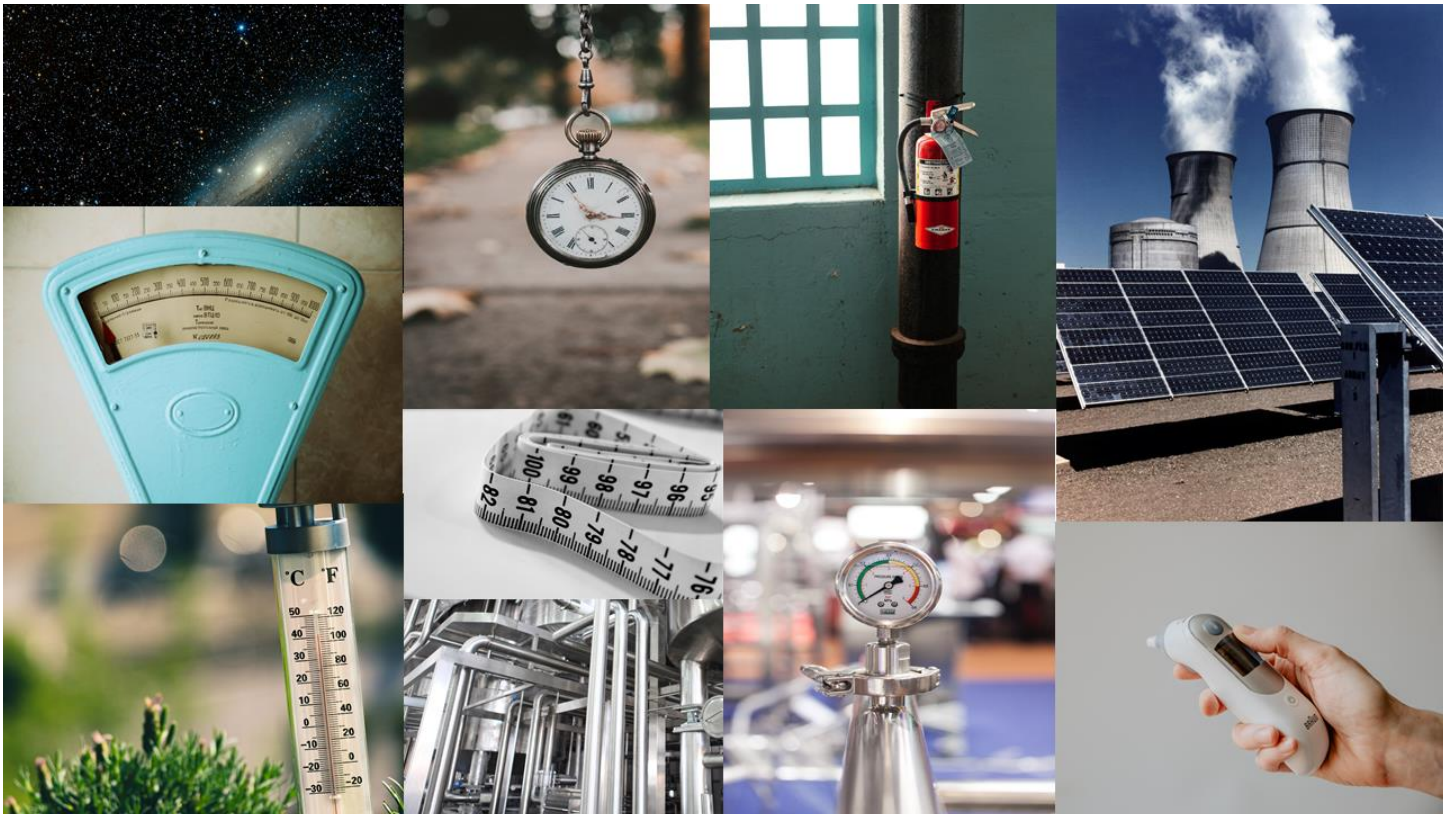
QM Aligned Course Design Template

Course Name: ENGI2430-Engeening Thermodynamics

Module 01: Introduction and Overview



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Module Overview / Introduction (ST. 1-8)

Thermodynamics study the effects of work, heat and energy on a system by using macroscopic observations. It is both, a branch of physics and an engineering science. For these reasons it is a very important discipline for engineers and scientists in general. Thermodynamics deal only with the macroscopic response of a system which we can observe and measure in experiments.

Nowadays, the scope of Thermodynamics is largely to deal with energy and its relationship with the properties of matter. Engineers are generally interested in studying systems and how they interact with their surroundings. To achieve this, engineers extend the subject of thermodynamics to the study of systems through which matter flows.

Engineers seek to achieve improved designs and better performance, as measured by factors such as an increase in the output of some desired product, a reduced input of a scarce resource, a reduction in total costs, or a lesser environmental impact. The principles of engineering thermodynamics play an important part in achieving these goals.

Module Learning Objectives (ST. 2 & 8)

Upon completion of this module, you will be able to:

1. Summarize the fundamental aspects that Thermodynamics deal with.

2. Identify the beginnings of Thermodynamics as a science.

3. Indicate the laws of Thermodynamics.

Instructional Materials (ST. 4 & 8)

Lesson 1: Basic of Thermodynamics

Scientists are normally interested in gaining a fundamental understanding of the physical and chemical behavior of fixed quantities of matter at rest and uses the principles of thermodynamics to relate the properties of matter with energy.

The word thermodynamics arises from the Greek words therme (heat) and dynamis (force). Although various aspects of what is now known as thermodynamics have been of interest since antiquity, the formal study of thermodynamics began in the early nineteenth century through consideration of the locomotive power of heat: the capacity of hot bodies to produce work (see Fig. 1.1).

Figure 1.1 Power of heat: the capacity of hot bodies to produce work in a locomotive. Source: Image of free use in https://unsplash.com

Subtheme 1.1: What studies thermodynamics?

Thermodynamics, the study of the transformations of energy, enables us to discuss all these matters quantitatively and to make useful predictions. Fire is an example about energy transformation (see Fig.1.2).

Figure 1.2 Fire is an example of transformation of energy, combustion reaction releases energy as heat. Source: Image of free use in https://unsplash.com

The release of energy can be used to provide heat when a fuel burns in a furnace, to produce mechanical work when a fuel burns in an engine, and to generate electrical work when a chemical reaction pumps electrons through a circuit. The batteries in electric cars convert the useful energy of a chemical reaction into work (Fig. 1.3).

Figure 1.3 Electric car is an example about how a chemical reaction pumps electrons through a circuit in order to impulse the vehicle. Source: Image of free use in https://unsplash.com

In chemistry, we encounter reactions that can be harnessed to provide heat and work, reactions that liberate energy, which is squandered but which give products we require, and reactions that constitute the processes of life.

Engineers use principles drawn from thermodynamics and other engineering sciences, such as fluid mechanics, heat and mass transfer, to analyze and design systems intended to meet human needs. The realm of application of these principles is very wide. However, here is a list of a few areas where engineering thermodynamics is important:

- ✓ **Automobile engines**: The chemical energy of the fuel is converted into heat energy by combustion, and part of this heat energy is converted into mechanical energy by the engine (internal combustion engines).

- ✓ **Turbines, compressors and pumps**: A pump is a machine that moves a fluid (either liquid or gas) from one place to another. A compressor is a machine that squeezes a gas into a smaller volume and (often) pumps it somewhere else at the same time. The turbine absorbs energy from a fluid stream and converts it to work.

- ✓ **Fossil- and nuclear-fueled power stations**: Nuclear reactor produces heat from radioactive metals, and a fossil-fuel plant burns coal, oil or natural gas.

- ✓ **Propulsion systems for aircraft and rockets**: An aircraft propulsion system comprises an engine and a propeller or a propulsive nozzle which converts motion from an engine and generates thrust. The propulsion of a rocket includes the tanks pumps, propellants, power head, and rocket nozzle.

- ✓ **Combustion systems**: Combustion systems convert essentially all the fuel into dioxide carbon, water and heat whereas gasification systems only partially oxidize the fuel, creating intermediates, such as monoxide carbon, hydrogen and hydrocarbons.

- ✓ **Cryogenic systems, gas separation, and liquefaction**: Cryogenic air separation process to produce gaseous pure oxygen and nitrogen with internal compression and the production of liquid oxygen, liquid nitrogen and liquid argon. Liquefaction is accomplished by cooling gases below the critical temperature with subsequent condensation as a result of the removal of the heat of vaporization (condensation).

- ✓ **Heating, ventilating, and air-conditioning systems**: The main purposes of a Heating, Ventilation and Air-Conditioning system are to help maintain good indoor air quality through adequate ventilation with filtration and provide thermal comfort.

- ✓ **Vapor compression and absorption refrigeration**: The vapor absorption refrigeration system comprises of all the processes in the vapor compression refrigeration system like compression, condensation, expansion and evaporation. In the vapor absorption system, the refrigerant used is ammonia, water or lithium bromide.

- ✓ **Heat pumps**: A heat pump is a device that transfers heat energy from a source of heat to what is called a thermal reservoir. Heat pumps move thermal energy in the opposite direction of spontaneous heat transfer, by absorbing heat from a cold space and releasing it to a warmer one.
- ✓ **Cooling of electronic equipment**: Heat sinks are devices that are used to extend the surface area of electronic components available for air cooling, helping to lower the components case temperature. Fans are used to increase the air flow.
- ✓ **Alternative energy systems**: An alternative energy system can be used to supply some or all of your electricity needs, using technologies such as solar, electric or wind systems.
- ✓ **Fuel cells**: A fuel cell is an electrochemical cell that converts the chemical energy of a fuel (often hydrogen) and an oxidizing agent (often oxygen) into electricity through a pair of redox reactions.
- ✓ **Thermoelectric and thermionic devices**: Any devices that convert heat directly into electricity using thermionic emission.
- ✓ **Magnetohydrodynamic (MHD) converters**: A magnetohydrodynamic converter (MHD converter) is an electromagnetic machine with no moving parts involving kinetics of electrically conductive fluids (liquid or ionized gas) in the presence of electromagnetic fields.
- ✓ **Solar-activated heating, cooling, and power generation**: Solar heating and cooling technologies collect the thermal energy from the sun and use this heat to provide hot water, space heating, cooling and pool heating for residential, commercial and industrial applications.
- ✓ **Geothermal systems**: Geothermal heating systems function with Earth's natural heat resources.
- ✓ **Ocean thermal, wave, and tidal power generation**: Wave power devices extract energy directly from the surface motion of ocean waves or from pressure fluctuations below the surface.
- ✓ **Wind power**: Wind power or wind energy is the use of wind to provide the mechanical power through wind turbines to turn electric generators and traditionally to do other work.
- ✓ **Biomedical applications**: Cells are open complex thermodynamic systems. Energy transformations, thermo-electro-chemical processes and transports occur across the cell's membranes.
- ✓ **Life-support systems**: a life-support system is a group of devices that allow a human being to survive in non-life conditions as the space.
- ✓ **Artificial organs**: An artificial organ is a human made organ device or tissue that is implanted or integrated into a human.

Subtheme 1.2: Beginnings of the Thermodynamics

The history of thermodynamics is fuzzy, and this brief introduction course necessarily omits mentioning many interesting discoveries and the scholars who made them. Its origin can be traced back to the times of the Greek civilization.

An Aeolipile ("the ball of Aeolus", Aeolus being the Greek god of the air and wind), also known as a Hero's engine (Fig. 1.4), is a simple, bladeless radial steam turbine which spins when the central water container is heated.

Torque is produced by steam jets exiting the turbine, much like a tip jet or rocket engine. It is the first recorded steam engine or reaction steam turbine. In the 1st century AD, Hero of Alexandria described the device and many sources give him the credit for its invention.

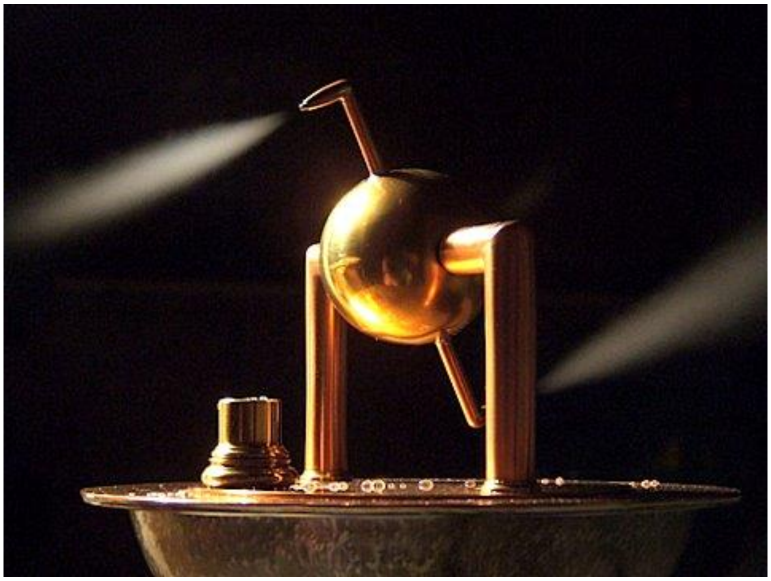

Figure 1.4 An Aeolipile, "the ball of Aeolus" is the first recorded steam engine or reaction steam turbine. Source: https://modelengines.info/aeolipile/

Modern Thermodynamics was born in the 19th century as scientists were first discovering how to build and operate steam engines. The name "thermodynamics" arrived on 1854, when the British mathematician and physicist William Thomson (Lord Kelvin) coined the term thermo-dynamics in his paper On the Dynamical Theory of Heat.

The Industrial Revolution, and especially the development of the steam engine (Fig. 1.5), were responsible for the evolution of the science of thermodynamics. It began as a pragmatic effort to examine the efficiency of steam engines in converting heat to useful work.

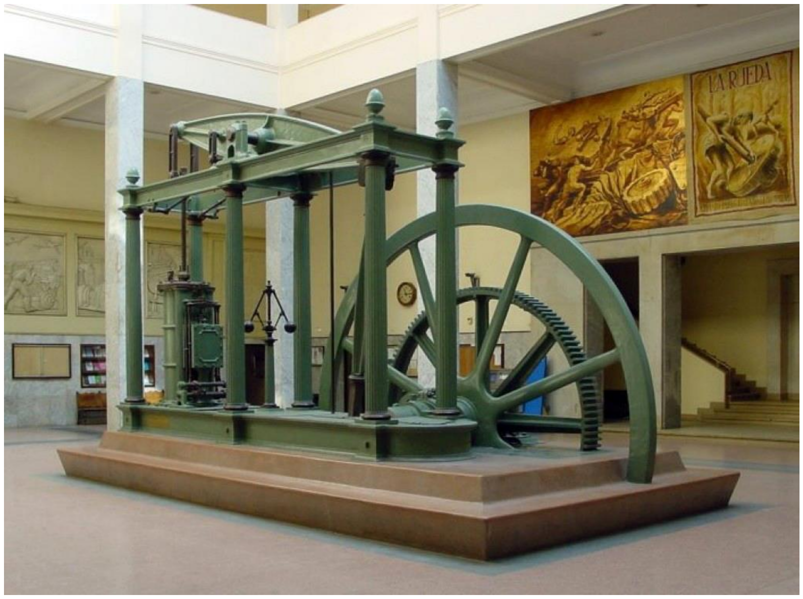

Figure 1.5 A Watt steam engine, the steam engine that propelled the Industrial Revolution in Britain and the world. Source: https://en.wikipedia.org/wiki/History_of_thermodynamics

In 1824, the French military engineer Sadi Carnot (1796−1832) wrote a highly important treatise: "*Reflections on the motive power of fire and on the machines to develop this power*". Carnot was prompted to write his book out of a desire to improve the efficiency of steam engines (Fig. 1.6).

Figure 1.6 Nicolas Léonard Sadi Carnot (1796 -1832) published the first successful theory of the maximum efficiency of heat engines. Source: https://en.wikipedia.org/wiki/Nicolas_L%C3%A9onard_Sadi_Carnot

Subtheme 1.3: Thermodynamics laws

There are three principal laws of thermodynamics. Each law leads to the definition of thermodynamic properties which help us understand and predict the operation of a physical system. We will present some simple examples of these laws and properties for a variety of physical systems, many of the classical examples of thermodynamics involve gases.

The zeroth law of thermodynamics involves some simple definitions of thermodynamic equilibrium. It leads to the macroscopic definition of temperature.

The first law of thermodynamics relates the various forms of energy in a system to the work which a system can perform and the heat it can transfer. This law is sometimes taken as the definition of internal energy, and introduces an additional state variable, enthalpy.

The first law of thermodynamics allows for many possible states of a system to exist. But experience indicates that only certain states occur. For instance, light bulbs transform electrical energy into light energy, and gas stoves transform chemical energy from natural gas into heat energy.

This leads to the second law of thermodynamics and the definition of another quantity called entropy. The second law stipulates that the total entropy of a system plus its environment cannot decrease; it can remain constant for a reversible process but must always increase for an irreversible process. All types of vehicles that we use, cars, motorcycles, trucks, ships, airplanes, and many other types work based on the second law of thermodynamics and Carnot Cycle.

The third law of thermodynamics states that the entropy of a system approaches a constant value as the temperature approaches absolute zero. The entropy of a system at absolute zero is typically zero, and in all cases is determined only by the number of different ground states it has. Specifically, the entropy of a pure crystalline substance (perfect order) at absolute zero temperature is zero. This statement holds true if the perfect crystal has only one state with minimum energy.

Conclusion (Closing statement paragraph)

We have introduced some of the fundamental ideas used in the study of thermodynamics. The principles of thermodynamics are applied by engineers to analyze and design a wide variety of devices intended to meet human needs.

Although thermodynamics developed rapidly during the 19th century in response to the need to optimize the performance of steam engines, the sweeping generality of the laws of thermodynamics makes them applicable to all physical and biological systems. In particular, the laws of thermodynamics give a complete description of all changes in the energy state of any system and its ability to perform useful work.

NOTE1: Up to 4 Lessons with no more than 4 Subthemes each lesson.
NOTE2: ST4.3 All resources and materials used in the module are appropriately cited.

Learning Activities and Learner Interactions

Activity 1.1 (ST. 3, 5, 6 & 8) Please read Notes 3-4 for more information about the activities

Objective:

This activity has the purpose of helping students summarize the fundamental aspects that thermodynamics deal with, identify the beginnings of thermodynamics as a science and indicate the laws of thermodynamics.

Student Instructions

Discuss your research in your Discussion Board for this Module titled "Impact of the thermodynamics in the technological development":

- ✓ You are expected to post at least 2 comments.
- ✓ You can participate any time during the week the material is posted. Be polite, professional, and respectful when writing your message to this forum; and, if you have an attachment, you can upload in the "Attachments" option in the Discussion Board.
- ✓ Your answer must be short, concise and well documented. Strong, direct connections are made to readings and/or other course materials (lectures, media, resources, etc.) and are clearly stated.
- ✓ Your answers must use the terminology discussed in material.

Please, check the course calendar for a due date for this activity. (**100 pts**.) Use the Rules for Online Discussion Board.

Assignment: Impact of the thermodynamics in the technological development

1.1.1 Conduct a research on the Greek artefact called "Aeolipile" and discuss the possible uses that the discovery of Hero in its age might have given it. Reason how history would have changed if this discovery had been applied.

1.1.2 Describe the important role of the steam engine in Industrial Revolution and the contribution of the thermodynamics in this event.

***NOTE[3]**: Please indicate the type of assessment to be used (Test, Quiz, Assignment) If you choose the Test or Quiz option, please indicate the type of question;(Calculated Formula, Calculated Numeric, Either/Or, Essay, File Response, Fill in Multiple Blanks, Hot Spot, Jumbled Sentence, Matching, Multiple Answer, Multiple Choice, Opinion Scale/Likert, Ordering, Quiz Bowl, Short Answer or True/False.) Please refer to the Assessment Instructor Guide for more details. Assignment option has the Safe Assign tool recommended to prevent plagiarism.*
***NOTE[4]**: Please indicate the tool to be used to promote student interaction: (Blog, Discussion Board, Journal, Wiki, Group or Blackboard Collaborate), point values, time frames and set the display dates.*

References (ST. 4 & 8)

NOTE: *All resources and materials referenced through the module are appropriately cited.*

Required Resources:

Michael J. Moran, Howard N. Shapiro, Fundamental of Engineering Thermodynamics, 5th Edition, John Wiley & Sons, 2006. England

Peter Atkins, Julio de Paula, Physical Chemistry, 8th Edition, Oxford University Press, 2006. Great Britain

Additional Resources:

Image of an Aeolipile (Hero's engine). Retrieved from ModelEngines.info, https://modelengines.info/aeolipile/.

Image of a Watt steam engine. Retrieved from Wikipedia, https://en.wikipedia.org/wiki/History_of_thermodynamics

Picture of Nicolas Léonard Sadi Carnot. Retrieved from Wikipedia, https://en.wikipedia.org/wiki/Nicolas_L%C3%A9onard_Sadi_Carnot