Rough Draft for
MILESTONES ALONG THE POWERS OF TEN

SCENES FROM THE VIDEO

"100 m the distance a man can run in 10 seconds"

"1 km the distance a racing car can drive in 10 seconds"

"10,000 m the distance a supersonic aircraft travels in 10 seconds"

"100,000 m the distance an orbiting satellite travels in 10 seconds"

10^1: *TEN to the First Power!*

TEN METERS, or a DEKAMETER

10m = 1dkm

The largest dinosaurs were measured in tens of meters.

The wingspread of a small plane is about ten meters.

10^0 *TEN to the Zero Power!*

The METER

Believe it or not, any number to the zero power is one!

Basketball players hover around two meters tall.

The Velociraptors in Jurassic Park were about 2m from nose to tail tip.

An average 5 year old is about a meter tall.

The designers of the metric system divided the distance from the North Pole to the equator through Paris into 10,000,000 equal pieces; each one is called a meter.

The official meter bar is made of gold and kept in a special envionmentally controlled chamber in Paris.

The largest Helium-neon and Argon lasers measure about a meter or two in length.

The typical story in a building rises about three meters high.

10^{-1} *TEN to the Negative First Power!*
A Tenth of a Meter, or the DECIMETER

.1m = 1dm; 10dm = 1m

The term decimeter, dm is not commonly used. Many common items are about a decimeter long, approximately the width of a hand, like laser pointers, BIC lighters, half-used pencils, etc.

$10^{-2,}$ *TEN to the Negative Second power!*
A Hundredth of a Meter, or CENTIMETER

.01m = 1cm; 10cm = 1m

This is the most common metric unit for measurement. It is slightly under a half an inch, or about the width of a finger.

Holographic film and plate sizes, since they are made in Belgium, come in centimeter proportions; 20 by 25, 30 by 40, 50 by 60, and meter square. (Approximately 8" by 10", 12" by 16", 20" by 24", and 40" square.)

10^{-3} *TEN to the Negative Third Power!*
A thousandth of a meter, or a MILLIMETER

.001m = 1mm; 1000mm = 1m

A millimeter, mm, is the finest division on the typical meter stick. It allows finer precision in measurement than a centimeter.

Most camera lenses' focal lengths are measured in millimeters.

ELECTROMAGNETIC RADIATION with wavelengths of millimeters (frequency of 3.33 x 10^{11} or 333 GigaHertz) are called MIllimeter Waves, and are in the microwave family. They are generated by HARMONIC GENERATORS and **MASERS**, are highly directional, and are transmitted and received by **ANTENNAE**, usually dish-shaped.

10^{-4} *TEN to the Negative Fourth Power!*
A ten-thousandth of a meter, or HUNDREDS OF MICRONS

.0001m = 100um

If the finest division on the typical meter stick, the millimeter is divided into ten equal parts, then we see this order of magnitude. Small but still easy enough to see items like needles and pins, the thickness of rubberbands, paper clips, thick cardboard, etc.

10^{-5} *TEN to the Negative Fifth Power!*

The Hundred-Thousandth Part of a Meter, or TENS OF MICRONS

.00001m = 10um

"red blood cells and a ruffly lymphocyte"

Although somewhat visible to the unaided eye, most objects on this scale need to be observed with magnifying glasses or microscopes.

The diameter of a **human hair** varies from 30 to 80 microns, depending on the color of the hair and what part of the body it comes from.

A **white blood cell** is about 10 microns in diameter, along with other microscopic creatures. (The "ruffly lymphocyte" in the video!)

A **resolving power** of *100 lines per millimeter* mean that the pair of bars on the **Resolution Target** are 10 microns big.

With our body temperature of **313 Kelvin**, the dominant *black-body radiation* of the *human body* is at **10.6 microns**. Some animals, most notably the *pit viper*, have special organs adapted to be sensitive to these wavelengths.

ELECTROMAGNETIC RADIATION with wavelengths of tens of microns (frequency of 3.33×10^{14} or 33 TeraHertz) are called *Far Infrared Waves*, of course in the **Infrared** Family. Anything that is warm radiates this energy, and it can be detected by our skin, and measured by instruments like **Bolometers**, and imaged by **Thermal Cameras**.

10^{-6} *Ten to the Negative Sixth Power!*

A Millionth of a Meter, or the MICRON

.000001m = 1um; 1,000,000um = 1m

A red blood cell is about 7 microns in diameter.

The coating on a holographic plate is about 7 microns thick. A black and white photographic emulsion's thickness is between 3 and 7 microns; a color emulsion is about 15 to 25 micrrons. A very high speed film, like for X-Ray work, could have a mean grain size of about a micron.

ELECTROMAGNETIC RADIATION with wavelengths of microns are called *Intermediate Infrared Waves*, of course in the **Infrared** Family. Anything that is warm radiates this energy, and it can be detected by our skin, and measured by instruments like **Bolometers**, and imaged by **Thermal Cameras**, like the **Far Infrared Waves**. **Photographic Film** is not sensitive to these wavelengths, but some **CCD Chips** used

in video cameras are.

A brilliant source of this size of wavelengths are the *Neodymium-doped solid-state lasers*, like **Nd:YAG** @ 1.06um, **Nd:Glass** @ 1.3um, and **Nd:YLF** @ 1.06um. Although these wavelengths are invisible, frequency doubling crystals halve these numbers into the visible, green 532 nanometers and red 650nm. See below for those units.

Diode lasers, made up of combinations of Aluminum, Gallium Arsenic and/or Phosphorus emit in the 1.3 to 1.5 micron range.

10^{-7} *Ten to the Negative Seventh Power!*

The Ten-Millionth Part of a Meter, or Hundreds of Nanometers

.0000001m = 100nm

The smallest details in computer microchips are in this range, produced by a technique called **Sub-micron Lithography**.

ELECTROMAGNETIC RADIATION with wavelengths from 400 to 700 nanometers are called *Light Waves*. Wavelengths less than 400nm lie in the *UltraViolet*, (**UV**), and longer than 700nm is still in the *InfraRed* (**IR**). It is generated by **incandescent bulbs, fluorescent tubes, lasers, flames**, etc., and is detected by **photographic films, televison tubes**, and of course the parts of our bodies known as the **eyes**.

Objects of these dimensions can sometimes be resolved by **optical microscopes**, but they are more than likely imaged by **electron microscopes**.

10^{-10} Ten to the Negative Tenth

The Ten-Billionth part of a Meter, or ANGSTROM

.0000000001m = 1A; 10,000,000,000A = 1m

10A = 1nm

Named after the scientist who correctly found the size of atoms.

"at one Angstrom we find ourselves amongst the outer electrons of the Carbon atom."

The nucleus of the atom is four orders of magnitude away, at *Ten to the negative fourteenth*.