Constructor University
Fall 2025

September 12, 2025

Stochastic Modeling and Financial Mathematics

Assignment Sheet 1

Due on September 19, 2025, before class

Note: The work is to be submitted via `git`, as discussed in class. The coding language is Python. Please make sure that your code actually runs and produces the requested output. Please make your code readable for the instructor and TA, and include comments wherever necessary. Please submit .py source code, not jupyter notebooks. Theoretical questions may be submitted as a scan of handwritten notes or typed up (e.g., using LaTeX).

Problem 1 [5 points]

An investment is guaranteeing a cash flow $C_1, \ldots, C_n$ at the end of each period. The period interest rate is r. Write Python functions to compute the present value of the investment in four different ways, using

1. an explicit Python loop summing up each summand,
2. an explicit Python loop using Horner's scheme,
3. the `polyval` function,
4. the dot product of vectors.

Compare the run-time of the four implementations on the following test case, using `timeit` (as shown in class) with 1 000 evaluations:

```
C = 120.0 * arange(500,1200)
r = 0.01
```

The outputs of your program should be: the present value (around 7 million), and the run times of the four different functions (depending on your computer up to a few seconds).

Problem 2 [3 points]

An individual who plans to retire in 40 years has decided to put an amount A in the bank at the beginning of each of the next 480 months, after which she will withdraw 2000 \$ at the beginning of each of the following 360 months. Assuming a nominal yearly interest rate of 2% compounded monthly, how large does A need to be? (Note: You can either solve this exercise with a python program or by hand. The answer is a bit more than 700 \$.)

Problem 3 [4 points]

Write a Python program which prints out an amortization schedule for a mortgage.

The program should take as input the nominal yearly interest rate r, the amount of the loan P, the number of compounding periods per year m, and the term of the mortgage n in years. Assume that the mortgage is fully redeemed at the end of the term.

The program should compute the monthly payment and the effective annual interest rate. Furthermore, it should display a detailed payment schedule, i.e., for each month the interest and principal parts of the payment, and the remaining principal.

Run your program with $P = 500\,000$, $r = 0.02$, $m = 12$, and $n = 20$.

Problem 4 [3 points]

An investment sold at price P is guaranteeing a cash flow $C_1, \ldots, C_n$ at the end of each year. Write a program to compute its IRR (internal rate of return), using Python's brentq function. Run your program on the following test case:

```
n = 10
C = 120.0 * arange(42,52)
P = 50000.0
```

(The answer is almost 2%.)

Problem 5 [5 points]

Implement the bisection method, Newton's method, and the secant method as python functions for computing the IRR. Use `timeit` to compare the efficiency of these functions and of python's own brentq function, using the parameters

```
N = 300
C = 120.0 * arange(10,N+10)
P = 15000
```