

## Partial derivative solution software with MATLAB

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**Abstract** The MATLAB software used in this research is a program that integrates numerical computing, visualization, and programming to express problems and their solutions in mathematical notation. This study aims to explain the reasons why the use of MATLAB needs to be utilized because it is considered to be able to solve mathematical problem solving theories and can be easily understood. This type of research uses descriptive qualitative research, because it describes and explores information in words. Data collection techniques using literature study and practice. To test the validity of the data used triangulation techniques. Data analysis was carried out by reducing data, presenting data and drawing conclusions. The results show that the use of MATLAB is very helpful in solving mathematics, especially on partial derivatives and produces comprehensive results. [PARTIAL DERIVATIVE SOLUTION SOFTWARE WITH MATLAB] (J. Math. Nat. Sci., 1(2): 56 - 60, 2021)

**Keywords:**  
Partial Derivative,  
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### Introduction

Multivariable Calculus is one of the courses that must be taken by students of mathematics education study program. Multivariable Calculus is an advanced calculus that previously students had to take calculus I and calculus II. If Calculus I and Calculus II generally discuss single variables in one-dimensional or two-dimensional space, in Variable Calculus many discuss more than one independent variable in more than 1-dimensional space. In the lectures we discuss in two and/or three-dimensional spaces and can be expanded and expanded on n dimensions R.

One of the topics discussed in this Multivariable Calculus course is Partial Derivatives. Partial derivative is a change in the value of a function that has 2 or more variables partially or not wholly and is derived one by one. If the function  $z = (x, y)$  we derive the variable  $x$  then  $y$  will be considered as a constant and we can say we are looking for the partial derivative of  $z$  with respect to  $x$ .

**The first partial derivative of a function of two variables.** If  $f$  is a function of two variables and  $(x, y)$  is a point in the domain of the function, then the partial derivative is:

$$\frac{\partial f(x, y)}{\partial x} = \lim_{\Delta x \rightarrow 0} \frac{f(x + \Delta x, y) - f(x, y)}{\Delta x}$$

$$\frac{\partial f(x, y)}{\partial y} = \lim_{\Delta y \rightarrow 0} \frac{f(x, y + \Delta y) - f(x, y)}{\Delta y}$$

The partial derivative of  $(x, y)$  with  $x$  where only the  $x$  variable is assumed to change, and  $y$  remains constant, vice versa. For example  $z = F(x, y)$  the first partial derivative of  $z$  with  $x$  and  $y$  is denoted by  $\frac{\partial z}{\partial x}$  and  $\frac{\partial z}{\partial y}$  (Anton et al., 2012).

**Second partial derivative.** The second partial derivative is a function of two variables that can be obtained from the first partial derivative. Since there are two first partial derivatives,  $f_x$  and  $f_y$ , and each has two partial derivatives, we get four second partial derivatives, namely:

$$\frac{\partial}{\partial x} \left( \frac{\partial f}{\partial x} \right) = \frac{\partial^2 f}{\partial x^2} = f_{xx}$$

$$\frac{\partial}{\partial y} \left( \frac{\partial f}{\partial y} \right) = \frac{\partial^2 f}{\partial y^2} = f_{yy}$$

$$\frac{\partial}{\partial y} \left( \frac{\partial f}{\partial x} \right) = \frac{\partial^2 f}{\partial x \partial y} = f_{xy}$$

$$\frac{\partial}{\partial x} \left( \frac{\partial f}{\partial y} \right) = \frac{\partial^2 f}{\partial y \partial x} = f_{yx}$$

**Third partial derivative.** The third partial derivative is a function that can be obtained from the second partial derivative (Stewart, 2012):

$$\begin{array}{lcl}
 \frac{\partial}{\partial x} \left( \frac{\partial f}{\partial x} \right) = \frac{\partial^2 f}{\partial x^2} = f_{xx} & \longrightarrow & \frac{\partial}{\partial x} \left( \frac{\partial^2 f}{\partial x^2} \right) = \frac{\partial^3 f}{\partial x^3} = f_{xxx} = f_{111} \\
 \frac{\partial}{\partial y} \left( \frac{\partial f}{\partial y} \right) = \frac{\partial^2 f}{\partial y^2} = f_{yy} & \longrightarrow & \frac{\partial}{\partial y} \left( \frac{\partial^2 f}{\partial y^2} \right) = \frac{\partial^3 f}{\partial y^3} = f_{yyy} = f_{222} \\
 \frac{\partial}{\partial z} \left( \frac{\partial f}{\partial z} \right) = \frac{\partial^2 f}{\partial z^2} = f_{zz} & \longrightarrow & \frac{\partial}{\partial z} \left( \frac{\partial^2 f}{\partial z^2} \right) = \frac{\partial^3 f}{\partial z^3} = f_{zzz} = f_{333}
 \end{array}$$

With the rapid advancement of computer technology, the use of mathematical aids in solving problems is also growing rapidly. Mathematics is one of the most important subjects for human daily life. Because mathematics can make it easier to carry out daily activities, especially in the trading process and also there are many more things that can be done with mathematics. The main function of mathematics is to make it easier to perform calculations in the form of addition, subtraction, and so on. Mathematics is also one of the sciences that develops along with technological advances. The development of science and technology has contributed a lot to progress in various fields of life. One of the obvious impacts of technological developments is progress in the field of education, which gave rise to the term education technology. In Indonesia, educational technology is used for the development of learning media, for example in learning mathematics using multimedia technology. Almost every home already has a computer. Thus, education does not always have to be done in a direct way but can also take advantage of technology by using media as a tool in supporting the learning process. So that parents who often have activities outside the home now need not worry anymore (Fajarianto and Wirawa, 2013).

Multiple Variable Calculus is the study of change, just as geometry is the study of shapes and algebra is the study of operations and their application to solving equations. Calculus has wide applications in the fields of science, economics, and engineering; and can solve various problems that cannot be solved by elementary algebra. Therefore, we need a computer program that can complete calculations quickly and accurately so that error calculations can be avoided. For example, solving partial derivatives, if done manually it will take a long

time and the risk of calculation errors (human error) is very large.

Many problems in mechanical engineering and the natural sciences can be formulated in terms of partial derivatives. For that we need a computer program that can solve multivariable calculus problems easily and quickly. The computer program that will be used to facilitate the completion of one of the Many Variable Calculus topics is MATLAB. MATLAB is a high-performance language for computing engineering problems. Matlab integrates computing, visualization, and programming in a very easy-to-use model in which problems and solutions are expressed in familiar mathematical notation. In learning mathematics, Matlab can help teachers and students to communicate mathematical concepts. Some mathematical concepts that can be described using Matlab include; matrix, vector, linear algebra, statistics, polynomial, function analysis, curve matching, interpolation, limit, differential, integral, Laplace transform, Fourier transform, Ordinary Differential Equation (ODE) and Partial Differential Equation (PDE) (Ariyanto and Caesarendra, 2011). Based on the description above, the author conducted a study that aims to describe how to operate MATLAB in solving partial derivative problems.

## Methodology

This research is a qualitative descriptive study to uncover, analyze, and provide an overview of partial derivatives and their solutions as well as the operation of MATLAB in solving partial derivative problems. The methods used to collect data and information are as follows:

**Literature study.** This method is done by studying the literature or references that can directly support the process of compiling this paper.

**Practice.** This method is done by solving partial derivatives using the results of calculations with a computer program.

In this study, the data analysis technique was carried out through 3 stages, namely: data reduction, data presentation and conclusion. To test the validity of the data, a triangulation technique was used by comparing the errors in solving partial derivative questions obtained from the answers manually with the results of the operation of the MATLAB software.

### Results

#### Solving the first partial derivative problem.

Completion of examples of partial derivative problems manually and reviewed with results in MATLAB software. The following is an example of a simple partial derivative problem that will be solved manually: Find  $f_x$  and  $f_y$  of the function  $f(x, y) = x^3y + 4xy^2$

By using the formula for the first partial derivative, we get:

$$\frac{\partial F(x, y)}{\partial x} = 3x^2y + 4y^2$$

$$\frac{\partial F(x, y)}{\partial y} = x^3 + 8xy$$

Then we use matlab software to solve partial derivative problems. The syntax that we must pay attention to in coding partial derivative problems is syms followed by the subject argument. Syms is a fast way to construct symbolic numbers, variables and objects. Syntax syms arg 1 arg 2 ... real. Syntax coding is done in M-File in MATLAB. Script File or M-File is a collection of commands written using the MATLAB programming language that can be stored and executed repeatedly. The script file is created with a name without spaces and with an extension (.m). M-File can be called by selecting the menu file ->new->M-File. The M-File input for solving the first partial derivative is like Figure 1 (Cahyono, 2013).

```

Editor - C:\Users\ACER\contoht
contohturunanparsial.m
1 - syms x y
2 - f=x^3*y+4*x*y^2
3 - diff(f,x)
4 - diff(f,y)
5
    
```

Figure 1. Input in M-File.

Command Window is the main window for executing commands, opening new windows, running Toolbox and software management in

MATLAB. After typing the syntax on the M-File then click F5 to save the script file, then the output appears as follows:

```

Command Window
>> contohturunanparsial

f =
x^3*y + 4*x*y^2

ans =
3*x^2*y + 4*y^2

ans =
x^3 + 8*y*x

fx >>
    
```

Figure 2. Command Window results in MATLAB.

#### Second partial derivative problem solving.

Find the first to second partial derivatives of the function  $f = x^2 + 4x^2y^3 - 2xy^2 - 5y^2 + 8$

Manual completion:

$$\begin{aligned}
 F &= x^2 + 4x^2y^3 - 2xy^2 - 5y^2 + 8 \\
 \frac{\partial F}{\partial x} &= 2x + 8xy^3 - 2y^2 - 2x \\
 \frac{\partial F}{\partial y} &= 12x^2y^2 - 4xy - 10y^2
 \end{aligned}$$

Figure 3. Manually solving the second partial derivative problem.

$$\begin{aligned}
 F &= x^2 + 4x^2y^3 - 2xy^2 - 5y^2 + 8 \\
 \frac{\partial^2 F}{\partial x^2} &= \frac{\partial}{\partial x} \left( \frac{\partial F}{\partial x} \right) \\
 &= \frac{\partial}{\partial x} (8xy^3 - 2y^2 - 2x) \\
 &= 8y^3 - 2 \\
 \frac{\partial^2 F}{\partial y^2} &= \frac{\partial}{\partial y} \left( \frac{\partial F}{\partial y} \right) \\
 &= \frac{\partial}{\partial y} (12x^2y^2 - 4xy - 10y^2) \\
 &= 24x^2y - 4x - 20y
 \end{aligned}$$

Figure 4. Manually solving the second partial derivative problem.

Then the completion of the MATLAB software using the syntax results as shown below:

```

1 - syms x y
2 - f=x^2 + 4*x^2*y^3 - 2*x*y^2 - 5*y^3 + 8
3 - diff(f,x)
4 - diff(f,y)
5 - diff(f,x,2)
6 - diff(f,y,2)
7
    
```

Figure 5. Script file in MATLAB.

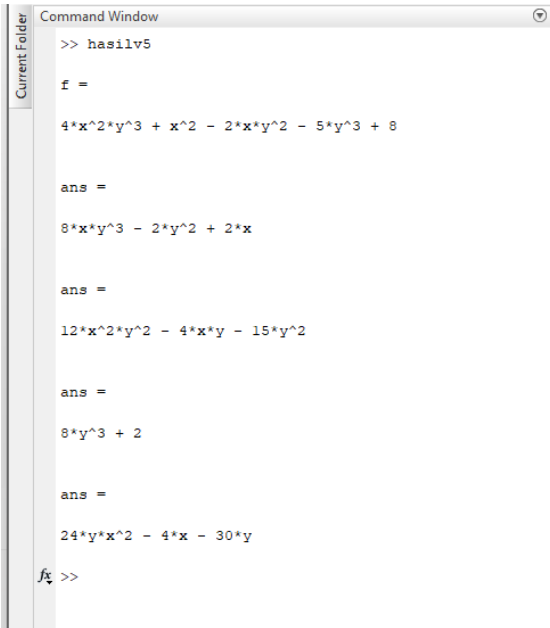


Figure 6. Command window results in MATLAB.

**Third-order partial derivatives.** The following is an example of a third-degree partial derivative that will be solved manually and using MATLAB software. If  $f(x, y, z) = 5x^2 - 12xy + 14y^2 + 6zxy - 7z^3$  then search  $f_{123}, f_{221}, f_{312}$ !

Manual completion:

$$\begin{aligned}
 f_{123} &= \frac{\partial}{\partial z} \left( \frac{\partial}{\partial y} \left( \frac{\partial}{\partial x} (5x^2 - 12xy + 14y^2 + 6zxy - 7z^3) \right) \right) \\
 &= \frac{\partial}{\partial z} \left( \frac{\partial}{\partial y} (10xy - 12y + 6zy) \right) \\
 &= \frac{\partial}{\partial z} (-12 + 6z) = 6 \\
 f_{221} &= \frac{\partial}{\partial x} \left( \frac{\partial}{\partial y} \left( \frac{\partial}{\partial y} (5x^2 - 12xy + 14y^2 + 6zxy - 7z^3) \right) \right) \\
 &= \frac{\partial}{\partial x} \left( \frac{\partial}{\partial y} (-12x + 28y + 6zx) \right) \\
 &= \frac{\partial}{\partial x} (28) = 0
 \end{aligned}$$

Figure 7. Manual results on third-order partial derivatives.

$$\begin{aligned}
 f_{312} &= \frac{\partial}{\partial y} \left( \frac{\partial}{\partial x} \left( \frac{\partial}{\partial z} (5x^2 - 12xy + 14y^2 + 6zxy - 7z^3) \right) \right) \\
 &= \frac{\partial}{\partial y} \left( \frac{\partial}{\partial x} (6xy - 7z^2) \right) \\
 &= \frac{\partial}{\partial y} (6y) = 6
 \end{aligned}$$

Figure 8. Manual results on third-order partial derivatives.

Then will the completion using MATLAB with the following syntax the same for the first and second partial derivatives.

```

1 - syms x y z
2 - f=5*x^2-12*x*y+14*y^2+6*z*x*y-7*z^3
3 - diff(f,x,y,z)
4 - diff(f,y,y,x)
5 - diff(f,z,x,y)
    
```

Figure 9. Display on M-file.

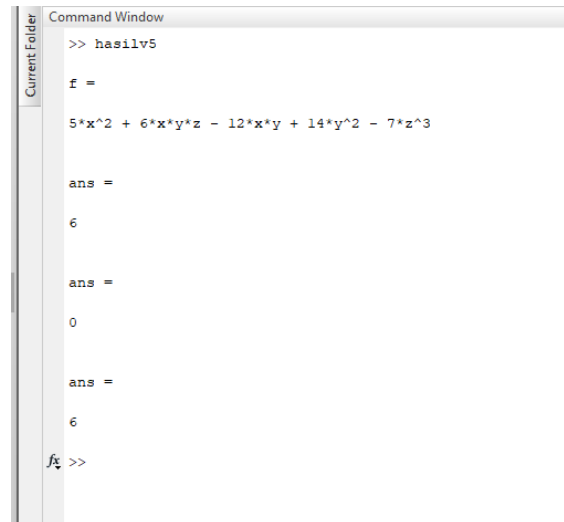


Figure 10. Display results in the Command Window.

### Discussion

Based on the results of the answers that have been simulated manually and the operation of the MATLAB software produces the same final result. If a solution provides a manual request, we can use MATLAB as our support tool to make solving partial derivative problems easier. Calculations manually, we often get errors during completion, because an error of 1 number will be fatal for the next settlement. Therefore, accuracy is needed so that the simulation does not contain errors.

The Mathematical tool software or that we are currently using, namely MATLAB has a good impact on all users who want to solve mathematical problems quickly and precisely, especially students from the Mathematics Department. MATLAB is very reliable for computing in the field of Mathematics. This reliability can be seen starting from the variable assignment process to the values contained in partial derivatives, to the fast calculation operations. The simplicity in the process of assigning variables to partial derivatives is due to the fact that there is no need to define the size of the variable. Automatically, the size or dimensions of the variables will adjust or in other words dynamic. Thus, we do not need to worry about the size of the variables needed for a calculation process, especially on partial derivatives.

## Conclusion

Based on the results of the discussion, it can be concluded that MATLAB is a high-performance language for computing engineering problems. Matlab integrates computation, visualization, and

programming in a very easy-to-use model in which problems and solutions are expressed in familiar mathematical notation. The Matlab program helps and makes it easier to solve partial derivative problems quickly and precisely. With the partial derivative solution program, solutions can be found quickly without the risk of errors in calculations.

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