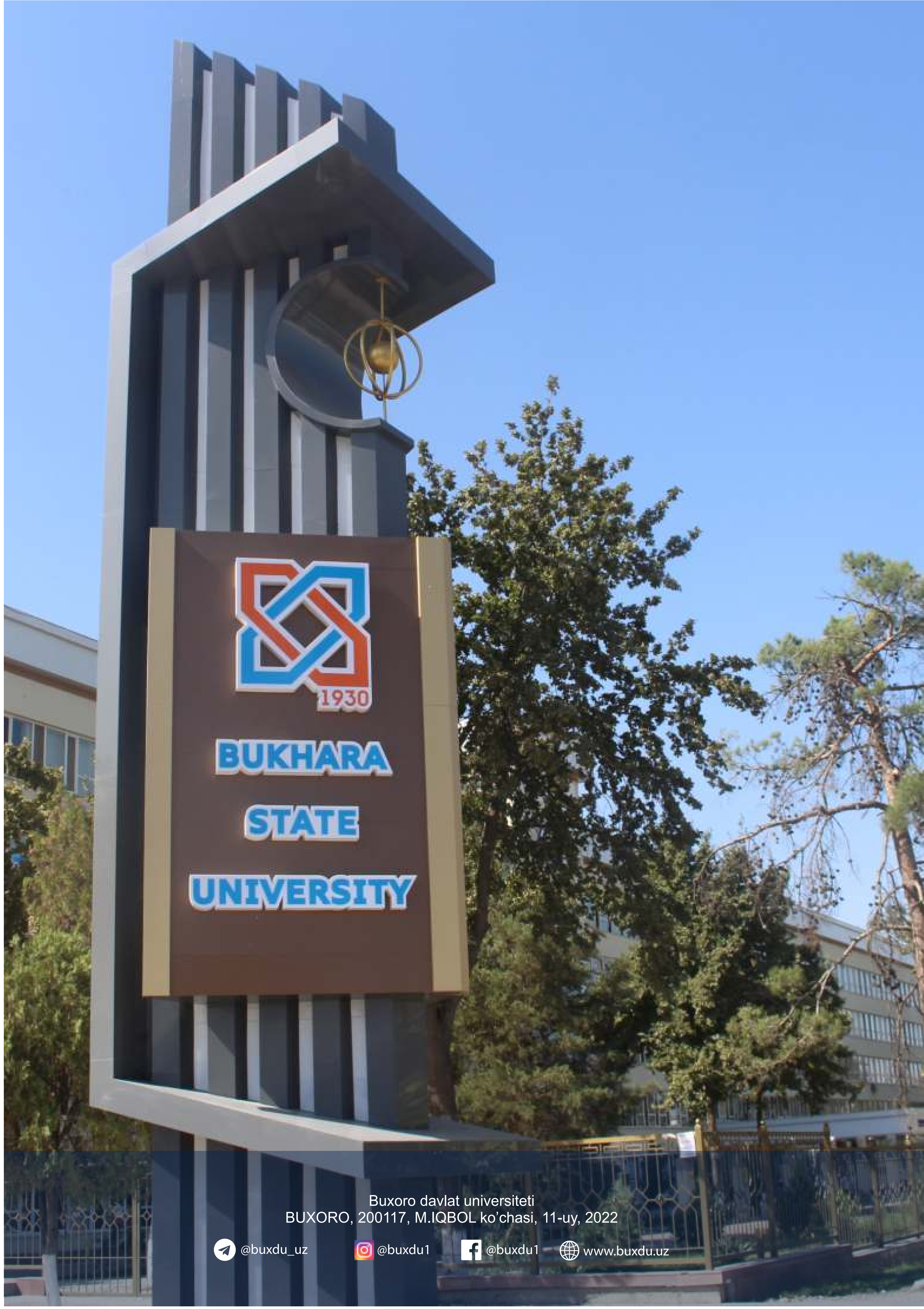

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«AMALIY MATEMATIKA VA AXBOROT TEXNOLOGIYALARINING ZAMONAVIY MUAMMOLARI»
XALQARO ILMIY-AMALIY ANJUMAN

TOSHKENT DAVLAT TRANSPORT UNIVERSITETI
Tashkent state transport university

BUXORO DAVLAT UNIVERSITETI

«AMALIY MATEMATIKA VA AXBOROT TEXNOLOGIYALARINING ZAMONAVIY MUAMMOLARI» XALQARO ILMIY-AMALIY ANJUMAN MATERIALLARI

ABSTRACTS INTERNATIONAL SCIENTIFIC AND PRACTICAL CONFERENCE «MODERN PROBLEMS OF APPLIED MATHEMATICS AND INFORMATION TECHNOLOGIES»

МАТЕРИАЛЫ МЕЖДУНАРОДНОЙ НАУЧНО-ПРАКТИЧЕСКОЙ КОНФЕРЕНЦИИ «СОВРЕМЕННЫЕ ПРОБЛЕМЫ ПРИКЛАДНОЙ МАТЕМАТИКИ И ИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ»

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ЎЗБЕКИСТОН РЕСПУБЛИКАСИ
ОЛИЙ ВА ЎРТА МАХСУС ТАЪЛИМ ВАЗИРЛИГИ
ЎЗБЕКИСТОН РЕСПУБЛИКАСИ ФАНЛАР АКАДЕМИЯСИ
В.И. РОМАНОВСКИЙ НОМИДАГИ МАТЕМАТИКА ИНСТИТУТИ
ЎЗБЕКИСТОН МИЛЛИЙ УНИВЕРСИТЕТИ
ТОШКЕНТ ДАВЛАТ ТРАНСПОРТ УНИВЕРСИТЕТИ
БУХОРО ДАВЛАТ УНИВЕРСИТЕТИ

Бухоро фарзанди, Беруний номидаги Давлат мукофоти лауреати, кўплаб ёш изланувчиларнинг ўз йўлини топиб олишида раҳнамолик қилган етук олим, физика-математика фанлари доктори Ғайбулла Назруллаевич Салиховнинг 90 йиллик юбилейларига бағишланади

АМАЛИЙ МАТЕМАТИКА ВА АХБОРОТ ТЕХНОЛОГИЯЛАРИНИНГ ЗАМОНАВИЙ МУАММОЛАРИ

ХАЛҚАРО ИЛМИЙ-АМАЛИЙ АНЖУМАН МАТЕРИАЛЛАРИ

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БУХОРО – 2022

almashtirish yordamida qayta yozib,

$$u(x, l(y)t) =: U(x, y, t)\,; \qquad \tilde{\mu}(y) = \mu(l(y))$$

belgilashlar kiritamiz: bu yerda $l(y)$ funksiya y va z o'rtasidagi bog'lanish.

Almashtirishlarni (1) tenglamaga keltirib qo'yish natijada, (1) tenglama quyidagi ko'rinishni oladi:

$$\frac{\partial^2 U}{\partial t^2} - \frac{\partial^2 U}{\partial y^2} + \tilde{\mu}(y)\frac{\partial^2 U}{\partial x^2} - a(y)\frac{\partial U}{\partial y} == \int_0^t k(x,\tau)\left(\frac{\partial^2 U}{\partial y^2} + \tilde{\mu}(y)\frac{\partial^2 U}{\partial x^2} - a(y)\frac{\partial U}{\partial y}\right)d\tau \qquad (5)$$

bu yerda $a(\mathrm{y}) = \frac{2\tilde{\mu}(y)+\tilde{\mu}'(y)}{2\tilde{\mu}^2(y)}$ ga teng.

Faraz qilaylik, noma'lum $\mathrm{k(x, t)}$ yadro x o'zgaruvchiga kuchsiz bog'liq bo'lsin, ya'ni :

$$k(x,t) = k_0(t) + \varepsilon x k_1(t) + \ldots \qquad (6)$$

bu yerda ε −kichik parametr.

Ushbu ishda biz $k_0(t)$ funksiyani topish bilan shug'ullanamiz. Buning uchun (1), (2) masala yechimini

$$\mathrm{U(x,y,t) = U_0(x,y,t) + \varepsilon U_1(x,y,t)} + \cdots \qquad (7)$$

va $g(x,y,t)$ ni

$$g(x,y,t) = g_0(x,y,t) + \varepsilon g_1(x,y,t) + \cdots \qquad (8)$$

ko'rinishda yozamiz.

Ishning asosiy maqsadi (3) qo'shimcha shart asosida (1)-(2) masaladan $\mathrm{U_0}$ va $\mathrm{k_0}$ funksiyalarni topish talab etiladi.

$\mathrm{U_0}$ va $\mathrm{k_0}$ funksiyaning ε bo'yicha yoyilmalarini (1), (5) tenglamalarga qo'yiladi va natijada bir xil darajali ε lar oldidagi koeffitsiyentlarni tenglashtirish natijasida U_0, k_0 funksiyalarga nisbatan quyidagi masalaga kelamiz:

$$\frac{\partial^2 U_0}{\partial t^2} = \left(\frac{\partial^2}{\partial y^2} - \tilde{\mu}(y)\frac{\partial^2}{\partial x^2} + a(y)\frac{\partial}{\partial y}\right)\left[U_0 + \int_0^t k_0(\tau)U_0(x,y,t-\tau)d\tau\right] \qquad (9)$$

$$U_0|_{\mathrm{t<0}} \equiv 0, \qquad (10)$$

$$U_{0y}\big|_{y=0} = \sqrt{\tilde{\mu}(0)}\delta(x)\cdot\delta'(t) \qquad (11)$$

$$U_0|_{y=0} = g_0(x,t) \qquad (12)$$

(9)-(12) masalani $D_T = \{(x,y,t): x \in R,\ 0 \le y \le t \le T - y\}$ sohada qaraymiz.

Quyidagi teorema o'rinli:

Teorema. *Faraz qilaylik,* $g_0(t) = -\sqrt{\tilde{\mu}(0)}\delta(t) + \theta(t)g_{00}(t)$ *bo'lib* $\tilde{\mu}(y)\epsilon C^3\left[0,\frac{T}{2}\right]$ *sinfdan bo'lsin, bu yerda* $g_{00}(t)\epsilon C^2[0,T]$ *−ma'lum funksiya va* $\theta(t)-$ *Xevisayde funksiyasi bo'lib,* $\delta(t) = \frac{d\theta}{dt}$. *U holda ixtiyoriy tayinlangan* $T > 0$ *lar uchun (9)−(12) teskari masalaning* $k(t)\epsilon C^2[0,T]$ *sinfga tegishli yagona yechimi mavjud, bu yerda*

$$g_m(t) = \int_{-\infty}^{+\infty} x^m g_m(x,t)dx\,, \qquad m = 0,1,2,\ldots.$$

O'ZGARUVCHAN KOFFITSIYENTLI ELASTIK YOPISHQOQLIK TENGLAMASIDAGI INTEGRAL HAD YADROSINI ANIQLASH.

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Gorizontal o'q bo'yicha kuchsiz maxsuslikka ega bo'lgan muhitda integro-differensial to'lqin tenglmasidan integral hadining yadrosini aniqlash bo'yicha quyidagi teskari masalani tadqiq qilamiz.

$$\frac{\partial^2 U}{\partial t^2} = \mu(z)\left[\frac{\partial^2 U}{\partial x^2} + \frac{\partial^2 U}{\partial z^2}\right] + \int_0^t k(x,\tau)\mu(\tau)\left[\frac{\partial^2 U}{\partial x^2} + \frac{\partial^2 U}{\partial z^2}\right](x,z,t-\tau)d\tau, \qquad (1)$$

$$U|_{t<0} \equiv 0, \qquad U_z|_{z=0} = \delta(x)\cdot\delta'(t) \qquad (2)$$

$$U|_{z=0} = f(x,t) \qquad (3)$$

bu yerda $(x,z,t)\epsilon R^3{}_T \coloneqq \{(x,z,t): x \in R, t > 0, z > 0\}$, $\delta(x), \delta'(t) -$ Dirakning delta funksiyasi va uning hosilasi. Faraz qilaylik, noma'lum $k(x,t)$ yadro x o'zgaruvchiga kuchsiz bog'liq bo'lsin, ya'ni:

$$k(x,t) = k_0(t) + \varepsilon x k_1(t) + \cdots, \qquad (4)$$

bu yerda ε −kichik parametr. Ushbu ishda biz $\{k_2, k_1\}$ funksiyalarni topish bilan shug'ullanamiz. Buning uchun (1), (2) yechimni

$$U(x,z,t) = U_0(x,z,t) + \varepsilon U_1(x,z,t) + \cdots \qquad (5)$$

ko'rinishda yozamiz. U va k funksiyalarning ε bo'yicha yoyilmalarini (1), (5) tenglamalarga qo'yiladi va bir xil darajali ε lar oldidagi koeffisiyentlarni tenglashtirish natijasida U_n funksiyalarga nisbatan

$$\frac{\partial^2 U_n}{\partial t^2} = \mu(z)\left[\frac{\partial^2 U_n}{\partial x^2} + \frac{\partial^2 U_n}{\partial z^2}\right] +$$

$$+\int_0^t \sum_{j=0}^{n} k_j\,(t-\tau)[\mu(z)\frac{\partial}{\partial x}(x^j U_{(n-j)x}) + \mu(z)\frac{\partial}{\partial z}(x^j U_{(n-j)z})]d\tau, \tag{6}$$

$$U_n|_{t<0} \equiv 0, \tag{7}$$

$$U_{nz}|_{z=0} = \delta_{n0}\delta(x)\cdot\delta'(t) \tag{8}$$

$$U_n|_{z=0} = f_n(x,t), \qquad n = 0,1,2,..., \tag{9}$$

masalalar olinadi, bu yerda δ_{n0} – Kroneker simvoli $\delta_{ij} = 1, \quad i = j, \delta_{ij} = \xi, \quad i \neq j.$ (6)–(9) tenglamalarning har ikkala tomonini x^m ga ko'paytirib, natijani x bo'yicha minus cheksizlikdan plyus cheksizlikgacha oraliqda integrallab, quyidagi tenglikga ega bo'lamiz

$$\left(U_{n,m}\right)_{tt} = \mu(z)\left[m(m-1)U_{n,m-2} + (U_{n,m})_{zz}\right] +$$

$$+\int_0^t \sum_{j=0}^{n} k_j(1-t)[\mu m(m+j-1)U_{n-j,m+j-2} + \mu\left(U_{n-j,m+j}\right)_{zz}]d\tau \tag{10}$$

(10) da $U_{n,m}$ orqali U_n funksiyaning m-momentlari belgilanadi.

$$U_{n,m}(z,t) = \int_{-\infty}^{+\infty} x^m U_n(x,z,t)dn \tag{11}$$

(10) tenglamani olishda ixtiyoriy chekli *t* lar uchun U_n *(n=0,1,2,...)* funksiyalar chekli tartibli singulyar umumlashgan va regulyar funksiyalarning yig'indisi ko'rinishida tasvirlanishi, hamda
U_n ning tashuvchisi chegaralanganligidan foydalanildi: $U_{n,m}$ quyidagi boshlang'ich va chegaraviy shartlarni qanoatlantiradi.

$$U_{n,m}|_{t<0} \equiv 0, \qquad U_{n,mz}|_{z=0} = \delta_{n0}\delta_{m0}\delta'(t). \tag{12}$$

Faraz qilaylik

$$U_{n,mz}|_{z=0} = \int_{-\infty}^{+\infty} x^n f_n(x,t)dx = f_n(t), \tag{13}$$

bo'lsin, bu yerda $f_n(t)$ *(n=0,1,2,...)* berilgan yetarlicha silliq funksiyalar.

Ishning asosiy maqsadi k_0 funksiyani topishdan iborat. Buning uchun $n = m = 0$ holni qaraymiz. U holda (10)-(12) lar yordamida k_0, U_0 larni aniqlash uchun quyidagi tenglamalar

$$\frac{\partial^2 U_{00}}{\partial t^2} = \mu(z)\frac{\partial^2 U_{00}}{\partial t^2} + \int_0^t k_0(t-\tau)\mu\frac{\partial^2 U_{00}}{\partial t^2}(z,\tau)d\tau \tag{14}$$

va

$$U_{00}|_{t<0} \equiv 0, \qquad U_{00z}|_{z=0} = \delta'(t), \tag{15}$$

$$U_{00}|_{z=0} = f_0(x,t)\,, \qquad n = 0,1,2,... \tag{16}$$

boshlang'ich chegaraviy shartlarni qanoatlantiruvchi masalani hosil qilamiz.
Yangi o'zgaruvchi y ni quyidagi formula bilan kiritamiz

$$y = \int_0^z \frac{d\xi}{\sqrt{\mu(\xi)}}\,. \tag{17}$$

$l(y)$ orqali y va z o'zgaruvchilar orasidagi bog'lanish va $\breve{\mu}(y) = \mu\big(l(y)\big)$ belgilashni kiritamiz (13)-(15) masalani $D_T \coloneqq \{(y,t)\colon 0 \le y \le t \le T - y\}$ sohada qaraymiz.Quyidagi teorema o'rinli.
Teorema 1.$f_0(t) = -\delta(t) + \theta(t)f_{00}(t)$ bo'lib $\breve{\mu}(y)\epsilon C^3\left[\xi;\,\frac{\tau}{2}\right]$ sinfdan bo'lsin, bu yerda $f_{00}(t)\epsilon C^2\left[0;\,\frac{\tau}{2}\right]$, $\theta(t)$ – Hevisayde funksiyasi va $\delta(t) = \frac{d\theta}{dt}$. U holda ixtiyoriy tayinlangan $T > 0$ lar uchun (13)–(16) teskari masalaning $k(t)\epsilon C^2[0,\tau]$ sinfga tegishli yechimi mavjud.