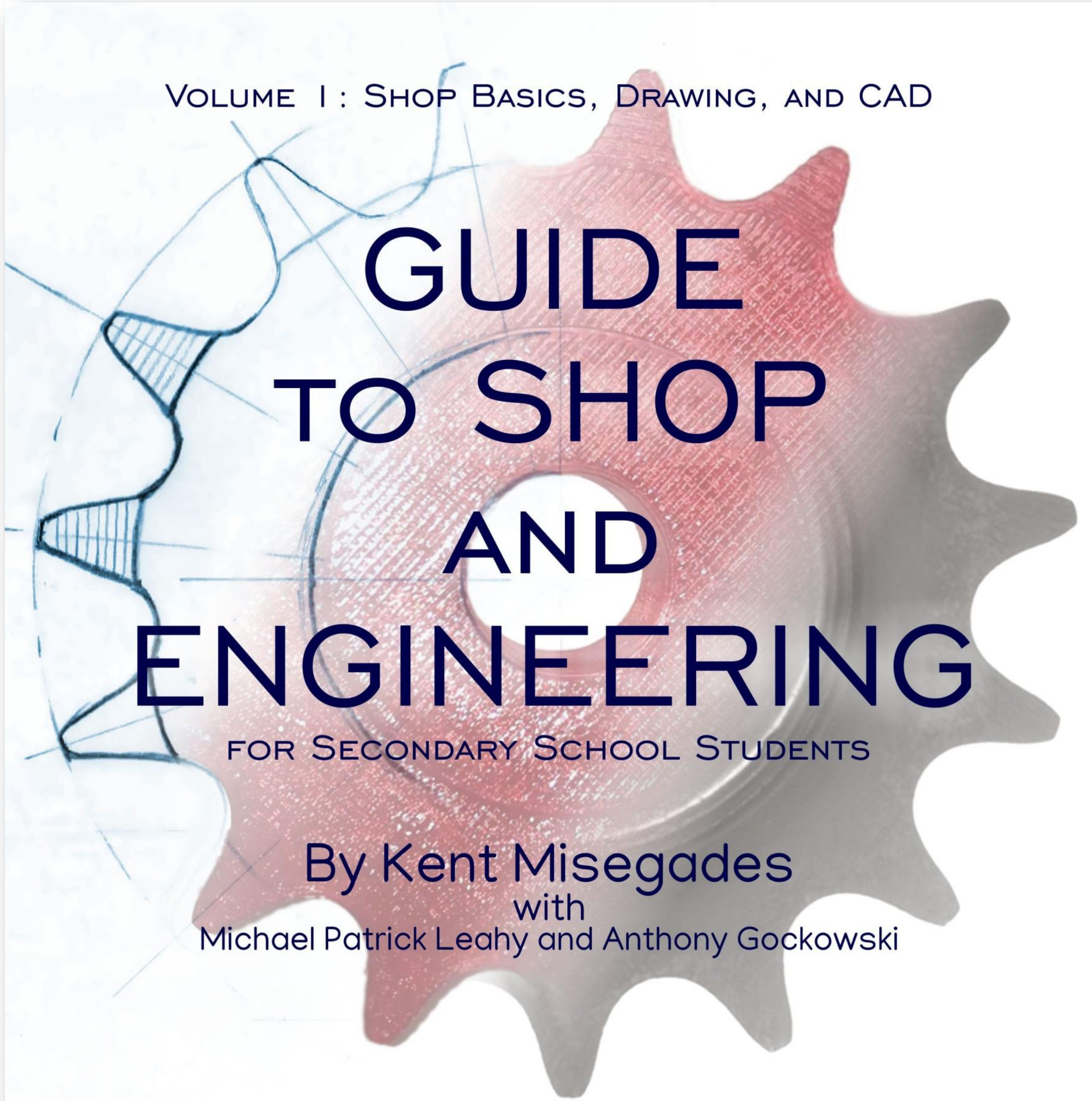
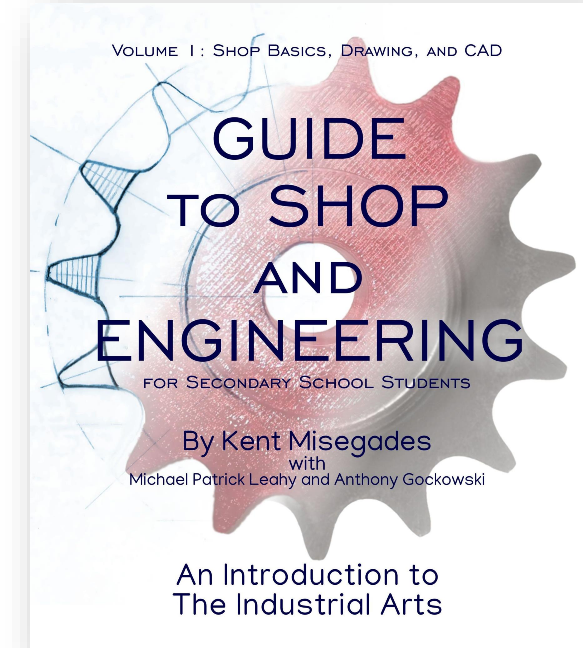


Lecture Notes for CHAPTER 6

With a Biblical Worldview

available at **LULU.com**

Contents


Volume I : Shop Basics, Drawing, and CAD
GUIDE
TO SHOP
AND
ENGINEERING
for Secondary School Students
By Kent Misegades
with
Michael Patrick Leahy and Anthony Gockowski
An Introduction to
The Industrial Arts

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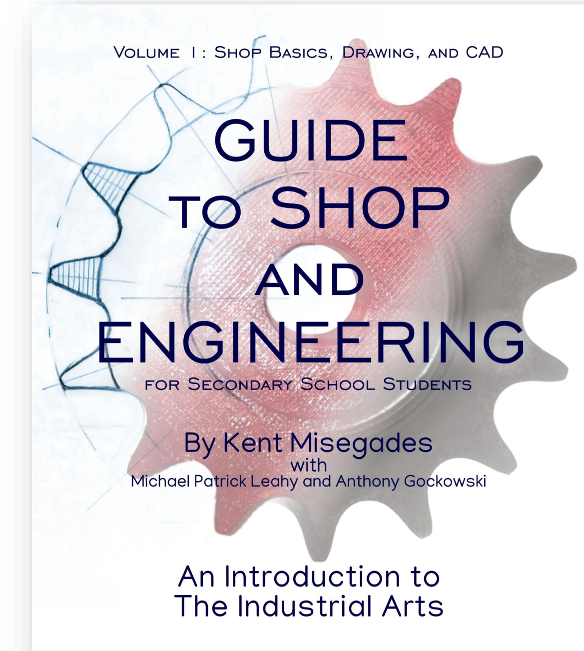


How to Use these Lecture Notes

1. **Read** the printed volume, **Shop & Engineering**, for this chapter.
2. **Gather materials** needed for this chapter's lessons, exercises and for recommended projects.
3. Use these Lecture Notes to **teach and discuss** the material. They contain more than the print version!
4. Work through all the **exercises** and check results. Correct errors and repeat until **100% correct.**
5. Take time to discuss the **"Questions to Ponder"** and **"What the Bible Says About"** sections at the end.
6. **Reinforce classroom learning** by doing one or more related **projects** in your workshop.

Engineering with a Biblical Worldview

- Everything in our lives is directed by **God**. At **home** and at **work**. His **wisdom and direction** for our lives is found in the **Bible**, so ***of course*** engineers should always have **scripture** first and foremost in their minds!
- Our **worldview** is developed as we establish beliefs about four critical topics: (from *Biblical Worldview*, Dr. J. Mulvihill)
  1. **Creation:** How did I get here? What is my purpose?
  2. **Rebellion:** What went wrong? Why is there evil and suffering?
  3. **Salvation:** What is the solution? Where do I find hope?
  4. **Restoration:** What happens in the future? How do we transform lives and change the world for the better?
- Engineers continually **face challenges** in their quest to develop products and solutions that ultimately **"transform lives and change the world for the better"**. The Bible provides many **answers**, the reason it should be found among every engineer's **most-used reference books.**

Volume I : Chapter 6

Units & Measurements

What this chapter covers:

- **Definitions**
- **Historical** Units
- **Conversion** between US and Metric
- **Mil, Micron & Micrometer**
- **Accuracy** and **Precision**
- Precision and Non-Precision **Instruments**
- American Inventor – **Harvey S. Firestone**
- **What the Bible Says**

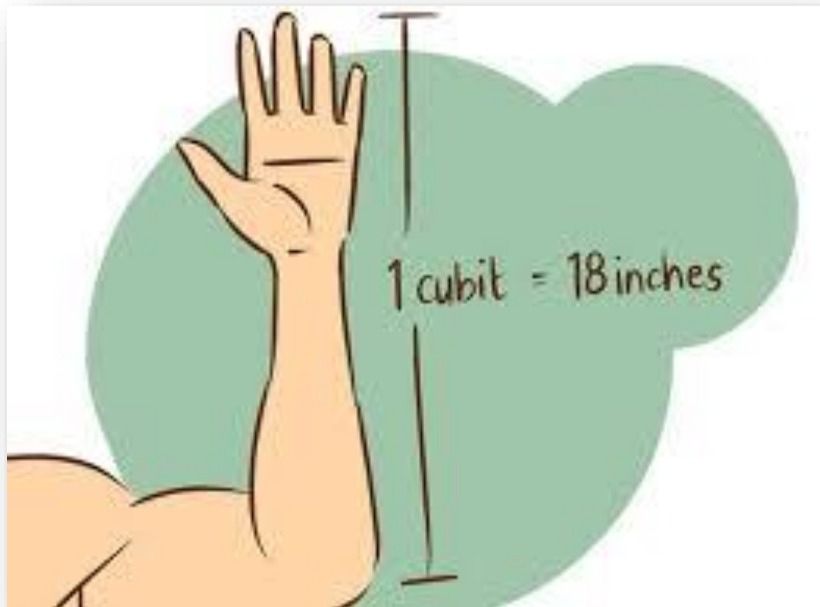
Definitions:

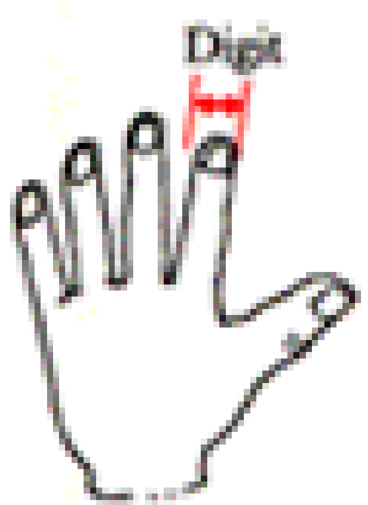
- **Unit** - a definite magnitude of a quantity.
- **System of Units** – a set of units defined and adopted by convention or by law, that is used as a standard for measurement of quantities of distance, mass, time, etc.
- **US Customary System** – The System of Units used primarily in the United States. Key units are the **foot, pound and second.**
- **Metric System** - The System of Units used primarily outside the United States. Key units are the **meter, kilogram and second.**
- **Dimensions** - A measurable extent of some kind, such as length, breadth, depth, or height. Typically found on drawings made by engineers.
- **Note:** To compete globally, American engineers **must have equal knowledge** of both the US Customary and the Metric systems of units!

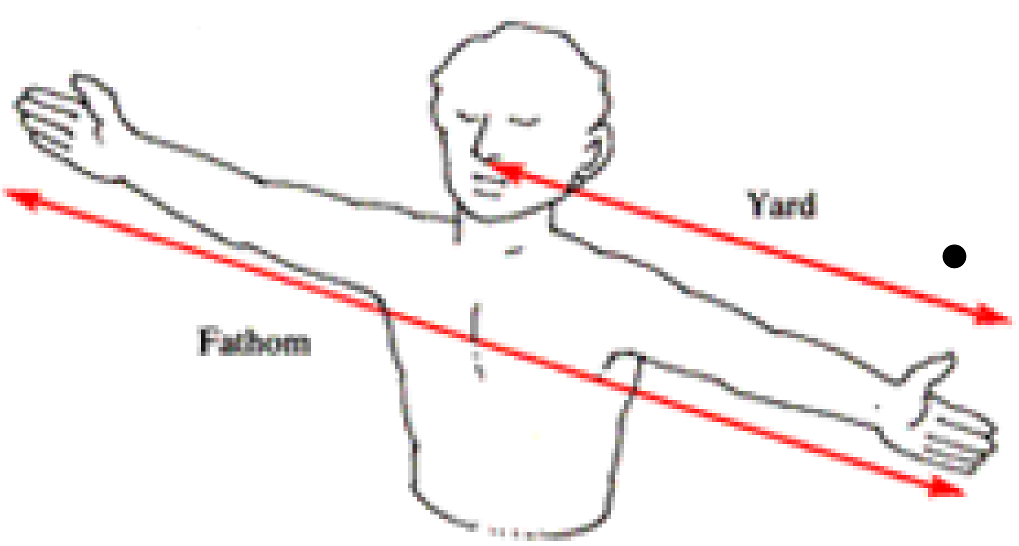
A Brief History of Unit Systems

- Not so many years ago, there were a huge number of **different measurement systems** around the world for the measurement of distance, area, volume, and mass and time.
- In **1799**, the Metric system was adopted by France during the **French Revolution**. Its modern standard is referred to as 'SI' for **Système International d'Unités**, or as it's called in English, the **International System of Units**.
- Only in recent decades have most nations agreed on the **metric system** as the universally accepted single set of measurements.
- In the **United States** most people still use what is called the **U.S. Customary System** in their daily lives, which evolved from the **British Imperial system**, which in turn derived from the older **English system** of units. **US industry** however makes increasing use of the **metric system** in order to compete globally.
- **Remnants** of older measurement systems remain in use or occur in historical literature. On the following slides some examples of historical units are described.

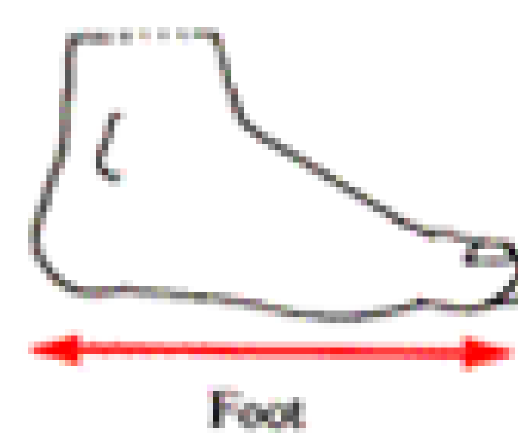
Historical Units - 1





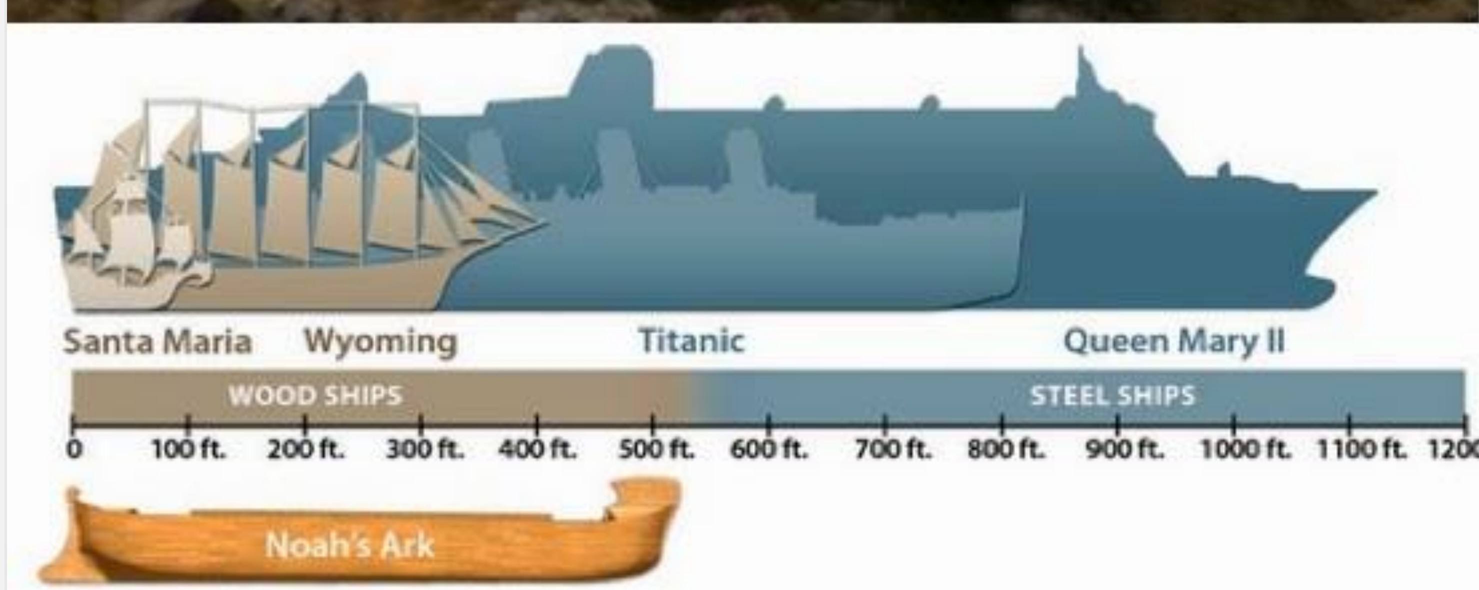


- **Cubit** - the distance from the elbow to the tip of the middle finger of a grown man, about 18”. The cubit’s use originated in Egypt around 3,000 B.C. and continued in common usage through into the start of the Industrial Revolution, 1760-1840.
- **Digit** - the width of a man’s finger, about ¾”, or 1/16th of a foot. There are **16 Digits in one Foot**, as opposed to **12 Inches**. A digit is also called a ‘finger’ when used to measure liquids, eg when pouring certain drinks.
- **Fathom** - the span of a person’s **outstretched arms**, later defined as six feet. **Rope or fabric** is sometimes still measured in this way. **Two yards = one fathom**. Fathoms are still used to describe the **depth of water.**
- **Foot** - originally the **length of a man’s foot**, which was divided into **12 Inches or 16 Digits**.

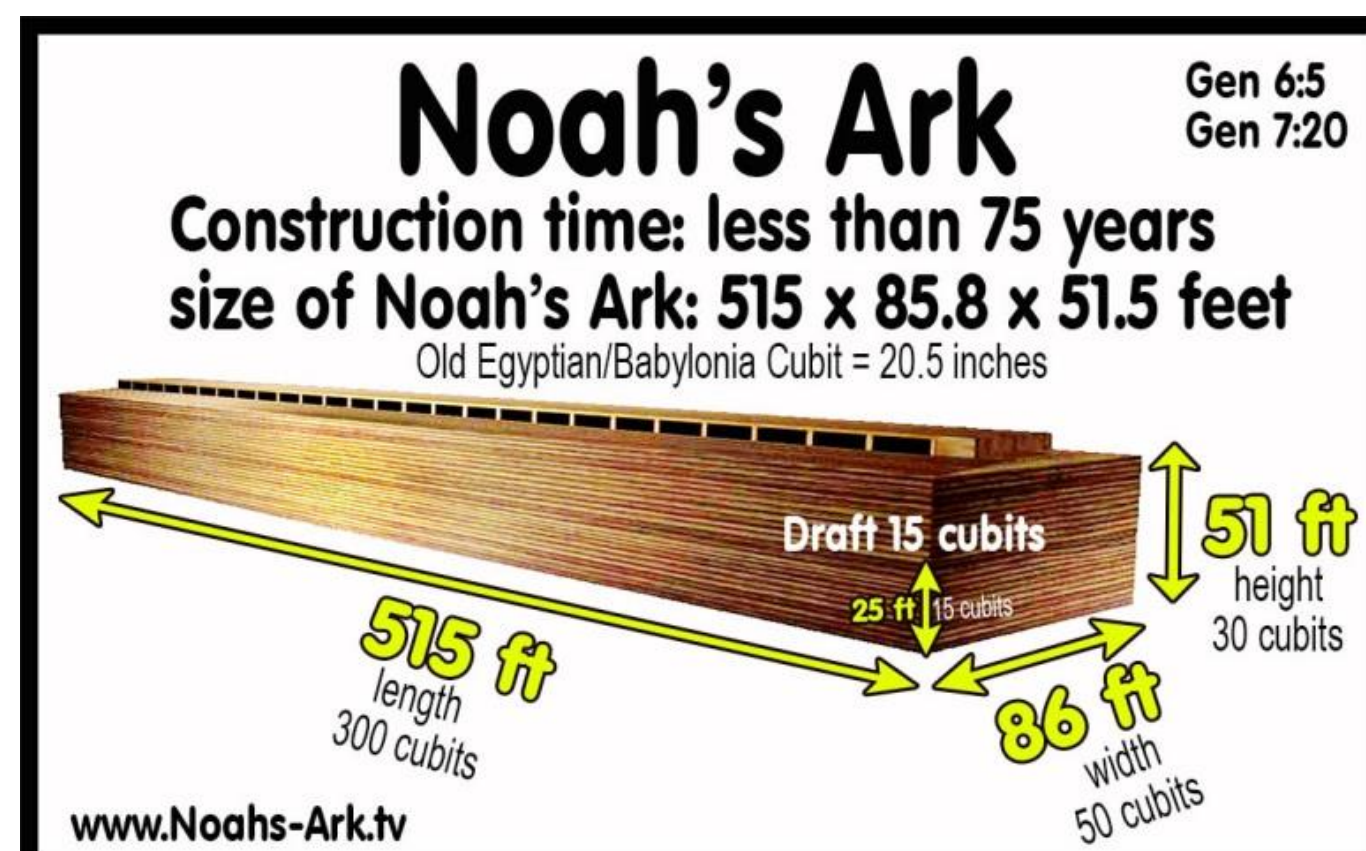


Noah’s Ark & Cubits

Genesis 6:15 *And this is how you shall make it: The length of the ark shall be three hundred* ***cubits****, its width fifty cubits, and its height* ***thirty cubits. 6:20*** *The waters rose and covered the mountains to a depth of more than* ***fifteen cubits****.*

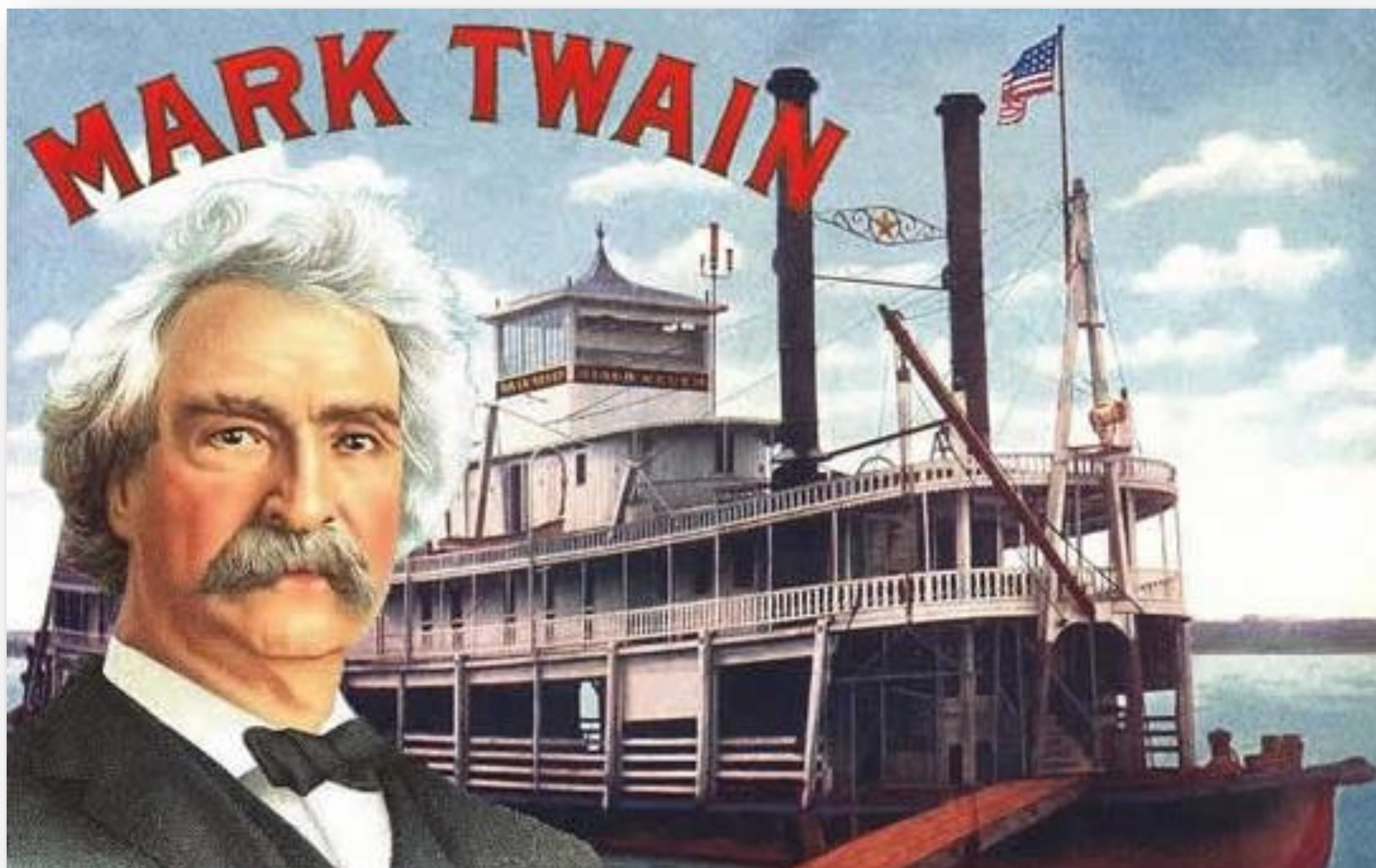


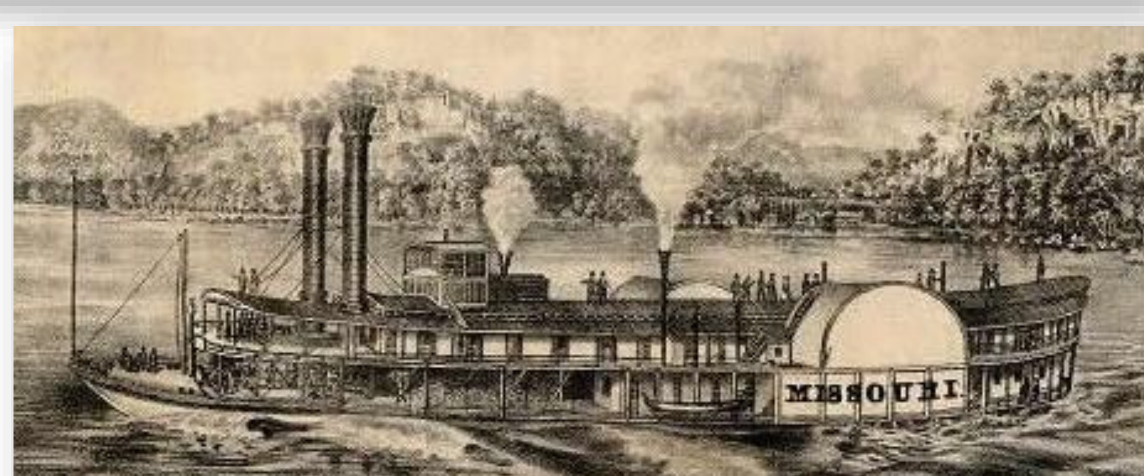
Full-scale replicas: Ark of Noah (Netherlands), Ark Encounter (Kentucky).

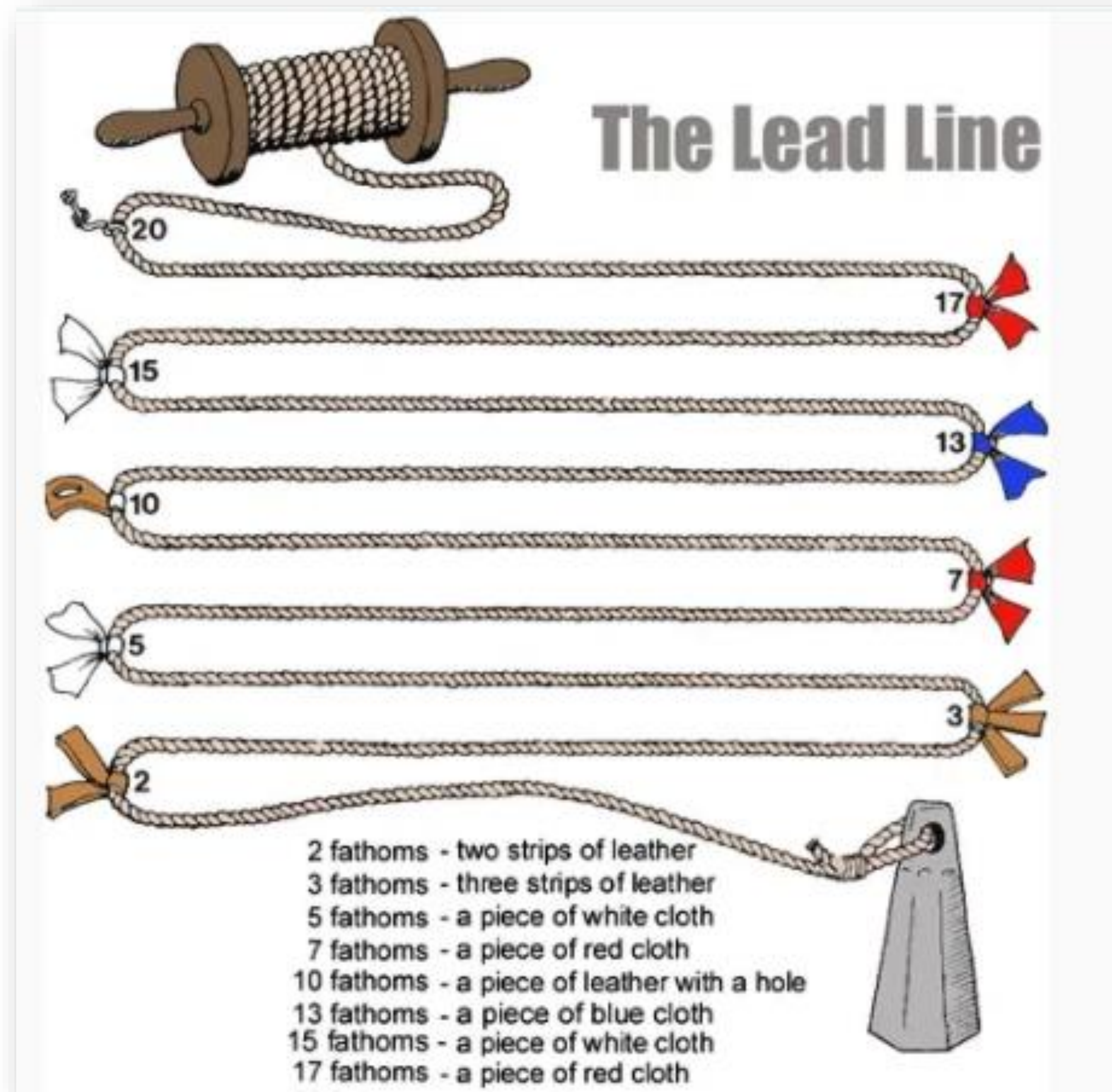


Mark Twain & Fathoms

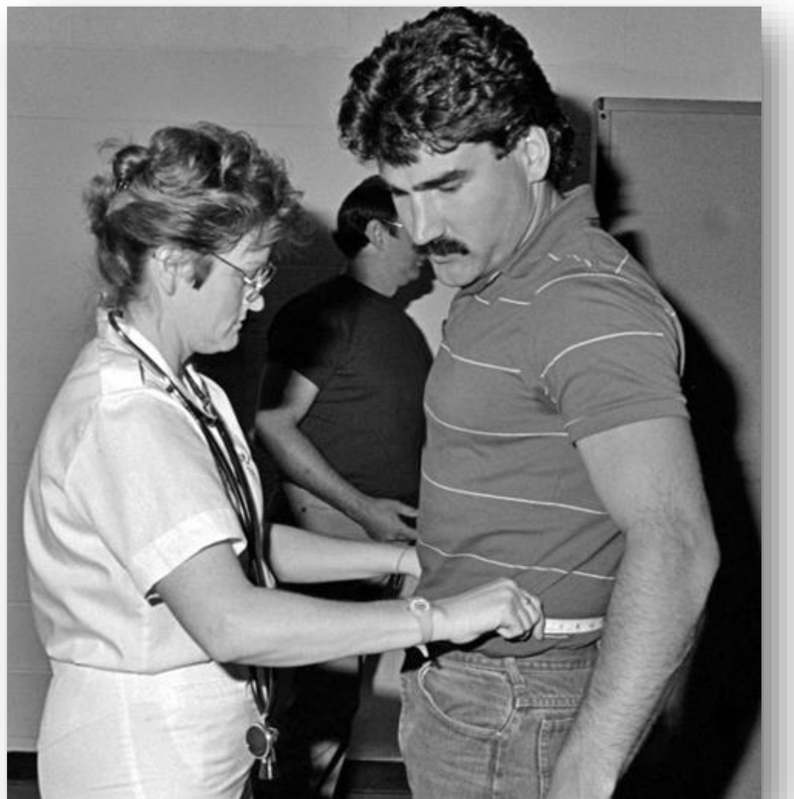
In 19th century America, riverboat captains would cast overboard a weighted rope marked off by knots every 6 feet. A depth of **two fathoms**, or 12 feet, was called "**Mark Twain**." **Samuel Clemens**, who worked on riverboats as a young man, adopted this as a pen name.





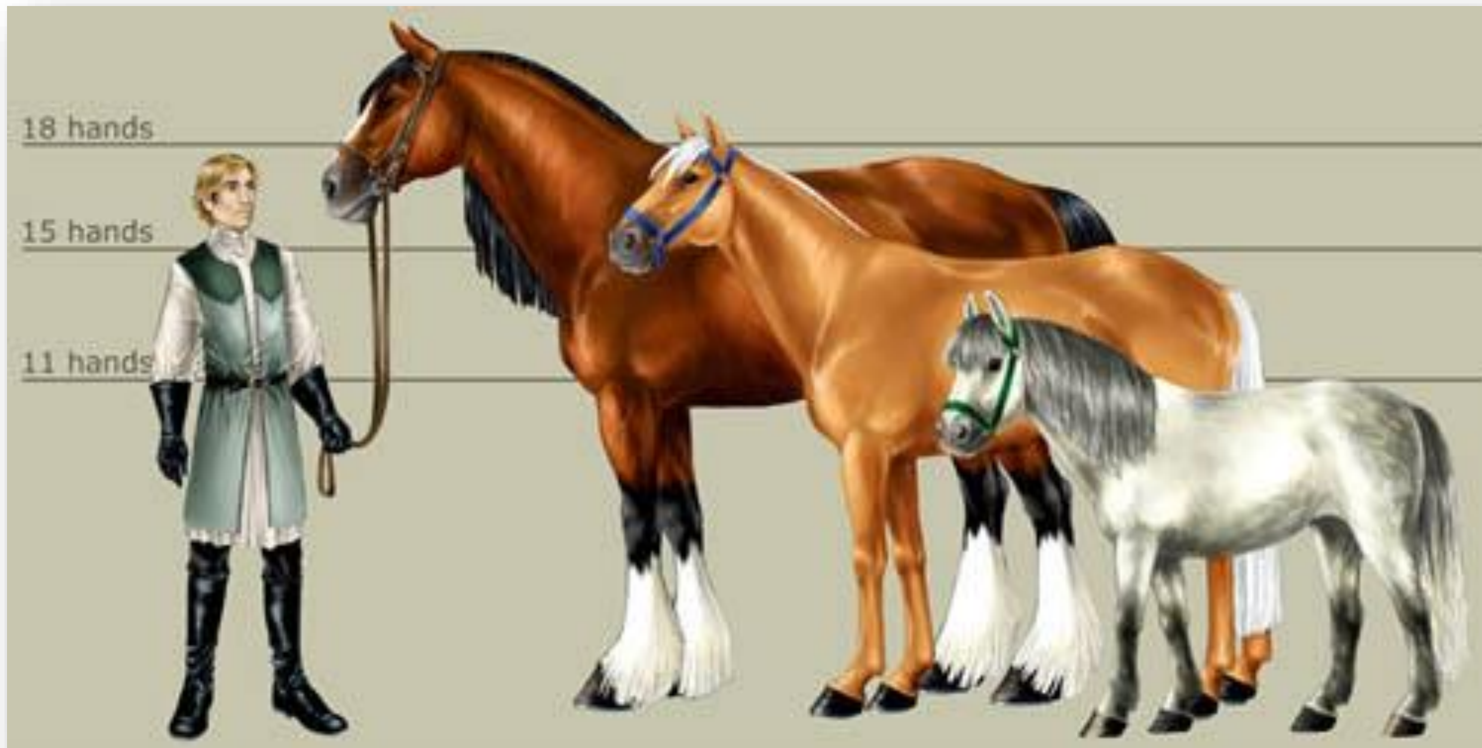


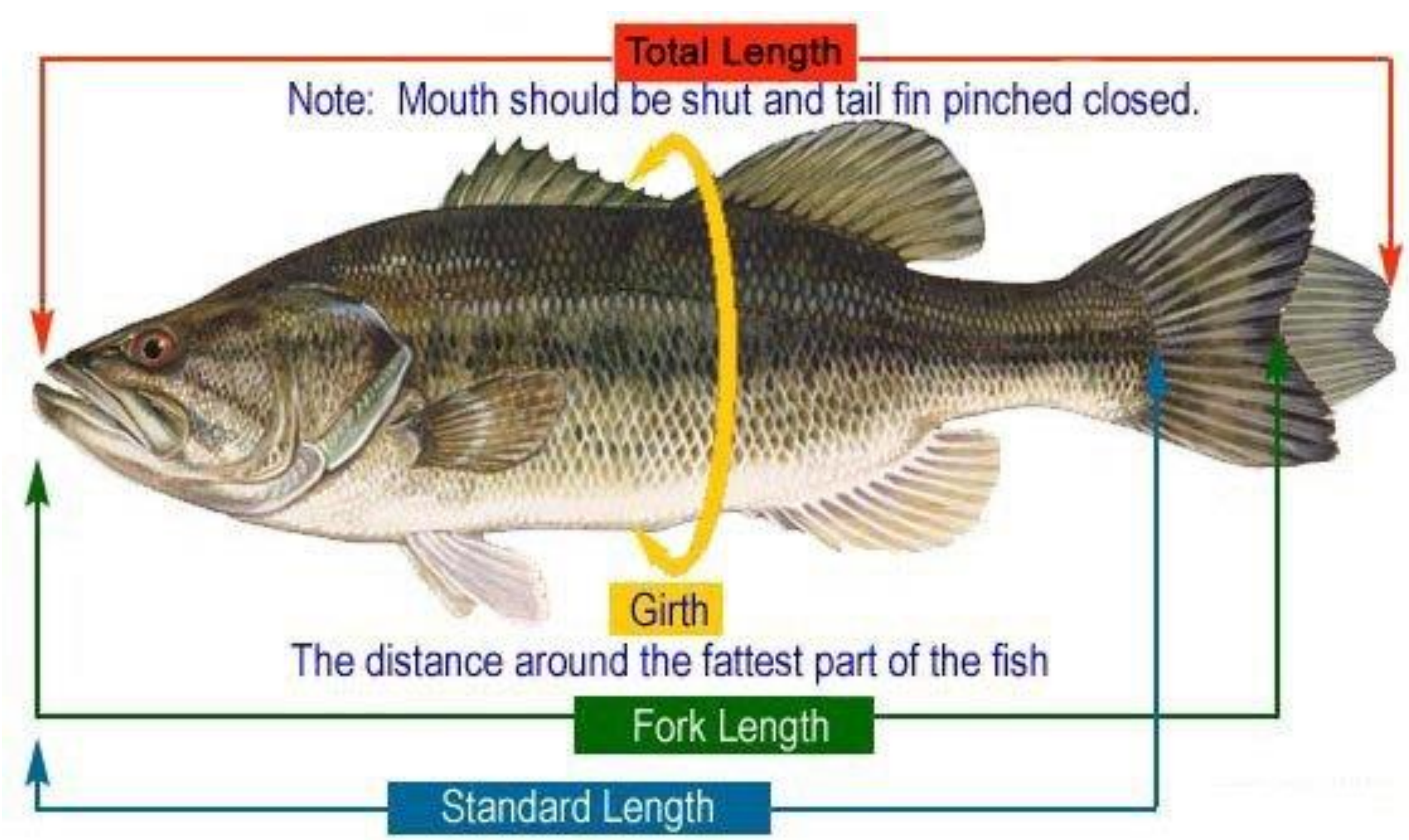
Historical Units - 2



- **Girth** - the measure around a man’s waist, equal to the **length of a belt**. Today still used to describe the distance around the **body of a fish**, measured at its tallest point when held as if swimming. A **girth** (also called a **cinch**) is also a strap around a horse’s midsection used to secure a **saddle**. The German word for a belt is ***der Gürtel***.
- **Hand** - a measurement across the palm, including the thumb, with all fingers flatly held together and not spread. Today, a hand is considered to be **four inches**. The **height of a horse** is still measured in hands, from the ground to its **withers**, the top of the highest non-variable point of its skeleton. Horses range in height from **15 to 18 hands**. Any horse measuring 14.2 hands or shorter is called a **pony.**

Girth, Hand, Fish, and Horses





How to Measure Fish

A: Eye-to-base-of-tail measurement (in inches)

B: Back edge of collar bone to base-of-tail measurements (in inches)

C: Girth around largest part of belly measurement (in inches)

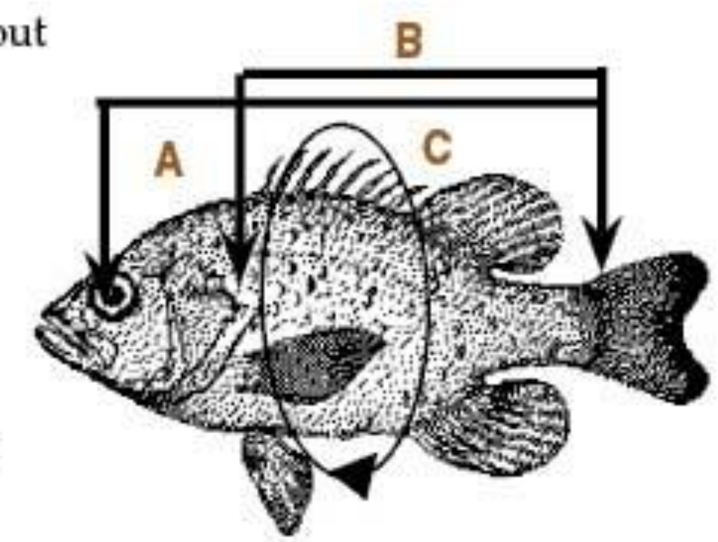
U: Tail action is up and out

D: Tail action is down and out

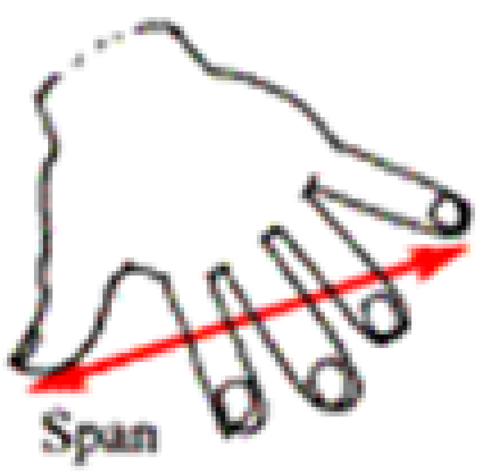
L or OL: Left show side

R or OR: Right show side

Note: Fish should be measured lying flat on the measuring table: because of turns etc., form measurement may differ.



Historical Units - 3

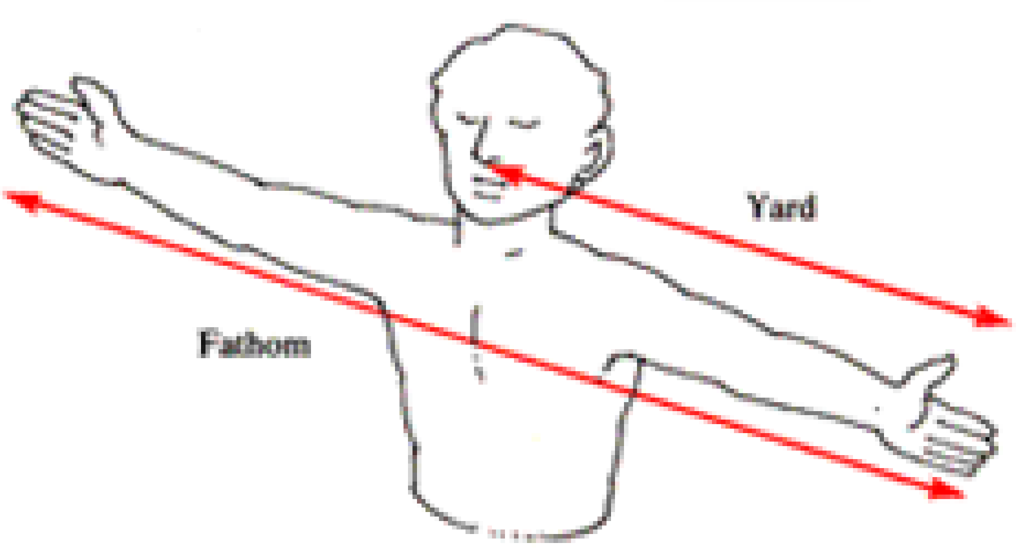


- **Inch -** The word inch derives from the Latin word *uncia*, which means 1 /12th. In Ancient Rome, where an uncia was a bronze coin, the smallest denomination in use, very much like our modern penny. An inch was originally defined as the **width of a man's thumb**. 12 inches equals **one foot**.
- **Span** - the distance from the **tip of the thumb to the tip of the little finger** when the fingers are spread out. The word itself derives from the Greek word *spithame*.
- The Roman **pace -** two steps, was about 58 inches, or approximately **five feet**.
- **Mile** - defined as **5,280** feet in the U.S. Customary Standard system. The word itself derives the Latin words for 'a thousand paces', ***mille passus***. Given that the Roman Pace was about approximately five feet, a Roman mile was 5,000 feet, compared to the U.S Customary mile of 5,280 feet.

Historical Units - 4

- **Palm** – the width of the **four fingers** when placed together. It is also described as the width of **four digits.**

- **Rod** – a surveyor's measuring stick that is **5 1/2 yards** (16 1/2 feet) long. In the US, *portage* distances (when canoes must be carried between lakes or rapids) appear in rods on some maps. **Pikes**, long thrusting weapons years ago, were about the same length.
- **Yard -** is one-half **fathom**, or **three feet**. Some historians claim that **King Henry I** of England proclaimed in the 12th century the yard to be the **distance from his nose to the thumb of his outstretched arm**. Others claim this was folklore, but it was common for rulers to set measurements to prevent fraud among traders.



Converting Between Units

- **It's all about "consistent units" :**
  - (Desired units) = (Given Units) x (Conversion Factor)
  - (Conversion factor) = (Desired Units / Given Units), for example:
    - Feet = Yards x (Number of Feet / 1 Yard)
    - Meters = Inches x (1 Meter / Number of Inches)
  - Always **show units** in your calculations.
  - Units should **cancel out** to leave only those desired.
  - When multiplying or dividing, always obey the rules of **Significant Digits.**
- **Example One: Convert 48 Inches to Yards**
  - (48 inches) x (1 Foot / 12 Inches) x (1 Yard / 3 Feet) = 1.3 Yards
- **Example Two: Convert 4 Inches to Millimeters**
  - (4 Inches) x (25.4 Millimeters / Inch) = 102 Millimeters = 0.102 Meters

Common Conversion Factors

NIST

United States Department of Commerce
Technology Administration
National Institute of Standards and Technology
Metric Program, Gaithersburg, MD 20899

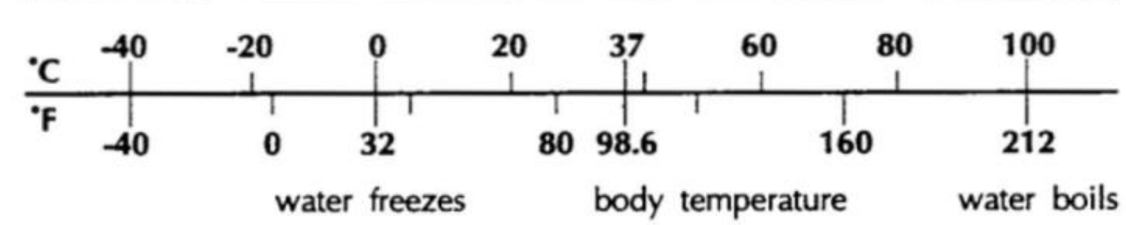
METRIC CONVERSION CARD

Approximate Conversions to Metric Measures

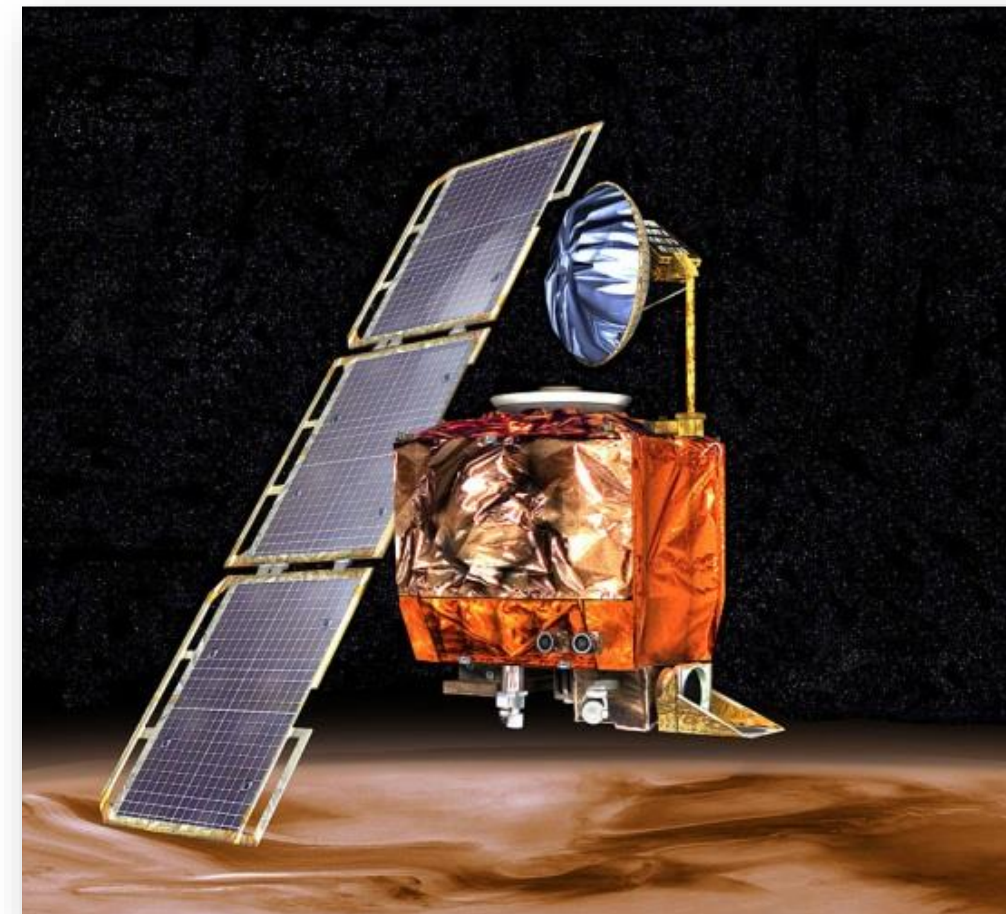
Symbol	*When You Know*	*Multiply by*	*To Find*	*Symbol*
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	metric ton	t
		VOLUME		
tsp	teaspoons	5	milliliters	mL
Tbsp	tablespoons	15	milliliters	mL
in^3	cubic inches	16	milliliters	mL
fl oz	fluid ounces	30	milliliters	mL
c	cups	0.24	liters	L
pt	pints	0.47	liters	L
qt	quarts	0.95	liters	L
gal	gallons	3.8	liters	L
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	degrees Fahrenheit	subtract 32, multiply by 5/9	degrees Celsius	°C

Approximate Conversions from Metric Measures

Symbol	*When You Know*	*Multiply by*	*To Find*	*Symbol*
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares ($10{,}000\ m^2$)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	metric ton (1,000 kg)	1.1	short tons	
		VOLUME		
mL	milliliters	0.03	fluid ounces	fl oz
mL	milliliters	0.06	cubic inches	in^3
L	liters	2.1	pints	pt
L	liters	1.06	quarts	qt
L	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	degrees Celsius	multiply by 9/5, add 32	degrees Fahrenheit	°F



Convert Units with Caution!



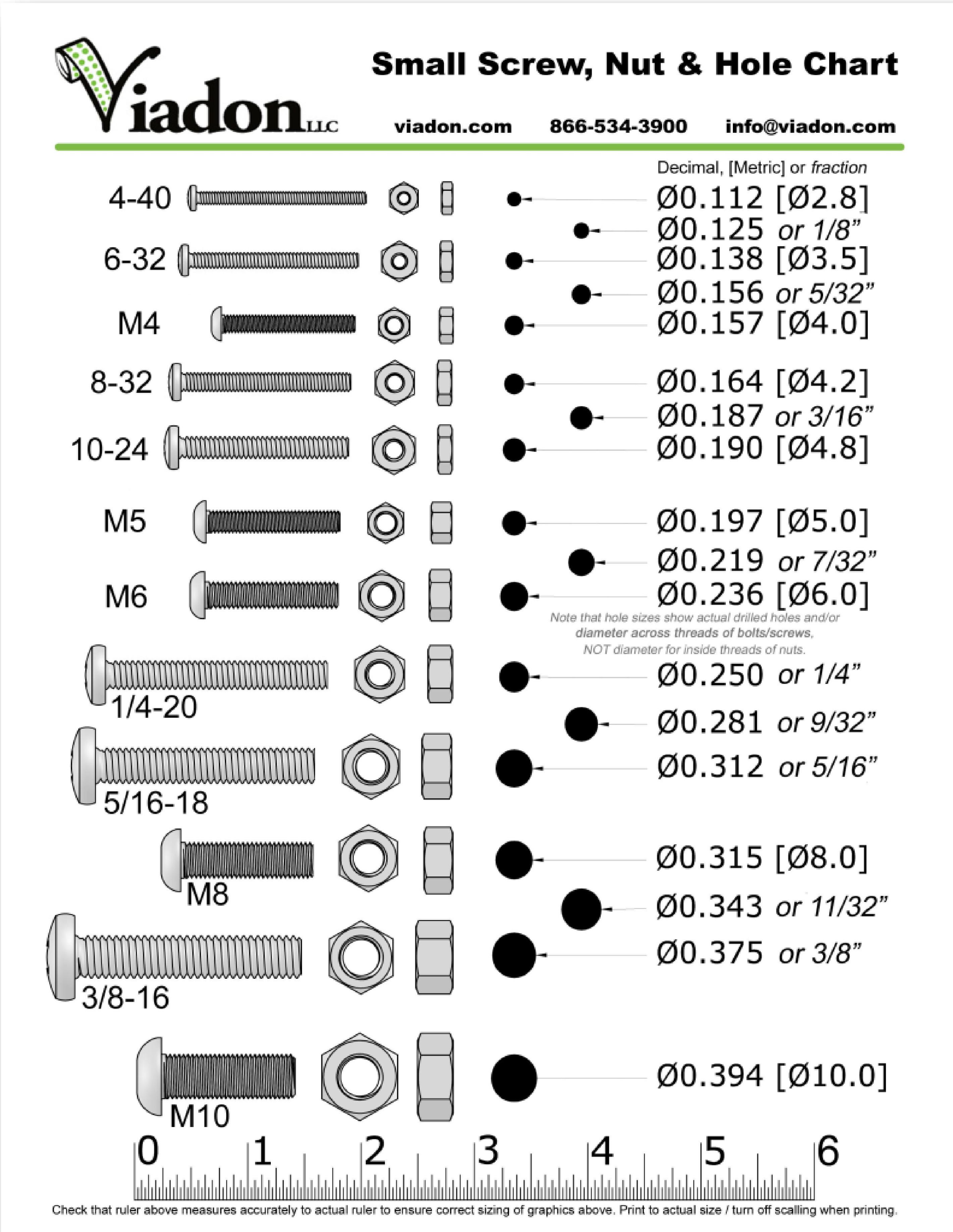
***Unit conversion errors** can have hazardous or costly consequences. **Left**: **Air Canada Flight 143**, a Boeing 767-200, **ran out of fuel** during flight in 1983 after the amount of fuel entered into the airplane's computer was given in **Imperial units (pounds) instead of Metric units (kilograms**) as required. It was successfully landed 'dead stick' on a racetrack resulting in no injuries. The event is sometimes referred to as the '**Gimli Glider**' after the name of the former Royal Canadian Air Force base in Gimli, Manitoba where it landed. **Right:** In 1999 the **NASA Mars Climate Orbiter** encountered Mars at a **lower than anticipated altitude** and it was either destroyed in the atmosphere or re-entered space after leaving Mars' atmosphere. The cause was thrust data generated by one piece of software in **US Customary units** that **should have been in Metric SI units.** The cost to US taxpayers for the mission was **$328 million**.*

Metric System Prefixes

PREFIX	SYMBOL	MULTIPLIER	EXPONENT FORM
exa	E	1, 000, 000, 000, 000, 000, 000	10^{18}
peta	P	1, 000, 000, 000, 000, 000	10^{15}
tera	T	1, 000, 000, 000, 000	10^{12}
giga	G	1, 000, 000, 000	10^{9}
mega	M	1, 000, 000	10^{6}
kilo	k	1, 000	10^{3}
hecto	h	100	10^{2}
deca	da	10	10^{1}
Basic Unit	Basic Unit	1	10^{0}
deci	d	0.1	10^{-1}
centi	c	0.01	10^{-2}
milli	m	0. 001	10^{-3}
micro	μ	0. 000, 001	10^{-6}
nano	n	0. 000, 000, 001	10^{-9}
pico	p	0. 000, 000, 000, 001	10^{-12}
femto	f	0. 000, 000, 000, 000, 001	10^{-15}
atto	a	0. 000, 000, 000, 000, 000, 001	10^{-18}

The most common prefixes for Shop and Engineering are giga-, mega-, kilo-, deci-, centi-, milli-, and micro. You should learn and instantly recognize their meaning.

A Word About Fastener Sizes



1/8 = 0.125	5/8 = 0.625
2/8 = 1/4 = 0.250	6/8 = 3/4 = 0.750
3/8 = 0.375	7/8 = 0.875
4/8 = 1/2 = 0.500	8/8 = 1.000

Remember that fasteners (screw, bolts, etc.) are most available and cost less when chosen in standard sizes with increments of 1/8" or 1.00mm. Thus M4/M6/M8/M10 for metric or those from the list above for inch sizes - which should be memorized! Fastener terminology is a complex topic but well explained from industrial suppliers like Fastenal, Grainger, and McMaster-Carr.

MIL, MICRON & MICROMETER

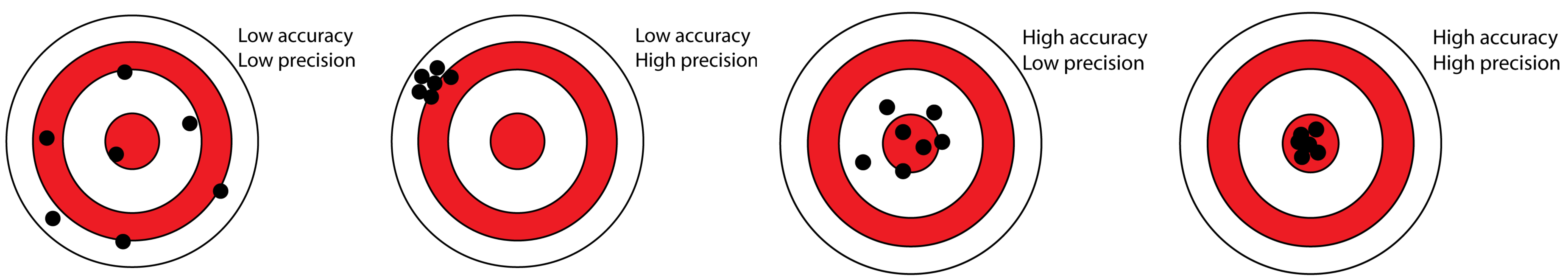
- **MIL –** One thousandth of an inch, or 0.001 inch. Also referred to as "a thousandth" or "a thou". Note that the Latin word for thousand is *mille*. The diameter of a human **hair** is 0.67 – 7.1 mils, on average about 4 mils. The thickness of plastic films and bags are given in mils, usually varying from 0.25-10 mils.
- **MICRON** - One millionth of a meter, or one thousandth of a millimeter. Also called a *micron.* Its symbol is μm. Since one inch = 25.4 mm, one micron = mil x (micron / mil) = mil x (0.001mm/0.001inch) = mil x (mm/inch) = mil x 25.4. Thus, the diameter of a human hair is 17 – 180 microns, on average about 102 microns.
- **MICROMETER** - micrometer screw gauge, a device incorporating a calibrated screw widely used for precise measurement of components in mechanical engineering and machining.

What's in a 0.6 mil plastic bag?

- Over the years, **plastic film** used in bags has become thinner and thinner, mainly to save its producer **money** and thus **lower costs** to consumers.
- You can easily determine this: cut open a typical plastic bag you get at a grocery store. The overall 'lay flat' dimensions are about **38" x 24".**
- For a 0.6 mil film thickness, the volume would be 38 x 24 x .0006 = 0.55 cubic inches, about the same as **two sugar cubes.**
- Thanks to Chemical, Mechanical and Plastics engineers, plastic film continues to become **thinner and less expensive, yet stronger**. In recent years, new forms of plastic have been developed that **degrade quicker**, making it an even better alternative to paper bags from years past.
- Look at everything you own, and wear, made from plastic. **Imagine a world without it!**

Accuracy and Precision

- The **general public** uses these two words interchangeably. But engineers know that these two words have **different meanings**.
- **Precision** - how close together or **repeatable** the results are when multiple measurements are made of the same dimension using the same measuring instrument. A **precision measuring instrument** will give nearly the same result each time that it is used. A **non-precision measuring instrument** won’t.
- **Accuracy** - how close a measurement is to the **actual value** as defined by a System of Units being used.
- Engineers should **always use precision measuring instruments** when their work requires it. Sometimes only **rough estimates** are needed, and then most any instrument is sufficient.



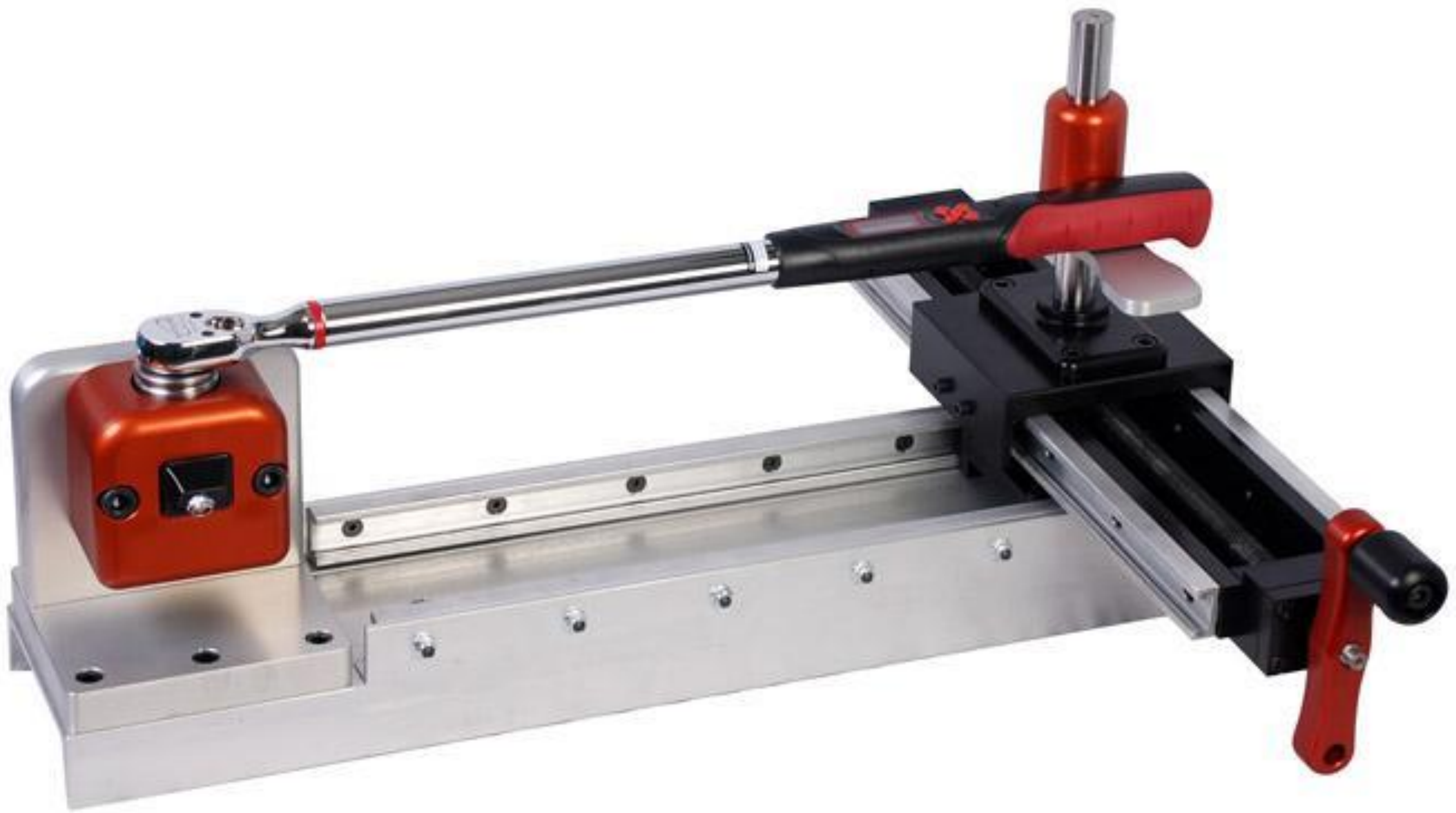
Precision Measurement Instruments

Stainless steel rulers, triangles, templates, calipers (digital, dial or caliper), micrometers, laser & optical distance & angle measuring devices.

Non-Precision Measurement Instruments

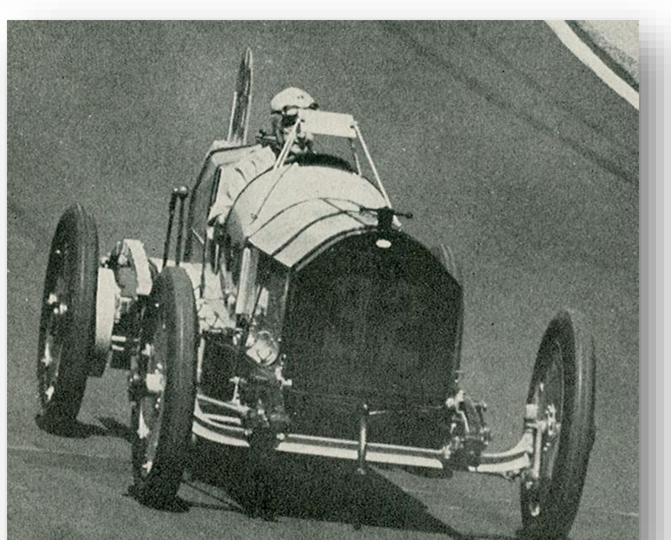
Flexible (tailor's) measuring tape, old wooden rulers, folding ruler, tape measure, old wooden T-square and triangles. Temperature and humidity fluctuations change wood's dimensions. Wood is also easily damaged.

Calibration of Instruments



*Regular **calibration** assures that an instrument shows results that are **accurate**, ie they match accepted values, within **allowable tolerances**. In industry, **regular calibration** by experts may be required by **contract or law**. Above: calibration of a torque wrench and a micrometer.*

American Inventor: Harvey S. Firestone

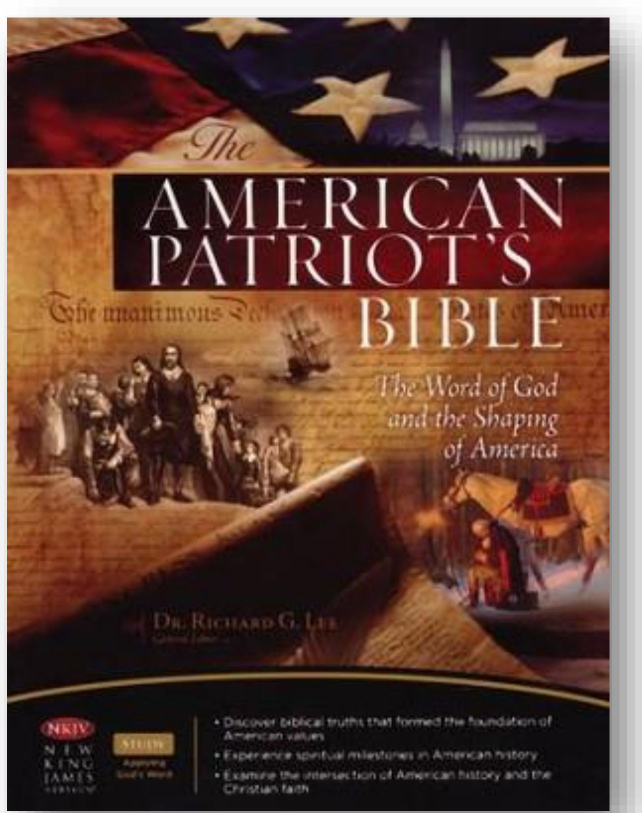


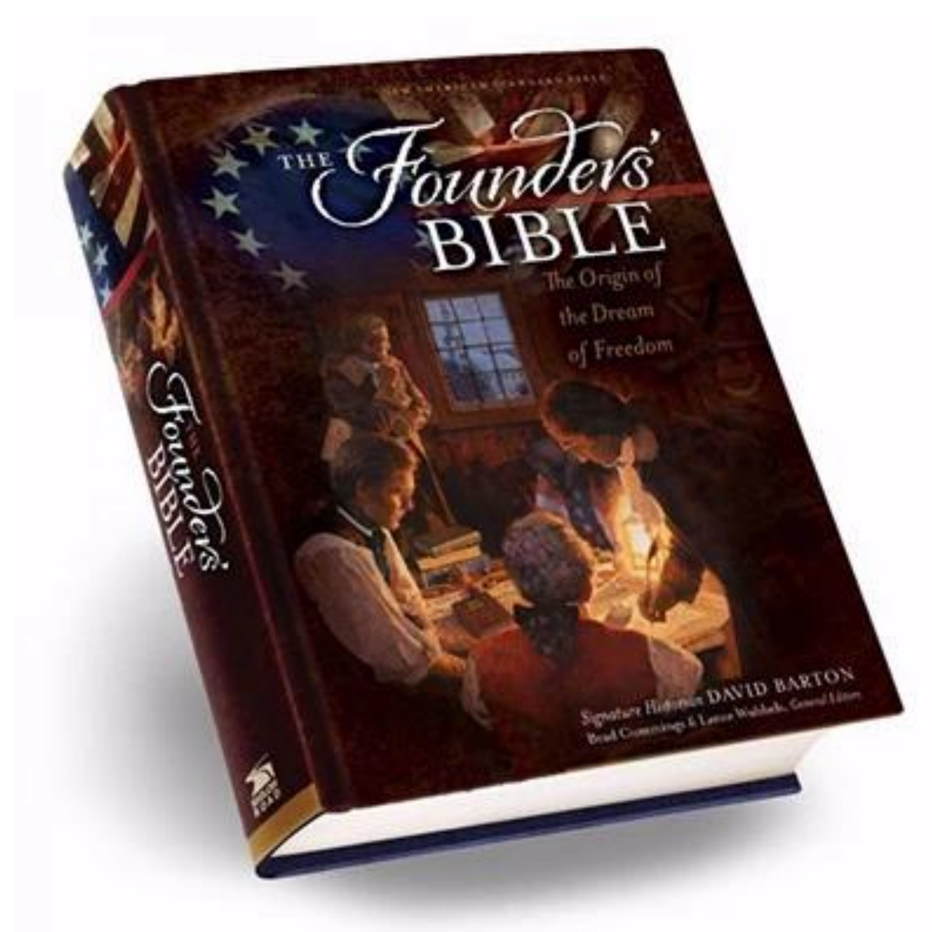
- **Born in 1868**, in Columbiana, Ohio to a **farming family** that immigrated to Pennsylvania from NE France in **1753**, changing their name from the German “**Feuerstein**”.
- At **age 18**, went to work for his uncle’s company, **Columbus Buggy Company** in Columbus, OH. Firestone excelled in **salesmanship** and was promoted to manager.
- He founded his first **rubber tire company** in 1896 in Chicago, IL; sold the company in 1899 at **$40,000 profit**.
- In **1900**, founded the **Firestone Rubber and Tire Company** in Akron, OH, to become the “rubber capital of the world.”
- **Grew revenues** from $100,000 in 1900 to $15m in 1913. Sponsorship of popular **motorsports** aided expansion.
- Became close friend of **Henry Ford** and **Thomas Edison**.
- Regarding **his success** he said “Capital isn’t that important in business. Experience isn’t that important. You can get both of these things. What is important is ideas.”

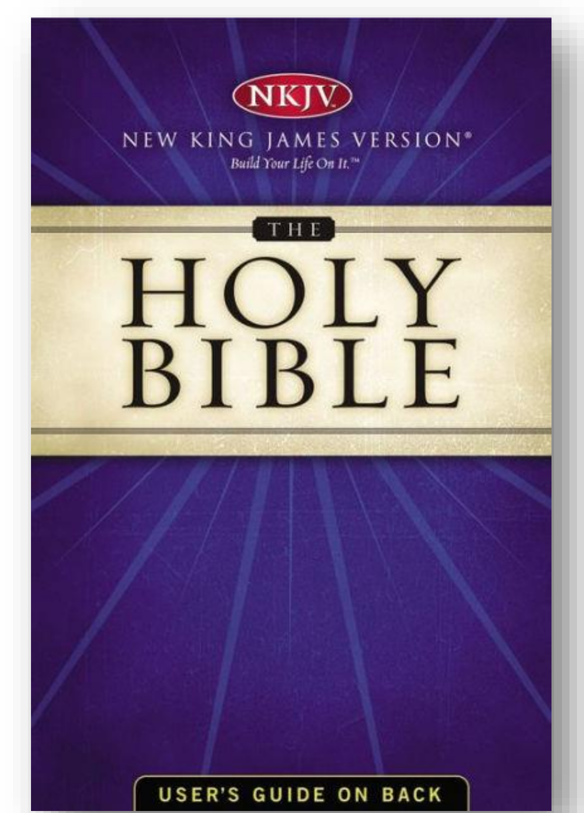
What does the

Bible

say about this chapter?







Inspired Engineering – Then and Now

- **Overall Dimensions:** 300 cubits long, 50 cubits wide, 30 cubits. Using the Old Egyptian / Babylonian cubit of 20.5”, this gives dimensions of 515’ x 86’ x 52’ or 157m x 26m x 16m. **Titanic overall dimensions**: 850’ x 92’ x 64’.
- The Ark was **not really a sailing vessel**, but a **floating barn** for animals, with living and working quarters.
- **Internally**, it was divided into **three levels**, each deck having the same height as the Temple in Jerusalem and three times the area of the Court of the Tabernacle.
- **Construction material**: gofer or gopherwood, cypress, cedar, “planed” wood, wood smeared with pitch, or other wood varieties used for boatbuilding.

Above left: artist’s rendering of the Ark’s construction (from Answers in Genesis). Right: the Syracusia, an actual ancient Greek ship, claimed to be the largest transport vessel of antiquity. Its dimensions were similar to those of Noah’s Ark. It could carry a cargo of some 1600 to 1800 tons and a capacity of 1,942 passengers.

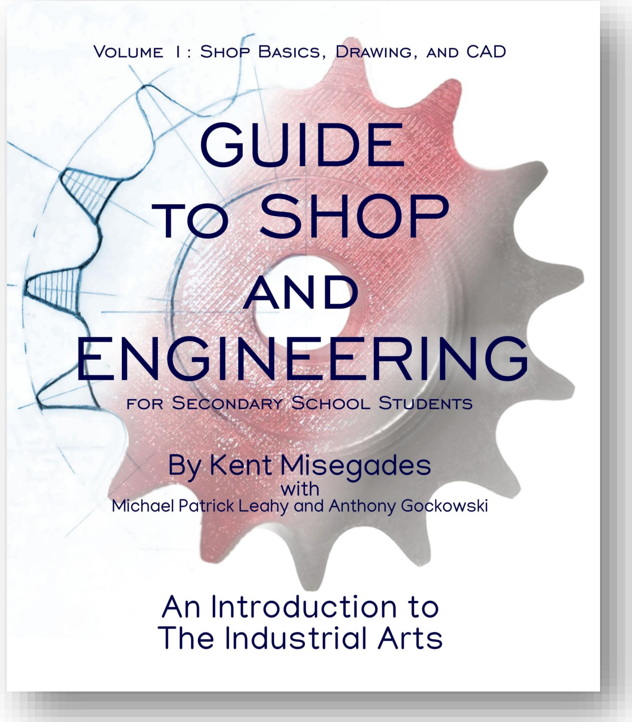
Ark of Noah - Netherlands

- Conceived by Christian carpenter/builder **Johan Huibers** from **Noord-Holland.** At **age 24** he encountered **God**, who planted a desire in his heart to help others, leading to adventure-filled aid projects in Ethiopia, Albania and Bosnia.
- Work on the Ark replica began when he was **33**, following a **dream** that his region of north Holland was **flooded** by a fierce storm tide, such as one that caused 2,551 deaths in late January 1953.
- Huibers first built a **half-scale Ark** in 1-1/2 years with **only the help of his son**, at the cost of one million Euros. It is now owned by Dutch TV and theater producer **Aad Peters**, who operates it as a **Bible museum** in Ipswich, England.
- The replica rests on **21 LASH barges** (Lighter Aboard Ship), allowing it to be towed or pushed on inland waterways or hauled on top of transport ships to cross oceans.
- **Cedar & pine** wood was used, the equivalent of 12,000 trees.
- Huibers built the **full-scale Ark** in four years with the help of only **eight** people at the cost of 4 million Euros. It opened to the public in 2012. **See arkofnoah.org**

Ark Encounter - Kentucky

- Conceived by **Ken Ham**, founder of **Answers in Genesis**. Located in Grant County, KY, between Cincinnati, OH and Lexington, KY.
- Constructed by **Amish** builders using **traditional timber framing** techniques. In total, over **1,000 craftsmen** were employed in the ark's construction, at a **total cost** of $100m.
- As possible, **board pulling** was used instead of steaming. The Ark Encounter is the largest timber frame structure in the US.
- The Ark consists of approximately **3,300,000 board feet** (7,800 m3) of wood. The framing of the ark consists mostly of **Englemann spruce**, while the exterior is made of **pine**.
- Includes permanent rainbow lighting and a “Rainbow Garden” to remind visitors of the **Noahic Covenant**: **Genesis 9:1-17** “I have set my bow in the clouds, and it shall be a sign of the covenant between me and the earth.”
- Internally, the Ark displays many **Biblical** exhibits.
- The Ark Encounter opened on July 7, 2016 and welcomes around a million visitors annually. See **arkencounter.com**

Volume I : Chapter 6



EXERCISES

Exercises – Chapter Six

Exercise 1 : Measure Dimensions

There is an old saying in shop work: “Measure twice, cut once.” Taking accurate measurements is an absolute when making things. Double-checking your work before you proceed helps avoid errors. Having someone else verify your work is often a requirement in industry.

1 . Take measurements of the width, length (depth) and height of five objects in the room where you are now sitting. For instance a table, desk, chair, book, refrigerator, cell phone, an eraser, etc. Vary between small objects and large objects. Use either US Customer or Metric units.

2. Record these measurements in a hand-written table, leaving room for two additional entries for every one that you make.

3. Have a helper now take the same measurements to verify yours. He should record these in the same table. If they differ, you and your helper should agree on which is correct.

4. Now proceed to Exercise 2.

Exercises – Chapter Six

Exercise 2: Convert Units

As an American, you will have to work in both the US Customary and Metric systems for many years to come. Errors in converting from one to the other system can have serious consequences, so resolve not to make them.

1 . Convert your final dimensions from Exercise 1 to another system. If your original measurements were in US Customary units, convert these to metric units. Use the conversion factors found in Addendum One. If your original measurements were made in metric units, convert these to US Customary units. If your original measurements were made in US Customary units, convert these to metric.

2. Now have your helper convert these new units back to the original, but without seeing your converted units. Do the two sets of results agree? If not, find the error and correct.

3. Now proceed to Exercise 3.

Exercises – Chapter Six

Exercise 3: Historical Units

While the older units described in Chapter Six are rarely used in daily life today, many are on occasion still found in specific activities. It is good to know that these exist and how to convert to and from them.

1 . From the results from Exercise 1 , choose the most appropriate historic units from Chapter Six. For instance, if the dimension you originally measured for an object was 6 inches, you might choose the 'Hand' unit for comparison, which is equal to 4 inches. Fractional use is OK, for instance 1 .5 Hands would be equal to 6 inches.

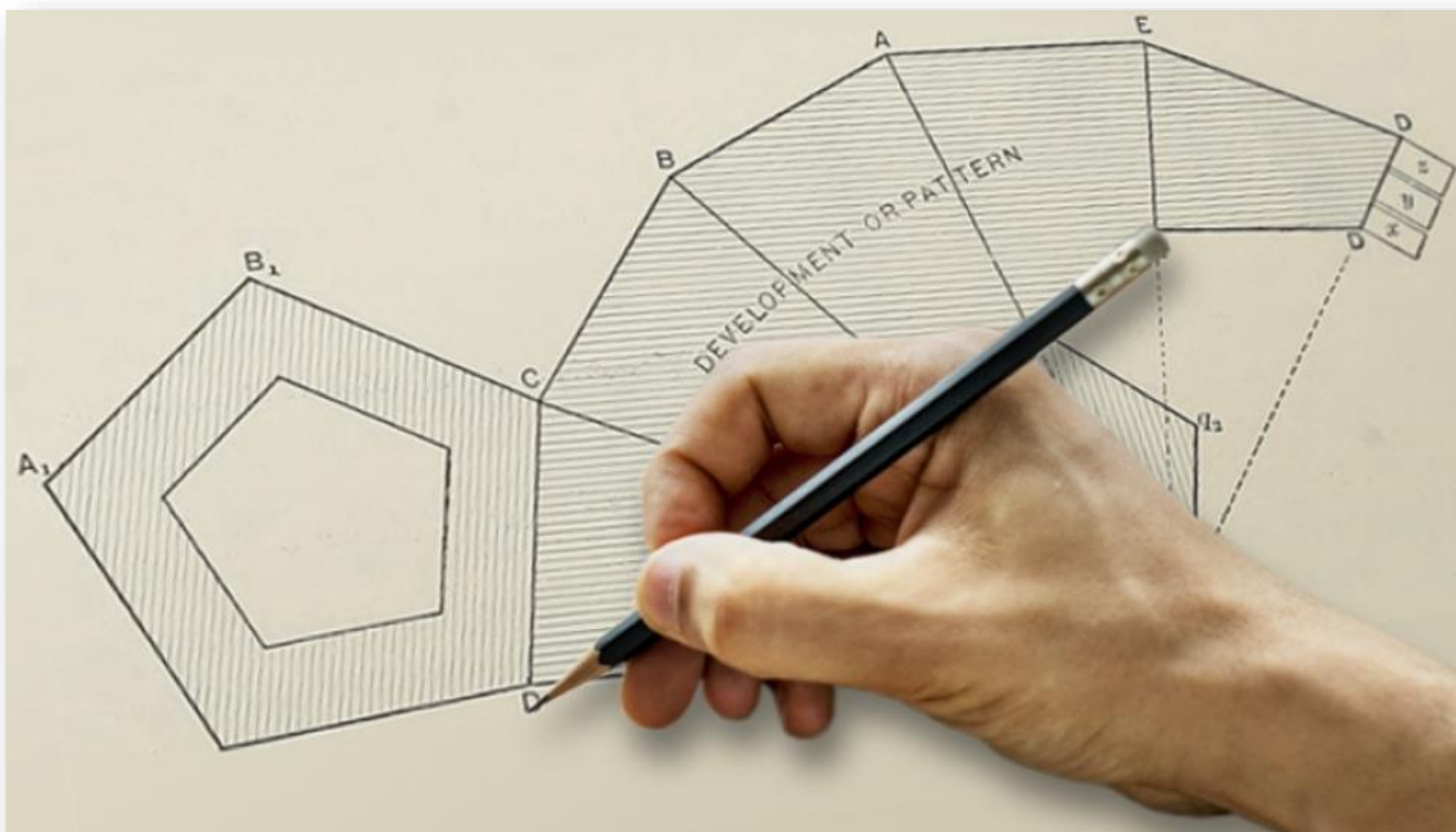
2. Convert all your original dimensions to your chosen units.

3. Determine your height in the following historical units: digits, hands, spans and cubits. Use only your fingers, hands and arms to take these measurements, as they would have been done centuries ago. Now have a friend take the same measurement of your height using his or her finger, hand and arm. Lastly, measure your friend's height using the same units. How do your measurements compare? Do you understand why we now use internationally-established systems of units instead of what was done in the past?

Recommended Shop Projects
Volume I : Chapter 6

End of Volume I : Chapter 6

Next: Chapter 7, Engineering Lettering



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- MSc Applied Aerodynamics, Von Karman Institute for Fluid Dynamics
- Helped establish world-class K-12 schools, Thales Academies
- Co-founded world-class apprenticeships, NCTAP.org
- Developed and taught high school shop & engineering curricula
- Passion is flying, sailing, designing & making things - and teaching young people skills
- Founder and President of AeroSouth.net, Seven Lakes, North Carolina