Contents

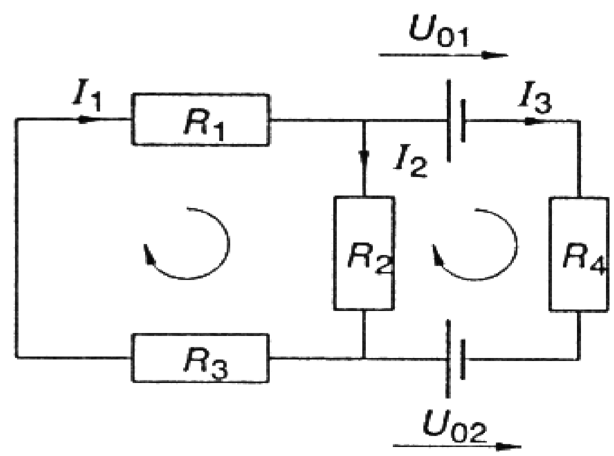
Applications in Engineering with the Help of the TI-92

Peter Skarke
University of Linz, Austria
Peter.Skarke@linz.info.at

DC Analysis

Example A:

We want to compute the electrical currents in the DC-circuit shown below:



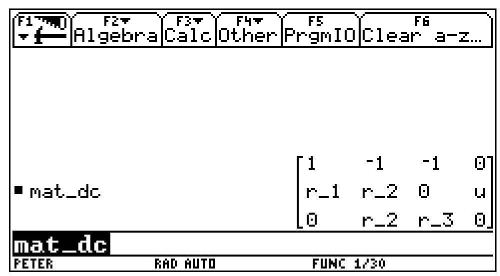


Figure 1

We have the following equations:

1) I1 - I2 - I3 = 0
2) R1*I1 + R2*I2 = U
3) R2*I2 - R3*I3 = 0

We use the DATA/MATRIX EDITOR to store this matrix: (see Figure 1)

$$\begin{array}{lrrrr} 1) & 1 & -1 & -1 & 0 \\ 2) & R1 & R2 & 0 & U \\ 3) & 0 & R2 & -R3 & 0 \end{array} \Rightarrow \text{mat\_dc}$$

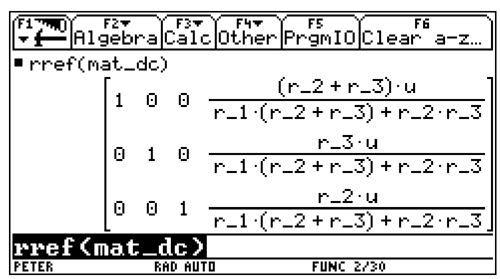


Figure 2

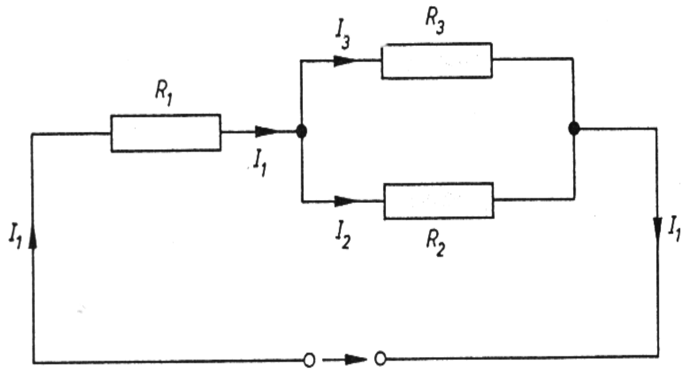
We use the rref-command to get the results:

rref(mat_dc) ⇒

The results I1,I2 and I3 can been seen in the right column of Figure 2:

Now we want to compute a numerical example:

Example B:



We get the corresponding equation system:

1) I1 - I2 - I3 = 0
2) 20*I1 + 30*I2 + 25*I3 = 0
3) - 30*I2 + 15*I3 = 20

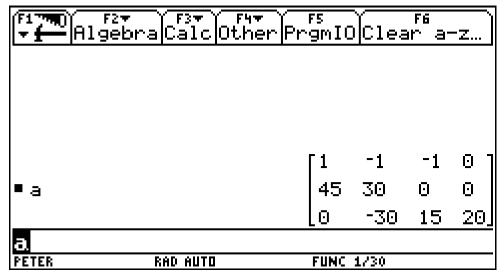


Figure 3

This time we store the data under the name a (see Figure 3) :
We can compute the results very easily using the rref-command:
You can see the results in the fourth column of the matrix: (see figure 4)

I1 = .24 A
I2 = -.36 A
I3 = .61 A

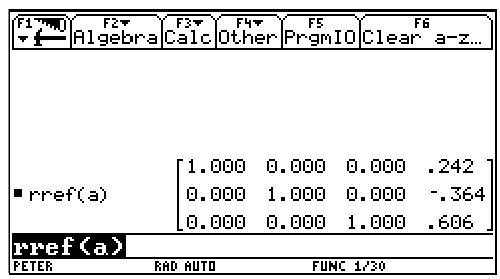


Figure 4

Example C:

Now we will compute the forces FA and FB of a supporting beam: (see Figure 5)

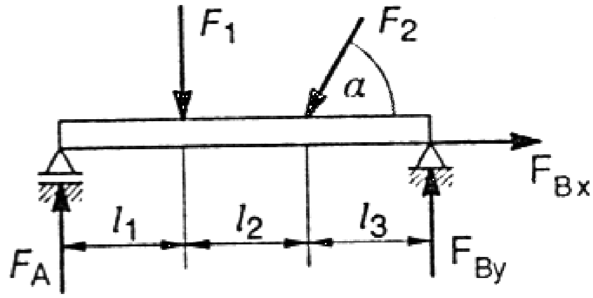


Figure 5

With F1 = 300 N
F2 = 250 N
α = 40 °
l1 = 0.7 m
l2 = 0.4 m
l3 = 0.3 m

We get the following equation system:

1)FA + FBY - F1 - F2*sin (α) = 0
2)FBX - F2* cos (α) = 0
3) - F1*l1 - F2*sin (α)*(l1+l2) +
+F BY*(l1+l2+l3) = 0

---

1) FA + FBY = 300+250* sin (40)
2) FBX = 250 * cos(40)
3) 1.4 FBY = 300 * .7 + 250 * 1.1 *sin (40)

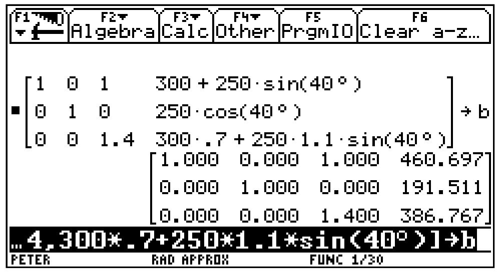


Figure 6

By using the rref-command we get the following solution:

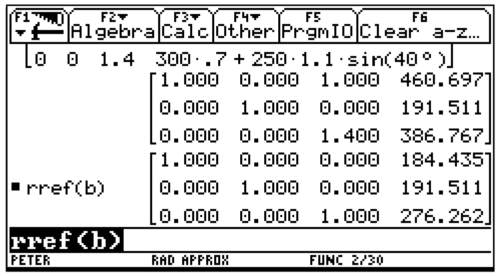


Figure 7

FA = 184.44 N
FBX = 191.51 N
FBY = 276.26 N
since

$$FB = \sqrt{FBX^2 + FBY^2}$$

thus we get

FB = 336.15 N

Cycloids (Rollcurves)

Rollcurves are created by a circle rolling on a straight line or on another circle (without sliding).
They have been developed in mechanical engineering with the investigation of cog wheels.

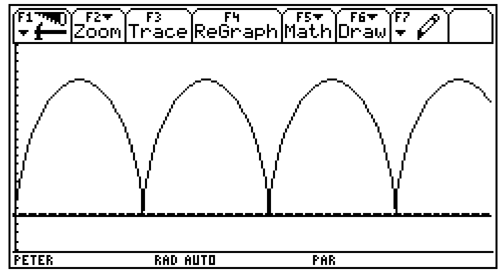


Figure 8

Example A: Cycloids

develop if a circle rolls on a straight line.
(without sliding):
We change the type of the FUNCTION to PARAMETRIC.

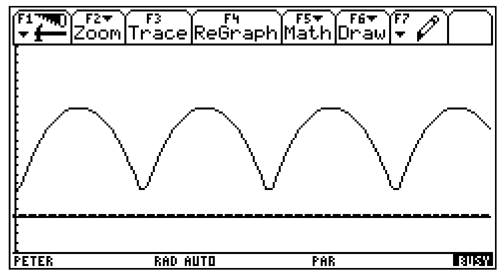


Figure 9

The formula of the regular cycloid is given by

xt = r* (t – a* sin (t)) and
yt = r* (1 – a* cos (t)).

We choose r = 4 and a = 1 to get the **regular form.** (Figure 8). We watch the path of a point on the circumference of the rolling circle.
For figure 9 we set a= .6 to get the **stretched form** of the cycloid. This curve develops if we watch a point inside the rolling circle

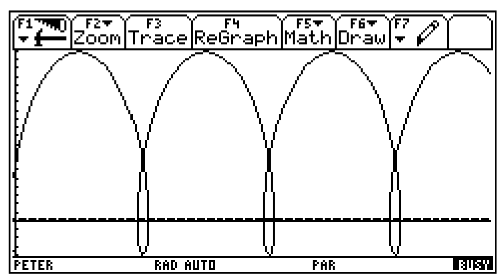


Figure 10

We set a = 2 (see figure 10) to get the **intricated form** of the cycloid. This form develops if the point we watch lies on the lenghtened radius of the rolling circle.

Example B: Epicycloids

These curves develop if a small circle rolls on a large circle.
We change the mode of the graph from FUNCTION to PARAMETRIC.

The formula of an epicycloid consists of two equations: (see figure 11).

xt = (r1 + r2) cos(t) – r2.cos ((r1 + r2)/r2)t)
yt = (r1 + r2) sin(t) – r2.sin ((r1 + r2)/r2)t)

with r1 is the radius of the large circle and
r2 is the radius of the small circle.

If you choose both radii in that way that their ratio is integer, then the curve is symmetric and closed.

We choose r1 = 4 and r2 = 1 to get the **regular form** of the curve: (see figure 12).

We use ZOOMSQR to get equal distances on both axes.

Now we are searching for the **stretched form** of the curve. We change the factor of the second term to .6 < r2
That means we watch a point inside the small circle by the movement.
Now the curve is not in contact with the circle.
(See figure 13).

Now we change the factor of the second term to 2 >r2. That means we watch a point on the lengthened radius of the smaller circle by the movement.
In this case we get the **intricated form** of the curve (see figure 14).

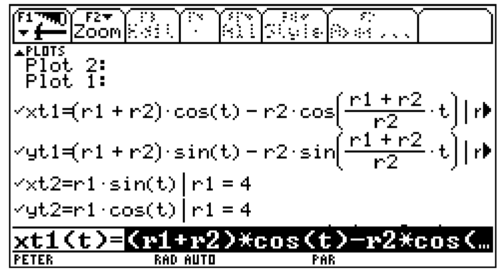


Figure 11

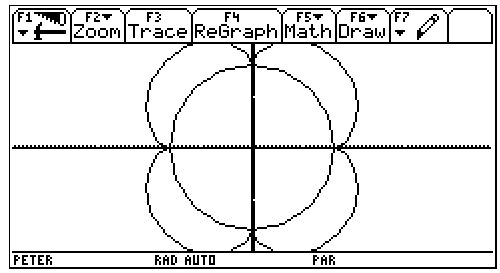


Figure 12

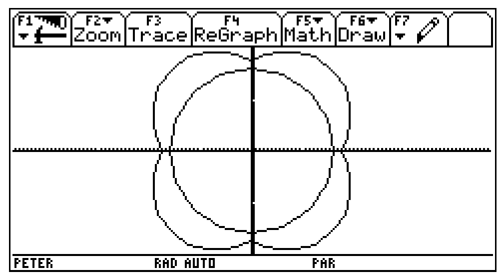


Figure 13

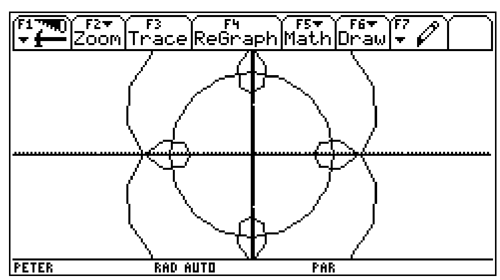


Figure 14

Example C: Hypocycloids

develop if a small circle rolls inside a larger circle.
The formula of a hypocycloid in parametric form is: (see figure 15):
xt = (r1-r2) cos(t) + r2.cos((r1-r2)/r2)t)
yt = (r1-r2) sin(t) +.r2.sin((r1-r2)/r2)t)

with r1 is the radius of the large circle and
r2 is the radius of the small circle.
With r1 = 5 and r2 = 1 we get the **regular form** of the curve: (see figure 16).

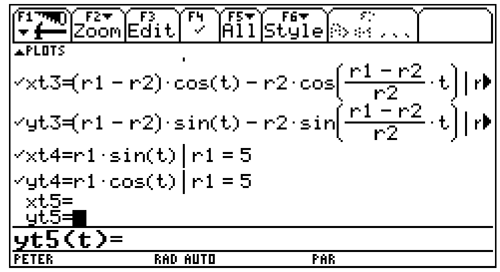


Figure 15

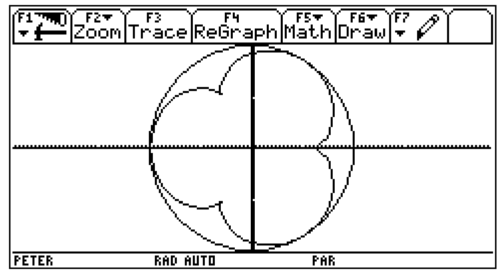


Figure 16

Now we are searching for the **stretched form** of the curve. We change the factor of the second term to .6 < r2
This means that we watch a point inside the small circle by the movement.
Now the curve doesn't contact the circle.
(see figure 17).

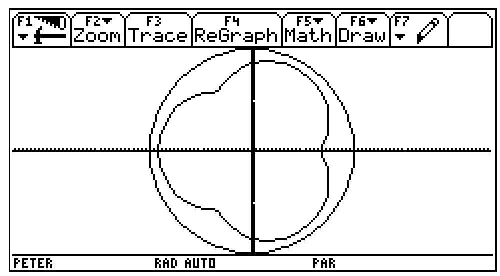


Figure 17

Then we change the factor of the second term to 2 >r2
We watch a point on the lengthened radius of the smaller circle by the movement.
In this case we get the **intricated form**
(see figure 18).

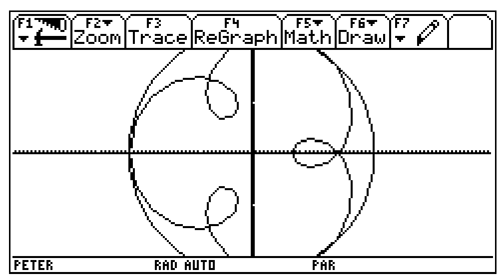


Figure 18

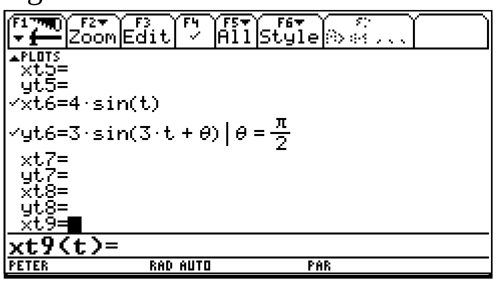
Lissajous figures

Lissajous figures develop, if two vertical oscillations superimpose each other.

In parametric form we have:

xt = 4.sin (t)
yt = 3.sin (3t+φ)   with φ = π/2, π/4, 3π/4 respectively (see figure 19).

Figure 19



The reader is encouraged to experiment on his own. See figures 20,21,22 for example.

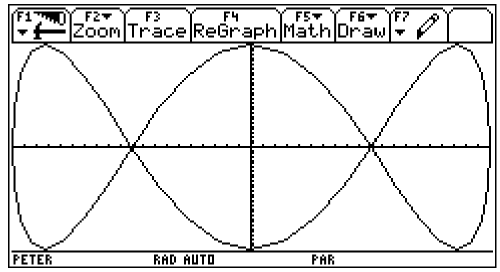


Figure 20

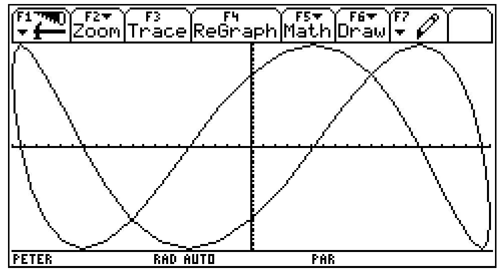
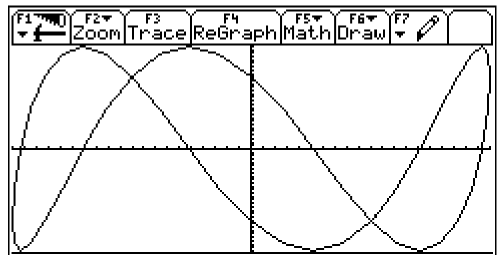


Figure 21



Beats

Beats are oscillations with a periodically encreasing and decreasing amplitude. They are created by the superposition of two harmonic oscillations:

We can write the formula as a product of sinus and cosinus functions with different periods. Let us investigate the following curves:

y1 = 2.cos(x).sin(19x)   (see figure 23)
Y2 = 3.cos(99x).sin(x)   (see figure 24)

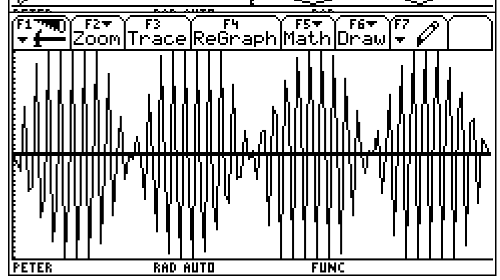


Figure 22
Figure 23

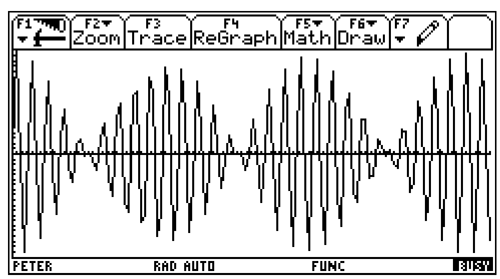


Figure 24

Fourier Analysis

In electrical engineering any oscillations can be built up by sinus and cosinus functions.

We will describe the most important examples. We change MODE to FUNCTION and use a trigonometric window.

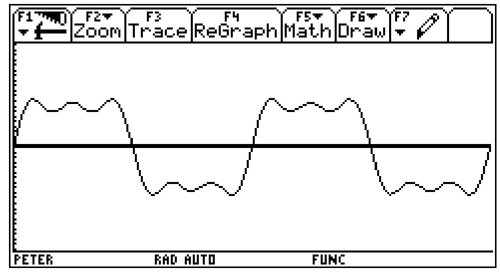


Figure 25

Example A: Rectangular pulse

It can be shown that a rectangular pulse can be described by the following formula:

sin(x) + sin(3x)/3 + sin (5x)/5 + sin(7x)/7 +..+..+....

If we start with 3 summands, only, we will get a very bad approximation. (see figure 25)
If we use more summands we'll get a better result. (see figure 26).

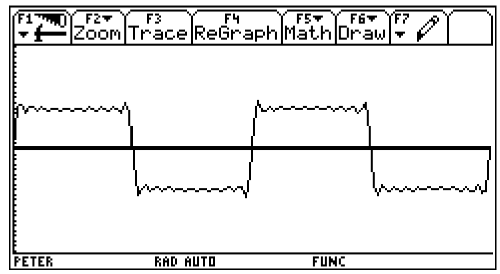


Figure 26

Example B: Sawtooth oscillation

A sawtooth oscillation can be described in the following way:
sin(x) – sin(2x)/2 + sin(3x)/3 – sin(4x)/4 + - +...
If we start with a few summands only, we'll get a bad approximation.
The reader is encouraged to improve the result by adding more summands (see figure 27).

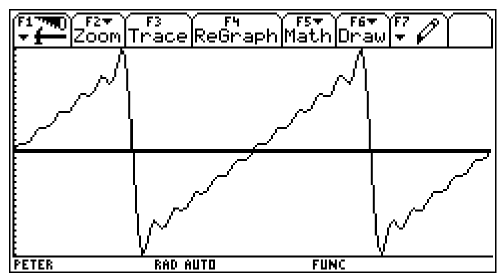


Figure 27

Example C: One-way-rectification

It can be shown that the following formula describes a one-way-rectification :

1/π + sin(x)/ 2 – 2/π*(cos(2x)/ 3 + cos(4x)/ 15 +
+ cos(6x)/ 35 + cos(8x)/ 63 + + +....)

The one-way-rectification is shown in figure 28.

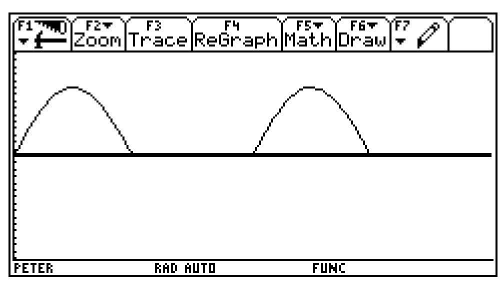


Figure 28