COURSE STRUCTURE
AND
DETAILED SYLLABUS

Metallurgical and Materials Engineering

(I–IV Years Syllabus)

RAJIV GANDHI UNIVERSITY OF KNOWLEDGE TECHNOLOGIES

Basar, Nirmal, Telangana – 504107

SEMESTER WISE COURSE STRUCTURE

FIRST YEAR (E1) – SEMESTER – II

E1S2_R22								
Sl. No.	**Course Code**	**Course Title**	**Course Category**	**Hours per Week**			**Total Contact Hours**	**Credits**
				L	**T**	**P**		
1	MA1201	Differential Equations and Vector Calculus	BSC	4	0	0	4	4
2	CY1201	Engineering Chemistry	BSC	3	0	0	3	3
3	CS1202	Programming for Problem Solving	ESC	3	0	0	3	3
4	BM1205	Constitution of India	MC	2	0	0	2	0
5	MM1201	Physics of Materials	PCC	3	0	0	3	3
6	CY1801	Engineering Chemistry Lab	BSCL	0	0	3	3	1.5
7	CS1802	Programming for Problem Solving Lab	ESCL	0	0	3	3	1.5
8	ME1802	Engineering Workshop	ESC	0	1	2	3	2
total credits offered -								**18**

SECOND YEAR (E2) – SEMESTER – II

Sl. No.	**Course Code**	**Course Title**	**Course Category**	**Hours per Week**			**Total Contact Hours**	**Credits**
				L	**T**	**P**		
1	BM2201	Managerial Economics and Financial Analysis	HSMC	3	0	0	3	3
2	**HS2201**	**Essence of Indian Traditional Knowledge**	HSMC	3	0	0	3	0
3	MM2203	Mechanical Properties of Materials	PCC	3	1	0	4	4
4	MM2204	Metal Casting and Joining	PCC	3	1	0	4	4
5	MM2201	Phase Transformations	PCC	3	1	0	4	4
6	MM2202	Iron and Steel Making	PCC	3	1	0	4	4
7	MM2801	Mechanical Properties of Materials Lab	PCCL	0	0	3	3	1.5
8	MM2802	Metal Casting and Joining Lab	PCCL	0	0	3	3	1.5
total credits offered -								22

THIRD YEAR (E3) – SEMESTER – II

Sl. No.	Course Code	Course Title	Course Category	Hours per Week			Total Contact Hours	Credits
				L	T	P		
1	HS3203	Soft Skills	HSMC	0	0	2	2	1
2	MM3201	Materials Characterization	PCC	3	1	0	4	4
3	MM3202	Corrosion Engineering	PCC	3	1	0	4	4
4	MM3203	Powder Metallurgy and Additive Manufacturing	PCC	3	0	0	3	3
5	MM3212	Fracture Mechanics	PEC-I	3	0	0	3	3
6	MM3221	Secondary Steel Making	PEC-II	3	0	0	3	3
7	MM3801	Materials Characterization Lab	PCCL	0	0	3	3	1.5
8	MM3802	Corrosion Engineering Lab	PCCL	0	0	3	3	1.5
9	MM3901	Project-I	SIP	-	-	-	-	1
total credits offered -								**22**

FOURTH-YEAR (E4) – SEMESTER – II

Sl. No.	Course Code	Course Title	Course Category	Hours per Week			Total Contact Hours	Credits
				L	T	P		
1	MM424X	Program Elective Course – IV	PEC-IV	3	0	0	3	3
	MM4241	**Light Metals and Alloys**						
	MM4242	**Composite Materials**						
2	MM4245X	Program Elective Course – V	PEC-V	3	0	0	3	3
	MM4251	**Advanced Materials Processing**						
	MM4252	**Polymer Engineering**						
3	MM4902	Project-II	SIP	-	-	12	12	12
4	MM4000	Comprehensive Viva	SIP	-	-	4	4	4
total credits offered -								22

FIRST YEAR (E1) – SEMESTER – II

Category:BasicScienceCourse

Subjectcode:

MA1201

Differential Equations and Vector Calculus

Externals:60Marks L-T-P-C*
Internals:40Marks 4- 0- 0- 4

CourseObjectives:

- TostudytheMethodsofsolvingthedifferentialequationsoffirstandhigherorder.
- Tostudythemethodsofsolvingimproperintegralsandtheconceptsofmultipleintegrals
- Thebasicpropertiesofvectorvaluedfunctionsandtheirapplicationstoline,surface and volume integral.
- Tostudynumericalmethodstoanalyzeanexperimentaldata.

Unit-1:OrdinaryDifferentialEquations-1

Ordinary differential equations of first order: exact first order differential equation, finding integrating factors, linear differential equations, Bernoulli's, Riccati, Clairautss differential equations, finding orthogonaltrajectoryoffamilyofcurves,NewtonsLawofcooling,lawofnaturalgrowthordecay.

Unit-2:OrdinaryDifferentialEquations-2

Ordinary differential equations of higher order: linear dependence and independence of functions, Wronskianofn-functionstodeterminelinearindependenceanddependenceoffunctions, solutionsof second and higher order differential equations (homogeneous & non-homogeneous) with constant coefficients,methodofvariationofparameters,Euler-Cauchyequation.

Unit-3:IntegralCalculus

Integralcalculus:convergenceofimproperintegrals,testsofconvergence,BetaandGamma functions - elementary properties, differentiation under integral sign, differentiation of integrals with variable limits - Leibnitz rule.Rectification, double and triple integrals, computations of surface and volumes,changeofvariablesindoubleintegrals-Jacobiansoftransformations,integrals dependentonparametersapplications.

Unit-4:VectorDifferentiation

Vectordifferentiation:vectorpointfunctionsandscalarpointfunctions.Gradient,divergencean d curl.Directionalderivatives,tangentplaneandnormalline.VectorIdentities.Scalarpotential functions.Solenoidal and irrotational vectors.

Unit-5:VectorIntegration

Vector integration:line, surface and volume integrals.Theorems of Green, Gauss and Stokes (without proofs) and their applications.

Courseoutcomes: Thestudentwillbeableto

- Solve first order linear differential equations and special nonlinear order equations like bernouli, riccati & clairauts equations
- Computedoubleintegralsoverrectanglesandtypeiandiiregionsintheplane
- Explaintheconceptofavectorfieldandmakesketchesofsimplevectorfieldsinthe plane.
- Explainconceptofaconservativevectorfield,stateandapplytheoremsthatgive necessary andsufficient conditions for when a vector field is conservative, and describe applicationstophysics.
- Recognize the statements of stokes' theorem and the divergence theorem and understand howtheyaregeneralizationsofthefundamentaltheoremofcalculus.
- Abletosolvetheproblemsindiversefieldsinengineeringscienceusingnumerical methods.

Textbooks:

- "AdvancedEngineeringMathematics",R.K.JainandS.R.K.Iyengar,3rd Edition,Narosa Publishing House, New Delhi

References:

- "AdvancedEngineeringMathematics",ErwinKreyszig,8thEdition,Wiley-India.
- "OrdinaryandPartialdifferentialequations",Dr.M.D.Raisinghania,17thEdition, S.CHAND,2014.

Category:BasicScienceCourse **Subject code:CY1201**

Engineering Chemistry

Externals:60Marks L-T-P-C*
Internals:40Marks 3- 0- 0- 3

CourseObjectives:

- Tounderstandtheimportanceofthespectroscopyindeterminingthestructuresofchemicalcompounds
- Tounderstandtheimportanceofelectrochemistryintechnicalfield
- Tounderstandtheratesofsomeofthereactionsandderivationoftheirratelaws
- Tounderstandthephaserulewithsomeexamples
- Tounderstandtheimportanceofmaterialsinthetechnicalfield

Unit-1:Electrochemistry

Introduction to electrochemistry: Galvanic cell (Daniel cell), Nernst equation. Types of electrodes:metal-metalionelectrodes,metal-insolublesalt-anionelectrodes,calomelelectrode,gas-ion electrodes, hydrogen and chlorine electrodes, oxidation-reduction electrodes (quinhydrone electrode), amalgam electrodes and ion exchange electrode (glass electrode).EMF and applications of EMF: determination of pH of the solution, potentiometric titrations, determination of the valency of the ions, solubility product of sparingly soluble salts. Thermodynamic data: enthalpy and entropy of cellreactions,Gibbs-Helmholtzequationandapplications.Classificationofcommercialcells-primary cells (dry cell) and secondary cells (Lithium-ion battery, Pb-acid storage battery). Fuel cells: H_2 – O_2fuel cell, methanol- oxygenfuelcell,phosphoricacidfuelcell.

Unit-2:CorrosionandWaterTreatment

Dry and wet corrosion and their mechanisms. Pilling - Bedworth Rule. Types of corrosion: galvanic corrosion,concentration cell corrosion,pitting corrosion and stress corrosion.Factors influencing therate of corrosion: Temperature, pH and dissolved oxygen. Corrosion Prevention methods: cathodic protectionsacrificialanodicmethodandimpressedcurrentmethod.Metalliccoatings: galvanization and tinning methods. Water: Hardness of water, degrees of hardness. Calculation of hardness by EDTA method. Disadvantages of hard water in boilers: priming, foaming, scales, sludges andcaustic embrittlement.Treatmentofboilerfeedwater:Zeoliteprocess,Ionexchangeprocess.

Unit-3:EnergySources

Introduction. Definition and classification of fuels. Calorific value of a fuel, Characteristics of a good fuel. Coal, types of coal. Analysis of coal: proximate and ultimate analysis. Bomb calorimeter and Junkers gas calorimeter. Problems on calculation of calorific value. Liquid fuels petroleum Extraction fractionaldistillation.SyntheticPetrol:BergiusprocessandFisherTropschprocess.Bio-fuels: bio- diesel,bio-gas.

Unit-4:ChemicalKinetics

Introduction to rate of reaction and rate constant determination. Factors influencing rate of reaction. Complex reactions: definition and classification of complex reactions, definition of reversible reactionswith examples, rate law derivation for reversible reactions. Consecutive reactions: definition, rate law derivation and examples of consecutive reactions. Parallel reactions: definition, rate law derivationandexamplesofparallelreactions.Steady-stateapproximation:introduction,kinetic ratelawderivation byapplyingsteadystateapproximationincaseoftheoxidationofNOand pyrolysisofmethane.

Unit-5:Nanochemistry

Introductiontonanomaterials,classification:Carbonbasednanomaterials,metallicnanoparticl es, metal oxide nanoparticles. Properties at nanoscale. Synthetic approaches: Top-Down (Lithography,spraypyrolysis,FIB,ballmilling)andbottom-up(Sol-gel,Hydrothermal,CVD,PVD).Brief overview on characterization of nanomaterials: UV, X-ray, SEM and TEM. Applications of nanomaterials.

Courseoutcomes: Attheendofthecoursestudentwillbeableto

- solve first order linear differential equations and special non linear first order equations likebernouli , riccati & clairauts equations
- computedoubleintegralsoverrectanglesandtypeiandiiregionsintheplane
- explaintheconceptofavectorfieldandmakesketchesofsimplevectorfieldsinthepla ne.
- explain concept of a conservative vector field, state and apply theorems that give necessary andsufficientconditionsforwhenavectorfieldisconservative,anddescribeapplica tions to physics.
- recognizethestatementsofstokes'theoremandthedivergencetheoremandunde rstand how they are generalizations of the fundamental theorem of calculus.
- solvetheproblemsindiversefieldsinengineeringscienceusingnumericalmethods.

References:

- "EngineeringChemistry",Jain&Jain
- "EngineeringChemistry",ShashiChawla
- "ChemistryforEngineers",B.K.Ambasta
- "EngineeringChemistry",H.C.Srivastava
- "FundamentalsofEngineeringChemistry",ShikhaAgarwal

Category: EngineeringScienceCourse

Subjectcode : CS1202

Programming for Problem Solving

Externals:60Marks L-T-P-C*
Internals:40Marks 3- 0- 0- 3

CourseObjectives:

- Tointroducethebasicconceptsofcomputingenvironment,numbersystemsandflo wchart.
- TofamiliarizethebasicconstructsofClanguagedatatypes,operatorsandexpressions
- TounderstandmodularandstructuredprogrammingconstructsinC
- Tolearntheusageofstructureddatatypesandmemorymanagementusingpointers
- Tolearntheconceptsofdatahandlingusingpointers

Unit-1:Arithmeticexpressions

Introductiontoprogramming&arithmeticexpressionsandprecedence:introductionto componentsofacomputersystem(disks,memory,processor,whereaprogramisstoredand executed, operating system, compilers etc.). Idea of algorithm: steps to solve logical and numerical problems. Representation of algorithm: flowchart/pseudocode with examples. From algorithms to programs:sourcecode,variables(withdatatypes)variablesandmemorylocations,syntaxand logical errors incompilation,object andexecutablecode-arithmeticexpressionsandprecedence

Unit-2:Arrays

Conditional branching, loops& arrays: writing and evaluation of conditionals and consequent branching,iterationand loops arrays(1-D,2-D), character arrays and strings

Unit-3:Functions

Function& basic algorithms: functions (including using built in libraries), parameter passing in functions, call by value, passing arrays to functions:idea of call by reference searching, basic sorting algorithms (bubble, insertion and selection), finding roots of equations, notion of order of complexity through example programs (noformaldefinitionrequired)

Unit-4:Structure

Recursion&structure:recursion,asadifferentwayofsolvingproblems.Exampleprograms,such as finding factorial, Fibonacci series, Ackerman function etc. Quick sort or merge sort. Structures, defining structures and array of structures

Unit-5:Pointers

Pointers&filehandling: ideaofpointers,definingpointers,useofpointersinself-referential structures,notion of linked list(no implementation) file handling (only if time is available, otherwise should be done as part of the lab)

Courseoutcomes: Thestudentswillbeableto

- Formulatesimplealgorithmsforarithmeticandlogicalproblems.
- testandexecutetheprogramsandcorrectsyntaxandlogicalerrors.
- implementconditionalbranching,iterationandrecursion.
- decomposeaproblemintofunctionsandsynthesizeacompleteprogram.
- usearrays,pointersandstructurestoformulatealgorithmsandprograms.

Textbooks:

- "Schaum'sOutlineofProgrammingwithC",ByronGottfried,McGraw-Hill,2017
- "ProgramminginANSIC",E.Balaguruswamy,TataMcGraw-Hill8thedition,2019

References:

- "TheCProgrammingLanguage",BrianW.KernighanandDennisM.Ritchie,Prentice HallofIndia, 1978.

Category:MandatoryCourse
Subjectcode:BM1205

Constitution of India

Externals:60Marks L-T-P-C*
Internals:40Marks 3- 0-0-0

CourseObjectives:

- UnderstandtheformationandprinciplesofIndianconstitution.
- Understandfundamentalrightsanditsimplicationsinlife
- Understandfundamentaldutiesofindividualtowardcountryandsociety

- Understanddirectiveprinciplestogovernthepolicyformation
- Understandthewayofrunningthegovernmentandbasicgovernance

Unit-1:IntroductiontoIndianConstitution

Meaning of the term constitution, historical background of Indian constitution, making of Indian constitution, constituent assembly

Unit-2:FeaturesofIndianConstitution

Preambleoftheconstitution,importance,scope,relevance,thesalientfeaturesofindian constitution, importance, scope, relevance

Unit-3:FundamentalRights

Fundamentalrights,importanceandscopeoffundamentalrights,categorizationoffundamental rights

Unit-4:FundamentalDuties&TheDirectivePrinciplesofStatePolicy

Fundamental duties,importanceandscopeoffundamentalduties,the directiveprinciplesofstate policy, importance, scope, relevance

Unit-5:Union/CentralGovernment

Union government, union legislature (parliament), lok sabha and rajya sabha (with powers and functions), union executive, president of India (with powers and functions), prime minister of India(with powers and functions)

Courseoutcomes: The studentswillbe ableto

- Understandtheformationandprinciplesofindianconstitution.
- Understandfundamentalrightsanditsimplicationsinlife
- Understandfundamentaldutiesofindividualtowardcountryandsociety
- Understanddirectiveprinciplestogovernthepolicyformation
- Understandthewayofrunningthegovernmentandbasicgovernance

Textbooks:

- “IndianPolity”,Laxmikanth
- “IndianAdministration”,SubhashKashyap
- “IndianConstitution”,D.D.Basu
- “IndianAdministration”,AvastiandAvasti

Category:ProgramCoreCourse

Subjectcode:MM

1201

Physics of Materials

Externals:60Marks
Internals:40Marks

L-T-P-C*
3- 0- 0- 3

CourseObjectives: Tounderstand

- theclassicalfreeelectrontheory
- quantummechanicalimprovementstothefreeelectronmodel
- incorporatingcrystalstructureintothemodel
- addressingspecificmaterialpropertiesusingthemodelsdeveloped

Unit-1:Relationshipbetweenthermalandelectronicconductivity

Introduction and approach,properties of materials and someimportant relationships,freeelectron theory of metals, Drude model electronic conductivity, Drude model thermal conductivity - ratio the Wiedemann Franz law

Unit-2:MaxwellBoltzmann&FermiDiracstatistics

MaxwellBoltzmannstatistics,limitationsoftheDrudemodel,elementaryquantummechanics: historyandsignificantconcepts,theDrudeSommerfieldmodel,FermiDiracstatistics,densityof states,Fermi energyand Fermi surface, improvements overDrudemodel, remaining limitations.

Unit-3:DiffractionConditionandItsSignificanceforElectronEnergy

Specific heat, phonons, real space Vs reciprocal space, diffraction condition and its significance for electron energy, Wigner Seitz cells, Brillouin zones, band theory, density of occupied states, the originof anisotropy

Unit-4:PropertiesofMaterials

Electrons and holes, classification of semiconductors, direct band gap, indirect band gap, opto-electronic materials, magnetic properties, superconductivity, Meissner effect.

Unit-5:PhysicsofNanoscaleMaterials

Bose-EinsteinStatistics,BCStheory,hightemperaturesuperconductors,physicsofnanoscale materials

Courseoutcomes: Thestudentwillbeableto

- Describethemechanical,electrical,thermalandopticalpropertiesofmaterials.
- Analyzetheimportanceofmaterialpropertiesforawidevarietyofengineeringsituations.
- Understandthemicro-physicsandchemistryresponsibleformaterialproperties,and analyzeits modification.
- Evaluateandselectsuitablematerialsfordifferentpracticalapplications.

- Getglimpsesoftypicalrangeforpropertiesofcommonmaterials.

Textbooks:

- PrathapHaridoss,“PhysicsofMaterials EssentialConcepts ofSolid-State Physics”,Wiley 2015.
- DavidJiles,“IntroductiontoElectronicPropertiesofMaterials”,ChapmanandHall,1994.
- AshcroftandMermin,“SolidStatePhysics”,SaundersCollegePublishing,1976.

References:

- DavidJiles,“IntroductionToElectronicPropertiesofMaterials”,ChapmanandHall,1994
- JohnWulfR.M.RoseandL.A.Shepard,“StructureandPropertiesofMaterials-Electronic Properties”, Wiley Eastern, 1964
- AlanCottrell,“IntroductiontotheModernTheoryofMetals”,AshgatePublishingCompany,1988
- LaszloSolymarandD.Walsh,“TheElectricalPropertiesofMaterials”,OxfordUniv.Press,1988.

Category:BasicScienceCourse

Subjectcode:

CY1801

Engineering Chemistry Lab

Externals:60Marks
Internals:40Marks

L-T-P-C*
0- 0- 3-1.5

CourseObjectives:

- Tolearnthepreparationoforganiccompoundsinthelaboratory.
- Toestimatethehardnessandalkalinityofthegivensampleofwater.
- TounderstandtheJob'smethodfordeterminingthecomposition.

- Learn how to use the pH meter and
  Polarimeter. The list of experiments are:

1. Determinationofthestrengthofweakacid(CH_3COOH)bypHmetry.
2. Conductometrictitration(strongacid(HCl)vsstrongbase(NaOH)).
3. ThrowingpowerofCopper.
4. Estimationofalkalinityofwater.
5. DeterminationoftotalhardnessofwaterbycomplexometricmethodusingEDTA.
6. Determinationofthecalorificvalueoffuelsamplebyusingbombcalorimeter.
7. Preparationofbio-dieselfrompalmoilbytransesterificationmethod.
8. Therateconstantandorderofthereactionofthehydrolysisofanestercatalyzedbyanacid (dil.HCl).
9. PreparationofNanoparticle(ZnO).

Courseoutcomes:

The students get the knowledge on basic synthesis, quantitative and qualitative analysis is being im- portant.

Referencebooks:

1) EssentialsofexperimentalengineeringchemistrybyShashichawla.
2) PracticalchemistrybyDr.O.P.Pandey,S.Chandpublication.
3) AtextbookofengineeringchemistrybyShashichawla.
4) CollegepracticalchemistrybyVKAhluwalia.
5) PracticalengineeringchemistrybyK.Mukkanti.
6) LaboratorymanualbyR.Kulakarni,Adil.

Category:EngineeringScienceCourse Subjectcode:ME1802

Engineering Workshop

Externals:60Marks L-T-P-C*
Internals:40Marks 0- 1- 2-2

CourseObjectives:

- To understand the basic manufacturing process of producing a component by casting, forming plastic molding, joining processes, machining of a component either by conventional or by unconventional processes.
- Tounderstandtheadvancedmanufacturingprocessofadditivemanufacturingprocess.

ListofExperiments:

1. **Fitting–**StepandVFit
2. **Carpentry**–HalflapjointandDovetailjoint
3. **HouseWiring**–Series,Parallel,StaircaseandGodownwiring
4. **TinSmithy**–TrayandCylinder
5. **Welding**–Beadformation,ButtandLapjointwelding
6. **Foundry**–MoldpreparationwithSinglepieceandSplitpiecepattern
7. **Machining**–Plainturning,Facing,StepandTaperturning
8. **Plasticmolding**– Demo
9. **WIREEDM,CNC,3DPrinter**-Demo

CourseOutcome:

- Studentswillgainknowledgeofthedifferentmanufacturingprocesseswhicharecommonly employed in the industry, to fabricate components using different materials.

TextBooks:

(i) HajraChoudhuryS.K.,HajraChoudhuryA.K.andNirjharRoyS.K.,"ElementsofWorkshop Technology",Vol.I2008andVol.II 2010,Mediapromoters and publishers privatelimited, Mumbai.
(ii) KalpakjianS.andStevenS.Schmid,"ManufacturingEngineeringandTechnology",4thedition, Pearson Education India Edition, 2002.

ReferenceBooks

(i) GowriP.HariharanandA.SureshBabu,"ManufacturingTechnology–I"PearsonEducation,2008.
(ii)RoyA.Lindberg,"ProcessesandMaterialsofManufacture",4thedition,PrenticeHallIndia, 1998.
(iii) RaoP.N.,"ManufacturingTechnology",Vol.IandVol.II,TataMcGrawHillHouse,2017.

SECOND YEAR (E2) – SEMESTER – II

Category: HumanitiesandSocialSciencescourse

Managerial Economics and Financial Analysis

Subjectcode:BM2201

Externals:60Marks **L-T-P-C***
Internals:40Marks **3-0-0-3**

CourseObjectives:Tounderstand,

- the nature and scope of managerial economics and the concepts of demand analysis.
- thesignificanceofdemandelasticityandtheconceptsofdemandforecasting.
- theconceptsofproductionandcostanalysis.
- the concepts of production and cost analysis different market structures and their competitive situations.
- theconceptandsignificanceofcapitalbudgeting.

Unit-1:Introductiontomanagerialeconomics

Definition, nature and scope, basic economic principles, the concept of opportunity cost, marginalism, incremental concept, time perspective, discounting principle, risk and uncertainty.

Unit-2:Theoryofdemand

Demand, demand function, law of demand, determinants of demand and types of demand, elasticity of demand and types, demand forecasting, need for demand forecasting, methods of demand forecasting. Supply: law of supply.

Unit-3:Theoryofproduction

Production meaning, production function, production function with one variable, production function with two variables: isoquants and isocosts, marginal rate of technical substitution, returns to scale. Cost concepts: meaning of costs, types of costs.

Unit-4:Marketstructure

Classificationofmarketstructures,features,competitivesituations.
Pricing practices: price output determination under perfect competition, oligopoly, monopoly, features of monopolistic competition; pricing strategies.

Unit-5:Capital

Introduction,definitionofcapital,sourcesofcapital.
Capital budgeting : significance, need for capital budgeting decisions, capital budgeting decisions, kinds of capital budgeting decisions, methods of capital budgeting - traditional methods (payback period and accounting rate of return methods), discounted cash ow methods, net present value method.

Courseoutcomes: Studentswillbeabletounderstand

- economicprinciplesinbusiness.
- forecastdemandandsupply.
- productionandcostestimates.
- marketstructureandpricingpractices.
- economicpolicies.

Textbooks:

- "BusinessEconomics", HL Ahuja,S.Chand&Co,13e, 2016.
- "BusinessEconomics",Chaturvedi,InternationalBookHouse,2012.
    - "ManagerialEconomics",CraigH.Petersen,W.CrisLewisandSudhirK.Jain,Pearson, 14e,2014.
- "ManagerialEconomics",DominickSalvatore,OxfordPublications,7e,2012.
- "BusinessEnvironment",JustinPaul,TataMcGrawHill,2010.
- "BusinessEnvironmentText&Cases",FrancisCherunilam,HimalayaPublications,2012.

Category:HumanitiesandSocialSciencescourse **Subjectcode:HS2201**

Essence of IndianTraditional Knowledge

Externals:60Marks	**L-T-P-C***
Internals:40Marks	**3-0-0-3**

Unit-1:BasicStructureofIndianKnowledgeSystem

Veda Definition Kinds Upavedas (Ayurveda, Gandhra veda, Shilpa veda, Artha veda)-
Vedangas (Shik-
sha, Kalapa, Chhanda, Niruktha, Vyakarana, Jyothishya), Dharma Shastra, Mimansa,
Purana, Tarka Shastra

Unit-2:ModernScience

Modern Science and Indian Knowledge System

Yoga Holistic Health Care

Unit-3:IndianPhilosophicalTradition

A) OrthodoxSchool:Samkya,Yoga,Nyaya,Vaisheshika,PurvaMimansa,Vedantha
B) HeterodoxSchool:Jainism,Buddhism,Ajivika,Anjana,Charvaka

Unit-4:LinguisticTradition

IndianLinguisticTradition

Unit-5:IndianArtisticTradition

ChithraKala(Painting),SangeethaKala(Music),NruthyaKala(Dance)

Category:ProgramCoreCourse **Subjectcode:MM2203**

Mechanical Properties of Materials

Externals:60Marks **L-T-P-C***
Internals:40Marks **3-1-0-4**

CourseObjectives:

- Tostudyvariousmechanismsofdislocationsandtheirinteractions.
- Tostudyvariousstrengtheningmechanismsinmaterials.
- Tohaveabasicknowledgeofvariousmechanicaltestsliketension,compression, hardness and impact.
- Tostudydeformationbyfracture.
- Tostudydeformationbyfatigueandcreep

Unit-1:Dislocation theory

Imperfections in solids, deformation by slip, slip in a perfect lattice, slip by dislocation movement, critical resolved shear stress, edge, screw and mixed dislocation, burgervector,stressfieldarounddislocation,dislocationglideandclimb,forceson dislocations, forces between dislocations, dislocation and plastic strain, dissociation of dislocations, dislocation multiplication, deformation by twinning, jogs and kinks,stacking faults, dislocation pileups.

Unit-2:strengtheningmechanisms

Types of strengthening mechanisms, grain boundary strengthening, hall-petch relation, hall-petch strengthening limit, strengthening from second phase, factors influencing second-phase particle strengthening, solid solutions strengthening, precipitationhardening, precipitation sequence-gp zones, factors affecting precipitation hardening, interaction between particles and dislocations-particle cutting and orowan mechanism, coherent and incoherent precipitates, fibre strengthening, martensitic strengthening, ausforming process, strain hardening or cold working, annealing of cold-worked metal- recovery, recrystallisation and grain growth.

Unit-3:MechanicalTesting

Tension Test: introduction to tension test and tensile properties, conditions for necking, effect of temperature andstrain rate on tensileproperties. Compression: elastic andplastic range, baushinger effect, buckling, barreling. Bending and torsion test. Hardness: classification of hardness, Moh's scale, brinell hardness, rockwell hardness, vicker'shard-ness, micro-hardness. Impact test: notched bar impact test and its significance,charpy and izod tests, dbtt curve and its importance, metallurgical factors affecting the transition temperature, temper embrittlement.

Unit-4:Fracture

Types of fracture in metals, theoretical cohesive strength, stress concentration factor, effect of notch, griffith theory of brittle fracture, elastic strain energy release rate, stress intensity factor, fracture toughness.

Unit-5:Fatigue,Creepandstressrupture

Fatigue failure, stress cycles, S-N curve, fatigue crack nucleation and growth, effect of mean stress, stress concentration effect, surface effects and surface treatments, effect of

metallurgical variables, temperature effect.

Thehigh-temperaturematerialsproblem,creepcurve,stress-rupturetest,strain-timerelationship, creep rate- stress-temperature relationship, creep deformation mechanism.

Courseoutcomes: Thestudentwillbeableto

- Understand the concept of plastic deformation and the role of dislocations inplastic deformation of materials
- Understandvariousstrengtheningmechanismstoenhancemechanicalproperties of metals.
- Understand different mechanical testing procedures and calculate mechanical properties like yield strength, hardness and toughness.
- Distinguishbetweendifferentdeformationmechanisms
- Understandthefactorsinfluencingdeformationandmeasurestopreventit.

Textbooks:

- GeorgeE.Dieter,"Mechanicalmetallurgy(SImetricedition)",McGraw-Hill, 1988.
- AmitBhaduri,"MechanicalPropertiesandWorkingofMetalsandAlloys", Springer Series inMaterial Science, Volume 264, 2018.
- Derek Hull and D.J. Bacon, "Introduction to Dislocations", Pergamon Press,2008.

References:

- ASMMetalsHandBook,"FailureAnalysisandPrevention",Vol.11,10th Edition, ASM International, 2002.
- Richard W. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials", 5th Edition, John Wiley & Sons, New York, 2012.
- DavidBroek,"ElementaryEngineeringFractureMechanics",MartinusNijhoff Publishers, Hingham, Massachusetts, 3rd Edition, 1984.
- WilliamF.Hosford,"MechanicalBehaviorofMaterials",Cambridge University Press 2005

Category:ProgramCoreCourse **Subjectcode:MM2204**

Metal Casting and Joining

Externals: 60Marks **L-T-P-C***
Internals: 40Marks **3-1-0-4**

CourseObjectives:

- Tostudyandunderstandthebasicconceptsofcasting
- Tostudyandunderstandthebasicconceptsofvariouscastingoperations
- TostudyandunderstandthebasicconceptsofMetalJoining
- Tostudyandunderstandvariousweldingprocesses
- Tostudyandunderstandthemetallurgyofweldment,testingforwelding defects

Unit-1:Introductiontocasting

Introductionandclassificationofcastingtechniques,melting,solidification,sand casting: tools of sandcasting, moulding sands, moulding sand properties and testing, core and core sands, pattern colors,pattern materials, pattern allowances, types of patterns, making ofmoulding sand, design of riser andgatingsystem,sandcastingdefects.

Unit-2:Castingprocessesandoperations

Permanent mould and special casting process: die casting, investment casting, vacuum sealed mouldingand squeeze casting, centrifugal casting, evaporative pattern casting and plaster moulding, continuouscasting, finishing and inspection: shakeout, fettling and finishing, testing and quality control.

Unit-3:IntroductiontoJoiningprocesses

Introduction, applications, classification, Soldering, Brazing, Mechanical Joining, Welding, Welding positions, Weld joints, arc welding processes, arc characteristics, shielded metal arc welding (SMAW), features of SMAW, V-I characteristics, electrodes used in SMAW.

Unit-4:Weldingprocesses

Metal inert gas welding (MIG), submerged arc welding (SAW), gas metal arc welding (GMAW), electro slag welding (ESW), Electro gas welding (EGW), tungsten inert-gas welding(TIG),plasmaarcwelding(PAW);Resistanceweldingadvantages, applications. Thermo chemical welding and atomic hydrogen welding; laser beam and electronbeamwelding;solidstateweldingdiffusion,ultrasonic,explosive,friction andforgewelding;gaswelding;oxyacetylenewelding,typesofoxyacetylene welding;

Unit-5:WeldmentTestsandAnalysis

Weldability,WeldingMetallurgy,Weldingdefects,InspectionandTestingof weldments, DestructiveandNonDestructiveTesting.

Courseoutcomes: Thestudentwillbeableto

- Explainthebasicconceptsofcasting
- Describevariouscastingoperations

- ExplainbasicconceptsofMetalJoining
- Describevariousweldingprocesses
- Describethemetallurgyofweldmentanddefectsassociatedwithit

Textbooks:

- R. W. Heine, C. R. Loper, P. C. Rosenthal, ”Principles of metal casting”, McGraw Higher Ed,1976.
- P.K.Jain,“Principlesoffoundrytechnology”,McGraw-Hill1987.
- K. Easterling, “Introduction to physical metallurgy of welding”, Butterworth-Hienemann 1992.
- SindoKou“WeldingMetallurgy”,JohnWiley&sonsPublications2003

Reference:

- ASMHandbookVolume6:Welding,Brazing,andSoldering,ASMInternational, 1993.
- ASMHandbookVolume15:Casting,ASMInternational,2008

Category:ProgramCoreCourse Subjectcode:MM2201

Phase Transformations

Externals:60Marks L-T-P-C*
Internals:40Marks 3-1-0-4

CourseObjectives:

- Correlatethermodynamicsandphasestability
- Tounderstandtheprinciplesofsolidification.
- Toanalyzethemechanismsandphenomenonassociatedwithdiffusion.
- Tostudyandunderstandpearliticandbainitictransformations.
- Tostudyandunderstandthediffusionlesstransformations

Unit-1Introduction

Phaseequilibrium:Introduction,thermodynamicsandstabilityofphases,classification of phase trans-formations, order of transformation, Gibbs rule and application, phase diagrams, construction and interpretation.

Unit-2Liquid-SolidTransformation

Nucleation: homogeneous and heterogeneous, growth: continuous and lateral, interface stability; alloy solidification: cellular and dendritic, eutectic, off-eutectic, peritectic solidification, welding, casting andrapidsolidification.

Unit-3Diffusion

Atomic mechanism, interstitial and substitutional diffusion, atomic mobility, tracer diffusion inbinaryalloys and diffusion inmultiphasebinarysystems.Solidstate diffusive transformation: classification, nucleation and growth - homogeneous and heterogeneousmechanism,precipitategrowthunderdifferentconditions,age hardening, spinodal decomposition, precipitate coarsening, transformation with startrange diffusion, recrystallization, grain growth, eutectoid transformation, discontinuous reactions.

Unit-4PearliticAndBainiticTransformation

Factors influencing pearlitic transformation, mechanism oftransformation, nucleationand growth, orientation relationship, degenerate pearlite. Bainite: mechanism of transformation,nucleationandgrowth,orientationrelationships,surfacerelief,classicalandnon-classicalmorphology,effectofalloy-ingelements.

Unit-5Non-DiffusiveTransformation

Characteristicsoftransformation,thermodynamicsandkinetics,nucleationandgrowth, morphology, crystallography, stabilization, strengthening mechanisms, non-ferrousmartensite,shapememoryef-fect/alloysandglasstransitionconcept.

Courseoutcomes:

Thestudentshouldbeableto

- Explainthebasicsofthermodynamicsandtheconceptofphasestability
- Explaintheprinciplesofsolidificationandusethemtocontrolthe microstructure

during solidification

- Toanalyzethemechanismsandphenomenonassociatedwithdiffusion.
- Describethepearliticandbainitictransformationsinsteels.
- Describethediffusionlesstransformationsinsteelsandnonferrousalloys

Textbooks:

- Porter,D,AAndEasterling,K.E.,"PhaseTransformationsInMetalsAnd Alloys", 2 nd Edition, CRC Press, 1992.
- Reed-Hill,R,EAndAbbaschian,R.,"PhysicalMetallurgyPrinciples",3rd Edition, PWS-Kent Publishing Company, 1994.

Referencebooks:

- AhindraGhosh,"TextbookofMaterialsandMetallurgical Thermodynamics", Prentice Hall of India Pvt. Ltd., 2003
- David R. Gaskell and David E. Laughlin, "Introduction to theThermodynamics of Materials", CRC Press, Taylor and Francis Group, 2017, 6th Edition.
- PaulG.Shewmon,"TransformationsinMetals",IndoAmericanBooks.

Category:ProgramCoreCourse Subjectcode:MM2202

Iron and Steel Making

Externals:60Marks **L-T-P-C***
Internals:40Marks **3-1-0-4**

CourseObjectives:

- Tostudyhistoryofironproductionandvariousmethodsofproducingiron from its ores.
- Tostudythephysicalchemistryofironproduction
- Tostudyandunderstandspongeironproduction.
- To study and understand thermodynamics and kinetics of the reactions during steel making
- To understand continuous casting processes and materials balance in iron and steel making

Unit-1:RawmaterialsofIronmaking

History of Iron; Occurrence of iron ore, limestone and coke in India; Raw materials for blast furnace pig iron production; Coke production, properties of coke, recoverable and non- recoverablecokeovens process;AgglomerationofIronorefines:Sintering, Dwight-Lloyd (DL) sintering, fluidized bed sintering; Pelletisation: disc and drum palletization processes.

Unit-2:Blastfurnacedesignandproduction

Blastfurnace(B/F)profileanddesignconsiderations;PhysicalchemistryofIron making; Furnace zones: combustion zone, RAFT zone, cohesive zone, thermal reserve zone, chemically inactive zone, B/F refractory lining, gas cleaning system, B/F gasstorage stoves.

Unit-3:AlternativeIronmakingprocesses

Blast furnace Blow-in process, blow-out/shut down processes; Blast furnace operationand its irregularities: deadman's zone, hanging, scaffold, pillering; Limitations of Blast furnaceIronproduction;SpongeIronProductions:Usinggases asreducingagent: Midrexprocess,HYL,Usingsolidasreducingagentprocess:SL/RNprocess;Smelt Iron ReductionMethods: COREX, INRED, ELRED; Burden/charge/mass balance calculations.

Unit-4:LDconvertersteelmaking

Pre-treatment; Role of slag; steelmaking reactions; Linz-Donawitz(LD) convertor steelmaking:LDdesign,rawmaterial,chemicalreactionsinLD:Thermodyanamicsof O, S, P, C removal; Modren developments in LD convertor.

Unit-5:EAFsteelmaking

Electricarcfurnacesteelmaking(EAF-SM):EAFDesign,rawmaterials,EAFsteelmaking process; Modern developments in EAF-SM.
Continuouscastingprocess(CCP):Castintosemi-finishedproducts;Grainstructure; Heattransfer

zones in CCP; Modern developments in CCP;
Burden/charge/massbalancecalculationsiniron andsteelmaking.

Courseoutcomes: Thestudentwillbeableto

- Getexposuretothehistoryofiron andsteelmakingmethods
- Understandthephysicalchemistryofironmaking
- Understandthespongeironmakingprocess
- Understandthephysicalchemistryofsteelmaking
- Understandtheoperationsofanintegratedsteelplant
- Understoodtheprocessofcontinuouscastingofsteel
- Balancematerialsinironandsteelmaking

Textbooks:

- AhindraGhosh&AmitChaterjee,IronmakingandSteelmaking,2008
- BashforthG.R,ManufactureofIronandSteel,VolumesI-IV,1996

References:

- Dr.R.H.TupkaryandV.H.Tupkary,ModernSteelmaking,1998
- Dr.R.H.TupkaryandV.H.Tupkary,ModernIronmaking,1998
- K.Chakrabarthi,SteelMaking,2007
- Turkdogen,Steelmaking,2000
- Bodsworth,PhysicalChemistryofIron&Steel,1999
- DuttaS.K.,LeleA.B.,MetallurgicalThermodynamicsKineticsand Numericals

Category:ProgramCoreCourseLab **Subjectcode:MM2801**

Mechanical Properties of Materials Lab

Externals:60Marks **L-T-P-C***
Internals:40Marks **0-0-3-1.5**

CourseObjectives:

- Toprovidehandsonexperienceonvariousmechanicaltestingprocedures.
- Tostudyvariousdeformationmechanisms.
- Investigatemechanicalpropertiesofferrousandnonferrousmetals.
- Toanalyzeresultsanddrawconclusionsfromthetests.

Listofexperiments:

1) BrinellHardnesstestingofferrousandnon-ferroussamples.
2) Rockwellhardnesstestingofferrousandnon-ferroussamples.
3) VickersHardnesstestingofferrousandnon-ferroussamples.
4) Analysisoftensiletestingdata.
5) CalculateTruestressVsTruestainandcomparewithengineeringstressstrain curve.
6) Compressiontestofabrittlematerial.
7) ThreepointbendtestofaRebar.
8) Erichsencuppingtestforductilitymeasurementofnon-ferrousmetals.
9) CharpyandIzodtest(V&UGroovenotch)atroomtemperature.
10) Establishment of the ductile - brittle transition temperature of the material.
11) Analysis of Creep testing data
12) AnalysisofFatiguetestingdata

Courseoutcomes: Thestudentwillbeableto

- Operatetestingequipmentformeasuringmechanicalproperties
- Extract,interpretandanalysedatafrommechanicaltesting.
- Designandselectmetalsforengineeringapplications.
- Deriverelationshipbetweenmechanicalpropertiesofmetals.

Textbooks:

- MechanicalBehaviorofMaterialsLaboratoryManual.
- MechanicalTestingandEvaluation,ASMMetalsHandbook,Vol08.
- HardnessTestingPrinciplesandApplications,ASMInternational,Konrad Herrman, 2011.
- Dieter,G,E.,“Mechanicalmetallurgy(SImetricedition)”,McGraw-Hill, 1988.

Category:ProgramCoreCourseLab **Subjectcode:MM2802**

Metal Casting and Joining Lab

Externals:60Marks **L-T-P-C***
Internals:40Marks **0-0-3-1.5**

CourseObjectives:

- Toprovidehandsonexperienceoncastingandweldingoperations
- TounderstandandanalyzedifferentCastingandweldingdefects.
- Todeterminegreensandmouldproperties
- Castingofmetalsandalloys

Listofexperiments:

1) preparationofGreensandmold
2) Todeterminethepermeabilitynumberofthesandmouldspecimen
3) Todeterminetheshearstrengthofthesandmoldspecimen
4) Todeterminethemoisturecontentinthesandmoldspecimen
5) Todeterminethehardnessofthesand moldspecimen
6) TodemonstratemeltingofAluminuminInductionfurnace
7) Tocastaluminumusinggreensandmould
8) Toweldthemildsteelsamplesbymanualmetalarcweldingprocessand visuallyinspectthedefectsalongwiththemicrostructurevariations.
9) Toweldthemildsteelsamplesbymetalinertgasweldingprocessand visuallyinspectthedefectsalongwiththemicrostructurevariations.
10) Toweldthemildsteelsamplesbyoxyacetylenegasweldingprocessand visuallyinspectthedefectsalongwiththemicrostructurevariations.
11) Toweldthealuminumsamplesbytungsteninertgasweldingprocessand visuallyinspectthedefectsalongwiththemicrostructurevariations.
12) To weldtwosimilarmetalsbyfrictionstirwelding processandvisually inspect the defects alongwith the microstructure variations

Courseoutcomes: Thestudentwillbeableto

- Describevariouscastingandweldingoperations
- Determinegreensandmouldproperties
- Demonstratemeltingandcastingofmetals/alloys
- AnalyzedifferentCastingdefects.
- Analyzedifferentweldingdefects

Textbooks:

- R. W. Heine, C. R. Loper, P. C. Rosenthal, ”Principles of metal casting”, Mc Graw Higher Ed, 1976.
- P.K.Jain,“Principlesoffoundrytechnology”,McGraw-Hill1987.
- K. Easterling, “Introduction to physical metallurgy of welding”, Butterworth-

Hienemann 1992.
- SindoKou“WeldingMetallurgy”,JohnWiley&sonsPublications2003

THIRD YEAR (E3) – SEMESTER – II

Category:HumanitiesandSocialSciencescourse **Subjectcode:HS3203**

SoftSkills

Externals:60Marks **L-T-P-C***

Internals:40Marks **0-0-2-1**

CourseObjectives:

- Toenablestudentsspeakeffectivelyinformalandinformalsituations
- To equip the students with necessary writing skills in order to face the corporateworld
- Tostrengthenthewritingskillsofthestudentsandhelpthemindocumentation
- To enable students sharpen their communication skills towards writing a persuasive resume andeffective job application letters
- To equip students with pre-presentation steps, to understand the structureof a good presentation,and devise various techniques for delivering a successful presentation
- To make students understand the importance of team work and group presentations and groupdiscussions

Unit-1:ActivitiesonFundamentalsofInter-personalCommunication

Starting a conversation - responding appropriately and relevantly, using the right body language, RolePlay in different situations& Discourse Skills using visuals.

Unit-2:ActivitiesonReadingComprehension

General Vs Local comprehension, reading for facts, guessing meanings from context, scanning, skimming, inferring meaning-critical reading, surfing Internet

Unit-3:ActivitiesonWritingSkills

Structureandpresentationofdifferenttypesof writing-Resumewriting/e-correspondence/ Technicalreport writing- planning for writing, improving one's writing.

Unit-4:ActivitiesonPresentationSkills

Oralpresentations(individualandgroup)throughJAMsessions/seminars/PPTsandwritten presentations

Unit-5:ActivitiesonGroupDiscussion,DebateandInterviewSkills

Dynamics of group discussion- intervention- summarizing-modulation of voice-body language-relevance-fluency and organization of ideas and rubricsfor evaluation- Concept and process-pre-interview planning-opening strategies-answering strategies- interview through tele-conference & video-conferencing - Mock Interviews.

Courseoutcomes: Thestudentshouldbeable to

- communicateeffectivelyinformalandinformalsituations

- understandthestructureandmechanicsofwritingresumes,reports,documents and e-mails
- presenteffectivelyinacademicandprofessionalcontexts
- developcommunicationinwritingforavarietyofpurposes
- identify areas of evaluation in Group Discussions conducted by organizations as part of theselection procedure
- overcomestagefearandtacklequestions

Textbooks:

- Soft Skills Training: A workbook to Develop Skills for Employment by Frederick H.Wentz
- EveryoneCommunicates,FewPeopleConnect:WhattheMostEffectivePeopledo Differently by John C. Maxwell
- How to Talk to Anyone: 92 Little Tricks to Have Big success in Relationships by Leil Lowndes
- Teamwork101:WhatEveryLeaderNeedstoKnowbyJohnC.Maxwell
- AdaptAbility:HowtoSurviveChangeYouDidn'tAskForbyM.J.Ryan
- ConflictCommunication:ANewParadigminConsciousCommunicationbyRory Miller

Category:ProgramCoreCourse **Subjectcode:MM3201**

Materials Characterization

Externals:60Marks **L-T-P-C***

Internals:40Marks **3-1-0-4**

CourseObjectives: Tounderstand

- Thebasicconceptofdifferentcharacterizationtechniquesandopticalmicroscope
- To analyze and understand the behavior of materials from characterization techniques.
- To study crystal structure, chemicalcomposition, phase, residual stress andtexture of materials.
- Tostudythemicrostructureofmaterialsfromopticalandelectronmicroscopes.
- To understand the spectroscopic, thermal and electrical characterizationtechniques.

Unit-1:OpticalMicroscope

Introduction, scope of subject, classification of techniques for characterization, macro& micro-characterizationstructure of solids, Metallographictechniques: Opticalmetallography, image analysis, quantitative phase estimation.

Unit-2:ElectronMicroscope

Electron optical methods: Scanning electron microscopy and image formation in the SEM, Transmissionelectron microscopy (TEM), Scanning tunneling microscopy (STM), Atomic forcemicroscopy(AFM)and scanning transmission electron microscopy (STEM).

Unit-3:XRD

Diffraction methods: X - ray diffraction, crystal systems and space groups, Bravais lattices, direct and reciprocal lattice, Braggs law, powder diffraction and phase identification, single crystal diffraction, structure factor, X-ray crystal structure determination, Residual stress analysis.

Unit-4:Spectroscopy

Optical& X -ray spectroscopy: atomic absorption spectroscopy, X -ray spectrometry,infraredspectroscopy,Ramanspectroscopy,EDSandWDS.

Unit-5:ThermalAnalysis

Bulk averaging techniques: Thermal analysis, DTA, DSC, TGA, TMA, dilatometry, resistivity/ conductivity.

Courseoutcomes: Thestudentwillbeableto

- Familiarondifferentcharacterizationtechniquesandopticalmicroscope.
- Describetheprinciplesofopticalandelectronmicroscopy.
- ExplaintheprinciplesofXRDformaterialscharacterization.
- UnderstandSpectroscopictechniquesforcharacterizematerials.

- Analysethermalreactionsusingthermalanalysisdata.

Textbooks:

- SpencerMichael,FundamentalsofLightMicroscopy,CambridgeUniversity Press, 1982

- DavidB.WilliamsandC.BarryCarter,TransmissionElectronMicroscopy:A Textbook for Mate rials Science, Springer, 2009.
- Joseph I Goldstein,Dale E Newbury,Patrick Echlin and David C Joy,ScanningElectron Microscopy and X-Ray Microanalysis, Springer, 2005.

References:

- B.D.CullityandS.R.Stock,ElementsofX-RayDiffraction,PrenticeHall,2001.
- G.W.H.Hohne,W.F.Hemminger,H.J.Flammersheim,DifferentialScanningCalorimetry, Springer, 2003.
- DouglasB.Murphy,Fundamentalsoflightmicroscopyandelectronicimaging, Wiley, 2001.
- DavidG.Rickerby,GiovanniValdrè,UgoValdrè,ImpactofElectronand Scanning Probe Microscopy on Materials Research, Springer, 1999.

Category:ProgramCoreCourse **Subjectcode:MM3202**

Corrosion Engineering

Externals:60Marks **L-T-P-C***

Internals:40Marks **3-1-0-4**

CourseObjectives:

- Tounderstandthetechnologicalimportanceofcorrosionstudies
- Tostudytypesandbasicconceptsofcorrosion
- Tostudyandunderstandthekineticsofcorrosion
- Tostudyandunderstandthepreventivemeasuresofcorrosion

Unit-1:Introduction

Technological importance of corrosion study - introduction to corrosion, definition, learning objectives, degradation process-mechanical and chemical process. Dry corrosion and wet corrosion. Local and uniform corrosion. Cost of corrosion-direct loss and indirect loss, costof corrosion in various industries.

Unit-2:BasicConceptsofCorrosion

Electochemical principles of corrosion - cell analogy, cathode, anode, electrolyte, cathodic and anodic reactions, types of corrosion cell. Concept of free energy (driving force of corrosion based on thermodynamical studies), cell potential and emf, Nernst equation and their application on corrosion. Concept of single electrode potential, reference electrodes,half cell reaction, types of reference electrode-SHE, Ag-AgCl, SCE, Cu-$CuSO_4$.Emf and galvanic series-their uses in corrosion studies. Eh-pH diagrams-fundamental aspects. Construction of Eh-pH diagrams.

Unit-3:CorrosionKinetics

Corrosionrateexpressions-Faraday'slaw, areaeffect,weightloss,thicknessloss.Electrode–solutioninterface – over potential, definitionand typesof polarization-factorsaffectingthem. Exchange current density-polarization relationships. Mixed potentials-concepts and basics. Mixed potential theory-mixed electrodes (bimetallic couples), activation and diffusion controlled processes. Application of mixed potential theory. Corrosion rate measurements (determination).Passivity-definitions and influencing parameters. Passivity-design of corrosion resistant alloys, factors affecting passivity.

Unit-4:TypesOfCorrosion

Different forms of corrosion Mechanism, characteristic features, causes and remedial measures of uniform corrosion, galvanic corrosion, crevice corrosion. Pitting corrosion, intergranular corrosion(including weld decay& knife-line attack). Erosion corrosion, selective leaching and stress corrosion cracking. Hydrogen damage-types, characteristics, mechanism and preventive measures.

Unit-5:CathodicProtectionandCoating

Principles of corrosion prevention-material selection, control of environment including

inhibitors. Cathodic protection-principle, classification, influencing factors and design aspects. Anodic protection-principle, influencing factors and design aspects. Coatings and design considerations (corrosion prevention).

Courseoutcomes: Thestudentshouldbeable to

- Understandelectrochemicalfundamentals
- Understandcorrosionpreventingmethods
- Understandenvironmentalinducedcorrosion
- Solvecorrosionproblems

Textbooks:

- Fontana.“CorrosionEngineering”,
- ZakiAhmad“PrinciplesofCorrosionengineeringandcorrosioncontrol”,
- PierreR.Roberge.“HandbookofCorrosionEngineering”

Category:ProgramCoreCourse **Subjectcode:MM3203**

Powder Metallurgy and Additive Manufacturing

Externals:60Marks **L-T-P-C***

Internals:40Marks **3-0-0-3**

CourseObjectives:

- Tounderstandthebasicsandoverviewofpowder metallurgy
- To study various powder production methods and analyzing the characteristics of powders
- Tounderstandvariouscoldandhotcompactionmethods
- Tostudyvarioussinteringandpostsinteringprocesses.
- Tostudyvariousadditivemanufacturingprocesses.

Unit-1:Introduction

Introduction to powder metallurgy, steps in powder metallurgy, advantages and limitations of powder metallurgy, recent trends.

Unit-2:FabricationandCharacteristics

Powder production methods: mechanical, chemical, atomisation and physical methods, powder treatment and handling.

Particle size & shape distribution, electron microscopy of powder, interparticle friction, packing and flow characteristics of powders, density compression ability, powder structure, chemical characterization

Unit-3:PowderShaping

Particle packing modifications, lubricants and binders, powder compaction and process variables, pressure and density distribution during compaction, isostatic pressing, injection molding, powder extrusion, slip casting, tape casting, analysis of defects of powder compact.

Unit-4:Sintering

Theory of sintering, sintering of single and mixed phase powder, liquid phase sintering, sintering variables, modern sintering techniques, physical& mechanical properties evaluation, structure-property correlation study, defects analysis of sintered components, post sintering operations.

Application of Powder Metallurgy: Filters, Tungsten Filaments, Self-Lubricating Bearings, Porous Materials, ODS Alloys.

Unit-5:AdditiveManufacturing

Introductionto AM, advantages ofAM, stepsin AM, classificationof AM processes and types of materials for AM.

Courseoutcomes: Thestudentshouldbeable to

- Understandtheneedforpmparts.
- Understandthepowderproductionandcharacterizationtechniques.
- Understandvariouspowdershapingtechniques.

- Understandtheroleofbindersandlubricantsinpm.

- Understandthesignificanceofvariousstagesinsinteringandinfluenceof sintering atmospheres.
- Uptimizeprocessparametersofthepowdermakingoperations.
- Haveabasicknowledgeofadditivemanufacturing.

Textbooks:

- R.M.German,"PowderMetallurgyScience",MetalPowderIndustry,1994.
- Anish Upadhyaya, G.S. Upadhyaya, "Powder Metallurgy science, technology and materials", Universities Press, 2011.
- Damir Godec, Joamin Gonzalez-Gutierrez, Axel Nordin, Eujin Pei, Julia Ureña Alcázar, "A Guide to Additive Manufacturing", Springer Tracts in Additive Manufacturing, 2022.

References:

- P.K. Samal and J. W. Newkird, "Powder Metallurgy", ASM Handbook, Volume7,2015.
- R.M. German,"PowderMetallurgy& ParticulateMaterials Processing",MPIF, 2005.
- J.S.Hirschhorn,"IntroductiontoPowderMetallurgy",AmericanPowderMetallurgy Institute, 1976.
- P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, 2008.

Category:ProgramCoreCourseLab **Subjectcode:MM3801**

Materials Characterization Lab

Externals:60Marks **L-T-P-C***

Internals:40Marks **0-0-3-1.5**

CourseObjectives:

- Tofamiliarizeinmicrostructurefeature
- Tounderstandmodeoffracture
- ToprovidehandsonexperienceofXRD,FESEM,andEDX
- TostudyandanalyzethepeaksofXRDofmaterials
- Toanalyzequantitativelythechemicalcompositionofmaterial
- Toanalyzethemicroscopicimagesofmaterialsproducedby FESEM

Listofexperiments:

1) ImageanalysisofmicrostructuresusingOM.
2) MicrostructuralanalysisusingSEM.
3) FractographyanalysisusingSEM.
4) ChemicalanalysisofphasesusingSEM-EDS
5) Indexandcalculatethelatticeparameterofcubicsystems.
6) IndexandcalculatethelatticeparameterofNoncubicsystems.
7) Calculatethepreciselatticeparameter.
8) Calculatethecrystallinesize,latticestrainandresidualstressfromXRDdata.
9) PhaseidentificationfromgivenXRDdata.
10) OxidationkineticsusingTGA/DTAdata.
11) DeterminationofthermalpropertiesusingDSCdata.
12) MicrostructuralanalysisusingTEMimage.

Courseoutcomes: Thestudentwillbeableto

- Quantifymicrostructuralfeaturesusingimageanalysistools.
- Identifythemodesoffracture.
- Analysethechemicalcompositionofmaterialsthroughsem-eds.
- Determinecrystalstructureofthematerialusingxrdtechnique.
- Determinethethermalpropertiesofmaterials.

Textbooks:

- SZhang,L.Liand AshokKumar,MaterialsCharacterization Techniques,CRC Press, 2008.
- David B. Williams, C.Barry Carter, Transmission Electron Microscopy, Textbook for Materials Science, Springer, 2009.
- KhangaonkarPR,Penram,AnIntroductiontoMaterialCharacterization,Intl. Publishing (India) Pvt. Ltd, mumbai, 2010.

References:

- B.D.CullityandS.R.Stock,ElementsofX-RayDiffraction,PrenticeHall,NJ, 2001.

- ASMHandbook,Vol.10,MaterialsCharacterization,ASMInternational,USA, 1998.

Category:ProgramCoreCourseLab **Subjectcode:MM3802**

Corrosion Engineering Lab

Externals:60Marks **L-T-P-C***

Internals:40Marks **0-0-3-1.5**

CourseObjectives:

- To measure the corrosion rate of two different metals and to establishing corrosion mechanisms.
- Definingcorrosionresistanceofmaterialsandhowtodevelopnewcorrosion resistant alloys and to Estimating service life of equipment.
- Developingcorrosionprotectionprocesses.
- Toshowtheeffectivenessoftheuseofinhibitors.
- Definingthecriticalpotentialvaluesformaterialsinvariousenvironments.

Thelistofexperiments:

1) Weightloss-corrosionratemeasurement
2) Effectofinhibitoronrateofcorrosion(inorganicinhibitororganicinhibitor)
3) Crevice&Pittingcorrosiontesting
4) Corrosionprotectivecoatings(Hot-dipgalvanization)
5) Corrosionprotectivecoatings(Anodization)
6) Corrosionprotectivecoatings(Electroplatingorelectrolessplating)
7) CorrosionpreventionProtectivecoatings(hardnesstestbypenciltest)
8) CorrosionpreventionProtectivecoatings(immersiontest)
9) CorrosionpreventionProtectivecoatings(saltspraytest)
10) CorrosionratemeasurementusingTafelextrapolationorpotentio-state
11) ConstructionandinterpretationofE-Phdiagram

References:

- ASTMG1—Standardpracticeforpreparingtestsspecimens.
- ASTM G31-72—Standard practice for laboratory immersion corrosion testing of metals.
- ASTMG48-11—Standard test methods for pitting and crevice corrosion resistance of stainless steels and related alloys by use of ferric chloride solution.
- ASTMD336305-Standardtestmethodforfilmhardnessbypenciltest.
- ASTMD6943-03—Standardpracticeforimmersiontestingofindustrial protective coatings.
- ASTMG36 94—Standardpracticeforevaluatingstress-corrosion-cracking resistance of metals and alloys in a boiling magnesium chloride solution

- ASTMG3-14—Standardpracticeforconventionsapplicabletoelectrochemical measurements in corrosion testing.\
- ASTMA262-15— Standardpracticesfordetectingsusceptibilitytointergranular attack in austenitic stainless steels
- ASTMG514—StandardreferencetestsmethodformakingPotentiostatanodic polarization measurements.
- ASTMG59-97— StandardtestmethodforconductingPotentiostatpolarizationresistance measurements.

FRACTURE MECHANICS

Subcode:

MM3212

Externals: 60Marks L-T-P-C*
Internals: 40Marks 3-1-0-3

Course Objectives:

* To provide an overview of the problems of fracture in structural materials and understand the basics of fracture mechanics.
* To understand the concept of plastic zone size and difference in fracture behavior of materials based on the crack-tip plastic deformation of materials.
* Effect of temperature and stress state on the fracture mechanics of different materials.
* To analyze the effect of energy supplied on fracture
* To study different fracture tests.
* To familiarize students to different case studies involving fracture of materials.
* To know the method of fractographic analyses.

Course Outcomes:

 Evolution of a pragmatic understanding regarding the conditions of the failure of materials.

 Honing the skills of the pupil in studying fractographic images and identifying the cause and type of failure.

 Students develop an ability to design different samples and tests for fracture toughness estimations and fractographic analyses of different materials.

 Study of the plastic deformation characteristics at the crack tip.

 To imbibe in the students the ability to derivative several stress equations to describe fracture of samples along with problem solving.

 Enhancing the ability of students to simulate real time situations and develop methods to avoid fracture under the given conditions.

Part 2: Concept of plastic zone and effect on fracture toughness
Elastic stress field and linear elastic fracture mechanics, crack-tip plastic zone and the elastic plastic fracture mechanics, design philosophy, the role of microstructure on fracture toughness and the fracture toughness approach for toughening of structural materials, plane stress and plane strain fracture modes.

Part 3: Energy and fracture relations
Transition temperature phenomenon, impact fracture test methods, impact energy-fracture toughness correlations, limitations, concepts of subcritical crack growth in cyclic loading, in environmental assisted cracking and at elevated temperature applications of structural materials.

Part 4: Testing
LEFM, EPFM and GYFM approach, plane strain fracture toughness measurement (E-399), indentation fracture toughness, plane stress fracture toughness measurement, J-integral approach, COD measurement.

Part 5: Fractograpy:
Mechanisms of failure associated with varied fractographic features, approach for failure analysis, problems and case studies.

Suggested References:
1. Dieter, G, E., Mechanical metallurgy (SI metric edition), McGraw-Hill book company, 1988.
2. Hertzberg, R, W., Deformation and fracture mechanics of engineering materials (3rd edition), John Wiley & sons, 1997
3. Broek, D., Elementary engineering fracture mechanics (3rd edition), Martinus Nijhoff publications, 1982.
4. Knott, J. F., Fundamentals of fracture mechanics, Butterworth publications, 1973.

Category:ProgramElectiveCourse **Subjectcode:MM3221**

Secondary Steel making

Externals:60Marks **L-T-P-C***

Internals:40Marks **3-0-0-3**

CourseObjectives:

- Tostudyandunderstandvariousrefiningtechniquesofsteelmaking
- Tostudyandunderstandvariousvacuumdegassingmethods
- Tounderstandthemetallurgyinvolvedintundishusedforstoringrefinedsteel before continuous casting
- TounderstandtheLaddle,TundishandInjectionmetallurgyprocess
- Tostudyandunderstandvarioussecondarytreatmentmethodsofsteels
- Tolearnthenumericalproblemsofsteelmaking

Unit-1:Classificationofsecondarysteelmaking

Ladle metallurgy, Injection metallurgy and Tundish metallurgy; Activity and composition relationships, Thermodynamics of steel making: Raoults and Henry's law; Deoxidation, Desiliconisation, Demanganesisaton, Decarburisation, Desulphurisation, Dephosphirisation;

Unit-2:Vacuumdegassingmethods

VOD (vacuum oxygen decarburizer), AOD (Argon oxygen decarburisation), RH and DH degassing of O, H, N from liquid steel; EAF+AOD (Electric Arc Furnace+Argon oxygen decarburisation) duplexing process, EAF+AOD+VOD triplexing process of stainless steel

Unit-3:Cleansteeltechnology

Inclusion engineering, Tundish design, Inclusions modifications, Remelting process: VAR (Vacuum arc remelting), ESR (Electro-slag Remelting)

Unit-4:SecondarytreatmentofAlloysteels

Production scheme of Dual Phase steels, TRIP Steels, TWIP steels, Interstitial-Free Steels,Bake hardened steels, HSLA Steels

Unit-5:Numericalproblemsofsteelmaking

Material/charge balance in steel making, Thermodynamics of steel making, deoxidation problems, Raoults and Henry's law based problems

CourseOutcomes:

Astudentshallbeableto,

- understandthetypesofsecondarysteelmakingmethods
- understoodtheadvantagesofdecarburization,desulphurization,deoxidation
- awareaboutvacuumdegassingmethodsofsteelproduction
- makethesteelofdesiredchemistryandcleanlinessbyperformingthesuitable treatments in "Ladle"
- understandtheproblemsofsteelmaking

Text books:

- AhindraGhosh,SecondarySteelMaking;Principlesandapplications,2000
- GoshandA.Chatterjee;,PrinciplesandPracticesinIronandSteelmaking,2000

References:

- DipakMazumdar,AfirstcourseinIronandSteelmaking,2000
- DuttaS.K.,LeleA.B.,MetallurgicalThermodynamicsKineticsandNumericals ,2000

FOURTH YEAR (E4) – SEMESTER – II

Category:ProgramElectiveCourse **Subjectcode:MM4251**

Advanced Materials Processing

Externals:60Marks **L-T-P-C***

Internals:40Marks **3-1-0-4**

Courseobjectives:

- Explain the principle concepts of Smart materials, structures, Fibre optics, Magneto/Electro resistive Fluids, Biomimetics and MEMS with principles of working.
- Structure, processing, properties of smart materials will be included with type of activation of smart materials included – Thermal, mechanical, electrical, magnetic, chemical and optical means.
- Fundamental aspects in design and their integration of smart materials to

wide range of applications.

Unit-1:Introduction

Introduction and classication of structural and functional materials; High T emperature Materials: Structure, Processing, mechanical behaviour and oxidation resistance of Stainless Steels, Ni- and Co- Based Superalloys, Aluminides and Silicides, Carbon-Carbon and Ceramic Composites;

Unit-2:Shape-MemoryAlloys

Mechanisms of One-way and Two-way Shape Memory E-ect, Reverse Transformation, Thermoelasticity and Psuedoelasticity, Examples and Applications; Bulk Metallic Glass: Criteria for glass formation and stability, Examples and mechanical behaviour;

Unit-3:Nano-materials

Classication, size effect on structural and functional properties, Processing and properties of nanocrystalline materials, thin lms and multilayered coatings, single walled and multiwalled carbon nanotubes;

Unit-4:MagneticMaterials

Soft and hard magnetic materials for storage devices: Design and Processing; Piezoelectric Materials: Processing and Properties;

Unit-5:Advanceprocesses

Advanced Processes applied for Advanced Materials: Single Crystal Growth, Rapid Solidication, Inert Gas Condensation, Physical and Chemical Vapour Deposition of Thin Films

Courseoutcomes: Attheendofthecourse,studentsshouldbeable to

- Understandthekeypracticaltheorywiththeoperationprinciplesofsmart materials, their manufacturing, properties and their applications
- Addressthekeychallengesandobstacleswithmanufacturingofdifferentsmart materials
- Designandjustifyappropriatematerials forspecificapplicationrelated to smart structures.

Category: **Professional Core Course** Subject code: **MM4252**

Polymer Engineering

Externals: 60Marks **L-T-P-C***
Internals: 40Marks **4-0-0-4**

Course Objectives:

 To introduce the characteristics which distinguish polymers from their analogous class in materials engineering – with study of definition, classification, structure-&-properties relations & Processing for engineering & technical aspects.

 To discuss the reactions of polymers that are useful of modifying or synthesizing new polymers for structural, functional applications.

 To discuss characterization & fundamental testing methods of polymers & polymer blends.

 To discuss advances in polymers with conductive, smart, power polymer, etc. And environmental aspects of polymers.

CourseOutcomes: • Understand the techniques and their characteristics/limitations of synthesis of polymers. • Understand the structure-processing-property relationship of polymers. • Understand and apply the various processing and manufacturing techniques. • Understand the basic issues involved in polymer blends, composites and nanocomposites.

UNIT-I

Introduction: Basic concepts, classification of polymers, structure and size & molecular weight relations, tacticity & isomerism and morphology relations in polymers.

UNIT-II

Chemistry of polymerization & properties: Condensation & addition polymers – types & their engineering, copolymerization & their techniques, control of polymer structure and molecular weights.

UNIT-III

Polymer characteristics and polymer characterizations: Elastomeric and Visco-elastic behaviours, glassy state, characterization techniques of polymers.

UNIT-IV

Plastics & Rubbers, Polymer blends & composites: Plastics & rubbers – materials & processing techniques.

UNIT-V

Miscellaneous polymers, polymers & their environmental impacts: Conductive and dendritics, inorganic and power polymers, nanotechnology. Recovery & recrystallization of polymers. Polymer – waste management.

Suggested References:

1. 'Polymer Science and Technology' - by - P.Ghosh

2. 'Polymer Science' – by - VR Gowariker, N V Viswanathan, Jayadev Sreedhar.
3. 'Textbook of Polymer science' – by – Fred W. Billmeyer Jr.

*L-T-P-C stands for number of lectures, tutorials, practices and credits

Category: **Professional Core Course** Subject code: **MM4242**

COMPOSITE MATERIALS

Externals: 60Marks **L-T-P-C***
Internals: 40Marks **4-0-0-4**

Course Objectives:

- To study the fundamentals, classifications and properties of composites.
- To study various methods of producing Metal Matrix, Ceramic Matrix and Polymer Matrix composites.
- To Characterize and analyse MMC's, CMC's, PMC's prepared.
- To study advanced methods of producing composites

Course Out comes:

- Students will be able to design the process for the production of a composite and asses the quality of the composite by different characterization techniques.
- The student will develop a knowledge of the manufacturing of composite materials.
- The student will be introduced to the various composite components e.g. reinforcement and matrices.
- The student will demonstrate basic knowledge on the various composite processing techniques.
- The student will develop a working knowledge of the various testing and performance protocols for composite materials.
- The student will demonstrate the ability to test the as synthesized composite materials.
- The student will demonstrate the ability to assess the performance of the composites.
- The student will develop an understanding of the economics of composite materials.
- The student will demonstrate an ability to determine material cost through modeling and case studies.

UNIT –I

Fundamentals of composites; Need for composites – Enhancement of properties; Classification of composites – Matrix-Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC); Reinforcements– introduction, glass fibers, boron fibers, carbon fibers, organic fibers, ceramic fibers, whiskers, nonoxide reinforcements, effect of high temperature exposure on the strength of ceramic fibers, comparison of fibers; Matrix materials – polymers, metals and ceramic materials; Interfaces. Iso Strain condition, Iso Stress condition, Load friction shared by the fibers.

UNIT – II Metallurgical and Materials Engineering

Polymer matrix resins – Thermosetting resins, thermoplastic resins – Reinforcement fibers – Rovings – Woven fabrics – Non woven random mats – various types of fibers. Processing of PMCs - Hand lay up processes – Spray up processes – Compression moulding – Reinforced reaction injection moulding - Resin transfer moulding – Pultrusion – Filament winding – Injection moulding. Fiber reinforced plastics (FRP), Glass fiber reinforced plastics (GRP); Structure & properties of PMCs; Applications.

UNIT – III

Characteristics of MMCs; Various types of MMCs; Alloy vs. MMC; Advantages & limitations of MMCs; Important Metallic Matrices; Reinforcements – particles, fibers; Processing of MMCs – liquid state, solid state & in-situ; interfaces in MMCs; Properties & applications.

UNIT – IV

Processing of CMCs – cold pressing & sintering, hot pressing, reaction bonding, infiltration, direct oxidation, in-situ chemical reaction, solgel, polymer infiltration & pyrolysis, electrophoretic deposition, selfpropagating high temperature sysnthesis; Interface in CMCs; Properties of CMCs, Toughness of CMCs; Thermal shock resistance; Applications of CMCs.

UNIT – V

Forging and extrusion of composites – critical issues, dynamic recovery and dynamic recrystallization, mechanical properties; Induction Heating, Fusion Bonding, Ultrasonic welding, Gas tungsten arc welding, Gas metal arc welding, Resistance spot & seam welding, Resistance brazing, Resistance spot joining, Resistant spot brazing, Resistance welding of thermoplasticgraphite composite, Weld bonding, Brazing of MMC.

TEXT BOOKS;

1. Mathews F.L. and Rawlings R.D., Composite materials: Engineering and Science, Chapman and Hall, 1st edition.

2. Composite Materials science and Application –Deborah.D.L.Chung

3. Composite materials, K.K. Chawala, 2nd ed., (1987) Springer-Verlag, New York.

REFERENCE;

1. Hand Book of Composite Materials-ed-Lubin

2. Composite Materials Science and Applications – Deborah D.L. Chung

3. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi
Metallurgical and Materials Engineering

4. Mechanics and Analysis of Composite Materials, V.V. Vasiliev and E.V. Morozov, (2001), Elsevier Science Ltd,

5. Advances in composite materials, G. Piatti, (1978) Applied Science Publishers Ltd., London