Fundamentals of Electric Theory and Circuits

by

Sridhar Chitta

IK International Publishing House Pvt. Ltd.
4435-36/7, Ansari Road, Daryaganj
New Delhi – 110 002 (India)
Email: info@ikinternational.com **Website:** www.ikbooks.com
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What is '*e*' ?

Several times when we solve differential equations, we encounter **'*e*'** and we rarely stop to figure out what this strange looking constant is and what is its interpretation. It is really not such a difficult concept to understand.

e is NOT Just a Number

Describing *e* as "a constant approximately 2.71828…" is like calling **pi** "an irrational number, approximately equal to 3.1415…". Sure, it's true, but you completely missed the point.

Pi is the ratio between circumference and diameter shared by all circles. It is a fundamental ratio inherent in all circles and therefore impacts any calculation of circumference, area, volume, and surface area for circles, spheres, cylinders, and so on. Pi is important and shows all circles are related, not to mention the trigonometric functions derived from circles (sin, cos, tan).

***e* is the base amount of growth shared by all continually growing processes.** 'e' lets you take a simple growth rate (where all change happens at the end of the year) and find the impact of compound, continuous growth, where every nanosecond (or faster) you are growing just a little bit.

The exponential function arises whenever a quantity grows or decays at a rate proportional to its current value. One such situation is continuously compounded interest, and in fact it was this that led Jacob Bernoulli in 1683 to the number.

'*e*' shows up whenever systems grow exponentially and continuously: population, radioactive decay, interest calculations, and more. Even jagged systems that don't grow smoothly can be *approximated* by *e*.
Just like every number can be considered a "scaled" version of 1 (the base unit), every circle can be considered a "scaled" version of the unit circle (radius 1), and every rate of growth can be considered a "scaled" version of *e* (the "unit" rate of growth).

So *e* is not an obscure, seemingly random number. ***e* represents the idea that all continually growing systems are scaled versions of a common rate.**

Read the full article that gives an intuitive explanation to *e* here
http://betterexplained.com/articles/an-intuitive-guide-to-exponential-functions-e/

In the article *e* is **defined** to be that rate of growth if we continually compound 100% return on smaller and smaller time periods:

$growth = e = \lim_{n\to\infty}\left(1+\frac{1}{n}\right)^n$, where, n represents percentage of growth in periods of time.

This limit appears to converge, and there are proofs to that effect. But as you can see, as we take finer time periods the total return stays around 2.718.

We will now write an Excel program that shows this convergence for the series in the growth formula. By inserting smaller and smaller time periods of growth by increasing the size of the number '*n*' we will demonstrate that the series converges to 2.718.

Checking the convergence of series for growth in Excel to '*e*'

1. Open a Microsoft Excel worksheet
2. Click and select the first cell A1.
3. Enter 1 into this cell A1 by simply typing 1.
4. Press shift and using the down arrow key, select cells from A1 upto row A35 or near about i.e upto cell A35– You will have the first cell filled and the remaining blank and all other cells highlighted
5. With the cells selected, click Edit>Fill>Series and in the dialog box with "Series In" = columns and "Type" = Linear and "Step value" = 1: ignore stop value and click OK.
   You will note that the cells A1 to A35 are filled with a series of numbers with step value 1 i.e 1 to 35.
6. Now select cell B1 and enter "=((1+(1/A1))^A1)" without the inverted commas. (**Note:** ^n means raising to power n)
   This formula is actually (1 + 1/n)^n. It picks the value in A1 as n and computes. It will display 2.
7. Now, select the cell B1 and press Ctrl + C to copy this formula
8. Now select all the cells from B2 down to B35 and with these highlighted, press Ctrl + V to paste the formula into all the cells from B2 to B35.
9. Observe the contents of the cells
10. Fill in numbers like 1000, 10000 and 100000 into cells A36, A37 and A38.
11. Now copy the formula in cell B1 into cells B36, B37 and B38.
12. Observe the contents in cells B36 to B38.
13. Is the value in B38 = e ? Are the values converging to **e = 2.71828 ?**

Comments on the Excel entries and formulas

You will note that in steps upto 5, the index values into the cells from A1 to A35.
In step 6 you have entered a formula: beginning with the "=" sign.
The computation is automatic and you need not use the calculator.
You can try other series as well :

For e.g study the convergence of power series.

$$\sum_{n=1}^{\infty} x^n$$

Follow the steps upto 5 to fill indexing entries in cells A1 to A35.
Then in cell B1 enter the value *x* as simply 0.5 which is the start value of the series.
Now, in cell B2 enter =0.5^A2. Then with cell B2 highlighted press Ctrl +C to copy the contents into the clipboard (invisible) and then select cells B3 upto B35 highlighting them and then press Ctrl + V to paste the formula.
All the values of *x*^*n* will now be visible.
Now select the cells from B1 to B35 using the Shift + down arrow key and then with the cells highlighted click on the ∑ symbol in the menu bar.
The sum of the series upto 35 terms will be automatically displayed in the cell B36.

Go ahead and fill index entries in cells A37 to A50 with the start value in cell A37 as 36 now and then clicking Edit>fill>series……as in step 5 above.
Again select cells from **B36 (to include the previous partial sum upto 35 terms)** to B50 and with these cells highlighted click on the ∑ symbol in the menu bar.
You will get the partial sums from $n = 1$ to $n = 49$.
Observe the convergence of the series with the start value 0.5.

Go ahead and in a new column say, C use the start value as 0.7 in C1 and check out the partial sums and the convergence …….in a similar way.