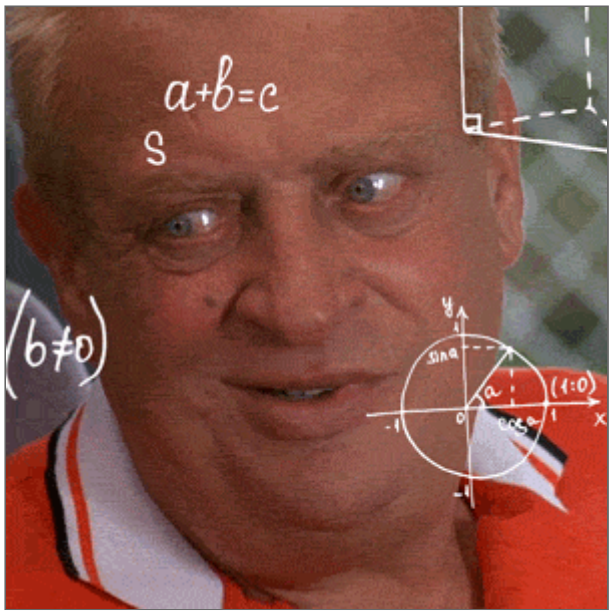


ARITHMETIC IN R

Created: 2021-09-07 Di 12:21

WHAT WILL YOU LEARN?

- Perform basic numerical operations
- Translate complex mathematical formulas
- Use logarithms and exponentials
- Brush up on mathematical E-notation
- Know R's special numbers
- Understand logical values and operators

ARITHMETIC OPERATORS

1. Parentheses: ( )
2. Exponentiation: ^ or **
3. Multiplication: *
4. Division: /
5. Addition: +
6. Subtraction: -

FORMULA TRANSLATOR I

$$24 + 6/3 \times 5 \times 2^3 - 9 \quad (1)$$

- What is the result of this expression?
- Compute in your head first
- Then check in the R console

FORMULA TRANSLATOR I

```
2³ = 2^3 = 8
6/3 = 2
2 * 5 * 8 = 80
24 + 80 = 104
104 - 9 = 95
```

You can check this in an R session:

```
>  24 + 6/3*5*8-9
[1] 95
```

- Remember the PEMDAS order
- Instead of ^ you can use **

FORMULA TRANSLATOR II

$$10^2 + \frac{3 \times 60}{8} - 3 \quad (2)$$

$$\frac{5^3 \times (6 - 2)}{61 - 3 + 4} \quad (3)$$

$$2^{2+1} - 4 + 64^{-2^{2.25-\frac{1}{4}}} \quad (4)$$

$$\left(\frac{0.44 \times (1 - 0.44)}{34} \right)^{\frac{1}{2}} \quad (5)$$

- Compute the expressions (2)-(5)
- Use the R console

FORMULA TRANSLATOR II

$$10^2 + \frac{3 \times 60}{8} - 3$$

```
R> 10^2+3*60/8-3
[1] 119.5
```

$$\frac{5^3 \times (6-2)}{61-3+4}$$

```
R> 5^3*(6-2)/(61-3+4)
[1] 8.064516
```

$$2^{2+1} - 4 + 64^{-2^{2.25-\frac{1}{4}}}$$

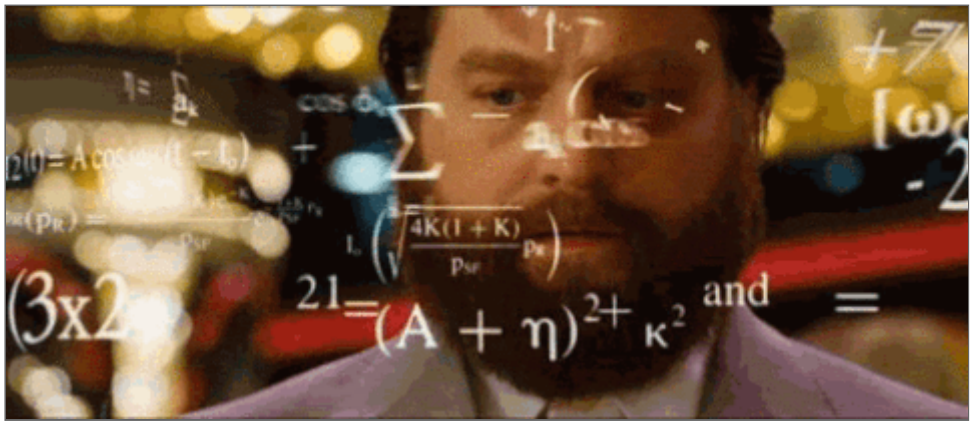
```
R> 2^(2+1)-4+64^((-2)^(2.25-1/4))
[1] 16777220
```

$$\left(\frac{0.44 \times (1-0.44)}{34}\right)^{\frac{1}{2}}$$

```
R> (0.44*(1-0.44)/34)^(1/2)
[1] 0.08512966
```

- You need parentheses in the exponent
- -2 is interpreted as `-1 * 2`
- What does `(-1)^(1/2)` return?

MATHEMATICAL FUNCTIONS



?sqrt
?log10
?exp
?pi

LOGARITHMIC TRANSFORMATION

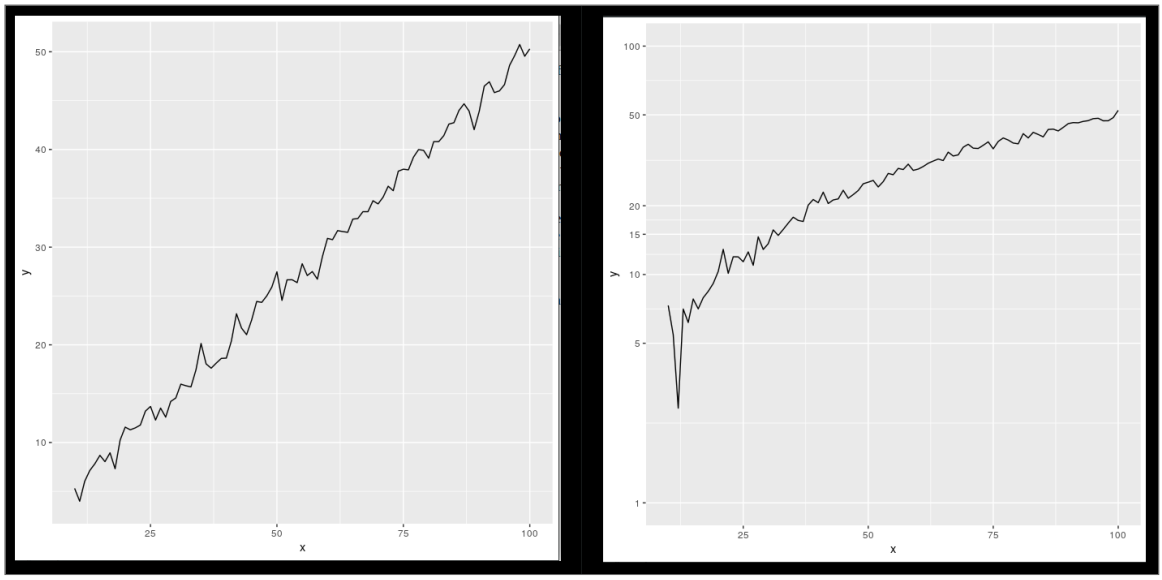


Figure 7: Dummy data without (left) and with (right) logarithmic transformation (Source: **R Graph Gallery**)
See also: **The Economist/Off The Charts 04/20/2021**

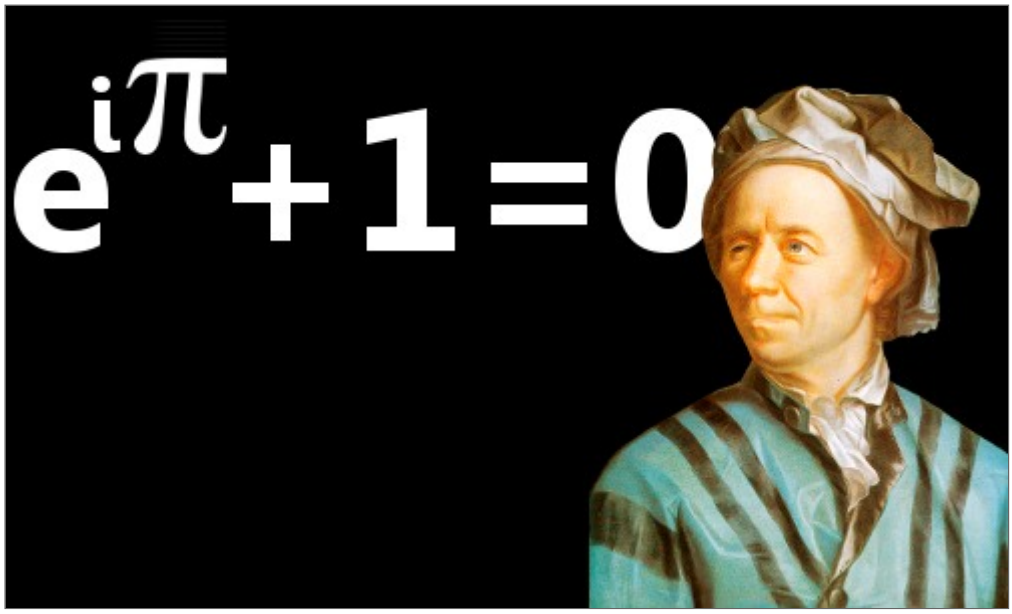
LOGARITHM RULES

- Argument x and base b must be positive
- $\forall x$: `log(x,b=x)=1` since only $x^1 = x$
- $\forall b$: `log(x=1,b)=0` since $b^0 = 1$

LOGARITHM PUZZLES

- Compute $log_{10}(10,000,000)$ in R
- Enter `log10(10,000,000)` in R
- Find the logarithm with base 10 for $10,000,010$.
- Why is the result the same as before?
- Check: enter `log10(10000100)`

EXPONENTIAL FUNCTION



- $log(x)$ implies $b = e \approx 2.7182$
- Verify for $x = 10$,$x = 2.718282$,$x = 0$:

$$e^{ln(x)} = ln(e^x) = x$$

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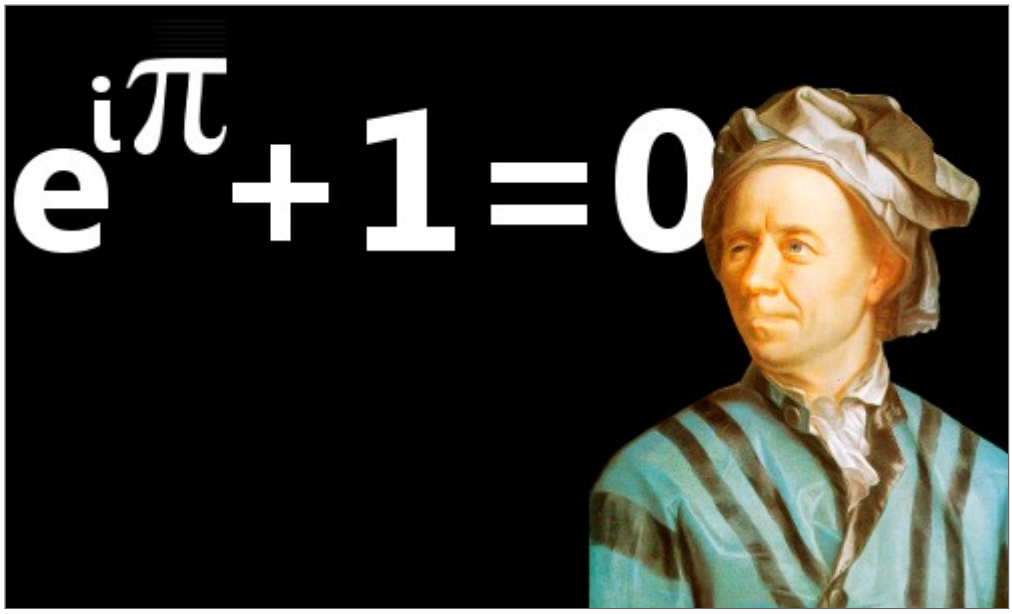
EXPONENTIAL FUNCTION



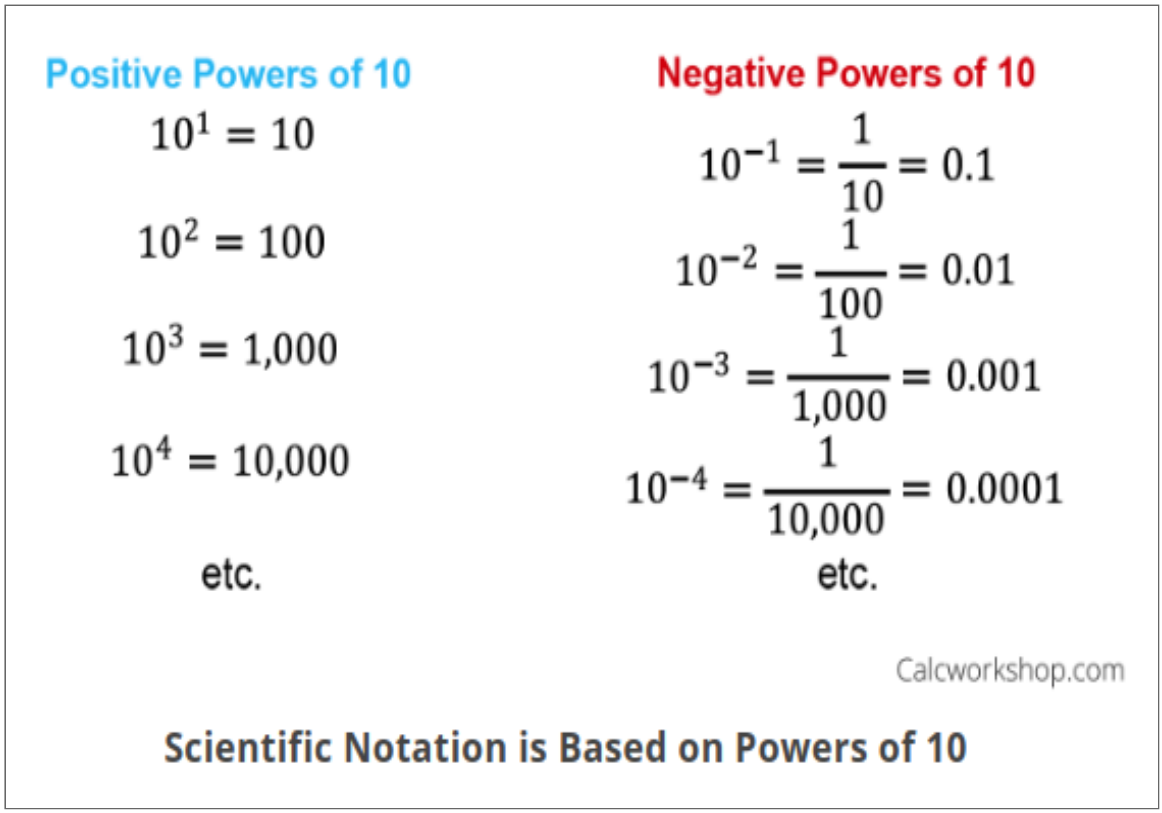
- $log(x)$ implies $b = e \approx 2.7182$
- Verify for $x = 10$,$x = 2.718282$,$x = 0$:

```
\begin{equation}
    \label{eqn:e}
    e^{ln(x)} = ln(e^x)=x
\end{equation}
```

CONSTANTS

- `pi` ($\pi \approx 3.14$)
- LETTERS and `letters`
- `month.name` and `month.abb`
- What about Euler's number e?

E-NOTATION


Positive Powers of 10
$10^1 = 10$
$10^2 = 100$
$10^3 = 1{,}000$
$10^4 = 10{,}000$
etc.
Negative Powers of 10
$10^{-1} = \frac{1}{10} = 0.1$
$10^{-2} = \frac{1}{100} = 0.01$
$10^{-3} = \frac{1}{1{,}000} = 0.001$
$10^{-4} = \frac{1}{10{,}000} = 0.0001$
etc.
Calcworkshop.com
Scientific Notation is Based on Powers of 10

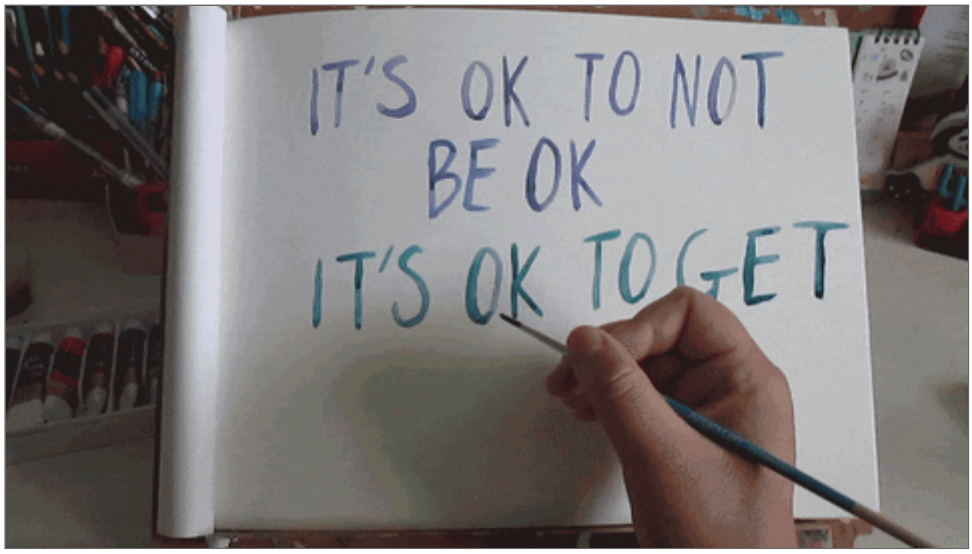
EXAMPLES

$10\,000 = 10 \times 10 \times 10 \times 10 \times 10 = 1 \times 10^5 =$ 1eR+05
7.45678389e12 = $7.45678389 \times 10^{12}$ = $745.678389 \times 10^{10}$
e = 271828182845e-11 $= 271828182845 \times 10^{-11}$

BE THE COMPUTER!

- Enter $100\,000\,000$
- Enter 0.00000000000000010
- Enter `exp(1000)` and `(-1)/0`
- Enter `sqrt(-1)`

MATH HELP IN R



- `?Arithmetic`
- `?Math`
- `?Comparison` etc.

TO INFINITY AND BEYOND

SPECIAL NUMBERS

- `Inf` for positive infinity (∞)
- `-Inf` for negative infinity ($-\infty$)
- `NaN` for "not-a-number" (not displayable)
- `NA` for "not available" (missing value)

BE THE COMPUTER!

Inf+1	Inf-1
Inf/Inf	Inf-Inf
NA	NA+NA
NaN	NaN+NaN

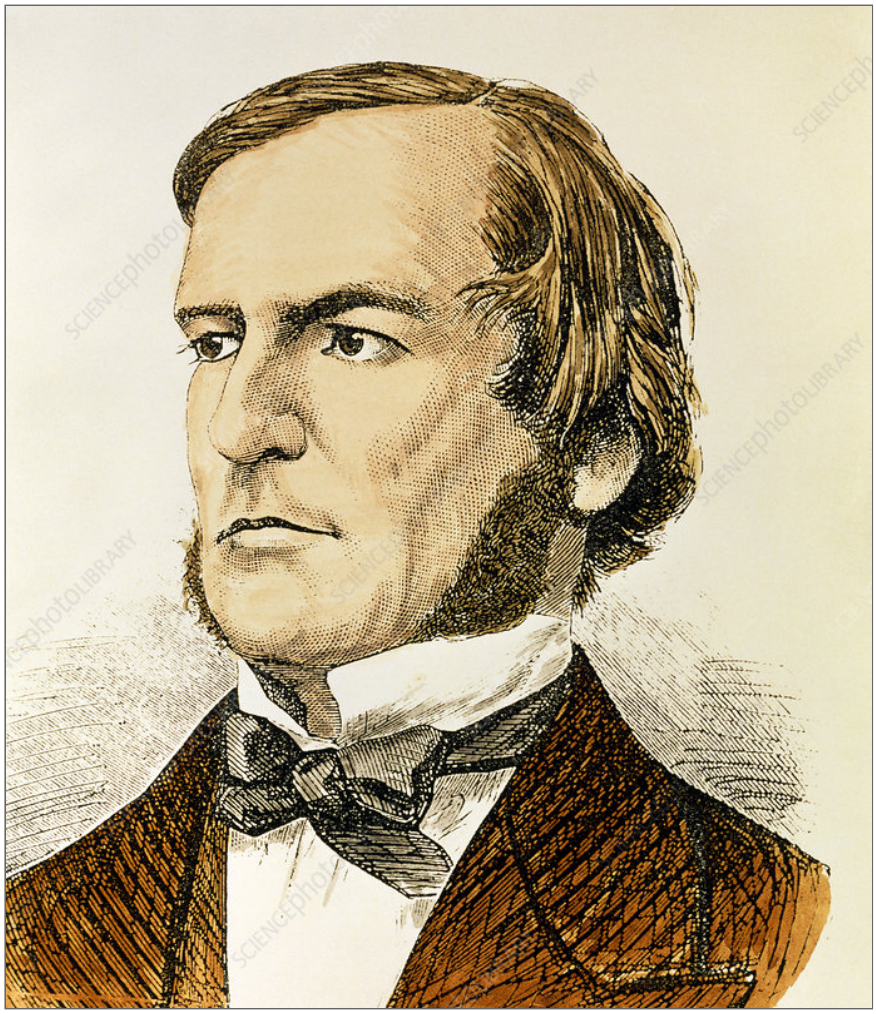
SPECIAL FUNCTIONS

`is.finite(Inf)`	`is.infinite(Inf)`
`is.finite(NA)`	`is.na(NA)`
`is.nan(NaN)`	`is.nan(NA)`

BE THE COMPUTER!

- Enter `10^309`
- Subtract $\sqrt{2}^2$ from 2

LOGICAL VALUES AND OPERATORS



BE THE COMPUTER!

T	= TRUE
F	= FALSE
T <- FALSE	=> ?
F <- TRUE	=> ?

LOGICAL OPERATORS

There are three logical operators in R:

! for "*not*":	1 != 1
& for "*and*":	~(1==1)&(1==2)
| for "*or*":	(1==2)|(1!=1)

BE THE COMPUTER!

```
sqrt(2)^2
```

```
sqrt(2)^2 == 2
```

```
all.equal(sqrt(2)^2, 2)
```

```
identical(sqrt(2)^2, 2)
```

CONCEPT SUMMARY

- In R mathematical expressions are evaluated according to the PEMDAS rule.
- The natural logarithm $ln(x)$ is the inverse of the exponential function e^x.
- In the scientific or e-notation, numbers are expressed as positive or negative multiples of 10.
- Each positive or negative multiple shifts the digital point to the right or left, respectively.
- Infinity `Inf`, not-a-number `NaN`, and not available numbers `NA` are special values in R.

CODE SUMMARY

CODE	DESCRIPTION
`log(x=,b=)`	logarithm of x, base b
`exp(x)`	e^x, exp[onential] of x
`is.finite(x)`	tests for finiteness of x
`is.nan(x)`	checks if x is not-a-number
`is.na(x)`	checks if x is not available
`all.equal(x,y)`	tests near equality
`identical(x,y)`	tests exact equality
`1e2, 1e-2`	$10^2 = 100, 10^{-2} = \frac{1}{100}$

THANK YOU! QUESTIONS?

REFERENCES

Richard Cotton (2013). **Learning R.** O'Reilly Media.
Tilman M. Davies (2016). **The Book of R. (No Starch Press).**
Rafael A. Irizarry (2020). **Introduction to Data Science** (also: CRC Press, 2019).
Norman Matloff (2020). **fasteR: Fast Lane to Learning R!**.