CHG 1125
Chemical Engineering Fundamentals

Chapter 1
The Chemical Engineer

Outline

- Historical perspective
- Definition of chemical engineering
- The chemical engineering program
- A chemical engineering graduate's skills profile
- An overview of possible tasks
- Professionalisms
- Workplace Health & Safety

A historical perspective

- The chemical industry, like others, evolved rapidly over the course of the second **half of the 19th century**. However, different industries developed independently of each other.
- This rapid expansion increased the demand for scientists possessing basic knowledge about **chemical processes**.
- At the start, **industrial chemists** provided this knowledge. They were specialists in a particular production area (sulfuric acid, potash, phenol, etc.).

A historical perspective

- This remarkable evolution in the chemical industries brought forth the following question: *"Would it be possible to formulate, with the use of mathematics and physical principles, a set of general laws for production in chemical industries, analogous to those used in the pure sciences?"* Efforts to answer this question gave birth to a new discipline, **chemical engineering**.
- Slowly, this new discipline was born. In France, the term "process engineer" was employed to describe chemical engineering.

A historical perspective

- The first attempt to systematically organize the basic principles of chemical processes and to define the scope of chemical engineering was made in England by George E. **Davis in 1880**.
- The first course in chemical engineering in the United States was organized by Lewis Norton at MIT in 1888 and the AIChE (American Institute of Chemical Engineers) was founded in 1908.
- Despite being started in England, chemical engineering saw its most rapid growth in the United States.

The Canadian context

- 1720: A course in chemistry is offered at the Séminaire de Québec (the 1st course in Canada).
- 1850-60: Several universities begin offering courses in chemistry (Toronto, Laval, McGill).
- 1874: A course in applied chemistry is offered at McGill.
- 1904: The first course in chemical engineering is offered at the University of Toronto.
- 1914: A chemical engineering course is offered at McGill.
- 1916: The first chemical engineering department in Canada is created at the University of Toronto.

The Canadian context

- 1922: Chemical engineering department at Queen's University.
- 1934: … at the University of Saskatchewan
- 1940: … at l'Université Laval
- 1947: … at McGill University
- 1949: … at the Nova Scotia Technical College
- 1949: … at l'École polytechnique de Montréal
- **1954: … at the University of Ottawa.**
- 1955: There were 8 chemical engineering departments.
- 1961: There were 16 departments.
- **1966: The CSChE (or SCGCh) is founded.**

Chemical Engineering at the University of Ottawa

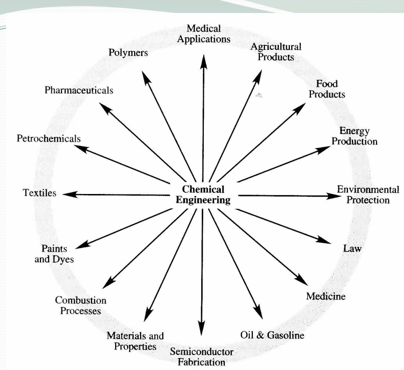
- **The University of Ottawa is founded in 1866.**
- The School of Applied Sciences is created in 1946 and is reorganized in 1953 to form the Faculty of Pure and Applied Sciences.
- The **Department of Chemical Engineering is started in 1954** and Professor Madonna is the first Chair.
- In **1986**, the Faculty of Science and Engineering is split to form two distinct faculties: the Faculty of Science and the **Faculty of Engineering**.
- In 2008, the Department changes its name to "**Department of Chemical and Biological Engineering**" to reflect the emerging role of the biological sciences in the discipline.

Chemical Engineering: a definition

- Chemical, or process engineering, at the crossroads of many disciplines, brings together knowledge and know-how permitting the industrial scale transformation of raw natural or synthetic materials into elaborate products by way of a series of operations.
- The mission of chemical engineering is to design processes, develop industrial scale processes from laboratory experiments, and maintain optimal process conditions.

Chemical Engineering: a definition

- Chemical engineering involves the simultaneous application of principles from physics, chemistry and economics to areas directly related to processes and process equipment, wherein materials undergo **changes in state, energy and composition.**
- Because the chemical engineer often works alongside other engineers, scientists and trades people, he/she should maintain good interpersonal skills, demonstrate leadership and be able to communicate effectively.



Chemical Engineering Achievements

- Semiconductor fabrication
- Medicine (antibiotics, diagnostic devices, artificial organs)
- Environmental protection (catalytic converters, jet engines, scrubbers)
- Crude oil processing (cracking to fuels, plastics, pharmaceuticals)
- Plastics
- Synthetic fibers
- Synthetic rubber
- Gases from air (nitrogen, oxygen)
- Food (fertilizers, pesticides, food processing)
- Separation and use of isotopes (nuclear energy, medicine)

The Chemical Engineering program

- The Bachelor's program in Chemical Engineering has the goal of developing students for **immediate placement in the workforce or to undertake graduate studies**. Graduates of the program can work in chemical and chemical-related industries, in the public sector, in R&D and in engineering consulting.
- The program is **accredited by the Canadian Engineering Accreditation Board** (CEAB) and provides the education component for professional engineering designation (e.g., Professional Engineers Ontario or Ordre des ingénieurs in Québec).

The Chemical Engineering program

- Program objectives:
  - To gain a basic understanding in the fundamental sciences in order to integrate that knowledge for the understanding of chemical engineering phenomena;
  - To understand phenomena linked to the fundamental operations characteristic of chemical engineering equipment and reactor design towards their utilization in industrial settings;
  - To master the design of chemical and chemical-related processes;
  - To acquire good communication skills;

The Chemical Engineering program

- Program objectives (cont.):
  - To integrate physical and biological aspects in a scientific way, into the industrial activities associated with chemical engineering, while respecting the environment;
  - To acquire the manual dexterity necessary to function as a chemical engineer;
  - To reinforce the personal qualities necessary for a fruitful career in chemical engineering;
  - To acquire the qualities of a good manager.

Fundamental Chemical Engineering Topics

- Mass and Energy Balances
- Fluid Mechanics
- Heat Transfer
- Reaction Engineering
- Process Control
- Materials
- Economics

In other words

- We heat and cool
- We mix and separate
- We react and stop reacting

Chemical Engineering – Regular program

1A	1B	2A	2B	3A	3B	4A	4B
CHM 1311 Princ. Chem 3 cr.	CHG 1125 CHG Fund. 3 cr.	CHG 2312 Fluid Flow 3 cr.	CHG 2314 Heat Transfer 3 cr.	CHG 3316 Transp Phen 3 cr.	CHG 3111 Unit Oper. 3 cr.	CHG 4116 CHG Lab 3 cr.	CHG 4300 Thesis Sem. 6 cr.
ENG 1112 Tech. Rep. Wri. 3 cr.	CHM 1321 Org. Chem. I 3 cr.	CHG 2317 Intro CPAD 3 cr.	CHM 2330 Phys. Chem. 3 cr.	CHG 3324 Fun CHG Ther 3 cr.	CHG 3112 Proc SDE 3 cr.	CHG 4343 CAD in CHG 3 cr.	CHG 4307 Clean Proc SD 3 cr.
GNG 1105 Eng. Mech. 3 cr.	MAT 1322 Calculus II 3 cr.	CHM 2120 Org. Chem. II 3 cr.	ECO 1192 Eng Econom 3 cr.	CHG 3331 App MM CHG 3 cr.	CHG 3122 CHG Pract. 3 cr.	CHG 4381 Intro Bio Eng 3 cr.	CHG 4344 Plant Des Pr 6 cr.
GNG 1106 Fun. Eng. Com. 3 cr.	MAT 1341 Intro. Lin. Alg. 3 cr.	MAT 2322 Calculus III 3 cr.	MAT 2377 Prob Stat Eng 3 cr.	CHG 3335 Process Cont 3 cr.	CHG 3127 Chem Re Eng 3 cr.	Techn. Elec II 3 cr.	GNG 4170 Eng. Law 3 cr.
MAT 1320 Calculus I 3 cr.	PHY 1102 Fund. Phy. II 3 cr.	MAT 2384 ODE Num Met 3 cr.	HIS 2129 Tech. Soc Env or PHI 2394 Scien Thougt 3 cr.	CHG 3337 Data Col Intrep 3 cr.	CHG 3326 Prin Ph Reac 3 cr.	Techn. Elec III 3 cr.	
		Comp Stu Elec I 3 cr.	Comp Stu Elec II 3 cr.	Techn. Elec I 3 cr.			
15 cr	15 cr	18 cr	18 cr	18 cr	15 cr	15 cr	18 cr

http://www.engineering.uottawa.ca/en/undergraduate/chemical_engineering/

A graduate’s skills profile

- The chemical engineering graduate will be able to accomplish the following various tasks over the course of his/her career:

1. Control of a chemical process:
   - The group of activities suitable to ensure profitability, efficiency, process safety and product quality while respecting the environment.

A graduate’s skills profile

2. Management
   - The group of activities with a goal to plan, organize, direct and control human, financial, material and technical resources within the framework of the construction, start-up or operation of a chemical or chemical-related factory.
3. Technical support
   - The group of activities aimed at ensuring the correct use of raw materials and services, as well as providing effective day-to-day operation.

A graduate’s skills profile

4. Process design and improvement
   - The group of activities including the design and profitability of a new process and/or the optimization of an existing one, in whole or in part.
5. Quality control of the environment
   - The group of activities including the prevention, diagnosis, measurement and correction of environmental problems of various origins and in various locations.

A graduate’s skills profile

6. Communication
   - The group of attitudes and actions aimed at ensuring the good transmission of information and knowledge in professional work.
7. Research and development
   - The group of activities seeking to enhance knowledge and to develop new processes, equipment and products.

A graduate’s skills profile

8. Sales and marketing
   - The group of activities used for evaluating the needs of a customer, promoting equipment, products, processes and services, while supporting their implications.

An outline of possible tasks

- A chemist in the laboratory of your company discovers that mixing two products at high temperature results in a product of great value. The company wishes to manufacture this product. At this moment, this becomes an engineering problem and actually, a multitude of engineering problems, which can be summarized as a series of design choices.

An outline of possible tasks

1. Reactor:
   - Which type of reactor should be used?
   - A long pipe? A large tank? Several small tanks in series or parallel? Of which dimension?
   - Made of which material? Material able to withstand corrosion? Will the selected material be subject to pressure?
   - Is the reaction endothermic or exothermic? If endothermic, how will we provide the heat necessary to the reaction? Do we use internal or external electric heating? A hot fluid passing through a coil located in the reactor?

An outline of possible tasks

1. Reactor (cont.):
   - Do we need to heat the reagents before feeding them to the reactor? Is there a danger of a loss of control of the reaction, even an explosion? If so, which steps should be taken?
2. Reagents:
   - Where should one get the reagents? Should one buy or manufacture them? If so, which quantity of each one and in which proportion should they be supplied to the reactor?

An outline of possible tasks

3. Product recovery:
   - Can the residual product and reagents be sold directly? Does one have to purify the product by a method of separation? Which method of separation does one have to choose? Distillation? Extraction with solvent? Adsorption? Crystallization?
   - What dimensions will the equipment need to be? Of what material of construction?
   - Heating and/or cooling?
   - Does it require an automatic control device?

An outline of possible tasks

4. Reagent and product transport:
   - How will the reagents be fed to the reactor and how will the product be transported to the reactor's exit?
   - By gravity? With the aid of a pump, compressor, fan, or conveyor belt? Which type? Which dimensions? How much energy will be necessary? Which material of construction?
5. Preliminary experiments:
   - Is the reaction sufficiently well-known? Does one have to make additional tests to evaluate its kinetics? Does one have to build a pilot scale reactor?
   - Do we need to design a set of experiments?

An outline of possible tasks

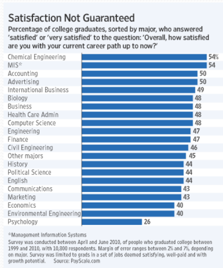
6. Safety measures:
   - What are the safety considerations? Could something function badly?
   - What can one do in the event of problems?
7. Pollution prevention:
   - Is there any waste from the process? In which quantities? What is their impact on the environment?
   - Can one make changes to the process?
   - How can the waste be treated? Does a waste treatment unit need to be built? Can we incinerate the waste?

An outline of possible tasks

8. Control and instrumentation:
   - What level of automatic control will be necessary? What instrumentation will be necessary?
9. Economic survey:
   - To make a complete study of the costs. Costs of purchasing the reagents? Selling price of the product? Construction costs? Operating and labour costs?
   - Should the factory be built?
10. Process operation:
    - Which procedure should be followed for start-up? If something does not function as planned, then what?
    - Which improvements could one make to the process?

What can you expect when you graduate?

- Source: http://www.payscale.com/best-colleges/degrees.asp



Best Undergrad College Degrees By Salary

	Starting Median Pay	Mid-Career Median Pay
Petroleum Engineering	$97,900	$155,000
Chemical Engineering	$64,500	$109,000
Electrical Engineering (EE)	$61,300	$103,000
Materials Science & Engineering	$60,400	$103,000
Aerospace Engineering	$60,700	$102,000
Computer Engineering (CE)	$61,800	$101,000
Physics	$49,800	$101,000
Applied Mathematics	$52,600	$98,600
Computer Science (CS)	$56,600	$97,900
Nuclear Engineering	$65,100	$97,800
Biomedical Engineering (BME)	$53,800	$97,800
Economics	$47,300	$94,700
Mechanical Engineering (ME)	$58,400	$94,500
Statistics	$49,000	$93,800
Industrial Engineering (IE)	$57,400	$93,100
Civil Engineering (CE)	$53,100	$90,200
Mathematics	$47,000	$89,900

CHG's of the future…

- Information proliferation:
  - Too much
  - Easy to acquire
  - Importance of being critical
- Technological development:
  - Key: multi-disciplinarity (CHG's are in good position to deal with this)
- Market globalization:
  - Appreciate other cultures
  - Knowledge of second (third?) languages

CHG's of the future…

- Environment endangered:
  - "The Natural Step" process has 4 guiding principles:
    - Substances extracted from the earth's crust (e.g. oil, fossil fuels) must not systematically accumulate in the ecosphere (i.e. rate of mining must not occur at a pace faster than reintegration of a species into the earth's crust).
    - Substances produced by society must not systematically increase in the ecosphere (i.e. synthetic substances must not be produced at a rate faster than they can be broken down and integrated into natural cycles).

CHG's of the future…

- Environment endangered:
  - "The Natural Step" process has 4 guiding principles:
    - Physical conditions for productivity and assimilation within the ecosystem cannot be systematically diminished (e.g. forests, wetlands, agricultural land, animals cannot be systematically destroyed).
    - Since resources are limited, basic human needs must be met with the most resource-efficient methods available. Industrialized nations cannot use the resources to create luxuries while the basic needs of people in underdeveloped nations are not being met.

CHG's of the future…

- Emerging social responsibility:
  - Threats to public health
  - Depletion of non-renewable natural resources
- Rapid change:
  - Because technology changes so quickly, people need to be trained in a way that facilitates lifelong learning and other skills needed to manage change rather than simply adapt to it.
  - CHG's must learn the fundamental building blocks that can be applied to a broad range of technologies.

The World's Challenges

- Make solar energy economical
- Provide energy from fusion
- Develop carbon sequestration methods
- Manage the nitrogen cycle
- Provide access to clean water
- Restore and improve urban infrastructure
- Advance health informatics
- Engineer better medicines
- Reverse-engineer the brain

The World's Challenges

- Prevent nuclear terror
- Secure cyberspace
- Enhance virtual reality
- Advance personalized learning
- Engineer the tools of scientific discovery

- See also: www.chemicalengineering.org

CHG 1125
Chemical Engineering Fundamentals

Professional Engineering Ethics

What is a profession?

- All professions are occupations, but not all occupations are professions.
- One can take a broad or narrow view of what is a "profession".
- A "self-regulated occupational group capable of legally prohibiting others (including incompetent or unethical members) from practicing" is one definition.

What is a profession?

- Group identified by extensive training and possessing a special uncommon knowledge, mastery of a subject.
- Knowledge used in the service of society.
- Professional association with standards and codes.
- Often self-regulating, via certifications and licensing.
- Involves individual judgment, (some) autonomy in decisions.
- Penalties for substandard performance (accountable to society).

What is a professional engineer?

- Has a bachelor's degree in engineering from an accredited school (CEAB).
- Performs engineering work.
- Is a registered P.Eng.
- Acts in a morally responsible way while practicing engineering.

What is ethics?

- Ethics refers to standards of conduct that indicate how one should behave based on principles (determined by society) of right and wrong.
- For engineers, ethics is often about how we meet the challenge of doing the right thing.
- Ethics are not directly enforced by the law.

What are codes?

- A systematically arranged and comprehensive collection of laws.
- A systematic collection of regulations and rules of procedure or conduct.
- Codes can be directly enforced by the law.

Code of Ethics

- The code of ethics is used as a guide to reach a decision or course of action when an engineer comes across an ethical issue and there are no existing laws or codes that directly address it.

Engineering Code of Ethics

- In fulfillment of their professional duties, engineers shall:
  1. Hold public safety, health and welfare paramount.
  2. Perform services only in areas of their competence.
  3. Issue public statements only in an objective and truthful manner.
  4. Act for each employer or client as faithful agents or trustees.
  5. Avoid deceptive acts.
  6. Conduct themselves honourably, responsibly, ethically, and lawfully so as to enhance the honour, reputation, and usefulness of the profession.

Issues addressed by Engineering Professional Codes

- Responsibility (acknowledging mistakes)
- Conflicts of interest (bribes, kickbacks)
- Environmental concerns (pollution)
- Product liability (safety)
- Quality control (reliability)
- Whistle-blowing

1- Safety, Health, Welfare of Public

- Notify client and appropriate authority of circumstances that endanger life or property.
- Approve only engineering documents that conform with applicable standards.
- Report alleged Code violations to appropriate professional bodies and, when relevant, to public authorities

2- Work Only in Area of Competence

- Undertake assignments only when qualified by specific technical education or experience.
- Do not sign plans or documents when you lack competence or supervisory control.

3- Issue Truthful and Objective Public Statements

- Be objective and truthful in professional reports, statements, or testimony.
- Publicly express technical opinions founded upon facts and competence.

4- Act as Faithful Agent

- Disclose all known or potential conflicts of interest
- Do not accept compensation from more than one party for services pertaining to the same project, without full disclosure and agreement.

5- Avoid Deceptive Acts

- Do not falsify or misrepresent qualifications or pertinent facts pertaining to you or your associates.
- Do not offer, give, solicit or receive, (directly or indirectly) a bribe or "kick-back."
- Avoid any appearance of impropriety.

6- Personal Conduct

- Public behaviour; behaviour when representing engineering profession.
- Personal integrity, honesty…

Ethical Dilemmas

- Situations evolving from conflicts between sets of moral considerations
  - Loyalty to employer, customer, general public
- Due to varying groups with differing interests within the "general public", the concept of public welfare may be vague.
- Guidelines for resolution of these ethical dilemmas come from personally adopting one of several Codes of Ethics.

A recent incident in the news

May 1, 2013 ... a former General Motors Co engineer was sentenced to **one year and one day in prison** and **her husband was sentenced to three years** for **conspiring to steal trade secrets** for use in China, ...

August 29, 2013 ... A former programmer for Motorola Solutions Inc. was sentenced Wednesday **to four years in prison for stealing trade secrets from Motorola**, said the Ministry of Justice. Hanjuan Jin, a naturalized US citizen , born in China, a federal judge said she was " sorry for what happened " and pleaded for a second chance at a barely audible voice and English heavily accented , the Associated Press reported . But US District Judge Ruben Castillo said it is important to send a message that would deter others with access to trade secrets to siphon vital information ... Ms. Jin was secretly working for Sun Kaisens, a Chinese company that developed telecommunications technology for the Chinese army, according to prosecutors . She was arrested by US Customs in Chicago O'Hare International Airport to travel on a one way ticket to China on 28 February 2007. **The representatives seized more than 1,000 Motorola documents found in the possession of Mrs. Jin that she tried to leave the country.**