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Stata tip 43: Remainders, selections, sequences, extractions: Uses of the modulus

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The mod(x, y) function produces remainders from division. It yields the remainder or residue when x is divided by y. The manual or online help definition is that mod(x, y) yields the modulus of x with respect to y. Mathematically, this definition is an abuse of terminology, but one that Stata shares with many other computing languages. In mathematics, the modulus is the divisor; somehow a few decades back in computing the term was transferred to the remainder.

Like several other functions, mod() may at first seem fairly trivial, so here are examples of some of its uses. All illustrations will be for first arguments (dividends) that are zero or positive integers and second arguments (divisors) that are positive integers. Stata's definition is more general, and yet more general definitions are possible, but the illustrations will show the main idea and cover most practical applications. Texts on discrete mathematics or the mathematics behind computing give fuller treatments (Biggs 2002; Knuth 1997; Graham, Knuth, and Patashnik 1994), but we need none of that material here. Authors often discuss these ideas under the heading of congruences.

How should you play with functions like mod() to get to know them? First, there is display:

```
. display mod(1,2)
1
. display mod(2,2)
0
. display mod(3,2)
1
```

One useful device is a loop to get several results at once:

```
. forvalues i = 0/8 {
.     display "'i' mod('i', 3)
. }
```

Second, there is generate, typically followed by list:

```
. set obs 9
. generate mod3 = mod(_n - 1, 3)
. list mod3
```

You can use the observation numbers _n, which are integers 1 and up, to produce variables corresponding to successive integers.

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Third, there is Mata, released in Stata 9:

```
. mata
: x = (0..8)
: mod(x, 3)
```

The first illustration, dividing 1, 2, and 3 by 2, points up a useful detail. Evidently, on division by 2, odd numbers have remainder 1 and even numbers, remainder 0. This example gives a way of characterizing odd and even in Stata. Suppose that you want to specify every other observation. Then

```
if mod(_n, 2) == 1
```

specifies odd-numbered observations and

```
if mod(_n, 2) == 0
```

specifies even-numbered observations. No new variable need be created, as Stata does the necessary calculations on the fly. We can be even more concise:

```
if mod(_n, 2)
```

selects odd observation numbers. Given mod(_n, 2), Stata evaluates it as 1 whenever _n is odd, which is nonzero and therefore true. Further,

```
if !mod(_n, 2)
```

selects even, as mod(_n, 2) is 0 whenever _n is even, but that result is flipped to 1 by the operator !, giving again 1, nonzero and true.

The idea extends easily to other divisors; for example, if mod(year, 10) == 0 or if !mod(year, 10) selects values of year divisible by 10 such as 1990 or 2000, and if !mod(year - 5, 10) selects years such as 1995 or 2005 (but not 1990 or 2000).

Now let us turn to sequences. For integers x from 0 up, mod(x, 3) is

```
0\ 1\ 2\ 0\ 1\ 2\ 0\ 1\ 2\ \dots
```

and for any positive integer y, mod(x, y) repeats cycles of 0 to y-1. You may often want to add 1 to get, e.g.,

```
1\ 2\ 3\ 1\ 2\ 3\ 1\ 2\ 3\ \dots
```

Here you should use in Stata 1 + mod(x, 3) and in Mata 1 :+ mod(x, 3)—note the elementwise operator :+.

You could get such sequences in other ways. Using cond() (Kantor and Cox 2005), we could type for observation numbers _n that run 1 upwards cond(mod(_n, 3) == 0, 3, mod(_n, 3)), giving the same result.

Hence, you now have a basic recipe for generating repetitive sequences. You may know that this functionality is wired into egen's seq() function, but the approach from first principles has merit, too.

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Extracting digits is yet another application. In the shadow world between numbers and strings dwell numeric identifiers and run-together dates (20070328 for 28 March 2007) or times (112233 for 11:22:33). Whether such beasts are best processed as numbers or strings can be a close call. Conversion functions real() and string() are available to throw each to the other side of the divide.

Suppose that your beasts arrive as numeric. mod(112233, 100) extracts the last two digits. Hence, second arguments that are 10^k will extract the last k digits from integers.

Other subsequences of digits require a little more work. We could get the first two, the second two, and the third two digits like this:

```
. local first = floor(112233/10000)
. local second = floor(mod(112233, 10000) / 100)
. local third = mod(112233, 100)
. display 'first''second''third'
112233
```

For more on floor() and its twin ceil(), see Cox (2003). You could also use int() here. An alternative is to work with (say) real(substr(string(112233),1,2)).

Naturally, if what you are given is just 112233, you do not need Stata or even a computer to extract digits. Rather, these are examples of the kind you can try for yourself to see what is necessary to convert information given in variables from one form to another.

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