

**Санкт-Петербургский Политехнический Университет
Петра Великого**

Институт компьютерных наук и технологий

Кафедра компьютерных систем и программных технологий

**ОТЧЕТ
по практической работе**

**«Отработка навыков решения практических задач»
Теория вероятностей и математическая статистика
Вариант №12**

Работу выполнил студент

группа 23501/4 Дьячков В.В.

Преподаватель

_____ к.т.н., доц. Никитин К.В.

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1 Операции с числами

Листинг 1: Задание 1.1

```
1 res = ((4.5 * 5/3 - 6.75) * 2/3) / ((3.333 * 0.3 + 0.222 * 4/9) * 8/3);
2 disp(res);
```

Листинг 2: Задание 1.2

```
1 fun = @(m) 2/3 * m * sqrt(m * nthroot(m * nthroot(m, 4), 3));
2
3 m = 3.6485e2;
4 disp(fun(m));
5
6 m = 24/37;
7 disp(fun(m));
```

Листинг 3: Задание 1.3

```
1 z1 = -1 + sqrt(5) * 1i;
2 z1_exp = abs(z1) * exp(angle(z1) * 1i);
3
4 z2 = 2.1 * exp(degtorad(211) * 1i);
5 z2_alg = real(z2) + imag(z2) * 1i;
6
7 z3 = 0.4 * exp(degtorad(32) * 1i);
8 z4 = 4 + 3 * 1i;
9
10 res = z1_exp^(1/3) * z2 * z3 + z4;
11 res_exp = abs(res) * exp(angle(res) * 1i);
12 disp(res_exp);
```

Листинг 4: Задание 1.4

```
1 p = [13 0.8 287];
2 r = roots(p);
3 disp(r);
```

2 Простейшие операции с векторами и матрицами

Листинг 5: Задание 2.1

```
1 fun = @(x) (4 + 7*x) .* sin(pi .* nthroot(1 + x, 3));
2
3 X = 0:0.7:7;
4 Y = fun(X);
5 disp(Y);
```

3 Функции прикладной численной математики

Листинг 6: Задание 3.1

```
1 disp('Task #1');
2 disp('A = ');
3 A = [
4     0, 1, 2, 3, 4, 5;
5     11, 10, 9, 8, 7, 6;
6     12, 13, 14, 15, 16, 17;
7     23, 22, 21, 20, 19, 18;
8 ];
9 disp(A);
10
11 fprintf('Sum of the max elements = %d\n', sum(max(A,.')));
```

```

1 disp('Task #2');
2 disp('A = ');
3 A = [
4     9, 8, 7, 6, 5;
5     10, 11, 12, 13, 14;
6     19, 18, 17, 16, 15;
7     0, 1, 2, 3, 4;
8     20, 21, 22, 23, 24;
9 ];
10 disp(A);
11
12 [min_val, index] = min(min(A.'));
13 sum_val = sum(A(index,:));
14
15 fprintf('Min element = %d\n', min_val);
16 fprintf('Sum of that row = %d\n', sum_val);

```

```

1 disp('Task #3');
2 disp('A = ');
3 A = [
4     0, 1, 2, 3, 4, 1, 2, 3, 4;
5     9, 8, 7, 6, 5, 8, 7, 6, 5;
6     10, 11, 12, 13, 14, 11, 12, 13, 14;
7     19, 18, 17, 16, 15, 18, 17, 16, 15;
8     20, 21, 22, 23, 24, 21, 22, 23, 24;
9     30, 31, 32, 33, 34, 31, 32, 33, 34;
10 ];
11 disp(A);
12
13 A([1,6],:) = A([6,1],:);
14
15 disp('Swaped first and last rows');
16 disp(A);

```

```

1 disp('Task #4');
2 disp('A = ');
3 A = [
4     20, 1, 2, 3, 41, 5;
5     6, 7, 8, 9, 10, 11;
6     22, 23, 24, 25, 26, 13;
7     30, 38, 12, 51, 0, 33;
8     12, 41, 64, 9, 73, 74;
9 ];
10 disp(A);
11
12 [min_vals, indexes] = min(A.');
13
14 disp('Min elements of each row');
15 for i = 1 : 5
16     fprintf('A(%d, %d) = %d\n', i, indexes(i), min_vals(i));
17 end
18 fprintf('Max element among them: %d\n', max(B));

```

```

1 disp('Task #5');
2 disp('A = ');
3 A = [
4     20, 1, 2, 3, 41, 5;
5     6, 7, 8, 9, 10, 11;
6     22, 23, 24, 25, 26, 13;
7     30, 38, 12, 51, 0, 33;
8     12, 41, 64, 9, 73, 75;
9 ];
10 disp(A);
11
12 max_vals = max(A.');
13
14 disp('Vector of max row elements');
15 disp(max_vals)

```

```

1 disp('Task #6');
2 disp('A = ');
3 A = [
4     20, 1, 2, 3, 41, 5;

```

```

5      6, 7, 8, 9, 10, 11;
6      22, 23, 24, 25, 26, 13;
7      30, 38, 12, 51, 0, 33;
8      12, 41, 64, 9, 73, 75;
9      ];
10 disp(A);
11
12 sum_vals = min(A.') + max(A. ');
13
14 disp('Vector of (row_max + row_min) elements');
15 disp(sum_vals);

```

```

1 disp('Task #7');
2 disp('A = ');
3 A = [
4      20, 1, 2, 3, 41, 5;
5      6, 7, 8, 9, 10, 11;
6      22, 23, 24, 25, 26, 13;
7      30, 38, 12, 51, 0, 33;
8      12, 41, 64, 9, 73, 75;
9      ];
10 disp(A);
11
12 mean_vals = mean(A. ');
13
14 disp('Vector of mean row values');
15 disp(mean_vals);

```

```

1 disp('Task #8');
2 disp('A = ');
3 A = [
4      20, 1, 2, 3, 41, 5;
5      6, 7, 8, 9, 10, 11;
6      22, 23, 24, 25, 26, 13;
7      30, 38, 12, 51, 0, 33;
8      12, 41, 64, 9, 73, 75;
9      ];
10 disp(A);
11
12 std_vals = std(A. ');
13
14 disp('Vector of mean row values');
15 disp(std_vals);

```

```

1 disp('Task #9');
2 disp('A = ');
3 A = [
4      20, 1, 2, 3, 41, 5;
5      6, 7, 8, 9, 10, 11;
6      22, 23, 24, 25, 26, 13;
7      30, 38, 12, 51, 0, 33;
8      12, 41, 64, 9, 73, 75;
9      ];
10 disp(A);
11
12 mean_vals = (min(A.') + max(A. ')) / 2;
13
14 disp('Vector of mean(max, min) row elements');
15 disp(mean_vals);

```

```

1 disp('Task #10');
2 disp('A = ');
3 A = [
4      20, 1, 2, 3, 41;
5      6, 7, 8, 9, 10;
6      22, 23, 24, 25, 26;
7      30, 38, 12, 51, 0;
8      12, 41, 64, 9, 73;
9      24, 11, 34, 32, 11;
10     ];
11 disp(A);
12
13 square_sums = sum(A.^2);
14

```

```

15 disp('Vector of sum of square of column');
16 disp(square_sums);

```

```

1 disp('Task #11');
2 disp('A = ');
3 A = [
4     20, 1, 2, 3, 41;
5     6, 7, 8, 9, 10;
6     22, 23, 24, 25, 26;
7     30, 38, 12, 51, 0;
8     12, 41, 64, 9, 73;
9 ];
10 disp(A);
11
12 sum_vals = sum(A);
13 prod_vals = prod(A);
14 min_vals = min(A);
15
16 disp('Vector of sum of column elements');
17 disp(sum_vals);
18 disp('Vector product of column elements');
19 disp(prod_vals);
20 disp('Vector of min elements of columns');
21 disp(min_vals);

```

```

1 disp('Task #12');
2 disp('A = ');
3 A = [
4     20, 1, 2, 3, 41, 5;
5     6, 7, 8, 9, 10, 11;
6     22, 23, 24, 25, 26, 13;
7     30, 38, 12, 51, 0, 33;
8     12, 41, 64, 9, 73, 75;
9 ];
10 disp(A);
11
12 min_val = min(min(A));
13 max_val = max(max(A));
14 mean_val = (min_val + max_val) / 2;
15
16 disp('Mean of min and max elements');
17 fprintf('mean(%d, %d) = %f\n', min_val, max_val, mean_val);

```

```

1 disp('Task #13');
2 disp('A = ');
3 A = [
4     20, 1, 2, 3, 41;
5     6, 7, 8, 9, 10;
6     22, 23, 24, 25, 26;
7     30, 38, 12, 51, 0;
8     12, 41, 64, 9, 73;
9 ];
10 disp(A);
11
12 diagonal = diag(A);
13
14 disp('Vector of diag elements');
15 disp(diagonal. ');
16
17 fprintf('Trace of matrix = %d\n', trace(A));

```

```

1 disp('Task #14');
2 disp('A = ');
3 A = [
4     20, 1, 2, 3;
5     6, 7, 8, 9;
6     22, 23, 24, 25;
7     30, 38, 12, 51;
8 ];
9 disp('B = ');
10 B = [
11     40, 1, 32, 3;
12     12, 3, 12, 44;
13     23, 0, 24, 12;

```

```

14     0, 12, 35, 52;
15 ];
16 disp(A);
17 disp(B);
18
19 cat_matrix = [A.', B.'];
20
21 disp(' (A|B) ')
22 disp(cat_matrix);

```

```

1 disp('Task #15');
2 disp('A = ');
3 A = [
4     20, 1, 2;
5     5, 15, 0;
6     0, 25, 35;
7     30, 0, 7;
8 ];
9 disp(A);
10
11 sum_val = sum(sum(A));
12
13 disp('Sum of all elements');
14 disp(sum_val);

```

Листинг 7: Задание 3.2

```

1 num = @(p) p.^2 + 1.8*p + 78;
2 denom = @(p) 2.65*p.^3 + 3.09*p.^2 + 7.04*p + 34.05;
3 w = @(p) num(p) ./ denom(p);
4
5 w_max = max(double(abs(imag(solve(denom)))));
6 input = linspace(0, 5 * w_max, 100);
7
8 abs_vals = abs(w(1i * input));
9 angle_vals = angle(w(1i * input));
10 real_vals = real(w(1i * input));
11 imag_vals = imag(w(1i * input));
12
13 disp('abs, angle, real, imag');
14 disp([abs_vals.', angle_vals.', real_vals.', imag_vals.']);

```

Листинг 8: Задание 3.3

```

1 A = [
2     9, 8, 3, 2, 5;
3    10, 1, 2, 0, 14;
4     9, 0, 7, 16, 0;
5    10, 12, 2, 1, 4;
6     2, 6, 11, 3, 14;
7 ];
8 disp(A);
9
10 disp('1. Matrix determinant');
11 disp(det(A));
12
13 disp('2. Inverse matrix');
14 disp(inv(A));
15
16 disp('3. Characteristic polynomial');
17 poly_vals = poly(A);
18 disp(poly_vals);
19
20 disp('4. Roots of polynomial');
21 roots_vals = roots(poly_vals);
22 real_roots = roots_vals(imag(roots_vals) == 0);
23 complex_roots = roots_vals(imag(roots_vals) ~= 0);
24 disp(sort(real_roots));
25 disp(complex_roots);
26
27 disp('5. Eigenvalues');
28 eigh_vals = eig(A);
29 disp(eigh_vals);
30 disp('Equal to the roots of the characteristic polynomial');

```

```

31
32 disp('6. LU decomposition');
33 [l_matrix, u_matrix] = lu(A);
34 disp('L matrix with permutation matrix');
35 disp(l_matrix);
36 disp('U matrix');
37 disp(u_matrix);
38 disp('LU = A');
39 disp(l_matrix * u_matrix);
40
41 disp('7. QR decomposition');
42 [q_matrix, r_matrix] = qr(A);
43 disp('Q matrix');
44 disp(q_matrix);
45 disp('R matrix');
46 disp(r_matrix);
47 disp('QR = A');
48 disp(q_matrix * r_matrix);
49
50 disp('8. Singular numbers');
51 sing_vals = svd(A);
52 disp(sing_vals);
53 [U, S, V] = svd(A);
54 disp(U*S*V');
55
56 disp('9. Matrix trace');
57 trace_val = trace(A);
58 disp(trace_val);
59
60 disp('10. Matrix condition');
61 cond_matrix = cond(A);
62 disp(cond_matrix);
63
64 disp('11. Matrix exponent');
65 expm_matrix = expm(A);
66 disp(expm_matrix);
67
68 disp('12. Matrix log');
69 logm_val = logm(expm_matrix);
70 disp(logm_val);

```

4 Построение простейших графиков

Листинг 9: Задание 4.1

```

1 fun = @(x) (4 + 7*x) .* sin(pi .* nthroot(1 + x, 3));
2
3 X = 0:0.7:7;
4 Y = fun(X);
5
6 disp(X);
7 disp(Y);
8 plot(X, Y);

```

Листинг 10: Задание 4.2

```

1 num = @(p) p.^2 + 1.8*p + 78;
2 denom = @(p) 2.65*p.^3 + 3.09*p.^2 + 7.04*p + 34.05;
3 w = @(p) num(p) ./ denom(p);
4
5 w_max = max(double(abs(imag(solve(denom)))));
6 input = linspace(0, 5 * w_max, 100);
7
8 abs_vals = arg(w(1i * input));
9 angle_vals = angle(w(1i * input));
10
11 plot(input, abs_vals, input, angle_vals);

```

5 Операторы управления вычислительным процессом

Листинг 11: Задание 5.1

```
1 x1 = 1.4;
2 x2 = 14;
3 m = 60;
4 step = (x2 - x1) / m;
5 r = 6;
6 err = 0.001;
7 X = x1:step:x2;
8
9 exact = z5_1_fun(X);
10 approx = z5_1_approx(X, r);
11 approx_relerr = z5_1_relerr(X, err);
12 error_approx = exact - approx;
13 error_relerr = exact - approx_relerr;
14
15 plot(X, error_approx, X, error_relerr);

1 function f = z5_1_fun(x)
2     f = atan(x);
3 end

1 function f = z5_1_approx(x, r)
2     f = 0;
3     for k = 1:r
4         f = f + (-1)^(k - 1) * x.^(2*k - 1) / (2*k - 1);
5     end
6 end

1 function f = z5_1_relerr(x, err)
2     i = 1;
3     relerr = 1;
4     while relerr > err
5         val = z5_1_approx(x, i);
6         exact_val = z5_1_fun(x);
7         relerr = abs(val - exact_val) / exact_val;
8         i = i + 1;
9     end
10    f = val;
11 end
```

Листинг 12: Задание 5.2

```
1 k = 100;
2 X = [];
3 denom = sqrt(10);
4
5 while k >= 0.1
6     X = [X k];
7     k = k / denom;
8 end
9
10 X = sort(X);
11 Y = z5_1_fun(X);
12 disp(X);
13 disp(Y);
```

Листинг 13: Задание 5.3

```
1 num = @(p) p.^2 + 1.8*p + 78;
2 denom = @(p) 2.65*p.^3 + 3.09*p.^2 + 7.04*p + 34.05;
3 w = @(p) num(p) ./ denom(p);
4
5
6 k = 100;
7 X = [];
8 denom = sqrt(10);
9 while k >= 0.1
10    X = [X k*1i];
```



```

11 k = k / denom;
12 end
13 X = sort(X);
14
15 abs_vals = abs(w(X));
16 angle_vals = 180 .* angle(w(X)) ./ pi;
17 disp('abs, angle');
18 disp([abs_vals.', angle_vals.']);

```

6 Создание простейших файл-функций (процедур)

Листинг 14: Задание 6.1

```

1 a = 0;
2 b = 7;
3
4 fplot(@z6_1_fun, [a,b]);
5 min_val = fminbnd(@z6_1_fun, a, b);
6 root_val = fzero(@z6_1_fun, min_val);
7
8 fprintf('quad = %f\n', quad(@z6_1_fun, a, b));
9 fprintf('quadl = %f\n', quadl(@z6_1_fun, a, b));
10 fprintf('integral = %f\n\n', integral(@z6_1_fun, a, b));
11 fprintf('Min val = %f\n', min_val);
12 fprintf('Root val = %f\n', root_val);

```

```

1 function f = z6_1_fun(x)
2     f = (4 + 7*x) .* sin(pi .* nthroot(1 + x, 3));
3 end

```

Листинг 15: Задание 6.2

```

1 x0 = 1.2;
2 y0 = -0.8;
3
4 min_vals = fminunc(@z6_2_fun, [x0, y0]);
5 disp(min_vals);

```

```

1 function f = z6_2_fun(x)
2     f = 2.^(x(1) + x(2)) - 2*x(1) + 2*x(2) + 2*(x(1) + x(2)).^2;
3 end

```

7 Создание функций от функций

Листинг 16: Задание 7.1

```

1 global d;
2 d = 2;
3
4 disp(z7_1_func1(@z7_1_func2, 1));
5 disp(z7_1_func1(@z7_1_func2, 2));
6
7 disp(z7_1_func1(@z7_1_func3, 1));
8 disp(z7_1_func1(@z7_1_func3, 2));

```

```

1 function f = z7_1_func1(func, t)
2     f = func(t);
3 end

```

```

1 function f = z7_1_func2(t)
2     global d;
3     f = 20 * log(sin(t)) + d;
4 end

```

```
1 function f = z7_1_func3(t)
2     global d;
3     f = 1 - exp(-d * t);
4 end
```