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SYSTEMS OF UNITS

Foot-Pound-Second (FPS) System

Since long, the foot-pound-second (fps) system of units has been used to measure dimensions and quantities of material. The fundamental units are the foot for length, the pound for weight, and the second for time. The FPS system has two variants, known as the American version and the Imperial version. Now-a-days none of the systems is being used by scientists (after implementation of SI units). The International System of Units (SI) is preferred because it is simple and convenient. However, FPS units are still used to some extent by the general public, especially in the United States and in India also.

Units of Length

There are different units such as thou, inch, hand, foot, yard, rod, pace, mile, furlong, fathom, etc. used to measure length. However, the conversion factors are not simple.

Thou

*One thousandth of an inch is called **thou***. In the United States it is called **mil**. The plural of thou is thou' and of mil is 'mils'.

Inch

An inch was originally defined as the width of a man's thumb, but later on it was defined as *the length of three barleycorns placed end to end*. The word inch comes from the Latin word for one-twelfth (*uncia*). The Romans, when invaded in the year 43, brought the concept of the 12 inch-foot to England and since then it had been used. Earlier the inch was subdivided into halves, quarters, eighths, sixteenths, and other powers of

two; and also into hundredths (as in the caliber of fire-arms) or thousandths (called thou in the UK and mils in the US). After introduction of SI system, one inch is defined as 0.0254 m (or 2.54 cm).

Hand

A hand is considered as *the width of a man's hand measured across the palm and including the thumb*. It was mostly used to measure the height of horses; not for other purposes. A standard hand is 4 inches.

Foot

A foot was defined as the length of a man‘s foot. *A standard foot is 12 inches*. Foot (ft) is the fundamental unit of length in FPS system. One foot (1 ft) represents a length of 12 inches. The inch was originally defined as the length of three typical barleycorns laid end-to-end. A foot was also approximately equal to three hand widths or 2/3rd of a cubit (the distance from an average person's elbow to the tips of the fingers). Nowadays, a foot is considered to be 0.3048 meter, where the meter is the fundamental unit of distances in the metric system and International System of Units (SI).

Cubit

The cubit is an ancient unit. *The distance between the elbow and the tip of the middle finger on a man's arm is called cubit.* The term was derived from the Latin word *cubitum* (elbow). It has been differently expressed at different places over different times. For example, the Roman cubit was 17.47 inches long, the Greek 18.20 inches, the Sumerian 20.42 inches, the Egyptian 20.6 to 20.8 inches and the English cubit is 18 inches.

Yard

Yard is an Old English word for staff, rod, or stick. *The length from the King's nose to his outstretched hand was considered as a yard*.

Afterwards, a stick measuring same length was marked and was considered as the standard stick of the kingdom. The word, yardstick was derived from this. *A standard yard is 3 feet long*.

Pace

The term, pace has originally arrived from Rome. The *passus* was measured *from the heel of one foot to the heel of the same foot when it*

next touched the ground (one normal walking step). This is a convenient unit for measuring walking distances (again, for men with feet). A standard pace is 5 feet long.

Fathom

The word fathom has its roots in the Old English word used for embracing arms (*foeom*). It is also a unit used to measure the length, commonly used by the navigators. It refers to *the length between two arms of a man at extended position*. Usually it was used to measure the ropes used to determine the depth of navigable waters. *A standard fathom refers to a length of 6 feet*.

Rod

One rod measures the length of 16½ feet or 5½ yards. It is also called a pole or a perch.

Chain

Chains are commonly used by the surveyors for measuring distances. The English mathematician

Edmund Gunter developed the chain and is commonly called as Gunter's chain. The links of Gunter's chain are $7\frac{92}{100}$ inches long. One chain measures one hundred links that make a total length of 792 inches or 66 ft or 22 yards.

Furlong

The concept of a furrow (furlong) originally came from the trench made in the ground by a plow. *A*

Standard furrow is 220 yards long or 1/8 mile.

Mile

One mile referred to the distance of a thousand paces – in Latin, mille passus. A pace measures 5 feet; thus, one mile is roughly 5000 feet. Actually one mile was defined as 5280 feet (1760 yards) by the decree of the English parliament during the reign of Elizabeth I. Since this was a legal definition, it became known as the statute mile. Statute is a legal word for law.

But, the value of a mile varies from country to country and from time to time; for example, in Austria 1 mile is 8297 yards; *in England, India and in US, 1 mile is 1760 yards*; in Hungary 1 mile is 9139 yards; in Brunswick, 1 mile is 11816 yards; in Italy 1 mile is 2025 yards; in Netherlands 1 mile is 1094 yards In Norway 1 mile is 12182 yards; in Poland 1 mile is 8,100 yards, in Prussia 1 mile is 8238 yards, in

Spain 1 mile is 1552 yards, in Sweden 1 mile is11660 yards, and in Switzerland 1 mile is 8548 yards.

Nautical mile

Originally a nautical mile was defined as the distance of arc covered by one minute. It was measured on a meridian of the Earth; basically 1/60 of 1/360 of the Earth‘s circumference from one pole to another and back. Thus, the circumference of the Earth becomes 21600 nautical miles.

The Earth is slightly flattened sphere (an oblate spheroid). The distance around the equator is 0.2% longer than that around the poles. This difference seems to be small; but is important to ships, planes, and spacecrafts travelling long distances. A 0.2% error over the width of the Pacific Ocean is about 20 miles (20 statute miles). Hence, a nautical mile is defined as 1852 m exactly, which is equal to 6076.115 feet approximately.

Conversion of the length units of the English system is given below

Units	Equivalent unit	Units	Equivalent unit
1 thou	0.001 inch (in)	1 fathom	2 yd = 6 ft = 72 in
1 hand	4 in	1 rod	$5\frac{1}{2}$ yd = $16\frac{1}{2}$ ft = 198 in
1 foot (ft)	12 in	1 chain	4 rods = 22 yd = 66 ft
1 cubit	18 in	1 furlong	10 chain = 220 yd = 660 ft
1 yard (yd)	3 ft = 36 in	1 statute mile (mi)	8 furlongs = 1760 yd = 5280 ft
1 pace	5 ft = 60 in	1 nautical mile	1852 m (exactly) = 6076.12 ft (approx)
		1 league	3 miles = 5280 yd = 15840 ft

Units of Mass or Weight

In fact, the english unit for mass and unit for weight for same mass under a standard gravitation force (9.80665 m/sec^2) are same. This part of the English system may be called the French system; because many of the units have come to England from France. There are two sub-systems or paths – avoirdupois and troy or apothecaries.

Apothecaries system or Troy system	Avoirdupois system
Troy system was used for Troyes, France to deal in precious metals, gems, and medicines. This system came from Cairo during crusades and apothecaries system came from France. The name, apothecaries was derived from the French word – 'apotecaire' referred to shopkeeper dealing in medicines. One pound = 12 ounces.	The term Avoirdupois came from the French phrase –"*aveir de pois"* or "aver de peis" which means "goods of weight" or "goods (sold) by weight", not "goods sold by piece". Avoirdupois system is used as mass units for most commodities. One pound = 16 ounces.

Grain

A grain was said *equal to the mass of an average grain of wheat* taken from the middle of an ear. One avoirdupois pound is equal to 7000 grains and in troy one pound is equal to 5760 grains.

Scruple

This term is derived from the Latin word *scrupus*, a small rough pebble or a chip of stone basically, something small. *A scruple is* 20 *grains*.

Pennyweight

At some time in England, 1 English *penny was considered to be 24 grains*.

Dram

This word is derived from the Greek word, drachma. It is a fraction of an ounce, its maybe $1/8^{th}$ or $1/16^{th}$ depending on the system. One drachma weighed about one dram. Dram also refers to serving of whiskey.

Ounce

The word ounce referred to one twelfth. It has the meaning similar to inch, the old English word for one twelfth, uncial. One inch is $1/12^{th}$ of a foot and ounce is $1/12^{th}$ of a pound. However, sometimes one ounce may be $1/6^{th}$ of a pound.

Pound

The term pound came from the Latin word pondus' for weight and its abbreviation ‗lb' came from the Roman unit libra' which means $3/4^{th}$ of an English pound. The word ‗libra' again came from the Latin word, ‗libro' meaning to weigh. One pound (1 lb) is the force that produces an acceleration of 32.1740 feet per second square (32.1740 ft/sec^2) when applied against a known standard mass. The acceleration of 32.1740 ft/sec^2 is approximately the value of the earth's gravitational acceleration at 45 degrees north latitude.

Stone

This unit usually used for bulk agricultural commodities and officially 1 stone = 14 pounds. In practice, the value of a stone depends on the article weighed. For example, for glass one stone is equal to 5 lbs; for fish, meat, sugar, or spices one stone is equal to 8 lbs; for wax one stone is equal to 12 lbs; for cheese one stone is equal to 16 lbs. the word stone stands for both singular and plural; that is, 1 stone, 10 stone, etc.

Hundredweight

By name it should be a hundred of something; in fact, hundredweight was adopted for hundred pounds in England in long back. Since stone was considered as the basic unit and 1 stone = 14 pounds, nearest multiple of one hundredweight (100 pounds) is 112 pounds or 8 stone. As a result, 100 pound hundredweight is called short hundredweight and 112 pound hundredweight is called long hundred weight.

Ton

The word 'ton' came from the English word 'tunne' which means 'a big container'. The word was used to refer the capacity of a big container. Thereafter, it was considered as a unit of both weight and volume Use as volume-unit is restricted in railroad and shipping industries; but, as

weight-unit it became popular and it was defined as the unit to represent 2000 pounds. Later on in England the value of one ton was changed from 2000 lbs to 2240 lbs; because 2240 lbs is a multiple of stone (160 stone); while 2000lbs is not a multiple of stone. However, American ton represents 2000 lbs. American ton (2000 lbs) is called short ton and English ton (2240 lbs) is called long ton.

Unit of Time (Second)

One second (1 s or 1 sec) is the time that elapses during 9.192631770×10^9 cycles of the radiation produced by the transition between two levels of Ce133 (Cesium). It is also $\frac{1}{86400}$ of a mean solar day. (60 seconds constitute a minute, 60 minutes constitute an hour, and 24 hours constitute a day; that is

$$1 \text{ day} = 60 \times 60 \times 24 = 86{,}400 \text{ sec})$$

International System of Units (SI)

As per the *United States Pharmacopeia or National Formulary,* the International System of Units (SI) is the official system for weights and measures. The International System of Units (SI) is the decimal system of weights and measure. It was internationally recognized and earlier known as the metric system. In late eighteenth century this system was developed in France and in 1988 it was implemented worldwide.

The base units of the SI are Meter – Kilogram - Second. Meter was originally defined as $\frac{1}{40000000}^{\text{th}}$ the Earth's polar circumference. Subsequently it has been redefined as the distance travelled by light in a vacuum in $\frac{1}{299792458}^{\text{th}}$ of a second. One meter is generally considered as 39.37 inches. The mass of a kilogram was originally defined as the mass of one liter of water. Later on the standard mass of platinum-iridium alloy representing one kilogram has been preserved in a vault in France. According to FPS system one kilogram is almost equal to 2.2 lbs. The relative value of the International System of Units (SI) and their prefixes are given below:

Relative values	Prefix	Unit
One quintillionth (10^{-18}) of meter, liter or gram	atto-	Attometer/Attoliter/Attogram
One quadrillionth (100^{-15}) of meter, liter or gram	femto-	Femtometer/Femtoliter/Femtogram
One trillionth (10^{-12}) of the meter, liter or gram	pico-	Picometer/Picoliter/Picogram
One billionth (10^{-9}) of meter, liter or gram One millionth (10^{-6}) of meter, liter	nano-	Nanometer/Nanoliter/Nanogram
	micro-	Micrometer/Microliter/Microgram
	milli-	Millimeter/Milliliter/Milligram
	centi-	Centimeter/Centiliter/Centigram
	deci-	Decimeter/Deciliter/Decigram
10 times of meter, liter or gram	deka-	Dekameter/Dekaliter/Dekagram
100 times (10^2) of meter, liter or gram	hecto-	Hectometer/Hectoliter/Hectogram
1000 times (10^3) of meter, liter or gram	kilo-	Kilometer/Kiloliter/Kilogram
10,000 times (10^4) of meter, liter or gram	myria-	Myriameter/Myrialiter/Myriagram

1 million times (10^6) of meter, liter or gram	mega-	Megameter/Megaliter/Megagr
1 billion times (10^9) of meter, liter or gram	giga-	Gigameter/Gigaliter/Gigagram
1 trillion times (10^{12}) of meter, liter or gram	tera-	Tetrameter/Teraliter/Teragram
1 quadrillion times (10^{15}) of meter, liter or gram	peta-	Petameter/Petaliter/Petagram
1 quintillion times (10^{18}) of meter, liter or gram	exa-	Exameter/Exaliter/Exagram

The base or primary SI unit for length is **meter**, for mass is **gram** and for time is **second**. However, historically and technically the base unit of mass is kilogram. The units for other quantities are derived. For example, volume is cubic length or mass by density. Its base unit is **liter**.

There is another system of SI units – centimeter-gram-second (CGS system).

The standard subdivisions and multiples of the base units are called **Denominations** and the number used in conjunction with a denomination is termed a **denominate number**.

There are certain rules or guidelines for correct use of SI units. In some cases, variation in writing is found. Hence, the guidelines for correct use of SI units are mentioned in a tabular form.

Correct use	Incorrect use	Remarks
5 *l*, 5L, 4g, 21 mm	4 G, 21 Mm	The symbol of liter may be L or l, the name of a unit should not be in capital form except at the beginning or heading of a sentence.
10.5 mL, 10.5 mL (U.S.)	10.5 mL (non-U.S.) or 10 5 mL	In USA the decimal point is placed on the line with the denomination and denomination number.
6 mL and 5 g	6 mL and 5 g.	Periods are not used following SI symbols except at the end of a sentence.
9 mL/h or 9 $mL.h^{-1}$	9 mL per hour	Compound unit indicated by solidus (/) or a negative exponent can only be used.
15 mg/mL	15 mg/milliliter	Symbols should not be combined with full terms.
1 mL or 1milliliters	1 mL	When full term is written plurals of unit name can be used.
mcg or µg	-	Both the symbols are valid.
cm^3,etc	cc	For cubic centimeter cc is not a valid SI symbol.
3.5 g	31/2 g	Decimal fractions are accepted, not common fractions.
0.75 g	0.75 g	Zero must be put before the decimal point, to avoid error.

It is most important to realize that a misplaced or misread decimal point can lead to an error in calculation. There are certain ways by which this can be eliminated or reduced greatly. The guidelines to be followed are mentioned below;

- After a whole number trailing zeros should *not* be put. For example, 25 mg, not 25.0 mg.

  Although in some cases to indicate exactness to a specific number of decimal places trailing zeros is often put. For example, 50.0 mg.
- While using symbols of unit dimensions the unit suitable for numeric value up to 1000 should be used. For example, write 750 g, not 0.75 kg; similarly write 500 mL, not 0.5 L.

Equivalence of units between SI (CGS) and other Systems of Measurement

As per the *United States Pharmacopeia National Formulary* the International System of Units (SI) is the official system for weights and measures.

The **Apothecaries' system of measurement** is the traditional system used in pharmacy. It has now become historic one, the components of this system are occasionally found even on prescriptions.

The **Avoirdupois system** is the common system of commerce, used in the United States along with the SI. Through this system, goods are purchased and sold in terms of ounce and pound. Thus, it is necessary to know the quantitative relationships among these systems and the means for inter system conversion. For example, conversion of temperature between the Fahrenheit and Celsius (or centigrade) scales, or conversion of concentration of alcohol from proof strength to %v/v. The FPS (foot-pound-second) system had been used in the US and in the British ruled countries till SI system came into effect.

Measurement of Volume

Over the definition of gallon the English and American units differed in 1824. According to the British Weights & Measure Act a gallon was defined as the volume of water that weighs 10 pounds; while the Americans accepted the old definition one gallon of water weighs 8 pounds. As a result, the English units for volume became 20% larger than the American units. The units set before 1824 are called English units and the units set after 1824 are called Imperial units. The English units that were continued in the United States are called US customary units.

Below in the table the units of the English and Imperial systems have been mentioned, not of the US customary system.

Unit & Abbreviation	English System	Unit & Abbreviation	Imperial System
1 cubic foot (cu ft)	1728 cubic inch (cu in)	1 dram (dr)	60 minim (min)
1 cubic yard (cu yd)	27 cu ft = 46656 cu in	1 teaspoon (tsp)	100 min
1 register ton	100 cu ft	1tablespoon (tbsp)	3 tsp = 300 min
1 cord	128 cu ft	1 ounce (oz)	$1\frac{3}{5}$ tbsp = $4\frac{4}{5}$ tsp = 8 dr = 480 min

Table *contd…*

Unit & Abbreviation	English System	Unit & Abbreviation	Imperial System
1 acre foot	$1613\frac{1}{3}$ cu yd = 43560 cu ft	1 gill (gi)	5 oz
1 cubic mile	5451776000 cu yd = 147197952000 cu ft	1 cup (c)	8 oz
		1 pint (pt)	$2\frac{1}{2}$ c = 20 oz
		1 quart (qt)	2 pt = 5 c = 40 oz
		1 gallon (gal)	4 qt = 8 pt = 20 c = 160 oz = 4.54609 liters
		1 peak (pk)	2 gal = 8 qt = 16 pt
		1 bushel (bu)	4 pk = 8 gal = 32 qt = 64 pt
		1 quarter (qr)	8 bu = 64 gal = 256 qt
		1 barrel (bbl)	$26\frac{1}{4}$ gal (wine) = 36 gal (beer)
		1 hogshead	$52\frac{1}{2}$ gal (wine) = 54 gal (beer)

Measurement of weight by the British Systems

Unit	Abbreviations Avoirdupois system ( ) Apothecaries' system [ ]	Avoirdupois system	Apothecaries'/Troy system
1 grain	(gr) [G]	1/7000 pound	1/5760 pound
1 scruple	[℈]		20 grains
1 pennyweight	[dwt]		24 grains
1 dram	(dr) [ʒ]	1/256 pound	3 scruples = 60 grains
1 ounce	[℥]	16 drams = 437.5 grains	8 drams = 480 grains
1 pound	(lb, ℔, #) [lb, ℔, #]	16 ounces = 7000 grains	12 ounces = 5760 grains
1 stone	(st)	14 pounds	
1 short hundred weight	(cwt)	100 pounds	
1 long hundred weight	(cwt)	112 pounds	
1 short ton	(tn)	2000 pounds	
1 long ton	(tn)	2240 pounds	

Conversion between the Systems

Sometimes it is necessary to convert a weight or measurement from units of one system to another system. Conversion of denomination of one system to that of another needs a *conversion factor* or *conversion equivalent.* The practical and precise conversion equivalents for measurement of weight, length and volume are there. Some useful equivalents are given below.

Unit	Equivalent unit	Unit	Equivalent unit
1 inch (in)	2.54 cm	1 fluidounce (fl. oz.)	29.57 mL
1 meter (m)	39.37 in	1 pint (16 fl. oz.)	473 mL
1 pound (lb, Avoirdupois)	454 g	1 quart (32 fl. oz.)	946 mL
1 kilogram (kg)	2.2 lb	1 gallon, US (128 fl. oz.)	3785 mL
		1 gallon, UK	4545 mL

Example

Convert 65765 mcg to g

Solution

1000 mcg = 1 mg

1 mcg = 65765 mcg 1000 mcg = 65.765 mg

1000 mg = 1 g

1 mg = 65.765 mg1000 mg

Ans. 0.066965 gm

Example

Convert 57668 µl to liter.

Solution

1000 µl = 1 ml

57668 µl = 57668 µl×1 ml 1000 µl = 57.668 ml

1000 ml = 1L

1 ml = 57.668 ml1000 ml

Ans. 0.057668 L

Example

Add 5 kg 457 mg, 76 mg and 8.75 g. Express the total in kg-g-mg.

Solution

1 kg = 1000 g, 1 g = 1000 mg.

1 kg = 1000000 mg

5 kg 457 mg = 5000000 mg + 457 mg = 5000457 mg

+ 76 mg

+ 8.75 g = 8.75 × 1000 mg = 8750 mg

Total = 5009283 mg

= 5009283 mg ÷ 1000 = 5009283 g

= 5009.283g ÷1000 =

Ans. 5 kg 9 g 283 mg

Example

As per record 5 g 95 mg of Cyanocobalamine was issued from a stock of 7.475 g. Calculate the balance amount and express in terms of milligrams.

Solution

Stock of Cyanocobalamine = 7.475g = 7.475 × 1000 mg = 7475 mg

(-) Quantity issued = 5g 95 mg = 5×1000 mg + 95 mg = 5095mg

Balance amount of Cyanocobalamine

Ans. 2380 mg

Example

A mixture contains substances of different weights; 0.075 g, 20 mg, 0.0005 g, 4 mg, and 500 μg. What is the total weight (in mg) of the mixture?

Solution

0.075 g + 20 mg + 0.0005g + 4 mg + 500μg

= (0.075g × 1000) + 20 mg + (0.0005g×1000) + 4 mg + (500μg ÷ 1000)

= 75mg + 20mg + 0.5mg + 4mg + 0.5mg

= 100 mg

The total weight of mixture is

Ans. 100 mg

Example

During manufacturing of a formulation 103 kg of a drug was initially issued. Based on IPQC report another amount of 573 g 35 mg was issued. The stock of the drug after second issue was 74 kg 865 g 75 mg. Find out the opening stock.

Solution

Quantity issued initially = 103 kg = 103kg×1000 = 103000g × 1000 = 103000000 mg

(+) Quantity issued second time = 573 g 35 mg = 573g×1000+35mg = 573035 mg

Total quantity issued = 103573035 mg

Balance after issue = 74 kg 865 g 75 mg = (74×1000 + 865)g 75 mg = 74865g 75 mg

= (74865 ×1000) mg +75 mg = 74865075 mg

Opening stock = Quantity issued + Balance = 103573035 mg + 74865075 mg

= 178438110 mg

Ans. 178kg 438g 110mg

Example

A shopkeeper purchased 24 lbs (avoir.) of olive oil. Out of which he sold 3kg and 25 g. How much stock he should have?

Solution

Olive oil purchased = 24 lbs (avoir.) = 24×454 g = 10896 g

(-) Olive oil sold = 3 kg + 25 g = 3×1000g + 25 g = 3025 g

Balance of olive oil = 7871 g = 7871 ÷ 1000 kg

= 7.871 kg

Ans. 7 kg 871 g

Example

Three-fourth liter of a solution for intravenous infusion contains 2.5 g of drug. How many milliliters of the solution would contain 75 mg of drug?

Solution

1 liter (1000 ml) of solution contains 2.5 g

3/4th liter of the solution = $\frac{3 \times 1000}{4}$ ml = 750 ml

That is, 750 ml of the solution contains 2.5 g of drug

In other words, 2.5 g (2.5 g × 1000 = 2500 mg) of the drug is present in 750 ml.

$$75\text{mg of the drug is present in } \frac{750\text{ml} \times 75\text{mg}}{2500\text{mg}}$$

Ans. 22.5 ml

Example

A 60ml suspension of Ampicillin contains 250 mg/5 mL. Find out the volume of the suspension (milliliters) that contain 400 mg of Ampicillin.

Solution

The suspension contains 250mg of Ampicillin in 5 ml

That is, 1ml of suspension contains $\frac{250\text{mg}}{5}$ = 50 mg of Ampicillin

In other words, 50 mg of Ampicillin is present in 1 ml of suspension

So, 400 mg of Ampicillin is present in $\frac{400\text{mg}}{50\text{mg/ml}}$

Ans. 8 ml of suspension

Example

An injection contains 70 mg of drug in 2 mL. To administer 0.02 g of drug how many milliliters of the injection should be injected?

Solution

70 mg of drug is present in 2 ml of injection

1 mg of drug is present in $\frac{2\text{ml} \times 1\text{mg}}{70\text{mg}}$ = 0.0286 ml

0.02 g = 0.02 g × 1000 = 20 mg of drug should be present in 0.0286 ml × 20

Ans. 0.572 ml

Example

A patient is administered dose of 21mg of drug per day for 6 weeks, followed by 14 mg per day for 2 weeks, and then 7 mg per day for 2 more weeks. Calculate the total quantity, in grams, of the drug administered to the patient during this course of treatment.

Solution

1 week = 7 days

6 weeks = 6 × 7 days = 42 days

In one day 21 mg of the drug is administered

In 42 days, 21 mg × 42 = 882 mg of drug is administered during 6 weeks

2 weeks = 2 × 7 days = 14 days

In one day 14 mg of the drug is administered

In 14 days, 14 × 14mg = 196 mg of drug is administered during 2 weeks

In one day 7 mg of the drug is administered

In 14 days, 14 × 7mg = 98 mg of drug is administered during 2 weeks

Total drug administered = 882mg + 196mg + 98mg = 1176 mg

1176 mg = 1176mg ÷ 1000

Ans. 1.176g of drug is administered during 10 weeks

Example

A solution contains 250 mg of drug in each 25 mL. Express the concentration of solution in terms of μg of drug per μL.

Solution

1 mg = 1000 μg

250 mg = 250 × 1000 μg = 250000 μg

1 ml = 1000 μL

25 ml = 25 × 1000 μL = 25000 μL

So, 25000μL contain 250000μg of drug

Or, each μL contains $\frac{250000\mu g}{25000}$ = 10 μg/mL

The concentration of solution is

Ans. 10 μg/ μL

Example

If an inhaler contains 9 mg of salbutamol, how many inhalation doses can be delivered if each inhalation dose contains 90μg?

Solution

The dose of the drug = 90 μg

1 mg = 1000 μg

9 mg = 9000 μg

Number of doses present in 9 mg = 90 × 1000 = 9000 μg

Each dose contains 90μg

The number of doses in 9000 μg = $\frac{9000}{90}$

Ans. 100 doses

Equivalence between Different Systems

There are three systems of measurement:

- International System,
- Avoirdupois and
- Apothecaries 'systems.

The avoirdupois system had been widely used in the United States in measuring body weight and in selling goods (ounce or pound). However, the system is being replaced by the international system. Earlier, in pharmacy the apothecaries' system had been the predominant system to measure volume and weight. Now it has largely been replaced by the SI.

For the sake of knowledge one must know the relationship between the various systems of measurement.

Sometimes, the quantities in units of the Apothecaries' or of the Avoirdupois systems of measurement are to be converted to equivalent quantities in SI units and vice versa for the purpose of calculation. Some important and useful equivalents are given below ***Equivalents of Length*** 1 inch = 2.54 cm 1 meter (m) = 39.37 inch ***Equivalents of Weight*** 1 pound (lb, Avoirdupois) = 454 g 1 kilogram (kg) = 2.2 lb	***Equivalents of Volume*** 1 fluidounce (fl. oz.) = 29.57 mL 1 pint (16 fl. oz.) = 473 mL 1 quart (32 fl. oz.) = 946 mL 1 gallon, US (128 fl. oz.) = 3785 mL 1 gallon, UK = 4545 mL

Example

A container has the capacity to contain 58 gallons, US of water. Calculate the capacity of the container in terms of liters.

Solution

1 gallon, US = 3785 ml

58 gallons, US = 58 × 3785 ml

= 219530 ml

$$= \frac{219530\text{ml}}{1000}$$

Ans. 219.53 L

Example

The volume of a container is 25 gallons, UK. What would be the volume in liter?

Solution

1 gallon, UK = 4545 ml

25 gallon, UK = 25 × 4545 ml

= 113625 ml

Ans. 113.625 L

Example

In a warehouse there are many drums of light liquid paraffin under different systems of measurement. These are listed as 2 drums of 10 gallons, UK; 5 drums of 21 gallons, US; 4 drums of 100 L and a drum containing 4 quarts 1 pint of light liquid paraffin. Find out how many liters of light liquid paraffin are there?

Solution

2 × 10 gallons, UK = 2 ×10 × 4545 ml = 90900 ml

5 × 21 gallons, US = 5 × 21 ×3785 ml = 397425 ml

4 × 100 L = 4×100×1000 ml = 400000 ml

4 quarts 1 pint = 4× 946 ml + 473 ml = 4257 ml

Total = 892582 ml = 892582ml ÷ 1000

Ans. 892.582 L

Example

There was a stock of 15 kg glycerin. An order for 16 bottles of one pound each is to be supplied after repacking. Find out the balance quantity.

Solution

1 kg = 2.2 lb and 1 lb = 454 g

15 kg = 15 × 2.2 lb = 33 lb

To be supplied = 16 bottles of 1lb = 16 lbs

Balance stock = 33 lbs – 16 lbs = 17 lb

= 17 lbs × 454.5 = 7726.5 g

= 7718 ÷ 1000 = 7.718 kg; or

Ans. 7 kg 718 g

Example

The dimensions of a transdermal patch are 4.5 cm by 3.8cm. Express the dimensions in corresponding inches. [1 inch is equivalent to 2.54 cm]

Solution

2.54 cm = 1 inch

4.5 cm = $\frac{1 \times 4.5}{2.54}$ = 1.77 in

3.8 cm = $\frac{1 \times 3.8}{2.54}$ = 1.50 in

Area of the patch = 4.5 cm × 3.8 cm = 1.77 in × 1.50 in

Ans. 2.655 sq in

Example

The dose of a drug is 0.36 mg/kg/day. This is equivalent to which of the following?

(a) 360 cg/lb/day

(b) 360 mg/lb/day

(c) 163.6 mcg/lb/day

Solution

(a) 1 mg = 110 cg = 0.1 cg [1cg is = 1 centigram = 10 mg]

0.36 mg = 0.36 × 0.1cg = 0.036 cg

1kg = 2.2 lb

The daily dose 0.36 mg/kg = 0.0362.2 cg/lb = 0.163 cg/l

(b) The daily dose 0.36 mg1kg = $\frac{0.36 \text{ mg}}{2.2 \text{ lb}}$ = 0.163 mg/lb

(c) 1 mg = 1000 mcg

The daily dose 0.36 mg1kg = $\frac{0.36 \times 1000 \text{ mcg}}{2.2 \text{ lb}}$ = 163.63 mcg/lb

The equivalent dose of 0.36 mg/kg/day is

163.6 mcg/lb/day

Ans. that is (c)

Example

An average speed of air is 414 miles per hour. Which is the closest equivalent air speed?

(a) 6 mi/min

(b) 257 km/h

(c) 666 km/h

(d) 180 m/sec

Solution

1 mile = 1.6093 km

414 mile = 1.6093 × 414 km = 666.25 km

(a) The speed of air = 414 miles/hour = 414/60 mi/min = 6.9 mi/min

(b) The speed of air = 414 mi/h = 666.251 km/h = 666.25 km/h

(c) The speed of air = 414 mi/h = $\frac{666.25 \times 1000}{60 \times 60}$ = 185.07 m/sec

The nearest equivalent air speed is **666.25 km/h**

Ans. (c)

Conversion of Temperature

In 1709, Gabriel Fahrenheit, the German scientist marked the melting temperature of ice at 32^o on a thermometer, and boiling temperature of water at 212^o; the difference between the two temperatures was 180^o.

In 1742, Anders Celsius, a Swedish astronomer, recommended a scale showing 0^o for the freezing point of water and 100^o for the boiling point of water, a difference of 100^o.

As a result, the *Fahrenheit* (^{o}F) and the *Celsius,* or *centigrade,* (^{o}C) thermometers were established. Both types of thermometers measure the difference of temperature of same activities (boiling and freezing of water). Thus, 100^{o}C is equivalent to 180^{o}F; each degree centigrade is the equivalent of 1.8 or 9/5 degree Fahrenheit.

$$^oF = \frac{9}{5}\,^oC + 32 \text{ and } ^oC = \frac{5}{9} \times (^oF - 32)$$

Example

Convert 60 ^{o}C to corresponding degrees Fahrenheit.

Solution

$^oF = \frac{9}{5}(60\ ^oC) + 32 = 140$

Hence, 60 ^{o}C

Ans. 140^{o}F

Example

Convert 128°F to corresponding degrees Centigrade.

Solution

$^{o}C = \frac{5}{9} \times (128\ ^{o}F - 32) = \frac{5}{9} \times 96 = 40\ ^{o}C$

Hence, 128 °F

Ans. 40 °C

Example

The body temperature was recorded as 37 °C when a *Celsius* thermometer was used. If a Doctor's thermometer were used what would had been the temperature?

Solution

Doctor's thermometer reads the temperature in *Fahrenheit* scale.

Say, the equivalent temperature in *Fahrenheit* scale was x°F

Then, $x = \frac{9}{5}(37^{o}C) + 32 = (37 \times \frac{9}{5} + 32)^{o}F$

Ans. 98.6°F

Storage temperatures

In manufacturing, shipping, and storage of pharmaceutical products temperature plays an important role. At high temperature physicochemical instability of a therapeutic agent or its product may takes place. For better stability of drug products, the manufacturer needs to specify the appropriate storage temperature in the label of each pharmaceutical product, this includes temperature range under which the product should be stored. The *United States Pharmacopeia* provides the following definitions for the storage of pharmaceuticals.

Storage condition	Temperature
Freezer:	Between -25°C and -10°C (-13°F and 14°F)
Cold:	Within 8°C (46°F)
Refrigerator:	Between 2°C and 8°C (36°F and 46°F)
Cool:	Between 8°C and 15°C (46°F and 59°F)
Warm:	Between 30°C and 40°C (86°F and 104°F)
Excessive Heat:	Above 40°C (104°F)
Controlled Room Temperature:	Between 20°C and 25°C (68°F and 77°F)

Calculation Involving Units

Many of the pharmaceutical products are derived from biological sources. The potency of such product is based on *units of activity*. Specific biologic standards are used to determine the units of activity and the units of activity vary among the products.

The units of activity is determined and expressed in terms of a measurable quantity, such as units per milligram or units per milliliter. For example, as per the USP the sterile penicillin G sodium must contain not less than 1500 and not more than 1750 Penicillin G Units per milligram. The potency of the USP Reference Standard of the antibiotic is 1590 USP Units of penicillin G sodium per milligram. The potency of antibiotics may also be designated in terms of μg (micrograms) of activity.

This relationship may be used to determine either the number of units of activity or the weight or volume containing a specified number of units, as shown below:

$$\frac{\text{Units of activity (given)}}{\text{Weight or volume (given)}} = \frac{\text{Units of activity (given or desired)}}{\text{Weight or volume (given or desired)}}$$

Example

Calculate the volume of insulin U-100 to be taken to inject 50 units dose. (U-100 insulin contains 100 units per mL)

Solution

$$\frac{\text{Units of activity (given)}}{\text{Weight or volume (given)}} = \frac{\text{Units of activity (given or desired)}}{\text{Weight or volume (given or desired)}}$$

Or, $\frac{100 \text{ units}}{1 \text{ mL}} = \frac{40 \text{ units}}{\text{x mL}}$

$x = \frac{40 \text{ units}}{100 \text{ units}} \text{ mL}$

Ans. 0.4 mL

Example

Sterile penicillin G sodium powder contains 1600 units per mg. How many milligrams of the sterile powder are to be taken to administer 500000 units?

Solution

$$\frac{\text{Units of activity (given)}}{\text{Weight or volume (given)}} = \frac{\text{Units of activity (given or desired)}}{\text{Weight or volume (given or desired)}}$$

or, $\frac{1600 \text{ units}}{1 \text{ mg}} = \frac{500000 \text{ units}}{\text{x mg}}$

or, $x = \frac{500000 \text{ units}}{1600 \text{ mg}}$

Ans. 312.5 mg

Example

A diabetic patient receives 20 units of insulin twice daily. The vial contains 10 mL of insulin U-100, in how many days the vial will be exhausted?

Solution

In a day the patient receives 2 × 20 units = 40 units.

10 ml of U-100 insulin contains = 10 × 100 units = 1000 units of insulin

$$\frac{\text{Units of activity (given)}}{\text{Weight or volume (given)}} = \frac{\text{Units of activity (given or desired)}}{\text{Weight or volume (given or desired)}}$$

or, $\frac{40 \text{ units}}{1 \text{ day}} = \frac{1000 \text{ units}}{x \text{ days}}$

or, $x = \frac{1000 \text{ units} \times \text{days}}{40 \text{ units}}$

Ans. 25 days

The units and micrograms of potency of some official drugs and their respective weight equivalents are given in Table 1.1

Table 1.1 Potency (Activity units) of some important drug substances

Drug substance	Potency as per the USP
Ampicillin Sodium	Not less than 845 µg and not more than 988 µg of Ampicillin per mg
Antihemophilic Factor	Not less than 100 Antihemophilic Factor Units per g of protein
Bacitracin	Not less than 40 Bacitracin Units per mg
Bacitracin Zinc	Not less than 40 Bacitracin Units per mg
Cephalothin Sodium	Not less than 850 µg of Cephalothin per mg
Chymotrypsin	Not less than 1000 USP Chymotrypsin Units per mg
Clindamycin HCl	Not less than 800µg of Clindamycin per mg
Colistimethate Sodium	
Digitalis	

Table 1.1 ***contd…***

Erythromycin Estolate	390 µg Colistin per mg
Gentamycin Sulfate	Not less than 1 USP Digitalis Unit per 100 mg
Heparin Calcium	Not less than 600 µg of erythromycin per mg
Heparin Sodium	Not less than 590µg of Gentamycin per mg
Insulin	Not less than 140 USP Heparin Units per mg
Insulin Human	Not less than 140 USP Heparin Units per mg
Kanamycin Sulfate	Not less than 26.5 USP Insulin Units per mg
Mitomycin	Not less than 27.5 USP Insulin Human Units per mg
Neomycin Sulfate	Not less than 750 µg of Kanamycin per mg
Nystatin	Not less than 970µg Mitomycin per mg
Pancreatin	Not less than 600 µg of neomycin per mg
	Not less than 4400 USP Nystatin Units per mg
Penicillin G Benzathine Penicillin G Potassium Penicillin G Sodium	Not less than 25 USP Units of amylase activity, not less than 2 USP Units of lipase activity, and Not less than 25 USP Units of protease activity per mg
Penicillin V Penicillin V Potassium	Not less than 1090 and not more than 1272 Penicillin G Units per mg
Polymyxin B Sulfate	Not less than 1440 and not more than 1680 Penicillin G Units per mg
Streptomycin Sulfate	Not less than 1500 and not more than 1750 Penicillin G Units per mg
Tobramycin	Not less than 1525 and not more than 1780 Penicillin V Units per mg
Trypsin, crystallized	Not less than 1380 and not more than 1610 Penicillin V Units per mg
Vancomycin	Not less than 6000 Polymyxin B Units per mg
Vasopressin	Not less than 650 µg and Not more than 850 µg of streptomycin per mg
Vitamin A	Not less than 900 µg of Tobramycin per mg
	Not less than 2500 USP Trypsin Units per mg
	Not less than 950 µg Vancomycin per mg
	Not less than 300 Vasopressin Units per mg
	1 USP Vitamin A Unit equals the biologic activity of 0.3 µg of the all-*trans* isomer of retinol

Example

The monograph of I.P. for Concentrated vitamin A oil states that it contains not less than 500000 Units of vitamin A per g and not less than 95% and not more than 110% of the stated number of Units per g. What would be the purity expression in terms of percent for a sample containing 475000 Units of vitamin A per g?

Solution

As per I.P. the lowest limit in terms of Units is 500000 which is equivalent to 95%.

$$\frac{500000 \text{ Units}}{95\%} = \frac{475000 \text{ Units}}{x\%}$$

or, $$x = \frac{475000 \times 95}{500000}$$

Ans. 90.25%

Example

Streptomycin sulphate 75 kg has been bought and analyzed. The potency of the drug is found to be 710 µg per mg. According to Master Formula 70 kg of 100% potency is required for a lot. Find out how much of the drug is to be issued by the store.

Solution

The limits of potency of the drug being from 650 to 850µg/mg; the potency of 750 [(650+850)/2] µg/mg represents 100%.

Thus, the potency, 710 µg/mg represents $\frac{710 \times 100}{750}$ = 94.67%

Say, *x* kg of 94.67% is equivalent to 70 kg of 100%

The amount of drug to be issued = $\frac{70 \times 100}{94.67}$

Ans. 73.94 kg

Exercise

1. The weights have been recorded differently by different students. Add 12 kg 85 mg, 95 kg 349 g, 1kg 986 g 446 mg, 764.9 g, 3.6437 kg, 6.643 g and write the result in the form of mixed units.

Ans: 113 kg 750 g 81 mg

2. Add 0.0025 kg, 1750 mg, 2.25 g, and 825,000 µg, and express the answer in grams.

Ans: 7.325 g

3. A capsule contains the following amounts of medicinal substances: 0.075 g, 20 mg, 0.0005 g, 4 mg, and 500 µg. What is the total weight of the substances in the capsule?

Ans: 100 mg

4. Each ml of a solution contains 1.04 g, 45 mg, 0.8 mg, 520 mcg of various ingredients. Calculate total quantity of ingredients per ml?

Ans: 1 g 86.32 mg

5. Add 51 L, 0.85 L and 395 mL. Express the total volume in milliliters.

Ans: 52245 ml

6. From a stock of 2.55 g Cyanocobalamine 770 mg is taken. How much is left?

Ans: 1780 mg or 1 g 780 mg

7. A cloth piece of length 4 meter was cut into pieces. Length of each is 1 foot 6 inches. Calculate the length of balance cloth.

Ans: 13.48 inch or 34.24 cm

8. There are five bottles of Almond oil; two bottles of 1 quart, one bottle of 1 pint, one bottle of 500 ml, and one bottle of 1L. Find out the total quantity of almond oil.

Ans: 3865 ml or 3 L 865 ml

9. A thermometer records 98 ^{o}C. Convert this temperature to Fahrenheit scale.

Ans: 208.4 ^{o}F

10. If the normal body temperature is 98.6 ^{o}F. What would it be in Centigrade scale?

Ans: 37 ^{o}C

11. A sample is found to contain 590 units of drug per mg. A dosage form containing 200000 units is prepared. How many milligram of the drug shall remain per unit dosage form?

Ans: 338.98 mg per dosage form

12. The monograph of I.P. for Concentrated vitamin A oil states that it contains not less than 500000 Units of vitamin A per g and not less than 95% and not more than 110% of the stated number of Units per g. What would be the purity expression in terms of units for a sample containing 98.5% of vitamin A?

Ans: 518421 units per g

12. Each Paracetamol tablet contains 650 mg of paracetamol. How many such tablets can be prepared from 15 kg of paracetamol?

Ans: 23076.9

13. An injectable solution contains 50 µg of a drug substance in each 0.5 mL, find out the volume to be injected so that a patient receives 0.25 mg of the drug substance.

Ans: 2.5 ml

14. A prefilled syringe contains 25 mg of drug in 2 mL of solution. How many micrograms of drug would be administered if 0.5 mL of the solution is injected?

Ans: 6250 µg

15. Each tablet contains the following ingredients:

Aspirin 325 mg

Calcium Carbonate 27.5 mg

Citric Acid 90.5 mg

Potassium Bicarbonate 29.5 mg

Sodium Bicarbonate 46.0 mg

Magnesium stearate 5 mg

Starch 25 mg

Talcum 5 mg

PVP 27.5 mg

(a) Calculate the total weight, in grams, of the ingredients in each tablet.

(b) How many tablets could be made with a supply of 5 kg of aspirin?

Ans: (a) 561, (b) 15384.6

16. The dimensions of a microscopic slide are 10.8 cm by 2.6 cm. Express these dimensions in corresponding inches and area in sq in. (1 inch = to 2.54 cm)

Ans: 4.25 in, 1.02 in, 4.34 sq in

17. An inhaler contains 20 mg of drug, how many inhalation doses can be delivered if each inhalation-dose contains 80 µg?

Ans: 250 doses

18. A formulation contains 0.3 mg of drug in each milliliter. Which of the following would be the equivalent expression of concentration?

(a) 0.03 mg/0.1 dL

(b) 300 mcg/0.01 dL

(c) 3 mcg/0.01 cL

(d) 300 mcg/10 cL

Ans: (b) 300 µg/0.01dL

19. An intravenous solution contains 520µg of drug substance per 5 ml. How many milligrams of the drug would be administered if 540ml of the solution is infused?

Ans: 280.8 mg

20. An analytical instrument can measure quantities of a chemical substance up to nanogram/ml. How many times more capable is this instrument than one that can measure microgram/ml?

Ans: 1000 times

21. A solution for IV injection contains 125 mg of drug in each 15 mL of injection. What would be the concentration of drug in terms of µg/µL?

Ans: 8.33 µg/µL

22. According to the label claim each milliliters of Ampicillin sodium injection contains 125 mg of Ampicillin100%. If the Ampicillin sodium used contains 900 µg of Ampicillin per mg, calculate the amount of Ampicillin present in two milliliters of injection. The potency limits of Ampicillin sodium is 845 to 988µg/mg.

Ans: 254.6 mg

23. A tube is 2ft 5 inches long and 7 inches wide. Convert the dimensions in terms of centimeter.

Ans: 73.66cm long and 17.78 cm wide

24. A mixing tank is 1.6 meter in height and its width is 0.98meter. Convert the dimensions in foot and inches.

Ans: 5 ft 2.99 inches long and 3ft 2.58 inches

25. The prophylactic dose of riboflavin is 2 mg. How many grams of riboflavin would be required to prepare 50000 tablets with 10% overage?

Ans: 110 mg