Why?

- ***US Food and Drug Admnistration***

Make No Mistake: Medical Errors Can Be Deadly Serious

The American Hospital Association lists these as some common types of medication errors:

- incomplete patient information
- unavailable drug information
- miscommunication of drug orders, which can involve poor handwriting, confusion between drugs with similar names, misuse of zeroes and decimal points, confusion of metric and other dosing units, and inappropriate abbreviations

example

….In a similar case, a mother gave her 2-year-old son four teaspoons of children's acetaminophen elixir because the label said to give one dose. Thinking that the dose cup held only one dose, she gave him an entire dose cup. Again, although it was more medication than he needed, it was not an overdose. The last case has a different twist to it: a mother gave her 5- year-old son Dimetapp® elixir, but she mistakenly used the dose cup from another medication. She gave him three teaspoons instead of one teaspoon, which was just shy of an overdose. Dose cups seem to create more problems for the convenience they offer. We recommend that you keep the dose cup together with the OTC medications it came with because there is no standard size or markings for dose cups. You can also ask your pharmacist for an oral syringe, which is even more accurate.

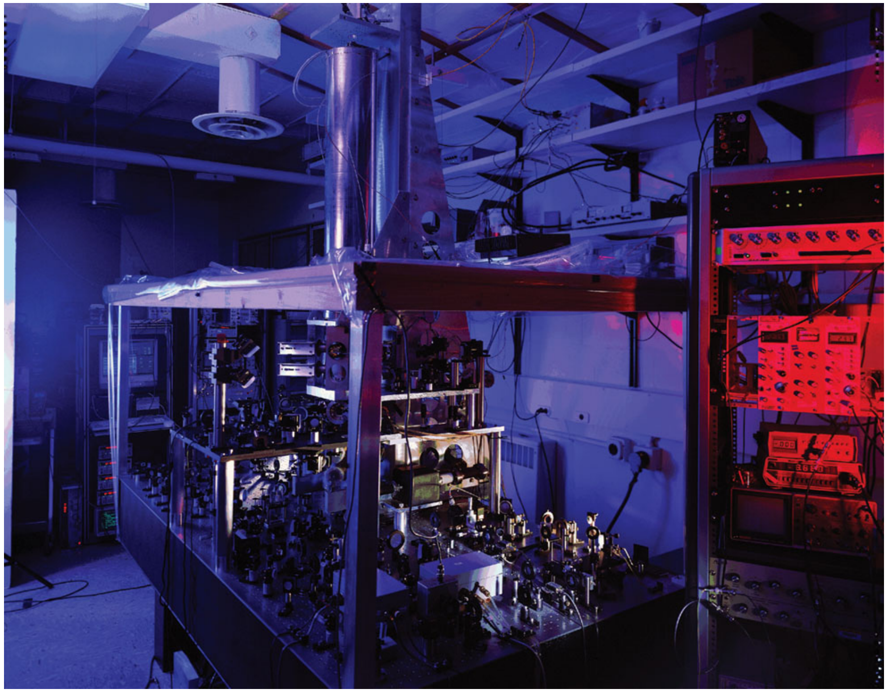
- Source: The Institute for safe medical practices (ISMP)

What is a meter?

- Early 18th Century:
  - Length of pendulum with half period of 1s
  - Distance from N-pole to Equator via Paris /10^7
- 1791: second was chosen and in 1874 Alloy was made
- 1889: more precise by using Platinum/Iridium Alloy
- 1960: Using wavelength by using Krypton-86 radiation
- 1983: distance traveled by light in vacuum in 1/299792458 s

What is a second?

- Originally 1/86400 of a mean solar day
- 1960: based on a tropical year
- 1967: 9192631770 periods of radiation corresponding to the transition between two hyperfine states of the ground state of ^{133}Cesium



What is a kilogram?

- End of 18^{th} century: 1 dm^3 of water
- 1889: defined to a Platinum-Iridium weight

Système Internationale (SI)

7 Standard Units: We will use them!!

Quantity	Name	unit
length	meter	m
mass	kilogram	kg
time	second	s
electrical Current	Ampere	A
temperature	Kelvin	K
amount of substance	mole	mol
Luminous intensity	candela	cd

Derived quantities

Examples:

Speed: m/s

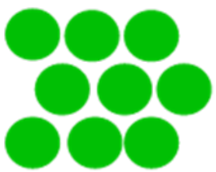
Acceleration: m/s^2

Force: $kg \cdot m/s^2$ (N)

NIST: http://physics.nist.gov/cuu/index.html

Building blocks and scale

~500 nm eye



~1 nm crystal

~0.1 nm atom

~10 fm nucleus

~1 fm nucleon

<0.01 fm quarks/gluons

Prefixes

In addition to mks units, standard prefixes can be used, e.g., cm, mm, μm, nm

TABLE 1.4

Some Prefixes for Powers of 10 Used with "Metric" (SI and cgs) Units

Power	Prefix	Abbreviation
10^{-18}	atto-	a
10^{-15}	femto-	f
10^{-12}	pico-	p
10^{-9}	nano-	n
10^{-6}	micro-	μ
10^{-3}	milli-	m
10^{-2}	centi-	c
10^{-1}	deci-	d
10^{1}	deka-	da
10^{3}	kilo-	k
10^{6}	mega-	M
10^{9}	giga-	G
10^{12}	tera-	T
10^{15}	peta-	P
10^{18}	exa-	E

Our solar system

	in miles	Simplify ($\times 10^7$)
Sun	0 miles	0.0
Mercury	$3.6 \cdot 10^7$	3.6
Venus	$6.7 \cdot 10^7$	6.7
Earth	$9.3 \cdot 10^7$	9.3
Mars	$1.4 \cdot 10^8$	14.1
Jupiter	$4.8 \cdot 10^8$	48.4
Saturn	$8.9 \cdot 10^8$	88.7
Uranus	$1.8 \cdot 10^9$	178.6
Neptune	$2.8 \cdot 10^9$	280.0
Pluto	$3.7 \cdot 10^9$	366.4

Dimensional Analysis

Checking equations with dimensional analysis:

$$x_f - x_i = v_i t + \frac{1}{2} a t^2$$

L

$(L/T)T = L$

$(L/T^2)T^2 = L$

- Each term must have same dimension
- Two variables can not be added if dimensions are different
- Multiplying variables is always fine
- Numbers (e.g. 1/2 or π) are dimensionless

Dimensional Analysis

Dimension should be treated as algebraic quantities!

$x = x_0 + (at^2)/2$ Correct dimensionally?

$[m]=[m]+([m]/[s]^2)[s]^2$... YES!

Think about unit conversions!

X, X_0 in ft. a in m/s^2

$[ft]=[ft]+([m]/[s]^2)[s]^2$... ????

1 m = 3.281 ft

$[ft]=[ft]+([ft]/[s]^2)[s]^2$... YES!

GOOD WAY TO CHECK IN EXAMS & LIFE!!

Example 1

Check the equation for dimensional consistency:

$$mgh = \frac{mc^2}{\sqrt{1-(v/c)^2}} - mc^2$$

Here, *m* is a mass, *g* is an acceleration,
***c* is a velocity, *h* is a length**

Example 2

Consider the equation:

$$m\frac{v^2}{r} = G\frac{Mm}{r^2}$$

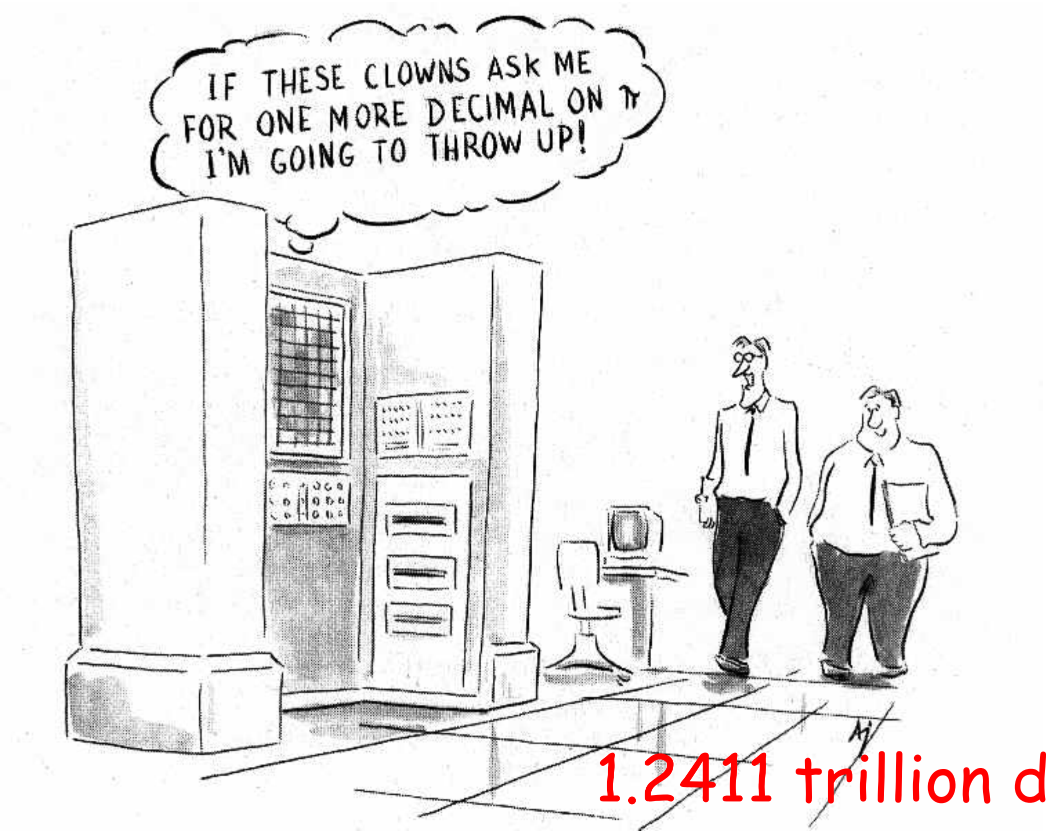
Where *m* and *M* are masses, *r* is a radius and *v* is a velocity.
What are the dimensions of *G* ?

$L^3/(MT^2)$

Units vs. Dimensions

- Dimensions: L, T, M, L/T …
- Units: m, mm, cm, kg, g, mg, s, hr, years …
- When equation is all algebra: check dimensions
- When numbers are inserted: check units
- Units obey same rules as dimensions:
  Never add terms with different units
- Angles are dimensionless but have units (degrees or radians)
- In physics sin(Y) or cos(Y) never occur unless Y is dimensionless

Uncertainty & Significance

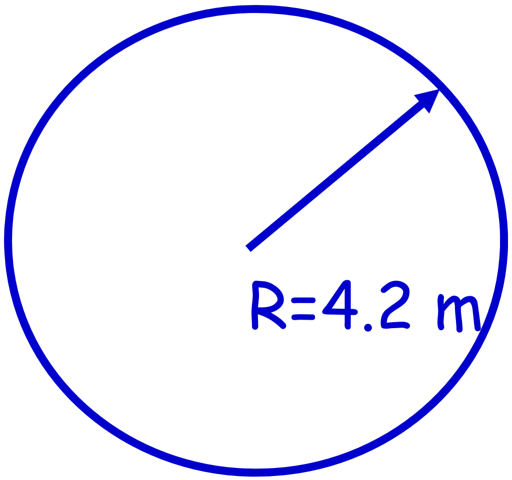


1.2411 trillion digits known!!

π=3.1415926535 8979323846 2643383279 5028841971
6939937510 5820974944 5923078164 0628620899
8628034825 3421170679 8214808651 3282306647
0938446095 5058223172 5359408128 4811174502
8410270193 8521105559 6446229489 5493038196…

Significance & Uncertainty

Circumference = $2\pi R$ = 2 x 3.1415926... x 4.2 =



Calculator: 26.38937... m

Right answer: 26 m.

4.2 means that the true value lies between 4.1 and 4.3:
$2\pi 4.1$ = 25.761... = 26 m
$2\pi 4.3$ = 27.0176... = 27 m
so: Right Answer with error: 26±1

The number of significant figures for a result of a division or multiplication is the least accurate of the quantities being divided or multiplied.

Significance & Uncertainty

For addition and subtraction the number of decimal places should be equal to the smallest number of decimal places of any term in the sum:

$$3.00013 + 0.0025 = 3.0026$$

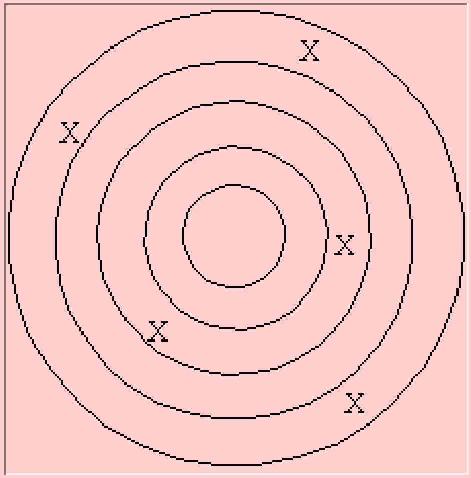
NUMBER OF DECIMAL PLACES IS <u>NOT</u> THE SAME AS THE NUMBER OF SIGNIFICANT FIGURES!

0.0025: 2 significant figures 4 decimal places

Scientific notation. For example $7 \cdot 10^7$ or 7E+07

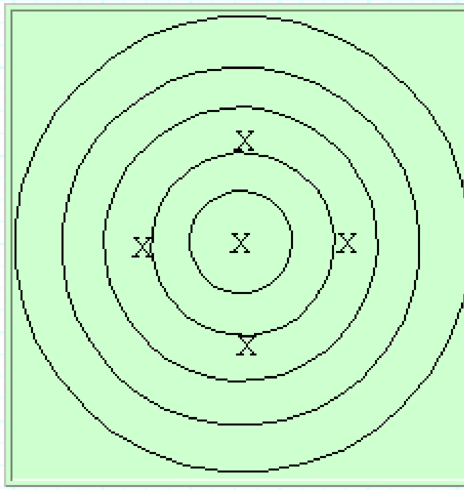
Precision vs. Accuracy

Neither Precise Nor Accurate



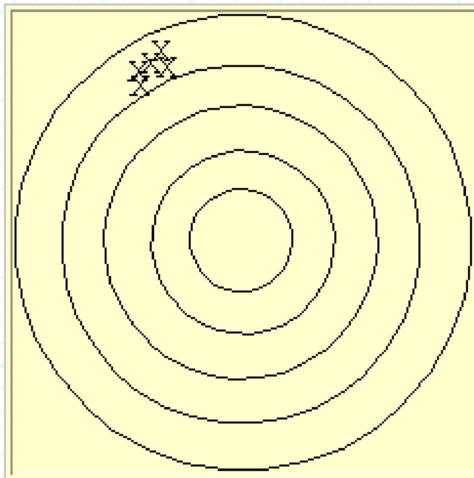
This is a randomlike pattern, neither precise nor accurate. The darts are not clustered together and are not near the bull's eye.

Accurate, Not Precise



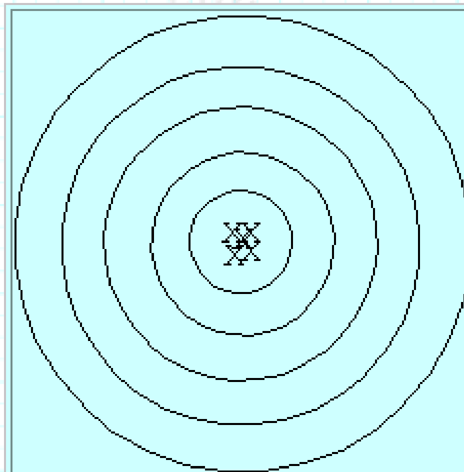
This is an accurate pattern, but not precise. The darts are not clustered, but their 'average' position is the center of the bull's eye.

Precise, Not Accurate



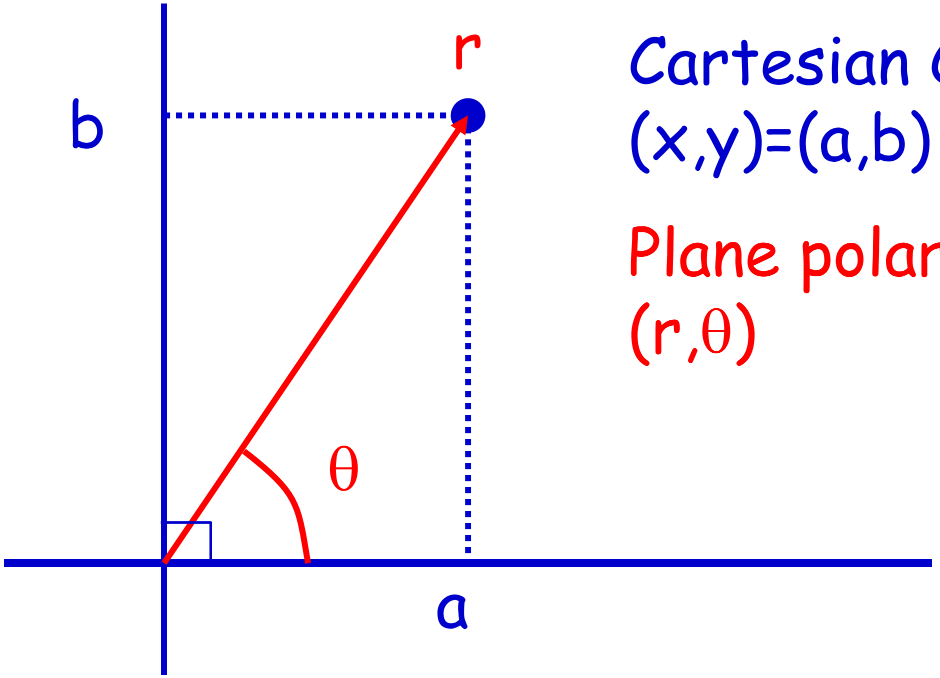
This is a precise pattern, but not accurate. The darts are clustered together but did not hit the intended mark.

Precise and Accurate



This pattern is both precise and accurate. The darts are tightly clustered and their average position is the center of the bull's eye.

Coordinate Systems



Cartesian Coordinates:
(x,y)=(a,b)

Plane polar coordinates:
(r,θ)

Frame transformation:

$$r = \sqrt{a^2 + b^2}$$

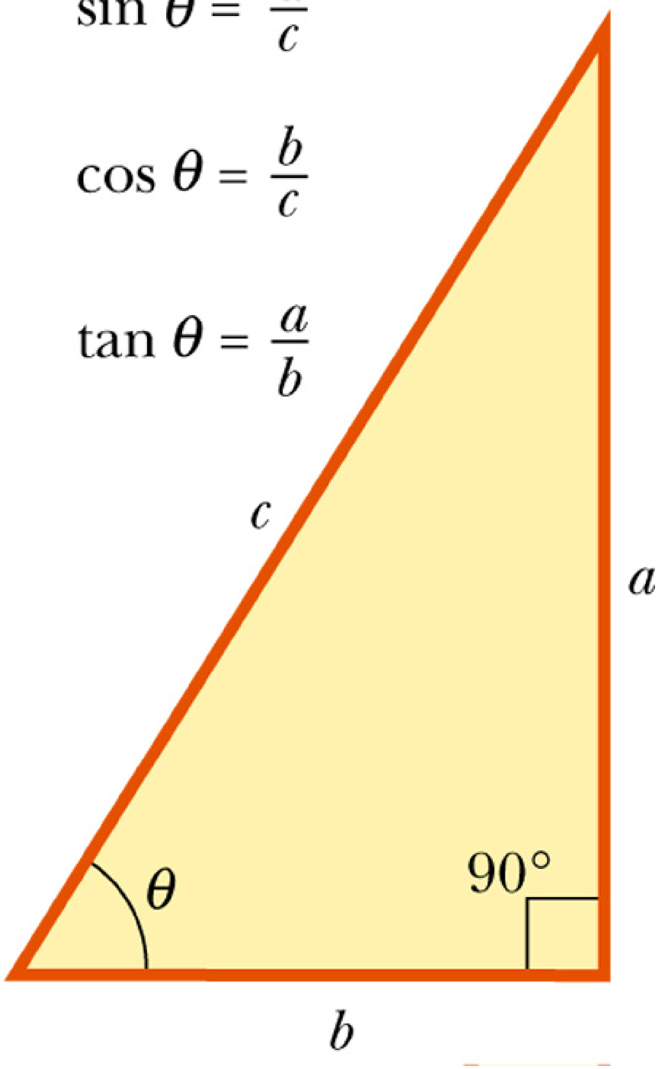
$$\tan(\theta) = b / a$$

TRIGONOMETRY

$$\sin\theta = \frac{a}{c}$$

$$\cos\theta = \frac{b}{c}$$

$$\tan\theta = \frac{a}{b}$$



sin=opposite/hypotenuse
cos=adjacent/hypotenuse
tan=opposite/adjacent

Pythagorean theorem:

$$c^2 = a^2 + b^2$$

Note that sin,cos,tan are dimensionless.

2π radians corresponds to 360°

How to solve a problem?

- READ THE PROBLEM!!!
- If you have a problem understanding what is asked, try to visualize it in a simpler system or in a comparable situation that you are familiar with.
- Determine what is known and how these quantities relate to the unknown. How do you combine the givens to find the unknown (dimensional analysis can help)
- Take care of the units!
- Calculate the unknown, taking care of significance and decimal places
- Check whether your answer makes sense

Problem: The diameter of the orbit of the earth around the sun is $4x10^{11}$ m. (1) What is the distance traveled by the earth in 1 year? (2) in the polar coord. system with the sun in the center, over what angle does the earth travel in 0.30 year?

(1)

a) $1x10^{12}$ m

b) $2x10^{12}$ m

c) $2.5x10^{12}$ m

d) $1.3x10^{23}$ m

(2)

a) 108 degrees

b) 120 degrees

c) 1.88 radians

d) $1.1x10^{2}$ degrees