

**COURSE SPECIFICATIONS**  
**Bachelor of Science in Ceramics Engineering**

**I. TECHNICAL COURSES**

**A. MATHEMATICS**

Course Name	<b>COLLEGE ALGEBRA</b>
Course Description	Algebraic expressions and equations; solution sets of algebraic equations in one variable: linear, quadratic, polynomial of degree $n$ , fractional, radical equations, quadratic in form, exponential and logarithmic equations; decomposition of fractions into partial fractions; solution sets of systems of linear equations involving up to three variables.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	None
Course Objectives	After completing this course, the student must be able to: <ol style="list-style-type: none"> <li>1. Operate and simplify algebraic expressions;</li> <li>2. Determine the solution sets of all types of algebraic equations, exponential and logarithmic equations; and inequalities;</li> <li>3. Use the manipulative and analytical skills acquired in Objectives 1 to 2 to solve word problems; and</li> <li>4. Identify the domain and range of a given relation/function.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. The Set of Real Numbers             <ol style="list-style-type: none"> <li>1.1. Integer Exponents</li> <li>1.2. Polynomials, Operations, Special Products</li> <li>1.3. Binomial Expansion (Binomial Theorem)</li> <li>1.4. Factoring Polynomials</li> </ol> </li> <li>2. Rational Expressions             <ol style="list-style-type: none"> <li>2.1. Rules of Exponents; Simplification of Rational Expressions; Operations on Rational Expressions</li> <li>2.2. Properties of Radicals; Simplification of Radicals</li> <li>2.3. Operations on Radicals</li> <li>2.4. Complex Numbers</li> </ol> </li> <li>3. Equations in One Variable             <ol style="list-style-type: none"> <li>3.1. Linear Equations; Literal Equations</li> <li>3.2. Quadratic Equations in One Variable</li> <li>3.3. Word Problems</li> <li>3.4. Other Equations in One Variable: Radical, Fractional, Quadratic in Form</li> <li>3.5. Polynomial Equation of Degree <math>n</math></li> </ol> </li> <li>4. Functions             <ol style="list-style-type: none"> <li>4.1. Inverse Functions</li> <li>4.2. Exponential and Logarithmic Functions</li> <li>4.3. Exponential and Logarithmic Equations</li> </ol> </li> <li>5. Systems of Linear Equations (by Elimination Methods)</li> <li>6. Decomposition of Rational Expressions into Partial Fractions</li> </ol>
Laboratory Equipment	None

Suggested References	<p>Dugopolski, Mark. <i>College Algebra</i>, 3rd ed. Addison-Wesley, 2002.</p> <p>Leithold, Louis. <i>College Algebra and Trigonometry</i>. Massachusetts: Addison-Wesley, 1989.</p> <p>Mijares, Catalina. <i>College Algebra</i>.</p> <p>Swokowski, Earl W. and Jeffrey A. Cole. <i>Algebra and Trigonometry with Analytic Geometry</i>, 10th ed. Brooks/Cole Publishing Co., 2001.</p>
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Course Name	<b>ADVANCED ALGEBRA</b>
Course Description	Matrices and determinants; arithmetic and geometric series; solution sets of different types of inequalities and systems involving quadratics; solution of linear equations using determinants and matrices.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Prerequisites	College Algebra
Course Objectives	<p>After completing this course, the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Determine the solution sets of inequalities;</li> <li>2. Determine the solution sets of systems involving quadratics;</li> <li>3. Use the manipulative and analytical skills acquired in Objective 2 to solve word problems;</li> <li>4. Operate and manipulate matrices and determinants;</li> <li>5. Solve systems of linear equations using matrices and determinants; and</li> <li>6. Determine the indicated sum of the elements in an arithmetic and geometric sequence.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Inequalities             <ol style="list-style-type: none"> <li>1.1. Linear, Quadratic, and Polynomial Inequality</li> <li>1.2. Linear Inequalities with Absolute Value</li> </ol> </li> <li>2. Ratio, Proportion, and Variation</li> <li>3. Determinants             <ol style="list-style-type: none"> <li>3.1. Expansion by Minors</li> <li>3.2. Solution of Linear Systems by Cramer's Rule</li> </ol> </li> <li>4. Matrices             <ol style="list-style-type: none"> <li>4.1. Identity Matrix</li> <li>4.2. Cofactor Matrix</li> <li>4.3. Transpose of a Matrix</li> <li>4.4. Adjoint Matrix</li> <li>4.5. Inverse of a Matrix</li> <li>4.6. Algebra on Matrices (Sum and Difference, Scalar Multiplication, Matrix Multiplication)</li> <li>4.7. Solution of Linear Systems Using Matrices</li> </ol> </li> <li>5. Sequence and Series             <ol style="list-style-type: none"> <li>5.1. Arithmetic and Geometric Means</li> <li>5.2. Arithmetic and Geometric Sequences</li> <li>5.3. Arithmetic and Geometric Series</li> <li>5.4. Infinite Series</li> </ol> </li> <li>6. Combinatorial Mathematics             <ol style="list-style-type: none"> <li>6.1. Sequences</li> <li>6.2. The Factorial of a Number</li> <li>6.3. Fundamental Principles of Counting, Permutation, and Combination</li> <li>6.4. Binomial Theorem</li> <li>6.5. Mathematical Induction</li> </ol> </li> </ol>
Laboratory Equipment	None

Suggested References	<p>Dugopolski, Mark. <i>College Algebra</i>, 3rd ed. Addison-Wesley, 2002.</p> <p>Leithold, Louis. <i>College Algebra and Trigonometry</i>. Massachusetts: Addison-Wesley, 1989.</p> <p>Swokowski, Earl W. and Jeffrey A. Cole. <i>Algebra and Trigonometry with Analytic Geometry</i>, 10th ed. Brooks/Cole Publishing Co., 2001.</p>
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Course Name	<b>PLANE AND SPHERICAL TRIGONOMETRY</b>
Course Description	Trigonometric functions; identities and equations; solutions of triangles; law of sines; law of cosines; inverse trigonometric functions; spherical trigonometry
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	None
Course Objectives	<p>After completing this course, the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Define angles and how they are measured;</li> <li>2. Define and evaluate each of the six trigonometric functions;</li> <li>3. Prove trigonometric functions;</li> <li>4. Define and evaluate inverse trigonometric functions;</li> <li>5. Solve trigonometric equations;</li> <li>6. Solve problems involving right triangles using trigonometric function definitions for acute angles; and</li> <li>7. Solve problems involving oblique triangles by the use of the sine and cosine laws.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Trigonometric Functions               <ol style="list-style-type: none"> <li>1.1. Angles and Measurement</li> <li>1.2. Trigonometric Functions of Angles</li> <li>1.3. Trigonometric Function Values</li> <li>1.4. The Sine and Cosine of Real Numbers</li> <li>1.5. Graphs of the Sine and Cosine and Other Sine Waves</li> <li>1.6. Solutions of Right Triangle</li> </ol> </li> <li>2. Analytic Trigonometry               <ol style="list-style-type: none"> <li>2.1. The Eight Fundamental Identities</li> <li>2.2. Proving Trigonometric Identities</li> <li>2.3. Sum and Difference Identities</li> <li>2.4. Double-Measure and Half-Measure Identities</li> <li>2.5. Inverse Trigonometric Functions</li> <li>2.6. Trigonometric Equations</li> <li>2.7. Identities for the Product, Sum, and Difference of Sine and Cosine</li> </ol> </li> <li>3. Application of Trigonometry               <ol style="list-style-type: none"> <li>3.1. The Law of Sines</li> <li>3.2. The Law of Cosines</li> </ol> </li> <li>4. Spherical Trigonometry               <ol style="list-style-type: none"> <li>4.1. Fundamental Formulas</li> <li>4.2. Spherical Triangles</li> </ol> </li> </ol>
Laboratory Equipment	None
Suggested References	<p>Dilley, et al. <i>Algebra 2 with Trigonometry</i>. D.C. Heath &amp; Co., 1990.</p> <p>Leithold, Louis. <i>College Algebra and Trigonometry</i>. Addison-Wesley, 1992.</p> <p>Sobel, Max A. and Norbert Lerner. <i>Algebra and Trigonometry</i>, 4th ed. New Jersey: Prentice Hall, Inc., 1995.</p>

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

Suggested References	<p>Fuller, Gordon and Dalton Tarwater. <i>Analytic Geometry</i>, 7th ed. Addison-Wesley, 1993.</p> <p>Protter, Murray H. and Philip E. Protter. <i>Calculus with Analytic Geometry</i>, 4th ed.</p> <p>Quirino and Mijares. <i>Plane and Analytic Geometry</i>, 2nd ed.</p> <p>Riddle, Douglas F. <i>Analytic Geometry</i>, 6th ed.</p> <p>Swokowski, Earl W. and Jeffrey A. Cole. <i>Algebra and Trigonometry with Analytic Geometry</i>, 10th ed. Brooks/Cole Publishing Co., 2001.</p>
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Course Name	<b>SOLID MENSURATION</b>
Course Description	Concept of lines and planes; Cavalieri's and Volume theorems; formulas for areas of plane figures, volumes for solids; volumes and surfaces areas for spheres, pyramids, and cones; zone, sector and segment of a sphere; theorems of Pappus.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Prerequisite	College Algebra, Plane and Spherical Trigonometry
Course Objectives	<p>After completing this course, the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Compute for the area of plane figures;</li> <li>2. Compute for the surface areas and volumes of different types of solids; and</li> <li>3. Determine the volumes and surface areas of solids using other methods such as the theorems of Pappus.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Plane Figures             <ol style="list-style-type: none"> <li>1.1. Mensuration of Plane Figures</li> </ol> </li> <li>2. Lines and Planes in Space             <ol style="list-style-type: none"> <li>2.1. Typical Proofs of Solid Geometry</li> <li>2.2. Angles</li> </ol> </li> <li>3. Solids for which <math>V = Bh</math> <ol style="list-style-type: none"> <li>3.1. Solid Sections</li> <li>3.2. Cubes</li> <li>3.3. Rectangular Parallelopiped</li> <li>3.4. Cavalieri's Theorem</li> <li>3.5. Volume Theorem</li> <li>3.6. Prism</li> <li>3.7. Cylindrical Surface</li> <li>3.8. Cylinder (Circular and Right Circular)</li> </ol> </li> <li>4. Solids for which <math>V = \frac{1}{3}Bh</math> <ol style="list-style-type: none"> <li>4.1. Pyramids</li> <li>4.2. Similar Figures</li> <li>4.3. Cones</li> <li>4.4. Frustum of Regular Pyramid</li> <li>4.5. Frustum of Right Circular Cone</li> </ol> </li> <li>5. Sphere             <ol style="list-style-type: none"> <li>5.1. Surface Area and Volume</li> <li>5.2. Zone</li> <li>5.3. Segment</li> <li>5.4. Sector</li> </ol> </li> <li>6. Theorems of Pappus</li> </ol>
Laboratory Equipment	None

Suggested Reference	Kern, Willis F. and James R. Bland. <i>Solid Mensuration</i> , 2nd ed. New York: John Wiley & Sons, Inc.
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Course Name	<b>DIFFERENTIAL CALCULUS</b>
Course Description	Basic concepts of calculus such as limits, continuity and differentiability of functions; differentiation of algebraic and transcendental functions involving one or more variables; applications of differential calculus to problems on optimization, rates of change, related rates, tangents and normals, and approximations; partial differentiation and transcendental curve tracing.
Number of Units for Lecture and Laboratory	4 units lecture
Number of Contact Hours per Week	4 hours lecture
Prerequisites	Advanced Algebra Analytic Geometry Solid Mensuration
Course Objectives	After completing this course, the student must be able to: <ol style="list-style-type: none"> <li>1. Have a working knowledge of the basic concepts of functions and limits;</li> <li>2. Differentiate algebraic and transcendental functions with ease;</li> <li>3. Apply the concept of differentiation in solving word problems involving optimization, related rates, and approximation; and</li> <li>4. Analyze and trace transcendental curves.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Functions <ol style="list-style-type: none"> <li>1.1. Definitions</li> <li>1.2. Classification of Functions</li> <li>1.3. Domain and Range of a Function</li> <li>1.4. Graph of a Function</li> <li>1.5. Functional Notation</li> <li>1.6. Evaluation of a Function</li> <li>1.7. Combinations of Functions</li> <li>1.8. One-Valued and Many-Valued Functions</li> <li>1.9. Odd and Even Functions</li> <li>1.10. Special Function Types</li> <li>1.11. Functions as Mathematical Models</li> </ol> </li> <li>2. Continuity <ol style="list-style-type: none"> <li>2.1. Definition</li> <li>2.2. Properties of Continuous Functions</li> </ol> </li> <li>3. Limits <ol style="list-style-type: none"> <li>3.1. Notion of a Limit</li> <li>3.2. Definition</li> <li>3.3. Properties of Limits</li> <li>3.4. Operations with Limits</li> <li>3.5. Evaluation of Limits</li> <li>3.6. One-Sided Limits</li> <li>3.7. Unbounded Functions</li> </ol> </li> <li>4. The Derivative <ol style="list-style-type: none"> <li>4.1. Notion of the Derivative</li> <li>4.2. Definition</li> <li>4.3. Determination of the Derivative by Increments</li> <li>4.4. Differentiation Rules</li> </ol> </li> <li>5. The Slope <ol style="list-style-type: none"> <li>5.1. Definition of Slope as the Derivative of a Function</li> <li>5.2. Determination of the Slope of a Curve at a Given Point</li> </ol> </li> <li>6. Rate of Change <ol style="list-style-type: none"> <li>6.1. Average Rate of Change</li> </ol> </li> </ol>

	<ol style="list-style-type: none"> <li>6.2. Instantaneous Rate of Change</li> <li>7. The Chain Rule and the General Power Rule</li> <li>8. Implicit Differentiation</li> <li>9. Higher-Order Derivatives</li> <li>10. Polynomial Curves             <ol style="list-style-type: none"> <li>10.1. Generalities About Straight Lines</li> <li>10.2. Tangents and Normal to Curves</li> <li>10.3. Extrema and the First Derivative Test</li> <li>10.4. Concavity and the Second Derivative Test</li> <li>10.5. Points of Inflection</li> <li>10.6. Sketching Polynomial Curves</li> </ol> </li> <li>11. Applications of the Derivative: Optimization Problems</li> <li>12. Applications of the Derivative: Related Rates</li> <li>13. The Differential             <ol style="list-style-type: none"> <li>13.1. Definition</li> <li>13.2. Applications of the Differential—Comparison of <math>\Delta x</math> and <math>dx</math></li> <li>13.3. Error Propagation</li> <li>13.4. Approximate Formulas</li> </ol> </li> <li>14. Derivatives of Trigonometric Functions             <ol style="list-style-type: none"> <li>14.1. Elementary Properties</li> <li>14.2. Definition</li> <li>14.3. Graphs of Trigonometric Functions</li> <li>14.4. Applications</li> </ol> </li> <li>15. Derivatives of Inverse Trigonometric Functions             <ol style="list-style-type: none"> <li>15.1. Elementary Properties</li> <li>15.2. Definition</li> <li>15.3. Graphs of Inverse Trigonometric Functions</li> <li>15.4. Applications</li> </ol> </li> <li>16. Derivatives of Logarithmic and Exponential Functions             <ol style="list-style-type: none"> <li>16.1. Elementary Properties</li> <li>16.2. Definition</li> <li>16.3. Graphs of Logarithmic and Exponential Functions</li> <li>16.4. Applications</li> </ol> </li> <li>17. Derivatives of Hyperbolic Functions             <ol style="list-style-type: none"> <li>17.1. Elementary Properties</li> <li>17.2. Definition</li> <li>17.3. Graphs of Hyperbolic Functions</li> <li>17.4. Applications</li> </ol> </li> <li>18. Solution of Equations             <ol style="list-style-type: none"> <li>18.1. Newton's Method of Approximation</li> <li>18.2. Newton-Raphson Law</li> </ol> </li> <li>19. Transcendental Curve Tracing             <ol style="list-style-type: none"> <li>19.1. Logarithmic and Exponential Functions</li> </ol> </li> <li>20. Parametric Equations</li> <li>21. Partial Differentiation</li> </ol>
Laboratory Equipment	None
Suggested References	<p>Anton, Howard. <i>Multivariable Calculus</i>, 4th ed. New York: John Wiley &amp; Sons, Inc., 1992.</p> <p>Berkey, Dennis D. <i>Calculus for Management and Social Sciences</i>, 2nd ed. Saunders College Publishing, 1990</p> <p>Cozzens, Margaret B. and Richard D. Porter. <i>Mathematics with Calculus</i>. D.C. Heath &amp; Co., 1987</p> <p>Ellis, Robert and Benny Gulick. <i>Calculus with Analytic Geometry</i>. Harcourt Brace Jovanovich, 1990.</p> <p>Farlow, Stanley J. <i>Calculus and Its Application</i>. McGraw-Hill Publishing, 1990.</p> <p>Goldstein, Larry J., David C. Lay and David I. Schneider. <i>Calculus and Its Application</i>, 6th ed. Prentice Hall, Inc., 1993.</p> <p>Harsbarger, Ronald J. and James J. Reynolds. <i>Calculus with Applications</i>. D.C. Heath &amp; Co., 1990.</p>

Hoffman, Laurence D. *Calculus for Business, Economics and the Social and Life Sciences*, 3rd ed. McGraw-Hill Book Co., 1989.  
 Holder, Leonard L. *A Primer for Calculus*, 4th ed. Wadsworth Publishing Co., 1987.  
 Larson, Roland E. and Bruce H. Edwards. *Finite Mathematics with Calculus*. D.C. Heath & Co., 1987.  
 Leithold, Louis. *The Calculus*, 7th ed. Addison-Wesley, 2001.  
 Lial, Margaret L. and Charles D. Miller. *Finite Mathematics and Calculus with Application*, 3rd ed. Scott, Foresman and Company, 1989.  
 Protter, Murray H. *Calculus with Analytic Geometry*. James & Barlett, 1988.  
 Swokowski, Earl W. *Calculus*, 5th ed. PWS-Kent Publishing, 1991.  
 Zill, Dennis G. *Calculus with Analytic Geometry*. PWS-Kent Publishing, 1988.  
 Zitarella, David E. and Raymond F. Coughlin. *Finite Mathematics with Calculus: An Applied Approach*. Sanders College Publishing, 1989.

Course Name	<b>INTEGRAL CALCULUS</b>
Course Description	Concept of integration and its application to physical problems such as evaluation of areas, volumes of revolution, force, and work; fundamental formulas and various techniques of integration applied to both single variable and multi-variable functions; tracing of functions of two variables.
Number of Units for Lecture and Laboratory	4 units lecture
Number of Contact Hours per Week	4 hours lecture
Prerequisite	Differential Calculus
Course Objectives	<p>After completing this course, the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Properly carry out integration through the use of the fundamental formulas and/or the various techniques of integration for both single and multiple integrals;</li> <li>2. Correctly apply the concept of integration in solving problems involving evaluation of areas, volumes, work, and force;</li> <li>3. Sketch 3-dimensional regions bounded by several surfaces; and</li> <li>4. Evaluate volumes of 3-dimensional regions bounded by two or more surfaces through the use of the double or triple integral.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Integration Concept / Formulas             <ol style="list-style-type: none"> <li>1.1. Anti-Differentiation</li> <li>1.2. Simple Power Formula</li> <li>1.3. Simple Trigonometric Functions</li> <li>1.4. Logarithmic Function</li> <li>1.5. Exponential Function</li> <li>1.6. Inverse Trigonometric Functions</li> <li>1.7. Hyperbolic Functions</li> <li>1.8. General Power Formula</li> <li>1.9. Constant of Integration</li> <li>1.10. Definite Integral</li> </ol> </li> <li>2. Integration Techniques             <ol style="list-style-type: none"> <li>2.1. Integration by Parts</li> <li>2.2. Trigonometric Integrals</li> <li>2.3. Trigonometric Substitution</li> <li>2.4. Rational Functions</li> <li>2.5. Rationalizing Substitution</li> </ol> </li> <li>3. Application             <ol style="list-style-type: none"> <li>3.1. Improper Integrals</li> <li>3.2. Plane Area</li> </ol> </li> </ol>

	<ul style="list-style-type: none"> <li>3.3. Areas Between Curves</li> <li>4. Other Applications <ul style="list-style-type: none"> <li>4.1. Volumes</li> <li>4.2. Work</li> <li>4.3. Hydrostatics Pressure and Force</li> </ul> </li> <li>5. Surfaces Multiple Integral as Volume <ul style="list-style-type: none"> <li>5.1. Surface Tracing: Planes</li> <li>5.2. Spheres</li> <li>5.3. Cylinders</li> <li>5.4. Quadratic Surfaces</li> <li>5.5. Double Integrals</li> <li>5.6. Triple Integrals</li> </ul> </li> <li>6. Multiple Integral as Volume <ul style="list-style-type: none"> <li>6.1. Double Integrals</li> <li>6.2. Triple Integrals</li> </ul> </li> </ul>
Laboratory Equipment	None
Suggested References	<p>Anton, Howard. <i>Multivariable Calculus</i>, 4th ed. New York: John Wiley &amp; Sons, Inc., 1992.</p> <p>Berkey, Dennis D. <i>Calculus for Management and Social Sciences</i>, 2nd ed. Saunders College Publishing, 1990.</p> <p>Cozzens, Margaret B. and Richard D. Porter. <i>Mathematics with Calculus</i>. D.C. Heath &amp; Co., 1987.</p> <p>Ellis, Robert and Benny Gulick. <i>Calculus with Analytic Geometry</i>. Harcourt Brace Jovanovich, 1990.</p> <p>Farlow, Stanley J. <i>Calculus and Its Application</i>. McGraw-Hill Publishing, 1990.</p> <p>Goldstein, Larry J., David C. Lay and David I. Schneider. <i>Calculus and Its Application</i>, 6th ed. Prentice Hall, Inc., 1993.</p> <p>Harsbarger, Ronald J. and James J. Reynolds. <i>Calculus with Applications</i>. D.C. Heath &amp; Co., 1990.</p> <p>Hoffman, Laurence D. <i>Calculus for Business, Economics and the Social and Life Sciences</i>, 3rd ed. McGraw-Hill Book Co., 1989.</p> <p>Leithold, Louis. <i>The Calculus</i>, 7th ed. Addison-Wesley, 2001.</p>

Course Name	<b>DIFFERENTIAL EQUATIONS</b>
Course Description	Differentiation and integration in solving first order, first-degree differential equations, and linear differential equations of order $n$ ; Laplace transforms in solving differential equations.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Integral Calculus
Course Objectives	<p>After completing this course, the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Solve the different types of differential equations; and</li> <li>2. Apply differential equations to selected engineering problems.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Definitions <ul style="list-style-type: none"> <li>1.1. Definition and Classifications of Differential Equations (D.E.)</li> <li>1.2. Order Degree of a D.E. / Linearity</li> <li>1.3. Solution of a D.E. (General and Particular)</li> </ul> </li> <li>2. Solution of Some 1st Order, 1st Degree D.E. <ul style="list-style-type: none"> <li>2.1. Variable Separable</li> <li>2.2. Homogeneous</li> </ul> </li> </ol>

	<ul style="list-style-type: none"> <li>2.3. Exact</li> <li>2.4. Linear</li> <li>2.5. Equations Linear in a Function</li> <li>2.6. Bernoulli's Equation</li> <li>3. Applications of 1st Order D.E.               <ul style="list-style-type: none"> <li>3.1. Decomposition / Growth</li> <li>3.2. Newton's Law of Cooling</li> <li>3.3. Mixing (Non-Reacting Fluids)</li> <li>3.4. Electric Circuits</li> </ul> </li> <li>4. Linear D.E. of Order <math>n</math> <ul style="list-style-type: none"> <li>4.1. Standard Form of a Linear D.E.</li> <li>4.2. Linear Independence of a Set of Functions</li> <li>4.3. Differential Operators</li> <li>4.4. Differential Operator Form of a Linear D.E.</li> </ul> </li> <li>5. Homogeneous Linear D.E. with Constant Coefficients               <ul style="list-style-type: none"> <li>5.1. General Solution</li> <li>5.2. Auxiliary Equation</li> </ul> </li> <li>6. Non-Homogeneous D.E. with Constant-Coefficients               <ul style="list-style-type: none"> <li>6.1. Form of the General Solution</li> <li>6.2. Solution by Method of Undetermined Coefficients</li> <li>6.3. Solution by Variation of Parameters</li> </ul> </li> </ul>
Laboratory Equipment	None
Suggested References	<p>Asin, Ricardo C. <i>Elementary Differential Equations</i>. National Book Store, 1991.</p> <p>Dela Fuente, Feliciano and Uy. <i>Elementary Differential Equations</i>. National Book Store, 1999.</p>

Course Name	<b>PROBABILITY AND STATISTICS</b>
Course Description	Basic principles of statistics; presentation and analysis of data; averages, median, mode; deviations; probability distributions; normal curves and applications; regression analysis and correlation; application to engineering problems.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	College Algebra
Course Objectives	<p>After completing this course, the student must be able to:</p> <ul style="list-style-type: none"> <li>1. Define relevant statistical terms;</li> <li>2. Discuss competently the following concepts:           <ul style="list-style-type: none"> <li>2.1. Frequency distribution</li> <li>2.2. Measures of central tendency</li> <li>2.3. Probability distribution</li> <li>2.4. Normal distribution</li> <li>2.5. Inferential statistics</li> </ul> </li> <li>3. Apply accurately statistical knowledge in solving specific engineering problem situations.</li> </ul>
Course Outline	<ul style="list-style-type: none"> <li>1. Basic Concepts           <ul style="list-style-type: none"> <li>1.1. Definition of Statistical Terms</li> <li>1.2. Importance of Statistics</li> </ul> </li> <li>2. Steps in Conducting a Statistical Inquiry</li> <li>3. Presentation of Data           <ul style="list-style-type: none"> <li>3.1. Textual</li> </ul> </li> </ul>

	<ul style="list-style-type: none"> <li>3.2. Tabular</li> <li>3.3. Graphical</li> <li>4. Sampling Techniques</li> <li>5. Measures of Central Tendency <ul style="list-style-type: none"> <li>5.1. Mean</li> <li>5.2. Median</li> <li>5.3. Mode</li> <li>5.4. Skewness and Kurtosis</li> </ul> </li> <li>6. Measures of Variation <ul style="list-style-type: none"> <li>6.1. Range</li> <li>6.2. Mean Absolute Deviation</li> <li>6.3. Variance</li> <li>6.4. Standard Deviation</li> <li>6.5. Coefficient of Variation</li> </ul> </li> <li>7. Probability Distributions <ul style="list-style-type: none"> <li>7.1. Counting Techniques</li> <li>7.2. Probability</li> <li>7.3. Mathematical Expectations</li> <li>7.4. Normal Distributions</li> </ul> </li> <li>8. Inferential Statistics <ul style="list-style-type: none"> <li>8.1. Test of Hypothesis</li> <li>8.2. Test Concerning Means, Variation, and Proportion</li> <li>8.3. Contingency Tables</li> <li>8.4. Test of Independence</li> <li>8.5. Goodness-of-Fit Test</li> </ul> </li> <li>9. Analysis of Variance</li> <li>10. Regression and Correlation</li> </ul>
Laboratory Equipment	None
Suggested References	<p>Sellers, Gene R. and Stephen A. Vardeman. <i>Elementary Statistics</i>, 2nd ed. Saunders College Publishing, 1982.</p> <p>Walpole, Ronald E., et al. <i>Probability and Statistics for Engineers and Scientists</i>, 7th ed. Prentice Hall, Inc., 2002.</p>

## B. NATURAL/PHYSICAL SCIENCES

Course Name	<b>GENERAL CHEMISTRY</b>
Course Description	Basic concepts of matter and its classification; mass relationships in chemical reactions; properties of gases, liquids, and solids; concepts of thermochemistry; quantum theory and electronic behavior; periodic relationship of elements in the periodic table; intramolecular forces; and solutions.
Number of Units for Lecture and Laboratory	4 units: 3 units lecture, 1 unit laboratory
Number of Contact Hours per Week	6 hours: 3 hours lecture, 3 hours laboratory
Prerequisite	None
Course Objectives	<p>After completing this course, the student must be able to:</p> <ul style="list-style-type: none"> <li>1. Apply significant figures and appropriate units in all measurements and calculations;</li> <li>2. Classify matter; distinguish between physical and chemical properties/changes;</li> <li>3. Define and explain the concepts of atomic mass, average atomic mass, mole, molar mass and perform calculations involving these;</li> <li>4. Balance and interpret chemical equations and perform stoichiometric</li> </ul>

	<p>calculations;</p> <ol style="list-style-type: none"> <li>5. Write, explain and apply the gas laws;</li> <li>6. Discuss the kinetic molecular theory (KMT) of gases and use the KMT to qualitatively explain the gas laws; argue the differences between ideal and non-ideal gas behavior;</li> <li>7. Define enthalpy; classify common processes as exothermic or endothermic and know the sign conventions;</li> <li>8. Trace the various atomic theories; discuss the Bohr model; and explain the line spectra of hydrogen; Discuss the concept of electron density; contrast the Bohr's orbits with orbitals in the quantum theory;</li> <li>9. Write electron configurations and orbital diagrams for multi electron atoms;</li> <li>10. Use the periodic table to classify elements and predict trends in properties;</li> <li>11. Write Lewis dot symbols and Lewis structure;</li> <li>12. Explain valence bond theory, hybrid orbitals, and hybridization in common compounds</li> <li>13. Distinguish between inter- and intramolecular forces; give examples of intramolecular forces and how they relate to physical properties;</li> <li>14. Distinguish between crystalline and amorphous solids</li> <li>15. Discuss various physical changes and interpret phase diagrams;</li> <li>16. Distinguish different types of solutions; work with different concentration units; Understand the effect of temperature and pressure on solubility; and</li> <li>17. Explain and apply colligative properties to determine molar mass.</li> </ol>
<p>Course Outline</p>	<ol style="list-style-type: none"> <li>1. The Study of Change       <ol style="list-style-type: none"> <li>1.1. Introduction to Chemistry</li> <li>1.2. Matter: Classification, States, Physical, and Chemical Properties</li> <li>1.3. Measurement and Handling of Numbers</li> </ol> </li> <li>2. Atoms, Molecules, and Ions       <ol style="list-style-type: none"> <li>2.1. The Atomic Theory</li> <li>2.2. The Structure of the Atom</li> <li>2.3. Atomic Number, Mass Number, Isotopes</li> <li>2.4. The Periodic Table</li> <li>2.5. Molecules and Ions</li> <li>2.6. Chemical Formulas</li> <li>2.7. Naming Compounds</li> </ol> </li> <li>3. Mass Relationships in Chemical Reaction       <ol style="list-style-type: none"> <li>3.1. Atomic Mass</li> <li>3.2. Molar Mass of an Element and Avogadro's Number</li> <li>3.3. Molecular Mass</li> <li>3.4. Percent Composition of Compounds</li> <li>3.5. Chemical Reactions and Chemical Equations</li> <li>3.6. Amounts of Reactants and Products</li> <li>3.7. Limiting Reagents</li> <li>3.8. Reaction Yield</li> </ol> </li> <li>4. Gases       <ol style="list-style-type: none"> <li>4.1. Substances That Exist as Gases</li> <li>4.2. Pressure of a Gas</li> <li>4.3. The Gas Laws</li> <li>4.4. The Ideal Gas Equation</li> <li>4.5. Gas Stoichiometry</li> <li>4.6. Dalton's Law of Partial Pressure</li> <li>4.7. The Kinetic Molecular Theory of Gases</li> <li>4.8. Deviation from Ideal Behavior</li> </ol> </li> <li>5. Thermochemistry       <ol style="list-style-type: none"> <li>5.1. Energy Changes in Chemical Reactions</li> <li>5.2. Introduction to Thermodynamics</li> <li>5.3. Enthalpy</li> </ol> </li> <li>6. Quantum Theory and the Electronic Structure of Atoms       <ol style="list-style-type: none"> <li>6.1. From Classical Physics to Quantum Theory</li> <li>6.2. Bohr's Theory of the Hydrogen Atom</li> <li>6.3. The Dual Nature of the Electron</li> </ol> </li> </ol>

	<ul style="list-style-type: none"> <li>6.4. Quantum Mechanics</li> <li>6.5. Quantum Numbers</li> <li>6.6. Atomic Orbitals</li> <li>6.7. Electron Configuration</li> <li>6.8. The Building-Up Principle</li> <li>7. Periodic Relationships Among the Elements               <ul style="list-style-type: none"> <li>7.1. Periodic Classification of the Elements</li> <li>7.2. Periodic Variation in Physical Properties</li> <li>7.3. Ionization Energy</li> <li>7.4. Electron Affinity</li> </ul> </li> <li>8. Chemical Bonding: Basic Concepts               <ul style="list-style-type: none"> <li>8.1. Lewis Dot Structure</li> <li>8.2. The Ionic Bond</li> <li>8.3. The Covalent Bond</li> <li>8.4. Electronegativity</li> <li>8.5. Writing Lewis Structure</li> <li>8.6. The Concept of Resonance</li> <li>8.7. Bond Energy</li> </ul> </li> <li>9. Chemical Bonding: Molecular Geometry and Hybridization               <ul style="list-style-type: none"> <li>9.1. Molecular Geometry</li> <li>9.2. Dipole Moments</li> <li>9.3. The Valence Bond Theory</li> <li>9.4. Hybridization of Atomic Orbitals</li> <li>9.5. Hybridization in Molecules Containing Double and Triple Bonds</li> </ul> </li> <li>10. Intermolecular Forces in Liquids and Solids               <ul style="list-style-type: none"> <li>10.1. The KMT of Liquids and Solids</li> <li>10.2. Intermolecular Forces</li> <li>10.3. Properties of Liquids</li> <li>10.4. Crystalline vs. Amorphous Solids</li> <li>10.5. Phase Changes</li> <li>10.6. Phase Diagrams</li> </ul> </li> <li>11. Physical Properties of Solutions               <ul style="list-style-type: none"> <li>11.1. Types of Solutions</li> <li>11.2. A Molecular View of the Solution Process</li> <li>11.3. Concentration Units</li> <li>11.4. Effect of Temperature and Pressure on Solubility</li> <li>11.5. Colligative Properties</li> </ul> </li> </ul>
Laboratory Equipment	Chemistry Laboratory(see attached)
Suggested References	<p>Chang, Raymond. <i>Chemistry</i>, 8th ed. (International Ed.). New York: McGraw Hill, 2005.</p> <p>Eubanks, Lucy P., et al. <i>Chemistry in Context</i>, 5th ed. Boston: McGraw Hill, 2006.</p> <p>Masterton, William L. and Cecile N. Hurley. <i>Chemistry: Principles and Reactions</i>, 5th ed. Canada: Thomson Brooks/Cole, 2004.</p> <p>Brady, James E., and Fred Senese. <i>Chemistry: Matter and Its Changes</i>, 4th ed. New Jersey: John Wiley &amp; Sons, Inc., 2004.</p> <p>Brown, Theodore L., et al. <i>Chemistry: The Central Science</i>, 9th ed. New Jersey: 2003.</p> <p>Silberberg, Martin S. <i>Chemistry: The Molecular Nature of Matter and Change</i>, 3rd ed. (International Ed.). New York: McGraw Hill, 2003.</p>

Course Name	<b>PHYSICS 1</b>
Course Description	Vectors; kinematics; dynamics; work, energy, and power; impulse and momentum; rotation; dynamics of rotation; elasticity; and oscillation.
Number of Units for Lecture and Laboratory	4 units: 3 units lecture, 1 unit laboratory

Number of Contact Hours per Week	6 hours: 3 hours lecture, 3 hours laboratory
Prerequisites	College Algebra Plane and Spherical Trigonometry
Course Objectives	<p>After completing this course, the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Differentiate a vector from a scalar;</li> <li>2. Determine the resultant of concurrent vectors;</li> <li>3. Solve problems in kinematics;</li> <li>4. Apply Newton's Laws of Motion;</li> <li>5. Determine the gravitational force between different masses;</li> <li>6. Solve problems involving centripetal force for horizontal and vertical curves;</li> <li>7. Compute the work done on a given body;</li> <li>8. Relate work and energy;</li> <li>9. Solve problems by applying the law of conservation of energy;</li> <li>10. Solve problems in impulse and momentum and collisions;</li> <li>11. Determine the stress and strain on a body; and</li> <li>12. Determine the period of a body in simple harmonic motion.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Work, Energy and Power             <ol style="list-style-type: none"> <li>1.1. Definition of Work, Energy and Power</li> <li>1.2. Conservation of Energy</li> </ol> </li> <li>2. Impulse and Momentum             <ol style="list-style-type: none"> <li>2.1. Definition of Impulse and Momentum</li> <li>2.2. Conservation of Momentum</li> </ol> </li> <li>3. Vector             <ol style="list-style-type: none"> <li>3.1. Vectors and Scalars</li> <li>3.2. Graphical Method</li> <li>3.3. Analytical Method</li> </ol> </li> <li>4. Vector Subtraction</li> <li>5. Kinematics             <ol style="list-style-type: none"> <li>5.1. Equations of Kinematics</li> <li>5.2. Freely Falling Bodies</li> <li>5.3. Projectile Motion</li> </ol> </li> <li>6. Dynamics             <ol style="list-style-type: none"> <li>6.1. Newton's Laws of Motion</li> <li>6.2. Friction</li> <li>6.3. First Condition of Equilibrium</li> </ol> </li> <li>7. Work, Energy and Power             <ol style="list-style-type: none"> <li>7.1. Definition of Work, Energy and Power</li> <li>7.2. Conservation of Energy</li> </ol> </li> <li>8. Impulse and Momentum             <ol style="list-style-type: none"> <li>8.1. Definition of Impulse and Momentum</li> <li>8.2. Conservation of Momentum</li> <li>8.3. Collisions, Coefficient of Restitution</li> </ol> </li> <li>9. Rotation             <ol style="list-style-type: none"> <li>9.1. Definition of torque</li> <li>9.2. Second Condition of Equilibrium</li> <li>9.3. Center of Gravity</li> </ol> </li> <li>10. Dynamics of Rotation             <ol style="list-style-type: none"> <li>10.1. Kinematics of Rotation</li> <li>10.2. Dynamics of Rotation</li> <li>10.3. Center of Gravity</li> </ol> </li> <li>11. Elasticity             <ol style="list-style-type: none"> <li>11.1. Hooke's Law</li> <li>11.2. Stress and Strain</li> <li>11.3. Modulus of Elasticity</li> </ol> </li> <li>12. Oscillations             <ol style="list-style-type: none"> <li>12.1. Definition of Vibration Motion and Simple Harmonic Motion</li> <li>12.2. Kinematics of Simple Harmonic Motion</li> </ol> </li> </ol>

	12.3. Simple Pendulum
Laboratory Equipment	Physics Laboratory (see attached)
Suggested References	<p>Cutnell, J.D. and K.W. Johnsons. <i>Physics</i>, 4th ed.</p> <p>Halliday, David, Robert Resnick and Jearl Walker. <i>Fundamentals of Physics</i>, 5th ed. John Wiley &amp; Sons, Inc., 1996.</p> <p>Serway, Raymond A. and John W. Jewett Jr. <i>Physics for Scientists and Engineers</i>, 6th ed. Brooks/Cole Publishing Co., 2003.</p> <p>Young, Hugh D. and Roger A. Freedman. <i>University Physics</i>, 10th ed. Addison Wesley.</p>

Course Name	<b>PHYSICS 2</b>
Course Description	Fluids; thermal expansion, thermal stress; heat transfer; calorimetry; waves; electrostatics; electricity; magnetism; optics; image formation by plane and curved mirrors; and image formation by thin lenses.
Number of Units for Lecture and Laboratory	4 units: 3 units lecture, 1 unit laboratory
Number of Contact Hours per Week	6 hours: 3 hours lecture, 3 hours laboratory
Prerequisite	Physics 1
Course Objectives	<p>After completing this course, the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Describe the characteristics of fluids at rest and in motion;</li> <li>2. Compute the buoyant force on an object immersed in a fluid;</li> <li>3. Compute the pressure and flow speed of a fluid at any point in a flow tube;</li> <li>4. Determine the amount of expansion of a given material in relation to temperature change;</li> <li>5. Determine the change in temperature of a given amount of material that loses or gains;</li> <li>6. Solve problems about the law of heat transfer;</li> <li>7. Describe the three methods of heat transfer;</li> <li>8. Discuss the properties of waves;</li> <li>9. Describe the modes of vibration of strings and air columns;</li> <li>10. Solve problems on Doppler Effect;</li> <li>11. Compute the electric force between electric charges;</li> <li>12. Compute the electric field due to electric charges;</li> <li>13. Compute the electric potential due to a charge and electric potential energy of charges;</li> <li>14. Define electric current, electric resistance and voltage;</li> <li>15. Solve problems on resistance and cells in series and parallel;</li> <li>16. State Kirchhoff's rules and apply them in a given circuit;</li> <li>17. Compute the magnetic field of a given current-carrying conductors;</li> <li>18. Compute the magnetic torque on a current conductor in a magnetic field; and</li> <li>19. Describe image formation by mirrors and lenses.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Fluids             <ol style="list-style-type: none"> <li>1.1. Pressure, Specific Gravity, Density</li> <li>1.2. Archimedes' Principle</li> <li>1.3. Rate of Flow and Continuity Principle</li> <li>1.4. Bernoulli's Principle</li> <li>1.5. Torricelli's Theorem</li> </ol> </li> <li>2. Thermal Expansion, Thermal Stress</li> <li>3. Heat Transfer</li> <li>4. Calorimetry             <ol style="list-style-type: none"> <li>4.1. Specific Heat</li> </ol> </li> </ol>

	<ul style="list-style-type: none"> <li>4.2. Law of Heat Exchange</li> <li>4.3. Change of Phase</li> <li>5. Waves <ul style="list-style-type: none"> <li>5.1. Types of Waves and Their Properties</li> <li>5.2. Sounds</li> </ul> </li> <li>6. Electrostatics <ul style="list-style-type: none"> <li>6.1. Charge</li> <li>6.2. Coulomb's Law</li> <li>6.3. Superposition Principle</li> <li>6.4. Electric Field Intensity</li> <li>6.5. Work and Potential</li> <li>6.6. Capacitors, Dielectrics</li> </ul> </li> <li>7. Electricity <ul style="list-style-type: none"> <li>7.1. Current</li> <li>7.2. Resistance</li> <li>7.3. EMF</li> <li>7.4. Ohm's Law</li> <li>7.5. Energy and Power in Circuits</li> <li>7.6. Series and Parallel Connections</li> <li>7.7. Kirchhoff's Rules</li> </ul> </li> <li>8. Magnetism <ul style="list-style-type: none"> <li>8.1. Magnetic Field of Moving Charges</li> <li>8.2. Magnetic Field of Current Element</li> <li>8.3. Motion of a Charge in a Magnetic Field</li> <li>8.4. Biot-Savart Law</li> <li>8.5. Force on a Moving Charge in a Magnetic Field</li> <li>8.6. Torque on a Current-Carrying Loop</li> </ul> </li> <li>9. Optics <ul style="list-style-type: none"> <li>9.1. Light as Electromagnetic Waves</li> <li>9.2. Properties of Reflection and Refraction</li> </ul> </li> <li>10. Image Formation by Plane and Curved Mirrors <ul style="list-style-type: none"> <li>10.1. Graphical Methods</li> <li>10.2. Mirror Equation</li> </ul> </li> <li>11. Image Formation by Thin Lenses <ul style="list-style-type: none"> <li>11.1. Graphical Methods</li> <li>11.2. Lens Equation</li> </ul> </li> </ul>
Laboratory Equipment	Physics Laboratory (see attached)
Suggested References	<p>Cutnell, J.D. and K.W. Johnsons. <i>Physics</i>, 4th ed.</p> <p>Halliday, David, Robert Resnick and Jearl Walker. <i>Fundamentals of Physics</i>, 5th ed. John Wiley &amp; Sons, Inc., 1996.</p> <p>Serway, Raymond A. and John W. Jewett Jr. <i>Physics for Scientists and Engineers</i>, 6th ed. 2004.</p> <p>Young, Hugh D. and Roger A. Freedman. <i>University Physics</i>, 10th ed. Addison Wesley.</p>

### C. BASIC ENGINEERING SCIENCES

Course Name	<b>ENGINEERING DRAWING</b>
Course Description	Practices and techniques of graphical communication; application of drafting instruments, lettering scale, and units of measure; descriptive geometry; orthographic projections; auxiliary views; dimensioning; sectional views; pictorial drawings; requirements of engineering working drawings; and assembly and exploded detailed drawings.
Number of Units for Lecture and Laboratory	1 unit laboratory

Number of Contact Hours per Week	3 hours laboratory
Prerequisite	None
Course Objectives	<p>After completing this course, the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Understand the importance of technical drawing knowledge and skills as applied to the various areas of engineering;</li> <li>2. Apply the basic concepts of technical drawing and sketching; and</li> <li>3. Prepare technical drawings.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Engineering Lettering</li> <li>2. Instrumental Figures</li> <li>3. Geometric Construction</li> <li>4. Orthographic Projection</li> <li>5. Dimensioning</li> <li>6. Orthographic Views with Dimensions and Section View</li> <li>7. Sectional View</li> <li>8. Pictorial Drawing</li> <li>9. Engineering Working Drawings</li> <li>10. Assembly and Exploded Detailed Drawings</li> </ol>
Laboratory Equipment	<ol style="list-style-type: none"> <li>1. Drafting table</li> <li>2. Drawing instruments               <ol style="list-style-type: none"> <li>2.1. One 30-60 degree triangle</li> <li>2.2. One 45 degree triangle</li> <li>2.3. One technical compass</li> <li>2.4. One protractor</li> </ol> </li> </ol>
Suggested References	<p>French, Thomas E., Charles J. Vierck and Robert J. Foster. <i>Engineering Drawing and Graphic Technology</i>, 14th ed. McGraw-Hill, 1993.</p> <p>Giesecke, Frederick E. <i>Principles of Engineering Graphics</i>, 2nd ed. Prentice Hall, Inc., 1993.</p> <p>Giesecke, Frederick E., et al. <i>Technical Drawing</i>, 12th ed. 2002.</p> <p>Luzadder, Warren J. <i>Fundamentals of Engineering Drawing</i>, 11th ed. Prentice Hall, Inc., 1992.</p> <p>Luzadder, Warren J. and Jon M. Duff. <i>Introduction to Engineering Drawing</i>, 2nd ed. 1992.</p>

Course Name	<b>COMPUTER FUNDAMENTALS AND PROGRAMMING</b>
Course Description	Basic information technology concepts; fundamentals of algorithm development; high-level language and programming applications; computer solutions of engineering problems.
Number of Units for Lecture and Laboratory	2 units laboratory
Number of Contact Hours per Week	6 hours laboratory
Prerequisite	Second Year Standing
Course Objectives	<p>After completing this course, the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Understand basic information technology concepts;</li> <li>2. Use application software and the Internet properly;</li> <li>3. Acquire proficiency in algorithm development using a high-level programming language;</li> <li>4. Use the computer as a tool in engineering practice.</li> </ol>

Course Outline	<ol style="list-style-type: none"> <li>1. Introduction to Computers             <ol style="list-style-type: none"> <li>1.1. Computer Organization</li> <li>1.2. Number Systems and Data Representation</li> <li>1.3. Application Software: Word Processing and Spreadsheet</li> <li>1.4. The Internet</li> </ol> </li> <li>2. Programming             <ol style="list-style-type: none"> <li>2.1. Algorithm Development</li> <li>2.2. Programming Fundamentals</li> </ol> </li> </ol>
Laboratory Equipment	<ol style="list-style-type: none"> <li>1. Personal computer with:             <ol style="list-style-type: none"> <li>1.1. Operating system</li> <li>1.2. Word processing software</li> <li>1.3. Spreadsheet software</li> <li>1.4. High-level programming language</li> <li>1.5. Internet browser and Internet connection</li> </ol> </li> </ol>
Suggested References	<p>Caputo, Tony C., <i>Build Your Own Server</i>, McGraw-Hill, 2003.</p> <p>Kruse, Robert L., Bruce P. Leung and Clovis L. Tondo. <i>Data Structures and Program Design in C</i>, 2nd ed. Prentice Hall, Inc., 1996.</p> <p>Press, Barry and Marcia Press. <i>PC Upgrade and Repair Bible</i>, Desktop Edition. John Wiley &amp; Sons, Inc., 2004.</p> <p>Sebesta, Robert W. <i>Concepts of Programming Languages</i>, 4th ed. Addison-Wesley Publishing Co., 1999.</p>

Course Name	<b>COMPUTER-AIDED DRAFTING</b>
Course Description	Concepts of computer-aided drafting (CAD); introduction to the CAD environment; terminologies; and the general operating procedures and techniques in entering and executing basic CAD commands.
Number of Units for Lecture and Laboratory	1 unit laboratory
Number of Contact Hours per Week	3 hours laboratory
Prerequisite	Third Year Standing
Course Objectives	<p>After completing this course, the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Define the terms related to computer-aided drafting systems;</li> <li>2. Identify the important tools used to create technical drawings in CAD;</li> <li>3. Create electronic drawings (e-drawing) using CAD; and</li> <li>4. Appreciate the usefulness of the knowledge and skills in computer aided drafting as applied in his/her professional development.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Introduction to CAD Software</li> <li>2. CAD Drawing</li> <li>3. Snapping, Construction Elements</li> <li>4. Dimensioning</li> <li>5. Plotting, Inputting Images</li> <li>6. 3D and Navigating in 3D</li> <li>7. Rendering</li> </ol>
Laboratory Equipment	<ol style="list-style-type: none"> <li>1. Personal computer with:             <ol style="list-style-type: none"> <li>1.1. Operating system</li> <li>1.2. CAD software</li> </ol> </li> <li>2. Printer or plotter</li> </ol>
Suggested References	<i>CAD Software User's Manual.</i>

Course Name	<b>STATICS OF RIGID BODIES</b>
Course Description	Force systems; structure analyses; friction; centroids and centers of gravity; and moments of inertia.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisites	Physics 1 Integral Calculus
Course Objectives	After completing this course, the student must be able to: <ol style="list-style-type: none"> <li>1. Understand the principles of equilibrium of particles;</li> <li>2. Undertake vector operations such as vector cross and dot product;</li> <li>3. Determine forces of 2D and 3D structures;</li> <li>4. Understand the principles of static, wedge and belt friction;</li> <li>5. Determine centroids, center of mass and center of gravity of objects;</li> <li>6. Determine moment of inertia, mass moment of inertia; and</li> <li>7. Analyze the stresses of trusses, beams and frames.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Introduction to Mechanics; Vector Operations</li> <li>2. Force Vectors and Equilibrium of Particles</li> <li>3. Vector Cross and Dot Product</li> <li>4. Moment of a Force</li> <li>5. Couples; Moment of a Couple</li> <li>6. Equivalent Force Systems in 2D and 3D</li> <li>7. Dry Static Friction, Wedge and Belt Friction</li> <li>8. Centroid; Center of Mass; and Center of Gravity</li> <li>9. Distributed Loads and Hydrostatic Forces; Cables</li> <li>10. Moment of Inertia; Mass Moment of Inertia</li> <li>11. Trusses; Frames and Machines; Internal Forces</li> <li>12. Beams; Shear and Bending Moment Diagrams</li> </ol>
Laboratory Equipment	None
Suggested References	Bedford, Anthony and Wallace Fowler. <i>Engineering Mechanics: Statics</i> , 3rd ed. New Jersey: Prentice Hall, Inc., 2002. Beer, Ferdinand P. and E. Russell Johnston Jr. <i>Vector Mechanics for Engineers: Statics</i> , 7th SI ed. Pacheco, Edgardo S. <i>Statics of Rigid Bodies</i> , SI ed.

Course Name	<b>DYNAMICS OF RIGID BODIES</b>
Course Description	Kinetics and kinematics of a particle; kinetics and kinematics of rigid bodies; work energy method; and impulse and momentum.
Number of Units for Lecture and Laboratory	2 units lecture
Number of Contact Hours per Week	2 hours lecture
Prerequisite	Statics of Rigid Bodies
Course Objectives	After completing this course, the student must be able to: <ol style="list-style-type: none"> <li>1. Understand the principles governing the motion of particles, velocity and acceleration;</li> <li>2. Understand the principles of Newton's Second Law and its applications;</li> <li>3. Understand kinetics of particles in particular energy and momentum methods; and</li> </ol>

Course Outline	<p>4. Understand kinematics of rigid bodies, its energy and momentum.</p> <ol style="list-style-type: none"> <li>1. Introduction to Dynamics</li> <li>2. Position, Velocity, and Acceleration</li> <li>3. Determination of the Motion of the Particles</li> <li>4. Uniform Rectilinear Motion</li> <li>5. Uniformly Accelerated Rectilinear Motion</li> <li>6. Position Vector, Velocity, and Acceleration</li> <li>7. Derivatives of Vector Functions</li> <li>8. Rectangular Components of Velocity and Acceleration</li> <li>9. Motion Relative to a Frame in Translation</li> <li>10. Tangential and Normal Components</li> <li>11. Radial and Transverse Components</li> <li>12. Motion of Several Particles (Dependent Motion)</li> <li>13. Kinetics of Particles: Newton's Second Law             <ol style="list-style-type: none"> <li>13.1. Newton's Second Law of Motion</li> <li>13.2. Linear Momentum of the Particle, Rate of Change of Linear Momentum</li> <li>13.3. System of Units</li> <li>13.4. Equation of Motion</li> <li>13.5. Dynamic Equilibrium</li> <li>13.6. Angular Momentum of Particle, Rate of Change of Angular Momentum</li> <li>13.7. Equations in Terms of Radial and Transverse Components</li> <li>13.8. Motion Under a Central Force</li> </ol> </li> <li>14. Kinetics of Particles: Energy and Momentum Methods             <ol style="list-style-type: none"> <li>14.1. Work of Force</li> <li>14.2. Kinetic Energy of a Particle, Principle of Work and Energy</li> <li>14.3. Applications of the Principle of Work and Energy</li> <li>14.4. Potential Energy</li> <li>14.5. Conservative Forces</li> <li>14.6. Conservation of Energy</li> <li>14.7. Principle of Impulse and Momentum</li> <li>14.8. Impulsive Motion</li> <li>14.9. Impact</li> <li>14.10. Direct Central Impact</li> <li>14.11. Oblique Central Impact</li> <li>14.12. Problems Involving Energy and Momentum</li> </ol> </li> <li>15. Systems of Particles             <ol style="list-style-type: none"> <li>15.1. Application of Newton's Second Laws to Motion of a System of Particles</li> <li>15.2. Linear and Angular Momentum of a System of Particles</li> <li>15.3. Motion of Mass Center of a System of Particles</li> <li>15.4. Angular Momentum of a System of Particles About Its Mass Center</li> <li>15.5. Conservation of Momentum for a System of Particles</li> <li>15.6. Kinetic Energy of a System of Particles</li> <li>15.7. Work-Energy Principle. Conservation of Energy for a System of Particles</li> <li>15.8. Principle of Impulse and Momentum for a System of Particles</li> </ol> </li> <li>16. Kinematics of Rigid Bodies             <ol style="list-style-type: none"> <li>16.1. Translation</li> <li>16.2. Rotation About a Fixed Axis</li> <li>16.3. Equations Defining the Rotation of a Rigid Body About a Fixed Axis</li> <li>16.4. General Plane Motion</li> <li>16.5. Absolute and Relative Velocity in Plane Motion</li> <li>16.6. Instantaneous Center of Rotation in Plane Motion</li> <li>16.7. Absolute and Relative Acceleration</li> <li>16.8. Rate of Change of a Vector with Respect to a Rotating Frame</li> <li>16.9. Plane Motion of a Particle Relative to a Rotating Frame; Coriolis Acceleration</li> <li>16.10. Motion About a Fixed Point</li> <li>16.11. General Motion</li> <li>16.12. Three-Dimensional Motion of a Particle Relative to a Rotating</li> </ol> </li> </ol>
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	<p>Frame; Coriolis Acceleration</p> <p>16.13. Frame of Reference in General Motion</p> <p>17. Plane Motion of Rigid Bodies: Forces and Accelerations</p> <p>17.1. Equation of Motions</p> <p>17.2. Angular Momentum of a Rigid Body in Plane Motion</p> <p>17.3. Plane Motion of a Rigid Body. D' Alembert's Principle</p> <p>17.4. Solution of Problems involving the Motion of a Rigid Bodies</p> <p>17.5. Systems of Rigid Bodies</p> <p>17.6. Constrained Plane Motion</p> <p>18. Plane Motion of Rigid Bodies: Energy and Momentum Methods</p> <p>18.1. Principle of Work and Energy for a Rigid Body</p> <p>18.2. Work of Forces Acting on a Rigid Body</p> <p>18.3. Kinetic Energy of a Rigid Body in Plane Motion</p> <p>18.4. Systems of Rigid Bodies</p> <p>18.5. Conservation of Energy</p> <p>18.6. Principle of Impulse and Momentum</p> <p>18.7. Conservation of Angular Momentum</p> <p>18.8. Impulsive Motion</p> <p>18.9. Eccentric Impact</p>
Laboratory Equipment	None
Suggested Reference	Beer and Johnston. <i>Vector Mechanics for Engineers: Dynamics</i> , 7th SI ed. McGraw-Hill, 2003.

Course Name	<b>MECHANICS OF DEFORMABLE BODIES</b>
Course Description	Axial stress and strain; stresses for torsion and bending; combined stresses; beam deflections; indeterminate beams; and elastic instability.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Statics of Rigid Bodies
Course Objectives	<p>After completing this course, the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Understand the concepts of stress and strain;</li> <li>2. Calculate stresses due to bending, shears, and torsion under plain and combined loading;</li> <li>3. Analyze statically determinate and indeterminate structures; and</li> <li>4. Determine the elastic stability of columns.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Load Classification</li> <li>2. Concept of Stress, Normal and Shear Stress</li> <li>3. Stresses under Centric Loading</li> <li>4. Stress Concentration</li> <li>5. Plane Stress</li> <li>6. Principal Stresses for Plane Stress</li> <li>7. Mohr's Circle for Plane Stress</li> <li>8. Deformations, Normal and Shear Strains</li> <li>9. Material Properties</li> <li>10. Working Stresses</li> <li>11. Deformation in a System of Axially Loaded Members</li> <li>12. Temperature Effects on Axially Loaded Members</li> <li>13. Statically Indeterminate Members</li> <li>14. Thin-Walled Pressure Vessel</li> <li>15. Torsional Stresses; Elastic Torsion Formula</li> <li>16. Torsional Deformation; Power Transmission</li> <li>17. Flexural Stresses by the Elastic Curve</li> </ol>

	18. Moment Equation Using Singularity Function 19. Beam Deflection by the Double Integration Method 20. Area Moment Theorems 21. Moment Diagram by Parts 22. Beam Deflection by Area Moment Method 23. Statically Indeterminate Beams 24. Buckling of Long Straight Columns 25. Combined Loadings 26. Analysis of Riveted Connections by the Uniform Shear Method 27. Welded Connections
Laboratory Equipment	None
Suggested References	Hibbeler, Russell C. <i>Mechanics of Materials</i> , 5th ed. Prentice Hall, Inc., 2002. Higdson, Archie, et al. <i>Mechanics of Deformable Bodies</i> , 4th ed. John Wiley & Sons, 1989. McGill, David and Wilton M. King. <i>Engineering Mechanics, An Introduction to Dynamics</i> , 3rd ed. PWS Publishing Co., 1995. Singer, Andrew and Singer, Ferdinand Leon, <i>Strength of Materials</i> ; 4th edition, 1987

Course Name	<b>ENGINEERING ECONOMY</b>
Course Description	Concepts of the time value of money and equivalence; basic economy study methods; decisions under certainty; decisions recognizing risk; and decisions admitting uncertainty.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisite	Third Year Standing
Course Objectives	After completing this course, the student must be able to: <ol style="list-style-type: none"> <li>1. Solve problems involving interest and the time value of money;</li> <li>2. Evaluate project alternatives by applying engineering economic principles and methods and select the most economically efficient one; and</li> <li>3. Deal with risk and uncertainty in project outcomes by applying the basic economic decision making concepts.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Introduction             <ol style="list-style-type: none"> <li>1.1. Definitions</li> <li>1.2. Principles of Engineering Economy</li> <li>1.3. Engineering Economy and the Design Process</li> <li>1.4. Cost Concepts for Decision Making</li> <li>1.5. Present Economy Studies</li> </ol> </li> <li>2. Money-Time Relationships and Equivalence             <ol style="list-style-type: none"> <li>2.1. Interest and the Time Value of Money</li> <li>2.2. The Concept of Equivalence</li> <li>2.3. Cash Flows</li> </ol> </li> <li>3. Basic Economy Study Methods             <ol style="list-style-type: none"> <li>3.1. The Minimum Attractive Rate of Return</li> <li>3.2. The Present Worth Method</li> <li>3.3. The Future Worth Method</li> <li>3.4. The Annual Worth Method</li> <li>3.5. The Internal Rate of Return Method</li> <li>3.6. The External Rate of Return Method</li> <li>3.7. The Payback Period Method</li> <li>3.8. The Benefit/Cost Ratio Method</li> </ol> </li> </ol>

	<ul style="list-style-type: none"> <li>4. Decisions Under Certainty               <ul style="list-style-type: none"> <li>4.1. Evaluation of Mutually Exclusive Alternatives</li> <li>4.2. Evaluation of Independent Projects</li> <li>4.3. Depreciation and After-Tax Economic Analysis</li> <li>4.4. Replacement Studies</li> <li>4.5. Break win Analysis</li> </ul> </li> <li>5. Decisions Recognizing Risk               <ul style="list-style-type: none"> <li>5.1. Expected Monetary Value of Alternatives</li> <li>5.2. Discounted Decision Tree Analysis</li> </ul> </li> <li>6. Decisions Admitting Uncertainty               <ul style="list-style-type: none"> <li>6.1. Sensitivity Analysis</li> <li>6.2. Decision Analysis Models</li> </ul> </li> </ul>
Laboratory Equipment	None
Suggested References	<p>Blank, Leland T. and Anthony J. Tarquin. <i>Engineering Economy</i>, 6<sup>th</sup> ed. McGraw-Hill, Inc., 2005.</p> <p>Grant, Eugene L., et al., <i>Principles of Engineering Economy</i>, 8th ed. John Wiley &amp; Sons, Inc., 1990.</p> <p>Newman, Donald G., Jerome P Lavelle and Ted S. Eschenbach. <i>Essentials of Engineering Economic Analysis</i>, 2nd ed., Oxford University Press, 2002.</p> <p>Park, Chan S. <i>Contemporary Engineering Economics</i>, 3rd ed. Addison Wesley, 2001.</p> <p>Riggs, James L., et al. <i>Engineering Economics</i>, 4th ed., McGraw-Hill, 1996.</p> <p>Sullivan, William G., Elin M. Wicks and James T. Luxhoj. <i>Engineering Economy</i>, 12th ed. Prentice Hall, Inc., 2002.</p> <p>Thuesen, Gerald J. and W.J. Fabrycky. <i>Engineering Economy</i>, 9th ed. Prentice Hall, Inc., 2001.</p>

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

Laboratory Equipment	None
Suggested References	<p>Eisner, Howard. <i>Essentials of Project and System Engineering Management</i>, 2nd ed. John Wiley &amp; Sons, Inc., 2002.</p> <p>Gram, Harold A. <i>An Introduction to Management</i>. Holt, Rinehart and Winston of Canada, Limited, 1990.</p> <p>Oberlender, Gerold D. <i>Project Management for Engineering and Construction</i>, 2nd ed. McGraw-Hill, 2000.</p> <p>Robbins, Stephen P. and Mary Coulter. <i>Management</i>, 6th ed. Prentice Hall, Inc., 1999.</p> <p>Wheeler, Thomas F. <i>Computer and Engineering Management</i>. McGraw-Hill, 1990.</p>

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

Suggested References	<p>Bellardi, O'Brien. <i>Hazardous Waste Site Remediation</i>. John Wiley &amp; Sons, Inc., 1995.</p> <p>Crites, Ron and G. Tchobanoglous. <i>Small and Decentralized Wastewater Management Systems</i>. McGraw-Hill, 1998.</p> <p>Davis, Mackenzie L. and Susan J. Masten. <i>Principles of Environmental Engineering and Science</i>. McGraw-Hill, 2004.</p> <p>Guzmar, Ruth and Roger Guzman. <i>Environmental Education for Sustainable Development</i>. Wisdom Advocate Publishing, 2000.</p> <p>Heisketh, Howard. <i>Air Pollution Control - Traditional and Hazardous Pollutants</i>. Technomic Publishing Co., Inc., 1996.</p> <p>Henze, M., et al. <i>Wastewater Treatment</i>. Berlin: Springer Verlag, 1997.</p> <p>Kay, J.G., G.E. Keller and J.F. Miller. <i>Indoor Air Pollution</i>. Chelsea, Michigan: Lewis Publishers, 1991.</p> <p>Kiely, Gerard. <i>Environmental Engineering</i>. McGraw-Hill, 1997.</p> <p>Metcalf and Eddy, Inc. <i>Wastewater Engineering - Collection, Treatment and Disposal</i>. McGraw-Hill, 1991.</p> <p>Mihelcic, James. <i>Fundamentals of Environmental Engineering</i>. John Wiley &amp; Sons, Inc., 1999.</p> <p>Nemerow, N.L. and F. Agardy. <i>Strategies of Industrial and Hazardous Waste Management</i>. International Thomson Publishing Company, 1998.</p> <p>Ortolano, Leonard. <i>Environmental Regulation and Impact Assessment</i>. John Wiley &amp; Sons, Inc., 1997.</p> <p>Perry, S., D. Rower and G. Tchobanoglous. <i>Environmental Engineering</i>. McGraw-Hill, 1985.</p> <p>Wark, K., C. Warner and W. Davis. <i>Air Pollution - Its Origin and Control</i>. Addison-Wesley, 1998.</p>
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Course Name	<b>SAFETY MANAGEMENT</b>
Course Description	Evolution of safety management; safety terminology; safety programs adopted by high risk industries; hazards in the construction, manufacturing, gas and power plants, and other engineering industries and how to prevent or mitigate them; techniques in hazard identification and analysis in workplaces; off-the-job safety; disaster prevention and mitigation; and incident investigation.
Number of Units for Lecture and Laboratory	1 unit lecture
Number of Contact Hours per Week	1 hour lecture
Prerequisites	Third Year Standing
Course Objectives	<p>After completing this course, the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Understand the importance and the value of safety;</li> <li>2. Know the health hazards and their prevention;</li> <li>3. Identify and mitigate or prevent hazards; and</li> <li>4. Apply the concepts and principles of safety in engineering practice.</li> </ol>

Course Outline	<ol style="list-style-type: none"> <li>1. Overview of Safety</li> <li>2. Basic Safety Procedures in High Risk Activities and Industries             <ol style="list-style-type: none"> <li>2.1. Procedure in Hazards Analysis in the Workplace</li> <li>2.2. Control of Hazardous Energies</li> <li>2.3. Confined Space Entry</li> <li>2.4. Basic Electrical Safety</li> <li>2.5. Fall Protection</li> <li>2.6. Barricades and Scaffolds</li> <li>2.7. Fire Safety and the Fire Code</li> <li>2.8. Industrial Hygiene</li> <li>2.9. Hazard Communication and Chemical Safety</li> </ol> </li> <li>3. Value Based Safety and Off-the-Job Safety             <ol style="list-style-type: none"> <li>3.1. Safety as a Value; Choice vs. Compliance</li> <li>3.2. Off-the-Job Safety (Residences and Public Places)</li> <li>3.3. Safety as Related to Health Practices</li> </ol> </li> <li>4. Disaster Prevention and Mitigation             <ol style="list-style-type: none"> <li>4.1. Rationale for Disaster Prevention and Loss Control</li> <li>4.2. Planning for Emergencies</li> <li>4.3. Emergency Response Procedures</li> </ol> </li> <li>5. Incident Investigation and Reporting             <ol style="list-style-type: none"> <li>5.1. Accident Escalation, Incident Investigation and Reporting</li> <li>5.2. Causal Analysis; Recognition of Root Cause</li> <li>5.3. Identification of Corrective or Preventive Actions</li> </ol> </li> </ol>
Laboratory Equipment	None
Suggested References	<p>Asfahl, C. Ray. <i>Industrial Safety and Health Management</i>, 5th ed. Prentice Hall, Inc., 2003.</p> <p>Department of Labor and Employment. <i>Occupational Health and Safety Standards</i>.</p> <p>Hopf, Peter S. <i>Designer's Guide to OSHA</i>, 2nd ed. New York: McGraw-Hill, 1982.</p>

#### D. ALLIED COURSES

Course Name	<b>GENERAL CHEMISTRY 2 (FOR CERAMIC ENGINEERS)</b>
Course Description	A course designed to instill in ceramic engineering students the fundamental principles of thermodynamics, solutions, rate of chemical reactions, and chemical and ionic equilibrium, and electrochemistry. The course focuses primarily on chemical calculations frequently performed by ceramic engineering students pertaining to concentration, dilution, reactions involving standard solutions, colligative properties, chemical equilibrium, pH and pOH, values of various equilibrium constants, as well as balancing of oxidation-reduction reactions.
No. of Units for Lecture and Laboratory	3 units lecture
No. of Contact Hours per week	3 hours lecture
Prerequisites	General Chemistry 1
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Perform simple stoichiometric calculations</li> <li>2. Apply stoichiometric principles in calculations involving gases, solutions, and heats of reactions</li> <li>3. Perform basic thermodynamic calculations</li> <li>4. Determine rates, orders and rate equations of chemical reactions</li> <li>5. Solve problems concerning methods of expressing concentration, dilution, titration, pH, pOH, colligative properties of solutions</li> </ol>

	6. Perform chemical equilibrium calculations 7. Perform electrochemical calculations
Course Outline	1. Basic stoichiometric calculations from chemical reactions; excess and limiting reagents; theoretical yield; actual yield and percent yield 2. Stoichiometric calculations in reactions in gas mixtures and aqueous solutions 3. Introduction to thermodynamics of chemical reactions (sensible heat, latent heat and heat of reaction, Hess's law) 4. Calculations in chemical kinetics 5. Calculations in chemical equilibria: ionic and acid-base equilibria 6. Calculations in chemical equilibria: precipitation equilibria 7. Electrochemistry: basic concepts and applications 8. Calculations in electrochemical and electrolytic cells
Laboratory Equipment	None
Suggested References	Brescia, F. Mehlman, S., Pellegrini, F., Student's Guide to Chemistry: A Modern Introduction Brescia, Fundamentals of Chemistry Brown, LeMay and Bursten, Chemistry: The Central Science R. Chang, Chemistry Harwood and Petrucci, General Chemistry King, Caldwell and William, Chemistry Seinko and Plane, College Chemistry Schaum and Rossenberg, Schaum's Outline of Theory and Problems of College Chemistry J.B. Russel, General Chemistry C.E. Mortimer, Chemistry, A Conceptual Approach Masterton, W.L., Hurley, C.N., Chemistry: Principles and Reactions, 5th Edition, Publisher: Brooks Cole Denbigh, K.G., The Principles of Chemical Equilibrium: With Applications in Chemistry and Chemical Engineering, Publisher: Cambridge University Press Atkins, P. and Jones, L., Chemical Principles, First Edition

Course Name	<b>ANALYTICAL CHEMISTRY</b>
Course Description	Principles and techniques of analysis with emphasis on volumetric methods and stoichiometry. Gravimetric, colorimetric and potentiometric methods. Survey of common instrumental methods. Analysis of substances and simple mixtures.
No. of Units for Lecture and Laboratory	4 units: 3 units lecture, 1 unit laboratory
No. of Contact Hours per week	6 hours: 3 hours lecture, 3 hours laboratory
Prerequisites	General Chemistry 2
Course Objectives	At the end of the course the student must be able to: <ol style="list-style-type: none"> <li>1. Identify analytical chemistry methods for substances and simple mixtures especially those involving ceramic systems</li> <li>2. Solve typical problems in analytical chemistry</li> <li>3. Perform stoichiometry calculations as part of analytical methods</li> <li>4. Identify the common instrumental methods for chemical analysis of substances and mixtures</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Principles of chemical analysis</li> <li>2. Volumetric methods of analysis</li> <li>3. Gravimetric methods of analysis</li> <li>4. Colorimetric methods of analysis</li> </ol>

	5. Potentiometric methods of analysis 6. Survey of common instrumental methods 7. Analysis of substances 8. Analysis of simple mixtures
Laboratory Equipment	Pipettes, burettes, volumetric flasks, Erlenmeyer flasks, Mettler balance, oven, porcelain crucible, glass beakers, mortar and pestle, Bunsen burner
Suggested References	Analytical Chemistry by Gary D. Christian, Hardcover: 848 pages Publisher: Wiley; 6th edition Quantitative Chemical Analysis, Sixth Edition by Daniel C. Harris, Hardcover: 928 pages, Publisher: W. H. Freeman Modern Analytical Chemistry by D. Harvey, 1st edition, McGraw Hill, 2000

Course Name	<b>PRINCIPLES OF GEOLOGY</b>
Course Description	A discussion of the origin of the earth, minerals, and rocks. Study of the different endogenetic and exogenetic processes which are responsible for the formation of physiographic/geologic features. Discussion on global and Philippine tectonics.
No. of Units for Lecture and Laboratory	3 units lecture
No. of Contact Hours per week	3 hours lecture
Prerequisites	General Chemistry
Course Objectives	At the end of the course the student must be able to: <ol style="list-style-type: none"> <li>1. Identify theories of the origin of the earth, mineral and rocks</li> <li>2. Differentiate different minerals and rocks</li> <li>3. Identify the different endogenetic and exogenetic processes</li> <li>4. Identify different physiographic/geologic features especially those found in the Philippine setting</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Origin of the earth, minerals and rocks</li> <li>2. Endogenetic processes</li> <li>3. Exogenetic processes</li> <li>4. Global tectonics</li> <li>5. Philippine tectonics</li> </ol>
Laboratory Equipment	None
Suggested References	F.G.H. Blyth, A Geology for Engineers, 7 <sup>th</sup> Ed., Edward Arnold, London, 1974

Course Name	<b>ELEMENTS OF MINERALOGY</b>
Course Description	Fundamentals of crystallography. The principles underlying the identification, classification, designation and methods of depicting crystal forms based on models, natural mineral and crystal drawings.
No. of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory
No. of Contact Hours per week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisites	Principles of Geology
Course Objectives	At the end of the course the student must be able to: <ol style="list-style-type: none"> <li>1. Identify and classify various crystals</li> <li>2. Identify the different symmetry elements in crystal models</li> <li>3. Identify various minerals and their structures</li> </ol>
Course Outline	To follow outline of a standard course on Elements of Mineralogy
Laboratory Equipment	Crystal models
Suggested References	C.S. Hurlbut, Manual of Mineralogy, 21 <sup>st</sup> ed., John Wiley & Sons, Inc., NY

Course Name	<b>FUNDAMENTALS OF MATERIALS SCIENCE AND ENGINEERING</b>
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Course Description	Structure and composition of materials (metals, polymers, ceramics and composites). Processing, properties and behavior in service environments.
No. of Units for Lecture and Laboratory	3 units lecture
No. of Contact Hours per week	3 hours lecture
Prerequisites	Physics 2, Integral Calculus
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify the importance of materials to mankind through specific examples of materials which have had significant impact to civilization</li> <li>2. Identify the different ways of classifying various materials</li> <li>3. Identify the different material properties and how these are affected by the composition and structure</li> <li>4. Determine the ways by which material properties can be engineered or modified to meet certain requirements related to their intended use</li> <li>5. Select the appropriate material(s) for a given application</li> <li>6. Evaluate feasibility of designs based on material considerations</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Introduction (1)</li> <li>2. Atomic structure and interatomic bonding (2)</li> <li>3. Atomic arrangement in solids (4)</li> <li>4. Structural imperfections and diffusion (5)</li> <li>5. Electronic structures and processes (3)</li> <li>6. Metals and their properties (4)</li> <li>7. Polymers and their properties (2)</li> <li>8. Ceramics and their properties (4)</li> <li>9. Composite materials (3)</li> <li>10. Materials selection and design considerations (3)</li> </ol>
Laboratory Equipment	None
Suggested References	<p>Elements of Materials Science by Van Vlack            Electronic Properties of Engineering Materials by Livingston, John Wiley &amp; Sons, 1999            The Science and Design of Engineering Materials by Schaffer            4. Fundamentals of Ceramics by Michel Barsoum, John Wiley &amp; Sons, NY</p>

Course Name	<b>KINETICS OF MATERIALS</b>
Course Description	Reaction rates, mechanisms and transport phenomena in materials from a phenomenological and atomistic point of view. Applications to nucleation, crystal growth, grain growth, recrystallization, precipitation, phase transformations. Role of kinetics in the development of microstructures.
No. of Units for Lecture and Laboratory	3 units lecture
No. of Contact Hours per week	3 hours lecture
Prerequisites	Thermodynamics of Materials
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify the factors governing the kinetics of ceramic reactions such as high temperature phase transformations, sintering, grain growth, nucleation and crystal growth from melts</li> <li>2. Solve fundamental problems in kinetics</li> <li>3. Identify the mechanisms of material transport in solid and liquid systems</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Kinetic Theory of Gases (3)               <ol style="list-style-type: none"> <li>1.1 Dimensions and shapes of molecules</li> <li>1.2 Number of molecules</li> <li>1.3 Velocity of gases</li> </ol> </li> <li>2. Elements of Ceramic Kinetics (8)               <ol style="list-style-type: none"> <li>2.1 Simple chemical reactions</li> <li>2.2 Order of molecularity of reactions (first order reactions, second order reactions, third order reactions)</li> </ol> </li> </ol>

	<ul style="list-style-type: none"> <li>2.3 Pseudo-molecular reactions</li> <li>2.4 Reversible or opposing reactions</li> <li>2.5 Consecutive reactions</li> <li>2.6 Effect of temperature on reaction velocities</li> <li>2.7 Activation energy</li> <li>2.8 Collision theory ( bimolecular reactions, unimolecular reactions)</li> <li>2.9 Absolute reaction theory</li> <li>3. Atom Mobility (11) <ul style="list-style-type: none"> <li>3.1 Diffusion and Fick's law</li> <li>3.2 Diffusion of a thermally activated process</li> <li>3.3 Temperature and impurity activated process</li> <li>3.4 Nomenclature and concepts of atomistic processes</li> <li>3.5 Diffusion in crystalline oxides</li> <li>3.6 Diffusion in glasses; dislocations, boundary and surface diffusion</li> </ul> </li> <li>4. Reactions with and between solids (9) <ul style="list-style-type: none"> <li>4.1 Kinetics of heterogeneous reactions</li> <li>4.2 Reactant transport through a planar boundary</li> <li>4.3 Reactant transport in particulate system</li> <li>4.4 Precipitation in crystalline ceramics</li> <li>4.5 Non-isothermal processes</li> </ul> </li> </ul>
Laboratory Equipment	None
Suggested References	Introduction to Ceramics by Kingery, Bowen and Uhlman, 2 <sup>nd</sup> edition, John Wiley & Sons, NY Diffusion of Solids by Shewmon, McGraw-Hill Book Company, Inc. Kinetics of High Temperature Processes by Kingery, John Wiley & Sons, Inc., NY USA

Course Name	<b>THERMODYNAMICS OF MATERIALS</b>
Course Description	Fundamental thermodynamic principles including energy, entropy, and free energy. Description of the macroscopic properties of various material systems such as equilibrium states, phases and phase transitions with emphasis on ceramic materials. Application in phase diagrams.
No. of Units for Lecture and Laboratory	3 units: 2 units lecture (if with lab), 1 unit laboratory or 3 units lecture (if no lab)
No. of Contact Hours per week	5 /3 hours: 2 hours lecture (if with lab), 3 hours laboratory or 3 hours lecture (if no lab)
Prerequisites	General Chemistry 2, Integral Calculus
Course Objectives	At the end of the course the student must be able to: <ol style="list-style-type: none"> <li>1. Identify the physical characteristics of gases, liquids and solids with particular emphasis on the thermodynamic properties of solids</li> <li>2. Solve Physical Chemistry problems which have relevance to Ceramic Engineering.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Gases and Liquids (6) <ul style="list-style-type: none"> <li>1.1. Ideal and real gases</li> <li>1.2. Boyle's Law</li> <li>1.3. Charles Law</li> <li>1.4. Gay-Lussac's law</li> <li>1.5. Combined Gas Law</li> <li>1.6. Gas Constant</li> <li>1.7. Calculations involving ideal gas law</li> <li>1.8. Dalton's law of partial pressure</li> <li>1.9. Amagat's law of partial volumes</li> <li>1.10. Graham's law of diffusion</li> <li>1.11. van der Waals equation of state</li> <li>1.12. Molecular weight of gases</li> <li>1.13. Kinetic theory of ideal gases</li> </ul> </li> </ol>

	<ol style="list-style-type: none"> <li>1.14. Heat capacity of gases</li> <li>2. Laws of Thermodynamics (7)           <ol style="list-style-type: none"> <li>2.1 First law</li> <li>2.2 Second law</li> <li>2.3 Third law</li> </ol> </li> <li>3. Free Energy and Equilibrium (6)           <ol style="list-style-type: none"> <li>3.1 Helmholtz free energy</li> <li>3.2 Enthalpy for reactions</li> <li>3.3 Free energy change for reactions</li> <li>3.4 Gibb's free energy</li> <li>3.5 Properties and significance of free energy change</li> </ol> </li> <li>4. Chemical Equilibrium (6)           <ol style="list-style-type: none"> <li>4.1 Equilibrium constant</li> <li>4.2 Le Chatelier-Braun principle</li> <li>4.3 Effect of inert gases on equilibrium</li> <li>4.4 Equilibrium constant for heterogeneous reactions</li> <li>4.5 Effect of pressure on heterogeneous equilibria</li> <li>4.6 Effect of temperature</li> </ol> </li> <li>5. Electrochemistry (6)</li> </ol>
Laboratory Equipment	For those with lab option: Bomb calorimeter, analytical balance, thermometer, hot plate, data logger
Suggested References	Introduction to Thermodynamics of Materials, 4 <sup>th</sup> Edition, David R. Gaskell, Taylor and Francis Publishers

Course Name	<b>PHASE EQUILIBRIUM IN CERAMIC SYSTEMS</b>
Course Description	Phase equilibrium in ceramic systems of one, two and three components. Determination of phase diagrams. Use of phase diagram as a tool for quality control, design and characterization studies in the development and formulation of ceramic batches. Quantitative applications to systems of interest to ceramic engineers.
No. of Units for Lecture and Laboratory	2 units lecture
No. of Contact Hours per week	2 hours lecture
Prerequisites	Thermodynamics of Materials
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Use phase diagrams of one, two and three components to determine the stable phases and relative amounts at a given temperature and composition</li> <li>2. Perform quantitative calculations dealing with phase diagrams</li> <li>3. Perform isoplethal analysis to predict microstructures after cooling of ceramic products</li> <li>4. Use of phase diagram to predict phase transformations</li> <li>5. Use phase diagrams to address problems in quality control, design and characterization studies</li> <li>6. Develop and formulate ceramic batches based on knowledge of phase equilibrium</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Foundation in the study of chemical equilibria (11)</li> <li>2. The Phase rule</li> <li>3. Ordinary phase rule; one component system</li> <li>4. The Phase rule of condensed system</li> <li>5. Statement of the rule; the two component system: Class A – Type I. Simple eutectic diagram</li> <li>6. The Two Component system – Class A – Type II. Formation of Compound with Congruent Melting Point</li> <li>7. The Two Component system – Class A – Type III. Compound Formation as Result of Peritectic Reaction</li> <li>8. The Two Component system – Class A – Type IV. Complete Miscibility in Solid State</li> </ol>

	<p>9. The Two Component system – Class A – Type V. Partial Miscibility in solid state with Eutectic</p> <p>10. The Two Component system – Class A – Type VI. Partial Miscibility in solid state with Peritectic (10)</p> <p>11. The Two Component system – Class B. Partial Miscibility in liquid state</p> <p>12. The Two Component system – Class C. Partial Miscibility in Solid and Liquid State</p> <p>13. Composite Diagram</p> <p>14. The Three Component System</p> <p>15. The Three Component System – Type I. Formation of one pair partially miscible liquids</p> <p>16. The Three Component System – Type II. Formation of two pair partially miscible liquids</p> <p>17. The Three Component System – Type III. Formation of three pair partially miscible liquids</p> <p>18. System Composed of Two Solids and Liquids – Type I. Crystallization of Pure Components only (10)</p> <p>19. System Composed of Two Solids and Liquids – Type II. Formation of Binary Compounds</p> <p>20. System Composed of Two Solids and Liquids – Type III. Formation of Ternary Compounds</p> <p>21. System Composed of Two Solids and a Liquid – Type IV. Formation of complete series of liquid solutions</p> <p>22. System Composed of Two Solids and a Liquid – Type III.. Partial miscibility of Solid phase</p>
Laboratory Equipment	None
Suggested References	<p>Phase Diagram for Ceramist, Vol I to Vol. II by Levin, Robbins and McMurdie, American Ceramic Society, Columbus, Ohio</p> <p>Phase Diagram for Ceramist, 1969 Supplement, Levin, Robbins, McMurdie, American Ceramic Society, Columbus, Ohio</p> <p>Theory, Principles and Techniques of Phase Diagram: 3.a The use of Phase Diagram in Metal, Refractory, Ceramic and Cement Technology 3b. The use of Phase Diagram in Electronic Materials and Glass technology by Alper, ed. Pergamon Press</p> <p>Phase Equilibria by Reisman, Academic Press</p> <p>Principles of Phase Diagrams in Materials System by Gordon</p> <p>Phase Rule and Heterogeneous Equilibria by Ricci</p> <p>Introduction to Phase Equilibria in Ceramic by Hummel, Marcel Dekker, 1984</p>

Course Name	<b>MECHANICS OF FLUIDS</b>
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	Dynamics of Rigid Bodies
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify the properties of fluids</li> <li>2. Identify the governing equations in fluid statics and kinematics</li> <li>3. Solve typical problems in fluid mechanics especially those relevant to ceramic engineering</li> <li>4. Differentiate mechanics of fluid flow in open and closed channels</li> <li>5. Identify the methods in fluid measurements</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Properties of fluids</li> <li>2. Statics of fluids</li> <li>3. Kinematics of fluids</li> <li>4. Forces in fluid flow</li> </ol>

	5. Energy and momentum in fluid flow 6. Fluid flow in open channels 7. Fluid measurements
Laboratory Equipment	Hydraulic Bench Software: WaterCAD Flowmaster Pondpack
Suggested References	Mays, Larry W. 2004. Water Resources Engineering, 2005 edition. USA Robert I. Daugherty, Joseph B. Franzini and E. John Finnemore. 2002. Fluid mechanics with Engineering Applications, SI Metric Edition, USA Ray K. Linsley, Joseph B. Franzini, David L. Freyberg and David L. Tchobanoglous. 1992. Water Resources Engineering, Fourth Edition. USA. John A. Roberson, John J. Cassidy and M. Hanif Chaudhry. 1988. Hydraulic Engineering, Second Edition. USA. H.W. King, J.O. Wisler and J.G. Woodburn. 1980. Hydraulics, Fifth Edition. R. E. Krieger Publishing Company.

Course Name	<b>BASIC ELECTRICAL ENGINEERING</b>
Course Description	Fundamentals of electric and magnetic circuits. Direct and alternating current machinery. Elementary distribution systems and electrical wiring.
No. of Units for Lecture and Laboratory	3 units lecture
No. of Contact Hours per week	3 hours lecture
Prerequisites	None
Course Objectives	At the end of the course the student must be to: 1. Solve typical problems in basic electrical engineering 2. Differentiate DC and AC machinery 3. Identify the governing equations for different types of electric and magnetic circuits 4. Identify elementary distribution systems 5. Identify important considerations in electrical wiring 6. Apply important electrical engineering concepts to ceramic engineering problems
Course Outline	1. Fundamentals of electric circuits 2. Fundamentals of magnetic circuits 3. DC machinery 4. AC machinery 5. Elementary distribution systems 6. Electrical wiring
Laboratory Equipment	None
Suggested References	Williams H. Hayt and Jack E. Kemmerly, Engineering Circuits Analysis

**E. PROFESSIONAL COURSES**

Course Name	<b>ADVANCED ENGINEERING MATHEMATICS FOR CERAMIC ENGINEERING</b>
Course Description	A study of selected topics in mathematics and their applications in ceramic engineering. It covers the study of Complex Numbers, Laplace and Inverse Laplace Transforms, Power Series, Fourier Series, Matrices and Determinants, Vector Analysis and Numerical Methods.
No. of Units for Lecture and Laboratory	3 units lecture
No. of Contact Hours per week	3 hours lecture
Prerequisites	Differential Equations

Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Familiarize themselves with the different parameters, laws, theorems and the different methods of solutions in advanced mathematics.</li> <li>2. Develop their abilities on how to apply the different laws, methods and theorems particularly in complex problems related to the field of ceramic engineering.</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Complex Numbers</li> <li>2. Laplace and Inverse Laplace Transforms</li> <li>3. Power Series</li> <li>4. Fourier Series</li> <li>5. Vector Analysis</li> <li>6. Numerical Methods</li> </ol>
Laboratory Equipment	None
Suggested References	<p>Dulay, Virgilio, <i>Advanced Engineering Mathematics</i>, 1996          Kreyszig, Erwin, <i>Advanced Engineering Mathematics</i>, John Wiley and Sons Publishing, 1972          Bromwell, Arthur, <i>Advanced Mathematics in Physics and Engineering</i>, McGraw Hill Publishing, 1953          Kolman, Bernard, <i>Linear Algebra</i>, McMillan Publishing House, 1991          Scheid, Francis, <i>Numerical Analysis</i>, McGraw Hill Publishing, 1968          MatLab Manuals Rel 12, MS Office 2000</p>

Course Name	<b>CERAMIC RAW MATERIALS AND PROCESSES</b>
Course Description	Comprehensive discussion on the different ceramic raw materials used in the ceramic industry (e.g., kaolins, ball clays, red clays, feldspar, flint, alumina, silica, etc.), the processing techniques involved, and how these influence the physical and chemical properties of ceramic products.
No. of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory
No. of Contact Hours per week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisites	Analytical Chemistry
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify the different raw materials for the ceramic industry such as various types of clay and non-clay minerals</li> <li>2. Identify the important physical, chemical and thermal properties of ceramic raw materials</li> <li>3. Rationalize the properties based on the ceramic formulation</li> <li>4. Perform laboratory exercises pertaining to the beneficiation of ceramic raw materials</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Introduction to Ceramic Raw Materials</li> <li>2. Sedimentary Clays</li> <li>3. Further Groupings of Clays</li> <li>4. Composition of Clays</li> <li>5. Chemical Properties of Clays</li> <li>6. Physical Properties of Clays</li> <li>7. Effect of Heat on Clays (2)</li> <li>8. Firing Properties of Clays</li> <li>9. Classification of Clays (e.g. according to uses)</li> <li>10. Technical Study and Design of Clay Beneficiation Plant (2)</li> <li>11. Silica (2)</li> <li>12. Alumina</li> <li>13. Feldspar</li> <li>14. Anhydrous Alumina-Silica Minerals</li> <li>15. Lime, Magnesia, Dolomite and Related Materials (2)</li> <li>16. Magnesium Silicate Minerals</li> <li>17. Fluorine Minerals</li> <li>18. Alkali Minerals and Compounds</li> <li>19. Refractory Raw Materials (2)</li> </ol>

	<p>20. Other Ceramic Raw Materials – Binders, etc. (2)                  21. Technical Study and Design of Silica Beneficiation Plant (2)                  22. Technical Study and Design of Feldspar Beneficiation Plant (2)</p> <p>Laboratory Experiments for Ceramic Raw Materials and Processes</p> <p>I. Plastic Materials</p> <ol style="list-style-type: none"> <li>1. Sieve analysis of various clays (2)</li> <li>2. Water of plasticity of clays</li> <li>3. Effect of water in the viscosity of suspended clays</li> <li>4. Effect of electrolytes on the viscosity of suspended clays</li> <li>5. Drying behavior of various clays</li> <li>6. Behavior in firing of various clays (color, firing shrinkage and warpage) (2)</li> <li>7. Volume change (fired and unfired)</li> <li>8. Apparent specific gravity of clays</li> <li>9. Bulk specific gravity of clays</li> <li>10. Strength test of clays (fired and unfired) (2)</li> <li>11. Pyrometric Cone Equivalent</li> </ol> <p>II. Non-plastic Materials</p> <ol style="list-style-type: none"> <li>1. Softening Range</li> <li>2. True Specific Gravity</li> <li>3. Petrographic Analysis (optional)</li> </ol>
Laboratory Equipment	Sieves and sieve shaker, balance, kiln, oven, caliper.
Suggested References	<p>Ceramic Raw Materials, 2<sup>nd</sup> revised edition by Worall, The Institute of Ceramics – Pergamon Press, NY USA, 1978                  Properties of Ceramic Raw Materials, 2nd Edition by Ryan, The Institute of Ceramics – Pergamon Press, NY, USA                  Elements of Ceramics by Norton, Addison-Wesley Press, Inc., USA, 1952                  Ceramics: Clay Technology by Wilson, McGraw-Hill Book Co., Inc., NY, USA, 1927                  Introduction to Ceramics, 2nd Edition, by Kingery, Bowen and Uhlmann, John Wiley &amp; Sons, NY, USA, 1976                  Ceramic Monographs: Handbook of Ceramics by Bilke and Paetsch, eds., Verlag Schmid GmbH, Freiburg i. Br., Germany, 1982                  Rheology and Rheometry of Clay-Water System, Phelps, Maguire and Wood                  Journals and Bulletins of the American Ceramic Society                  Ceramic Raw Materials, 2nd revised edition by Wornal, The Institute of Ceramics – Pergamon Press, Inc. NY USA, 1982                  Properties of Ceramic Raw Materials, 2nd Edition, Ryan, Pergamon Press, Inc., NY USA, 1978                  Elements of Ceramics by Norton, Adison-Wesley Press, Inc., Cambridge, Mass., USA, 1952                  Introduction to Ceramics by Kingery, Bowen and Uhlman, 2nd edition, John Wiley &amp; Sons, NY                  Ceramic Monographs: Handbook of Ceramics by Bilke and Paetsch, eds., Verlag Schmid GmbH, Freiburg i. Br., Germany, 1982</p>

Course Name	<b>CERAMIC CRYSTAL CHEMISTRY</b>
Course Description	Basic principles and theories in ceramic crystals with emphasis on symmetry, point-, space- and lattice groups essential to the understanding of crystalline solids such as silicates and glass-ceramics including other related structures. Relationships of structure and chemistry with various crystal properties.
No. of Units for Lecture and Laboratory	3 units lecture
No. of Contact Hours per week	3 hours lecture

Prerequisites	Fundamentals of Materials Science and Engineering
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify the structure of ceramic crystals in terms of symmetry, point groups, space groups and lattices</li> <li>2. Determine structure-property relationships</li> <li>3. Solve typical problems in crystal chemistry</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Atomic Structure (1)             <ol style="list-style-type: none"> <li>1.1. Bohr atoms</li> <li>1.2. Electron orbits</li> <li>1.3. Periodic relationships</li> </ol> </li> <li>2. Atomic Bonding in Solids (2)             <ol style="list-style-type: none"> <li>2.1. Ionic</li> <li>2.2. Covalent</li> <li>2.3. Metallic</li> <li>2.4. Secondary bonding</li> </ol> </li> <li>3. Crystal Structures             <ol style="list-style-type: none"> <li>3.1 Radius ratio coordination principles</li> <li>3.2 Pauling's rule (1)</li> <li>3.3 Space lattice (linear, planar and space lattices)</li> <li>3.4 Three dimensional point groups (repetition theory, basic rotational symmetries, symmetry combination) (2)</li> <li>3.5 General mathematical relations (axial ratio, crystal parameters, zones) (2)</li> </ol> </li> <li>4. Isomorphism, Polymorphism, Pseudomorphism (1)</li> <li>5. Oxide Structures (10)             <ol style="list-style-type: none"> <li>5.1 Rock salt (MgO)</li> <li>5.2 SiO<sub>2</sub></li> <li>5.3 Al<sub>2</sub>O<sub>3</sub></li> <li>5.4 Zirconia</li> <li>5.5 Perovskite</li> <li>5.6 Spinel</li> <li>5.7 Rutile</li> <li>5.8 Ilmenite</li> </ol> </li> <li>6. Silicate Structures (4)</li> <li>7. Other Structures (8)             <ol style="list-style-type: none"> <li>7.1 Rock salt structure</li> <li>7.2 Wurtzite structure</li> <li>7.3 Zinc blende structure</li> <li>7.4 Cesium chloride structure</li> <li>7.5 Fluorite structure</li> <li>7.6 Antifluorite structure</li> <li>7.7 Derivative structures</li> </ol> </li> </ol>
Laboratory Equipment	None
Suggested References	<p>Introduction to Ceramics by Kingery, Bowen and Uhlman, 2<sup>nd</sup> edition, John Wiley &amp; Sons, NY</p> <p>Fundamentals of Ceramics by Michel Barsoum, John Wiley &amp; Sons, NY</p> <p>Introduction to Crystal Chemistry by Evann, Cambridge University Press</p> <p>Introduction to Solid State Physics, 2nd edition by Kittel, John Wiley &amp; Sons, NY</p> <p>Manual of Mineralogy, 19th edition by Hurlbut and Klein, John Wiley &amp; Sons, NY</p> <p>Elements of Mineralogy by Mason and Berry, W.H. Freeman, San Francisco</p> <p>A Textbook of Mineralogy, 4th Edition, John Wiley &amp; Sons, NY</p> <p>An Introduction to Crystallography, Phillips, E.C. 1971, 4th edition, Longman Publishing</p> <p>Elementary Crystallography by Buerger, 1978, MIT Press</p> <p>Elements of X-ray Diffraction, 2nd Edition by Cullity</p>

Course Name	<b>CERAMIC TESTING</b>
Course Description	Methods of testing basic properties of ceramic materials and products with emphasis on procedures, calculations and evaluation of acquired data.
No. of Units for Lecture and Laboratory	2 units: 1 unit lecture, 1 unit laboratory
No. of Contact Hours per week	4 hours: 1 hour lecture, 3 hours laboratory
Prerequisites	Fundamentals of Materials Science and Engineering
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Understand the principles behind basic testing methods useful for the ceramic industry</li> <li>2. Identify which method is appropriate for measuring a specific ceramic property</li> <li>3. Determine the advantages and limitations of each method</li> <li>4. Acquire exposure and/or hands-on experience in the basic testing methods through actual laboratory exercises and/or visits to other facilities</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Physical testing (2)               <ol style="list-style-type: none"> <li>1.1 Specific Gravity</li> <li>1.2 Bulk density</li> <li>1.3 Porosity</li> <li>1.4 Shrinkage or Expansion</li> <li>1.5 Whiteness or color</li> <li>1.6 Permeability</li> <li>1.7 Viscosity</li> <li>1.8 Sieve analysis</li> </ol> </li> <li>2. Compositional Analysis (2)               <ol style="list-style-type: none"> <li>2.1 Wet Chemical Methods</li> <li>2.2 Instrumental methods (e.g. XRF, XRD, SEM-EDAX)</li> </ol> </li> <li>3. Thermal Analysis (2)               <ol style="list-style-type: none"> <li>3.1 Dilatometer</li> <li>3.2 TGA-DTA</li> <li>3.3 DSC</li> <li>3.4 TMA</li> </ol> </li> <li>4. Microstructural Analysis (2)               <ol style="list-style-type: none"> <li>4.1 Optical microscopy</li> <li>4.2 Scanning electron microscopy</li> <li>4.3 Transmission electron microscopy</li> </ol> </li> <li>5. Mechanical Properties (1)               <ol style="list-style-type: none"> <li>5.1 Compressive strength</li> <li>5.2 Modulus of rupture</li> <li>5.3 Hardness and Fracture Toughness</li> </ol> </li> <li>6. Electrical and Magnetic Properties (1)               <ol style="list-style-type: none"> <li>6.1 Dielectric constant</li> <li>6.2 Resistivity</li> <li>6.3 Magnetic permeability</li> </ol> </li> <li>7. Other Properties (1)</li> </ol> <p>Laboratory</p> <ol style="list-style-type: none"> <li>1. Determination of physical properties of clay bodies before and after firing (specific gravity, bulk density, porosity, shrinkage or expansion, whiteness or color) (8)</li> <li>2. Optical microscopy of ceramic products (3)</li> <li>3. Modulus of rupture determination (1)</li> <li>4. Compression testing of bricks (1)</li> <li>5. Thermal shock testing (3)</li> <li>6. Chemical resistance test (1)</li> </ol>
Laboratory Equipment	Optical microscope, kiln, oven, viscometer, moisture analyzer, analytical balance, sieves and sieve shaker, pycnometer, water bath, hardness tester, vernier caliper, micrometer caliper
Suggested References	Thermal Analysis, 3rd Edition by Wesley Win Wedlandt

	<p>Ceramic Monographs by Interceram          JACS          Ceramic Tests and Calculations by Andrews          Research Techniques in Non-destructive Testing by Sharpe, Academic Press, 1982          Manual of Industrial Instrumentation          Ceramic Industrial Processing and Testing by Jones et al.</p>
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Course Name	<b>CERAMIC FORMING TECHNOLOGY</b>
Course Description	Study of different forming techniques used in the manufacture of various ceramic products with emphasis on structure-property-processing relationships. To include examples of several ceramic components.
No. of Units for Lecture and Laboratory	2 units: 1 unit lecture, 1 unit laboratory
No. of Contact Hours per week	4 units: 1 hour lecture, 3 hours laboratory
Prerequisites	Ceramic Raw Materials and Processes, Ceramic Testing
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify the different forming techniques used in the manufacture of various ceramic products</li> <li>2. Understand the effects of processing on the structure and properties of ceramic products</li> <li>3. Identify the most appropriate manufacturing technique for a given ceramic product</li> <li>4. Determine local practices in ceramic forming technology</li> <li>5. Develop hands-on skills in the various ceramic forming techniques</li> </ol>
Course Outline	<p>Lecture:</p> <ol style="list-style-type: none"> <li>1. Hand forming (1)</li> <li>2. Throwing</li> <li>3. Jiggering (1)</li> <li>4. Casting (4)</li> <li>5. Extrusion (1)</li> <li>6. Pressing (1)</li> <li>7. Molding (3)</li> </ol> <p>Laboratory</p> <ol style="list-style-type: none"> <li>1. Preparation of clay materials (3)</li> <li>2. Hand forming of clay body (1)</li> <li>3. Jiggering of clay body (1)</li> <li>4. Throwing of clay body (2)</li> <li>5. Slip casting of clay body (3)</li> <li>6. Extrusion of clay body (1)</li> <li>7. Pressing of clay body (1)</li> <li>8. Making of mold (4)</li> <li>9. Firing of clay body (1)</li> </ol>
Laboratory Equipment	Extruder, Mixer, Kiln, Potter's wheel, Pressing Equipment
Suggested References	<p>Forming of Ceramics, Advances in Ceramics Vol. 9 by Mangels and Messing (eds.), The American Ceramic Society, Inc., 1984          Ceramic Fabrication Processes, Treatise on Material Science and Technology, Vol. 9 by Wang, Academic Press, 1976          Ceramic Processing Before Firing by Onoda and Hench, John Wiley &amp; Sons, 1978          Emergent Process Methods for High-Technology Ceramics, Materials Science Research, Vol. 17 by Davis, Palmar and Porter, Plenum Publishing, 1984          Ultrastructure Processing of Advance Structural and Electronics Materials by Hench, Noyes Publications, 1984          Ultrastructure processing of Ceramics, Glasses and Composites by Hench and Ulrich, John Wiley &amp; Sons, 1984          Pottery Science, Materials, Processes and Products by Dinsdale, John Wiley</p>

	& Sons, 1986 Ceramic Whitewares by Newcomb, Pitman Publishing Corporation
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Course Name	<b>RESEARCH AND DEVELOPMENT IN CERAMIC ENGINEERING</b>
Course Description	Research and development methodologies applicable to study of ceramic engineering systems. Writing of research proposals on assigned topics.
No. of Units for Lecture and Laboratory	3 units: 2 units lecture (if with lab), 1 unit laboratory (optional) or 3 units lecture (if no lab)
No. of Contact Hours per week	5/3 hours: 2 hours lecture (if with lab), 3 hours laboratory (optional) or 3 hours lecture (if no lab)
Prerequisites	Ceramic Raw Materials and Processes, Probability and Statistics, Ceramic Testing
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify appropriate research and development methodologies pertaining to ceramic engineering systems</li> <li>2. Determine appropriate methodologies to an assigned research problem</li> <li>3. Write a research proposal on the undergraduate thesis</li> <li>4. Apply design of experiment (DOE) fundamentals to assigned problems</li> <li>5. Perform statistical analysis of experimental results using techniques such as ANOVA</li> <li>6. Present results in appropriate form using graphs, tables and fitted regression models</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Design of Experiments (2) <ol style="list-style-type: none"> <li>1.1 Major benefits of using statistical experimental design</li> <li>1.2 Stages of investigation where DOE is useful</li> <li>1.3 Major considerations in DOE</li> </ol> </li> <li>2. Hypothesis Testing (4) <ol style="list-style-type: none"> <li>2.1 Confidence intervals</li> <li>2.2 Hypothesis testing of means and variances</li> </ol> </li> <li>3. Variable Screening Designs (15) <ol style="list-style-type: none"> <li>3.1 2k Factorial Design</li> <li>3.2 Fractional factorial experiments</li> <li>3.3 Analysis of Variance of factorial experiments</li> <li>3.4 Interaction plots of significant effects</li> </ol> </li> <li>4. Optimization Methods (8) <ol style="list-style-type: none"> <li>4.1 Fundamental considerations</li> <li>4.2 Method of steepest ascent</li> <li>4.3 Central composite design</li> <li>4.4 Simplex method</li> <li>4.5 Analysis of optimization experiments (finding parameters in first order and second order models)</li> <li>4.6 Test for goodness of fit</li> </ol> </li> <li>5. Preparation of the Research Proposal (2) <ol style="list-style-type: none"> <li>5.1 Sections of the Research Proposal</li> <li>5.2 Major Considerations in Writing the Proposal</li> </ol> </li> </ol>
Laboratory Equipment	None
Suggested References	Probability and Statistics for Engineers and Scientists by Walpole and Myers, MacMillan Publishing House, Inc., NY 1978 Probability and Statistics for Engineers and Scientists by Hayter Statistical Methods for Engineers by Vining; Brooks Cole Publishing Company

Course Name	<b>FUELS AND COMBUSTION</b>
Course Description	Study of the principles of combustion including stoichiometry and energy calculations of the principal fuels used in ceramic engineering such as coke, coal, oil and LPG.
No. of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory
No. of Contact Hours per week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisites	Analytical Chemistry
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify the different fuels used in ceramic engineering such as coke, coal, oil and LPG</li> <li>2. Make stoichiometry and energy calculations pertaining to principal fuels used in ceramic engineering</li> <li>3. Understand the general principles of combustion</li> <li>4. Select the most appropriate fuel for a given application</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Introduction (1)             <ol style="list-style-type: none"> <li>1.1. Energy Resources</li> <li>1.2. Coal Resources</li> </ol> </li> <li>2. Analysis of Coal (1)             <ol style="list-style-type: none"> <li>1.3. Proximate Analysis</li> <li>1.4. Ultimate Analysis</li> <li>1.5. Calorific Value of Coals using Dulong's Formula</li> </ol> </li> <li>3. Classification of Coal (1)             <ol style="list-style-type: none"> <li>3.1 Grade of Coal</li> <li>3.2 Storage of Coal</li> </ol> </li> <li>4. Coke and coke making (2)             <ol style="list-style-type: none"> <li>4.1 Metallurgical coke</li> <li>4.2 Coke Ovens</li> <li>4.3 Properties of coke</li> <li>4.4 Formed coke</li> </ol> </li> <li>5. Solid fuels (4)             <ol style="list-style-type: none"> <li>5.1 Pertinent Calculation (composition &amp; heat value) based on the combustion of coal and coke</li> <li>5.2 Pertinent Calculation (composition &amp; heat value) based on the analysis of the flue gas</li> </ol> </li> <li>6. Liquid fuels (4)             <ol style="list-style-type: none"> <li>6.1 Properties of liquid fuels</li> <li>6.2 Fuel Oils</li> <li>6.3 Calorific Value of liquid fuels</li> <li>6.4 Calculation based on the combustion of coal and coke</li> <li>6.5 Calculation based on the analysis of the flue gas</li> </ol> </li> <li>7. Gaseous fuels (6)             <ol style="list-style-type: none"> <li>7.1 Preparation of gaseous fuels</li> <li>7.2 Calorific value of gaseous fuels</li> <li>7.3 Gasification of solid fuels</li> <li>7.4 Manufacture of producer gas</li> <li>7.5 High pressure gas generators</li> <li>7.6 Fluidized bed gasification process</li> <li>7.7 Dilute phase or entrained-suspension gasification</li> <li>7.8 Substitution by natural gas</li> <li>7.9 Calculation based on the combustion of coal and coke</li> <li>Calculation based on the analysis of the flue gas</li> </ol> </li> <li>8. Combustion (5)             <ol style="list-style-type: none"> <li>8.1 Metallurgical furnaces</li> <li>8.2 Material balances in combustion</li> <li>8.3 Combustion of hydrocarbon fuels</li> <li>8.4 Maximum adiabatic flame temperature</li> <li>8.5 Performance of metallurgical furnaces</li> </ol> </li> <li>9. Secondary fuels (2)</li> </ol>

	9.1 Production 9.2 Combustion 10. Fuels and Combustion Application in (3) 10.1 Glass Industry 10.2 Cement Industry 10.3 Refractory Industry 10.4 Whiteware and Structural Industry 10.5 Artware Industry 11. Energy balances (2)  Laboratory 1. Determination of the calorific value of coal, rice hull and coconut shell (4) 2. Determination of the calorific value of kerosene and bunker oil. (3) 3. Determination of the calorific value of LPG.(3) 4. Flame temperature measurement (3) 5. Determination of kindling temperature of solid, liquid and gas fuels (4)
Laboratory Equipment	Kiln, bomb calorimeter, Orsat analyzer
Suggested References	Industrial Stoichiometry by Lewis, Radasch and Lewis Industrial Stoichiometry by Williams and Johnson Industrial Chemical Calculations by Hougen and Watson Chemical Calculations by Anderson Industrial Chemistry by Raymond Riegel Fuels , Combustion and Furnaces by John Griswold

Course Name	<b>WHITEWARES</b>
Course Description	Technology of whitewares manufacture with emphasis on product formulation, production, firing techniques, finishing, packaging and control of properties. Case studies of actual manufacturing problems.
No. of Units for Lecture and Laboratory	3 units: 2 units lecture (if with lab), 1 unit laboratory (if with lab) or 3 units lecture (if no lab)
No. of Contact Hours per week	5/3 hours: 2 hours lecture (if with lab), 3 hours laboratory (if with lab) or 3 hours lecture (if no lab)
Prerequisites	Phase Equilibrium in the Ceramic System Ceramic Raw Materials & Processes Ceramic Raw Materials & Processes Laboratory Properties of Ceramics Products
Course Objectives	At the end of the course the student must be able to: 1. Apply principles of product formulation in connection with whitewares 2. Identify the different production, firing, finishing and packaging techniques for ceramic whitewares 3. Suggest procedures necessary for control of properties 4. Perform case studies of manufacturing problems
Course Outline	1. Introduction (1) 1.1 History and Identification of white wares and Structural products 1.2 Functions and Limitations of Products. 2. Raw Materials for Whitewares production (7) 2.1 Sources and properties of the raw materials 2.2 Plasticity 2.3 Colloidal Chemistry 2.4 Deflocculation. 3. Testing, Quality Control and Beneficiation of Raw Materials (4) 4. Phase Diagrams of Target Products and their Role in Product formulation (2) 5. Whiteware body Preparation Operation (5) 5.1 Methods of Fabrication 5.2 Rheology and Rheometry 5.3 Quality Control for Green ware production. 6. Drying of White wares (4)

	<p>6.1 Effect of heat on Plastic clay and on green wares</p> <p>6.2 Effect of various salts and electrolytes on the drying properties of clay</p> <p>6.3 Finishing techniques on green wares</p> <p>6.4 Quality Control of drying of green wares.</p> <p>7. Kilns and Settings (5)</p> <p>7.1. Effect of heat (vitrification) on green wares</p> <p>7.2. Different periods in vitrification</p> <p>7.3. Melting, fusion and crystallization of silicates</p> <p>7.4. Quality control of fired wares.</p> <p>8. Finishing and Packaging of Wares (3)</p> <p>7.5. Research and Development Tools</p> <p>7.6. Advanced Finish Technology.</p> <p>Laboratory Option</p> <p>1. Laboratory inventory (materials and equipment) (1)</p> <p>2. Sampling of raw materials. Moisture content on delivery. Particle size distribution. (1)</p> <p>3. Beneficiation of plastic and non-plastic raw materials (1)</p> <p>4. Testing and quality control of plaster of paris (heat treated vs. commercial plaster) (2)</p> <p>5. Testing and quality control of plastic and non-plastic raw materials (2)</p> <p>6. Testing and quality control of products from various product formulations (5)</p> <p>7. Production of chosen wares (5)</p>
Laboratory Equipment	Kiln, mixer, blunger, viscometer, oven, balance, sieve and sieve shaker, vernier caliper, pot mill and roller, pug mill, extruder
Suggested References	Whitewares Production, Testing and Quality Control by Ryan & Radford, 1987 Rheology and Rheometry of Clay-Water Systems by Phelps, Maguire, Kelly & Wood Elements of Ceramics by Norton. 1952 Ceramics Clay Technology by Hewitt Wilson Introduction to Ceramics by Kingery, Bowen & Uhlmann Introduction to Phase Equilibria in Ceramic Systems by Hummel

Course Name	<b>PROPERTIES OF CERAMIC PRODUCTS</b>
Course Description	Influence of composition, temperature, pressure, time and other controllable parameters on the microstructure and resultant thermal, mechanical, chemical, optical, electrical, magnetic properties of ceramic products.
No. of Units for Lecture and Laboratory	2 units lecture
No. of Contact Hours per week	2 hours lecture
Prerequisites	Fundamentals of Materials Science and Engineering, Ceramic Crystal Chemistry
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify the different properties of ceramic products such as thermal, mechanical, chemical, optical, electrical and magnetic properties</li> <li>2. Rationalize the properties in terms of the microstructure</li> <li>3. Relate the properties and microstructure to controllable parameters such as composition, temperature, and time</li> <li>4. Identify methods of modifying properties through a change in microstructure</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Physical properties (2) <ol style="list-style-type: none"> <li>1.1 Melting point</li> <li>1.2 Density</li> </ol> </li> <li>2. Thermal properties (6) <ol style="list-style-type: none"> <li>2.1 Definition and fundamental principles of heat capacity, Thermal expansion and heat conduction</li> </ol> </li> </ol>

	<ul style="list-style-type: none"> <li>2.2 Density and thermal expansion of crystals, glasses and composites</li> <li>2.3 Effect of heat treatment</li> <li>2.4 Effect of polymorphic transformations</li> <li>2.5 Thermal conduction mechanisms</li> <li>2.6 Thermal stress, thermal shock resistance and thermal spalling</li> <li>3. Optical properties (3) <ul style="list-style-type: none"> <li>3.1 Electromagnetic waves in ceramics</li> <li>3.2 Refractive index and dispersion, reflection and refraction</li> <li>3.3 Boundary reflectance and surface gloss</li> <li>3.4 Opacity and translucency</li> <li>3.5 Absorption and color</li> <li>3.6 Ceramic stains</li> </ul> </li> <li>4. Mechanical properties (7) <ul style="list-style-type: none"> <li>4.1 Elastic and anelastic behavior of ceramics (stress-strain curves, elastic moduli)</li> <li>4.2 Plasticity in ceramics (dislocation theory for ceramic materials, deformation mechanism maps, viscous flow in liquids and glasses, dependence of plasticity on temperature and composition)</li> <li>4.3 Fracture Mechanisms (Brittle fracture and crack propagation, fatigue, creep, effects of microstructure on fracture behavior)</li> <li>4.4 Strengthening and fracture toughening of ceramics</li> </ul> </li> <li>5. Electrical properties (7) <ul style="list-style-type: none"> <li>5.1 Electrical conduction and mobility</li> <li>5.2 Charge carriers</li> <li>5.3 Ionic conduction in crystals and glasses</li> <li>5.4 Electronic conduction in crystals and glasses</li> <li>5.5 Effects of composition</li> <li>5.6 Conduction in semiconductors (non-stoichiometric and solute controlled electronic conduction, valency-controlled semiconductors)</li> <li>5.7 Mixed conduction in poor conductors and polycrystalline ceramics</li> </ul> </li> <li>6. Dielectric properties (3) <ul style="list-style-type: none"> <li>6.1 Definition of capacitance, inductance, polarization, loss factor and dielectric strength</li> <li>6.2 Mechanisms for polarization in a dielectric field</li> <li>6.3 Dielectric constant of crystals and glasses</li> <li>6.4 Effects of frequency and temperature</li> <li>6.5 Dielectric loss factor for crystals and glasses</li> <li>6.7 Dielectric conductivity</li> <li>6.8 Classes of dielectrics</li> <li>6.9 Ferroelectric ceramics</li> </ul> </li> <li>7. Magnetic Properties (3) <ul style="list-style-type: none"> <li>7.1 Magnetic phenomena</li> <li>7.2 Diamagnetic and paramagnetic materials</li> <li>7.3 Magnetic domains</li> <li>7.4 Hysteresis</li> <li>7.5 Spinel ferrites</li> <li>7.6 Rare earth garnets</li> <li>7.7 Orthoferrites</li> <li>7.8 Ilmenites</li> <li>7.9 Hexagonal ferrites</li> <li>7.10 Polycrystalline ferrites</li> <li>7.11 Effects of temperature</li> <li>7.12 Effects of composition, grain size and porosity</li> </ul> </li> </ul>
Laboratory Equipment	None
Suggested References	<p>Introduction to Ceramics by W.D. Kingery, H.K. Bowen, D.R. Uhlmann.. John Wiley and Sons, Inc.</p> <p>Fundamentals of Ceramics by Michel Barsoum, John Wiley &amp; Sons, NY</p> <p>Ceramic Materials for Electronics by R.C. Buchanan,. 1991</p> <p>Handbook of ceramics and composites.</p> <p>Toughening Mechanism in Quasi-brittle materials.</p> <p>Failure mechanisms in semiconductors.</p>

	<p>Materials Science and Engineering by W.D. Callister, Jr..1994          Elements of Ceramics by F.H.Norton.. Addison-Wesley Publishing Co.,Inc.          Lectures on Electrical Properties of Materials, 5<sup>th</sup> edition by L.Solymar and D. Walsh</p>
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Course Name	<b>GLAZES AND ENAMELS</b>
Course Description	Study of the raw materials, processing and formulation of glazes and enamels including body-and-glaze compatibility. Testing of final ceramic products.
No. of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory
No. of Contact Hours per week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisites	Ceramic Raw Materials and Processes, Phase Equilibrium in Ceramic Systems
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify the raw materials for glazes and enamels</li> <li>2. Solve problems on formulation of glazes and enamels</li> <li>3. Assess body-and-glaze compatibility based on formulation</li> <li>4. Identify appropriate testing methods for final ceramic products especially those used in local practice</li> <li>5. Develop hands-on skills in the preparation of glazes through the laboratory experiments</li> </ol>
Course Outline	<p>Introduction (1)</p> <ol style="list-style-type: none"> <li>1. Raw Materials for Glazes and Enamels (2)</li> <li>2. Formulations and Phase Diagrams of Glazes and Enamels (7)</li> <li>3. Batch Preparation of Glazes and Enamels (5)</li> <li>4. Applications of Glazes and Enamels (3)</li> <li>5. Firing of Glazes and Enamels (2)</li> <li>6. Mechanism of Melting and Cooling (3)</li> <li>7. Colors in Glazes and Enamels (3)</li> <li>8. Defects in Glazes and Enamels (5)</li> </ol> <p>Laboratory</p> <ol style="list-style-type: none"> <li>1. Formulation of glazes (4)</li> <li>2. Batch preparation for glazes and enamels (5)</li> <li>3. Determination of glaze slip properties (4)</li> <li>4. Application and firing of glazes (spraying, painting, dipping, pouring) (4)</li> </ol>
Laboratory Equipment	Kiln, balance, pot mill, sieves and sieve shaker, mixer, oven, autoclave or equivalent
Suggested References	<p>Ceramic Glazes by Parmelee, Industrial Publications, Inc., 1951          Vitreous enamels, Borax Consolidated Limited, 1965          Ceramic Glazes: Science Technology, Ravaglioli          Ceramic Glaze Technology by Taylor and Bull, Institute of Ceramics, Pergamon Press, NY, 1986</p>

Course Name	<b>THERMAL PROCESSES AND PYROMETRY</b>
Course Description	Principles and theories involved in drying, firing and/or sintering of ceramic products with emphasis on study of kiln construction and operations.
No. of Units for Lecture and Laboratory	3 units: 2 units lecture, 1 unit laboratory
No. of Contact Hours per week	5 hours: 2 hours lecture, 3 hours laboratory
Prerequisites	Kinetics of Materials, Fuels and Combustion
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify methods of drying, firing and/or sintering of ceramic products</li> <li>2. Identify the governing principles and theories behind each method</li> </ol>

	<ol style="list-style-type: none"> <li>3. Solve computational problems on heat transfer</li> <li>4. Develop skills in the design and construction of kilns and furnaces</li> <li>5. Acquire knowledge about high temperature measurements and control</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Introduction (2)</li> <li>2. Fuels and Combustion (2)</li> <li>3. Structure of kiln (5)</li> <li>4. Heat retention and transfer (3)</li> <li>5. Refractory for kiln materials (2)</li> <li>6. Kiln design (9)</li> <li>7. Measurement and control over temperatures (2)</li> <li>8. Firing techniques and temperatures of ceramic bodies (6)</li> <li>9. Laboratory Activities</li> <li>10. Actual Design of Laboratory Furnace and Kiln (7)</li> <li>11. Actual Operation and Control of Furnaces and Kilns (7)</li> <li>12. Pyrometric cone equivalent (3)</li> </ol>
Laboratory Equipment	Thermocouple and pyrometer, kiln
Suggested References	<p>Elements of Ceramics by Norton, Addison-Wesley Press, Inc., Cambridge, Mass. USA, 1952</p> <p>Fundamentals of Ceramics by Osborn</p> <p>Fine Ceramics by Norton, McGraw-Hill Book Co.</p> <p>Industrial Furnaces, Vol. I and II, Trinks, John Wiley &amp; Sons, Inc., 1951</p> <p>Kiln Building by Gregory</p> <p>The Kiln Book- Material Specifications and Construction by Olsen</p> <p>Kilns: Design, Construction and Operation by Rhodes</p> <p>Journals and Bulletins of The American Ceramic Society</p> <p>The Kanthal Handbook, The Kanthal Corporation, Connecticut, 1975</p> <p>Kaiser Refractories Handbook, Kaiser Refractories Corporation</p> <p>Modern Refractory Practice, Harbison-Walker Refractories Company, Pennsylvania, USA, 1961-</p>

Course Name	<b>CERAMIC PLANT DESIGN</b>
Course Description	Basic principles of plant design with emphasis on basic material handling, energy balance, location, lay-out, determination of machineries and equipment specifications. Environmental and economic considerations.
No. of Units for Lecture and Laboratory	2 units: 1 unit lecture, 1 unit laboratory
No. of Contact Hours per week	4 hours: 1 hour lecture, 3 hours laboratory
Prerequisites	Regular 5th year standing , Engineering Economy
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify the different components of plant design</li> <li>2. Apply principles of material balance and energy balance in plant design</li> <li>3. Determine machine specifications of major equipment in plant</li> <li>4. Determine environmental and building regulations needed for plant design</li> <li>5. Identify major economic factors in the design</li> <li>5. Conduct general evaluation and assessment of an existing ceramic plant design based on lay-out and other major considerations</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Plant lay-out and design (3)</li> <li>2. Environmental considerations (2)</li> <li>3. Building regulations (2)</li> <li>4. Economic considerations (2)</li> <li>5. Basic material handling concepts (2)</li> </ol>

	6. Transportation (2) 7. Plant location (2) 8. Lay-out analysis of existing manufacturing plant (2)  Laboratory Activities 1. Computer aided layouting (4) 2. Literature and library search of design related data (4) 3. Computation of tonnages, capacities and energy requirements (3) 4. Benchmarking activities (5) 5. Finalization of plant design output (1)
Laboratory Equipment	Computer facility with design software
Suggested References	Ceramic Monographs by the German Ceramic Society Plant Design and Economics for Chemical Engineers, 3 <sup>rd</sup> edition by Peters and Timmerhaus, McGraw-Hill Book Company, NY, 1980 National Building Code

Course Name	<b>REFRACTORIES</b>
Course Description	Study of the processes and operations in the manufacture of refractories with emphasis on raw materials and product formulations which could affect mechanical, thermal and chemical properties of refractory materials
No. of Units for Lecture and Laboratory	2 units lecture
No. of Contact Hours per week	2 hours lecture
Prerequisites	Phase Equilibrium in Ceramic Systems, Ceramic Raw Materials and Processes , Properties of Ceramic Products
Course Objectives	At the end of the course the student must be able to: 1. Identify the different refractory raw materials and products 2. Identify the processes and operations involved in the manufacture of refractories 3. Identify physical and chemical characterization methods for raw materials 4. Select the appropriate refractory for a given application 5. Understand the degradation behavior of refractories
Course Outline	1. Introduction to refractories (2) 2. Sources of raw materials (natural and synthetic) (4) 3. Physical characterization of raw materials (5) 4. Chemical characterization of raw materials (5) 5. Refractory formulations (7) 6. Processes and operations in the manufacture of applicable products (6) 7. Properties and application of finished products (3)
Laboratory Equipment	None
Suggested References	Refractories by Norton, McGraw-Hill Book Company Modern Refractory Practice, Harbison and Walker Refractories Company The Technology of Ceramics and Refractories by Budnikov, The MIT Press, Mass., 1964 Handbook of Refractory Compounds, Samsonov et al. New Developments in Monolithic Refractories by Fisher (ed.) Raw Materials for the Refractory Industry by Cooper and Dickson Refractories: Production and Properties by Chesters

Course Name	<b>ADVANCED CERAMICS I</b>
Course Description	Study of the synthesis, characterization, and microstructure-modification of advanced ceramics consisting of high purity oxides and non-oxides used in high technology applications
No. of Units for Lecture and Laboratory	2 units lecture
No. of Contact Hours per week	2 hours lecture
Prerequisites	4 <sup>th</sup> year standing
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify examples of advanced ceramics and their applications in high technology</li> <li>2. Identify various methods which can be used in the synthesis of advanced ceramics</li> <li>3. Identify important methods of characterizing advanced ceramics</li> <li>4. Suggest ways of modifying the microstructure of advanced ceramics to control certain properties</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Introduction (3)             <ol style="list-style-type: none"> <li>1.1 High technology ceramics</li> <li>1.2 Raw materials for high technology ceramics</li> </ol> </li> <li>2. Synthesis of advanced ceramics (10)             <ol style="list-style-type: none"> <li>2.1 Sol-gel processing</li> <li>2.2 Co-precipitation</li> <li>2.3 CVD</li> <li>2.4 Hydrothermal methods</li> <li>2.5 MBE</li> <li>2.6 Planetary Ball Milling</li> </ol> </li> <li>3. Special Characterization methods for advanced ceramics (9)             <ol style="list-style-type: none"> <li>3.1 TEM</li> <li>3.2 AFM</li> <li>3.3 Raman</li> <li>3.4 FTIR</li> <li>3.5 STM</li> <li>3.6 ESCA or XPS, AES, RBS</li> <li>3.7 Ellipsometry</li> </ol> </li> <li>4. Discussion of special properties of selected advanced ceramics (9)             <ol style="list-style-type: none"> <li>4.1 Superconducting oxides and borides</li> <li>4.2 Ferroelectric ceramics</li> <li>4.3 Thermoelectric ceramics</li> <li>4.4 Semiconducting ceramics</li> <li>4.5 High-K and low-K dielectrics</li> <li>4.6 Fracture-toughened ceramics</li> </ol> </li> </ol>
Laboratory Equipment	None
Suggested References	<p>Present State of Mineral Resources, T.Nishiyama, Alum Press, 1989, 357p          Earth Resources, B.J.Skinner, 2nd Ed., Kyoritsu Press, 1982, 177p          Sol-gel Science, C.J.Brinker and G.W. Scherer, Academic Press Inc., 1990, Chapter 2, 3, 13, and 14.          TiO<sub>2</sub> Photocatalysis; its application to self-cleaning, anti-bacterial and air purifying materials, K. Hashimoto and A. Fujishima, CMC Press, Tokyo, (in Japanese) 1998, Chapter 1-3.          Handbook of Ceramics, 2nd edition (Ouyou-henn) Ed. Ceramic Society of Japan, Giho-do Press (in Japanese) 2002, 68-130p          Introduction to Ceramics by Kingery, Bowen, Uhlmann          Fundamentals of Ceramics by Michel Barsoum, John Wiley &amp; Sons, NY          Ceramic Materials for Electronics by Relva C. Buchanan          Ceramic Processing by Terpstra, Pex and de Vries. 1995          *Compiled literature from the internet.*          W.D. Kingery, H.K. Bowen, D.R. Uhlmann. Introduction to Ceramics. John Wiley and Sons, Inc.          R.C. Buchanan, Ceramic Materials for Electronics. 1991          Handbook of ceramics and composites.</p>

	<p>Toughening Mechanism in Quasi-brittle materials.                  Failure mechanisms in semiconductors.                  W.D. Callister, Jr. Materials Science and Engineering.1994                  F.H.Norton.Elements of Ceramics. Addison-Wesley Publishing Co.,Inc.                  Solymar and D. Walsh. Lectures on Electrical Properties of Materials 5<sup>th</sup> ed.</p>
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Course Name	<b>GLASS TECHNOLOGY</b>
Course Description	Review of the raw materials, characterization and processing of glasses and glass-ceramics with emphasis on mechanical, thermal, optical and electrical properties.
No. of Units for Lecture and Laboratory	2 units lecture
No. of Contact Hours per week	2 hours lecture
Prerequisites	Ceramic Raw Materials and Processes, Properties of Ceramic Products
Course Objectives	At the end of the course the student must be able to: <ol style="list-style-type: none"> <li>1. Acquire an overview of the technology of glasses and glass-ceramics</li> <li>2. Make formulations of glasses and glass-ceramics based on phase diagram information</li> <li>3. Identify best practices especially in local plants</li> <li>4. Rationalize procedures and formulations in terms of their effects on various properties</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Introduction (1)</li> <li>2. Raw Materials for Glasses and Glass-Ceramics (2)</li> <li>3. Formulations and Phase Diagrams of Glasses and Glass-Ceramics (6)</li> <li>4. Batch Preparation of Glasses and Glass-Ceramics (4)</li> <li>5. Applications of Glasses of Glass-Ceramics (4)</li> <li>6. Forming of Glasses and Glass-Ceramics (3)</li> <li>7. Mechanism of Melting and Cooling (4)</li> <li>8. Colors in Glasses and Glass-Ceramics (3)</li> <li>9. Defects in Glasses and Glass-Ceramics (4)</li> </ol>
Laboratory Equipment	None
Suggested References	Glass: The Miracle Maker by Philips, Pitman Publishing Corporation, 1941 Elements of Ceramics by Norton, Addison-Wesley Press, Inc., 1952 Glass Science by Doremus, John Wiley & sons, Inc. The Structure and Mechanical Properties of Inorganic Glasses by Bortenev, Walters-Noodhoff Publishing, Inc. Glass-Ceramics, McMillan Physical Properties of Glass by Standworth, Oxford University Press Handbook of Glass Manufacture Vo1. I and II by Tooley, Ashlee Publishing Company Glass: Its Industrial applications by Phillips, Reinhold Publishing Corporation, NY

Course Name	<b>CEMENT MANUFACTURING TECHNOLOGY</b>
Course Description	Comprehensive discussion on the unit processes and operations in cement manufacture including raw materials, product formation, fuel and combustion, kiln characterization, machineries and equipment used. Mechanical and chemical properties of cement products.
No. of Units for Lecture and Laboratory	2 units lecture
No. of Contact Hours per week	2 hours lecture
Prerequisites	Ceramic Raw Materials and Processes, Phase Equilibrium in Ceramic

Systems	
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify the raw materials for cement manufacture and their sources</li> <li>2. Identify the unit processes and operations in cement manufacture</li> <li>3. Identify the different machineries and equipment used in cement manufacture</li> <li>4. Identify important mechanical and chemical properties of cement products and how they are affected by the cement formulation</li> <li>5. Gain familiarity with local cement manufacturing practices</li> <li>6. Develop awareness about environmental concerns in cement manufacture</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Introduction. (2)               <ol style="list-style-type: none"> <li>1.1 History of Cement manufacturing</li> <li>1.2 Cement industries of the Philippines</li> <li>1.3 Cement raw materials and deposits in the Philippines</li> <li>1.4 Imported raw materials for cement manufacture</li> <li>1.5 Different types of cement</li> </ol> </li> <li>2. Cement clinker (4)               <ol style="list-style-type: none"> <li>2.1 Phases in cement clinker (albite, belite, aluminate phase, ferrite phase)</li> <li>2.2 Physical and Chemical properties of phases</li> <li>2.3 High temperature chemistry of cement clinker</li> </ol> </li> <li>3. Cement formulations (7)               <ol style="list-style-type: none"> <li>3.1 Phase diagrams of various kinds of cement</li> <li>3.2 Batch preparation of various kinds of cement</li> <li>3.3 Manufacture of various kinds of cement clinker</li> <li>3.4 Finish millings of various kinds of cement clinker</li> <li>3.5 Cement additives (source, properties and functions)</li> <li>3.6 Chemistry of cement manufacture</li> </ol> </li> <li>4. Properties of Cement Clinker and Cement (5)               <ol style="list-style-type: none"> <li>4.1 Hydration of calcium silicate, aluminate, ferrite and sulfate phases</li> <li>4.2 Hydration of Cement.</li> </ol> </li> <li>5. Characterization of Cement (6)               <ol style="list-style-type: none"> <li>5.1 Physical characterization</li> <li>5.2 Chemical characterization</li> </ol> </li> <li>6. Uses and applications of various kinds of cement</li> <li>7. Environmental concerns on Cement Production (3)</li> <li>8. Recent Developments in the Manufacture of cement and Cement Products. (3)</li> </ol>
Laboratory Equipment	None
Suggested References	<p>H.F.W. Taylor. Cement Chemistry. 2<sup>nd</sup> Edition.1997            Hill, Holmes, Mather. Lime and other Alternative Cements. 1992            Fibre &amp; Micro-concrete Roofing Tiles.            Condensed Silica Fume in Concrete            Fiber-Reinforced Cement Composites            Plasticity in Reinforced Concrete.            The Chemistry of Portland Cement, 2<sup>nd</sup> edition by Bogue, Reinhold Publishing Corporation, NY</p>

Course Name	<b>UNDERGRADUATE THESIS</b>
Course Description	Individual/group research study of the student with supervision of a faculty leading to the application of the different concepts and principles in the field of ceramic engineering. Presentation of undergraduate thesis output and submission of final report.
No. of Units for Lecture and Laboratory	2 units laboratory
No. of Contact Hours per week	6 hours laboratory
Prerequisites	Fifth year standing

Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Conduct an individual or group research study on an appropriate topic in the field of ceramic engineering</li> <li>2. Apply different concepts and principles previously learned on a research project</li> <li>3. Develop writing and presentation skills</li> <li>4. Defend the results of the study in an oral presentation</li> <li>5. Submit a written report output</li> </ol>
Course Outline	Not applicable (progress to be monitored based on Gantt chart in the submitted undergraduate thesis proposal)
Laboratory Equipment	Multimedia facility
Suggested References	Depends on the selected topic

Course Name	<b>STRUCTURAL CLAY PRODUCTS</b>
Course Description	Unit processes and operations in structural clay manufacture. Control of physical, mechanical and chemical properties of structural clay products.
No. of Units for Lecture and Laboratory	3 units: 2 units lecture (if with lab), 1 unit laboratory or 3 units (if no lab)
No. of Contact Hours per week	5/3 hours: 2 hours lecture (if with lab), 3 hours laboratory or 3 hours (if no lab)
Prerequisites	Phase Equilibria in the Ceramic System Ceramic Raw Materials & Processes Ceramic Raw Materials & Processes Laboratory Properties of Ceramics Products
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify the unit processes and operations in the manufacture of structural clay products</li> <li>2. Identify means of controlling the physical, mechanical and chemical properties of structural clay products during the manufacturing process</li> <li>3. Perform actual formulation and manufacture of a structural clay product in the laboratory (applicable to those with laboratory option)</li> </ol>
Course Outline	<p>Lecture</p> <ol style="list-style-type: none"> <li>1. Introduction (1)</li> <li>2. Raw Materials for Structural Clay Products (2)</li> <li>3. Product Formulation using Phase Diagram (8)</li> <li>4. Manufacturing Processes of Structural Clay Products (8) <ul style="list-style-type: none"> <li>4.1 Batch Making</li> <li>4.2 Forming</li> <li>4.3 Drying</li> <li>4.4 Finishing</li> <li>4.5 Firing</li> <li>4.6 Testing and Quality Control</li> </ul> </li> <li>5. Physical Characterization (5)</li> <li>6. Chemical Characterization (5)</li> <li>7. Uses and Applications (2)</li> </ol> <p>Laboratory (for those with lab option)</p> <ol style="list-style-type: none"> <li>1. Laboratory inventory (materials and equipment) (1)</li> <li>2. Sampling of raw materials. Moisture content on delivery. Particle size distribution. (1)</li> <li>3. Beneficiation of plastic and non-plastic raw materials (1)</li> <li>4. Testing and quality control of plastic and non-plastic raw materials (2)</li> <li>5. Testing and quality control of products from various product formulations (6)</li> <li>6. Production of chosen wares (6)</li> </ol>
Laboratory Equipment	Kiln, mixer, blunger, viscometer, oven, balance, sieve and sieve shaker,

	vernier caliper, pot mill and roller, pug mill, extruder, pressing equipment
Suggested References	<p>Elements of Ceramics by Norton, Addison-Wesley Press, Inc.</p> <p>Chemistry of Engineering Materials by Leighou, McGraw-Hill Book Co., Inc.</p> <p>Ceramic Monograph: Handbook of Ceramics by Bilke and Paestch, eds., Verlag Schmid GmbH, Freiburg I Br., Germany, 1982</p> <p>Brick Manufacture in Developing Countries by Keddie et al.</p> <p>Structural Clay Products by Brownell</p>

Course Name	<b>QUALITY ASSURANCE</b>
Course Description	Study of the basic principles of quality assurance using established quality techniques based on statistical tools such as control charts for variables and attributes, ANOVA and lot-by-lot acceptance sampling.
No. of Units for Lecture and Laboratory	1 unit lecture
No. of Contact Hours per week	1 hour lecture
Prerequisites	Probability and Statistics
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify the basic principles in quality assurance</li> <li>2. Prescribe procedures to control the quality of manufactured ceramic products</li> <li>3. Identify the most relevant quality standards such as ISO parameters</li> <li>4. Make proper use of statistical tools such as control charts, ANOVA and lot-by-lot acceptance sampling</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Quality Control Requirements in the Ceramic Industry (4)</li> <li>2. Quality Standards (5)</li> <li>3. International Standards (e.g.ISO, ASTM, IEC)</li> <li>4. Philippine National Standards</li> <li>5. Other National Standards (e.g JIS)</li> <li>6. Statistical Tools for Quality Control (5)</li> <li>7. Control charts</li> <li>8. ANOVA</li> <li>9. Sampling Methods (3)</li> </ol>
Laboratory Equipment	None
Suggested References	<p>ISO 9000 Series</p> <p>Quality Assurance in Ceramic Industry, Frechette (ed.)</p> <p>Quality Control for Profit by Lester, Enrick and Mottley</p> <p>Quality Control by Thorman, ACS Bulletin, vol. 14 II, pp. 335-358</p> <p>Standardization and Plant Control as Applied to Body Making by Riddle and Twells, JACS vol. 10(4), pp. 281-291</p> <p>The Necessity for Operating Standards and Procedure Controls in the Enameling Industry by Landrum, ACS Bulletin, vol. 6(4), pp. 121-132</p> <p>Control Testing of Borax and Soda Ash Stocks used in the Smelting of Enamel Frits by Knowles, ACS Bulletin vol. 6(4), pp. 132-134</p> <p>Quality Control as Applied to Fire Clay and Aluminum-Diaspore Fire Clay Bricks by Hunt and Lesar, ACS Bulletin Vol. 32 (3), pp. 74-77</p> <p>Raw Materials Control by the Talc Producer by Gaskins, ACS Bulletin vol. 32 (4), pp. 162-163</p> <p>Statistical Quality Control in the Glass Container Industry, Past, Present and Future by Toulouse, ACS Bulletin vol. 32 (10), pp. 333-340</p> <p>Quality Control system in a Porcelain Insulator Plant by Fritz, ACS Bulletin vol. 10(10),k pp. 313-318</p> <p>Quality production by Bach, ACS Bulletin vol. 11 (5), pp. 149-152</p> <p>Works Control of Uniformity of Refractories by Hannah, ACS Bulletin Vol. 23 (10), pp. 370-372</p> <p>Control System Problems with Semisilica Brick by Bicekly Remmrey, ACS Bulletin Vol. 32(3), pp. 70-73</p>

	<p>Improvement of Analytical Control for Silica Brick by Rozca, JACS Vol. 31 (10), pp. 280-283</p> <p>Product Quality Specifications by Powell, ACS Bulletin vol. 26 (6), pp. 181-183</p> <p>Statistical Quality Control for Enameled Steel Production by Stevan, ACS Bulletin vol. 34(10), pp. 340-341</p> <p>Quality Control as Applied to Stiff Mud Manufacture by Lesar and McGee, ACS Bulletin vol. 32(3), pp. 403-411</p> <p>Applications of the Apparent Specific Gravity Test to Ceramic Whiteware by Thiemann, ACS Bulletin vol. 34(9), pp. 279-282</p> <p>A Method for Determining Shot in Refractory Fibers by Hoeman, ACS Bulletin Vol. 34 (10), pp. 325-327</p> <p>PNS 154</p>
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Course Name	<b>ADVANCED CERAMICS II</b>
Course Description	Continuation of the study of the new- generation of advanced ceramics focusing on nanotechnology
No. of Units for Lecture and Laboratory	2 units lecture
No. of Contact Hours per week	2 hours lecture
Prerequisites	Advanced Ceramics I
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Identify the synthesis, characterization and microstructure-modification methods for nanoceramics</li> <li>2. Gather information from literature about the latest research and development efforts and challenges pertaining to nanoceramic systems</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. Synthesis of nanomaterials (8)</li> <li>2. Properties of nanomaterials (8)</li> <li>3. Potential applications of nanomaterials (8)</li> <li>4. Research challenges in nanotechnology (7)</li> </ol>
Laboratory Equipment	None
Suggested References	<p>Nanochemistry: A Chemical Approach to Nanomaterials by G. Ozin and A. Arsenault</p> <p>Nanophysics and Nanotechnology: An introduction to modern concepts in nanoscience by E. Wolf</p> <p>The Chemistry of Nanomaterials: Synthesis, Properties and Applications by C.N.R. Rao</p> <p>Nanobiotechnology: Concepts, Applications and Perspectives by C. Niemeyer</p> <p>Sol-gel Science, C.J.Brinker and G.W. Scherer, Academic Press Inc., 1990, Chapter 2, 3, 13, and 14.</p>

Course Name	<b>CERAMIC PLANT VISITS</b>
Course Description	Plant visits to ceramic industries with emphasis on observation of actual process and operation. Submission and presentation of reports of the visits.
No. of Units for Lecture and Laboratory	1 unit Laboratory
No. of Contact Hours per week	3 hours Laboratory
Prerequisites	Senior standing
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Make visits to plants in the ceramic industry</li> <li>2. Observe actual process and operations in these plants</li> </ol>

	<ol style="list-style-type: none"> <li>3. Rationalize observed practices during the visit</li> <li>4. Write and submit a report about the plant tour</li> <li>5. Deliver an oral report about the plant visit in a seminar</li> </ol>
Course Outline	<ol style="list-style-type: none"> <li>1. General orientation on plant tours</li> <li>2. Plant visits to various ceramic plants</li> <li>3. Report writing and submission</li> </ol> <p>*Student will make a report or presentation about the plant visit.</p> <p>Suggested Plants which can be visited</p> <ol style="list-style-type: none"> <li>1. Republic Asahi (glass)</li> <li>2. Nakayama Technology ( floor &amp; wall tiles)</li> <li>3. Keramos ( tablewares &amp; artwares )</li> <li>4. Stoneware ( tableware &amp; artwares )</li> <li>5. HolCim (Cement)</li> <li>6. ICC (Cement)</li> <li>7. RCP (Refractory)</li> <li>8. Fairchild (semiconductor)</li> <li>9. Solid Waste Incineration plants</li> <li>10. Siam Mariwasa Toto (sanitary wares)</li> <li>11. HCG (sanitary)</li> <li>12. San Miguel (glass containers)</li> <li>13. Asia Brewery (glass containers)</li> <li>14. Sunpower (solar cells)</li> </ol>
Laboratory Equipment	None
Suggested References	None

Course Name	<b>SEMINAR</b>
Course Description	Seminar with emphasis on technical papers on different topics involved in the current trends of ceramic engineering research and development
No. of Units for Lecture and Laboratory	1 unit lecture
No. of Contact Hours per week	1 hour lecture
Prerequisites	5 <sup>th</sup> year standing
Course Objectives	<p>At the end of the course the student must be able to:</p> <ol style="list-style-type: none"> <li>5. Identify current trends in ceramic engineering research and development</li> <li>6. Attend seminar presentations</li> <li>7. Make oral presentations during seminar</li> <li>8. Ask questions after presentations</li> <li>9. Identify relevant topics for research proposals</li> </ol>
Course Outline	<p>Presentations and discussions in the suggest fields below:</p> <ol style="list-style-type: none"> <li>1. Ceramic Art Ware</li> <li>2. Ceramic Whitewares</li> <li>3. Structural Clay Products</li> <li>4. Refractories</li> <li>5. Glass, Enamels and Glazes</li> <li>6. Bio-ceramics</li> <li>7. Grinding media and Abrasives</li> <li>8. Electrical/Electronics Ceramics</li> <li>9. High Technology Ceramics</li> </ol>
Laboratory Equipment	None
Suggested References	No particular textbook is recommended but the students can consult papers and articles from the following suggested publications: Journals of the American Ceramic Society

	American Ceramic Society Bulletin Materials Research Society Publication Proceedings of Technical and Scientific Conferences Advances in Ceramics Other Sources of Scientific and Technological Information on Ceramics
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Course Name	<b>SPECIAL TOPICS</b>
Course Description	Specialization topics of interest to ceramic engineers. Suggested Special Topics: Materials Selection, Instrumentation, X-ray Diffraction, Advanced Microscopy Techniques, Materials in Microelectronic Packaging, Failure Analysis and Reliability, Degradation of Materials, Surface Technology, Surface Science, Entrepreneurship, Marketing Strategies, Technological Innovation, Ceramic Arts and Design
No. of Units for Lecture and Laboratory	2 units Lecture
No. of Contact Hours per week	2 hours Lecture
Prerequisites	Consent of instructor
Course Objectives	At the end of the course the student must be able to: <ol style="list-style-type: none"> <li>1. Specialize in a topic of interest</li> <li>2. Acquire special skills on the topic</li> <li>3. Gain competitive advantage over other graduates</li> </ol>
Course Outline	To be developed according to specialization topic selected
Laboratory Equipment	None
Suggested References	To be determined according to specialization topic selected

Course Name	<b>CERAMIC ON-THE-JOB TRAINING (SUMMER)</b>
Course Description	
No. of Units for Lecture and Laboratory	Minimum of 240 hours
No. of Contact Hours per week	None (however school may have option of assigning units if to be formally enrolled)
Prerequisites	4 <sup>th</sup> year standing in the Ceramic Engineering program
Course Objectives	At the end of the training the student must be able to: <ol style="list-style-type: none"> <li>1. Accumulate minimum of 240 hours work experience in the company or facility</li> <li>2. Write a profile of the company which includes thrusts/visions, site geography, organizational structure and company affiliations (if any)</li> <li>3. Submit a written technical report following the prescribed outline describing the company operations, personal work experiences in the company and assessment of the company including recommendations for improvement</li> <li>4. Apply theories learned from previous courses to rationalize certain observed practices</li> <li>5. Recognize possible areas for improvement and innovation in the existing company set-up</li> <li>6. Submit prescribed documents as evidence of training such as Certificate of Completion, reports of projects conducted (if any), Results of exams (if any)</li> </ol>
Course Outline	Suggested Final Technical Report Format <ol style="list-style-type: none"> <li>1. Title Page</li> <li>2. Table of Contents</li> </ol>

	<p>3. Introduction</p> <p>3.1 The On-the-Job Training Program – description and objectives</p> <p>3.2 The Company – company profile, thrusts/visions, site geography (i.e. location map, accessibility, etc.), organizational structure, affiliated companies (if any)</p> <p>3.3 Schedule of Training</p> <p>4. Technical Report</p> <p>4.1 Company Product(s) – description and uses or applications</p> <p>4.2 Processing Line – process flowsheet, machines and equipment, materials handling and storage, test and quality control, waste management, personnel involved</p> <p>4.3 Support Services – administration, human resource department, quality assurance department, safety department, shipping or transportation, industry/community relation, rehabilitation/reclamation services, waste treatment/environmental section</p> <p>5. Personal Work Experiences - narration of work/tasks undertaken at different sections</p> <p>6. Assessment of the Company – observations, comments and reactions, recommendations</p> <p>7. Acknowledgements</p> <p>Appendix – Copy of Certificate of Completion, reports of projects conducted (if any), results of exams (if any), pictures, mementos of training (optional) such as ID card, time card, salary slip, etc.</p>
Laboratory Equipment	Not applicable
Suggested References	Not applicable

## II. NON-TECHNICAL COURSES

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

Course Name	<b>ENGLISH 3 (TECHNICAL COMMUNICATION)</b>
Course Description	The nature of technical communication; skills and strategies for reading and writing literature reviews, journal articles, and technical reports; making oral presentations.
Number of Units for Lecture and Laboratory	3 units lecture
Number of Contact Hours per Week	3 hours lecture
Prerequisites	English 2
Course Objectives	<p>After completing this course, the student must be able to:</p> <ol style="list-style-type: none"> <li>1. Differentiate technical writing from other types of writing;</li> <li>2. Engage him/herself critically in the reading of a specialized text;</li> <li>3. Write a summary and review of a journal article;</li> <li>4. Write a research paper on a technical topic; and</li> <li>5. Properly acknowledge sources by using a prescribed citation format;</li> <li>6. Prepare an oral presentation on a technical topic; and</li> <li>7. Deliver properly an oral technical presentation.</li> </ol>

Course Outline	<ol style="list-style-type: none"> <li>1. The Nature of Technical Communication</li> <li>2. Technical Writing             <ol style="list-style-type: none"> <li>2.1. Introduction to Technical Writing</li> <li>2.2. Library Orientation</li> <li>2.3. Technical Writing: Formal Schema/Style; Word Choice</li> <li>2.4. Types of Text Structure in Technical Writing</li> <li>2.5. Introduction to Research: Choosing a Topic, Outlining</li> <li>2.6. Skills and Strategies for Reading and Writing Journal Articles, Literature Reviews, and Technical Reports</li> <li>2.7. Evaluating Sources and Preparing a Preliminary Bibliography</li> <li>2.8. Preparing and Interpreting Non-Prose Forms</li> <li>2.9. Summarizing and Analyzing a Journal Article</li> <li>2.10. Preparing the Different Parts of the Research Paper or Technical Report</li> <li>2.11. Writing Bibliographies Using a Prescribed Format</li> <li>2.12. Independent Study</li> </ol> </li> <li>3. Oral Technical Presentations             <ol style="list-style-type: none"> <li>3.1. Preparing the Presentation Materials</li> <li>3.2. Delivering the Technical Presentation</li> </ol> </li> </ol>
Laboratory Equipment	None
Suggested References	<p>American Psychological Association. <i>Publication Manual of the American Psychological Association</i>, 4th ed. Washington, DC: American Psychological Association, 1994.</p> <p>Carreon, E. and C. Balarbar. <i>Series in English for Specific Purposes: Engineering</i>. Manila: DLSU Press, 1995.</p> <p>McWhorter, K. <i>Guide to College Reading</i>. New York: Longman, 2003.</p> <p>Penrose, J.M., R.W. Rasberry and R.J. Myers. <i>Advanced Business Communication</i>. Cincinnati: South-Western College Publishing, 1997.</p> <p>Weissberg, R. and S. Buker. <i>Writing Up Research: Experimental Research Report Writing for Students of English</i>. New Jersey: Prentice Hall, Inc., 1990.</p>