



**6th Ya.B. Lopatynsky International  
School-Workshop on Differential  
Equations and Applications**

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Vinnytsia, Ukraine**

**Book of Abstracts**

Ministry of Education and Science of Ukraine  
Vasyl' Stus Donetsk National University  
Taras Shevchenko National University of Kyiv  
Institute of Mathematics of the National Academy of Sciences of Ukraine  
Institute of Applied Mathematics and Mechanics  
of the National Academy of Sciences of Ukraine

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## Classical solution to the Poisson's equation

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Consider the Poisson's equation [1, c. 276]

$$\frac{\partial^2 u(x, y)}{\partial x^2} + \frac{\partial^2 u(x, y)}{\partial y^2} = -f(x, y), \quad (1)$$

and such function:

$$u_1(x, y) = \frac{i}{2} \int_0^y d\eta \int_{x-i(y-\eta)}^{x+i(y-\eta)} f(\xi, \eta) d\xi, \quad i = \sqrt{-1}. \quad (2)$$

Find the partial derivatives of the first and second orders of the function  $u_1(x, y)$ . On the basis of formula (2) we find

$$\frac{\partial u_1}{\partial x} = \frac{i}{2} \int_0^y (f(x+i(y-\eta), \eta) - f(x-i(y-\eta), \eta)) d\eta. \quad (3)$$

Introduce the notation:  $\alpha(x, y, i, \eta) = x+i(y-\eta)$ ;  $\beta(x, y, i, \eta) = x-i(y-\eta)$ . For  $f(x, y) \in C^{1,0}$  we have

$$\frac{\partial^2 u_1}{\partial x^2} = \frac{i}{2} \int_0^y \left( \frac{\partial f(\alpha(x, y, i, \eta), \eta)}{\partial \alpha} - \frac{\partial f(\beta(x, y, i, \eta), \eta)}{\partial \beta} \right) d\eta;$$

$$\frac{\partial u_1}{\partial y} = \frac{i}{2} \int_0^y (if(x+i(y-\eta), \eta) + if(x-i(y-\eta), \eta)) d\eta;$$

$$\frac{\partial^2 u_1}{\partial y^2} = \frac{i}{2} \int_0^y (i^2 \partial f(\alpha(x, y, i, \eta), \eta) - i^2 \partial f(\beta(x, y, i, \eta), \eta)) d\eta - f(x, y).$$

So,

$$\frac{\partial^2 u(x, y)}{\partial x^2} + \frac{\partial^2 u(x, y)}{\partial y^2} = -f(x, y).$$

This signifies that the function  $u_1(x, y)$  defined by the formula (3) is a partial solution to the equation (1).

Similarly we prove, the function

$$u_2(x, y) = \frac{i}{2} \int_y^\pi d\eta \int_{x+i(y-\eta)}^{x-i(y-\eta)} f(\xi, \eta) d\xi, \quad i = \sqrt{-1}, \quad (4)$$

for  $f(x, y) \in C^{1,0}$ , is a partial solution to the equation (1).

**Theorem.** If the function  $f(x, y) \in C^{1,0}$ , then the function

$$u(x, y) = \frac{i}{4} \int_0^y d\eta \int_{x-i(y-\eta)}^{x+i(y-\eta)} f(\xi, \eta) d\xi + \frac{i}{4} \int_y^\pi d\eta \int_{x+i(y-\eta)}^{x-i(y-\eta)} f(\xi, \eta) d\xi.$$

is the classical ( $u \in C^{2,2}$ ) solution to the equation (1).

## References

- [1] A. N. Tikhonov, A. A. Samarskiy, Equations of mathematical physics, M Nauka, 1977, 735 p.

## Operator research of classical solutions to boundary-value problems for hyperbolic second order equations

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Statement of the problem: to find a classical solution to the hyperbolic second equation

$$u_{tt} - u_{xx} = g(x, t), \quad 0 \leq x \leq \pi, \quad t \in \mathbb{R},$$

which satisfies the boundary conditions

$$u(0, t) = u(\pi, t) = 0, \quad t \in \mathbb{R}.$$

We have proved that the classical solution to the problem (1), (2) is the function [1,

$$u(x, t) = (Rg)(x, t) \equiv (Sg)(x, t) + (\tilde{S}g)(x, t),$$

where

$$(Sg)(x, t) = -\frac{1}{4} \int_0^x d\xi \int_{t-x+\xi}^{t+x-\xi} g(\xi, \tau) d\tau - \frac{1}{4} \int_x^\pi d\xi \int_{t+x-\xi}^{t-x+\xi} g(\xi, \tau) d\tau;$$

$$(\tilde{S}g)(x, t) = \frac{\pi-x}{4\pi} \int_0^\pi d\xi \int_{t-\xi}^{t+\xi} g(\xi, \tau) d\tau - \frac{x}{4\pi} \int_0^\pi d\xi \int_{t-\pi+\xi}^{t+\pi-\xi} g(\xi, \tau) d\tau;$$

$g(x, t) \in C^{0,1}$ ,  $C^{0,1}$  – is the space of functions of two variables, continuous and bounded together with the derivative of  $t$ , defined on the set  $[0, \pi] \times \mathbb{R}$ .