CHAPTER ONE
INTRODUCTION

1.9 FORM OF ENERGY:

Energy can exist in numerous forms such as thermal, mechanical, kinetic, potential, electric, magnetic, chemical, and nuclear, and their sum constitutes the total energy **E** of a system. The total energy of a system on a unit mass basis is denoted by **e** and is defined as

$$e = \frac{E}{m} \quad (J/kg) \quad or \quad (kJ/kg)$$

In thermodynamic analysis, it is often helpful to consider the various forms of energy that make up the total energy of a system in two groups, macroscopic and microscopic. The macroscopic forms of energy, on one hand, are those a system possesses as a whole with respect to some out side reference frame, such as kinetic and potential energies. The microscopic forms of energy, on the other hand, are those related to the molecular structure of a system and the degree of the molecular activity, and they are independed of outside reference frames. The sum of all the microscopic forms of energy is called the **internal energy** of a system and is denoted by **U**.

The macroscopic energy of a system is related to a motion and the influence of some external effects such as gravity, electricity, and surface tension.

1. **Kinetic Energy:** it is the energy that a system possesses as a result of its motion relative to some reference frame, when all parts of a system move with the same velocity, the kinetic energy is expressed as

$$KE = \frac{1}{2} m C^2 \quad [J]$$

Or, on a unit mass basis,

$$ke = \frac{1}{2} C^2 \quad [J/kg]$$

And the change in kinetic energy between two state of the system

$$\Delta KE = \frac{1}{2}(m_2 C_2^2 - m_1 C_1^2) \quad [J]$$

or
$$\Delta KE = \frac{1}{2000}(m_2 C_2^2 - m_1 C_1^2) \quad [kJ]$$

And for the same mass m

$$\Delta KE = \frac{1}{2000} m (C_2^2 - C_1^2) \quad [kJ]$$

Where C denotes the velocity of the system relative to some fixed reference frame.

2. **Potential Energy :** It is the energy that a system possesses as a result of its elevation in a gravitational- field and is expressed as

$$PE = mgZ \quad [J]$$

Or, on a unit mass basis

$$pe = gZ \quad [J/kg]$$

and the change in the potential energy is

$$\Delta PE = mg(Z_2 - Z_1) \quad [J]$$

or

$$\Delta PE = \frac{1}{1000} mg(Z_2 - Z_1) \quad [kJ]$$

The total energy of a system consists of the kinetic, potential, and internal energies and is expressed as

$$E = U + KE + PE \quad \text{kJ}$$

or per unit mass $e = u + ke + pe$ kJ/kg

internal energy is defined as the sum of all the microscopic forms of energy of a system. It is related to the molecular structure and the degree of molecular activity, and it may be viewed as the sum of the kinetic energy of the molecular.

1.10 EQUALITY OF TEMPERATURE:

Two bodies have equality of temperature when no change in any observation property occurs when they are in thermal communication.

1.11 ZEROTH LAW OF THERMODYNAMICS:

When two bodies have equality of temperature with a third body, they are in turn have equality of temperature with each other.

1.12 TEMPERATURE SCALE:

Celcsius scale symbol ^oC or called Centigrade. The Celsius scale was based on two fixed, easily duplicated points, the ice point and the steam point, these two points are numbered 0^oC and 100^oC on the Celsius scale. And absolute scale related to Celsius is referred to as the Kelvin scale and is designated as K.

$$K = {}^oC + 273.15$$

There is other scale of temperature called Fahrenheit scale has symbol ^oF at which the ice point and steam point are numbered 32^oF and 212^oF.

$$0^o C \rightarrow 32^o F$$
$$100^o C \rightarrow 212^o F$$
$$t(^o F) = 32 + 1.8t(^o C)$$

And the absolute scale related to Fahrenheit scale is referred as the Rankin and designated R

$$R = ^o F + 460$$
$$T(R) = 1.8T(K)$$

1.13 THERMODYNAMIC EQUILIBRIUM:

The system is in thermal equilibrium, when the temperature is same throughout the entire system, and if a system is in mechanical equilibrium, there is no tendency for the pressure at any point to change with time as long as the system is isolated from the surrounding, and the system is in chemical equilibrium if there is no change in its energy.

So where the system is in thermal, mechanical, and chemical equilibrium, the system is in thermodynamic equilibrium.

1.14 SI UNITS:

The basic units of mass, length and time is kg, meter, and second respectively. These units are used to find the other units that called the secondary units like force, work, energy, power, torque, and acceleration.

Acceleration =α =[m/sec^2]

Force =F =Newton[N]

The force is defined as product of acceleration and mass

$$F = \alpha \times m$$

N=[m/sec^2]x[kg]

The torque can be defined as the force multiply by length

T= F x L

J= N x m = kg . m^2/sec^2

The work also defined as force into distance so the unit of work is [J].

The power is the rate of doing work

Power =Work / Time

W = J/sec =kg.m^2/sec^3

Where W=Watt , J=Joule

Table 1.1

SI UNITE PREFIXES

Factor	prefix	symple
10^{12}	Tera	T

10^9	Giga	G
10^6	Mega	M
10^3	Kilo	k
10^{-3}	Milli	Mi
10^{-6}	Micro	μ
10^{-9}	Nano	N
10^{-12}	Pico	P

Example 1.1

What is the force required to accelerate a mass of 30kg at a rate of 15m/sec^2.

Solution: given , mass m=30kg
Acceleration a = 15m/sec^2

F= m x a =30kg x 15m/sec^2 =450N

Example 1.2

5kg plastic tank that has a volume of 0.2m^3 is filled with liquid water. Assuming the density of water is 1000kg/m^3, determine the weight of the combined system.

Solution: given mass of tank m_t=5kg
Volume of the tank V=0.2m^3
Density of water ρ_w=1000kg/m^3

Mass of water $m_w= V_w x \rho_w$
=0.2m^3 x 1000kg/m^3 =200kg

total mass $m= m_w+m_t$
=200kg+5kg

total weight w= m x g =205kg x 9.81m/sec^2=2011N

Example 1.3

The deep body temperature of a healthy person is 37^{o}C. What is it in Kelvin.

Solution: given t=37^{o}C
T=t+273=310K

Example 1.4

Consider a system whose temperature is 18^{o}C. Express this temperature in R, K, and ^{o}F.

Solution: given t=18^{o}C
t(^{o}F)=32+1.8t(^{o}C)
=32+1.8 x 18=64.4^{o}F
T(K)=t(^{o}C)+273
=18+273.15=291.15K

$$T(R) = t(^{o}F)+459.67$$
$$=64.4+459.67=524.07R$$
or $$T(R)=1.8T(K)=1.8 \times 291.15=524.07R$$

PROBLEMS-1

1.1 Can mass cross the boundary of a closed system? How about energy?

1.2 What is the difference between the macroscopic and microscopic?

1.3 What is the difference between intensive and extensive properties?

1.4 For a system to be in thermodynamic equilibrium, do the temperature and pressure have to be the same every where?

1.5 What is the difference between gage pressure and absolute pressure?

1.6 What is the zeroth law of thermodynamic?

1.7 What are the ordinary and absolute temperature scale in the SI and English unit systems?

1.8 A steady force of 5kN acts on a mass of 20kg. What is the acceleration of this mass. ($250 m/sec^2$)

1.9 The " standard " acceleration (at sea level and 45 degree latitude) due to gravity is $9.80665 m/sec^2$. Calculate the force due to "standard" gravity acting on a mass of 50kg.

1.10 The reading on a pressure gage is 1.75Mpa, and the local barometer reading is 94kPa. Calculate the absolute pressure that is being measured.

1.11 A gas is contained in a vertical cylinder fitted with a piston as shown in Fig(1.3). atmospheric pressure is 1bar, and the piston area is $400mm^2$. what is the mass of piston, if the gas pressure inside is 120kPa? Assume standard gravitational acceleration.

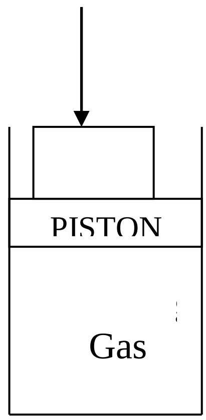

Fig.1.3 Sketch for Problem 1.11

1.12 A vacuum gage connected to a tank reads 30kPa at a location where the barometric reading is 755mm Hg. Determine the absolute pressure in the tank. Take ρ_{Hg}=13590kg/m^3.

1.13 A pressure gage connected to a tank reads 3.15bar at a location where the barometric reading is 75cm Hg. Determine the absolute pressure in tank. Take ρ_{Hg}=13590kg/m^3. (4.15 bar)

1.14 A pressure gage connected to a tank reads 600kPa at a location where the atmospheric pressure is 94kPa. Determine the absolute pressure in the tank.

1.15 The barometer of a mountain hiker reads 930mbar at the beginning of hiker tip and 780mbar at the end. Neglecting the effect of altitude on local gravitational acceleration, determine the vertical distance climbed. Assume an average air density of 1.2kg/m^3 and take g=9.7m/sec. (1288.65m)

1.16 The basic barometer can be used to measure the height of a building. If the barometric readings at the top and at the bottom of a building are 730 and 755mm Hg, respectively. Determine the height of the building, assume an average air density of 1.18kg/m^3. (288m)

1.17 A gas is contained in a vertical, frictionless piston-cylinder device. The piston has a mass of 4kg and cross-sectional area of 35cm^2. a compressed spring above the piston exerts a force 60N on the piston. If the atmospheric pressure is 95kPa, determine the pressure in side the cylinder. (123.35kPa)

1.18 Both a gage and a manometer are attached to a gas tank to measure its pressure. If the reading on the gage is 80kPa, determine the distance between the two fluid levels of the manometer if the fluid is (a) mercury (ρ=13600kg/m^3) or is (b) water (ρ=1000kg/m^3).

1.19 The level of the water in an enclosed water tank is 40m above ground level. The pressure in the air space above the water is 120kPa, and the density of water is 1000kg/m^3. what is the water pressure at ground level. (512.4 kPa)

1.20 A manometer contains a fluid having a density of 800kg/m^3. The difference in height of the two columns 300mm. What pressure difference is indicated? What would be the height difference be if a manometer containing mercury (density of 13600kg/m^3) had measured this same pressure difference?

1.21 During a heating process, the temperature of a system rises by 10^{o}C. Express this rise in temperature in K,R, and ^{o}F.

1.22 The deep body temperature of a healthy person is 98.6^{o}F. What is it in Rankine.

1.23 Consider a system whose temperature is 18^{o}C. Express this temperature in R, K, ^{o}F.

1.24 Consider two closed systems A and B. System A contains 2000kJ of thermal energy at 20^{o}C whereas system B contains 200kJ of thermal energy at 50^{o}C. Now the two systems brought into contact with each other. Determine the direction of any heat transfer between the systems.

1.25 A lift of mass 972kg moving up a distance 14.5km. Determine the minimum work required.

1.26 Determine the kinetic energy possesses by a car has a mass of 1050kg with a speed of 82km/hr.

1.27 Water is stored in a tank at a height of 85.3m over a hydraulic turbine.(a) calculate the potential energy per unit mass of the water (b)the mass flow rate to product 75000kW.

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

1.29 A 5-kg rock is thrown upward with a force of 150N at a location where the local gravitational acceleration is $9.79 m/sec^2$. Determine the acceleration of the rock in m/sec^2.

1. Engineering thermodynamics does not include energy

(A) transfer

(B) utilization

(C) storage

(D) transformation

2. Which of the following would be identified as a control volume?

(A) Compression of the air-fuel mixture in a cylinder

(B) Filling a tire with air at a service station

(C) Compression of the gases in a cylinder

(D) The flight of a dirigible

3. Which of the following is a quasiequilibrium process?

(A) Mixing a fluid

(B) Combustion

(C) Compression of the air-fuel mixture in a cylinder

(D) A balloon bursting

4. The standard atmosphere in meters of gasoline (*g* = 6660 N/m3) is nearest

(A) 24.9 m

(B) 21.2 m

(C) 18.3 m

(D) 15.2 m

5. A gage pressure of 400 kPa acting on a 4-cm-diameter piston is resisted by a spring with a spring constant of 800 N/m. How much is the spring compressed? Neglect the piston weight and friction.

(A) 63 cm

(B) 95 cm

(C) 1.32 m

(D) 1.98 m

6. Which of the following processes can be approximated by a quasie quilibrium process?

(A) The expansion of combustion gases in the cylinder of an automobile engine

(B) The rupturing of a balloon

(C) The heating of the air in a room with a radiant heater

(D) The cooling of a hot copper block brought into contact with ice cubes

7. Determine the weight of a mass at a location where *g* = 9.77 m/s2 (on the top of Mt. Everest) if it weighed 40 N at sea level.

(A) 39.62 N

(B) 39.64 N

(C) 39.78 N

(D) 39.84 N

8. Determine γ if $g = 9.81\ m/s^2$, $V = 10\ m^3$, and $v = 20\ m^3/kg$.

(A) 2.04 N/m^3

(B) 1.02 N/m^3

(C) 0.49 N/m^3

(D) 0.05 N/m^3

9. If *P*atm = 100 kPa, the pressure at a point where the gage pressure is 300 mmHg is nearest (γHg = 13.6 γwater)

(A) 40 kPa

(B) 140 kPa

(C) 160 kPa

(D) 190 kPa

10. A large chamber is separated into compartments 1 and 2, as shown, that are kept at different pressures. Pressure gage *A* reads 400 kPa and pressure gage *B* reads 180 kPa. If the barometer reads 720 mmHg, determine the absolute pressure of *C*.

(A) 320 kPa

(B) 300 kPa

(C) 280 kPa

(D) 260 kPa

11. A 10-kg body falls from rest, with negligible interaction with its surroundings (no friction). Determine its velocity after it falls 5 m.

(A) 19.8 m/s

(B) 15.2 m/s

(C) 12.8 m/s

(D) 9.9 m/s

12. The potential energy stored in a spring is given by *Kx*2/2, where *K* is the spring constant and *x* is the distance the spring is compressed. Two spring sare designed to absorb the kinetic energy of an 1800-kg vehicle. Determine the spring constant necessary if the maximum compression is to be 100 mm for a vehicle speed of 16 m/s.

(A) 23 MN/m

(B) 25 MN/m

(C) 27 MN/m

(D) 29 MN/m

13. In a quasiequilibrium process, the pressure

(A) remains constant

(B) varies with location

(C) is everywhere constant at an instant

(D) depends only on temperature

14. Which of the following is not an extensive property?

(A) Momentum

(B) Internal energy

(C) Temperature

(D) Volume

15. The joule unit can be converted to which of the following?

(A) kg .m^2/s

(B) kg . m/s^2

(C) Pa .m^3

(D) Pa/m^2

16. Convert 178 kPa gage of pressure to absolute millimeters of mercury (ρhg = 13.6 ρwater).

(A) 2080 mm

(B) 1820 mm

(C) 1640 mm

(D) 1490 mm

17. Calculate the pressure in the 240-mm-diameter cylinder shown. The spring is compressed 60 cm. Neglect friction. 40 kg Air K = 2 kN/m

(A) 198 kPa

(B) 135 kPa

(C) 110 kPa

(D) 35 kPa

18. A cubic meter of a liquid has a weight of 9800 N at a location where g = 9.79 m/s^2. What is its weight at a location where g = 9.83 m/s^2?

(A) 9780 N

(B) 9800 N

(C) 9820 N

(D) 9840 N

19. Calculate the force necessary to accelerate a 900-kg rocket vertically upward at the rate of 30 m/s^2.

(A) 18.2 kN

(B) 22.6 kN

(C) 27.6 kN

(D) 35.8 kN

20. Calculate the weight of a body that occupies 200 m^3 if its specific volume is 10 m3/kg.

(A) 20 N

(B) 92.1 N

(C) 132 N

(D) 196 N

21. The pressure at a point where the gage pressure is 70 cm of water is nearest

(A) 169 kPa

(B) 107 kPa

(C) 69 kPa

(D) 6.9 kPa

22. A bell jar 200 mm in diameter sits on a flat plate and is evacuated until a vacuum of 720 mmHg exists. The local barometer reads 760 mmHg. Estimate the force required to lift the jar off the plate. Neglect the weight of the jar.

(A) 3500 N

(B) 3000 N

(C) 2500 N

(D) 2000 N

23. An object that weighs 4 N traveling at 60 m/s enters a viscous liquid and is essentially brought to rest before it strikes the bottom. What is the increase in internal energy, taking the object and the liquid as the system? Neglect the potential energy change.

(A) 734 J

(B) 782 J

(C) 823 J

(D) 876 J

24. A 1700-kg vehicle traveling at 82 km/h collides head-on with a 1400-kg vehicle traveling at 90 km/h. If they come to rest immediately after impact, determine the increase in internal energy, taking both vehicles as the system.

(A) 655 kJ

(B) 753 kJ

(C) 879 kJ

(D) 932 kJ

الرمز	الكمية		الوحدة *	
			SI	BU
A	Area	المساحة	m^2	ft^2
a	Acceleration	التعجيل	m/s^2	$ft/sec.^2$
C	Velocity	السرعة	m/s	ft/sec.
C	Specific heat	الحرارة النوعية	J/kg.k	Btu/lbm.
D	Diameter	القطر	m	ft
E	Energy	الطاقة	J=N.m	Ft.lb,Btu
F	Force	القوة	$N=kg.m/s^2$	Lb_f=slug.ft/sec 2
g	Local acceleration of grafity	التعجيل الارضي	m/s^2	ft/sec^2
H	Enthalby	الانثالبي	kJ	Btu
h	Specific enthalby	الانثالبي النوعي	kJ/kg	Btu/lbm
J	Mechanical equivalent of heat	المكافئ الميكانيكي للحرارة	kcal=427kg.m	778,2ft.lbf/Btu
M	Molecular weight	الكتلة الجزيئية	kg/kg.mol	Lbm/lbm.mole
m	Mass	الكتلة	kg	Slug,lbm
$\dot{m}$	Mass flow rate	معدل التدفق الكتلي	kg/s	Slug/sec,lbm/sec.
N	Mole	الجزئي		
n	Polytropic index	الاس البولتروبي		
P	Pressure	الضغط	$Pa = N/m^2$	Lb_f/in^2=psi
P	Power	القدرة	W = J/s	Ft.lb/s,h.p
Q	Heat	الحرارة	kJ	Btu
$\dot{Q}$	Heat rate	معدل الحرارة	kJ/s = kW	Btu/sec.
q	Heat per unit	الحرارة لكل وحدة كتلة	kJ/kg	Btu/Lbm

R	Gas Constant	ثابت الغاز	kJ/.kg.K	Btu/ Lb. F
$\overline{R}$	Universal Gas Constant	الثابت العام للغازات	8.314kJ/kmol.K	1545 ft.lbf/mole.R
S	Entropy	الانتروبي	kJ / K	Btu /F
s	Specific Entropy	الانتروبي النوعي	kJ / kg . k	Btu/Lbm.ft
T	Absolute Temperature	درجة الحرارة المطلقة	K	F
T	Torque	العزم	N.m	Lbf . Ft
U	Internal Energy	الطاقة الداخلية	kJ	Btu
u	Specific Internal E .	الطاقة الداخلية النوعية	kJ / kg	Btu / Lbm
V	Volume	الحجم	m^3, Liter	Ft^3
W	Work	الشغل	J= N.m	Ft . Lb
$\dot{W}$	Work Rate	معدل الشغل	kJ/s =kW	Lbf . Ft/s
w	Work per Unit mass	الشغل لكل وحدة كتلة	kJ/kg	Btu / Lbm
X	Displacement.	ازاحة عامة	m	Ft
Z	Hight	الارتفاع	m	Ft

الرمز		الرمز	
α	Alpha	ø	Function , ph
β	Beta	π	النسبة الثابتة (باي)
γ	Gamma, Ratio of Specific heat	d	Differential,(derivative) (مشتق) تفاضل
Δ	Delta فرق محدد	θ	Theta
η	Efficiency , Etta الكفاءة	∫	Integration تكامل
ρ	Density , Rho الكثافة	Σ	Sigma , Summation جمع

التعبير في SI	الوحدة		الابعاد (الكميات الفيزياوية)	
	الحرف الرمزي	الاسم	الحرف الرمزي	الاسم
s	s	الثانية	t	الزمن
10^{-3} m^3	L	اللتر	V	الحجم
kg	kg	الكيلوغرام	m	الكتلة
$kg.m/s^2$	N	النيوتن	F	القوة
N/m^2	Pa	الباسكال	P	الضغط
N.m	J	الجول	E	الطاقة
J/s	W	الواط	P	القدرة
N.m	J	الجول	W	الشغل
N.m	J	الجول	Q	الحرارة

	Quantity الكمية	الرمز	Units			
			SI		English	
A	الوحدات الاساسية					
1.	Length الطول	L	meter	m	foot	ft
2.	Mass الكتلة	m	Kilogram	kg	Slug or pound	Lbm
3.	Time الزمن	t	second	S	second	sec.
4.	Electric current التيار الكهربائي	I	ampere	A	Ampere	A
5.	Absolute Temperature درجة الحرارة المطلقة	T	Kelvin	K	RanKine	°R
6.	Amount of substance كمية المادة			kg-mole	Pound-mole	Lbm-mole