Ministry of Higher Education
Higher Institute for Engineering and Technology at Manzala
Electronics Engineering Dept.

Thermodynamics and Heat Transfer (MEC121)

Lecture 1:Preface & Introduction

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Course Syllabus

(ميك ١٢١) **ديناميكا حرارية وانتقال حرارة** (٣+٢)

مبادئ الديناميكا الحرارية ، حركة الموائع، الغاز المثالي ، القانون الأول للديناميكا الحرارية ، العمليات الانعكاسية ، العمليات الغير انعكاسية ، القانون الثانى للديناميكا الحرارية ، الدورة الحرارية ، العمليات الانعكاسية ، العمليات الغير انعكاسية ، القانون الثانى للديناميكا الحرارية ، الدورة الحرارية ، درجة التعادل الحراري، نظرية الحركة للغازات ، انتقال الحرارة بالتوصيل ، الحمل الحر والحمل الجبري والإشعاع، التبادل الحراري، مبادئ ميكانيكا الموائع، خصائص الموائع ، معادلة بيرنولي وتطبيقاتها ، التحليل البعدي، ديناميكا النموذج والتحليل .

Course Outline

- Introduction to Thermodynamics and Heat Transfer
- First Law of Thermodynamics
- Second Law of Thermodynamics
- Ideal Gases and Processes
- Power and Refrigeration Cycles
- Heat Transfer Mechanisms: Conduction, Convection, and Radiation

Course Specification

Title: Thermodynamics and Heat Transfer	Code: MPE440
Lectures / Week	2 hours
Tutorials / Week	2 hours
Laboratory / Week	------
Total / Week	4 hours

Marks Distribution

Assessment Method		Marks	Weeks
Exercises	Mid-term	15	8th
	Attendance	5	Every Week
	Tutorial, Reports Assessment	10	Every two Weeks
Oral Examination		30	15th
Final Examination		90	16th
Total		**150**	

References

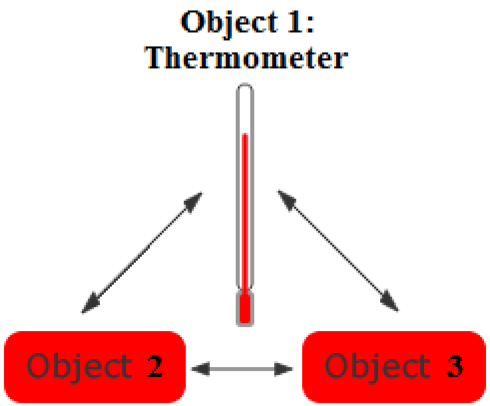
1. Y. A. Cengel, 2008, “**Introduction to Thermodynamics and Heat Transfer**,” 2nd Edition, The McGraw-Hill Company, Inc., ISBN: 0–390–86122–7.
2. C. Borgnakke and R. E. Sonntag, 2013, “**Fundamentals of Thermodynamics**,” 8th Edition, John Wiley & Sons, Inc., ISBN 978-1-118-13199-2.
3. Y. A. Cengel and A. J. Ghajar, 2015, “**Heat and Mass Transfer: Fundamental & Applications**,” 5th Edition, McGraw-Hill Education, ISBN 978-0-07-339818-1.
4. Y. A. Çengel, J. M. Cimbala and R. H. Turner, 2017, **Fundamentals of Thermal-Fluid Sciences**, 5th Edition, McGraw-Hill Education.
5. O. Singh, 2009, **Applied Thermodynamics**, 3rd Edition, New Age International (P) Ltd.
6. M. J. Moran, H. N. Shapiro, B. R., Munson and D. P. DeWitt, 2003, **Introduction to Thermal systems engineering: Thermodynamics, Fluid mechanics, and Heat Transfer**, 1st Edition, John Wiley & Sons.

Thermodynamics

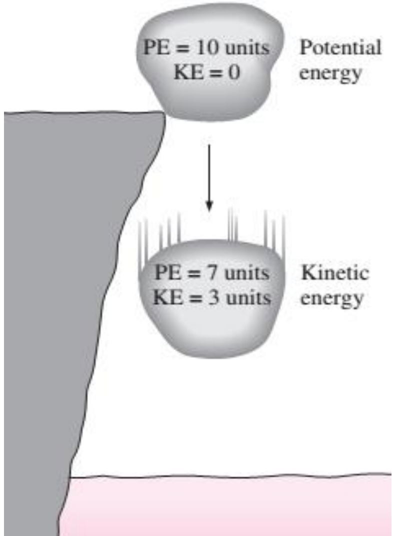
- Thermodynamics can be defined as the **science of energy**.
- The name thermodynamics stems from the Greek words **therme** (heat) and **dynamis** (power).
- Today, the Thermodynamics name is broadly interpreted to include **all aspects of energy and energy transformations**, including power generation, refrigeration, and relationships among the properties of matter.
- There are **four laws of thermodynamics**. These laws are a set of scientific laws which define a group of physical quantities, such as temperature, energy, entropy, etc.

Thermodynamics

- The **zeroth law of thermodynamics** defines **thermal equilibrium**: If two systems are each in thermal equilibrium with a third system, then they are in a thermal equilibrium with each other.

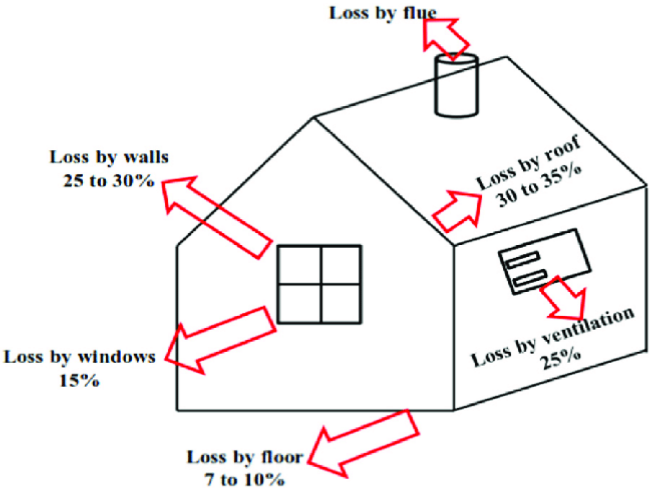


- One of the most fundamental laws of nature is the **conservation of energy principle (1st Law of Thermodynamics)**. It simply states that energy can change from one form to another but the total amount of energy remains constant.



Thermodynamics

- The **second law of thermodynamics** states that as energy is transferred or transformed, more and more of it is wasted **(losses)**.

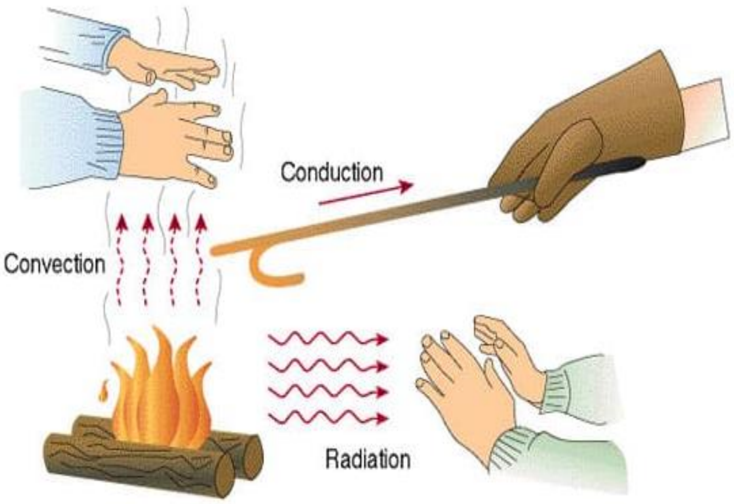


- The third law of thermodynamics is about a change in a specific property called entropy… it won't be addressed in our course.

Heat Transfer

- **Heat**, which is a form of energy, can be transferred from one system to another as a result of temperature difference.

- This transfer of heat is always from the **higher temperature** medium to the **lower temperature** one, and the transfer stops when the two mediums reach the same temperature (reach equilibrium).



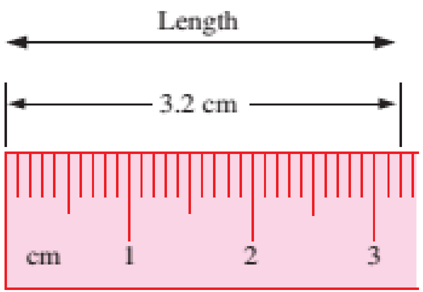
- But, what is the difference between **thermodynamics** and **heat transfer**???

Difference Between Heat Transfer & Thermodynamics

- For example, we can determine the amount of heat transferred from a **thermos bottle** as the hot coffee inside cools from 90˚C to 80˚C by a **thermodynamic analysis** alone. But a designer of a thermos is primarily interested in how long it will be before the hot coffee inside cools to 80˚C, and a thermodynamic analysis cannot answer this question.

- Determining the rates of heat transfer to or from this thermos bottle and thus the times of cooling or heating, as well as the variation of the temperature, is the subject of heat transfer.

SI and British Units



- Unit is defined as a reference used to measure a physical quantity, such as mass or length.

- There are **two common used systems of units**:

√ International system (SI)

√ British [English] system

Quantity	SI	British
Length	Meter (m)	Foot (ft)
Mass	Kilogram (kg)	Pound-mass (lbm)
Force	Newton (N)	Pound- force (lbf)
Time	Second (s)	Second (s)
Temperature	Kelvin (K)	Rankin (R)
Energy	Joule (J)	Foot- pound (ft-lbf)

SI and British Units

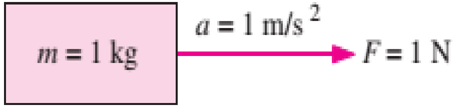
- The prefixes used to express the multiples of the various units are listed in the opposite Table.

Standard prefixes in SI units

Multiple	Prefix
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

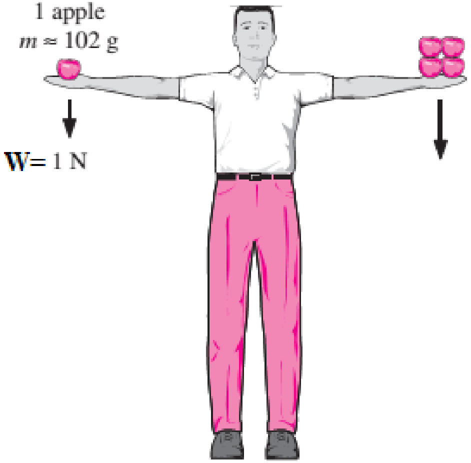
Mass, Force and Weight

- **Mass (m)** is defined as the quantity of the matter.
- According to **Newton's second law**, **Newton (N)** is defined as the force required to accelerate a mass of 1 kg at a rate of 1 m/s^2.



$$\boxed{F = m.a \quad (N)} \ldots\ldots 1$$

- Weight (N) is the gravitational force applied to a body, and its magnitude is also determined based on Newton's second law:



$$\boxed{W = m.g \quad (N)} \ldots\ldots 2$$

where g is the local gravitational acceleration (9.807 m/s2 at sea level).

Example

A 5-kg rock is thrown upward with a force of 150 N at a location where the local gravitational acceleration is 9.79 m/s^2. Determine the acceleration of the rock, in m/s^2. **(Ans. 30 m/s^2)**

Pressure

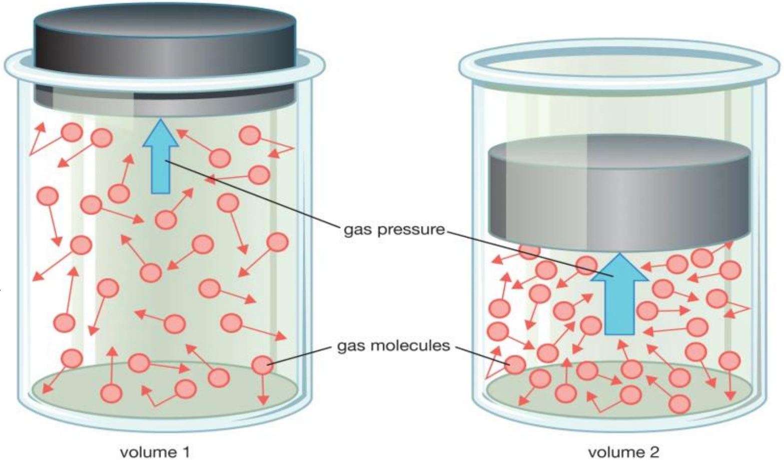
- **Pressure (p)** is defined as the force exerted by the fluid on unit area of the boundary:

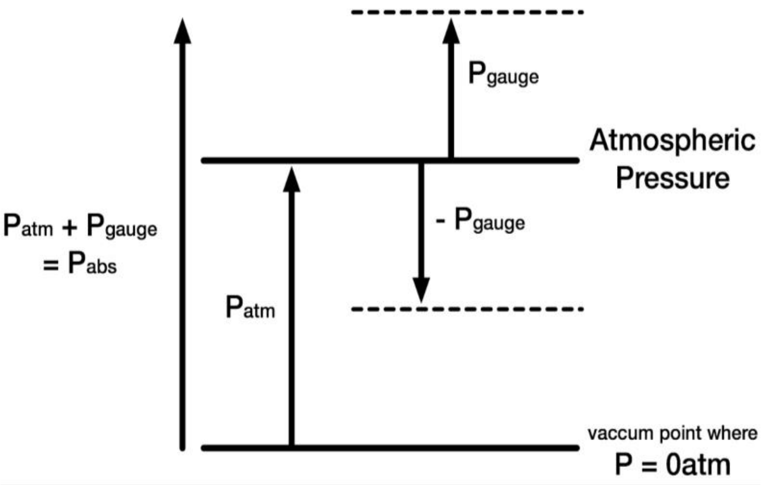
$$\boxed{p = \frac{F}{A} \quad (\text{Pa})} \ldots\ldots\ 3$$

where A is the area in square meters (m^2).
Pressure unit is pascal (Pa)

- Generally, you can measure the gauge pressure (p_g) and the absolute pressure (p_{abs}) can be calculated as:

$$\boxed{p_{abs} = p_{atm} \pm p_g} \ldots\ 4$$

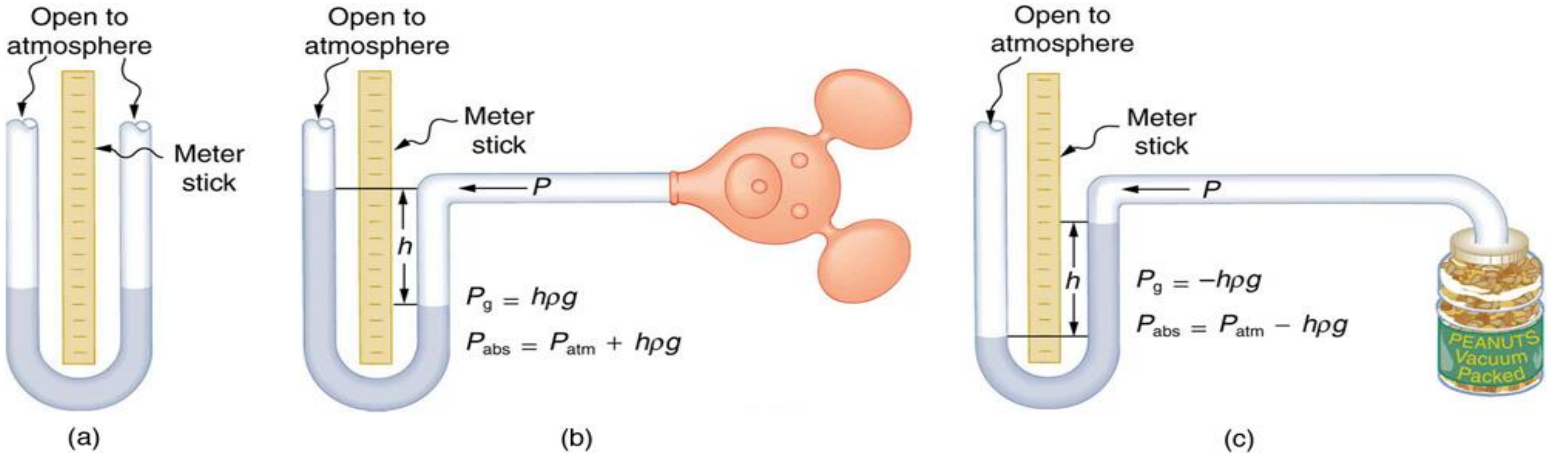




Pressure

- **Gauge pressure (p_g)** is calculated from:

$$\boxed{p = h\,\rho\,g} \quad \ldots\ldots\ (5)$$



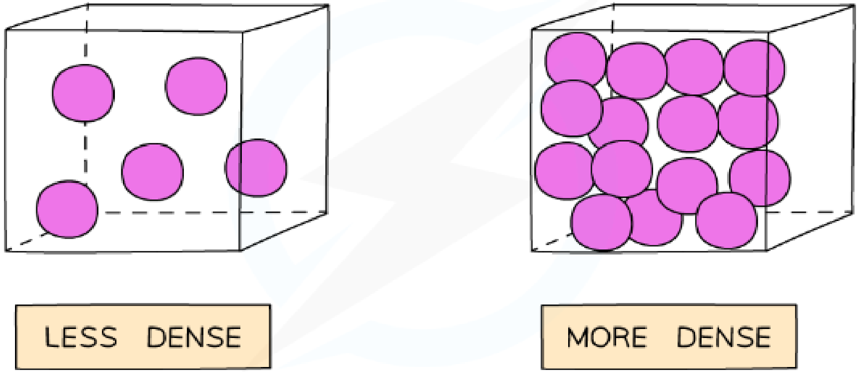
Example

What is the difference in the water pressure between the faucet at the bathroom and the top surface of a water tank located 70m above the faucet? **(Ans. 686,700 Pa)**

Density and Specific Volume

- **Density (ρ)** is the amount of mass per unit of volume:

$$\boxed{\rho = \frac{m}{V} \ (kg/m^3)} \ \ldots . \ 6$$



- **Specific Volume (ν)** is the volume per unit mass :

$$\boxed{v = \frac{V}{m} \ (m^3/kg)} \ \ldots\ldots . \ 7$$

Example

Determine the mass and the weight of the air contained in a room whose dimensions are 6 m x 6m x 8m. Assume the density of the air is 1.16 kg/m^3.

(Ans. 334.08 kg, 3277.32 N)

Temperature

- **Temperature (t)** of a system can be defined as the **property** that determines whether or not the body is in thermal equilibrium with the neighboring systems.
- In the **Celsius** (formally called **centigrade**) system, The temperature of ice point is designated as 0 degrees (0˚C) and that of the steam point as 100 degrees (100˚C).
- The absolute temperature in SI unit is in K, where:

$$\boxed{T\ \mathbf{K} = t\ ^{\circ}\mathbf{C} + 273.15} \quad \ldots\ldots (8)$$

- The absolute temperature in British [English] unit is in Rankine (R):

$$\boxed{T\ \mathbf{R} = t\ ^{\circ}\mathbf{F} + 459.67} \quad \ldots\ldots (9)$$

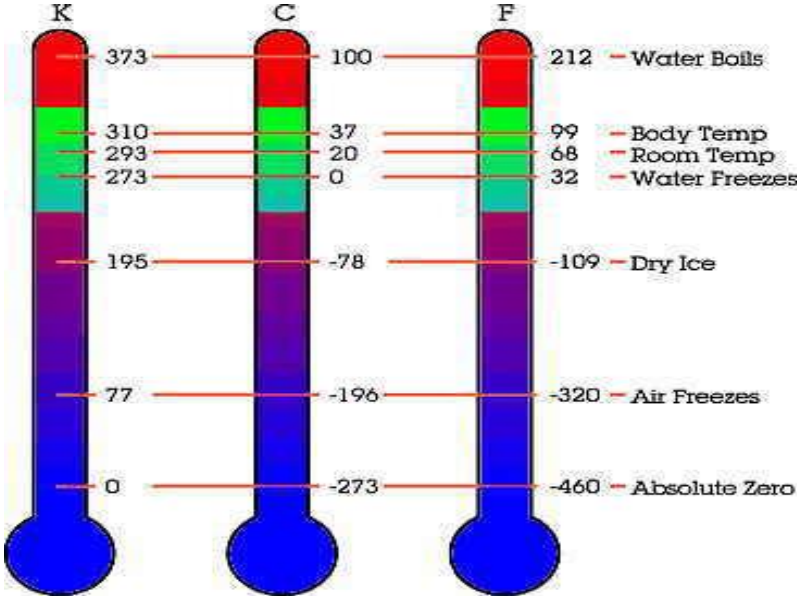
where ˚F (Fahrenheit) is the British unit of temperature.

Temperature

- The relation between two unit systems are:

$$\boxed{t\,°F = 1.8 \times t\,°C + 32} \quad \ldots\ldots (10)$$

$$\boxed{T\,R = 1.8 \times T\,K} \quad \ldots\ldots\ldots (11)$$



Example

The temperature of ambient air in a certain location is measured to be -40˚C. Express this temperature in Fahrenheit (˚F), Kelvin (K) and Rankine (R) units.

Discussion About

- Any questions?