Al-Mustaqbal University
Department of Biomedical Engineering
Third Stage / 2nd Course
"Thermodynamics"
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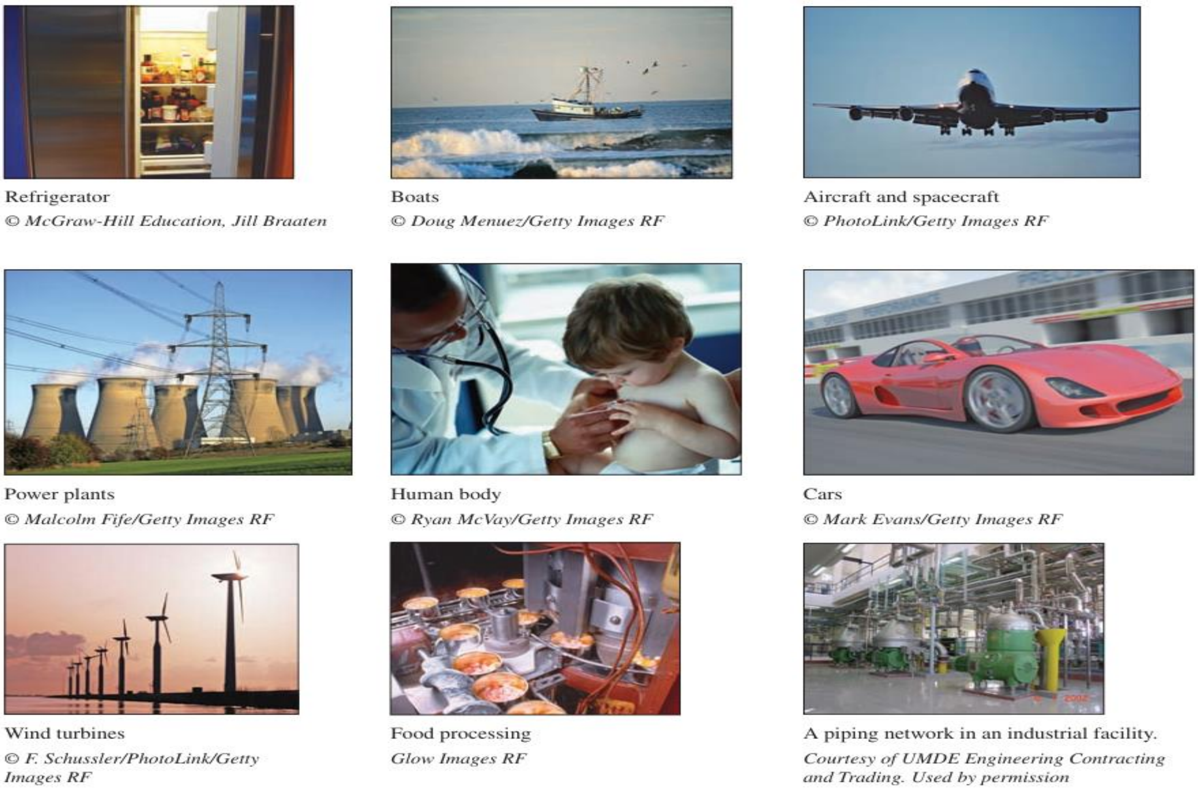
Lecture 1
"A Review of Thermodynamic Concepts"

Thermodynamics & Energy

- **Thermodynamics** can be defined as the science of energy. Although everybody has a feeling of what energy is, it is difficult to give a precise definition for it.
- **Energy** can be viewed as the ability to cause changes.
- The name thermodynamics stems from the Greek words *therme (heat)* and *dynamics (power),* which is most descriptive of the early efforts to convert heat into power. Today the same name is broadly interpreted to include all aspects of energy and energy transformations including power generation, refrigeration, and relationships among the properties of matter.
- One of the most fundamental laws of nature is the **conservation of energy principle**. It simply states that during an interaction, energy can change from one form to another but the total amount of energy remains constant. That is, **energy cannot be created or destroyed.**



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A piping network in an industrial facility.
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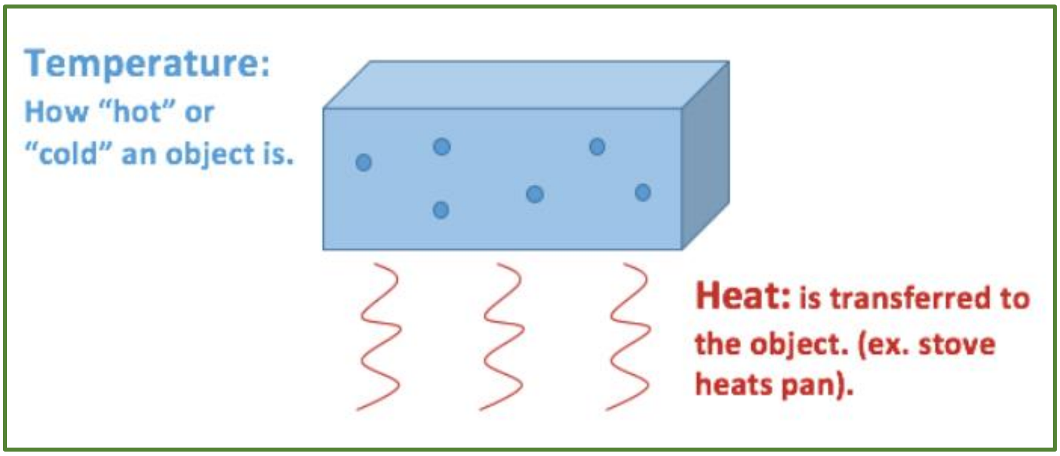
FIGURE 1–5
Some application areas of thermodynamics.

Heat and Temperature:

Heat and **temperature** are a closely related topic, and as such, the difference between the two can be a bit confusing. The core difference is that heat deals with thermal energy, whereas temperature is more concerned with molecular kinetic energy.

Heat describes the transfer of thermal energy between molecules within a system and is measured in Joules. Heat measures how energy moves or flows. An object can gain heat or lose heat, but it cannot have heat. Heat is a measure of change, never a property possessed by an object or system. Therefore, it is classified as a process variable.

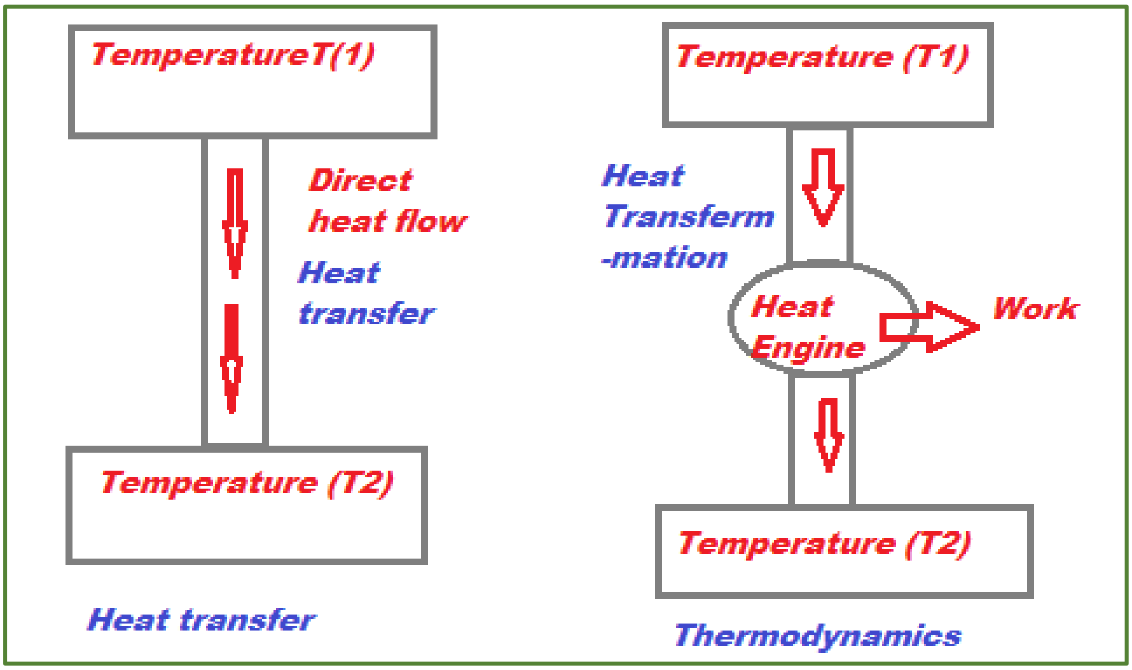
Temperature describes the average kinetic energy of molecules within a material or system and is measured in Celsius (°C), Kelvin (K), Fahrenheit (°F), or Rankine (R). It is a measurable physical property of an object, also known as a state variable. Other measurable physical properties include velocity, mass, and density.



Thermodynamics & Heat Transfer:

Thermodynamics and Heat transfer are both interlinked subjects. Thermo is overall energy and heat is one form of energy, here the difference between thermodynamics and heat transfer is observed by knowing about transformation and transfer.

In Heat transfer, the heat directly flows from high temperature to low temperature. but through thermodynamics, the heat is converted into work with the help of an external heat engine is known as heat transformation which is a thermodynamic process.



What is the thermal-fluid sciences?

Thermal-Fluid science is a branch of science that deals with thermal energy and fluid flow, and involves a study of thermodynamics, heat transfer, and fluid mechanics. Thermal-Fluid science examines many phenomena all around us, from the blood flow in our veins to ocean currents and atmospheric turbulence. Engineers frequently use and advance the thermal-fluid technologies to design safe and more efficient energy-related systems.

The second important aspect is heat transfer, which is concerned with the exchange of heat between physical systems. It involves several mechanisms, such as conduction, convection, radiation, and the transfer of energy by phase changes. It always occurs from a region of high temperature to another region of lower temperature. Heat conduction, or diffusion, is the direct microscopic exchange of kinetic energy of particles through the boundary between two systems. Heat convection occurs when the bulk flow of a fluid carries heat along with the fluid flow. The flow of fluid may be forced by external processes (forced convection), or sometimes by buoyancy forces caused when thermal energy expands the fluid (natural convection). An example of the latter process is a fire plume. Thermal radiation is the transfer of energy by means of photons in electromagnetic waves. Radiation heat transfer can occur in any transparent medium (solid or fluid) or through a vacuum. Even though these mechanisms have distinct characteristics, in practice they often occur together in a system.

Importance of Dimensions Units:

Any physical quantity can be characterized by dimensions. The magnitudes assigned to the dimensions are called units. Some basic dimensions such as mass m, length L, time t, and temperature T are selected as primary or fundamental dimensions, while others such as velocity V, energy E, and volume V are expressed in terms of the primary dimensions and are called secondary dimensions, or derived dimensions.

Several unit systems have been developed over the years. Despite strong efforts in the scientific and engineering community to unify the world with a single-unit system, two sets of units are still in common use today: the English system, which is also known as the United States Customary System (USCS), and the metric SI (from Le Système International d' Unités), which is also known as the International System. The SI is a simple and logical system based on a decimal relationship between the various units, and it is being used for scientific and engineering work in most of nations.

TABLE 1–1

The seven fundamental (or primary) dimensions and their units in SI

Dimension	Unit
Length	meter (m)
Mass	kilogram (kg)
Time	second (s)
Temperature	kelvin (K)
Electric current	ampere (A)
Amount of light	candela (cd)
Amount of matter	mole (mol)

TABLE 1–2

Standard prefixes in SI units

Multiple	Prefix
10^{24}	yotta, Y
10^{21}	zetta, Z
10^{18}	exa, E
10^{15}	peta, P
10^{12}	tera, T
10^{9}	giga, G
10^{6}	mega, M
10^{3}	kilo, k
10^{2}	hecto, h
10^{1}	deka, da
10^{-1}	deci, d
10^{-2}	centi, c
10^{-3}	milli, m
10^{-6}	micro, μ
10^{-9}	nano, n
10^{-12}	pico, p
10^{-15}	femto, f
10^{-18}	atto, a
10^{-21}	zepto, z
10^{-24}	yocto, y

Table A.1: Conversion Factors

Quantity	Conversion
Length	1 m = 100 cm
	= 3.28084(ft) = 39.3701(in)
Mass	1 kg = 10^3 g
	= 2.20462(lb_m)
Force	1 N = 1 kg m s^{-2}
	= 10^5(dyne)
	= 0.224809(lb_f)
Pressure	1 bar = 10^5 kg m^{-1} s^{-2} = 10^5 N m^{-2}
	= 10^5 Pa = 10^2 kPa
	= 10^6(dyne) cm^{-2}
	= 0.986923(atm)
	= 14.5038(psia)
	= 750.061(torr)
Volume	1 m^3 = 10^6 cm^3 = 10^3 liters
	= 35.3147$(ft)^3$
	= 264.172(gal)
Density	1 g cm^{-3} = 10^3 kg m^{-3}
	= 62.4278(lb_m)$(ft)^{-3}$
Energy	1 J = 1 kg m^2 s^{-2} = 1 N m
	= 1 m^3 Pa = 10^{-5} m^3 bar = 10 cm^3 bar
	= 9.86923 cm^3(atm)
	= 10^7(dyne) cm = 10^7(erg)
	= 0.239006(cal)
	= 5.12197 × $10^{-3}$$(ft)^3$(psia) = 0.737562(ft)($lb_f$)
	= 9.47831 ×10^{-4}(Btu) = 2.77778 ×10^{-7} kWhr
Power	1 kW = 10^3 W = 10^3 kg m^2 s^{-3} = 10^3 J s^{-1}
	= 239.006(cal) s^{-1}
	= 737.562(ft)(lb_f) s^{-1}
	= 0.947831(Btu) s^{-1}
	= 1.34102(hp)