The problems that lead to the differential equation and the ways to solve them

A.Turgunov-Kokand SPI senior teacher
M.Askaraliyeva-Kokand SPI teacher

Annotation: This article covers the simple issues that lead to differential equations and the ways to solve them, and provides solutions to issues and examples related to them.

Keywords: Differential Equation, continuous, material point, simple differential equation, private derivative differential equation.

Let's see the first simple issues that lead to differential equations.

1) in the Hoy coordinate equation, find such a continuous curve that the tangent of the angle formed by the positive direction of the abscissa axis of the attempt on each (x,y) point of it is equal to the hesitant of the abscissa of the attempt point.

Suppose y=f (x) be the sought curve. Under the condition of the issue y=f(x) the angular coefficient of the attempt at the point M(x,f (x)) of the curve is equal to f^' (x)= 2x.

Solution of the issue

$$\frac{dy}{dx} = 2x$$

it is brought to the solution of the seemingly simple equation.

The solution to this equation will be y=x^2+C,C - an optional invariant number. The geometric meaning of the solution of the tense issue consists of a family of parabolas on the Hoy coordinate plane.

2) Find the law of motion of a moving material point with invariant acceleration.

It is known that the second order derivative (d^2 s)/(dt^2) obtained by Time t from Path S gives acceleration. Under the condition of the issue (d^2 s)/(dt^2)=a, a is an invariant number.

The solution to this equation is s=(at^2)/2+C_1 t+C_2,C_1,C_2-optional invariant numbers.

Description. Erkli variable x, unknown function y and its y^', y^'',..., the equation that represents the link between the derivatives y^((n)) is called the differential equation.

The differential equation can be written symbolically as follows:

$$F\left(x, y, y', y'', \dots y^{(n)}\right) = 0 \qquad (1)$$

When an unknown function involved in an equation is a function with one variable, such an equation is called a simple differential equation. If the unknown function involved in the equation is a function of one variable, such an equation is called a differential equation with a private derivative.

x ∂u/∂x=y ∂u/∂y (2)

(∂^2 u) / (∂x^2) =ə^2 (∂^2 u)/(∂y^2) (3)

here u=u (x, y), equations in appearance are examples of a differential equation with a private derivative.

In this course, we deal only with simple differential equations.

The order of the differential equation is said to be the highest order of the derivative entering the equation

For example, the equation y^'-2xy+3=0 will be an example of a first-order differential equation, and y^'' - xy^'=0 will be an example of a second-order differential equation.

The equation above (1), on the other hand, is an N-order differential equation.

The differential equation solution or integral is said to any y=(x) function that transforms it into an integral when it is put into a differential equation.

For example: 1) the solutions of the equation xy^'-y-x^2 =0 will be functions in the form y=x^2+Cx (C - optional invariant number). The solution can be made sure to put it in the equation.

2) y^''+4Y =0 of the equation y=sin2x,y=cos2x functions, generally y=c_1 sin2x,y=C_2 cos2x, or y=C_1 sin2x +C_2 cos2x functions in the form C_1,C_2 can be sure by putting the functions shown to the differential equation given in any values of the optional invariant quantities.

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General view of the first order differential equation

$F(x,y,y') = 0$ (1)

will. If the equation (1) can be solved in relation to y', it can be

$y'=f(x,y)$ (2)

it can be written in the form, and it is called the differential equation of the First Order, which is solved in relation to the derivative.

when $x=x_0$ y the condition that the function should be equal to a given number y_0 is called the initial condition. This condition is often

$y|_{x=x_0}=x_0$ (3)

it is written in appearance.

One of the main issues of the theory of differential equations of the First Order $y'=f(x,y)$ consists in finding a solution that satisfies the initial (3) condition. This issue is called the Cauchy issue.

The general solution of the first-order differential equation is that of one arbitrary C which depends on the invariant quantity, as well as satisfying the following conditions

y= form (x,C)

the function is told:

a) this function satisfies the differential equation C in any concrete value of the invariant quantity.

b) when $x=x_0$ is $y=y_0$ i.e. (3) even if the initial condition is any C of the quantity such a $C=C_0$ value can be found that y=form(x, C_0) the function satisfies the given initial condition.

In search of a general solution to a differential equation, it is often not solved in relation to y

F (x,y,Ç) =0 (4)

it remains to come to a visible attitude. When we solve this relationship in relation to y, we form a common solution. But solving (4) in relation to y will not be possible all the time. The equality in the Form (4), which represents the general solution without disclosure, is called the general integral of the differential equation.

As a result of assigning a certain value $C=C_0$ to an invariant quantity of optional C,the function y=form(x,C_0), which is formed from a common solution, is called a private solution. In this case,the relation F(x,y, C_0)=0 is called the private integral of the equation.

Example. $dy/dx=-y|x$ of the equation $y|_{x=2}=1$ Find the solution that satisfies the initial condition.

The general solution to a given equation will be y=C/X. Based on the initial conditions

In this case, we form a y=2/x private solution.

The action of finding the general solution or integral of a differential equation is called the Integral of a differential equation.

Solve the following equation. This equation is called an equation in which the exponents of the corresponding variables are integrated after being transferred to both sides of the equation .

$y'=f(x,y)$ the general solution to the equation y= (x,C) XOY represents a family of curves in the coordinate plane. These curves are called integral curves.

The differential equation and its solution have a simple geometric meaning.

Given $Y'=F(x,y)$ the family of straight lines that pass through each point of the area of determination of the equation and form an angle α=arctgf(x,y) with the abscissa axis is called the area of directions of the differential equation.

A line whose area of \ u200b \ u200bThe directions at each point is the same is called isoclina. The concept of isoclina can be interpreted again as follows:

Attempts at an integral curve with a homogeneous direction are called isoclina, the geometric role of the attempt points.

$y'=f(x,y)$ The isocline family of the equation is determined by equations f (x,y)=K.

(4) to describe the integral line passing through the point of the equation (x_0,y_0), isoclines are drawn corresponding to the sufficiently multiple values of K. Along each isoclina, barcodes with a corresponding angular coefficient k are made.

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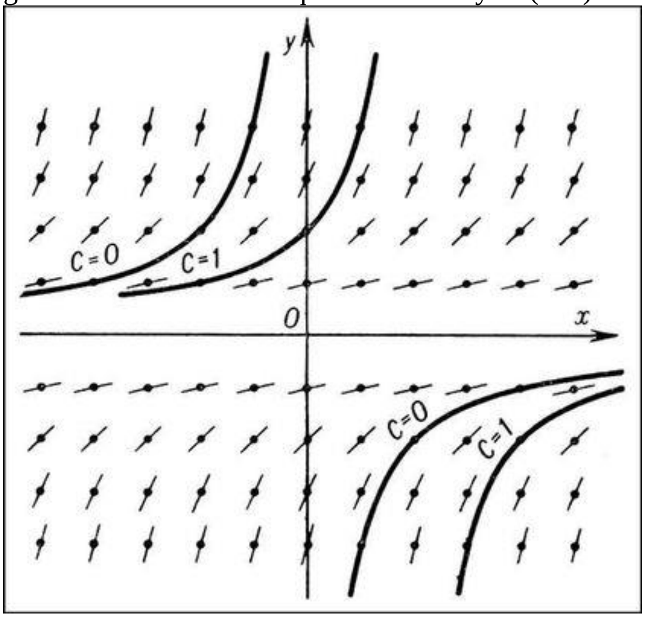
starting from the point (x_0,y_0), an integral line is made, parallel to these stryxes, each isocline.

In Figure 1, these constructions were carried out for equation dy/dx=y^2. It is not difficult to verify that the general solution to this equation will be y=1/(C-x).



$the\ equation\ y^{\wedge\prime}$
$= f(x,y)\ in\ some\ cases\ is\ as\ form\ substitutions\ be\ able\ to\ apply. Its\ right\ side\ is\ also\ the\ multiplication\ of\ a$

$$f\ (x,y) \cdot N(x,y)/N(x,y)\ = -M\ (x,y)/N\ (x,y)\ ,$$

$where\ f(x,y) \cdot N(x,y)\ is\ defined\ through\ the\ multiplication - M\ (x,y). Without\ it\ (2)\ the\ equation$

$$M\ (x,y)\ dx + N\ (x,y)dy = 0\ (*)$$

$$it\ can\ be\ recorded\ in\ a\ symmetrical\ view.$$

$In\ a\ symmetric - view\ ($
$*)\ differential\ equation, the\ variables\ x\ and\ y\ are\ equally\ strong, and\ the\ solution\ to\ the\ equation\ can\ be\ sou$
$= (x,C), or\ x = \psi(y,C), or\ oshkar\ \Phi(x,y\ C) = 0.$

$$The\ following$$

$$dy\ /\ dx = \ f(x)\varphi(y)\ (1)$$

$we\ look\ at\ the\ first$
$-\ order\ differential\ equation\ in\ appearance. we\ assume\ that\ the\ functions\ f(x)\ and\ \varphi(y)\ are\ continuous\ in$
$\neq 0\ in(c;d)\ intervals. By\ dividing\ (1)\ by\ \varphi\ (y)\ and\ multiplying\ by\ dx, the\ following$

$$dy/(\varphi\ (y)) = f\ (x)\ dx\ (2)$$

$$we\ write\ in\ appearance.$$

$$and\ F\ (x)\ functions\ are\ continuous, which\ means\ that\ there\ are\ initial\ functions:$$

$$\Phi\ (y) = \int\ dy\ /\ (\varphi(y)), f(x) = \ 〚〚f(x)dx〛$$

$$Hence, we\ see\ (2)\ as\ the\ equality\ of\ two\ differentials:$$

$$d\Phi\ (y) = dF(x)\ (3)$$

$From\ the\ danger\ of\ the\ differential\ of\ two\ functions\ (where\ y\ is\ considered\ a\ function\ of\ variable\ x), the\ i$

$$\Phi\ (y) = F\ (x) + Ç\ (4)$$

$$or$$

$$\int\ dy\ /\ (\varphi(y))\ = \ 〚〚f\ (x)\ DX〛 + ç(5)$$

$(4)\ or\ (5)\ (1)\ will\ be\ the\ general\ integral\ of\ the\ equation. Indeed\ (4)\ if\ we\ write\ down\ the\ relationship\ as\ fo$

$$G\ (x,y) = F\ (x)\ - \Phi(y)\ - S = 0\ (6),$$

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$The\ function\ G(x,y)\ satisfies\ the\ conditions\ of\ the\ theorem\ on\ an\ unmatched\ function: G\_x^{\wedge\prime}$
$= f(x), G\_y^{\wedge\prime} = -1/\varphi(y)\ functions\ D = \{\{(A < x < b@c < y$
$< d)\}\ in\ the\ field\ continuous\ and\ G\_y^{\wedge\prime}$
$\neq 0. For\ this\ reason, equation\ (6)\ defines\ y\ as\ the\ continuous\ and\ differentiating\ function\ of\ variable\ x\ and$

$$y^{\wedge\prime} = -(G\_x^{\wedge\prime})/(G\_y^{\wedge\prime}) = f\ (x)\varphi\ (y),$$

$thus, the\ function\ that\ is\ determined\ by\ the\ relation\ (6), then\ (5)\ will\ be\ the\ solution\ of\ a\ given\ differential$
$Any\ y\ function\ that\ is\ the\ solution\ of\ a\ differential\ equation\ given\ from\ the\ second\ side\ must\ satisfy\ the\ re$
$It\ also\ appears\ from\ (4)\ that\ for\ any\ (x\_0, y\_0)\ initial\ condition\ derived\ from\ D, a\ value\ of\ C\ corresponding$
$from\ the\ point\ ((x\_0, y\_0), the\ integral\ line\ \Phi(y) = F(x) + \Phi\ (y\_0\ ) - F\ (x\_0\ )\ passes.$
$Since\ \Phi\_y^{\wedge\prime} = 1/(\varphi(y))$
$\neq is\ 0, \Phi(y)\ will\ be\ the\ inverse. By\ defining\ the\ inverse\ function\ with\ \Phi^{\wedge}(-1), we\ find\ the\ sought\ solution:$

$$[\![y = \Phi]\!]\ ^{\wedge}(-1)\ (F(x) + \Phi\ (y\_0) - F\ (x\_0)))$$

$$Thus\ the\ following\ theorem\ proved:$$

$Theorem. If\ in\ the\ differential\ equation, where\ the\ variables\ dy/dx =$
$f(x)\varphi(y)\ are\ separated, the\ functions\ f\ (x)\ and\ \varphi(y)\ are\ continuous\ in\ the\ intervals\ (a; b)\ and\ (c; d)\ respect$
$0\ in\ the\ interval (c; d), then\ this\ equation\ has\ a\ common$integrali

$$\int \frac{dy}{\varphi(y)} = \int f(x)dx + C$$

is, in which the only solution of the equation under the terms initial x_0, y_0 is determined, where (x_0, y_0) D={[redacted](A<x<b@c<y<D)} is the arbitrary point of the rectangle.

The satisfying integral of the initial conditions of the differential equation can be written as follows: Φ(y) - Φ(y_0) =F (x) - F (x_0), or $\int_{y_0}^{y} \frac{dy}{\varphi(y)} = \int_{x_0}^{x} f(x)dx$

The results obtained above were obtained by assuming φ(y)≠0 at all points in the area being looked at. What happens if a y=β has φ(β)=0? It is directly seen that the equation (1) in this case has a solution y=β. But y=β da ∫▒dy / (φ(y)) the integral does not exist, which means that y=β the solution will not be formed (not derived) from a common solution.

Thus, if the equation(1) has φ (β)=0, then the equation will have a solution y=β that does not come from a common solution other than the common integral.

y = β the solution is considered to be a special yecim, that is, the condition of uniqueness at each of its points is considered to be non-breaking.

(2) Type

M(x)dx+N (y)dy =0 (4)

the variables of the differential equation are called the separated differential equation. According to what we have proven above, the general integral of this equation is

∫▒ 〖M(x)DX〗 +∫▒ 〖n(y)Dy〗 =C is.

Example. xdx + ydy=0

∫▒xdx +∫▒ydy = c_1 ⇒ X ^ 2/2+y^2/2=c_1⇒

⇒x^2+y^2=C^2, C^2=2C_1

The general integral of a given equation is x^2+y^2=C^2, consisting of a family of concentric circles with a center at the beginning of the coordinate, with a radius equal to C.

The following

M_1 (x) N_1 (y)dx+M_2 (x) N_2 (y)dy =0 (5)

the apparent equation variables are called the separable differential equation. By dividing both sides of this equation into an expression N_1 (y) M_2 (x)≠0, it can be brought to the equation in which its variables are separated.

(M_1(x))/(M_2(x)) dx+(N_2(y))/(N_1 (y)) dy =0

that is, we will have the equation in the Form (4).

Example. 1) let the general solution of the following equation y'=xy+x+y+1 be found. The given equation

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dy/dx=x(y+1)+(y+1)⇒ dy / dx=(x+1) (y+1)

we will record in appearance. This is an equation in which the variables of the equation are separated. assuming that y≠-1

dy|(y+1)=(x+1)dx⇒ln⁡|y+1 / =(x+1)^2/2+lnC⇒

⇒ln 〖〖(y+1)/ç〗 = (x+1)^2/2⇒y=Ce^(x+1)^2/2) -1

a common solution is formed.

2) solve the equation dy/dx=-y/X.

This is an equation in which the variables of the equation are separated and we divide and integrate the variables.

dy / dx=-y / x⇒dy / y= - dx / x⇒ln⁡|y|=-ln⁡|x / +lnC⇒y=C / x

a common solution is formed.

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