UNITED STATES MARINE CORPS

LESSON PLAN

METEOROLOGICAL CONVERSIONS

INTRODUCTION:

1. Gain Attention. Have you ever been on an international flight and noticed that the stewardess was announcing the current flight level in meters vice feet? Or have you ever driven a car that had a speedometer that read in kilometers per hour (kph) vice miles per hour (mph)?

2. Overview. The meteorological field measures and depicts numerous atmospheric parameters. In the process of measuring and depicting these parameters such as temperatures, wind directions and speeds, cloud heights and so on, different measurements and units of measurements are used to obtain and depict the data. This period of instruction introduces the student to basic fundamental units and conversions specifically related to the study of the atmosphere.

3. Introduce Learning Objectives.

a. Terminal Learning Objective. Without aid of references, and given a constant pressure chart, the student shall be able to convert isoheights, isotherms, isotachs, and station temperatures to feet, Fahrenheit, miles per hour, and Fahrenheit, respectively.

b. Enabling Learning Objective(s). Without the aid of references, the student shall successfully:

(1) Define “fundamental quantity”, and which fundamental quantities are most associated with meteorology.

(2) State the definition of a “fundamental unit” and which units are most commonly used in the study of the atmosphere.

(3) State the various numerical prefixes in order of largest to smallest.

(4) Define the significant digits used in meteorology.

(5) Explain the value of expressing numbers in Scientific Notation.

4. Method/Media. This period of instruction will be taught using the lecture method with the aid of QMMCBT-001 “Introduction to the Dynamics of the Atmosphere”.

5. Evaluation. The student will be expected to maintain the knowledge and apply unit conversions on a routine basis.

TRANSITION. There are many theories and computations that are used while studying the Earth and its atmosphere. The first topic of discussion introduces the basic concepts of computing and expressing numbers, defining fundamental quantities and units.

BODY:

1. Fundamental Quantities. A "Fundamental Quantity" is one of the four quantities that are the basis of systems of measurement. Fundamental quantities act to express parameters as a number or measure or quantity. There are seven (7) fundamental quantities recognized by the International System of Units (SI). They are length, mass, time, electric current, thermodynamic temperature, amount of substance, and luminous intensity. For the purposes of this class, four (4) of the seven that are most commonly used in meteorology are defined:

a. Length. "Length" is defined as the linear extent in space from one end to the other or the longest horizontal dimension of something that is fixed in space. For example "the length of the table was five (5) feet long.

(1) One mile = 5280 feet or 1609 meters.

(2) One inch = 0.08 feet or 2.54 centimeters.

(3) One meter = 100 centimeters or 3.28 feet or 39.37 inches.

(4) One centimeter = 0.39 inch or 0.01 meter.

b. Mass. Mass is defined as the property of a body that causes it to have weight in a gravitational field.

(1) One gram = 0.035 ounce 0.002 pound.

(2) One kilogram = 1000 grams or 2.2 pounds.

(3) One calorie = 4.186 joules.

c. Temperature. The degree of "hotness" or "coldness" of a body or an environment corresponding to its molecular activity.

(1) One degree Fahrenheit (F) = F°-32/1.8=C°

(2) One degree Celsius (C) = C°x1.8+32=F°

(3) One Kelvin (K) = K°-273=C°

d. Time. A period over which an action takes place. For example, "He spent seven weeks in the hospital recovering from his illness."

TRANSITION. Once it has been determined which fundamental quantity is to be used, one can further break down the quantity into units of measurements, or how the quantity will be measured. There are many different measures of units, however for the purpose of this period of instruction, we will only cover units that relate to the field of meteorology.

2. <u>Units of Measurement</u>. All units of measurement are derived from the *International System of Units* (SI), which is a complete metric system of units of measurement for scientists. The metric system is a decimal system of weights and measures based on the meter and the kilogram and the second. The following units are meteorologically related:

a. "Meter" for distance.
b. "Kilogram" for mass.
c. "Second" for time.
d. "Kelvin" for temperature.
e. "Newton" for force.
f. "Pascal" for pressure.
g. "Calorie" for energy.
h. "Celsius" for everyday temperature.
i. "Knot" for speed.

<u>TRANSITION</u>. Once we have the ability to determine the appropriate fundamental quantity to use, and then choose the related unit of measurement, it becomes necessary to understand how to express very large or very small numbers. This is done by simply using standard "prefixes" to units of measurement.

3. <u>Numerical Prefix Conversions</u>. Prefix conversions are used to represent very large and very small values of fundamental quantities. They are placed ahead of the *base unit* (grams, meters or seconds) and allow for magnitudes to be expressed in smaller numbers. For example, 100 kilometers is equal to 100,000 meters. In order from largest to smallest, the prefixes are as follows:

a. Giga = one billion (ex. 1 Gigabyte = 1,000,000,000 bytes)
b. Mega = one million
c. Kilo = one thousand
d. Hecto = one hundred
e. Deca = one ten
f. Base = Base Unit
g. Deci = one-tenth
h. Centi = one-hundredth
i. Milli = one-thousandth
j. Micro = one-millionth

<u>TRANSITION</u>. We have just introduced some unit prefixes. Please note that there are additional unit prefixes that are not covered in this period of instruction. The next topic of discussion focuses directly on these units and their conversions as expressed in "*Scientific Notation*".

4. <u>Scientific Notation</u>.

a. History and Definition.

(1) Scientific notation is an abbreviated form of expressing very large or very small numbers.

(2) The basic concept of scientific notation has been around so long that its first use cannot be traced. The traditional terms of scientific notation that we use today can be traced back to the philosopher Rene Descartes. Rene Descartes started using our current form of scientific notation in the mid-17th century. An example of the scientific notation that Rene Descartes used is shown in figure one.

$$2 \text{ X } 10^3$$

Figure 1 - A Scientific Notation Expression.

(3) In figure one, you can notice that the number three is raised above the ten. Before Rene Descartes, it (the way that scientific notation terms were expressed) wouldn't have had the number three raised above the ten.

b. Basic Terms.

(1) Three terms that are used when explaining scientific notation are an integer, base, and exponent.

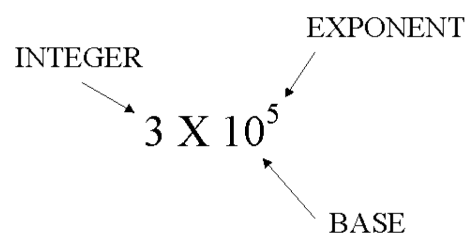

Figure 2 - Integer Representation.

(2) Using figure 2, we call the number 3 in this scientific notation example the integer. The integer is the number that we will multiply the ending answer of the 10 and 5 by.

(3) Using figure 2, we call the number 10 in this scientific notation example the base. The base is the number that we will be multiplying by itself the number of times that the exponent [explained next] states.

(4) Using figure 2, we call the raised number above the base in this scientific notation example the exponent of the base. The exponent is the number that determines how many times the base will be multiplied by itself.

c. Basic Rules.

(1) The basic form of scientific notation is "**a X 10^n**", where the following conditions apply:

(a) The "a" must be a number between 1 and 10.

(b) The "n" must be an integer (a whole number, no decimals).

(2) If the scientific form ever looks like "a X 10^0", it would be the same as saying "a X 1" because 10^0 always equals 1.

(3) If the "a" is between 1 and 10, and it would stay the number of the "a", than there is no need to write the power of 10. For instance, instead of writing a problem as follows: 2 X 10^0 =2, drop the base and the exponent and write the problem 2 X 1 = 2.

(4) If a number is a power of 10, then it isn't necessary to write the "a" in the scientific notation expression since the number is implied in the base and its exponent. For example, the number 1,000 can be expressed 1 X 10^3, but according to the rules, the expression doesn't have to have the "a" of the expression. So for this example, instead of writing the 1, the only thing needed in the expression would be 10^3.

(5) If the number that is being expressed is a negative number, than a minus sign will be added to the exponent, and the negative exponent will multiply the base.

d. <u>Expressing Number in Scientific Notation</u>.

(1) To express a number such as "1,236" in scientific notation, three steps would need to be completed. We will use the expression stated above, a x 10^n, as a reference:

(a) First, find what the "a" will be in the number. Using this example, the "a" would be 1.236. This number is appropriate since it is between 1 and 10.

(b) Next, find what the exponent of the "10" would be. Using this example, the exponent will be 3 because 10 x 10 x 10 equals 1,000.

(c) Lastly, combine the equation and solve. 1.236 X 10^3 = 1,236.

e. <u>Turning Scientific Notation Expressions into Numbers</u>.

(1) The process of turning a scientific notation expression into an integer is an easy one. Simply put, all one needs to do is solve the expression.

(2) To solve for a scientific notation expression, the first step is to multiply the base by its exponent. The second step would be to multiply the integer by the product of the base and its exponent.

That is all that has to be done to solve a scientific notation expression. It’s actually quite a simple process.

TRANSITION. We have just discussed various ways that numbers or parameters can be measured and/or defined. The next topic of discussion focuses directly on these units and the significant digits that are used in meteorology.

5. Meteorological Significant Digits.

a. Rounding Figures. When rounding figures, it is a common rule to round any figure to the larger number or worst-case scenario.

(1) Fractions and Decimals. The fractional part of a positive number to be dropped is equal to or greater than one-half (i.e. 5¾, 5.75), the preceding digit shall be increased by one (rounded up to “6”). If the fractional part of a negative number to be dropped is greater than one-half (i.e. –5¾, -5.75), one shall decrease the preceding digit (rounded to “-6”).

(2) In all other cases the digit shall remain the unchanged; For example, a number of “1.4” would be rounded to “1” and -1.4” becomes “-1”.

b. Sky Condition. Meteorological sky conditions are broken down into sky cover classification and estimated or measured height values.

Height Value Ranges (feet)	**Reportable Increments (feet)**
≤ 50	0
51 to ≤ 5,000	To the nearest 100
5,001 to ≤ 10,000	To the nearest 500
› 10,000	To the nearest 1,000

Table 1 – Reportable values for sky condition heights.

Classification	**Clarification**	**Layer Summation**
SKC	Clear	0/8
FEW	Trace	1/8 – 2/8
SCT	Scattered	3/8 – 4/8
BKN	Broken	5/8 – 7/8
OVC	Overcast	8/8
VV	Total obscuration	8/8

Table 2 – Reportable values for sky condition layers.

c. Visibility. Surface visibility is reported in statute miles (sm) for METAR observations (Continental United States - CONUS) and in meters (m) for Terminal Aerodome Forecasts (TAF).

INCREMENTS OF SEPARATION					
Nautical	**Statute**	**Meters (m)**	**Nautical**	**Statute**	**Meters (m)**

Miles (nm)	Miles (sm)		Miles (nm)	Miles (sm)	
0	0	0	1.4	1 1/8	2600
.05	1/16	0100	1.5	1 ¾	2800
.1	1/8	0200	1.6	1 7/8	3000
.15	3/16	0300	1.7	2	3200
.2	¼	0400	1.8	----	3400
.25	5/16	0500	1.9	2 ¼	3600
.3	3/8	0600	2.0	2	3700
.4	----	0700	2.2	----	4000
.45	½	0800	----	2 ½	4400
.5	----	0900	2.4	2 ¾	4500
.55	5/8	1000	2.5	----	4700
.6	----	1100	2.6	3	4800
----	¾	1200	2.7	----	5000
.7	----	1300	3.0	4	6000
----	7/8	1400	4.0	----	7000
.8	----	1500	4.3	5	8000
----	1	1600	5.0	6	9000
.9	----	1700	6.0	7	9999
1	1 1/8	1800	7.0	8	9999
1.1	1 ¼	2000	8.0	9	9999
1.2	1 3/8	2200	9.0	10	9999
1.3	1 ½	2400			

Table 3 – Increments of visibility units.

d. Precipitation Values. All precipitation values are reported in inches. The unit of measurement depends on the type of precipitation.

Type of Precipitation	Unit of Measurement
Liquid Precipitation	0.01 inch
Liquid Equivalent of Solid Precipitation	0.01 inch
Solid Precipitation	0.1 inch
Snow Depth	1 inch

Table 4 – Precipitation units of measurement.

e. Pressure Values.

(1) Altimeter setting will be reported in inches of mercury to the nearest hundredth.

(2) Station Pressure will be recorded in inches of mercury to the nearest thousandth.

(3) Sea level pressure will be reported in millibars to the nearest hectopascal.

f. Temperature Values.

(1) All temperatures will be reported in Celsius to the nearest tenth degree.

(2) Wet Bulb Globe Temperature Index - Dry bulb temperature x 0.1 + wet bulb temperature x 0.7 + globe temperature x0.2 = WBGTI

(3) Wind Chill - $F^{\circ}=35.74+0.6215(T)-35.75(V^{0.16})+0.4247(V^{0.16})$, where "V" equals wind speed and "T" equals temperature.

g. Wind Values.

(1) Direction - Direction is measured in degrees of a compass rose using three digits *from* which the wind is blowing.

(2) Speed - Wind speed is recorded to the nearest whole knot.

TRANSITION. By discussing the quantities and units that were previously discussed, one should now have a basic understanding of atmospheric measurement that will be fined tuned with practical application.

OPPORTUNITY FOR QUESTIONS:

1. Questions from the Class. At this time, are there any questions concerning the material that was just presented to you?

2. Questions to the Class. There are no questions for the class at this time.

SUMMARY: In this class we have covered fundamental quantities, units of measure, prefix conversions, scientific notation, as well as, meteorological significant digits. This period of instruction provides a basis for all other atmospheric elements.

REFERENCE.

NAVMETOCCOMINST 3141.2. Surface Observation Users' Manual.

Ahrens, Donald C. Meteorology Today. 4th Edition. West Publishing Company, 1991.

Glickman, Todd S. Glossary of Meteorology. Department of Defense, 1994.

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