BSP1153
Mechanics & Thermodynamics
Physics & measurement

by
Dr. Farah Hanani bt Zulkifli

Faculty of Industrial Sciences & Technology
farahhanani@ump.edu.my

Chapter Description

- Expected Outcomes
  - To resolve physical quantity and international systems of measurement
  - To perform the dimensional analysis
  - To solve problems involving unit conversion

- References
  - Young, H.D. & Freeman, R.A. University Physics with Modern Physics (14th Ed.) Pearson, 2015
  - University physics with modern physics / Wolfgang Bauer, Gary D. Westfall, Mc Graw Hill, 2014
  - Paul E. Tippens, Physics 7th Edition. Mc Graw Hill, 2013
  - Physics for scientists and engineers : a strategic approach / Randall D. Knight, Boston, MA : Pearson, 2013
  - Giancoli, D.C. Physics for Scientists and Engineers: with Modern Physics (4th Edition). Pearson Prentice Hall, 2013

Content #1

1.1 Units, Standard and SI Systems

- 1.1.1 Standard of length, mass and ti

- 1.1.2 Unit Prefix

1.2 Dimensional Analysis

1.3 Unit Conversions

1.4 Significant figures

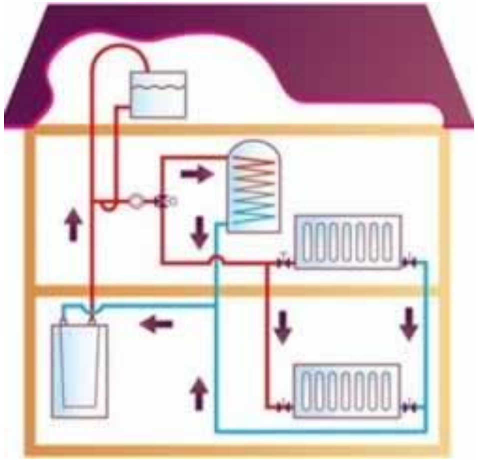
What is Physics?

Physics is one of the most fundamental of sciences involving the observation of the phenomena in nature such as;

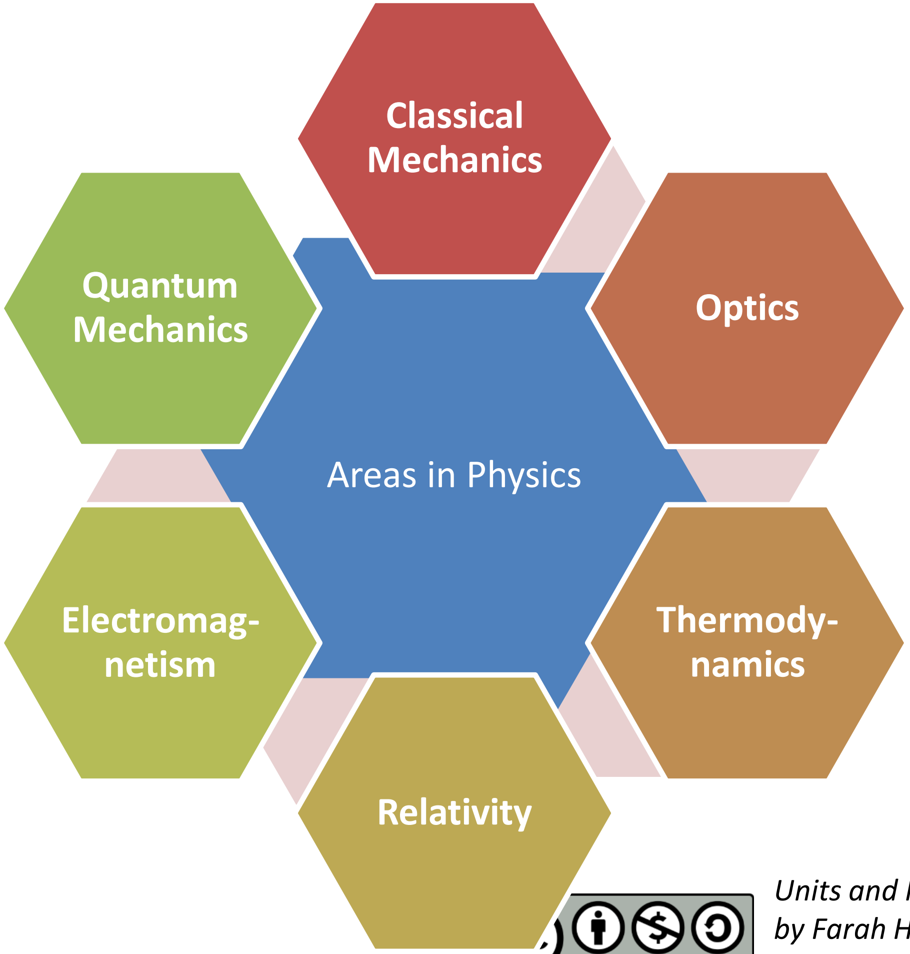
- Ball falling from the top of building
- Two cars collide each other
- A boy is climbing a ladder

Structure design

Medical imaging systems



Heating System


Classical Mechanics
Quantum Mechanics
Optics
Areas in Physics
Electromag- netism
Thermody- namics
Relativity

Physical quantity

- Any number that is used to describe a physical (e.g. object) phenomenon (e.g. weight, height, distances) quantitatively.
- The measurement of any **QUANTITY** is made relative to a particular standard or unit.
- **UNIT** (e.g., meter, kilogram, hour) is used as a standard for measurement of the same physical quantity.

Physical quantities must includes:

- symbol
- number value
- units of measurement

For example:

Height of Ahmad, **H** is **1.40 m**. Therefore,

H represents the symbol

1.40 represents the number value

m represents the unit

Standards and units

International system of units (S.I)

- Formerly known as "metric system".
- The most common unit used by scientists and engineers around the world.
- 1960 - known as International System.

Quantity	SI unit
Length	meter
Mass	kilogram
Time	second
Temperature	Kelvin
Electric current	Ampere
Luminous Intensity	Candela
Amount of substance	mole

Unit prefix

- ✓ Refer to the powers of 10.
- ✓ Usually express multiples of **10** or **1/10** in **exponential notation**.
- ✓ Each prefix has a **specific name** and **abbreviation**.

E.g., 1 000 000 = 10^6 (**mega**, M)

1/1 000 000 = 10^{-6} (**micro**, m)

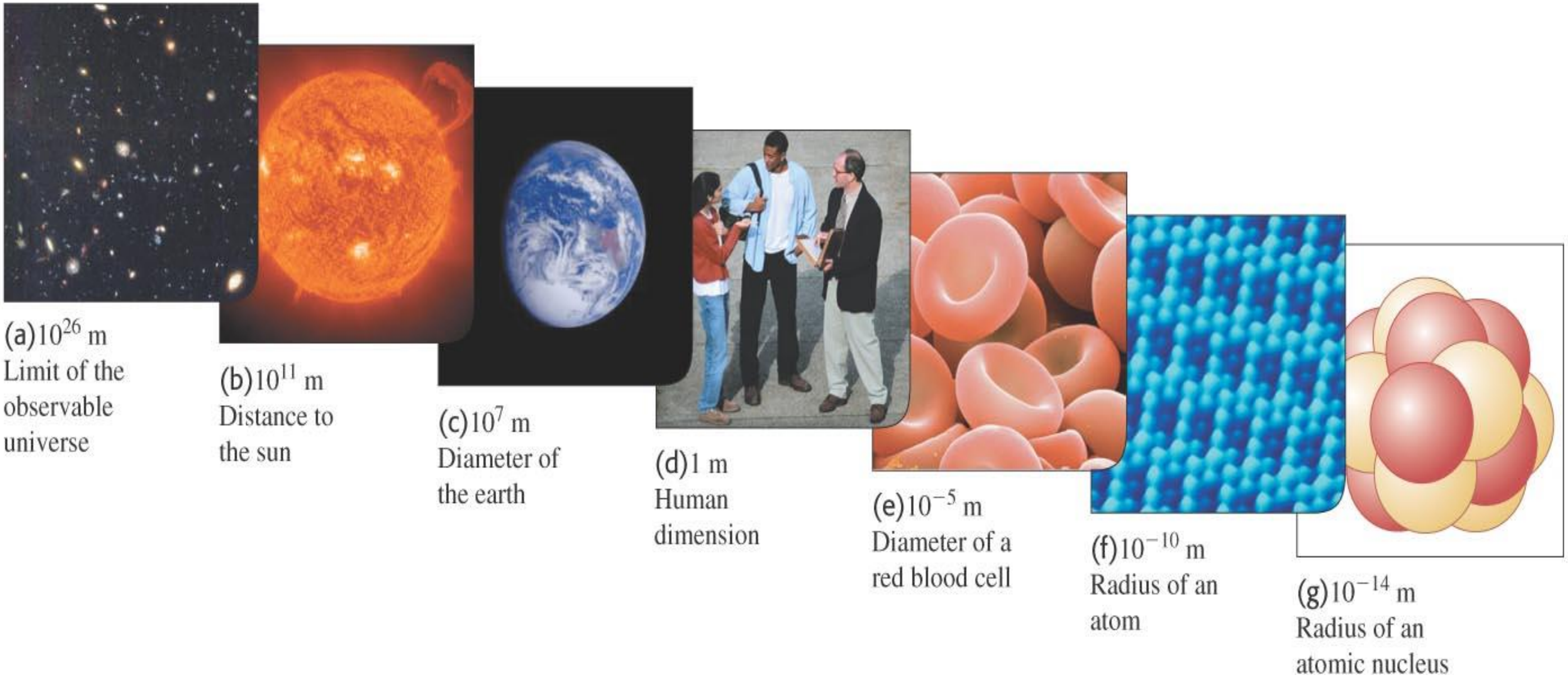
- ✓ In physics, it is usually used with any basic units.

E.g. **kilometer**, **mililiter**

TABLE 1–4 Metric (SI) Prefixes

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

† μ is the Greek letter "mu."



(a) 10^{26} m
Limit of the observable universe
(b) 10^{11} m
Distance to the sun
(c) 10^{7} m
Diameter of the earth
(d) 1 m
Human dimension
(e) 10^{-5} m
Diameter of a red blood cell
(f) 10^{-10} m
Radius of an atom
(g) 10^{-14} m
Radius of an atomic nucleus

Base quantities

There are three (3) fundamental basic quantities used in physics:

<u>Length</u> SI Unit - Meter, m

- What? - Distance between two points in space.

<u>Mass</u> (SI Unit - kilogram, kg)

- What? How heavy the object w/o considered the gravity.

<u>Time</u> (SI unit – second, s)

- What?

Quantity	Unit	Unit Abbreviation
Length	meter	m
Time	second	s
Mass	kilogram	kg
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Derived quantities

- Quantities that can be prompted from various of basic quantities.
- E.g., pressure, density, area,

Dimensional Analysis

- Technique to ensure the equation is expressed correctly.
- Dimensions :
  - Includes → **Length [L], Mass [M], Time [T].**
  - denoted with square brackets.
  - can be treated as algebraic quantities.
  - **must have the same dimensions for both sides of equation.**

Continued…

– is not a **<u>CONSTANT</u>**.
– can have many actual units. e.g.: dimension of area always $[L^2]$: the unit can be m^2, ft^2, cm^2 and so on.
– are remain same even though the formula for a quantity is different.

e.g. : area of a triangle of base b and height h is $A = ½\, bh$, whereas area of circle is πr^2. Their dimensions are always $[L^2]$.

Does $x = ½ at^2$ is a correct expressions?

First: Confirm the dimensions on both LHS and RHS.

$$L = \frac{L}{T^2} \cdot T^2 = L$$

Second: If the T^2's cancel, the left hand side (LHS) equation will leave L at the equation.

Third: So, Left Hand side (LHS) = Right Hand Side (RHS)

Conclusion: Equation is dimensionally correct.

Unit Conversion

- In a several situation, when the units are not constant, it can be converted to a same unit.

  E.g., 1 m = 39.37 in. = 3.281 ft.

  1 in. = 0.0254 m = 2.54 cm

- Remember!!
  - Units can be treated as algebraic quantity.
  - Units can also being cancel each other out.
  - You are advised to carry the units through the entire calculation. **MUST!!**

E.g., Find the length of 10.0 inch ruler in cm.
Knowing that 1 in. = 2.54 cm

$$10.0\,\text{in.} = ?\,\text{cm}$$

$$10.0\,\text{in.} = \left(\frac{2.54\text{cm}}{1.0\text{in.}}\right) = 25.4\text{cm}$$

Find the distance of the 1.00 mile travelling when it expressed in km.

if 1 mile = 1609m , 1 km = 1000 m

Answer : 1.61 km

Conversion Factors

Length

	m	cm	km	in.	ft	mi
1 meter	1	10^2	10^{-3}	39.37	3.281	6.214×10^{-4}
1 centimeter	10^{-2}	1	10^{-5}	0.393 7	3.281×10^{-2}	6.214×10^{-6}
1 kilometer	10^3	10^5	1	3.937×10^4	3.281×10^3	0.621 4
1 inch	2.540×10^{-2}	2.540	2.540×10^{-5}	1	8.333×10^{-2}	1.578×10^{-5}
1 foot	0.304 8	30.48	3.048×10^{-4}	12	1	1.894×10^{-4}
1 mile	1 609	1.609×10^5	1.609	6.336×10^4	5 280	1

Mass

	kg	g	slug	u
1 kilogram	1	10^3	6.852×10^{-2}	6.024×10^{26}
1 gram	10^{-3}	1	6.852×10^{-5}	6.024×10^{23}
1 slug	14.59	1.459×10^4	1	8.789×10^{27}
1 atomic mass unit	1.660×10^{-27}	1.660×10^{-24}	1.137×10^{-28}	1

Note: 1 metric ton = 1 000 kg.

Time

	s	min	h	day	yr
1 second	1	1.667×10^{-2}	2.778×10^{-4}	1.157×10^{-5}	3.169×10^{-8}
1 minute	60	1	1.667×10^{-2}	6.994×10^{-4}	1.901×10^{-6}
1 hour	3 600	60	1	4.167×10^{-2}	1.141×10^{-4}
1 day	8.640×10^4	1 440	24	1	2.738×10^{-5}
1 year	3.156×10^7	5.259×10^5	8.766×10^3	365.2	1

Speed

	m/s	cm/s	ft/s	mi/h
1 meter per second	1	10^2	3.281	2.237
1 centimeter per second	10^{-2}	1	3.281×10^{-2}	2.237×10^{-2}
1 foot per second	0.304 8	30.48	1	0.681 8
1 mile per hour	0.447 0	44.70	1.467	1

Note: 1 mi/min = 60 mi/h = 88 ft/s.

Force

	N	lb
1 newton	1	0.224 8
1 pound	4.448	1

continued

Work, Energy, Heat

	J	ft · lb	eV
1 joule	1	0.737 6	6.242×10^{18}
1 foot-pound	1.356	1	8.464×10^{18}
1 electron volt	1.602×10^{-19}	1.182×10^{-19}	1
1 calorie	4.186	3.087	2.613×10^{19}
1 British thermal unit	1.055×10^3	7.779×10^2	6.585×10^{21}
1 kilowatt hour	3.600×10^6	2.655×10^6	2.247×10^{25}

	cal	Btu	kWh
1 joule	0.238 9	9.481×10^{-4}	2.778×10^{-7}
1 foot-pound	0.323 9	1.285×10^{-3}	3.766×10^{-7}
1 electron volt	3.827×10^{-20}	1.519×10^{-22}	4.450×10^{-26}
1 calorie	1	3.968×10^{-3}	1.163×10^{-6}
1 British thermal unit	2.520×10^2	1	2.930×10^{-4}
1 kilowatt hour	8.601×10^5	3.413×10^2	1

See You in Chapter 2