Republic of the Philippines
OFFICE OF THE PRESIDENT
COMMISSION ON HIGHER EDUCATION

CHED MEMORANDUM ORDER(CMO)
No. 11
Series of 2008

SUBJECT : **POLICIES AND STANDARDS (PS) FOR THE DEGREE OF BACHELOR OF SCIENCE IN METALLURGICAL ENGINEERING (BSMetE) PROGRAM**

In accordance with the pertinent provisions of Republic Act (RA) No. 7722, otherwise known as the "Higher Education Act of 1994," and by virtue of Resolution No. 741 - 2007 of the Commission en banc dated 15th day of October 2007 and for the purpose of rationalizing the metallurgical engineering education in the country, the set of policies is hereby adopted and promulgated by the Commission.

ARTICLE I - INTRODUCTION

Section 1 **Rationale and Background.**

Metallurgical Engineering is a profession which embraces the scientific, engineering, environmental and economic aspects of Mineral Processing and Extractive Metallurgy, Adaptive and Physical Metallurgical and Fuel Technology.

The herein Policies and Standards have been reviewed in accordance with recently approved CMO, industry needs, latest trends and technology in the field of metallurgical engineering. This PS emerged as a result of consolidated efforts of the academe, industry and other related agencies.

ARTICLE II - AUTHORITY TO OPERATE

Section 2. All private higher education institutions (PHEIs) intending to offer **Bachelor of Science in Metallurgical Engineering** must first secure proper authority from the Commission in accordance with existing rules and regulations. State Universities and Colleges (SUCs), and Local Colleges and Universities (LCUs) should likewise strictly adhere to the provisions in these policies and standards.

ARTICLE III - PROGRAM SPECIFICATION

Section 3. Degree Name

The degree program herein is called **BACHELOR OF SCIENCE IN METALLURGICAL ENGINEERING (BSMetE)**

Section 4. Program Description

4.1 Nature of the Program

This program trains the student in the three major fields of metallurgical engineering and enables them to attain the basic competencies such as conceptualizing and designing of metallurgical process and products, generating technical specification and standards, undertaking research and development, process improving and optimizing, applying metallurgical principles to metallurgical processing and operations and process control of metallurgical plants. This Metallurgical Engineering program is designed especially to meet this educational challenge by emphasizing fundamental knowledge, transferable skills, and lifelong learning.

4.2 Program Outcomes

The Bachelor of Science in Metallurgical (BSMetE) program must produce graduates possessing the following :

a. An ability to apply knowledge of mathematics, sciences, engineering sciences to the practice of metallurgical engineering.
b. An ability to design and conduct experiments, as well as to analyze and interpret data.
c. An ability to design a system, build, improve, and install systems or processes which meet desired needs within realistic constraints.
d. An ability to work effectively in multi-disciplinary and multi-cultural teams.
e. An ability to identify, formulate, and solve metallurgical engineering problems.
f. An understanding of professional, ethical, social & environmental responsibilities.
g. An ability to communicate effectively in verbal and non-verbal communication.
h. A broad education necessary to understand impact of engineering solutions in a global/societal context
i. An ability to engage in life-long learning and to keep current of the development in a specific field of specialization
j. A knowledge of contemporary issues.
k. An ability to use the appropriate techniques, skills and modern engineering tools necessary for metallurgical engineering practice to be locally and globally competitive.

4.3 Specific Professions/ Careers/ Occupations or trades in government and private sectors that the graduates may go into

4.3.1 Research and Development Engineer
4.3.2 Failure Analysis and Reliability Engineer
4.3.3 Quality Assurance Engineer
4.3.4 Metallurgy Process Engineer
4.3.5 Extractive Metallurgy Engineer
4.3.6 Mineral Processing
4.3.7 Foundry Metallurgist
4.3.8 Heat Treatment Metallurgist
4.3.9 Non Destructive Metallurgist
4.3.10 Consultant
4.3.11 Government Technical Service
4.3.12 Teaching

Section 5. Allied Programs

The BSMetE allied programs are Materials Science, Materials Engineering, Mining Engineering and Chemical Engineering.

ARTICLE IV – COMPETENCY STANDARDS

Section 6. This section defines the entry-level competency standards, knowledge, attitudes, values and skills applicable to the BS Metallurgical Engineering graduate, which are contained in **ANNEX I** of this Memorandum.

ARTICLE V – CURRICULUM

Section 7. Curriculum Description

7.1 The BS Metallurgical Engineering program has a total of **203** credit units. The program comprised of the general education, basic engineering courses, professional courses, allied and elective courses.
7.2 The general education courses are in accordance with the CHED Memorandum Order No. 59, s. 1996 "The New General Education Curriculum (GEC)"
7.3 The Technical Course includes Mathematics with a total of **26** units Physical Sciences with a total of **12** units and the Basic Engineering Sciences with a total of **21** units and the PE/NSTP, with a total of **14** units and elective **6** units.
7.4 There are **21** professional courses with a total of **61** credit units.
7.5 There are **8** allied courses with a total of **24** units
7.6 Monitoring of OJT in conformity with course objective will be responsibility of the department.
7.7 There are **2** elective courses with **6** credit units.

Section 8. Curriculum Outline

Classification/Course	Minimum No. of Hours per week		Minimum Credit Units
	Lecture	Laboratory	
I. TECHNICAL COURSES			
A. Mathematics			
College Algebra	3	0	3
Advanced Algebra	2	0	2
Plane and Spherical Trigonometry	3	0	3
Analytic Geometry	2	0	2
Solid Mensuration	2	0	2
Differential Calculus	4	0	4
Integral Calculus	4	0	4
Differential Equations	3	0	3
Probability and Statistics	3	0	3
Sub-Total	**26**	**0**	**26**
B. Natural/Physical Sciences			
General Chemistry	3	3	4
Physics 1	3	3	4
Physics 2	3	3	4
Sub-Total:	**9**	**9**	**12**
C. Basic Engineering Sciences			
Computer Fundamentals & Programming	0	6	2
Engineering Drawing	0	3	1
Computer –Aided Drafting	0	3	1
Statics of Rigid Bodies	3	0	3
Dynamics of Rigid Bodies	2	0	2
Mechanics of Deformable Bodies	3	0	3
Engineering Economy	3	0	3
Engineering Management	3	0	3

Classification/Course	Minimum No. of Hours per week		Minimum Credit Units
	Lecture	Laboratory	
Environmental Engineering	2	0	2
Safety Management	1	0	1
Sub-Total:	**17**	**12**	**21**
*** D. Electives**			
Elective 1	3	0	3
Elective 2	3	0	3
Sub-Total:	**6**	**0**	**6**
E. Allied Courses			
General Chemistry 2	2	3	3
Analytical Chemistry (Lec)	2	0	2
Analytical Chemistry (Lab)	0	6	2
Principles of Geology	3	0	3
Elementary Mineralogy	2	6	4
Principles of Mining	3	0	3
Mechanics of Fluids	2	3	3
Basic Metallurgical Engineering	3	0	3
Workshop Theory & Practice	0	3	1
Sub-Total:	**17**	**21**	**24**
F. Professional Courses			
Introduction to Metallurgy	2	0	2
Introduction to Materials Science	3	0	3
Metallurgical Measurements	0	6	2
Metallurgical Analysis	1	6	3

*** Electives**

Special Topics in Metallurgical Engineering

Semiconductor Materials and Processes

Polymer Materials and Processes

Ceramic Materials and Processes

Classification/Course	Minimum No. of Hours per week		Minimum Credit Units
	Lecture	Laboratory	
Metallurgical Physical Chemistry	3	3	4
Mineral Processing 1	3	0	3
Mineral Processing 2	3	6	5
Hydrometallurgy	3	3	4
Electrometallurgy	2	3	3
Pyrometallurgy 1	3	3	4
Pyrometallurgy 2	3	3	4
Adaptive Metallurgy 1	2	3	3
Adaptive Metallurgy 2	2	3	3
Physical Metallurgy 1	3	3	4
Physical Metallurgy 2	2	3	3
Metallurgical Plant Design (Lecture)	2	0	2
Metallurgical Plant Design (Laboratory)	0	3	1
Metallurgical Research	1	6	3
Metallurgical Law and Ethics	1	0	1
Metallurgical Seminar & Plant Tours	0	3	1
Computer Applications in Metallurgical Engineering	2	3	3
Metallurgical Plant Practice (OJT)	320 hrs. / 8 weeks		
Sub-Total:	**41**	**60**	**61**
II NON-TECHNICAL COURSES			
A. Social Sciences			
Social Science 1	3	0	3
Social Science 2	3	0	3
Social Science 3	3	0	3
Social Science 4	3	0	3
Sub-Total	**12**	**0**	**12**
B. Humanities			
Humanities 1	3	0	3
Humanities 2	3	0	3

Classification/Course	Minimum No. of Hours per week		Minimum Credit Units
	Lecture	Laboratory	
Humanities 3	3	0	3
Sub-Total	**9**	**0**	**9**
C. Languages			
English 1	3	0	3
English 2	3	0	3
English 3 (Technical Communication)	3	0	3
Pilipino 1	3	0	3
Pilipino 2	3	0	3
Sub-Total	**15**	**0**	**15**
D. Mandated Course			
Life and Works of Rizal	3	0	3
Sub-Total	**3**	**0**	**3**
E. Physical Education			
P.E. 1			2
P.E. 2			2
P.E. 3			2
P.E. 4			2
Sub-Total			**8**
F. National Service Training Program			
NSTP 1			3
NSTP 2			3
Sub-Total:			**6**
GRAND TOTAL			**203**

SUMMARY

Classification/ Field	Total No. of Hours per week		Total No. of Units
	Lecture	Laboratory	
I. TECHNICAL COURSES			
A. Mathematics	26	0	26
B. Natural Sciences	9	9	12
C. Basic Engineering Sciences	17	12	21
D. Elective	6	0	6
E. Allied Courses	17	21	24
E. Professional Course	41	60	61
Sub- Total	**116**	**102**	**150**
II. NON- TECHNICAL			
A. Social Sciences	12	0	12
B. Humanities	9	0	9
C. Languages	15	0	15
D. Life and Works of Rizal	3	0	3
Sub-Total	**39**	**0**	**39**
Total	**155**	**102**	**189**
Physical Education			8
NSTP			6
Grand Total			**203**

Section 9. Relationship of the Courses to the Program Outcomes

The relationship of the identified courses in section 8 to the identified program outcomes in section 4 – 4.2 are contained in ANNEX II of this Memorandum.

Section 10. Sample/ Model program of study

The institution may enrich the sample/model program of study depending on the needs of the industry, provided that all prescribed courses required in the curriculum outlines are offered and pre-requisite are complied with.

Bachelor of Science in Metallurgical Engineering

FIRST YEAR

1st Year – First Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
College Algebra	3	0	3	None
Plane & Spherical Trigonometry	3	0	3	None
Gen.Chemistry I	3	3	4	None
Engineering Drawing	0	3	1	None
English 1	3	0	3	None
Pilipino 1	3	0	3	None
Humanities 1	3	0	3	None
PE 1			(2)	None
TOTAL	**18**	**6**	**22**	

1st Year – Second Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Analytic Geometry	2	0	2	College Algebra, Plane Trigonometry
Solid Mensuration	2	0	2	College Algebra, Plane Trigonometry
Gen. Chemistry 2	2	3	3	
English 2	3	0	3	English 1
Pilipino 2	3	0	3	Pilipino 1
Physics 1	3	3	4	College Algebra, Plane Trigonometry
Advance Algebra	2	0	2	College Algebra
Computer Aided Drafting	0	3	1	3rd Year Standing
PE 2			(2)	PE 1
TOTAL	**17**	**9**	**22**	

SECOND YEAR

2nd Year – First Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Differential Calculus	4	0	4	Analytical Geometry 7 Solid Mensuration
Physics 2	3	3	4	Physics 1
English 3 (Technical Communication	3	0	3	English 2
Analytical Chemistry(Lec)	2	0	2	General Chemistry 2
Analytical Chemistry(lab)	0	6	2	General Chemistry 2
Humanities 2	3	0	3	Humanities 1
Social Science 1	3	0	3	None
PE 3			(2)	PE 2
NSTP 1			(3)	None
TOTAL	**18**	**9**	**26**	

2nd Year – Second Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Integral Calculus	4	0	4	Differential Calculus
Metallurgical Physical Chemistry	3	3	4	Analytical Chemistry
Introduction to Material Science	3	0	3	General Chemistry 2; Physics 2
Metallurgical Measurement	0	6	2	Calculus, Chemistry
Principles of Geology	3	0	3	General Chemistry
Introduction to Metallurgy	2	0	2	General Chem. 2 ; Analytic Geometry
PE 4			(2)	PE 3
NSTP 2			(3)	NSTP 1
TOTAL	**15**	**9**	**23**	

THIRD YEAR

3rd Year – First Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Differential Equations	3	0	3	Integral Calculus
Statics of Rigid Bodies	3	0	3	Physics 1, Integral Calculus
Elementary Mineralogy	2	6	4	General or Analytical Chemistry
Mineral Processing 1	3	0	3	3rd Year Standing
Metallurgical Analysis	1	6	3	Analytical Chemistry
Basic Metallurgical Engineering	3	0	3	College Algebra, Plane Trigonometry, Physics 2
TOTAL	**15**	**12**	**19**	

3rd Year – Second Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Dynamics of Rigid Bodies	2	0	2	Statics of Rigid Bodies
Engineering Economy	3	0	3	Analytical Chem.
Mineral Processing 2	3	6	5	Mineral Processing 1
Physical Met 1	3	3	4	Met. Physical Chemistry
Workshop Theory & Practice	0	3	1	–
Social Science 2	3	0	3	Social Science 1
TOTAL	**14**	**12**	**18**	

FOURTH YEAR

4th Year – First Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Probability and Statistics	3	0	3	College Algebra 1
Computer Fundamental & Programming	0	6	2	–
Mechanics of Deformable Bodies	3	0	3	Statics of Rigid Bodies
Adaptive Metallurgy 1	2	3	3	Physical Met 2
Physical Met 2	2	3	3	Physical Met 1
Principles of Mining	3	0	3	Co-requisite Principles of Geology
TOTAL	**13**	**12**	**17**	

4th Year – Second Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Engineering Management	3	0	3	None
Adaptive Metallurgy 2	2	3	3	Physical Metallurgy 2 ; Strength of Materials
Hydrometallurgy	3	3	4	Met. Physical Chem; Principles of Met.
Met Plant Design (Lecture)	2	0	2	4th year standing
Pyrometallury 1	3	3	4	-
Mechanics of Fluids	2	3	3	Dynamics of Rigid Bodies, Mechanics of Deformable Bodies
TOTAL	**15**	**12**	**19**	

Summer
Metallurgical Plant Practice On-the job-training (OJT) – 320 hours/8 weeks

FIFTH YEAR

5th Year – First Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Environmental Engineering	2	0	2	Gen. Chemistry
Safety Management	1	0	1	None
Elective 1	3	0	3	None
Met Plant Design (Lab)	0	3	1	4th Year Standing, Met Plant Design (Lecture)
Metallurgical Laws & Ethics	1	0	1	Introduction to Metallurgy
Metallurgical Research	1	6	3	5th year standing
Pyrometallurgy 2	3	3	4	Pyrometallurgy 1
Social Science 3	3	0	3	Social Science 2
TOTAL	**14**	**12**	**18**	

5th Year – Second Semester

Courses	No. of Hours		Units	Pre-requisites
	Lec.	Lab		
Elective 2	3	0	3	None
Electrometallurgy	2	3	3	Physical Chemistry
Computer Application in Met. Engineering	2	3	3	Computer Fundamentals, Introduction to Metallurgy
Metallurgical Seminars and Plant Tours	0	3	1	Introduction to Metallurgical Engineering
Social Science 4	3	0	3	Social Science 3
Humanities 3	3	0	3	Humanities 2
Life & Works of Rizal	3	0	3	None
TOTAL	**16**	**9**	**19**	

Section 11. Thesis/ Research/ Project Requirements

11.1 Suggested topics maybe of the following:

11.1.1 Application of the different fields of specialization in Metallurgical Engineering

11.1.2 Industry – based project related to metallurgical engineering fields

11.1.3 Socio-economic projects related to metallurgical engineering

Section 12. On-the-Job –Training or Practicum Requirements

12.1 To expose the student to the actual operations of a metallurgical plant or facility

12.2 Three hundred twenty (320) hours of actual practice

12.3 On –the- Job Training in a Metallurgical Plant or any facility involved in processes which include but not limited to the:

12.3.1 preparation, separation, concentration of minerals, coal and metallurgical fuels.

12.3.2 extraction of metals such as hydrometallurgical, pyrometallurgical and electrometallurgical processes

12.3.3 adaptation and application of metals such as melting, casting, forging, rolling, extrusion, powder metallurgy, heat treatment, metal working and finishing operations.

ARTICLE VI – COURSE SPECIFICATION

Section 13. The course specifications for the BS Metallurgical Engineering program are contained in **ANNEX II** of this Memorandum.

1. Course Name
2. Course Description
3. Number of units for lecture and laboratory
4. Number of contact hours per week
5. Prerequisite
6. Course Objectives
7. Course Outlines
8. Equipment
9. References

ARTICLE VII – GENERAL REQUIREMENTS

Section 14 The general requirements for the BS Metallurgical Engineering program are contained in **"CMO 25, s. 2005 – Revised Policies, Standards and Guidelines (PSG) for Engineering Education,"** a separate Memorandum issued by the Commission.

Compliance with the policies on the following was hereby required:

1. Instructional Program Quality
2. Research
3. Community Involvement
4. Administration and Support

ARTICLE VIII - TRANSITORY PROVISION

Section 14. HEIs that have been granted permit or recognition for Bachelors of Science in Metallurgical Engineering degree program are hereby given a non-extendable period of four (4) years from the effectivity thereof, within which to fully complied with. State Universities and Colleges (SUCs) and Local Colleges and Universities (LCUs) shall also comply with the requirements herein set forth.

Student currently enrolled in the Bachelor of Science in Metallurgical Engineering programs shall be allowed to graduate under the old curriculum. However, students enrolling for the abovementioned program beginning school year 2008-2009 shall be covered by this CMO.

ARTICLE IX- SANCTIONS

Section 15. For violation of this Order, the Commission may impose such administrative sanction as it may deem appropriate pursuant to the pertinent provisions of Republic Act No. 7722, in relation to Section 69 of BP 232 otherwise known as the Higher Education Act of 1982, and Sections 24 and 101 of the Manual of Regulations for Private Schools (MRPS), and other related laws.

ARTICLE IX – SEPARABILITY AND REPEALING CLAUSE

Section 16. Any provision of this Order, which may thereafter be held invalid, shall not effect the remaining provisions.

Section 17. All issuances, including but not limited to CMO No. 49, s. 1997, and CMO 34, s. 2001 and/ or any part thereof inconsistent herewith, are deemed repealed or modified accordingly.

ARTICLE X - EFFECTIVITY CLAUSE

Section 18. This CMO shall take effect starting 1st semester of SY 2008-2009, after publication in an official gazette or in newspaper of general circulation.

Section 19. An educational institution applying to offer the new BSMetE program shall likewise comply with all the provisions of this CMO.

Pasig City, Philippines _____

For the Commission:

ROMULO L. NERI
Chairman

ARTICLE VIII - TRANSITORY PROVISION

Section 14. HEIs that have been granted permit or recognition for Bachelors of Science in Metallurgical Engineering degree program are hereby given a non-extendable period of four (4) years from the effectivity thereof, within which to fully complied with. State Universities and Colleges (SUCs) and Local Colleges and Universities (LCUs) shall also comply with the requirements herein set forth.

Student currently enrolled in the Bachelor of Science in Metallurgical Engineering programs shall be allowed to graduate under the old curriculum. However, students enrolling for the abovementioned program beginning school year 2008-2009 shall be covered by this CMO.

ARTICLE IX- SANCTIONS

Section 15. For violation of this Order, the Commission may impose such administrative sanction as it may deem appropriate pursuant to the pertinent provisions of Republic Act No. 7722, in relation to Section 69 of BP 232 otherwise known as the Higher Education Act of 1982, and Sections 24 and 101 of the Manual of Regulations for Private Schools (MRPS), and other related laws.

ARTICLE IX – SEPARABILITY AND REPEALING CLAUSE

Section 16. Any provision of this Order, which may thereafter be held invalid, shall not effect the remaining provisions.

Section 17. All issuances, including but not limited to CMO No. 49, s. 1997, and CMO 34, s. 2001 and/ or any part thereof inconsistent herewith, are deemed repealed or modified accordingly.

ARTICLE X - EFFECTIVITY CLAUSE

Section 18. This CMO shall take effect starting 1st semester of SY 2008-2009, after publication in an official gazette or in newspaper of general circulation.

Section 19. An educational institution applying to offer the new BSMetE program shall likewise comply with all the provisions of this CMO.

Pasig City, Philippines April 10, 2008

For the Commission:

ROMULO L. NERI
Chairman

ANNEX I

COMPETENCY STANDARDS FOR BS METALLURGICAL ENGINEERING

TECHNICAL PANEL FOR ENGINEERING, TECHNOLOGY AND ARCHITECTURE

Workshop On the Identification of Competency Standards for Engineering Education (Ceramic, Metallurgical & Mining Engineering)
Days Hotel, Tagaytay City
March 25-26, 2004

PROFILE OF DUTIES AND COMPETENCIES OF A METALLURGICAL ENGINEER

DUTIES		COMPETENCIES/SKILLS/TASKS					
WORK EFFECTIVELY IN A BUSINESS ORGANIZATION	**Communicate effectively and efficiently**	Demonstrate verbal, written and other forms of communication	Communicate proficiently through technical reprty writing and documentation				
	Understand Engineering Business	Understand basic concepts, tools and areas of applications of business management, with particular emphasis on operation and project management	Understand organization structure of metallurgical plants and facilities.	Monitor the performance of project milestone and operational targets			
	Understand Ethical Practices	Familiarize with pertinent laws such as the Metallurgical Engineering Law, Mining Act of 1995, Dangerous Material Act	Practice the code of ethics for metallurgical engineers				
	Understand human behavior and develop strategy, work in a multi-disciplinary team	Understand organization, culture and basic principles of leadership	Aware of the general principles of change management				
	Apply metallurgical principles to metallurgical process and operations	Understand concepts of metallurgical engineering as stated in conceptual design (A)	Perform heat and material balance of a metallurgical process	Understand the concepts of process control	Perform metallurgical balance and accounting	Familiar with various metallurgical operating equiptment and testing devices	

TECHNICAL PANEL FOR ENGINEERING, TECHNOLOGY AND ARCHITECTURE

Workshop On the Identification of Competency Standards for Engineering Education (Ceramic, Metallurgical & Mining Engineering)
Days Hotel, Tagaytay City
March 25-26, 2004

PROFILE OF DUTIES AND COMPETENCIES OF A METALLURGICAL ENGINEER

DUTIES		COMPETENCIES/SKILLS/TASKS					
N E S S	**Apply metallurgical principles to metallurgical process control and metallurgical plants**	Understand concepts of metallurgical engineering as stated in conceptual design (A)	Understand concepts of metallurgical sampling	Interpret metallurgical data	Familiar with various metallurgical testing equiptment		

TECHNICAL PANEL FOR ENGINEERING, TECHNOLOGY AND ARCHITECTURE

Workshop On the Identification of Competency Standards for Engineering Education (Ceramic, Metallurgical & Mining Engineering)
Days Hotel, Tagaytay City
March 25-26, 2004

PROFILE OF DUTIES AND COMPETENCIES OF A METALLURGICAL ENGINEER

DUTIES		COMPETENCIES/SKILLS/TASKS					
RESEARCH & PROCESS IMPROVEMENT	**Undertake R & D**	Write a research proposal	Collect data through surveys, use of internet or other information system	Understand and apply metallurgical sampling measures and techniques in the collection and analysis of data	Able to operate various metallurgical testing and laboratory equiptment	Apply classical experimental design	Apply and interpret probability and statistical tools and techniques
		Prepare technical reports					
	Undertake Process Improvement and Optimization	Use of Metallurgical principles and benchmarking data to identify access for improvement and optimization	Use statistical and correlation techniques to interpret metallurgical data	Conduct in-plant audit and/or evaluate of a metallurgical process			

PARTICIPATE IN A PROJECT PLANNING TEAM	Understand the planning process	Use knowledge of metallurgical engineering principle to contribute to the planning process	Aware of effects of metallurgical processes in occupational safety and health and the immediate environment	Recognize that the resources must be used in optimized manner		

TECHNICAL PANEL FOR ENGINEERING, TECHNOLOGY AND ARCHITECTURE

Workshop On the Identification of Competency Standards for Engineering Education (Ceramic, Metallurgical & Mining Engineering)
Days Hotel, Tagaytay City
March 25-26, 2004

PROFILE OF DUTIES AND COMPETENCIES OF A METALLURGICAL ENGINEER

DUTIES		COMPETENCIES/SKILLS/TASKS					
CONCEPTUAL DESIGN	**Apply knowledge of mathematics and engineering principles**	Understand general engineering principles.	Understand the principles of mathematics, natural, physical and applied sciences	Develop the ability to use techniques, skills and medium tools such as computer softwares necessary for engineering practice			
	Conceptualize and design metallurgical processes and products	Understand general engineering principles in the various areas of Metallurgical Enginering.	a. MinE - Understand the Concepts of mineralogy, liberation, comminution, sizing and classification, concentration, solid-liquid separation, tailings treatment and disposal.	b. ExtE - Understand the principles of qualitative, quantitative and physical chemistry, thermodynamics, pyrometallurgical, mass balance, heat balance, refractories, hydrometallurgy and electrometallurgy	c. FerE - Understand the principles of making, shaping and treating of ferrous and non-ferrous metal and metallography	d. Foundry - Understand the principlesof pattern making, molding methods and materials, different melting furnaces,gating and risering, metallography, heat treatment, metal finishing and surface treatment	e. Semicon- Understand the concepts of physical metallurgy and microscopy
			Understand and interpret technical metallurgical diagrams, flow sheets and plans and apply the concept of metallurgicalplant design	Familiarize with physical and mechanical properties of metals and alloys			
	Generate technical specifications and standards	Know benchmarking techniques and best manufacturing practices	Familiarize with pertainent standards and the behaviour of metals, minerals and industrial chemicals	Know and understand behavior of metals and alloys during metallurgical treatments	Appreciate and understand social,safety, health, and environmental impacts of solution	Familiarize with good manufacturing practices and techniques	

ANNEX II

PROGRAM OUTCOMES FOR BS METALLURGICAL ENGINEERING

Program Outcomes of the BS Metallurgical Engineering

Column LEGEND:

Letter	Program Outcomes
a	An ability to apply knowledge of mathematics, sciences, engineering sciences to the practice of metallurgical engineering.
b	An ability to design and conduct experiments, as well as to analyze and interpret data.
c	An ability to design a system, build, improve, and install systems or processes which meet desired needs within realistic constraints.
d	An ability to work effectively in multi-disciplinary and multi-cultural teams.
e	An ability to identify, formulate, and solve metallurgical engineering problems.
f	An understanding of professional, ethical, social & environmental responsibilities.
g	An ability to communicate effectively in verbal and non-verbal communication.
h	A broad education necessary to understand impact of engineering solutions in a global/societal context
i	An ability to engage in life-long learning and to keep current of the development in a specific field of specialization
j	A knowledge of contemporary issues.
k	An ability to use the appropriate techniques, skills and modern engineering tools necessary for metallurgical engineering practice to be locally and globally competitive.

Key: [ ] very little or no emphasis [x] some, moderate, or substantial emphasis

Relationship of the Courses to the Program Outcomes

I. TECHNICAL COURSES	a	b	c	d	e	f	g	H	i	j	k
A. Mathematics											
College Algebra	x							x			
Advanced Algebra	x							x			
Plane and Spherical Trigonometry	x							x			
Analytic Geometry	x							x			
Solid Mensuration	x							x			
Differential Calculus	x							x			
Integral Calculus	x							x			
Differential Equations	x							x			
Probability and Statistics	x							x			
B. Natural/Physical Sciences											
General Chemistry	x							x			
Physics 1	x							x			
Physics 2	x							x			

C. Basic Engineering Sciences	a	b	c	d	e	f	g	h	i	j	k
Computer Fundamentals and Programming	x	x	x				x	x			
Engineering Drawing	x	x	x					x			x
Computer – Aided Drafting	x	x	x					x			
Statics of Rigid Bodies	x							x			
Dynamics of Rigid Bodies	x							x			
Mechanics of Deformable Bodies	x							x			
Engineering Economy	x	x		x	x	x		x	x	x	x
Engineering Management			x	x	x	x		x	x	x	x
Environmental Engineering	x	X	x	x	x	x		x	x	x	x
Safety Management	x	X	x	x	x	x		x	x	x	x
D. Allied Courses	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
General Chemistry 2	x	x						x			
Analytical Chemistry (Lec)	x	x						x			
Analytical Chemistry (Lab)	x	x						x			
Principles of Geology	x	x	x		x	x		x	x	x	
Elementary Mineralogy	x	x	x		x			x	x	x	
Principles of Mining	x	x	x		x	x		x	x	x	
Mechanics of Fluids	x	x	x		x			x			
Basic Electrical Engineering	x	x	x					x			
Workshop Theory and Practice	x			x			x				
E. Professional Courses	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Introduction to Metallurgy	x					x		x			
Introduction to Materials Science	x							x			
Metallurgical Measurements	x	x	x	x	x		x	x			
Metallurgical Analysis	x	x	x	x	x			x			
Metallurgical Physical Chemistry	x	x	x	x	x			x			
Mineral Processing 1	x	x	x	x	x			x			
Mineral Processing 2	x	x	x	x	x	x		x		x	x
Hydrometallurgy	x	x	x	x	x	x		x		x	x
Electrometallurgy	x	x	x	x	x	x		x		x	x
Pyrometallurgy 1	x	x	x	x	x			x			
Pyrometallurgy 1	x	x	x	x	x	x		x		x	x
Adaptive Metallurgy 1	x	x	x	x	x			x			
Adaptive Metallurgy 2	x	x	x	x	x	x		x		x	x
Physical Metallurgy 1	x	x	x	x	x			x			
Physical Metallurgy 2	x	x	x	x	x	x		x		x	x
Metallurgical Plant Design (Lecture)	x	x	x	x	x	x		x	x	x	
Metallurgical Plant Design (Laboratory)	x	x	x	x	x	x		x	x	x	
Metallurgical Research	x	x	x	x	x	x	x	x	x	x	
Metallurgical Law and Ethics						x		x		x	
Metallurgical Seminars & Plant Tours				x		x	x	x		x	

	a	b	c	d	e	f	g	h	i	j	k
Computer Applications in Metallurgical Engineering	x							x	x	x	x
Metallurgical Plant Practice (OJT)				x		x	x	x		x	
F. Elective											
Elective 1	x	x	x	x	x	x		x	x	x	x
Elective 2	x	x	x	x	x	x		x	x	x	x
II. NON - TECHNICAL COURSES	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Social Science 1, 2, 3, 4				x		x		x		x	x
Humanities 1, 2, 3				x		x		x	x	x	
English 1, 2, 3				x			x	x	x	x	
Pilipino 1, 2				x			x	x		x	
Life and Works of Rizal						x		x		x	
P.E. 1, 2, 3, 4				x			x	x			
NSTP 1,2				x				x			

ANNEX III

COURSE SPECIFICATIONS FOR BS METALLURGICAL ENGINEERING

ANNEX III
COURSE SPECIFICATIONS FOR THE BSMetE

TABLE OF CONTENTS

ANNEX III
COURSE SPECIFICATIONS FOR THE BSMetE

TABLE OF CONTENTS

ANNEX III
COURSE SPECIFICATIONS FOR THE BSMetE

TABLE OF CONTENTS

COURSE SPECIFICATIONS
BACHELOR OF SCIENCE IN METALLURGICAL ENGINEERING

I. TECHNICAL COURSES

A. MATHEMATICS

Course Name	**COLLEGE ALGEBRA**
Course Description	Algebraic expressions and equations; solution sets of algebraic equations in one variable: linear, quadratic, polynomial of degree *n*, fractional, radical equations, quadratic in form, exponential and logarithmic equations; decomposition of fractions into partial fractions; solution sets of systems of linear equations involving up to three variables.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	None
Course Objectives	After completing this course, the student must be able to: 1. Operate and simplify algebraic expressions; 2. Determine the solution sets of all types of algebraic equations, exponential and logarithmic equations; and inequalities; 3. Use the manipulative and analytical skills acquired in Objectives 1 to 2 to solve word problems; and 4. Identify the domain ad range of a given relation/function.

Course Outline	1. The Set of Real Numbers 1.1. Integer Exponents 1.2. Polynomials, Operations, Special Products 1.3. Binomial Expansion (Binomial Theorem) 1.4. Factoring Polynomials 2. Rational Expressions 2.1. Rules of Exponents; Simplification of Rational Expressions; Operations on Rational Expressions 2.2. Properties of Radicals; Simplification of Radicals 2.3. Operations on Radicals 2.4. Complex Numbers 3. Equations in One Variable 3.1. Linear Equations; Literal Equations 3.2. Quadratic Equations in One Variable 3.3. Word Problems 3.4. Other Equations in One Variable: Radical, Fractional, Quadratic in Form 3.5. Polynomial Equation of Degree *n* 4. Functions 4.1. Inverse Functions 4.2. Exponential and Logarithmic Functions 4.3. Exponential and Logarithmic Equations 5. Systems of Linear Equations (by Elimination Methods) 6. Decomposition of Rational Expressions into Partial Fractions
Laboratory Equipment	None

Course Name	**ADVANCED ALGEBRA**
Course Description	Matrices and determinants; arithmetic and geometric series; solution sets of different types of inequalities and systems involving quadratics; solution of linear equations using determinants and matrices.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Prerequisites	College Algebra
Course Objectives	After completing this course, the student must be able to: 1. Determine the solution sets of inequalities; 2. Determine the solution sets of systems involving quadratics; 3. Use the manipulative and analytical skills acquired in Objective 2 to solve word problems; 4. Operate and manipulate matrices and determinants; 5. Solve systems of linear equations using matrices and determinants; and 6. Determine the indicated sum of the elements in an arithmetic and geometric sequence.

Course Outline	1. Inequalities 1.1. Linear, Quadratic, and Polynomial Inequality 1.2. Linear Inequalities with Absolute Value 2. Ratio, Proportion, and Variation 3. Determinants 3.1. Expansion by Minors 3.2. Solution of Linear Systems by Cramer's Rule 4. Matrices 4.1. Identity Matrix 4.2. Cofactor Matrix 4.3. Transpose of a Matrix 4.4. Adjoint Matrix 4.5. Inverse of a Matrix 4.6. Algebra on Matrices (Sum and Difference, Scalar Multiplication, Matrix Multiplication) 4.7. Solution of Linear Systems Using Matrices 5. Sequence and Series 5.1. Arithmetic and Geometric Means 5.2. Arithmetic and Geometric Sequences 5.3. Arithmetic and Geometric Series 5.4. Infinite Series 6. Combinatorial Mathematics 6.1. Sequences 6.2. The Factorial of a Number 6.3. Fundamental Principles of Counting, Permutation, and Combination 6.4. Binomial Theorem 6.5. Mathematical Induction
Laboratory Equipment	None

Course Name	**PLANE AND SPHERICAL TRIGONOMETRY**
Course Description	Trigonometric functions; identities and equations; solutions of triangles; law of sines; law of cosines; inverse trigonometric functions; spherical trigonometry
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	None

Course Objectives	After completing this course, the student must be able to: 1. Define angles and how they are measured; 2. Define and evaluate each of the six trigonometric functions; 3. Prove trigonometric functions; 4. Define and evaluate inverse trigonometric functions; 5. Solve trigonometric equations; 6. Solve problems involving right triangles using trigonometric function definitions for acute angles; and 7. Solve problems involving oblique triangles by the use of the sine and cosine laws.
Course Outline	1. Trigonometric Functions 1.1. Angles and Measurement 1.2. Trigonometric Functions of Angles 1.3. Trigonometric Function Values 1.4. The Sine and Cosine of Real Numbers 1.5. Graphs of the Sine and Cosine and Other Sine Waves 1.6. Solutions of Right Triangle 2. Analytic Trigonometry 2.1. The Eight Fundamental Identities 2.2. Proving Trigonometric Identities 2.3. Sum and Difference Identities 2.4. Double-Measure and Half-Measure Identities 2.5. Inverse Trigonometric Functions 2.6. Trigonometric Equations 2.7. Identities for the Product, Sum, and Difference of Sine and Cosine 3. Application of Trigonometry 3.1. The Law of Sines 3.2. The Law of Cosines 4. Spherical Trigonometry 4.1. Fundamental Formulas 4.2. Spherical Triangles
Laboratory Equipment	None

Course Name	**ANALYTIC GEOMETRY**
Course Description	Equations of lines and conic sections; curve tracing in both rectangular and polar coordinates in two-dimensional space.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Prerequisites	College Algebra Plane and Spherical Trigonometry

Course Objectives	After completing this course, the student must be able to: 1. Set up equations given enough properties of lines and conics; 2. Draw the graph of the given equation of the line and the equation of the conic section; and 3. Analyze and trace completely the curve, given their equations in both rectangular and polar coordinates, in two-dimensional space.
Course Outline	1. Plane Analytic Geometry 1.1. The Cartesian Planes 1.2. Distance Formula 1.3. Point-of-Division Formulas 1.4. Inclination and Slope 1.5. Parallel and Perpendicular Lines 1.6. Angle from One Line to Another 1.7. An Equation of a Locus 2. The Line 2.1. Point-Slope and Two-Point Forms 2.2. Slope-Intercept and Intercept Forms 2.3. Distance from a Point to a Line 2.4. Normal Form 3. The Circle 3.1. The Standard Form for an Equation of a Circle 3.2. Conditions to Determine a Circle 4. Conic Sections 4.1. Introduction 4.2. The Parabola 4.3. The Ellipse 4.4. The Hyperbola 5. Transformation of Coordinates 5.1. Translation of Conic Sections 6. Curve Sketching 6.1. Symmetry and Intercepts 6.2. Sketching Polynomial Equations 6.3. Asymptotes (Except Slant Asymptotes) 6.4. Sketching Rational Functions 7. Polar Coordinates 7.1. Polar Coordinates 7.2. Graphs in Polar Coordinates 7.3. Relationships Between Rectangular and Polar Coordinates
Laboratory Equipment	None

Course Name	**SOLID MENSURATION**
Course Description	Concept of lines and planes; Cavalieri's and Volume theorems; formulas for areas of plane figures, volumes for solids; volumes and surfaces areas for spheres, pyramids, and cones; zone, sector and segment of a sphere; theorems of Pappus.
Number of Units for Lecture and Laboratory	2 units lecture

Number of Contact Hours per Week	2 hours lecture
Prerequisite	College Algebra, Plane and Spherical Trigonometry
Course Objectives	After completing this course, the student must be able to: 1. Compute for the area of plane figures; 2. Compute for the surface areas and volumes of different types of solids; and 3. Determine the volumes and surface areas of solids using other methods such as the theorems of Pappus.
Course Outline	1. Plane Figures 1.1. Mensuration of Plane Figures 2. Lines and Planes in Space 2.1. Typical Proofs of Solid Geometry 2.2. Angles 3. Solids for which V = Bh 3.1. Solid Sections 3.2. Cubes 3.3. Rectangular Parallelopiped 3.4. Cavalieri's Theorem 3.5. Volume Theorem 3.6. Prism 3.7. Cylindrical Surface 3.8. Cylinder (Circular and Right Circular) 4. Solids for which V = ⅓Bh 4.1. Pyramids 4.2. Similar Figures 4.3. Cones 4.4. Frustum of Regular Pyramid 4.5. Frustum of Right Circular Cone 5. Sphere 5.1. Surface Area and Volume 5.2. Zone 5.3. Segment 5.4. Sector 6. Theorems of Pappus
Laboratory Equipment	None

Course Name	**DIFFERENTIAL CALCULUS**
Course Description	Basic concepts of calculus such as limits, continuity and differentiability of functions; differentiation of algebraic and transcendental functions involving one or more variables; applications of differential calculus to problems on optimization, rates of change, related rates, tangents and normals, and approximations; partial differentiation and transcendental curve tracing.
Number of Units for Lecture and Laboratory	4 units lecture

Number of Contact Hours per Week	4 hours lecture
Prerequisites	Advanced Algebra Analytic Geometry Solid Mensuration
Course Objectives	After completing this course, the student must be able to: 1. Have a working knowledge of the basic concepts of functions and limits; 2. Differentiate algebraic and transcendental functions with ease; 3. Apply the concept of differentiation in solving word problems involving optimization, related rates, and approximation; and 4. Analyze and trace transcendental curves.
Course Outline	1. Functions 1.1. Definitions 1.2. Classification of Functions 1.3. Domain and Range of a Function 1.4. Graph of a Function 1.5. Functional Notation 1.6. Evaluation of a Function 1.7. Combinations of Functions 1.8. One-Valued and Many-Valued Functions 1.9. Odd and Even Functions 1.10. Special Function Types 1.11. Functions as Mathematical Models 2. Continuity 2.1. Definition 2.2. Properties of Continuous Functions 3. Limits 3.1. Notion of a Limit 3.2. Definition 3.3. Properties of Limits 3.4. Operations with Limits 3.5. Evaluation of Limits 3.6. One-Sided Limits 3.7. Unbounded Functions 4. The Derivative 4.1. Notion of the Derivative 4.2. Definition 4.3. Determination of the Derivative by Increments 4.4. Differentiation Rules 5. The Slope 5.1. Definition of Slope as the Derivative of a Function 5.2. Determination of the Slope of a Curve at a Given Point 6. Rate of Change 6.1. Average Rate of Change 6.2. Instantaneous Rate of Change 7. The Chain Rule and the General Power Rule 8. Implicit Differentiation 9. Higher-Order Derivatives 10. Polynomial Curves 10.1. Generalities About Straight Lines 10.2. Tangents and Normal to Curves

	10.3. Extrema and the First Derivative Test 10.4. Concavity and the Second Derivative Test 10.5. Points of Inflection 10.6. Sketching Polynomial Curves 11. Applications of the Derivative: Optimization Problems 12. Applications of the Derivative: Related Rates 13. The Differential 13.1. Definition 13.2. Applications of the Differential—Comparison of Δx and dx 13.3. Error Propagation 13.4. Approximate Formulas 14. Derivatives of Trigonometric Functions 14.1. Elementary Properties 14.2. Definition 14.3. Graphs of Trigonometric Functions 14.4. Applications 15. Derivatives of Inverse Trigonometric Functions 15.1. Elementary Properties 15.2. Definition 15.3. Graphs of Inverse Trigonometric Functions 15.4. Applications 16. Derivatives of Logarithmic and Exponential Functions 16.1. Elementary Properties 16.2. Definition 16.3. Graphs of Logarithmic and Exponential Functions 16.4. Applications 17. Derivatives of Hyperbolic Functions 17.1. Elementary Properties 17.2. Definition 17.3. Graphs of Hyperbolic Functions 17.4. Applications 18. Solution of Equations 18.1. Newton's Method of Approximation 18.2. Newton-Raphson Law 19. Transcendental Curve Tracing 19.1. Logarithmic and Exponential Functions 20. Parametric Equations 21. Partial Differentiation
Laboratory Equipment	None

Course Name	**INTEGRAL CALCULUS**
Course Description	Concept of integration and its application to physical problems such as evaluation of areas, volumes of revolution, force, and work; fundamental formulas and various techniques of integration applied to both single variable and multi-variable functions; tracing of functions of two variables.
Number of Units for Lecture and Laboratory	4 units lecture
Number of Contact	4 hours lecture

Hours per Week	
Prerequisite	Differential Calculus
Course Objectives	After completing this course, the student must be able to: 1. Properly carry out integration through the use of the fundamental formulas and/or the various techniques of integration for both single and multiple integrals; 2. Correctly apply the concept of integration in solving problems involving evaluation of areas, volumes, work, and force; 3. Sketch 3-dimensional regions bounded by several surfaces; and 4. Evaluate volumes of 3-dimensional regions bounded by two or more surfaces through the use of the double or triple integral.
Course Outline	1. Integration Concept / Formulas 1.1. Anti-Differentiation 1.2. Simple Power Formula 1.3. Simple Trigonometric Functions 1.4. Logarithmic Function 1.5. Exponential Function 1.6. Inverse Trigonometric Functions 1.7. Hyperbolic Functions 1.8. General Power Formula 1.9. Constant of Integration 1.10. Definite Integral 2. Integration Techniques 2.1. Integration by Parts 2.2. Trigonometric Integrals 2.3. Trigonometric Substitution 2.4. Rational Functions 2.5. Rationalizing Substitution 3. Application 3.1. Improper Integrals 3.2. Plane Area 3.3. Areas Between Curves 4. Other Applications 4.1. Volumes 4.2. Work 4.3. Hydrostatics Pressure and Force 5. Surfaces Multiple Integral as Volume 5.1. Surface Tracing: Planes 5.2. Spheres 5.3. Cylinders 5.4. Quadratic Surfaces 5.5. Double Integrals 5.6. Triple Integrals 6. Multiple Integral as Volume 6.1. Double Integrals 6.2. Triple Integrals
Laboratory Equipment	None

Course Name	**DIFFERENTIAL EQUATIONS**
Course Description	Differentiation and integration in solving first order, first-degree differential equations, and linear differential equations of order *n*; Laplace transforms in solving differential equations.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Integral Calculus
Course Objectives	After completing this course, the student must be able to: 1. Solve the different types of differential equations; and 2. Apply differential equations to selected engineering problems.
Course Outline	1. Definitions 1.1. Definition and Classifications of Differential Equations (D.E.) 1.2. Order Degree of a D.E. / Linearity 1.3. Solution of a D.E. (General and Particular) 2. Solution of Some 1st Order, 1st Degree D.E. 2.1. Variable Separable 2.2. Homogeneous 2.3. Exact 2.4. Linear 2.5. Equations Linear in a Function 2.6. Bernoulli's Equation 3. Applications of 1st Order D.E. 3.1. Decomposition / Growth 3.2. Newton's Law of Cooling 3.3. Mixing (Non-Reacting Fluids) 3.4. Electric Circuits 4. Linear D.E. of Order *n* 4.1. Standard Form of a Linear D.E. 4.2. Linear Independence of a Set of Functions 4.3. Differential Operators 4.4. Differential Operator Form of a Linear D.E. 5. Homogeneous Linear D.E. with Constant Coefficients 5.1. General Solution 5.2. Auxiliary Equation 6. Non-Homogeneous D.E. with Constant-Coefficients 6.1. Form of the General Solution 6.2. Solution by Method of Undetermined Coefficients 6.3. Solution by Variation of Parameters
Laboratory Equipment	None

Course Name	**PROBABILITY AND STATISTICS**
Course Description	Basic principles of statistics; presentation and analysis of data; averages, median, mode; deviations; probability distributions; normal curves and applications; regression analysis and correlation; application

	to engineering problems.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	College Algebra
Course Objectives	After completing this course, the student must be able to: 1. Define relevant statistical terms; 2. Discuss competently the following concepts: 2.1. Frequency distribution 2.2. Measures of central tendency 2.3. Probability distribution 2.4. Normal distribution 2.5. Inferential statistics 3. Apply accurately statistical knowledge in solving specific engineering problem situations.
Course Outline	1. Basic Concepts 1.1. Definition of Statistical Terms 1.2. Importance of Statistics 2. Steps in Conducting a Statistical Inquiry 3. Presentation of Data 3.1. Textual 3.2. Tabular 3.3. Graphical 4. Sampling Techniques 5. Measures of Central Tendency 5.1. Mean 5.2. Median 5.3. Mode 5.4. Skewness and Kurtosis 6. Measures of Variation 6.1. Range 6.2. Mean Absolute Deviation 6.3. Variance 6.4. Standard Deviation 6.5. Coefficient of Variation 7. Probability Distributions 7.1. Counting Techniques 7.2. Probability 7.3. Mathematical Expectations 7.4. Normal Distributions 8. Inferential Statistics 8.1. Test of Hypothesis 8.2. Test Concerning Means, Variation, and Proportion 8.3. Contingency Tables 8.4. Test of Independence 8.5. Goodness-of-Fit Test 9. Analysis of Variance 10. Regression and Correlation
Laboratory Equipment	None

B. NATURAL/PHYSICAL SCIENCES

Course Name	**GENERAL CHEMISTRY**
Course Description	Basic concepts of matter and its classification; mass relationships in chemical reactions; properties of gases, liquids, and solids; concepts of thermochemistry; quantum theory and electronic behavior; periodic relationship of elements in the periodic table; intramolecular forces; and solutions.
Number of Units for Lecture and Laboratory	4 units: 3 units lecture, 1 unit laboratory
Number of Contact Hours per Week	6 hours: 3 hours lecture, 3 hours laboratory
Prerequisite	None
Course Objectives	After completing this course, the student must be able to: 1. Apply significant figures and appropriate units in all measurements and calculations; 2. Classify matter; distinguish between physical and chemical properties/changes; 3. Define and explain the concepts of atomic mass, average atomic mass, mole, molar mass and perform calculations involving these; 4. Balance and interpret chemical equations and perform stoichiometric calculations; 5. Write, explain and apply the gas laws; 6. Discuss the kinetic molecular theory (KMT) of gases and use the KMT to qualitatively explain the gas laws; argue the differences between ideal and non-ideal gas behavior; 7. Define enthalpy; classify common processes as exothermic or endothermic and know the sign conventions; 8. Trace the various atomic theories; discuss the Bohr model; and explain the line spectra of hydrogen; Discuss the concept of electron density; contrast the Bohr's orbits with orbitals in the quantum theory; 9. Write electron configurations and orbital diagrams for multi electron atoms; 10. Use the periodic table to classify elements and predict trends in properties; 11. Write Lewis dot symbols and Lewis structure; 12. Explain valence bond theory, hybrid orbitals, and hybridization in common compounds 13. Distinguish between inter- and intramolecular forces; give examples of intramolecular forces and how they relate to physical properties; 14. Distinguish between crystalline and amorphous solids 15. Discuss various physical changes and interpret phase diagrams; 16. Distinguish different types of solutions; work with different concentration units; Understand the effect of temperature and pressure on solubility; and 17. Explain and apply colligative properties to determine molar mass.
Course Outline	1. The Study of Change 1.1. Introduction to Chemistry 1.2 Matter: Classification, States, Physical, and Chemical

	Properties 1.3. Measurement and Handling of Numbers 2. Atoms, Molecules, and Ions 2.1. The Atomic Theory 2.2. The Structure of the Atom 2.3. Atomic Number, Mass Number, Isotopes 2.4. The Periodic Table 2.5. Molecules and Ions 2.6. Chemical Formulas 2.7. Naming Compounds 3. Mass Relationships in Chemical Reaction 3.1. Atomic Mass 3.2. Molar Mass of an Element and Avogadro's Number 3.3. Molecular Mass 3.4. Percent Composition of Compounds 3.5. Chemical Reactions and Chemical Equations 3.6. Amounts of Reactants and Products 3.7. Limiting Reagents 3.8. Reaction Yield 4. Gases 4.1. Substances That Exist as Gases 4.2. Pressure of a Gas 4.3. The Gas Laws 4.4. The Ideal Gas Equation 4.5. Gas Stoichiometry 4.6. Dalton's Law of Partial Pressure 4.7. The Kinetic Molecular Theory of Gases 4.8. Deviation from Ideal Behavior 5. Thermochemistry 5.1. Energy Changes in Chemical Reactions 5.2. Introduction to Thermodynamics 5.3. Enthalpy 6. Quantum Theory and the Electronic Structure of Atoms 6.1. From Classical Physics to Quantum Theory 6.2. Bohr's Theory of the Hydrogen Atom 6.3. The Dual Nature of the Electron 6.4. Quantum Mechanics 6.5. Quantum Numbers 6.6. Atomic Orbitals 6.7. Electron Configuration 6.8. The Building-Up Principle 7. Periodic Relationships Among the Elements 7.1. Periodic Classification of the Elements 7.2. Periodic Variation in Physical Properties 7.3. Ionization Energy 7.4. Electron Affinity 8. Chemical Bonding: Basic Concepts 8.1. Lewis Dot Structure 8.2. The Ionic Bond 8.3. The Covalent Bond 8.4. Electronegativity 8.5. Writing Lewis Structure 8.6. The Concept of Resonance 8.7. Bond Energy

	9. Chemical Bonding: Molecular Geometry and Hybridization 9.1. Molecular Geometry 9.2. Dipole Moments 9.3. The Valence Bond Theory 9.4. Hybridization of Atomic Orbitals 9.5. Hybridization in Molecules Containing Double and Triple Bonds 10. Intermolecular Forces in Liquids and Solids 10.1. The KMT of Liquids and Solids 10.2. Intermolecular Forces 10.3. Properties of Liquids 10.4. Crystalline vs. Amorphous Solids 10.5. Phase Changes 10.6. Phase Diagrams 11. Physical Properties of Solutions 11.1. Types of Solutions 11.2. A Molecular View of the Solution Process 11.3. Concentration Units 11.4. Effect of Temperature and Pressure on Solubility 11.5. Colligative Properties
Laboratory Equipment	Chemistry Laboratory(see attached)

Course Name	**PHYSICS 1**
Course Description	Vectors; kinematics; dynamics; work, energy, and power; impulse and momentum; rotation; dynamics of rotation; elasticity; and oscillation.
Number of Units for Lecture and Laboratory	4 units: 3 units lecture, 1 unit laboratory
Number of Contact Hours per Week	6 hours: 3 hours lecture, 3 hours laboratory
Prerequisites	College Algebra Plane and Spherical Trigonometry
Course Objectives	After completing this course, the student must be able to: 1. Differentiate a vector from a scalar; 2. Determine the resultant of concurrent vectors; 3. Solve problems in kinematics; 4. Apply Newton's Laws of Motion; 5. Determine the gravitational force between different masses; 6. Solve problems involving centripetal force for horizontal and vertical curves; 7. Compute the work done on a given body; 8. Relate work and energy; 9. Solve problems by applying the law of conservation of energy; 10. Solve problems in impulse and momentum and collisions; 11. Determine the stress and strain on a body; and 12. Determine the period of a body in simple harmonic motion.
Course Outline	1. Work, Energy and Power 1.1. Definition of Work, Energy and Power

	1.2. Conservation of Energy 2. Impulse and Momentum 2.1. Definition of Impulse and Momentum 2.2. Conservation of Momentum 3. Vector 3.1. Vectors and Scalars 3.2. Graphical Method 3.3. Analytical Method 4. Vector Subtraction 5. Kinematics 5.1. Equations of Kinematics 5.2. Freely Falling Bodies 5.3. Projectile Motion 6. Dynamics 6.1. Newton's Laws of Motion 6.2. Friction 6.3. First Condition of Equilibrium 7. Work, Energy and Power 7.1. Definition of Work, Energy and Power 7.2. Conservation of Energy 8. Impulse and Momentum 8.1. Definition of Impulse and Momentum 8.2. Conservation of Momentum 8.3. Collisions, Coefficient of Restitution 9. Rotation 9.1. Definition of torque 9.2. Second Condition of Equilibrium 9.3. Center of Gravity 10. Dynamics of Rotation 10.1. Kinematics of Rotation 10.2. Dynamics of Rotation 10.3. Center of Gravity 11. Elasticity 11.1. Hooke's Law 11.2. Stress and Strain 11.3. Modulus of Elasticity 12. Oscillations 12.1. Definition of Vibration Motion and Simple Harmonic Motion 12.2. Kinematics of Simple Harmonic Motion 12.3. Simple Pendulum
Laboratory Equipment	Physics Laboratory (see attached)

Course Name	**PHYSICS 2**
Course Description	Fluids; thermal expansion, thermal stress; heat transfer; calorimetry; waves; electrostatics; electricity; magnetism; optics; image formation by plane and curved mirrors; and image formation by thin lenses.
Number of Units for Lecture and Laboratory	4 units: 3 units lecture, 1 unit laboratory
Number of Contact	6 hours: 3 hours lecture, 3 hours laboratory

Hours per Week	
Prerequisite	Physics 1
Course Objectives	After completing this course, the student must be able to: 1. Describe the characteristics of fluids at rest and in motion; 2. Compute the buoyant force on an object immersed in a fluid; 3. Compute the pressure and flow speed of a fluid at any point in a flow tube; 4. Determine the amount of expansion of a given material in relation to temperature change; 5. Determine the change in temperature of a given amount of material that loses or gains; 6. Solve problems about the law of heat transfer; 7. Describe the three methods of heat transfer; 8. Discuss the properties of waves; 9. Describe the modes of vibration of strings and air columns; 10. Solve problems on Doppler Effect; 11. Compute the electric force between electric charges; 12. Compute the electric field due to electric charges; 13. Compute the electric potential due to a charge and electric potential energy of charges; 14. Define electric current, electric resistance and voltage; 15. Solve problems on resistance and cells in series and parallel; 16. State Kirchhoff's rules and apply them in a given circuit; 17. Compute the magnetic field of a given current-carrying conductors; 18. Compute the magnetic torque on a current conductor in a magnetic field; and 19. Describe image formation by mirrors and lenses.
Course Outline	1. Fluids 1.1. Pressure, Specific Gravity, Density 1.2. Archimedes' Principle 1.3. Rate of Flow and Continuity Principle 1.4. Bernoulli's Principle 1.5. Torricelli's Theorem 2. Thermal Expansion, Thermal Stress 3. Heat Transfer 4. Calorimetry 4.1. Specific Heat 4.2. Law of Heat Exchange 4.3. Change of Phase 5. Waves 5.1. Types of Waves and Their Properties 5.2. Sounds 6. Electrostatics 6.1. Charge 6.2. Coulomb's Law 6.3. Superposition Principle 6.4. Electric Field Intensity 6.5. Work and Potential 6.6. Capacitors, Dielectrics 7. Electricity 7.1. Current 7.2. Resistance

	7.3. EMF 7.4. Ohm's Law 7.5. Energy and Power in Circuits 7.6. Series and Parallel Connections 7.7. Kirchhoff's Rules 8. Magnetism 8.1. Magnetic Field of Moving Changes 8.2. Magnetic Filed of Current Element 8.3. Motion of a Charge in a Magnetic Field 8.4. Biot-Savart Law 8.5. Force on a Moving Charge in a Magnetic Field 8.6. Torque on a Current-Carrying Loop 9. Optics 9.1. Light as Electromagnetic Waves 9.2. Properties of Reflection and Refraction 10. Image Formation by Plane and Curved Mirrors 10.1. Graphical Methods 10.2. Mirror Equation 11. Image Formation by Thin Lenses 11.1. Graphical Methods 11.2. Lens Equation
Laboratory Equipment	Physics Laboratory (see attached)

C. BASIC ENGINEERING SCIENCES

Course Name	**ENGINEERING DRAWING**
Course Description	Practices and techniques of graphical communication; application of drafting instruments, lettering scale, and units of measure; descriptive geometry; orthographic projections; auxiliary views; dimensioning; sectional views; pictorial drawings; requirements of engineering working drawings; and assembly and exploded detailed drawings.
Number of Units for Lecture and Laboratory	1 unit laboratory
Number of Contact Hours per Week	3 hours laboratory
Prerequisite	None
Course Objectives	After completing this course, the student must be able to: 1. Understand the importance of technical drawing knowledge and skills as applied to the various areas of engineering; 2. Apply the basic concepts of technical drawing and sketching; and 3. Prepare technical drawings.

Course Outline	1. Engineering Lettering 2. Instrumental Figures 3. Geometric Construction 4. Orthographic Projection 5. Dimensioning 6. Orthographic Views with Dimensions and Section View 7. Sectional View 8. Pictorial Drawing 9. Engineering Working Drawings 10. Assembly and Exploded Detailed Drawings
Laboratory Equipment	1. Drafting table 2. Drawing instruments 2.1. One 30-60 degree triangle 2.2. One 45 degree triangle 2.3. One technical compass 2.4. One protractor

Course Name	**COMPUTER FUNDAMENTALS AND PROGRAMMING**
Course Description	Basic information technology concepts; fundamentals of algorithm development; high-level language and programming applications; computer solutions of engineering problems.
Number of Units for Lecture and Laboratory	2 units laboratory
Number of Contact Hours per Week	6 hours laboratory
Prerequisite	Second Year Standing
Course Objectives	After completing this course, the student must be able to: 1. Understand basic information technology concepts; 2. Use application software and the Internet properly; 3. Acquire proficiency in algorithm development using a high-level programming language; 4. Use the computer as a tool in engineering practice.
Course Outline	1. Introduction to Computers 1.1. Computer Organization 1.2. Number Systems and Data Representation 1.3. Application Software: Word Processing and Spreadsheet 1.4. The Internet 2. Programming 2.1. Algorithm Development 2.2. Programming Fundamentals
Laboratory Equipment	1. Personal computer with: 1.1. Operating system 1.2. Word processing software 1.3. Spreadsheet software 1.4. High-level programming language 1.5. Internet browser and Internet connection

Course Name	**COMPUTER-AIDED DRAFTING**
Course Description	Concepts of computer-aided drafting (CAD); introduction to the CAD environment; terminologies; and the general operating procedures and techniques in entering and executing basic CAD commands.
Number of Units for Lecture and Laboratory	1 unit laboratory
Number of Contact Hours per Week	3 hours laboratory
Prerequisite	Third Year Standing
Course Objectives	After completing this course, the student must be able to: 1. Define the terms related to computer-aided drafting systems; 2. Identify the important tools used to create technical drawings in CAD; 3. Create electronic drawings (e-drawing) using CAD; and 4. Appreciate the usefulness of the knowledge and skills in computer aided drafting as applied in his/her professional development.
Course Outline	1. Introduction to CAD Software 2. CAD Drawing 3. Snapping, Construction Elements 4. Dimensioning 5. Plotting, Inputting Images 6. 3D and Navigating in 3D 7. Rendering
Laboratory Equipment	1. Personal computer with: 1.1. Operating system 1.2. CAD software 2. Printer or plotter

Course Name	**STATICS OF RIGID BODIES**
Course Description	Force systems; structure analyses; friction; centroids and centers of gravity; and moments of inertia.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisites	Physics 1 Integral Calculus

Course Objectives	After completing this course, the student must be able to: 1. Understand the principles of equilibrium of particles; 2. Undertake vector operations such as vector cross and dot product; 3. Determine forces of 2D and 3D structures; 4. Understand the principles of static, wedge and belt friction; 5. Determine centroids, center of mass and center of gravity of objects; 6. Determine moment of inertia, mass moment of inertia; and 7. Analyze the stresses of trusses, beams and frames.
Course Outline	1. Introduction to Mechanics; Vector Operations 2. Force Vectors and Equilibrium of Particles 3. Vector Cross and Dot Product 4. Moment of a Force 5. Couples; Moment of a Couple 6. Equivalent Force Systems in 2D and 3D 7. Dry Static Friction, Wedge and Belt Friction 8. Centroid; Center of Mass; and Center of Gravity 9. Distributed Loads and Hydrostatic Forces; Cables 10. Moment of Inertia; Mass Moment of Inertia 11. Trusses; Frames and Machines; Internal Forces 12. Beams; Shear and Bending Moment Diagrams
Laboratory Equipment	None

Course Name	**DYNAMICS OF RIGID BODIES**
Course Description	Kinetics and kinematics of a particle; kinetics and kinematics of rigid bodies; work energy method; and impulse and momentum.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Prerequisite	Statics of Rigid Bodies
Course Objectives	After completing this course, the student must be able to: 1. Understand the principles governing the motion of particles, velocity and acceleration; 2. Understand the principles of Newton's Second Law and its applications; 3. Understand kinetics of particles in particular energy and momentum methods; and 4. Understand kinematics of rigid bodies, its energy and momentum.
Course Outline	1. Introduction to Dynamics 2. Position, Velocity, and Acceleration 3. Determination of the Motion of the Particles 4. Uniform Rectilinear Motion 5. Uniformly Accelerated Rectilinear Motion 6. Position Vector, Velocity, and Acceleration 7. Derivatives of Vector Functions 8. Rectangular Components of Velocity and Acceleration 9. Motion Relative to a Frame in Translation

	10. Tangential and Normal Components 11. Radial and Transverse Components 12. Motion of Several Particles (Dependent Motion) 13. Kinetics of Particles: Newton's Second Law 13.1. Newton's Second Law of Motion 13.2. Linear Momentum of the Particle, Rate of Change of Linear Momentum 13.3. System of Units 13.4. Equation of Motion 13.5. Dynamic Equilibrium 13.6. Angular Momentum of Particle, Rate of Change of Angular Momentum 13.7. Equations in Terms of Radial and Transverse Components 13.8. Motion Under a Central Force 14. Kinetics of Particles: Energy and Momentum Methods 14.1. Work of Force 14.2. Kinetic Energy of a Particle, Principle of Work and Energy 14.3. Applications of the Principle of Work and Energy 14.4. Potential Energy 14.5. Conservative Forces 14.6. Conservation of Energy 14.7. Principle of Impulse and Momentum 14.8. Impulsive Motion 14.9. Impact 14.10. Direct Central Impact 14.11. Oblique Central Impact 14.12. Problems Involving Energy and Momentum 15. Systems of Particles 15.1. Application of Newton's Second Laws to Motion of a System of Particles 15.2. Linear and Angular Momentum of a System of Particles 15.3. Motion of Mass Center of a System of Particles 15.4. Angular Momentum of a System of Particles About Its Mass Center 15.5. Conservation of Momentum for a System of Particles 15.6. Kinetic Energy of a System of Particles 15.7. Work-Energy Principle. Conservation of Energy for a System of Particles 15.8. Principle of Impulse and Momentum for a System of Particles 16. Kinematics of Rigid Bodies 16.1. Translation 16.2. Rotation About a Fixed Axis 16.3. Equations Defining the Rotation of a Rigid Body About a Fixed Axis 16.4. General Plane Motion 16.5. Absolute and Relative Velocity in Plane Motion 16.6. Instantaneous Center of Rotation in Plane Motion 16.7. Absolute and Relative Acceleration 16.8. Rate of Change of a Vector with Respect to a Rotating Frame 16.9. Plane Motion of a Particle Relative to a Rotating Frame; Coriolis Acceleration 16.10. Motion About a Fixed Point 16.11. General Motion

	16.12. Three-Dimensional Motion of a Particle Relative to a Rotating Frame; Coriolis Acceleration 16.13. Frame of Reference in General Motion 17. Plane Motion of Rigid Bodies: Forces and Accelerations 17.1. Equation of Motions 17.2. Angular Momentum of a Rigid Body in Plane Motion 17.3. Plane Motion of a Rigid Body. D' Alembert's Principle 17.4. Solution of Problems involving the Motion of a Rigid Bodies 17.5. Systems of Rigid Bodies 17.6. Constrained Plane Motion 18. Plane Motion of Rigid Bodies: Energy and Momentum Methods 18.1. Principle of Work and Energy for a Rigid Body 18.2. Work of Forces Acting on a Rigid Body 18.3. Kinetic Energy of a Rigid Body in Plane Motion 18.4 Systems of Rigid Bodies 18.5 Conservation of Energy 18.6 Principle of Impulse and Momentum 18.7 Conservation of Angular Momentum 18.8 Impulsive Motion 18.9 Eccentric Impact
Laboratory Equipment	None

Course Name	**MECHANICS OF DEFORMABLE BODIES**
Course Description	Axial stress and strain; stresses for torsion and bending; combined stresses; beam deflections; indeterminate beams; and elastic instability.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Statics of Rigid Bodies
Course Objectives	After completing this course, the student must be able to: 1. Understand the concepts of stress and strain; 2. Calculate stresses due to bending, shears, and torsion under plain and combined loading; 3. Analyze statically determinate and indeterminate structures; and 4. Determine the elastic stability of columns.
Course Outline	1. Load Classification 2. Concept of Stress, Normal and Shear Stress 3. Stresses under Centric Loading 4. Stress Concentration 5. Plane Stress 6. Principal Stresses for Plane Stress 7. Mohr's Circle for Plane Stress 8. Deformations, Normal and Shear Strains 9. Material Properties 10. Working Stresses 11. Deformation in a System of Axially Loaded Members

	12. Temperature Effects on Axially Loaded Members 13. Statically Indeterminate Members 14. Thin-Walled Pressure Vessel 15. Torsional Stresses; Elastic Torsion Formula 16. Torsional Deformation; Power Transmission 17. Flexural Stresses by the Elastic Curve 18. Moment Equation Using Singularity Function 19. Beam Deflection by the Double Integration Method 20. Area Moment Theorems 21. Moment Diagram by Parts 22. Beam Deflection by Area Moment Method 23. Statically Indeterminate Beams 24. Buckling of Long Straight Columns 25. Combined Loadings 26. Analysis of Riveted Connections by the Uniform Shear Method 27. Welded Connections
Laboratory Equipment	None

Course Name	**ENGINEERING ECONOMY**
Course Description	Concepts of the time value of money and equivalence; basic economy study methods; decisions under certainty; decisions recognizing risk; and decisions admitting uncertainty.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Third Year Standing
Course Objectives	After completing this course, the student must be able to: 1. Solve problems involving interest and the time value of money; 2. Evaluate project alternatives by applying engineering economic principles and methods and select the most economically efficient one; and 3. Deal with risk and uncertainty in project outcomes by applying the basic economic decision making concepts.
Course Outline	1. Introduction 1.1. Definitions 1.2. Principles of Engineering Economy 1.3. Engineering Economy and the Design Process 1.4. Cost Concepts for Decision Making 1.5. Present Economy Studies 2. Money-Time Relationships and Equivalence 2.1. Interest and the Time Value of Money 2.2. The Concept of Equivalence 2.3. Cash Flows 3. Basic Economy Study Methods 3.1. The Minimum Attractive Rate of Return 3.2. The Present Worth Method

	3.3. The Future Worth Method 3.4. The Annual Worth Method 3.5. The Internal Rate of Return Method 3.6. The External Rate of Return Method 3.7. The Payback Period Method 3.8. The Benefit/Cost Ratio Method 4. Decisions Under Certainty 4.1. Evaluation of Mutually Exclusive Alternatives 4.2. Evaluation of Independent Projects 4.3. Depreciation and After-Tax Economic Analysis 4.4. Replacement Studies 4.5. Break win Analysis 5. Decisions Recognizing Risk 5.1. Expected Monetary Value of Alternatives 5.2. Discounted Decision Tree Analysis 6. Decisions Admitting Uncertainty 6.1. Sensitivity Analysis 6.2. Decision Analysis Models
Laboratory Equipment	None

Course Name	**ENGINEERING MANAGEMENT**
Course Description	Decision-making; the functions of management; managing production and service operations; managing the marketing function; and managing the finance function.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Third Year Standing
Course Objectives	After completing this course, the student must be able to: 1. Understand the field of engineering management; 2. Know and apply the different functions of management.
Course Outline	1. Introduction to Engineering Management 2. Decision Making 3. Functions of Management 3.1. Planning / Coordinating 3.2. Organizing 3.3. Staffing 3.4. Communicating 3.5. Motivating 3.6. Leading 3.7. Controlling 4. Managing Product and Service Operations 5. Managing the Marketing Function 6. Managing the Finance Function
Laboratory Equipment	None

Course Name	**ENVIRONMENTAL ENGINEERING**
Course Description	Ecological framework of sustainable development; pollution environments: water, air, and solid; waste treatment processes, disposal, and management; government legislation, rules, and regulation related to the environment and waste management; and environmental management system.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Prerequisites	General Chemistry
Course Objectives	After completing this course, the student must be able to: 1. Understand the various effects of environmental pollution; 2. Know the existing laws, rules, and regulations of the government on environmental issues; 3. Identify, plan, and select appropriate design treatment schemes for waste disposal; and 4. Understand the importance of waste management and its relevance to the engineering profession.
Course Outline	1. Ecological Concepts 1.1. Introduction to Environmental Engineering 1.2. Ecology of Life 1.3. Biogeochemical Cycles 1.4. Ecosystems 2. Pollution Environments 2.1. Water Environment 2.2. Air Environment 2.3. Solid Environmental 2.4. Toxic and Hazardous Waste Treatment 3. Environmental Management System 3.1. Environmental Impact Assessment 3.2. Environmental Clearance Certificate
Laboratory Equipment	None

Course Name	**SAFETY MANAGEMENT**
Course Description	Evolution of safety management; safety terminology; safety programs adopted by high risk industries; hazards in the construction, manufacturing, gas and power plants, and other engineering industries and how to prevent or mitigate them; techniques in hazard identification and analysis in workplaces; off-the-job safety; disaster prevention and mitigation; and incident investigation.

Number of Units for Lecture and Laboratory	1 unit lecture
Number of Contact Hours per Week	1 hour lecture
Prerequisites	Third Year Standing
Course Objectives	After completing this course, the student must be able to: 1. Understand the importance and the value of safety; 2. Know the health hazards and their prevention; 3. Identify and mitigate or prevent hazards; and 4. Apply the concepts and principles of safety in engineering practice.
Course Outline	1. Overview of Safety 2. Basic Safety Procedures in High Risk Activities and Industries 2.1. Procedure in Hazards Analysis in the Workplace 2.2. Control of Hazardous Energies 2.3. Confined Space Entry 2.4. Basic Electrical Safety 2.5. Fall Protection 2.6. Barricades and Scaffolds 2.7. Fire Safety and the Fire Code 2.8. Industrial Hygiene 2.9. Hazard Communication and Chemical Safety 3. Value Based Safety and Off-the-Job Safety 3.1. Safety as a Value; Choice vs. Compliance 3.2. Off-the-Job Safety (Residences and Public Places) 3.3. Safety as Related to Health Practices 4. Disaster Prevention and Mitigation 4.1. Rationale for Disaster Prevention and Loss Control 4.2. Planning for Emergencies 4.3. Emergency Response Procedures 5. Incident Investigation and Reporting 5.1. Accident Escalation, Incident Investigation and Reporting 5.2. Causal Analysis; Recognition of Root Cause 5.3. Identification of Corrective or Preventive Actions
Laboratory Equipment	None

D. ELECTIVE COURSES

Course Name	**SPECIAL TOPICS IN METALLURGICAL ENGINEERING**
Course Description	New developments in metallurgical engineering and technology and/or additional technical knowledge in various topics in metallurgical engineering practice.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hrs per Week	3 hours lecture
Prerequisite	5th year standing
Course Objectives	At the end of the semester, the students should be able to:

	1. Discuss a new development in metallurgical engineering and/or; 2. Identify additional elements of metallurgical engineering practice.
Course Outline	The specific course topic and outline may be changed depending on the state of development of technology in the following : 1. preparation, separation, concentration of minerals, coal and metallurgical fuels. 2. extraction of metals such as hydrometallurgical, pyrometallurgical and electrometallurgical processes 3. adaptation and application of metals such as melting, casting, forging, rolling, extrusion, powder metallurgy, heat treatment, metal working and finishing operations. Attendance in technical symposia, lectures and conferences is included. The topic may be related to research activities Metallurgical Research
Laboratory Equipment	None

Course Name	**CERAMIC RAW MATERIALS AND PROCESSES**
Course Description	Comprehensive discussion on the different ceramic raw materials used in the ceramic industry (e.g., kaolins, ball clays, red clays, feldspar, flint, alumina, silica, etc.), the processing techniques involved, and how these influence the physical and chemical properties of ceramic products.
Number of Units for Lecture and Laboratory	3 units: 2 units Lecture, 1unit Laboratory
Number of Contact hours per Week	5 hours: 2 hours Lecture, 3 hours Laboratory
Prerequisites	Analytical Chemistry
Course Objectives	At the end of the course the student is expected to: 1. Identify the different raw materials for the ceramic industry such as various types of clay and non-clay minerals 2. Identify the important physical, chemical and thermal properties of ceramic raw materials 3. Rationalize the properties based on the ceramic formulation 4. Perform laboratory exercises pertaining to the beneficiation of ceramic raw materials
Course Outline	1. Introduction to Ceramic Raw Materials 2. Sedimentary Clays 3. Further Groupings of Clays 4. Composition of Clays 5. Chemical Properties of Clays 6. Physical Properties of Clays 7. Effect of Heat on Clays (2) 8. Firing Properties of Clays 9. Classification of Clays (e.g. according to uses)

	10. Technical Study and Design of Clay Beneficiation Plant (2) 11. Silica (2) 12. Alumina 13. Feldspar 14. Anhydrous Alumina-Silica Minerals 15. Lime, Magnesia, Dolomite and Related Materials (2) 16. Magnesium Silicate Minerals 17. Fluorine Minerals 18. Alkali Minerals and Compounds 19. Refractory Raw Materials (2) 20. Other Ceramic Raw Materials – Binders, etc. (2) 21. Technical Study and Design of Silica Beneficiation Plant (2) 22. Technical Study and Design of Feldspar Beneficiation Plant (2) Laboratory Experiments for Ceramic Raw Materials and Processes I. Plastic Materials 1. Sieve analysis of various clays (2) 2. Water of plasticity of clays 3. Effect of water in the viscosity of suspended clays 4. Effect of electrolytes on the viscosity of suspended clays 5. Drying shrinkage of various clays 6. Behavior in firing of various clays (color and firing shrinkage) (2) 7. Volume change (fired and unfired) 8. Apparent specific gravity of clays 9. Bulk specific gravity of clays 10. Strength test of clays (fired and unfired) (2) II. Non-plastic Materials (Feldspar) 1. Pyrometric Cone Equivalent 2. Softening Range 3. True Specific Gravity 4. Petrographic Analysis (optional)
Laboratory Equipment	For those with lab option: Bomb calorimeter, analytical balance, thermometer, hot plate, data logger

Course Name	**POLYMER MATERIALS & PROCESSES**
Course Description	Study of the structure – property relationship of polymers, synthesis of polymers, processing and conversion to plastics, and application and performance of polymers.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hrs per Week	3 hrs lecture
Prerequisite	none
Course Objectives	At the end of the term, the students should be able to able to : 1. Acquire an understanding of the properties and characteristics of polymer 2. Understand the synthesis, Rheology, and mechanical properties of polymers 3. Know how to characterize polymer. 4. Understand the different polymer processing, its technology and

	application and the impact to the environment.
Course Outline	1. Orientation and introduction to the Course 2. Review hydrocarbons 3. Review hydrocarbons and the different functional 4. Introduction to Polymer Science 5. Polymer Molecules and its chemistry, size, shape, molecular structure, molecular configuration both stereoisomerisms and geometrical isomerism 6. Molecular forces and chemical bonding in polymers Intermolecular Forces & Polymers, physical properties, texture of polymers 7. Polymer crystallinity, types based on repeating units, classifications and processes 8. Synthesis of Polymers 9. Steps growth Polymerization 10. Chain-Growth polymerization 11. Polymerization techniques (Bulk polymerization, Solution Polymerization, Suspension Polymerization, Emulsion Polymerization, Solid State, Gas Phase and Plasma Polymerization) 12. Reaction of Synthetic Polymers 13. Rheology & Mechanical Properties of Polymers 14. Viscous Flow, Kinetic Theory of Rubber Elasticity, Viscoelasticity 15. Mechanical Properties of Polymer (Stress-Strain Behavior, Glass Transition temperature, Polymer Fracture 16. Crazing and shear yielding, Fatigue failure, Improving Mechanical properties) 17. Characterization of Polymer: Measurement of Molecular Weight and Size 18. End-Group analysis, colligative property measurement, light scattering, ultracentrifugation 19. Solution viscosity and molecular size, gel permeation chromatography 20. Characterization of Polymer: Analysis and Testing of Polymers 21. Chemical Analysis of Polymer, Spectroscopic methods, X-ray diffraction Analysis 22. Microscopy, thermal analysis, physical testing 23. Polymer Processing: Plastic Technology 24. Polymer Processing: Fiber Technology 25. Polymer Processing: Elastomer Technology 26. Degradation, Stability, and Environmental Issues 27. Polymer degradation and Stability (Thermal Degradation, Oxidative and UV Stability, Chemical and Hydrolytic Stability, Radiation Effects, Mechanodegradation) 28. Polymer degradation and Stability (Thermal Degradation, Oxidative and UV Stability, Chemical and Hydrolytic Stability, Radiation Effects, Mechanodegradation) 29. Management in Plastics in the Environment 30. Application of polymers in Separations, Biotechnology and Electronics
Laboratory Equipment	None

Course Name:	**SEMICONDUCTOR MATERIALS & PROCESSES**
Course Description	A study of materials preparation; physics of semiconductors; device fabrication technologies; packaging and encapsulation.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per week	3 hours lecture
Prerequisite/Co-requisite	None
Course Objectives	At the end of the course the student must be able to: 1. Apply knowledge of mathematics, science, and engineering 2. Design a system, component, or process to meet desired needs 3. Function on multi-disciplinary teams 4. Identify, formulate, and solve engineering problems 5. Gain understanding of professional and ethical responsibility 6. Communicate effectively 7. Understand the impact of engineering solutions in a global and societal context 8. Recognize the need for, and an ability to engage in life-long learning 9. Apply knowledge of contemporary issues
Laboratory Equipment	None
Suggested References	Van Zant, Peter, Microchip Fabrication: A Practical Guide to Semiconductor Processing, 3rd Ed. Tumalla, R., Microelectronic Packaging Handbook, Van Nostrand 1989 Am. Society of Metals, Electronic Materials Handbook, Volume 1, Packaging, 1989 Moore, T., Characterization of IC Packaging Materials, Butterworth, 1993 Lau, J., Thermal Stress ans Strain in Microelectronic Packaging, Van Nostrand, 1993 Herman G., Wire Binding in Microelectronics, ISHM, 1989. Kasap, S.O., Principles of Electronic Materials and Devices Mc Evily, Arthur, Metal Failures-Mechanisms, Analysis, Prevention

D. ALLIED COURSES

Course Name	**GENERAL CHEMISTRY 2**
Course Description	Continuation of General Chemistry 1, this course aims to provide comprehensive understanding of the basic principles of thermo-chemistry, chemical kinetics, chemical equilibrium, electro chemistry, metallurgy, organic chemistry and nuclear chemistry
Number of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory
Number of Contact Hrs per Week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisite	General Chemistry
Course Objectives	At the end of the course the student must be able to:

	1. Learn the basic principles of thermochemistry and chemical kinetics. 2. Understand the concepts of equilibria and techniques in solving stoichiometric problems on molecular and ionic equilibria 3. Learn the basic of electrochemistry. 4. Learn the basic of nuclear chemistry and its important application in real world situations in which chemistry affects human lives
Course Outline	1. Thermochemistry: Energy Flow and Chemical Change 1.1 Forms of Energy and their Interconvertions 1.2 Enthalphy: Heat of Reaction and Chemical 1.3 ChangeStandard Heats of Reactions 1.4 Calorimetry : Laboratory Measurements of Heats of Reactions 1.5 Stoichiometry of Thermochemical Equations 1.6 Hess' Law of Heat of Summation 2. Kinetics: Rates and Mechanism of Chemical Reactions 2.1 Factors that influence Reaction Rates 2.2 Expressing the Reaction Rates 2.3 The Rate Law and its Components 2.4 Integrated Rate Laws: Concentration Change over time 2.5 The Effect of Temperature on Reaction Rate 2.6 Explaining the Effects of Concentration and Temperature 2.7 Reaction Mechanisms: Step in the Overall Reaction 2.8 Catalysis: Speeding Up a Chemical Reaction 3. Equilibrium: The Extent of Chemical Reactions 3.1 The equilibrium State and the Equilibrium Constant 3.2 The Reaction Quotient and the Equilibrium Constant 3.3 Expressing Equilibria with Pressure Terms: Relationship between Kc and Kp 3.4 Reaction Direction: Comparing Q and K 3.5 How to Solve Equilibrium Problems 3.6 Reaction Conditions and the Equilibrium State: Le Chatelier's Principle 4. Acid-Base Equilibria 4.1 Acids and Bases in Water 4.2 Autoionization of Water 4.3 Proton Transfer and the Bronstead-Lowry Acid-Base Definition 4.4 Solving Problem Involving Weak-Acid Equilibria 4.5 Weak Bases and their Relation to Weak Acids 4.6 Molecular properties and Acid Strength 4.7 Acid Base Properties of Salt Solutions 4.8 Generalizing Bronstead-Lowry 4.9 Concept: The Leveling Effect 4.10 Electron Pair Donation and the Lewis Acid-Base Definition 5. Ionic Equilibria in Aqueous System

	5.1 Equilibria of Slightly Soluble Ionic Compounds 5.2 Predicting the Formation of Precipitates: Qsp vs.Ksp 6. Electrochemistry Chemical Change and Electrical Work 6.1 Redox Reactions and Electrochemical Cells 6.2 Voltaic Cells: Using Spontaneous Reaction to Generate Electrical Energy 6.3 Free Energy and Electrical Work 6.4 Cell Potential : Output of a Voltaic Cells 6.5 Electrochemical Processes in Batteries 6.6 Corrosion: A Case of Environmental Electrochemistry 6.7 Electrolytic Cell: Using Electrical Energy to Drive Non-Spontaneous Reactions 7. The Elements in Nature and Industry 7.1 How the Elements Occur in Nature 7.2 The Cycling of Elements Through the Environment 7.3 Metallurgy : Extracting a Metal from its Ore 7.4 Tapping the CRsut: isolation and Uses of Elements 8. Organic Compounds and the Atomic Properties of Carbon 8.1 The Special nature of Carbon and the Characteristics of Organic Molecules 8.2 The structure and Classes of Hydrocarbons 8.3 Properties and Reactivities of Common Functional Groups 8.4 Petroleum Refining 9. Nuclear Reactions and their Applications 9.1 Radioactive Decay and Nuclear Stability 9.2 The Kinetics and Radioactive Decay 9.3 Nuclear Transmutation Induced Changes of Nuclei 9.4 The Effect of Nuclear Radiation on Matter 9.5 Application of Radioisotopes 9.6 The Interconversion of mass and Energy 9.7 Applications of Fission and Fusion
Laboratory Equipment	none

Course Name:	**ANALYTICAL CHEMISTRY (LECTURE)**
Course Description	Theory and practice of gravimetric and volumetric methods of analysis, including an introduction to instrumental methods of analysis.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per week	2 hours lecture
Prerequisite	General Chemistry (Lecture and Laboratory)
Course Objectives	At the end of the course, the student must be able to: 1. understand the concepts and be familiar with the steps and techniques employed in volumetric and gravimetric methods of

	analysis; 2. execute calculation techniques used in neutralization, precipitation, complex titration, and redox titration methods; 3. choose the suitable titration method in the analysis a given sample type; 4. solve stoichiometric problems involving the analysis of samples; 5. understand the basic concepts of ultraviolet and visible molecular absorption spectroscopy; and, 6. understand current trends in analytical techniques in volumetric, gravimetric and spectrometric analyses.
Course Outline	1. Introduction to Analytical Chemistry 2. Definition, classification, and nature of Analytical Chemistry 3. Review of calculations used in Analytical Chemistry 4. Mole and millimole calculations 5. Stoichiometry 6. Solutions and methods of expressing concentration of solutions 7. Aqueous solutions and chemical equilibria 8. Solutions of electrolytes, acids and bases, amphiprotic species, strengths of acids and bases 9. Chemical equilibrium and equilibrium constant expressions 10. Buffer solutions 11. Solving equilibrium problems for complex systems 12. Titrimetric methods 13. Equivalence points and end points, primary standards, standard solutions, and standardization 14. Volumetric calculations 15. Principles of neutralization titrations 16. Solutions and indicators for acid-base titrations 17. Titration curves and concentration changes in strong acid – strong base titrations 18. Titration curves and concentration changes in weak acid – weak – base titrations 19. Applications of neutralization titrations: elemental analysis of carbonates and carbonate mixtures, organic functional groups, and salts 20. Precipitation titrimetry 21. Precipitation titration curves involving silver ion 22. Applications of argentometric titrations 23. Complexometric reactions 24. EDTA titrations, properties and complexes, indicators 25. Applications of EDTA titrations 26. Introduction to electrochemistry 27. Oxidation/reduction (Redox) reactions 28. Electrochemical cells and electrode potentials 29. Strength of redox titrants 30. Redox titrations 31. Iron, sodium thiosulfate, potassium permanganate and cerium (IV), potassium dichromate, iodine, and potassium bromate titrations 32. Gravimetric methods of analysis 33. Precipitation and evolution gravimetry 34. Calculation of results from gravimetric data (from pure and mixture of precipitates) 35. Introduction to spectrochemical methods 36. Interaction of electromagnetic radiation with matter

	37. The Spectronic 20
Laboratory Equipment	None

Course Name:	**ANALYTICAL CHEMISTRY (LABORATORY)**
Course Description	Laboratory application of the principles and theories of gravimetric and volumetric methods of analysis of chemical samples, with an emphasis on laboratory techniques and accuracy of measurements.
Number of Units for Lecture and Laboratory	2 units laboratory
Number of Contact Hours per week	6 hours laboratory
Prerequisite/s	General Chemistry (Lecture and Laboratory)
Course Objectives	At the end of the course, the student must be able to: 1. Acquired skills in laboratory techniques required to perform chemical analysis in the laboratory; 2. Plan experimental analysis of chemical samples; and, 3. Collect and interpret data obtained in quantitative analytical process.
Course Outline	1. Basic tools and operations of Analytical Chemistry 2. Data handling in Analytical Chemistry 2.1 Accuracy, precision, errors, significant figures, rounding off, propagation of errors 2.2 Use of spreadsheets and calibration curves 2.3 Confidence limits, rejection of results, etc. 3. Exercises 3.1 Use of the analytical balance 3.2 Making qualitative transfers 3.3 Delivering an aliquot 3.4 Calibration a pipet 3.5 Reading a buret 4. Experiments 4.1 Acid-base titration 4.1.1 Preparation and standardization of titrant solutions 4.1.2 Determination of the purity of KHP sample 4.1.3 Determination of total alkalinity of soda ash 4.1.4 Determination of the components of a base mixture by double-indicator method 4.2 Potentiometric titration 4.3 Determination of the ionization constant of a weak acid by potentiometric titration 5. Complexometric titration 5.1 Preparation and standardization of EDTA titrant 5.2 Determination of water hardness using EDTA 6. Redox titrations

	6.1 Preparation and standardization of potassium permanganate titrant 6.2 Determination of calcium in limestone 6.3 Preparation and standardization of potassium bromate 6.4 Determination of ascorbic acid in Vitamin C tablets 7. Gravimetric analysis 7.1 Gravimetric determination of Ca as calcium oxalate 8. Spectrophotometric methods 8.1 Spectrophotometric determination of iron
Laboratory Equipment	Glasswares (burets, pipets, flasks, test tubes, stirring rods, etc.), water bath, furnace, oven, spectrophotometer, analytical balances, platform-type heaters, thermometer, fume hood and, burners.

Course Name	**PRINCIPLES OF GEOLOGY**
Course Description	Study of earth materials, the nature and consequences of endogenic and exogenic geologic processes; Plate Tectonics
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hrs per Week	3 hours lecture
Prerequisite	General Chemistry or Instructor's Consent
Course Objectives	At the end of the course the student must be able to: 1. Understand the fundamental concepts and basic understanding of the geological science. 2. Know the basic and first hand appreciation of the materials that make up the earth, their characteristics, uses and behavior. 3. Develop an appreciation of the world we live in and how to adapt to hazards posed by natural geological processes. 4. Prepare the students in their undertaking of subjects that use basic geological knowledge, upon which more advanced concepts are based. 5. Inculcate and develop the ability of deductive reasoning. 6. Develop the ability in conducting scientific literature research. 7. Develop interest in economic, environmental and societal issues related to Geology and Geological Engineering. 8. Develop desire towards continuous learning.

Course Outline	1. Orientation and introduction to the course. 2. Definitions 3. How the Earth was formed. 4. Introduction to Plate Tectonics and the Geologic Time Scale 5. Materials of the Earth – Elements, Minerals and Rocks 6. The Rock Cycle 7. Igneous Rocks and Processes 8. Sedimentary Rocks and Processes 9. Metamorphic Rocks and Processes 10. Earthquakes 11. The Earth's interior 12. Crustal Deformation 13. Plate Tectonics 14. Weathering and Erosion 15. Mass Wasting 16. Landforms 17. The Hydrologic Cycle 18. Streams 19. Groundwater 20. Oceans and shorelines 21. Geologic Time 22. Environment and Earth resources 23. Beyond Earth (The Universe and the Solar System)
Laboratory Equipment	none

Course Name	**ELEMENTARY MINERALOGY**
Course Description	Introduction to crystallography and the physical and chemical properties of minerals, including their megascopic identification and the description of their symmetry, face indices, zones, forms, irregularities; mineral occurrences and uses.
Number of Units for Lecture and Laboratory	4 units: 2 units lecture, 2 units laboratory
Number of Contact Hrs per Week	8 hour: 2 hours lecture, 6 hours laboratory
Prerequisite Co-Requisite	General or Analytical Chemistry Principles of Geology
Course Objectives	At the end of the course the student must be able to: 1. Acquire a basic knowledge and understanding of crystal morphology, particularly symmetry elements, parameters, Miller's Index, and interfacial angels 2. Gain a basic knowledge on crystal drawing using orthographic projections 3. Appreciate the importance of minerals and the various uses of minerals 4. Familiarized the students with the physical, engineering and chemical properties in the identification of common minerals 5. Familiarize with chemical composition of common chemical classes of minerals
Course Outline	1. Crystallography 1.1 Crystal Morphology 1.2 Crystal Symmetry

	1.3 Crystallograhic Axes 1.4 Miller Indicates 1.5 Forms 1.6 Zones 1.7 Crystal Projection and Morphological Calculations 1.8 Lattice Theory 2. Physical Properties 2.1 X-Ray Crstallography 2.2 X-Ray Specta 2.3 Bragg's Law 2.4 Laue Method and other Single Crystal Technique 2.5 Crystallographic Tables 2.6 Powder Technique 2.7 ASTMS card uses of poede data 2.8 Indexing Refraction 2.9 Crystal habit and aggregates 2.10 Cleavage 2.11 Parting 2.12 Fracture 2.13 Mhardness luster streak 2.14 Tenacity 2.15 Specific Gravity Color 2.16 Chatoyancy and asterism, 2.17 Luminisence 2.18 Electrical and magnetic Properties 2.19 Optival Properties
Laboratory Equipment	XRD, crystal model, mineral samples, microscope

Course Name	**PRINCIPLES OF MINING**
Course Description	Socioeconomic importance and characteristics of the mineral industry. Principles of mineral exploration, mine development, exploitation and rehabilitation. Introduction to surface and underground mining methods.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hrs per Week	3 hours lecture
Prerequisite	Co-requisite Principles of Geology
Course Objectives	At the end of the course the students must be able to know the history and overview of the mining industry.
Course Outline	1. Introduction. Film and/ or video showing. 2. Mining laws and government regulations. 3. Prospecting and Exploration – Techniques and methods 4. Introduction to reserve estimation 5. Mine development 6. Mine exploitation 7. Mineral deposits 8. Mine production cycles. Drilling, Blasting, Loading, Hauling. 9. Surface mining methods 10. Underground mining methods 11. Miscellaneous topics.
Laboratory Equipment	none

Course Name	**MECHANICS OF FLUIDS**
Course Description	Properties of fluids; fluid statics, hydrokinetics and hydrodynamics; ideal fluid flow for past external and internal boundaries; flow similitude; computer and laboratory fluid experiments.
Number of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory
Number of Contact Hrs per Week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisite/Co-requisite	Dynamics of Rigid Bodies, Mechanics of Deformable Bodies
Course Objectives	At the end of the course, the student must be able to: 1. Develop a good understanding of the properties of fluid and the principles of fluid behavior. 2. Understand the principles involving physical ideas, as well as mathematical ones, and includes derivations and analysis of resulting equations, which describe fluid behavior. 3. Develop skill in solving practical problems, which involve numerical calculations from working formulas, often with the conclusion of experimentally determined coefficient. 4. Develop awareness in all of you that your solutions and decisions on a particular problem has social and moral impacts. Mediocre solutions could cause a loss of life and/or property. 5. Develop the awareness that you are the future professional engineers of this country. Those people that have more should contribute more for the welfare of their fellowmen in whatever status you may be in a society.
Course Outline	1. Fundamental Properties of Fluids 2. Hydrostatic Forces on Surfaces 3. Total Hydrostatic Pressure on Plane Surfaces 4. Forces on Submerged Plane Surfaces Semi-Graphical Approaches 5. Forces on Submerges Curved-Surfaces 6. Relative Equilibrium of Liquids 7. Hoop Tension in Circular Pipes and Tanks 8. Dams 9. Principle of Archimedes 10. Stability of Submerged Bodies

Course Outline	11. Stability of Floating Bodie 12. Kinematics of Fluid Flows 13. Flow of ideal, Real Fluids 14. Classification of Flow Types 15. Pathlines, Streamlines and Flownets 16. Transport Theorems 17. Reynold's Transport Theorem 18. Mass Transport/Continuity Equation 19. Momentum Equations 20. Energy Systems 21. Flow Through Porous Media (optional) 22. Momentum Equations of Fluid Flow 23. Conservation of Momentum 24. Applications 25. Impact on Blades 26. Bernoulli/Navier-Stokes Equation 27. Equation of Motion Theories 28. Application 29. Trajectories 30. Measuring Devices 31. Pipe Flows 32. Dimensional Analysis and Hydraulic Similitude 33. Geometric/Kinetic/Dynamic Similarity 34. PI Buckingham Theorem 35. The Boundary Layer in Incompressible Flow 36. Definition of Boundary layer 37. Momentum Equation Applied to Boundary Layer 38. Laminar Boundary Flow and Turbulent Boundary Layer **39.** Software Application
Laboratory Equipment	Hydraulic Bench. Software: WaterCAD Flowmaster Pondpack

Course Name	**BASIC ELECTRICAL ENGINEERING**
Course Description	Theory and concepts of the fundamental and basic laws of electricity and magnetism. Practical applications such as electrical equipment, electrical safety, blueprint reading, industrial wiring, and lighting are introduced
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per week	3 hours lecture
Prerequisite	College Algebra, Plane Trigonometry, Physics 2
Course Objectives	1. At the end of the course, the student must be able to: 2. Gain a deeper understanding and appreciation about electric circuits. 3. Understand the basic operating principles of AC-DC equipment. 4. Familiarization with the basic electrical blueprint reading, industrial wiring and lighting and electrical safety. 5. Appreciate the importance of the course to the student's field of study.

Course Outline	1. DIRECT CURRENT. Ohm's Law, Series, Parallel Connections, Batteries and Power. 2. ALTERNATING CURRENT. Voltage, Current & Phase, Peak, rms, Average Values. 3. MAGNETISM. Fundamentals, Magnetic Circuits, Units of Magnetics. 4. ELECTRICAL MATERIALS. Conductors, Insulators, Semiconductors. 5. DC MACHINES / EQUIPMENT. Fundamental Concepts, Motors, Meters. 6. AC MACHINES / EQUIPMENT. Fundamental Concepts, Motors, Transformers. 7. ELECTRICAL SAFETY. Equipment Protection, Personnel Protection. 8. BLUEPRINT READING. Electrical Symbols, Electrical Diagrams. 9. COMMERCIAL AND INDUSTRIAL ELECTRICAL FACILITIES
Laboratory Equipment	None

Course Name	**WORKSHOP THEORY AND PRACTICE**
Course Description	Elements and Standards in workshop organization, workshop safety. Different Tolls and processes in workshop. Introduction to Machine shop practices.
Number of Units for Lecture and Laboratory	1 unit Laboratory
Number of Contact Hours per week	3 hours Laboratory
Prerequisite	None
Course Objectives	At the end of the course the student must be able to: 1. Familiarized with the uses of different tools applicable in basic cutting, format processes in machine shop practice.
Course Outline	2. Introduction to Machine Shop Operations, Layouts, Tools and Measuring Instruments 3. Machine Shop Safety, Rules and Regulations 4. Metal working processes and new technologies 5. Familiarization on machine tools and processes 6. Inside and outside caliper 7. Lathe Practice centering and straight turning 8. Knitting 9. Shaper Practice 10. Off hand Method Bali Peen Hammer 11. Tapering 12. Gear Cutting Spur and Bevel Gear 13. Threading Process 14. Welding (Principles of welding processes, welding technology, joining processes, testing and inspection of welds) 15. Tempering and Quenching 16. Foundry & metal casting 17. Fitting bench work, bench drill and bench grinder
Laboratory Equipment	

E. PROFESSIONAL COURSES

Course Name	**INTRODUCTION TO METALLURGY**
Course Description	Introduction to mineral processing to pyrometallurgy, hydrometallurgy, and electro-metallurgy, and to adaptive metallurgy. Terminology, principles, processes , flow diagrams and overview of Philippine Metallurgical industry
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hrs per Week	2 hours lecture
Prerequisite	General Chemistry 2, Analytic Geometry
Course Objectives	At the end of the course the student must be able to: 1. Provide the students general/introductory knowledge on metallurgy – from mineral processing to extractive metallurgy to adaptive metallurgy. 2. Provide an over view the Philippine metallurgical industry from mineral processing to semiconductor packaging operations. 3. Familiarize the students with flow diagrams vis-a –vis metallurgical processes. 4. Provide the students with basic concepts on material balances and metallurgical accounting.
Course Outline	1. Overview of different processes: 2. Mineral processing 3. Pyrometallurgy 3.1 Smelting 3.2 calcination 4. Hydrometallurgy 4.1 Leaching, etc 5. Electrometallurgy 5.1 Electrowinning 5.2 Electro-refining 6. Adaptive metallurgy 6.1 Foundry 6.2 Metal forming 7. Semiconductor packaging
Laboratory Equipment	None

Course Name	**INTRODUCTION TO MATERIALS SCIENCE**
Course Description	Structure & composition of materials (metals, polymers, ceramics & composite materials) properties & behavior in service environments.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hrs per Week	3 hours lecture
Prerequisite	General Chemistry, Physics 2
Course Objectives	At the end of the course the student must be able to:

	1. Impart to students the structure – property – application interrelationship of materials. 2. Familiarize students with the different engineering materials, their respective compositions, structures and applications. 3. Teach the students the interaction between materials and environment. 4. Provide students with principles processes for the modification of the structure and properties of materials.
Course Outline	1. Structure of Materials 1.1 Atomic structure and bonding 1.2 Structure of solids 1.3 Crystalline imperfections 2. Properties of materials 2.1 Electrical 2.2 Mechanical 2.3 Magnetic 2.4 Optical 3. Strengthening Mechanisms 3.1 Dislocation and plastic deformation 3.2 Mechanisms of strengthening in metals 3.3 Recovery, re-crystallization and grain growth 4. Phase transformation 4.1 Equilibrium phase diagram 4.2 Fe-C diagram 5. Control of Structure during metals processing 5.1 Mechanical working and annealing 5.2 Age hardening 5.3 Heat treatment of steels 6. Responsive to service conditions 6.1 Fatigue 6.2 Creep 6.3 Corrosion 7. Survey of metals for engineering 7.1 Ferrous alloys 7.2 Copper and its alloys 7.3 Aluminum and its alloys 7.4 Superalloys and refractory metals 8. Non-metallic Materials 8.1 Ceramics 8.2 Polymers 8.3 Composites 8.4 Semiconductors
Laboratory Equipment	None

Course Name	**METALLURGICAL MEASUREMENTS**
Course Description	Measurements of length, density, temperature, & particle size distribution, routine hardness measurements, microstructure related measurements using surface morphology apparatus
Number of Units for	2 units laboratory

Lecture and Laboratory	
Number of Contact Hrs per Week	6 hours laboratory
Prerequisite	Calculus, Chemistry and Physics at second year college level.
Course Objectives	At the end of the course the student must be able to: 1. Educate the student the various methods used for data acquisition of metallurgical data, including the basic equipment and instruments; 2. Introduce the student with the various safety practices in the laboratory; 3. Educate the students on the various techniques in the metallurgical data measurement; 4. Familiarize the student with the use of simple statistical methods in the evaluation of metallurgical data; and 5. Develop awareness among students the importance of technical reports as a result of the conduct of laboratory experiments and/or investigations.
Course Outline	1. Safety in Laboratory /Laboratory Hazards and Safety Gadgets 2. Recording of Data 3. Useful Statistics 4. Familiarization with Laboratory Equipment and Devices 4.1 Measurement of Dimensions, Density and Ore 5. Characteristics 6. Particle Size Analysis and Moisture Determination 7. Hardness and Temperature Measurement 8. Measurements of pH
Laboratory Equipment	Oven, Screens, Balance, Pycnometer, Hydrometer, Thermometer, Thermocouple, Hardness Tester, Rotap sieve shaker, Microscope

Course Name	**METALLURGICAL ANALYSIS**
Course Description	Conventional, classical and modern methods of analyzing minerals and metallurgical products, in solid and liquid forms, including fire assaying, Atomic Absorption Spectrophotometer, gravimetric and volumetric methods, X-ray diffraction and other applicable methods.
Number of Units for Lecture and Laboratory	3 units: 1 unit lecture, 2 units laboratory
Number of Contact Hrs per Week	7 hours: 1 hour lecture, 6 units laboratory
Prerequisite	Analytical Chemistry

Course Objectives	At the end of the course the student must be able to: 1. Acquaint the basic principles and fundamentals of the different methods of metallurgical analysis. 2. Familiarize on the different laboratory procedures and equipment involved in metallurgical analysis of metals and materials. 3. Develop problem-solving skills in charge and flux calculations as applied to fire assaying of ores and minerals. 4. Understand and select metallurgical analysis techniques appropriate for specific minerals. 5. Instill the desire towards continuous learning and towards better writing and speaking skills. 6. Show the importance of metallurgical analysis in material balances and metallurgical accounting in evaluating operations in relation to technical, economic and environmental considerations.
Course Outline	1. Review of basic chemistry 2. General Consideration Sampling 2.1 Sample preparation 2.2 Accuracy and precision 2.3 Sensitivity 3. Fire Assay of Precious Metals 1.1 Definition of Terms 1.2 Reagents and apparatus 1.3 Assay fusions and related smelting processes 1.4 Slag calculations for acidic and basic slags 1.5 Inquartation 1.6 Scorification assay 1.7 Bullion assay and solution assay 4. Classical Methods of Analysis 1.1 Copper assays 1.2 Lead assays 1.3 Zinc assays 1.4 Iron assays 5. Instrumentation Methods of Analysis 5.1 Spectrophotometry 5.2 X-ray Diffraction/Fluorescence 5.3 Microanalysis
Laboratory Equipment	Furnace, Oven, Balance, Crusher, Pulverizer, AAS,XRF,XRD, hot plate, fume hood

Course Name	**METALLURGICAL PHYSICAL CHEMISTRY**
Course Description	Metallurgical Thermodynamics and kinetics. Principles of thermodynamics, application of thermodynamics to metallurgical systems. Application to kinetics metallurgical processes and heterogeneous system.
Number of Units for Lecture and Laboratory	4 units: 3 units lecture, 1 unit laboratory
Number of Contact Hrs per Week	6 hours : 3 hours lecture, 3 hours laboratory
Prerequisite	Analytical Chemistry

Course Objectives	At the end of the course the students must be able to: 1. Know the principles and laws of thermodynamics and their applications to the understanding of metallurgical processes. 2. Apply various metallurgical system and their corresponding equilibrium diagrams 3. Know the principles of kinetics as applied to the study of metallurgical processes with emphasis and heterogeneous.
Course Outline	1. Simple Equilibrium, the Ideal Gas 2. Laws of Thermodynamics 3. Calculation and Representation of Heat Content 4. Free Energy Concepts 5. Equilibrium Constant and Activity 6. Ideal Solutions 7. Surface Chemistry 8. Eh-pH Diagrams 9. Composition Temperature Diagrams 10. Gas-Solid Diagrams 11. Kinetics 12. Heterogeneous System
Laboratory Equipment	Pycnometer, Thermometer, Thermocouple, Capillary Tube

Course Name	**MINERAL PROCESSING 1**
Course Description	Comminution (crushing and grinding), concentration (gravity, magnetic and electrostatic separation), screening, classification, particle size distribution, materials handling, material balance and accounting, dewatering.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hrs per Week	3 hours lecture
Prerequisite	Analytical chemistry, Principles of metallurgy
Course Objectives	At the end of the course the students must be able to: 1. Acquaint the basic principles and fundamentals on the different processes involved in mineral processing – comminution and concentration (magnetic, gravity, electrostatic) 2. Gain knowledge on the auxiliary operations on mineral dressing– screening and classification, materials handling 3. Impart the basic principles and operations involved solid-liquid separation 4. To develop problem solving skills on material balances as applied to mineral processing 5. Understand and select mineral processing techniques appropriate for specific minerals 6. Develop the desire towards continuous learning and towards better writing and speaking skills. 7. Know the importance of material balances and metallurgical accounting in evaluating operations in relation to technical, economic and environmental considerations

Course Outline	1. Properties of minerals in relation to processing 2. Comminution laws 3. Crushing - types of crushers, equipment selection, crushing circuits 4. Grinding - work indices, types of tumbling mills, critical speeds, grinding circuits 5. Screening/classification – principles, types of screens/classifiers, screening/classification efficiencies 6. Material balances and Metallurgical accounting 7. Gravity concentration - basic principles, equipment 8. Dense media separation - basic principles, equipment 9. Magnetic and high tension separation - basic principles, equipment 10. Dewatering – thickening, filtering, flocculation, coagulation, electrical double layer and other surface properties/phenomena
Laboratory Equipment	None

Course Name	**MINERAL PROCESSING 2**
Course Description	Flotation. Production of industrial minerals. Mineral resources re-cycling. Tailings treatment
Number of Units for Lecture and Laboratory	5 units: 3 units lecture, 2 units laboratory
Number of Contact Hrs per Week	9 hours: 3 hours lecture, 6 hours laboratory
Prerequisite	Mineral Processing I, Met Physical Chem.
Course Objectives	At the end of the course the students must be able to: 1. Learn the basic principles and fundamentals on the different processes involved in mineral processing – flotation, industrial minerals processing, re-cycling and tailings treatment 2. Develop problem solving skills on material balances as applied to mineral processing 3. Understand and select mineral processing techniques appropriate for specific minerals 4. Instill within the students the desire towards continuous learning and towards better writing and speaking skills. 5. Show the importance of material balances and metallurgical accounting in evaluating operations in relation to technical, economic and environmental considerations
Course Outline	1. Flotation 1.1 Surface properties – surface tension, contact angle, electrical double layer, zeta potential, zero point charge, etc. 1.2 Basic chemistry/mechanism of flotation 1.3 Flotation reagents – collectors, frothers, regulators, activators, etc 1.4 Common flow diagrams 2. Processing of Industrial minerals – calcination, activation, ultrafine grinding 3. Recovery of minerals from mine wastes and mill tailings 4. Tailings treatment – thickening, detoxification, tailings pond

	management, effluent standards, etc.
Laboratory Equipment	Grinding Mill, Crusher, Flotation Machine, Balance, Oven, Muffle furnace

Course Name	**HYDROMETALLURGY**
Course Description	Physical chemistry of hydrometallurgical processes. Dissolution, solid-liquid separation, equilibrium diagrams for aqueous solutions, solution purification, metal/compound recovery from solutions, wastewater treatment, biotechnology-based methods for metal and solution treatment.
Number of Units for Lecture and Laboratory	4 units: 3 units lecture, 1 unit laboratory
Number of Contact Hrs per Week	6 hours: 3 hours lecture, 3 hours laboratory
Prerequisite	Met Physical Chem., Principles of Met
Course Objectives	At the end of the course the student must be able to: 1. Learn the different methods and steps involved in hydrometallurgy 2. Gain knowledge on practical leaching systems 3. Develop problem solving skills on material balances and recoveries of metals by leaching and subsequent operations 4. Understand the basic reactions, thermodynamics and kinetics involved in hydro-metallurgical processes 5. Understand and select hydrometallurgy processes appropriate for specific metals/minerals 6. Develop the desire towards continuous learning and towards better writing and speaking skills. 7. Understand the importance of hydrometallurgy, the economics of operations and the environmental/societal concerns in the recovery of metals from their ores.

Course Outline	1. Review of mineral processing 2. Leaching 1.1 Principles of leaching 1.2 Types of leaching operations 1.3 Pre-treatment operations 1.4 Leaching reactions, dissolution kinetics 1.5 Thermodynamic Aspects of Leaching 1.5.1 Solution equilibria 1.5.2 Eh-pH equilibria 1.6 Equilibrium diagrams for leaching systems 3. Solution purification 3.1 Precipitation 3.2 Ion exchange 3.3 Solvent extraction 4. Metal/compound recovery 4.1 Cementation 4.2 Carbon/resin adsorption 4.3 Electrowinning 4.4 Crystallization 4.5 Precipitation 5. Solid-liquid separation 5.1 Counter current decantation 5.2 Filtration 6. Common Hydrometallurgy operations 6.1 Gold 6.2 Copper 6.3 Nickel and Cobalt 6.4 Zinc 6.5 Aluminum 7. Wastewater treatment 7.1 Effluent standards, detoxification, thickening, tailings containment 7.2 Biotech applications in leaching and wastewater treatment
Laboratory Equipment	Furnace, Ovens, Balance, roller, bottle rolls, autoclave, screens, filter

Course Name	**ELECTROMETALLURGY**
Course Description	Electrowinning, electrolytic refining, electroplating, electrodeposition. Corrosion engineering
Number of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory
Number of Contact Hrs per Week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisite	Physical Chemistry
Course Objectives	At the end of the course the student must be able to: 1. Know basic fundamentals and principles involved in electrochemical systems 2. Understand the different methods and steps involved in electrometallurgical processes 3. Gain knowledge on electro winning, electrolytic refining, and electroplating 4. Develop basic reactions, thermodynamics and kinetics involved in

	electrometallurgical processes; and corrosion principles 5. Understand and select electrometallurgy/ electrochemical processes appropriate for specific metals/minerals 6. Know the importance of electrometallurgy, the economics of operations and the environmental/societal concerns in the recovery of metals from their ores.
Course Outline	1. Basic electrochemistry 2. Electro metallurgy principles/operations 2.1 Electrolytic-refining 2.2 Electrowinning 2.3 Electroplating 2.4 Electrodeposition 3. Common electrometallurgy operations 3.1 Electrolytic refining of copper 3.2 Electrowinning of gold from pregnant solution 3.3 Aluminum extraction from molten alumina-cryolite 4. Corrosion 4.1 Fundamentals 4.2 Prevention
Laboratory Equipment	Electro winning cell, electroplating kit

Course Name	**PYROMETALLURGY 1**
Course Description	Combustion, mass and energy balance, heat transfer, fuels, metallurgical stoichiometry, refractories
Number of Units for Lecture and Laboratory	4 units: 3 units lecture, 1 unit laboratory
Number of Contact Hrs per Week	6 hours: 3 hours lecture, 3 hours laboratory
Prerequisite	Introduction to Metallurgical & Physical Chemistry
Course Objectives	At the end of the course the student must be able to: 1. Know the basic principle of high temperature reactions and of energy balance and heat transfer. 2. Understand the different types of metallurgical fuels and refractories other production to application 3. Learn to solve heat transfer problems. 4. Know the basic reactions, stoichiometry, materials and heat balance.
Course Outline	1. Review of the law of conservation of mass, law of definite proportion and the gas laws 2. Quantities and units of measures 3. Setting up material balance, charge calculations and product calculations 4. Review of the First Law of Thermodynamics and Hess' law 5. Heat capacity and sensible heat calculations 6. Setting up a heat balance 7. Classification of fuels 8. Manufacture of Coke and Producer Gas 9. Calorific power and adiabatic flame temperature calculations 10. Combustion stoichiometry

	11. Fuel combustion calculations 12. Variables affecting heat utilization 13. Heat recovery and regeneration 14. Heat transfer: 14.1 Conduction 14.2 Convection 14.3 Radiation
Laboratory Equipment	Furnace, Balance, thermocouples, bomb calorimeter, gas analyzer

Course Name	**PYROMETALLURGY 2**
Course Description	High temperature processing thru separation, compound formation, metal production and metal purification processes. Different high temperature processes, including such as calcining, roasting, smelting converting and refining will be discussed.
Number of Units for Lecture and Laboratory	4 units: 3 units lecture, 1 unit laboratory
Number of Contact Hrs per Week	6 hours: 3 hours lecture, 3 hours laboratory
Prerequisite	Pyromet 1
Course Objectives	At the end of the course the student must be able to: 1. Learn the basic principles and fundamentals of the different methods involved in pyrometallurgy. 2. Gain knowledge on the basic reactions and kinetics of the different pyrometallurgical processes involved in metal production and purification. 3. Familiarize on the different laboratory procedures and equipment involved in high temperature processing of metals and materials. 4. Develop problem solving skills on material balances as applied to pyrometallurgical processing. 5. Understand and select pyrometallurgical processing techniques appropriate for specific minerals. 6. Develop the desire towards continuous learning and towards better writing and speaking skills. 7. Learn the importance of material balances and metallurgical accounting in evaluating operations in relation to technical, economic and environmental considerations.

Course Outline	1. General Characteristics of High Temperature Processes 2. Different reactor types 3. Energy sources 4. Reactor materials 5. Processes Aimed at Separation 6. Vapour phase separation 7. Chemical changes in the solid state 8. Liquid/liquid separation 9. Compound Formation 10. Metal Production from: 10.1 Metal oxides 10.2 Metal sulphides 10.3 Metal halides 11. Metal Purification 12. Removal of impurities by forming compounds 12.1 Vacuum refining 12.2 Zone refining 13. Environmental Problems associated with high temperature processes 14. Economic characteristics of pyrometallurgical processes
Laboratory Equipment	Furnace, Balance, thermocouples, bomb calorimeter

Course Name	**ADAPTIVE METALLURGY 1**
Course Description	Metal casting and powder metallurgy.
Number of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory (foundry)
Number of Contact Hrs per Week	5 hours: 2 hours lecture, 3 hours laboratory (foundry)
Prerequisite	Physical metallurgy 2
Course Objectives	At the end of the course the students must be able to: 1. Learn the basic principles and fundamentals of metal casting and powder metallurgy 2. Familiarize the procedures and equipment involved in metallurgical analysis of metals and materials. 3. Develop solving skills in pattern design, riser/gate dimension computation, etc. 4. Understand and select casting operation for specific products 5. Enhance the desire towards continuous learning 6. Learn the importance of metal casting and powder metallurgy in relation to technical, economic and environmental considerations.
Course Outline	1. Metal casting 1.1 Metal casting design and practice 1.2 Sand casting 1.3 Investment casting 1.4 Die casting 1.5 Permanent-mold casting 1.6 Shell-mold casting 1.7 Centrifugal casting 2. Powder metallurgy 2.1 Compacting

	2.2 Sintering 2.3 Densification
Laboratory Equipment	Furnace, balance, lathe machine, molds, green sand tester, moulding sand tester

Course Name	**ADAPTIVE METALLURGY 2**
Course Description	Metal forming and joining processes, welding, mechanical metallurgy, fabrication of metals by plastic deformation.
Number of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory
Number of Contact Hrs per Week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisite	Physical metallurgy 2; Mechanics of Deformable Bodies
Course Objectives	At the end of the course the students must be able to: 1. Know the basic principles and fundamentals metals fabrication by plastic deformation, joining processes and welding. 2. Familiarize the different laboratory procedures and equipment involved in mechanical testing. 3. Develop problem solving skills in plastic deformation. 4. Understand and select metal forming process for specific metal alloys and products 5. Know the importance of metal forming and joining processes in relation to technical, economic and environmental considerations.
Course Outline	1. Mechanical Working 2. Metal Working Fundamentals – Stress tensor, Mohr circle, stress-strain relations, work of plastic deformation, yield criteria, Von Misses, Tresca criterion 3. Metal Working Processes-Forging, rolling extrusion, drawing 4. Fabrication by Joining 4.1 Welding, brazing, soldering, mechanical fastening 5. Machining 5.1 Mechanical cutting, flame cutting and other processes
Laboratory Equipment	Hardness testing machine, metallurgical microscope, metallograph, polishing machine,

Course Name	**PHYSICAL METALLURGY 1**
Course Description	Origin, mechanisms of development and control of internal structure of metals; phase transformation and heat treatment. .
Number of Units for Lecture and Laboratory	4 units: 3 units lecture, 1 unit laboratory (metallography)
Number of Contact Hrs per Week	6 hours: 3 hours lecture, 3 hours laboratory
Prerequisite	Metallurgical Physical Chemistry
Course Objectives	At the end of the course the student must be able to: 1. Learn the ability to use and interpret various phase diagrams for alloy systems.

	2. Understand the development and control of internal structure in metals and the corresponding effect on physical properties 3. Know the principles of hardinability of steel and different ferrous heat treatment procedures. 4. Show the various mechanism by which metals can be strengthened.
Course Outline	1. Introduction 1.1 Metal Structures 1.2 Diffusion 1.3 Microstructure and Phase Diagrams 2. Hardenability 2.1 Fe-C Diagram 2.2 TTT Diagram 2.3 Factors Affecting Hardenability 2.4 Heat Treatment Principles 3. Strengthening Mechanisms in Metals 3.1 Elements of Dislocation Theory 3.2 Cold Work-Anneal Cycle 3.3 Grain Refinement 3.4 Solid Solution Strengthening 3.5 Dispersed Second Phase Strengthening
Laboratory Equipment	Metallurgical microscope, polishing machine, hardness tester, tensile and compressive strength tester

Course Name	**PHYSICAL METALLURGY 2**
Course Description	Detailed study of the alloy series including superalloys. Solid-state reactions. Deformation and fracture. Strengthening mechanisms. Fatigue. NDT, Thermal Analysis, Fractography.
Number of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory (SEM, NDT, Thermal analysis, fractography
Number of Contact Hrs per Week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisite	Physical metallurgy 1
Course Objectives	At the end of the course the student must be able to: 1. Understand the concepts related to the formation of cracks and the resulting mechanisms of fracture in metals and alloys. 2. Familiarize on the major mechanisms of interactions between metals and environmental factors during utilization in particular plastic deformation , creep fatigue and facture. 3. Gain knowledge on the properties and applications of the major metals and alloys.
Course Outline	1. Fracture Mechanisms 1.1 Stress Concentration 1.2 Griffith Theory 1.3 Design Concepts 2. Creep 2.1 Stages of Creep 2.2 Types and Mechanisms

	2.3 Creep-resistant Materials 3. Fatigue 3.1 S-N Curve 3.2 Mechanisms of Failure 3.3 Haigh Diagram 3.4 Design Considerations 4. Alloy Series 4.1 Ferrous alloys 4.2 Non-ferrous, super alloys
Laboratory Equipment	X-ray machine, ultrasonic device, thermal analyzer, SEM

Course Name	**METALLURGICAL PLANT DESIGN (LECTURE)**
Course Description	Selection and integration of processes, equipment and materials, site and plant lay-out; sampling and control systems in plants; environmental regulations and compliance and considerations.
Number of Units for Lecture and Laboratory	2 unit lecture
Number of Contact Hrs per Week	2 hours lecture
Prerequisite	4th year standing
Course Objectives	At the end of the course students must be able to: 1. Select and size various metallurgical equipment 2. Understand the concepts of metallurgical plant design 3. Familiarize the various laws and regulations pertinent to metallurgical plant operations and set –up. 4. Gain knowledge on the principles of metallurgical sampling and process systems 5. Apply the principles of metallurgy in designing metallurgical plants and processes.
Course Outline	1. Design Process 1.1 Facilities Planning 1.2 Engineering Design 1.3 Decision Theory 1.4 Network Models, PERT-CPM 2. Forecasting 2.1 Product Analysis 2.2 Value Engineering 3. Methods of Production 3.1 Equipment 3.2 Materials flow and handling 3.3 Plant lay-out and Work Areas 3.4 Introduction to Operations Research 3.5 Maintenance and service 3.6 Organization 4. Site selection and Process 4.1 Physical plant 4.2 Cost Estimates 5. Metallurgical Sampling and Process Control Systems 6. Design problems 7. Group design presentation

Laboratory Equipment	None

Course Name	**METALLURGICAL PLANT DESIGN (LABORATORY)**
Course Description	Application of the principles of metallurgical plant design
Number of Units for Lecture and Laboratory	1unit laboratory
Number of Contact Hrs per Week	3 hours laboratory
Prerequisite	4th year standing, Metallurgical Plant Design (Lecture)
Course Objectives	At the end of the course the student must be able to Prepare a design of a metallurgical plant or any facility involved in any of the following: (From Met. Plant Tours) 1. preparation, separation, concentration of minerals, coal and metallurgical fuels. 2. extraction of metals such as hydrometallurgical, pyrometallurgical and electrometallurgical processes 3. adaptation and application of metals such as melting, casting, forging, rolling, extrusion, powder metallurgy, heat treatment, metal working and finishing operations
Course Outline	1. Design Proposal 2. Literature Review 3. Process Plant Parameters 4. Identification of specific major equipment 5. Final Report Writing 6. Presentation of Report
Laboratory Equipment	As required

Course Name	**METALLURGICAL RESEARCH (LECTURE)**
Course Description	Design and analysis of experiments, optimization techniques, data presentation and report writing.
Number of Units for Lecture and Laboratory	1 unit lecture
Number of Contact Hrs per Week	1 hour lecture
Prerequisite	4th year standing, Probability and Statistics
Course Objectives	At the end of the course the students must be able to: 1. Understand and undertake the research process, from the rudiments of literature review, research proposal preparation, conducting research, data gathering, preparation and presentation of research output. 2. Know the basic concepts in designing experiments 3. Understand the importance of probability and statistics in undertaking experiments.
Course Outline	1. Introduction to Experimental Design 2. Variable screening Experiments

	2.1 2^k factorial experiments 2.2 Fractional factorial experiments 3. Optimization methods 3.1 Methods of steepest ascent 4. Linear and Multiple Regression Analysis 5. Central composite design 6. Understanding the research process 7. Writing a research proposal
Laboratory Equipment	None

Course Name	**METALLURGICAL RESEARCH (LABORATORY)**
Course Description	Application of basic statistical concepts, design and analysis of experiment in the research process.
Number of Units for Lecture and Laboratory	2 units laboratory
Number of Contact Hrs per Week	6 hours laboratory
Prerequisite	Metallurgical Research (lecture)
Course Objectives	At the end of the course the students must be able to: 1. Conduct rudiments of literature review, research proposal preparation, conducting research, data gathering, preparation and presentation of research output. 2. Apply the basic concepts in designing experiments 3. Conduct of experiments and data gathering in the laboratory plant and field with the knowledge of laboratory and field safety 4. Analyze research results using and present statistical concepts 5. Write a research report project.
Course Outline	1. Conduct of a metallurgical research 2. Preparation of the metallurgical research report 3. Presentation and defense of the metallurgical research report
Laboratory Equipment	As required by the research topic

Course Name	**METALLURGICAL LAW AND ETHICS**
Course Description	Metallurgical law and jurisprudence, code of ethics and other laws relevant to the practice of metallurgical engineering
Number of Units for Lecture and Lecture	1 unit lecture
Number of Contact Hrs per Week	1 hour lecture
Prerequisite	Introduction to Metallurgy

Course Objectives	At the end of the course the student must be able to: 1. Discuss and describe pertinent laws, implementing rules and regulations which govern the practice of metallurgical engineering and allied professions 2. Understand and practice the code of ethics for metallurgical engineers
Course Outline	1. PD 1536 – Metallurgical Engineering Law of the Philippines 2. Code of ethics for Metallurgical Engineers 3. RA 7249 Mining Act of 1995 4. Iron and Steel Act 5. Hazardous Waste Act – RA 6969 6. Clean Air Act
Laboratory Equipment	None

Course Name	**METALLURGICAL SEMINAR & PLANT TOURS**
Course Description	Visits to metallurgical plants and facilities, attendance in metallurgical symposiums, seminars and conferences
Number of Units for Lecture and Laboratory	1 unit laboratory
Number of Contact Hrs per Week	3 hours laboratory
Prerequisite	Introduction to Metallurgical Engineering
Course Objectives	To expose the student to the actual operations of a metallurgical plant or facility and issues affecting metallurgical engineering practice
Course Outline	A minimum of one visit to each of the following metallurgical plant or any facility involved in processes which include but not limited to the: 1. preparation, separation, concentration of minerals, coal and metallurgical fuels. 2. extraction of metals such as hydrometallurgical, pyrometallurgical and electrometallurgical processes 3. adaptation and application of metals such as melting, casting, forging, rolling, extrusion, powder metallurgy, heat treatment, metal working and finishing operations. Minumum four(4) hours attendance in symposia, seminars, conferences or special lectures on mining, metallurgy and material science.
Laboratory Equipment	None

Course Name	**METALLURGICAL PLANT PRACTICE (OJT)**
Course Description	On the job training in a metallurgical plant or facility
Number of Units for Lecture and Laboratory	n/a
Number of Contact Hrs per Week	Three hundred twenty (320) hours of actual practice
Prerequisite	Must have finished the major subjects related to the type metallurgical plant or facility
Course Objectives	To expose the student to the actual operations of a metallurgical plant

	or facility
Course Outline	On –the- Job Training in a Metallurgical Plant or any facility involved in processes which include but not limited to the: 1. preparation, separation, concentration of minerals, coal and metallurgical fuels. 2. extraction of metals such as hydrometallurgical, pyrometallurgical and electrometallurgical processes 3. adaptation and application of metals such as melting, casting, forging, rolling, extrusion, powder metallurgy, heat treatment, metal working and finishing operations.
Laboratory Equipment	None

Course Name	**COMPUTER APPLICATIONS IN METALLURGICAL ENGINEERING**
Course Description	Computational methods and techniques in the description, simulation and modelling of metallurgical engineering processes and systems.
Number of Units for Lecture	3 units: 2 units lecture, 1 unit laboratory
Number of Contact Hrs per Week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisite	Computer Fundamentals, Introduction to Metallurgy
Course Objectives	At the end of the course, the students must be to demonstrate computation techniques in metallurgical engineering applicable to the following: 1. preparation, separation, concentration of minerals, coal and metallurgical fuels. 2. extraction of metals such as hydrometallurgical, pyrometallurgical and electrometallurgical processes 3. adaptation and application of metals such as melting, casting, forging, rolling, extrusion, powder metallurgy, heat treatment, metal working and finishing operations.
Course Outline	1. Correlational techniques 1.1 Spreadsheets 1.2 Linear programming 2. Basic simulation 2.1 Process control systems 2.2 Reaction systems 2.3 Metal forming 3. Computer models 3.1 Surface response techniques 3.2 Prediction and forecasting
Laboratory Equipment	PC and printer

II. NON-TECHNICAL COURSES

A. SOCIAL SCIENCES (Please refer to CMO 59., s. 1996)
B. HUMANITIES (Please refer to CMO 59., s. 1996)
C. LANGUAGES (Please refer to CMO 59., s. 1996 for English 1 and 2)

Course Name	**ENGLISH 3 (TECHNICAL COMMUNICATION)**
Course Description	The nature of technical communication; skills and strategies for reading and writing literature reviews, journal articles, and technical reports; making oral presentations.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisites	English 2
Course Objectives	After completing this course, the student must be able to: 1. Differentiate technical writing from other types of writing; 2. Engage him/herself critically in the reading of a specialized text; 3. Write a summary and review of a journal article; 4. Write a research paper on a technical topic; and 5. Properly acknowledge sources by using a prescribed citation format; 6. Prepare an oral presentation on a technical topic; and 7. Deliver properly an oral technical presentation.
Course Outline	1. The Nature of Technical Communication 2. Technical Writing 2.1. Introduction to Technical Writing 2.2. Library Orientation 2.3. Technical Writing: Formal Schema/Style; Word Choice 2.4. Types of Text Structure in Technical Writing 2.5. Introduction to Research: Choosing a Topic, Outlining 2.6. Skills and Strategies for Reading and Writing Journal Articles, Literature Reviews, and Technical Reports 2.7. Evaluating Sources and Preparing a Preliminary Bibliography 2.8. Preparing and Interpreting Non-Prose Forms 2.9. Summarizing and Analyzing a Journal Article 2.10. Preparing the Different Parts of the Research Paper or Technical Report 2.11. Writing Bibliographies Using a Prescribed Format 2.12. Independent Study 3. Oral Technical Presentations 3.1. Preparing the Presentation Materials 3.2. Delivering the Technical Presentation
Laboratory Equipment	None

ANNEX IV - A

LABORATORY REQUIREMENTS
for
CHEMISTRY & PHYSICS LABORATORY

GENERAL CHEMISTRY LABORATORY

Exercise	Required Equipment	Required Quantity*
1. Basic Laboratory Techniques a. Use of burner b. Preparation of solutions • Determination of mass • Measurements of volume • Calculation of density	 Burner Beaker Graduated cylinder Triple beam balance NaCl solution $Pb(NO_3)_2$ solution	 5 pcs. 5 pcs. 5 pcs. 5 pcs. 25 mL 25 mL
2. Separation techniques a. Filtration/decantation b. Sublimation c. Adsorption d. Distillation	Glass funnel Beaker Evaporating dish Filter stand Distillation apparatus Activated charcoal Staple wire Food color $KMnO_4$ solution	5 pcs. 5 pcs. 5 pcs. 5 pcs. 1 set-up 5 g 25 pcs. 5 g 25 mL
3. Classification of matter a. Differentiation of elements, compounds mixtures, colloids b. Differentiation of electrolyte from non-electrolyte c. Differentiation of acid, bases, salts.	Test tube pH paper Conductivity apparatus I_2 crystals $KClO_3$ solid NaOH solution HCl solution NaCl solution Sugar solution	50 pcs. 20 pcs. 1 set-up 3 g 3 g 25 mL 25 mL 25 mL 25 mL
4. Changes of matter and energy transformation a. Differentiation of physical from chemical change b. Law of conservation of mass c. Types of chemical reactions	Test tube Burner Evaporating dish Beaker Alcohol I_2 crystals Zn strips HCl solution Staple wire $CuSO_4$ solution	50 pcs. 5 pcs. 5 pcs. 5 pcs. 5 mL 5 g 5 pcs. 25 mL 25 pcs. 25 mL
5. Gas Laws a. Boyle's Law b. Charles's Law c. Graham's Law	Beaker Thermometer Syringe Glass tubing Sand bag NH_4OH solution HCl solution	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 mL 5 mL
6. Solutions a. Factors affecting solubility b. Colligative properties	Test tube Beaker Alcohol	50 pcs. 5 pcs. 25 mL

	Hexane Sugar NaCl Urea Oil	25 mL 5 g 5 g 5 g 5 mL
7. Rates of chemical reactions, chemical equilibrium	Test tube Beaker Mg ribbon HCl solution $FeCl_3$ solution KSCN solution KCl solution Fe $(NO_3)_3$ solution	50 pcs. 5 pcs. 5 pcs. 25 mL 25 mL 25 mL 25 mL 25 mL
8. Redox reaction and electrochemistry	Battery Test tube Zn strips Cu strips Pb strips Pb $(NO_3)_2$ solution Zn $(NO_3)_2$ solution Alligator clip	5 pcs. 50 pcs. 5 pcs. 5 pcs. 5 pcs. 25 mL 25 mL 10 pcs.
9. Corrosion	Petri dish Battery Alligator clip Cu strips Zn strips Al strips Mg strips Electrolyte solution	5 pcs. 5 pcs. 10 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 25 mL

* Required Quantity is based on a class size of 25 students

PHYSICS 1 LABORATORY

Exercise	Required Equipment	Required Quantity*
1. An exercise to illustrate the principles, use, and precision of the vernier caliper and micrometer caliper	Ruler Vernier caliper Micrometer caliper Objects for measuring	5 pcs. 5 pcs. 5 pcs. 5 sets
2. An exercise to verify the graphical and analytical methods of determining resultant forces.	Force table Weight holder Masses Meter stick Protractor	5 pcs. 20 pcs. 5 sets 5 pcs. 5 pcs.

	Alternate apparatus: Force frame Spring balance Weight holder Masses Ruler	 5 pcs. 15 pcs. 15 pcs. 5 sets 5 pcs.
3. An exercise to observe and verify the elements of motion along the straight line	Linear air track with blower and trolley Timer/stopwatch Meter stick Free fall apparatus Metal balls of different sizes Clamp Support rod *Alternate apparatus:* Spark timer/ticker timer Paper tape Stopwatch Plane board with stand Clamp Wooden cart Scissors Carbon paper Masking tape Meter stick	5 pcs. 5 pcs. 5 pcs. 5 pcs. 12 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 1 set 5 pcs.
4. An exercise to observe and verify the elements of motion in two dimensions	Blackwood ballistic pendulum Metal ball Meter stick Carbon paper Inclined plane Protractor *Alternate apparatus:* Projectile apparatus Metal ball/plastic solid ball Photogate Timer/stopwatch Time of flight receptor pad Carbon paper White paper Meter-stick	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
5. An exercise to verify the laws of motion	Atwood's machine Masses Stopwatch String *Alternate apparatus:* Frictionless dynamic track Smart pulley Stopwatch Weight holder	5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.

	String Clamp	5 pcs. 5 pcs.
6. An exercise to determine the coefficients of static and kinetic friction of various surfaces	Friction board with pulley Friction block with different surfaces Glass plate of size similar to friction board Platform/triple beam balance Weight holder Meter stick Slotted masses, 5-500g	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 sets
7. An exercise to verify the work-energy theorem	Dynamic cart Frictionless dynamic track Masses Weight holder Clamp String Timer/stopwatch Platform/triple beam balance Support rod	5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
8. An exercise to verify the principles of conservation of mechanical energy	Metal stand Clamp Metal ball String Meter stick Cutter blade Hanging mass Carbon paper White paper Masking tape	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 10 pcs. 10 pcs. 1 set
9. An exercise to verify the principles of conservation of momentum	Ramp/launcher Metal stand Clamp Metal balls of different sizes Meter stick Carbon paper White paper Masking tape	5 pcs. 5 pcs. 5 pcs. 10 pcs. 5 pcs. 10 pcs. 10 pcs. 1 set
10. An exercise to verify the condition of the body in rotational equilibrium	Demonstration balance Vernier caliper Platform/triple beam balance Masses Meter stick	5 pcs. 5 pcs. 5 pcs. 5 sets 5 pcs.
11. An exercise to verify the forces involved in uniform circular motion	Centripetal force apparatus Meter stick Mass with hook Platform/triple beam balance Stopwatch	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.

12. An exercise to verify the principle of simple harmonic motion	Clamp Masses Weight holder Meter stick Support rod Spring *Alternate apparatus:* Hooke's Law apparatus	5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
13. An exercise to measure specific gravity	*Liquids:* Hydrometer jar U-tube Inverted U-tube Beaker Masses Meter stick Vernier caliper Specimen of liquids *Solids*: Beam balance Hydrometer jar Beaker Thread Thermometer Specimen of solids *Alternate apparatus:* Mohr-Westpal Balance	 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 sets 5 pcs.
14. An exercise to observe and verify the elements of transverse wave motion	Sonometer Weight holder Set of masses Tuning forks of three different frequencies Rubber hammer Meter stick	5 pcs. 5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs.

* Required Quantity is based on a class size of 25 students

PHYSICS 2 LABORATORY

Exercise	Required Equipment	Required Quantity*
1. An exercise to determine the specific heats of solids by the methods of mixture	Calorimeter Stirrer for shot Specimen for shot Thermometer Platform/triple beam balance Beaker	5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs.

	Ice Water	5 sets
2. An exercise to measure the coefficient of linear expansion	Thermal expansion apparatus Steam generator Ohmmeter/VOM Connectors Basin/container Hot and cold water	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
3. An exercise to measure the mechanical equivalent of heat	Mechanical equivalent of heat apparatus Ohmmeter/VOM Mass (10 kg) Thermometer Vernier caliper Platform/triple beam balance	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
4. An exercise to observe and verify the elements of electric charge	Van de Graff generator Tissue paper Aluminum foil Metal conductor with insulated handle Fluorescent lamp Masking Tape Power Source Galvanometer Conducting paper Field mapper kit/mapping Apparatus Connectors	2 sets 2 sets 2 sets 2 sets 2 sets 1 set 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 sets
5. An exercise to illustrate Ohm's Law	Panel board/circuit board VOM or multitester DC power supply Bridging plugs/connecting wires Fixed resistor SPST switch SPDT switch *Alternate apparatus:* Bread board Jumper	5 pcs. 5 pcs. 5 pcs. 5 sets 15 pcs. 5 pcs. 5 pcs. 5 pcs. 5 sets
6. An exercise to determine and compare the resistance of different conductors	1-m slide wire/ wheatstone bridge Power supply VOM or multitester Galvanometer Potentiometer Fixed resistor Unknown resistor SPST switch Connecting wires	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 sets

7. An exercise to verify the principles of series and parallel connections	Panel board/circuit board VOM or multitester DC power supply Bridging plugs/connecting wires Fixed resistors *Alternate apparatus:* Bread board Jumper	5 pcs. 5 pcs. 5 pcs. 5 sets 15 pcs. 5 pcs. 5 sets
8. An exercise to verify the relationship among the electromotive force, current, and resistance of cells in series and parallel	Dry cells Switch VOM or multitester Resistors Panel board/circuit board Bridging plugs/connecting wires *Alternate apparatus:* Bread board Jumper	10 pcs. 5 pcs. 5 pcs. 10 pcs. 5 pcs. 5 sets 5 pcs. 5 sets
9. An exercise to observe the applications of Kirchhoff's Law	Power supply Fixed resistors VOM or multitester Bridging plugs/connecting wires Panel board/circuit board *Alternate apparatus:* Bread board Jumper	10 pcs. 25 pcs. 10 pcs. 5 sets 5 pcs. 5 pcs. 5 sets
10. An exercise to determine the electrical equivalent of heat	Electric calorimeter Thermometer Beam balance Masses Stop watch VOM or multitester Rheostat DC power source Connecting wires Switch	5 pcs. 5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 sets 5 pcs.
11. An exercise to observe the relationships between resistance and capacitance in the circuit	Power source Fixed capacitor (330 microfarad) Fixed Resistor (100 ohms) Connecting wires VOM or multitester Stopwatch	5 pcs. 5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs.
12. An exercise to observe the principle of magnetic field	Natural magnets Horseshoe magnets Bar magnets	5 pcs. 5 pcs. 10 pcs.

	Ring Glass plate Iron fillings Frame for bar magnets Compass Mounted straight wire Coil Solenoid Battery Reversing switch *Alternate apparatus:* Tesla meter / tangent galvanometer	5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 2 sets
13. An exercise to demonstrate the Faraday's law of electromagnetic induction	Coils Galvanometer VOM or multitester AC power supply Bar magnets Connecting wires	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
14. An exercise to verify the law of reflection and refraction	Optics bench Light source, sodium/mercury lamps Ray table and base Component holder Slit plate Slit mask Ray optics mirror Cylindrical lens	5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.
15. An exercise to investigate and study the image formation in mirror and lenses	Optic bench Light source Ray table and base Component holder Parallel ray lens Slit plate Ray optics mirror 5 cm focal length spherical mirror -15cm focal length concave lens 10cm/7.5 cm focal length convex lens 15 cm focal length convex lens Viewing screen Crossed arrow target	5 pcs. 5 pcs. 5 pcs. 15 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.

* Required Quantity is based on a class size of 25 students

ANNEX IV - B

LABORATORY REQUIREMENTS
for
BS METALURGICAL ENGINEERING

LABORATORY REQUIREMENTS FOR BS METALLURGICAL ENGINEERING

Metallurgical Measurements

Exercise	Required Equipment	Required Quantity*
1. Dimensional measurements	Vernier caliper micrometer caliper optical microscope	5 pcs 5 pcs 1 unit
2. Density measurements	pycnometer hydrometer graduated cylinder weighing balance	5 pcs 5 pcs 5 pcs 1 unit
3. Ore measurements	Sieve Screens Weighing balance Sieve shaker Drying Oven Drying Pan	1 set 1 unit 1 unit 1 unit 20 pcs.
4. Moisture determination	Drying oven Drying pan Weighing balance	1 unit 20 pcs 1 unit
5. Hardness measurements	Rockwell hardness tester Vickers /Brinell hardness tester Grinder/polisher	1 unit 1 unit 1 unit
6. Temperature measurement	thermometer Thermocouple pyrometer	1 unit 1 unit 1 unit

* Required Quantity is based on a class size of 25 students

Metallurgical Analysis

Exercise	Required Equipment	Required Quantity*
1. Sampling	Jones riffle Rolling matt Shovel Bucket Spatula Sieve screens Sieve shaker (optional) Weighing balance	1 unit 5 pcs 5 pcs 10 pcs 5 pcs 1 set 1 unit 1 unit
2. Fire Assaying of Ores	Crusher Pulverizer Muffle furnace Crucible Tongs Pouring mold Fire clay Crucibles Parting cups Cupel Cupel machine Weighing balance Gold balance Hammer and anvil Tweezer Personal Protective Equipment Bunsen burner hot plate Spatulas and scoops	1 unit 1 unit 1 unit 2 pcs 1 pc 20 pcs 20 pcs 40 pcs 1 unit 1 unit 1 unit 2 pairs 2 pcs 2 sets 1 unit 1 unit 5 pcs.
3. Determination of gold in cyanide solution	Bunsen burner hot plate Weighing balance Gold balance beaker (600 ml) stirring rod vacuum filter Cupel Cupel machine (optional) Furnace	1 unit 1 unit 1 unit 1 unit 10 pcs 10 pcs 1 unit 10 pcs 1 unit 1 unit
4. Determination of Free Cyanide in solutions	Burette pipette Erlenmeyer flask stirring rod funnel filter	2 pcs 2 pcs 10 pcs 10 ocs 10 pcs

5. Atomic Absorbtion Spectrophotometry Experiment	hot plate beaker (600 ml) stirring rod funnel filter Volumetric flask, 250 ml Volumetric flask, 100 ml AAS	1 pc 10 pcs 10 pcs 10 pcs 5 pcs 5 pcs 1 unit/access to existing units in the same university o
6. Iodide Method for Copper	hot plate beaker (600 ml) stirring rod funnel filter burette Erlenmeyer flask Fume hood	1 pc 10 pcs 10 pcs 10 pcs 2 pcs 10 pcs 1 unit
7. Xray Diffraction or XRF experiment	XRD/XRF machine (optional)	access to exisitng private or public institutions

Metallurgical Physical Chemistry

Exercise	**Required Equipment**	**Required Quantity***
1. Distribution of a solute between immiscible solvents	Separatory funnel Graduate cylinder	4 units 4 units
2. Partial molar volume	Pycnometer Analytical balance	5 pcs 1 unit
3. Heat of reaction	Bomb calorimeter Pelletizer Balance	1 unit 1unit 1unit
4. Lead-Tin phase diagram	Pyrex Beaker Thermocouple TGA (optonal)	1 unit 1 unit 1 unit

5. Change of state of matter	Pyrex Beaker Thermocouple TGA (optonal)	1 unit 1 unit 1 unit
6. Viscosity measurements by the falling ball method	Graduated cylinder (at least 100 ml) Timer Aluminum or stainless steel ball	2 units 2 units 2 units
7. Surface tension measurements by the ring method	DuNuy tensiometer	1 unit
8. Adsorption at liquid surfaces	DuNuy tensiometer	1 unit

Mineral Processing 2

Exercise	Required Equipment	Required Quantity
1. Comminution Experiments (mesh-of-grind determination and Bond's work index)	Crusher Ball/rod mill Weighing Balance Drying oven Sieve screens Sieve shaker	1 unit 1 unit 1 unit 1 unit 1 set 1 unit
2. Gravity concentration experiments (wet tabling, dense media separation)	Crusher Ball/rod mill Weighing Balance Drying oven Miner's pan or equivalent 2 liter beaker Shaking table Sluice box	1 unit 1 unit 1 unit 1 unit 5 units 5 units 1 unit 1 unit
3. Flotation Experiments (flotation by bubble pick-up, froth flotation)	Crusher Ball/rod mill Weighing Balance Drying oven Flotation machine Vacuum filter	1 unit 1 unit 1 unit 1 unit 1 unit 1 unit

4. Dewatering Experiments (continuous thickener design based on sedimentation test, flocculation)	Weighing Balance Drying oven Timer Graduated cylinder (1000 ml)	1 unit 1 unit 5 units 5 units

Hydrometallurgy

Exercise	Required Equipment	Required Quantity
1. Leaching of Copper Sulfide Ore	Crusher Ball/rod mill Weighing Balance Drying oven Magnetic Stirrer Burette Funnels	1 unit 1 unit 1 unit 1 unit 1 unit 5 units 5 units
2. Solvent Extraction	Separatory funnels Erlenmeyer Flask Iron stand	5 units 5 units 5 units
3. Cyanidation Test	Bottle roller Burette Erlenmeyer Flask Beakers (500 ml) Pipettes Funnels	1 unit 5 units 5 units 5 units 5 units 5 units
4. Adsorption of Gold in activated carbon	Bottle roller Burette Erlenmeyer Flask Beakers (500 ml) Pipettes Funnels	1 unit 5 units 5 units 5 units 5 units 5 units
5. Desorption of Gold from Loaded Carbon	Bottle roller Burette Erlenmeyer Flask Beakers (500 ml) Pipettes Funnels	1 unit 5 units 5 units 5 units 5 units 5 units

6. Precipitation of Gold from Pregnant solution	Bottle roller Burette Erlenmeyer Flask Beakers (500 ml) Pipettes Funnels Bunsen burner Hot plate	1 unit 5 units 5 units 5 units 5 units 5 units 5 units 1 unit

Electrometallurgy

Exercise	Required Equipment	Required Quantity*
1. Electrowinning of copper from copper sulfate solution	Electrowinning cell Burette Erlenmeyer Flask Beakers (500 ml) Pipettes Funnels	1 unit 5 units 5 units 5 units 5 units 5 units
2. Electroplating of copper	Electroplating kit Burette Erlenmeyer Flask Beakers (500 ml) Pipettes Funnels	1 unit 5 units 5 units 5 units 5 units 5 units
3. Pulse plating of copper (optional)	Electroplating kit Burette Erlenmeyer Flask Beakers (500 ml) Pipettes Funnels Pulse plating apparatus	1 unit 5 units 5 units 5 units 5 units 5 units 1 unit
4. Cementation	Burette Erlenmeyer Flask Beakers (500 ml) Pipettes Funnels	5 units 5 units 5 units 5 units 5 units

5. Corrosion Exercise	Electrowinning cell Burette Erlenmeyer Flask Beakers (500 ml) Pipettes Funnels	1 unit 5 units 5 units 5 units 5 units 5 units

Pyrometallurgy 1

Exercise	Required Equipment	Required Quantity*
1. Proximate analysis of coal	Electric furnace or tube furnace Analytical Balance Oven	1 unit 1 unit 1 unit
2. Heat transfer exercise	Thermocouples Electric furnace Thermometer	5 units 1 unit 5 units
3. ORSAT analysis	Gas analyzer (optional) Sample holders	1 unit
4. Heating Value measurement	Bomb calorimeter Balance Pelletizer	1 unit 1 unit 1 unit

Pyrometallurgy 2

Exercise	Required Equipment	Required Quantity*
1. Roasting of Copper Sulfide Ore	Crusher Sieve screens Electric Furnace X ray diffraction equipment Fume hood (optional) Hot plate	1 unit 1 set 1 unit Access 1 unit 1 unit
2. Calcination of Limestone	Crusher Sieve screens Electric Furnace X ray diffraction equipment Balance	1 unit 1 set 1 unit Access 1 unit

3. Magnetizing Roast of Hematite (not done anymore)	Crusher Sieve screens Magnet Electric Furnace X ray diffraction equipment	1 unit 1 set 5 units 1 unit Access
4. Reduction of Magnetite	Crusher Sieve screens Electric Furnace X ray diffraction equipment (optional)	1 unit 1 set 1 unit Access

Adaptive Metallurgy 1

Exercise	Required Equipment	Required Quantity*
1. Pattern Making	Wood lathe Drill Saw Caliper Tape measure or 'shrink rule' Mold press Wood plane	1 unit 1 unit 5 units 5 units 5 units 5 units 5 units
2. Molding Sand Analysis	Mixing bowl Mold Spatula Sand tester Drying oven	5 units 5 units 5 units 1 unit 1 unit
3. Green sand molding	Mixing Trough Sand muller Shovel Cope & drag molds Pattern (see exercise 1) Striker plates	1 unit 1 unit 5 units 5 sets 5 units 5 units
4. Metal Casting choice of: 4.1 Sand Casting (optional)	Crucible or induction furnace Crucibles Spectrophotometer Sand molds (see exercise 3)	1 unit 5 units 1 unit 5 units
4.2 Investment Casting or Equivalent (optional)	Crucible or induction furnace Crucibles Spectrophotometer Wax melting and casting equipment Mixing vat for ceramic mold solution Drying racks	1 unit 5 units 1 unit 1 set 1 unit 5 units

Adaptive Metallurgy 2

Exercise	Required Equipment	Required Quantity*
1. Tension Test of Steel	Tensile Tester Specimens Extensometer or strain gauge Strip chart recorder	1 unit 5 units 1 unit Optional
2. Bend Test (optional)	Compression tester Bend test fittings Specimens	1 unit 1 set 5 units
3. Impact Test	Charpy or Izod Tester Specimens	Optional Sufficient
4. Effect of Cold working (rolling or forging) on hardness, and microstructure	Hammer & anvil Manual rolling 'mill' Metallograph or metallurgical microscope Polishing equipment Polishing media Etchants and solvents Rolled and/or forged samples Hardness tester Heat treatment furnace	Optional Optional 1 unit 1 set 1 set 1 set 5 units 1unit 1 unit
5. Effect of Hot Working on hardness and microstructure	Hammer & anvil Manual rolling 'mill' Metallograph or metallurgical microscope Polishing equipment Polishing media Etchants and solvents Rolled and/or forged samples Hardness tester Heat treatment furnace	Optional Optional 1 unit 1 set 1 set 1 set 5 units 1unit 1 unit
6. Welding exercises	Oxy-acetylene welder w/ tanks Arc welder w/ electrode holder Welding mask Leather/ Heat resistant gloves Leather/ Heat resistant apron Slag hammer	1 set 1 set 5 units 5 pairs 5 units 5 units

Physical Metallurgy 1

Exercise	Required Equipment	Required Quantity*
1. Specimen preparation (molding, grinding, polishing)	Polishing equipment Plastic encapsulation equipment Polishing media Cloth apron	1 set 1 set 1 set 5 units
2. Etching	Etchants & solvents Watch glass Wash bottle Cloth apron	1 set 1 set 5 units 5 units
3. Metallography in Steal Iron	Metallograph or metallurgical microscope Camera (if metallograph is not available) Specimen a. Pearlite – fernite b. Pearlite – cementite c. Martenite d. Bainite e. Gray cast iron (different graphite forms) Samples Ferrous for exercise 1 in Physical Met 2 a. Low Carbon Steel b. Medium Carbon Steel c. High Carbon Steel d. Stainless Steel e. Tool Steel f. Manganese Steel g. Grey cast iron h. White cast iron Non Ferrous Samples a. Brass b. Aluminum c. Bronze d. Lead – tin solder e. Super alloy (nickel)	1 set 1 set As needed

4. Jominy End Quench Test	Jominy End Quench Equipment Specimens Tongs Heat treatment furnace Steel table Leather/ Heat resistant apron Leather/Heat resistant gloves Safety Glasses Hardness tester	1 unit 5 pcs 5 pairs 1 unit 1 unit 5 units 5 pairs 5 units
5. Quenching and Tempering of Steel	Heat treatment furnace Specimens Tongs Steel table Leather/ Heat resistant apron Leather/ Heat resistant gloves Safety Glasses Hardness tester	1 unit 5 pcs 5 units 1 unit 5 units 5 pairs 5 units
6. Annealing and normalizing of steel	Heat treatment furnace Specimens Tongs Steel table Leather/ Heat resistant apron Leather/ Heat resistant gloves Safety Glasses Hardness tester	1 unit 5 pcs 5 units 1 unit 5 units 5 pairs 5 units
7. Case Hardening (make optional)	Heat treatment furnace Specimens Tongs Steel table Leather/ Heat resistant apron Leather/ Heat resistant gloves Safety Glasses Carburizing box Hardness tester	1 unit 5 pcs 5 units 1 unit 5 units 5 pairs 5 units 5 units

Physical Metallurgy 2

Exercise	Required Equipment	Required Quantity*
1. Metallographic examinations of different types of ferrous and non-ferrous alloys and super alloys.	Metallograph or metallurgical microscope Polishing equipment Polishing media Etchants and solvents Specimens	1 unit 1 set 1 set 1 set as needeed
2. Tension test of non ferrous metals	Tensile Tester Specimens Extensometer or strain gauge Strip chart recorder	1 unit 5 pcs 1 unit Optional
3. Compression testing of concrete	Compression tester Specimens	1 unit 5 units
4. Recrystallization of brass	Specimens Hammer & anvil Heat treatment furnace Tongs Metallograph or metallurgical microscope Polishing equipment Polishing media Etchants and solvents	5 units 1 set 1 unit 5 units 1 unit 1 set 1 set 1 set
5. Sintering of copper	Molds Heat treatment furnace	5 units 1 unit
6. NDT: Dye Penetrant Test and Ultrasonic Test	Samples Dye Penetrant Test Set Cloth apron Ultrasonic tester	Sufficient 1 set 5 pcs Optional
7. Cooling Curves (Phase Diagram of Pb – Sn System)	Thermocouple Crucible Pb – Sn alloys a. 100% Pb b. 80% Pb – 20% Sn c. 60% Pb – 40% Sn d. 50% Pb – 50% Sn e. 40% Pb – 60% Sn f. 20% Pb – 80% Sn g. 100% Sn Bruisen burner	1 unit 1 unit 7 types 1 unit
8. Thermal Analysis	Thermal analysis equipment	Optional

9. Fractography	Stereo microscope Hand held magnifier 10x Samples Scanning electron microscope (optional)	1 unit 5 units Sufficient 1 unit

Re public of the Philippines
OFFICE OF THE PRESIDENT
COMMISSION ON HIGHER EDUCATION

TECHNICAL PANEL FOR ENGINEERING, TECHNOLOGY AND ARCHITECTURE

#15

TPETA RESOLUTION No. 13
August 14, 2007

RECOMMENDATION FOR THE APPROVAL OF THE POLICIES AND STANDARDS (PS) FOR BACHELOR OF SCIENCE IN METALLURGICAL ENGINEERING

Whereas, CMO 49, s. 1997- Curricular Guidelines for Engineering Education (Metallurgical Engineering) were reviewed and revised by the Task Force on Metallurgical Engineering;

Whereas, the said revision was done in consultation with the academe, industry and other government agencies;

Whereas, the said PS had undergone National Public Hearing November 18, 2006 in Baguio City

Whereas, the proposed revision is in conformity with the harmonized format indicated in CSO 42, S. 2003;

WHEREFORE, TPETA hereby resolves to strongly recommend to CHED for the approval of the Proposed Policies and Standards for the Bachelor of Science in Metallurgical Engineering.

ENGR. RODOLFO PEÑALOSA
Chairman

USEC. FORTUNATO DELA PEÑA
Co-Chairman

PROF. EDGARDO G. ATANACIO
Member

ATTY. JULITO D. VITRIOLO
Member

DIR. IRENE ISAAC
Member

ENGR. ENRICO NERA
Member

ENGR. AUGUSTO C. SOLIMAN
Member

ENGR. CARLA FALCONIT
Member

ENGR. EFREN SISON
Member

ARCHT. EDRIC MARCO FLORENTINO
Member

5/F Upper DAP Bldg., San Miguel Avenue, Ortigas Center, Pasig City, 1605 Philippines
Website: www.ched.gov.ph Tel. Nos. 638-54-59; 638-70-76; 638-48-69; 634-68-68

TECHNICAL PANEL FOR ENGINEERING, TECHNOLOGY AND ARCHITECTURE

TPETA RESOLUTION No. 13
August 14, 2007

RECOMMENDATION FOR THE APPROVAL OF THE POLICIES AND STANDARDS (PS) FOR BACHELOR OF SCIENCE IN METALLURGICAL ENGINEERING

Whereas, CMO 49, s. 1997- Curricular Guidelines for Engineering Education (Metallurgical Engineering) were reviewed and revised by the Task Force on Metallurgical Engineering;

Whereas, the said revision was done in consultation with the academe, industry and other government agencies;

Whereas, the said PS had undergone National Public Hearing November 18, 2006 in Baguio City

Whereas, the proposed revision is in conformity with the harmonized format indicated in CSO 42, S. 2003;

WHEREFORE, TPETA hereby resolves to strongly recommend to CHED for the approval of the Proposed Policies and Standards for the Bachelor of Science in Metallurgical Engineering.

ENGR. RODOLFO PEÑALOSA
Chairman

USEC. FORTUNATO DELA PEÑA
Co-Chairman

PROF. EDGARDO G. ATANACIO
Member

ATTY. JULITO D. VITRIOLO
Member

DIR. IRENE ISAAC
Member

ENGR. ENRICO NERA
Member

ENGR. AUGUSTO C. SOLIMAN
Member

ENGR. CARLA FALCONIT
Member

ENGR. EFREN SISON
Member

ARCHT. EDRIC MARCO FLORENTINO
Member

Republic of the Philippines
OFFICE OF THE PRESIDENT
COMMISSION ON HIGHER EDUCATION

TECHNICAL PANEL FOR ENGINEERING, TECHNOLOGY AND ARCHITECTURE

TFMetE RESOLUTION No. 1
August 14, 2007

RECOMMENDATION FOR THE APPROVAL OF THE POLICIES AND STANDARDS (PS) FOR THE BACHELOR OF SCIENCE IN METALLURGICAL ENGINEERING (BSMetE)

Whereas, the Task Force on Metallurgical Engineering (BSMetE) was appointed and was tasked to review and revise the existing Curricular Guidelines for the BS Metallurgical Engineering;

Whereas, CMO 49, s. 1997- Curricular Guidelines for Engineering Education (Metallurgical Engineering) was reviewed and revised by the Task Force on Metallurgical Engineering;

Whereas, the said revision was done in consultation with the representatives from academe, industry and other government agencies;

Whereas, the proposed PS is in conformity with the harmonized format indicated in CSO 42, S. 2003;

Whereas, the proposed PS will be implemented starting SY 2008-2009;

Wherefore, the Task Force on Metallurgical Engineering hereby resolves to endorse to the Technical Panel for Engineering, Technology and Architecture (TPETA) the herein attached PS for the BSMetE for recommendation to the CHED for approval.

ENGR. ENRICO NERA
Chairman

DR. ADOLFO JESUS GOPEZ
Member

ENGR. JUANCHO PABLO CALVEZ
Member

TECHNICAL PANEL FOR ENGINEERING, TECHNOLOGY AND ARCHITECTURE

TFMetE RESOLUTION No. 1
August 14, 2007

RECOMMENDATION FOR THE APPROVAL OF THE POLICIES AND STANDARDS (PS) FOR THE BACHELOR OF SCIENCE IN METALLURGICAL ENGINEERING (BSMetE)

Whereas, the Task Force on Metallurgical Engineering (BSMetE) was appointed and was tasked to review and revise the existing Curricular Guidelines for the BS Metallurgical Engineering;

Whereas, CMO 49, s. 1997- Curricular Guidelines for Engineering Education (Metallurgical Engineering) was reviewed and revised by the Task Force on Metallurgical Engineering;

Whereas, the said revision was done in consultation with the representatives from academe, industry and other government agencies;

Whereas, the proposed PS is in conformity with the harmonized format indicated in CSO 42, S. 2003;

Whereas, the proposed PS will be implemented starting SY 2008-2009;

Wherefore, the Task Force on Metallurgical Engineering hereby resolves to endorse to the Technical Panel for Engineering, Technology and Architecture (TPETA) the herein attached PS for the BSMetE for recommendation to the CHED for approval.

ENGR. ENRICO NERA
Chairman

DR. ADOLFO JESUS GOPEZ
Member

ENGR. JUANCHO PABLO CALVEZ
Member