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Analysis of Linear Equations with Parameters in Python Programming Language

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Abstract:

This article provides information about parametric linear equations. Mathematical solution and analysis of several examples in Python programming language were shown.

Keywords: Parametric equation, parametric linear equation, python

A parametric equation is an equation in mathematics that expresses some connection using parameters. In an abstract sense, a set of equations can be called a parametric equation. As a simple example, we can cite an equation that expresses the location, acceleration, and other properties of an object in motion with the time parameter. Parametric equations are one of the most important branches of mathematics. The existence of a solution of a parametric linear equation depends on the parameters involved in the equation, and solving such equations means determining at which values of the parameters the equation has a solution and at which values it does not have a solution (linear equations - only the first degrees of the unknowns are involved with specific coefficients, and their equations without higher levels, cross-multiplications and complex functions).

For example, consider the equation $a \cdot x = b$, which is linear with respect to the unknown x, where a, b are parameters. This equation is as strong as the equation $a \cdot x = b$ and has a unique solution $x = b/a$ for $a \neq 0$; if $a = b = 0$, the equation has infinitely many solutions. If $a = 0;\ b \neq 0$, the equation has no solution.

Let's build a program in the Python programming environment:

main.py

```
a = float(input(" Enter a real number: "))
b = float(input(" Enter b real number: "))
# for the equation ax-b=0:
if a!=0:
    x=b/a
    print("The equation has a unique solution:", x)
elif a==0 and b==0:
    print("The equation has infinitely many solutions: ")
elif a==0 and b!=0:
    print("The equation has no solution: ")

```

Result window (for all three conditions):

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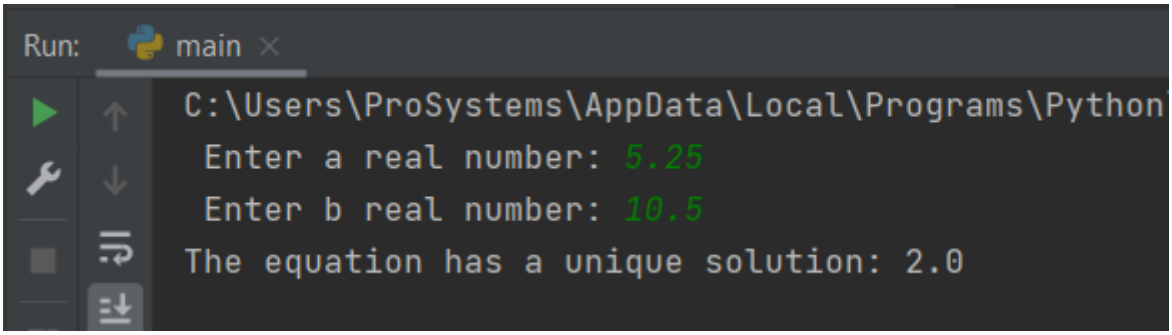
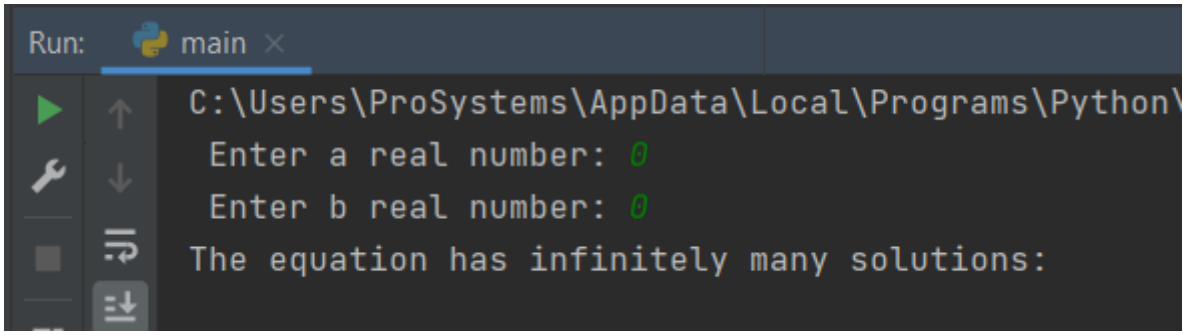
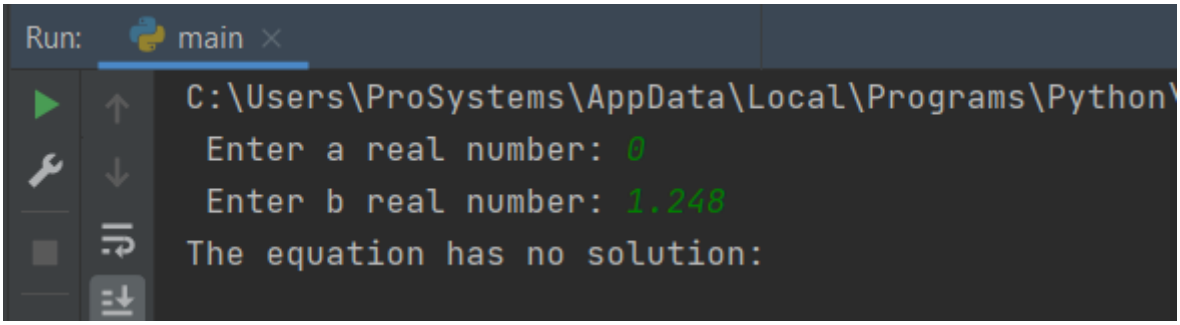




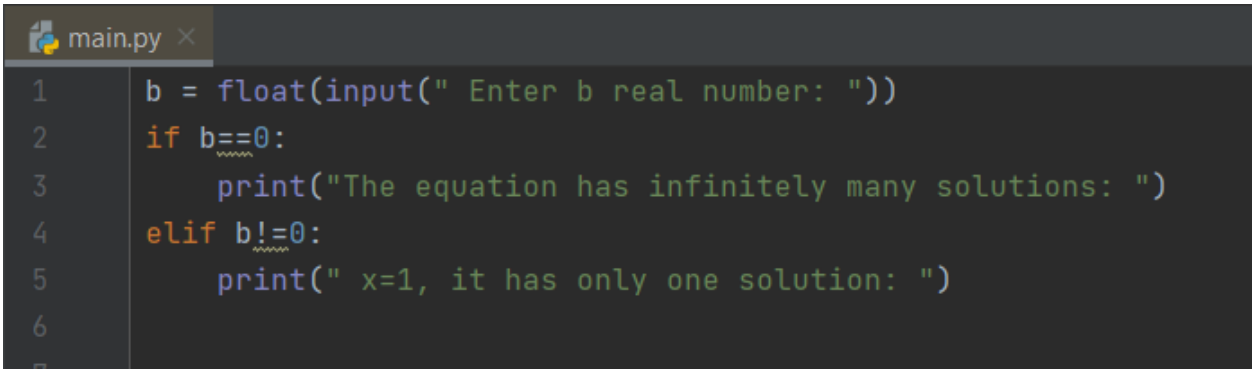


Examples: Solve parametric equations.

1) $b \cdot x = b$.

Solution: If $b = 0$, then $0 \cdot x = 0$, and the equation has infinitely many solutions. If $b \neq 0$ then $x = b/b = 1$ has a unique solution.

In Python, a program is structured as follows:



Result window (for both conditions):

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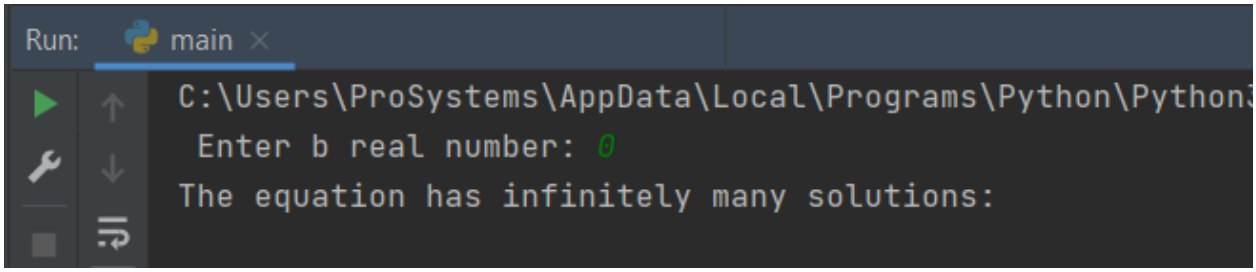
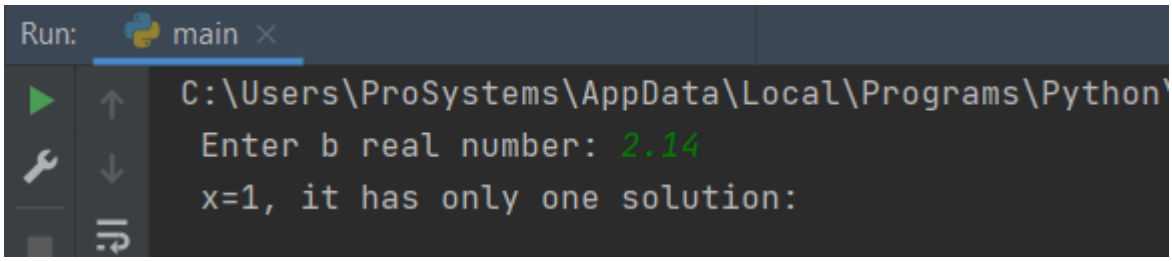




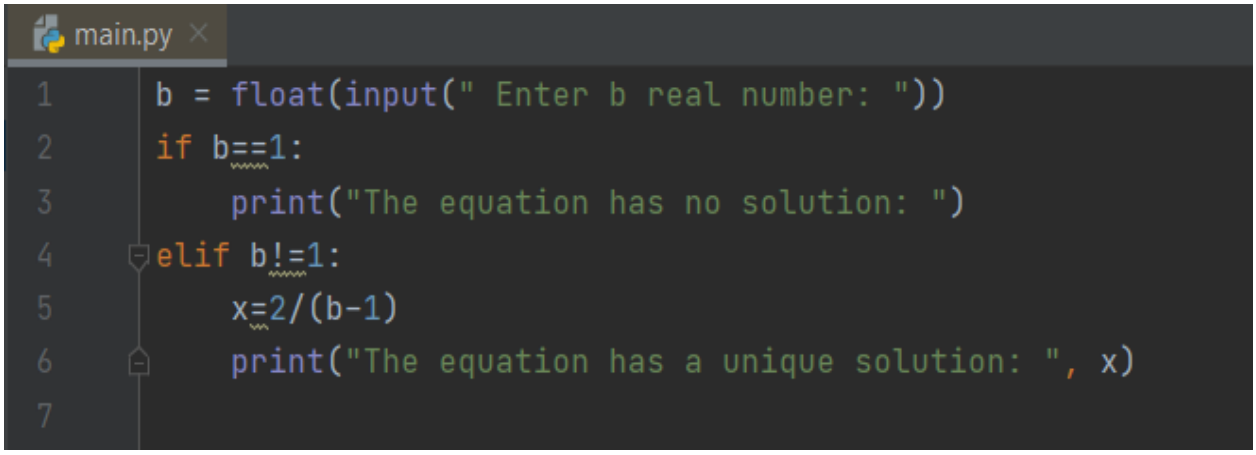
2) $x + 2 = bx$ (where b is an arbitrary number).

Solution:

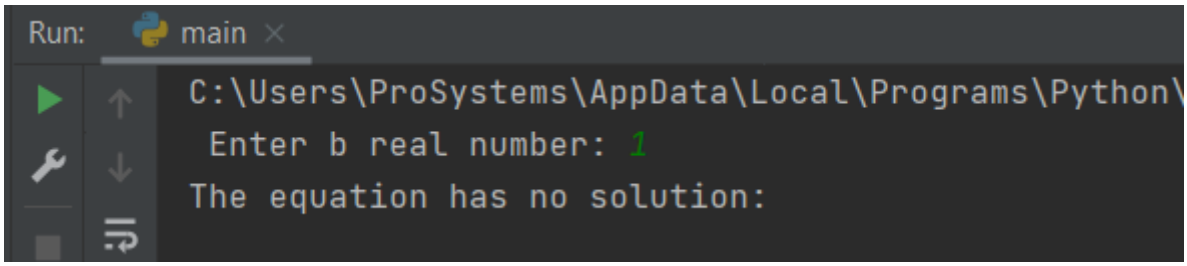
$x + 2 = bx \Rightarrow x - bx = -2 \Rightarrow x(1 - b) = -2 \Rightarrow x(b - 1) = 2 \Rightarrow$

$\begin{cases} \text{if b} = 1, \text{the equation has no solution;} \\ \text{if } b \neq 1, \text{then the equation } x = \frac{2}{b-1} \text{ has a unique root.} \end{cases}$

In Python, a program is structured as follows:



Result window (for both conditions):



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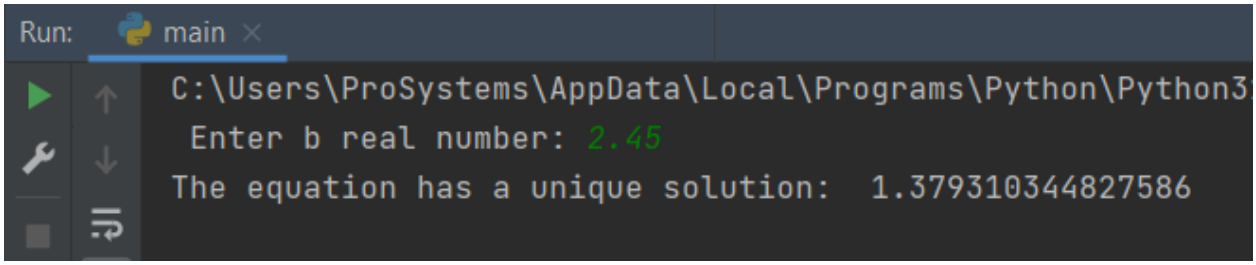


3) $ax - 3 = a + 2x$. At what values of a does the equation have no solution?; has a unique solution?.

Solution:

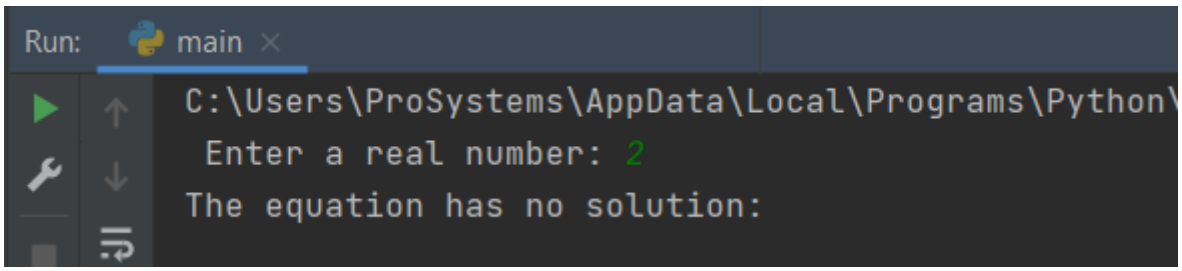
$ax - 3 = a + 2x \Rightarrow ax - 2x = a + 3 \Rightarrow x(a-2) = a + 3 \Rightarrow x = \frac{a+3}{a-2} \Rightarrow$

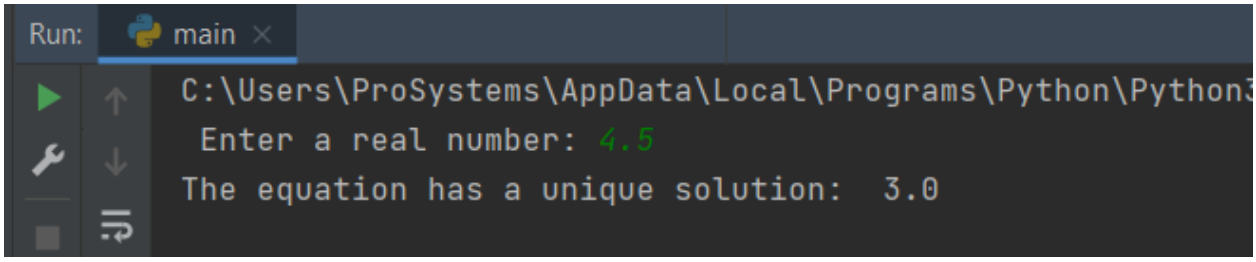
$\begin{cases} \text{if a} = 2, \text{the equation has no solution;} \\ \text{otherwise, the equation has a unique solution.} \end{cases}$

In Python, a program is structured as follows:

```
main.py
1  a = float(input(" Enter a real number: "))
2  # For the equation ax-3=a+2x
3  if a==2:
4      print("The equation has no solution: ")
5  else:
6      x=(a+3)/(a-2)
7      print("The equation has a unique solution: ", x)
8
```

Result window (for both conditions):





4) $(a^2 - 1)x = 2a^2 + a - 3$.

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Solution: The given equation is linear with respect to the unknown x. $(a^2-1)x = 2a^2+a-3 \Leftrightarrow (a-1)(a+1)x = (2a+3)(a-1) \Rightarrow$

$$\begin{cases} \text{if } a = 1, \text{the equation } 0 \cdot x = 0 \text{ has infinitely many solutions;} \\ \text{if } a = -1, \text{the equation } 0 \cdot x = -2 \text{ has no solution;} \\ \text{if } a \neq \pm 1, \text{the equation } x = (2a+3)/(a+1) \text{ has a unique root.} \end{cases}$$

In Python, a program is structured as follows:

```
main.py
1   a = float(input(" Enter a real number: "))
2   # For the equation ax-3=a+2x
3   if a==1:
4       print("The equation has infinitely many solutions: ")
5   elif a==-1:
6       print("The equation has no solution: ")
7   elif a!=1 or a!=-1:
8       x=(2*a+3)/(a+1)
9       print("The equation has a unique solution: ", x)
10
```

Result window (for all three conditions):

```
Run:  main
C:\Users\ProSystems\AppData\Local\Programs\Python\Python3
 Enter a real number: 1
The equation has infinitely many solutions:
```

```
Run:  main
C:\Users\ProSystems\AppData\Local\Programs\
 Enter a real number: -1
The equation has no solution:
```

```
Run:  main
C:\Users\ProSystems\AppData\Local\Programs\Python\Python310
 Enter a real number: 1.24
The equation has a unique solution:  2.446428571428571
```

1) Determine at what value of k the system of equations does not have a solution:

$$\begin{cases} kx - y = 3, \\ -x + ky = -3. \end{cases}$$

Solution: It is known that in a system of two unknown equations of the first order, the coefficients are proportional, and if the free terms are not proportional, the system will not have a solution: $\frac{k}{-1} = \frac{-1}{k} \neq -\frac{3}{3}$, from this $k^2 = 1 \Rightarrow (k-1)(k+1) = 0 \Rightarrow \begin{cases} k_1 = -1, \\ k_2 = 1. \end{cases}$ So, at $k = 1$, the system has infinitely many solutions, and at $k = -1$, the system has no solution.

Conclusion:

Parametric equations are one of the important branches of mathematics. Even the simplest equations in one unknown are special cases of their corresponding parametric equations. This article shows the solution of linear equations with several parameters and a program in the python programming environment. This is important for students interested in programming and mathematics.

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