Introduction to Chemical Engineer Profession
What are Chemical Engineers?

“Chemical engineers” use math, physical sciences (physics, chemistry), life sciences (biology, microbiology and biochemistry), and economics to solve practical problems. The difference between chemical engineers and other types of engineers is that they apply a knowledge of chemistry in addition to other engineering disciplines. Chemical engineers may be called “universal engineers” because their scientific and technical mastery is so extensive.
From Test Tube to Truckload

LABORATORY

Ideas
Long-lasting lipstick
A new AIDS drug
Cleaner rivers
Faster bone repair
Delicious pizza at home
Cleaner air

REAL WORLD

End User

12-hour lipstick at every drugstore
Enough AIDS drugs for Africa
Zero-effluent pulp mills
“Instant Grow Potion” for bones
Pizza factory with special freezing process
Scrubbers that remove chemicals from factory outputs

CHEMICAL ENGINEERING
History of Chemical Engineering

**Before 18\textsuperscript{th} Century:**
Industrial chemicals were mainly produced through *batch processing*.

**Industrial Revolution (1700-1800):**
Industrial production shifted from batch to *continuous processing*. 
History of Chemical Engineering

ChE Principles:

1805 - John Dalton published Atomic Weights, allowing chemical equations to be balanced and the basis for chemical engineering *mass balances*.

1824 - Sadi Carnot was the first to study the *thermodynamics* of combustion reactions.

1850 - Rudolf Clausius applied the principles developed by Carnot to *chemical systems* at the atomic to molecular scale.
History of Chemical Engineering

ChE Principles:

1873 to 1876 - Josiah Willard Gibbs developed a mathematical-based, graphical methodology, for the study of chemical systems using the thermodynamics of Clausius.

1882 - Hermann von Helmholtz showed that measure of chemical affinity is determined by the measure of the free energy of the reaction process.

1883 - Osborne Reynolds defines the dimensionless group for fluid flow, leading to practical scale-up and understanding of flow, heat and mass transfer.
History of Chemical Engineering

ChE Education:

1882 – a course in "Chemical Technology" is offered at University College London.

1885 – a course in "chemical engineering" is offered at Central College (later Imperial College), London.

1888 – a new curriculum at Massachusetts Institute of Technology (MIT) started: Course X, Chemical Engineering.
Course X at MIT: "to meet the needs of students who desire a general training in mechanical engineering, and at the same time to devote a portion of their time to the study of the applications of chemistry to the arts, especially to those engineering problems which relate to the use and manufacture of chemical products."
History of Chemical Engineering

ChE Institutes:

1908 – the American Institute of Chemical Engineers (AIChE) is founded.

1922 – the UK Institution of Chemical Engineers (IChemE) is founded.

1996 – the Thailand Institute of Chemical Engineering and Applied Chemistry (TiChE) is founded.
A Century of ChE Profession

What are the great accomplishments do we come up with?
TOP 10 Chemical Engineering Contribution to Society
TOP 10 Chemical Engineering Contribution to Society

1. FUELING THE WORLD’S ECONOMIES

• The world's economy needs energy to keep it moving.
• Chemical engineers stretch fossil fuels into various energy supplies, e.g. gasoline, diesel, jet oil, etc.
TOP 10 Chemical Engineering Contribution to Society

2. CREATING CLEANER ENERGY

Chemical engineers are creating a new generation of clean energy technologies.

- Nuclear power plant
- NiMH battery
- Alternative energies such as Air, Wind, Water, Solar, etc.
NiMH battery for vehicles
Air for vehicles
Price vs CO₂ emission (France)

- Plug in Hybrid
- Full Hybrid
- Diesel & mild Hybrid
- Hybrid Air
- Gasoline

Price (€) France - wo fiscal incentive

CO₂ (g/km)
TOP 10 Chemical Engineering Contribution to Society

3. PRODUCTS FOR GROWING POPULATIONS

- Water purification
- Water desalination
- GMO foods
- Green productions
Ultrafiltration hollow fiber membrane model 4040B/S
PAN, double-skin hydrophilic, 0.01 micron, 2200 liters/hour
TOP 10 Chemical Engineering Contribution to Society

4. REMOVING HARMFUL SULFUR FROM FUELS

- Catalytic converter for car’s exhausted gas
- Unleaded gasoline $\rightarrow$ gasohol
- Air pollution control
TOP 10 Chemical Engineering Contribution to Society

5. BETTER LIVING THROUGH CHEMISTRY

Chemical engineers have made plastics possible.
TYPICAL AUTO MATERIALS BREAKDOWN

2005 average passenger car materials value

- Iron & Steel: 46%
- Others: 11%
- Glass: 5%
- Fluids and lubricants: 1%
- Textiles: 6%
- Coatings: 5%
- Rubber: 5%
- Thermoplastics: 5%
- Adhesives: 2%
- Magnesium: 12%
- Thermosets: 1%

Total: $6,660 (£4,447)

SOURCES: AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION, AUTOMOTIVE COMPOSITES ALLIANCE

AUTO PLASTICS & COMPOSITES USE

North American average, lbs per vehicle

- Reinforced thermoset
- Reinforced thermoplastic
- Unreinforced thermoplastic and other

<table>
<thead>
<tr>
<th>Year</th>
<th>Reinforced thermoset</th>
<th>Reinforced thermoplastic</th>
<th>Unreinforced thermoplastic and other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>195</td>
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<tr>
<td>2000</td>
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<td>2004</td>
<td>266</td>
<td>266</td>
<td>266</td>
</tr>
<tr>
<td>2010*</td>
<td>286</td>
<td>286</td>
<td>286</td>
</tr>
</tbody>
</table>

SOURCES: AMERICAN COMPOSITES MANUFACTURERS ASSOCIATION; AUTOMOTIVE COMPOSITES ALLIANCE
NOTE: *Estimate

http://www.bmw-security-vehicles.com
TOP 10 Chemical Engineering Contribution to Society

6. STRETCHING NATURAL RESOURCES

Chemical engineers make innovative materials.
- Synthetic rubbers
- Bio-plastics
- Kevlar
- etc.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, 2010
Kevlar Vests

HOW IT WORKS

TRADITIONAL VEST:
Contains 31 layers of Kevlar. When bullet hits, the impact is concentrated on a small area and causes a deep indentation.

Left: A digital image of the future armour

LIQUID ARMOUR:
Contains ten layers of Kevlar with thick fluid between each layer. When bullet hits, the fluid solidifies and absorbs the impact over a wider area.
TOP 10 Chemical Engineering Contribution to Society

7. LARGE SCALE PRODUCTION ENGINEERING

Even if a product was created by a scientist, there is a good chance it was perfected and made practical by chemical engineers.
In 1929, Sir Alexander Fleming discovered a strain of mould that inhibit bacteria *Staphylococcus* growth, called penicillin.
Penicillin

Mass production of drug replaces slow laboratory methods to meet military needs and provide a limited civilian supply.
8. CONVENIENT & ABUNDANT FOOD

When popping your favorite ready-to-eat meal in the microwave, thank chemical engineers!

- Processed food, canned food
- Powder coffee, Powder milk
- Sterilized food
TOP 10 Chemical Engineering Contribution to Society

9. HEALING DISEASES & EXTENDING LIFE

Chemical engineering has advanced medical science, improving the quality of life and saving millions of lives.
Dialysis (Artificial Kidneys)

Line artery to vein pump

Tubing made of a selectively permeable membrane

Line from apparatus to vein

Dialysing solution

Fresh dialysing solution

Used dialysing solution (with urea and excess salts)

www.kidneycaregroup.com
Transdermal Patch

Medicine Reservoir

Outer Covering

Skin

Diffusion of medicine across porous membrane, and into skin

Porous Membrane
10. POWERING THE PERSONAL COMPUTER

The tools chemical engineers use to improve computers may have long-winded names, but their advances make our gadgets all the more powerful.

- Germanium-based silicon chips that help your laptop perform faster.
- From thin-film liquid crystal displays to software that simulates complex industrial processes.
Chemical Engineers in Action

1. Energy
2. Environment
3. Material Sciences
4. Semiconductor Manufacturing
5. Bio-medic
6. Food
Jobs Opportunity for ChE

- Chemicals: 22%
- Fuels: 20%
- Electronics: 4%
- Food & Consumer Products: 9%
- Materials: 4%
- Biotechnology: 9%
- Pulp & Paper: 2%
- Design & Construction: 7%
- Research & Testing: 6%
- Environmental Engineering: 4%
- Business Services: 4%
- Other Industry: 7%
- Public Utilities: 1%
- Aerospace: 1%
### Figure 1: Top-Paying Majors for 2012-13 Bachelor’s Degree Graduates

<table>
<thead>
<tr>
<th>Major</th>
<th>Average Starting Salary</th>
</tr>
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<tbody>
<tr>
<td>Petroleum Engineering</td>
<td>$93,500</td>
</tr>
<tr>
<td>Computer Engineering</td>
<td>$71,700</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>$67,600</td>
</tr>
<tr>
<td>Computer Science</td>
<td>$64,800</td>
</tr>
<tr>
<td>Aerospace/Aeronautical/Astronautical Engineering</td>
<td>$64,400</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>$64,000</td>
</tr>
<tr>
<td>Electrical/Electronics and Communications Engineering</td>
<td>$63,400</td>
</tr>
<tr>
<td>Management Information Systems/Business</td>
<td>$63,100</td>
</tr>
<tr>
<td>Engineering Technology</td>
<td>$62,200</td>
</tr>
<tr>
<td>Finance</td>
<td>$57,400</td>
</tr>
</tbody>
</table>

*Source: April 2013 Salary Survey, National Association of Colleges and Employers*
ChE Salaries Survey (by AIChE in 2013)

• Salaries vary with experience ($67,000 for chemical engineers with fewer than six years of experience to about $140,000 for those with more than 30 years).

• Other factors, including age, gender, education, job function, and industry, were also examined for their impact on chemical engineers’ paychecks.

• The variables having the largest impact on salaries are years of work experience, time with current employer, and time taken off for family reasons.