

The Mathematical Mysteries of a U.S. \$1 Bill **David Masunaga (Iolani School Dept. of Mathematics)**

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Abstract: Money intrigues and motivates everyone--young and old. Who could have predicted that our common US \$1 bill could have a multitude of arithmetic, geometric, and origami connections for students of all ages? Hear the amazing story behind this rectangle, what it has to do with radar and polyhedra, and when \$1 can be worth much more than a dollar!

Facts about U.S. Currency:

Bureau of Engraving and Printing (BEP) -- prints our bills as well as all U.S. bonds and stamps. 24-hours a day, everyday. 9.5 to 10 billion notes are printed per year with an average face value of approximately \$15, ∴ an annual production of approximately \$150 billion in face value per year.

BEP in Washington D.C. and Fort Worth Texas turn out 35,000,000 bills per day at a face value of \$635,000,000.

45% of all bills produced are \$1 bills.

The 2018 fiscal year Yearly Currency Order includes 2.2 billion \$1 notes.

Dozens of different kinds of coinage and notes in circulation during the colonies. Thomas Jefferson envisioned a standardized system to clear up the monetary mess. With his backing came the unified monetary system, "The Mint Act" of 1792.

During this period private individuals, governments and banks printed their own forms of paper notes which were more like promises to pay. Because it was backed solely by the promise of the issuer to pay, the value of the note was constantly changing and worth less the farther away you went from the issuer. They were traded at discount since it was too bothersome to redeem for some people. More convenient than carrying around gold or other coinage.

At the start of the Civil War, both sides realized they needed money fast -- so they printed it. Need for money exceeded coinage at that time.

California passed laws to ensure that paper notes would not circulate in its economy.

1861: Notes were printed with green ink to prevent forgeries (e.g. photoreproduction was possible with Matthew Brady's black and white methods), and green ink was more chemically

stable. Engraving officials believed green represented stability. This is the origin of term “greenback” By law all U.S. currency printed from 1861 is useable at face value.

Though the first U.S. dollars were larger, they are produced by virtually the same ink and papers.

The paper for U.S. currency contains cotton and linen fibers, is not woven, but is a paper.

In the beginning the notes were of variable worth, depending on fortunes of Union or Confederacy. In far Western states, paper notes not welcome, especially California. Only Joshua Norton's imperial bonds.

Paper money became part of national culture, e.g. the 1895 Educational Series. World-renown artists designed notes depicting scenes of the arts and sciences. One note showed enough nudity such that it was banned from circulation. This is where the term, “Banned in Boston” was derived.

Late 1890's: Federal Government advocated for a gold standard -- Every piece of U.S. paper money backed by gold. Gold Standard Act passed in 1900.

After WWII American coin and currency took on more uniformity and standardization with less attempts to inject unique forms of money into the economy. Currency size established at 2.61 to 6.14 inches. (Until 1929 they were approximately a ½ inch wider and an 1-1/2 inches longer than today's currency.)

There are 9 engravers who etch the master plate for the U.S. currency, each person with a specific task. This ensures that no one engraver can replicate the bill him/herself.

Thomas Jefferson's pantograph method is used to replicate the engraved original to size, and a plate of 32 copies is seamed together.

Same intaglio printing process is used as was in the 1900's. The difference today is speed of replication -- then on hand-presses, now on high speed presses. 10,000 sheets per hour (32 bills on a sheet)

At any one time, there are approximately 12 billion U.S. currency notes in circulation around the world with estimated value of \$400 billion in face value. 60% is outside of the U.S. U.S. Secret Service works with the Treasury Department to insure security. The Series 1996 \$100 note was the first major change in design since the late 1920's. Special ink, polymer threads with denomination, watermark in paper, "United States of America" or denomination in letters too small for a Xerox machine to duplicate.

According to the U.S. Mint, the life expectancy of a circulating coin is 30 years; the US gov. site lists average life expectancy of a \$1 bill at 5.8 years (compare with 5.5 years for \$5, 4.5 years for \$10, 7.9 years for \$20, 8.5 years for \$50 and 15 years for \$100).

Since 1879 the Crane Company in Dalton MA has been making the specialized paper for U.S. bank notes. Waste cotton 75%, waste flax 25%. Fibers in wood pulp not as strong and not as long.

1913 Woodrow Wilson signs the Federal Reserve act which provides an elastic currency which expands and contracts to the economy's demands. 12 Districts nationwide monitor America's money supply. When the amount of money falls below a supply in a district, the Federal Reserve Bank in that district puts in an order of money to the U.S. Mint and the Bureau of Engraving and Printing.

Until 20th century, no U.S. President on American money, from a tradition started by George Washington as not wanting to emulate European rulers. Lincoln penny in 1909 was first image of a President on U.S. money.

A new piece of American currency can be folded back and forth at least 4000 times before it tears.

Highest denomination ever produced by the BEP was the \$100,000 Gold Certificate (Series 1934), used only for transactions between Federal Reserve Banks.

In order to thwart counterfeiters, government officials have decided to redesign the bank notes every 7 to 10 years.

Since 1865 the U.S. Secret Service has sought out counterfeit cash and counterfeiters.

New York branch of the Federal Reserve processes 13 million notes every day.

Shredders dispose of 4 million bills daily.

Because the \$1 note is infrequently counterfeited, the government has no plans to redesign this note. In addition, there is a recurring provision in Section 116 of the annual Financial Services and General Government Appropriations Act that prohibits the redesign of the \$1 note.

The BEP puts an FW mark on bills printed at the Fort Worth facility (whereas the Washington D.C. printed bills have none). Can you find it?

On Valentine's Day 2014 the BEP begins printing a 50-subject sheet which has a small change in alpha-numeric position identifier code. On the 32-subject sheet the font size for the alphabet is larger than the number. On the new sheets they are the same smaller font size.

Special Currency:

Radar Notes – currency with palindromic serial numbers, e.g. 27188172. A “perfect” radar note includes the same capital letters before and after the 8 digit serial number, e.g. E27188172E

Repeater Notes – currency with the first 4 digits of the serial number repeated, eg. 27182718

Star Notes – currency with a star either before or after the serial numbers indicating that this bill was a replacement bill for an original defective one in the original stack of 100 bills.

Ladder Notes – currency with serial numbers containing consecutive numbers ascending or descending, e.g. 98765432. There is no consensus on the definition and many variations exist.

Others – some collectors also seek bills with very low serial numbers or favorite numbers, e.g. bills with many 7’s in them. In Chinese culture the number “8” is lucky, so the BEP makes notes available which included serial numbers “8888” -- for an addition cost, of course!

MORE:

Go to the following webpages for more information on the U.S. currency, coinage and tours:

<https://www.moneyfactory.gov>

<http://www.usmint.gov/>

<https://www.moneyfactory.gov/services/takeatour.html>

Resources:***Websites:***

Bureau of Engraving and Printing site contains much information about American money and its history. Believe it or not, it is: www.moneyfactory.gov

The History Channel has produced two programs on U.S. coins and currency in the Modern Marvels series: “Money” and “Money Machines.”

See: www.history.com/shows/modern-marvels

Books:

Two books serve as standard references for U.S. currency:

Friedburg, Arthur L. and Ira S. *A Guide Book of United States Paper Money: Complete Source for History, Grading, and Prices.* Atlanta: Whitman, 2006.

Oakes, Dean and John Schwartz. *Standard Guide to Small-size U.S. Paper Money: 1928 to Date.* Iola (WI): KP Books, 2005.

Money Fold Origami Books and Resources:

Many books on money folds exist. Most of the following authors have several books published on the subject.

Fukumoto, Jodi. *American Money Folds*. Honolulu: Island Heritage, 2004.

Johnson, Anne Akers. *The Buck Book*. Palo Alto: Klutz, 1993.

LaFosse, Michael and Richard Alexander. *Money Origami*. North Clarendon (VT): Tuttle, 2009

Montroll, John. *Dollar Bill Animals in Origami*. Mineola (NY): Dover, 2000.

Nguyen, Duy. *Origami with Dollar Bills*. New York: Sterling, 2004.

Park, Won. *Dollar Origami: 10 Origami Projects Including the Amazing Koi Fish*. Thunder Bay Press, 2011.

Temko, Florence. *Money Folding*. Torrance: Heian International, 2000.

Money origami: <https://www.origami-resource-center.com/money-origami.html>

Web resources:

Do a Google images search for more “ori-money” objects on the web. Be sure not to miss Won Park’s site: orudorumagi11.deviantart.com/

Money Origami from the Origami Resource Center:
www.origami-resource-center.com/money-origami.html

Resources from Origami USA, the American national origami society:
www.origami-usa.org/