The Leap Year: Invented by the Egyptians, Implemented by Caesar, Perfected by a Pope

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The Old Town Astronomical Clock dating from the 15th century is one of the most treasured and best-known of Prague's historical sites. The Astronomical Clock is a one of the best examples of Czech Gothic technology. It is a prized work of art. On the hour, small statues of the twelve apostles appear in small windows at the top of the clock. On either side of the clock a Skeleton, a Turk, a Miser, and a figure representing Vanity come to life. When all the apostles have presented themselves to the crowds below, a cockerel crows and the clock chimes the hour. (Image Credit: CzechTourism.com - official travel site of the Czech Republic)

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If your watch is slow by one second per day, most likely you won't notice. But after six months, you'll be getting to meetings three minutes late. After a year, you'll be behind time by about six minutes. Most likely you'll reset your watch.

That is exactly what we do by adding an additional day to February. Feb. 29 is "leap day." Three out of four Februarys have only 28 days.

"By adding a day to February, once every fourth year, we are synchronizing our calendar to the seasons, the workings of nature," says Ed Murphy, Associate Professor of Astronomy at the University of Virginia. He came up with the watch analogy to show why it's so important to keep time.

"The reason we add a day to the calendar every fourth year is because the length of time it takes the Earth to orbit the sun, what we call a year, is not exactly 365 days," he says. "It's actually about 365-and-a-quarter days. But a day on earth is 24 hours, the amount of time it takes for the Earth to rotate on its axis. So the two are out of synch. We make up for the additional quarter-day each year by adding a full day – leap day – to the calendar every fourth year.

Otherwise our calendar would slowly slip through the seasons."

A leap year contains one extra day which is added at the end of February as February 29. It takes the Earth 365.242190 days to make a complete revolution around the sun. The extra .242190 days is rounded up to .25 days a year or one full day every four years. The extra day is added to synchronize the year with the seasons. Because the .25 days overcorrects for the actual .242190 days there is occasionally a fourth year that not a leap year.

The ancient Egyptians noted the year was 365 and a quarter days long. Around 238 B.C., King Ptolemy III proposed adding an extra day every fourth year to the calendar, but, against all common sense, the priests of the time were opposed, so this didn't happen.

In the Roman calendar September, which comes from the Latin for seven, was the seventh month; October, after the Latin number eight, was the eighth month, etc. They then added January and February to the end of their calendar making 12 months. In 47 BC Julius Caesar developed the Julian Calendar where every fourth year February had 30 days. After his death the fifth month, Qunitilius, was re-named Julius in his honor. Augustus Caesar later changed the sixth month from Sextilius to Augustus and took another day from poor February to make his month as long as Julius.

Caesar's astronomer, Sosigenes, developed the Julian calendar based on the fact that it takes the earth 365 days, 5 hours, 48 minutes and 46 seconds to revolve around the sun. This time was abbreviated to 365 1/4 days, and a calendar year was defined as 365 days, with one "leap day" added every four years to compensate for the lost quarter day.

But a nagging, although slow-developing, problem arose: 5 hours, 48 minutes and 46 seconds isn't exactly a quarter day. In 730 A.D., the Venerable Bede, a mathematically skilled Anglo-Saxon monk, pointed out that the 365 1/4-day Julian year was 11 minutes, 14 seconds too long. But since the error added up so slowly (the calendar fell out of sync with the sun by only a day every 128 years) no one did anything about it.

Now, fast forward to 1563 when King Charles IX of France decided that the year should begin near the celebration of the birth of Christ. So he changed the beginning of the year from March to January. Now, September, named after the Latin number seven, became the ninth month, etc.

With an extra day added for a leap year every fourth year, the average length of the calendar was 365.2500 days long. That’s an error of 0.0078 days per year. By 1582 this amounted to an error of ten whole days and Pope Gregory XIII set up by decree what we now know as the Gregorian Calendar. Here are his rules for leap year:

- Years evenly divisible by 4 are leap years unless they are century years, i.e., years evenly divisible by 100.

- Century years are not leap years unless they are evenly divisible by 400.

- Years evenly divisible by 400 are leap years.

Based upon this formula, 1900 was not a leap year but the year 2000 was a leap year even though it was divisible by 100. The next year divisible by four that will not be a leap year is the year 2100. And 2008 is a leap year since it is evenly divisible by 4 and is not a century year.

Pope Gregory XII's calendar, known as the Gregorian calendar, now hangs on most of our walls. "That is the Gregorian Calendar that we use today. It is accurate to the day for 3,323 years. We're not likely to see it reformed any time soon" says Ed Murphy.

However, it wasn't as popular when it was first developed. Although most Roman Catholic countries adopted it at once because it recalibrated the beginning of spring and restored Easter to its proper time, Protestant countries didn't make the change for 200 years. England resisted the switch until 1752. It wasn’t until September 2, 1752 that those countries, including the American colonies, changed from the ancient Julian calendar to the Gregorian Calendar.

Even though the simple leap year approach solves most of the problems of keeping artificial calendars aligned with what the Earth actually does in its orbit around the sun, the Earth's orbital behaviors are responsible for more than just presenting us with a leap year every four years. According to Michael E. Wysession, Ph.D., Associate Professor of Earth and Planetary Sciences at Washington University in St. Louis, parameters such as planetary gravitational attractions, the Earth's elliptical orbit around the sun, and the degree of tilt of our planet's axis with respect to its path around the sun, also have implications for climate change and the advent of ice ages.

People often think of orbits as circular, but they're not that smooth and simple. They are often a less-than-perfect eccentric circle.

"All planets travel in an ellipse around the sun, but the shape of that ellipse oscillates," he explains. "When the Earth's orbit is more elliptical, the planet spends more time farther away from the sun, and the Earth gets less sunlight over the course of the year. These periods of more-elliptical orbits are separated by about 100,000 years. Ice ages occur about every 100,000 years, and they line up exactly with this change in the Earth's elliptical shape."

The purpose of the leap year is to keep our artificial calendars aligned with what the Earth actually does in its orbit around the sun and to ensure that roughly at noon on the winter solstice (Dec. 21) each year, the same point on the Earth is tilted toward the sun.

A leap second is a second added to Coordinated Universal Time (UTC) to make it agree with astronomical time to within 0.9 second. UTC is an atomic time scale, based on the performance of atomic clocks. Astronomical time is based on the rate of rotation of the earth. Since atomic clocks are more stable than the rate at which the earth rotates, leap seconds are needed to keep the two time scales in agreement.

The first leap second was added on June 30, 1972. Since then, they have occurred at an average rate of less than one per year.

For more information:

http://www.wwu.edu/depts/skywise/leapyear.html

http://www.virginia.edu/uvatoday/newsRelease.php?id=4344

http://www.pari.edu/about_pari/astro/leap-year-2008

http://www.fairfaxcounty.gov/library/information/events/leapyear.htm

http://www.gi.alaska.edu/ScienceForum/ASF12/1272.html

http://news-info.wustl.edu/tips/page/normal/10874.html

http://www.bu.edu/today/2008/02/28/what-s-leap-year-anyway

http://tf.nist.gov/general/leaps.htm