CHAPTER 1

THE INTERNATIONAL SYSTEM : SI UNITS

INTRODUCTION

A metric system which uses the meter, kilogram and second as fundamental units has been adopted around the world. This is known as the SI or international system.

Length in meter	(m)
Mass in kilogram	(kg)
Time in second	(s)

These units are know as fundamental units. It is also referred to as the MKS system.

SCIENTIFIC NOTATION

Scientific notation	Prefix	Symbol
10^{12}	T	tera
10^{9}	G	giga
10^{6}	M	mega
10^{3}	k	kilo
10^{-3}	m	milli
10^{-6}	μ	micro
10^{-9}	n	nano
10^{-12}	p	pico

UNIT OF FORCE

The SI unit of force is the newton (N).

$F = ma$

F = force in newton (N)

m = mass in kilogram (kg)

a = acceleration in meter/second^2 (m/s^2)

If a body is to be accelerated from the earth's surface, the acceleration due to gravity (g) must be overcome. (THIS IS USED WHEN MOVING OVER A VERTICAL DISTANCE)

$g = 9.81 \text{ m/s}^2$

Example: Calculate the force required to lift a 200 kg elevator.

$F = ma$ OR = mg
$= 200 \times 9.81$
$= 1.962$ kN

WORK

Work is done when moving a body over a certain distance.

$W = Fd$
W = work in joule (J)
F = force in newton (N)
d = distance in meter (m)

Example: Calculate the work done in raising the 200 kg elevator through a height of 20 meter.

$W = Fd = mgd$ = mad
$= 200 \times 9.81 \times 20$
$= 39.24$ kJ

ENERGY

Energy is the capacity for doing work. Energy can exist in several forms.

Potential Energy is the energy due to position.

A dam filled with water has the potential for doing work as the water runs to a lower level.

$W = Fh$
$= mgh$

Potential energy, $E_p = mgh$ Joule h = Height in meter (m)

Example:

A dam with the following average dimensions 30 km long, 1.2 km wide and 30 m deep is situated at an average height of 100 m above sea level. Calculate the potential energy of the water.

$W = Fh$ 1 liter water = 1 kg
$= mgh$ 1 liter = 1000 cm^3

A dam with the following average dimensions 30 km long, 1.2 km wide and 30 m deep is situated at an average height of 100 m above sea level. Calculate the potential energy of the water.

$$E_p = m \times g \times h$$

For the mass (m): The length of the dam = 30km
The width of the dam = 1,2km
The depth of the dam = 30m

What can we calculate?

The volume of the dam (in cm^3) = length of the dam x the width of the dam x the depth of the Dam
$= (30 \times 1000 \times 100) \times (1,2 \times 1000 \times 100) \times (30 \times 100)$
$= 1.08 \times 10^{15}\ cm^3$

However, we also know that: 1 litre = 1 kg
and 1 litre = $1000cm^3$

$\Rightarrow \therefore 1kg = 1000cm^3$

Therefore, to get the mass of the dam, we do the following:

The mass of the dam in kg $= \dfrac{\text{the volume of the dam} \times 1\ kg}{1000cm^3}$
$= \dfrac{1.08 \times 10^{15} \times 1kg}{1000cm^3}$
$= 1.08 \times 10^{12}\ kg$

$\Rightarrow \dfrac{1kg}{1000cm^3} = 1$

Finally, we can calculate the potential energy of the water:

$E_p = m \times g \times h$
$= 1.08 \times 10^{12} \times 9.81 \times 100$
$= 1.05948 \times 10^{15}\ J$

$$= \left(\frac{\text{Volume of water in cm}^3}{1000}\right) x\ 1kg\ x\ g\ x\ h$$

$$= \frac{(30x10^3x100)\ x\ (1.2\ x\ 10^3\ x\ 100)\ x\ (30\ x\ 100)}{1000} x1x9.81x100$$

$$= 1.05948 \times 10^{15} J$$

KINETIC ENERGY

It is the energy possessed by a body in motion. When the velocity is increased from ø to v in a time t, its average acceleration is:

	a	=	v/t
and	a	=	acceleration in m/s^2
where	v	=	velocity in m/s (maximum velocity)
and	t	=	time in seconds
Average velocity		=	v/2
Distance travelled		=	(average velocity) x t
	d	=	½vt
	W	=	Fd
		=	mad
		=	m x $\underbrace{v/t}_{\text{acceleration}}$ x $\underbrace{½ vt}_{=\ \text{distance}}$
		=	½ mv^2
Kinetic Energy, E_k		=	½ mv^2 Joule

POWER

P	=	W/t Watt
P	=	Power in watt (W)
W	=	work in joule (J)
t	=	time in seconds (s)

Example: Calculate the power developed by a hydro electric power station if the total mass of water from the dam in the previous example is released within 15 weeks.

P = W/t

$$(1.05948 \times 10^{15}) / (15 \times 7 \times 24 \times 60 \times 60) = 116.79\ MW$$

TEMPERATURE AND HEAT

There are two SI temperature scales. Celsius scale and Kelvin scale.

0°C	=	273.15 K
100°C	=	373.15K
-273.15°C	=	0 K absolute zero temperature

The Kelvin temperature scale is also known as the absolute scale.

To raise 1 liter of water through 1 °C requires an energy input of 4187 J. This is known as the Joules equivalent or the mechanical equivalent of heat.

When water is heated, the container must also be raised to the same temperature. The water equivalent is the quantity of water that will absorb the same amount of energy as the water container when heated through a given temperature change.

Note: The container specifications may also be expressed as the efficiency in percentage. Thus, if an urn has an efficiency of only 80 % , then 20 % of the input power is lost to heat radiation of the surface area of the urn.

Example: Calculate the amount of energy and power to boil 10 litres of water in 15 minutes. The water equivalent of the urn is 0.15 liter. Room temperature is 25 °C.

ENERGY = (Total water) x temp raise x 4 187J [BOILING TEMP OF WATER = 100°C]
= (10 + 0.15) x 75 x 4187
= 3.19 MJ (Total energy input for the urn.)

POWER = Energy/t
= $(3.19 \times 10^6)/(15 \times 60)$
= 3.54 kW

OUTPUT ENERGY = 10 x 75 x 4187 = 3.14 MJ

EFFICIENCY = (Output energy / Input energy) x 100
= (3.14 / 3.19) x 100
= 98 %

CHAPTER 1: SI UNITS:

UNIT	FORMULA	MEASURED IN	SYMBOL
FORCE [F]	$F = m\ a$ where m = mass in kg and a = acceleration in m/s^2	Newtons	N
WORK [W]	$W = F \times d = m \times a \times d$ where F = force in newtons and d = distance in metres	Newton metres / Joules	Nm / J
ENERGY [E] Potential Energy Kinetic Energy	$E = m \times c \times \Delta t$ [FOR TEMPERATURE & HEAT] $E_p = m \times g \times h$ where m = mass in kg g = gravitational acceleration constant h = height in metres $E_k = \frac{1}{2} \times m \times v^2$ $= m \times a \times d$ where m = mass in kg a = acceleration in m/s^2 = v/t d = distance travelled = average velocity x t = v/2 x t = ½vt	Joules	J
POWER [P]	$P = W / t$ Where W = work T = time	Watts	W