INTRODUCTION

I. INTRODUCTION

A. **Initial Comment**: The earth is our home and habitat, without its abundant resources (air, water, heat) we would not be in existence today.

1. The earth is approximately 4.6 billion years old,

We as a species have evolved significantly within the last 10,000 years, and within the last 125 years have created more havoc and have had a greater influence than any other living creature(s) in the history of the planet... a result of our advanced capability of "intellect" and "reason"...increased cranial capacity and cerebral development.

2. Basic Earth-Resource Visualization

a. Food----soil----atmosphere + Rock/weathering
b. clothing: synthetics/oil, natural/soil
c. building materials: plastics/oil, gypsum, cement, metals
d. energy: gas, electric/coal, fuel oil
e. transportation: gasoline, cars

B. **Earth Science Defined**: Interdisciplinary study of the earth's naturally occurring phenomena, its processes and evolution.

1. Earth Science by necessity involves the marriage of a number of specialty sciences

a. **Astronomy**- Study of the origin, evolution and composition of the universe, solar system and planetary bodies.

(1) Cosmology: origin of the universe
(2) Astrogeology: comparison of extra-terrestrial planetary bodies with the earth
(3) Astrophysics: quantitative study of the physical nature of the universe

b. **Geology**- study of the earth, its composition, origin, evolution and processes.

(1) Mineralogy/Petrology: study of rocks and minerals
(2) Geophysics: study of earth physics and processes
(3) Volcanology: study of volcanoes
(4) Seismology: study of earthquakes and seismic waves
(5) Geomorphology: study of surface processes and landforms
(6) Paleontology/Historical Geology: study of past life and historical evolution of the earth through time
(7) Plate Tectonics

c. **Meteorology**: Study of atmospheric phenomena

(1) Climatology: study of geographic climate patterns: processes and causes

(a) Future Climate Prediction: Green House
(b) Paleoclimatology

(2) Weather studies and weather prediction
(a) Storm Prediction and Emergency Management

(3) Atmospheric Science: study of physics and chemistry of earth's atmosphere

(a) Environmental/Air Pollution Control

d. **Oceanography**: study of earth's ocean systems

(1) Earth's surface covered by 70% ocean water... hence the reference to the "Blue Planet".
(2) Study of ocean chemistry and circulation patterns
(3) Physical study of seafloor

C. Employment Opportunities for Earth Scientists

1. Basic Education: B.S. to M.S. in Earth Science-Related Field
2. Employment Opportunities
a. Government Agencies
(1) U.S. Geological Survey (Geologists, Seismologists, Hydrologists, Cartographers)
(a) Earth Quake Prediction
(2) Natn'l Oceanographic and Atmospheric Admin. (Oceanographers, Geologists, Cartographers, Atmospheric Scientists, Meteorologists)
(3) Bureau of Land Management
(4) U.S. Forest Service, USDA, Soil Conservation Service
(5) Environmental Protection Agency
(6) U.S. Weather Service
(7) State Department of Environmental Resources, County Planning Commissions
(8) Academic institutions

b. Private Industry
(1) Environmental Resource Management
(a) Mining Companies (coal, metals, minerals)
(b) Oil Companies (petroleum, natural gas)
i) Geologists, Environmental Scientists
(2) Environmental Quality and Protection
(a) Private consulting to industry (geologists, hydrologists, air pollution scientists)
i) Remediation vs. Regulatory
ii) Health and Safety Specialists

(3) Meteorological Services and Consultants

D. Environmental Spheres of the Earth

1. the earth can be subdivided into spheres" of composition represented by the complex interface of four principal components of the environment: the lithosphere, atmosphere, hydrosphere, and biosphere.

a. The **Lithosphere**: comprised of the solid, inorganic portion of the earth's framework including elements to form atoms to form minerals to form rocks (the very foundation of the planet)

(1) Lithosphere and Interior of the Solid Earth - The earth is comprised of a series of compositionally distinct shells of rock.

(a) inner core, a solid iron-rich zone with a radius of 1216 km
(b) outer core, a molten metallic layer 2270 km thick
(c) mantle, a solid rocky layer 2885 km thick
i) includes the upper portion of the mantle referred to as the aesthenosphere - a plastic, viscous zone that is capable of flowing

(d) Lithosphere/crust, the outer rocky skin of the earth, 4 - 40 km thick, designated to include the upper portion of the aesthenosphere and near surface crustal rocks, thicker over continents and thinner over oceans (continental crust vs. oceanic crust).

The earth is a dynamic organism, even though it is made of solid "rock" it is capable of global movements on the lithosphere

b. The **Atmosphere**: the gaseous envelope of air that surrounds the earth

(1) a thick envelope of air (100's of miles thick) that surrounds the earth's surface. Provides the air we breath, together coupled with the sun's energy, drives our climatic and weather systems.

(2) Troposphere-Stratosphere-Mesosphere-Thermosphere-Magnetosphere

c. The **Hydrosphere**: the waters of the earth including ground water (beneath the surface), surface water (rivers, streams, lakes, oceans), and water locked up as ice in the form of glaciers.

(1) the water and liquid that is present on the earth's surface, in its atmosphere, and beneath its surface.

(2) Oceans cover 71% of the earth's surface and contain 97% of the earth's water.

(3) Water cycles from the ocean's to the air via evaporation, moves to land, precipitates as rain/snow, partially infiltrates the earth's surface, and eventually flows back to oceans via rivers.

Water and air uniquely combine on the earth's surface and make it habitable for life forms.

d. **Biosphere**: all living matter and cellular tissue on the earth, in the form of plant and animal, both microscopic and macroscopic.

(1) All life on the planet is contained within its uppermost layer of the earth, including its atmosphere.

(2) the vast majority of all earthly life inhabits a zone less than 3 miles thick, and the total vertical extent of the life zone is less than 20 miles.

These 4 environmental spheres are not discrete and separated but are interdependent and interwoven with one another.

E.g. soil- composed of mineral matter (lithosphere), contains life forms (biosphere), soil moisture (hydrosphere), and soil gas (atmosphere) in pore spaces.

E. Basic Earth Perspective

1. The Earth is our home

a. Seemingly infinite in its size and abundance relative to our personal lives, our Earth however is merely an infinitesimal speck floating in the vastness of space, the buffer of life between us as individuals and the hostile vacuum of space.

2. Earth Facts: Radius = 4000 miles
Diameter = 8000 miles
Circumference = 24,900 miles
Distance to Moon = 230,000 miles
Distance to Sun = 93,000,000 miles
Distance to Next Nearest Star=2.5 x 10^{13} mi.
Highest Elevation = 30,000 ft AMSL
Lowest Elevation = 36,000 ft BMSL

a. Shape of Earth: almost a perfect sphere, but not quite, actually best termed an "oblate spheroid", i.e. the diameter of the earth at the poles is slightly less than the diameter at the equator
(1) Polar diameter = 7900 miles
Equatorial diameter = 7927 miles

Plus topographic irregularities and the concentration of the earth's continents in the northern hemisphere make it slightly less than a perfect blue ball.

F. The Scientific Method

Modern science believes that fundamental, organized laws exist in nature and that through detailed study these laws can be transcribed into human symbolism. Steps in scientific investigations:

1. Collection of scientific facts through careful observation.

   a. Use of Earth "Sensing" Instruments for measurements of:
      (1) Magnetism
      (2) Seismic Waves
      (3) Satellite Imagery
      (4) Physical Atmospheric Properties
   b. Quantification of Data
   c. Pattern Recognition, Relationship Definition

2. The development of a working hypothesis to explain the existence of these relationships
   a. Quantitative Model Development: Explanation

3. Construction of experiments to validate or reject the hypostheses
   a. Repeatable results

4. The acceptance, modification, or rejection ofthe hypothesis basedon extensive testing
   a. Development of Scientific Theory/Paradigm: accepted as truth

II. BASIC MATHEMATICS REVIEW

A. Decimal Fractions, basics and definitions

1. Decimal Fractions - a fraction whose deonominator is 10 or some multiple of 10 such as 100, 1000, 10000, etc.

2. We use a decimal point to denote a fraction/denominator. Numbers to the right of the decimal point are fractions less than 1 expresses in a decimal format. Numbers to the left of a decimal point are whole numbers of our counting system.

3. Fractional Form = 47/100 vs. Decimal Form = 0.47

4. Examples and place values

8/10 = 0.8 79/100 = 0.79 183/1000 = 0.83

5925/10000 = 0.5925
1st place to right of decimal = tenths
2nd place to right of decimal = hundredths
3rd place to right of decimal = thousandths
4th place to right of decimal = 10 thousandths

5th place to right of decimal = 100 thousandths
6th place to right of decimal = millionths

Number	Powers of 10	Exponential Form
1,000,000	= 10 x 10 x 10 x 10 x 10 x 10	= 10^6
100,000	= 10 x 10 x 10 x 10 x 10	= 10^5
10,000	= 10 x 10 x 10 x 10	= 10^4
1000	= 10 x 10 x 10	= 10^3
100	= 10 x 10	= 10^2
10	= 10	= 10^1
1	= 1	= 10^0
0.1	= 1/10	= 10^{-1}
0.01	= 1/10 x 1/10	= 10^{-2}
0.001	= 1/10 x 1/10 x 1/10	= 10^{-3}
0.0001	= 1/10 x 1/10 x 1/10 x 1/10	= 10^{-4}
0.00001	= 1/10 x 1/10 x 1/10 x 1/10 x 1/10	= 10^{-5}

5. To determine decimal format of a common fraction, divide the denominator into the numerator, place decimal a end of numerator, and move decimal directly above quotient line, and divide out

6. To convert decimals back to fractions, place the decimal no. to the right of the decimal over its corresponding place value (10, 100, 1000, 10000) and reduce to lowest terms.

.75 = 75/100 = 3/4 (factor out 25 from numerator and denominator)

7. To convert to common fractions used in industry (1/4, 1/8, 1/16, 1/32), first place decimal in standard fractional format as above

e.g. 0.316 = 316/1000

8. Mixed numbers (whole and fractions) can be converted to mixed decimal nos. with whole numbers and decimals

e.g. 7 3/4 = 7.75 and converted back to fractional format vice-versa 7.75 = 7 3/4

B. THE METRIC SYSTEM AND CONVERSION

1. Metric system- developed in Europe (France) in 1700's, offered as an alternative to the British or English system of measurement. Metric measurement standards were established during an international conference, the metric system has generically come to be known as the SI or Systeme Internationale.

2. S.I./metric system involves measurements of length (meter), mass or weight (kilogram), temperature (celsius), time (second), and volume (litre).

3. Metric system based on powers of 10 and a decimal approach with prefixes attached to the basic units of measurment to indicate the power of 10 in question.

Greek prefixes > 1 base unit, Latin prefixes < 1 base unit

1. Mega = 10^6 e.g. 1 megameter = $1x10^6$ meter
2. Kilo = 10^3 1 kilometer = $1x10^3$ meters
3. Hecto = 10^2 1 Hectometer = $1x10^2$ meters
4. Deka = 10^1 1 Dekameter = $1x10^1$ meters
5. Base unit = 10^0 1 meter = 1×10^0 meters
6. Deci = 10^{-1}
7. Centi = 10^{-2} and so on
8. Milli = 10^{-3}
9. Micro = 10^{-6}
10. Nanno = 10^{-9}
11. Pica = 10^{-12}

The movement of the decimal point to the left or right of the given quantity of a unit is all that is needed to change a given type of unit to the next higher or lower unit:

e.g. 1 m = 10 dm = 100 cm = 1000 mm = 1,000,000 um
1 m = 0.1 Dam = 0.01 Hm = 0.001 Km = 0.0000001 Mm

4. METRIC MEASUREMENT OF DISTANCE

a. Based on the meter (analogous to the yard in English system)

1 Km = 1000 m, 1 Hm = 100 m, 1 Dam = 10 m, 1 m = 1 m,
1 dm = 0.1 m, 1 cm = 0.01 m, 1 mm = 0.001 m, 1 um = 0.000001 m

b. Conversion of One metric unit to another

e.g. convert 8.9 km to m: $8.9 \text{ km} \ \frac{1000 \text{ m}}{1 \text{ km}} = 8900 \text{ m}$

e.g. convert 1230 m to km: 1230 m $\frac{1\text{ km}}{1000\text{ m}}$ = 1.23 km

5. METRICATION OF AREA

a. SI units: km^2, m^2, cm^2, etc.
b. Metric equivalent of Acre = Hectare (Ha) = 100 m x 100 m which equals 10,000 m^2; i.e. 10,000 m^2/Ha

e.g. determine the no. of hectares in a plot of land: 1.6 km x 1.2 km = 1600 m x 1200 m = 1,920,000 m^2 (1 Ha/10,000m^2)= 192 Ha

c. Examples of converting square metric units to other square metric units: e.g. km^2 to m^2.

6. METRICATION OF VOLUME

a. volume- the amount of space within a container or enclosed within a solid

b. SI units of volume: cubic meters which can be equated to litres.

c. Can use same metric-prefix approach as given for meters, can be used with litres as well

e.g. 1 l = 1000 ml = .001 kl and so on
e.g. convert 17 litres to milliliters:
17 l (1000 ml/l) = 17,000 ml

d. E.g. of problems converting volume in metric system

(1) Find the volume in liters of a rectangular tank (lxwxh) 2 m x 20 dm x 28 cm

7. METRICATION OF MASS

a. Mass - quantity of material contained in a given body
(1) Weight - measure of the force of gravity upon a given body.

Thus mass and weight are interchangeable under a given force of gravity, but may differ in cases of 2 different gravitational forces (e.g. a given mass will have different weights on the earth as compared to the moon (G moon = 1/6 G earth), but the mass or quantity of material occupying space will be same on earth as on the moon).

b. Metric unit of measuring mass = gram, kilogram, etc.
(1) converting from volume to capacity to weight:

1000 cu. cm = 1000 ml = 1000 gram of pure water
For pure water: 1 L = 1 Kg, thus 1 gm of water = 1 ml of water = 1 cu. cm

c. E.g. of metric conversions: convert 2700 mg to grams

2700 mg (1 gm/1000 mg) = 2.7 grams

8. METRIC MEASUREMENT OF TEMPERATURE

a. Metric unit = celsius, English unit = Farenheit
b. water freezes at 32° F = 0° C water boils at 212° F = 100° C
c. Conversion Factors:
(1) From C to F: F = 9/5C + 32°
(2) From F to C: C = 5/9(F - 32°)

(a) E.g. convert 40 C to F
F = 9/5(40) + 32 = 104° F

d. CONVERSION FROM ENGLISH SYSTEM TO METRIC AND VICE VERSA
(1) Conversion charts/factors given for units of length, area, volume, and weight/mass on p. 300.

(a) E.g. of conversion problems:
Given that 1 yard = 0.9144 m, how many meters are there in 100 yards?
100 yd (0.9144 m/1 yd) = 91.44 m.

III. PHYSICS REVIEW: ENERGY, HEAT, GRAVITY

A. Energy- ability/capacity to do work
1. Potential Energy: energy of position or location
2. Kinetic Energy: energy of motion

B. Heat: vibrational energy of molecules
1. Molecules of atoms vibrate at subatomic level
a. > Heat of system, > vibrational energy
b. energy of molecular motion

C. Matter and Energy: relationship described by Einstein

1. Matter may convert to energy and vice-versa
a. e.g. decaying plant: plant tissue is converted to heat in compost pile and food energy for bacteria

D. Temperature: a measure of heat energy/kinetic vibration of molecules (e.g. air, water, rock)

1. Units of measurent: Fahrenheit and Celcius (see above in math review)

2. Kelvin: 0 degrees Kelvin = -273 degrees Celsius= absolute zero: i.e. theoretical state of zero molecular/kinetic motion.

a. e.g. to go from celsius to K, add 273
b. to go from K to C, subtract 273

E. Temperature, Energy and Influence on Physical State

1. Transformation Processes related to energy input and entropy of water: heating of water, > atomic activity of the water molecules, i.e. > vibrational energy of water atoms.

ICE ----------HEAT----- WATER-------HEAT -------WATER VAPOR
(<32 degrees) (32-212) (>212 degrees F)

2. Evaporation- process of transforming water from liquid to gaseous state (Heat Gain)
3. Freezing- process of transforming water from liquid to solid state (Heat Loss)
4. Condensation- transformation of water vapor to liquid form (Heat Loss)
5. Sublimation- process of transforming ice to water vapor directly through superheating, bypassing liquid form. (Heat Gain)

F. Mechanisms of Heat Transfer
1. Convection - transfer of heat with transfer of mass
   a. e.g. pot of heating water on stove
2. Conduction - transfer of heat with no transfer of mass
   a. e.g. hot spoon in cup of coffee
3. Radiation - transfer of heat by electromagnetic radiation
   a. wave energy
      (1) e.g. Sun's energy

G. Heat Flow
1. Thermal systems at equilibrium = no temperature difference = no heat flow
2. Thermal systems at disequilibrium
   a. = temperature difference in system
   b. heat flow from high temperature to low temperature

H. Basics of Gravity

1. Force of attraction between bodies in the universe stars, planets, moons drives
   a. $F = G [(m_1 m_2)/r^2]$; where F = force of gravity, G = gravitational constant, m = mass of 2 objects in space, r = distance separating the two objects in space. Given all other variables constant, F > with < r, and F < with >r. Each body exerts an equal force of attraction
      (1) g = acceleration of a falling object (e.g. sediment) due to gravitational force F, assumed to be constant at 9.80 m/sec^2

   b. Gravity obviously influnces surface water flow, mass wasting/hillslope movement processes, serving as a driving force