Лабораторная работа 4. Задача 2 Вариант 23. Метод с возвратом при неудачном шаге Условие задания Склад оптовой торговли отпускает 5 видов товаров. Известны потребности Vi, издержки заказывания Ki, издержки содержания si, расход складской площади на единицу товара fi, а также величина складской площади торгового зала F. Хотя бы одна единица товара каждого вида должна храниться на складе. Требуется определить оптимальные партии поставок при ограничении на максимальный уровень запаса при условии, что все пять видов продукции поступают на склад от разных поставщиков (раздельная оптимизация). 1) Решить указанным в задании методом. Выводить промежуточные результаты вычислений (координаты точки и значения функции в точке, полученные на каждой итерации). Выписать полученный ответ. Формула издержек (L) $L(q) = (\frac{120*48000}{q_1} + \frac{200*q_1}{2}) + (\frac{160*22400}{q_2} + \frac{280*q_2}{2}) + (\frac{130*6400}{q_3} + \frac{260*q_3}{2}) + (\frac{140*8600}{q_4} + \frac{200*q_4}{2})$ $+\left(\frac{110*2460}{q_5}+\frac{250*q_5}{2}\right)$ Алгоритм метода с возвратом при неудачном шаге . 1. Задать начальную точку x^0 , коэффициент сжатия 0<eta<1, M - максимальное число неудачно выполненных испытаний на текущей итерации, t_0 - начальную величину шага, R - минимальную величину шага, N - максимальное число итераций. Положить k = 0, j = 1. 2. Получить случайный вектор $\xi^j=(\xi^j_1,\dots,\xi^j_n)^T$, где ξ^j_i - случайная величина, равномерно распределённая на интервале 3. Вычислить $y^j=x^k+t_krac{\xi^j}{\|arepsilon^j\|}.$ 4. Проверить выполнение условий: ullet если $f(y^j) < f(x^k)$, шаг удачный. Положить $x^{k+1} = y^j$, $t_{k+1} = t_k$, k=k+1 и проверить условие окончания. Если k < N, положить j=1 и перейти к шагу 2. Если k=N, поиск завершить: $x^*\cong x^k$; • если $f(y^j) \ge f(x^k)$, шаг неудачный и перейти к шагу 5. 5. Оценить число неудачных шагов из текущей точки: • если j < M, следует положить j = j + 1 и перейти к шагу 2; • если j = M, проверить условие окончания: lacktriangle если $t_k \leq R$, процесс закончить: $x^* \cong x^k$, $f(x^*) \cong f(x^k)$; $lacktriangledown t_k > R$, положить $t_k = eta t_k$, j=1 и перейти к шагу 2. Начальные значения • N = 200• $\beta = 0.5$ • M = 10• $t_0 = 10$ • R = 0.1• $x^0 = [1, 1, 1, 1, 1]$ Алгоритм решения In [1]: import numpy as np import pandas as pd In [2]: df = pd.read excel("Задание2.xlsx", header=None, names=['v', 'k', 's'], usecols='B:D', skiprows=1, nrows=5) df.head() Out[2]: **0** 48000 120 200 **1** 22400 160 280 6400 130 260 8600 140 200 2460 110 250 In [3]: import task2 lib as lib In [4]: def generate func(df): def L(q : np.ndarray): **def** f(v, k, s, q): **return** k * v / q + 0.5 * s * q return np.sum(np.vectorize(f)(df['v'], df['k'], df['s'], q)) return L L func = generate func(df) In []: q = np.array([1, 1, 1, 1, 1], dtype=np.float64)func_min_finder = lib.FuncMinFinder(L_func) q = func_min_finder.return_on_an_unsuccessful_step(q, N=200) Результат: In [9]: print("q =", lib.get str cords(q)) print("L =", L_func(q)) q = [x0 = 239.93888913795735, x1 = 159.95894034358054, x2 = 79.99146659440059, x3 = 109.70798380025687, x4 = 46.510]918112891765] L = 147177.24378656517Приложение 1 (исходный код алгоритма метода из task2_lib.py) from random import uniform import numpy as np import pandas as pd class Cords(np.ndarray): def __str__(self) -> str: cords_str_list = [f"x{i} = {self.__getitem__(i)}" for i in range(self.size)] return '[' + ','.join(cords_str_list) + ']' def get_str_cords(cords): cords_str_list = [f"x{i} = {cords[i]}" for i in range(len(cords))] return '[' + ','.join(cords_str_list) + ']' class FuncMinFinder: print_tries = False def __init__(self, func) -> None: self.func = func def return_on_an_unsuccessful_step(self, x0 : np.ndarray, betta=0.5, M=10, t0=10, R=0.1, N=10) -> np.ndarray: $cords_num = len(x0)$ k = 0j = 1xk = x0tk = t0is_k_reached_N = False while not is_k_reached_N: print(f"Итерация {k}") print(f"\tx{k}: {get_str_cords(xk)}") $f_xk = self.func(xk)$ print(f"\tf(x{k}): {f_xk}") print(f"\tt{k}: {tk}\n") while True: if self.print_tries: print(f"\tПопытка {j}") y = 0while True: rand_vec = np.array([uniform(-1, 1) for _ in range(cords_num)]) vec_norm = np.linalg.norm(rand_vec, ord=2) y : np.ndarray = xk + tk * (rand_vec / vec_norm) **if** ((y > 0).all()): break if self.print_tries: print(f"\t\ty: {get_str_cords(y)}") $f_y = self.func(y)$ if self.print_tries: $print(f'' \setminus t \setminus f(y) : \{f_y\}'')$ is_new_f_less = f_y < f_xk</pre> inequality_symb = '<' if is_new_f_less else '>=' if self.print_tries: $print(f'' \setminus t(y) \{inequality_symb\} f(x\{k\}) (\{f_y\} \{inequality_symb\} \{f_xk\})")$ if (is_new_f_less): xk = yk += 1is_k_reached_N = k == N j = 1 break **if** j < M: j += 1 continue if self.print_tries: print("\n\t\tj = M") if tk <= R:</pre> if self.print_tries: $print(f'' \setminus t \setminus t\{k\} \leftarrow R (\{tk\} \leftarrow \{R\})'')$ print("\t\t0становка процесса оптимизации.") is_k_reached_N = True break tk *= betta if self.print_tries: print $(f'' \setminus t \setminus t \{k\} = t\{k\} * betta = \{tk\}'')$ $print(f"\t\tHaчaлo нoвых пoпытoк итерации {k}.\n")$ j = 1print(f"x_min = {get_str_cords(xk)}") $print(f"f_min = \{f_xk\}")$ return xk Приложение 2 (полный вывод результатов каждой итерации алгоритма) Итерация 0 x0: [x0 = 1.0,x1 = 1.0,x2 = 1.0,x3 = 1.0,x4 = 1.0] f(x0): 11651195.0 t0: 10 3.127741327700381] f(x1): 2345283.801943963 t1: 10 7.16482075700339] f(x2): 2180103.039246074 t2: 10 Итерация 3×3 : [x0 = 19.4869149763687, x1 = 8.609294594182604, x2 = 13.47249597571642, x3 = 6.46169752367297, x4 = 8.609294594182604, x2 = 13.47249597571642, x3 = 6.46169752367297, x4 = 8.609294594182604, x2 = 13.47249597571642, x3 = 6.46169752367297, x4 = 8.609294594182604, x2 = 13.47249597571642, x3 = 6.46169752367297, x4 = 8.609294594182604, x2 = 13.47249597571642, x3 = 6.46169752367297, x4 = 8.609294594182604, x2 = 13.47249597571642, x3 = 6.46169752367297, x4 = 8.609294594182604, x2 = 13.47249597571642, x3 = 6.46169752367297, x4 = 8.609294594182604, x2 = 13.47249597571642, x3 = 6.46169752367297, x4 = 8.609294594182604, x2 = 13.47249597571642, x3 = 6.46169752367297, x4 = 8.609294594182604, x3 = 8.609294594182604, x3 = 8.609294594182604, x4 = 8.609294604, x4 = 8.60929404, x4 = 8.609294604, x4 = 8.60924604, x4 = 8.6092404, x4 = 8.60924604, x4 = 8.6092404, x4 = 89.115288772676712] f(x3): 996338.8073670467 t3: 10 Итерация 4×4 : [x0 = 18.72961456455491, x1 = 15.132843454186936, x2 = 20.857215073382942, x3 = 5.351300034691135, x4 = 20.857215073382942, x3 = 20.85721507324, x3 = 20.857215073382942, x3 = 20.857215073382942, x3 = 20.85721507324, x3 = 20.857215073324, x3 = 20.85721507324, x3 = 20.85721507324, x3 = 20.857215073324, x3 = 20.85721507324, x3 = 20.85721507324, x3 = 20.85721507324, x3 = 20.8572150724, x3 = 20.8572150740000000000000000000000000010.165406681496957] f(x4): 844381.0441380995 t4: 10 Итерация 5×5 : [x0 = 23.705250024447746,x1 = 19.621608973577725,x2 = 16.090385804150042,x3 = 6.889513902871991,x4 = 10.090385804150042,x3 = 10.090385804150044,x3 = 10.090385804150044,x3 = 10.090385804150044,x3 = 10.0903858044,x3 = 10.090385804404,x3 = 10.0903858044,x3 = 10.0903858044,x3 = 10.090385804,x3 = 10.090385804,x3 = 10.090385804,x3 = 10.090385804,x3 = 10.090385804,x3 = 10.090385804,x3 = 10.0903864,x3 = 10.090464,x3 = 10.090464,x3 = 10.090464,x3 = 10.090464,x3 = 10.090464,x3 = 10.000464,x3 = 10.0004644.687699798511528] f(x5): 718315.9021219147 t5: 10 Итерация 6 х6: [х0 = 29.96160126378821,х1 = 16.83095576038035,х2 = 9.022544262173458,х3 = 8.254135321034664,х4 = 5.80740875010383] f(x6): 697939.1865702815 t6: 10 Итерация 7 х7: [x0 = 25.13919407236004, x1 = 19.38372112372684, x2 = 11.680492046631505, x3 = 12.749813385394342, x4 = 12.749813382, x4 = 12.74981382, x4 = 12.74981382, x4 = 12.74981382, x4 = 12.749813382, x4 = 12.74981382, x4 = 12.748812, x4 = 12.748812, x4 = 12.748812, x4 = 12.748812, x4 = 1212.361184012995452] f(x7): 611141.6801673885 t7: 10 11.6473543116364] f(x8): 496969.2662141787 t8: 10 Итерация 9 х9: [x0 = 35.87696024122815,x1 = 26.863101497619162,x2 = 10.52082010797776,x3 = 23.789898433245206,x4 = 20.863101497619162,x2 = 10.863101497619162,x2 = 10.86310149162,x2 = 10.86310149162,x2 = 10.86310144164,x2 = 10.863101444,x2 = 10.863101444,x2 = 10.863101444,x2 = 10.863101444,x2 = 10.86310144,x2 =15.920587470665005] f(x9): 453739.09050718334 t9: 10 20.618740541877262] f(x10): 387391.569779589 t10: 10 Итерация 11 x11: [x0 = 44.34655140918833,x1 = 34.37827481280605,x2 = 22.4618848433207,x3 = 25.94637020217685,x4 = 25.41343692106917] f(x11): 346168.7909018772 t11: 10 Итерация 12 x12: [x0 = 50.5334211789553, x1 = 38.25751392544934, x2 = 19.092884036352604, x3 = 31.65636042549692, x4 = 20.092884036352604, x3 = 31.65636042549692, x4 = 20.092884036352604, x3 = 31.65636042549692, x4 = 20.092884036352604, x3 = 20.0928840363604, x3 = 20.092884036352604, x3 = 20.0928840364, x3 = 20.0928840364, x3 = 20.0928840364, x3 = 20.09288404, x3 = 20.0928404, x3 = 20.0028404, x3 = 20.00244, x3 = 20.0028404, x3 = 20.00244, x3 = 20.00244, x3 = 20.002427.062676615934553] f(x12): 318713.74019446824 t12: 10 21.426733667674497] f(x13): 300449.7857938705 t13: 10 Итерация 14×14 : [x0 = 59.568563714407624, x1 = 42.53094965683714, x2 = 19.318172146271525, x3 = 36.61576107447744, x4 = 36.61576107447444, x4 = 36.61576107447444076107447444, x4 = 36.6128.03769632031357] f(x14): 288153.7469282058 t14: 10 Итерация 15 x15: [x0 = 68.57713622006099,x1 = 46.19229959645197,x2 = 21.514835221760386,x3 = 36.15163746120259,x4 = 21.514836,x3 = 36.15163746120259,x4 = 21.514836,x3 = 21.514846,x3 = 21.51486,x3 = 21.514846,x3 = 21.51486,x3 = 21.51486,x3 = 21.514827.405716388311607] f(x15): 266593.1466032714 t15: 10 Итерация 16×16 : [x0 = 72.43893351192621,x1 = 50.658935968083824,x2 = 25.940991792573342,x3 = 29.48964233748937,x4 = 20.48964233748937,x4 = 20.489642337489,x4 = 20.489642337489,x4 = 20.489642337489,x4 = 20.489642337489,x4 = 20.48964233748,x4 = 20.4896423748,x4 = 20.4896444,x4 = 20.48964444,x4 = 20.4896444,x4 = 20.4896444,x4 = 20.4896444,x4 = 20.4896444,x4 = 20.4896444,x4 =28.48397432703891] f(x16): 256881.58612023667 t16: 10 Итерация 17 x17: [x0 = 76.46827701742396,x1 = 56.65973658508565,x2 = 29.779971198109937,x3 = 24.8043225596231,x4 = 24.804322559621,x4 = 24.804322559621,x4 = 24.80425701,x4 = 24.80425701,x4 = 24.80425701,x4 = 24.80425701,x4 = 24.80425701,x4 = 24.80425701,x4 = 24.25.157595128466586] f(x17): 250890.2292321818 t17: 10 Итерация 18×18 : [x0 = 71.05137612761939, x1 = 61.31243158844454, x2 = 30.966219604867813, x3 = 31.703608914433243, x4 = 31.70360891443324, x4 = 31.70360891443324, x4 = 31.7036089144334, x4 = 31.7036089144434, x4 = 31.7036089144434, x4 = 31.7036089144434, x4 = 31.7036089144434, x4 = 31.7036089144344, x4 = 31.7036089144434, x4 = 31.703608914444, x4 = 31.70360891444, x4 = 31.703608144, x4 = 31.70360844, x4 = 31.7036084, x4 = 31.7025.205307470147396] f(x18): 241138.88398078937 t18: 10 27.425027987000295] f(x19): 234455.68768336897 t19: 10 Итерация 20×20 : [x0 = 70.23601069615742, x1 = 58.690569978873796, x2 = 33.84918476285675, x3 = 39.25447869441748, x4 = 58.690569978873796, x2 = 33.84918476285675, x3 = 39.25447869441748, x4 = 58.690569978873796, x2 = 33.84918476285675, x3 = 39.25447869441748, x4 = 58.690569978873796, x2 = 33.84918476285675, x3 = 39.25447869441748, x4 = 58.690569978873796, x2 = 33.84918476285675, x3 = 39.25447869441748, x4 = 58.690569978873796, x2 = 33.84918476285675, x3 = 39.25447869441748, x4 = 58.690569978873796, x2 = 33.84918476285675, x3 = 39.25447869441748, x4 = 58.69056978873796, x2 = 33.84918476285675, x3 = 39.25447869441748, x4 = 58.69056978873796, x2 = 33.84918476285675, x3 = 39.25447869441748, x4 = 58.69056978873796, x3 = 39.25447869441748, x4 = 58.69056978873796, x3 = 39.25447869441748, x4 = 58.69056978876, x3 = 39.25447869441748, x4 = 58.69056976, x3 = 39.25447869441748, x4 = 58.69056976, x3 = 39.254478696, x3 = 39.254478696441748, x4 = 58.69056976, x3 = 39.254478696, x3 = 39.2544786, x3 = 39.254476, x3 = 39.2544786, x3 = 39.254476, x3 = 39.254476,35.19911246400074] f(x20): 233980.2238469392 t20: 10 34.75178539181458] f(x21): 229513.80440944733 t21: 10 Итерация 22 x22: [x0 = 72.88698830335657,x1 = 61.27302678288085,x2 = 35.666396593301386,x3 = 42.98844010988862,x4 = 39.16798995199338] f(x22): 225460.65503105219 t22: 10 43.32171105220631] f(x23): 219459.9959032323 t23: 10 48.55524037490323] f(x24): 212299.23192597379 t24: 10 53.820934308090955] f(x25): 205013.04613547702 t25: 10 58.82505165971057] f(x26): 203887.62499082572 t26: 10 67.34875001540755] f(x27): 201419.8484578466 t27: 10 Итерация 28×28 : [x0 = 85.86431348447479,x1 = 71.72442558973552,x2 = 35.64743910039509,x3 = 64.8718678084786,x4 = 71.72442558973560,x4 = 71.724425786,x4 = 71.72442576,x4 = 71.724425786,x4 = 71.72442576,x4 = 71.72447676,x4 = 71.724476,x4 = 71.724476,x4 = 71.72442576,x4 = 71.724476,69.34509668972348] f(x28): 201270.52647441765 t28: 10 Итерация 29×29 : [x0 = 87.23501613979079, x1 = 77.76487870825983, x2 = 37.48889011152475, x3 = 58.425746179287465, x4 = 58.4257461792874665, x4 = 58.4257461792874665, x4 = 58.425746674666, x4 = 58.42574666, x4 = 58.42574666, x4 = 58.42574666, x4 = 58.4257466, x4 = 58.425746, x4 =73.43051887952264] f(x29): 198107.41601661933 t29: 10 Итерация 30×30 : [x0 = 84.18467749763715, x1 = 82.80981736032037, x2 = 43.98853824079356, x3 = 56.49578683130859, x4 = 43.98853824079356, x3 = 56.49578663130859, x4 = 43.98853824079356, x3 = 56.4957866, x3 = 56.495766, x3 = 56.49566, x3 = 56.49566, x3 = 577.82071924806749] f(x30): 196510.98012928435 t30: 10 74.17226610554886] f(x31): 192101.1031757276 t31: 10 80.38122396119878] f(x32): 187217.4652465736 t32: 10 83.54331863437586] f(x33): 185978.46254288175 t33: 10 Итерация 34×34 : [x0 = 100.07151076447545, x1 = 95.4612378549397, x2 = 47.07221963231662, x3 = 63.977631461757035, x4 = 47.07221963231662, x3 = 47.072219632162, x3 = 47.07221963231662, x3 = 47.07221963231662, x3 = 47.07221963231662, x3 = 47.072219632162, x3 = 47.0722196322, x3 = 47.0722196322, x3 = 47.0722196322, x3 = 47.072219632, x3 = 47.07221962, x3 = 47.072219632, x3 = 47.07221962, x3 = 47.0721962, x3 = 47.07221962, x3 = 47.072219687.51934140894637] f(x34): 181517.60133222016 t34: 10 84.97418740703453] f(x35): 179917.88620585817 t35: 10 78.27917653548587] f(x36): 179525.9048555937 t36: 10 Итерация 37×37 : [x0 = 105.33988339404695,x1 = 111.76326242891004,x2 = 36.353843302087675,x3 = 64.82946786569383,x4 = 82.42607194671571] f(x37): 179181.88379436848 t37: 10 77.6051057218397] f(x38): 173645.89217148718 t38: 10 Итерация 39 x39: [x0 = 111.04324463125708,x1 = 105.11920789276716,x2 = 47.64769961071199,x3 = 65.23375827443168,x4 = 73.44166389241292] f(x39): 173287.85876291685 t39: 10 Итерация 40 х40: [х0 = 115.28843321292855,х1 = 100.58956016954775,х2 = 51.267988798000225,х3 = 63.54384059316946,х4 = 66.69641742986312] f(x40): 171792.43161174082 t40: 10 Итерация 41 x41: [x0 = 121.39421631509109,x1 = 99.97888516503033,x2 = 48.37967102891506,x3 = 67.98565466306015,x4 = 60.84198347075894] f(x41): 169480.43486924074 t41: 10 Итерация 42 х42: [х0 = 122.00459626724323,х1 = 107.84847314930502,х2 = 52.34417791071061,х3 = 66.80819678698768,х4 = 56.30399940225003] f(x42): 166988.54404421386 t42: 10 Итерация 43×43 : [x0 = 124.77639371099485, x1 = 106.88232477587076, x2 = 48.30283741997357, x3 = 72.0823682012327, x4 = 106.88232477587076, x2 = 48.30283741997357, x3 = 72.0823682012327, x4 = 106.88232477587076, x2 = 48.30283741997357, x3 = 72.0823682012327, x4 = 106.88232477587076, x2 = 48.30283741997357, x3 = 72.0823682012327, x4 = 106.88232477587076, x2 = 48.30283741997357, x3 = 72.0823682012327, x4 = 106.88232477587076, x2 = 48.30283741997357, x3 = 72.0823682012327, x4 = 106.88232477587076, x3 = 106.8827076, x3 = 106.863.17672660347169] f(x43): 166731.6417371573 t43: 10 68.12972107498004] f(x44): 165365.8622685202 t44: 10 62.602482085798854] f(x45): 164971.98570195312 t45: 10 57.4462252313293] f(x46): 164266.52881363983 t46: 10 Итерация 47×47 : [x0 = 137.01149404328754, x1 = 106.59606119054206, x2 = 47.675680655429254, x3 = 77.76215957633656, x4 = 106.59606119054206, x4 = 106.5960611906000, x4 = 106.59606000, x4 = 106.59606000, x4 = 106.59606000, x4 = 106.59606000, x4 = 106.596000, x53.23913268818037] f(x47): 162933.1498411918 t47: 10 Итерация 48 х48: [x0 = 135.74918366948646,x1 = 106.1270431773149,x2 = 49.77168194026895,x3 = 85.61880049535327,x4 = 47.576397774108784] f(x48): 162080.35192512537 t48: 10 53.367076869858536] f(x49): 161948.4452500055 t49: 10 Итерация 50×50 : [x0 = 136.9152935492052, x1 = 115.23398522494853, x2 = 46.870509122589795, x3 = 91.86473855734192, x4 = 110.23398522494853, x4 = 110.23398522494853, x5 = 46.870509122589795, x5 = 91.86473855734192, x5 = 110.23398522494853, x5 = 46.870509122589795, x5 = 91.86473855734192, x5 = 110.23398522494853, x5 = 46.870509122589795, x5 = 91.86473855734192, x5 = 110.23398522494853, x5 = 46.870509122589795, x5 = 91.86473855734192, x5 = 110.23398522494853, x5 = 46.870509122589795, x5 = 91.86473855734192, x5 = 110.23398522494853, x5 = 46.870509122589795, x5 = 91.86473855734192, x5 = 110.23398522494853, x5 = 46.870509122589795, x5 = 91.86473855734192, x5 = 110.23398522494853, x5 = 46.870509122589795, x5 = 91.86473855734192, x5 = 110.23398522494853, x5 = 46.870509122589795, x5 = 91.86473855734192, x5 = 110.23398522494853, x5 = 46.870509122589795, x5 = 110.23398522494853, x5 = 110.23398522494854, x5 = 110.23398522494854, x5 = 110.23398522494864, x5 = 110.2339864, x5 = 149.02139941275224] f(x50): 160780.6431066656 t50: 10 Итерация 51 x51: [x0 = 140.86931897609284,x1 = 115.93391060612636,x2 = 55.30902126538023,x3 = 88.89238388031059,x4 = 50.97905307829609] f(x51): 158467.88110966678 t51: 10 46.50062669777686] f(x52): 156597.19605077174 t52: 10 Итерация 53×53 : [x0 = 150.495621915404, x1 = 118.845920107818, x2 = 63.955668512188545, x3 = 89.01748534591724, x4 = 118.845920107818, x2 = 63.955668512188545, x3 = 89.01748534591724, x4 = 118.845920107818, x2 = 63.955668512188545, x3 = 89.01748534591724, x4 = 118.845920107818, x2 = 63.955668512188545, x3 = 89.01748534591724, x4 = 118.845920107818, x2 = 63.955668512188545, x3 = 89.01748534591724, x4 = 118.845920107818, x2 = 63.955668512188545, x3 = 89.01748534591724, x4 = 118.845920107818, x453.03976729797575] f(x53): 155600.4556435212 t53: 10 Итерация 54 x54: [x0 = 156.11857297217435,x1 = 118.90915524457007,x2 = 70.16671575997458,x3 = 91.23902145781143,x4 = 48.05317606548388] f(x54): 154231.89492974954 t54: 10 Итерация 55×55 : [x0 = 162.34052121759598, x1 = 115.3789709256245, x2 = 71.4193424675948, x3 = 84.40499660507366, x4 = 84.4049666, x4 = 84.4049666, x4 = 84.4049666, x4 = 84.404966, x4 = 84.40496, x4 = 84.404966, x4 = 84.404966, x4 = 84.404966, x4 = 84.40496, x4 = 84.40496, x4 = 84.40496, x4 = 84.40496,48.79627050704871] f(x55): 154215.0534045488 t55: 10 Итерация 56×56 : [x0 = 163.0992206413886, x1 = 123.11429512459924, x2 = 73.39241748797541, x3 = 83.09428159847913, x4 = 123.11429512459924, x2 = 73.39241748797541, x3 = 83.09428159847913, x4 = 123.11429512459924, x2 = 73.39241748797541, x3 = 83.09428159847913, x4 = 123.11429512459924, x2 = 73.39241748797541, x3 = 83.09428159847913, x4 = 123.11429512459924, x2 = 73.39241748797541, x3 = 83.09428159847913, x4 = 123.11429512459924, x2 = 73.39241748797541, x3 = 83.09428159847913, x4 = 123.11429512459924, x2 = 73.39241748797541, x3 = 83.09428159847913, x4 = 123.11429512459924, x2 = 73.39241748797541, x3 = 83.09428159847913, x4 = 123.11429512459924, x2 = 73.39241748797541, x3 = 83.09428159847913, x4 = 123.11429512459924, x2 = 73.39241748797541, x3 = 83.09428159847913, x4 = 123.11429512459924, x2 = 73.39241748797541, x3 = 83.09428159847913, x4 = 123.11429512459924, x2 = 73.39241748797541, x3 = 83.09428159924, x3 = 123.11429512459924, x3 = 123.1142951245994, x3 = 123.1142951245994, x3 = 123.114295124594, x3 = 123.114295144594, x3 = 123.1142951444, x3 = 123.114295144, x3 =42.9671937485448] f(x56): 153318.06556410802 t56: 10 Итерация 57×57 : [x0 = 167.87959866908147, x1 = 116.4598381165949, x2 = 77.46658885656558, x3 = 87.1252587504782, x4 = 87.1252587504760476047604, x4 = 87.12525876047604, x4 = 87.1252587604760404, x4 = 87.12525876047604, x4 = 87.1252560404, x4 = 87.1252560404, x4 = 87.1252560404, x4 = 87.1252604, x4 = 87.1252604, x4 = 87.125260404, x4 = 87.12526040404, x4 = 87.1252604, x4 = 87.1252604, x4 = 87.1252604, x4 = 87.1243.1033506447884] f(x57): 153185.53218879257 t57: 10 47.65459359132866] f(x58): 153077.90056107432 t58: 10 49.90155023833537] f(x59): 152121.2689222734 t59: 10 Итерация 60 x60: [x0 = 174.43092122662222,x1 = 124.91485926915892,x2 = 68.43781484418452,x3 = 97.31640135652442,x4 = 54.27759922602945] f(x60): 151572.15815620183 t60: 10 Итерация 61 x61: [x0 = 175.49514620829143,x1 = 128.9212372375568,x2 = 75.36633243325147,x3 = 95.07629627783642,x4 = 128.921237237568,x2 = 75.36633243325147,x3 = 95.07629627783642,x4 = 128.921237237564,x4 = 128.92123764,x4 =48.81921722976414] f(x61): 150873.30793381197 t61: 10 Итерация 62 x62: [x0 = 181.74592656776818,x1 = 134.641668337922,x2 = 73.28184839604371,x3 = 91.06735985394019,x4 = 51.60987449487902] f(x62): 150238.0251502099 t62: 10 44.89104110425574] f(x63): 150015.3685813055 t63: 10 Итерация 64×64 : [x0 = 183.9219348585702, x1 = 146.6955418071626, x2 = 66.41511054243009, x3 = 93.38226849948057, x4 = 146.6955418071626, x2 = 66.41511054243009, x3 = 93.38226849948057, x4 = 146.6955418071626, x2 = 66.41511054243009, x3 = 93.38226849948057, x4 = 146.6955418071626, x2 = 66.41511054243009, x3 = 93.38226849948057, x4 = 146.6955418071626, x2 = 66.41511054243009, x3 = 93.38226849948057, x4 = 146.6955418071626, x2 = 66.41511054243009, x3 = 93.38226849948057, x4 = 146.6955418071626, x2 = 66.41511054243009, x3 = 93.38226849948057, x4 = 146.6955418071626, x2 = 66.41511054243009, x3 = 93.38226849948057, x4 = 146.6955418071626, x2 = 66.41511054243009, x3 = 93.38226849948057, x4 = 146.6955418071626, x2 = 66.41511054243009, x3 = 93.38226849948057, x4 = 146.6955418071626, x2 = 66.41511054243009, x3 = 93.38226849948057, x4 = 146.6955418071626, x2 = 66.41511054243009, x3 = 93.38226849948057, x4 = 146.6955418071626, x2 = 66.41511054243009, x3 = 93.38226849948057, x4 = 146.6955418071626, x2 = 66.41511054243009, x3 = 93.38226849948057, x4 = 146.6955418071626, x3 = 146.69554180, x3 = 146.6955438.206805811745575] f(x64): 149929.8172757695 t64: 10 Итерация 65×65 : [x0 = 189.91375584951518, x1 = 152.16854615891208, x2 = 60.71203615149494, x3 = 93.95557114835279, x4 = 10.71203615149494, x3 = 10.7120361514944, x3 = 10.7120361514944, x3 = 10.7120361514944, x3 = 10.7120361514944, x3 = 10.712036151494, x3 = 10.712036151494, x3 = 10.71203615144, x3 = 10.71203615144, x3 = 10.71203615144, x3 = 10.712036144, x3 = 10.712036144, x3 = 10.71203615144, x3 = 10.71203614, x3 = 10.712044, x3 = 10.71204, x3 = 10.71204, x3 = 10.71204, x3 = 10.71204, x3 = 10.39.3428388845292] f(x65): 149779.93936112884 t65: 10 46.53913489169344] f(x66): 149222.55571205975 t66: 10 Итерация 67×67 : [x0 = 191.05913930524923, x1 = 151.11491498498762, x2 = 71.01544688273759, x3 = 99.15983716772186, x4 = 71.01544688273759, x3 = 71.0154688273759, x3 = 71.015468827759, x3 = 71.015468827759, x3 = 71.01546882759, x3 = 71.01546882759, x3 = 71.01546882759, x3 = 71.015468760, x3 = 71.015468760, x3 = 71.015468760, x3 = 71.015468760, x3 = 71.01546860, x3 = 71.01546860, x3 = 71.01541.77344567183591] f(x67): 148832.0310139478 t67: 10 Итерация 68 x68: [x0 = 195.91631051961465,x1 = 151.44467386854055,x2 = 65.27011310586954,x3 = 101.7118617843657,x4 = 47.83788769245751] f(x68): 148736.63255888247 t68: 10 50.01780529599934] f(x69): 148602.21314890034 t69: 10 Итерация 70 x70: [x0 = 197.82721236095094,x1 = 154.28206473985986,x2 = 68.06354383569526,x3 = 106.3316025543981,x4 = 106.331602554391,x4 = 106.331602554391,x4 = 106.331602554391,x4 = 106.331602554391,x4 = 106.331602554391,x4 = 106.33160255441,x4 = 106.3316025441,x4 = 106.331602541,x4 = 106.331602541,x4 = 106.331602541,x4 = 106.331602541,x4 = 106.33160241,x4 = 106.33160241,x4 = 106.33160241,x4 = 106.33160254.44000273999367] f(x70): 148532.67781291637 t70: 10 Итерация 71 x71: [x0 = 200.30720970027951,x1 = 158.394372741771,x2 = 76.48298568533681,x3 = 108.6943768844622,x4 = 55.12471618373147] f(x71): 148155.6798101138 t71: 10 49.25491167055332] f(x72): 147867.73957557115 t72: 10 Итерация 73 x73: [x0 = 207.29308133418402,x1 = 153.77155664844688,x2 = 76.72906695897622,x3 = 119.47681586237296,x4 = 45.16631396862844] f(x73): 147831.42984723664 t73: 10 Итерация 74×74 : [x0 = 208.66814051699222, x1 = 157.5975542818628, x2 = 84.55293346343805, x3 = 114.7666692854998, x4 = 114.766669285499, x4 = 114.7666692854999, x4 = 114.7666692854999, x4 = 114.766669285499, x4 = 114.76666928549, x4 = 114.7666692854, x4 = 114.7666692845.435732783117615] f(x74): 147710.10054164444 t74: 10 Итерация 75 x75: [x0 = 209.52615407261234,x1 = 162.4073186314563,x2 = 78.08376793254641,x3 = 112.85559167361458,x4 = 112.85559167361464,x4 = 112.85559167361464,x4 = 112.85559167464,x4 = 112.85559164,x4 = 112.85559167464,x4 = 112.85559164,x4 =50.969958956217724] f(x75): 147688.64052163446 t75: 10 46.23276325308156] f(x76): 147535.27402892674 t76: 10 Итерация 77 x77: [x0 = 221.5123315110886,x1 = 168.54975987075434,x2 = 79.43043790126029,x3 = 111.48559129207507,x4 = 120.5123315110886,x1 = 120.5123151086,x1 = 120.5123151086,x1 = 120.5123151086,x1 = 120.5123151086,x1 = 120.5123151086,x1 = 120.5123151086,x1 = 120.51231086,x1 = 120.512316,x1 = 120.512316,x1 = 120.512316,x1 = 120.512316,x1 =40.00593248423426] f(x77): 147528.44710912651 t77: 10 Итерация 78×78 : [x0 = 225.27286937231705,x1 = 162.85363252825866,x2 = 77.32485853356842,x3 = 116.50924892904195,x4 = 12.85363252825866,x2 = 78.32485853356842,x3 = 116.50924892904195,x4 = 12.85363252825866,x2 = 12.8536266,x2 = 12.85363252825866,x2 = 12.8536266,x2 = 12.8536266,x2 = 12.8536266,x2 = 12.8536266,x2 = 12.8536266,x2 = 12.8536266,x2 = 12.853666,x2 = 12.85366,x2 = 12.853666,x2 = 12.85366,x2 = 12.85366,x2 = 12. 44.878497287829504] f(x78): 147339.60422206248 t78: 10 Итерация 79×79 : [x0 = 231.54186989667605,x1 = 166.55871495546748,x2 = 79.45170092375281,x3 = 109.99635808108451,x4 = 45.05397059942442] f(x79): 147250.87556329995 t79: 10 Итерация 80×80 : [x0 = 233.40250679181264, x1 = 164.1856558672348, x2 = 76.95490773029924, x3 = 112.69535425722648, x4 = 164.1856558672348, x4 = 164.1856558672348, x5 = 164.1856558672348, x5 = 164.1856558672348, x6 = 164.18565766, x6 = 164.1856576, x6 = 164.185676, x6 = 164.1856576, x6 = 164.1856576, x6 = 164.146.59930690538104] f(x80): 147234.32432524202 t80: 5.0 Итерация 81 x81: [x0 = 231.8655550538187,x1 = 163.35480247076677,x2 = 80.16700266112991,x3 = 109.86282196980945,x4 = 44.70018369065093] f(x81): 147224.82151280495 t81: 5.0 Итерация 82 x82: [x0 = 236.21858078361313,x1 = 162.77056453753568,x2 = 78.92310765584226,x3 = 109.90235030078858,x4 = 46.740035587233585] f(x82): 147191.95425146728 t82: 5.0 Итерация 83 x83: [x0 = 237.91518443624733,x1 = 158.3219536801171,x2 = 80.09698616029111,x3 = 108.93533835875506,x4 = 46.87529328898615] f(x83): 147182.46965952622 t83: 5.0 46.46824783354464] f(x84): 147179.57843220545 t84: 1.25 Итерация 85×85 : [x0 = 238.5826177634002,x1 = 159.33572447837676,x2 = 80.26266980017193,x3 = 108.99567635029531,x4 = 46.837537310746036] f(x85): 147179.32837162958 t85: 0.625 Итерация 86×86 : [x0 = 238.6992725166494, x1 = 159.63994174029804, x2 = 80.61082054787047, x3 = 109.30880220879867, x4 = 109.308867, x4 = 109.30867, x4 = 109.308867, x4 = 109.30867, x4 =46.58217133864526] f(x86): 147178.83175482767 t86: 0.625 Итерация 87 x87: [x0 = 239.06987180871175,x1 = 159.71420566855633,x2 = 80.267299802357,x3 = 109.21729476321178,x4 = 46.23376651880697] f(x87): 147178.2597099474 t87: 0.625 Итерация 88 x88: [x0 = 239.15009164837258,x1 = 160.04064827181566,x2 = 79.98627020236049,x3 = 109.55982707660743,x4 = 46.518931352381685] f(x88): 147177.56905723782 t88: 0.625 Итерация 89 х89: [x0 = 239.2733422379065, x1 = 159.76456597667263, x2 = 79.97705522554465, x3 = 109.51555867708377, x4 = 109.5155766767676, x4 = 109.515576676, x4 = 109.515576, x4 = 109.515576, x4 = 109.515576, x4 = 109.515576, x4 = 109.51576, x4 = 109.5156, x4 = 109.5156, x4 = 109.546.5837349131943] f(x89): 147177.55899671634 t89: 0.3125 Итерация 90×90 : [x0 = 239.42660909421517,x1 = 159.79598263663868,x2 = 79.73870437626402,x3 = 109.58808508389508,x4 = 200.58808508389508,x4 = 200.58808508,x4 = 200.5880850808,x4 = 200.58808508,x4 = 200.58808508,x4 = 200.58808508,x4 = 200.58808508,x4 = 200.58808508,x4 = 200.58808508,x4 = 200.5880850808,x4 = 200.58808508,x4 = 200.5880808,x4 = 200.588080808,x4 = 200.5880808,x4 = 200.5880808,x4 = 200.5880808,x4 = 200.5880808,x46.478343702953225] f(x90): 147177.54874150202 t90: 0.3125 46.54302361543054] f(x91): 147177.5353512168 t91: 0.3125 Итерация 92 х92: [х0 = 239.4993683709802,х1 = 159.9670214281702,х2 = 79.98489230915474,х3 = 109.65701100313616,х4 = 46.62530535403612] f(x92): 147177.37569975026 t92: 0.3125 46.44325143379219] f(x93): 147177.35876319435 t93: 0.3125 46.37074806408619] f(x94): 147177.33590072326 t94: 0.3125 46.523362274095625] f(x95): 147177.27579804807 t95: 0.3125 46.553983644298135] f(x96): 147177.27546285087 t96: 0.15625 46.50513152347873] f(x97): 147177.26242699876 t97: 0.15625 46.53125717309098] f(x98): 147177.2440851102 t98: 0.15625 46.54271320320478] f(x99): 147177.24280493316 t99: 0.078125 46.54271320320478] f_min = 147177.24280493316