STATE COUNCIL FOR TECHNICAL EDUCATION AND VOCATIONAL TRAINING, ODISHA

TEACHING AND EVALUATION SCHEME FOR 4th Semester (Metallurgy)(wef 2019-20)

Subject Number	Subject Code	Subject	Periods/week			Evaluation Scheme			
			L	T	P	Internal Assessment/ Sessional:	End Sem Exams	Exams (Hours)	Total
		Theory							
Th.1		Material Testing	4		-	20	80	3	100
Th.2		Physical Metallurgy	5		-	20	80	3	100
Th.3		Principles of Extractive Metallurgy	4		-	20	80	3	100
Th.4		Sponge Iron & Ferro Alloys	4			20	80	3	100
		Total	17			80	320	-	400
		Practical							
Pr.1		Material Testing Lab	-	-	6	25	100	3	125
Pr.2		Metallography Lab-I.	-	-	6	25	100	3	125
Pr.3		Machine Drawing / CAD	-	-	3	50			50
Pr.4		Technical seminar		-	4	50			50
		Student Centred Activities(SCA)			3				
		Total	-	-	*22*	*150*	*200*	-	*350*
		Grand Total	**17**	**-**	**39**	**230**	**520**	**-**	**750**

Abbreviations: L-Lecturer, T-Tutorial, P-Practical. Each class is of minimum 55 minutes duration

Minimum Pass Mark in each Theory subject is 35% and in each Practical subject is 50% and in Aggregate is 40%

SCA shall comprise of Extension Lectures/ Personality Development/ Environmental issues /Quiz /Hobbies/ Field visits/ cultural activities/Library studies/Classes on MOOCS/SWAYAM etc., Seminar and SCA shall be conducted in a section.

There shall be 1 Internal Assessment done for each of the Theory Subject. Sessional: Marks shall be total of the performance of individual different jobs/ experiments in a subject throughout the semester

CURRICULLUM OF 4TH SEMESTER

For

DIPLOMA IN METTALURGY ENGINEERING

(Effective FROM 2019-20 Sessions)

STATE COUNCIL FOR TECHNICAL EDUCATION & VOCATIONAL TRAINING, ODISHA, BHUBANESWAR

Th1. MATERIAL TESTING

Name of the Course: Diploma in Metallurgical Engineering			
Course code:		Semester	4th
Total Period:	60	Examination :	3 hrs
Theory periods:	4P / week	Internal Assessment:	20
Maximum marks:	100	End Semester Examination ::	80

A. RATIONALE:

Selection and use of various metals and alloys depend on their mechanical properties. Mechanical properties largely depend on various metallurgical processes these materials undergo. It is important for a metallurgical engineer to understand and measure these mechanical properties.

1. OBJECTIVE:

After completion of this course student will have knowledge about

2. Different mechanical properties like strength,fatigue,creep etc.
3. Measuring different mechanical properties of materials.
4. Non-destructive testing and their application.
5. Temperature measurement instruments and their application.
6.

B. Topic wise distribution of periods:		
Sl. No.	**Topics**	**Period**
1	Hardness Test	10
2	Tensile Test	10
3	Impact Test	06
4	Fatigue Test	08
5	Creep Test	06
6	Non-Destructive Testing	14
7	Temperature Measurement and Calibration	06
	Total	**60**

C. COURSE CONTENTS

1. Hardness Test

1.1 Explain and derive expressions for Brinell, Vickers and Rockwell hardness test

1.2 Discuss rebound hardness with reference to shore's Scleroscope.

1.3 Describe scratch hardness and explain mho's scale.

1.4 Discuss the imperical relationship of hardness with strength.

2. Tensile Test :

2.1 Draw and explain stress-strain curve
2.2 Explain modulus of elasticity, proof stress
2.3 Discuss with sketch about yield point phenomenon.
2.4 Explain true stress and true strain curve.
2.5 Define ductility and toughness

3. Impact Test:

3.1 Define impact strength
3.2 Discuss about Charpy and Izod impact tests
3.3 Discuss about transition temperature and ductility, brittle fracture

4. Fatigue Test:

4.1 Explain different stress cycles
4.2 Describe S.N curve and endurance limit
4.3 Explain the procedure of fatigue testing and fatigue testing machine
4.4 Mention different metallurgical factors that affect fatigue behavior

5. Creep Test:

5.1 Define creep and its importance
5.2 Discuss engineering creep curve,constant stress creep curve and Andrad concept
5.3 Explain equicohesive temperature
5.4 State various factors that affect creep
5.5 Describe creep testing machine
5.6 Describe stress rupture test

6. Non – destructive Testing:

6.1 Discuss the scope and elementary idea about different NDT and their significance

6.2 Give brief description of the following NDT

(a) Visual testing
(b) Leakage test
(c) Magnetic particle testing
(d) Dye penetration test
(e) Acoustic methods and ultrasonic testing
(f) Eddy current testing
(g) X – ray diffraction

7. Temperature Measurement and Calibration:

7.1 Analysis the basic principle of pyrometry

7.2 Explain different types of pyrometer and thermocouples.

Syllabus to be covered up to I.A.

Chapter: 1,2,3, 4.1 & 4.2

Learning Resources:			
Sl.No	**Title of the Book**	**Name of Authors**	**Name of Publisher**
1.	Testing of Metallic Material	Surya Narayan	B.S.Publication
2.	Mechanical Metallurgy	Deiter	Mc Graw Hill
3.	Introduction to Physical Mettallurgy	Avner	Mc Graw Hill
4.	X-Ray diffraction	BD Culity	Person Publication
5.	Mechanical Testing of Engineering Materials	C.Mohapatra	JJTP,Bhubaneswar

Th2. PHYSICAL METALLURGY

Name of the Course: Diploma in Metallurgical Engineering			
Course code:		Semester	4th
Total Period:	75	Examination :	3 hrs
Theory periods:	5P / week	Internal Assessment:	20
Maximum marks:	100	End Semester Examination ::	80

RATIONALE :

Physical properties of metals and alloys are dependent on their crystal structures. Physical metallurgy explains different aspects of crystal structures of metals and alloys. It is, therefore, a very important subject for a metallurgical engineering.

OBJECTIVES :

After completion of the subject students will have knowledge about

1. Physical properties & related mechanical properties of metals & alloys.
2. Structure of metals & alloys.
3. Solidfication process of metals & alloys.
4. Various types of equilibrium diagrams.
5. Iron carbon equilibrium diagram.
6. Optical Metallurgical microscope & electron microscope.

C.TOPIC WISE DISTRIBUTION OF PERIODS		
SL.NO.	**TOPIC**	**PERIODS**
1	Crystal Structure of metals	10
2	Solidification of Pure metals and alloys	10
3	Equilibrium Diagrams	20
4	Solid Solution	12
5	Cast Iron	15
6	Metallurgical Microscope	08
	TOTAL	75

1.0 **Crystal Structure of metals** :

1.1 Define crystal and crystallography

1.2 Define space lattice and unit cell

1.3 Compare different types of crystal lattices, bravis lattices and primitive lattices.
1.4 Define with sketch B.C.C., F.C.C & H.C.P.
1.5 Define Miller indices, planes and directions
1.6 Define isotropy and anisotropy in metallic materials
1.7 Define imperfections in metallic materials
1.8 Differentiate between types of imperfections : point defect, line defect, surface defect and volume defect (elementary idea)

2.0 **Solidification of pure metals & alloys** :
2.1 Define alloys and solid solution
2.2 Define solidification and crystallization
2.3 Explain role of free energy thermodynamic potential in conversion of liquid to solid
2.4 Define super cooling, under cooling, degree of super cooling
2.5 Explain mechanism of solidification/ crystallization, nucleation, critical size nucleus, spontaneous nucleation, relation between ration of nucleation and grain growth.
2.6 Discuss shape of crystals and solidification of ingot.

3.0 **Equilibrium Diagram** :
3.1 Define equilibrium diagram
3.2 Discuss the importance of equilibrium diagram
3.3 Draw equilibrium diagram of binary alloys
3.4 State types of equilibrium diagram
3.5 Explain isomorphous equilibrium diagram with examples
3.6 Explain eutectic type and eutectoid equilibrium diagram with example
3.7 Explain peritectic type and peritectoid equilibrium diagram with example
3.8 Define phase rule, lever rule
3.9 Apply phase rule, and lever rule in each equilibrium diagram.
3.10 Draw iron carbon equilibrium diagram and describe different phases and micro constituent in iron carbon diagram
3.11 Discuss role of carbon with iron to differentiate steel and cast iron
3.12 Apply lever rule in iron and carbon diagram
3.13 Differentiate between iron-carbon, iron-cementite, and iron-graphite diagram.

4.0 **Solid solution** :
4.1 Define solution, alloying
4.2 Explain different types of solid solution
4.3 Differentiate between substitutional and interstitial solid solution, chemical compound, mechanical mixture and intermetallic compounds.
4.4 Differentiate between ordered and disordered solid solution.

4.5 Define Hume Rothery rule and describe the different factors governing the formation of solid solutions.

5.0 **Cast iron** :

5.1 Define cast iron, differentiate between steel and cast iron, alloy steel and alloy cast iron.

5.2 Discuss different types of cast iron with their composition

5.3 Define graphitization and role of graphitization in cast iron

5.4 Draw structures of cast iron

6.0 **Metallurgical Microscope** :

6.1 Differentiate between metallurgical microscope & biological microscope

6.2 Describe different types of metallurgical microscope

6.3 State working principle of metallurgical microscope

6.4 Define magnifying power & resolving power, spherical and chromatic aberration.

6.5 Explain with sketch principle of electron microscope

6.6 Prepare a sample for study of microstructures e.g. sampling, cutting, grinding, rough polishing, intermediate polishing, fine polishing and etching.

Portion for Internal Assessment:

Topics:-1, 2 & 3.1 TO 3.9

Learning Resources:

Sl.No	Title of the Book	Name of Authors	Name of Publisher
1.	Engineering Physical Metallurgy	Laktin	CBS Publishers & Distribution
2.	Physical Metallurgy	Reed Hill	EWP
3.	Material Science and Engineering	Raghavan	PHI
4.	Physical Metallurgy	Smallman	Cutterworth- Heinemann
5.	Introduction to Engineering Materials	C.Mohapatra	JJTP,Bhubaneswar
6.	Engineering materials and Metallurgy	R.K.Rajput	S.Chand,New Delhi
7.	Material Science	R.S.Khurmi & R.S.Sendha	S.Chand,New Delhi
8.	Physical Metallurgy	Bijendra Singh	Standard Publishers

Th3. PRINCIPLES OF EXTRACTIVE METALLURGY

Name of the Course: Diploma in Metallurgical Engineering			
Course code:		Semester	4th
Total Period:	60	Examination :	3 hrs
Theory periods:	4P / week	Internal Assessment:	20
Maximum marks:	100	End Semester Examination ::	80

RATIONALE :

This subject deals with different methods and principles of extraction of metals from their mineral/ores. It is therefore, a very important topic under metallurgical engineering.

OBJECTIVES:

After completion of the course, the students will have knowledge about:-

1. Different types of extraction process – pyrometallurgical extraction, hydrometallurgical extraction, and electrometallurgical extraction.
2. Extraction process applicable to different ores.
3. Refining operation of the extracted metals.
4. Application of metallurgical thermodynamics and kinetics in extraction processer.

C. TOPIC WISE DISTRIBUTION OF PERIODS		
SL.NO.	**TOPIC**	**PERIODS**
1	Definition of metallurgical terms	05
2	Principles of pretreatment of ores for metal extraction	10
3	General methods and principle of extraction	25
4	Basic approaches to refining	03
5	Principles of metal extractions	10
6	Principles of metallurgical thermodynamics reaction kinetics	07
	TOTAL	60

D.COURSE CONTENT :

1.0 Definition of metallurgical terms :

1.1 Define ores and minerals

1.2 Define gangue, flux and slag

1.3 Define matte and speiss

1.4 Define metals and alloys

2.0 Principle of pre-treatment of ores for metal extractions :

2.1 Explain drying

2.2 Define and explain calculation

2.3 Explain different agglomeration process like briquetting nodulising, vacuum extrusion, sintering, palletizing.

3.0 General Methods of Extraction :

3.1 Pyrometallurgical processes

3.2 Explain roasting and different roasting methods

3.3 Explain Ellingham diagram (oxides) and predominance area diagram (sulphides)

3.4 Explain smelting and different smelting practices, Flash smelting, hearth smelting, matte smelting

3.5 Explain the method of distillation and sublimation

3.6 Explain the process of converting of matte and pig iron

3.7 Explain hydrometallurgical process

3.8 Explain different stages of hydrometallurgical process

3.9 Write the flow diagram of hydrometallurgical extraction

3.10 Explain leaching and different leaching methods, bacterial leaching and pressure leaching

3.11 Electrometallurgical process

3.12 Define electrolysis, ionic conductivity, EMF series, faraday's law of electrolysis

3.13 Explain electro wining, electro refining

4.0 Basic approaches to refining :

Explain refining, process – zone refining, fire refining

5.0 Principle of metal extractions :

5.1 Explain principles of metallurgical thermodynamics, zeroth law of thermodynamics

5.2 Review 1^{st}, 2^{nd}, and 3^{rd} law of thermodynamics, explain their application to metallurgical process.

5.3 Explain on details the concept of Internal Energy, enthalpy, entropy and entropy change, Free energy of a chemical reaction.

5.4 State Henry's law and Sivert's Law.

6.0 Reaction Kinetics :

6.1 Explain first order reaction and its significance.

6.2 Explain the application of first order reaction of metallurgical processes.

Portion for Internal Assessment:

Topics:-1, 2 & 3.1 TO 3.6

Learning Resources:			
Sl.No	**Title of the Book**	**Name of Authors**	**Name of Publisher**
1.	Extraction of Non-ferrous Metals	H. S. Roy, Shridhar & Abraham	EWP Distribution
2.	Principle of Extractive Metallurgy	A. Ghosh & H. S. Roy	New Age
3.	Metallurgy Thermodynamics	R. H. Trupkary	Khanna
4.	Elements of Metallurgy	Swarup & Saxsena	Rastogi Publication

Th4. SPONGE IRON AND FERRO ALLOYS

Name of the Course: Diploma in Metallurgical Engineering			
Course code:		Semester	4th
Total Period:	60	Examination :	3 hrs
Theory periods:	4P / week	Internal Assessment:	20
Maximum marks:	100	End Semester Examination ::	80

A.RATIONALE:

Sponge iron and Ferro alloys have lot of importance as raw materials for steel manufacture; sponge iron is gradually replacing pig iron due to scarcity of coke in India and its use in B. F. to produce pig iron.

B.OBJECTIVES:

After completion of the course, the students will have knowledge about:-

1. Importance of sponge iron & Ferro alloys.
2. Various raw materials & their qualify requirements for sponge iron & ferroalloy production.
3. Principal & process of sponge iron production.
4. Various practical processes / furnaces are in use for production of Sponge iron & Ferro alloys..
5. Various uses of the sponge iron & ferroalloys.

C. **TOPIC WISE DISTRIBUTION OF PERIODS**

SL.NO.	TOPIC	PERIODS
1	Review of Sponge Iron Making Processes	04
2	Thermodynamics of Sponge Iron Making	12
3	Major direct reduction processes	08
4	Parameters of Sponge Iron Making	08
5	DRI Plant Operation and Abnormalities	08
6	Quality Control in Sponge Iron Plant	06
7	Environmental Management in DRI Plants	06
8	Production of Ferro-alloys	08
	TOTAL	60

D.COURSE CONTENTS:

Chapter-1: Review of Sponge Iron Making Processes:

1.1 Historical Development.
1.2 Reasons for Rapid growth of DR Process
1.3 Chronological Evolutions of some of the DRI Processes
1.4 Conventional versus DRI Steel Making
1.5 Direct Reduction of Iron Ore.

Chapter-2: Thermodynamics of Sponge Iron Making:

2.1. Principles of Direct Reduction Reactions.
2.2. Reaction between Coal, Oxygen and Carbon dioxide. (Set-I).
2.3. Reaction between Iron ore and CO (Set-II).
2.4. Reaction Mechanism in Coal based DRI
2.5. Reaction Mechanism in Gas based DRI.
2.6. Reduction by Carbon monoxide
2.7. Reduction by Hydrogen
2.8. Boudourd reaction and Reduction by Carbon
2.9. Carbon Deposition
2.10. Kinetics in DRI
2.12. Factors Influencing the Reducibility of Iron Ore.
2.13. Rate Controlling Theories.

Chapter-3: Major direct reduction processes

3.1 Coal based DR process using rotary kilns.
SL/RN,CODIR,ACCAR,TDR,OSIL,Krupp-Rein processes.
3.2 Coal based processes using reactors other than rotary kilns.
Rotary hearth processes based on
Inmetco,fastmet,It mk-3,
Tunnel kiln processes
kinglor-meter,hogans,
3.3 Gas based direct reduction
HYL processes,MIDREX
Fluidwise bed processes-FIOR-HIB
3.4 Uses of DRI in iron making and steel making.

Chapter-4: Parameters of Sponge Iron Making:

4.1 Raw materials of Sponge Iron Making
4.2. Chemical and Physical Tests on iron ore: Chemical composition, Reducibility, Strength, Tumbling, Abrasion and Shatter Index, Porosity, Bulk Density, Thermal Degradation Index (TDI).
4.3. Tests on Non Coking Coal: Proximate and Ultimate Analysis, Reactivity, Calorific Value, Coking Index, Swelling Index, Ash Fusion Temperature, Bulk Density.
4.4. Effect of Iron Ore size on Reduction
4.5 Carbon Enrichment of Sponge Iron
4.6 How Carbon Enrichment of Sponge Iron is performed
4.7. Flow of Solids in the Reactor or Kiln
4.8. Process Parameters of Sponge Iron Production: Raw materials, Iron Ore Feed Rate, Coal Feed Rate, C/FeRatio, Dolomite Feed, Rate, Reduction Coal to Blow Coal Ratio , Ratio of coarse and Fines in Blow Coal, Blow Coal Pressure, Temperature Profile, Kiln Speed,Ore Retention Time and Cooler Discharge end Pressure.

4.9. Nonmagnetic Percentage in the Kiln Discharge

Chapter-5: DRI Plant Operation and Abnormalities:

5.1. Daily Operating Parameters.

5.2 Operational Abnormalities: Process Pressure Fluctuations, Temperature Deviations, Back Spill, Loss of Process Fan(s), High Temperature of Cooler Discharge, Loss of Product Quality

5.3 Major Problems of DRI Kiln Operation: Injection Coal Jam, Feed Pipe Jam, Transfer Chute Jam, Main Drive Problem, Refractory Failure their causes and remedies

5.4. Shutdown Procedure: Normal Shutdown Schedule for a 500 TDP Kiln.

5.5. The Start Up process: Heating of the Reactor Refractory

5.6. Accretion Formation

5.7. Key notes on process plant operation.

Chapter-6: Quality Control in Sponge Iron Plant

6.1. Sampling: Sponge Iron and the Raw materials

6.2. Chemical Analysis of Sponge Iron, Iron Ore, Lime Stone/Dolomite and Coal

6.3. Scheme of Quality Control of input Raw Materials: Reactor Feed Iron Ore, Reactor Feed Coal, Back –Spill Coal, Slinger Coal.

6.4. Determination of Total Iron (FeT), Ferrous Iron and metallic Fe.

Chapter-7: Environmental Management in DRI Plants:

7.1. Air Pollution Mitigation Measures

7.2. Fugitive Dust Generation

7.3. Water Pollution Mitigation Measures

7.4. Solid Waste Generation and Disposal

7.5. Hazardous Wastes and Chemicals

7.6. Occupational Health and Safety

7.7. Environmental Monitoring

7.8. Environmental Standards

Chapter - 8: Production of Ferro-alloys:

8.1. Introduction to Ferro-alloying elements.

8.2. Different Ferro alloys.

8.3. General methods of producing Ferro alloys: carbothermic and aluminothermy reductions,

8.4. Refining of Ferro alloys.

8.5. Production of individual Ferro alloys: Ferro manganese, Ferro chrome, charge chrome,ferrosilicon

Fe-Ti, Fe-W, Fe-Mo and Fe-V.

<u>Portion for Internal Assessment:</u>

Topics: - 1,2,3 & 4

Learning Resources:			
Sl. No.	**Title of the Book**	**Name of Authors**	**Name of Publisher**
1.	Sponge iron Production	Direct Reduction of Iron oxide	PHI
2.	DRI Process and its relevance to India	S. Dasgupta, T. K. Ray & B. Ray	M.N. Dastur companies Pvt Ltd.
3.	DRI Process in Rotary kiln	Alis Chalmers	USA
4.	Production of ferro alloys	A. Riss, Y. Khodorrosky	ForeignLanguage Publishing House
5.	Fundamentals of Sponge Iron making	C.Mohapatra & D. Patnaik	JJTP BBSR.
6.	Alternate methods of iron making	Surya Kumar Dutta & R.Saha	S.Chand New Delhi,

Pr1. MATERIAL TESTING LABORATORY

Name of the Course: Diploma in Metallurgical Engineering			
Course code:		Semester	4th
Total Period:	90	Examination :	3 hrs
Theory periods:	6P / week	Sessional	25
Maximum marks:	125	End Semester Examination ::	100

(Student are required to perform at least seven experiments)

1. Study the operation of different hardness testers such as Brinell, Rockwell & Vickers hardness testers.
2. Determination of BHN of metals & alloys
3. Determination of VHN of metals & alloys
4. Determination of RB & RC hardness values for metals & alloys
5. Study & operation of micro hardness tester..
6. Study the operation of impact tester
7. Determination of impact value of a steel specimen by Charpy & Izod machine
8. Study of fatigue testing machine and determination of fatigue limits
9. Study of U.T.M. & determination of tensile & compression strength values.

Sl. No	**Title of the Book**	**Name of Authors**	**Name of Publisher**
1	Testing of Engineering Materials	AVK Suryanaryan	TMH
2	Practical Experimental Metallurgy	Rawlings	EWP
3	Mechanical Metallurgy	Dietor	TMH
4	Introduction To Physical Mettalurgy	S.H.Avner	TMH

Pr2. METALLOGRAPHY LAB-I

Name of the Course: Diploma in Metallurgical Engineering			
Course code:		Semester	4th
Total Period:	90	Examination :	3 hrs
Theory periods:	6P / week	Sessional	25
Maximum marks:	125	End Semester Examination ::	100

(Students are required to perform atleast five experiments out of the followings)

1. Study of metallurgical microscope.
2. Preparation of metallic specimen for metallographic study by grinding, polishing and etching
3. Study of specimen mounting press and preparation of mounted specimens.
4. Study of microstructure of different steels (hypo, eutectoid and hypereutectoid steels)
5. Study of microstructure of different cast iron (atleast three)
6. Study of microstructure of nonferrous metals and alloys e. g. copper, aluminum, brass and bearing metals.

Sl. No	**Title of the Book**	**Name of Authors**	**Name of Publisher**
1	Principles of Metallographic practice	Khel	Mc Graw Hill
2	Physical metallurgy	Sydeny H Avner	Mc Graw Hill

Pr3. MACHINE DRAWING/CAD

Name of the Course: Diploma in Metallurgical Engineering			
Course code:		Semester	4th
Total Period:	60	Examination :	3 hrs
Theory periods:	4P / week	Sessional	50

1. Drawing of Isometric views of Nuts, Bolts, Screws, Rivets and Locking devices is free hand.
2. Drawing of different thread forms: left and right, single and multi-start.
3. Knuckle and cotter joints front view, top view, and side view.
4. Plummer block and flange coupling sectional front view, plan & side view.
5. AutoCAD theory & practice on latest auto-cad software using computers in Auto cad Lab.

Sl. No	**Title of the Book**	**Name of Authors**	**Name of Publisher**
1	Machine Drawing	N. D. Bhatt	Charotor Publishing
2	CAD/CAM (Theory and Practice)	Kuldeep Saren, & Chandan Deep Grewal	S.Chand

LABORATORY WISE LIST OF EQUIPMENTS FOR 3RD SEMESTER

MINERAL DRESSING LABROTORY
(For 30 students)

1. Jaw crusher with Grindability Index Attachment ----01no.
2. Ball mill with media ----------01no.
3. Sieve shaker with set of sieves ---------03sets.
4. Jigging m/c ----------01no.
5. Wilfley table ----------01no.
6. Flotation cell ----------01no.
7. Magnetic separator ----------01no.
8. Electrostatic separator ----------01no.
9. Crushing Rolls ----------01no
10. Cone Crusher ---------- 01no
11.Pulverizert ---------- 01no
12. Digital balance(2 kg)----------03 nos.

FUEL TESTING AND CHEMICAL ANALYSIS LAB
(For 30 students)

1. Pensky Martin Digital flash and fire Point Apparatus. --- 2 nos
2. Electrolytic Analyzer. ---------- 02 nos
3. Heating Oven(heating up to 130 deg. C) ----------02 nos
4. All standard set up for chemical analysis.----------15 sets.

LABORATORY WISE LIST OF EQUIPMENTS FOR 4TH SEMESTER
MATERIAL TESTING LABORATORY
(FOR 30 STUDENTS)

1. Brinell hardness tester ---------- 02nos.
2. Rockwell hardness tester ---------- 02nos.
3. Vickers hardness tester ---------- 02nos.
4. Charpy impact tester ---------- 01nos.
5. Izod impact tester ---------- 01nos.
6. Fatigue testing m/c ---------- 01nos.
7. Universal testing m/c ---------- 01nos.
8. Microhardness Tester ---------- 1 no

METALLOGRAPHY LAB-

(FOR 30 STUDENTS)

1. Sample cutter ----------01
2. Power hacksaw ----------01
3. Belt polisher ---------- 03
4. Wheel grinder ----------01
5. Polishing machine (two disc type)---------- 03
6. Metallurgical Microscope----------03
7. Specimen mounting press----------03
8. Automatic polishing etching machine--------03