Course Description

General Education Courses **38 Credits**
General Education Core Courses **15 Credits**

202108 Digital Literacy **2(2-0-4)**

Prerequisite : none

Selecting sources of information for research; using digital technology in information retrieval; collecting and evaluating information qualities; analyzing and synthesizing information; writing reports and referencing; security, effects, ethics, morals, and laws regarding media and digital technology using

202109 Use of Application Programs for Learning **1(0-2-1)**

Prerequisite : none

Basics of computer programming; using application software for document management; presenting information; data management for calculation and creative database management; designing and developing a website for working in a daily life

202201 Life Skills **3(3-0-6)**

Prerequisite : none

Knowing and understanding self and others; rational thinking and analyzing; systems and holistic thinking; creative decision-making and problem-solving; self-directed learning in a context of lifelong learning; work-life balance; sufficiency in living; self-care; stress and emotion management; solutions to life issues

202202 Citizenship and Global Citizens **3(3-0-6)**

Prerequisite : none

Important characteristics of citizens; roles of Thai and global citizens; important concept of international relations; international organizations; trans boundary impacts; critique and lesson-learned from international phenomena

202203 Man, Society and Environment **3(3-0-6)**

Prerequisite : none

Conditions of being human; cultural diversity; social order; ecological system; natural resources and environment; utilization of natural resources; sustainable development

202207 Man, Economy and Development **3(3-0-6)**

Prerequisite : none

Economy and social development; trends of economic and social development; exclusive development; inclusive development; innovation-based development; creative economy; community engagement; social entrepreneurship

English Courses **15 Credits**

213101 English for Communication I **3(3-0-6)**

Prerequisite : none

Developing students' abilities for effective communication in social settings; focusing on integrated skills with the primary emphasis on listening and speaking; developing communication and language learning strategies; and promoting autonomous learning using various resources

213102 English for Communication II **3(3-0-6)**

Prerequisite : 213101 English for Communication I

Further developing students' abilities for effective communication in social and academic settings; focusing on integrated skills, particularly listening and speaking for academic purposes; further developing communication and language learning strategies; and reinforcing autonomous learning using various semi-academic materials from a variety of resources

213203 English for Academic Purposes **3(3-0-6)**

Prerequisite : 213102 English for Communication II

Course content dealing with English for academic purposes for effective communication in an academic field of study; text-based activities involving integrated language skills with an emphasis on reading; exposure to both authentic and semi-authentic materials from both printed and audiovisual materials, as well as online resources

213204 English for Specific Purposes **3(3-0-6)**

Prerequisite : 213203 English for Academic Purposes

Further enhancement of students' language skills and ability in science and technology content; exposure to authentic language in science and technology from both printed and audiovisual materials, as well as online resources; focus on text-based tasks involving integrated skills with an emphasis on reading and writing

213305 English for Careers **3(3-0-6)**

Prerequisite : 213204 English for Specific Purposes

Developing English skills needed for employment preparation, covering such topics as job search, resumes, cover letters, and job interviews; effective communication skills in the workplace; skills needed in preparing for the Test of English for International Communication (TOEIC)

General Education Elective Courses **8 Credits**

202111 Thai for Communication **2(2-0-4)**

Prerequisite : none

Principles of Thai Language; skill of using Thai in speaking; listening; reading; and writing; composition in Thai for communication and work presentation

202175 Art Appreciation **2(2-0-4)**

Prerequisite : none

Definition of art; artists' aspiration for art creation from various perspectives; values and aesthetic for soul; contexts of arts; visual culture towards art interpretation; roles and effects of arts in a society and world cultures through various perspectives; artwork creation valuable for self and others; arts and museums; public arts; music and art therapy; arts for sufficient life

202181 Holistic Health **2(2-0-4)**

Prerequisite : none

Concepts regarding holistic health and health balance; weight control; sleep and relaxation; concentration and mental health; stress management; body strengthening; alternative healthcare

202222 Professional and Community Engagement **2(1-2-3)**

Prerequisite : none

Projects and activities for building students' working experiences with a community or a professional group that enhance life skills and respond to visions and objectives of a community or a professional group

202241 Law in Daily Life **2(2-0-4)**

Prerequisite : none

Basic principle of law; hierarchy of law; population registry law; useful law in daily life law concerning person; property, juristic act and contract; loan agreement; service contract; made-to-order contract; contract of sale; property rental contract; hire-purchase contract; surety ship agreement; mortgage contract; basic law of family and inheritance; consumer protection law; basic law of intellectual property

202324 Pluri-Cultural Thai Studies **2(2-0-4)**

Prerequisite : none

Understanding of systems of Thai society and culture; plurality in Thai economic and political development; significance of plural folk wisdoms; concept of sufficiency economy in global trends

202331 ASEAN Studies **2(2-0-4)**

Prerequisite : none

Origins and purposes of ASEAN community; unity based on a socio-cultural diversity; respects for rights, civic responsibility and human dignity under different types of governments in each ASEAN Member State; living together happily and peacefully with ASEAN friends; quality of life in education and working systems

202373 Design Thinking **2(2-0-4)**

Prerequisite : none

Creative thinking; questioning and problem-solving; brainstorming and society need-based service design; prototyping; appropriate application of innovation; lesson-learned

Major Courses **136 Credits**

Science and Mathematics Foundation Courses **30 Credits**

102111 Fundamental Chemistry I **4(4-0-8)**

Prerequisite : none

Atomic theory and electronic structure of atoms, periodic properties of atoms, representative elements and transition metals, chemical bonding, stoichiometry, gases, liquids, solids, chemical equilibrium, general properties of acids and bases, chemical kinetics.

Learning outcomes

On completion of this course, students are able to

1. gain knowledge and understanding of atomic theory and electronic structure of atoms, periodic properties of atoms, representative elements and transition metals, chemical bonding, stoichiometry, gases, liquids, solids, chemical equilibrium, general properties of acids and bases, and chemical kinetics.
2. solve problems in the class.
3. describe the subject in details to others.
4. learn, honest, punctual, disciplined, responsible, and voluntary.

102112 Fundamental Chemistry Laboratory I **1(0-3-0)**

Prerequisite : 102111 Fundamental Chemistry I or study concurrently

Experimental works in the laboratory which include the basic techniques in experimental chemistry, properties of gases and liquids, metallic models, chemical equilibruim, acid - base titrations, chemical kinetics and various types of chemical reactions.

Learning outcomes

Students will gain knowledge and understanding about safety practice in laboratory. They are expected to have experimental skill on each topic. They will know how to record data, discuss and conclude the results. Moreover, they will have familiarity with materials, apparatus and equipment that they use in each class.

103101 Calculus I **4(4-0-8)**

Prerequisite : 999103 Mathematics Placement Test, or 103001 Foundations for Calculus

Limits, continuity, the derivative, applications of the derivative, inverse functions, indeterminate forms, the definite integral and the fundamental theorem of calculus.

Learning outcomes

Students will have an understanding of the concepts of limit, continuity, the derivative and the definite integral of a function of a single variable. In particular, they will be able to compute limits of functions and the derivatives of various functions, and apply the product, quotient and chain rules of differentiation. Moreover, they will be able to compute limits of indeterminate forms applying l'Hopital's rule, and finally they will also be able to compute the indefinite and definite integrals of basic functions, including integration by substitution.

103102 Calculus II **4(4-0-8)**

Prerequisite : 103101 Calculus I

Techniques of integration (of functions of a single variable), improper integrals, numerical integration, mathematical induction, sequences and series, Taylor expansion of elementary functions, vectors and geometry in three dimensions, lines and planes, vector valued functions, functions of several variables, partial derivatives and applications.

Learning outcomes

Students will master the various integration techniques, including integration by parts, partial fractions and trigonometric substitution. They will be able to compute improper integrals, and to compute definite integrals numerically. They will be able to work with sequences, series and Taylor series. Moreover, students will develop facility in 3 dimensions, such as 3-dimensional vector geometry, lines and planes. They will be able to compute partial and directional derivatives, and find the local extrema of a function of two variables.

103103 Probability and Statistics **3(3-0-6)**

Prerequisite : 103102 Calculus II

Elementary probability theory, random variables and distributions, moments, moment generating functions and characteristic functions, limit theorems, random samples and sampling distributions, estimations, tests of hypothesis.

Learning outcomes

On completion of this course, students are able to:

1. explain the elementary theorems of probability, and calculate the probability of an event;
2. explain the meaning of random variable, classify the types of the random variables, and give an example for each type of the random variable;
3. explain the main properties, give examples, and calculate the probability of events related with the main discrete random variables;
4. explain the main properties and calculate probability of events related with the main continuous random variables;
5. explain the ideas and the key concepts of random sampling;
6. explain the key concepts of parameter estimations, and estimate the statistical parameters;
7. explain the key concepts and the method of hypothesis testing, and apply the hypothesis testing to problems in statistics.

103105 Calculus III **4(4-0-8)**

Prerequisite : 103102 Calculus II

Polar coordinates, surfaces in three-dimensional space, multiple integration, integrals of vector-valued functions, line integrals, first order and second order linear ordinary differential equations with applications.

Learning outcomes

Students will be able sketch surfaces in 3 dimensions. They will be able to work in the Cartesian, polar, cylindrical and spherical coordinate systems, and to integrate functions of two and three variables in theses coordinate systems. Furthermore, they will be able to integrate vector valued functions

and compute line integrals. Finally, students will have the skills to solve first order and linear second order differential equations.

105101 Physics I **4(4-0-8)**

Prerequisite : 103001 Foundations for Calculus, or 999103 Mathematics Placement Test

The content of Physics 1 includes kinematics and dynamics of a particle, work-energy theorem, conservative forces and conservation of mechanical energy, kinematics and dynamics of a system of particles, conservation of momentum, kinematics and dynamics of rigid bodies, angular momentum, harmonic oscillations, damp and forced harmonic oscillations, mechanical waves, sound waves, basic fluid statics and dynamics, kinetic theory of gas, and thermodynamics.

Learning outcomes

1. Define and describe the following quantities, principles and relations: displacement velocity, acceleration, Newton laws' of motion, work, kinetic energy, potential energy, mechanical energy, momentum, moment of inertia, angular displacement, angular velocity, angular acceleration, angular momentum, torque, period and frequency of oscillation, wavelength and wave speed, intensity and intensity level of sound, pressure, buoyancy force, Pascal's principle, viscosity, flow rate, continuity equation, Bernoulli's principle, state equation of ideal gas, and laws of thermodynamics.
2. Calculate the physical quantities related to the motion in one, two and three dimensions of a particle or a rigid body,
3. Apply Newton laws' of motion to obtain acceleration, angular acceleration, or unknown forces,
4. Apply the work-energy theorem to calculate physical quantities related to motion,
5. Recognize the situations, where the mechanical energy or total momentum of a system is conserved,
6. Identify if an oscillation is underdamped, overdamped or critically damped,
7. Apply the continuity equation and Bernoulli's principle to calculate the speed and pressure of fluids,
8. Apply the equation of state to obtain state quantities of an ideal gas,
9. And implement the laws of thermodynamics to calculate the heat flowing in and out of an ideal gas that undergoes reversible processes.

105102 Physics II **4(4-0-8)**

Prerequisite : 105101 Physics I

This course covers electrostatics, circuits and magnetism, Maxwell's equations, physical optics and introductory quantum mechanics.

Learning outcomes

Students will be able to

1. To describe, in words, the various concepts in electromagnetism, in physical optics, and in quantum mechanics that come into play in particular situations;
2. To represent these electromagnetic, physical optic, and quantum mechanics phenomena mathematically in those situations;
3. To predict outcomes in other similar situations.

105191 Physics Laboratory I **1(0-3-0)**

Prerequisite : 105101 Physics I or study concurrently with 105101 Physics I or consent of the school

This course is intended to expose student to hand-on basic physics experiments supporting contents described in Physics I course. The student must perform at least 8 experiments covering mechanics, wave and fluids.

Learning outcomes

Students will be able :

1. To use various analog and digital devices to make corresponding measurement consistent with the content covered in class,
2. To estimate associated uncertainties of measuring devices,
3. To record and organize their observations in a laboratory notebook,
4. To perform data analysis.

105192 Physics Laboratory II **1(0-3-0)**

Prerequisites : 105191 Physics Laboratory I and 105102 Physics II or enrolling with
105102 Physics II or consent of the school

In a similar manner to Physics Laboratory I, this course is supporting contents described in Physics II course. The student must perform at least 8 experiments covering electrostatics, circuits, physical optics and photoelectric effect.

Learning outcomes

Students will be able :

1. To use various analog and digital devices to make corresponding measurement consistent with the content covered in class,
2. To estimate associated uncertainties of measuring devices,
3. To record and organize their observations in a laboratory notebook,
4. To perform data analysis.

Basic Engineering Courses **33 Credits**

523101 Computer Programming I **2(1-3-5)**

Prerequisite : none

Computer concepts and components, hardware and software interaction, Electronic Data Processing (EDP) concepts, program design and development methodology, programming with C language, variable type declaration, expressions, control statements, programming practice

Learning outcomes

Students will understand the function of various components of a computer for both hardware and software. Students will be able to write program to receive and process data.

523201 Computer Programming II **2(1-3-5)**

Prerequisite : 523101 Computer Programming I

Programming with C language, function and parameter passing, array, pointer, sorting and searching, data structure, data file

Learning outcomes

Students will learn the various structures of C language. Students will be able to apply those structures for storing and managing complex data.

525101 Engineering Graphics I **2(1-3-5)**

Prerequisite : none

Practice to lettering, line and plane, geometric applications. Reading and drawing on orthographic projection, fundamental of dimensioning and tolerance, section view, standards and symbols. Practice to sketch by free-hand.

Learning outcomes

After the course, the students should be able to:

1. Lettering with standard and symbols and sketching with free-hand
2. Reading and drawing of orthographic, isometric, pictorial, descriptive geometry and auxiliary projection, and section view.
3. Specify the geometric dimensioning integration with basic tolerancing.
4. Drawing the assembly.

525301 Mechanical Drawing **2(1-3-5)**

Prerequisite : 525101 Engineering Graphics I

Reading and drawing of mechanical systems according to industrial standard, dimensioning, limit and tolerances, surface textures, thread and fasteners, welding, gears and other mechanical components such as Cams, Piping, drawing of mechanics parts in standardized format.

Learning outcomes

After the course, the students should be able to:

1. Reading of mechanical systems according to industrial standard.
2. Specify the dimensioning, limit and tolerances, surface textures.
3. Drawing thread and fasteners, welding, gears and other mechanical components.
4. Drawing of mechanics parts in standardized format.

526416 Quality Control **4(4-0-8)**

Prerequisite : 103103 Probability and Statistics

Principle of industrial quality management. Application of statistics for quality control system. Evaluation of process capability and variation in production. Design of different control methods and sampling plan for monitoring control charts. Application of sampling plan from standard tables. Evaluation of reliability in product quality. Organization structure of quality control unit. Modern concept in quality control techniques. International standard concerning quality. Management of quality assurance systems such as ISO9000, ISO14000 and TIS18000.

Learning outcomes

The students understand and analyse the statistic data obtained from quality control. The students can calculate and construct control charts and apply the sampling plans for quality control.

529292 Electrical Engineering **4(4-0-8)**

Prerequisite : 105102 Physics II

General principles of electrical engineering: DC and AC circuits, magnetic circuits and transformers, electrical machines, electronic devices and circuits, logic gates and digital ICs, control systems.

Learning outcomes

Students obtain a comprehensive learning and some analytical approach to DC, AC circuits, electrical machines, electronic devices, logic gates and control systems.

529294 Electrical Engineering Laboratory **1(0-3-3)**

Prerequisite : 529292 Electrical Engineering

Experimental works on electric circuits and electrical machines to reinforce the topics in Electrical Engineering.

Learning outcomes

Students obtain a comprehensive learning and some trainings about the practical skills relating to electrical circuit fundamental and machines.

530201 Engineering Statics **4(4-0-8)**

Prerequisite : 105101 Physics I

Force systems, resultant forces and moments,equilibrium, friction,virtual work, stability. Introduction to dynamics.

Learning outcomes

1. Transfer knowledge of basic physics and mathematics in applying on equilibriumof bodies.
2. Able to separate particle or rigid body away from their environment in order to draw a free body diagram and then it can be solved by equilibrium equations.
3. Able to apply the equilibrium condition to analysis internal force of structure member.
4. Develop self-learning, recording, researching and together with self-experiences for self-independent learning.

530211 Mechanics of Materials I **4(4-0-8)**

Prerequisite : 530201 Engineering Statics

Forces and stresses, stress-strain relations, stresses in beams, shear diagram and moment diagram, deflection of beams, torsion, buckling of columns, Mohr's circle and combined stresses, failure criteria.

Learning outcomes

1. Be able to interpret and apply the stress-strain relationship and other relevant properties of materials, and the concept of factor of safety.
2. Be able to determine and understand various type of stresses cause by loads, and perform stress analysis of the combined stresses.
3. Be able to determine and understand the deformations cause by loads, and use concept of stress and strength to design simple member.

531101 Engineering Materials **4(4-0-8)**

Prerequisite : none

Classification of engineering materials; Relationships between structure, properties, processing and applications of engineering materials such as metals, ceramics, polymers and composites; Crystallographic structure of metals; Macro- and microstructural examinations; Mechanical properties and mechanical testing; Phase equilibrium diagrams and their interpretations; Metal processing; Heat treatment of metals; Corrosion in metals and protection; Structure and properties of ceramic materials; Conventional and advanced ceramics; Ceramic processing and engineering applications of ceramics; Polymers in daily life; Polymer blends; Polymer composites; Polymeric materials in engineering applications; Structures of polymers; Polymer synthesis; Basic properties of polymers. Polymer processing; Plastic degradations; Materials for engineering application; Materials innovation.

Learning outcomes

Students are able to categorize engineering materials, explain basic properties, test-analysis methods, and their interpretations. Students are able to relate structure, property, processing, and property improvement of engineering materials. Students are capable of selecting appropriate materials for the desired basic engineering applications. Students are able to gain the concept of materials innovation for engineering applications.

533221 Engineering Economy **4(4-0-8)**

Prerequisite : none

Brief principles of engineering economy focusing on interest and time value of money; analysis and comparison of industrial projects investment such as break-even analysis; depreciation; replacement analysis; risk and uncertainty; after-tax analysis.

Learning outcomes

1. To understand the basic knowledge of economy especially in the topics of interest and time value of money
2. Students are able to apply the knowledge of economy to engineering problems
3. Students are able to analyze and compare various investment options and are able to recommend appropriate option to invest
4. Students are able to apply basic economy knowledge for using in daily lives

Major Engineering Courses **58 Credits**

531211 Principles of Metallurgical Engineering **3(3-0-6)**

Prerequisite : 102111 Fundamental Chemistry I

Introduction to metallurgical operation; Raw materials and fuels for metal industry; Chemical equation and stoichiometry; Material balances in metallurgical processes; Thermochemistry of reactions; Heat balances in metallurgical processes; Combustion of fuels and heat utilization.

Learning outcomes

Students shall be able to calculate basic material balances and heat balances in metallurgical engineering processes.

531212 Metal Processing **4(4-0-8)**

Prerequisite : none

Metal casting; Fundamental theory of metal casting; Basic casting design: risering, gating system, and patternmaking for metal casting; Modern foundry processes; Theory of mechanical forming; Bulk-metal forming processes: rolling, forging, extrusion, drawing; Sheet metal forming processes: shearing, bending, and deep drawing; Defects in formed parts and their prevention; Metal removal processes; Novel forming technologies; Metal joining; Improvement of metal properties.

Learning outcomes

Students will be able to classify manufacturing processes of metals and distinglish merits, demerits and limitations of the processes. Also, students are able to choose manufacturing processes, appropriately. Students can explain principles and fundamental theory of processes such as metal casting, mechanical forming, welding and improvement of metal properties.

531213 Metal Manufacturing Laboratory I **1(0-3-3)**

Prerequisite : 531212 Metal Processing or study concurrently

Metal casting processes: molding and patternmaking; Sand testing; Melt preparation; Forming of metal parts by cutting, machining, milling, threading; Metal removal using electrical discharge machine: wire-type and rod-type electrode machines; Metal forming with computer numerical control machine; making of drawing using CAD software and generation of machine code.

Learning outcomes

Students will be able to perform basic molding operations, test the properties of molding sand and prepare melt for casting. Students can produce specimens by cutting, machining, drilling and threading using conventional machines. Students can operate CNC machine for producing metal parts.

531214 Metal Processing Laboratory II **1(0-3-3)**

Prerequisite : 531213 Metal Processing Laboratory I

Metallurgical quality control of cast irons; Application of computer simulation software for designing metal casting; Simulation of mechanical forming processes: forming, drawing, sheet metal bending using finite element method software

Learning outcomes

Students will be able to use CAD software for making metal forming models and can use computer software for simulating metal forming processes, i.e. metal casting and mechanical forming.

531215 Transport Phenomena in Materials Processing **4(4-0-8)**

Prerequisite : 103105 Calculus III

Fundamental of units and measurement; Introduction to materials processing; Fundamentals of fluid statics; Pascal's law and its applications; Laminar flow and turbulent flow; Newton's law of viscosity; Type of fluids; Mass-balance equation; Momentum-balance equation; Similitude and dimensional analysis; Flow in pipe; Creep flow; Heat transfer mechanisms; Steady state heat conduction; Transient state heat conduction; Introduction to convection and radiation heat transfer; Energy-balance equation; Fick's laws of diffusion and its application.

Learning outcomes

Students shall be able to explain the phenomena occurring during materials manufacturing. Students shall be able to forecast the results on properties of materials according to changes in materials manufacturing parameters.

531216 Physical Metallurgy **4(4-0-8)**

Prerequisite : none

Crystal structure; Crystal defects; Crystal interfaces and microstructure; Solid solution and compound; Phase equilibrium diagrams; Solidification; Diffusion; Principles of solid-state phase transformation; Plastic deformation in crystalline solid; Recovery, recrystallization, grain growth; Strengthening mechanism and microstructural control.

Learning outcomes

Students shall be able to explain relationships between crystal structures and material properties. Students shall be able to interpret phase diagrams. Students should be able to describe the relationship between microstructure, processing and engineering properties of metallic materials.

531217 Physical Metallurgy Laboratory **1(0-3-3)**

Prerequisite : 531216 Physical Metallurgy

Preparation of metallographic specimens for macrostructural and microstructural observations; Hardness measurements; Determination of grain size; Cooling curves of metals and alloys; Microstructure of carbon steels.

Learning outcomes

Students shall be able to prepare samples and operate equipments according to metallographic examination procedures in relation to microstructure analysis and cooling curves.

531218 Thermodynamics of Materials I **3(3-0-6)**

Prerequisite : 102111 Fundamental Chemistry I and 105101 Physics I

First law and second law of thermodynamics; Heat capacity, enthalpy, entropy, and the third law of thermodynamics; Term and definition of thermodynamics; Function and relationship among thermodynamics properties; Thermodynamic processes and spontaneous change; Condition at equilibria; Phase diagrams and interpretation.

Learning outcomes

Students shall be able to solve thermodynamics problems using First law and Second law of thermodynamics. Students shall be able to calculate heat and work from changes of substance states under various conditions. Students shall be able to read and interpret phase diagrams.

531219 Thermodynamics of Materials II **3(3-0-6)**

Prerequisite : 531218 Thermodynamics of Materials I

Fundamental principles and functions of thermodynamics reviews; Solutions: thermodynamic functions of mixing, behavior of solutions, reactions involving gases, reactions between condensed phases and gas phases; Equilibria: reaction equilibria, criteria of reaction equilibrium; alternative standard states, interaction coefficients; Ellingham-Richardson diagram; Phase equilibria: phase rule, phase transformations, phase equilibria and Gibbs energies; Phase diagram, Electrochemistry: electrochemical concepts and thermodynamics, electrochemical cells, aqueous solutions.

Learning outcomes

Students are able to explain the fundamental principles of thermodynamics in the view of metallurgical engineering including: laws of thermodynamic, solution, equilibrium and electrochemistry. Students shall be able to calculate thermodynamics problems and are able apply thermodynamics calculation to solve problems in metallurgical engineering processes.

531314 Mechanical Metallurgy **4(4-0-8)**

Prerequisite : 530211 Mechanics of Materials I

Stress-strain relationships; Elastic behavior, stress analysis in two and three dimensions; Yield criteria; Theory of plasticity; Dislocation theory; Deformation parameters and metallurgical factors affecting deformation in metals; Fractures; Standard mechanical testing: hardness, compression, tensile, creep, torsion, bending and impact testing; Introduction to fracture mechanics and safety assessment; Fatigue-life assessments, fatigue crack growth; Mechanical failures and prevention.

Learning outcomes

Students shall be able to explain of elastic and plastic behaviors of metals subjected to different types of external loads, calculate stress-strain and relavant parameters. Students can identify deformation parameters and metallurgical factors and their effects on deformation and fracture of metals. Students are able to explain principles of standard mechanical tests and interpret the test data provided for engineering uses.

531315 Mechanical Metallurgy Laboratory **1(0-3-3)**

Prerequisite : 531314 Mechanical Metallurgy or study concurrently

Introduction to mechanical testing for metals; assessment, analytical techniques of experimental data and presenting of data; Mechanical testing laboratories: engineering measurement, hardness testing, tensile testing, torsion testing, creep testing, impact testing, bend testing, fatigue testing and fractography.

Learning outcomes

Students are able to explain principles of mechanical testing of metals following the standard test methods, along with fractographic observation. Students are able to report mechanical test data and give reasonable interpretation.

531316 Phase Transformation in Metals and Alloys **4(4-0-8)**

Prerequisite : 531216 Physical Metallurgy

Thermodynamics and phase equilibrium diagrams; Diffusion in solids, Crystal interface and microstructure; Solidification of pure metals and alloys: nucleation and growth, eutectic solidification and peritectic solidification, microstructure of castings, Principle of solid-state phase transformation; Heat treatment: metallurgy and processes: normalizing, full annealing, recovery and recrystallization annealing, quenching and tempering, case hardening by carburizing, age hardening; Microstructural control.

Learning outcomes

Students shall be able to explain and distinguish differences between solidification of pure metals and alloys. Students shall be able to interpret the transformation reaction in phase equilibrium diagrams. Students shall be able to forecast the microstructure of steels and some other alloys subjected to various heat treatment processes.

531317 Phase Transformation in Metals and Alloys Laboratory **1(0-3-3)**

Prerequisite : 531316 Phase Transformation in Metals and Alloys

Full Annealing; Normalizing; Recovery and recrystallization annealing; Quenching and tempering; Case hardening by carburizing; Determination of hardenability of steels; Solution treatment and ageing; Austempering and martempering.

Learning outcomes

Students shall be able to explain the effect of heat treatment processes on microstructure and mechanical properties of steels , and other alloys. Students shall be able to able to discuss the influence of heat treatment parameters such as temperature, time, and cooling rates.

531318 Chemical Metallurgy **4(4-0-8)**

Prerequisite : 531219 Thermodynamics of Materials II

Principles of mineral processing: sampling, comminution and liberation, screening, classification, size determination, gravity concentration, magnetic and electrostatic separation, froth flotation; Principles of pyrometallurgy: thermodynamic applications, calcination, roasting, metal reduction and refining; Principles of hydrometallurgy: thermodynamics of aqueous solutions, kinetics of leaching and precipitation, solvent extraction and ion exchange; Electrochemistry of aqueous solution: electrowinning and electrorefining, Extraction of ferrous and nonferrous metals.

Learning outcomes

Students shall be able to explain principles of extractive metallurgy including: pyrometallurgy, hydrometallurgy and electrometallurgy. Students are capable of solving problems in extractive metallurgy by using thermodynamics principles and chemistry.

531319 Chemical Metallurgy Laboratory **1(0-3-3)**

Prerequisite : 531318 Chemical Metallurgy

Experiment in extractive metallurgy: pyrometallurgy, hydrometallurgy, electrochemistry including electrowinning and electrorefining; Recycling of metals from waste; Corrosion testing.

Learning outcomes

Students shall be able to explain method of metal extraction from ore or recycling of metal from waste. Students shall be able to interpret and discuss experimental results related to metal extraction. Students shall be able to understand corrosion testing of metals.

531320 Corrosion of Metals **4(4-0-8)**

Prerequisite : 531101 Engineering Materials

Principles of corrosion; Forms of corrosion; Pourbaix diagrams; Corrosion prevention by design; Materials selection: stainless steels, copper and its alloys, nickel and its alloys, aluminium and its alloys, titanium and its alloys; Corrosion protection, cathodic protection and anodic protection, role of inhibitors; Corrosion testing.

Learning outcomes

Students shall be able to explain corrosion behaviors of metals subjected to environment, the influences of environmental parameters and metallurgical factors on corrosion behaviors of metals. Students are able to give reasonable interpretation of corrosion protection and select proper metals for specific applications.

531331 Materials Characterization **4(4-0-8)**

Prerequisite : 531216 Physical Metallurgy

Physics of light and electron; Physics of atom and molecules; Principle of chemical analysis and spectroscopy; Phase and crystal structure analysis by X-ray diffraction technique; Microstructural characterization using electron microscopy; Chemical microanalysis.

Learning outcomes

Students shall be able to describe the basic principles of different characterization methods. Likewise, students should be able to assess the appropriate characterization methods for different materials problems.

531391 Undergraduate Metallurgical Engineering Project **3(0-6-6)**

Prerequisite : consent of the school

Conducting project on the topic of interest concerning metallurgical engineering. This includes literature survey, proposal of research topic, experimentation., progress. Reseach summary report. or manuscripts and oral presentation are required to fullfill the couse assessment by advisors and project assessment committee.

Learning outcomes

Students can employ research methodology to conduct a project in metallurgical engineering field and deliver an oral presentation.

531404 Metallurgical Failure Analysis **4(4-0-8)**

Prerequisite : 531314 Mechanical Metallurgy

Introduction to analysis of metallurgical failures; Procedure of failure analysis; Failure modes of metallic components, e.g., ductile, brittle failures; Introduction to fracture mechanics; Fatigue failures in engineering services; Failures due to creep, corrosion, stress-corrosion cracking; Failures in weldments;

Failures and defects in metallic components due to heat treatments, metal forming and casting; Case studies of analysis of metallurgical failures

Learning outcomes

Students shall be able to describe metal failures behavior, identify the causes of metallurgical failures in services due to differences in loading conditions, environmental and fabrication methods of the metals. Students are able to explain investigation procedures, tools and techniques for failure analysis. Students can implement the theory for correction and prevention the metal failures occurred during services.

531405 Materials Selection for Engineering Design 4(4-0-8)

Prerequisite : 530211 Mechanics of Materials I

Roles of materials on design and engineering applications; Evolution of engineering materials; Designing processes for engineering applications and case studies; Important engineering materials and properties; Materials indices; Materials property diagrams; Construction of materials property diagrams from electronic database; Theory of materials selection; Case studies of materials selection for structural applications, thermal applications, electronic applications; Processes and process selection; Materials selection with multiple constraints; Selection of materials by shapes; Designing composite materials; Materials selection and the environment; Materials and industrial design; Forces for change.

Learning outcomes

Students shall be able to select appropriate materials for engineering design. Students will be able to use and construct materials property diagrams, derive for material indices, select the appropriate materials with multiple constraints, design composite materials, describe the relationship between materials and environment.

Engineering Electives Courses 15 Credits

Metal Manufacturing Elective Courses

531332 Foundry Engineering 3(2-3-7)

Prerequisite : 531212 Metal Processing

Introduction to metal casting; History of metal casting; Types and properties of molding sand; Molding processes and equipments; Pattern design; Melting Furnaces; Charge calculation; Melting operations and metallurgical quality control; Melt treatments; Cooling curve analyses; Other metal casting processes; Principle of solidification; Microstructural evolution during solidification; Shrinkage; Fluid dynamics during mold filling; Directional solidification; Feeding system and design; Gating system and design; Casting design; Secondary operations; Inspection and quality control; Casting defects and analyses; Foundry engineering laboratory; Casting Technology, status of metal casting industry and new development; Occupational health and safety

Learning outcomes

Students will be able to describe steps and details of metal casting processes, design patterns, castings, gating systems and risering systems. Students will be able to analyze casting defects.

531333 Principles of Foundry Sand Control **3(2-3-7)**

Prerequisite : 531212 Metal Processing

Types and characteristics of foundry sands; Moisture testing and control; Characteristics and control of clays; Supplementary additives and modifiers; Phenomena in foundry sand during casting and solidification; Loss on ignition; Thermal load; Molding sand preparation; Laboratory on standard tests of foundry sand; Relationships of sand properties, testing and casting results; Sand reclamation; Uses of spent foundry sand.

Learning outcomes

Students will be able to describe the principles of foundry sand control, relationships of sand properties, testing and casting results; sand reclamation, uses of spent foundry sand. Students will be able to conduct standard foundry sand tests.

531334 Analysis of Die Casting Processes **3(3-0-6)**

Prerequisite : 531212 Metal Processing

Overview of die casting processes; Die casting machine systems; P-Q^2 analysis; Process control in die casting; Gating design and analysis; Design of die casting dies; Melting and metallurgical control; Die casting defects; Numerical modeling of die casting processes; Simulation of die castings

Learning outcomes

Students will be able to describe die casting processes, die casting machine systems, melting and metallurgical control. Students will be able to analyze the die casting processes with P-Q^2 principle, analyze the die casting defects, design the die casting dies, construct the numerical models of die casting processes.

531335 Mechanics of Metal Forming **3(3-0-6)**

Prerequisite : 531212 Metal Processing and 531314 Mechanical Metallurgy

Fundamental of mechanical forming of metals: stress, strain, yield criteria for metal forming, strain hardening, effects of temperature and strain rate on metal forming; Analysis of metal forming using slab analysis; Slip-line field analysis; Tendency of forming-defect occurrence such as cracks; Pattern of residual stresses; Friction and lubrication; Formability of metals and formability tests

Learning outcomes

Students shall be able to explain basic of mechanical forming: stress, strain, yielding criteria, effects of forming parameters on forming processes. Also, students will be able to calculate forming parameters such as forming load resistance and plastic zone size. In addition, students can apply calculation results to predict the occurrence of forming defects.

531336 Metallurgy of Metal Joining **4(3-2-8)**

Prerequisite : 531212 Metal Processing

Introduction to metal joining; Metals joining processes; Weldability of various metals and alloys; Metallurgical effects of the weld thermal cycles; In-service welding; Welding drawing; Welding cost analysis; Introduction to quality control and quality assurance in welding. Basic of welding Robot

Learning outcomes

Students shall be able to choose the welding process suitable for application used. Students shall be able to assign the important process parameters of each welding process. Students shall be able

to read and write welding drawings. Students shall be able to assess the welding project cost. Students shall be able to perform quality control of welding job.

531337 Laser in Materials Processing 3(2-2-6)

Prerequisite : 105102 Physics II

Characteristics of laser; Principle of laser generator; Types of laser; Interaction of laser and materials; Transport phenomena in laser processing; Laser welding, Laser cutting; Laser engraving; Laser cleaning; Laser soldering; Laser application in additive manufacturing; Other Laser applications and trend of laser development in materials processing;

Learning outcomes

Students shall be able to choose the laser type suitable for application used. Students shall be able to assign the important process parameters of each laser manufacturing process. Students shall be able to apply appropriate laser source on novel manufacturing process.

531338 Heat Treatment Technology 3(3-0-6)

Prerequisite : 531316 Phase Transformation in Metals and Alloys

Heat treatment processes; Furnace atmosphere control; Quenching medium and quenching technology; Distortion and cracking; Industrial furnaces; Quality test of heat treated parts; Quality control.

Learning outcomes

Students shall be able to choose the proper heat treatment processes and able to discuss the advantages and disadvantages of each process. Students shall be able to define the final microstructure and mechanical properties of steels, and other alloys subjected to heat treatment. Students shall be able to explain the function of device or equipment use for carried out the heat treatment and for quality control.

531339 Non-Equilibrium Processing of Metals 3(3-0-6)

Prerequisite : 531316 Phase Transformation in Metals and Alloys

Thermodynamics of metastable systems; Rapid solidification in metals; Mechanical alloying, Laser processing: laser melting, laser cladding, and laser joining; Spray forming; Nanostructured metals; Amorphous metals.

Learning outcomes

Students shall be able to explain the microstructure evolution in non-equilibrium systems and able to discuss the principle and the limitation of non-equilibrium processing of metals e.g. rapid solidification; mechanical alloying, laser processing, nanostructured metal processing and amorphous metal processing.

531340 Powder Metallurgy 3(2-3-7)

Prerequisite : 531101 Engineering Materials

Introduction and history of powder metallurgy; Powder fabrication by chemical and physical methods; Powder types; Powder characterization and interpretation; Powder mixing; Additives; Lubricants; Binders; Principles of powder compaction technology; Tool design and production; Thermodynamics and kinetics of sintering; Sintering technology; Sintering defects; Characterization and mechanical testing of

sintered parts; Secondary processes; Powder metallurgy of steels; Additive manufacturing; Future and trends of powder metallurgy industry; Occupational health and safety in powder metallurgy processes

Learning outcomes

Students will be able to describe principles and steps of powder metallurgy processes. Students will be able to design compaction dies and analyze powder metallurgy defects. Students will be able to conduct powder characterization test and mechanical test.

531341 Additive Manufacturing 3(2-3-7)

Prerequisite : 531212 Metal Processing

Introduction and basic principles of Additive Manufacturing (AM); Development of additive manufacturing technology; General process workflow; Photopolymerization; Powder bed fusion process; Extrusion-based processes; 3D Printing process; Sheet lamination process; Beam deposition process; Direct write technology; Guidelines for process selection; Design for additive manufacturing; Properties of additive manufacturing parts; Applications of additive manufacturing such as medical, aerospace, automotive, tooling and dentistry; Functionally-Graded Materials (FGM); Future trends of additive manufacturing; Additive manufacturing laboratories

Learning outcomes

Students shall be able to explain basic principles and development of additive manufacturing. Students will be able to describe additive manufacturing processes, to design additive manufacturing parts, and to describe properties of additive manufacturing parts and applications.

531343 Man and Metals 3(3-0-6)

Prerequisite : none

Creation of metals from astrophysics perspective; Uses of metals during Paleolithic; Meteoric iron; Historical developments of metallurgy during Neolithic, Chalcolithic, Bronze Age and Iron Age; History of metallurgy in South East Asia; Roles of metallurgy during the Industrial revolution; Looking at metals from materials selection and industrial design perspective; Etymology of metallurgy related terms; Important discoveries in metallurgy; Historical developments in metal processing such as extracting, casting, metal forming; Innovations and future trends in metallurgy

Learning outcomes

Students shall be able to explain role of man and metal. Students will be able to describe the development of metals and processing in different ages.

531344 Metallurgy in Jewelry Manufacturing 3(2-2-6)

Prerequisite : none

Precious metals; Jewelry mastering; Jewelry making; Jewelry casting; Surface techniques for jewelry.

Learning outcomes

Students shall be able to describe the jewelry making process. Students should be able to detail the processes of jewelry mastering, jewelry making, jewelry casting and finishing surface techniques.

531431 Selected Topic in Metal Manufacturing 3(3-0-6)

Prerequisite : none

Study of selected topic of advances in metal processing field under supervision of faculty in charge of the program.

Learning outcomes

Students shall be capable of researching and self-learning in metal processing advances.

531432 Advanced Topic in Metal Manufacturing 3(3-0-6)

Prerequisite : none

Study of advanced topic of emerging technology in metal processing field under supervision of faculty in charge of the program

Learning outcomes

Students shall be capable of researching and self-learning of emerging technology in metal processing field.

Processing, Recycling & Sustainable Elective Courses

531351 Mineral Processing for Metallurgical Engineering 3(3-0-6)

Prerequisite : none

Fundamental of mineral processing: comminution and liberation, screening, size determination, sampling; Physical methods of mineral processing: gravitation concentration, electrostatic and magnetic separation; Froth flotation and solid-liquid separation, Case study of mineral processing for metallurgical engineering.

Learning outcomes

Students are able to describe basic principle of mineral processing and able to select the method of mineral processing suited for subsequent metallurgical processing.

531352 Ironmaking and Steelmaking 3(3-0-6)

Prerequisite : 531101 Engineering Materials

General overview of iron and steel manufacture; Introduction to physical chemistry of iron and steel making; Raw materials of ironmaking and steelmaking; Ironmaking process: blast furnace; smelting and direct reduction process; Primary steelmaking process: pre-treatment of liquid iron, Basic Oxygen Furnace (BOF) and Electric Arc Furnace (EAF) ; Secondary steelmaking: ladle metallurgy, vacuum metallurgy; Metallurgy of slag in ironmaking and steelmaking; Removal of undesirable elements: deoxidation, dephosphorization, desulfurization, decarburization, degassing; Clean steel production: technology, calcium metallurgy for inclusion removal; Continuous casting: principles and operation, tundish metallurgy, quality control of casting products; Interesting updated technology for iron and steel making; Sustainable metallurgy for iron and steel manufacture.

Learning outcomes

Students shall be able to explain processing for the production of iron and steels including: raw materials, ironmaking, and steelmaking, clean steels and continuous casting of steels. Students shall be able to apply the principles of physical chemistry in the view of metallurgical engineering to ironmaking

and steelmaking. Students shall be able to calculate the basic chemical reactions involving ironmaking and steelmaking by using available thermodynamics data.

531353 Recycling Process of Metals **3(3-0-6)**

Prerequisite : 531318 Chemical Metallurgy

Thermodynamics and extractive metallurgy reviews; Recycling process of industrial or household wastes; Process studies with respect to raw materials, chemical reaction, energy consumption, process intensity yield, environment impact and economy; Case study of recycling process of metals from interested industrial or household wastes, for example, alkaline batteries, solder dross, electronics wastes, etc.; Regulations and management of wastes.

Learning outcomes

Students shall be able to select, determine and manage the recycling process of metals from wastes by considering to the principles of extractive metallurgy, environmental impact and economy.

531354 Kinetics of Metallurgical Reactions **3(3-0-6)**

Prerequisite : 102111 Fundamental Chemistry I

Types of reactions; Rate of reaction; Order of reaction; Determination of order and rate constant of reaction; Reaction rates for homogeneous and heterogeneous reaction; Diffusion; Thermal analysis techniques; Case study or study of kinetics in metallurgical processes.

Learning outcomes

Students are able to explain the principles of kinetics applied to metallurgical engineering processes and shall be able to calculate the kinetics of basic reaction in the field of metallurgical processes.

531355 Nonferrous Process Technology **3(3-0-6)**

Prerequisite : none

Mineral processing of nonferrous metals; Technology for non-ferrous metals processing, i.e., extraction of metals from ores, metal scraps or industrial wastes. Technology for metal refining.

Learning outcomes

Students shall be able to explain mineral processing and technology for nonferrous metals, apply principles of nonferrous processing to the extraction of industrial and community wastes.

531356 Industrial Furnaces **3(3-0-6)**

Prerequisite : none

Background of industrial furnaces in metallurgical processing: definition and classification; Melting furnaces: principles of electric heating, resistance heating; electric arc heating; induction heating and melting; Re-heating furnace: industrial furnaces for hot forming processes, energy balance, gaseous fuels, combustion, burner, emission concern; Heat treatment furnace: heat treatment furnace of steel and aluminum, fundamentals of the heat treatment with hydrogen.

Learning outcomes

Students are able to explain the working principles and functions of the furnaces used in metallurgical industry.

531357 Gas-Metal Reactions for Heat Treatment 3(3-0-6)

Prerequisite : 531219 Thermodynamics of Materials II

Metallurgical thermodynamics and calculations of basic thermodynamic functions reviews: chemical potential and chemical equilibrium; Furnace atmospheres: gas reactions in the furnace, classifications of prepared atmospheres, composition of atmospheres inert to heated steels; Furnace atmosphere control; Surface hardening of steels by gas-metal reactions; Control of surface carbon content in heat-treated steels and process control in gas carburizing.

Learning outcomes

Students shall be able to explain the application of metallurgical thermodynamics for heat treatment of steels. Students shall be able to determine and calculate the proper furnace atmosphere for heat treatment process of steel.

531451 Green Technology for Sustainable Metallurgy 3(3-0-6)

Prerequisite : none

Reviews of important and interested metal manufacture; Metal manufacturing and its impact on environment: pollution, emission, global warming; Development of new environmental friendly technology for metal manufacture; Management of metals recycling; Environmental regulations for metal manufacture.

Learning outcomes

Students are able to signify the impact of metal manufacture on environment. Students are able to explain the development of modern metal manufacture on the consideration of environmental impact.

531452 Advanced Topics in Sustainable Metallurgy 3(3-0-6)

Prerequisite : none

Study of advanced topics or new technology development for metal manufacture.

Learning outcomes

Students are able of researching the development of new technology to produce metals by considering to the reduction of resource consumption, environmental impact and recycling.

Testing, Characterization & Analysis Elective Courses

531361 Characterization Techniques for Metals and Alloys 3(3-0-6)

Prerequisite : none

Relationship between structure, composition and property of metallic materials; Optical microscopy and image analyzer; Differential scanning calorimeter; X-ray Fluorescence Spectrometer

Learning outcomes

Students shall be able to describe the basic principles of different characterization methods. Students shall be able to assess the appropriate characterization methods for different metallurgical studies.

531362 Scanning Electron Microscopy **3(3-0-6)**

Prerequisite : none

Introduction to electron optics; Interaction volume; Signal and image formation; Techniques for image optimization; Chemical analysis via energy dispersive x-ray spectroscopy: qualitative and quantitative analysis, mapping; Advanced SEM techniques: EBSD (Electron Backscatter Differentiation for imaging crystallographic orientations in metals), FIB (Focus Ion Beam)

Learning outcomes

Students shall be able to articulate the working principles of scanning electron microscope. Students shall be capable of analyzing and interpreting data collected from SEM.

531363 Non-Destructive Testing **3(2-2-6)**

Prerequisite : 105102 Physics II

Fundamental and basics of Non-Destructive Testing (NDT); Non-destructive Testing in metallic materials; Visual inspection; Liquid penetration test; Radioactive test; Ultrasonic test; Magnetic penetration test; Eddy current test; Other testing

Learning outcomes

Students shall be able to perform the non-destructive tests as follows; visual inspection, liquid penetration test, radioactive test, ultrasonic test, magnetic penetration test, and Eddy current test.

531364 Corrosion Testing **3(3-0-6)**

Prerequisite : 531320 Corrosion of Metals or study concurrently

Corrosion of metals; Electrochemical reaction; Equilibrium electrode; Construction of Pourbaix diagram; Application of electrode mechanism; Tafel slope; Definition of polarization curve, Determination of polarization curve by potentiostat analyzer; Interpretation of polarization curve; Corrosion testing; Sensitization test, Stress corrosion cracking test, Salt spray test, and High temperature oxidation test

Learning outcomes

Students shall be able to explain corrosion behaviors of metals subjected to different types of environments. Students are able to give reasonable interpretation of corrosion test data based on corrosion standard test methods and principles.

531365 Coating and Cathodic Protection **3(2-2-6)**

Prerequisite : none

Introduction to corrosion and preventions; Coating fundamentals; Coating technology and curing mechanism; Coating specification; Surface preparation for coating; Coating application tools and equipment; Coating defects and failures; Non-destructive/destructive test instruments for coating; Basic principle of electricity; Corrosion theory for cathodic protection; Sacrificial anode system; Impressed current cathodic protection system; Design of cathodic protection system.

Learning outcomes

Students shall be able to outline and explain quality control of coating job/work following the regulations and to perform non-destructive tests of the coat performed in industrial sectors. Students shall be able to design and evaluate the cathodic protection system.

531366 Tribology in Materials Perspectives **3(3-0-6)**

Prerequisite : none

Tribology, terminology, scope and engineering significance; Tribological surfaces; Friction and lubrication; Wear mechanisms; Wear tests, properties and characterization; Surface engineering and coatings; Surface properties and characterization; Design against tribological failures.

Learning outcomes

Students shall be able to explain tribological failure and its effects in engineering services. Students are able to describe principles, theory and tribology mechanics, tribology test assessments and design against tribological failure.

531461 Selected Topic in Testing and Analytical Field **3(3-0-6)**

Prerequisite : none

Study of selected topic in advances and development of techniques for analysis, characterization and testing of metals under supervision of faculty in charge of the program

Learning outcomes

Students shall be capable of researching and self-learning of advances and development of techniques for analysis, characterization and testing of metals.

531462 Advanced Topic in Testing and Analytical Field **3(3-0-6)**

Prerequisite : none

Study of topic in the application of advanced techniques for analysis, characterization and testing of metals and materials under supervision of faculty in charge of the program

Learning outcomes

Students shall be capable of researching and self-learning in the application of advanced techniques for analysis, characterization and testing of metals and materials for metallurgical engineering.

Advanced Metal and Materials Technology Elective Courses

531371 Metallurgy of Cast Irons **3(2-3-7)**

Prerequisite : 531316 Phase Transformation in Metals and Alloys

Classification of irons; Basic metallurgy and solidification theory of cast irons; Metallurgy and properties of gray cast irons, ductile cast irons, compacted graphite cast irons, malleable cast irons, high-alloy white cast irons, and high-alloy graphitic cast irons; Casting processes and metallurgical quality control for cast irons; Heat treatment of irons; Austempered Ductile Iron (ADI); Metallurgical casting defects and failure analysis of cast irons laboratory

Learning outcomes

Students shall be able to explain metallurgy of cast irons. Students will be able to describe the structure-property-processing-application of cast irons, analyze the metallurgical casting defects and failure of casting irons.

531372 Structures and Properties of Alloy Steels **3(3-0-6)**

Prerequisite : 531316 Phase Transformation in Metals and Alloys

Classification of steels; Introduction to steel making processes; Effects of alloying elements on alloy steels; Physical metallurgy and properties of low alloy steels, tool steels, stainless steels, high strength low alloy steels (HSLAs), multi-phases steels, cast steels and silicon steels; Mechanical property improvement by heat treatment processes.

Learning outcomes

Students shall be able to explain steel making process and physical metallurgy of carbon steel and alloy steels: low alloy steels, tool steels, stainless steels, high strength low alloy steels (HSLAs), multi-phases steels, cast steels and silicon steels. Students are able to identify the effects of alloying elements on alloy steels, implementing appropriate heat treatment processes on alloy steels for mechanical propertiy improvement.

531373 Stainless Steels **3(3-0-6)**

Prerequisite : none

Types of stainless steels; Metallurgy of stainless steels; Mechanical properties, Chemical properties, Physical properties; Heat treatment and forming processes of stainless steels; Application of stainless steels.

Learning outcomes

Students are able to differentiate types of stainless steels, explain metallurgy, mechanical properties and corrosion resistance of stainless steels. Students are able to explain the principles of heat treatment and forming processes for stainless steels and give reasonable selection of stainless steels for particular applications.

531374 Nonferrous Metallurgy **3(3-0-6)**

Prerequisite : 531101 Engineering Materials

Metallurgy of commercial nonferrous metals and alloys:, aluminium, magnesium, copper, zinc, titanium, nickel and other significant alloys such as cobalt and lithium; Phase equilibrium diagrams of selected non-ferrous alloy systems; Relationships among chemical compositions, microstructures, forming processes and heat-treatments; Factors influencing physical, mechanical and chemical properties of nonferrous metals; Selection of non-ferrous metals for engineering applications; Protection of metal degradation in service; Newly developed forming technology for high-performance nonferrous metals and alloys.

Learning outcomes

Students shall be able to classifly significant nonferrous metals used for engineering applications. Students shall be able to explain metallurgy of essential nonferrous metals and differentiate their properties such that the selection of proper nonferrous metals can be made based on metallurgy point of view.

531375 High Temperature Metals and Alloys 3(3-0-6)

Prerequisite : 531316 Phase Transformation in Metals and Alloys

Behaviors and characteristics of metals and alloys at elevated temperature; Mechanical properties at elevated temperature; Corrosion at elevated temperature; Physical metallurgy and properties of iron-based superalloys, Nickel-based superalloys and cobalt-based superalloys.

Learning outcomes

Students shall be able to explain behaviors related to elevated temperature properties of high temperature metal and alloys. Students wills be able to clarify physical metallurgy and properties of iron-based superalloys, nickel-based superalloys and cobalt-based superalloys.

531376 Metal Matrix Composites 3(3-0-6)

Prerequisite : 531314 Mechanical Metallurgy

Introduction to composites, metal matrix composites; Metal matrices and reinforcing materials; Mechanics of unidirectional continuous fiber, short fiber and particulate reinforced composites, porous composites; Interfacial between matrix and reinforcement; Manufacturing and forming techniques; Property assessment; Engineering applications of significant metal matrix composites: aluminium, magnesium, titanium, cobalt and cobalt-nickel alloys; Failure and degradation; Concept of materials design and recycling.

Learning outcomes

Students are able to identify strengthening mechanisms of different types of reinforced composites, explain manufacturing and forming techniques to give composites of desirable properties. Students are able to calculate basic mechanics of composite materials and give guideline for materials design and recycling concepts.

531377 Aluminium Technology 3(3-0-6)

Condition : none

Introduction to life-cycle of aluminium; Aluminium's engineering applications and its properties; Equilibrium aluminium alloys; Major alloying systems and property relations; Non-equilibrium aluminium alloys; Metallography and phases of aluminium alloys; Hardening of aluminium alloys; Commercial aluminium alloys; Aluminium casting and forming technologies; Aluminium welding technology; Emerging technologies of aluminium, aluminium powder technology, aluminium composites and nanotechnology; Aluminium in engineering applications, architectural and surface decorations; Engineering design and recycling aspects of aluminium

Learning outcomes

Students are able to classify commercial aluminium alloys and identify microstructures and phases in relation to its forming and heat treatment history. Students are able to select appropriate technology for aluminium production according to its intended engineering applications regarding design aspects and properties.

531378 Surface Technology **3(3-0-6)**

Prerequisite : Prerequisite : none

Wear mechanisms; Surface technology; Wear resistance; Corrosion resistance; Wear testing; Physical vapor deposition (PVD); Chemical vapor deposition (CVD); Thermal spraying; Hard facing; Electroplating

Learning outcomes

Students are able to describe wear behaviors of metals subjected to different types of external loads, explain the influences of external loads and metallurgical factors on wear behaviors of metals. Students can explain principles of different types of surface technology for wear and corrosion resistance, and give reasonable selection of surface technology for particular applications.

531379 Materials Innovation **3(2-2-6)**

Prerequisite : none

Materials in daily life; Properties of materials such as strength, electrical conductivity and magnetic properties; Sequence of materials developments: past, present and future; Impacts of materials development on living-style, Issues in materials development and design in terms of economic factors and fundamental/scientific limitations; Implementation of fundamental science for novel materials development such as Hall-patch equation for the development of high strength steel, or Einstein prediction for stimulated emission on laser source invention, etc.; Applications of new materials; Future of new materials, Current trends of materials development and guidelines to direct the trends of new materials development such as the development of high magnetic materials for future direct drive motor, or the development of new materials for 3D printing

Learning outcomes

After finishing this course, students could signify the importance of new materials development, provide guidelines for new materials development, explain how to apply the new materials, and value of materials innovation in the world market

531471 Selected Topic in Metal and Materials Technology **3(3-0-6)**

Prerequisite : none

Study of selected topic in metals and materials advances under supervision of faculty in charge of the program.

Learning outcomes

Students shall be capable of researching and self-learning of advances in metals and materials.

531472 Advanced Topic in Metal and Materials Technology **3(3-0-6)**

Prerequisite : none

Study of advanced topic in emerging technology for metal and materials development under supervision of faculty in charge of the program

Learning outcomes

Students shall be capable of researching and self-learning of emerging technology for advanced metals and materials.

Computational Analysis Elective Courses

531382 Modeling in Metal Casting **3(2-3-7)**

Prerequisite : 531212 Metal Processing

Review on transport phenomena during solidification; Review on computer programming; Principles of solidification; Mathematical modeling; General workflow; Workshop on 2D computer modeling of casting solidification; Applications of commercial casting simulation software and their interpretations; Industrial case studies and group projects;

Learning outcomes

Students will be able to construct mathematical modeling and program casting solidification, as well as apply commercial casting simulation software.

531383 Computational Methods in Metallurgical Engineering **3(2-3-7)**

Prerequisite : none

The application of computer software aided for thermodynamic calculations, or finite element analysis, or mathematical analysis in relation to engineering metallurgical processes.

Learning outcomes

Students will be able to apply computer software for problem solving in supporting metallurgical processes.

531384 Computer application for Metallurgical Engineering **3(2-3-7)**

Prerequisite : none

Application of MS Excel in factory tasks such as basic calculation by formula; Data Manipulation; Data Analysis Pivot Table and Chart Analysis; Collaborating with Others; Auditing Worksheets; Basic of PLC; Basic for establish and control the robots; Basic application of MATLAB for calculation

Learning outcomes

Students are able to efficiently apply MS Excel to factory tasks, capable of basic robot programming and using basic MATLAB for calculation.

531385 Finite Element Method for Metal Forming Analysis **3(2-3-7)**

Prerequisite : 531212 Metal Processing

Fundamental and procedures of finite element method for analyzing engineering problems: construction of finite element model, making element equation, assembly system equation, assignment of boundary conditions; Determination of constitutive equation for metal forming simulation; Simulation of mechanical-thermal problem; Chain forming processes; Die stress analysis; Investigation and use of finite element simulation results.

Learning outcomes

Students can explain principles and procedures of finite element method analysis. In addition, students can simulate advanced metal forming such as chain process simulation and die stress analysis. Moreover, students can investigate and interpret simulation results.

531386 Selected Topic in Computational Analysis 3(2-3-7)

Prerequisite : none

Study of selected topic concerning the application of computer software for analyzing engineering problems under supervision of faculty in charge of the program.

Learning outcomes

Students are capable of self-learning in topic concerning computer technology for engineering works.

531387 Advanced Topic in Computational Analysis 3(2-3-7)

Prerequisite : none

Study of selected topic concerning the advanced computer technology for analyzing engineering problems under supervision of faculty in charge of the program.

Learning outcomes

Students are capable of self-learning in topics concerning advanced computer technology for engineering works.

Industrial Management Elective Courses

531475 Occupational Health and Safety for Metallurgical Engineering 4(4-0-8)

Prerequisite : none

Basic of occupatinal health and safety acts and regulations for engineers; Occupatinal health and safety management; Occupatinal health and safety concerning machine, vibration, pressure, light, sound, dust, electronics, radiation and chemical, Occupatinal health and safety standards

Learning outcomes

Students are able to respond and make themselves to the right way while working in the risk area or risk situation of works.

533021 Industrial Management 4(4-0-8)

Prerequisite : none

Functioning of management in industry; planning, production and operations strategies; forecasting; locations analysis; plants layout; product and service design; project analysis; safety and industrial law.

Learning outcomes

Students can explain management function, step of production and operations strategy, and product and service design method. The students can also select forecasting techniques, identify production input, and analyze plant location. The students can identify safety principles and labor law.

533041 Quality Management 4(4-0-8)

Prerequisite : none

Quality management and quality assurance in industry; principles of quality cost; statistical process control (SPC); concept of Taguchi's method and quality loss function.

Learning outcomes

Students will be able to explain total quality management, quality management system, and quality cost. Students will be able to define process control techniques. Students will be able to explain concept of Taguchi's method and quality loss function.

533063 Industrial Project Feasibility **4(4-0-8)**

Prerequisite : 533221 Engineering Economy

Application of economic theories to analyze problems in industrial business, investment study, cost control, depreciation, payback theory, and feasibility in investment.

Learning outcomes

The students can identify cost control method in industry. They can also compute depreciation and payback period, and analyze investment feasibility.

533301 Operations Research I **4(4-0-8)**

Prerequisite : none

An introduction to the methodology of operations research in industrial engineering problem solving; emphasis is made on the use of mathematical models; linear programming; transportation model; project management; game theory; queuing theory; inventory model and decision analysis

Learning outcomes

This course provides a comprehensive understanding of developing a variety of mathematical models such as linear programming; transportation model; project management; game theory; queuing theory; inventory model and decision analysis. Students will be able to solve the mathematical models using several techniques such as simplex method; Big - M method; and Two - phases method

533342 Quality Assurance **4(4-0-8)**

Prerequisite : none

Total quality management; quality management system; tools used in quality assurance; quality improvement techniques including six sigma; statistical tools for designing for quality

Learning outcomes

This course provides the basic knowledge of quality management. Students will be able to explain total quality management; quality management system. Student s will be able to define quality improvement techniques including six sigma; statistical tools for designing quality.

541299 Innovation and Design for Engineers **2(1-2-4)**

Prerequisite : none

Innovation and Design, Differentiation between Innovation and Re-engineering, Innovation and Interlectaul Properties, Think out the box, Engineering Design Proncipal, Prototyping, Material and Manufacturing selection and Case Study.

Learning outcomes

After finishing this course, student should have fundamental engineering aspect on innovation and design. They also can differentiate between the original design and re-engineering. They will aslo value the innovation and intellectual properties right. Moreover, they should have the encouragement to

have “think-out-the box” mind. Engineering design, prototyping and right choice for material and manufacturing processes are the obviouse out come for graduated students.

Engineering Communication Skills Elective Courses

531476 Technical Demostration Skills 1(0-3-3)

Prerequisite : none

Demonstration of technical data, graphs, figures, diagrams, tables; Excel for technical demonstration; Word document for smart wirting, headings, labels, content, caption, tabulation, index, appendices, referencing and bibliography.

Learning outcomes

Students are able to prepare reliable graphical demonstrations, figures, diagrams and tables from provided technical data and produce a report by using excel and word document programs.

531477 English Writting for Metallurgical Engineers 1(0-3-3)

Prerequisite : none

Written communication in the context of after graduation in industrial, governmental and research environments; Writing as a process, planning, drafting, reviewing, revising, and criticizing; General structure and writing conventions of technical reports; Report guidelines; Technical report writing in practice.

Learning outcomes

Students are able to produce a summary report and a technical report comprising text and demonstrations of at least 1-2 and 15 pages respectively. Students participate in a collaborative assignment of team review documents.

531478 English Communication for Metallurgical Engineers 1(0-3-3)

Prerequisite : none

English communication in the context of after graduation in industrial, governmental and research environments; Meeting conversation; Meeting minutes; Preparation of technical data presentation; Meeting conversation and technical presentation in practice.

Learning outcomes

Students can converse and take minutes in technical meetings and can deliver technical presentation by participating in collaborative assignments of team review.

Cooperative Education **9 Credits**

531495 Pre-cooperative Education **1(1-0-2)**

Prerequisite : none

Principals and concepts relating to Cooperative Education; Process and steps of undertaking Cooperative Education;Protocols relating to Cooperative Education; Basic knowledge on and techniques for job application such as workplace selection, job application letter writing, job interviews and communication skills;Basic knowledge necessary for undertaking Cooperative Education at workplace; Building up self-confidence;Entrepreneurial potential development; Occupational health and safety in workplace;Organizational culture, Quality management systems at workplace such as5S,ISO 9000 andISO 14000; Report writing and presentation techniques;Personality development

Learning outcomes

1. Students have a deep understanding of the concepts, principles, processes and procedures as well as relevant regulations of cooperative education.
2. Students have knowledge and basic skills to work in the enterprises.
3. Students have knowledge and skills in presentation and academic report writing.
4. Students have the basic skills in personality development to adapt themselves to work environment.

531496 Cooperative Education I **8 Credits**

Prerequisite : Courses specified by the School and 531495 Pre-cooperative Education

The student has to perform full-time academic or professional work as a temporary staff member at a workplace for 1 entire Cooperative Education trimester according to the School's specifications. Once completed the work, the student has to submit an operational report and present his/her performance results to the School faculties for the assessment, Evaluation by the supervising faculties and job supervisor(s) based on the student's performance on the assigned work and the operational reports as well as his/her performance at the post-placement interview and seminar activities will determine the assessment result of the student to be either pass or fail

Learning outcomes

1. Apply relevant engineering knowledge, skills, techniques, and tools in a work context.
2. Identify and analyse issues, and suggest practical solutions in engineering problems.
3. Design a system, component, or process to meet desired needs.
4. Effectively communicate verbally and in writing.
5. Schedule a work plan and have the flexibility to respond to changing circumstances.
6. Establish good working relationships in a multi-disciplinary team.
7. Understand and apply professional and ethical responsibility.
8. Recognise the need for, and engage in lifelong learning.

531497 Cooperative Education II **8 Credits**

Prerequisite : 531496 Cooperative Education I

The student has to perform full-time academic or professional work as a temporary staff member at a workplace for 1 entire Cooperative Education trimester according to the School's specifications. Once completed the work, the student has to submit an operational report and present his/her performance results to the School faculties for the assessment, Evaluation by the supervising faculties and job supervisor(s) based on the student's performance on the assigned work and the operational reports as well as his/her performance at the post-placement interview and seminar activities will determine the assessment result of the student to be either pass or fail

Learning outcomes

1. Apply relevant engineering knowledge, skills, techniques, and tools in a work context.
2. Identify and analyse issues, and suggest practical solutions in engineering problems.
3. Design a system, component, or process to meet desired needs.
4. Effectively communicate verbally and in writing.
5. Schedule a work plan and have the flexibility to respond to changing circumstances.
6. Establish good working relationships in a multi-disciplinary team.
7. Understand and apply professional and ethical responsibility.
8. Recognise the need for, and engage in lifelong learning.
9. Develop professional contacts.
10. Take initiative in a professional setting.

531498 Cooperative Education III **8 Credits**

Prerequisite : 531497 Cooperative Education II

The student has to perform full-time academic or professional work as a temporary staff member at a workplace for 1 entire Cooperative Education trimester according to the School's specifications. Once completed the work, the student has to submit an operational report and present his/her performance results to the School faculties for the assessment, Evaluation by the supervising faculties and job supervisor(s) based on the student's performance on the assigned work and the operational reports as well as his/her performance at the post-placement interview and seminar activities will determine the assessment result of the student to be either pass or fail

Learning outcomes

1. Adaptively apply relevant engineering knowledge, skills, techniques, and tools in a work context.
2. Identify and analyse issues, and suggest practical and economical solutions in engineering problems.
3. Design a system, component, or process to meet desired needs.
4. Effectively communicate verbally and in writing.
5. Schedule a work plan and have the flexibility to respond to changing circumstances.
6. Establish good working relationships in a multi-disciplinary team.
7. Understand and apply professional and ethical responsibility.
8. Recognise the need for, and engage in lifelong learning.
9. Develop professional contacts.
10. Take initiative in a professional setting.

531499 Metallurgical Engineering Professional Project **9 Credits**

Prerequisite : consent of the school

This project be in metallurgy or metallurgical engineering professional fields for the development or integration of the new knowledge. Research project methodology includes literature review, project proposal, experimentation, progress report. Final report and oral presentation are required to fullfill the couse assessment by advisors and project assessment committee.

Learning outcomes

Students shall be capable of implementing research methodology via project based learning to conduct a scientific research in metallurgy or metallurgical engineering professional fields and deliver an oral presentation.