

Homework 2 — Multi-step Predictor/Corrector Method

Numerical Solution for ODEs

Due date: December 19th, 2025

Support files for this homework can be found as a ZIP file on the webpage.

Exercise 1. Write a MATLAB function, with the name `pred_corr`, to implement one of the following *predictor/corrector* methods (see support files for initial template):

| Algorithm | <i>Predictor</i> | <i>Corrector</i> |
|---------------|------------------------|----------------------|
| 1. $PECE$ | 3-step Nyström | 2-step Milne-Simpson |
| 2. $P(EC)^4$ | 1-step Adams-Bashforth | 3-step Adams-Moulton |
| 3. $P(EC)^3E$ | 1-step Adams-Bashforth | 3-step Adams-Moulton |
| 4. $P(EC)^2E$ | 2-step Nyström | 2-step Milne-Simpson |

Exercise 2. Test your script on the following problems from the support files:

1. The logistic equation $x' = (1 - x)x$ (`logistic.m`) for $t \in [0, 3]$, $x_0 = 2$, $\tau = 0.1$ and plot t versus the solution x :

```
x0=2.0; h=0.1;
figure;
[t,x]=pred_corr(@logistic, 0, 3, x0, h);
plot(t,x, '-bx');
```

2. The linear oscillator (`oscillator.m`)

$$\begin{aligned}x'_1 &= x_2 \\x'_2 &= -9x_1 + 10 \cos(2.5t)\end{aligned}$$

for $t \in [0, 10]$, $\mathbf{x}_0 = (2, 1)^\top$, $\tau = 0.1$ and plot t versus the solution x_1 :

```
figure;
x0 = [2;1]; h = 0.1;
[t,x]=pred_corr(@oscillator, 0, 10, x0, h);
plot(t,x(:,1), '-bx');
```

3. The satellite problem (`sat_ode.m`) with $\mu = \frac{1}{82.45}$

$$\begin{aligned}x'_1 &= x_3 \\x'_2 &= x_4 \\x'_3 &= 2x_4 + x_1 - (1 - \mu) \frac{x_1 + \mu}{((x_1 + \mu)^2 + x_2^2)^{1.5}} - \mu \frac{x_1 - 1 + \mu}{((x_1 - 1 + \mu)^2 + x_2^2)^{1.5}} \\x'_4 &= -2x_3 + x_2 - (1 - \mu) \frac{x_2}{((x_1 + \mu)^2 + x_2^2)^{1.5}} - \mu \frac{x_2}{((x_1 - 1 + \mu)^2 + x_2^2)^{1.5}}\end{aligned}$$

for $t \in [0, 6.19216933131963970674]$, $\mathbf{x}_0 = (1.2, 0, 0, -1.04935750983031990726)^\top$, $\tau = 0.001$ and plot x_1 versus x_2 :

```
figure
x0 = [1.2; 0; 0; -1.04935750983031990726];
h = 1e-3;
[t, x] = pred_corr(@sat_ode, 0, 6.19216933131963970674, x0, h);
plot(x(:,1), x(:,2));
```

Save each of these plots as a PDF file using `Save > Save As`.

Exercise 3. Apply linear regression to estimate the method order. See `conv_analysis.m` for a script to perform this, when called with the `pred_corr`:

```
conv_analysis(@pred_corr);
```

Submission

Submit the MATLAB script for the implemented method from *exercise 1*, the PDF files of the plots from *exercise 2*, and enter the order of the method deduced in *exercise 3* via the *Study Group Roster* (ZáZNAMNÍK učitele) in SIS before the deadline.