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Some mathematical issues with MATLAB

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Abstract

The paper must have abstract not exceeding 200 words. In this paper, we shall investigate some mathematical difficulties that is facing learners and undergraduates in science and engineering when they use MATLAB. When solving some mathematical problems using this software, one may unfortunately, face the following: no answer at all, wrong answer, long and complicated answer. Therefore, our main aim is to investigate such problems through mathematical examples in order for the user to be aware of.

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1 Introduction

MATLAB is a scientific software tool which is increasingly used by engineers and applied mathematicians in academic and industrial fields. Special atten-

tion is paid to the users in various backgrounds of science, economics and engineering, whose being encouraged to use powerful, multi-purpose and widely accessible scientific packages such as MATLAB [1]. It has been widely used as not only as a numerical computing software, but also for solving algebraic and differential equations. MATLAB is considered as one of the easiest programming languages for writing mathematical programs and it has powerful graphical tools for plotting the results [2, 3, 4, 5, 6].

There are basically three types of errors that can face the MATLAB users, as mentioned in [7], these are: syntax errors, runtime errors or logical errors and rounding errors. Syntax errors are caused by grammatical mistakes in the statement included in the program. MATLAB detect most of these errors when the program is compiled giving a message describing the error. Runtime errors are caused mainly by the programmer wrong logic in the algorithm use to solve the problem. Therefore runtime errors are more difficult to track as MATLAB does not report the type of error or its location. In the end the problem is left completely to the program's skill to judge whether the results are expected or not. Finally, rounding errors occur because a computer can store numbers only to a finite accuracy.

In this paper, we shall investigate different types of difficulties , one may encounter when solving some mathematical problems using MATLAB.

2 Results and examples

There are some difficulties that facing the undergraduate students in science and engineering, who are using MATLAB for solving some mathematical problems, and these are described briefly in this section by dividing such difficulties into specific cases. All examples in this section were executed using R2015b version of MATLAB.

case 1: MATLAB can not solve some simple mathematical problems such as differentiation, integration and summation of series, and here are some examples.

Example 1:

$$\text{if} \quad y' = sin(x+y), \quad \text{then} \quad y'' = cos(x+y)sin(x+y).$$

If we want to solve this example using Matlab then we should write:

```
>> syms x y
>> dsolve('Dy=sin(x+y)',x)
   ans =
        [ empty sym ]
```

but MATLAB gives no answer for this simple example.

Example 2:

$$\int_0^1 \frac{x^{20}}{x^{20}+(x-1)^{20}}\,dx = \frac{1}{2},$$

and solving it using MATLAB

```
>> syms x
>> int(x^(20)/(x^20+(x-1)^20),x,0,1)
   ans =
      int(x^20/(x^20+(x-1)^20),x = 0 .. 1)
```

again no answer, similarly the following examples have no solutions in MATLAB.

Example 3:

$$\int_0^{\pi} \frac{xsin(x)}{1+cos^2(x)}\,dx = \frac{\pi^2}{4}$$

```
>> syms x
>> int((x*sin(x))/(1+cos(x)^2)),x,0,pi)
   ans =
      int(x*sin(x)/(1+cos(x)^2),x = 0 .. pi)
```

In general all integrations of the form

$$\int_0^a \frac{f(x)}{f(x)+f(a-x)}\,dx$$

can not be executed in MATLAB.

Example 4:

$$\sum_{n=1}^{\infty} \frac{1}{x^{1/3}} = \infty,$$

but using Matlab there is no answer.

```
>> syms x
>> symsum(1/(x)^(1/3),x,1,inf)
   ans =
      symsum(1/(x)^(1/3),x = 0 .. inf)
```

Case 2: Matlab also does not deal with the fractional derivatives such as: Example 5:

$$\frac{d}{dx}(\sqrt{x})|_{x=\frac{1}{2}} = \frac{2}{\sqrt{\pi}}\sqrt{x}.$$

```
>> syms x
>> diff(x,1/2)
   ans =
       1
```

In complex analysis MATLAB deals only with the principal value without taking into account the argument value, also this programming language does not differentiate between *Log* and log. For example,

$$Log(-1) = log(-1) = \pi * i$$

but mathematically,

$$Log(-1) = \pi i, \qquad log(-1) = (2n+1)\pi i.$$

Case 3: MATLAB also gives very long answers without any simplifications and the following are some examples to describe clearly this case.

Example 1:

$$y'' - y' = 2y = 0$$
$$y = c_1 e^{-x} + c_2 e^{2x}$$

, using MATLAB we do receive the following answer which is really long and complicated.

```
>> dsolve('D^2-Dy+2*y=0',x)
   ans =
       c2*exp(x/2)*cos((7^(1/2)*x)/2)+c3*exp(x/2)*sin(7^(1/2)-x/2)
```

Example 2: This is a substitution example where MATLAB gives unnecessarily, very long answer,

$$f = exp(-2log(3)) = 0.1111,$$

```
>> f=exp(-2*x);
>> subs(f,log(3))
   ans =
       exp(-2473854946935173/1125899906842624).
```

Example 3:Laplace transform

$$\pounds\{(t^2 - t + 2)(t-2)\} = e^{-2s}\left(\frac{2}{s^3} + \frac{3}{s^2} + \frac{4}{s}\right)$$

```
>> laplace((t^2-t+2)*heaviside(t-2),s)
   ans =
      (exp(2s)(((4*s^2+4*s+2)/exp(2*s)-2)/exp(2*s)-2)/s^3)-1/s^2)/exp(2*s)
```

Case 4: MATLAB does not display the full answers, actually it does not give all the solutions.

Example 1:

$$(-4)^{\frac{1}{2}} = \pm 2i,$$

but MATLAB gives only one root as we can see in this example.

```
>> (-4)^(1/2)
   ans =
        2i
```

Example 2:

$$|x| - 4 = 0, \quad \text{the answer is} \quad x = \pm 4$$

```
>> syms x
>> solve(abs(x)-4,x)
   ans =
        4
```

Matlab failed to find both roots.

Example 3:

$$A^{1/2} = \begin{pmatrix} 2 & 0 \\ 0 & 3 \end{pmatrix}, \quad \begin{pmatrix} 2 & 0 \\ 0 & -3 \end{pmatrix}, \quad \begin{pmatrix} -2 & 0 \\ 0 & 3 \end{pmatrix}, \quad \begin{pmatrix} -2 & 0 \\ 0 & -3 \end{pmatrix},$$

MATLAB gives only one root out of four for this matrix.

```
>> A=[4 0; 0 9]
>> A^(1/2)=
   ans =
        2  0
        0  3
```

Case 5: MATLAB gives wrong answers for solving these mathematical problems.

Example 1:

$$x - 1 > 6 \longrightarrow x = (7, \infty)$$

but Matlab gives completely a wrong answer.

```
>> syms x
>> solve('x-1>6',x)
   ans =
        8
```

Example 2:

$$|x^2| + 1 = 0 \longrightarrow x = \pm i$$

```
>> syms x
>> solve(abs(x^2)+1,x)
   ans =
        [empty sym]
```

Example 3: In complex analysis

$$\Gamma(-3) = -\infty,$$

but in MATLAB

```
>> gamma(-3)
   ans =
        inf
```

Example 4:

$$\beta(4, -3) = -\infty$$

```
>> beta(4,-3)
   ans =
        inf
```

Example 5: on limits

$$\lim_{x \to -0} (\sqrt{x}) = \text{undefined}$$

In this example, MATLAB gives seriously wrong answer

```
>> syms x
>> limit(sqrt(x),x,0,'left')
   ans =
        0
```

Example 6: integration

$$\int_{-4}^{-1} \sqrt{x}\, dx = \text{undefined}$$

clearly, the interval of integration for this function is outside its domain which is $[0, \infty)$, but MATLAB gives an answer,

```
>> syms x
>> int(sqrt(x),x,-4,-1)
   ans =
        14i/3
```

Example 7: differentiation of absolute value function of x when $x \to 0$,

$$\frac{d}{dx}(|x|) = \left\{ \begin{array}{ll} +1, & \text{when } x > 0 \\ -1, & \text{when } x < 0 \end{array} \right\}$$

thus, the derivative does not exist at $x = 0$.

```
>> syms x
>> diff(abs(x),x)
   ans =
        sign(x)
```

Case 6: MATLAB gives wrong logical answers as we shall see in the following examples.

Example 1:

$$\frac{x}{x} = 1, \ \forall x \neq 0,$$

```
>> x/x==1
   ans=
        1
```

it gives the answer 1 without any conditions.

Example 2: Trigonometric identity

$$sin(2x) = 2sin(x)cos(x)$$

```
>> sin(2*x)==2*sin(x)*cos(x)
   ans =
        command !!!!!!!!!!
```

3 conclusion

There is no doubt that MATLAB is a powerful software with many scientific packages for many applications. It has spread widely in academic and industrial fields. Millions of researchers in science and technology are using this software to analyze and design their own systems and products. It contains tools for solving mathematical, scientific and engineering problems successfully. Though it seems to have some difficulties and problems in solving some

basic problems in mathematics that users in this filed should be aware of. We do suggest more effort to be paid for the people in charge of developing and promoting this software [1], to such problems to make it work properly, and to avoid any confusion among learners between exact and computed MATLAB answers.

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