University of Anbar

Engineering Thermodynamics
CHE 215

Lecture 01

Introduction and Basic Concepts

Objectives of Lecture Note

- **Identify the unique vocabulary associated with thermodynamics through the precise definition of basic concepts to form a sound foundation for the development of the principles of thermodynamics.**
- **Be comfortable with the metric SI and English units..**

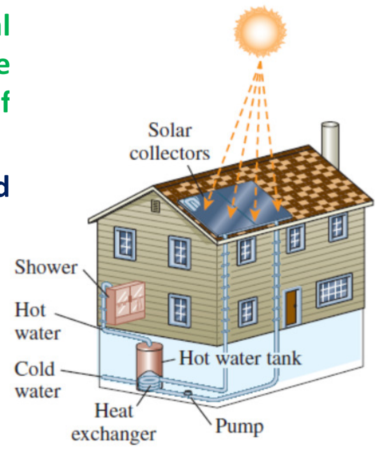
Introduction to Thermo

- **Thermal-fluid sciences: The physical sciences that deal with energy and the transfer, transport, and conversion of energy.**
- **Thermal-fluid sciences are studied under the subcategories of**

❖ **Fluid mechanics**

❖ **Thermodynamics**

❖ **Heat transfer**



The design of many engineering systems, such as this solar hot water system, involves thermal-fluid science.

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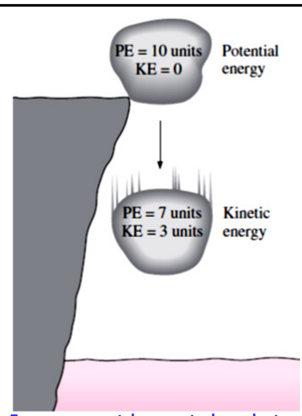
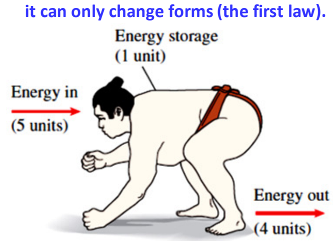
1.1 Thermodynamics and Energy

- **Thermodynamics:** can be defined the science of ***energy*** **and** ***entropy*.**
- **Energy:** The ability to cause changes.
- The name ***thermodynamics*** stems from the Greek words ***therme*** (heat) and ***dynamis*** (power).
- **Conservation of energy principle:** During an interaction, energy can change from one form to another but the total amount of energy remains ***constant*.**
- ***Energy cannot be created or destroyed.***
- **The first law of thermodynamics:** An expression of the conservation of energy principle.
- The first law asserts that ***energy*** is a thermodynamic property.



Energy cannot be created or destroyed; it can only change forms (the first law).



Conservation of energy principle for the human body.

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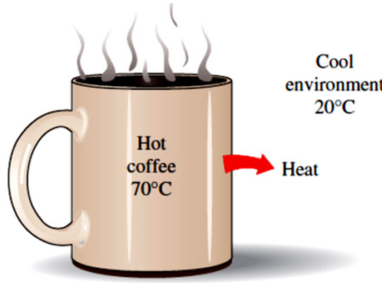
1.1 Thermodynamics and Energy

- **The second law of thermodynamics:** It asserts that energy has ***quality*** as well as ***quantity***, and actual processes occur in the direction of decreasing quality of energy.
- **Classical thermodynamics:** A **macroscopic approach** to the study of thermodynamics that does not require a knowledge of the behavior of individual particles.
- It provides a direct and easy way to the solution of engineering problems and it is used in this text.
- **Statistical thermodynamics:** A **microscopic approach**, based on the average behavior of large groups of individual particles.
- It is used in this text only in the supporting role.



Heat flows in the direction of decreasing temperature.

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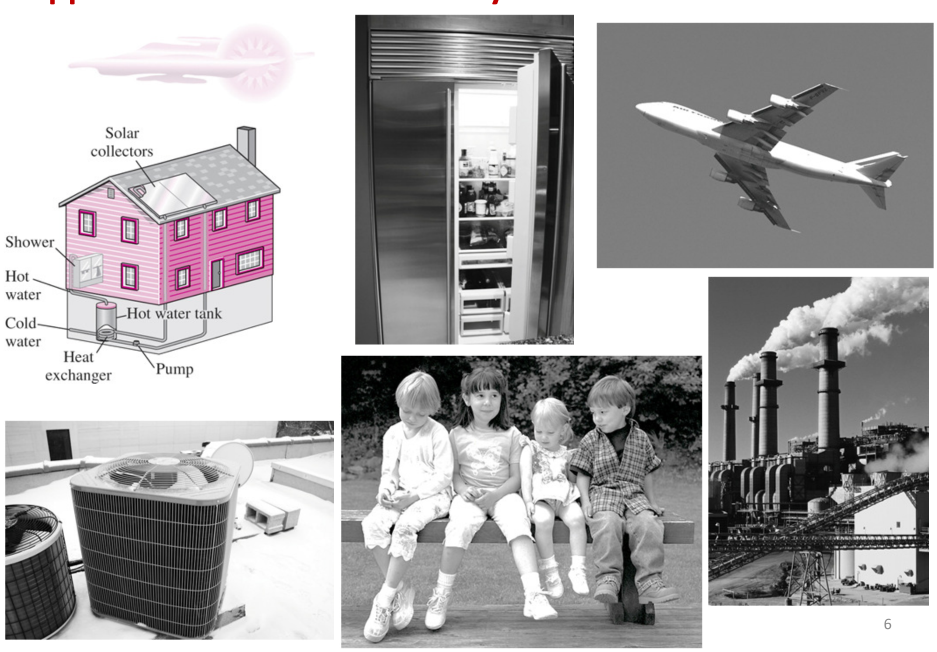
Application Areas of Thermodynamics



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Importance of Dimensions and 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**.
- **Metric SI system:** A simple and logical system based on a decimal relationship between the various units.
- **English system:** It has no apparent systematic numerical base, and various units in this system are related to each other rather arbitrarily.

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^{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

- **SI Units:** The international System of units, abbreviated SI.
- **U.S. Customary:** Abbreviated FPS.

English Unit	SI Unit	Conversion
Mile	Kilometer	1 mile = 1.609 Km
Foot	Meter	1 ft = .305 M
Inch	Centimeter	1 inch = 2.54 Cm
Pound	Grams	1 lb = 453.59 G
Ounce	Grams	1 oz = 28.35 G
Gallon	Liter	1 gallon = 3.79 L
Celsius	Kelvin	0 Degree C = 273.15 K

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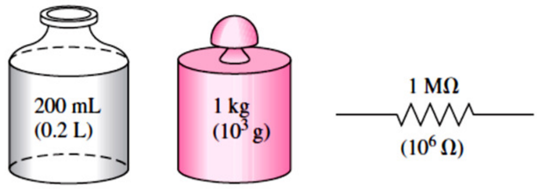
Some SI and English Units

$$1 \text{ lbm} = 0.45359 \text{ kg}$$
$$1 \text{ ft} = 0.3048 \text{ m}$$

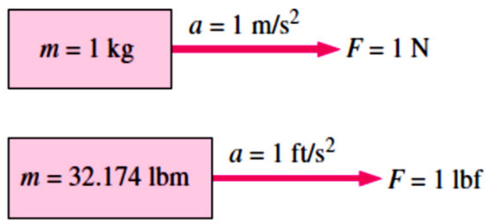


The SI unit prefixes are used in all branches of engineering.

Work = Force × Distance
1 J = 1 N·m
1 cal = 4.1868 J
1 Btu = 1.0551 kJ

$$\text{Force} = (\text{Mass})(\text{Acceleration})$$
$$F = ma$$

$$1 \text{ N} = 1 \text{ kg} \cdot \text{m/s}^2$$
$$1 \text{ lbf} = 32.174 \text{ lbm} \cdot \text{ft/s}^2$$



The definition of the force units.

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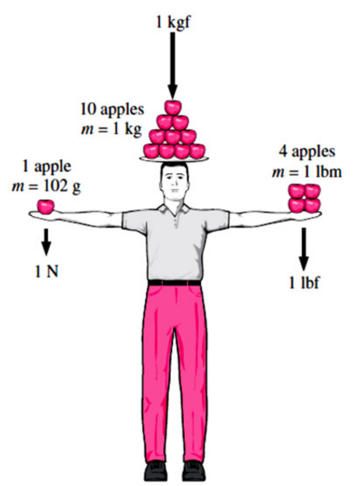
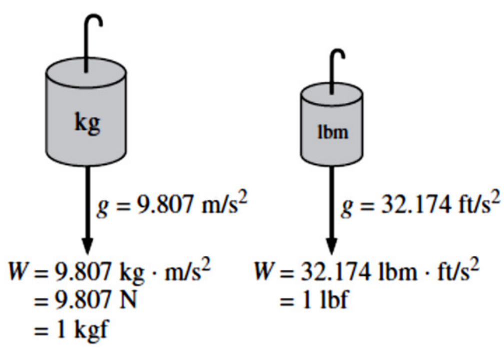
$$W = mg \quad (\text{N})$$

W weight
m mass
g gravitational acceleration

A body weighing 60 kgf on earth will weigh only 10 kgf on the moon.



The relative magnitudes of the force units newton (N), kilogram-force (kgf), and pound-force (lbf).



The weight of a unit mass at sea level.

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Dimensional homogeneity

All equations must be dimensionally *homogeneous*.

To be dimensionally homogeneous, all the terms in an equation must have the same unit.

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Unity Conversion Ratios

***All nonprimary units (secondary units) can be formed by combinations of primary units*.**
Force units, for example, can be expressed as

$$\text{N} = \text{kg}\,\frac{\text{m}}{\text{s}^2} \quad \text{and} \quad \text{lbf} = 32.174\ \text{lbm}\,\frac{\text{ft}}{\text{s}^2}$$

They can also be expressed more conveniently as unity conversion ratios as

$$\frac{\text{N}}{\text{kg}\cdot\text{m/s}^2} = 1 \quad \text{and} \quad \frac{\text{lbf}}{32.174\ \text{lbm}\cdot\text{ft/s}^2} = 1$$

Unity conversion ratios are identically equal to 1 and are unitless, and thus such ratios (or their inverses) can be inserted conveniently into any calculation to properly convert units.

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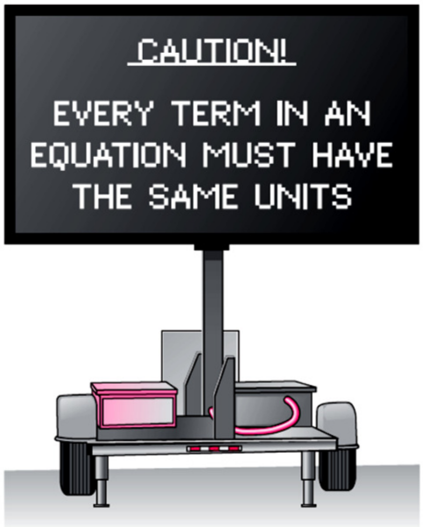

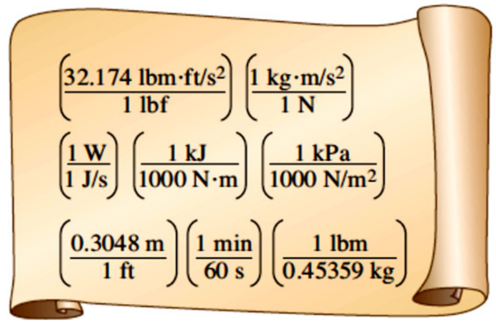

Every unity conversion ratio (as well as its inverse) is exactly equal to one. Shown here are a few commonly used unity conversion ratios.

Always check the units in your calculations!!

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FIGURE 1–33
A mass of 1 lbm weighs 1 lbf on earth.

EXAMPLE 1–4   The Weight of One Pound-Mass

Using unity conversion ratios, show that 1.00 lbm weighs 1.00 lbf on earth (Fig. 1–33).

Solution A mass of 1.00 lbm is subjected to standard earth gravity. Its weight in lbf is to be determined.

Assumptions Standard sea-level conditions are assumed.

Properties The gravitational constant is $g = 32.174$ ft/s^2.

Analysis We apply Newton's second law to calculate the weight (force) that corresponds to the known mass and acceleration. The weight of any object is equal to its mass times the local value of gravitational acceleration. Thus,

$$W = mg = (1.00 \text{ lbm})(32.174 \text{ ft/s}^2)\left(\frac{1 \text{ lbf}}{32.174 \text{ lbm}\cdot\text{ft/s}^2}\right) = \mathbf{1.00 \text{ lbf}}$$

Discussion Mass is the same regardless of its location. However, on some other planet with a different value of gravitational acceleration, the weight of 1 lbm would differ from that calculated here.

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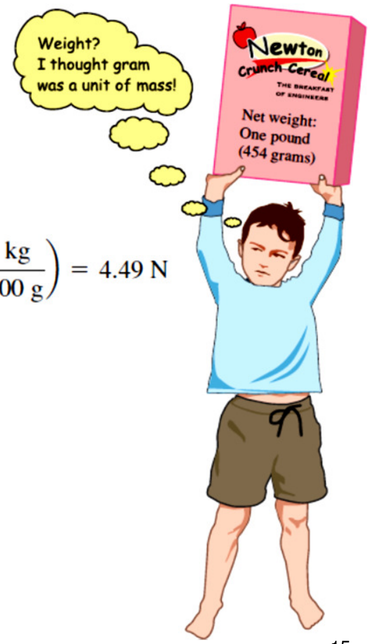
$$W = mg = (453.6\text{ g})(9.81\text{ m/s}^2)\left(\frac{1\text{ N}}{1\text{ kg}\cdot\text{m/s}^2}\right)\left(\frac{1\text{ kg}}{1000\text{ g}}\right) = 4.49\text{ N}$$



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