

## STANDARDS AND UNITS - CH 1

PHYSICS - STUDY OF NATURE BY ASKING THE QUESTION "WHY?"

WHY DO OBJECTS FALL?

WHY DO ATOMS FORM MOLECULES?

PHYSICS IS THE FUNDAMENTAL SCIENCE → IT IS THE BASIS FOR ALL OTHER SCIENCES.

ENGINEERS → TAKE GRAVITY INTO ACCOUNT WHEN DESIGNING AN AIRPLANE BUT AREN'T CONCERNED WHY IT HAPPENS

CHEMISTS → PREDICT WHAT TYPE AND IN WHAT QUANTITY MOLECULES CAN BE CREATED.

TO ANSWER THE QUESTION "WHY", WE USE SCIENTIFIC METHOD

↓  
GALILEO & FRANCIS BACON (1500)

### STEPS

- ① LOOK FOR SIMPLEST UNDERLYING LAWS OF NATURE → ALG OR HYPO
- ② MODEL THESE LAWS MATHEMATICALLY
- ③ MAKE PREDICTIONS FROM THE MATHEMATICS
- ④ TEST THESE PREDICTIONS EXPERIMENTALLY
- ⑤ IF PREDICTIONS ARE FOUND FALSE → START OVER  
IF PREDICTIONS ARE VERIFIED → ACCEPT AS TRUE

ALL CONCEPTS COVERED IN CLASS HAVE BEEN REPEATEDLY EXPERIMENTALLY VERIFIED

①

UNITS → TO COMPARE ~~DIFFERENTLY MEASURED~~ PHYSICAL QUANTITIES, EVERYONE MUST USE THE SAME SYSTEM OF UNITS.

PHYSICS USES THE S.I. SYSTEM (Système International)

UNIT OF POSITION = Meter (m)

MASS = Kilogram (kg)

TIME = SECOND (s)

OTHER UNITS ARE SOME COMBINATION OF m, kg, AND s.

PREFIXES → S.I. USES MULTIPLIERS TO AID WITH VERBAL COMMUNICATION.

e.g. Kilo = K = MULTIPLY BY 1000

$$2.5 \text{ Km} = 2.5 \text{ Kilometer} = 2.5 \times 1000 \text{ m} = 2500 \text{ m}$$

$$3.6 \text{ Ks} = 3.6 \times 1000 \text{ s} = 3600 \text{ s} = 1 \text{ hour}$$

COMMON PREFIXES:

$$\text{Kilo (K)} = 1000 = 10^3$$

$$\text{Mega (M)} = 1,000,000 = 10^6$$

$$\text{Giga (G)} = 1,000,000,000 = 10^9$$

$$\text{Centi (c)} = .01 = 10^{-2}$$

$$\text{Milli (m)} = .001 = 10^{-3}$$

$$\text{Micro (\mu)} = .000001 = 10^{-6}$$

$$\text{Nano (n)} = .000000001 = 10^{-9}$$

[ $\mu$  = Greek letter, mu]

## Scientific Notation

To Express VERY LARGE OR SMALL NUMBERS,  
WE USE SCIENTIFIC NOTATION.

13 500 000 000 000 m ← too large

to write!  
(usually)

$$= 1.35 \times 10^{16} \text{ m}$$

↑              ↗  
Number Between      TEN RAISED TO A POWER.  
1 AND 10      THE POWER IS # OF PLACES TO  
                    SHIFT DECIMAL

slightly EASIER EXAMPLE    13 500.m =  $1.35 \times 10^4$  m

SMALL NUMBERS  $\Rightarrow$  NEGATIVE EXPONENTS     $\underbrace{.000\ 000\ 7}_{1\ 2\ 3\ 4\ 5\ 6\ 7} \text{ s} = 7 \times 10^{-7} \text{ s}$

NOTE: THERE IS ALSO "ENGINEERING NOTATION" WHICH USES POWERS WHICH ARE MULTIPLES OF 3 ONLY.

$$13 500 \text{ m} = 13.5 \times 10^3 \text{ m} = 13.5 \text{ km}$$

$$.000\ 000\ 7 \text{ s} = .7 \times 10^{-6} \text{ s} = .7 \mu\text{s}$$

## MOTION

MECHANICS - STUDY OF HOW AND WHY OBJECTS MOVE

KINEMATICS - MOTION W/OUT REGARD TO HOW IT'S CAUSED

ONE-DIMENSION - STRAIGHT LINE MOTION. OBJECT CAN ONLY GO LEFT/RIGHT OR UP/DOWN.

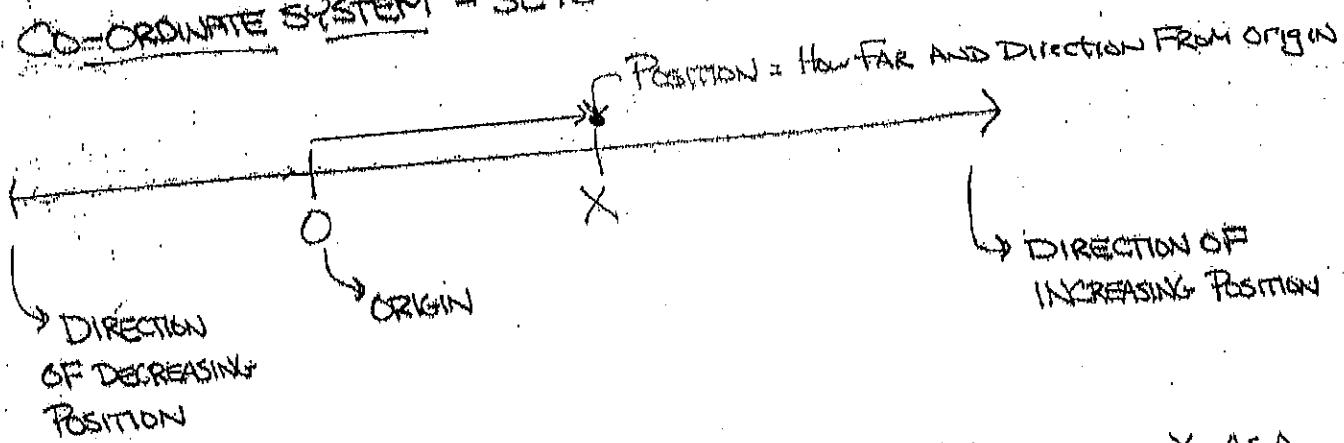
TO DESCRIBE MOTION COMPLETELY, WE NEED TO KNOW:

- ① WHERE THE MOVING OBJECT IS LOCATED AT EVERY TIME  $\rightarrow$  POSITION
- ② DIRECTION OF THE MOVING OBJECT AT EVERY TIME  $\left.\right\}$  VELOCITY
- ③ HOW FAST THE MOVING OBJECT IS GOING AT EVERY TIME

Position - LOCATION.

TO MEASURE POSITION, WE SET UP A CO-ORDINATE SYSTEM.

CO-ORDINATE SYSTEM - SETS SCALE AND DIRECTION



POSITION - LOCATION ON AXIS. IN KINEMATICS, WE WANT X AS A FUNCTION OF TIME. FOR NOW IT SUFFICES TO TREAT MOVING OBJECTS AS A PARTICLE = SINGLE POINT  $\Rightarrow$  SINGLE NUMBER TO SPECIFY POSITION.

(4)

# Velocity → How fast AND DIRECTION of motion

FASTER OBJECTS TRAVEL FARTHER THAN SLOWER ONES

IN A GIVEN PERIOD OF TIME; THEREFORE, WE Define  
How fast = SPEED AS

Speed =  $\frac{\text{distance}}{\text{elapsed time}}$  ← TECHNICALLY THIS IS THE  
AVERAGE SPEED. WE'LL  
BE MORE CAREFUL IN CHAPTER 2.

Unit: WHEN WE MULTIPLY OR DIVIDE UNITS, WE MAKE A NEW COMPOUND  
UNIT. WE CAN USE ANY DISTANCE AND TIME COMBINATIONS IN SPEED. ~~OR~~ Velocity  
Typically, we'll use  $m/s$  = meters per second.

TO INCLUDE INFORMATION ABOUT DIRECTION, WE SIMPLY USE DISPLACEMENT  
INSTEAD OF DISTANCE.

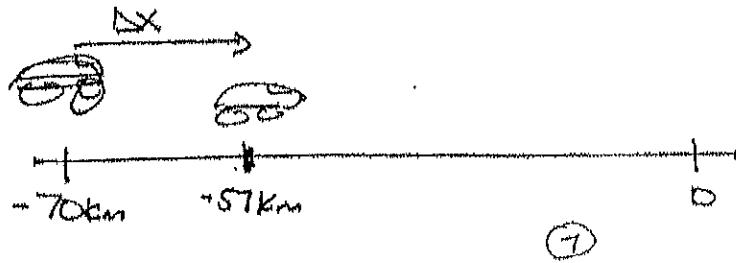
Velocity,

$$V = \frac{\text{displacement}}{\text{elapsed time}} = \frac{\Delta X}{\Delta t}$$

Elapsed time:  
 $\Delta t = t_2 - t_1$

Example: A CAR TRAVELS FROM  $X = -70\text{ km}$  TO  $X = -57\text{ km}$

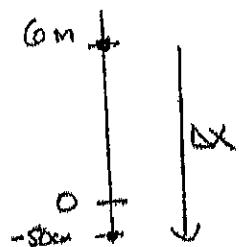
IN 7 MINUTES. WHAT IS THE CAR'S VELOCITY?



$$X_1 = -70\text{ km}, X_2 = -57\text{ km}$$

$$\begin{aligned} \Delta X &= -57\text{ km} - (-70\text{ km}) \\ &= -57\text{ km} + 70\text{ km} = 13\text{ km} \end{aligned}$$

Example: The Bird, 6m above the ground, swoops down to get worm which is 50cm below ground. What is Bird's displacement?



$$x_1 = 6\text{m}, x_2 = -50\text{cm}$$

To add or subtract, quantities must have  
same unit.

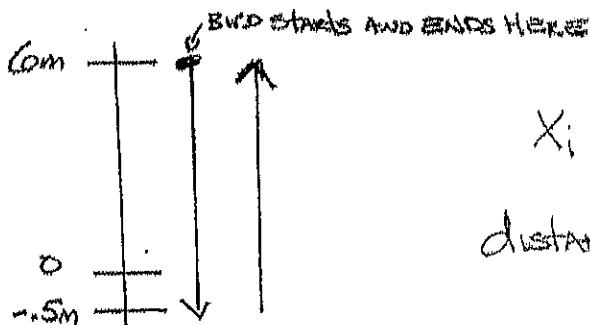
$$50\text{cm} = 50 \times .01\text{m} = .5\text{m}$$

$$\Rightarrow x_2 = -.5\text{m}$$

$$\Delta x = x_2 - x_1 = -.5\text{m} - 6\text{m} = -6.5\text{m} = 6.5\text{m, downward}$$

Distance:  $\rightarrow$  Always positive number which gives how far an object has traveled

Example: After getting the worm, the bird flies straight back up to its original position (6m above ground). For the down and back total motion, what is the bird's displacement and distance covered?



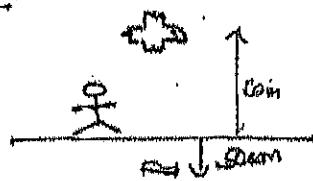
$$x_1 = 6\text{m}, x_2 = 6\text{m} \Rightarrow \Delta x = 0$$

$$\text{distance} = 6.5\text{m} + 6.5\text{m} = 13\text{m}$$

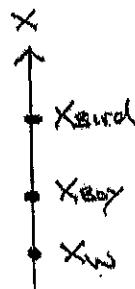
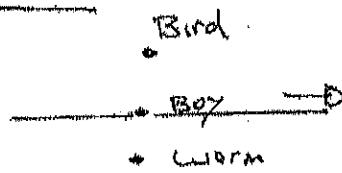
For straight-line motion, direction can be indicated by positive or negative values. Usual convention (but not necessary) is Right = Positive, Left = Negative, and Up = Positive, Down = Negative.

Example: A bird, flying 6m above the ground, is watched by a boy on the ground and by a worm which is 50cm below the ground. Find the position of all 3.

Pictures:



PARTICLE MODEL:



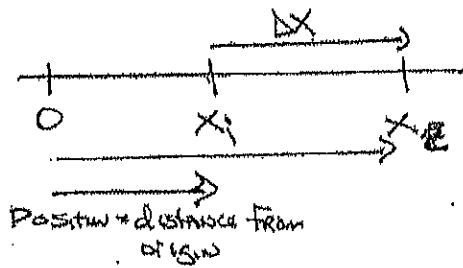
If we set origin at ground,  $\Rightarrow$  at the boy

$$x_{\text{boy}} = 0, x_{\text{bird}} = 6\text{m}, x_{\text{worm}} = -50\text{cm}$$

Moving objects change their position, so we introduce Displacement

DISPLACEMENT  $\rightarrow$  Change in position =  $\Delta x \rightarrow$  "Delta x"

(Starting) Initial Position =  $x_1$ , Final Position =  $x_2$



$$\Delta x = x_2 - x_1$$

⑤

Note:  $\Delta = \text{CHANGE IN} = \text{FINAL} - \text{INITIAL}$

NOTE:  $\Delta x = +13 \text{ km} \Rightarrow$  positive velocity because car is moving to the right. Remember, velocity gives direction of motion.

$$\Delta t = 7 \text{ min}$$

$$V = \frac{\Delta x}{\Delta t} \Rightarrow V = \frac{13 \text{ km}}{7 \text{ min}} = 1.857142857 \text{ km/min}$$

TOO MANY DIGITS IN ANSWER! WE ROUND BASED ON # OF SIG FIGS (SIGNIFICANT FIGURES).

SIGNIFICANT FIGURES — Expresses the precision of a measurement

$13 \text{ km} \rightarrow 2 \text{ sig fig}$  since THE TWO DIGITS ARE RELIABLY KNOWN

$7 \text{ min} \rightarrow 1 \text{ sig fig}$  since only one digit known

WHEN MULTIPLYING OR DIVIDING, WE ROUND TO THE FEWEST # OF

SIG FIG  $\Rightarrow \frac{13 \text{ km}}{7 \text{ min}} = 2 \text{ km/min}$

WHEN ADDING OR SUBTRACTING, WE ROUND TO THE FEWEST PLACES PAST DECIMAL.

$$\begin{array}{r} 4.5 \text{ kg} \\ + 5.66 \text{ kg} \\ \hline 10.16 \text{ kg} \rightarrow 10.2 \text{ kg} \end{array}$$

(8)

EXCEPTIONS: ① STRINGS OF ZEROS AT THE END OF  
LARGE NUMBERS OR AT THE BEGINNING OF SMALL NUMBERS  
ARE NOT SIGNIFICANT.

$$13\text{ Km} = 13 \times 1000\text{ m} = 13,000\text{ m} \leftarrow \begin{array}{l} \text{\# of sig figs hasn't} \\ \text{changed by changing} \\ \text{unit} \Rightarrow \text{still 2 sig fig} \end{array}$$
$$5\text{ m} = .00005\text{ m} \leftarrow 1 \text{ sig fig.}$$

② ZEROS AT THE END OF ALL NUMBERS ARE SIGNIFICANT.

$$13.0\text{ Km} \leftarrow 3 \text{ sig fig}$$

$$.000050\text{ m} \leftarrow 2 \text{ sig fig}$$

$$\frac{13.0\text{ km}}{7.00\text{ min}} = 1.86\text{ km/min}$$

(NOTE: I will not usually take  
the time to write #'s to 3 sig  
figs, but that's what we'll ~~assume~~  
assume in calculations)

### UNIT CONVERSION

EXAMPLE: A CAR WITH CONSTANT VELOCITY OF 1.86 Km/min

WILL TRAVEL HOW FAR IN 1 hour?

$$V = 1.86\text{ Km/min}, \Delta t = 1 \text{ hour}, \Delta x = ?$$

$$V = \frac{\Delta x}{\Delta t} \Rightarrow \Delta x = V(\Delta t) = 1.86 \frac{\text{km}}{\text{min}} (1 \text{ hour}) \leftarrow \begin{array}{l} \text{WRONG UNITS!} \\ \text{*} \end{array}$$

④

$$1 \text{ hour} = 60 \text{ min}$$

$$\Rightarrow \Delta x = 1.86 \frac{\text{Km}}{\text{min}} \times 60 \text{ min} \xrightarrow{(11.6)} = 112 \frac{\text{Km} \cdot \cancel{\text{min}}}{\cancel{\text{min}}} = 112 \text{ Km}$$

This CANCELING OF UNITS, MAKES CONVERSIONS Simple.

Example: Convert 1.86 km/min to mi/h (miles per hour).

$$\text{Use } 1.00 \text{ mi} = 1.609 \text{ km} \text{ AND } 1 \text{ h} = 60 \text{ min}$$

$$1.00 \text{ mi} = 1.609 \text{ km} \Rightarrow \frac{1.00 \text{ mi}}{1.609 \text{ km}} = 1. \quad 1 \text{ h} = 60 \text{ min} \Rightarrow \frac{60 \text{ min}}{1 \text{ h}} = 1$$

$$1.86 \frac{\text{Km}}{\text{min}} \times \frac{1.00 \text{ mi}}{1.609 \text{ km}} \times \frac{60 \text{ min}}{1 \text{ h}} = 69.4 \text{ mi/h}$$

↑  
Wrote original  
QUANTITY  
GIVEN

↑ ↑  
Multiplying by 1  
DOES NOT CHANGE  
QUANTITY, BUT DOES  
CHANGE UNIT.