Brief Description of CN Courses

Workload for the courses is displayed in an A-B-C-D- E format where:

A – No. of lecture hours per week
B – No. of tutorial hours per week
C – No. of laboratory hours per week
D – No. of project/assignment hours per week
E – No. of hours for preparatory work per week

CN5010 Mathematical & Computing Methods for Chemical Engineers
Units: 4
Workload: 3-0-0-1-6
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
This course provides research students and practicing engineers with a strong foundation in mathematical and computing methods applicable to the chemical industry. The course covers techniques for formulating mathematical models of chemical processes and analytical techniques for solving the derived models. Modern software and programming languages are introduced to facilitate numerical solution of complex engineering problems. Machine learning concepts and their potential application to problems in chemical engineering are discussed.

CN5020 Advanced Reaction Engineering
Units: 4
Workload: 3-0-0-0-7
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
The course aims to train the students in the fundamentals of reaction engineering and their application to the design and analysis of reactor. The concepts and theory in reaction kinetics are applied to reactor design of single phase reaction system. These are extended to multiphase reaction systems, incorporating the effects of physical rate processes and the interfacial equilibrium leading to the formulation of procedure for the design performance and stability analysis of reactors. This postgraduate course is targeted at students with interests in reaction systems. Background in chemical kinetics and transport phenomena will be beneficial.

CN5030 Advanced Chemical Engineering Thermodynamics
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Physical chemistry and/or thermodynamics at undergraduate level
Preclusion(s): Nil
Cross-listing(s): Nil
The objective is to give students the fundamentals of thermodynamics at an advanced level, so that they can apply them to the analysis of complex processes and equipment design in chemical engineering. The course will begin by reviewing the basic laws of thermodynamics, the basic thermodynamic variables and molecular interactions. This is to be followed by the fundamentals of equilibrium thermodynamics, thermodynamics of the real gas mixture and the real solution systems, criteria of equilibrium and stability; molecular thermodynamics; thermodynamics of aqueous electrolyte and polymer-solutions; and an introduction to statistical thermodynamics. This is targeted at students who have a basic degree in science and engineering and are pursuing a higher degree in chemical engineering.

CN5040 Advanced Transport Phenomena
Units: 4
Workload: 3-0-0-0-7
Prerequisite(s): Fluid mechanics and/or heat and mass transfer at undergraduate level
Preclusion(s): Nil
Cross-listing(s): Nil
Its objective is to introduce to the students the concept and theory of fluid mechanics, and heat and mass transfer at advanced level. This course starts with derivation of three conservation equations for momentum, energy and mass, and introduction of constitutive equations that relate fluxes to material properties and driving forces. Application and simplification of these basic equations for various cases is then followed. Various classical methods are learned to solve different problems. It is targeted at students who have interested in the three transports. Some background in engineering mathematics, fluid mechanics, and heat and mass transfer is beneficial.

CN5050 Advanced Separation Processes
Units: 4
Workload: 3-0-0-0-7
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
The objective is to introduce the concept and theory of diffusion, and their application in the design and analysis of industrially important advanced separation processes. The course starts with a review of basic diffusion concepts and calculations followed by the impact of flow dynamics on diffusional mass transfer. These concepts are then applied to the understanding and design of absorption with chemical reaction, adsorption, and membrane separation processes. This is a postgraduate course targeted at students who are interested in design and/or operation of diffusional separation processes. Some background in equilibrium thermodynamics and principles of diffusion will be beneficial.

CN5111 Optimisation of Chemical Processes
Units: 4
Workload: 3-0-0-5-2
Prerequisite(s): Linear algebra and numerical methods at undergraduate level
Preclusion(s): Nil
Cross-listing(s): Nil
Students will learn the fundamentals, methods and software for formulating and solving optimisation problems of relevance to chemical engineering. They will study various methods of linear/nonlinear and unconstrained/constrained programming, which would enable them to select and use appropriate solution algorithm and/or software for solving a given problem. They will also execute the various steps in optimisation and demonstrate their acquired knowledge by solving a sufficiently complex practical problem of their own choice in a term project. This is for graduate students who wish to learn optimisation methodology to solve real-life problems in research and/or industry.

CN5111B Process Optimization with Industrial Applications
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Calculus, linear algebra and numerical methods at undergraduate level
Preclusion(s): Nil
Cross-listing(s): CN5111
Students will learn fundamentals, methods, and software for formulating and solving optimization problems related to chemical engineering. They will study various methods of linear/nonlinear and unconstrained/constrained programming, which would enable them to select and use appropriate solution algorithms and/or software for solving a given problem. Guest lecturer with extensive industrial experience in the optimization area will discuss many case studies in reality, to demonstrate how these theoretical tools can be used.

CN5112 Introduction to Electrochemical Systems
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Nil
Preclusion(s): MLE5212
Cross-listing(s): Nil
Electrochemical processes are crucial for sustaining our daily lives: from the batteries that power our electronics to the industrial production of aluminium. This course will give students sound working knowledge on the fundamental concepts of electrochemistry, introduction to theoretical concepts and common electrochemical methods. In addition, we will cover some important applications of electrochemistry such as electrodeposition, photoelectrochemistry, and electrocatalysis for water splitting and CO_2 conversion to chemicals/fuels. Students are assessed by means of small individual homework assignments, a mid-term and a final exam.

CN5124 Fluid-Particle Systems
Units: 4
Workload: 3-0-0-4-3
Prerequisite(s): CN2106
Preclusion(s): CN3124
Cross-listing(s): Nil
This course provides students with concepts of various multiphase processes that are important to Chemical Engineering applications. These include sedimentation, flow through packed beds, filtration, fluidisation, pneumatic transport and cyclone separation. The concept of terminal velocity of a single particle in a fluid is introduced and subsequently extended to the concept of hindered settling velocity in multiple particle systems. This is then applied to engineering designs of batch and continuous settling systems for solid-liquid separation. The principles associated with fluid flow through packed beds are discussed and applied towards engineering designs of filtration systems. These principles are then extended further to the study of fluidized bed systems. Pressure drop calculations for pneumatic transport of particles through vertical and horizontal pipes and engineering design calculations for gas cyclone systems to achieve gas-solid separation are discussed.

CN5131 Colloids and Surfaces
Units: 4
Workload: 3-0-0-0-7
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
The objective of the course is to introduce fundamental concepts of describing and interpreting interfacial phenomena and to discuss important applications in selected technological areas. The course commences with key theories such as surface tension, contact angle, Young-Laplace equation, and Kelvin equation, followed by the thermodynamics of surfaces, forces that govern interfacial interactions, adsorption at various interfaces, colloidal systems, self assembly system, and surfactants. Investigative techniques for analyses of interfacial and colloidal systems are presented to demonstrate the application of the concepts. Students who are interested in physicochemical events at interface and in colloidal systems are strongly encouraged to study this course. Background in physical chemistry, thermodynamics, transport phenomena, engineering mathematics, and materials science and engineering will be beneficial.

CN5150 Principles of Polymer Science and Engineering
Units: 4
Workload: 3-0-0-0-7
Prerequisite(s): Nil
Preclusion(s): MLE3104
Cross-listing(s): Nil
This course introduces the fundamentals of polymer science and engineering. It covers (i) polymer synthesis (i.e., molecular weight, molecular weight distribution, and step growth and chain growth polymerizations and kinetics), (ii) physical properties of polymers (i.e., polymer conformation, thermodynamics of polymer solution and polymer blend, kinetics of polymer blend, measurements of molecular weight and size, glass transitions in polymers, and morphology and crystallization in semicrystalline polymers), and (iii) mechanicl and rheological properites of polymers (i.e., mechanical behaviour, mechanisms of deformation, mechanical models for viscoelasticity, Newtonian and non-Newtonian fuilds, viscosity, nonlinear behaviour of polymer melt).

CN5160 Advanced Topics in Catalysis
Units: 4
Workload: 3-0-0-4-5
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
Catalysis plays a key role to tackle the increasing societal demand for sustainable production. The course introduces “disruptive innovations” in catalysis that may revolutionize the way to conduct catalytic reactions, and/or fundamentally change the views on catalytic active sites and cycles. The course consists of five core contents: 1) advanced catalytic kinetic concepts including multiscale modelling and energetic span model; 2) advanced synthetic procedures affording catalyst with high structural precision and complexity; 3) in situ characterization tools; 4) catalysis beyond thermal activation; and 5) emerging frontiers, such as auxiliary promotion, dynamic catalysis, data-driven catalyst design etc.

CN5161 Polymer Processing Engineering
Units: 4
Workload: 3-0-0-1-6
Prerequisite(s): Nil
Preclusion(s): CN4203
Cross-listing(s): Nil
Polymer Production, polymerisation kinetics, methods of bulk, solution, dispersion, suspension and emulsion polymerisation; design of polymerisation reactors; analysis of polymer processing operations, extrusion, film blowing, wire-coating, injection molding, blow moulding, thermoforming, calendering and mixing; polymer rheology, the kinematics of deformation and flow, viscometry and rheometry, constitutive equations based on continuum/rational mechanics and on molecular theory.

CN5162 Advanced Polymeric Materials
Units: 4
Workload: 3-0-0-1-6
Prerequisite(s): General knowledge on chemistry, chemical engineering, and materials science. Students are encouraged to take CN5150 before enrolling in CN5162 to gain foundational knowledge in polymer science and engineering.
Preclusion(s): CN6162
Cross-listing(s): Nil
An advanced introduction to polymer chemistry and physics. Current state of development in controlled polymerisations. Survey of functional polymers. Electroactive polymers and polymers in optoelectronics. Polymers in microelectronics: as photoresists, e-beam resists, and IC encapsulants. Polymer blends and polymer membranes. Membrane fabrication, characterisation and applications. Liquid crystalline polymers. Polymers as biomaterials. Surface modified and functionalised polymers.

CN5172 Biochemical Engineering
Units: 4
Workload: 3-0-0-2-5
Prerequisite(s): CN1111, CN2122, CN2116, LSM1401 or with the consent of the instructor
Preclusion(s): CN4208
Cross-listing(s): Nil
The objective of this course is to familiarise students with the upstream section of a bioprocess for the manufacture of a biological product. The course starts with the drug discovery process and natural products research. Growth and product kinetics are reviewed through a cursory treatment. This is followed by introduction to rDNA and hybridoma technology for biopharmaceuticals production. Detailed treatment of fermenter design including operating strategies, and transport phenomena with respect to agitation and aeration follows. Considerations for mammalian cell cultivation are discussed as well as media sterilisation and process monitoring of a bioprocess. These concepts are finally applied to a term paper. This course is targeted at graduate students who are interested in biopharmaceuticals production.

CN5173 Downstream Processing of Biochemical and Pharmaceutical Products
Units: 4
Workload: 3-0-0-2-5
Prerequisite(s): CN3132 or with the consent of the instructor
Preclusion(s): CN4231
Cross-listing(s): Nil
The objective of this course is to familiarise students with the downstream section of a bioprocess for the production of biochemical and pharmaceutical products. The course first discusses drug requirements for different applications, and an overview of the downstream processes involved in obtaining an acceptable product quality. The general characteristics and fundamental principles of unit operations encountered in each of the major section of a downstream train are then discussed in detail: removal of insolubles, product isolation, high resolution techniques and product polishing. The current state of the research in some unit operations is also highlighted. The concepts covered are finally applied to a term paper. This course is targeted at graduate students who are interested in biopharmaceuticals production.

CN5181 Computer Aided Chemical Engineering
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Nil
Preclusion(s): CN4229
Cross-listing(s): Nil
This course introduces students to advanced computational methods and their application to common chemical engineering problems. Computational techniques are commonly used for process design, planning and scheduling, and control. The course provides a practical introduction to basic concepts, tools and techniques in artificial intelligence, symbolic computation, and numerical optimisation. Knowledge representation, object-oriented programming, and solution techniques such as search algorithms, neural networks, symbolic algebra, and linear and nonlinear optimisation are covered in a hands-on fashion. These are then applied to various industrially relevant problems. This course is for students interested in state-of-the-art computational methods. Some programming background will be beneficial.

CN5190 Hydrogen Energy and Technology
Units: 4
Workload: 3-0-0-4-3
Prerequisite(s): Familiar with general chemistry, materials science, thermodynamics, chemical kinetics and chemical engineering
Preclusion(s): Nil
Cross-listing(s): Nil
This course gives a comprehensive overview of the fundamental knowledge of hydrogen, and introduction to the development of hydrogen technologies, including hydrogen production, storage and transportation, hydrogen utilization in industry, and as a clean fuel. Opinions and perspectives on future hydrogen economy will also be introduced. Students will learn various types of hydrogen related research and technologies, their significance, advantages, challenges and opportunities ahead. Guest lectures from academic and industrial experts, literatures from key areas will also be introduced to reinforce classroom learning. This course is meant for students with some chemical engineering, chemistry, materials science, or related background.

CN5191 Project Engineering
Units: 4
Workload: 3-0-0-4-3
Prerequisite(s): Nil
Preclusion(s): CN4225
Cross-listing(s): Nil
The objective of this course is to provide a step-by-step description and illustration of a project's lifecycle in the chemical industry. Beginning with an overview of the chemical process industry (CPI) and project terminology, the course will discuss in detail the organization of projects, team composition and roles of various personnel, planning and scheduling of activities, project management tools, and plant operations. It will involve guest speakers from various industries and real-life cases studies. This course is targeted at students with a potential career interest in engineering and construction field.

CN5192 Future Fuel Options: Prospects and Technologies
Units: 4
Workload: 3-0-0-4-3
Prerequisite(s): Familiar with general chemistry, chemical kinetics and chemical engineering thermodynamics
Preclusion(s): Nil
Cross-listing(s): Nil
This course introduces fuel options for mankind beyond coal, conventional natural gas and petroleum. It is a multidisciplinary course integrating cutting edge technologies for the utilization of future fossil fuels (such as shale gas, coal bed methane and methane hydrates), biofuels and hydrogen fuel. Students will learn various types of alternative fuels, their advantages, significance, current practice, production strategies, and challenges ahead. A term project along with several real and literature case studies from key areas will be used to illustrate and reinforce the learning. This course is meant for graduate students having chemical engineering background.

CN5192X Advanced Topics in Catalysis *(for students in Double Master Degree between TJU & NUS)*
Units: 4
Workload: 3-0-0-2-5
Prerequisite(s): Nil
Preclusion(s): CN5192
Cross-listing(s): Nil
Catalysis is important to tackle the increasing demand for sustainable production. The course introduces "disruptive innovations" in catalysis that may revolutionize the way to conduct catalytic reactions, and/or fundamentally change the views on catalytic active sites and cycles. The course consists of five core contents: 1) advanced catalytic kinetic concepts including multiscale modelling and energetic span model; 2) advanced synthetic procedures affording catalyst with high structural precision and complexity; 3) in situ characterization tools; 4) catalysis beyond thermal activation; and 5) emerging frontiers, such as auxiliary promotion, dynamic catalysis, data-driven catalyst design etc. This course is NUS's equivalent of CN5192

CN5193 Instrumental Methods of Analysis
Units: 4
Workload: 3-0-0-0-7
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
The objective of this course is to introduce to the students principles of advanced analytical techniques, and their practical applications. This course covers a number of topics including the analytical process, sample preparation, calibration methods, fundamental aspects of spectrophotometry, applications of atomic spectroscopy, introduction to analytical separations, chromatographic methods, and thermal and surface analysis. In addition, the use of advanced instrumental techniques for specific research applications, data analysis, and spreadsheet calculations are discussed. This is a postgraduate course targeted at students who are interested in using advanced analytical techniques in their research. Some background in Analytical Chemistry will be beneficial.

CN5194 Carbon Capture Sequestration and Utilization
Units: 4
Workload: 3-0-0-2-5
Prerequisite(s): Familiar with general knowledge of chemistry and chemical engineering.
Preclusion(s): Nil
Cross-listing(s): Nil
The link between global warming and rising anthropogenic CO_2 in the atmosphere is now well recognized. The urgency to address this existential threat requires a multi-pronged approach where carbon capture, concentration, sequestration and utilization are among the leading mitigation options. This course provides a broad introduction to global warming and an overview of various intervention strategies. Various carbon capture and concentration technologies, and sequestration options are discussed in detail. The challenges and opportunities of CO_2 utilization for chemicals production are addressed. Renewable and low CO_2 emission alternative energy technology options are also discussed.

CN5195 Biomass and Energy
Units: 4
Workload: 3-0-0-2-5
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
This course provides a comprehensive and interdisciplinary examination of biomass as a renewable energy source. The main focuses of this course include types of biomass, main conversion technologies, quality and characterization of biofuels, and process evaluation metrics. In this course, students will learn about the science of biomass and its use as a sustainable feedstock for the production of fuels in lieu of finite fossil fuels. Further, the merits, demerits, barriers, and way forward solutions of energy exploitation will also be delivered upon the completion of the entire course.

CN5202 Selected Topics in Energy Systems *(for students in MSc Energy Systems programme)*
Units: 4
Workload: 3-0-0-2-5
Prerequisite(s): Familiar with general knowledge of energy technologies.
Preclusion(s): Nil
Cross-listing(s): Nil
As the world moves into a greener future, new technologies and solutions are emerging rapidly. This course will introduce new concepts and development in energy technologies and systems.

CN5203 Circular Economy in the Chemical Industry
Units: 4
Workload: 3-0-0-2-5
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
Resource conservation and waste minimization are some of the greatest current concerns for chemical process industries. With impending resource depletion and climate change issues, it is imperative for process industries to transform and adapt to a more efficient and sustainable operating mode. In this course, the concepts of circular economy, and the implementation of waste-to-energy and waste-to-chemicals technologies will be evaluated. The versatile and useful techniques of process integration and resource conservation networks (RCNs) will also be introduced to prepare students in process design or retrofitting projects with waste minimization as an objective.

CN5204 Green Chemical Process and Technology
Units: 4
Workload: 3-0-0-2-5
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
With rising concerns over climate change and resource depletion in this century, the role of chemical engineers in developing processes that are cleaner and greener is evident. This course introduces the concepts of green engineering and clean technologies with a focus on the process design, implementation and techno-economic evaluation for various scales. The applications of upcoming clean technologies such as chemical looping and use of supercritical CO2 will be highlighted. The concepts and principles of Process Intensification will also be taught to help students understand the development and operation of more compact, efficient, and cleaner unit operations.

CN5205 Machine Learning in Chemical Engineering
Units: 4
Workload: 3-0-0-4-3
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
The course will provide the students with essential knowledge on machine learning technologies in chemical engineering applications. It incorporates introductory concepts, mathematical models for machine learning, including data classification, clustering, regression, kernel methods, and artificial neural networks, and applications of machine learning in chemical engineering. Projects in python is a part of course project presented in class. The course also incorporates case studies that prepare the students to apply machine learning methods to address practical challenges associated with chemical, pharmaceutical, and energy systems. This course is for students pursuing MSc, MEng and PhD in chemical engineering as well as BEng (Chem Eng) students.

CN5215 Atomistic Modelling of Molecules and Materials
Units: 4
Workload: 2-0-2-1-5
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): MLE5215
The course equips students interested in computational chemistry and materials science materials with: (1) Foundation of force-field and interatomic potentials. (2) Foundation of first principles methodologies. (3) Foundation of the methodologies aforementioned when applied in molecular dynamics and Monte Carlo studied. (4) Hands-on application of computational techniques to chemical and materials science problems.

CN5216 Electronic Materials and Energy Technologies
Units: 4
Workload: 3-0-0-4-3
Prerequisite(s): Familiar with general chemistry and materials science.
Preclusion(s): Nil
Cross-listing(s): Nil
Electronic materials have become essential for modern society, and new breakthroughs in electronic materials promise to offer next generation technologies. This course explores the fundamental mechanisms for understanding existing and emerging electronic materials for green energy devices in the modern world. This survey course will enable students to learn the fundamental properties in order to understand the operation and development of materials for applications such as organic electronics, hybrid semiconductors, photovoltaics, photocatalysts, and optoelectronic devices. This course is also intended to introduce contemporary research to students through discussion and analysis of research manuscripts as case studies.

CN5219 Engineering Nanobiotechnology
Units: 4
Workload: 3-0-0-4-3
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
This course explores the use of chemical and biological engineering principles to develop nanoscale tools for studying biological systems. It begins with the fundamental properties of DNA, RNA, and proteins, emphasizing their biotechnological relevance in therapeutics, food security and sustainability. The second part focuses on nanoparticle properties and their interactions with biomolecules, highlighting how nanotechnology can be engineered to probe biointerfaces at the molecular level. Students will integrate knowledge from chemical engineering, biochemistry, and nanoscience to address challenges in healthcare and sustainability.

CN5220 Colloids and Soft Matter Engineering
Units: 4
Workload: 3-0-0-0-7
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
In recent decades, colloidal and soft material systems have advanced rapidly and have wide-ranging applications in healthcare and environmental sustainability. This course covers the fundamentals of colloidal interactions between surfaces, particles, and surfactants, as well as applications of various soft materials, including nanoparticles, microparticles, polymeric hydrogels, and other newly-emerged soft materials. In this course, materials science, condensed matter physics, and chemical engineering are integrated to address today's most challenging issues, such as wearable electronics, drug delivery, and wastewater treatments.

CN5222 Pharmaceuticals and Fine Chemicals
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Nil
Preclusion(s): CN4232
Cross-listing(s): Nil
The objective of this course is to provide an overview of the chemical reaction engineering aspects of pharmaceutical and fine chemical synthesis. Emphasis is placed on the importance of controlling chemo- regio- and stereoselectivity. Most pharmaceutical and fine chemical syntheses are performed in the liquid phase. As preliminaries, a number of relevant physical-chemical concepts are introduced. Since many liquid syntheses are metal-mediated, emphasis is given to homogeneous catalysis and modified heterogeneous. This naturally leads to a host of important environmental issues. This is a postgraduate course targeted at students who have are interested chemical reaction engineering and particularly the special considerations required for the pharmaceutical and fine chemical industries.

CN5246 Catalysis Science and Engineering
Units: 4
Workload: 3-0.5-0-3-3.5
Prerequisite(s): Nil
Preclusion(s): CN4246R
Cross-listing(s): Nil
Students will learn the concepts of heterogeneous catalysis with increasing complexities, starting from those involving polymeric phases, enzyme pockets, up to those involving zeolite cages and complex oxide surfaces. To achieve these, students will learn steady state approximation, catalytic cycles, catalyst structures, reaction mechanisms & kinetics, transport phenomena (diffusion, mass and heat transfer), and reaction engineering. Many reactions and catalysts of industrial importance will be emphasised throughout the course to illustrate these principles. Students will then learn how to apply their knowledge of these principles to the design of catalysts, reaction mechanism, and reaction kinetics rate laws for reactor design.

CN5251 Membrane Science and Technology
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): CN6251
The objective of this course is to provide students with a broad spectrum of knowledge in fundamentals of membrane science and engineering, as well as in membrane applications for chemical, environmental and biomedical engineering. The course starts with the introduction of various membranes and their applications. We then teach the general theory of membrane transport for pressure, concentration and electric field driven separation and purification processes. The basic principles of membrane fabrication for symmetric, asymmetric and composite membranes will be studied. Other focuses will be given to membrane fouling, liquid membranes, and facilitated transport in order to broaden students' knowledge in membrane usage and functional membranes. In order to inspire student interests in membrane applications for life science, the course will also include membranes for controlled release devices, biomimetic and biological membranes for life science.

CN5252 Molecular and Computational Tools for Biotechnology
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Linear algebra and numerical methods at undergraduate level, Fundamentals of Biochemistry
Preclusion(s): Nil
Cross-listing(s): Nil
Biotechnology plays increasingly important roles in chemical manufacturing, because it can utilize renewable resources and carry out the reactions at milder, safer and more environmentally-friendly conditions. This course introduces the foundational molecular biology tools that have enabled many biotechnological processes. To enable the students to have hands-on experiences with these theories, this course is also heavy in using computational tools during teaching and assessments. The computations would allow the students to practice the theories in silico and be able to handle large volume of data that are being generated by the omics technologies in many biotechnological applications.

CN5277 Molecular Engineering of Advanced Drug Delivery Systems
Units: 4
Workload: 3-0-0-4-3
Prerequisite(s): Familiar with general chemistry and materials science
Preclusion(s): Nil
Cross-listing(s): Nil
Molecular engineering plays a pivotal role in the development of next generation drug delivery systems. Toward that end, the goal of this course will be to educate students on the fundamental principles that underlie the molecular engineering of drug delivery systems. Key concepts of this course will include the exploration of fundamental reaction paradigms for polymeric synthesis and their modifications using small molecule based mechanistic paradigms including polar, radical, pericyclic, and transition metal mediated pathways across length scales. Students can thus expect to learn how to engineer advanced drug delivery systems at the molecular level for the treatment of disease.

CN5371 Special Topics in Biochemical Engineering and Bioseparations
Units: 4
Workload: 2-0-3-3-2
Prerequisite(s): Students should have taken topics in Biochemical Engineering, Bioseparations, and have a strong interest in the biomanufacturing and the biotechnology industry.
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
The objective of this course is to give students opportunity to critique current papers in biochemical engineering and provide practical understanding of cell culture and purification methods. Students will critique scientific impact of protein therapeutics and engineering aspects of recombinant protein production at commercial scales. They will be introduced to bioreactors, media design and analytical methods for cell culture. This is followed by topics on protein purification, and analytical methods of structure and function. Two practical sessions include culture of animal cells to produce, purify and characterise antibodies, SDS Page, western blots and ELISAs. This is a postgraduate course targeted at students who are interested in bioprocesses such as animal cell culture and protein purification.

CN5391 Selected Topics in Advanced Chemical Engineering I
Units: 4
Workload: Depends on the selected topic offered
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
This is an advanced course in Chemical Engineering. Specific topics are selected on the basis of current teaching and research needs. Lectures will be given by both department staff and visiting specialists.

CN5392 Selected Topics in Advanced Chemical Engineering II
Units: 4
Workload: Depends on the selected topic offered
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
This is an advanced course in Chemical Engineering. Specific topics are selected on the basis of current teaching and research needs. Lectures will be given by both department staff and visiting specialists.

CN5401 Contemporary Topics in Advanced Chemical Engineering
Units: 2
Workload: 1.5-0.5-0-1-2
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
This is an advanced course in Chemical Engineering. Specific topics are selected based on teaching and research needs of the Department and current trends in chemical / biomolecular engineering research. Lectures will be given by Department staff and / or visiting specialists.

CN5432 Fundamentals and Applications of Porous Materials
Units: 4
Workload: 3-0-0-4-3
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
The recent decade has witnessed the rapid development of porous materials and their applications in clean energy and environmental sustainability including storage, separation, sensing, and catalysis. This course covers the chemistry, structure, characterization, and applications of various porous materials including zeolites, inorganic mesoporous materials, metal-organic frameworks (MOFs), covalent organic frameworks (COFs), and other newlyemerged porous materials. It is a multidisciplinary course integrating chemistry, materials science, and chemical engineering with a focus on addressing some of the most challenging problems such as hydrogen storage, carbon capture, and CO2 utilization.

CN5550 Energy Systems Project *(for students in MSc Energy Systems programme)*
Units: 8
Workload: 0-0-0-20-0
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
The aim of this course is to allow students to acquire knowledge in a selected field of energy systems through experiential learning. This will be done through a basic or applied research project hosted by a research lab or centre. The student will be guided by a professor in the domain chosen but is expected to work independently mostly. The project will be graded through a report and presentation.

CN5555 Chemical Engineering Project *(for students in MSc Chemical Engineering programme)*
Units: 8
Workload: 0-0-0-7-3
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
This course involves supervised project over two semesters, on a topic approved by the Department. The project work should relate to one of the sub-areas of chemical engineering: chemical engineering sciences, chemical and biological systems engineering, environmentally benign processing and sustainability, biomolecular and biomedical sciences, and nanostructured and functionalized materials/devices. The student has to find a suitable supervisor or supervisors. The study area is to be finalized after consultation with the supervisor(s). Approval will be granted by the Program Manager. The student shall carry out the project within the period of his/her candidature.

CN5555X MSc Project *(for students in Double Master Degree between TJU & NUS)*
Units: 8
Workload: 0-0-16-0-4
Prerequisite(s): Nil
Preclusion(s): CN5555
Cross-listing(s): Nil
This is a project-based course. The student will undertake a one semester course of independent research on an advanced topic in chemical engineering under the direction of an academic staff member. In addition, the student is required to perform any preparatory course in laboratory techniques which the Department deems necessary.

CN5566 Chemical Engineering Industrial Practice *(or students in MSc Chemical Engineering programme)*
Units: 8
Workload: 0-0-0-20-10
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
This is an industrial attachment course that provides students with work attachment experience in the field of chemical engineering and related processes in a company.

CN5611X Industry Practices in Chemical Engineering *(for students in Double Master Degree between TJU & NUS)*
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
An appreciation of principles and practices of the chemicals industry, including regulatory and business landscape, is vital preparation for entry to industry. This course covers the essential aspects in: (i) Industrial Safety; (ii) Environmental Protection and Regulation; and (iii) Industry Overview of five selected sub-sectors in: (a) Petrochemicals, (b) Specialty Chemicals, Materials & Polymers, (c) Pharmaceuticals, (d) Medical and Bio Technologies, (e) Electronics and Advanced Manufacturing, (f) Sustainable Solutions, (g) Analytical Instrumentation, and/or (h) Chemical Consultancy Services. The Overview will be delivered by company executives/industry experts, covering respective industry status & outlook, business overview, key innovations and emerging trends.

CN5666 Industrial Attachment *(for MEng & PhD students)*
Units: 4
Workload: 0-0-0-10-0 (minimum 60 days)
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
This course provides engineering research students with work attachment experience in a company.

CN5999 Graduate Seminars *(for MEng students)*
Units: 4
Workload: 0-0-0-0-0
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
Seminar-style course class.

CN6020 Advanced Reaction Engineering *(for PhD students)*
Units: 4
Workload: 3-0-0-2-7
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
The primary aim of the course is to provide graduate students with a strong foundation in the engineering of chemical reactions and reactors. The course will cover a variety of topics, including molecular basis of chemical phenomena, theories to estimate kinetic rate coefficients, complex gas phase kinetics, heterogeneous catalysis, analysis of reactors for single and multi-phase chemical reactions, and multi-scale coupling of transport phenomena with chemical reactions. Strong links to current research in several fields will be established, with an emphasis on the generality of the underlying conceptual foundation and its utility in the research pursued by the enrolled students.

CN6162 Advanced Polymeric Materials *(for PhD students)*
Units: 4
Workload: 3-0-0-1-6
Prerequisite(s): CN5150
Preclusion(s): CN5162
Cross-listing(s): Nil
An advanced introduction to polymer chemistry and physics. Current state of development in controlled polymerisations. Survey of functional polymers. Electroactive polymers and polymers in optoelectronics. Polymers in microelectronics: as photoresists, e-beam resists, and IC encapsulants. Polymer blends and polymer membranes. Membrane fabrication, characterisation and applications. Liquid crystalline polymers. Polymers as biomaterials. Surface modified and functionalised polymers.

CN6163 Inorganic Nanomaterials for Sustainability *(for MEng & PhD students)*
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): CN5020, CN5030 or equivalent, or Lecturers' Permission. This course is designed for Ph.D. and M.Eng. students.
Preclusion(s): Nil
Cross-listing(s): Nil
The course begins with an introduction of how chemical engineering principles contribute to nanomaterials-driven sustainability. Following that is in-depth discourses on the fundamental concepts in the chemistry and physics of inorganic nanomaterials. Then, design of functional inorganic nanomaterials is introduced followed by the systematic discussion on synthesis, characterization, functionalization, properties and applications. Applications of these concepts would be realized in diverse, current and important sustainability topics such as inorganic nanomaterials for renewable energy generation and storage, green catalysis for fine chemicals, applications in environment and human health, and public concerns of inorganic nanomaterials exposure.

CN6163X Inorganic Nanomaterials for Sustainability *(for students in Double Master Degree between TJU & NUS)*
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Nil
Preclusion(s): CN6163
Cross-listing(s): Nil
The course begins with an introduction of how chemical engineering principles contribute to nanomaterials-driven sustainability. Following that is in-depth discourses on the fundamental concepts in the chemistry and physics of inorganic nanomaterials. Then, design of functional inorganic nanomaterials is introduced followed by the systematic discussion on synthesis, characterization, properties and applications. Applications of these concepts would be realized in diverse, current and important sustainability topics such as inorganic nanomaterials for renewable energy generation and storage, green catalysis for fine chemicals, applications in environment and human health, and public concerns of inorganic nanomaterials exposure. This course is NUS's equivalent of CN6163.

CN6222 Pharmaceuticals and Fine Chemicals
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Nil
Preclusion(s): CN4232 and CN5222
Cross-listing(s): Nil
The objective of this course is to provide an overview of the chemical reaction engineering aspects of pharmaceutical and fine chemical synthesis. Emphasis is placed on the importance of controlling chemo- regio- and stereoselectivity. Most pharmaceutical and fine chemical syntheses are performed in the liquid phase. As preliminaries, a number of relevant physical-chemical concepts are introduced. Since many liquid syntheses are metal-mediated, emphasis is given to homogeneous catalysis and modified heterogeneous. This naturally leads to a host of important environmental issues. This is a postgraduate course targeted at students who are interested in chemical reaction engineering and particularly the special considerations required for the pharmaceutical and fine chemical industries.

CN6251 Membrane Science and Technology *(for PhD students)*
Units: 4
Workload: 3-0-0-3-4
Prerequisite(s): Nil
Preclusion(s): CN4210 and CN5251
Cross-listing(s): Nil
The objective of this course is to provide students with a broad spectrum of knowledge in fundamentals of membrane science and engineering, as well as in membrane applications for chemical, environmental and biomedical engineering. The course starts with the introduction of various membranes and their applications. We then teach the general theory of membrane transport for pressure, concentration and electric field driven separation and purification processes. The basic principles of membrane fabrication for symmetric, asymmetric and composite membranes will be studied. Other focuses will be given to membrane fouling, liquid membranes, and facilitated transport in order to broaden students' knowledge in membrane usage and functional membranes. In order to inspire student interests in membrane applications for life science, the course will also include membranes for controlled release devices, biomimetic and biological membranes.

CN6999 Doctoral Seminars *(for PhD students)*
Units: 8
Workload: 0-0-0-0-0
Prerequisite(s): Nil
Preclusion(s): Nil
Cross-listing(s): Nil
Seminar-style course class.