Basic Materials Science and Engineering at UG Level
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Crystallography: Overviews in bonding, Bravais lattices, Miller indices, imperfections in crystals, crystal structures of common metal, ceramics, polymers. symmetries in crystals, point groups, space groups, reciprocal lattice, morphology

X-ray Diffraction Techniques: Production of X-rays, its properties and hazards, photon scattering, X-ray diffraction and Bragg's law, intensities calculations, Laue techniques, Debye-Scherrer techniques. modern diffractometers, diffractometer measurements, determination of crystal structure of powder sample, small angle scattering, line broadening, particle size, crystallite size, residual stress measurement, plane indexing, precise parameter measurement, phase identification, phase quantification, phase diagram determination, stereographic projection, pole figure, preferred orientation (texture analysis) and chemical analysis, profile fitting and Rietveld analysis.

Optical Microscopy: Principles and operations of microscopy, resolution, magnification, numerical aperture, depth of field, viewing area, contrast, geometry of optical microscopes, application of microscopy in metallurgical studies (qualitative and quantitative), morphology and symmetry, grain boundaries and dislocations, phase contrast microscopy, polarized light microscopy, hot-stage microscopy, sample preparation.

Electron Microscopy: Electron sources, electron diffraction, principles and operation of scanning electron microscope. Construction of electron microscopes, specimen handling and preparation, secondary electron image, backscattered electron image, image processing, analysis of electron micro-graphs and fractography studies, transmission electron microscopy (TEM).

Scanning Probe Microscopy: Principles and operation of scanning probe microscopes, scanning tunneling microscope, atomic force microscope, magnetic force microscopy, topography studies, nano-indentation and its probing.

Thermal Analysis: Thermo gravimetric analysis, differential thermal analysis, differential scanning calorimetery, thermo-mechanical analysis and their applications.

Solid State and Surface Spectroscopies: Electron Energy Loss Spectroscopy (EELS), Reflection Absorption Infra-red Spectroscopy (RAIRS), Transmission IR, Raman, Photoelectron Spectroscopy (PES), Auger Electron Spectroscopy (AES), X-ray Fluorescence (XRF), Nuclear Magnetic Resonance (NMR), Extended X-ray Absorption Fine Structure (EXAFS).

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Crystals and Crystal structures, R.J.D. Tilley, John Wiley and Sons, 2006
2. Elements of X-ray Diffraction, Cullity B. D., Addison-Wesley Publishing Co.
3. Electron Microscopy and Analysis, P.J. Goodhew, F.J. Humphreys, Taylor & francis, Second edition.
4. Solid state chemistry and its Applications, Antony R. West, Wiley Student Edition.
5. Fundamentals of Molecular spectroscopy, Colin N. Banwell and Elaine M. McCash, Tat McGraw-Hill Publishing Co. Ltd., Fourth edition.
6. Materials Characterization :Introduction to Microscopic and Spectroscopic, Yang Leng, John Wiley&Sons.

R Tewari

AM2203 Bio-Materials		
Designation	:	Elective
Pre-requisites	:	None
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Classes of biomaterials, Bulk Properties of Materials, Surface properties and surface characterization of materials, Properties of biomaterials: Physical, thermal, electrical and optical properties of bio-materials. Biocompatibility, Biofunctionality , Mechanical and Biological Testing of Biomaterials

Metallic Implant Materials: Stainless steels, Co-based alloys, Ti and Ti-based alloys and Other metals.

Corrosion of metallic implants.

Ceramic Implant Materials: Aluminum oxides, Calcium Phosphate, Glass Ceramics and Carbons. Medical applications of Ceramic Materials.

Polymeric implant: Polymerization, Polymeric implant materials, Degradable Polymers used for Biomedical Applications. Silicone used for Biomaterials, Hydrogels, Smart Polymers as biomaterials, Polymers used for drug delivery and Tissue Engineering Applications. Natural polymers found in human body, Composites as Biomaterials, Cardiovascular Biomaterials, Orthopedic Biomaterials, Ophthalmological Biomaterials, Biomaterials for soft tissue applications and hard tissue application. Biomaterials used for artificial skin, artificial hair implantation etc.

Novel Biomaterials and Uses in Engineering and Tissue Engineering.

Recent advances in the field of Biomaterials.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Buddy D. Ratner Allan S. HoffmanFrederick J. SchoenJack E. Lemons Biomaterials Science, Second Edition: Wiley Science.
2. Jef A. Helsen H. Jürgen Breme Metals as Biomaterials Wiley.
3. Kinam Park and Randall J. Mrsny Controlled Drug Delivery Designing Technology for the future American chemical society Publication.
4. Park .J.B. & Lakes R.S, Biomaterials: An Introduction, Plenum Press, New York.
5. Silver F .H, Biomaterials, Medical Devices &TissueEngineering: An Interated approach, Chapman &Hall.

AM2213 Mechanics of Composite Materials		
Designation	:	Elective
Pre-requisites	:	Continuum Mechanics / Solid Mechanics, Basic Engineering Mathematics, Linear Algebra, Differential Equations
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction: Classification and characteristics of composites, Conventional vs. Composite materials, Advantages and limitations, Salient applications in various fields, Fabrication technologies, Properties of matrix and reinforcement materials

Micromechanics: Fiber volume fraction, micro-mechanical relations, determination of strength and stiffness, Environmental effects-Hygro-thermal behavior.

Macromechanics: Basic stress-strain relationships for anisotropic materials, engineering constants for orthotropic materials, stress-strain relations for a lamina of arbitrary orientation, effective moduli, invariant properties of anorthotropic lamina, special cases of laminate stiffness, laminate strength analysis, concept of inter-laminar stresses and delamination

Failure theories and Damage mechanics: Failure mechanisms, maximum stress theory, maximum strain theory, Tsai-Hill theory, Tensor polynomial failure criterion, first ply failure theory, Introduction to damage theory based on continuum damage mechanics.

References books

1. Carl T. Herakovich, Mechanics of fibrous composites, John wiley & sons.
2. R. F. Gibson, Principles of Composite Material Mechanics, McGraw Hill Inc.
3. R. M. Jones, Mechanics of Composite Materials.
4. Stephen W.Tsai and H. Thomas Hahn, Introduction to Composite Material.
5. J. R. Vinson and T.W. Chou, Composite Materials and their use in Structures.
6. 6.J. N. Reddy and A.V. Krishna Moorty, Composite Structures, Testing, Analysis and Design.
7. 7.D. Gay, S. V. Hoa, S. W. Tsai, Composite Materials - Design and Applications, CRC Press

AM2218 Continuum Damage Mechanics		
Designation	:	Elective
Pre-requisites	:	Continuum Mechanics, Linear Algebra, Differential Equations
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Essentials of Continuum mechanics: Tensorial notation, stress, strain, invariants, equilibrium equations, Domain and validity of continuum damage mechanics, concept of representative volume element.

Phenomenological aspects of damage: Damage, measurement of damage, modeling of damage through effective area reduction, void volume fraction and stiffness reduction, representation of damage through different orders of tensors, concept of effective stress, hypothesis of strain equivalence, strain energy equivalence, and complementary strain energy equivalence.

Thermodynamics of damage: State variables, damage as state variables, first and second law of thermodynamics, thermodynamics potentials, dissipation potentials, constitutive equations, evolution equations.

Kinetic Laws of Damage Evolution: Unified formulation of damage laws, damage laws for brittle, quasi-brittle, ductile, creep, low cycle and high cycle fatigue.

Damage Analysis of Structures: Implementation of isotropic damage theory, case studies from literature.

References books

1. Jean Lemaitre, A Course on damage mechanics, Springer.
2. S. Murakami, Continuum damage mechanics, Springer.
3. Jean Lemaitre and J. L. Chaboche, Mechanics of solid materials.
4. L. M. Kachanov, An Introduction to damage mechanics, Kluwer Academic publisher.
5. P. I. Kattan and G. Z. Voyiadjis, Damage mechanics with finite elements, Springer
6. Dusan Krajcinovic, Damage mechanics, North Holland.
7. George Z. Voyiadjis and Peter I. Kattan, Damage mechanics, Taylor and Francis

AM2220 Computational Material Science		
Designation	:	Elective
Pre-requisites	:	Applied Mathematics and computation
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction and Fundamentals: Introduction to various regimes, multiscale modelling & simulation of materials, System size vs computation time, Parallel processing

Ab Initio Methods: Density functional theory, quantum mechanics, schrodinger wave equation, many particle system, car parrinello method, born openheimer approximation, hohenberg-kohn theorem, kohn sham formulation, local density approximation, bloch's theorem, pseudo potential, energy minimisation techniques, examples of crystals and non-crystals.

Lattice Mesoscale methods: Lattice gas automata, lattice director model.

Coarse graining: Particle based models-Lattice gas model, connolly williams approximation, spatial models, dynamic (temporal) models, application to polymer and polar materials. grain continuum modelling, computational micro-mechanics, multiscale coupling.

Term Paper on application of Multiscale Modelling to Composite damage, Dislocation behavior, Phase field modeling, Modelling of grain growth and microstructure in polycrystalline materials, Modelling of structural materials And other recent advances based on literature survey

Term paper on material modeling.

References books

1. Introduction to Materials Modelling, Ed Zoe H. Barber, Maney Publishing.
2. Computational Material Science From Ab Initio to Monte Carlo Methods, K. Ohno, K.Esfarjani, Y. Kawazoe, Springer.
3. Multiscale Materials Modelling: Fundamentals and Applications, Ed Z Xiao Guo, Woodhead Publishing Limited, Cambridge.
4. Computational Meso-mechanics of Composites, Leon Mishnaevsky, Jr., John Wiley & Sons.
5. Multi-scale modelling of Composite Material Systems, C. Soutis & P. W. R. Beaumont Woodhead Publishing Ltd.
6. Continuum Scale Simulation of Engineering Materials-Fundamentals, Microstructures, Process Applications, Dierk Rabbe, Barlat,Wiley.
7. Annual Review of Materials Research on Computational Materials Research, Vol 32.
8. Understanding Molecular Simulation- from Algorithm to Application, Frenkel Daan, Smit Berend. Academic Press.
9. Notes of Workshop on Computational Materials Science, Indian Institute of Sciences, Bangalore, 06-08 Mar 2009.
10. Computational Material Science, Dierk Raabe, Wiley-VCH Verlag GmbH
11. Multiscale Modelling & Simulation, Attringer & Coumoutsakos, Springer
12. Computational Materials Design, Tetsuya, Springer
13. Combinatorial Material Science, Balaji narasimhan, Surya K Mallaprajada, Wiley
14. Materials Informatics, Data-Driven Discovery in Material Sc, Krishana Rajan, Wiley.

AM2221 Energy Materials		
Designation	:	Elective
Pre-requisites	:	None
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Nuclear Metallurgy: Structures and properties of materials with special relevance for nuclear power generation: uranium and other actinides, beryllium, zirconium, rare-earth elements, graphite. The materials of nuclear fuels and nuclear fuel element fabrication. Reprocessing of nuclear fuel elements.

Nuclear Power Plant and Their Materials: Nuclear reactor, pressurised reactor, breeder reactor. Materials for fuel, control rods, coolant, moderator, shielding.

Effects of Radiation on Materials Properties: Effects of α,β, γ rays on creep, fatigue, tensile, and other properties of metals, alloys, ceramics, polymers, rubbers etc. Effects on electrical, electronic and magnetic behaviour of materials. Effects on crystal structure, grain size etc.

Materials in Fuel cells and Solar Cells Electrocatalyst materials for low temperature fuel cells, Conductive membranes for low-temperature fuel cells, Materials for high temperature fuel cells, silicon, quantum dots for solar energy, nanomaterials for solar thermal energy and photovoltaic.

Materials in Thermal Power Generation Superalloys, steels, ceramics, TBC, hydrogen membrane materials, sensor and sensor materials, biomass, coal, flyash, etc.

Materials in Hydro Power Generation Materials for power plant components, steel, stainless steel, ceramics, etc.

Energy storage Artificial photosynthesis/solar to fuels, CO2 separation and utilization, Safer nuclear waste disposal, biofuels production, biological fuel cell technologies, reduction of energy use in manufacturing processes, Improved grid technologies, sustainable energy economic.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Introduction to Nuclear Science, Bryan, J. C., CRC Press.
2. Fundamentals of Radiation Materials Science, G.S. Was, Springer
3. Nuclear Reactor Materials and Applications, B.M. Ma, Van Nostrand Reinhold Company.
4. Nuclear Reactor Materials, C.O. Smith, Addison-Wesley Publishing Company.
5. Fundamentals Aspects of Nuclear Fuel Elements, D.R. Olander,
6. Structural Materials in Nuclear Power Systems, J. T. A. Roberts, Plenum Press.
7. Handbook of Fuel Cells, Wolf Vielstich, Arnold Lamm, Hubert A. Gasteiger, and Harumi Yokokawa, John Wiley and Sons, Inc.
8. Advanced power plant materials, design and technology, Edited by D Roddy, Woodhead Publishing Series in Energy No. 5 and CRC Press

AM2222 Carbon Nanotube and Carbon Nanostructures		
Designation	:	Elective
Pre-requisites	:	None
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc).

Syllabus

Introduction to Carbon Nanostructure: Carbon molecule, carbon small clusters, carbon big clusters, fullerenes, discovery of C_{60}, synthesis of C_{60}, properties of C_{60}, other buckeyballs, CNT.

CNT Morphology: From a graphene sheet to a nanotube, structure - chiral nanotubes, singlewall, multiwall and bundled nanotubes, zigzag and armchair nanotubes, Euler's Theorem in cylindrical and defective nanotubes.

Production Techniques of Nanotubes: Growth of single-wall/multiwall nanotubes, carbon arc bulk synthesis in presence and absence of catalysts, high purity material (bucky paper) production using pulsed laser vaporization (PLV) of pure and doped graphite, high-pressure co-conversion (HIPCO), nanotube synthesis based on Boudoir reaction-chemical vapor deposition (CVD), laser ablation, synthesis of aligned nanotube films.

Structural, Electronic Properties: Structural changes in free standing and interacting nanotubes – librations, rotations, twistons, effect of inter tube interactions on the electronic structure, electronic structure of graphite as building block of nanotubes, effect of chirality and discrete atoms, conducting versus insulating nanotubes, band structure of metallic carbon nanotubes, effect of doping on conductivity, electrical properties, vibrational properties, chemical properties, mechanical properties, physical properties, optical properties.

Applications of Nanotubes Harnessing field enhancement, flat panel displays, hydrogen storage, carbon nanotubes & drug delivery, structural application of CNTs, CNT nanocomposites.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

References books

1. Carbon Nanotubes, M. Endo, S. Iijima, M. S. Dresselhaus, Pergamon.
2. Carbon Nanotubes: Advanced Topics in the Synthesis, Structure, Properties and Applications, Ado Jorio, Mildred S. Dresselhaus, and Gene Dresselhaus, Springer.
3. Carbon Nanostructures, Springer.
4. Physics of Carbon Nanostructures, Stefano Bellucci, Alexander Malesevic, Springer.
5. Fullerenes, Nanotubes, and Carbon Nanostructures, F. D'Souza, P. Kamat, N. Martin, R. Weisman, S. Rotkin, H. Shinohara, Z. Slanina, Y. Iwasa, L. Wilson, N. Solladie: ECS Transactions: Vol 6, Issue 16.
6. Carbon Nanotube and Graphene Device Physics, H.-S. Philip Wong and Deji Akinwande, Cambridge University Press, 2011.

AM2223 MEMS & Bio-MEMS		
Designation	:	Elective
Pre-requisites	:	None
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction: MEMS, microsystem, sensor, actuator, history, market, applications, etc.

Review of Essential Mechanical, Electrical Concepts: Mechanical: stress, strain, beam, cantilever, plates, bending, thermal stress, torsion of beam, fracture, vibration etc, Electrical: Conductor, insulator, semiconductor.

Scaling Laws in Miniaturization: Scaling in geometry, force, electricity, fluid, heat transfer, etc.

Material for MEMS: Review of crystal structure, miller indices, material for MEMS, substrate, device, packaging, silicon, silicon compound, gallium arsenide, piezoelectric martial, quartz, polymer, biomaterials and biocompatibility issues etc.

Micro Total Analysis System (μTAS): Fluid control components, μ-TAS: sample handling, μ-TAS: separation components, μ-TAS: detection, cell handling and characterization systems, systems for biotechnology and PCR, polynucleotide arrays and genetic screening.

Sensing and Actuation: Electrostatic sensing and actuation, thermal sensing and actuation, piezoelectric and piezoresistive sensing and actuation, magnetic sensing and actuation, miniature biosensors, biosensors arrays and implantable devices, neural interfaces, microsurgical tools, micro needles, and drug delivery, Microsystems for tissue engineering, tissue scaffolds, optical biosensors, etc.

Fabrication of MEMS: Bulk micromachining, surface micromachining, lithography, LIGA, SLIGA, etc.

MEMS Packaging: MEMS metrology, Overview of packaging of microelectronics, packaging design, technique, material, etc.

MEMS Design and Software: Design methodologies for MEMS, study of following softwares based on availability: Ansys multiphysics, COMSOL multiphysics, MatLab, Intellisuite, AutoCAD, SolidWorks, Spice, Ledit, etc.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

References books

1. Foundations of MEMS, Chang Liu, Pearson Education International.
2. MEMS and MICROSYSTEM Design and Manufacture, Tai-Ran Hsu, Tata Mcgraw-Hill Publishing Company Ltd., New Delhi.
3. Microsystem Design, S. D. Senturia, Kluwer Academic Publishers.
4. Fundamentals of Microfabrication, Marc Madou, CRC Press, NY.
5. Microsystem Technology in Chemistry and Life Sciences, A. Manz and H. Becker, Eds. Springer-Verlag, New York.
6. Fundamentals of Micro Fabrication, the Science of Miniaturization, M. Madou, Nanogen Corporation, USA, CRC Press.

AM2224 Electroacoustic Transducers		
Designation	:	Elective
Pre-requisites	:	None
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction to Acoustics: Acoustic variables & basic relations, plane & spherical waves, reflection & transmission, radiation & reception of acoustic waves, absorption and attenuation of sound.

Electro-Mechano-Acoustical Analogy: Introduction, basic equations and impedances, transformer and gyrator, simple harmonic oscillator, Helmholtz resonator, loop analysis, circuit elements, Lagrange equation.

Acoustical Elements: Basic acoustic elements, specific acoustic impedance, mechanical impedance, electrical impedance, acoustic radiation impedance, duct impedance, equivalent circuit model, various acoustical examples, frequency and wavelength, dB scale, sound pressure level.

Basic Theory and Modeling of Microphone: Introduction, types, response, sensitivity, specifications, directivity pattern, microphone array, microphone equation, electret condenser microphone (ECM), ECM model for various types of microphone.

Basic Theory and Modeling of Moving Coil Transducer: Introduction, types, reciprocal and anti-reciprocal system, TS parameters, speaker non-linearities, equivalent circuit representation, loudspeaker enclosure, types of loudspeaker enclosure and corresponding circuits, total harmonic distortion, intermodulation distortion, miniature loudspeaker.

Theory and Analysis of Piezoelectric Transducer: Brief introduction to piezoelectricity, piezoelectric materials, piezoelectric devices, polarization, equivalent circuit, piezoelectric accelerometer, piezoelectric speaker, piezoelectric microphone.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

References books

1. Acoustics, L. L. Beranek, Acoustical Society of America.
2. Introduction to Electro acoustics and Amplifier Design, W. M. Leach, Kendall Hunt Publishing Company.
3. Acoustics-An Introduction, H. Kuttruff, Taylor & Francis.
4. Fundamentals of Acoustics, Kinsler, Frey, Coppens, and Sanders, John Wiley and Sons.
5. Audio Engineer's Reference Book, Edited by Michael Talbot-Smith, Focal Press.

AM2225 Materials in Service		
Designation	:	Elective
Pre-requisites	:	Material Science, Chemistry
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc.)

Syllabus

Tribology: Components of tribology; Wear, Friction and Lubrication, Laws of friction, Measurement of Friction, Effect of viscosity, Effect of Temperature, Types of wear, Mechanism of wear, Degradation and strength loss of materials due to wear, Surface morphology, Advantage and Disadvantage of lubrication in various application. Preventive measures of wear loss, Methods of surface improvement

Corrosion: Thermodynamics of Corrosion; Free energy change, EMF and galvanic series, Pourbaix diagrams, Nernst equation. Electrochemical Theory; Corrosion rate, activation polarization, concentration polarization, anodic, cathodic, mixed control. Passivation, Tafel equation. Types of Corrosion; Different forms of corrosions-uniform, galvanic, crevice, pitting, intergranular, erosion-corrosion, SCC, hydrogen cracking, corrosion fatigue, fretting corrosion, effect of metallurgical variables and environments on different forms of corrosion. Corrosion Protection; Corrosion prevention methods-anodic protection, cathodic protection, inhibitors. Corrosion Testing; Electrochemical techniques-potentiostat, Tafel extrapolation, linear polarization, galvanostat, impedance spectroscopy. thermogravimetric technique, salt spray test, weight change measurements, corrosion and oxidation resisting materials. Hot Corrosion: High temperature oxidation of metals and alloys, laws governing oxidation, molten salt corrosion, liquid metal corrosion.

Structural Health Monitoring: Introduction, Motivation of SHM, SHM and Non Destructive technique, Passive and Active SHM, Vibration based Techniques for SHM, Damage localization and quantification, Fibre optic sensors, Electrical resistance based SHM, Low frequency Electromagnetic Techniques, Capacitive methods for SHM.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Material Science for Engineers: An Introduction, W. D. Callister, Jr, John Wily and Sons, Inc.
2. G. E. Dieter, Mechanical Metallurgy, McGraw Hill
3. Bharat Bhushan, Introduction to Tribology, Wiley
4. Stachowiak, Wear: Materials, Mechanism and Practice
5. Principles and Prevention of Corrosion, Denny A. Jones, 2nd ed., Prentice-Hall, Inc.
6. Corrosion Engineering, Fontana M. G., and Greene N. D., McGraw Hill.
7. Corrosion and Corrosion Control, Uhlig H. H. and Revie R. W., 3rd Ed., John Wiley & Sons.
8. Corrosion, Metals Handbook, Vol.13 A & B, 9th ed., ASM.
9. The Fundamental of Corrosion, J. C. Scully, 2nd ed., Pergamon Press.
10. Fundamentals of Electrochemical Corrosion, E. E. Stansbury and R. A. Buchanan, ASM International
11. Structural Health Monitoring, edited by Daniel Balageas, Claus-Peter Fritgen and Alfredo Guemes

AM2252 Material Synthesis and Characterization Laboratory		
Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	0(L) - 0(T) – 6(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks
		Internal Assessment: (Scheme) 50 marks (10 marks for attendance + 40 marks shall be for the day-to-day assessment of performance in the all the Lab Sessions evaluated through daily preparedness for conducting Experiments, participation in conduct of Experiments, Report Writing and submission, Interaction, Sincerity, Attendance and Quizzes.

Project	**Details**
1.	Synthesis and characterization of given composition by sol gel, hydrothermal and solid state route.
2.	Role of metallurgical process (e.g. heat treatment processes) on micro-structural and mechanical properties of given alloy
3.	Fabrication and mechanical behavior of any composite
4.	Design and simulation of material using any commercial software
Reference	1. Books and Research articles through referred journals.

ANNEXURE – 2

मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
इलाहाबाद - २११००४ [उ०प्र०] भारत
Motilal Nehru National Institute of Technology Allahabad
Allahabad – 211004 [UP] India

THIRTEENTH (13TH) ANNUAL CONVOCATION – 2016

SUMMARY OF DEGREES CONFERRED

Bachelor of Technology (B.Tech.)	–	803	
Master of Technology (M.Tech.)	–	341	
Master of Computer Applications (MCA)	–	83	
Master of Business Administration (MBA)	–	54	
Master of Science (M.Sc.)	–	18	
Master of Social Work (MSW)	–	05	
Doctor of Philosophy (Ph.D.)	–	44*	May increase
Total	–	1348	

Number of Institute Gold Medals		
UG	–	14
PG	–	33
Number of Sponsored Gold Medals	–	22

मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
इलाहाबाद - २११००४ [उ०प्र०] भारत
Motilal Nehru National Institute of Technology Allahabad
Allahabad – 211004 [UP] India

Summary of Degrees and Medals conferred in the Thirteenth (13th) Annual Convocation – 2016 of the Institute

Bachelor of Technology (B.Tech.)

Sl. No.	Branch	No. of Degree Recipients
1.	Biotechnology –	33
2.	Chemical Engineering –	44
3.	Civil Engineering –	91
4.	Computer Science & Engineering –	172
5.	Electrical Engineering –	69
6.	Electronics & Communication Engineering –	144
7.	Information Technology –	89
8.	Mechanical Engineering –	128
9.	Production & Industrial Engineering –	33
Total Degree Recipients of B.Tech. Programme	**–**	**803**

Masters' Programmes

Sl. No.	Branch / Specialization	No. of Degree Recipients
1.	M.Tech. – Applied Mechanics –	13
2.	M.Tech. – Biomedical Engineering –	11
3.	M.Tech. – Fluids Engineering –	10
4.	M.Tech. – Material Science and Engineering –	16
5.	M.Tech. – Biotechnology –	13
6.	M.Tech. – Chemical Engineering –	04
7.	M.Tech. – Civil Engineering (Environmental Engineering) –	11
8.	M.Tech. – Civil Engineering (Geotechnical Engineering) –	09
9.	M.Tech. – Civil Engineering (Structural Engineering) –	09
10.	M.Tech. – Civil Engineering (Transportation Engineering) –	10
11.	M.Tech. – Computer Science and Engineering –	15
12.	M.Tech. – Information Security –	13
13.	M.Tech. – Software Engineering –	14
14.	M.Tech. (Part-time) – Software Engineering –	03
15.	M.Tech. – Electrical Engineering (Control & Instrumentation) –	18
16.	M.Tech. – Electrical Engineering (Power Electronics & Drives) –	13
17.	M.Tech. – Electrical Engineering (Power System) –	15
18.	M.Tech. – Electronics Engineering (Communication Systems) –	15
19.	M.Tech. – Electronics Engineering (Digital Systems) –	20
20.	M.Tech. (Part-time) – Electronics Engineering (Digital Systems) –	07
21.	M.Tech. – Microelectronics and VLSI Design –	15
22.	M.Tech. – GIS and Remote Sensing –	19

Sl. No.	Branch / Specialization		No. of Degree Recipients
23.	M.Tech. – Mechanical Engineering (Computer Aided Design and Manufacturing)	–	14
24.	M.Tech. – Mechanical Engineering (Design)	–	10
25.	M.Tech. – Mechanical Engineering (Product Design and Development)	–	12
26.	M.Tech. – Mechanical Engineering (Production Engineering)	–	11
27.	M.Tech. (Part-time) – Mechanical Engineering (Production Engineering)	–	07
28.	M.Tech. – Mechanical Engineering (Thermal Engineering)	–	14
Total Degree Recipients of M.Tech. Programme			**341**

Other Masters' Programmes

Sl. No.	Programme / Course		No. of Degree Recipients
29.	Master of Computer Applications	–	83
30.	Master of Business Administration	–	54
31.	Master of Science (Mathematics and Scientific Computing)	–	18
32.	Master of Social Work	–	05

Doctoral Programme

Sl. No.	Programme		No. of Degree Recipients
1.	Doctor of Philosophy (Ph.D.)	–	44* (May increase)

Gold Medals

Number of Institute Gold Medals	UG	–	14
	PG	–	33
Number of Sponsored Gold Medals		–	22

ANNEXURE – 3

मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
इलाहाबाद - २११००४ (उ०प्र०) भारत
Motilal Nehru National Institute of Technology Allahabad
Allahabad – 211004 (UP) India

List of Gold Medal recipients for Thirteenth Annual Convocation – 2016 of the Institute

Names of Gold Medal awardees for Convocation – 2016

GOLD MEDALS FOR POST GRADUATE EXAMINATION – 2016

1. Gold Medal awarded to **Mr. Santanu Choudhury** (Registration No. **2014AM13**) for standing first at M.Tech. Applied Mechanics, Final Examination 2016. **(CPI 9.65)**
2. Gold Medal awarded to **Ms. Shivangi Giri** (Registration No. **2014BM09**) for standing first at M.Tech. Biomedical Engineering, Final Examination 2016. **(CPI 8.95)**
3. Gold Medal awarded to **Ms. Sristi V R L B Srivani** (Registration No. **2014FE11**) for standing first at M.Tech. Fluids Engineering, Final Examination 2016. **(CPI 9.35)**
4. Gold Medal awarded to **Mr. Amit Kumar** (Registration No. **2014MT12**) for standing first at M.Tech. Material Science & Engineering, Final Examination 2016. **(CPI 8.55)**
5. Gold Medal awarded to **Ms. Sindhu K J** (Registration No. **2014BT14**) for standing first at M.Tech. Biotechnology, Final Examination 2016. **(CPI 9.75)**
6. Gold Medal awarded to **Mr. Nikhare Roshan Udaramji** (Registration No. **2014CH05**) for standing first at M.Tech. Chemical Engineering, Final Examination 2016. **(CPI 9.10)**
7. Gold Medal awarded to **Mr. Rahul Singh** (Registration No. **2014EN14**) for standing first at M.Tech. Civil Engineering (Environmental Engineering), Final Examination 2016. **(CPI 9.35)**
8. Gold Medal awarded to **Mr. Manish Jain** (Registration No. **2014GE01**) for standing first at M.Tech. Civil Engineering (Geotechnical Engineering), Final Examination 2016. **(CPI 9.25)**
9. Gold Medal awarded to **Mr. Rishi Raj Singh** (Registration No. **2014ST13**) for standing first at M.Tech. Civil Engineering (Structural Engineering), Final Examination 2016. **(CPI 9.20)**
10. Gold Medal awarded to **Mr. Amit Kumar** (Registration No. **2014TR09**) for standing first at M.Tech. Civil Engineering (Transportation Engineering), Final Examination 2016. **(CPI 8.40)**
11. Gold Medal awarded to **Ms. Chanchal Talreja** (Registration No. **2014CS17**) for standing first at M.Tech. Computer Science & Engineering, Final Examination 2016. **(CPI 8.90)**
12. Gold Medal awarded to **Ms. Bhavna Sharma** (Registration No. **2014IS02**) for standing first at M.Tech. Information Security, Final Examination 2016. **(CPI 9.45)**
13. Gold Medal awarded to **Mr. Vishwajeet Rana** (Registration No. **2014SW12**) for standing first at M.Tech. Software Engineering, Final Examination 2016. **(CPI 9.10)**
14. Gold Medal awarded **Ms. Konica Garg** (Registration No. **2014EE03**) for standing first at M.Tech. Electrical Engineering (Control & Instrumentation), Final Examination 2016. **(CPI 9.45)**
15. Gold Medal awarded to **Mr. Rahul Sharma** (Registration No. **2014PE03**) for standing first at M.Tech. Electrical Engineering (Power Electronics and Drives), Final Examination 2016. **(CPI 9.40)**
16. Gold Medal awarded to **Ms. Aradhna Patel** (Registration No. **2014PS04**) for standing first at M.Tech. Electrical Engineering (Power System), Final Examination 2016. **(CPI 9.65)**

17. Gold Medal awarded to **Ms. Anjali Verma** (Registration No. **2014CM08**) for standing first at M.Tech. Electronics Engineering (Communication Systems), Final Examination 2016. **(CPI 9.85)**

18. Gold Medal awarded to **Mr. Patel Chirag Jayantibhai** (Registration No. **2014EL03**) for standing first at M.Tech. Electronics Engineering (Digital Systems), Final Examination 2016. **(CPI 9.85)**

19. Gold Medal awarded to **Ms. Rohini Srivastava** (Registration No. **2013PTEL10**) for standing first at M.Tech. (Part-time) Electronics Engineering (Digital Systems), Final Examination 2016. **(CPI 9.75)**

20. Gold Medal awarded to **Mr. Shah Mihirkumar Pinakinbhai** (Registration No. **2014VL09**) for standing first at M.Tech. Microelectronics and VLSI Design, Final Examination 2016. **(CPI 9.80)**

21. Gold Medal awarded to **Mr. Chousalkar Charudatta Gopalrao** (Registration No. **2014GI17**) for standing first at M.Tech. GIS and Remote Sensing, Final Examination 2016. **(CPI 9.70)**

22. Gold Medal awarded to **Mr. Vaishnav Kumar Singh** (Registration No. **2014CC11**) for standing first at M.Tech. Mechanical Engineering (Computer Aided Design and Manufacturing), Final Examination 2016. **(CPI 9.30)**

23. Gold Medal awarded to **Mr. Avtar Singh** (Registration No. **2014DN08**) for standing first at M.Tech. Mechanical Engineering (Design), Final Examination 2016. **(CPI 9.65)**

24. Gold Medal awarded to **Mr. Mohit Bajpai** (Registration No. **2014PD10**) for standing first at M.Tech. Mechanical Engineering (Product Design and Development), Final Examination 2016. **(CPI 9.25)**

25. Gold Medal awarded to **Mr. Pradeep Kumar Yadav** (Registration No. **2014PR06**) for standing first at M.Tech. Mechanical Engineering (Production Engineering), Final Examination 2016. **(CPI 8.85)**

26. Gold Medal awarded to **Ms. Shalini Awasthi** (Registration No. **2013PTPR08**) for standing first at M.Tech. (Part-time) Mechanical Engineering (Production Engineering), Final Examination 2016. **(CPI 8.85)**

27. Gold Medal awarded to **Mr. Sachin Kumar Garg** (Registration No. **2014TH02**) for standing first at M.Tech. Mechanical Engineering (Thermal Engineering), Final Examination 2016. **(CPI 9.50)**

28. Gold Medal awarded to **Mr. Vijit Chawla** (Registration No. **2014MB41**) for standing first at Master of Business Administration, Final Examination 2016. **(CPI 9.93)**

29. Gold Medal awarded to **Ms. Vineeta Bedi** (Registration No. **2013CA17**) for standing first at Master of Computer Applications, Final Examination 2016. **(CPI 9.44)**

30. Gold Medal awarded to **Ms. Saraswati Bajaj** (Registration No. **2014MSC02**) for standing first at Master of Science (Mathematics & Scientific Computing), Final Examination 2016. **(CPI 9.48)**

31. Gold Medal awarded to **Ms. Swati Rawal** (Registration No. **2014MSC14**) for standing first at Master of Science (Mathematics & Scientific Computing), Final Examination 2016. **(CPI 9.48)**

32. Gold Medal awarded to **Ms. Aanya Srivastava** (Registration No. **2014MW03**) for standing first at Master of Social Work, Final Examination 2016. **(CPI 9.38)**

33. Gold Medal awarded to **Ms. Arti** (Registration No. **2014MW02**) for standing first at Master of Social Work, Final Examination 2016. **(CPI 9.38)**

GOLD MEDALS FOR UNDER GRADUATE EXAMINATION – 2016

1. Gold Medal awarded to **Ms. Saubhagya Srivastava** (Registration No. **20120044**) for standing first at B.Tech. (Biotechnology), Final Examination 2016. **(CPI 9.07)**
2. Gold Medal awarded to **Mr. Sankalp Tripathi** (Registration No. **20129050**) for standing first at B.Tech. (Chemical Engineering), Final Examination 2016. **(CPI 9.26)**
3. Gold Medal awarded to **Mr. Priyanjul Shukla** (Registration No. **20121089**) for standing first at B.Tech. (Civil Engineering), Final Examination 2016. **(CPI 8.93)**
4. Gold Medal awarded to **Mr. Priyanshu Srivastava** (Registration No. **20124064**) for standing first at B.Tech. (Computer Science and Engineering), Final Examination 2016. **(CPI 9.73)**
5. Gold Medal awarded to **Mr. Deepankar Kumar Singh** (Registration No. **20129011**) for standing first at B.Tech. (Information Technology), Final Examination 2016. **(CPI 9.20)**
6. Gold Medal awarded to **Mr. Priyanshu Gupta** (Registration No. **20120016**) for standing first at B.Tech. (Electrical Engineering), Final Examination 2016. **(CPI 9.18)**
7. Gold Medal awarded to **Ms. Anumita Gupta** (Registration No. **20128003**) for standing first at B.Tech. (Electronics and Communication Engineering), Final Examination 2016. **(CPI 9.84)**
8. Gold Medal awarded to **Mr. Vishal Ajmera** (Registration No. **20123109**) for standing first at B.Tech. (Mechanical Engineering), Final Examination 2016. **(CPI 9.43)**
9. Gold Medal awarded to **Mr. Gaurav Agrawal** (Registration No. **20126061**) for standing first at B.Tech. (Production and Industrial Engineering), Final Examination 2016. **(CPI 8.65)**

INSTITUTE GOLD MEDAL FOR UNDER GRADUATE EXAMINATION – 2016

1. Institute Gold Medal awarded to **Ms. Anumita Gupta** (Registration No. **20128003**) of B.Tech. (Electronics and Communication Engineering) for standing first amongst students of all branches of the Institute Final Examination 2016. **(CPI 9.84)**

GOLD MEDALS – 2016 FOR UNDER GRADUATE

1. Gold Medal awarded to **Mr. Aman Verma** (Registration No. **20138047**) of B.Tech. (Computer Science and Engineering) for standing first at B.Tech. **Third Year** Examination 2016. **(CPI 9.58)**
2. Gold Medal awarded to **Mr. Pradeep Kumar Srivastava** (Registration No. **20142013**) of B.Tech. (Electrical Engineering) for standing first at B.Tech. **Second Year** Examination 2016. **(CPI 9.54)**
3. Gold Medal awarded to **Mr. Aman Sharma** (Registration No. **20143090**) of B.Tech. (Mechanical Engineering) for standing first at B.Tech. **Second Year** Examination 2016. **(CPI 9.54)**
4. Gold Medal awarded to **Ms. Stuti Jain** (Registration No. **20158025**) of B.Tech. (Computer Science and Engineering) for standing first at B.Tech. **First Year** Examination 2016. **(CPI 9.50)**

MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY ALLAHABAD

(List of Sponsored Gold Medals for Thirteenth Annual Convocation – 2016 of the Institute)

S. No.	Name of Gold Medal	Awarded to	CPI
1.	**RATAN PRAKASH MEMORIAL GOLD MEDAL** for Standing First at M.Tech. (Design) Examination 2016	**Name:** Avtar Singh **Registration No.:** 2014DN08	9.65
2.	**RATAN PRAKASH MEMORIAL GOLD MEDAL** for Standing First at M.Tech. (Computer Aided Design and Manufacturing) Examination 2016	**Name:** Vaishnav Kumar Singh **Registration No.:** 2014CC11	9.30
3.	**RATAN PRAKASH MEMORIAL GOLD MEDAL** for Standing First at M.Tech. (Production) Examination 2016	**Name:** Pradeep Kumar Yadav **Registration No.:** 2014PR06	8.85
4.	**LAKHMIRI DEVI GOLD MEDAL** for Standing First in Chemistry at B.Tech. First Year (All Branches) Examination 2016	**Name:** Tushar Baliyan **Registration No.:** 20151031	9.22
5.	**LAKHMIRI DEVI GOLD MEDAL** for Standing First in Chemistry at B.Tech. First Year (All Branches) Examination 2016	**Name:** Prabhat Singh **Registration No.:** 20154018	8.98
6.	**LAKHMIRI DEVI GOLD MEDAL** for Standing First in Chemistry at B.Tech. First Year (All Branches) Examination 2016	**Name:** Vishal Pruthi **Registration No.:** 20154098	8.84
7.	**VISHWAMITRA DUGGAL GOLD MEDAL** for Standing First in Basic Surveying (Survey- I) at B.Tech. Second Year (Civil) Examination 2016	**Name:** Prabhakar Kumar **Registration No.:** 20141083	8.69
8.	**YASHI MISHRA GOLD MEDAL** for Standing First in Structural Analysis (Structural Analysis – I) at B.Tech. Second Year (Civil) Examination 2016	**Name:** Prabhakar Kumar **Registration No.:** 20141083	8.69
9.	**SAROJ AGARWAL GOLD MEDAL** for Standing First at B.Tech. Third Year (Mechanical) Examination 2016	**Name:** Piyush Chandra Chaturvedi **Registration No.:** 20133050	9.56
10.	**KIRAN AGARWAL GOLD MEDAL** for Standing First in Machine Design at B.Tech. Third Year (Mechanical) Examination 2016	**Name:** Sidhartha Chowdhury **Registration No.:** 20139023	9.31
11.	**BALBIR SINGH YADAV GOLD MEDAL** for Standing First in Transportation Engineering at B.Tech. Third Year (Civil) Examination 2016	**Name:** Pranshu Agarwal **Registration No.:** 20131089	9.09
12.	**MOHIT CHATURVEDI MEMORIAL GOLD MEDAL** for Standing First at B.Tech. Fourth Year (Mechanical) Examination 2016	**Name:** Vishal Ajmera **Registration No.:** 20123109	9.43
13.	**RAM CHARAN SINGH GOLD MEDAL** for Standing First in Water Resources (Water Resources Engineering) at B.Tech. Fourth Year (Civil) Examination 2016	**Name:** Chirayu Katara **Registration No.:** 20129053	8.53
14.	**SUNIL CHAUDHARY GOLD MEDAL** for Standing First in Steel Structure (Steel Structure-II) at B.Tech. Fourth Year (Civil) Examination 2016	**Name:** Himanshu Gautam **Registration No.:** 20121082	8.80
15.	**VIMAL CHANDRA AGARWAL GOLD MEDAL** for Standing First Amongst All The B.Tech. Fourth Year Students (All Branches) Examination 2016	**Name:** Anumita Gupta **Registration No.:** 20128003	9.84
16.	**PROF. R. N. TIWARI GOLD MEDAL** for Standing First at B.Tech. Fourth Year (Electrical Engineering) Examination 2016	**Name:** Priyanshu Gupta **Registration No.:** 20120016	9.18
17.	**DR. RAMJI SAHAI AND SMT. VIJAY PRABHA DEVI MEMORIAL GOLD MEDAL** for Standing First in Physics at B.Tech. First Year Examination 2016	**Name:** Chinmay Pani **Registration No.:** 20155149	9.22
18.	**MADHAVA VIDYADHAR GORE GOLD MEDAL** for Standing First in Final Year M.Tech. (Computer Science and Engineering) Examination 2016	**Name:** Chanchal Talreja **Registration No.:** 2014CS17	8.90
19.	**T.C.S. GOLD MEDAL** for Best Project Amongst All The B.Tech. Fourth Year Students (Computer Science and Engineering) Examination 2016	**Name:** Gourav Sahni **Registration No.:** 20125109	8.60
20.	**T.C.S. GOLD MEDAL** for Best Student B.Tech. Fourth Year Student (Computer Science and Engineering) Passing Out Batch 2016	**Name:** Priyanshu Srivastava **Registration No.:** 20124064	9.73
21.	**LATE (DR.) MALAY RAJ MUKHERJEE GOLD MEDAL** for standing First amongst the students of B.Tech. (Electrical Engineering), B.Tech. (Electronics and Communication Engineering) and B.Tech. (Computer Science and Engineering) Examination 2016	**Name:** Anumita Gupta **Registration No.:** 20128003 (ECE)	9.84
22.	**DR. YASH P. GUPTA GOLD MEDAL** for Standing First in M.Tech. (Civil Engineering-Structural Engineering) Examination 2016	**Name:** Rishi Raj Singh **Registration No.:** 2014ST13	9.20

ANNEXURE-4

कार्यालय अधिष्ठाता [शैक्षिक]
मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
इलाहाबाद - २११००४ [उ०प्र०] भारत
Office of the Dean [Academic]
Motilal Nehru National Institute of Technology Allahabad
Allahabad – 211004 [UP] India
Phone: 0532-2271046, 1044 Fax: 0532-2546144, 2545677, E-Mail: academics@mnnit.ac.in, website: www.mnnit.ac.in

Minutes of the Meeting of the Standing Committee held on 07.09.2016 [Wednesday] at 11:00 a.m. in the office of the Dean [Academic].

Following members were presents:

1.	Prof. Geetika, Dean [Academic]	-Convener
2.	Prof. Rajeev Tripathi, Professor, ECED	-Member
3.	Prof. R. K. Singh, Dean [Student Welfare]	-Member
4.	Prof. R. S. Yadav, Chairman, SDPC	-Member
5.	Prof. K. N. Pandey, Chairman, SMPC	-Member
6.	Prof. R. C. Vaishya, Chairman, SUGC	-Member

Following are the resolutions of the Committee:

1. The Committee discussed the cases of students as per Senate resolution 55.03 (iii). Following are the recommendations:

   (i) Mr. Mohd. Tufail (20111029) B.Tech. Civil Engineering has accumulated 6 E / F till IV semester and has SPI and CPI less than 5 (2.87) in I semester and (2.46) in II semester. He cannot move to V semester (i.e. III year).

   The Committee recommends that Mr. Tufail may be allowed to repeat the I and II semester to clear ACD, or he may be allowed semester leave for odd semester with permission to register in Even Semester to clear his ACD of II / IV semesters.

   (ii) Mr. Ravi Ranjan Kumar (20106057) B.Tech. Production and Industrial Engineering has accumulated 7 E / F till VI Semester. Moreover he has not been able to secure 5 SPI and CPI in any of the six semesters

   The student had submitted fee for registration in V semester on 16.07.2016 and subsequently applied for permission to register in VII Semester.

   Keeping in view the academic performance of the student, the Committee recommends that Mr. Ravi Ranjan Kumar may be allowed to register in the V semester only.

   Further the DUGC MED may advice him on the Courses to be studied to clear his ACD.

   Further, Mr. Ravi Ranjan Kumar (20106057) has applied for refund of fee submitted for Odd Semester 2016. The Committee resolved that this does not relate to academic matter hence may be treated administratively as per Institute rules.

   (iii) Mr. Dev Dutt Dwivedi (20102059) B.Tech. Department of Electrical Engineering has accumulated 4 E / F till VI semester and he has attained less than 5 SPI/ CPI in III, V & VI Semesters.

7.9.16

Further, the Chairman, SUGC put forward the recommendation of DUGC - EED as following:

1. One year leave without registration because of his poor financial condition.
2. Permission to appear in supplementary examination in 04 back paper subject in supplementary 2017.
3. Extension of one year to complete his course as he would be completing seven years by June, 2017.

The Committee resolved the following:

(i). 2016-17 is the seventh year of Mr. Dev Dutt Dwivedi (Reg. No. 20102059) in the B.Tech Programme, hence a permission of leave for one year will automatically disqualify him from completing the programme (Clause 8.3). Hence, the Committee recommends that he may be granted semester leave for odd semester 2016-17 and may be asked to register for Even Semester 2016-17 to clear his VI Semester.

(ii) Other recommendations of the DUGC may be deliberated upon only after his registration in even semester 2016-17.

2. The Committee considered the application of Mr. Rohit Nayak Rathula (20144154) B.Tech. Computer Science and Engineering, for semester leave for odd semester 2016. The DUGC - CSED has turned down his application. However the Committee deliberated in detail and recommended that Mr. Rohit Nayak Rathula may be allowed semester leave for odd semester 2016 as a special case.

3. The Committee considered the recommendion of Chairman SMPC on application of Mr. Saddam Husain (2015PS18) for semester leave for odd semester 2016 and recommended to allow the same.

4. The Committee reviewed the case of Mr. Satya Narayan Yadav (Reg. No. 20111072) who has applied for updation of his grade sheet as the grades for the course CE-1301 is shown as 'w'. The Faculty In-charge (Examination) informed that the course coordinator had returned the answer book on the ground that the student had used unfair means. The answer book was sent to hand writing expert and it was found that the answer book was not written by the student.

Hence, the committee resolved that the answer book may be evaluated but the marks shall not be carried forward for the award of grade.

Mr. Satya Narayan Yadav (Reg. No. 20111072) should be awarded 'F' grade in the course CE-1301.

07/09/2016 07.9.2016 7.9.16

(R. C. Vaishya) Chairman, SUGC
(K. N. Pandey) Chairman, SMPC
(R. S. Yadav) Chairman, SDPC
(R. K. Singh) Dean (Student Welfare)

(Rajeev Tripathi) Professor, ECED
(Geetika) 7.9.16 Dean (Academic)

Chairman Senate
Submitted for kind approval please
10-9-16

Approved
12/9/16

कार्यालय अधिष्ठाता [शैक्षिक]
मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
इलाहाबाद - २११००४ [उ०प्र०] भारत
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Motilal Nehru National Institute of Technology Allahabad
Allahabad – 211004 [UP] India
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Minutes of the Meeting of the Standing Committee held on 23.09.2016 [Friday] at 03:30 p.m. in the office of the Dean [Academic].

Following members were presents:

1.	Prof. Geetika, Dean [Academic]	-Convener
2.	Prof. Rajeev Tripathi, Professor, ECED	-Member
3.	Dr. Rakesh Kumare, Dy. Dean [Student Welfare]	-Member
4.	Prof. R. S. Yadav, Chairman, SDPC	-Member
5.	Prof. K. N. Pandey, Chairman, SMPC	-Member
6.	Prof. R. C. Vaishya, Chairman, SUGC	-Member

Following are the resolutions of the Committee:

1. The Committee reviewed the applications of following B.Tech. students who could not appear in Mid (odd) Sem. examination 2016-17 due to medical.

   (i). Ms. Stuti Gupta (Registration No. 20160004)

   (ii). Mr. Siddhant (Registration No. 20168059)

   Further, the Institute medical officer has verified for each of them that they cannot sit for examination. Considering the emergent situation and importance of Mid (odd) Semester Examination 2016-17 in final grade, and recommendation of medical officer, the committee resolved that these students may be allowed to appear in Mid (odd) Semester Examination 2016-17 on a future date. The course coordinator will conduct the exam with intimation to Dean [Academic], F. I. [Examination] and Head of the Department.

2. The Committee considered the recommendation of DUGC- CSED and Chairman, SUGC to allow Ms. Akanksha Dutta (Registration No. 20094119) an extension of one year to clear her ACD in II semester.

   The Committee resolved that she may be allowed an extension of one year as per Resolution 55.03(i) of the Senate Meeting held on 16.08.2016.

3. The Committee considered the request of Mr. Mohammad Omar Alam (Registration No. 20158009) for grant of semester leave for Odd Semester 2016-17.

   The DUGC- CSED has declined to consider his request. However, considering his plea, the Committee recommends that he may be allowed semester leave for odd semester and permission to register in Even Semester to enable him to clear his ACD and continue in the programme.

4. The Committee reviewed the mercy application of Mr. Pradeep Kumar Verma (Registration No. 20071013) against termination and request for permission to clear his ACD, duly forwarded by DUGC and Head Civil Engineering Department. The Committee deliberated on the case in the light of Senate resolution 54 (iv).

Mr. Pradeep Kumar Verma has no E / F but has less that 5 CPI in V semester.

The Committee resolved that he may be allowed to register in Even ([redacted]) Semester of session 2016-17 and DUGC may advise him to study a course / courses ~~within~~ which may qualify to clear the ACD of V semester.

5. The Committee reviewed the request of F. I. [Admission] to review the notification for refund rules and to make it more clear and understandable as many candidates interpret it differently.

The committee resolved to present it as attached (Annexure -1)

26/9/16
(R. C. Vaishya)
Chairman, SUGC

26.9.2016
(K. N. Pandey)
Chairman, SMPC

26.9.16
(R. S. Yadav)
Chairman, SDPC

26.9.16
(Rakesh Kumar)
Dy. Dean (Student Welfare)

26/9/16
(Rajeev Tripathi)
Professor, ECED

26.9.16
(Geetika)
Dean (Academic)

Director's Office
Received [illegible]
DOR 3547
Date 7.10.2016

Director / Chairman Senate
For kind consideration and approval please

27.9.16

Approved

17/x/16.

कार्यालय अधिष्ठाता [शैक्षिक]
मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
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Refund Policy of the Institute

llowing is the refund policy for Institute fee of the Institute for the students who hdraw their admission:

Case 1. In case, a candidate withdraws his/her admission after the close of admission process, no fee except the caution money will be refunded to him/her.

Case 2. In case, a candidate withdraws his/her admission before the start of registration but before the close of admission process fee deposited by him/her may be refunded after deduction of ₹ 1000.00 as processing charge.

Case 3. In case, a candidate withdraws his/her admission after the commencement of classes but before the close of admission process; fees deposited by him/her may be refunded after proportionate deduction of monthly charges.

Note:

- Above provisions are applicable to only Institute fees including tuition fess.
- Candidate have to write application for the refund to 'Dean [Academic] Motilal Nehru National Institute of Technology Allahabad - 211004' with photocopy of admission letter and draft/e-receipt. E-mail will not be entertained. Date of receipt of application will be valid for calculation of refund.

- Please provide following details also in the application form for e- transfer of refunded amount: (In case amount is above ₹ 25000.00):

NAME	:
COMPLETE BANK ACCOUNT No	:
BANK NAME	:
BANK BRANCH ADDRESS	:
BANK IFS CODE	:
PERMANENT ACCOUNT NUMBER [PAN]	:
CONTACT NUMBER [For SMS]	:
E-MAIL ID [For Information]	:

- If a candidate is admitted in the Institute, he/she shall enclose **NO DUES Certificate** also with the application.
- Original documents will be returned only after completion of all formalities.
- Separate application is required for refund of hostel fee/mess fee. Please refer hostel rules.

26.9.16

26.9.2016

26/9/16

26.9.16