Paramedic Resource Manual

MEDICAL MATH

SECTION TEN

2014 Update by
Ontario Base Hospital Group Education Subcommittee

OBJECTIVES: MEDICAL MATH

The objectives indicate what you should know, understand and be prepared to explain upon completion of this module. The self-assessment questions and answers will enable you to judge your understanding of the material.

Upon completion of this module, the student should be able to:

1. state the six base units of the SI system and name the physical quantity that they measure.

2. differentiate between a base unit and a derived unit of the SI system.

3. with specific reference to the SI unit of volume, state the "special" derived unit that is recommended for use in the health technologies.

4. with specific reference to the SI unit for temperature:

   a) name the base unit
   b) state the derived unit of measurement recommended for use in the health technologies
   * c) given a temperature in one of these units convert to the other unit.

5. name and define the prefixes used in the SI System to denote multiples and submultiples of any unit.

*6. convert SI units of different magnitudes.

7. write all symbols and numbers used in the SI system according to the basic rules for writing symbols and numbers.

*8. interconvert between SI, metric and imperial systems of measurement for the following physical quantities:

   a) temperature
   b) weight
   * c) length

9. given a series of lines, estimate the length within one centimetre without aid of a measure or calculator.

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* Calculations for these must be done without the aid of a calculator.

10. given mathematical problems similar to those encountered in A.L.S. field situations, correctly perform the appropriate calculations without aid of a calculator.

If you have studied this subject previously, you may test your ability using the self-assessment questions. If you are able to obtain 90% or greater, you may choose not to do the unit and merely review the sections, or parts of sections, where weakness may exist. If you obtain less than 90%, it is recommended that the module be done in its entirety, stressing areas where more review is needed.

INTRODUCTION

Unit of measurement have evolved from many sources. Many of the systems found their origins in local customs and usage. Most lacked a rational structure and had poorly correlated units. Interconversion between the systems was difficult if not impossible.

Of all the systems that have evolved, two (imperial system and metric system) have had common usage in Canada.

THE IMPERIAL SYSTEM

This system, used for everyday measurements, uses units such as the yard, pound and quart. Not only is there poor correlation between the units but also two different sets of unit have evolved. The first being developed by countries of British origin and the second by the United States.

THE METRIC SYSTEM

This system, developed in France over two hundred years ago, uses such units as metre, litre and gram. Although widely accepted by most European countries and by the scientific community, it too was often confusing to work with. Several versions of the metric system have evolved and many of the measurements made with this system incorporated both imperial and metric units.

In 1960, the international system of Units was established. Basically it is a modernized metric system designed to replace all former systems of measurement, including former versions of the metric system. It is commonly referred to as the SI system of measurement, **i.e.** Le Systeme International.

Canada officially adopted the SI system of measurement in 1970.

On April 1, 1983, all members of the Hospital Council of Metropolitan Toronto converted to the SI system. Since this changeover has taken place , and since many people still use the imperial system and/or the metric system for everyday measurements, this module will deal with the SI system for everyday measurements, This module will deal with the SI system, as related to the health sciences, and where applicable, the conversion of the SI system to imperial and/or metric units of measurement.

METRIC REVIEW

It is important that the student have a good command of the metric system in order to fully understand pharmacology, fluid administration, and body weight.

The metric system, which employs the decimal scale, is composed of units measuring length, volume and weight.

Because the metrics system employs the decimal scale, its numerical scale is based on 10. The prefixes used in the metric system indicate which unit of 10 applies to the measure in use. Three of the prefixes are used to indicated multiples of 10

- Deca refers to units of 10
- Hecto refers to units of 100
- Kilo refers to units of 1000

Of these, the one most often used is Kilo.

Three of the prefixes are used to indicate fractional units.

A litre is a liquid measure and a centimetre is a linear measure. However, in the metric system, the two are directly related, since 1 litre occupies the space of 1000 cubic centimetres.

EQUIVALENTS

Linear Measure

1 Metre (m)	=	10 Decimetres (dm)
1 Metre	=	100 Centimetres (cm)
1 Metre	=	1000 Millimetres (mm)
1 Metre	=	1 000 000 Micrometres (µm)
1 Metre	=	1 000 000 000 Nanometres (nm)
10 Metre	=	1 Decametre (dam)
100 Metre	=	1 Hectometre (hm)
1000 Metre	=	1 Kilometre (km) (5/8 Mile)

Volume

1 Litre (L)	=	10 Decilitres (dL)
1 Litre	=	100 Centilitres (cL)
1 Litre	=	1000 Millilitres (mL)
10 Litre	=	1 Decalitre (daL)
100 Litre	=	1 Hectolitre (hL)
1000 Litre	=	1 Kilolitre (kL)

Weight

1 Gram (G)	=	10 Decigrams (dg)
1 Gram	=	100 Centigrams (cg)
1 Gram	=	1000 Milligrams (mg)
1 Gram	=	1 000 000 Micrograms (µg)
10 Gram	=	1 Decagram (dag)
100 Gram	=	1 Hectogram (hg)
1000 Gram	=	1 Kilogram (kg) (2.2 lb)
.000001 Gram or .001 Milligram	=	1 Microgram (µg)

The most useful of these measures in prehospital care are highlighted in this module.

TYPES OF UNITS

There are three types of units in the SI system:

1. Base units
2. Derived units
3. Supplementary units.

BASE UNITS

The six base units in the SI system most relevant to prehospital care serve as the reference units for the derived units of measurement. By using appropriate combinations of the base units, any physical quantity can be expressed.

The base units (Table 1) can be independently define or calculate.

TABLE 1 BASE UNITS		
PHYSICAL QUANTITY	BASE UNIT	SI SYMBOL
length	metre	m
mass	kilogram	kg
time	second	s
amount of substance	mole	mol
thermodynamic temperature	Kelvin	K
electric current	ampere	A

DERIVED UNITS

Derived units cannot be independently defined or calculated without reference to base units, supplementary units and/or other derived units.

EXAMPLE 1:

A newton is the derived unit for the physical quantity force.

A newton (N) is defined as the force which, when applied to a mass of one kilogram (kg) gives it an acceleration of one metre (m) per square second (s^2).

$$1 \text{ N} = 1 \text{ kg.m/s}^2$$

In this example, the derived unit newton (N) is defined in terms of the base units kilogram, metre and second.

EXAMPLE 2:

A joule (J) is defined as unit of work done by a force of one newton (N) when its point of application is displaced one metre (m) in the direction of the force.

$$1\ J = 1\ N.m$$

In this example, the derived unit joule (J) is defined in terms of another derived unit, the newton, and a base unit, the metre. The term joule will be particularly useful for those students who will be studying defibrillation in a subsequent module. Joule replaces the formerly used term watt/second.

1 J	=	Watts	x	seconds
(energy)		(power)		(duration)

Therefore: 1 j = 1 W/s

A list of derived units can be found in Appendix A. It is not intended that you memorize these units at this time, but rather, that this list serve as a reference source for future studies.

There are two derived units of measurement, volume and temperature, which are routinely used, or ret-erred to, by all health technologies. They will be discussed here in detail because each is "special" in the SI system.

Volume

The SI derived unit for volume is the cubic metre (m^3). However, the litre (L) is also accepted as a "special" name for a derived unit of volume. In fact, because of its convenience, the litre (L) is recommended as the unit for volume of fluid. Concentrations of all fluids are expressed per litre not per cubic metre.

The abbreviation cc (cubic centimetre) formerly used in medicine to express fluid volume is now replaced by the millilitre (mL), **e.g.** if we have a 10 cubic centimetre syringe, we can fit exactly 10 millilitres of fluid in it.

TEMPERATURE

Reference to the base units of the SI system will show that the unit for measuring temperature is the Kelvin (K). However, since the Kelvin temperature scale has limited application in medicine, a derived unit for measurement with wider applications, was approved. This accepted derived unit is the degree Celsius (°C). However, some household thermometers still record in Fahrenheit degrees.

The Celsius and Fahrenheit temperature scales are related as shown in Table 2.

TABLE 2 CELSIUS/FARENHEIT TEMPERATURE SCALES		
CELSIUS °C	FAHRENHEIT °F	
100°	212	BOILING POINT OF WATER
41	105.8	
40	104	
39	102.2	
38	100.4	
37	98.6	HUMAN BODY TEMPERATURE
0	32	FREEZING POINT OF WATER

SUPPLEMENTARY UNITS

Certain units of the SI have not yet been classified as either base units or derived units. They are referred to as supplementary units and may be regarded as either base or derived. Since there are no supplementary units used in general medical practice, they will not be discussed in this module.

SI UNITS USED IN HEALTH CARE

Appendix B has a list of more common SI units applicable to the health technologies. It is meant as a reference source for future studies.

PREFIXES OF THE SI SYSTEM

Multiples and submultiples of SI units are denoted using a system of prefixes (Table 3).

PREFIXES OF THE SI SYSTEM			
PREFIX	SYMBOL	FACTOR	
Mega	M	1,000,000	10^6
*kilo	k	1,000	10^3
Hecto	h	100	10^2
Deca	da	10	10^1
*deci	d	0.1	10^{-1}
*centi	c	0.01	10^{-2}
*milli	m	0.001	10^{-3}
*micro	u	0.000001	10^{-6}
*nano	n	0.000000001	10^{-9}

*Prefixes commonly used in the health technologies.

Examples of Using Prefixes

EXAMPLE 5:

Kilo means 1 x 10^3

Therefore, 1 kilogram (kg) = 1 x 10^3 g = 1000 g

1 kilometer (km) = 1 x $10^{3\ m}$ = 1000 m

EXAMPLE 6:

Milli means 1 x 10^{-3}

Therefore, 1 millilitre (mL) = 1 x 10^{-3} L = 0.001 L

1 milligram (mg) = 1 x 10^{-3} g = 0.001 g

EXAMPLE 7:

nano means 1 x 10^{-9}

Therefore, 1 nanometre (nm) = 1 x 10^{-9} m = 0.000000001 L

RULES FOR WRITING SYMBOLS AND NUMBERS IN SI

One of the main advantages of SI is that there is a unique symbol for each unit. Because these are international symbols and not abbreviations, they do not change for different languages. It is easier and in most cases faster to use the SI symbol than writing the name of the unit in full.

Examples of Symbols

m = metre
g = gram
μg = microgram
°C = degree Celsius
s = second

RULES FOR WRITING NUMBERS

1. Use decimals, not fractions: 0.25 g (not ¼ g).

2. Use a zero before the decimal marker if the numerical values are less than one: 0.45 g (not .45 g). **This is particularly important when documenting decimals associated with drug usage**.

3. As a decimal marker, both the point and the comma are widely used in the world today. *Metric Commission Canada's policy is to use the comma in French-language documents and the point in English-language. This practice is being followed by the Department of Justice in printing legislation.

RULES FOR WRITING SYMBOLS

1. Symbols are written in lower case, except when the unit name is derived from a proper name: m for metre; s for second; but N for newton.

   Exception: The symbol for litre (L) is always written as an upper case letter.

2. When the names of the units are written out in full, lower case letters are always used even if the unit is derived from a proper name: newton not Newton.

   Exception: Celsius is the only unit that when written in full, is capitalized.

3. Prefix symbols are printed in upright type without spacing between the prefix symbol and the unit symbol: kg for kilogram; km for kilometre.

4. Symbols are never pluralized: 1 g, 45 g (not 45 gs).

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* Source: How to Write SI (fifth edition) Metric Commission Canada

5. Names and symbols should not be mixed. N○m or newton metre, but not N metre or newton m.

6. Never use a period after a symbol, except when the symbol occurs at the end of a sentence.

7. Symbols should be used in conjunction with numerals instead of writing out the unit names; when no numerals are involved, unit names should be written out:

   Weigh out 16 g of chemical (not 16 grams). Calculate the weight of chemical in grams (not g).

8. The product of two or more units in symbolic form is indicated by a dot. The dot must be positioned above the line to distinguish it from a decimal marker dot on the line: $kg{\circ}m{\circ}s^{-2}$.

COMMON CONVERSION FACTORS

Although SI has been adopted by Canadian hospitals, there is still a need to know some units in the metric and imperial systems and be able to convert these units to SI.

Patients, unfamiliar with SI may give pertinent information in the imperial system.

Textbooks and periodicals used as reference sources may have been written either before the adoption of SI or by individuals in other countries where the conversion to SI is not yet completed.

TEMPERATURE CONVERSIONS

Formulas:

$$°C = \frac{5}{9}(°F - 32)$$

$$°F = \frac{9}{5}(°C + 32)$$

WEIGHT CONVERSIONS

2.2 pounds (lb) = 1 kg.

LENGTH CONVERSIONS

1 inch = 2.54 cm

1 mile = 1.6 km

1 mile per hour = 1.6 km per hour

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SELF-ASSESSMENT

Marks

[3] 1. Name six base units of the SI systems and state the physical quantity that they measure.

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[2] 2. Differentiate between a base unit and a derived unit in the SI system.

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[1] 3. Name the special derived unit of volume used by the health technologies.

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[1] 4. a) State the derived unit for temperature used by the health technologies. State the scale used commonly in the home.

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b) State the relationship between these two units.

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[7] 5. Convert the following:

a) 500 mL = ____________________________ L

b) 500 mL = ____________________________ µL

c) 0.5 cc = ____________________________ mL

d) 4.55 kg = ____________________________ g

e) 495.8 mg = ____________________________ g

f) 294 µg = ____________________________ mg

g) 56.5 cm = ____________________________ m

[6] 6. Convert the following:

a) 175 lb = ____________________________ kg

b) 43 inches = ____________________________ cm

c) 27°F = ____________________________ °C

d) 48°C = ____________________________ °F

e) 56.7 kg = ____________________________ lb

[3] 7. You have an I.V. bag containing 250 mL of fluid. Your administration set delivers 60 drops per minute. Sixty drops comprise 1 mL of fluid. The physician orders an administration rate of 75 cc/hr.

a) How many drops per minute will you give?

b) How long will it take to empty the bag?

c) 250 mL =______________ L

[2] 8. One gram of a medication is supplied pre-mixed in 250 mL of fluid. Express the concentration of the drug in mg/mL.

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[1] 9. A medication is supplied in a 200 mg pre-loaded syringe. You add this to a 250 mL bag of IV fluid. Express the concentration of the medication in mg/mL.

___ 27 TOTAL

ADVANCED LIFE SUPPORT
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SELF-ASSESSMENT ANSWERS

1. For each incorrect answer deduct ¼ of a mark.

BASE UNIT	PHYSICAL QUANTITY
metre (m)	length
kilogram (kg)	mass
second (s)	time
mole (mol)	amount of substance
kelvin (K)	temperature
ampere (A)	electrical current

2.
   - A base unit can be independently defined or calculated.
   - A derived unit is defined in terms or base units or other derived units.

3. The special derived unit of volume is the litre (L).

4. a) The derived unit is the degree Celsius (°C). The common unit is the degree Fahrenheit (°F).

   b) These units are related as follows:

$$°C = \frac{5}{9}(°F - 32) \quad \text{[or]} \quad °F = \frac{9}{5}°C + 32$$

5.

a)	500 mL	=	500×10^{-3}	= <u>0.500</u> L
b)	500 mL	=	500×10^{3}	= $\underline{5 \times 10^5}$ µL or <u>500,000</u> µL
c)	0.5 cc	=	<u>0.5</u> mL	
d)	4.55 kg	=	4.55×10^{3}	= <u>4550</u> g
e)	495.8 mg	=	495.8×10^{-3}	= <u>0.4958</u> g
f)	294 µg	=	294×10^{-3}	= <u>0.294</u> mg
g)	56.5 cm	=	56.5×10^{-2}	= <u>0.565</u> m

6. Convert the following:

a)	175 lb	=	175 ÷ 2.2	= <u>79.5</u> kg
b)	43 inches	=	43 x 2.54	= <u>109</u> cm = <u>1.09</u> m
c)	27°F	=	<u>-2.8</u> °C	
d)	48°C	=	<u>118.4</u> °F	
e)	56.7 kg	=	56.7 x 2.2	= <u>124.7</u> lb

7. a) 75 cc/hr = 75 mL/60 min

$\frac{75}{60}$ = 1.25 mL/min = 1.25 x 60 = 75 drops/min

b) 75 mL/hr; 250 mL will take $\frac{250}{75}$ = 3.33 hours

c) 0.25 L

8. 1 g = 1000 mg

$\frac{1000 \text{ mg}}{250 \text{ mL}}$ = 4 mg/mL

9. 200mg 250 mL = 4 mg/mL = 0.8 mg/mL

If you have experienced difficulties in the self-assessment, proceed to the mathematics review exercises to assist you in developing accuracy in handling mathematical calculations and conversions.

APPENDIX A

COMMON DERIVED UNITS OF THE SI SYSTEM

SI DERIVED UNITS WITH SPECIAL NAMES*

QUANTITY	NAME OF UNIT	SYMBOL FOR UNIT	DERIVATION OF UNIT
Celsius temperature	degree Celsius	°C	K
force	newton	N	Kg○m/s^2
pressure	pascal	Pa	N/m^2
work; energy; quantity of heat	joule	J	N○m
power	watt	W	J/s
electric charge; quantity of electricity	coulomb	c	A○s
electrical potential; potential difference	volt	v	W/A
electric resistance	ohm	O	V/A

*These will be useful to the students who will be studying defibrillation in subsequent modules.

SI UNITS APPLICABLE TO HEALTH cont'd

QUANTITY	SI UNIT	SYMBOL	CUSTOMARY UNIT	TYPICAL APPLICATION
8. energy	joule kilojoule	J kJ	Calorie kilocalorie, calorie	food energy metabolic energy, kinetic energy
9. pressure	pascal kilopascal	Pa kPa	millimetre of mercury, inches of water	ocular, cerebrospinal, and blood pressure
10. frequency	hertz	Hz	cycle per second	audio, radio and x-ray frequencies
11. substance concentration	mole/litre	mol/L	milligram per cent milliequivalent per litre	composition of body fluid.

MATHEMATICAL REVIEW EXERCISES

STANDARD OR SCIENTIFIC NOTATION

Frequently it is necessary to represent very large or very small quantities numerically.

The mass of an electron is:
0.000 000 000 000 000 000 000 000 911g

The number of molecules in a mole, know as Avogadro's number is:
620 000 000 000 000 000 000 000.

Writing and working with numbers in this form is difficult and may lead to mathematical errors. To avoid this, such numbers are expressed in a standard form using powers of 10.

10^4 is a power of 10

[10 is the base] [^{4} is the exponent]

The standard or scientific form of a number consists of:

A value between 1 and 10 x a power of 10 to locate the decimal point

Example:

2×10^4
2×10^{-3}

For numbers greater than 1, the exponent is positive and indicates how many places the decimal point is located to the right.

Example:

$$2 \times 10^4 = 2 \times 10 \times 10 \times 10 \times 10 = 20,000$$

For numbers less than 1, the exponent is negative and indicates how many places the decimal point is located to the left.

Example:

$$2 \times 10^{-3} = \frac{2}{10 \times 10 \times 10} = 0.002$$

The standard or scientific form of the mass of an electron is written: 9.11×10^{-23} g
The standard or scientific form of the mass of Avogadro's is written: 6.02×10^{23} g

Exercise 1.1

Study the following tables and complete the missing information.

40	4 x 10	4×10^{1}
400	4 x 100	4×10^{2}
4000		
7680	7.68 x	
76,800		7.68 x
370		3.7
6,200,000		

	Standard	Exponent Number	Form of 10
52,600	5.26 x 10, 000	5.26×10^{4}	4
5,260	5.26 x 1, 000	5.26×10^{3}	3
526	5.26 x 100	5.26 x	
52.6	5.26 x		
5.26	5.26 x 1	5.26×10^{0}	
0.526	5.26 ÷10	5.26×10^{-1}	-1
0.0526	5.26 ÷ 100	5.26×10^{-2}	-2
0.00526	5.26 ÷		

Exercise 1.2

Rewrite the following in standard form:

a) 579	b) 1300	c) 47.6	d) 724.8
e) 12 000 000.	f) 38 200.	g) 6	h) 980 000.
i) 0.0523	j) 0.246	k) 0.00761	l) 0.00864
m) 0.000002	n) 0.179	o) 0.000751	p) 0.0297

Exercise 1.3

Expand each of the following:

a) 4×10^{2}	b) 5.72×10^{5}	c) 6.3×10^{1}
d) 1.89×10^{-2}	e) 2.34×10^{-1}	f) 9.09×10^{4}
g) 5.55×10^{7}	h) 4.12×10^{-6}	i) 8.76×10^{3}
j) 7.34×10^{-4}	k) 6.19×10^{-3}	l) 5.82×10^{3}
m) 4.79×10^{-3}	n) 5.26×10^{-1}	o) 4.38×10^{6}
p) 3.24×10^{-2}		

UNITS OF MEASURE

In dealing with units of measurement, e.g. length, mass and volume, it is necessary to convert units from one form into another quickly and accurately. This is particularly important when dealing with drugs, their concentration (mass per unit volume) and their dosages (concentration per unit body mass). The following examples and exercises are designed to give the student practice with the units of measurement singly and then in combination.

MASS

The units of mass are expressed in terms of the gram (g).

1 kilogram (kg) = 1000 g (10^{3} g)
1 milligram (mg) = 1/1000 g (10^{-3} g)
1 microgram (µg) = 1/1000000 g (10^{-6} g)

Interconversion Units of Mass

kg	g	mg	µg
kilogram	kg x 10^{3} = g	kg x 10^{6} = mg	kg x 10^{9} = µg
g x 10^{-3} = kg	gram	g x 10^{3} = mg	g x 10^{6} = µg
mg x 10^{-6} = kg	mg x 10^{-3} = g	milligram	mg x 10^{3} = µg
µg x 10^{-9} = kg	µg x 10^{-6} = g	µg x 10^{-3} = mg	microgram

Examples

Convert 0.05 g to mg

g x 10^3 = mg
0.05 g x 10^3 = 50 mg

Convert 0.05 g to µg

g x 10^6 = µg
0.05 g x 10^6 = 50000 µg

Convert 7.2 mg to g

mg x 10^{-3} = g
7.2 mg x 10^{-3} = 0.0072 g

Convert 7.2 mg to µg

mg x 10^3 = µg
7.2 mg x 10^3 = 7200 µg

Exercise 2.1

Express each of the following in grams.

a) 52 mg	b) 645 µg	c) 2.7 kg	d) .032 mg
e) 9 µg	f) 8763 mg	g) 71860 µg	h) 0.45 kg

Exercise 2.2

Express each of the following in milligrams.

a) 0.021 g	b) 62.3 µg	c) 0.00731 kg	d) 175 g
e) 89 kg	f) 0.49 µg	g) 0.000056 g	h) 12347 µg

WEIGHT CONVERSIONS

Patients, unfamiliar with SI will give their weight in terms of pounds.

1 kg = 2.2 pounds (lb)

$$\text{kg} = \frac{\text{weight in pounds}}{2.2}$$

Exercise 2.3

Express each of the following in kilograms. Do all calculations mentally. Express your answer to the nearest whole kg.

a)	45 lbs	b)	130 lbs	c)	105 lbs	d)	175 lbs
e)	114 lbs	f)	150 lbs	g)	200 lbs	h)	80 lbs
i)	210 lbs	j)	27 lbs	k)	183 lbs	l)	142 lbs

VOLUME

The units of measurement for volume are expressed in terms of the litre (L).

1 litre (L) = 1000 millitres (mL)

The abbreviation cc (cubic centimetres) is now replaced by the millilitre (mL).

Another measure of volume applies specifically to Intravenous (IV) drips where the drip rate (number and size of drops) determines the volume of fluid delivered to the patient.

Exercise 3.1

Express the following in millilitres (mL).

a)	0.250 L	______________	b)	1.86 L	___________	c)	0.000013 L	____________
d)	0.0782 L	______________	e)	59.2 L	___________	f)	0.00037 L	____________
g)	0.563 L	______________	h)	0.00945 L	___________			

Exercise 3.2

For an IV drip, regular tubing, 10 drops (10 gtt) equals 1 mL. How many drops are required to deliver the following volumes?

a)	5.0 mL	______________	b)	250 mL	______________	c)	0.003 L	______________
d)	75 mL	______________	e)	0.5 L	______________	f)	0.10 mL	______________
g)	12 mL	______________	h)	1 L	______________			

Exercise 3.3

For an IV minidrip, 60 drops (60 gtt) equals 1 mL. How many drops are required to deliver the following volumes?

a)	0.125 mL	______________	b)	186 mL	______________	c)	7.8 mL	______________
d)	13 L	______________	e)	563 mL	______________	f)	0.0009 L	______________
g)	0.75 mL	______________	h)	0.08 L	______________			

CONCENTRATION

Concentration is the quantity of a substance, e.g. a drug, dissolved in a given volume of solution. There are many ways of expressing concentration:

mol/L	moles per litre (SI unit)
g/L	grams per litre
g/dL	grams per decilitre = grams per 100 mL
g% or %	grams per 100 mL
mg%	milligrams per 100 mL
Eq/L	equivalents per litre
mEq/L	milliequivalents per litre

Though the SI unit is mol/L, all other units are commonly used particularly in expressing the concentration of drugs. Given the concentration of a drug, the student must be able to determine quickly and accurately the volume required to obtain a given concentration or the quantity of drug in a given volume.

EXAMPLE 1: GIVEN A 50% DEXTROSE SOLUTION

50% dextrose = 50 g/100 mL

Therefore: 1 mL contains $\frac{50}{100}$ g = 0.5 g

Question 1: How many mL of dextrose solution contain 20 g?

If 1 mL contains 0.5 g

Then $\frac{20.0}{0.5}$ = 40.0 mL – the number of mL that contains 20 g

Question 2: How many grams of dextrose are contained in 15 mL?

If 1 mL contains 0.5 g

Then 15 mL contain 15 x 0.5 g = 7.5 g

Exercise 4.1

Calculate the concentration in mg/mL for each of the following solutions.

a)	1 g/L	__________	b)	0.6 g%	__________	c)	200 mg%	__________
d)	0.5 g/dL	__________	e)	0.2 g/L	__________	f)	10 g/dL	__________
g)	20 g/L	__________	h)	4000 mg%	__________	i)	0.1 g/L	__________

Exercise 4.2

For each of the solutions in Exercise 4.1, calculate the number of mg contained in the volumes shown.

a)	0.5 cc of (a)	__________	b)	3.5 cc of (b)	__________	c)	0.2 cc of (c)	__________
d)	2 mL of (d)	__________	e)	5.0 mL of (e)	__________	f)	10.00 mL of (f)	__________
g)	2.5 mL of (g)	__________	h)	4.0 mL of (h)	__________	i)	9 mL of (i)	__________

Exercise 4.3

For each of the solutions in Exercise 4.1, calculate the number of mL required to obtain the following quantity.

a)	7.3 mg of (a)	___________	b)	12 mg of (b)	___________	c)	1 mg of (c)	___________
d)	7.5 mg of (d)	___________	e)	0.8 mg of (e)	___________	f)	650 mg of (f)	___________
g)	85 mg of (g)	___________	h)	30 mg of (h)	___________	i)	0.4 mg of (i)	___________

PROBLEMS

The following problems require the student to integrate calculations involving mass, volume and concentration. They are representative of the type of problems that can be encountered in the prehospital setting.

5.1 An IV, regular tubing (10 gtt/mL) is to be adjusted to deliver 250 cc per hour. How many drops per minute are required?

5.2 Nitroglycerine tablets contain 0.3 mg per tablets. The physician orders 0.6 mg. How many tablets are required?

5.3 Your drug kit contains a 10 cc pre-loaded syringe containing epinephrine in a concentration of 1:10000 (that is 1 g in 10 000 mL). How many mL must be used to provide a dose of 0.5 mg?

5.4 An IV bag contains 250 mL 5% D/W mixed with 5 mL Dopamine, concentration 40 mg/mL. What is the resulting concentration of Dopamine in mg/mL and in g/L? (For the total volume in IV bag, ignore the 5 mL volume of drug in your calculations.)

5.5 Lidocaine is provided in an IV solution containing 1 g/250 mL and administered as a minidrip (60 gtt/mL). How many drops per minute are required to achieve a rate of administration of 2 mg/min?

5.6 Your drug kit contains a 5 cc pre-loaded syringe containing lidocaine in a concentration or 20 mg/mL. The patient weights 70 kg. You are ordered to prepare 3 doses of 1 mg/kg. How many mL will you require?

MATHEMATICAL REVIEW EXERCISES

The answers are given in the complete form including units, decimal points, and a zero before the decimal as required. An answer is correct only if complete in all detail.

Exercise 1.1

40	4 x 10	4×10^{1}
400	4 x 100	4×10^{2}
4000	4 x 1000	4×10^{3}
7680	7.68 x 1000	7.68×10^{3}
76,800	7.68 x 10000	7.68×10^{4}
1200	1.2 x 1000	1.2×10^{3}
370	3.7 x 100	3.7×10^{2}
6,200,000	6.2 x 1000000	6.2×10^{6}

	Standard	Exponent Number	Form of 10
52,600	5.26 x 10, 000	5.26×10^{4}	4
5,260	5.26 x 1, 000	5.26×10^{3}	3
526	5.26 x 100	5.26×10^{2}	2
52.6	5.26 x 10	5.26×10^{1}	1
5.26	5.26 x 1	5.26×10^{0}	0
0.526	5.26 ÷10	5.26×10^{-1}	-1
0.0526	5.26 ÷ 100	5.26×10^{-2}	-2
0.00526	5.26 ÷ 1000	5.26×10^{-3}	-3

Exercise 1.2

Rewrite the following in standard form:

a)	5.79×10^{2}	b)	1.3×10^{3}
c)	4.76×10^{1}	d)	7.248×10^{2}
e)	1.2×10^{7}	f)	3.82×10^{4}
g)	6×10^{0}	h)	9.8×10^{5}
i)	5.23×10^{-2}	j)	2.46×10^{-1}
k)	7.61×10^{-3}	l)	8.64×10^{-3}
m)	2×10^{-6}	n)	1.79×10^{-1}
o)	7.51×10^{-4}	p)	2.97×10^{-2}

Exercise 1.3

a)	400	b)	572 000
c)	63	d)	0.0189
e)	0.234	f)	90 900
g)	55 500 000	h)	0.00000412
i)	8760	j)	0.000734
k)	0.00619	l)	5820
m)	0.00479	n)	0.526
o)	4 380 000	p)	0.0324

Exercise 2.1

a)	0.052 g	b)	0.000645 g
c)	2700 g	d)	0.00032 g
e)	0.000009 g	f)	8.763 g
g)	0.07186 g	h)	450 g

Exercise 2.2

a)	21 mg	b)	0.0623 mg
c)	7310 mg	d)	175 000 mg
e)	89 000 000 mg	f)	0.00049 mg
g)	0.056 mg	h)	12.347 mg

Exercise 2.3 (Answer correct if within +1 kg)

a)	20 kg	b)	59 kg
c)	48 kg	d)	80 kg
e)	52 kg	f)	68 kg
g)	91 kg	h)	36 kg
i)	95 kg	j)	12 kg
k)	83 kg	l)	64 kg

Exercise 3.1

a)	250 mL	b)	1860 mL
c)	0.013 mL	d)	78.2 mL
e)	59 200 mL	f)	0.37 mL
g)	563 mL	h)	9.45 mL

Exercise 3.2

a)	50	b)	2500
c)	30	d)	750
e)	5000	f)	1
g)	120	h)	10 000

Exercise 3.3

a)	7500	b)	11 160
c)	468	d)	780 000
e)	33 780	f)	54
g)	45	h)	4800

Exercise 4.1

a)	1 mg/mL	b)	6 mg/mL
c)	2 mg/mL	d)	5 mg/mL
e)	0.2 mg/mL	f)	100 mg/mL
g)	20 mg/mL	h)	40 mg/mL
i)	0.1 mg/mL		

Exercise 4.2

a)	0.5 mg	b)	21 mg
c)	0.4 mg	d)	10.0 mg
e)	1.0 mg	f)	1000 mg
g)	50 mg	h)	160mg
i)	0.9 mg		

Exercise 4.3

a)	7.3 mL	b)	2.0 mL
c)	0.5 mL	d)	1.5 mL
e)	4.0 mL	f)	6.5 mL
g)	4.25 mL	h)	0.75 mL
i)	4.0 mL		

5.1 42 drops

5.2 2 tablets

5.3 5 mL

5.4 0.8 mg/mL; 0.8 g/L

5.5 30 drops per min

5.6 3.5 mL

ADVANCED LIFE SUPPORT
PRECOURSE

MEDICAL MATH

EVALUATION

Upon completion of this module, please fill in and return this form to your base hospital co-ordinator.

Your comments will help to ensure that this unit is a useful learning module. Please indicate any problems that you may have encountered. All suggestions for improvement are welcomed.

1. How long did it take to complete this module? Please estimate.

Reading	____________	hours
Self assessment	____________	hours
Total time	____________	hours

2. Were the objectives of the module clearly stated?

   [ ] yes [ ] no
   If no, please comment.

3. Did you use any of the resource materials?

   [ ] yes [ ] no
   If yes, which items ______________________________
   ____
   ____
   Were they helpful? ______________________________

4. Were the reference notes adequate?

   [ ] yes [ ] no
   If no, please comment.

5. Were the reference notes easy to follow?

[ ] yes [ ] no
If no, please comment.

6. Were the examples provided satisfactory?

[ ] yes [ ] no
If no, please comment.

7. Were the diagrams helpful?

[ ] yes [ ] no
If yes, please specify.

8. Was the level of the module satisfactory for your program of study?

[ ] yes [ ] no
If no, please comment.

Base Hospital ____

9. General comments or suggested improvements.