# Adopting Maxima as an Open-Source Computer Algebra System into Mathematics Teaching and Learning

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The workshop introduced and explained the computer algebra system (CAS) Maxima for teaching and learning of calculus and linear algebra at the tertiary level. The didactic principle underlying this approach is a necessity to combine an element of technology into our classroom to enhance student understanding of calculus and linear algebra concepts. Maxima is an open-source computer software that can be used for the manipulation of symbolic and numerical expressions, including limit calculation, differentiation, integration, Taylor series, systems of linear equations, polynomials, matrices, and tensors. It can also sketch some graphical objects with excellent quality (http://maxima.sourceforge.net/).

The workshop started by providing information on getting help in Maxima, which can be done using the command `describe` or `?`, for instance, `describe(diff)` and `describe(integrate)` to obtain information about the derivative and the integral, respectively. The symbol `%` refers to the most recent calculated result. The workshop continued with simple examples of calculus computation, as presented in the following table. The participants were also invited to try exercises related to the presented materials. Other examples presented were sketching curves in two and three dimensions, including several interesting parametric plots. Three examples of the plots are displayed in this article. The first is a cardioid, which comes when studying polar curve; the second is a Möbius band as an example of a non-orientable surface; and the third is a torus, which appears when discussing a solid of revolution.

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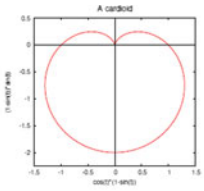


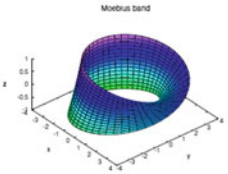


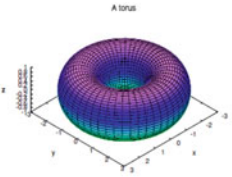


| Description | Symbolic | *Maxima* code | Output |
|---|---|---|---|
| Finding a limit | $\lim_{x\to 1} \dfrac{3x^2-4x+1}{x^2+x-2}$ | `limit((3*x^2 - 4*x + 1)/ (x^2 + x - 2),x,1);` | $\dfrac{2}{3}$ |
| Evaluating first derivative | $\dfrac{d}{dx}(x^2e^x)$ | `diff(x^2*exp(x),x); factor(%);` | $x^2e^x + 2xe^x$ $x(x+2)e^x$ |
| Evaluating second derivative | $\dfrac{d^2}{dx^2}(x^2e^x)$ | `diff(x^2*exp(x),x,2); factor(%);` | $x^2e^x + 4xe^x + 2e^x$ $(x^2+4x+2)e^x$ |
| Calculating indefinite integral | $\displaystyle\int \frac{1}{1+x^2}\,dx$ | `integrate(1/(1 + x^2),x);` | $\arctan(x)$ |
| Calculating definite integral | $\displaystyle\int_0^1 \frac{1}{1+x^2}\,dx$ | `integrate(1/(1 + x^2),x,0,1); %,numer;` | $\pi/4$ 0.7853981634 |