READ Ch 1 1.1-1.6
1.7 (omit ex 1.1
1.8
1.9 (up to 1.1
NOTE 1.1

I. Systems of Measures

Brit. system

mile - 1000 standard paces (l-r-l) of a Roman legion (milia)

yard - nose to outstretched fingers

foot - size 12 shoe - Did the olde English have big feet?

inch - last joint of thumb

Metric system developed in France, imposed on much of world by Napoleon

meter ≈ 1 yard subdivided into $\frac{1}{100}$ (centi) etc.

gram = mass of 1 cm^3 of H_2O

second - time difficult orig based on rot'n of earth (day) hard to subdivide naturally.

meter - $1/10^7$ polar circumference of earth (Barcelona - Dunkirk)

Pt-Ir bar in Int Bur. Wts Measures Sèvres France 1889

$1,650,763.73 \times \lambda$ (Kr^{86} orange red) 196

Now defined in terms of speed of light

gram - 1 cm^3 H_2O @ 4°C

mass of Pt-Ir bar

sec - Cs^{133} 9,192,631,770 cycles of hyperfine transition

2

	LENGTH	MASS	TIME	FORCE	ENERGY	CHARGE
SI (mks)	meter	kilogram	second	Newton $1\,kg\,m\,s^{-2}$	JOULE	Later
cgs	centimeter	gram	second	dyne $1\,g\,cm\,s^{-2}$	erg	
British	foot	pound (slug)	second	(poundal) pound	BTU	

Conversions:

1 mi = 1.6 km

1g = 27g

$1\ m = 100\ cm = 3.281\ ft = 39.37\ in$

$1\ kg = 1000\ g = 2.205\ lb \qquad 1\ lb = 434\ g = 0.434\ kg$

II Units / Dimensional Analysis

Keep track of units! dimensions often prove invaluable in keeping track of complex problems (and sometimes making order of magnitude estimates)

How many seconds in a year?

$$1\ \text{year} = 1\ \cancel{\text{year}} \times 365 \frac{\cancel{\text{days}}}{\cancel{\text{year}}} \times 24 \frac{\cancel{\text{hours}}}{\cancel{\text{day}}} \times 60 \frac{\cancel{\text{min}}}{\cancel{\text{hour}}} \times 60 \frac{\text{sec}}{\cancel{\text{min}}}$$

$$= 3.15 \times 10^7\ \text{sec} \quad (\simeq \pi \times 10^7 \text{ easy to remember})$$

Always carry dimensions through

Ex: Driving from S.D. to Pasadena, distance 100 miles is traversed in 90 min (ha!) What is average speed? Should I get a ticket

$$\bar{v} = \frac{\Delta d}{\Delta t} = \frac{100\ mi}{90\ min \times \frac{hr}{60\ min}}$$

$$\bar{v} = \frac{100\ (60)}{90} \frac{mi}{\frac{\cancel{min}}{\cancel{min}}\ hr} = 66.7\ \text{miles/hr}$$

nb. $100\ mi / (90\ min \cdot 60\ min/hr) = .0185\ \frac{mi\ hr}{min^2}$ MAKES NO SENSE

III Order of Magnitude Estimates

A. What is the mass of the Galaxy?

The Milky Way galaxy consists of approx 100 billion stars

The sun, a typical star, has a mass of

$$2 \times 10^{33} \text{ grams} = 2 \times 10^{30} \text{ kg}$$

$$M_{Gal} \approx 1 \times 10^{11} \cancel{\text{stars}} \times 2 \times 10^{30} \text{ kg}/\cancel{\text{star}}$$

$$\approx 2 \times 10^{41} \text{ kg}$$

Each H atom has a mass $m_H = 1.67 \times 10^{-27}$ kg so that there are approx (considering that most of Universe is hydrogen)

$$n = \frac{2 \times 10^{41} \text{ kg}}{1.67 \times 10^{-27} \text{ kg/atom}} \approx 10^{68} \text{ atoms in MW}$$

B. What is the angular size of the space shuttle in the sky

$$l \sim 20 \text{ people lengths} \times 2 \text{ m/person} \approx 40 \text{ m}$$

$$d \sim 100 \text{ miles} \times 1.6 \text{ km/mile} \approx 1.6 \times 10^2 \times 10^3$$

(low earth orbit)

$$\theta \approx \frac{l}{d} = \frac{4 \times 10^1 \text{ m}}{1.6 \times 10^5 \text{ m}} = 2.5 \times 10^{-4} \text{ radians} \quad \left(2 \times 10^5 \frac{\text{sec}}{\text{rad}}\right)$$

[recall 57° per radian]

$$= 50 \text{ arcsec}$$

$$\approx 1 \text{ arc min}$$

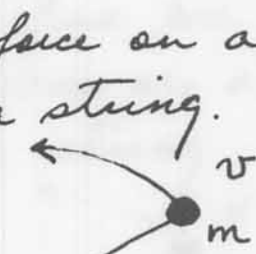
IV Dimensional Analysis

This technique can prove very powerful in simple physical arguments and has varying degrees of sophistication. Simply consider

<u>Force</u> units $1\ N$ (newton) $= 1\ kg\,m\,s^{-2}$

$\vec{F} = m\,\vec{a}$ we can write MLT^{-2}

There are various kinds of forces consider the force on a mass rotating ~~ar~~ at the end of a string. What can the force depend upon



1) mass - larger mass has more force M
2) velocity - larger $\vec{v} \Rightarrow$ greater force LT^{-1}
3) radius - larger $r \Rightarrow$ smaller force L

We want dimensions MLT^{-2}. What quantities can we construct w/ available quantities

$$F_{cent} = \frac{m^{\alpha}\, v^{\beta}}{r^{\gamma}}$$

try $\alpha = 1$ want $\frac{v^{\beta}}{r^{\gamma}} \Rightarrow LT^{-2}$; v is the only quantity which has time that yields $\beta = 2$. In order to get L^{+1} need $\gamma = 1$

$$F_{cent} = \frac{m v^2}{r}$$

We cannot rule out some constant, but in fact (as we shall see) this is the correct law.