

Institute of Natural Resource Management
National Taipei University
Class Handout of the Fall Semester, 2013

Lectures 5: Conservations of Mass and Energy

- INTRODUCTION – UNIFYING THEORIES
 - Conservation of Matter => Chemical Reactions
 - Conservation of Energy => Laws of Thermodynamics
 - Conservation of Matter and Energy => The Theory of Relativity

- MATERIAL BALANCE
 - Control Volume, Control Mass, and System
 - Steady State vs. Transit or Dynamic => Rate of Change
 - (Accumulation Rate) = (Input Rate) – (Output Rate) ± (Transformation Rate)
 - Steady-State Conservative Systems
 - Batch Systems with Non-conservative Pollutants
 - Steady-State Systems with Non-conservative Pollutants

- ENERGY BALANCE
 - First Law of Thermodynamics
 - ⇒ Thermal Unit of Energy
 - ⇒ Specific Heat Capacity
 - ⇒ Latent Heat, Overheated Stream, Subcritical and Supercritical
 - ⇒ Pressurized Water Reactors (vs. Boiling Water Reactors)
 - Second Law of Thermodynamics
 - ⇒ Energy: Heat, Kinetic Energy, Potential, Electricity, etc.
 - ⇒ Work, Unusable Energy, Entropy and Disorder/Randomness
 - ⇒ Thermal Efficiency: Carnot Engine
 - ⇒ Thermal Power Plants: Coal, Oil and Natural Gas; Steam Generator and Internal combustion; Combined Cycle and IGCC
 - Conductive and Convective Heat Transfer
 - Radiant Heat Transfer
 - ⇒ Solar Energy: Heat vs. Photovoltaic
 - ⇒ Electromagnetic Spectrum
 - ⇒ Wavelength vs. Frequency
 - Heat Engine vs. Heat Pump

- UNIT OF MEASUREMENT
 - Basic Units: Length, Mass, Time, and Temperature
 - International System of Units (SI) vs. Imperial System (U.S. customary units)
 - Extended Units: Concentration, Dose, ppm(m), ppb(v), Energy, “Equivalent”

- Units for Air Pollutants: ppm(v), ppb(v), $\mu\text{g}/\text{m}^3$, iTEQ
- Units for Water Pollutants: mg/L, ppm(m), $\mu\text{-mho}/\text{cm}$
- Units for Soil Contaminants: mg/kg, meq/100g (CEC)
- Common Prefixes: p, n, μ , m, c, d, k, M, G, T
- Conversion Factors => Emission Factors
- Dimensionless Analysis: Manning Equation

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

TABLE 1.1 Some Basic Units and Conversion Factors^a

Quantity	SI Units	SI Symbol	Conversion Factor = USCS Units	
Length	Meter	m	3.2808	ft
Mass	Kilogram	kg	2.2046	lb
Temperature	Celsius	$^{\circ}\text{C}$	$1.8 (^{\circ}\text{C}) + 32$	$^{\circ}\text{F}$
Area	Square meter	m^2	10.7639	ft^2
Volume	Cubic meter	m^3	35.3147	ft^3
Energy	Kilojoule	kJ	0.9478	Btu
Power	Watt	W	3.4121	Btu/hr
Velocity	Meter/sec	m/s	2.2369	mi/hr
Flow rate	Meter ³ /sec	m^3/s	35.3147	ft^3/s
Density	Kilogram/meter ³	kg/m^3	0.06243	lb/ft^3

SI prefixes							
Prefix	Symbol	1000 ^m	10 ⁿ	Decimal	Short scale	Long scale	Since
yotta	Y	1000 ⁸	10²⁴	1000000000000000000000000	Septillion	Quadrillion	1991
zetta	Z	1000 ⁷	10²¹	100000000000000000000000	Sextillion	Trilliard	1991
exa	E	1000 ⁶	10¹⁸	10000000000000000000000	Quintillion	Trillion	1975
peta	P	1000 ⁵	10¹⁵	1000000000000000000000	Quadrillion	Billiard	1975
tera	T	1000 ⁴	10¹²	1000000000000000000000	Trillion	Billion	1960
giga	G	1000 ³	10⁹	1000000000000000000000	Billion	Milliard	1960
mega	M	1000 ²	10⁶	1000000	Million		1960
kilo	k	1000 ¹	10³	1000	Thousand		1795
hecto	h	1000 ^{2/3}	10²	100	Hundred		1795
deca	da	1000 ^{1/3}	10¹	10	Ten		1795
		1000 ⁰	10⁰	1	One		–
deci	d	1000 ^{-1/3}	10⁻¹	0.1	Tenth		1795
centi	c	1000 ^{-2/3}	10⁻²	0.01	Hundredth		1795
milli	m	1000 ⁻¹	10⁻³	0.001	Thousandth		1795
micro	μ	1000 ⁻²	10⁻⁶	0.000001	Millionth		1960
nano	n	1000 ⁻³	10⁻⁹	0.000000001	Billionth	Milliardth	1960
pico	p	1000 ⁻⁴	10⁻¹²	0.000000000001	Trillionth	Billionth	1960
femto	f	1000 ⁻⁵	10⁻¹⁵	0.000000000000001	Quadrillionth	Billiardth	1964
atto	a	1000 ⁻⁶	10⁻¹⁸	0.00000000000000001	Quintillionth	Trillionth	1964
zepto	z	1000 ⁻⁷	10⁻²¹	0.0000000000000000001	Sextillionth	Trilliardth	1991
yocto	y	1000 ⁻⁸	10⁻²⁴	0.000000000000000000001	Septillionth	Quadrillionth	1991