Outcome Based Education

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a.k.a. DR. JJ

Curriculum Review for the Chemistry-based group
Faculty of Applied Sciences, UiTM, May 20th-22nd 2008

MQF, MQA, MQR

WHAT IS IT?

ALDs, ALOs, PEOs, POs, POs, LOs, PCs, ALDs

Why is it important?

What is the implication?

Why change?
Ain't broken, why fix it?

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Change is like a shark in the ocean. Change never stops, never sleeps: it must always keep moving. The good news is if you hate the way things are, they will change. The bad news is if you love the way things are, they are certain to change as well. The only thing inevitable about life is change, not death. Change is here to stay!

“The ILLITERATE of the 21st century will not be those who can't read or write but those who can't learn, unlearn and relearn” Alvin Toffler
1930’s: Chemistry is the study of the nature, properties, and composition of matter, and how these undergo changes.

Area: physical (physics, chemistry, geology and astronomy) and biological (botany and zoology) sciences,

Transition: New Fields: oceanography, paleobotany, meteorology, pharmacy and biochemistry

NOW: geochemistry, astro-chemistry, physical and analytical chemistry, operational definition: Chemistry is what chemists do!

Plant growth and metabolism, the formation of igneous rocks, the role played by ozone in the atmosphere, the degradation of environmental pollutants, the properties of lunar soil, the medical action of drugs, establishment of forensic evidence
Chemistry is a way of studying matter. What is matter? Matter is hard to define. Matter is anything which has mass and occupies space. But then what are "mass" and "space"? Matter is anything which has real physical existence; in a word, matter is just stuff. Iron, air, wool, gold, milk, aspirin, monkeys, rubber, and pizza - these are all matter. Some things which are not matter are heat, cold, colours, dreams, hopes, ideas, sunlight, beauty, fear, and x-rays. None of these is "stuff"; none is matter.

**Atomic Absorption Spectroscopy**

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**Education results in behavioral change**

The 3 Domains of Educational Goals

Cognitive
The Head

Psychomotor
The Hand

Affective
The Heart

3H
While reading a textbook of chemistry, I came upon the statement, ‘nitric acid acts upon copper’... and I was determined to see what this meant. Having located some nitric acid... I had only to learn what the words ‘act upon’ meant... In the interest of knowledge I was even willing to sacrifice one of the few copper cents then in my possession. I put one of them on the table: opened the bottle marked ‘nitric acid’ poured some of the liquid on the copper; and prepared to make an observation. But what was this wonderful thing which I beheld? The cent was already changed, and it was not a small change either. A greenish blue liquid foamed and fumed over the cent and the table. The air... became colored dark red... How could I stop this? I tried by picking up the cent and throwing it out of the window... I learned another fact; nitric acid... acts upon fingers. The pain led to another unpremeditated experiment. I drew my fingers across my trousers and discovered nitric acid acts upon trousers.... I tell it even now with interest. It was revelation to me. Plainly the only way to learn about such remarkable kinds of action is to see the results, to experiment, to work in the laboratory’. (Adopted from Gutman, 1940).

A quote from Ira Ramsen (1846-1927), who wrote his memories as a child experiencing a chemical phenomenon:
“…The Government of Malaysia is considering new policy directions to make the country an even more competitive player in the world economy. Such a strategy will require bold innovations in many sectors, including the university system whose contribution to greater value-added production should come from the generation and diffusion of relevant knowledge and the production of a critical mass of graduates with appropriate skills. **Malaysia is thus attempting to transform its universities into dynamic and responsive institutions which can hold their place internationally….**”

‘…The international league tables show that the highest ranked universities in the world are the ones that make significant contributions to the advancement of knowledge through research, teach with the most innovative curricula and pedagogical methods under most conducive circumstances, make research an integral component of undergraduate teaching, and **produce graduates who stand out because of their success in intensely competitive arenas during their education and, more importantly, after graduation….**”
“…… ‘a “world-class” education implies achieving a much higher threshold of quality where academic performance and output are measured relative to a league of very select institutions.”

“…Various reforms that can contribute to the transformation of the Malaysian universities into world-class institutions should be considered, including rethinking academic programs, faculty management, pedagogical methods, and student learning.”

“…High quality teaching and innovative methods of delivery, particularly at the undergraduate level, are key components of top level universities. To this end, faculty management reforms should ensure that: (a) the faculty is not overloaded with teaching assignments and there are opportunities to plan and introduce innovative teaching methods;…”
Learning Outcomes

At the end of day 1 workshop, participants will be able to:

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Instructional Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Explain the role of MQF and MQA in promoting and maintaining quality &amp; standards of higher education in Malaysia.</td>
<td>Lecture-discussion</td>
</tr>
<tr>
<td>2. Explain the meaning of outcome and Outcome-Based Education.</td>
<td>Lecture-discussion</td>
</tr>
<tr>
<td>3. Discuss the general and special features of OBE.</td>
<td>Lecture-discussion</td>
</tr>
<tr>
<td>4. Verbally state and visually relate the concepts &amp; terminologies used in OBE.</td>
<td>Independent reading &amp; lecture on concept map</td>
</tr>
<tr>
<td>5. Select and use the appropriate action verbs for the cognitive, psychomotor and affective learning domains.</td>
<td>Lecture-discussion</td>
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<td>6. Discuss &amp; agree on a set of workable Program Educational Objectives (PEO)</td>
<td>Group discussion</td>
</tr>
<tr>
<td>7. Discuss &amp; agree on a set of workable Program outcomes (PO)</td>
<td>Group discussion</td>
</tr>
<tr>
<td>8. Complete the PO-PEO matrix &amp; the PO-PEO-ALO-MOHE Soft Skills matrix.</td>
<td>Group discussion</td>
</tr>
<tr>
<td>9. Rewrite the existing course outcomes in the present course file and hence the syllabus to suit the principles of OBE.</td>
<td>Group discussion</td>
</tr>
<tr>
<td>10. Complete the CO-PO matrix with the designated learning activities and assessment tools.</td>
<td>Group discussion</td>
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Learning Outcomes

At the end of day 2 workshop, participants will be able to:

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Plants are shaped by cultivation and men by education...
We are born weak, we need strength;
we are born totally unprovided, we need aid;
we are born stupid, we need judgment.
Everything we do not have at our birth and which we need when
we are grown is given to us by

EDUCATION.

(Jean Jacques Rousseau, Emile, On Philosophy of Education)
To promote public confidence that the quality of provision and standards of awards in higher education institutions (HEIs) are being safeguarded and enhanced.

Confidence is promoted by:

- Conducting institutional self-review to evaluate
  - The performance of programme outcomes
  - Quality of learning opportunities
  - The institutional capacity and management of standards and quality
- Ensuring intense scrutiny and transparency of the process of institutional self-review through the use of nationally agreed guidelines on criteria and standards, a qualifications framework and procedures for quality assurance
- Reporting and making available objective and independent information on the reviews.
## Quality Assurance involves

The use of evidence
To check that goals are being achieved

The use of evidence
To reshape goals and practices

Bring about improvement

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**MQA Aspects of Standards**

- Vision, mission, and learning outcomes
- Leadership, governance, and administration
- Curriculum design and delivery
- Programmes monitoring and review
- Educational resources
- Academic staff
- Assessment of students
- Student selection and support services
- Total contextual quality improvement

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Functions of MQA

- To implement MQF as a reference point for Malaysian Qualifications
- To develop standards and criteria and all other relevant instruments as national references for the conferment of awards with the cooperation of stakeholders
- To assure quality of HEIs and programmes
- To accredit courses that fulfill the set criteria and standards
- To facilitate the recognition and articulation of qualifications
- To maintain the Malaysian Qualification Register (MQR)

MQA Code of Practice

Good Practices:

...the quality assurance process is built on the following attributes:

- encourages a variety of teaching and learning methods
- ensures the choice of credible student assessment methods appropriate for the teaching and learning methods chosen;
- ensures there are adequate resources to deliver the curriculum;
- is concerned with good outcomes rather than detailed specifications of content
• Point of reference & joint understanding of HE Qualifications in Malaysia
• An instrument that
  • develops and classifies qualifications based on a set of criteria that are approved nationally and benchmarked against international best practices,
  • and which clarifies the earned academic levels, learning outcomes of study areas and credit system based on student academic load (Student Learning Time, SLT).
• These criteria are accepted and used for all qualifications awarded by recognised higher education providers. Hence, MQF integrates with and links all national qualifications.
QUALIFICATION LEVELS & PATHWAYS

- UNIVERSITY
  - DOCTORAL
  - MASTERS
  - B. (HONS) (120C)

- POSTGRAD CERT & DIPLOMA
- GRADUATE CERT & DIPLOMA

- POLYTECH & NON DEGREE GRANTING COLLEGES
  - ADV DIPLOMA (40C)
  - TECH & VOC (90C)
  - DIPLOMA
  - TECH & VOC CERTIFICATE (60C)

- SCHOOL CERT
- MIN HUMAN RESOURCE
  - ADV DIPLOMA
  - SKILLS DIPLOMA
  - SKILLS CERT

- MQF

- LIFE LONG LEARNING
- HIGHER SCHOOL CERT; FOUNDATION MATRICULATION

Malaysian Qualifications Register (MQR)

- Registers all accredited qualifications and programmes.
- The reference point for credit transfer between programmes and qualifications that are accredited.
I. What policy does the institution have to ensure that its education expertise and methodologies are appropriate for the delivery of the curriculum?

ii. Does institution have access to an expert education unit or other educational expertise and how are they used?
What is OBE??
Aligning the Vision
The Outcomes
The Content
The Learning Activities
The Assessment

The result or consequence of a performance (in terms of success and failure).
the way a thing turns out; a consequence

- The outcomes of the meeting between CUEPACS & the Prime Minister were...
- After 3-4 years of formal & and non-formal education at FSG, students must be able to...
- This workshop will produce....
• Learning Outcomes are **statements that explain what students should know, understand and can do upon the completion of a period of study.**
• Learning outcomes are **references for standard and quality** as well as for the development of curriculum in terms of teaching and learning, determination of credits and the assessment of students.
• Learning outcomes are linked to the credit system which **gives value to all student learning time** and are not based on the contact hours between lecturers and students.

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**What is a Program/Course/Lesson Outcome??**

A statement of what students will be able to do when they have completed the program/course/lesson and it involves graduate’s skills and knowledge that arise from the educational activities of the program/course/lesson which lead to the achievement of the Program Objectives

An outcome has three major components:

➢ A description of what the students will be able to do
➢ The conditions under which the students will perform the task.
➢ The criteria for evaluating students’ performance.
At the end of this activity, you will be able to write at least 5 attributes of your graduates for the program you are developing.
Outcome Based Education

OBE is a method of curriculum design and teaching that focuses on what students can actually do after they are taught. OBE addresses the key questions as:

- Why do you want them to learn it? – Vision, Mission, PEOs, POs
- What do you want the students to learn? – course structure, syllabus
- How can you best help students learn it? – Learning Activities
- How will you know what they have learnt? - Assessment

Towers (1996) listed four points to the OBE system that are necessary to make it work:

a) What the student is to learn must be clearly identified.
b) The student’s progress is based on demonstrated achievement.
c) Multiple instructional and assessment strategies need to be available to meet the needs of each student.
d) Adequate time and assistance need to be provided so that each student can reach the maximum potential.
Outcome Based Education

**What is OBE?**

OBE’s instructional planning process is a reverse of that associated with traditional educational planning.

The desired outcome is selected first and the curriculum, instructional materials and assessments are created to support the intended outcome (Spady 1988; 1993).

All curriculum and teaching decisions are made based on how best to facilitate the desired final outcome.

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**Why OBE?**

OBE is able to measure—‘what the students are capable of doing’

Choosing an answer from 5 options in a multiple-choice question do not allow students to demonstrate what they have learnt. Ideally, students should have an understanding of the content, which is a cognitive skill that goes much deeper than finding the correct answer. OBE requires the students to understand the contents by “extending the meaning of competence far beyond that of narrow skills and the ability to execute structured tasks in a particular subject area and classroom” (Spady, 1995).
Outcome Based Education

OBE goes beyond ‘structured tasks’ (e.g. memorization)

OBE demands that students demonstrate his/her skills through more challenging tasks like writing project proposals and completing the projects, analyzing case studies and giving case presentations etc. Such exercises require students to practice and demonstrate their ability to think, question, research, make decisions and give presentations.

OBE involves students in a complete course of learning, developing their skills in designing to completing a whole process (Spady, 1994a, 1995).

OBE also identifies higher levels of thinking (e.g. creativity, ability to analyze and synthesize information, ability to plan and organize tasks). Such skills are emphasized especially when students are assigned to organize and work as a community or entrepreneurial service teams to propose solutions to problems and market their solutions.
1. Clarity of focus about outcomes
   - Always have the significant, culminating exit outcomes as the focus.
   - Let the students know what they are aiming for.

2. Designing backwards
   - Design curriculum backward by using the major outcomes as the focus and linking all planning, teaching and assessment decisions directly to these outcomes.

3. Consistent, high expectations of success
   - Set the expectation that OBE is for ALL learners.
   - Expect students to succeed by providing them encouragement to engage deeply with the issues they are learning and to achieve the high challenging standard set (Spady, 1994b).

4. Expanded opportunity
   - Develop curriculum to give scope to every learner to learn in his/her own pace.
   - Cater for individual needs and differences, for example, expansion of available time and resources so that all students succeed in reaching the exit outcomes.
Why OBE??

MQA Aspects of Standards

- Vision, mission, and learning outcomes
- Curriculum design and delivery
- Assessment of students
- Programme monitoring and review

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1. Individually, list out 10 attributes of graduates of CHEM/BSAC/ENV
2. Discuss with your neighbour and justify your choices.
3. Agree on 5 of the most important attributes.
4. List out 3 measurable products for each attribute.
5. Discuss with your neighbor and justify your choices.
6. Agree on 2 of the most important products for each of the attributes.

The objective of Malaysian Higher Education system is to produce professionals as demanded by the nation for human resources.

One purpose of higher education is to graduate students who will become productive citizens. Skills employers consistently seek from university graduates:

- Scientific (problem-solving) skills
- Communication skills
- Decision-making skills which enable students to become leaders
- Well developed analytical skills
- Teamwork skills
- Well-practiced leadership skills.
- Good interpersonal skills
## MOHE’s Attributes of Human Capital with First-Class Mentality*

### Knowledge Attributes:
- Mastery of core subjects and ability to apply that knowledge
- Mastery of Bahasa Malaysia and English, and at least one other global language.
- A continuing passion for knowledge through lifelong learning.
- Excellent general knowledge and interest in current events.
- Appreciation of the arts, culture, and sports.
- Sound analytical and problem-solving skills.
- Awareness of business and management principles, and technology.

### Personal Attributes:
- Goal-oriented: proactive, self-starting, self-disciplined, confident, resilient, motivated, and fiercely competitive.
- Intellectually engaging: creative, innovative, and possessing critical thinking skills.
- Quick learner, adaptable, and flexible.
- Entrepreneurial.
- Ethically and morally upright.
- Spiritually grounded.
- Compassionate and caring (through volunteerism and social services).

### Interpersonal Attributes:
- Able communicator and effective presenter.
- Able to relate and be comfortable with people at all levels.
- Able to develop and leverage on personal and professional networks to achieve goals.
- Natural leader.
- Team player.

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### MOHE’s Learning Outcomes

Academic Learning Domains (ALDs)

1. Knowledge (K)
2. Practical Skills (P)
3. Social skills and responsibility (A)
4. Values, attitudes and professionalism (A)
5. Communication, leadership and team skills (P/A)
6. Problem solving and scientific skills (K/P)
7. Information management and lifelong learning skills(P/A)
8. Managerial and entrepreneurial skills (K/P/A)
1. Communication skills (P)
2. Critical thinking and problem solving (P)
3. Lifelong learning and information management (A)
4. Group working skills (A)
5. Entrepreneurship skills (P)
6. Ethics and professionalism (A)
7. Leadership skills (A)
A Bachelor's degree prepares students for general employment, entry into postgraduate programme and research as well as highly skilled careers. It enables the individuals to pair responsibilities, which require great autonomy in professional decision-making. The bachelor's degree is conferred on individuals who are able to:

(i) demonstrate knowledge and comprehension on fundamental principles of a field of study, acquired from advanced textbooks;
(ii) use the knowledge and comprehension through methods that indicate professionalism in employment;
(iii) argue and solve problems in their field of study;
(iv) show techniques and capabilities to search and use data to make decisions having considered social, scientific and relevant ethical issues;
(v) communicate effectively and convey information, ideas, problems and solutions to experts and non-experts;
(vi) apply team and interpersonal skills which are suitable to employment; and
(vii) posses independent study skills to continue further study with a high degree of autonomy.
UiTM’s VISION (2006)
To establish UiTM as a premiere university of outstanding scholarship and academic excellence capable of providing leadership to Bumiputera’s dynamic involvement in all professional fields of world-class standards in order to produce globally

UiTM’s PHILOSOPHY (2006)
A believe that every individual has the ability to attain excellence through the transfer of knowledge and the assimilation of moral values so as to become professional graduates capable of developing knowledge, self, society and the nation.
UiTM’s MISSION (2006)
➢ To enhance the knowledge and expertise of Bumiputera’s in all fields of study through professional programmes, research work and community service based on moral values and professional ethics

FSG’s VISION
➢ To Become The Premier Institution In Science And Technology Through Quality Teaching, Research, And Service.

FSG’s MISSION
➢ Contributing to the country’s growth & sustainability through teaching & learning by:
   ➢ Developing student’s potential via the most effective instructional strategies & producing graduates who are knowledgeable, creative, innovative, competitive, skillful in science & thinking skills and having personal & moral attributes coherent with the social, religious, societal and professional needs.
Domains of Learning

Cognitive Skills (psychomotor)

Affective (attitudes, feelings...)

Cognitive Domain
(thinking, knowledge)

**INVOLVES KNOWLEDGE AND THE DEVELOPMENT OF INTELLECTUAL SKILLS**

**Knowledge**
- **Definition:** Remembers previously learned material.
- **Sample Verbs:** define, identify, list, recall, state.

**Comprehension**
- **Definition:** Understands the meaning of material as a whole.
- **Sample Verbs:** describe, discuss, explain, evaluate, paraphrase, give examples, translate.

**Application**
- **Definition:** Uses learning in real and concrete situations.
- **Sample Verbs:** apply, carry out, demonstrate, evaluate, prepare, solve, test.

**Analysis**
- **Definition:** Understands both the content and structure of material.
- **Sample Verbs:** analyze, categorize, compare, contrast, discriminate, generalize, justify, propose.

**Synthesis**
- **Definition:** Formulates new ideas from existing knowledge and skills.
- **Sample Verbs:** combine, construct, design, develop, generate, plan, propose.

**Evaluation**
- **Definition:** Judges the value of material or a given product.
- **Sample Verbs:** assess, evaluate, interpret, justify, select, support.

Based on “Taxonomy of Educational Objectives”, B.S. Bloom Editor: 1956
Psychomotor Domain
(design, skills)

**Higher order**

**Guided Response**

**Definition:** Inductive and creative skills, often in abstract areas.

**Sample Verbs:**
- adapt
- invent
- discover
- formulate
- evaluate
- analyze
- synthesize
- interpret
- transform

**Lower order**

**Perception**

**Definition:** Sensory awareness of physical activity.

**Sample Verbs:**
- detect
- hear
- see
- smell
- taste
- visualize

**Organization**

**Definition:** Creates new patterns for specific situations.

**Sample Verbs:**
- design
- originate
- formulate
- compose
- construct

**Psychomotor Domain Includes Physical Movement, Coordination & Use of the Motor Skill Areas**

Affective Domain
(Feeling, attitudes)

**Higher order**

**Valuing**

**Definition:** Attitude value or worth to something.

**Sample Verbs:**
- accept
- evaluate
- criticize
- cooperate
- tolerate
- care
- share
- concern
- express
- value

**Lower order**

**Receiving**

**Definition:** Sensory awareness of physical activity.

**Sample Verbs:**
- accept
- evaluate
- criticize
- cooperate
- tolerate
- care
- share
- concern
- express
- value

**Things Emotionally (e.g. Feelings, Interests, Attitudes, Appreciation, Enthusiasms, Motivations) - That Might Result from Instruction**

Based on “Taxonomy of Educational Objectives”, B.S. Bloom, Editor, 1956
Format: Lecture/Tutorial/Lab: CHM 470

Presently: On completion of this course, students should be able to:

1. **Understand** the definition, calculation and factors affecting rates of reaction.
2. **Determine** the order and mechanism of reactions.
3. **Understand** the characteristics of endothermic and exothermic reactions, energy profile of reactions and calculations involving heats of reactions and activation energy.
4. **Understand** the concept and use of phase rule in one and two component systems.
Presently: On completion of this course, students should be able to:

5. **Understand** the types of colloid, preparation and methods of stabilising colloids and uses of a few commercial colloids.

6. **Understand** the concept of chemical equilibrium and use of Le Chatelier’s Principles and calculations involving ionic equilibrium, salt hydrolysis and buffer.

7. **Understand** the concept of adsorption and factors causing surface tension.

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Format: Lecture/Tutorial/Lab: **CHM 470**

Presently: On completion of this course, students should be able to:

1. **Understand** the three laws of thermodynamics concerning enthalpy, entropy and absolute entropy.

2. **Use** the concept of thermodynamics in reversible and non reversible processes, isothermal and adiabatic processes.

3. **Understand** entropy concept in ideal gas system, liquid, solid and changing phase systems.
Outcome Based Education

Format: Lecture/Tutorial/Lab: **CHM 520**
Presently: On completion of this course, students should be able to:

4. **Understand** basic principles of electrochemistry such as ionic activity, electrolytic conductivity, electrochemical cells, calculation of EMF of cells, electrochemical concept in battery and fuel cells.
5. **Understand** the concept of radiochemistry such as atomic nucleus, radioactive decay, nucleus reaction and methods used to detect radiation and protection against radiation.
6. **Understand** nuclear reactor systems and usage of radioactive materials.

Format: Lecture/Tutorial/Lab: **CMT 510**
Presently: On completion of this course, students should be able to:

1. **Understand and apply** the latest techniques in gas and liquid chromatography for separation of mixtures of compounds.
2. **Understand and apply** the new separation techniques such as supercritical fluid chromatography
3. **Understand** the concept and the use of electrophoresis as a technique of separation
Format: Lecture/Tutorial/Lab: CMT 580
Presently: On completion of this course, students should be able to:

1. **Have knowledge and understanding** of a range of analytical techniques both molecular and atomic.
2. **A quantitative understanding** of analytical instrumentation.
3. **Learned about and had practical experience** with selected analytical instrumentation available in the faculty.
4. Apply the relevant principles to practical laboratory experiments.
5. **Perform data analysis and obtain** useful physical properties for a given set of data.
6. **Write up scientific** results in a formal report using scientific language.
7. Collaborate, motivate and truthful to
Course Outcomes: Upon completion of this course, students will be able to:

1. **State, write and explain** the concepts, laws and theories in electrostatics, electricity, magnetism, introductory atomic physics and modern physics. (C-Knowledge) (PO1)

2. **Verbally, visually (pictures & graphs) and algebraically relate and discuss** the concepts, laws and theories in electrostatics, electricity, magnetism, introductory atomic physics and modern physics. (C-Comprehension) (PO1, PO6)

3. **Verify, assess & employ** the concepts, laws and theories in electrostatics, electricity, magnetism, light, introductory atomic physics and modern physics to solve qualitative & quantitative problems visually, algebraically and occasionally, numerically. (C-Application) (PO1)

4. **Analyze, summarize and discuss** solution to real world problems associated with electrostatics, electricity, magnetism, introductory atomic physics and modern physics. (for 3rd year course only) (PO1, 6, 8)

5. **Observe, plan, conduct and justify** scientific investigations in areas of electrostatics, electricity. (PO3, 5, 6,7)

6. **Communicate to peers verbally** and to the facilitator in writing, the science investigations and justification in areas of electrostatics, electricity and magnetism.

7. **Collaborate, motivate and truthful** with team members and with facilitators in both the labs and in the classroom. (PO5, 8)
Outcome Based Education

DAY 2: Curriculum Design

Course structure
Notional Credits

Course Content a.k.a. syllabus

Delivery methods a.k.a. Learning Strategies

Assessment Tools & Evaluation

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Modern Chemistry

2000 years of chemistry in 14 weeks

Rethinking OUTCOMES & NOT CONTENT

Adopt "Less is More"

Rethinking learning strategies via outcomes

Student-centred outcome-based education

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MQF – Bachelors degree (Hons.)

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(ii) use the knowledge and comprehension through methods that indicate professionalism in employment;
(iii) argue and solve problems in their field of study;
(iv) show techniques and capabilities to search and use data to make decisions having considered social, scientific and relevant ethical issues;
(v) communicate effectively and convey information, ideas, problems and solutions to experts and non-experts;
(vi) apply team and interpersonal skills which are suitable to employment; and
(vii) possess independent study skills to continue further study with a high degree of autonomy.
**MQF Framework for Degree level-Outcomes**

**Knowledge & Comprehension**
- systematic and coherent body of complex knowledge, some of it at the boundaries of an academic discipline
- major studies in which significant literature is available. Course content is taken to a significant depth and progressively developed to a high level which provides a basis for postgraduate study and professional careers.

**Intellectual Skills**
- analytical techniques and problem solving skills that can be applied in many types of employment, including in a professional

**Psychomotor Skills**
- Practical skills relevant to the discipline

**Generic Skills**
- communicate effectively.
- interpersonal and team skills appropriate for employment
- prepared to undertake research, comprehend and evaluate new information and concepts from a range of sources, weigh evidence, arguments and assumptions, to reach sound judgments,
- have developed a foundation for self-directed and life long learning
- exercise of personal substantial responsibility and decision-making in complex and unpredictable circumstances.
- Observation of professional ethics
MQF Framework for Diploma level- Outcomes

Diploma level education balances theory and practice or practical, and stresses on the instillation of values, ethics and attitudes to enable students to:

(i) use knowledge, comprehension and practical skills at work;
(ii) assess and decide, taking into account social, scientific and ethical issues with moderate autonomy;
(iii) be confident and entrepreneurial in pursuing their own careers;
(iv) be responsible members of society;
(v) possess study skills in adapting to ideas, processes and new procedures for career development;
(vi) acquire team and interpersonal skills that are appropriate to employment; and
(vii) communicate effectively and to transmit information, ideas, problems and resolutions cogently to experts and non-experts.

Knowledge & Comprehension
• breadth, depth and complexity of knowledge for complex skills (degree of emphasis on breadth as against depth of knowledge may vary between qualifications granted at this level)

Intellectual Skills
• substantial degree of judgment for problem solving

Psychomotor Skills
• perform a broad range of complex technical operations

Generic Skills
• Communication & participation in teams
• Exercise responsibility and substantial autonomy for own continuing learning Some exercise of personal responsibility
• work related attitudes and ethics shown in exercise of responsibility and substantial autonomy for own output in work and responsibility for the work of others
Outcome Based Education

**MQF Framework for University Preparatory Level-Outcomes**

**Foundation or University Preparatory Course**

Foundation Courses or University Preparatory Courses such as *Sijil Tinggi Persekolahan Malaysia (STPM)*, Matriculation and Foundation Certificates are not in the MQF as they are the entry qualifications to universities. Nonetheless, MQF determines standards for these certificates to ensure comparability and standardisation of student abilities. Generally, these are conferred on students who are able to:

(i) show knowledge and comprehension in the field of study that is continued from secondary school as indicated in advanced textbooks;
(ii) use knowledge and comprehension to identify and use data in respond to concrete and complex problems;
(iii) communicate and clarify understanding and skills to peers and supervisors; and
(iv) demonstrate skills for purposes of pursuing higher education.

---

**MQF Framework for Preparatory Level-Outcomes**

**Knowledge & Comprehension**
- basic concepts of the relevant academic disciplines that enable students to enter Arts or Science based university courses

**Intellectual Skills**
- skills of the different approaches to solving problems

**Psychomotor Skills**
- basic laboratory skills, project work, group work and field activities.

**Generic Skills**
- communicate accurately, effective use of ICT
- Some exercise of personal responsibility
Coles (2003) argues that:
A curriculum is more than a list of topics to be covered by an educational programme, for which the more commonly accepted word is a ‘syllabus’. A curriculum is:

- first of all a policy statement about a piece of education, and
- secondly an indication as to the ways in which that policy is to be realised through a programme of action.

In practice, a working definition of a curriculum is

- the sum of all the activities, experiences and learning opportunities for which an institution (such as the Society) or a teacher (such as a faculty member) takes responsibility – either deliberately or by default. This includes in such a broad concept of curriculum the formal and the informal, the overt and the covert, the recognised and the overlooked, the intentional and the unintentional.
Designing Curriculum: curriculum is an academic plan. It is a total blueprint for actions where:

- the objectives (PEOs), outcome (POs) of the curriculum are clarified;
- the processes to achieve these are identified; (course structure & syllabus (content) & instructional strategies)
- the ways to measure whether success has been achieved (assessment); and
- systematic review and adjustment are also part of the plan (evaluation & CQI).

Science programmes must focus on presentations, discussions and practical work that enable students to demonstrate understanding of theory, skills in analysis, ability to speak, write, plan and manage as well as teamwork and leadership.

Industrial training is a must for Applied Science programmes.
Outcome Based Education

Course outcomes

DOMAINS

Cognitive
- Evaluation
- Synthesis
- Analysis
- Application
- Comprehension
- Knowledge

Affective
- Exhibit, display, demonstrate
- organisation
- Valuing
- Responding
- Receiving

Psychomotor / skills
- Naturalisation
- Articulation
- Precision
- Manipulation
- Imitation

Higher order

lower order

Depth (according to year of study in BSc program)
Refers to the levels in the cognitive domain, practical skills & scientific skills.

Cognitive
- Analysis
- Application
- Comprehension
- Knowledge

Year 1

Year 2

Year 3

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**Outcome Based Education**

**What is Curriculum**

**I do & I remember**

Depth (according to year of study in BSc program)
Refers to the levels in the cognitive domain, practical skills & scientific skills.

- **Report**
- **Data**
- **Interpret**
- **Experiment**
- **Manipulate**
- **Procedures**
- **Hypothesize**
- **Observe**
- **Problem**

Year 1
- Sample Prep Techniques
- Physical
- Organic
- Inorganic
- General Chem

Year 2
- Year 3

**Curriculum considers...**

**Breadth (core, non-core, electives)**
Breadth relates to range. This can be defined simply in terms of the different subjects or areas of learning within a programme, but increasingly its definition includes students experiencing a range of:

- teaching and learning styles
- levels of learning and assessment
- assessment types
- learning contexts
- wider activities.
Balance
Balance relates to the relationship between the component parts of the programme. It can be defined simply as the relative proportions of time (notional credit hour) allocated to those components (subjects or areas of learning). It can also be seen as the complementary or contrasting nature of components.
Determining Credit Hours for a course: SLT & Notional Credit

Credit and Academic Load

19. Credit is the quantitative measure that represents the volume of learning or academic load to attain the set learning outcomes.¹

20. Academic load is a quantitative measure of all learning activities required to achieve a defined set of learning outcomes. These activities include lecture, tutorial, seminar, practical, self-study, retrieval of information, research, fieldwork, as well as preparing for and sitting of an examination. In Malaysia, 40 hours of notional student learning time is valued as one credit.²

Credit system based on Student Learning Time (SLT)

- SLT - The number of learning hours spent by student for each learning activities need to be identified i.e learning load – basis of determining the credit for a course
- Credit is the quantitative measure that represents the learning load in order to attain the set of outcomes.
- 1 credit = 40 hrs of Student Learning Time
- Standard Lecture
- New approach
Different writers ascribe different meanings to lifelong education and lifelong learning. One such meaning is:

"The single crucial element in the notion of lifelong education is to be found in the word 'lifelong': it embraces a set of guidelines for developing educational practice ('education') in order to foster learning throughout life ('lifelong'). Lifelong education thus defines a set of organisational, administrative, methodological and procedural measures which accept the importance of promoting lifelong learning."

(Knapper and Cropley, 2000, p.9)

In essence, the basic idea behind the term 'lifelong learning' is that deliberate, focused learning does and should occur throughout a person's lifetime.
What would a lifelong learner look like? Deep learners rather than surface learners...

Consider the following criteria adapted from Knapper and Cropley Lifelong learners:

- Plan their own learning
- Assess their own learning
- Are active rather than passive learners
- Learn in both formal and informal settings
- Learn from their peers, teachers, mentors etc.
- Integrate knowledge from different subject areas when required
- Use different learning strategies for different situations.

Achieved through doing research

Formalise the process of planning learning goals collaboratively—if students can participate in developing their own learning they are more likely to feel internally committed to it. Internal commitment to learning is a hallmark of lifelong learning.

It's not what & how much students learn but **HOW**

<table>
<thead>
<tr>
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<th>Teaching for Lifelong Learning</th>
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### Lifelong Learning Criteria

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<tbody>
<tr>
<td>Students plan their own learning (cont..)</td>
<td>Use formative assessment (i.e. ongoing feedback)—this allows students to experience the learning benefits of assessment. They can uncover errors or deficits and use this knowledge to direct their learning. Develop focussed internships—these can give students concrete real world learning goals that they will need to respond to with their own initiative.</td>
</tr>
<tr>
<td>Students assess their own learning</td>
<td>Use self-assessment and peer assessment—students learn to take control of the crucial first step in learning; finding out what it is they do not know. Peer and self assessment assumes assessment is a skill that is vital for students to learn if they are to monitor their learning in</td>
</tr>
</tbody>
</table>
### It's not what & how much students learn but **HOW**

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<tr>
<td>Learning in informal settings</td>
<td>Use learning and teaching strategies that start with the students’ present understandings—learning how to learn in informal settings first requires students to value the knowledge they have acquired informally.</td>
</tr>
</tbody>
</table>

### Lifelong Learning Criteria | Teaching for Lifelong Learning
--- | ---
Active Learning | Use a research oriented curriculum—where students are seeking knowledge rather than being passive receivers. They learn how to acquire and filter information.  
Peer Learning | Use peer assessment and group learning—this helps students to learn from each other and also develops explicit peer learning skills.
Problem-Based-Learning is the prime example here, because it usually takes ‘messy’ real-world problems that almost invariably take the student across discipline boundaries. Students integrate knowledge from different disciplines using strategies that stress the learning process at least as much as learning content—here students are explicitly instructed in how to learn. This can incorporate teaching attitudes and skills, and then assessing them.

“I hear & I forget, I see I remember I do and I understand” - Confucious

Active Learning (After the lab & simulation)-Lecture-Discussion

This activity addresses CO1, CO2, CO3 & CO4

Lesson Outcomes: Upon completion of this activity, you will be able to:

1. State & explain the gravitational forces acting on any object.
2. Mathematically represent the gravitational force and describe its impact on physical events.
3. Describe existence of electrical charges in matter and its quantization property.
4. Sketch and explain the charging by induction and charging by contact
5. State & mathematically represent forces acting between electrical charges (Coulomb’s Law)
6. Represent forces acting between charges both pictorially and vectorially.
7. Compare & contrast the similarities and difference of the gravitational field and electric field.
1. Draw the electric force diagram exerted by one point charge onto another and describe the motion of charges in the presence of another point charge.
2. Describe how the strength of the force changes when the distance between the charges is varied.
3. Describe and produce a model for the electrical force in terms of the strength and direction that are acting between point charges.
4. Describe and draw the electric field patterns created by a point charge.
5. Produce a relationship between the electric field produced by a point charge and the force it exerts on a test charge.
6. Produce a model for electrical potential produced by point charges and a charged plate.
7. Describe and obtain the relationship between electrical force, electrical field and electrical potential or voltage.

"I hear & I forget, I see I remember I do and I understand" - Confucious

This activity addresses CO5 & CO6

Pre Lab activity:
- Read on the electrical force and electrical field
- Download the vector and electric field simulation form my website

Lesson Outcomes: Upon completion of this activity, you will be able to:
1. Draw the electric force diagram exerted by one point charge onto another and describe the motion of charges in the presence of another point charge.
2. Describe how the strength of the force changes when the distance between the charges is varied.
3. Describe and produce a model for the electrical force in terms of the strength and direction that are acting between point charges.
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7. Describe and obtain the relationship between electrical force, electrical field and electrical potential or voltage.
“I hear & I forget, I see I remember I do and I understand” - Confucious

This activity addresses CO5 & CO6

Pre Lab activity:
- Read on the black body radiation and the photoelectric effect
- Download the photoelectric effect simulation from my website
- List out the 4 observed results in photoelectric effect experiment.

Lesson Outcomes: Upon completion of this activity, you will be able to:

1. Propose 3 research questions you want to investigate
2. Make some predictions in your investigation.
3. Operationally define the variables involved.
4. Sketch & label the devices used in the experiment.
5. Outline the procedure to conduct the investigation/experiment.
6. Explain the purpose of each of the apparatus used.
7. Conduct a virtual experiment to test your predictions.
8. Communicate and justify orally your findings to your peers.

Lesson Outcomes: Upon completion of this activity, you will be able to:

1. Propose 3 research questions you want to investigate
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8. Communicate and justify orally your findings to your peers.
The 3 Domains of Educational Goals

Cognitive
The Head

Psychomotor
The Hand

Affective
The Heart

Course outcomes

DOMAINS

Cognitive
Evaluation
Synthesis
Analysis
Application
Comprehension
Knowledge

Affective
Exhibit, display, demonstrate
organisation
Valuing
Responding
Receiving

Psychomotor / skills
Naturalisation
Articulation
Precision
Manipulation
Imitation
INVOLVES KNOWLEDGE AND THE DEVELOPMENT OF INTELLECTUAL SKILLS

Cognitive Domain
(thinking, knowledge)

lower order

Comprehension
Definition: Understands the meaning of material (higher level of understanding).
Sample Verbs:
- describe
- discuss
- explain
- locate
- paraphrase
- give examples
- translate

Knowledge
Definition: Recounts previously learned material.
Sample Verbs:
- define
- identify
- label
- list
- matches
- name
- state

Sample Verbs:
- apply
- carry out
- demonstrate
- illustrate
- prepare
- apply
- infer

Level 2 – Comprehension
The ability to grasp the meaning of material. This may be shown by translating material from one form to another, by interpreting material (explaining or summarising), and by estimating future trends (predicting consequences or effects). These learning outcomes go one step beyond the simple remembering of material, and represent the lowest level of understanding.

Analysis
Definition: Breaks down the meaning of material (lower level of understanding).
Sample Verbs:
- apply
- carry out
- demonstrate
- illustrate
- prepare
- apply
- infer

Level 1 – Knowledge
The remembering of previously learned material. This may involve the recall of a wide range of material, from specific facts to complete theories, but all that is required is the bringing to mind of the appropriate information. Knowledge represents the lowest level of learning outcomes in the cognitive domain.

Conversion, defends, distinguishes, estimates, explains, extends, generalises, gives examples, infers, paraphrases, predicts, rewrites, summarises.

Eg.
- Describe three main features of...
- Explain the 3 main components of a learning outcome.
- Summarise the main causes of the American war in Iraq.

Bloom’s Taxonomy

Categories in the Cognitive Domain
(Taxonomy of Educational Objectives, Bloom, 1956)

<table>
<thead>
<tr>
<th>Level 1 – Knowledge</th>
<th>Level 2 – Comprehension</th>
</tr>
</thead>
<tbody>
<tr>
<td>The remembering of previously learned material. This may involve the recall of a wide range of material, from specific facts to complete theories, but all that is required is the bringing to mind of the appropriate information. Knowledge represents the lowest level of learning outcomes in the cognitive domain.</td>
<td>The ability to grasp the meaning of material. This may be shown by translating material from one form to another, by interpreting material (explaining or summarising), and by estimating future trends (predicting consequences or effects). These learning outcomes go one step beyond the simple remembering of material, and represent the lowest level of understanding.</td>
</tr>
</tbody>
</table>

 Defines, describes, identifies, labels, lists, matches, names, outlines, reproduces, selects, states.

Eg.
- List the six levels in the cognitive domain of Bloom's taxonomy.
- Define...
- State the main principles of Theory X.

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### Bloom's Taxonomy

<table>
<thead>
<tr>
<th>Level 3 – Application</th>
<th>Changes, computes, demonstrates, discovers, manipulates, modifies, operates, predicts, prepares, produces, relates, shows, solves, uses.</th>
</tr>
</thead>
</table>
| **The ability to use learned material in new and concrete situations. This may include the application of such things as rules, methods, concepts, principles, laws and theories.** Learning outcomes in this area require a higher level of understanding than those under 'Comprehension'. | **E.g.:**
*Construct measurable learning outcomes that include lower and higher order cognitive skills for a one-semester course.* |

<table>
<thead>
<tr>
<th>Level 4 – Analysis</th>
<th>Breaks down, differentiates, discriminates, distinguishes, identifies, illustrates, infers, outlines, points out, relates, selects, separates, subdivides</th>
</tr>
</thead>
</table>
| **The ability to break down material into its component parts so that its organisational structure may be understood. This may include the identification of the parts, analysis of the relationships between parts, and recognition of the organisational principles involved. Learning outcomes here represent a higher intellectual level than ‘Comprehension’ and ‘Application’ because they require an understanding of both the content and the structural form of the material.** | **E.g.:**
*Analyse authentic data from various sources and prepare...* |

<table>
<thead>
<tr>
<th>Level 5 – Synthesis</th>
<th>Categorises, combines, compiles, composes, creates, devises, designs, explains, generates, modifies, organises, plans, rearranges, revises, rewrites, summarises, tells, writes.</th>
</tr>
</thead>
</table>
| **The ability to put parts together to form a new whole. This may involve the production of a unique communication (theme or speech), a plan of operations (research proposal), or a set of abstract relations (scheme for classifying information). Learning outcomes in this area stress creative behaviours, with major emphasis on the formulation of new patterns or structures.** | **E.g.:**
*Analyse authentic data from various sources and prepare a recommendation report for a specified audience.* |

<table>
<thead>
<tr>
<th>Level 6 – Evaluation</th>
<th>Appraises, compares, concludes, contrasts, criticises, describes, discriminates, explains, justifies, interprets, relates, summarises, supports.</th>
</tr>
</thead>
</table>
| **The ability to judge the value of material. The judgements are to be based on definite criteria. These may be internal criteria (organisational) or external criteria (relevance to the purpose) and the student may determine the criteria or be given them. Learning outcomes in this area are highest in the cognitive hierarchy because they contain elements of all the other categories, plus conscious value judgements based on clearly defined criteria.** | **E.g.:**
*Evaluate the strengths and weaknesses of the cognitive domain of Bloom's taxonomy in relation to the National Educational Philosophy.* |
**Psychomotor Domain**

*Higher order*

**Guided Response**

**Definition:**
Indicates and coordinates skills, often in alternate situations.

**Sample Verbs:**
- obey
- duplicate
- manipulate with guidance
- operate under supervision
- operate
- write

**Perception**

**Definition:**
Senses that guide motor activity.

**Sample Verbs:**
- detect
- hear
- taste
- touch
- write

**Mechanism**

**Definition:**
A process that occurs automatically.

**Sample Verbs:**
- act
- observe
- manipulate
- create
- restore
- maintain

**Set**

**Definition:**
To mentally, emotionally, and physically get ready to act.

**Sample Verbs:**
- achieve a posture
- assume a body stance
- establish a body position
- place hands, arms, or legs
- position the body
- sit
- stand
- station

**Adaptation**

**Definition:**
Adapts skill sets to meet a problem situation.

**Sample Verbs:**
- adapt
- organize
- change

**Organization**

**Definition:**
Creatures new patterns for specific situations.

**Sample Verbs:**
- design
- originate
- coordinate
- compose
- construct

**Affective Domain**

*Higher order*

**Valuing**

**Definition:**
Attaches value or worth to something.

**Sample Verbs:**
- adapt
- assume responsibility
- behave according to principles
- consent
- create
- exhibit loyalty
- express
- involve
- profit
- seek

**Receiving**

**Definition:**
Successfully attends to stimuli.

**Sample Verbs:**
- accept
- evaluate
- listen
- respond
- pay attention
- tolerate

**Responding**

**Definition:**
Responds to stimuli.

**Sample Verbs:**
- agree
- debate
- question
- communicate
- think
- understand
- cooperate
- balance
- participate
- contribute
- discuss
- evaluate

**Things Emotionally (e.g. Feelings, Interests, Attitudes, Appreciation, Enthusiasms, Motivations) - That Might Result from Instruction**

Based on "Taxonomy of Educational Objectives", B.S. Bloom Editor, 1956

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Creating a course to achieve specified outcomes requires effort in three domains:

- planning (identifying course content and defining measurable learning outcomes for it)
- Instruction (selecting and implementing the methods that will be used to deliver the specified content and facilitate student achievement of the outcomes)
- assessment and evaluation (selecting and implementing the methods that will be used to determine whether and how well the outcomes have been achieved and interpreting the results)
Thermodynamics Lecture Series

Assoc. Prof. Dr. J.J.

First Law of Thermodynamics & Energy Balance – Control Mass, Open System

Faculty of Applied Sciences
Universiti Teknologi MARA

email: drjlanita@hotmail.com
http://www2.uitm.edu.my/drjj/index.html

Course outcome for Thermodynamics: (address PO1)

➢ Write energy balance representing the first law of thermodynamics and use it in both closed and open systems.

Lesson outcomes: Upon completion of this unit, students will be able to:

1. **State** the conservation of energy principle and name all the forms of energy entering & leaving a system and energy changes within the system.

2. **Discuss** the energy exchange process and write mathematical expressions representing the **energy balance** in units of kJ, for a general system undergoing any process.

3. **Rewrite** the energy balance in the **unit-mass basis** and **unit-time basis** (or **rate-form basis**) for a general system undergoing any process.
Quotes

"One who learns by finding out has sevenfold the skill of the one who learned by being told."
- Arthur Gutterman

"The roots of education are bitter, but the fruit is sweet." - Aristotle

Energy Conservation

In any process, the total energy must always remain the same. Hence the total energy entering a system must equal the total energy leaving the system.

- Forms of dynamic energies include heat (thermal energy in motion), work done (electrical, shaft, boundary) and mass flow.
- Forms of energy changes within a system include its internal energy, its kinetic energy and potential energy.
Energy Transfer - Heat Transfer

Oven
Nasi Lemak 20°C
200°C
25°C

What happens to the properties of the system after the energy transfer?

Example: A steam power cycle.

The net work output is

\[ W_{\text{net, out}} = W_{\text{out}} - W_{\text{in}}, \text{kW} \]
Energy Transfer – Work Done

**Mechanical work:**
Piston moves up
Boundary work is done by system

**Electrical work is done on system**

No heat transfer  
$T$ increases after some time

**$W_{e,in} = Vi\Delta t/100$, kJ**

**$W_e = Vi$**

**$W_{p,m,in},kJ$**

**Control volume**

**$W_{sh}$**

*FIGURE 4-46*
Pipe or duct flow may involve more than one form of work at the same time.
First Law – Energy Transfer

System’s initial total energy is
\[ E_1 = U_1 + KE_1 + PE_1 \]
or
\[ e_1 = u_1 + ke_1 + pe_1 \text{, kJ/kg} \]

System in thermal equilibrium

Can it change? How? Why?

Movable boundary position gone up

E_1 = U_1 + KE_1 + PE_1

System expands

A change has taken place.
First Law – Energy Transfer

A change has taken place

System’s final energy is $E_2 = U_2 + KE_2 + PE_2$

Movable boundary position gone up

System expands

Initial

System, $E_1$

Final

Initial

System, $E_1$

Final

How to relate changes to the cause

Properties will change indicating change of state

Heat as a cause (agent) of change

$Q_{in}$, $kW$

$q_{in}$, or $Q_{in}$

$q_{out}$, or $Q_{out}$

$Q_{out}$, $kW$
First Law – Energy Transfer

How to relate changes to the cause

Properties will change indicating change of state

System

\[ E_1, P_1, T_1, V_1 \]

To

\[ E_2, P_2, T_2, V_2 \]

Work as a cause (agent) of change

\[ W_{in}, kW \]

\[ W_{out}, kW \]

\[ \omega_{in}, kJ/kg \]

\[ \omega_{out}, kJ/kg \]

\[ W_{in}, kWm \]

\[ \omega \]

\[ (m \ \vartheta)_{out}, kW \]

\[ (m \ \vartheta)_{in}, kW \]

\[ (\vartheta)_{in}, kJ/kg \]

\[ (\vartheta)_{out}, kJ/kg \]

Mass transfer as a cause (agent) of change

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First Law – Energy Transfer

How to relate changes to the cause

Properties will change indicating change of state

System
E₁, P₁, T₁, V₁
To
E₂, P₂, T₂, V₂

Mass in
W_in
W_out

Mass out

Q_in
Q_out

Dynamic Energies as causes (agents) of change

First Law – Interaction Energies

Energy Balance – The Agent

Eₐᵢₙ = Qₐᵢₙ + Wᵢₙ + E_mass,ₐᵢₙ, kJ

eₐᵢₙ = qₐᵢₙ + ωₐᵢₙ + θₐᵢₙ, kJ/kg

Eᵢₙ = Qᵢₙ + Wᵢₙ + E_mass,ᵢₙ ; kW

For Closed system: E_mass,ᵢₙ = 0, kJ, θᵢₙ = 0, kJ/kg

E_mass,ᵢₙ = 0, kW

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First Law - Interaction Energies

Energy Balance – The Agent

\[ E_{\text{out}} = Q_{\text{out}} + W_{\text{out}} + E_{\text{mass,out}}, \text{kJ} \]

\[ e_{\text{out}} = q_{\text{out}} + w_{\text{out}} + \theta_{\text{out}}, \text{kJ/kg} \]

\[ E_{\text{in}} = Q_{\text{out}} + W_{\text{out}} + E_{\text{mass,out}}; \text{kW} \]

For Closed system: \[ E_{\text{mass,out}} = 0, \text{kJ} \]

\[ \dot{E}_{\text{mass,out}} = 0, \text{kW} \]

First Law - System’s Energy

Energy Balance – The Change Within

Energy change within the system, \( \Delta E_{\text{sys}} = E_2 - E_1 \)

is the sum of

- Internal energy change, \( \Delta U = U_2 - U_1 \)
- kinetic energy change, \( \Delta KE = KE_2 - KE_1 \)
- potential energy change, \( \Delta PE = PE_2 - PE_1 \)
First Law – Energy Change

Energy Balance – The Change Within

\[ \Delta E_{sys} = \Delta U + \Delta KE + \Delta PE, \text{ kJ} \]

\[ \Delta e_{sys} = \Delta u + \Delta ke + \Delta pe, \text{ kJ/kg} \]

\[ \Delta \dot{E}_{sys} = \Delta \dot{U} + \Delta \dot{KE} + \Delta \dot{PE}, \text{ kW} \]

For Stationary system: \( \Delta KE = \Delta PE = 0, \text{ kJ} \)

\[ \Delta ke = \Delta pe = 0, \text{ kJ/kg} \]

\[ \Delta \dot{KE} = \Delta \dot{PE} = 0 \]

First Law – General Energy Balance

Energy Balance – General system

\[ \dot{Q}_{in} + \dot{W}_{in} + \dot{E}_{\text{mass,in}} - \dot{Q}_{out} - \dot{W}_{out} - \dot{E}_{\text{mass,out}} = \Delta U + \Delta KE + \Delta PE, \text{ kJ} \]

\[ q_{in} + \omega_{in} + \theta_{in} - q_{out} - \omega_{out} - \theta_{out} = \Delta u + \Delta ke + \Delta pe, \text{ kJ/kg} \]

\[ \dot{Q}_{in} + \dot{W}_{in} + \dot{E}_{\text{mass,in}} - \dot{Q}_{out} - \dot{W}_{out} - \dot{E}_{\text{mass,out}} = \Delta \dot{U} + \Delta \dot{KE} + \Delta \dot{PE}, \text{ kW} \]
First Law – Stationary System

Energy Balance – Stationary system

\[ Q_{in} - Q_{out} + W_{in} - W_{out} + E_{mass,in} - E_{mass,out} = \Delta U + 0 + 0 \]

\[ q_{in} - q_{out} + \omega_{in} - \omega_{out} + \theta_{in} - \theta_{out} = \Delta u + 0 + 0, \text{ kJ/kg} \]

\[ \dot{Q}_{in} - \dot{Q}_{out} + \dot{W}_{in} - \dot{W}_{out} + \dot{E}_{mass,in} - \dot{E}_{mass,out} = \Delta \dot{U} + 0 + 0 \]

First Law – Closed System

Energy Balance – Closed system

\[ Q_{in} - Q_{out} + W_{in} - W_{out} + 0 - 0 = \Delta U + \Delta KE + \Delta PE, \text{ kJ} \]

\[ q_{in} - q_{out} + \omega_{in} - \omega_{out} + 0 - 0 = \Delta u + \Delta ke + \Delta pe, \text{ kJ/kg} \]

\[ \dot{Q}_{in} - \dot{Q}_{out} + \dot{W}_{in} - \dot{W}_{out} + 0 - 0 = \Delta \dot{U} + \Delta KE + \Delta PE, \text{ kW} \]