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**ANALYTICAL SOLUTION OF SIMPLE DIFFERENTIAL EQUATIONS  
FIND OUT WITH THE MAPLE PROGRAM**  
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**Abstract:** This article deals with the solution of simple differential equations using the Maple mathematical package using analytical methods, demonstration of this process in specific practical problems, the creation of algorithms and programs for solving the problem.

**Keywords:** Numerical solution, math package, maple, dsolve, method.

One of the areas of application of the computer remains the study of mechanical processes and mathematical models of objects using computational methods and computer software. The methods of computational mathematics and the modern capabilities of computers together serve to reveal the hitherto unknown features of mechanical processes and objects, and at the same time to improve technological processes.

Today, with the development of science and technology, the role of mathematics is growing. Mathematics is used in physics, mechanics and astronomy, as well as in solving economic problems, analyzing biological processes, and many other fields. The mathematical model of processes in these fields is called differential equations.

This scientific article deals with the application of computational mathematics and computers in scientific research and is scientifically and practically relevant (2). The paper deals with the problem of analytical and approximate solution of simple differential equations using the Maple program. The following is a sequential algorithm for problem solving and problem solving. Describe the calculation methods required to solve simple differential equations.

### **Object of research and methods used**

The object of research is simple differential equations, boundary value problems. Research methods: exact methods of problem solving, approximate-exact methods and numerical methods.

### **The results obtained and their analysis**

In practice, a chain of "elementary" calculations and substitutions that can be performed using an arbitrary mathematical package can also solve complex problems (for example, simple differential equations, solving boundary value problems). The Maple software package allows you to find solutions to many problems in specialized departments of higher mathematics. The technology of working in the Maple environment can be found in the specialized **References:** (4). The Maple math package can be used in practical classes on "Differential Equations" and "Higher Mathematics", in seminars, in the classes of elective disciplines on simple differential equations and systems of equations, numerical solution of boundary value problems.

Suppose a material point moves along the OX axis. Let the motion function be

$f(t)$ . Moreover, at a moment  $t=t_0$ , let its abscissa take the value  $x_0$ . Find the law of motion of this material point (6).

This is the mathematical model of the problem

$$\frac{dx}{dt} = f(t), \quad x(t_0) = x_0$$

is represented by the differential equation and the initial condition. Let's take another example. The rate of decay of radium, which is a radioactive substance, is directly proportional to its amount. Suppose that at moment  $t$  there is a radius  $R_0$ g. Determine the amount of radium  $R$ g at an arbitrary moment  $t$ .

If the coefficient of proportionality is equal to  $c$  ( $c > 0$ ), then the problem is reduced to the solution of this differential equation (3).

$$\frac{\partial R}{\partial t} = -cR$$

This is the solution of the equation at  $R=R_0$  at  $t=t_0$

$$R=R_0 e^{-c(t-t_0)}$$

represented by the function.

From the above problems, it can be seen that a single differential equation can be satisfied by several functions, so the main goal of the theory of differential equations is to find all the solutions of a given equation and study their properties. To achieve this goal, we now have special math packages. These are Maple, Mathcad, MathLab, Mathematica and so on. Using these packages, we can solve simple differential equations.

To achieve this, we first discuss the differential equations, boundary value problems, their general and specific solutions, their analytical finding, and in what cases mathematical packages can be used.

The following command is used to find analytical solutions of differential equations in Maple:

```
dsolve (eq, var, options),
here
eq - differential equation;
var - indefinite functions;
options.
```

When entering a differential equation, the `diff` command is used to denote the product, for example, the differential equation  $y'' + y = x$  is written as:

```
diff(y(x),x$2)+y(x)=x.
```

This is to construct a graph of a numerical solution of a differential equation

```
odeplot(dd, [x,y(x)], x=x1..x2)
```

can be used as a function, where  $dd := dsolve(\{eq, cond\}, y(x), numeric)$  is used as a function, followed by a variable and unknown function in square brackets  $[x, y(x)]$  and the graph construction interval is shown as  $x = x1..x2$ .

To do this, we first find a numerical solution to the Cauchy problem, and then construct a graph of the solution found:

Let's find the numerical and approximate solution of the following Cauchy problem in the form of a 2nd order series:

$$y'' + x \sin(y) = -\sin x, \quad y(0) = -1, \quad y'(0) = 1.$$

To do this, we first find a numerical solution to the Cauchy problem, and then construct a graph of the solution found:

```
> restart; ordev=6:
> eq:=diff(y(x),x$2)+x*sin(y(x))= - sin(x):
> cond:=y(0)=-1, D(y)(0)=1:
> de:=dsolve({eq,cond},y(x),numeric);
> de:=proc(rkf45_x)...end proc
```

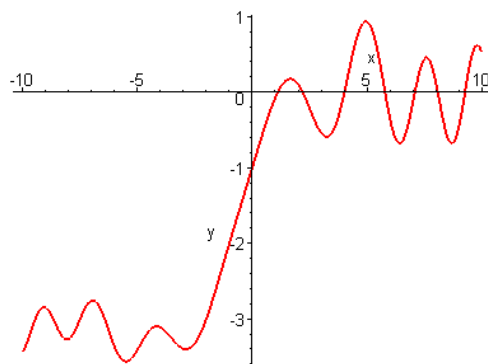
The result shows the use of the `rkf45` method. If the line does not provide the required information, this intermediate command should be separated by a colon. If it is necessary to obtain a result for a fixed value of  $x$  (for example, to subtract the value of the product of the solution at this point), for example, at  $x = 0.5$ , then the following is dialed (Figure 1):

```
> de(0.5);
```

$$\left[ x = 0.5, y(x) = -0.506443236120395878, \frac{d}{dx} y(x) = 0.954575202000664592 \right]$$

```
> with(plots):
```

```
>odeplot(de,[x,y(x)],-10..10,thickness=2);
```



**Figure 1. Graph of the numerical solution of the Cauchy problem.**

Cauchy problem or solution of boundary value problem. The dsolve command can find a solution to a Cauchy problem or a boundary value problem if the initial and boundary conditions of the indefinite function are given for a given differential equation. A differential operator is used to denote products under initial or boundary conditions, for example,  $y''(0) = 2$ , or  $y'(1) = 0$ . Note that it is written as an n-th order product.

1). Let's try to solve the problem in practice and do the following, that is, find a solution to the Cauchy problem.

$y^{(4)} + y'' = 2\cos x$ ,  $y(0) = -2$ ,  $y'(0) = 1$ ,  $y''(0) = 0$ ,  $y'''(0) = 0$ .

**Solution:**

```
> de:=diff(y(x),x$4)+diff(y(x),x$2)=2*cos(x);
```

$$de := \left( \frac{\partial^4}{\partial x^4} y(x) \right) + \left( \frac{\partial^2}{\partial x^2} y(x) \right) = 2 \cos(x)$$

```
> cond:=y(0)=-2, D(y)(0)=1, (D@@2)(y)(0)=0,
```

```
(D@@3)(y)(0)=0;
```

```
2, D(y)(0)=1, (D-cond:=y(0)=(2))(y)(0)=0, (D(3))(y)(0)=0
```

```
> dsolve({de,cond},y(x));
```

```
y(x2cos(-) = x-)xsin(x)+x.
```

2). Solve another type of simple differential equation using the Maple program using a variety of analytical methods:

$\sin(x) y'(x) - \cos(x) y(x) = 0$

**Solution:**

```
> ode_L:=sin(x)*diff(y(x),x)-cos(x)*y(x)=0;
```

$$ode\_L := \sin(x) \left( \frac{d}{dx} y(x) \right) - \cos(x) y(x) = 0$$

```
> dsolve(ode_L,[linear],useInt);
```

$$y(x) = \_CI e^{\int \frac{\cos(x)}{\sin(x)} dx}$$

> value(%);

$$y(x) = \_CI \sin(x)$$

> dsolve(ode\_L,[separable],useInt);

$$\int \frac{\cos(x)}{\sin(x)} dx - \left( \int^{y(x)} \frac{1}{\_a} d\_a \right) + \_CI = 0$$

> value(%);

$$\ln(\sin(x)) - \ln(y(x)) + \_CI = 0$$

There is no clear analytical solution to most types of differential equations. In this case, the solution of the differential equations can be found using approximate methods, that is, by finding the indefinite function by spreading it on a series of levels.

To find the solution of a differential equation in the form of a power series, you must specify the type = series (or simply series) parameter after the variables in the dsolve command. To specify the nth order of the spread, that is, the order of the degree before the end of the spread, place the command Order: = n, which determines the order before the dsolve command.

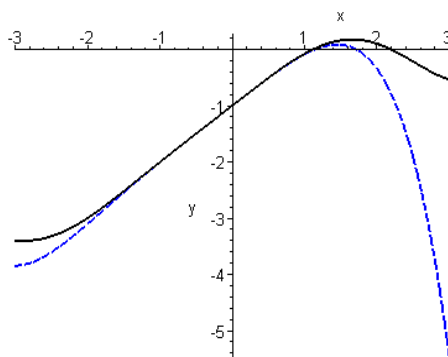


Figure 2. Graph of the solution of the Cauchy problem.

Now we find the solution of the Cauchy problem in the form of a series of levels, and make a numerical solution and a graph of the resulting level series for the interval at which they can fall (Figure 2).

```
> dsolve({eq, cond}, y(x), series);
```

$$y(x) = -1 + x + \left( \frac{1}{6} \sin(1) - \frac{1}{6} \right) x^3 - \frac{1}{12} \cos(1) x^4 + \left( -\frac{1}{40} \sin(1) + \frac{1}{120} \right) x^5 + O(x^6)$$

```
> convert(%, polynom):p:=rhs(%):
```

```
> p1:=odeplot(de,[x,y(x)],-3..3, thickness=2,
color=black):
```

```
> p2:=plot(p,x=-3..3,thickness=2,linestyle=3,
color=blue):
```

```
> display(p1,p2);
```

1-The graph shows that the values of the solution that are very close to the power series are  $-3 < x < 1$ .

If it is necessary to solve such problems in a simple mathematical way, as well as to create a schedule, it will take a lot of time and skills from students, researchers and teachers. From the above problem, it can be easily solved in Maple environment and at the same time create a graph of it.

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