



## Preface

This is a continuation of last year's professional development activity with  $\text{\LaTeX}$ . This material, however, is somewhat different and is also independent from that utilised last year. The manual and activities for last year can be found here

[http://faculty.ccp.edu/dept/math/TeX\\_Resources.html](http://faculty.ccp.edu/dept/math/TeX_Resources.html)

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## 1 Activity IV: Graphing a Polynomial

I am assuming you are using Winedt/Miktex. Open a new document in Winedt, type was on the yellow rectangle below, but do not type the numbers of the lines. Save is as activity4.tex.<sup>1</sup> On the Winedt menu click on  $\text{\LaTeX}$ , which will compile the document. Again, click on **dvips** and then on **pspdf**. This three-step process produces first a dvi (device independent document), a ps (postscript) document, and a pdf (portable document file) document. Do not worry about how much blank space you leave between words,  $\text{\LaTeX}$  tokenises multiple white spaces as one white space. Also, two or more blank lines are tokenised as two blank lines, creating a new paragraph. Always put one or more spaces between the period of a sentence and the capital letter of the next sentence.

Here is the graph of  $x \mapsto \frac{x^3 - x}{3}$ .

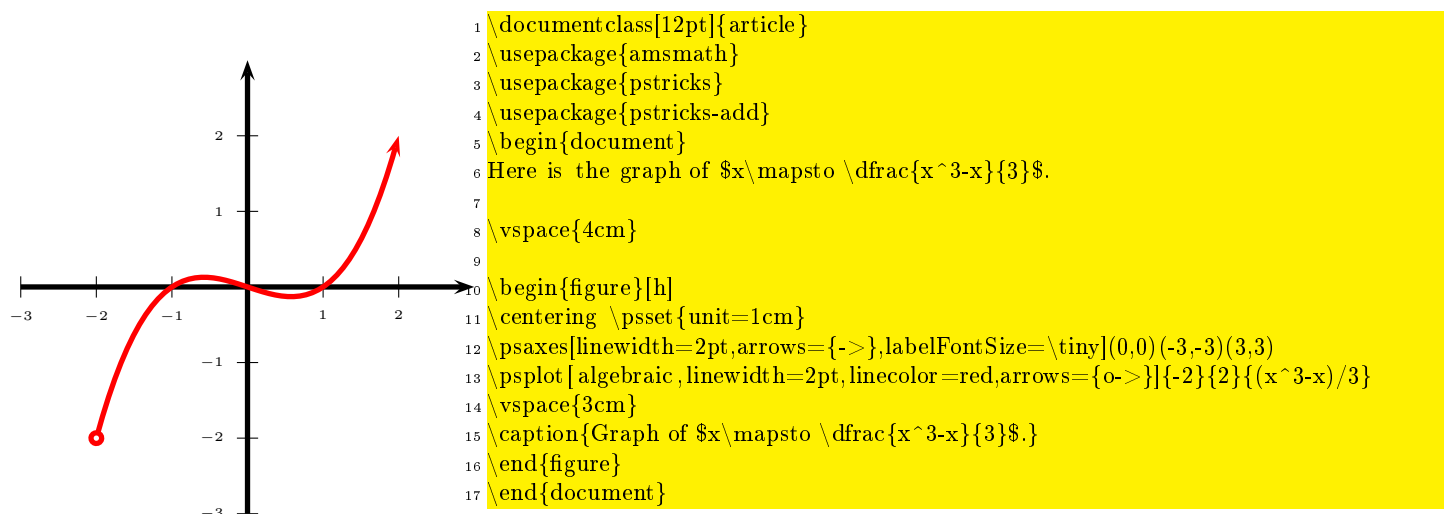


Figure 1: Graph of  $x \mapsto \frac{x^3 - x}{3}$ .

**Explanation:** Line 1 tells  $\text{\LaTeX}$  the size of the font. Generally, commands enclosed in brackets [] are optional, hence if you don't write this,  $\text{\LaTeX}$  will use the default value, 10pt. Other values are 9pt and 11pt.

Line 1 also tells  $\text{\LaTeX}$  the nature of the document. There are various document classes, among them article, report, book, slides, prosper, beamer and letter. Each of these document classes obey different default behaviours. For most part, and for writing exams and syllabi, I recommend simply using article

Line 2 loads the American Mathematical Society symbols and fonts. We use it here in order to have access to the command `dfrac`, display fraction.

<sup>1</sup>The first three activities were part of last year's professional development workshop.

Lines 3 and 4 load the libraries of the packages `pstricks`, `pstricks-add`, which are a series of postscript commands for drawing figures and graphs. enclose the main body of the document.

Lines 5 and 18 open and close the document.

Single dollar signs  $\$$   $\$$  are used to enclose mathematics commands in the text. Double dollar signs  $\$\$$   $\$\$$  are used to enclosed mathematical commands to be displayed and centred. In line 5 we use single dollar signs to write a a fraction. There are various commands for writing fractions, of which we mention `tfrac` text fraction, `frac` fraction, and `dfrac` display fraction.

In line 8 we give 4 cm of vertical space between the text and the figure. In most cases  $\LaTeX$  can figure out automatically how much space to put between elements. In the cases of figures, the algorithm sometimes goes awry, and you may wish to help  $\LaTeX$ .

Lines 10 and 17 open and close and figure. The parameter `[h]` means that the figure will be put here, but position is actually quite tricky. Other alternatives are `[p]` paragraph, `[t]` top, and `[b]` bottom.

In line 11 we center and give the unit dimension of our figure.

Line 12 defines the axes. Observe that the linewidth, the arrows, and the label fonts are declared. If these are omitted,  $\LaTeX$  will choose its own default values. The coordinate  $(0,0)$  is where the axes intersect,  $(-3,-3)$  is the leftmost lowermost coordinate, and  $(3,3)$  is the rightmost uppermost coordinate for the axes.

Line 13 plots the graph. The parameter `algebraic` tells latex that it is not using Reverse Polish Notation, but rather, an algebraic notation akin to that of Maple. Notice again that one is able to modify the thickness of the plot, its arrows, and its colour.

Line 15 gives a caption to our graph.

## 2 Activity V: The Nine-Point Circle

Consider  $\triangle ABC$ . Let  $H_A$  be the foot of the perpendicular (height) from  $A$  to the side  $BC$ , and define similarly  $H_B$  as the foot of the height from  $B$  to the side  $CA$ , and  $H_C$  as the foot of the height from  $C$  to the side  $AB$ . Let  $M_A$  be the midpoint of side  $BC$ ,  $M_B$  be the midpoint of the side  $CA$ , and  $M_C$  be the midpoint of the side  $AB$ . Let  $H$  be orthocentre of the triangle, that is, the point of concurrence of the heights of the triangle. Let  $I$  be the midpoint of the line segment  $[AH]$ ,  $J$  be the midpoint of the line segment  $[BH]$ , and  $K$  be the midpoint of the segment  $[CH]$ . Then the nine points

$$H_A, H_B, H_C, M_A, M_B, M_C, I, J, K,$$

all lie on a circle, called the *Nine-Point Circle* or the *Euler-Feuerbach* circle.

To draw the figure of such an elaborate result it would be to our advantage to be able to calculate and remember the coordinates of points, and to use transformations of these coordinates that use names and not numbers. In this way, should we need to change a coordinate later on, we would only have to change the coordinate, and not the calculations regarding this coordinate. The package `pst-eucl` provides a series of postscript commands for Euclidean geometry manipulation and it is just what we need.

In line 10 below we give the Cartesian coordinates of our  $\triangle ABC$ . It is also possible to use polar coordinates, in this case one enters a coordinate of the form  $(r;\theta)$ , with  $r > 0$  and semi-colon instead of comma. Notice that the coordinates are enclosed in parentheses and the name of the coordinates in braces. The `PosAngle` parameter is the relative angle (in degrees) where the label is put. Here the first coordinate given  $B$ , has its label  $180^\circ$  about the coordinate, the second coordinate  $C$ , has it  $0^\circ$  about the coordinate, and  $A$  has its label  $300^\circ$  about the coordinate.

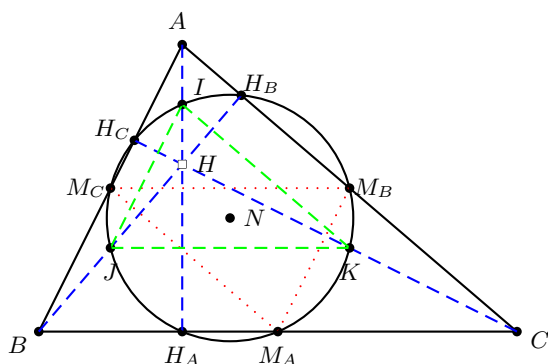


Figure 2: Euler-Feuerbach Circle.

```

1 \documentclass[12pt]{article}
2 \usepackage{pstricks}
3 \usepackage{pst-eucl}
4 \begin{document}
5
6 \vspace{4cm}
7
8 \begin{figure}[h]
9 \centering \psset{unit=1.5pc}
10 \pstTriangle[PosAngle={180,0,300}](-2,0){B}(8,0){C}(1,6){A}
11 % midpoints and circumcentre, and Feuerbach circle
12 \pstMiddleAB[PosAngle=-90]{B}{C}{M_A}
13 \pstMiddleAB[PosAngle=0]{C}{A}{M_B}
14 \pstMiddleAB[PosAngle=180]{A}{B}{M_C}
15 \ncline[linecolor=red,linestyle=dotted]{M_A}{M_B}
16 \ncline[linecolor=red,linestyle=dotted]{M_B}{M_C}
17 \ncline[linecolor=red,linestyle=dotted]{M_C}{M_A}
18 % heights
19 \pstProjection{B}{A}{C}[H_C] \pstProjection{B}{C}{A}[H_A]
20 \pstProjection[PosAngle=30, PointNameSep=3mm]{A}{C}{B}[H_B]
21 \ncline[linecolor=blue,linestyle=dashed]{A}{H_A} \ncline[linecolor=blue,linestyle=
22 dashed]{C}{H_C} \ncline[linecolor=blue,linestyle=dashed]{B}{H_B}
23 \pstInterLL[PointSymbol=square]{A}{H_A}{B}{H_B}{H}
24 % middles of segments from vertices to H
25 \pstMiddleAB[PosAngle=45]{A}{H}{I}
26 \pstMiddleAB[PosAngle=-90]{B}{H}{J}
27 \pstMiddleAB[PosAngle=-90]{C}{H}{K}
28 \ncline[linecolor=green,linestyle=dashed]{I}{J}
29 \ncline[linecolor=green,linestyle=dashed]{J}{K}
30 \ncline[linecolor=green,linestyle=dashed]{K}{I}
31 %DRAWING THE CIRCLE
32 \pstCircleABC{M_A}{M_B}{M_C}{N}
33 \vspace{1cm} \caption{Euler-Feuerbach Circle.}
34 \end{figure}
35 \end{document}
    
```

Lines 11, 18, 23 and 30 are comments. They are invisible to  $\text{\LaTeX}$  and must be preceded by a  $\%$ .

To calculate the midpoint of the line segment  $BC$ , we use the command  $\text{\pstMiddleAB}[PosAngle=-90]{B}{C}{M_A}$ , which means that the name of new point just created is  $M_A$  (I could have call it Peter, if I wanted). Notice the advantage of using node addresses. If we later decide that a prettier position for  $A$  is  $(50, 52)$  rather than the  $(1, 6)$  given now, we simply change the coordinate definition on line 10 without having to make any changes subsequently.

The commands  $\text{\ncline}$  draw lines between the nodes.

The command  $\text{\pstProjection}{B}{A}{C}[H_C]$  projects the point  $B$  on the line  $AC$  and calls the projection point  $H_C$ .

The command  $\text{\pstInterLL}[PointSymbol=square]{A}{H_A}{B}{H_B}{H}$  calculates the point of intersection between lines  $AH_A$  and  $BH_B$  and calls it  $H$ , which in this case, is the orthocentre of the triangle.

Finally, the command  $\text{\pstCircleABC}{M_A}{M_B}{M_C}{N}$  draws the circle passing through the three points  $M_A$ ,  $M_B$ , and  $M_C$  (recall that a unique circle is determined by three non-collinear points) and calls its centre  $N$  for future reference.