%% номер 1 метод трапеций (и метод трапеций с процедурой Рунге)

clc, clearvars, close all;

x\_exp = [1 2 3 4 5 6 7 8];

y\_exp = [-32.47 14.82 49.33 -7.26 -45.89 28.64 3.71 -19.58];

x = linspace(1, 8, 1e4);

f = @(x) interp1(x\_exp, y\_exp, x, 'spline');

a = min(x\_exp); b = max(x\_exp);

e = 1e-3;

M2 = max(gradient(gradient(interp1(x\_exp, y\_exp, x, 'spline'), x), x));

h = sqrt(12\*e/((b-a)\*M2));

x\_h = a:h:b;

x\_h2 = a:h/2:b;

I\_h2 = trapz(x\_h2, interp1(x\_exp, y\_exp, x\_h2, 'spline'));

I\_h = trapz(x\_h, interp1(x\_exp, y\_exp, x\_h, 'spline'));

p = 2;

I\_Runge = I\_h2 + (I\_h2 - I\_h)/(2^p - 1);

fprintf('Интеграл с шагом h: %.5f\n', I\_h);

fprintf('Интеграл с шагом h/2: %.5f\n', I\_h2);

fprintf('Интеграл с процедурой Рунге: %.5f\n', I\_Runge);

F\_h = cumtrapz(x\_h, interp1(x\_exp, y\_exp, x\_h, 'spline'));

F\_h2 = cumtrapz(x\_h2, interp1(x\_exp, y\_exp, x\_h2, 'spline'));

figure(1)

hold on;

fplot(f, [min(x\_exp) max(x\_exp)], 'r');

plot(x\_h, F\_h, 'm');

plot(x\_h2, F\_h2, 'b--');

title("Функции y = f(x) и интегралы с разными шагами");xlabel('x'); ylabel('y'); grid on; yline(0, 'k--'); xline(0, 'k--'); xlim([min(x\_exp)-1 max(x\_exp)+1]); ylim([min(y\_exp)-10 max(y\_exp)+10]); legend('y = f(x)', 'y = F(x) с шагом h', 'y = F(x) с шагом h/2'); xticks(min(x\_exp) - 1:0.5:max(x\_exp) + 1);



%% номер k

clc; clearvars; close all;

x\_exp = [1 2 3 4 5 6 7 8];

y\_exp = [-32.47 14.82 49.33 -7.26 -45.89 28.64 3.71 -19.58];

f = @(x) interp1(x\_exp, y\_exp, x, 'spline');

a = min(x\_exp); b = max(x\_exp);

h = linspace(1e-4, 1, 100);

I = zeros(size(h));

for i = 1:length(h)

x\_h = a:h(i):b;

y\_h = f(x\_h);

I(i) = trapz(x\_h, y\_h);

end

figure(1);

plot(h, I, 'k');hold on;

plot([0 1], [14.57479 14.57479], 'k--');

title('Функция I = I(h)'); xlabel('h'); ylabel('Интеграл I'); grid on; legend('I = I(h)', 'I истинное');



% номер k+1

clc; clearvars; close all;

x\_exp = [1 2 3 4 5 6 7 8];

y\_exp = [-32.47 14.82 49.33 -7.26 -45.89 28.64 3.71 -19.58];

f = @(x) interp1(x\_exp, y\_exp, x, 'spline');

a = min(x\_exp); b = max(x\_exp);

h = linspace(1e-4, 1, 100);

I = zeros(size(h));

for k = 1:length(h)

x\_h = a:h(k):b;

y\_h = f(x\_h);

I(k) = trapz(x\_h, y\_h);

end

figure(1);

plot(h, I, 'k');hold on;

plot([0 1], [14.57479 14.57479], 'k--');

title('Функция I = I(h)'); xlabel('h'); ylabel('Интеграл I'); grid on; legend('I = I(h)', 'I истинное');



%% номер k+2

clc, clearvars, close all;

x\_exp = [1 2 3 4 5 6 7 8];

y\_exp = [-32.47 14.82 49.33 -7.26 -45.89 28.64 3.71 -19.58];

f = @(x) interp1(x\_exp, y\_exp, x, 'spline');

a = min(x\_exp); b = max(x\_exp);

e = 1e-3;

x\_for\_grad = linspace(1,8,1e6);

y\_spline = interp1(x\_exp, y\_exp, x\_for\_grad, 'spline');

d4f = gradient(gradient(gradient(gradient(y\_spline, x\_for\_grad), x\_for\_grad), x\_for\_grad), x\_for\_grad);

M4 = max(abs(d4f));

hMax = (180\*e/((b-a)\*M4))^0.25; % = 0.1041

q = @(x) quad(f, a, x);

figure(1)

fplot(q, [a b], 'm');

title("Функции y = F(x) методом Симпсона"); xlabel('x'); ylabel('y'); grid on; yline(0, 'k--'); xline(0, 'k--'); xlim([min(x\_exp)-1 max(x\_exp)+1]); ylim([min(y\_exp)-10 max(y\_exp)+10]); xticks(min(x\_exp) - 1:0.5:max(x\_exp) + 1);



%% номер k+3

clc, clearvars, close all;

x\_exp = [1 2 3 4 5 6 7 8];

y\_exp = [-32.47 14.82 49.33 -7.26 -45.89 28.64 3.71 -19.58];

f = @(x) interp1(x\_exp, y\_exp, x, 'spline');

F = @(x) integral(f, min(x\_exp), x);

figure(1)

hold on;

fplot(F, [min(x\_exp) max(x\_exp)], 'r');

title("Функции y = F(x) встроенными функциями матлаб");xlabel('x'); ylabel('y'); grid on; yline(0, 'k--'); xline(0, 'k--'); xlim([min(x\_exp)-1 max(x\_exp)+1]); ylim([min(y\_exp)-10 max(y\_exp)+10]); legend('y = F(x) с шагом h'); xticks(min(x\_exp) - 1:0.5:max(x\_exp) + 1);



%% номер k+4 (пример с сайта)

clc, clearvars, close all;

% a = 7;

syms x a;

f = a^x\*exp(-x);

df = int(f, x)



%% номер k+5 (пример с сайта)

clc, clearvars, close all;

% a = 7;

syms x a p;

f = (1 + x)/(x+a)^(p+1);

df = int(f, x)

