Physics_2 : **Elementary Physics of Energy**

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Patterns in our classes will be

- Background and Context.
- Physics Concepts and basic theory of the phenomenon
- Formulas needed and how to use them
- An example or two in detail to understand how we use the formulas.
- HW and exams will be on problem basis,
- Quizzes on concepts
- One midterm
- Final exam
- Attendance quiz: (Unannounced) Your name and major.

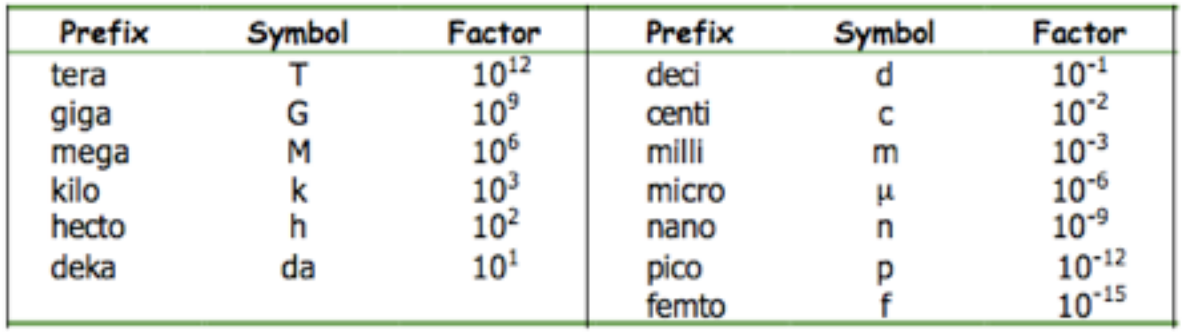
Comments on course are welcome.

- Goals for the first two lectures:
- Numbers and how to represent them in scientific notation:
- Exponential growth, linear growth and quadratic growth examples.
- Units and examples
- Concepts of energy, work done, force and power...
- Forms of energy and their conversion
- Renewable versus non renewable energy

Numbers and scientific notation

Kilo	Mega	Giga	Tera	Peta	Quadrillion		
k	M	G	T	P	Q	Note that Q=P	
$10^{\{3\}}$	$10^{\{6\}}$	$10^{\{9\}}$	$10^{\{12\}}$	$10^{\{15\}}$	$10^{\{15\}}$		

As an example: 1 millimeter = 10^{-3} meter
1 mega Joule = 10^{6} Joule



Prefix	Symbol	Factor	Prefix	Symbol	Factor
tera	T	10^{12}	deci	d	10^{-1}
giga	G	10^{9}	centi	c	10^{-2}
mega	M	10^{6}	milli	m	10^{-3}
kilo	k	10^{3}	micro	μ	10^{-6}
hecto	h	10^{2}	nano	n	10^{-9}
deka	da	10^{1}	pico	p	10^{-12}
			femto	f	10^{-15}

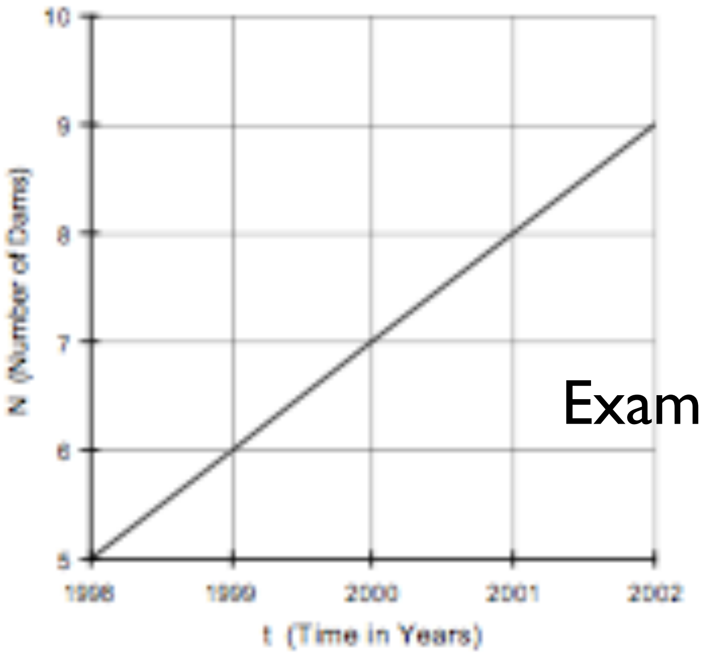
Examples for manipulating with scientific notation by multiplying and dividing numbers and raising to a power

$$\begin{aligned} 10^{-6} \times 10^{-3} &= 10^{-9} \\ \frac{10^{-6}}{10^{-13}} &= 10^{7} \\ (10^{-4})^{2} &= 10^{-8} \end{aligned}$$

Hypothetical examples of linear and exponential growth

Fig. 1.2: Linear Growth of Dams

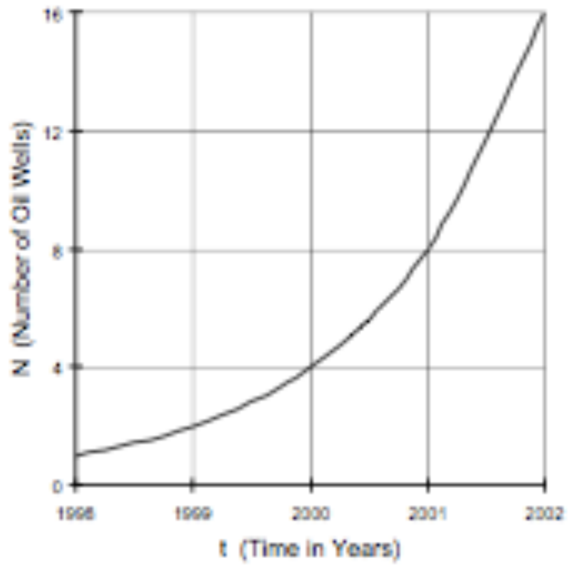
Years	Time Periods	Dams
1998	0	5
1999	1	6
2000	2	7
2001	3	8
2002	4	9



Example of linear growth

Fig. 1.3: Exponential Growth of Oil Wells

Years	Time Periods	Oil Wells	Number of Wells as exponentials
1998	0	1	$1 = 2^0$
1999	1	2	$2 = 2^1$
2000	2	4	$4 = 2^2$
2001	3	8	$8 = 2^3$
2002	4	16	$16 = 2^4$



Example of exponential growth

Key to understanding linear and exponential growth is think of how things change in some small time interval

$N(t) = \text{number of things at time t}$

$\Delta N(t) = \text{ change in number of things between time t and } \Delta t$

$$N(t + \Delta t) = N(t) + \Delta t\ \Delta N(t)$$

Conceptual part.

Here LHS is the number of things at a later time

Provided

$$\Delta N(t) \propto \text{constant}$$

Linear Growth problem

Examples: Saving $$ in the bank

Provided

$$\Delta N(t) = aN(t)$$

Exponential growth problem

Examples: Population Growth of species, Nuclear Fission (will study later)

Growth becomes decay if change the sign of constant.

Units for Energy, Force and Work done Lightning Review of mechanics. MKS and older units (FPS)

(1)

$$[F] = \frac{[M][L]}{[T]^2}$$

$$F = M \times A$$

Relevant Formula

Newtons's law A= acceleration M=mass F=force

Newton= kg meter /second^2

Pound (old units)

(2)

$$[W] = [F][L] = \frac{[M][L]^2}{[T]^2}$$

Relevant Formula

$$Work = Force \times distance$$

Joule = kg meter^2 /second^2

FP = 1ft x 1 lb
(1Foot x 1Pound) (Older Units)

(3)

$$\Delta E = \Delta W$$

Work done on a body results in change of its energy. Same units for energy and work done

(3)

Power= rate of doing work

$$[P] = [W]/[T] = \frac{[M][L]^2}{[T]^3}$$

Watt = Joule/sec

Horsepower (Old units)

1 horsepower = 745.699872 watts

(4) Therefore Energy can be given in two possible ways.

Energy = Force x distance
= Joule or FP

Energy = Power x time
=kWH

	Energy equivalents			
	Conversion table			
		J	kWh	Btu
1 Joule		1	2.78×10^{-7}	9.49×10^{-4}
1 kWh Kilowatt Hour		3.60×10^{6}	1	3413
1 calorie		4.184	1.16×10^{-6}	3.97×10^{-3}
1 British Thermal Unit BTU		1055	2.93×10^{-4}	1
1 ft pound (ft-lb)		1.36	3.78×10^{-7}	1.29×10^{-3}
1 electron volt (eV)		1.60×10^{-19}	4.45×10^{-26}	1.52×10^{-22}
1 Barrel petroleum		6.12×10^{9}	1700	5.8×10^{6}
(42 US Gallon)				

Define the thermal energy units
BTU, Calorie, Joules

(1) Thermal units

New concept is involved.
Example. Cold water is heated to give hot water, this costs energy of a different type from what Newton described.
Heat energy is associated with random motion of particles in a medium

Energy needed to raise 1 gm of water through 1 degree celsius = 1 calorie
(1 Calorie= 1000 calories)

1 calorie = 4.18400 joules

Question: What happens with glycerine instead of water? Or any other material?

First law of thermodynamics:
(Loose statement is enough for our purpose)
Thermal heat is equivalent to mechanical energy.

Energy needed to raise 1 pound of water through 1 degree Farenheight =
1 Btu
(British Thermal unit)

$$1 Btu = 1055 Joules$$

First Example of energy unit conversion

Problem#1 A car running with a 50 HP engine for one hour produces how many Joules of energy?
How many BTU?
Is all of this available for running the car?

To do the conversion, we will need to use energy = power x time .

Solution in detail.
Step (1).
(a) Convert to MKS
Power: 50 HP= 50 x 745.7 watts
=37.285 kW (this is the power in MKS)
(b) Calculate energy in MKS
Energy = power x time
37.285 kWH (that is the unit of energy)
Step (2).
Convert from kWH to Joules using table.
1.34×10^8 Joules
That is a pretty large number in Joules!!
Step (3) Convert to BTU divide by 1055
1.27×10^6 BTu

No much of the energy is lost as waste heat.
This leads us to study the concept of "Efficiency", and what factors govern this important factor.

Some basic ideas regarding different forms of energy and efficiency.

- Efficiency is often given as a % figure. e.g. given that energy.
- Its meaning is clarified by an example: If we say that a heater produces 1400 Watts of heat at 80% efficiency,

it means that only 1120 Watts is actually usable and the rest is lost as waste heat.

Different forms of energy are listed now (read book for more details-)

- Chemical energy: e.g. burning of wood or coal releases chemical energy
- Heat energy: As discussed above heat is another form of energy and can be converted to mechanical energy
- Kinetic energy is familiar in mechanics. Faster particles have more $E = 1/2\ m\ v^2$ energy
- Potential energy is also familiar. A stretched spring has stored energy, as does a ball on a hill relative to that on the ground level.
- Mass energy: This is a great idea (new to many of you) and goes back to Albert Einstein's eqn. $E = M C^2$ Dimensionally this is same as kinetic energy but since C is the velocity of light 3.10^8 meters per second, the values are enormous. This energy is intrinsic, and to release it we need to think of nuclear reactions.
- Electrical energy: Electrical energy is commonplace and we all know it comes from power stations to homes offices and workplaces. We will study in some detail, the sources of the electrical energy (power stations, hydroelectric, nuclear etc) in this course.
- Sunlight: This is the "mother of all energies" and made life on earth possible- treated as divine in old civilizations. Today it remains the one great relatively untapped source and our future depends on how e use this. Technically this is called electromagnetic radiation.