



**Samarqand davlat universitetning kattaqo'rg'on filiali Aniq va tabiiy fanlar fakulteti 3-bosqich Matematika ta'lim yo'nalishi talabalariga 5-semestr uchun « Funksional Analiz » fanidan yakuniy nazorat savollari**

**Imtihon shakli: yozma**

| No | Mavzu                                                                                                                                                  | 1-QISM                                            | 2-QISM                                                           | 3-QISM                                                                                                             | 4-QISM                                                                                                        | 5-qism                                                                                                           |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| 1. | Metrik fazolar va ularga misollar. Metrik fazolarni uzluksiz akslantirishlar. Izometriya. Metrik fazolarda yaqinlashishlar. Ochiq va yopiq to'plamlar. | Metrik fazoning ta'rifi va misollar.              | Metrik fazoda uzluksiz akslantirish ta'rifi va misol             | $\rho(x, y) =  \cos x - \cos y $ , $x, y \in \mathbb{R}$ metrika bo'ladimi? Metrikaning qaysi sharti bajarilmaydi. | $X = \mathbb{R}^1$ . $\rho(x, y) = (x - y)^2$ metrika bo'ladimi? Qaysi metrik shart bajarilmaydi.             | $X = \mathbb{R}^1$ . $\rho(x, y) =  \sin x - \sin y $ metrika bo'ladimi. Qaysi metrika sharti bajarilmaydi.      |
| 2. |                                                                                                                                                        | Metrik fazoda gomeomorfizm ta'rifi va misol       | Gyolder tengsizligini isbotlang                                  | $\mathbb{Q}$ ni $\mathbb{R}$ ning hamma yerida zich ekanligini isbotlang.                                          | $X = \mathbb{R}^n$ , $\rho(x, y) = \sum_{k=1}^n  x_k - y_k ^2$ akslantirishni metrika shartlariga tekshiring. | $X = \mathbb{R}^2$ , $\rho(x, y) =  x_1 - y_2  +  y_1 - x_2 $ akslantirishni metrika shartlariga tekshiring.     |
| 3. |                                                                                                                                                        | Minkovskiy tengsizligini isbotlang.               | Metrik fazoda izometriya ta'rifi va misol                        | $\mathbb{R}$ metrik fazo bo'lishini isbotlang.                                                                     | $C[a; b]$ metrik fazo bo'lishini isbotlang.                                                                   | $\ell_2$ metrik fazo bo'lishini isbotlang.                                                                       |
| 4. |                                                                                                                                                        | Metrik fazoda yopiq to'plam ta'rifi va unga misol | Limit nuqta, yakkalangan nuqta ta'riflari va ularga oid misollar | $\mathbb{R} \setminus \mathbb{Q}$ ning barcha limitik nuqtalari to'plamini toping.                                 | Biror bo'sh bo'lmagan $X$ - to'plam va                                                                        | Shunday metrik fazoga va undagi ikkita $B(x_1, r_1)$ , $B(x_2, r_2)$ sharlarga misol keltiringki, $r_1 < r_2$ va |

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|    |  |                                                                               |                                                           |                                                                                                                                                                          | <p>bu to'plamda quyidagicha funksiya</p> $d(x, y) = \begin{cases} 0, & \text{agar } x = y \\ 1, & \text{agar } x \neq y \end{cases}$ <p>berilgan bo'lsin. Berilgan <math>d(x, y)</math>- funksiya metrika ekanligi isbotlansin.</p> | $B(x_1, r_1) \supset B(x_2, r_2)$<br>bo'lsin.                                                                                                                           |
| 5. |  | Metrik fazolarda yaqinlashish ta'rifi va unga doir misol.                     | Metrik fazolarda zich to'plamlar va ularga doir misollar. | $X = \ell_2, \rho(x, y) = \sum_{n=1}^{\infty}  x_n - y_n ^2$ akslantirishni metrika shartlariga tekshiring.                                                              | $[0,1]$ metrik fazoda $y_n(t) = t^n - t^{2n}$ ketma-ketlik yaqinlashuvchi bo'ladimi?                                                                                                                                                | $C[0,1]$ metrik fazoda $x_n(t) = t^n - t^{n+1}$ ketma-ketlik yaqinlashuvchi bo'ladimi?                                                                                  |
| 6. |  | To'plamning yopig'i ta'rifi                                                   | Metrik fazoda ochiq to'plam ta'rifi va unga misol         | $[0,1]$ metrik fazoda $x_n(t) = t^n - 2t^{n+1} + t^{n+2}$ ketma-ketlik yaqinlashuvchi bo'ladimi?                                                                         | $[0,1]$ metrik fazoda $x_n(t) = \frac{t^n}{n} - \frac{t^{n+1}}{n+1}$ ketma-ketlik yaqinlashuvchi bo'ladimi?                                                                                                                         | $x_n(t) = n^2 t e^{-nt}$ funksiyalar ketma-ketligi $x(t)=0$ funksiyaga har bir nuqtada yaqinlashuvchi, ammo $C_1[0,1]$ metric fazoda yaqinlashuvchi emas. Isbotlang.    |
| 7. |  | To'plam yopig'ining xossalari.                                                | To'plamning urinish nuqtasi ta'rifi va unga oid misol     | $X = N, x = 5, y = 24, \rho(x, y) = \frac{1}{10}  x - y $ . Berilgan metrikaga nisbatan bu funksiyalar orasidagi masofani toping.                                        | $X = R^2, \rho(x, y) =  x_1 - y_1  +  x_2 - y_2 ^2$ akslantirishni metrika shartlariga tekshiring.                                                                                                                                  | $\rho_1(f, g) = \int_a^b  f(x) - g(x)  dx, X = C[a, b]$ . Bu akslantirishni metrika shartlariga tekshiring.                                                             |
| 8. |  | Metrik fazoda yopiq to'plamlarning birlashmasi va kesishmasi haqidagi teorema | To'plamning limitik nuqtasi ta'rifi va unga oid misol     | $X = \mathbb{R}^3, \rho(x, y) = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2}$ . Berilgan metrikaga nisbatan $x = (8; 4; 3), y = (6; 0; -1)$ vektorlar orasidagi masofani toping. | $X = R^2, \rho(x, y) =  x_1 - y_1  + 2 x_2 - y_2 ^2$ akslantirishni metrika shartlariga tekshiring.                                                                                                                                 | $X = C[0, \pi], x(t) = \sin t, y = \cos t, \rho(x, y) = \max_{0 \leq t \leq \pi}  x(t) - y(t) $ . Berilgan metrikaga nisbatan bu funksiyalar orasidagi masofani toping. |

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| 9.  | To'la metrik fazolar.<br>Metrik fazolarni to'ldirish haqidagi teorema<br>Metrik fazolarda kompakt va nisbiy kompakt to'plamlar.<br>Qisuvchi akslantirishlar prinsipi va uning tadbiqlari | To'la metrik fazo ta'rifi va unga oid misollar.    | Metrik fazoni to'ldirmasi ta'rifi va unga oid misol           | $C[a, b]$ fazo to'la metrik fazodir. Isbotlang.                                                                                                                          | $\rho_1(f, g) = \int_a^b  f(x) - g(x)  dx$ , $X = C[a, b]$ .<br>Bu akslantirishni metrika shartlariga tekshiring.                                                        | $X = \ell_2, x = (1, 1, 0, 1, 0, 0, \dots), y = (0, 0, 0, \dots), \rho(x, y) = \sqrt{\sum_{n=1}^{\infty}  x_n - y_n ^2}$ . Berilgan metrikaga nisbatan bu elementlar orasidagi masofani toping. |
| 10. |                                                                                                                                                                                          | Kompakt metrik fazo ta'rifi va unga oid misollar   | Nisbiy kompakt tushunchasi va unga oid misollar               | $l_2$ fazosida yopiq va chegaralangan, ammo kompakt bo'lmagan to'plamga misol keltiring.                                                                                 | To'plamning chegaralanganligidan, uning nisbiy kompakt bo'lishi kelib chiqadimi? Misol keltiring.                                                                        | $C[0; 1]$ fazoda $\Phi = \{x_\alpha t = \frac{2\alpha t}{1+\alpha^2 t^2}, \alpha \in (0; \infty)\}$ funksiyalar oilasini nisbiy kompaktlikka tekshiring.                                        |
| 11. |                                                                                                                                                                                          | Qisuvchi akslantirish ta'rifi va unga oid misollar | Qo'zg'almas nuqta ta'rifi va unga oid misollar                | $f(x) = x + \frac{1}{x}$ akslantirish $[1; \infty)$ nurda qisqartiruvchi bo'ladimi?                                                                                      | $f(x) = 4x - 4x^2$ funksiya $[0; 1]$ kesmani o'zini-o'ziga akslantirishga tekshiring. Bu akslantirish qisqartiruvchi bo'ladimi?                                          | $A: f(x) \rightarrow \frac{1}{2} \int_0^1 x t f(t) dt + \frac{5}{6} x$ akslantirishning $C[0; 1]$ fazosida qisqartiruvchi ekanligini ko'rsating va uni qo'zg'almas nuqtasini toping.            |
| 12. |                                                                                                                                                                                          | Qisuvchi akslantirishlar prinsipi                  | Qisuvchi akslantirishga misol keltiring                       | $X = \mathbb{R}^3, \rho(x, y) = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2}$ . Berilgan metrikaga nisbatan $x = (7; 2; 3), y = (6; 0; -1)$ vektorlar orasidagi masofani toping. | $X = \mathbb{R}^3, \rho(x, y) = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2}$ . Berilgan metrikaga nisbatan $x = (8; 4; 3), y = (5; 1; -2)$ vektorlar orasidagi masofani toping. | $C[0, 2]$ fazoda aynan nol ( $\theta(t) \equiv 0$ ) va quydagi funksiya orasidagi masofani toping: $f(x) = x^3 - x^2 + 6$ .                                                                     |
| 13. | Chiziqli fazo ta'rifi va unga misollar. Izomorof                                                                                                                                         | Chiziqli fazo ta'rifi va unga oid misollar.        | Chiziqli fazolarning o'zaro izomorfligi ta'rifi va unga misol | Berilgan fazoda quyidagi elementlar chiziqli bog'lilanganmi? $\mathbb{R}^3: \bar{a} = (1, -2, 4), \bar{b} = (-1, 2, 3), \bar{c} = (1, 1, 0)$ .                           | Chiziqli bog'langanlikka tekshiring: $x_1(t) = 1, x_2(t) = \cos t, x_3(t) = \cos^2 t \in C[0, 2\pi]$ .                                                                   | Chiziqli bog'langanlikka tekshiring: $x_1 = (1, 1, 2), x_2 = (1, 0, 1), x_3 = (1, 0, 0) \in \mathbb{R}^3$ .                                                                                     |

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| 14<br>. | fazolar.<br>Chiziqli bog'langanli k. Chiziqli fazo o'lchami.                            | Chiziqli bog'langan elementlar sistemasi ta'rifi va unga misol   | Chiziqli fazo o'lchami va unga oid misollar                           | Chiziqli bog'langanlikka tekshiring: $x_1 = (1,1,0)$ $x_2 = (1,0,1)$ , $x_3 = (1,0,0) \in R^3$ .                                              | Chiziqli bog'langanlikka tekshiring: $x_1 = (1,1,2)$ $x_2 = (1,0,1)$ , $x_3 = (1,1,1) \in R^3$ .         | Chiziqli bog'langanlikka tekshiring: $x_1 = (2,1,2)$ $x_2 = (1,0,1)$ , $x_3 = (1,1,0) \in R^3$ .    |
| 15<br>. |                                                                                         | Chiziqli bog'lanmagan elementlar sistemasi ta'rifi va unga misol | Cheksiz o'lchamli chiziqli fazo ta'rifi va unga doir misol            | $C[a, b]$ chiziqli fazo ekanligini ko'rsating.                                                                                                | $\mathbb{R}^n$ chiziqli fazo ekanligini ko'rsating.                                                      | $\dim \mathbb{R}^3 = 3$ ekanligini ko'rsating.                                                      |
| 16<br>. |                                                                                         | Chekli o'lchamli chiziqli fazo ta'rifi va unga doir misol        | Chiziqli bog'langan va bog'lanmagan elementlar sistemalari ta'riflari | $E = R^3$ ; $x = (0,1,1)$ , $y = (1,0,1)$ , $z = (1,1,1)$ . Chiziqli erklilikka tekshiring..                                                  | $E = R^3$ , $x = (-1,0,1)$ , $y = (0,-1,1)$ , $z = (2,0,-1)$ . Chiziqli erklilikka tekshiring.           | $\dim \mathbb{R}^2 = 2$ ekanligini ko'rsating.                                                      |
| 17<br>. | Chiziqli fazoning qism fazosi. Chiziqli fazoning faktor fazosi                          | Chiziqli fazoning qism fazosi ta'rifi va misol                   | Chiziqli fazoning factor fazosi ta'rifi va misol                      | Berilgan fazoda quyidagi elementlar chiziqli bog'liqmi? $\mathbb{R}^3$ : $\bar{a} = (1,-2,-1)$ , $\bar{b} = (-1,2,3)$ , $\bar{c} = (1,1,0)$ . | Quyidagi vektorlar chiziqli erklimi: $\bar{a} = (1,-2,0)$ , $\bar{b} = (-1,0,3)$ , $\bar{c} = (1,1,0)$ . | $d = (2,-3,4)$ vektorni $a = (-1,2,0)$ , $b = (1,0,3)$ , $c = (0,-1,1)$ vektorlar orqali ifodalang. |
| 18<br>. | Chiziqli funksionallar . Qavariq to'plam va qavariq funksionallar . Xan-Banax teoremasi | Chiziqli fazoda chiziqli funksional ta'rifi va unga oid misol    | Qavariq to'plam ta'rifi va unga oid misol                             | Funksional chiziqlimi? $f: C[0,1] \rightarrow C$ , $f(x) = \int_0^\pi x(t) \cos t \, dt$ .                                                    | Funksional chiziqlimi? $f: L_1[0,1] \rightarrow C$ , $f(x) = \int_0^1 e^t x(t) dt$ .                     | $p: C[a,b] \rightarrow \mathbb{R}$ , $p(x) = \int_b^a  x(t)  dt$ funksional norma bo'ladimi?        |

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| 19<br>. |                                                                       | Chiziqli fazoda qavariq funksional ta'rifi va unga oid misol | Chiziqli fazolarda Xan-Banach teoremasi             | $p: C[a, b] \rightarrow R$ va $p(x) = \int_a^b  x(t)  dt$ bo'lsa $p$ akslantirish qavariq funksional ekanligini isbotlang | $\mathbb{R}^2$ fazoda $p(x, y) = x^2 + y^2$ funksionalni qavariqlikka tekshiring                                       | $\mathbb{R}^2$ fazoda $p(x, y) = \sqrt{x^2 + y^2}$ funksionalni qavariqlikka tekshiring                                                                                      |
| 20<br>. |                                                                       | Qavariq jism ta'rifi va unga oid misol                       | Qavariq to'plamlarning kesishmasi haqidagi teorema  | Funksional chiziqlimi? $f: R^3 \rightarrow R^*, f(x) = a_1x_1 + a_2x_2 + a_3x_3$ .                                        | Funksional chiziqlimi? $f: C_{[0,1]} \rightarrow C, f(x) = \int_0^1 t^2 x(t) dt$ .                                     | Funksional chiziqlimi? $f: L \rightarrow C, f(x) = \int_0^1 \sin t x(t) dt$ .                                                                                                |
| 21      |                                                                       | Qavariq to'plam va qavariq jism ta'riflari                   | Chiziqli funksionalni davomi ta'rifi                | Funksional chiziqlimi? $f: R \rightarrow R, f(x) = a_1x_1 + a_3x_3$ .                                                     | Funksional chiziqlimi? $f: L \rightarrow C, f(x) = \int_0^1 e^{3t} x(t) dt$                                            | Funksional chiziqlimi? $f: L \rightarrow C, f(x) = \int_0^1 \cos t x\left(\frac{t}{3}\right) dt$ .                                                                           |
| 22<br>. | Chiziqli normalangan fazo ta'rifi va unga misollar. To'la normalangan | Chiziqli normalangan fazo ta'rifi va unga oid misollar       | To'la normalangan fazo ta'rifi va unga oid misollar | $p: C^{(2)}[a, b] \rightarrow R, p(x) =  x(a)  +  x'(a)  + \max_{a \leq t \leq b}  x''(t) $ funksional norma bo'ladimi?   | $p: C^{(2)}[a, b] \rightarrow R, p(x) =  x(a)  +  x(b)  + \max_{a \leq t \leq b}  x''(t) $ funksional norma bo'ladimi? | $x_n(t) = \frac{nt}{1+n^2+t^2} \in C[0; 1], n = 1, 2, 3, \dots$ ketma-ketlik ko'rsatilgan fazoda nolga yaqinlashadimi? Bunda norma $\ x\  = \max_{a \leq t \leq b}  x(t) $ . |

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| 23<br>. | fazolar.<br>Normalangan fazoning qism fazosi va faktor fazosi.              | Norma ta'rifi va unga oid misol                            | Normalangan fazoning qism fazosi ta'rif va unga oid misol | $p: C[a, b] \rightarrow \mathbb{R}, p(x) = \int_b^a  x(t)  dt$ funksional norma bo'ladimi?                                   | $p: C^{(1)}[a, b] \rightarrow \mathbb{R}, p(x) = \max_{a \leq t \leq b}  x'(t) $ funksional norma bo'ladimi?                       | $P: C_{[a, b]} \rightarrow \mathbb{R}, p(x) = \left( \int_a^b  x(t) ^2 dt \right)^{\frac{1}{2}}$ funksional norma bo'ladimi? |
| 24<br>. |                                                                             | To'la normalangan fazo ta'rifi va unga oid misol           | Normalangan fazoning faktor fazosi                        | $p: \mathbb{R}^2 \rightarrow \mathbb{R}, p(x) = 2 x_1  + 3 x_2 $ funksional norma shartlarini qanoatlantirishini tekshiring. | $p: C^{(1)}[a, b] \rightarrow \mathbb{R}, p(x) =  x(b) - x(a)  + \max_{a \leq t \leq b}  x'(t) $ funksional norma bo'ladimi?       | $P: \mathbb{R}^n \rightarrow \mathbb{R}, p(x) =  x_1  +  x_2  + \dots +  x_n $ funksional norma bo'ladimi?                   |
| 25<br>. | Evklid fazosi ta'rifi.<br>Koshi-Bunyakovskiy tengsizligi.<br>Misollar.      | Evklid fazosi ta'rifi va unga oid misollar                 | Koshi-Bunyakovskiy tengsizligi                            | $E = C[a, b], p(x, y) = \int_a^b e^t x(t) y(t) dt$ ifoda skalyar ko'paytma bo'ladimi?                                        | $E = \mathbb{R}^3, p(x, y) = x_1 y_1 + x_2 y_2 - x_3 y_3$ ifoda skalyar ko'paytma bo'ladimi?                                       | $E = C[a, b], (x, y) = \int_a^b x^4(t) y^4(t) dt$ ifoda skalyar ko'paytma bo'ladimi?                                         |
| 26<br>. | Ortogonal normallangan sistema.<br>Shmidtning ortogonallashtirish jarayoni. | Ortogonal normallangan sistema tushuncha va unga oid misol | Shmidtning ortogonallashtirish jarayoni                   | $E = L_2[0, 1], x_1(t) = 1, x_2(t) = t$ . Chiziqli erklilikka tekshiring va ularni ortogonallashtiring.                      | $E = \mathbb{R}^3, x = (-1, 0, 1), y = (0, -1, 1), z = (2, 0, -1)$ . Chiziqli erklilikka tekshiring va ularni ortogonallashtiring. | $E = \mathbb{R}^3, x = (0, -1, 1), y = (2, 0, -1)$ . Chiziqli erklilikka tekshiring va ularni ortogonallashtiring.           |
| 27<br>. | Parseval tengsizligi va Parseval tengligi.<br>Yopiq ortogonal sistema.      | Bessel tengsizligi                                         | Parseval tengligi. Yopiq ortogonal sistema.               | $C_2[-\pi; \pi]$ separabel Evklid fazosida $\{\phi_n(t) = \pi^{-0.5} \sin nt\}_{n=1}^{\infty}$ sistema ortonormal bo'ladimi? | $C_2[-\pi; \pi]$ separabel Evklid fazosida $\{\phi_n(t) = \pi^{-0.5} \sin nt\}_{n=1}^{\infty}$ sistema to'la bo'ladimi?            | $C_2[-\pi; \pi]$ Evklid fazosida $\{\phi_n(t) = \sin nt\}_{n=1}^{\infty}$ sistemaning ortogonal ekanligini isbotlang.        |
| 28<br>. | To'la Evklid fazosi. Riss-Fisher teoremasi.<br>Evklid fazosining            | To'la Evklid fazosi ta'rifi va unga oid misollar           | Riss-Fisher teoremasi.                                    | $E = \mathbb{R}^2, (x, y) = x_1 y_1 - x_2 y_2$ ifoda skalyar ko'paytma bo'ladimi?                                            | $E = \mathbb{R}^2, (x, y) = x_1 y_1 - x_2 y_1 + 2x_2 y_2$ ifoda skalyar ko'paytma bo'ladimi?                                       | $L_2[-\pi; \pi]$ Evklid fazosida $\phi_n(t) = e^{int}, n \in \mathbb{Z}$ sistemaning ortogonal ekanligini isbotlang.         |

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|      | xarakteristik xossalari.                                                                          |                                                     |                                                                    |                                                                                    |                                                                                      |                                                                                                 |
| 29 . | Hilbert fazolari. Izomorfizm haqidagi teorema.                                                    | Hilbert fazo ta'rif va unga oid misollar            | Separabel Hilbert fazolarining o'zaro izomorfligi haqidagi teorema | $E = C[a, b], (x, y) = \int_a^b x^2(t)y^2(t)dt$ ifoda skalyar ko'paytma bo'ladimi? | $E = R^3, \rho(x, y) = x_1y_1 - 2x_2y_2 - 7x_3y_3$ skalyar ko'paytmani aniqlaydimi?  | $E = C[a; b], p(x, y) = \int_a^b e^t x(t)y(t)dt$ ifoda skalyar kopaytma bo'ladimi?              |
| 30 . | Hilbert fazolarining qism fazosi. Ortogonal to'ldiruvchi. Hilbert fazolarining to'g'ri yig'indisi | Hilbert fazosida ortogonal to'ldiruvchi tushunchasi | Hilbert fazolarining to'g'ri yig'indisi tushunchasi                | $E = R^3, (x, y) =  x_1y_1 + x_2y_2 - x_3y_3 $ ifoda skalyar ko'paytma bo'ladimi?  | $E = R^3, \rho(x, y) =  x_1y_1 + 2x_2y_2 + x_3y_3 $ skalyar ko'paytmani aniqlaydimi? | $E = \ell_2, (x, y) = \sum_{k=1}^{\infty} \frac{x_k y_k}{k}$ ifoda skalyar ko'paytma bo'ladimi? |