CLUTCH

www.clutchprep.com

CONCEPT: INTRODUCTION TO UNITS AND THE S.I. SYSTEM

● Physics = study of natural phenomena, which includes lots of measurements & equations! Physics = Math + Rules

- In nature, we measure **physical quantities** (*mass, length…*), which must have ____________ & __________

(*Example: You measure the mass of a box*)

________ ____________

[Number] **[Unit]**

● For physics equations to work, ALL units in it must be _____________ with each other.

- Groups of compatible units that "work together" form a ___________ of units.
- In Physics, *always* use S.I. units (*Système International*)

Quantity	S.I.	Imperial
MASS	Kilogram [ ]	Pound [lb]
LENGTH	Meter [ ]	Foot [ft]
TIME	Second [ ]	Second [s]
FORCE	Newton [ ]	Foot-pound

Force = **Mass** × **Acceleration**

$$F = m \times a$$

[ ] = [ ] × [ ] → [COMPATIBLE | INCOMPATIBLE]

[ ] = [ ] × [ ] → [COMPATIBLE | INCOMPATIBLE]

CONCEPT: METRIC PREFIXES

● A metric prefix is a **letter** or **symbol** that goes before a base unit: [Base Unit] m, g, s → [Prefixes] **k**m, ,**m**g, **μ**s,

- Each letter / prefix stands for a specific power of 10 multiplied by the base unit.

Example: 5 km **=** ______________ m **=** _________ m

4.6 ms **=** ______________ s **=** _________ s

Bigger Units ←

•	•	•	1000	100	10		0.1	0.01	0.001	•	•	•
10^{12}	10^{9}	10^{6}	10^{3}	10^{2}	10^{1}	$10^{0} = 1$	10^{-1}	10^{-2}	10^{-3}	10^{-6}	10^{-9}	10^{-12}
tera-	giga-	mega-	kilo-	hecto-	deca-	[Base Unit]	deci-	centi-	milli-	micro-	nano-	pico-
(T)	(G)	(M)	(k)	(h)	(da)		(d)	(c)	(m)	(μ)	(n)	(p)

Smaller Units →

EXAMPLE: Express the following measurements using the desired prefix.

STEPS
1) Identify starting & target prefixes
2) Move from start → target, count # of exponents moved
3) Shift decimal place in the same direction moved in Step 2

a) 6.5 hm to m

b) 3.89 mm to m

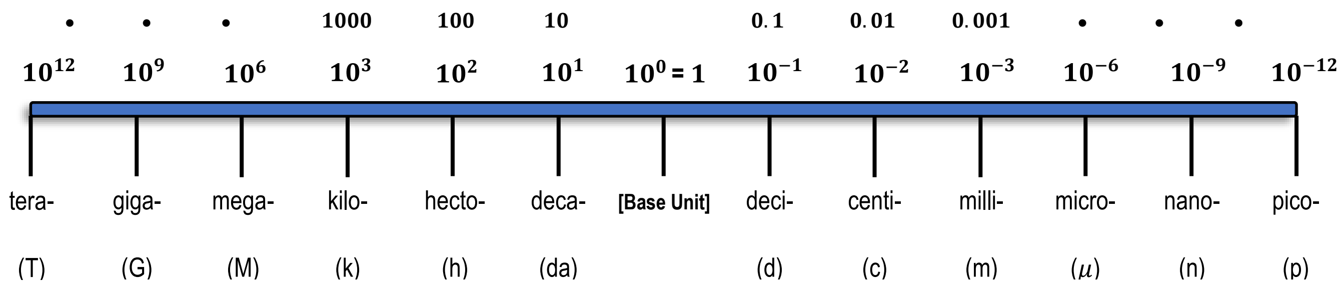
c) 7.62 kg to μg

● When re-writing numbers with metric prefixes,

- Shifting from a ***bigger*** to ***smaller*** unit, number becomes **[LARGER | SMALLER]**
- Shifting from a ***smaller*** to ***bigger*** unit, number becomes **[LARGER | SMALLER]**

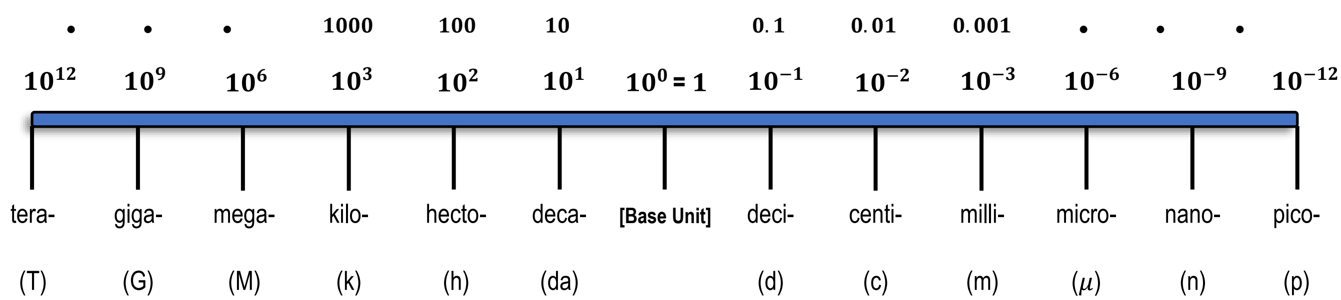
PRACTICE: The earth's circumference is approximately 40.1 Mm (megameters). What is this circumference in kilometers?

A) 0.0401 km
B) 40,100,000 km
C) 40,100 km
D) 0.00401 km



PRACTICE: Astronomers often detect radio waves with wavelengths of 3,000,000,000 nm. What is this wavelength expressed in decameters (dam)?

A) 3 dam
B) 0.3 dam
C) 30 dam
D) 0.03 dam



CONCEPT: SCIENTIFIC NOTATION

● We use **Scientific Notation** to ______________ very LONG, inconvenient numbers into SHORTER ones.

Mass of Earth = 5,972,000,000,000,000,000,000,000 kg

= _______________

General Format for Scientific Notation

$$A.BC \times 10^{D}$$

[# ≥ ___ but < ___]　　　　[__________]

STANDARD FORM → SCIENTIFIC NOTATION

Standard Form → Scientific Notation

1) Move decimal to get # ≥ 1 but < 10

2) Round long numbers with many non-zero numbers to 2 decimal places

3) # of decimal places moved = Exponent
- If original number > 10, exponent is **+**
- If original number < 1, exponent is **–**

a) 304,605.27 kg

b) 0.000102 m

c) 7 s

SCIENTIFIC NOTATION → STANDARD FORM

Scientific Notation → Standard Form

1) Exponent = # of decimal places moved
- If exponent is **+**, number becomes ***larger***
- If exponent is **–**, number becomes ***smaller***

a) 5.45×10^{8} kg

b) 9.62×10^{-5} s

PRACTICE: Rewrite 0.00016 kg in scientific notation.

A) 1.6×10^{-4} kg
B) 16×10^{-3} kg
C) 1.6×10^{4} kg
D) 1.6×10^{-3} kg

PRACTICE: Rewrite 299,800,000 m/s in scientific notation.

A) 2.998×10^{5} m/s
B) 3.00×10^{8} m/s
C) 3.00×10^{5} m/s
D) 2.998×10^{-8} m/s

EXAMPLE: Express 0.0000529×10^{-6} m in scientific notation.

PRACTICE: Rewrite 3.41×10^{-4} in standard form:

A) 0.000341
B) 34,100
C) 0.0000341
D) 3,410

PRACTICE: Rewrite 9.98×10^{7} in standard form.

A) 0.000000998
B) 0.0000000998
C) 9,980,000,000
D) 99,800,000

CONCEPT: UNIT CONVERSIONS

● You'll often see non-**S.I.** units in problems, so you MUST ____________ them to **S.I.** units before using equations!

EXAMPLE: Convert 22 **lbs** into **kg.**

____[   ] × (______) × (______) = ____[   ]

(__________) (____________________) (________)

Quantity	Conversion Factors / Ratios		
MASS	1 kg = 2.2 lbs	1 lb = 450 g	1 oz = 28.4 g
LENGTH	1 km = 0.621 mi	1 ft = 0.305 m	1 in = 2.54 cm
VOLUME	1 gal = 3.79 L	1 mL = 1 cm^3	1 L = 1.06 qt

STEPS FOR CONVERTING UNITS

1) Write **Given, Target** units

2) Write **Conversion Factors / Ratios** as ____________

- Write fractions to cancel out _____ units with ________ units

3) Multiply all **#s** on top, all **#s** on bottom, and solve

EXAMPLE: Convert the following measurements to the desired units.

a) 67.5 **mi/hr** to **m/s**

____[   ] × (______) × (______) × (______) = ____[   ]

b) 100 **ft^2** to **m^2**

____[   ] × (______) × (______) = ____[   ]

● When converting units with exponents, multiply conversion factors as many times as the # in the exponent.

PRACTICE: Convert 850 ft to km.

Quantity	Conversion Factors / Ratios		
MASS	1 kg = 2.2 lbs	1 lb = 450 g	1 oz = 28.4 g
LENGTH	1 km = 0.621 mi	1 ft = 0.305 m	1 in = 2.54 cm
VOLUME	1 gal = 3.79 L	1 mL = 1 cm^3	1 L = 1.06 qt

A) 259 km
B) 0.259 km
C) 2.79×10^6 km
D) 2.79 km

PRACTICE: The speed of light is approximately 3.00×10^8 m/s. Convert this speed to yards/week (yd/wk).

A) 1.84×10^{13} yd/wk
B) 1.98×10^{14} yd/wk
C) 1.78×10^{15} yd/wk
D) 1.8×10^7 yd/wk

Quantity	Conversion Factors / Ratios		
MASS	1 kg = 2.2 lbs	1 lb = 450 g	1 oz = 28.4 g
LENGTH	1 km = 0.621 mi	1 ft = 0.305 m	1 in = 2.54 cm
VOLUME	1 gal = 3.79 L	1 mL = 1 cm^3	1 L = 1.06 qt

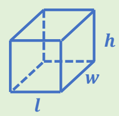
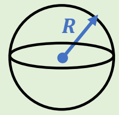
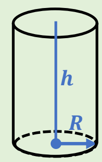
PRACTICE: How many gallons are in 1 cubic meter (m^3)?

Quantity	Conversion Factors / Ratios		
MASS	1 kg = 2.2 lbs	1 lb = 450 g	1 oz = 28.4 g
LENGTH	1 km = 0.621 mi	1 ft = 0.305 m	1 in = 2.54 cm
VOLUME	1 gal = 3.79 L	1 mL = 1 cm^3	1 L = 1.06 qt

CONCEPT: SOLVING DENSITY PROBLEMS

● Density is defined as __________ divided by ____________ ⇒ $\rho = \frac{\quad}{\quad}$ [Units: $\frac{\quad}{\quad}$]
(amount of stuff) (amount of space taken up)

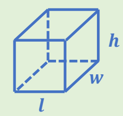
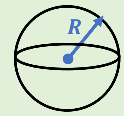
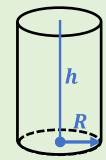
- Many problems involve relating density, mass, and volume of **geometric shapes,** and converting units.

RECTANGULAR PRISM	SPHERE	CYLINDER
		
$V = l \times w \times h$	$V = \frac{4}{3}\pi R^3$	$V = \pi R^2 h$

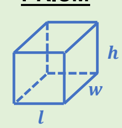
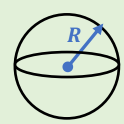
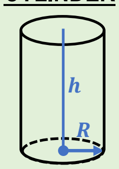
EXAMPLE: The average density of Earth is 5500 kg/m^3. If we assume it is approximately a sphere with a radius of 3960mi, what is the mass of Earth? (1 mi ≈ 1609 m)

PRACTICE: A wooden cylinder has a radius of 3.5 cm and a height of 6 cm. If the mass is 161 g, what is the density of the wooden cylinder?

A) 222 kg/m^3
B) 3.767×10^3 kg/m^3
C) 700 kg/m^3
D) 2440 kg/m^3

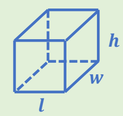
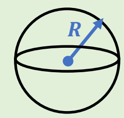
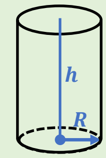
RECTANGULAR PRISM	SPHERE	CYLINDER
		
$V = l \times w \times h$	$V = \frac{4}{3}\pi R^3$	$V = \pi R^2 h$

EXAMPLE: An iron cube has a mass of 0.515 kg. The density of iron is 7.87×10^3 kg/m^3. What is the length of the sides of the cube?

RECTANGULAR PRISM	SPHERE	CYLINDER
		
$V = l \times w \times h$	$V = \frac{4}{3}\pi R^3$	$V = \pi R^2 h$

PRACTICE: Copper has a density of 8.96 g/cm^3. If a single copper atom as a mass of 1.055×10^{-25} kg, what is the volume of a copper atom?

A) 1.18×10^{-26} m^3
B) 9.45×10^{-25} m^3
C) 1.18×10^{-29} m^3
D) 1.18×10^{-26} cm^3

RECTANGULAR PRISM	SPHERE	CYLINDER
		
$V = l \times w \times h$	$V = \frac{4}{3}\pi R^3$	$V = \pi R^2 h$

CONCEPT: DIMENSIONAL ANALYSIS

● Equations work only if they are *dimensionally consistent*, meaning the units on both sides are __________.

- Easy way to check if equations make sense ***without*** calculations.

EXAMPLE: You walk a constant speed v = 5m/s for a time **t** of 2s. Which equation from below would be appropriate for determining the distance **d** in meters?

Distance = speed × time

$$d = v \times t$$

[   ] = [   ] × [   ]

OR

Distance = speed × time²

$$d = v \times 2\,t^2$$

[   ] = [   ] × [   ]

[CONSISTENT | INCONSISTENT]   [CONSISTENT | INCONSISTENT]

DIMENSIONAL CONSISTENCY
1) Replace variables with units
2) Ignore **–** signs & numbers (2, ½, etc..)
3) Multiply & divide to cancel out units
4) Check if units on left **=** units on right

DETERMINING UNITS OF UNKOWN VARIABLES

● You'll also need Dimensional Analysis to figure out the units of unknown variables.

EXAMPLE: Hooke's Law states that a restoring Force **F**, measured in Newtons [N], in springs is related to the distance from equilibrium **x** by the equation **F = —kx.** What are the units of the force constant **k**?

SOLVING UNITS OF VARIABLES
1) Replace variables with units
2) Ignore **–** signs & numbers (2, ½, etc..)
3) Isolate unknown variable
4) Solve

PRACTICE: A box moving with an initial speed **v** is accelerated horizontally. If **x** is measured in [m], **v** in [m/s], **a** in [m/s^2], **t** in [s] which of the following equations is correct for solving the distance **x**?

A) x = $\frac{a}{t^2}$
B) x = v + ½ at
C) x = vt + ½ at^2

PRACTICE: Newton's Law of Gravitation describes the attraction force between two masses. The equation is $\boldsymbol{F} = \mathbf{G}\frac{\boldsymbol{m_1 m_2}}{\boldsymbol{r^2}}$, where F is in [$\frac{\mathbf{kg \cdot m}}{\mathbf{s^2}}$], $\boldsymbol{m_1}$ and $\boldsymbol{m_2}$ are masses in [**kg**], and ***r*** is the distance in [**m**] between them.

Determine the units of the Universal Constant ***G***.

A) $\frac{kg \cdot s^2}{m^3}$

B) $\frac{m^3}{kg \cdot s^2}$

C) $\frac{m}{s^2}$

D) $\frac{m^3}{s^2}$

CONCEPT: COUNTING SIGNIFICANT FIGURES (SIG FIGS)

● In Physics, measurements have **PRECISION**, indicated by the # of digits:

10 kg — **[LESS | MORE]** precision

10.27 kg — **[LESS | MORE]** precision

● Not ***all*** digits in measurements matter. Significant Figures are the # of digits that __________________.

15 kg

digits given: _____
digits that matter: _____

015 kg

digits given: _____
digits that matter: _____

EXAMPLE: Determine the number of significant figures in the number below:

0 . 0 1 3 2 0 0 9 7 2 0 0 0

________ 0s ________ 0s ________ 0s

# of Significant Figures: _____

STEPS
1) Eliminate Leading 0's
2) If # has no decimal, eliminate Trailing 0's
3) Count remaining digits **-** *Never* eliminate non-zeroes or Middle 0's

EXAMPLE: How many significant figures are there in each of the following numbers?

a) 100.00 **b)** 0.0043 **c)** 31000092

d) 100 **e)** 73917000 **f)** 0.00900

PRACTICE**:** How many significant figures are in each of the following numbers?

a) 0.0032 **b)** 10790 **c)** 08.02

CONCEPT: MATH WITH SIGNIFICANT FIGURES

● When doing math to calculate values, there are additional rules to determine # of Sig Figs:

IF + | – *only*,	Round answer to same **[Sig Figs | Decimal Places]** as # with *least* **[Sig Figs | Decimal Places]**
IF × | ÷ *only*,	Round answer to same **[Sig Figs | Decimal Places]** as # with *least* **[Sig Figs | Decimal Places]**
IF + | – *and* **× | ÷**,	Use P→E→MD→AS and round answer to the *most* # of **[Sig Figs | Decimal Places]**

EXAMPLE: Write the answer for the following calculations below, expressed in the appropriate # of Sig Figs:

a) 2.56 + 6.2901

b) 5.389 – 4.3 + 0.103

c) 43.5287 ÷ 0.05192 × 0.0023

d) 123.57 × 0.031 + 4.68

PRACTICE**:** What is the area of a sidewalk that is 2.293 m wide and 90 m long? Write your answer with the correct number of significant figures**.**

A) 206.4 m^2
B) 210 m^2
C) 206.37 m^2
D) 200 m^2

EXAMPLE**:** Block A has side lengths 0.50 m × 0.875 m × 2.250 m**.** Block B has a volume of 2.6 m^3**.** What is the combined volume of the blocks, expressed with the correct number of significant figures?