Exam B – Asset Allocation Module

Submission Guidelines

- **Deliverables:** one single `.zip` by email containing (i) a **PDF report** of 10-15 pages (maximum) in which you discuss your results with the help of tables and plots, and (ii) all **MATLAB codes** used to generate the results.
- **Deadline: 10 December 2025**.

Important: Each group has been assigned one version of the exam (A, B, or C). Check the file `Exam_Assignments_2025.pdf` on WeBeep to verify which version your group must solve.

Exam Objective

Each exercise involves building one or more portfolios under specific models or constraints. The goal is to compare their characteristics and evaluate the stability of results across different approaches and time periods.

Investment Universe

The dataset (`asset_prices.csv`) contains **daily prices** from 10/10/2001 to 29/11/2024 for 16 synthetic indices representing different areas of the equity market. These indices have been constructed to display distinct macro sensitivities and realistic cross-correlations, suitable for portfolio optimization exercises.

Each asset is labeled according to its macro-sensitivity category (`mapping_table.csv`):

- **Cyclical assets:** higher sensitivity to the business cycle and market expansions.
- **Neutral assets:** intermediate or mixed behavior across macro regimes.
- **Defensive assets:** lower sensitivity to economic growth and higher resilience in downturns.

Note: The dataset has been anonymized while preserving realistic return dynamics, variance–covariance structure, and relative macro behavior across groups.
All exercises must use the following periods:

- **In-sample:** January 2018 – December 2022
- **Out-of-sample:** January 2023 – December 2024

Exercise 1 – Constrained and Robust Efficient Frontier

a) Build the mean–variance efficient frontier using in-sample data under the following constraints:

   - Full investment: $\sum_i w_i = 1$

- No short selling: $w_i \geq 0$
- Maximum weight per asset: $w_i \geq 0$, $w_i \leq 0.20$
- Exposure limits: Cyclical $\leq 35\%$, Defensive $\geq 25\%$

Identify and save:

- **Portfolio A:** Minimum Variance Portfolio (MVP)
- **Portfolio B:** Maximum Sharpe Ratio Portfolio (MSRP)

b) Re-estimate the frontier using a resampling approach to obtain a robust frontier. Save:

- **Portfolio C:** Robust MVP
- **Portfolio D:** Robust MSRP

Exercise 2 – Black–Litterman Model

Starting from the market-cap weighted portfolio (provided in `capitalization_weights.csv`):

a) Compute **equilibrium returns**.

b) Introduce the following **views:**

- Defensive assets expected to outperform Cyclical ones by +1.5% annualized
- Asset_5 expected to outperform Asset_14 by +0.8% annualized
- Neutral assets expected to underperform the market by –0.5% annualized

c) Obtain **posterior expected returns** and compute the efficient frontier under standard constraints (i.e. full investment & no short-selling) using the in-sample data.

d) Save:

- **Portfolio E:** Minimum Variance Portfolio
- **Portfolio F:** Maximum Sharpe Portfolio

e) Discuss the effects of the investor's views on portfolio composition and efficiency.

Exercise 3 – Diversification-Based Optimization

Using the in-sample data:

a) Construct the following portfolios:

- **Portfolio G:** Maximum Entropy in Risk Contributions
- **Portfolio H:** Maximum Entropy in Volatility Contributions

under constraints:

- $0 \leq w_i \leq 0.25$, $\sum_i w_i = 1$

- Cyclical + Defensive $\leq 75\%$

b) Compare the portfolios and the equally weighted benchmark in terms of: Diversification ratio, Volatility, Sharpe ratio, Effective number of assets (Herfindahl index)

Exercise 4 – PCA and Conditional Value-at-Risk

a) Apply Principal Component Analysis (PCA) to the covariance matrix of in-sample returns. Identify how many components explain at least 90% of total variance.

b) Construct:

- **Portfolio I:** Use the correlation matrix reconstructed from the first k principal components of the standardized in-sample returns, where k explains at least 90% of total variance. Impose standard investment constraints (full investment, $0 \leq w_i \leq 0.25$) and an additional target volatility constraint of 12% annualized. Within these constraints, compute the minimum-variance portfolio.
- **Portfolio J:** Compute the maximum Sharpe ratio portfolio under standard constraints and a nonlinear CVaR cap at the 5% tail probability, ensuring the portfolio CVaR does not exceed 5% of the initial capital.

c) Compare the two portfolios in terms of: Tail risk (CVaR), Volatility and Maximum Drawdown.

Exercise 5 – Personal Strategy

Design your own allocation strategy, based on one or more methods studied in class. You may use the entire historical dataset (2001–2022) for model estimation, feature engineering, or training. Your strategy will be evaluated based on its **risk-adjusted performance** and **methodological coherence**.

a) Explain the rationale and quantitative intuition of your approach.

b) Apply your strategy to the **evaluation period January 2023 – November 2024**.

c) Plot and discuss performance indicators:

- Returns and volatility
- Sharpe and Calmar ratios
- Maximum drawdown

d) After submission, you will receive **updated prices for 2025**. Apply your strategy out-of-sample on these new data and submit a one-page summary of results.

Final Discussion

Each group must include a final comparative section discussing:

- Out-of-sample performance of all computed portfolios (A–J)
- Differences in risk-adjusted performance and robustness
- Impact of Cyclical / Neutral / Defensive exposures on portfolio behaviour

Files Provided

- `asset_prices.csv` – daily prices of 16 anonymized assets
- `capitalization_weights.csv` – market portfolio weights
- `mapping_table.csv` – asset classification (Cyclical, Neutral, Defensive)