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

CHED MEMORANDUM ORDER
No. 99
Series of 2017

SUBJECT: POLICIES, STANDARDS AND GUIDELINES FOR THE BACHELOR OF SCIENCE IN MINING ENGINEERING (BSEM) PROGRAM EFFECTIVE ACADEMIC YEAR (AY) 2018-2019

In accordance with the pertinent provisions of Republic Act (RA) No. 7722, otherwise known as the *"Higher Education Act of 1994,"* in pursuance of an outcomes-based quality assurance system as advocated under CMO 46 s. 2012 (Policy-Standard to Enhance Quality Assurance (QA) in Philippine Higher Education through an Outcomes-Based and Typology-Based Quality Assurance) and as addendum to CMO 37, s. 2012 (Establishment of an Outcomes-Based Educational System in Higher Education Institutions offering Engineering Programs), and by virtue of Commission *en banc* Resolution No. 788-2017 dated October 24, 2017, the following Policies, Standards and Guidelines (PSG) are hereby adopted and promulgated by the Commission.

ARTICLE I
INTRODUCTION

Section 1. Rationale

Based on *CMO 37, s 2012* and the *Guidelines for the Implementation of CMO 46 s 2012*, this PSG implements the shift to learning competency-based standards/ outcomes-based education. It specifies the core competencies expected of BS Mining Engineering graduates regardless of the type of HEI they graduated from. However, in recognition of the spirit of outcomes-based education and the typology of HEIs, this PSG also provides ample space for HEIs to innovate in the curriculum in line with the assessment of how best to achieve learning outcomes in their particular contexts and their respective missions.

ARTICLE II
AUTHORITY TO OPERATE

Section 2. Government Recognition

All private higher education institutions (PHEIs) intending to offer **BS** Mining Engineering must first secure proper authority from the Commission in accordance with this PSG. All PHEIs with an existing BS Mining Engineering program are required to shift to an outcomes-based approach based on CMO 37, s. 2012 and guided by this PSG. State universities and colleges (SUCs), and local colleges and universities should likewise strictly adhere to the provisions in these policies and standards.

ARTICLE III
GENERAL PROVISIONS

Section 3. Minimum Standards

The Articles that follow give minimum standards and other requirements and guidelines. The minimum standards are expressed as a minimum set of desired program outcomes which are given in Article IV Section 6. The Technical Committee designed a curriculum to attain such outcomes. This curriculum is given in Article V Section 9 as **minimum standards**. The number of units of this curriculum is here prescribed as the minimum unit requirement under Section 13 of RA 7722. To assure alignment of the curriculum with the program outcomes, the Technical Committee provided a sample curriculum map in Article V Section 10 (Details in **Annex II**) for the HEI to refer to in compliance with the implementing guidelines of CMO 37, s.2012.

Using a learner-centered/outcomes-based approach as basis, the Technical Committee provided a description of Outcomes Based Teaching and Learning delivery method in Article V Section 11. A sample course syllabus is also given in Article V Section 12 as support to the outcomes-based delivery method.

Based on the curriculum and the means of its delivery, the Technical Committee determined the physical resource requirements for the library, laboratories and other facilities and the human resource requirements in terms of administration and faculty. These are provided for in Article VI.

Section 4. Curriculum Design

The HEIs are allowed to design curricula suited to their own contexts and missions provided that they can demonstrate that the same leads to the attainment of the required minimum set of outcomes, albeit by a different route. In the same vein, they have latitude in terms of curriculum delivery and in terms of specification and deployment of human and physical resources as long as they can show that the attainment of the program outcomes and satisfaction of program educational objectives can be assured by the alternative means they propose.

The HEIs can use the *CHED Implementation Handbook for Outcomes-Based Education (OBE) and the Institutional Sustainability Assessment (ISA)* as a guide in making their submissions for Sections 19 to 24 of Article VII.

This PSG is aligned with the new K-12 basic education system and the new General Education requirements, following the OBE system.

ARTICLE IV
PROGRAM SPECIFICATIONS

Section 5. Program Description

5.1 Degree Name

The degree program described herein shall be called Bachelor of Science in Mining Engineering (BSEM).

5.2 Nature of the Field of Study

Mining Engineering is a profession that deals with the application of mathematics, natural and applied sciences, humanities and social sciences in mineral deposit assessment; mine feasibility study; mine design, development and construction; management of mining operations, mining and mineral economics, environmental protection and safety, and associated activities and processes; and, mine progressive rehabilitation, closure, and decommissioning to harness mineral resources safely and economically for the social and economic benefits of the country.

5.3 Program Educational Objectives

Program Educational Objectives (PEOs) are broad statements that describe the career and professional accomplishments that the program is to prepare graduates to achieve within a few years of graduation. PEOs are based on the needs of the program's constituencies and these shall be determined, articulated, and disseminated to the general public by the unit or department of the HEI offering the BSEM program. The PEOs should also be reviewed periodically for continuing improvement.

5.4 Specific Professions/careers/occupations for graduates

The scope of the practice of Mining Engineering is defined in the Mining Engineering Law of Republic Act No. 4274 and pertains to professional service in Mining Engineering in the form of consultation, investigation, management, valuation, planning, capacity building and education, designing or supervision of operation.

Mining Engineering embraces:

(a) Management, engineering or supervisory positions in mines, mine installation or construction projects where knowledge in mining engineering is necessary in carrying out such function;

(b) Calculation, estimation and certification of mineral and/or ore reserves, preparation of mine pre-feasibility and feasibility studies; mine valuation, mine auditing, mine consulting, third party independent opinion, third party mine audits and appraisal of mining machinery and equipment;

(c) Participation in the preparation of environmental studies for mining projects and monitoring under the Environmental Impact Assessment (EIA) system that calls for knowledge of mining engineering;

(d) Preparation, approval or signing of mining documents such as but not limited to mine reports, mine plans and designs, specifications or project estimates, and mining engineer's report;

(e) Design of mines, mining methods and applicable machinery, works or installation and commissioning or decommissioning of mines;

(f) Employment in government service requiring professional knowledge of mining engineering;

(g) Management or supervision of small-scale mines or similar projects as prescribed by law;

(h) Formulation of Mineral Reporting Codes and/or Engineering/Technical standards for use by Professional and Registered Mining Engineers; and,

(i) Teaching, lecturing and reviewing of professional mining engineering subjects in government recognized and accredited universities, colleges, schools and institutes.

5.5 Allied Fields

The BSEM allied programs are Geology, Metallurgical Engineering, Geodetic Engineering, Civil Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering, and Environmental Engineering.

Section 6. Institutional and Program Outcomes

The minimum standards for the BS Mining Engineering program are expressed in the following *minimum* set of institutional and BSEM program outcomes.

6.1 Institutional outcomes

a) Graduates of professional institutions must demonstrate a service orientation in one's profession;
b) Graduates of colleges must participate in various types of employment, development activities, and public discourses, particularly in response to the needs of the communities one serves;
c) Graduates of universities must participate in the generation of new knowledge or in research and development projects;
d) Graduates of State Universities and Colleges must, in addition, have the competencies to support "national, regional and local development plans." (RA 7722);
e) A PHEI, at its option, may adopt mission-related program outcomes that are not included in the minimum set; and,

f) Graduates of higher educational institutions must preserve and promote the Filipino historical and cultural heritage.

6.2 BSEM Program Outcomes

By the time of graduation, the students of the program shall have the ability to:

a) Apply knowledge of mathematics and science to solve Mining Engineering problems;
b) Design and conduct experiments, as well as to analyze and interpret data;
c) Design a system, component, or process to meet desired needs within realistic constraints, in accordance with standards;
d) Function in multidisciplinary and multi-cultural teams;
e) Identify, formulate, and solve Mining Engineering problems;
f) Understand professional and ethical responsibility;
g) Communicate effectively Mining Engineering activities with the engineering community and with society at large;
h) Understand the impact of Mining Engineering solutions in a global, economic, environmental, and societal context
i) Recognize the need for, and engage in life-long learning
j) Know contemporary issues;
k) Use techniques, skills, and modern engineering tools necessary for Mining Engineering practice; and,
l) Know and understand engineering and management principles as a member and leader of a team, and to manage projects in a multidisciplinary environment;

Section 7. Sample Performance Indicators

Performance Indicators are specific, measurable statements identifying the performance(s) required to meet the outcome; confirmable through evidence.

Table 1. Sample Performance Indicators of a Program Outcome

Program Outcomes		Performance Indicators	
L	know and understand engineering and management principles as a member and leader of a team, and to manage projects in a multidisciplinary environment	1	Understand the management principles applicable to the practice of mining engineering
		2	Choose applicable management options in the design, planning and implementation of mining engineering project.
		3	Assess the merits of mining operations and develop improvement processes.

Section 8. Program Assessment and Evaluation

Program Assessment refers to one or more processes that identify, collect, and prepare data to evaluate the attainment of Program Outcomes and Program Educational Objectives.

Program Evaluation pertains to one or more processes for interpreting the data and evidence accumulated from the assessment. Evaluation determines the extent at which the Program Outcomes and the Program Educational Objectives are achieved by comparing actual achievement versus set targets and standards. Evaluation results in decisions and actions regarding the continuous improvement of the program.

All HEIs are encouraged to form a Consultative Body to be part of the assessment and evaluation processes to be represented by the stakeholders.

8.1 Assessment and Evaluation of PEOs

The Assessment of Program Educational Objectives may include the following: the stakeholders of the program have to be contacted through surveys or focus group discussion to obtain feedback data on the extent of the achievement of the PEOs.

8.2 Assessment and Evaluation of POs

In the case of Program Outcomes Assessment, the defined Performance Indicators shall be connected to Key Courses (usually the Demonstrating or "D" courses in the Curriculum map), and an appropriate Assessment Methods (AM) may be applied. These methods may be direct or indirect depending on whether the demonstration of learning was measured by actual observation and authentic work of the student or through gathered opinions from the student or his peers. Refer to the

Table 2. Sample Matrix Linking Performance Indicators with Key Courses and Assessment Methods

Performance Indicators		Key Courses	Assessment Methods
1	Understand the management principles applicable to the practice of mining engineering	Mine Management	Case study on the application of basic principles of management, administration, corporate planning, organization, industrial relations
		Mine Economics	Economic evaluation report of a mining project
2	Choose applicable management options in the design, planning and implementation of mining engineering project.	Mine Plant Design	Plant design report
		Mine Environmental Management	Integration of environmental best practices in the report

	Performance Indicators	Key Courses	Assessment Methods
3	Assess the merits of mining operations and develop improvement processes.	Mine research and study Mine and mill practice	Research and Development (R&D) report Submission of report and certificate of completion

Table 3. Sample Matrix Linking Assessment Methods with Set Targets and Standards

Key Courses	Assessment Methods	Target and Standards
Mine Management	Case study on the application of basic principles of management, administration, corporate planning, organization, industrial relations	75% of the students get a rating of 75%
Mine Economics	Economic evaluation report of a mining project	75% of the students get a rating of 80%
Mine Plant Design	Plant design report	100% of the students to submit, 75% of the students get a rating of 80%
Mine Environmental Management	Integration of environmental best practices in the report	70% of the students get a rating of 75%
Mine research and study	Research and Development (R&D) report	70% of the students get a rating of 75%
Mine and mill practice	Submission of report and certificate of completion	100% of the students to submit, 75% of the students get a rating of 75%

Other Methods of Program Assessment and Evaluation may be found in the *CHED Implementation Handbook for Outcomes-Based Education (OBE) and Institutional Sustainability Assessment (ISA).*

Section 9. Continuous Quality Improvement

There must be a documented process for the assessment and evaluation of program educational objectives and program outcomes.

The comparison of achieved performance indicators with declared targets or standards of performance should serve as basis for the priority projects

or programs for improving the weak performance indicators. Such projects and programs shall be documented as well as the results of its implementation. This regular cycle of documentation of projects, programs for remediation and their successful implementation shall serve as the evidence for Continuous Quality Improvement.

By AY 2018-2019, after a benchmarking project of the Technical Committee for Mining Engineering, the Commission shall release a set of minimum standards for a number of key performance indicators for selected program outcomes, and these shall serve as the common targets for achievement by all HEIs offering B.S.E.M programs for their Continuous Quality Improvement program.

ARTICLE V
CURRICULUM

Section 10. Curriculum Description

The Mining Engineering curriculum is designed to meet the BSEM Program Outcomes stated in Article IV, Section 6.2. This is articulated in a Curriculum Map discussed in Section 12. The curriculum must develop engineers who have a background in mathematics, natural, physical and allied sciences. The Mining Engineering curriculum also contains mandated general education and elective courses as connected to the desired program outcomes. As such the curriculum contains courses in mathematics, physics, chemistry and statistics. The Mining Engineering curriculum also contains language courses, social sciences and humanities. This is to ensure that the Mining Engineering graduate is articulate and understands the nature of his/her special role in society and the impact of his/her works on the environment. The curriculum is designed to encompass the Mining Engineering disciplines through a set of core courses. The curriculum allows the student to acquire the basic engineering tools and skills necessary to solve problems in the field of Mining Engineering.

Section 11. Sample Curriculum

11.1. Components

Below is a sample curriculum of the BSEM program. The institution may enrich the sample curriculum depending on the needs of the industry and community, provided that all prescribed courses are offered and pre-requisite and co-requisite are observed.

Classification/ Field / Course	Minimum No. of Hours/week		Minimum Credit Units
	Lecture	Laboratory	
I. TECHNICAL COURSES			
A. Mathematics			
Calculus 1	3	0	3
Calculus 2	3	0	3
Engineering Data Analysis	3	0	3
Differential Equations	3	0	3
Sub-Total	**12**	**0**	**12**
B. Natural/ Physical Sciences			
Chemistry for Engineers	3	3	4
Physics for Engineers	3	3	4
Sub-Total	**6**	**6**	**8**
C. Basic Engineering Sciences			
Computer –Aided Drawing & Drafting	0	3	1
Engineering Economics	3	0	3
Engineering Management	3	0	3
Engineering Mechanics	3	0	3
Environmental Science	3	0	3
Technopreneurship 101	3	0	3
Sub-Total	**15**	**3**	**16**
D. Allied Courses			
Basic Electrical Engineering	3	0	3
Elementary Mineralogy	3	0	3
Fluid Mechanics	3	0	3
General Surveying	2	3	3
Mineral Deposits	3	0	3
Mineral Processing	2	3	3
Petrology	2	3	3
Principles of Geology	3	0	3
Principles of Metallurgy	3	0	3
Structural Geology	2	3	3
Techniques of Metallurgical Analysis	1	3	2
Sub-Total	**27**	**15**	**32**
E. Professional Courses			
Mine Economics	3	0	3
Mine Environmental Management	3	0	3
Mine Management	3	0	3
Mine Design	2	3	3
Mine Safety	3	0	3
Mine Research and Study	1	6	3
Mine Ventilation	2	3	3
Mining and Environmental Laws and Ethics	3	0	3

Classification/ Field / Course	Minimum No. of Hours/week		Minimum Credit Units
	Lecture	Laboratory	
I. TECHNICAL COURSES			
E. Professional Courses			
Principles of Mining	3	0	3
Rock Mechanics	2	3	3
Surface Mining	3	0	3
Underground Mining	3	0	3
Track Specialization 1	3	0	3
Track Specialization 2	3	0	3
Track Specialization 3	3	0	3
Sub-Total	**40**	**15**	**45**
TOTAL TECHNICAL COURSES	**100**	**39**	**113**
II. GENERAL EDUCATION/ ELECTIVE/ AND MANDATED COURSES			
A. General Education Courses (GEC)			
Science, Technology, and Society	3	0	3
The Contemporary World	3	0	3
Readings in Philippine History	3	0	3
Understanding the Self	3	0	3
Art Appreciation	3	0	3
Purposive Communication	3	0	3
Mathematics in the Modern World	3	0	3
Ethics	3	0	3
Sub-Total	**24**	**0**	**24**
B. GEC Electives/ Mandatory Courses			
GE Elective 1	3	0	3
GE Elective 2	3	0	3
GE Elective 3	3	0	3
Free Elective	3	0	3
Life and Works of Rizal	3	0	3
Sub-Total	**15**	**0**	**15**
C. Physical Education			
P.E. 1, 2, 3, 4 (2 units each)	8		8
Sub-Total	**8**		**8**
D. National Service Training Program			
NSTP 1 & 2 (3 units each)	6		6
Sub-Total	**6**		**6**
TOTAL GENERAL EDUCATION/ ELECTIVE/ AND MANDATED COURSES	**53**	**0**	**53**
GRAND TOTAL	**153**	**39**	**166**

Classification/ Field / Course	Minimum No. of Hours/week		Minimum Credit Units
	Lecture	Laboratory	
*Mine and Plant Practice (Certificate of Practice)	0	320	0

* Students are required to undergo three hundred twenty (320) hours of On-the-Job Training (OJT). It is recommended that the time allotments of the OJT are as follows: Two hundred four (204) hours for mine operation; fifty-eight (58) hours for mineral exploration: and fifty-eight (58) hours for mineral processing.

Suggested Tracks Specializations:

Mining:
1. Coal Mining
2. Drilling and Blasting,
3. Tunneling
4. Mine Feasibility Studies
5. Mine Surveying
6. Mine Project Development
7. Contract Mining
8. Best Practices in Mining
9. Computer Application in Mining Engineering
10. Mine Valuation

Energy Resource Extraction:
1. Introduction to Petroleum Engineering
2. Introduction to Geothermal Engineering
3. Energy related courses
4. Geotechnical Engineering

These track specializations are composed of two (2) subjects under Mining (equivalent to 6 units) and one (1) subject under the energy resource extraction electives (equivalent to 3 units). One of the mining tracks must be three (3) units of computer application in Mining Engineering.

SUMMARY of the BSEM CURRICULUM			
Classification/ Field	**Total No. of Hours per week**		**Total No. of Units**
	Lecture	**Laboratory**	
I. TECHNICAL COURSES			
A. Mathematics	12	0	12
B. Natural/ Physical Sciences	6	6	8
C. Basic Engineering Sciences	15	3	16
D. Allied Courses	27	15	32
E. Professional Courses	40	15	45
Total Technical Courses	**100**	**39**	**113**
II. GENERAL EDUCATION/ ELECTIVE/ AND MANDATED COURSES			
A. General Education Courses (GEC)	24	0	24
B. GEC Elective/ Mandatory Courses	15	0	15
C. Physical Education	8	0	8
D. National Service Training Program	6	0	6
Total Non-Technical Courses	**53**	**0**	**53**
Grand Total	**153**	**39**	**166**

11.2 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.

The sample Program of Study listed below is meant for HEIs operating on a Semestral System. HEIs with CHED approved trimester or quarter term systems may adjust their courses and course specifications accordingly to fit their delivery system, as long as the minimum requirements are still satisfied.

The HEIs are also encouraged to include other courses to fulfill their institutional outcomes, as long as the total units for the whole program shall not exceed 240 units, including P.E., and NSTP.

FIRST YEAR				
First Semester				
Course	**No. of Hours**		**Units**	**Prerequisite/ Co-requisite**
	Lec	**Lab**		
Principles of Geology	3	0	3	Chemistry for Engineers
Calculus 1	3	0	3	
Chemistry for Engineers/ Lab	3	3	4	
Understanding the Self	3	0	3	
GE Elective 1	3	0	3	
NSTP 1	3	0	3	
PE 1	2	0	2	
Total	**20**	**3**	**21**	

FIRST YEAR				
Second Semester				
Course	No. of Hours		Units	Prerequisite/ Co-requisite
	Lec	Lab		
Principles of Mining	3	0	3	Principles of Geology
Elementary Mineralogy	3	0	3	Principles of Geology
General Surveying	2	3	3	Calculus 1
Calculus 2	3	0	3	Calculus 1
GE Elective 2	3	0	3	
PE 2	2	0	2	
NSTP 2	3	0	3	NSTP1
Total	**19**	**3**	**20**	

SECOND YEAR				
First Semester				
Course	No. of Hours		Units	Prerequisite/ Co-requisite
	Lec	Lab		
Underground Mining	3	0	3	Principles of Mining
Principles of Metallurgy	3	0	3	Chemistry for Engineers
Petrology	2	3	3	Elementary Mineralogy
Physics for Engineers/Lab	3	3	4	
Mathematics in the Modern World	3	0	3	
GE Elective 3	3	0	3	
PE 3	2	0	2	
Total	**19**	**6**	**21**	

SECOND YEAR				
Second Semester				
Course	No. of Hours		Units	Prerequisite/ Co-requisite
	Lec	Lab		
Surface Mining	3	0	3	Principles of Mining
Structural Geology	2	3	3	Principles of Geology, Petrology
Mineral Processing	2	3	3	Principle of Metallurgy, Mineralogy
Environmental Science	3	0	3	
Differential Equations	3	0	3	Calculus 2
Engineering Mechanics	3	0	3	
PE 4	2	0	2	
Total	**18**	**6**	**20**	

THIRD YEAR				
First Semester				
Course	No. of Hours		Units	Prerequisite/ Co-requisite
	Lec	Lab		
Mine Safety	3	0	3	Principles of Mining, Surface Mining, Underground Mining
Mine Environmental Management	3	0	3	Principles of Mining, Environmental Science
Techniques of Metallurgical Analysis	1	3	2	Principles of Metallurgy
Fluid Mechanics	3	0	3	Engineering Mechanics
Purposive Communication	3	0	3	
Engineering Data Analysis	3	0	3	Calculus 2
Basic Electrical Engineering	3	0	3	Physics for Engineers
Total	**19**	**3**	**20**	

THIRD YEAR				
Second Semester				
Course	No. of Hours		Units	Prerequisite/ Co-requisite
	Lec	Lab		
Mine Ventilation	2	3	3	Fluid Mechanics
Rock Mechanics	2	3	3	Engineering Mechanics, Underground Mining, Surface Mining
Mineral Deposits	3	0	3	Structural Geology, Senior Standing
Ethics	3	0	3	Third Year Standing
Engineering Management	3	0	3	
Engineering Economics	3	0	3	Engineering Data Analysis
Track Specialization 1	3	0	3	Third Year Standing
Total	**19**	**6**	**21**	

Summer or Third Term				
Course	Lec	Lab hours	Units	Prerequisite
*Mine and Plant Practice (Certificate of Practice)	0	320	0	Fourth Year Standing

FOURTH YEAR				
First Semester				
Course	No. of Hours		Units	Prerequisite/ Co-requisite
	Lec	Lab		
Mine Research and Study	1	6	3	Mine and Mill Practice, Senior Standing
Mine Management	3	0	3	Engineering Management, Senior Standing
The Contemporary World	3	0	3	
Computer Aided Drawing & Drafting	0	3	1	
Art Appreciation	3	0	3	
Science, Technology, and Society	3	0	3	
Readings in Philippine History	3	0	3	
Track Specialization 2	3	0	3	Track Specialization 1
Total	**19**	**9**	**22**	

FOURTH YEAR				
Second Semester				
Course	No. of Hours		Units	Prerequisite/ Co-requisite
	Lec	Lab		
Mine Economics	3	0	3	Mineral Deposits, Surface Mining, Underground Mining, Engineering Economics
Mine Design	2	3	3	Mine and Mill Practice, Senior Standing
Mining and Environmental Laws and Ethics	3	0	3	Senior Standing
Technopreneurship 101	2	3	3	Engineering Management
Track Specialization 3	3	0	3	Track Specialization 2
Life and Works of Rizal	3	0	3	
Free Elective	3	0	3	
Total	**19**	**6**	**21**	

Section 12. Sample Curriculum Map

Refer to **Annex II** for the Minimum Program Outcomes and a Sample Curriculum Map. The HEI develops their own Curriculum Map.

Section 13. Description of Outcomes Based Teaching and Learning

Outcomes-based teaching and learning (OBTL) is an approach where teaching and learning activities are developed to support the learning outcomes (University of Hong Kong, 2007). It is a student-centered approach for the delivery of educational programs where the curriculum

topics in a program and the courses contained in it are expressed as the intended outcomes for students to learn. It is an approach in which teachers facilitate and students find themselves actively engaged in their learning.

Its primary focus is the clear statement of what students should be able to do after taking a course, known as the Intended Learning Outcomes (ILOs). The ILOs describe what the learners will be able to do when they have completed their course or program. These are statements, written from the students' perspective, indicating the level of understanding and performance they are expected to achieve as a result of engaging in teaching and learning experience (Biggs and Tang, 2007). Once the ILOs have been determined, the next step in OBTL is to design the Teaching / Learning Activities (TLAs), which require students to actively participate in the construction of their new knowledge and abilities. A TLA is any activity that stimulates, encourages or facilitates learning of one or more intended learning outcome. The final OBTL component is the Assessment Tasks (ATs), which measure how well students can use their new abilities to solve real-world problems, design, demonstrate creativity, and communicate effectively, among others. An AT can be any method of assessing how well a set of ILO has been achieved.

A key component of a course design using OBTL is the constructive alignment of ILOs, TLAs, and ATs. This design methodology requires the Intended Learning Outcomes to be developed first, and then the Teaching /Learning Activities and Assessment Tasks are developed based on the ILOs. (Biggs, 1999).

"Constructive" refers to the idea that students construct meaning through relevant learning activities; "alignment" refers to the situation when teaching and learning activities, and assessment tasks, are aligned to the Intended Learning Outcomes by using the verbs stipulated in the ILOs. Constructive alignment provides the "how-to" by stating that the TLAs and the assessment tasks activate the same verbs as in the ILOs. (Biggs and Tang, 1999)

The OBTL approach shall be reflected in the Course Syllabus to be implemented by the faculty.

Section 14. Sample Syllabi for Selected Courses

The Course Syllabus must contain at least the following components:

14.1 General Course Information (Title, Description, Code, Credit Units, Prerequisites)
14.2 Links to Program Outcomes
14.3 Course Outcomes
14.4 Course Outline (Including Unit Outcomes)
14.5 Teaching and Learning Activities
14.6 Assessment Methods
14.7 Final Grade Evaluation
14.8 Learning Resources
14.9 Course Policies and Standards

14.10 Effectivity and Revision Information

See **Annex III** for Sample Course Specifications for the courses listed in the suggested Curriculum Map as prepared by some institutions already implementing OBE.

See **Annex IV** for sample syllabi for selected courses as volunteered by some institutions already implementing OBE.

ARTICLE VI
REQUIRED RESOURCES

Section 15. Administration

The administration of the college of engineering must provide academic governance and leadership to engineering programs by exerting efforts to achieve program educational objectives and program outcomes. As such, the college must have a full-time dean and full-time department or program chair who are adept in the principles of outcomes-based education and are trained to implement the elements of OBE and OBTL required by CMO 37 s2012.

The department or program Chair who will lead in the curriculum planning, implementation, monitoring, assessment, evaluation and continuous improvement of the B.S. Mining Engineering program must have the following qualifications:

a) Holder of a B.S. Mining Engineering degree;
b) Registered Mining Engineer with valid PRC license;
c) Holder of Master's and preferably Doctoral degree in Mining Engineering, Geo-Mining Engineering, Mineral Engineering and/or other relevant Engineering program and allied or other related allied fields;
d) With at least three (3) years of college-level teaching experience relevant to BS Mining Engineering program.

To ensure his/her work effectiveness, the Department/Program Chair must be given an administrative load equivalent to at least 50% of the regular teaching load given by the HEI.

Section 16. Faculty

16.1 Requirements

There must be adequate number of competent and qualified faculty to teach all of the curricular areas of the Mining Engineering program and appropriate student-faculty ratio to effectively implement dynamic minimum program requirements set by CHED and the Professional Regulations Commission.

All faculty members teaching professional courses in BS Mining Engineering program must have the following qualifications:

a) Holder of BS Mining Engineering degree
b) Registered Mining Engineer with valid PRC ID

Faculty members teaching Mining Engineering Design and other professional courses in Mining Engineering must preferably have relevant industry training or experience.

16.2 Duties

The faculty must be actively involved in the following areas of implementation of Mining Engineering program:

(1) Curriculum review, decision-making, and implementation of the academic program;
(2) Program assessment and evaluation, and implementation of continuous improvement of the program;
(3) Development, improvement, and achievement of course outcomes (COs);
(4) Enrichment of teaching and learning activities (TLAs)
(5) Development and improvement of assessment tasks, constructively aligned with COs and TLAs;
(6) Student advising activities of the program;
(7) Research and scholarly work;
(8) Professional services offered by the program; and,
(9) Linkage and extension work

Section 17. Library and Other Learning Resources

The library services and other learning resources are covered in Section 2.3 of CMO No. 86, s. 2017.

Section 18. Laboratory Equipment and Resources

Facilities are covered by CMO No. 86, s. 2017, Policies Standards and Guidelines for Requirements Common to All BS Engineering Programs.

18.1 Laboratories for BS Mining Engineering Program

The program must provide laboratories for the following courses, but the laboratories need not be separate or under the maintenance of the EM Department.

1. Chemistry for Engineers
2. Physics for engineers
3. Mining Engineering Laboratories

Refer to **Annex IV** (A and B) for lists of Laboratory and Physical Facilities for the program.

18.2 Modernization of Facilities

Each school/college of engineering shall have a program for the continuing modernization and upgrading of its instructional laboratories,

facilities, and equipment. There shall be a recorded annual allocation and disbursement of funds to fulfill the modernization program.

18.3 Calibration of Equipment

Each school/college of engineering shall ensure that the measuring instruments in its laboratories are recalibrated regularly. The date of the last calibration of the measuring instrument shall be indicated on each instrument.

ARTICLE VII
COMPLIANCE OF HEIs

Section 19. Full Compliance with CMO 37, s. 2012

Before the start of AY 2018-2019, all HEIs offering BS in Mining Engineering programs must show evidence of full compliance with CMO 37, s. 2012 (Establishment of an Outcomes-Based Education System) by the following actions:

19.1 CMO 37 Monitoring Workbook and Self-Assessment Rubric

The Commission, through its Regional offices or the TPET Website shall make available to all HEIs currently offering or applying to offer BS in Mining Engineering programs a Monitoring Workbook (CMO 37-MW-2017-HEI-BSEM) and Self-Assessment Rubric (SAR) (CMO-37-HEI-SAR-2017-BSEM).

The five-year BSEM curriculum shall be the basis of the monitoring. The completed Monitoring Workbook with a List of Supporting Evidences and Self-Assessment Rubric must be submitted to CHED or online through the CHED TPET website (*www.ched-tpet.org*) within 30 working days after the effectivity of this CMO. Failure to submit these documents will disqualify the concerned HEIs from continuing or starting their BSEM programs in AY 2018-2019.

19.2 Review of Submitted Forms by CHED

CHED shall review the submitted Monitoring Workbooks and Self-Assessment Rubrics, and may schedule monitoring visits to the HEI thereafter. These visits shall determine the extent of compliance of the concerned HEI with CMO 37, s. 2012. HEIs with BSEM programs with low SAR total scores may be asked to submit a one- or two-year development plan to CHED.

19.3 Exemptions

HEIs with BSEM programs that have applied as COEs/CODs during AY 2015-2016 and whose applications have been approved as COE or COD shall not be required to comply with Section 19.1 and 19.2. Instead, these HEIs must submit only their proposed four-year curriculum,

corresponding curriculum map, and program of study using the Application Workbook for AY 2018-2019 (AW-2018-HEI-BSEM). See Section 20. Those HEIs whose COD/COE applications were disapproved for AY 2018-2019 must still comply with Sections 19.1 and 19.2.

Section 20. Application Workbook for AY 2018-2019

HEIs currently offering the BSEM program for AY 2018-2019 shall be made to complete a new Application Workbook (AW-2018-HEI-BSEM) which shall be made available through CHED or downloadable from the CHED-TPET website. The Application Workbook shall be completed and submitted to CHED or uploaded to the CHED-TPET website before the start of AY 2018-2019.

Section 21. Approval of Application

All HEIs with BSEM programs with COE or COD status submitting their completed Application Workbooks shall automatically receive certifications from CHED and shall be given approval to implement their programs beginning AY 2018-2019.

Other concerned HEIs which have submitted their CMO Monitoring Workbooks, Self-Assessment Rubrics, and Application Workbook shall be given conditional approval by CHED to start offering their new BSEM Curriculum following this CMO effective AY 2018-2019. CHED shall, however, conduct monitoring of HEIs to assure complete compliance of this PSG within the transitory period, during which HEIs with BSEM programs with weak implementation may be asked to submit developmental plans, which shall be subject to constant monitoring.

ARTICLE VIII
TRANSITORY, REPEALING and EFFECTIVITY PROVISIONS

Section 22. Transitory Provision

All private HEIs, state universities and colleges, and local universities and colleges with existing authorization to operate the Bachelor of Science in Mining Engineering program are hereby given a period of three (3) years from the effectivity thereof to fully comply with all the requirements in this CMO. However, the prescribed minimum curricular requirements in this CMO shall be implemented starting AY 2018-2019.

Section 23. Repealing Clause

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

All CHED issuances or part thereof inconsistent with the provision in this CMO shall be deemed modified or repealed.

Section 24. Effectivity Clause

This CMO shall take effect fifteen (15) days after its publication in the Official Gazette or in a newspaper of general circulation. This CMO shall be implemented beginning AY 2018-2019.

Quezon City, Philippines December 4, 2017

For the Commission:

PATRICIA B. LICUANAN, Ph.D.
Chairperson

Attachments:

Annex I – Competency Standards
Annex II – Minimum Program Outcomes and Sample Curriculum Map
Annex III – Sample Course Specifications
Annex IV – Laboratory Requirements
Annex V – Sample Course Syllabus

ANNEX I: 2018 BSEM Competency Standards

Mining Engineering is a profession that deals with the application of mathematics, natural and applied sciences, humanities and social sciences in mineral deposit assessment; mine feasibility study; mine design, development and construction; management of mining operations, mining and mineral economics, environmental protection and safety, and associated activities and processes; and, mine progressive rehabilitation, closure, and decommissioning to harness mineral resources safely and economically for the social and economic benefits of the country.

ANNEX I - COMPETENCY STANDARDS ATTRIBUTES AND COMPETENCIES OF A MINING ENGINEER				
ATTRIBUTES		COMPETENCY LEVEL		
		NEW GRADUATE	1 - 7 YEARS ENGG. EXPERIENCE	GLOBALLY QUALIFIED ENGINEER (APEC/ASEAN)
1	Apply knowledge of mathematics and science to solve Mining Engineering problems;	Understand the principles of mathematics, chemistry, physics, biology, natural and applied sciences including information technology. Determine relevant and appropriate applied science, engineering principles and techniques that can be used to address engineering concerns related to process design and operations.	Use relevant and appropriate applied science, engineering principles and techniques in formulating process design and operations improvement and optimization. Develop simple computer programs to solve mining engineering problems.	Propose innovations in process design and operations improvement and optimization and impart these to peers. Develop and continually upgrade proficiency in numerical and computational modeling in solving mining engineering problems.
2	Design and conduct experiments, as well as to analyze and interpret data;	Use relevant information gathered from research literature and other available technological information sources in coming out with solutions to complex engineering problems.	Apply results research literature and other technological advances in process design and operations improvement and optimization. Propose changes in parameter settings used in manufacturing processes or lab-scale set-ups to achieve the desired outputs.	Consolidate results of research and technical information in formulating solutions to mining engineering processes and adapt these into systems to achieve energy and process efficiency targets. Impart these technological advances to peers.
3	Design a system, component, or process to meet desired needs within realistic constraints, in accordance with standards	Study, investigate and gather data related to complex engineering problems and propose solutions based on the fundamentals of engineering principles while incorporating ethics, safety and environmental considerations.	Study, investigate and gather data related to problems in industrial processes and operations and prepare proposals to implement solutions while incorporating ethics, safety and environmental considerations. Conduct test runs and prepare final recommendations based on results gathered.	Consolidate studies made on problems in industrial processes and operations and propose changes in operational parameters. Specialize in specific fields of practice in the Mining Engineering Professional and use the technical expertise in design of solutions to applicable compex engineering problems. Prepare project proposals, budget and reports related to improvements and optimizatin of industrial processes and operations. Impart learnings to peers.
4	Function in multidisciplinary and multi-cultural teams;	Conceptualize, formulate and implement design of experiments in a standard scientific manner in conducting investigations of complex engineering problems with consideration of cost, quality, security, and environmental impact. Recommend valid conclusions based on gathered information and results of investigation.	Use available database information, coordinate with other technical experts, plan and design experiments in conducting investigations of complex engineering problems. Conduct labscale and plant scale trials as may be deemed necessary to validate conclusions. Prepare reports and make presentations to concerned entities on the proposed solutions to the complex engineering problems.	Organize teams of experts, plan and design experiments in conducting investigations of complex engineering problems. Conduct labscale and plant scale trials as may be deemed necessary to validate conclusions. Prepare feasibility, optimization reports, implementation plans and make presentations to the concerned entities on the proposed solutions to the complex engineering problems.
5	Identify, formulate, and solve Mining Engineering problems;	Be familiar with the appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, with an understanding of the limitations. Recommend the applicable modern tools that can be used to solve complex engineering problems.	Be familiar with the appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, with an understanding of the limitations. Consolidate applicable techniques and modern tools that can be used to solve complex engineering problems. Prepare recommendations based on results considering optimization, practical applications and limitations of process parameters and equipment.	Be familiarized with process operations and applicable modern tools and techniques to solve operational problems taking into consideration process limitations. Use industrial experience in conjunction with technical expertise and appropriate modern tools in solving complex engineering problems. Prepare reports and recommendations and present these to the concerned entities.
6	Understand professional and ethical responsibility;	Be familiar with the Philippine Code of Ethics forf Mining Engineers and apply and behave according to this code in professional practice. Apply ethical principles in conjunction with engineering practice.	Be familiar with the Philippine Code of Ethics for Mining Engineers and apply and behave according to this code in professional practice. Be familiar with corporate and industrial policies. Apply ethical principles in conjunction with engineering practice incorporating public safety as a priority. Be an example to upcoming engineers in terms of integrity, morality and ethics.	Be familiar with the Philippine Code of Ethics for Mining Engineers and apply and behave according to this code in professional practice. Be familiar with corporate and industrial policies. Apply ethical principles in conjunction with engineering practice incorporating public safety as a priority. Be an example to upcoming engineers in terms of integrity, morality and ethics. Exemplify ethical and moral values through participation in socially relevant projects that contribute to national development. Impart learning to peers.

7	Communicate effectively Mining Engineering activities with the engineering community and with society at large;	Prepare reports, presentations and other engineering documents in an organized way and relay information related to these effectively. Communicate clearly both verbally and in written form all instructions to peers, subordinates and superiors as may be deemed necessary. Organize, coordinate and implement activities or projects in a clear way.	Prepare reports, presentations and other engineering documents in an organized way and relay information related to these effectively. Prepare policies, procedures and other documents related to an activity or project and cascade to subordinates, peers and superiors effectively. Conduct trainings to subordinates and peers. Communicate clearly with legal entities/ authorities regarding engineering activities.	Consolidate reports and make presentations to peers and superiors on projects or on assigned endeavors . Conduct trainings to subordinates, peers and superiors. Communicate and coordinate clearly and act as liaison officer on matters concerning legal or regulatory issues. Prepare policies, rules, regulations, instructions, procedures and implements them.
8	Understand the impact of Mining Engineering solutions in a global, economic, environmental, and societal context	Be familiar with relevant applicable technical and engineering standards that can be applied in professional mining engineering practice. Assess the effects of professional engineering work on process operational problems. Gather relevant data in relation to the professional engineering work.	Be familiar with relevant applicable technical and engineering standards that can be applied in professional mining engineering practice. Use gained experience in industrial professional practice to measure impacts on society and environment. Be familiar with carbon footprint calculations, life cycle assessment, green technologies and other upcoming standards. Impart learning to peers.	Be familiar with relevant applicable technical and engineering standards that can be applied in professional mining engineering practice. Use gained experience in industrial professional practice to measure impacts on society and environment. Be familiar with carbon footprint calculations, life cycle assessment, green technologies and other upcoming standards. Do research, develop projects and prepare implementation plans to implement and assess professional engineering works in relation to complex engineering problems. Impart learning to peers.
9	Recognize the need for, and engage in life-long learning	Attend trainings, seminars, conferences or participate in projects that encourage continued learning in the mining engineering profession. Pursue graduate studies.	Attend trainings, seminars, conferences and participate in professional organizations that encourage continued learning in the mining engineering profession Pursue graduate studies. Comply with CPD units required annually. Conduct research studies and impart results to peers.	Attend trainings, seminars, conferences and participate in professional organizations that encourage continued learning in the mining engineering profession. Prepare modules for training peers, subordinates and students. Organize seminars, trainings or conferences. Publish research papers.
10	Know contemporary issues;	Be familiar with relevant policies, laws, regulations and technical standards locally in conjunction with the Mining Engineering Professional Practice. Make a personal commitment to societal, health, safety, legal and cultural issues recognising obligations to society, subordinates, and the environment.	Be familiar with relevant policies, laws, regulations and technical standards both locally and internationally in conjunction with the Mining Engineering Professional Practice. Prepare plans and designs to address industrial process problems while taking into consideration moral, ethical and environmental concerns. Impart learning to peers.	Be familiar with relevant policies, laws, regulations and technical standards both locally and internationally in conjunction with the Mining Engineering Professional Practice. Be familiar with specific country regulations on professional engineering practice in implementing solutions to complex engineering problems. Prepare plans and designs to address industrial process problems while taking into consideration moral, ethical and environmental concerns. Impart learning to peers.
11	Use techniques, skills, and modern engineering tools necessary for Mining Engineering practice	Perform functions required in the completion of a task as part of a project or endeavor or as an employee of a company. Interact with peers and higher levels in a professional manner. Participate in activities either as a team leader or member and perform designated tasks.	Plan, lead, coordinate and implement designated tasks either as a team leader or member. Interact with a network of professionals and participate in projects or activities. Handle small to medium-sized projects.	Supervise and manage processes, people and facilities locally or internationally enabling efficiency, improved performance, business profitability and safety. Train other engineers.
12	Know and understand engineering and management principles as a member and leader of a team, and to manage projects.	Plan, lead, organize and control small projects or tasks as may be deemed necessary in the practice of mining engineering.	Plan, lead, organize and control small to medium-sized projects or tasks as may be deemed necessary in the practice of mining engineering. Manage financial aspects of the project. Supervise subordinates and peers when needed. Prepare reports related to projects.	Manage and implement medium-sized to major projects or tasks as may be deemed necessary in the practice of miningl engineering. Manage financial aspects of the project. Manage supervisors and peers. Prepare reports related to projects.

ANNEX II: 2018 BSEM MINIMUM PROGRAM OUTCOMES AND SAMPLE CURRICULUM MAP

Program Outcomes

Graduates of the BSEM program shall be able to:

a) Apply knowledge of mathematics and science to solve Mining Engineering problems;
b) Design and conduct experiments, as well as to analyze and interpret data;
c) Design a system, component, or process to meet desired needs within realistic constraints, in accordance with standards;
d) Function in multidisciplinary and multi-cultural teams;
e) Identify, formulate, and solve Mining Engineering problems;
f) Understand professional and ethical responsibility;
g) Communicate effectively Mining Engineering activities with the engineering community and with society at large;
h) Understand the impact of Mining Engineering solutions in a global, economic, environmental, and societal context
i) Recognize the need for, and engage in life-long learning
j) Know contemporary issues;
k) Use techniques, skills, and modern engineering tools necessary for Mining Engineering practice; and,
l) Know and understand engineering and management principles as a member and leader of a team, and to manage projects

Legend:

Code	*Descriptor*	*Definition*
I	Introductory	A course that provides foundational understanding of the outcome
E	Enabling	A course that strengthens the outcome
D	Demonstrating	A course that exhibits or shows the outcome

2018 SAMPLE BSEM CURRICULUM MAP														
Math/Sciences/GenEd/Mandated/Engg Sciences Courses	**Units**	**Code**	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**
Calculus 1	3	M-01	I											
Calculus 2	3	M-02	I											
Engineering Data Analysis	3	M-03	I	I										
Differential Equations	3	M-04	I											
Chemistry for Engineers	3	S-01	I											
Chemistry for Engineers Lab	1	L-01	I	I									I	
Physics for Engineers	3	S-02	I											
Physics for Engineers Lab	1	L-02	I	I									I	
Computer –Aided Design	1	E-01	I						I				I	
Engineering Mechanics	3	E-02	E											
Engineering Economy	3	E-03	E		E		E			I			E	E
Engineering Management	3	E-04				I		I	I	I		I		I
Science, Technology, and Society	3	G-01								I	I	I		
The Contemporary World	3	G-02								I	I	I		
Readings in Philippine History	3	G-03						I				I		
Understanding the Self	3	G-04									I	I		
Art Appreciation	3	G-05			I	I	I			I				I
Purposive Communication	3	G-06						I		I				
Mathematics in the Modern World	3	G-07	I				I							
Ethics	3	G-08								I	I	I		
Environmental Science	3	G-09	E		E		E	E		E		E		
Technopreneurship	3	G-10		I										I
Free Elective	3	G-11				I				I		I		
Life and Works of Rizal	3	G-12				I				I		I		
GE Elective 1,2,3	9	G-13												
P.E. 1, 2, 3, 4 (2 units each)	8	PE				I								
NSTP 1 & 2 (3 units each)	6	NSTP				I						I		
Sub Total	**89**													

2018 SAMPLE BSEM CURRICULUM MAP														
Allied Courses	Units	Code	a	b	c	d	e	f	g	h	i	j	k	l
Basic Electrical Engineering	3		E		I								I	
Elementary Mineralogy	3		E										I	
Fluid Mechanics	3		E		I		I							
General Surveying	3		E	D									I	
Mineral Deposits	3		E				I						I	
Mineral Processing	3		E		E		I		E				I	
Petrology	3		E										I	
Principles of Geology	3		E										I	
Principles of Metallurgy	3		E										I	
Structural Geology	3		E	D								I		
Techniques of Metallurgical Analysis	2		E	D					E				E	
Sub Total	32													

2018 SAMPLE BSEM CURRICULUM MAP														
Professional Courses	Units	Code	a	b	c	d	e	f	g	h	i	j	k	l
Mine Economics	3		I				E		E					
Mine Environmental Management	3		I		I	E	E	E	E	E	E			
Mine Management	3		I		E	E	E	E	E		E	E		
Mine Design	3		D	D	D		E	E	E	E	E	E	E	
Mine Safety	3		E		E		E	E	E	E	E	E	E	
Mine Research and Study	3		D	D	E	E	D	E	E	D	E	E	D	
Mine Ventilation	3		I	E	D		E	E		E	E		E	
Mining and Environmental Laws and Ethics	3					E	E	E	E		E	E		
Principles of Mining	3		I											
Rock Mechanics	3		I	E	E		E				E		E	
Surface Mining	3		I		E		E	E		E				
Underground Mining	3		I		E		E	E		E				
*Mine and Plant Practice (Certificate of Practice)	0		D	D	D	D	D	D	D	D	D	D	D	
Track Specialization 1	3									E	E		E	E
Track Specialization 2	3									E	E		E	E
Track Specialization 3	3									E	E		E	E
Sub Total	45													

ANNEX III: 2018 BSEM COURSE SPECIFICATIONS

I. TECHNICAL COURSE

A. Mathematics

Course Name	**CALCULUS 1 (DIFFERENTIAL CALCULUS)**
Course Description	An introductory course covering the core concepts of limit, continuity and differentiability of functions involving one or more variables. This also includes the application of differential calculations in solving problems on optimization, rates of change, related rates, tangents and normal, and approximations; partial differentiation and transcendental curve tracing.
Number of Units for Lecture and Laboratory	3 units, lecture
Number of Contact Hours per Week	3 hours, lecture
Prerequisites	None if STEM graduate
Program Outcomes Link(s)	a-l
Course Outcomes	At the end of the course, the students must be able to 1. Differentiate algebraic and transcendental functions 2. Apply the concept of differentiation in solving word problems 3. Analyze and trace transcendental curves
	1. Functions, Limits and Continuity 2. Continuity and Limits 3. The Derivative 4. The Slope 5. Rate of Change 6. The Chain Rule and the General Power Rule 7. Implicit Differentiation 8. Higher-Order derivatives 9. Polynomial curves 10. Applications of the Derivative 11. The Differential 12. Derivatives of Trigonometric Functions 13. Derivative of Inverse Trigonometric Functions 14. Derivative of Logarithmic and Exponential Functions 15. Derivative of Hyperbolic Functions 16. Solutions of Equations 17. Transcendental Curve Tracing 18. Parametric Equations 19. Partial Differentiation
Laboratory Equipment	None

Course Name	**CALCULUS 2 (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. The course introduces the concepts of integration and its application to some physical problems such as evaluation of areas, volumes of revolution, force, and work. The fundamental formulas and various techniques of integration are taken up and applied to both single variable and multi-variable functions. The course also includes tracing of functions of two variables for a better appreciation of the interpretation of the double and triple integral as volume of a three-dimensional region bounded by two or more surfaces.
Number of Units for Lecture and Laboratory	3 units, lecture
Number of Contact Hours per Week	3 hours, lecture
Prerequisite	Calculus 1
Program Outcomes Link(s)	a-l
Course Outcomes	After completing this course, the student must be able to: 1. Apply integration to the evaluation of areas, volumes of revolution, force and work 2. Use integration techniques on single and multi-variable functions 3. Explain the physical interpretation of the double and triple integral
Course Outline	I. Integration Concepts/Formulas A. Anti-differentiation B. Indefinite Integrals C. Simple Power Formula D. Simple Trigonometric Functions E. Logarithmic Function F. Exponential Function G. Inverse Trigonometric Functions H. Hyperbolic Functions (sinh u and cosh u only) I. General Power Formula (include Substitution Rule) J. Constant of Integration K. Definite Integral (include absolute; odd & even functions) II. Integration Techniques A. Integration by Parts B. Trigonometric Integrals C. Trigonometric Substitution D. Rational Functions E. Rationalizing Substitution III. Improper Integrals IV. Application of Definite Integral A. Plane Area B. Areas between Curves V. Other Applications A. Volumes B. Work C. Hydrostatic Pressure VI. Multiple Integrals (Inversion of order/change of coordinates)

	A. Double Integrals B. Triple Integrals VII. Surface Tracing A. Planes B. Spheres C. Cylinders D. Quadric Surfaces E. Intersection of Surfaces VIII. Multiple Integrals as Volume A. Double Integrals B. Triple Integrals
Laboratory Equipment	None

Course Name	**ENGINEERING DATA ANALYSIS**
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	None for STEM graduate
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. Obtaining Data 1.1 Methods of Data Collection 1.2 Planning and Conducting Surveys 1.3 Planning and Conducting Experiments: Introduction to Design of Experiments 2. Probability 2.1 Sample Space and Relationships among Events 2.2 Counting Rules Useful in Probability 2.3 Rules of Probability 3. Discreet Probability Distributions 3.1 Random Variables and their Probability Distributions 3.2 Cumulative Distribution Functions 3.3 Expected Values of Random Variables 3.4 The Binomial Distribution 3.5 The Poisson Distribution

	4. Continuous Probability Distribution 4.1 Continuous Random Variables and their Probability Distribution 4.2 Expected Values of Continuous Random Variables 4.3 Normal Distribution 4.4 Normal Approximation to the Binomial and Poisson Distribution 4.5 Exponential Distribution 5. Joint Probability Distribution 5.1 Two or More Random Variables 5.1.1. Joint Probability Distributions 5.1.2. Marginal Probability Distribution 5.1.3. Conditional Probability Distribution 5.1.4. More than Two Random Variables 5.2 Linear Functions of Random Variables 5.3 General Functions of Random Variables 6. Sampling Distributions and Point Estimation of Parameters 6.1. Point Estimation 6.2. Sampling Distribution and the Central Limit Theorem 6.3 General Concept of Point Estimation 6.3.1. Unbiased Estimator 6.3.2. Variance of a Point Estimator 6.3.3. Standard Error 6.3.4. Mean Squared Error of an Estimator 7. Statistical Intervals 7.1. Confidence Intervals: Single Sample 7.2. Confidence Intervals: Multiple Samples 7.3. Prediction Intervals 7.4. Tolerance Intervals 8. Test of Hypothesis for a Single Sample 8.1. Hypothesis Testing 8.1.1. One-sided and Two-sided Hypothesis 8.1.2. P-value in Hypothesis Tests 8.1.3. General Procedure for Test of Hypothesis 9. Statistical Inference of Two Samples 9.1. Inference on the Difference in Means of Two Normal Distribution, Variances Known 9.2. Inference on the Difference in Means of Two Normal Distributions, Variances Unknown 9.3. Inference on the Variance of Two Normal Distributions 9.4. Inference on Two Population Proportions 10. Simple Linear Regression and Correlation 10.1 Empirical Models 10.2. Regression: Modeling Linear Relationships – The Least-Squares Approach 10.3. Correlation: Estimating the Strength of Linear Relation 10.4 Hypothesis Tests in Simple Linear Regression 10.4.1. Use of t-tests 10.4.2. Analysis of Variance Approach to Test Significance of Regression 10.5 Prediction of New Observations 10.6 Adequacy of the Regression Model 10.6.1 Residual Analysis 10.6.2 Coefficient of Determination 10.7 Correlation

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. This course is intended for all engineering students to have a firm foundation on differential equations in preparation for their degree-specific advanced mathematics courses. It covers first order differential equations, nth order linear differential equations and systems of first order linear differential equations. It also introduces the concept of Laplace Transforms in solving differential equations. The students are expected to be able to recognize different kinds of differential equations, determine the existence and uniqueness of solution, select the appropriate methods of solution and interpret the obtained solution. Students are also expected to relate differential equations to various practical engineering scientific problems as well as employ computer technology in solving and verifying solutions.
Number of Units for Lecture and Laboratory	3 units, lecture
Number of Contact Hours per Week	3 hours, lecture
Prerequisite	Calculus 2
Program Outcome Link(s)	a-l
Course Outcomes	After completing this course, the student must be able to: 1. Apply integration for the evaluation of areas, volumes of revolution, force and work 2. Use integration techniques on single and multi-variable functions 3. Explain the physical interpretation of the double and triple integral.
Course Outline	1. Functions of Several Variables 1.1 Directional derivatives and gradient 1.2 Tangent planes to level surfaces 1.3 Relative extrema (second derivative test) 1.4 Absolute extrema and Lagrange Multipliers 1.5 Parametric surfaces 1.6 Surfaces of revolution 2. Multiple Integrals 2.1 Double integrals 2.2 Double integrals in polar coordinates 2.3 Applications of double integrals (area, volume, mass, surface area) 2.4 Triple integrals 2.5 Triple integrals in cylindrical and surface integrals 3. Vector fields, line and surface integrals 3.1 Curl and divergence 3.2 Line integrals of scalar and vector fields

	3.3 The Fundamental Theorem of Line Integrals 3.4 Independence of path 3.5 Green's Theorem 3.6 Surface integrals of scalar and vector fields 3.7 Stokes' and Gauss' Divergence Theorem 4. Sequences and Series 4.1 Sequences and their convergence 4.2 Series of constant terms 4.3 Convergence tests for series with nonnegative terms 4.4 Convergence tests for series with positive and negative terms 4.5 Power series; radius and interval of convergence 4.6 Differentiation and integration of power series 4.7 Taylor, Maclaurin, binomial series 4.8 Approximation using Taylor polynomials
Laboratory Equipment	None

B. Natural/ Physical Sciences

Course Name	**CHEMISTRY FOR ENGINEERS (LECTURE)**
Course Description	This course provides students with core concepts of chemistry that are important in the practice of engineering profession.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours per week
Prerequisite	None
Co-requisites	Chemistry for Engineers Lab
Program Outcome/s Addressed by the Course	a-l
Course Objectives	At the end of the course, the students must be able to: 1. Discuss the application of chemistry in relation to the generation of energy 2. Explain the chemical principles and concepts of structures and bonding of common materials 3. Discuss the chemical processes that takes place in the environment 4. Identify key chemistry concepts related to the specific field of engineering
Course Outline	***Lecture*** 1. Energy 1.1. Electrochemical energy 1.2. Nuclear chemistry and energy 1.3. Fuels 2. The Chemistry of Engineering Materials 2.1. Basic Concepts of Crystal Structure 2.2. Metals 2.3. Polymers

	2.4. Engineered Nanomaterials 3. The Chemistry of the Environment 3.1. The Chemistry of the Atmosphere 3.2. The Chemistry of Water 3.3. Soil Chemistry 4. Chemistry Safety 5. Special Topics specific to field of expertise
Laboratory Equipment	None

Course Name	**CHEMISTRY FOR ENGINEERS (LABORATORY)**
Course Description	A fundamental laboratory course designed to relate and apply the principles and theories in chemistry to engineering practices. It is a combination of experimental and calculation laboratory.
Number of Units for Lecture and Laboratory	1 unit laboratory
Number of Contact Hours per Week	3 hours per week
Prerequisite	None
Co-requisites	Chemistry for Engineers (Lecture)
Program Outcome/s Addressed by the Course	a-I, b-I, k-I
Course Objectives	At the end of the course, the students must be able to: 1. Explicitly state experimental observation in relation to specific principles and fundamental concepts of chemistry 2. Interpret results clearly obtained from the experiments 3. Answer questions related to the performed experiment 4. Develop critical and technical communication skills 5. Explain the mechanics of alpha, beta and gamma decay as well as the correlation between half-lives 6. Understand the natural environment and its relationships with human activities 7. Design and evaluate strategies, technologies, and methods for sustainable management of environmental systems and for the remediation or restoration of degraded environments.
Course Outline	EXPERIMENTS 1. Calorimetry 2. Heat of Combustion 3. Metals and Some Aspects of Corrosion 4. Mechanical Properties of Materials 5. Water: Its Properties and Purification 6. Determination of the Dissolved Oxygen Content of Water 7. Cigarette Smoking and Air Pollution ACTIVITIES: 1. Nuclear Reactions, Binding Energy and Rate of Decay 2. Crystal Lattices and Unit Cells

	3. Community Immersion: Care for the Environment
Laboratory Equipment	Refer to Annex of Lab Requirements

Course Name	**PHYSICS FOR ENGINEERS**
Course Description	Vectors; kinematics; dynamics; work, energy, and power; impulse and momentum; rotation; dynamics of rotation; elasticity; and oscillation; 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 Hours per Week	6 hours: 3 hours, lecture; 3 hours, laboratory
Prerequisites	Calculus 1; Co-requisite: Calculus 2
Program Outcome/s Addressed by the Course	a-I, b-1, k-1
Course Outcomes	After completing this course, the student must be able to: 1. Use calculus to solve problems in force statics and kinematics; 2. Apply Newton's Laws of Motion; 3. Use calculus to solve work and energy problems; 4. Apply the law of conservation of energy to problems; 5. Solve problems on impulse and momentum of collisions; 6. Determine the stress and strain on a body; 7. Solve simple harmonic motor applications; 8. Describe the characteristics of fluids at rest and in motion; 9. Solve basic problems in fluid statics and kinematics; 10. Describe the three methods of heat transfer; 11. Solve basic problems in heat transfer; 12. Discuss the properties of waves, modes of vibration of strings and air columns; 13. Define electric current, electric resistance and voltage; 14. Compute the electric force between electric charges; 15. Solve problems on resistance and cells in series and parallel; 16. State Kirchoff's rules and apply them in a given circuit; 17. Describe electromagnetism and apply its principles to problem on magnetic field and torque 18. Describe image formation by mirrors and lenses and solve basic optics problems
Course Outline	1. Work, Energy and Power 2. Impulse and Momentum 3. Kinematics 4. Dynamics 5. Rotation 6. Dynamics of Rotation 7. Elasticity 8. Oscillations 9. Fluids

	10. Heat Transfer 11. Waves 12. Electrostatics 13. Electricity 14. Magnetism 15. Optics
Laboratory Equipment	Physics Laboratory (see attached)

C. Basic Engineering Sciences

Course Name	**COMPUTER-AIDED DRAWING AND 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. 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. Explain 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 3. Computer workstation with licensed computer-aided drawing software

Course Name	**ENGINEERING ECONOMICS**
Course Description	Concepts of the time value of money and equivalence; basic economic 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	Engineering Data Analysis/ Second Year Standing
Program Outcomes	e. ability to identify, formulate, and solve engineering problems k. ability to use techniques, skills, and modern engineering tools necessary for engineering practice
Learning Outcomes	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 Economics 1.3. Engineering Economics and the Design Process 1.4. Cost Concepts for Decision Making 1.5. Present Economic 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. Economic Study Methods 3.1. The Minimum Attractive Rate of Return 3.2. Basic Economic Study Methods: Present Worth, Future Worth, Annual Worth, Internal Rate of Return, External Rate of Return 3.3. Other Methods: Discounted Payback Period, Benefit/Cost Ratio 4. Decisions Under Certainty 4.1. Evaluation of Mutually Exclusive Alternatives 4.2. Evaluation of Independent Projects 4.3. Effects of Inflation 4.4. Depreciation and After-Tax Economic Analysis 4.5. Replacement Studies 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
Number of Units for Lecture and Laboratory	3 units, lecture
Number of Contact Hours per Week	3 hours, lecture
Prerequisite	Engineering Economics
Course Objectives	After completing this course, the student must be able to: 1. Describe the field of engineering management; 2. Describe and apply the different functions of management.
Course Outline	1. Introduction 1.1 Components of Decision-Making problems 1.2 Classification of Mathematical Models 2. Linear Programming 3. Project Scheduling 4. Inventory Management 5. Network Models 6. Qualitative and Quantitative Forecasting 7. Decision Models 8. Queuing Models
Laboratory equipment	None

Course Name	**ENGINEERING MECHANICS**
Course Description	Force, moment, and motion concepts. Newton's Laws of Motion. Analysis of particles and rigid bodies in static and dynamic equilibrium using vector mechanics and energy and momentum methods. Geometric properties of lines, areas, and volumes.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisites	Physics for Engineers
Program Outcome	ability to apply knowledge of mathematics and science to solve complex industrial engineering problems
Course Outcomes	After completing this course, the student must be able to: Explain the fundamental concepts related to engineering mechanics; Solve for the components and resultants of force, moment, and motion vectors; Analyze static and dynamic equilibrium of particles and rigid bodies Analyze particles and rigid bodies in motion using energy and momentum methods; and Compute for geometric properties (centroids and moments) of lines, areas, and volumes.

Course Outline	Introduction to Mechanics, Discussion on Newton's Laws of Motion, Concept of Particles and Rigid Body; Review of Vector Operations Motion Concepts; Definition of Position, Velocity and Acceleration of a Particle, Equations of Motion, Rectilinear Motion Concept of a Force, Components and Resultants of Forces, Concurrent Force Systems Equilibrium of Particles, Concepts of Static Equilibrium, Free Body Diagram, Analysis of Particles in Static Equilibrium Equilibrium of Particles, Static, Kinetic and Limiting Friction Concepts, Belt Friction, Wedges Rectilinear Motion Curvilinear Motion of Particles Relative Motion and Moving Frames of Reference Concept of Dynamic Equilibrium, Concept of Inertia, Force and Inertia, Effective Force Diagram for Particles Dependent Motion Work and Energy Principle for Particles; Concepts of Work and Energy, Conservative Forces, Conservation of Mechanical Energy Principle of Impulse and Momentum for Particles, Concepts of Impulse and Momentum Analysis of Impact of Colliding Particles Moment of a Force About a Point, Moment of a Force About a Line, Noncurrent Forces in Space Couples and their Moments, Components and Resultants of Moment Vectors Reduction of Force-Couple Systems, Coplanar Force Systems Equivalent Force-Couple Systems First Moment of Lines and Areas, Centroid and Center of Gravity of Lines and Areas (Centroids of Common Shapes, Centroid and Center of Gravity of Composite Figures) Equilibrium of Rigid Bodies First Moment of Volumes, Centroid and Center of Gravity of Volumes (Centroids of Common Shapes, Centroid and Center of Gravity of Composite Shapes and Volumes) Analysis of Rigid Bodies in Static Equilibrium; Three Dimensional Problems on Static Equilibrium Types of Plane Motion, Analysis of a Rigid Body in Translation, Rotation about a Fixed Axis Absolute and Relative Velocity in General Planar Motion (Pole Method for Velocity Analysis) Absolute and Relative Acceleration in General Planar Motion (Pole Method for Acceleration Analysis) Mass Moment of Inertia of Shapes Plane Motion of a Rigid Body: Forces and Accelerations Instantaneous Center Method for Velocity Analysis Work and Energy Principle for Rigid Body Motion; Concepts of Work and Energy, Conservative Forces, Conservation of Mechanical Energy Principle of Impulse and Momentum for Rigid Bodies, Concepts of Impulse and Momentum Analysis of Impact of Colliding Particles and Rigid Bodies

Course Name	**TECHNOPRENEURSHIP 101**
Course Description	*Technopreneurship* is a philosophy, a way of building a career or perspective in life. The course covers the value of professional and life skills in entrepreneurial thought, investment decisions, and action that students can utilize in starting technology companies or executing R&D projects in companies as they start their careers. The net result is a positive outlook towards wealth creation, high value adding, and wellness in society.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	None
Program Outcome	I. knowledge and understanding of engineering and management principles as a member and leader in a team, to manage projects and in multidisciplinary environments
Course Outcomes	After completing this course, the student must be able to: 1. Evaluate and define the market needs; 2. Solicit and apply feedback from mentors, customers and other stakeholders; 3. Experience the dynamics of participating on a business team; 4. Pitch a business plan for a technology idea; 5. Develop an initial idea into a "prototype."
Course Outline	1. Introduction 1.1. Entrepreneurial Mindset 1.2. Innovation and Ideas 1.3. Products and Services 1.4. Team Formation 2. Customers 3. Value Proposition 4. Market Identification and Analysis 5. Creating Competitive Advantage 6. Business Models 7. Introduction to Intellectual Property 8. Execution and Business Plan 9. Financial Analysis and Accounting Basics 10. Raising Capital 11. Ethics, Social Responsibility, and Globalization

D. Allied Courses

Course Name	ELEMENTARY MINERALOGY
Course Description	A systematic approach in identifying and understanding the different rocks and ore forming silicates as well as non- silicate minerals. 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	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Principles of Geology
Program Outcomes	a - Ability to apply knowledge of mathematics and science to solve complex mining engineering problems i - Recognition of the need for, and an ability to engage in lifelong learning
Course Outcomes	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. Familiarize 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 powder data 2.8 Indexing Refraction 2.9 Crystal habit and aggregates 2.10 Cleavage 2.11 Parting 2.12 Fracture 2.13 M-hardness luster streak

	2.14 Tenacity 2.15 Specific Gravity Color 2.16 Chatoyancy and asterism, 2.17 Luminescence 2.18 Electrical and magnetic Properties 3. Optical Properties 4. Crystal Chemistry: Halides, Carbonates, Silicates, Oxides, special minerals (precious stones).
Laboratory Equipment	XRD, crystal model, mineral samples, microscope
Suggested References	Hurlbut and C. Kelin, Dana's Manual of Mineralogy 20th ed. Sabtos and M. Tejada, Manual of Mineralogy C. Evans, Crystal Chemistry Philips, Crystallograhy

Course Name	**FLUID MECHANICS**
Course Description	Properties of fluids. Fluid statics and kinematics. Forces, energy and momentum in fluid flow. Fluid flow in open and closed channels. Fluid measurements.
No. of Units for Lecture and Laboratory	3 units, lecture
No. of Contact Hours per week	3 hours, lecture
Prerequisites	Engineering Mechanics
Program Outcomes	a - Ability to apply knowledge of mathematics and science to solve complex mining engineering problems c - Ability to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability, in accordance with standards. e - Ability to identify, formulate, and solve engineering problems
Course Outcomes	At the end of the course the student must be able to: 1. Identify the properties of fluids 2. Identify the governing equations in fluid statics and kinematics 3. Solve typical problems in fluid mechanics especially those relevant to ceramic engineering 4. Differentiate mechanics of fluid flow in open and closed channels 5. Identify the methods in fluid measurements
	1. Introduction – Fluid Properties 2. Fluid Statics 2.1 Fluid at Rest 2.2 Pressure at a Point 2.3 Pressure Variation in Static Fluid 2.4 Manometers 2.5 Forces on Submerged Plane Area and Curved Surfaces 3. Fluid Flow Concepts 3.1 Fluid Flow Field 3.2 System and Control Volume 3.3 Continuity Equation 3.4 Bernoulli Equation 3.5 Energy Equation 3.6 Linear Momentum Equation

	4. Dimensional Analysis and Similitude 4.1 Dimensional Analysis 4.2 Buckingham PI Theorem 4.3 Dimensionless Numbers 4.4 Similitude 5. Viscous Effects 5.1 Laminar Flow 5.2 Navier-Stokes Equation 5.3 Basic Examples 5.4 Turbulent Flow 5.5 Forces on Immersed Bodies 5.6 Drag and Lift 6. Closed Conduit Flow 6.1 Pipe Flow; Heat Losses; 6.2 Moody Diagram; 6.3 Energy and Hydraulic Grade Line 6.4 Open Channel Flow

Course Name	**GENERAL SURVEYING**
Course Description	Use of principal surveying instruments; surveying measurements and error theory; basic plane surveying operations and computational method of position, traverses and areas; basic cartography
Number of Units for Lecture and Laboratory	3 units: 2 units Lecture, 1 unit laboratory
Number of Contact Hours per week	5 hours: 2 hrs. lecture, 3 hrs. laboratory
Prerequisite	Calculus 1
Program Outcomes	a - Ability to apply knowledge of mathematics and science to solve complex mining engineering problems b - Ability to design and conduct experiments, as well as to analyze and interpret data k - Ability to use techniques, skills and modern engineering tools necessary for engineering practice
Course Outcomes	At the end of the course, the students must be able to: 1. Understand the theory and use of surveying instruments; 2. Acquire and understand the field procedures of executing plane surveys; 3. Compute traverses, areas and subdivision problems; 4. Prepare survey plans.
Course Outline	1. General Concepts of Surveying 1.1 Introduction to Surveying and Mapping 1.1.1 Definition of Terms 1.1.2 Purpose of Surveys 1.1.3 Uses and/or Applications of Surveys 1.1.4 Classification of Surveys 1.1.5 Drawings of Surveys 1.2 Survey Measurements and Adjustments 1.2.1 Observations and Measurements 1.2.2 The Mathematical Order 1.2.3 Classification of Errors 1.2.4 Basic Statistics 2. Basic Survey Measurements

	2.1 Distance Measurements 1.1.1 Methods 1.1.2 Instruments 1.1.3 Errors and Corrections 2.2 Angle and Direction Measurements 2.2.1 Definition of Terms 2.2.2 Methods 2.2.3 Instruments 2.2.4 Field Procedures and the Field Notebook 2.2.5 Errors 3. Survey Operations 3.1 Traverse and Areas 3.1.1 Definition of Terms 3.1.2 Types of Traverse 3.1.3 Traverse Computations and Adjustment 3.1.4 Linear Error of Closure 3.1.5 Methods of Area Computation 3.1.6 Area Subdivision 3.2 Land Surveys 3.2.1 Introduction to Land Surveys 3.2.2 Organization and Equipment 3.2.3 Kinds of Boundary Surveys 3.2.4 Technical Description of a Property 3.2.5 Legal Aspects of Land Surveys 4. Mapping (Map and Plan Drafting) 4.1 Methods of Plotting 4.2 Preparation of Plans of Land Surveys
Laboratory Equipment	Engineering transit, Automatic Level, Steel Tape, etc

Course Name	**MINERAL DEPOSITS**
Course Description	Ore deposit types and origin of mineral deposits with emphasis on Philippine examples.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hrs per Week	3 hours lecture
Prerequisite/Co-Requisite	Structural Geology, Senior Standing
Program Outcomes addressed by the course	a - apply knowledge of mathematics and science to solve complex engineering problems; g - communicate effectively engineering activities with the engineering community and with society at large; h - understand the impact of engineering solutions in a global, economic, environmental, and societal context;
Course Outcomes	At the end of the Course, the student will be able to: 1. Understand the occurrences of the various types of ore deposit and elucidate the origin of different mineral deposits. 2. Communicate effectively characteristics of various types of ore bodies and general approach in their extraction; 3. Understand the impacts of mining ore deposits in global, economic, environmental and societal context.
Course Outline	1. Introduction

	2. Features of ore deposits and ore-forming processes 3. The exploration for mineral deposits 4. Major ore deposit types
Laboratory Equipment	None

Course Name	MINERAL PROCESSING
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	2 units lecture; 1 unit laboratory
Number of Contact Hrs per Week	2 hours lecture; 3 hours laboratory
Prerequisite	Principles of metallurgy and Mineralogy
Program Outcomes	a - Ability to apply knowledge of mathematics and science to solve complex mining engineering problems c - Ability to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability, in accordance with standards. e - Ability to identify, formulate, and solve engineering problems i - Recognition of the need for, and an ability to engage in lifelong learning
Course Outcomes	At the end of the course the students must be able to: 1. Distinguish different types of equipment used in comminution, beneficiation (gravity, magnetic and electrostatic separation), size classification screening and dewatering operations. 2. Evaluate various size reduction processes and identify the right equipment or combination thereof for particular application 3. Evaluate classification and screening efficiencies and perform particle size analysis and screening/ classification efficiency calculations. 4. Evaluate various concentration methods: flotation, gravity concentration, magnetic, and electrostatic separation processes, and identify proper concentration/separation technique that should be applied to recover common valuable 5. Describe the different dewatering techniques used in Mineral Processing plants and identify the features of tailings storage facilities 6. Prepare flow diagrams for gravity, magnetic and electrostatic separation methods for the recovery of valuable minerals incorporating therein proper equipment selection and material balance

Course Outline	1. Properties of minerals in relation to processing 2. Comminution or size reduction 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. Flotation - theoretical and engineering applications 9. Dense media separation - basic principles, equipment 10. Magnetic and high tension separation - basic principles, equipment 11. Dewatering – thickening, filtering, flocculation, coagulation, electrical double layer and other surface properties/phenomena
Laboratory Equipment	None
Suggested References	Mineral Processing Technology, B.A. Wills, 1996 SME – Mineral Processing Handbook, 1985 Edition

Course Name	**PETROLOGY**
Course Description	Igneous Rock Classification, structures, chemistry and genesis, magmatic processes, metamorphism
Number of Units for Lecture and Laboratory	2 units lecture; 1 unit laboratory
Number of Contact Hours per Week	2 hours lecture, 3 hours laboratory
Prerequisite	Elementary Mineralogy
Program Outcomes	a - apply knowledge of mathematics and science (Petrologic principles and properties of rocks) to solve complex engineering problems; k - use techniques, skills, and modern engineering tools necessary for engineering practice.
Course Outcomes	At the end of the course, the student must be able to: 1. Acquire the knowledge and understanding of the various principles in Petrology. 2. Understand the physical and chemical properties of various rocks and their origin and mode of occurrences. 3. Identify rock and mineral specimen
Course Outline	1. Igneous Rock classification, textures and structures 2. Petro genesis and Phase diagrams 3. Magmatism and igneous processes 4. Metamorphism and Metamorphic rocks 5. Rock chemical composition and mineral assemblage
Laboratory Equipment	none

Course Name	**PRINCIPLES OF GEOLOGY**
Course Description	Definition and historical evolution of Geology, Earth's Structure, Major Geologic Principles and Processes, Standard Stratigraphic Column, analysis of rock formations, and modern applications.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite/ Co-Requisite	Chemistry for Engineers
Program Outcomes	a - apply knowledge of mathematics and science (Geologic principles) to solve complex engineering problems; k - use techniques, skills, and modern engineering tools necessary for engineering practice.
Course Outcomes	At the end of the course, the student must be able to: Acquire the knowledge and understanding of the various principles in Geology and geologic processes.
Course Outline	1. Definition and historical evolution of Geology 2. Major principles in Geology 3. Structure of the Earth and Plate Tectonics 4. Igneous Geology and Volcanisms 5. Metamorphism 6. Sedimentary processes 7. Standard Stratigraphic column 8. Paleontology and rock dating methods 9. Weathering and Erosional processes 10. Geomorphology and geologic structures 11. Modern applications
Laboratory Equipment	none

Course Name	**PRINCIPLE OF 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	3 units lecture
Number of Contact Hrs per Week	3 hours lecture
Prerequisite	Chemistry for Engineers
Program Outcomes	a - Ability to apply knowledge of mathematics and science to solve complex mining engineering problems i - Recognition of the need for, and an ability to engage in lifelong learning
Course Outcomes	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 1.1 Smelting 1.2 Calcination 4. Hydrometallurgy 4.1 Leaching, etc 5. Electrometallurgy 1.1 Electrowinning 1.2 Electro-refining 6. Adaptive metallurgy 1.1 Foundry 1.2 Metal forming 7. Environmental Impacts and Mitigation Measures
Laboratory Equipment	None
Suggested References	Introduction to Metallurgy by Joseph Newton The making, shaping and treating of steel – United State Steel Physical Chemistry of Iron & Steel Manufacture- Badsworth & Bell

Course Name	**STRUCTURAL GEOLOGY**
Course Description	Mechanics of structural geological deformation; nature, origin, types, and field examples of primary and secondary rock structures; photo-interpretation of geologic structures.
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	Principles of Geology, Petrology
Program Outcomes	a - apply knowledge of mathematics and science to solve complex engineering problems; b - design and conduct experiments, as well as to analyze and interpret data; e - identify, formulate, and solve complex engineering problems; g - communicate effectively engineering activities with the engineering community and with society at large; k - use techniques, skills, and modern engineering tools necessary for engineering practice;
Course Outcomes	At the end of the Course, the student will be able to: 1. Understand and describe the processes responsible for the deformation in rocks and geologic structures and recognize

	different rock formation/ structures and faults, fractures, joints folds in the field. 2. Apply knowledge on geologic structures to be able to prepare and interpret geologic maps; 3. Apply knowledge on strain analysis for interpretation of structural history of an area; 4. Communicate effectively plate tectonic theory in relation to crustal structures and their impacts in global, economic, environmental and societal context; and 5. Solve graphically and mathematically common problems affecting geologic structures to be able to understand their origin or geologic history.
Course Outline	1. Introduction 2. Concepts of structural analysis 3. Three-point Problem 4. Introduction to faults 5. Rock mechanics 6. Stress and Strain 7. Folds and Folding 8. Fabrics 9. Plate Tectonics – The anatomy of organic belts
Laboratory Equipment	Brunton Compass, Lens, Meter - tape

Course Name	**TECHNIQUES OF METALLURGICAL ANALYSIS**
Course Description	The course is designed to provide basic knowledge on the conventional/classical and modern methods of analyzing minerals and metallurgical products, both in solid and liquid forms. These include fire assaying, Atomic Adsorption Spectrophotometer, gravimetric and volumetric methods, X-ray diffraction and similar methods.
Number of Units for Lecture and Laboratory	2 units: 1 unit lecture, 1 unit laboratory
Number of Contact Hrs per Week	4 hours: 1 hour lecture, 3 hours laboratory
Prerequisite	Principles of Metallurgy
Program Outcomes	a - Ability to apply knowledge of mathematics and science to solve complex mining engineering problems b - Ability to design and conduct experiments, as well as to analyze and interpret data g - Ability to communicate effectively k - Ability to use techniques, skills and modern engineering tools necessary for engineering practice
Course Outcomes	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 1.1 Spectrophotometry 1.2 X-ray Diffraction/Fluorescence 1.3 Microanalysis
Laboratory Equipment	Manual and mechanical samplers, fire assaying furnaces and facilities, weighing balance, Atomic Absorption Spectrophotometry (AAS), XRray Diffraction (XRD) facilities
Suggested References	Fire Assaying by Bugbee Manual on Standard Analytical Procedures of the MGB Laboratories (Revised Edition, 2001) Other Analytical Chemistry Books Manuals for AAS, XRF, etc. Fire Assaying, Sheapard

E. Professional Courses

Course Name	**MINE ECONOMICS**
Course Description	Fundamentals of feasibility studies, methods of sampling, ore reserve estimations and statistical analysis for evaluating mineral deposits, engineering economic principles with emphasis on the economic evaluation of mineral development and mining projects.
Number of Units for Lecture & Laboratory	3 units lecture
Numbers of Contact Hours per Week	3 hours lecture
Prerequisites	Mineral Deposits, Surface and Underground Mining, Engineering Economics, Senior Standing
Program Outcomes	a - apply knowledge of mathematics and science to solve complex engineering problems; e - identify, formulate, and solve complex engineering problems;

	g - communicate effectively engineering activities with the engineering community and with society at large;
Course Outcomes	At the end of the course, the student must be able: 1. Acquire the basic principles of economics in relation to mine engineering applications; 2. Understand and apply basic knowledge in making technical economic analysis for mine operation and allied projects; and, 3. Understand the importance of economics factors as well as other related factors affecting the Philippine Mining Industry.
Course Outline	1. Peculiar features of the mining industry 2. Introduction to investment decision making 3. Cash flows, depreciation, depletion and amortization 4. Production cost variations, profit and breakeven point 5. Compound interest formulas and equivalence 6. Present worth, annual worth, and future worth equations 7. Evaluation of investment alternatives 8. Tax consideration and leverage concepts 9. Sensitivity analysis
Laboratory Equipment	none

Course Name	**MINE ENVIRONMENTAL MANAGEMENT**
Course Description	The course is designed to provide knowledge on the environmental management, design and rehabilitation in the mine.
Number of Units for Lecture & Laboratory	3 units lecture
Numbers of Contact Hours per Week	3 hours lecture
Prerequisites	Principles of Mining and Environmental Science
Program Outcomes	a - apply knowledge of mathematics and science to solve complex engineering problems; c - design a system, component, or process to meet desired needs within realistic constraints, in accordance with standards; d - function in multidisciplinary and multi-cultural teams; e - identify, formulate, and solve complex engineering problems; f - understand professional and ethical responsibility; g - communicate effectively engineering activities with the engineering community and with society at large; h - understand the impact of engineering solutions in a global, economic, environmental, and societal context; i - recognize the need for, and engage in life-long learning.
Course Outcomes	At the end of the course, the student must be able to: 1. Familiarize with the various environmental impacts brought about by mining operations and production, and mineral processing and tailings disposal; 2. Appreciate the social and environmental responsibilities that are essential to future mining engineers; and, 3. Formulate mitigation measures, monitoring plans, and best practices for the environmental management of a mining operation.
Course Outline	1. International Perspective of Sustainable Development; 2. Corporate Responsibilities; 3. Legislation & Regulatory Framework; 4. Environmental Impact Assessment;

	5. Environmental Management Systems & Company Initiatives - corporate reporting/code for environmental management/case studies, 6. Environmental Auditing; 7. Mine Planning/Feasibility; 8. Studies/Documentation to Avoid Environmental Impact; 9. Environmental Management - an introduction, Environmental issues in mining; 10. Management of Mine Wastes; 11. Mine Tailings Disposal and Storage; 12. Environmental issues in tailings management; 13. Tailings dam incidents; 14. Chemical (Cyanide) Management; 15. Water pollution/Acid Mine Drainage and its remediation; 16. Environmental Monitoring; 17. Environmental Impacts and Management: o Air Quality; o Mineral Exploration, Quarries/extractives/industrial minerals, o Small scale & placer mining, o Uranium mining, (optional) 18. Mining in developing countries - a case study, Social impact, Rehabilitation and closure.
Laboratory Equipment	none

Course Name	**MINE MANAGEMENT**
Course Description	Introduction to mine administration, corporate planning, organization, maintenance management, mine labor cost analysis, industrial relations and human resource development. Concept of corporate social responsibilities and quantitative management techniques.
Number of Units for Lecture & Laboratory	3 units lecture
Numbers of Contact Hours per Week	3 hours lecture
Prerequisites	Mine and Plant Practice, Engineering Management, Senior Standing
Program Outcomes	a - apply knowledge of mathematics and science to solve complex engineering problems; c - design a system, component, or process to meet desired needs within realistic constraints, in accordance with standards; d - function in multidisciplinary and multi-cultural teams; e - identify, formulate, and solve complex engineering problems; f - understand professional and ethical responsibility; g - communicate effectively engineering activities with the engineering community and with society at large; i - recognize the need for, and engage in life-long learning; j - know contemporary issues;
Course Outcomes	At the end of the course, the student must be able to: Acquire and understand the basic principles of mine administration, corporate planning, organization, maintenance and management; mine labor cost analysis, industrial relations and human resources development.

Course Outline	1. Introduction to mine management. 2. Corporate Planning 3. Organization 4. Management by Objectives 5. Performance Appraisal System 6. Education, Training and Development 7. Management Information system. 8. Mine productivity 8. Underground Incentive Bonus System. 9. Maintenance Management. 10. Material Management. 11. Industrial Relations and Corporate Social Responsibility. 12. Introduction to Quantitative Management Techniques
Laboratory Equipment	none

Course Name	**MINE DESIGN**
Course Description	Analysis and design of materials handling systems including hauling and hoisting, mineral resource and ore reserve estimation, mine ventilation, mine dewatering, compressed air and power systems. Application of operations research in mining.
Number of Units for Lecture & Laboratory	3 units: 2 units lecture, 1 unit laboratory
Numbers of Contact Hours per Week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisites	Mine and Plant Practice, Senior Standing
Program Outcomes	a - apply knowledge of mathematics and science to solve complex engineering problems; b - design and conduct experiments, as well as to analyze and interpret data; c - design a system, component, or process to meet desired needs within realistic constraints, in accordance with standards; e - identify, formulate, and solve complex engineering problems; f - understand professional and ethical responsibility; g - communicate effectively engineering activities with the engineering community and with society at large; h - understand the impact of engineering solutions in a global, economic, environmental, and societal context; i - recognize the need for, and engage in life-long learning; j - know contemporary issues; k - use techniques, skills, and modern engineering tools necessary for engineering practice.
Course Outcomes	At the end of the course, the student must be able to: 1. Understand the concepts and principles of mine plant design; 2. Recognize the different aspects of mine operation and planning as applied to surface and/ or underground; and, 3. Apply the various principles and techniques in solving practical mining problems pertaining to mine design.
Course Outline	1. Engineering Design Process 2. Facilities planning, process, manufacturing engineering, and reengineering 3. Design Problems (Mineral resource and ore reserve estimation; Surface mine fleet design; Mine dewatering; Underground fleet

	design; Ventilation: Underground track haulage; Conveyors and Hoist design)
Laboratory Equipment	Computer facilities and mining softwares (mine operation and planning)

Course Name	**MINE SAFETY**
Course Description	Causes and prevention of mine accidents; safety management and organization; mine rescue training; mine safety and health regulations; introduction to the principles of quantitative risk assessment in a mining context.
Number of Units for Lecture & Laboratory	3 units lecture
Numbers of Contact Hours per Week	3 hours lecture
Prerequisites	Principles of Mining, Surface Mining, Underground Mining
Program Outcomes	a - apply knowledge of mathematics and science to solve complex engineering problems; c - design a system, component, or process to meet desired needs within realistic constraints, in accordance with standards; e - identify, formulate, and solve complex engineering problems; f - understand professional and ethical responsibility; g - communicate effectively engineering activities with the engineering community and with society at large; h - understand the impact of engineering solutions in a global, economic, environmental, and societal context; i - recognize the need for, and engage in life-long learning; j - know contemporary issues; k - use techniques, skills, and modern engineering tools necessary for engineering practice.
Course Outcomes	At the end of the course, the student must be able to: 1. Recognize the causes of mine-related accidents; 2. Incorporate safe operation practices and procedures into the designs of all types of earth excavations to prevent mine-related accidents; 3. Understand the basic aspect of safety management and organization; 4. Apply basic knowledge of mine rescue; 5. Acquire an overview of mine safety and health regulations; and, 6. Acquire an overview of the principles of quantitative risk assessment in a mining context.

Course Name	**MINE RESEARCH AND STUDY**
Course Description	Research design, formulation of methodology, technical writing of research proposal and research outputs., and presentation of research output of selected topics with emphasis on mine practices and current issues.
Number of Units for Lecture & Laboratory	1 unit lecture; 2 units laboratory
Numbers of Contact Hours per Week	1 hour lecture; 6 hours laboratory
Prerequisites	Mine and Plant Practice, Senior Standing

Program Outcomes	b- Ability to design and conduct experiments, as well as to analyze and interpret data c- Ability to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability, in accordance with standards. e- Ability to identify, formulate, and solve engineering problems g- Ability to communicate effectively h- Broad education necessary to understand the impacts of engineering solutions in a global, economic, environmental, and societal context i- Recognition of the need for, and an ability to engage in lifelong learning k-Ability to use techniques, skills and modern engineering tools necessary for engineering practice
Course Outcomes	At the end of the course, the student must be able to: Conduct independent research on basic mining principles, mine engineering and environmental issues by understanding the research process.
Course Outline	1. Identify and develop mining engineering research problems; 2. Conduct an independent literature review relevant to the specific mining engineering problem; 3. Design research proposals which will assess research constraints based on time, availability of resources (manpower and materials), and budgetary requirements; 4. Design methodologies (experiment and date analysis) to serve as basis of conducting specific activities to address the research problem; 5. Conduct experiments and data gathering 6. Analyze /interpret research data and results; 7. Defend and present research outputs 8. Recommend future research initiatives based on the conclusions and finding of the current research work. 9. Write progress reports and technical journals/papers
Laboratory Equipment	None

Course Name	MINE VENTILATION
Course Description	Fundamentals of mine ventilation, including gas, dust, temperature and humidity control. Economics of airflow, natural and mechanical ventilation. Analysis and design of ventilation systems.
Number of Units for Lecture & Laboratory	3 units: 2 units lecture; 1 unit laboratory
Numbers of Contact Hours per Week	2 hours lecture, 3 hours laboratory
Prerequisite/Co-requisite	Fluid Mechanics
Program Outcomes addressed by the course	a - apply knowledge of mathematics and science to solve complex engineering problems; b - design and conduct experiments, as well as to analyze and interpret data; c - design a system, component, or process to meet desired needs within realistic constraints, in accordance with standards;

	e - identify, formulate, and solve complex engineering problems; f - understand professional and ethical responsibility; h - understand the impact of engineering solutions in a global, economic, environmental, and societal context; I - recognize the need for, and engage in life-long learning; k - use techniques, skills, and modern engineering tools necessary for engineering practice;
Course Outcomes	At the end of the course, the student will be able to: 1. Acquire understanding and knowledge of the basic principles/ fundamentals of mine underground ventilation necessary in solving complex problems; 2. Design and conduct experiments on underground ventilation as well as analyse and interpret data. 3. Design mine ventilation system, component or process to meet desired needs within realistic constraints and accordance with standards; 4. Identify, formulate and solve complex mine ventilation problems; 5. Understand professional and ethical responsibilities associated with Mine ventilation management; 6. Understand the impacts of underground mining engineering solutions in a global, economic, environmental and societal context; 7. Recognize the need for and engage in life-long learning for uplifting mine ventilation management, and 8. Use techniques, skills and modern engineering tools on mine ventilation necessary for mining engineering practice.
Course Outline	1. Introduction. Definitions. Control Process 2. Properties and behaviour of air. 3. Quality control (Contaminants, gas and dust control) 4. Quality control in ventilation. 5. Types of ventilation and economics of airflow 6. Temperature and humidity control. 7. Ventilation surveys
Laboratory Equipment	none

Course Name	**MINING AND ENVIRONMENTAL LAWS AND ETHICS**
Course Description	The mining and environmental laws, policies, implementing rules and regulations, legal and ethical issues affecting the practice of Mining Engineering.
Number of Units for Lecture & Laboratory	3 units lecture
Numbers of Contact Hours per Week	3 hours lecture
Prerequisites	Senior Standing
Program Outcomes	d - Ability to function in multidisciplinary teams e - Ability to identify, formulate, and solve engineering problems f - Understanding of professional and ethical responsibility g - Ability to communicate effectively I - Recognition of the need for, and an ability to engage in lifelong learning j - Knowledge of contemporary issues
Course Outcomes	At the end of the course, the student must be able to:

	1. Understand and apply the Code of Ethics for Mining Engineers. 2. Understand the legal framework of the mining industry notably the Philippine Mining Act and its implementing rules and regulations; 3. Understand the Philippine Environmental Laws and its Implementing rules and regulation 4. Apply the principles of safety and ethical behavior to the practice of the Mining Engineering profession.
Course Outline	1. Evolution of Philippine mining legislation. 2. Philippine Mining Act and its Implementing Rules and Regulations. 3. Mine safety and health standards 4. Mining Engineering Law 5. Code of Ethics for Mining Engineers 6. Philippine Mineral Resource and Reserves Classification System 7. Philippine Environmental Laws 8. IPRA, LGC, NIPAS and other related laws 9. Decided cases related to the mining industry.
Laboratory Equipment	none

Course Name	**PRINCIPLES OF MINING**
Course Description	Principles of mineral exploration, mine development, exploitation and rehabilitation. Introduction to surface and underground mining methods. Socioeconomic importance and characteristics of the mineral industry.
Number of Units for Lecture & Laboratory	3 units lecture
Numbers of Contact Hours per Week	3 hours lecture
Prerequisite/Co-requisite	Co-requisite: Principles of Geology
Program Outcomes addressed by the course	a - apply knowledge of mathematics and science to solve complex engineering problems.
Course Outcomes	At the end of the course the students will be able to: Understand and apply knowledge on basic principle of mining, mining cycle, mining methods, history and overview of the mining industry in elucidating the socioeconomic importance of the mineral industry.
Course Outline	1. Introduction: Mining laws and government regulations; 2. Prospecting and Exploration – Techniques and methods; 3. Introduction to mineral resource/ore reserve estimation; 4. Mine development; 5. Mine exploitation; 6. Introduction of mineral deposits; 7. Mine production cycles. Drilling, Blasting, Loading, Hauling; 8. Surface and underground mining methods; and, 9. Miscellaneous topics.
Laboratory Equipment	none

Course Name	ROCK MECHANICS
Course Description	Introduction to rock mechanics. Physical and engineering properties of rocks, rock failures and fundamentals of rock mass and rock response to applied loads. Principle of the design of underground openings and pit slopes, ground support, tunnelling, and other practical applications.
Number of Units for Lecture & Laboratory	3 units: 2 units lecture; 1 unit laboratory
Numbers of Contact Hours per Week	2 hours lecture; 3 hours laboratory
Prerequisite/Co-requisite	Underground Mining, Surface Mining, Engineering Mechanics
Program Outcomes addressed by the course	a - apply knowledge of mathematics and science to solve complex engineering problems; b - design and conduct experiments, as well as to analyze and interpret data; c - design a system, component, or process to meet desired needs within realistic constraints, in accordance with standards; e - identify, formulate, and solve complex engineering problems; i - recognize the need for, and engage in life-long learning; k - use techniques, skills, and modern engineering tools necessary for engineering practice.
Course Outcomes	At the end of the course, the student will be able to: 1. Understand and apply the basic principles of rock mechanics and its related fields necessary in solving complex mining engineering problem; 2. Design and conduct experiments on rock mechanics as well as analyse and interpret data. 3. Design mine support system, component or process to meet desired needs within realistic constraints and accordance with standards; 4. Identify, formulate and solve complex rock mechanics related problems (e.g. underground supports and rock fragmentation); 5. Recognize the need for and engage in life-long learning on developments in rock mechanics, and 6. Use techniques, skills and modern engineering tools on testing mechanical properties of rocks necessary for mining engineering practice.
Course Outline	1. Introduction, definitions and applications. 2. Rock classification system. 3. Intact rock strength classification 4. Rock mass classification 5. Rock strength and failure criteria. (Modes of failure, laboratory tests, stress-strain behaviour, and failure criterion) 6. Application of rock mechanics in engineering for underground openings. 7. Observational methods of design. (Monitoring techniques, tunnelling method, and convergence-confinement method) 8. Analytical methods of design 9. Integrated designs 10. Design of Mine Pillars
Laboratory Equipment	none

Course Name	**SURFACE MINING**
Course Description	Merits of surface mining, engineering and economic factors in the selection and use of various equipment and systems in surface mining, ore estimations, grade control, mine planning, cost estimation, slope stability and control, placer and coal mining operations.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Principles of Mining
Program Outcomes	a - apply knowledge of mathematics and science to solve complex engineering problems; c - design a system, component, or process to meet desired needs within realistic constraints, in accordance with standards; e - identify, formulate, and solve complex engineering problems; f - understand professional and ethical responsibility; h - understand the impact of engineering solutions in a global, economic, environmental, and societal context;
Course Outcomes	At the end of the course, the student must be able to: 1. Acquire knowledge and skills in planning and designing of open pit and other surface mining methods; 2. Understand the important concepts on the mine management including selection of mine equipment, stripping ratios, grade control and mine planning.
Course Outline	6. Overview of surface mining methods. 7. Surface and open pit design considerations. 8. Orebody modeling. Grade determination and sampling techniques. Mineral resource/Ore reserve estimation and surface mapping. 9. Mine planning and design 10. Economics of surface mining. 11. Pit optimization 12. Production scheduling and operations. Equipment considerations, cycle of operations and sample problems. 13. Pit maintenance and auxiliary operations. 14. Rehabilitation of Mined-out areas
Laboratory Equipment	None

Course Name	**UNDERGROUND MINING**
Course Description	Criteria for the selection of underground mining method including coal mining. Techniques, unit operations and mine systems involved in the different underground mining methods. Development planning, engineering layout and extraction. Underground haulage systems, draw and grade control.
Number of Units for Lecture and Laboratory	3 units lecture

Number of Contact Hours per Week	3 hours lecture
Prerequisite	Principles of Mining
Program Outcomes	a - apply knowledge of mathematics and science to solve complex engineering problems; c - design a system, component, or process to meet desired needs within realistic constraints, in accordance with standards; e - identify, formulate, and solve complex engineering problems; f - understand professional and ethical responsibility; h - understand the impact of engineering solutions in a global, economic, environmental, and societal context.
Course Outcomes	At the end of the course, the student must be able to: Acquire the knowledge and understanding of the different underground mining methods and the associated mining basic operations.
Course Outline	1. Introduction (Definition of terms. Surface versus Underground Mining. Classification of underground mining methods. Guidelines and considerations in the selection of underground mining methods.) 2. Unsupported Mining Methods 3. Supported Mining Methods 4. Caving Methods 5. Basic operations in underground mining. (Drilling/Boring, Blasting, Shaft Sinking, Raise Driving, Hauling and Hoisting, Underground Support Systems)
Laboratory Equipment	none

Course Name	**TRACK SPECIALIZATION 1, 2, and 3**
Course Description	Discussion of current practices in mining and other relevant issues.
Number of Units for Lecture & Laboratory	3 units lecture
Numbers of Contact Hours per Week	3 hours lecture
Prerequisites	Senior Standing
Program Outcomes	h - Broad education necessary to understand the impacts of engineering solutions in a global, economic, environmental, and societal context i- Recognition of the need for, and an ability to engage in lifelong learning k - Ability to use techniques, skills and modern engineering tools necessary for engineering practice l - Knowledge and understanding of engineering and management principles as a member and leader in a team, to manage projects and in multidisciplinary environments
Course Outcomes	At the end of the course, the student must be able to: Acquire additional knowledge and understanding of various mining related topics that are not specifically taken into account by the regular mining courses.
Course Outline	Course outline will differ from semester to semester depending on the topics to be discussed. Topics include the following:

	I. MINING 1. Coal Mining 2. Drilling and Blasting 3. Tunneling 4. Mine Feasibility Studies 5. Mine Surveying 6. Mine Project Development 7. Contract Mining 8. Best Practices 9. Computer Applications in Mining II. ENERGY RESOURCE EXTRACTION 1. Introduction to Petroleum Engineering 2. Introduction to Geothermal Engineering 3. Energy related courses 4. Geotechnical Engineering
Laboratory Equipment	none

ANNEX IV: 2018 BSEM LABORATORY REQUIREMENTS

1. 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 Hexane Sugar NaCl Urea Oil	50 pcs. 5 pcs. 25 mL 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

2. 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	5 pcs.
	Spring balance	15 pcs.
	Weight holder	15 pcs.
	Masses	5 sets
	Ruler	5 pcs.
3. An exercise to observe and verify the elements of motion along the straight line	Linear air track with blower and trolley	5 pcs.
	Timer/stopwatch	5 pcs.
	Meter stick	5 pcs.
	Free fall apparatus	5 pcs.
	Metal balls of different sizes	12 pcs.
	Clamp	5 pcs.
	Support rod	5 pcs.
	Alternate apparatus:	
	Spark timer/ticker timer	5 pcs.
	Paper tape	5 pcs.
	Stopwatch	5 pcs.
	Plane board with stand	5 pcs.
	Clamp	5 pcs.
	Wooden cart	5 pcs.
	Scissors	5 pcs.
	Carbon paper	5 pcs.
	Masking tape	1 set
	Meter stick	5 pcs.
4. An exercise to observe and verify the elements of motion in two dimensions	Blackwood ballistic pendulum	5 pcs.
	Metal ball	5 pcs.
	Meter stick	5 pcs.
	Carbon paper	5 pcs.
	Inclined plane	5 pcs.
	Protractor	5 pcs.
	Alternate apparatus:	
	Projectile apparatus	5 pcs.
	Metal ball/plastic solid ball	5 pcs.
	Photogate	5 pcs.
	Timer/stopwatch	5 pcs.
	Time of flight receptor pad	5 pcs.
	Carbon paper	5 pcs.
	White paper	5 pcs.
	Meter-stick	5 pcs.
5. An exercise to verify the laws of motion	Atwood's machine	5 pcs.
	Masses	5 sets
	Stopwatch	5 pcs.
	String	5 pcs.
	Alternate apparatus:	
	Frictionless dynamic track	5 pcs.
	Smart pulley	5 pcs.
	Stopwatch	5 pcs.
	Weight holder	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	5 pcs. 5 sets 5 pcs. 5 pcs.

	Support rod Spring *Alternate apparatus:* Hooke's Law apparatus	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

3. 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 Ice Water	5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 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:*	5 pcs. 5 pcs. 5 pcs. 5 sets 15 pcs.

	Bread board Jumper	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 Ring Glass plate Iron fillings Frame for bar magnets Compass Mounted straight wire Coil Solenoid Battery Reversing switch	5 pcs. 5 pcs. 10 pcs. 5 pcs. 5 pcs. 5 sets 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs. 5 pcs.

	Alternate apparatus: Tesla meter / tangent galvanometer	 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 V: 2018 BSEM COURSE SAMPLE SYLLABUS

Course Name	**MINE ENVIRONMENTAL MANAGEMENT**
Course Description	The course is designed to provide knowledge on the environmental management, design and rehabilitation in the mine.
Number of Units for Lecture & Laboratory	3 units lecture
Numbers of Contact Hours per Week	3 hours lecture
Prerequisites	Principles of Mining, Environmental Science, and Engineering Management
Program Outcomes	a - apply knowledge of mathematics and science to solve complex engineering problems; c - design a system, component, or process to meet desired needs within realistic constraints, in accordance with standards; d - function in multidisciplinary and multi-cultural teams; e - identify, formulate, and solve complex engineering problems; f - understand professional and ethical responsibility; g - communicate effectively engineering activities with the engineering community and with society at large; h - understand the impact of engineering solutions in a global, economic, environmental, and societal context; i - recognize the need for, and engage in life-long learning.
Course Outcomes	At the end of the course, the student must be able to: 1. Familiarize with the various environmental impacts brought about by mining operations and production, and mineral processing and tailings disposal; 2. Appreciate the social and environmental responsibilities that are essential to future mining engineers; and, 3. Formulate mitigation measures, monitoring plans, and best practices for the environmental management of a mining operation.
Course Outline	1. International Perspective of Sustainable Development; 2. Corporate Responsibilities; 3. Legislation & Regulatory Framework; 4. Environmental Impact Assessment; 5. Environmental Management Systems 6. Environmental Auditing; 7. Mine Planning/Feasibility; 8. Studies/Documentation to Avoid Environmental Impact; 9. Environmental Management - an introduction, Environmental issues in mining; 10. Management of Mine Wastes; 11. Mine Tailings Disposal and Storage; 12. Environmental issues in tailings management; o Tailings dam incidents; o Chemical (Cyanide) Management; o Water pollution/Acid Mine Drainage and its remediation; 13. Environmental Monitoring; 14. Environmental Impacts and Management: o Air Quality; o Mineral Exploration, Quarries/extractives/industrial minerals, o Small scale & placer mining, o Uranium mining, (optional)

	15. Mining in developing countries - a case study, Social impact, Rehabilitation and closure.
Laboratory Equipment	none

Main topic	Time Allotment	Topic-Level Outcomes (TLO)	Assessment Strategies	Outcome-Based Evidence
PRELIMS				
1. International Perspective of Sustainable Development; 2. Corporate Responsibilities;	5 hours	TLO 1: Discuss the principles of environmental management and social system	• Recitation • Group / individual seat works • Presentations • Quiz	At least 70% of the students in the class get a rating of 75%.
3. Legislation & Regulatory Framework; 4. Environmental Impact Assessment;	5 hours	TLO 2: Discuss the legislative rulings. Implementing guidelines, and policies. Concepts of EIA: impact prediction and identification, predicting mitigating and proposing monitoring measures	• Recitation • Group / individual seat works • Presentation • Quiz • Case studies	At least 70% of the students in the class get a rating of 75%.
5. Environmental Management Systems; 6. Environmental Auditing;	5 hours	TLO 3: Explains the role of environmental management systems and importance of subsequent environmental auditing.	• Recitation • Group / individual seat works • Presentation • Exams and Quizzes • Case studies	At least 70% of the students in the class get a rating of 75%.
MIDTERMS				
7. Mine Planning/Feasibility; 8. Studies/Documentation to Avoid Environmental Impact; 9. Environmental Management - an introduction, Environmental issues in mining;	10 hours	TLO 4: Discuss the importance of implementing Environmental Management to address issues related to Mine Planning and Feasibility Studies.	• Recitation • Group / individual seat works • Presentation • Exams and Quizzes • Case studies	At least 70% of the students in the class get a rating of 75%.
10. Management of Mine Wastes; 11. Mine Tailings Disposal and Storage; 12. Environmental issues in tailings management; • Tailings dam incidents;	5 hours	TLO 5: Discuss the importance of managing mine (solid and liquid) wastes through proper storage, disposal, and treatment.	• Recitation • Group / individual seat works • Presentation • Exams and Quizzes • Case studies	At least 70% of the students in the class get a rating of 75%.

• Chemical (Cyanide) Management; • Water pollution/Acid Mine Drainage and its remediation;				
FINALS				
13. Environmental Monitoring; 14. Environmental Impacts and Management: o Air Quality; o Mineral Exploration, Quarries/extractives/industrial minerals, o Small scale & placer mining, o Uranium mining, (optional)	12 hours	TLO 6: Discuss the importance of establishing an environmental monitoring program/ plan in an environmental management system.	• Recitation • Group / individual seat works • Presentation • Exams and Quizzes • Case studies	At least 70% of the students in the class get a rating of 75%.
15. Mining in developing countries - a case study, Social impact, Rehabilitation and closure.	3 hours	TLO 7: Understand various cases of Mine Environment Management in the local, regional and international settings.	• Recitation • Group / individual seat works • Presentation • Exams and Quizzes • Case studies	At least 70% of the students in the class get a rating of 75%.

Final Grade Evaluation:

Assessment Measures	Preliminary Periods	Midterm Period	Final Period
1. Quizzes	40%	35%	35%
2. Class Participation (Problem sets/ assignments)	10%	10%	10%
3. Case Study	10%	15%	15%
4. Major Examination	40 %	40 %	40 %
Total	**100 %**	**100 %**	**100 %**

Final Grade= (Prelim + Midterm + Final) / 3

Learning Resources

1. References: a. DENR MGB shared documentation
   b. DENR EMB shared documentation
   c. Mining Issues (local, regional, and International)
   d. Internet guide

2. Laboratory: none