Name _____
Date_____ **Block**_____
Physical Science
Mr. Decipeda

Dimensional Analysis

Dimensional Analysis is a simple method for changing from one unit of measure to another.

Can you answer these questions? How many feet are in 3.5 yards?

How many yards are in 49 ft?

Did you ever get confused about whether to multiply or divide in these situations? Then **Dimensional Analysis** is what you need to know!

Dimensional Analysis makes use of the fact that everyone knows from arithmetic, namely:

Any number (or quantity) $\times$ 1 = the number (or the quantity)

Stated another way, $a \times 1 = a$

For example: $5 \times 1 = 5$

$$\frac{2}{3} \times 1 = \frac{2}{3}$$

$3 \text{ yds} \times 1 = 3 \text{yds}$

$7.25 \text{ mi} \times 1 = 7.25 \text{ mi}$

Conclusion: Multiplying by 1 does **not** change the value of a number or quantity.

From your work with fractions, you know that the number 1 can take on many forms:

$$1 = \frac{3}{3}, \quad 1 = \frac{4}{4}, \quad 1 = \frac{125}{125}, \quad 1 = \frac{36}{36} \text{ etc.}$$

Or using the following conversion equations: 1 foot (ft) = 12 inches (in)

3 ft = 1 yard (yd)

5280 ft = 1 mile (mi)

We can think of the number 1 in the following ways:

$$1 = \frac{1 \text{ ft}}{12 \text{ in}} \qquad 1 = \frac{3 \text{ ft}}{1 \text{ yd}} \qquad 1 = \frac{5280 \text{ ft}}{1 \text{ mi}}$$

$$1 = \frac{12 \text{ in}}{1 \text{ ft}} \qquad 1 = \frac{1 \text{ yd}}{3 \text{ ft}} \qquad 1 = \frac{1 \text{ mi}}{5280 \text{ ft}}$$

NOTE: Fractions that are equal to 1 are called unit fractions.

We can use these two ideas, $a \times 1 = a$ and $1 = \frac{\text{a quantity}}{\text{an equivalent quantity}}$, to convert from one unit to another.

Ex1: How many feet are in $3\frac{1}{2}$ yards?

$3\frac{1}{2}$ yards $= 3\frac{1}{2}$ yd $\times 1$ (Multiplying by 1 does not change the value of $3\frac{1}{2}$ yds.)

$= \frac{3\frac{1}{2}\text{ yd}}{1} \times \frac{3\text{ ft}}{1\text{ yd}}$ $\left(\text{Since } 3\text{ ft} = 1\text{ yd, then } 1 = \frac{3\text{ ft}}{1\text{ yd}}\right)$ (See note below.)

$= \frac{3\frac{1}{2}\text{ } \cancel{\text{yd}}}{1} \times \frac{3\text{ ft}}{1\text{ } \cancel{\text{yd}}}$ (Cancel yd, which is the unwanted unit. You then are left with ft, the unit that you are changing to.)

$= \frac{3\frac{1}{2} \times 3\text{ ft}}{1} = \frac{\frac{7}{2} \times \frac{3}{1}\text{ ft}}{1} = \frac{\frac{21}{2}\text{ ft}}{1} = 10\frac{1}{2}\text{ ft}$ (Do the arithmetic.)

Therefore $3\frac{1}{2}$ yd $= 10\frac{1}{2}$ ft.

NOTE: From the conversion equation, $3\text{ ft} = 1\text{ yd}$, we could also get $1 = \frac{1\text{ yd}}{3\text{ ft}}$. However, if we multiply $\frac{3\frac{1}{2}\text{yd}}{1} \times \frac{1\text{yd}}{3\text{ft}}$ the yd would **not** cancel.

Steps to follow when converting from one unit of measure to another:

1. Find the conversion that relates the units you have and the units you want.
2. Multiply the measurement you are given by a fraction equal to 1 (unit fraction) using the conversion you chose in Step 1. Be sure to write the unit fraction in such a way so that you can cancel the unwanted units.
3. Cancel the unwanted units.
4. Find an answer to the arithmetic problem that is left.

COMMONLY USED CONVERSION FACTORS:

The HESI assumes you know many common conversions. Many people have the following conversions memorized:

LENGTH	VOLUME	WEIGHT/MASS	TIME
12 inches = 1 foot	1000 ml = 1 L	16 oz. = 1 lb.	60 sec. = 1 min.
1 inch = 2.54 cm	8 ounces = 1 cup	2.2 lb. = 1 kg	60 min. = 1 hour
100 cm = 1 m	16 ounces = 1 pint	2000 lb. = 1 ton	24 hours = 1 day
1000 m = 1 km	1 pint = 2 cups	1000 g = 1 kg	365 days = 1 year
1 mile = 1.6 km	2 pints = 1 quart	1000 mg = 1 g	
	4 quarts = 1 gallon		

Ex 2: How many miles are in 400 km?

$400\text{ km} = 400\text{ km} \times 1$ (Multiplying by 1 does not change the value of 400 km.)

$= \dfrac{400\text{ km}}{1} \times \dfrac{0.621\text{ mi}}{1\text{ km}}$ (Since 1 km = 0.621 mi, $1 = \dfrac{0.621\text{ mi}}{1\text{ km}}$. We place 1 km in the denominator so we can cancel km.)

$= \dfrac{400\ \cancel{\text{km}}}{1} \times \dfrac{0.621\text{ mi}}{1\ \cancel{\text{km}}}$ (Cancel km, the unwanted unit.)

$= \dfrac{400 \times 0.621\text{ mi}}{1 \times 1} = \dfrac{248.4\text{ mi}}{1} = 248.4\text{ mi}$ (Do the arithmetic.)

Therefore: 400 km = 248.4 mi.

Ex 3: Change 0.825 liters to milliliters.

$0.825\text{ L} = 0.825\text{ L} \times 1$ (Multiplying by 1 does not change the value of 0.825 L.)

$= \dfrac{0.825\text{ L}}{1} \times \dfrac{1000\text{ ml}}{1\text{ L}}$ (Since 1 L = 1000 ml, $1 = \dfrac{1000\text{ ml}}{1\text{ L}}$. We place L in the denominator so we can cancel L.)

$= \dfrac{0.825\ \cancel{\text{L}}}{1} \times \dfrac{1000\text{ ml}}{1\ \cancel{\text{L}}}$ (Cancel L, the unwanted unit.)

$= \dfrac{0.825 \times 1000\text{ ml}}{1 \times 1} = 825\text{ ml}$ (Do the arithmetic.)

Therefore: 0.825 L = 825 ml.

Sometimes it is necessary to multiply by two unit fractions in order to obtain the correct unit.

Ex 4: How many yards are in 12 miles?

(Since our conversion equations do not directly relate miles and yards, we must first convert miles to feet, then feet to yards.)

$12\text{ mi} = 12\text{ mi} \times 1 \times 1$ (Multiplying by 1 does not change the value of 12 mi.)

$= \dfrac{12\text{ mi}}{1} \times \dfrac{5280\text{ ft}}{1\text{ mi}} \times \dfrac{1\text{ yd}}{3\text{ ft}}$ (Since 5280 ft = 1 mi, $1 = \dfrac{5280\text{ ft}}{1\text{ mi}}$ and 1 yd = 3 ft, so $1 = \dfrac{1\text{ yd}}{3\text{ ft}}$.)

$= \dfrac{12\ \cancel{\text{mi}}}{1} \times \dfrac{5280\ \cancel{\text{ft}}}{1\ \cancel{\text{mi}}} \times \dfrac{1\text{ yd}}{3\ \cancel{\text{ft}}}$ (Cancel mi and ft, the unwanted units.)

$= \dfrac{12 \times 5280 \times 1\text{ yd}}{1 \times 1 \times 3} = 21{,}120\text{ yd}$ (Do the arithmetic.)

Therefore 12 mi = 21,120 yd.

Exercises: Use Dimensional analysis to convert the units for items 1 - 16. SHOW ALL OF YOUR WORK.

1. Convert 5 feet to inches
2. Convert 96 inches to feet.
3. Convert 12 gallons to pints.
4. Convert 48 meters to millimeters.
5. Convert 45.38 milligrams to grams.
6. How many pounds are in 36 ounces?
7. How many miles are in 600 kilometers?
8. Convert 7,920 feet to miles.
9. How many seconds are in $2\frac{1}{2}$ hours?
10. Convert 16 quarts to liters.
11. Convert 20 inches to centimeters.
12. Convert 7.62 centimeters to inches.
13. Convert 9 gallons to liters.
14. How many yards are in 24 miles?
15. Convert 5 pounds to grams.
16. Convert 70 weeks to hours.

Check your answers on page 5.
Then complete items 17 - 52 on page 6.
Again - show your work for each problem.

Do all of your work on SEPERATE LOOSE LEAF PAPER with your name on each page.

DUE ON MONDAY 9/9.

Selected Answers and Solutions: **1 - 16 only**

1. $\frac{5\ \cancel{ft}}{1} \times \frac{12\ \text{in}}{1\ \cancel{ft}} = \frac{5 \times 12\ \text{in}}{1 \times 1} = \frac{60\ \text{in}}{1} = 60\,\text{in}$

2. 8 ft

3. $\frac{12\ \cancel{gal}}{1} \times \frac{4\ \cancel{qt}}{1\ \cancel{gal}} \times \frac{2\ \text{pt}}{1\ \cancel{qt}} = \frac{12 \times 4 \times 2\ \text{pt}}{1 \times 1 \times 1} = \frac{96\ \text{pt}}{1} = 96\,\text{pt}$

4. 48,000 mm

5. $\frac{45.38\ \cancel{mg}}{1} \times \frac{1\ \text{g}}{1000\ \cancel{mg}} = \frac{45.38\ \text{g}}{1000} = 0.04538\ \text{g}$

6. $2\frac{1}{4}$ lb

7. $\frac{600\ \cancel{km}}{1} \times$ ——— = ——— $= 372.6\ \text{mi}$

8. ——— × ——— = ——— $= 1.5\,\text{mi}$

9. 9000 sec

10. ——— × ——— × ——— = ——— $= 15.1412\,\text{L}$

11. 50.8 cm

12. ——— × ——— = ——— $= 3\ \text{in}$

13. 34.0677 L

14. ——— × ——— × ——— = ——— $= 42,240\ \text{yd}$

15. 2,268 g

16. ——— × ——— × ——— = ——— $= 11,760\ \text{hr}$

MORE Practice Problems!

Level 1

17. Convert 14 mm to its equivalent in m.
18. Convert 35 kg to its equivalent in g.
19. Convert 57 mL to its equivalent in L.
20. Convert a speed of 88 m/s to its equivalent in cm/s.
21. Convert a density of 9.45 g/L to its equivalent in g/mL.
22. The density of mercury metal is 13.6 g/mL. What is the mass of 3.55 mL of the metal?
23. The density of lead is 11.3 g/mL. What is the mass of 45 mL of the metal?
24. The density of table salt, NaCl, is 2.16 g/mL. What is the mass of 100.0 mL of this solid?
25. A particle moves through a gas at a speed of 15 km/s. How far will it move in 5.5 s?
26. A mole of copper contains 6.02×10^{23} atoms. How many atoms are there in 0.525 moles?
27. A solution of barium nitrate contains 61.2 g per liter of solution. How many grams of barium nitrate is contained in 2.75 L of this solution?
28. A sample of seawater contains 0.000245 g of sodium chloride per 1 mL of solution. How much sodium chloride is contained in 50.0 mL of this solution?

Level 2

29. Convert 15.9 mm to its equivalent in km.
30. Convert 0.0982 hg to its equivalent in cg.
31. Convert 13,455 g to its equivalent in kg.
32. Convert a speed of 73.5 km/hr to its equivalent in m/s.
33. Convert a density of 4.52 g/mL to its equivalent in kg/L.
34. The density of iron is 7.86 g/mL. What volume of iron will have a mass of 50.00 g?
35. The density of helium gas is 0.178 g/L. What would be the mass of 375.0 mL of this gas?
36. A particle moving through a gas at a speed of 45.8 m/s strikes one wall of the container, bounces off and hits the other wall 25.0 cm away. How long did it take to go from one wall to the other?
37. A mole of sodium atoms contains 6.02×10^{23} atoms. How many moles would be needed in order to have 25.0×10^{23} atoms?
38. A mole of hydrogen atoms contains 6.02×10^{23} atoms. A section of outer space contains 25 atoms. How many moles of hydrogen is this?
39. The speed of light is 3.0×10^{10} cm/sec. Express this speed in km/hr?
40. A sample of seawater contains 6.277 g of sodium chloride per litre of solution. How many mg of sodium chloride would be contained in 15.0 mL of this solution?

Level 3

41. Convert 32.5 oz to its equivalent in cg.
42. Convert 3.55 yd to its equivalent in cm.
43. Convert 143.55 mL to its equivalent in pints.
44. Convert a speed of 35.8 mi/hr to its equivalent in m/s.
45. Convert a density of 13.6 g/mL to its equivalent in lb/ft3.
46. A mole of hydrogen atoms contains 6.02×10^{23} atoms and occupies 22.4 L. How many hydrogen atoms are contained in 25.00 mL of this gas?
47. What volume of hydrogen would contain 4.5×10^{18} hydrogen atoms? How many moles of hydrogen would this be?
48. A molecule of hydrogen moves at a speed of 115 cm/s. How long will it take to travel the length of a football field (100 yd long)?
49. The speed of light is 3.0×10^{10} cm/s. Express this in mi/hr.
50. A sample of sea water contains 0.075 g of sodium chloride per mL of solution. How many moles of sodium chloride are there per L of this solution? A mole of sodium chloride is equivalent to 58.5 g of sodium chloride.
51. A doctor orders that a patient recieve 1.5×10^{-3} mole of sodium chloride. The only solution available contains 1.00 g per 100 mL of solution. A mole of sodium chloride is equivalent to 58.5 g of sodium chloride. How much of this solution should the nurse give the patient?
52. A sample of air contains 2.33×10^{-4} mg of lead per mL of gas. This air passes through an office, the volume of which is 3.25×10^{4} L. Seven people normally work in this office. How many μg of lead will each person in the office recieve from this sample of air?