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اسم التدريسي : أ.م حسن غانم حسن رجبو
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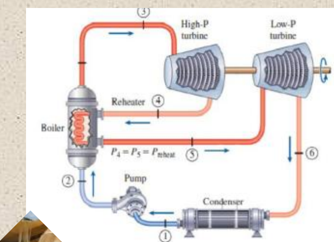
السنة الدراسية : 2025 - 2026
عنوان المحاضرة: مراجعة 1

Thermodynamic II

LECTURE 1
Review I



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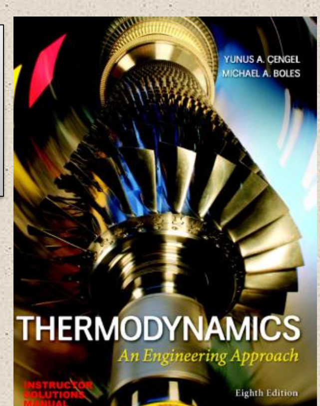
Text Books

1- **Thermodynamics: An Engineering Approach**
8th Edition
Yunus A. Çengel, Michael A. Boles
McGraw-Hill



Grading Program أسلوب التقييم

- ***Quizzes 10%***
- ***Assignments 10%***
- ***Laboratory 10%***
- ***Reports 10%***
- ***Midterm Exam 10%***
- ***Final Exam 50%***

Objectives

- 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.
- Review the metric SI and the English unit systems.
- Explain the basic concepts of thermodynamics such as system, state, state postulate, equilibrium, process, and cycle.
- Review concepts of temperature, temperature scales, pressure, and absolute and gage pressure.
- Introduce an intuitive systematic problem-solving technique.

THERMODYNAMICS AND ENERGY

- **Thermodynamics**: The science of *energy.*
- **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.

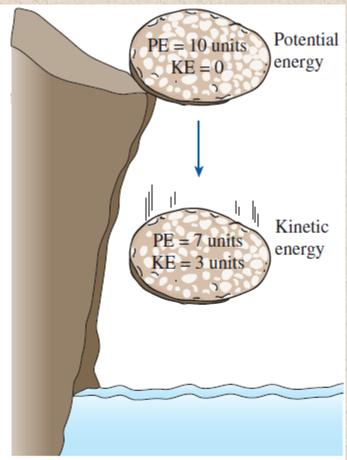


FIGURE 1–1
Energy cannot be created or destroyed; it can only change forms (the first law).

- **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.

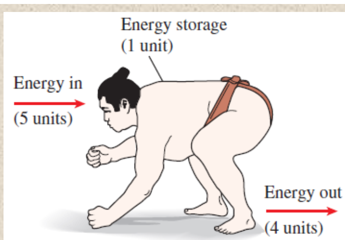


FIGURE 1–2
Conservation of energy principle for the human body.

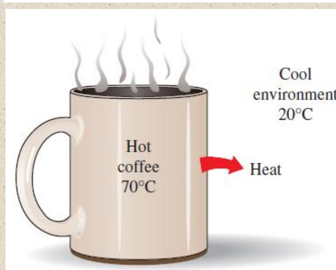


FIGURE 1–3
Heat flows in the direction of decreasing temperature.

Application Areas of Thermodynamics

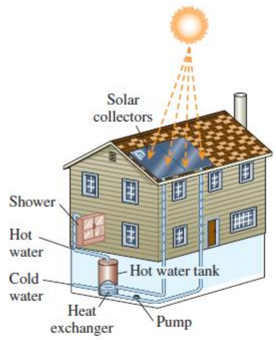


FIGURE 1–4

The design of many engineering systems, such as this solar hot water system, involves thermodynamics.

Refrigerator

© McGraw-Hill Education, Jill Braaten

Boats

© Doug Menuez/Getty Images RF

Aircraft and spacecraft

© PhotoLink/Getty Images RF

Power plants

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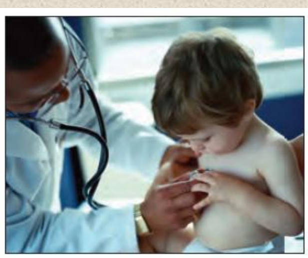
All activities in nature involve some interaction between energy and matter; thus, it is hard to imagine an area that does not relate to thermodynamics in some manner.



Human body

© Ryan McVay/Getty Images RF

Cars

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Wind turbines

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Food processing

Glow Images RF

A piping network in an industrial facility.

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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^{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

Some SI and English Units

1 lbm = 0.45359 kg

1 ft = 0.3048 m

Force = (Mass) (Acceleration)

$$F = ma$$

$$1\ \text{N} = 1\ \text{kg·m/s}^2$$

$$1\ \text{lbf} = 32.174\ \text{lbm·ft/s}^2$$

Work = Force × Distance

1 J = 1 N·m

1 cal = 4.1868 J

1 Btu = 1.0551 kJ

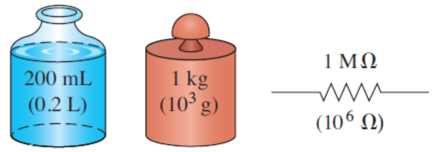

FIGURE 1–6
The SI unit prefixes are used in all branches of engineering.

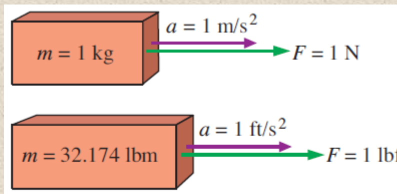

FIGURE 1–7
The definition of the force units.

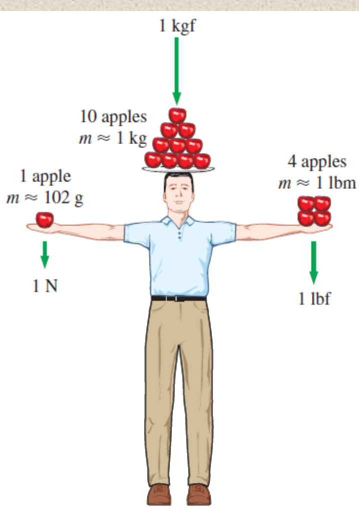

FIGURE 1–8
The relative magnitudes of the force units newton (N), kilogram-force (kgf), and pound-force (lbf).

FIGURE 1–9
A body weighing 150 lbf on earth will weigh only 25 lbf on the moon.

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

W weight
m mass
g gravitational acceleration

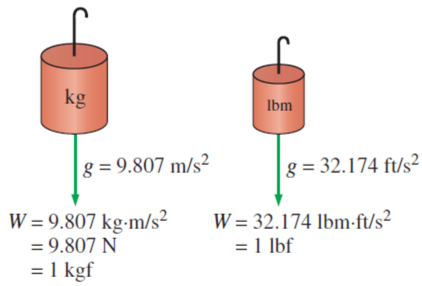

FIGURE 1–10
The weight of a unit mass at sea level.

FIGURE 1–11
A typical match yields about one Btu (or one kJ) of energy if completely burned.

Specific weight γ: The weight of a unit volume of a substance.

$$\gamma = \rho g$$

Dimensional homogeneity

All equations must be dimensionally **homogeneous**.

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.

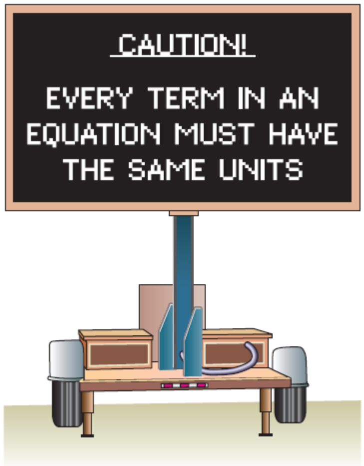

FIGURE 1–14
Always check the units in your calculations.

$$\left(\frac{32.174\ \text{lbm}\cdot\text{ft/s}^2}{1\ \text{lbf}}\right)\left(\frac{1\ \text{kg}\cdot\text{m/s}^2}{1\ \text{N}}\right)$$

$$\left(\frac{1\ \text{W}}{1\ \text{J/s}}\right)\left(\frac{1\ \text{kJ}}{1000\ \text{N}\cdot\text{m}}\right)\left(\frac{1\ \text{kPa}}{1000\ \text{N/m}^2}\right)$$

$$\left(\frac{0.3048\ \text{m}}{1\ \text{ft}}\right)\left(\frac{1\ \text{min}}{60\ \text{s}}\right)\left(\frac{1\ \text{lbm}}{0.45359\ \text{kg}}\right)$$

FIGURE 1–15
Every unity conversion ratio (as well as its inverse) is exactly equal to one. Shown here are a few commonly used unity conversion ratios.

FIGURE 1–16
A mass of 1 lbm weighs 1 lbf on earth.

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

FIGURE 1–17
A quirk in the metric system of units.

SYSTEMS AND CONTROL VOLUMES

- **System**: A quantity of matter or a region in space chosen for study.
- **Surroundings**: The mass or region outside the system
- **Boundary**: The real or imaginary surface that separates the system from its surroundings.
- The boundary of a system can be *fixed* or *movable*.
- Systems may be considered to be *closed* or *open*.
- **Closed system (Control mass):** A fixed amount of mass, and no mass can cross its boundary

17

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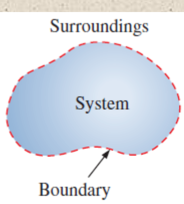

FIGURE 1–18
System, surroundings, and boundary.

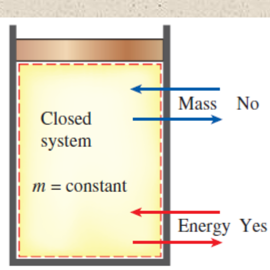

FIGURE 1–19
Mass cannot cross the boundaries of a closed system, but energy can.

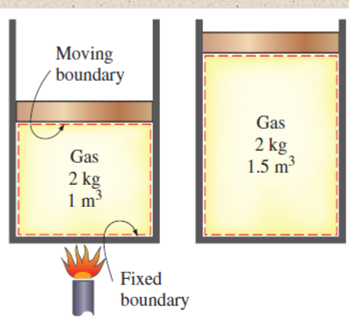

FIGURE 1–20
A closed system with a moving boundary.

18

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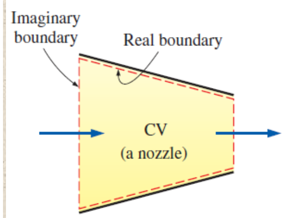
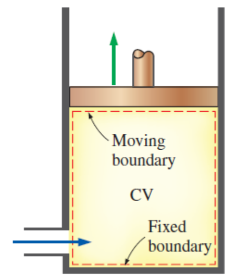
FIGURE 1–22
An open system (a control volume) with one inlet and one exit.

- **Open system (control volume)**: A properly selected region in space.
- It usually encloses a device that involves mass flow such as a compressor, turbine, or nozzle.
- Both mass and energy can cross the boundary of a control volume.
- **Control surface**: The boundaries of a control volume. It can be real or imaginary.

A control volume can involve fixed, moving, real, and imaginary boundaries.



(*a*) A control volume (CV) with real and imaginary boundaries



(*b*) A control volume (CV) with fixed and moving boundaries as well as real and imaginary boundaries

PROPERTIES OF A SYSTEM

- **Property:** Any characteristic of a system.
- Some familiar properties are pressure *P*, temperature *T*, volume *V*, and mass *m*.
- Properties are considered to be either *intensive* or *extensive*.
- **Intensive properties:** Those that are independent of the mass of a system, such as temperature, pressure, and density.
- **Extensive properties:** Those whose values depend on the size—or extent—of the system.
- **Specific properties:** Extensive properties per unit mass.

$$(v = V/m)$$

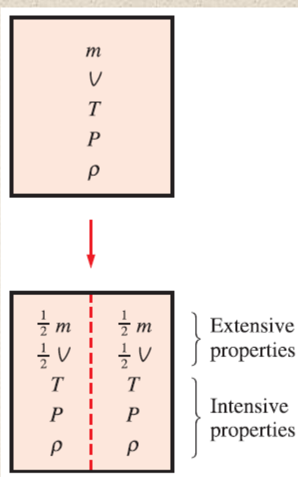


FIGURE 1–23
Criterion to differentiate intensive and extensive properties.

Continuum

- Matter is made up of atoms that are widely spaced in the gas phase. Yet it is very convenient to disregard the atomic nature of a substance and view it as a continuous, homogeneous matter with no holes, that is, a **continuum**.
- The continuum idealization allows us to treat properties as point functions and to assume the properties vary continually in space with no jump discontinuities.
- This idealization is valid as long as the size of the system we deal with is large relative to the space between the molecules.
- This is the case in practically all problems.
- In this text we will limit our consideration to substances that can be modeled as a continuum.

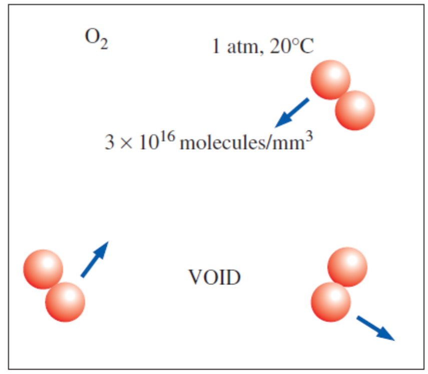


FIGURE 1–24
Despite the relatively large gaps between molecules, a gas can usually be treated as a continuum because of the very large number of molecules even in an extremely small volume.

DENSITY AND SPECIFIC GRAVITY

Density

$$\rho = \frac{m}{V} \qquad (\text{kg/m}^3)$$

Specific volume

$$v = \frac{V}{m} = \frac{1}{\rho}$$

$$V = 12 \text{ m}^3$$
$$m = 3 \text{ kg}$$
$$\Downarrow$$
$$\rho = 0.25 \text{ kg/m}^3$$
$$v = \frac{1}{\rho} = 4 \text{ m}^3/\text{kg}$$

Density is mass per unit volume; specific volume is volume per unit mass.

Specific gravity: The ratio of the density of a substance to the density of some standard substance at a specified temperature (usually water at 4°C).

$$\text{SG} = \frac{\rho}{\rho_{H_2O}}$$

Specific weight: The weight of a unit volume of a substance.

$$\gamma_s = \rho g \qquad (\text{N/m}^3)$$

TABLE 1–3
Specific gravities of some substances at 0°C

Substance	SG
Water	1.0
Blood	1.05
Seawater	1.025
Gasoline	0.7
Ethyl alcohol	0.79
Mercury	13.6
Wood	0.3–0.9
Gold	19.2
Bones	1.7–2.0
Ice	0.92
Air (at 1 atm)	0.0013

STATE AND EQUILIBRIUM

- Thermodynamics deals with *equilibrium* states.
- **Equilibrium**: A state of balance.
- In an equilibrium state there are no unbalanced potentials (or driving forces) within the system.
- **Thermal equilibrium**: If the temperature is the same throughout the entire system.
- **Mechanical equilibrium:** If there is no change in pressure at any point of the system with time.
- **Phase equilibrium:** If a system involves two phases and when the mass of each phase reaches an equilibrium level and stays there.
- **Chemical equilibrium:** If the chemical composition of a system does not change with time, that is, no chemical reactions occur.

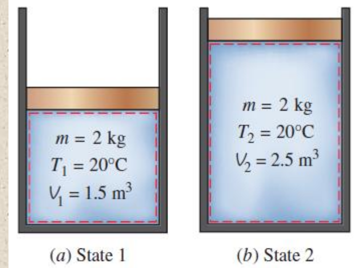


FIGURE 1–26
A system at two different states.

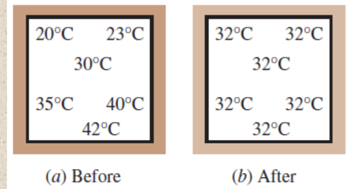


FIGURE 1–27
A closed system reaching thermal equilibrium.

The State Postulate

- The number of properties required to fix the state of a system is given by the **state postulate**:
  - ✓ *The state of a simple compressible system is completely specified by two independent, intensive properties.*
- **Simple compressible system:** If a system involves no electrical, magnetic, gravitational, motion, and surface tension effects.

FIGURE 1–28
The state of nitrogen is fixed by two independent, intensive properties.

PROCESSES AND CYCLES

Process: Any change that a system undergoes from one equilibrium state to another.

Path: The series of states through which a system passes during a process.

To describe a process completely, one should specify the initial and final states, as well as the path it follows, and the interactions with the surroundings.

Quasistatic or quasi-equilibrium process: When a process proceeds in such a manner that the system remains infinitesimally close to an equilibrium state at all times.

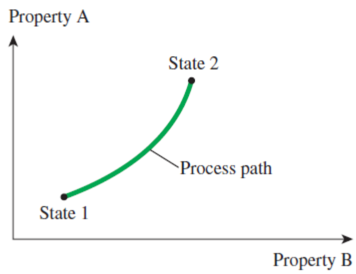


FIGURE 1–29
A process between states 1 and 2 and the process path.

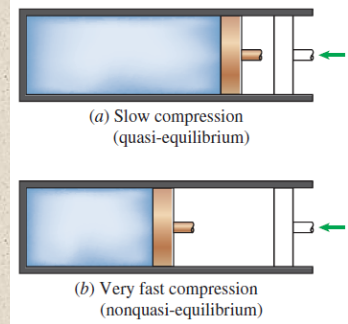


FIGURE 1–30
Quasi-equilibrium and nonquasi-equilibrium compression processes.

- Process diagrams plotted by employing thermodynamic properties as coordinates are very useful in visualizing the processes.
- Some common properties that are used as coordinates are temperature *T*, pressure *P*, and volume *V* (or specific volume *v*).
- The prefix *iso-* is often used to designate a process for which a particular property remains constant.
- **Isothermal process**: A process during which the temperature *T* remains constant.
- **Isobaric process**: A process during which the pressure *P* remains constant.
- **Isochoric (or isometric) process**: A process during which the specific volume *v* remains constant.
- **Cycle**: A process during which the initial and final states are identical.

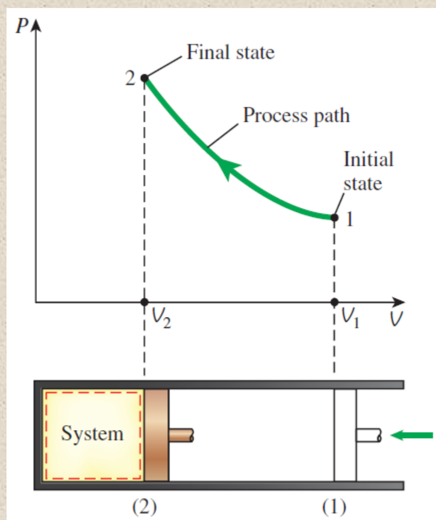


FIGURE 1–31
The *P*-*V* diagram of a compression process.

The Steady-Flow Process

- The term *steady* implies *no change with time*. The opposite of steady is *unsteady*, or *transient*.
- A large number of engineering devices operate for long periods of time under the same conditions, and they are classified as *steady-flow devices*.
- **Steady-flow process**: A process during which a fluid flows through a control volume steadily.
- Steady-flow conditions can be closely approximated by devices that are intended for continuous operation such as turbines, pumps, boilers, condensers, and heat exchangers or power plants or refrigeration systems.

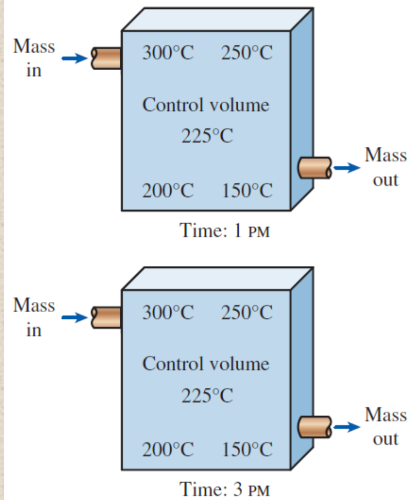


FIGURE 1–32
During a steady-flow process, fluid properties within the control volume may change with position but not with time.

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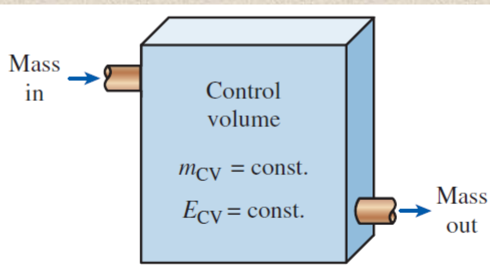

FIGURE 1–33
Under steady-flow conditions, the mass and energy contents of a control volume remain constant.

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Any Questions???

29

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