# THE MAYAN CALENDAR ROUND Keeping Time

How often does New Year's Day come around? With the calendar most of us use, a new year begins every 365 days, on January 1. But suppose you had two calendars to follow, each with a different number of days? A new year would begin at a different point on each calendar. How often would the two New Year's Days occur on the same day? How could you figure that out? That's a problem the Maya had.
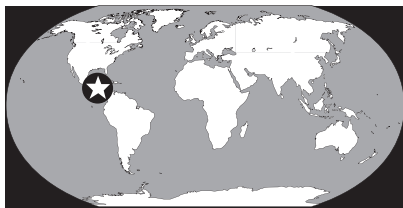
About Mayan Calendars

The Maya, who came to prominence in the New World in the third century A.D., kept extensive records of possessions, important dates, and astronomical observations. They were sophisticated in their understanding of science and math and had an advanced knowledge of astronomy, which they developed through observation and calculation.

For the Maya, religion, math, astronomy, architecture, and culture were all interrelated. People still gather at the Mayan city of Chichén Itzá at the equinoxes (the two days each year when day and night are of equal length) to watch at sunrise, when the shadow of the serpent carved along the grand stairway of the Temple of El Castillo (right) seems to snake its way up the pyramid's side.

The Maya blended together their complex mathematics and precise astronomy in a cycle known as

THE MAYAN TEMPLE OF EL CASTILLO IN CHICHÉN ITZÁ IS A HUGE STONE PYRAMID THAT RISES OUT OF THE MEXICAN JUNGLE ON THE YUCATÁN PENINSULA. IT IS PROBABLY NO ACCIDENT THAT THERE ARE 90 STEPS ON EACH OF THE PYRAMID'S FOUR SIDES, A TOTAL OF 360 STEPS—THE SAME AS THE NUMBER OF REGULAR DAYS IN THE MAYAN CALENDAR YEAR.

the "Calendar Round." They used two different calendars—one for the *haab,* an astronomical year of 365 days, and one for the *tzolkin,* a ritual year of 260 days.

The haab was related to seasonal changes and agriculture, and corresponds to most calendars in use today, with a few differences. It had 18 months of 20 days each. The five days that were left over, known as *uayeb,* were considered unlucky.

The 260-day cycle of the ritual calendar, the tzolkin, can be inferred from the Dresden Codex, one of the few Mayan books that still exist today. (For more about the Maya and the Dresden Codex, see Chapter 6.)

In that manuscript, dates are written as a combination of vertical bars and dots (representing the numbers 1 to 13), followed by one of 20 roundish glyphs, which are
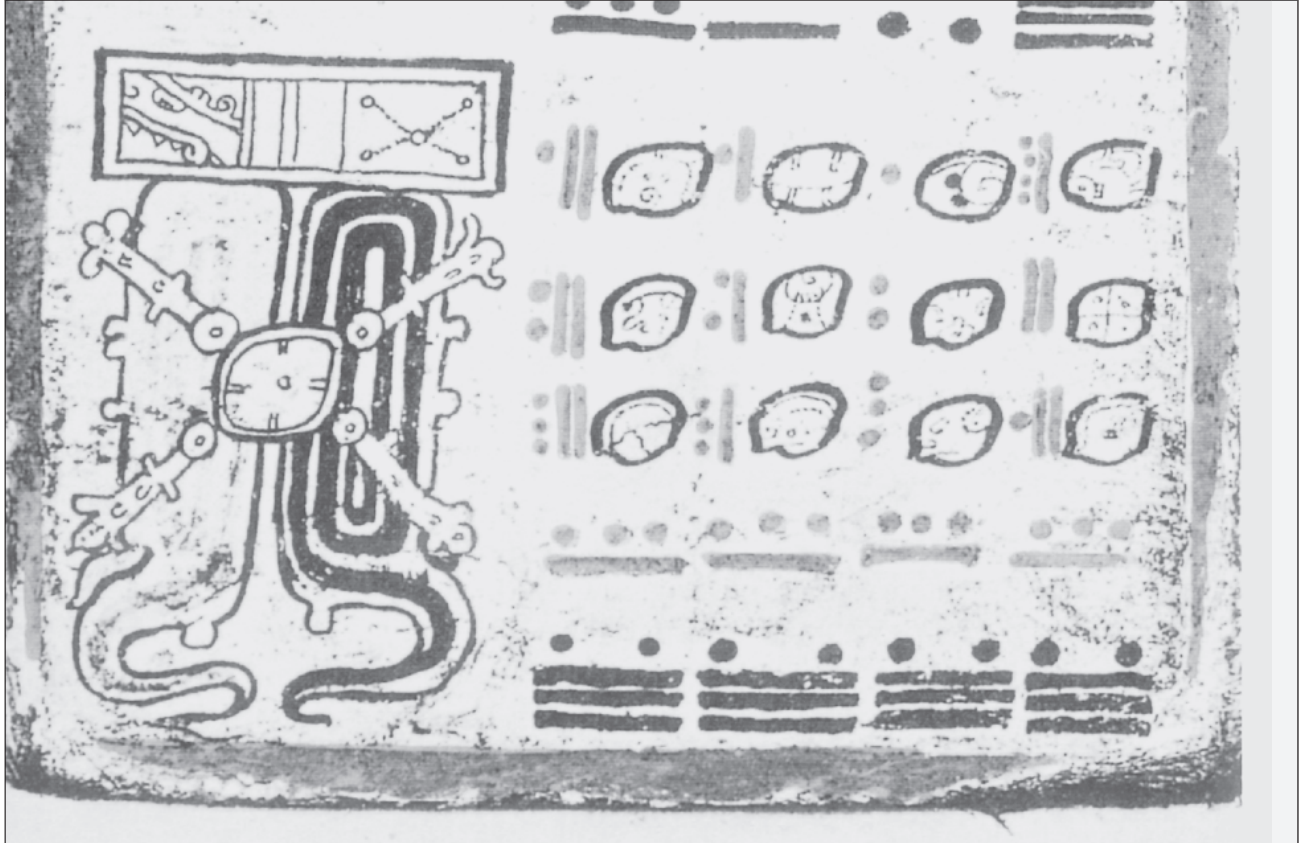
A detail of the Dresden Codex, one of the few surviving Mayan books. The bars and dots represent numbers (see Chapter 6); the roundish glyphs are the names of individual days.

What's It All About?

In this activity, you'll learn about the two calendars the Maya used. You'll solve the problem of how often the two cycles coincided and find out about:

- What we know about the Mayan calendar system and calendar rounds
- The smallest common multiple of two numbers
- Prime numbers and how they are used to find smallest common multiples
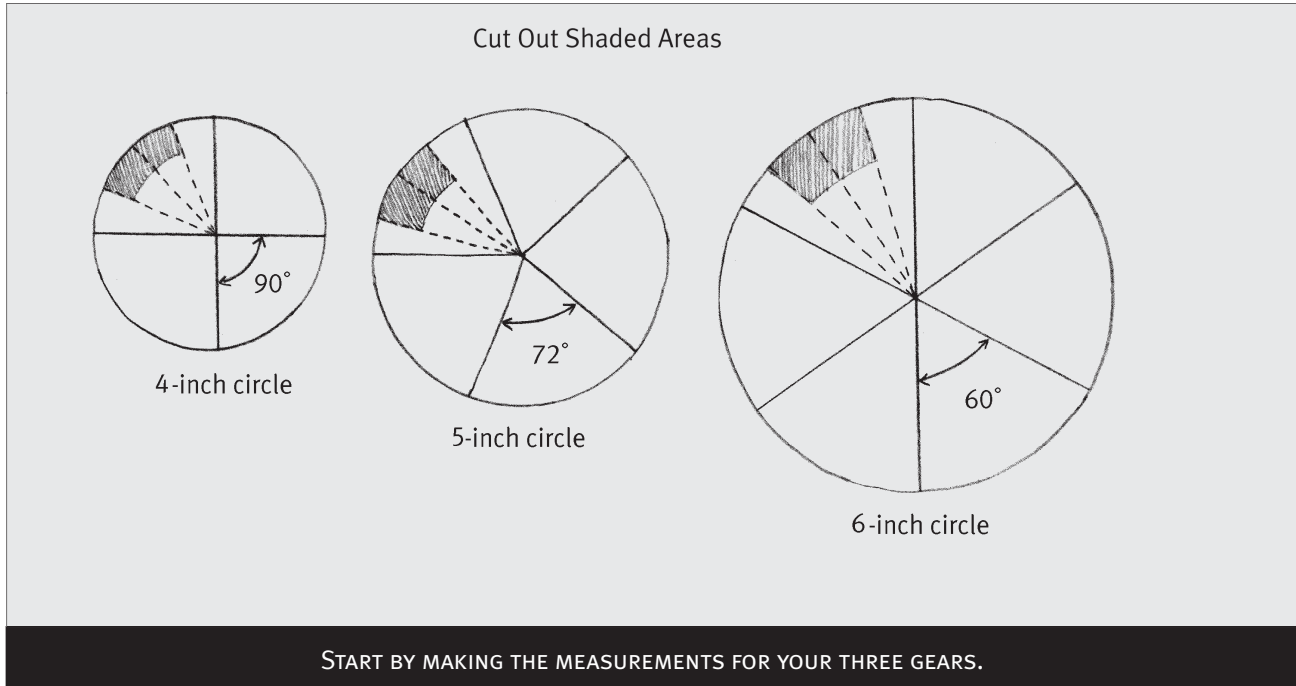
Is there anything special I should know?

- This activity is recommended for ages 12 and up
- You can work alone or with a small group
- You should be familiar with the concept of prime numbers and know how to use a compass and protractor to make circles of different diameters

How much time will I need?

- About 1 to 2 hours

What materials will I need?

- A sheet of posterboard or thin cardboard at least 11 x 14 inches
- A sheet of heavy cardboard at least 9 x 12 inches
- Compass
- Protractor
- Thumbtacks or pushpins
- Scissors

Cut Out Shaded Areas

4-inch circle

5-inch circle

6-inch circle

START BY MAKING THE MEASUREMENTS FOR YOUR THREE GEARS.

the names of individual days. Each date is written with one number and one glyph. So the total possible number of days for one cycle of the ritual calendar is 13 x 20, or 260 days.

The Maya believed in the continuing cycles of their world, so the moments when the haab and the tzolkin came together were important events.

Making Gears

In order to figure out how the two Mayan calendars meshed, you need to construct simple gears.

1. Use a compass to draw three circles on the posterboard. One circle should have a 4-inch diameter, one a 5-inch diameter, and one a 6-inch diameter.

2. Use the protractor to draw lines that:

• Divide the 4-inch circle into four equal parts (90° each).

• Divide the 5-inch circle into five equal parts (72° each).

• Divide the 6-inch circle into six equal parts (60° each). (See illustrations.)

3. Each gear needs to have a number of teeth equal to its diameter in inches. That means, for example, that the 4-inch circle will have four teeth. How can you make four teeth and four spaces of equal width? 🌑

• Divide each quadrant of your 4-inch circle into four equal wedges, like slices of pizza. (See the drawing at the top of the page.)

4. Carefully cut out the circles. Then use the lines of the two inner wedges in each quadrant as guides to cut out the teeth. Cut about one-third of the way to the center of the circle.

When you're done, you'll have a gear with four teeth and four spaces of equal width, like the one shown on page 75.

Use the same method to make five equal teeth and spaces on the 5-inch circle, and six equal

teeth and spaces on the 6-inch circle. Again, the drawings will help guide you.

5. Put two of the gears together and see how well they turn against each other. You'll notice that the teeth of one gear probably won't fit perfectly into the spaces of the other. Trim the sharp outer corners of the teeth on all three gears to make sure they mesh together well. (If you look at the gears of a mechanical device such as a clock, you'll notice that the edges of the teeth on those gears are also rounded off to make the teeth and spaces mesh properly.) Trim your gear teeth a little at a time, until they mesh smoothly.

6. When you're done constructing your gears, you need to label them.

• First, label the *teeth* of the 4-inch gear 1, 2, 3, 4, going *counterclockwise*, as shown on the next page. This will represent a four-day year.

• Next, label the *spaces* of the 5-inch gear with the numbers 1, 2, 3,

4, 5, going *clockwise*, to represent a five-day year.

• Finally, label the *spaces* of the 6-inch gear 1, 2, 3, 4, 5, 6, going *clockwise*, to represent a six-day year. ◐

Meshing Gears

Each gear you made represents one way of grouping days. In this sense, each one is a calendar.

To begin your investigation, set the 6-inch gear aside. You'll need it later.

Now put a thumbtack or push-pin through the center of the 5-inch gear, and pin it to a large piece of cardboard to hold it in place. Set tooth 1 of the 4-inch gear in space 1 of the 5-inch gear. Then pin the 4-inch gear into place. (See the photo on page 76.) Turn the gears a little to make sure they're meshing well. ◐

Now let time flow and the days mesh as you turn both gears. How many turns of each wheel does it take before you're back to the starting position—with the same tooth 1 and space 1 meshing together again? ◐

If you let the smaller gear make one revolution clockwise, tooth 1 will be in space 5 of the larger gear. After the next revolution of the smaller gear, tooth 1 will be in space 4. Keep turning the smaller gear until tooth 1 falls again into space 1 of the larger gear. How many revolutions did each gear have to make? ◐

You'll find that the 4-inch gear made five revolutions and the 5-inch gear made four revolutions.

To visualize these cycles, imagine putting ink on the edges of the gears and rolling them along a piece of paper in a straight line. One turn of the 4-inch gear gives you a group of four marks. One turn of the 5-inch gear gives you a group of five marks.

How many marks will you have to make before "groups of 4" and "groups of 5" coincide? ◐

You'll find that five turns of the 4-inch gear (five groups of 4) will bring you to the same place as four turns of the 5-inch gear (four groups of 5). At the twentieth mark, both will coincide again.

$$4 \times 5 = 20$$
$$5 \times 4 = 20$$

Working with Larger Numbers

If the 4-inch gear and 5-inch gear represent two different calendars of 4 days and 5 days, we can say that there is a 20-day cycle in the system using both calendars. Every 20 days, they will come together again. Once every 20 days, it will be New Year's Day on both cardboard-gear calendars.
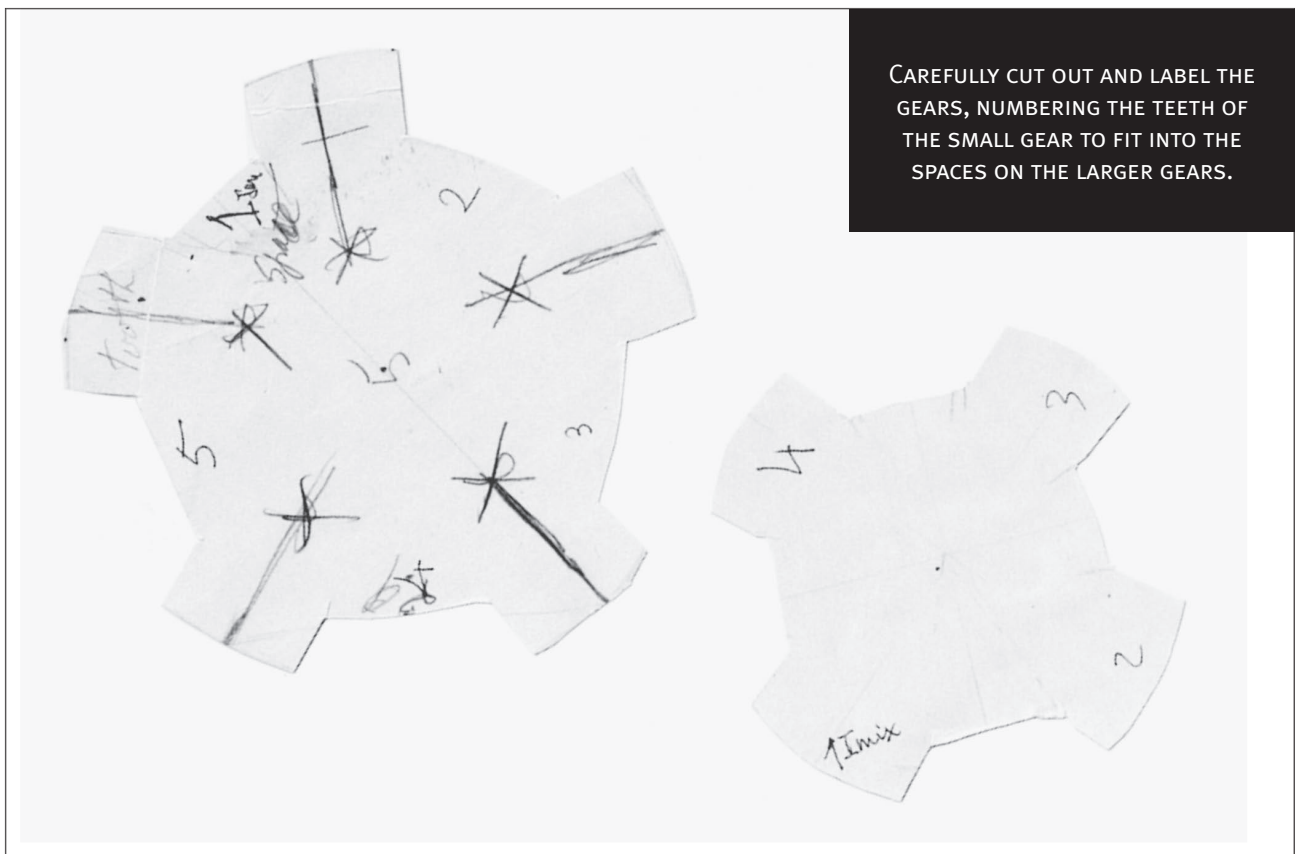
CAREFULLY CUT OUT AND LABEL THE GEARS, NUMBERING THE TEETH OF THE SMALL GEAR TO FIT INTO THE SPACES ON THE LARGER GEARS.
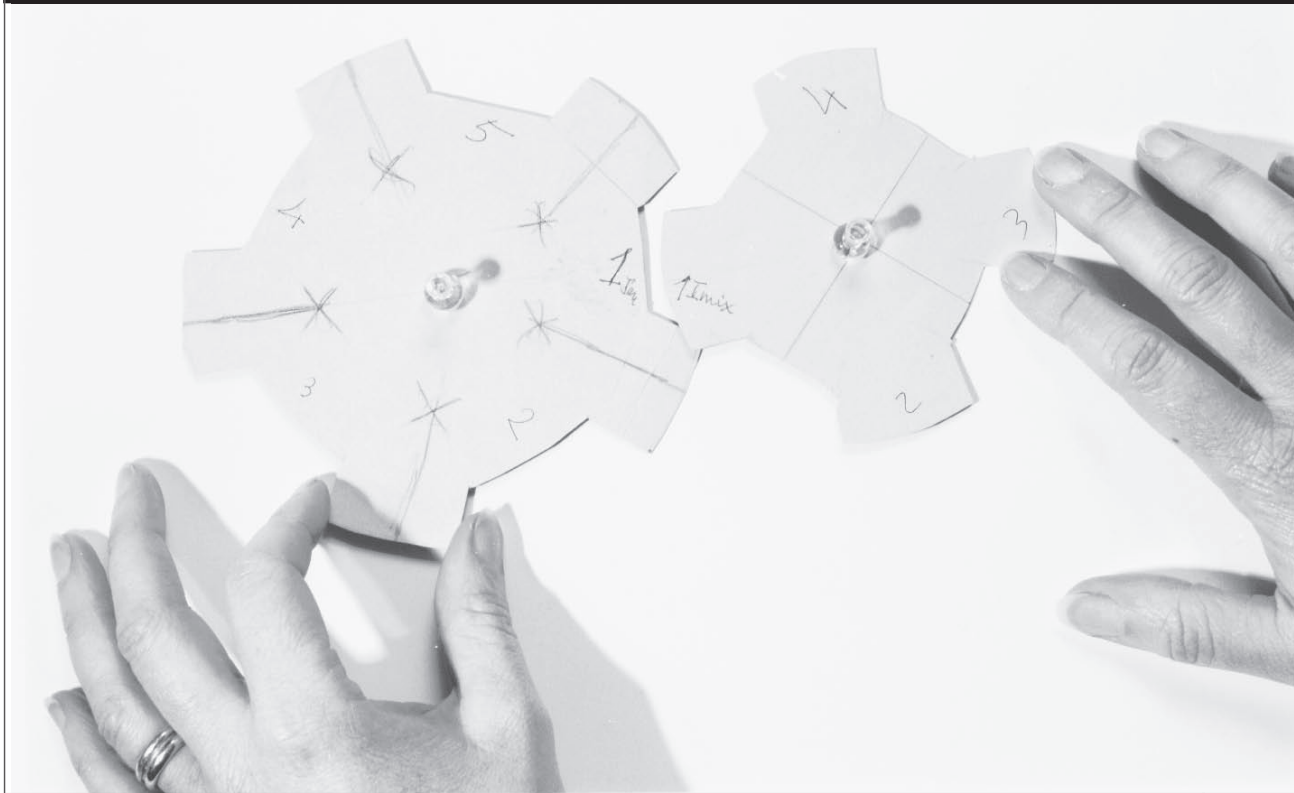
But what about the two Mayan calendars, with 365 days and 260 days? Will it take 94,900 days (365 x 260) for the two New Year's Days to happen together again? That's only once every 260 astronomical years!

You can use the 6-inch gear and the 4-inch gear to see that the two New Year's Days will actually coincide in a much shorter time.

Take the 5-inch gear off the cardboard base and set it aside. Pin the 6-inch gear onto the base so that tooth 1 of the 4-inch gear meshes with space 1 of the 6-inch gear. Make sure these two gears mesh smoothly.

Now turn the gears. How many times does each gear revolve before tooth 1 and space 1 line up again?

You'll find that tooth 1 and space 1 mesh again after only two turns of the 6-inch gear and three turns of the 4-inch gear.

Why is this so? Imagine again that you ink and roll each gear on its edge. One turn of the 4-inch gear gives you a group of four marks. One turn of the 6-inch gear gives you a group of six marks. When do the two groupings end together?

The 4-inch and 6-inch gears coincide at the twelfth mark. This corresponds to the mathematical idea of the smallest common multiple—that is, 12 is the first number that contains both "groups of 4" and "groups of 6."

$$3 \times 4 = 12$$
$$2 \times 6 = 12$$

Why did the 4- and 5-inch gears have to complete the full 20 (4 x 5) turns while the 4- and 6-inch gears didn't have to turn the full 24 times (4 x 6)?

Look at the first and third lines in the illustration on the next page, showing the results of "grouping by 4s" and "grouping by 6s." Notice that each group contains a smaller internal grouping—"groups of 2." That means that 4 and 6 share a common factor of 2.

6 = 3 x 2 (three groups of 2)
4 = 2 x 2 (two groups of 2)
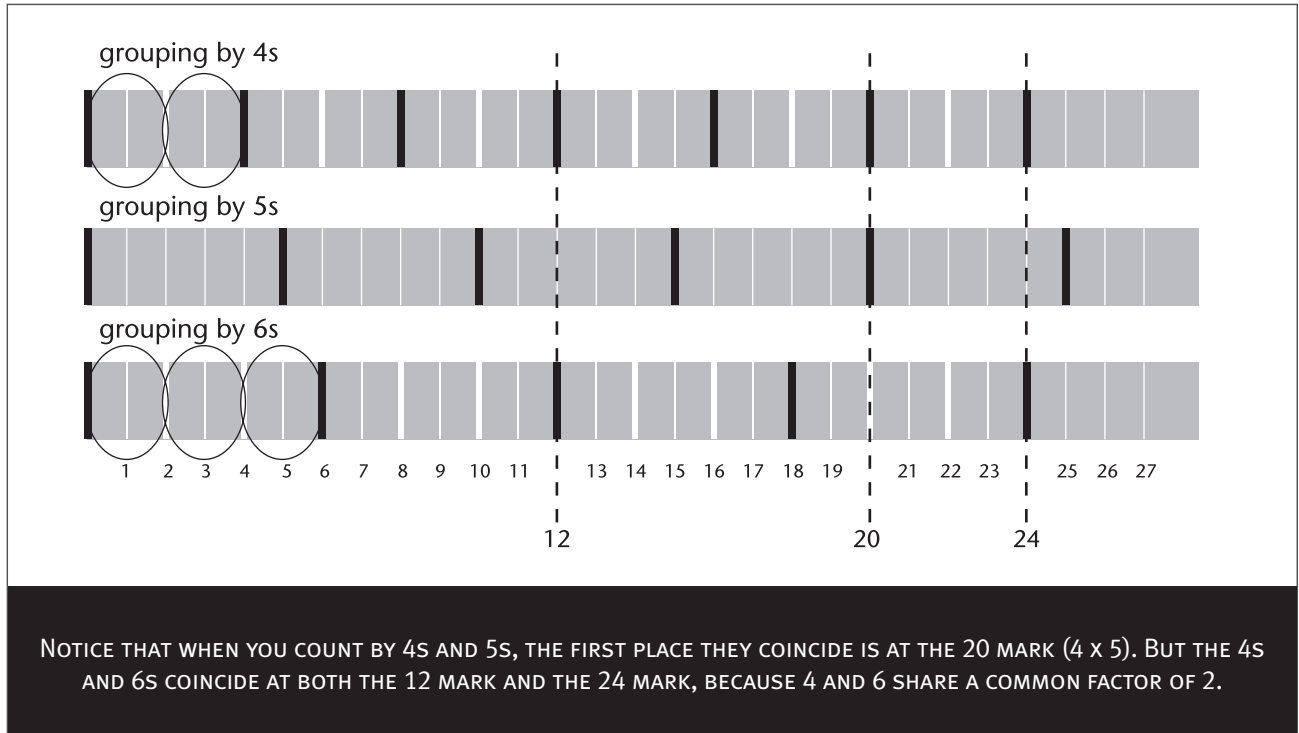
If you multiply 6 x 4, then factor out the common 2 (divide by 2), you get the smallest common multiple of 6 and 4, which is 12.

There is no smaller common internal grouping—no common factor—for the numbers 4 and 5, so those gears had to complete the full 20 turns.

Putting the Mayan Calendars Together

Now imagine that you have a gear for each Mayan calendar. One gear has 260 teeth and the other has

grouping by 4s

grouping by 5s

grouping by 6s

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27

Notice that when you count by 4s and 5s, the first place they coincide is at the 20 mark (4 x 5). But the 4s and 6s coincide at both the 12 mark and the 24 mark, because 4 and 6 share a common factor of 2.

365 teeth. When we mesh tooth 1 of one calendar with space 1 of the other, it's the first day of the year for both calendars. Then time moves on and the gears turn. How long will it take before the two years begin on the same day again?

To find out how long it will take for the two Mayan calendars to coincide, you'll need to find the smallest common multiple for the numbers 365 and 260. To do that, you need to start by finding all the numbers by which 365 and 260 can be divided exactly.

This process is called finding the prime factors of a number. Prime factors are all the factors of a number that are prime numbers.

Prime numbers are numbers that can be divided exactly only by themselves and 1. For example, 7 is a prime number because it can be divided only by 1 and itself. But 9 is not a prime number because it can also be divided by 3.

The first ten prime numbers are 1, 2, 3, 5, 7, 11, 13, 17, 19, and 23.

To find the prime factors of 260, the number of days in the Mayan ritual calendar, begin by dividing 260 by 2. Keep dividing by 2 until the result is an odd number. (You can't divide an odd number exactly by 2.) Then try dividing that odd number by the next prime number—3. Divide by 3 as many times as you can. Then try dividing by 5, and so on.

Try finding the prime factors of 260. ✋

The prime factors of 260 are 2 x 2 x 5 x 13.

Now do the same thing with the prime factors of 365, the number of days in the Mayan astronomical calendar. ✋

You probably discovered quickly that you can't divide 365 exactly by 2 or by 3. But you can divide it by 5, which gives you a result of 73. When you try to divide 73 by successive prime numbers, you will discover that 73 is itself a prime number!

The number 365 can only be factored into 5 x 73. The numbers 260 and 365 share only one common factor: 5.

$$260 = 5 \times 52$$
$$365 = 5 \times 73$$

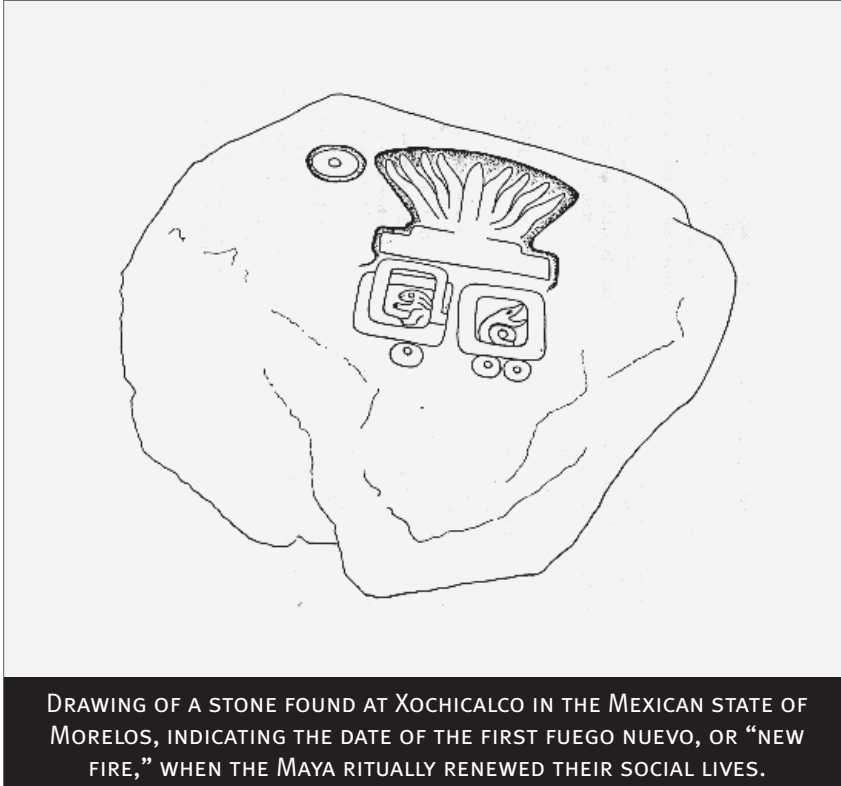Now that you know this, can you figure out the smallest common multiple for 260 and 365? ✋

If you factor out the common 5 (that is, divide by 5), you get 18,980 (5 x 73 x 52), which is the smallest common multiple of 260 and 365.

What does that tell you about when the two Mayan calendars coincide?

As you have discovered, exactly 18,980 days will pass before the two New Year's Days occur on the same day again. They will come together again after 52 astronomical years of 365 days each, which is the same amount of time as 73 ritual years of 260 days each.

The Mayan Calendar Round

The 52-year cycle in Mayan life has been called a "calendar round"

Drawing of a stone found at Xochicalco in the Mexican state of Morelos, indicating the date of the first fuego nuevo, or "new fire," when the Maya ritually renewed their social lives.

because it involves the ways of counting days in both calendars, and leads to a new start for both calendars at the same time. Scholars have found a large numerical table of multiples of 52 in the Dresden Codex.

Anthropologists have known for a long time that a cycle of 52 astronomical years was important in the social life of the Maya. Every 52 years the Maya extinguished all fires in their households and threw away all their clay utensils. Then they "renewed" their social life by bringing a new fire (*el fuego nuevo*) from a central location into all the villages and cities.

The last time the Maya celebrated el fuego nuevo, the beginning of the 52-year cycle, was shortly before the Spanish conquest. By our calendar, that was in December of 1507. For the Maya, this last celebration of the calendar round occurred in the month of *Yaxkin*.

Counting for a Long, Long Time

The Maya had an even longer view of their calendar than the cycle of the haab and tzolkin together. There is a calendar called the "Long Count" that was used to record dates over long periods of time. The long count "year," called *a tun*, has 360 days. A period of 20 tuns (7,200 days) is called a *katun*, and 20 katuns (144,000 days) is called a *baktun*.

A period of 13 baktuns is called the "Great Cycle" of the Long Count. It is 5,200 years long (in 360-day years). The current Great Cycle will come to an end on what most of us will call December 21, 2012 (the winter solstice), which will be a significant date to modern Maya people.

Making Connections

- Ask your grandparents, or the oldest people you know in your family or community, about times of renewal, such as New Year's Day, Chinese New Year, and Rosh Hashanah. Do they know of other traditions that were practiced before you were born or in other places?

- Your birthday probably comes once a year. But what if you were born on February 29? That date occurs only every four years, during a "Leap Year." How often could you celebrate your real birthday? How "old" would you be now if you counted only that day as your birth date? How "old" would an elder of your family or community be?

Recommended Resources

Coe, Michael D. *The Maya*. New York: Thames and Hudson, 1999.

Malmstrom, Vincent H. *Cycles of the Sun, Mysteries of the Moon: The Calendar in Mesoamerican Civilization*. Austin: University of Texas Press, 1997.

Sharer, Robert J. *Daily Life in Maya Civilization*. Westport, CT: Greenwood Publishing Group, 1996.