SINGAPORE

EECE International Experience 2014
NUS Overview

- Vision: A leading global university centered in Asia
- Divided into 14 schools and faculties, gives 55 bachelor's degree
- Student population in the 12’-13’ school year is 27,216 UG and 10,210 graduate students.
- School of engineering, with ~7000 UG students and ~350 faculties, has comprehensive programs that encompass many major fields in engineering.

Elements of the NUS logo:
Open book - portal to knowledge
3 rings - creating, imparting and applying knowledge, and they reinforce each other
Lion - symbol of the nation of Singapore
# NUS ChBE Department

## Chemical Engineering Undergraduate Programme

### Recommended Semester Schedule

**SEMESTER 1**
- Singapore Studies
- GEM - 1
- ES1101 Critical Thinking & Writing
- ENGLISH
- IT1005 Intro to Programming with Matlab
- MA1501 Mathematics I

**SEMESTER 2**
- ES2331 Communicating Engineering (UEM - 1)
- CM1502 General and Physical Chemistry for Engineers
- CN1111 Chemical Engineering Principles
- MLE1101 Introductory Materials Science and Engineering
- MA1506 Mathematics II

**SEMESTER 3**
- GEM - 2
- CM1501 Organic Chemistry
- CN2121 Chemical Engineering Thermodynamics
- CN2122 Fluid Mechanics
- CS01401 Fundamentals of Biochemistry

**SEMESTER 4**
- CN2108 Chemical Engineering Lab I
- CN2110 Chemical Kinetics & Reactor Design
- CN2125 Heat and Mass Transfer
- CN2124 Fluid-Solid Systems Engineering Professionalism
- ES2401 Electrical Engineering Professionalism

**SEMESTER 5**
- CN2108 Chemical Engineering Lab II
- CN2112 Process Dynamics & Control
- CN2132 Separation Processes
- CN2421 Process Modelling and Numerical Simulation
- CN2136 Process Safety, Health, & Environment

**SEMESTER 6**
- CN2401 Elective 1
- HR0021 Human Capital in Organizations
- Restricted Elective Modules (12 MCs) – Industrial Attachment (IA) and other Enhancement Programmes of FOC, and/or from modules of student's choice

**SEMESTER 7**
- CN414R B.Eng. Dissertation
- CN4122 Process Synthesis and Simulation
- CN40xx Elective 2
- CN40xx Elective 3
- CN3109 Chemical Engineering Lab III

**SEMESTER 8**
- Breadth - 2
- UEM - 2
- CN414R B.Eng. Dissertation
- (continued)
- CN4123 Design Project
- CN40xx Elective 4

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### Modules in semesters 6 and 7 can be swapped to do Industrial Attachment in Semester 7

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## Chemical Engineering Sciences

- Carbon Capture & Utilization
- Catalysis
- Chemical & Statistical Thermodynamics
- Colloids & Interface Phenomena
- Reaction Engineering
- Polymer Science & Engineering
- Separation & Purification
- Transport Processes

## Chemical & Biological Systems Engineering

- Artificial Intelligence Applications
- Chemical Supply Chains
- Design & Development
- Operations & Safety
- Process Dynamics & Control
- Process Optimization
- Systems Biology and Biotechnology

## Environmentally Relevant Processing & Sustainability

- Biotechnology
- Environmental Technology
- Bioprocessing Technology
- Bio-Chemical Sensors
- Drug Delivery Systems
- Protein Biotechnology
- Protein Purification & Stability
- Tissue Engineering

## Biomedical & Biotechnological Sciences

- Biotechnology
- Biotechnology & Analytical Devices
- Biotechnology
- Nanomaterials & MEMS
- Nanomaterials & BioMimetics
- Surface Science & Engineering
Chemical Engineering Labs

Fume hoods and workbenches seen in NUS ChBE research labs.
Clathrate Hydrates

Dr. Praveen Linga’s research interests include:

- storage of carbon dioxide with Hydrate Based Gas Separation technique;
- development of method to recover methane from hydrates
- development of inhibitors to prevent undesired hydrate formation in pipelines
Methane Hydrates

- Clathrates - gas molecules trapped in water-based solid that resembles ice.
- Water cages are made by hydrogen bonds, and can form different crystal structures (as seen in the figure on the right).
- A large amount of methane is trapped in clathrate form on the deep ocean floor, a vast potential clean energy source.
- Sudden release of methane from clathrate form is a major cause of greenhouse effect.
Hydrogen Storage

Why store hydrogen in hydrates form?

- A small volume of hydrate can store hydrogen that are >100x larger in standard state.
- It requires only moderate temperature and pressure to accomplish.
- It is safe to store, and is environmentally benign.
- Using of THF can reduce pressure need, but THF also reduced storage capacity.
The Merlion

- Mascot and personification of Singapore.
- Fish tail represents Singapore’s origin as a fishing village.
- Lion head symbolizes Singapore’s original name in Malay: Singapura - “Lion City”
- Now located in the most prosperous area by the bay.
Multi-Objective Optimization

Real-life problems have multiple objectives, decision variables, and constraints.

Dr G. P. Rangaiah investigates solutions to these problems in Chemical Engineering.
Using Excel: EMOO

Excel-based Multi-Objective Optimization (EMOO) is a program written by Dr Rangaiah and Shivom Sharma to solve MOO. It is in beta and currently used in academic settings.
Research in particle modeling is in the application to practical systems.

Dr. Eldin Lim researches the application of CFD-DEM theory to fluidized beds, granular materials, and evacuation.
Nanyang Technological U.

NTU is another major university in Singapore. A $849M grant in 2008 helped build the Nanyang Environmental and Water Research Institute (NEWRI).
Transportation in Singapore

It costs $80K to purchase a “driving permit” in Singapore, intended to reduce congestion.

Most people get around using the robust public transit network of subways, light rail, and busses.
Self-Assembly of Amphiphiles

The interaction of the hydrophilic and hydrophobic sections allow these molecules to have emerging material science applications, usefulness as drug delivery systems, and possibilities as innovative medical diagnostic tools.
Methodology

- Rheometry
- Calorimetry
- Fluorescence Microscope
- UV-vis spectrometry
- Computer simulation

Dynamic Light Scattering (DLS)
Clean Energy

Jim Yang Lee, Department Head

- Energy consumption scales with global economic growth.
- Clean energy = clean energy source + efficient use of the energy
- Sustainability involves environmental, economic, and social impact.
CO2 Emissions vs. GDP

“Energy system transformation is not only a technical issue, but also a high level management, financial, and political issue. We need a program of planned activities from all governments and market-based actions for a solution in the short time we have.” -Dr. Lee
Cleaner Fuels?

Biofuels: The main value of biofuels is not in reducing global warming, but in increasing energy security.

- 1st generation- from food crops - food vs. energy debate
- 2nd generation- cellulosic -- positive net energy gains?
- 3rd generation- photosynthetic algae or cyanobacteria -- carbon negative?
- 4th generation- genetically engineered photosynthetic cells -- carbon negative?

Greener Fossil Fuels: Thermodynamics favors the use of high-energy, low oxidation state carbon starting materials as it will release the most heat when burned.
Lowering of the carbon oxidation state requires energy input (e.g. photosynthesis).

Source: Jim Yang Lee’s presentation
Singapore International Water Week

- Innovative Technology in the water treatment sector and beyond
- Encouraging Professionals from around the globe
- Introduction to specific aspects of industry

Pictured with sand filtration display
Gardens by the Bay

Above: Super Trees lit up at night

Right: Waterfall inside Cloud Forest Conservatory
Process Systems Engineering
Challenges in Oil & Gas Supply Chains

Professor Karimi
Department of Chemical & Biomolecular Engineering

- Broad, qualitative overview: modeling, simulation, and optimization (EMOO)
- The lecture as it applies to my major:
  - Methods of systems eng. applied within the domain of chemical eng.
  - Signals & Systems: input-output, state-space models
  - Operations Research: linear programming
Jurong Island
Not the Earthquake’s Fault
Geophysical Hazards and Post-Colonial Ecology in Haiti

Brian McAdoo
Professor of Environmental Studies and Geophysics

- Defining engineering
  - Practical application of pure sciences
  - Scientists point out problems. Engineers fix them.
  - “Science with accountability”

- Risk = hazard x vulnerability - mitigation resilience
Case Study: 2010 Haiti Earthquake
Just outside Port-au-Prince

1989 Loma Prieta

• M=7.1
• 7.4 M exposed population
• 6,688 p/km² (SF)
• 63 deaths
• Bay Area GDP- $300 B
• 42 Fire Stations

2010 Haiti

• M=7.0
• 10 M in Haiti
• 28,353 p/km² (P-au-P)
• 230,000 deaths
• Haiti GDP- $11 B
• 2 Fire Stations in Haiti
The Coastline Problem

Haiti’s Gross Domestic Product Growth

- J-C Duvalier 1971-1986
- Aristide 1991; ’94-’96; ’01-’04
- Transition 1986-1994

- 2010-2005 coastline
- 2005-1986 coastline
- 1986-1978 coastline

Fouche

Petit Paradis

150 m

50 m
Large-Scale Sedimentation

The positive feedback loop of deforestation and poverty
NEWater

The Process
1. Membrane filtration
2. Reverse osmosis
3. UV treatment

The Need
High population density on a small plot of land

The Future
NEWater currently meets 30 percent of the nation’s water demands. It hopes to bring that number to 55 percent by 2060.
Food
Diverse, Communal and Cheap

- Sentosa
- Boat Quay
- Market food

3 proteins, rice and veggie:
$4 SG = $3.20 US
Waste Biomass to Fuels

Ning Yan
Assistant Professor, Dept. of ChBE
PhD (Chemistry) Peking University, 2009
From Nature to Product

- Lignin transformation: aromatic polymer with many C-O bonds, cut them by Hydrogenolysis
- Glucose to HMF: dehydration reaction using chromium chloride in synthesis
- Oxidize HMF to get FDCA, make bottles from it
Chitin to Chemicals

- Chitin has amine group on carbon 2, otherwise same as cellulose
- Synthesize chitin into oil, natural gas, or coal
- New source for nitrogen-containing products, good alternative to using \( \text{N}_2 \)
- Reduce waste and utilize by low-energy means all at once
Impacts of Biomass Burning

Rajasekhar Bala
Associate Professor, Dept. of CEE
Ph.D. (Atmospheric Chem.), University of Miami, 1991

Regional air pollution caused by airborne particulate matter >

In Southeast Asia, particularly in Sumatra, Indonesia, peat fires affect the soil, the rainfall, the stratosphere, biodiversity, air, solar radiation, etc.
Global Issue for Humans

- Burning of fossil fuels results in ozone destruction, loss of biodiversity, release of aerosols, effects on soil, etc.
- Forest fires do occur naturally, but many of the fires that affect entire ecosystems are caused by humans
- From the haze in Beijing to the peat fires in Sumatra, we all have to help stop environmental destruction
Biopolis

- Multi-discipline research complex
- Publically funded
- Buildings organized by research topics
The Nanos Institute of bioengineering and nanotechnology


“From Biomass to Bio-Chemicals” Biomass sugars to HMF to FDCA to make nylon and polymer
Night Safari