Indian Institute of Technology Ropar
Department of Mathematics
MA634: Financial Risk Management
1st Semester of Academic Year 2025-26
Assignment

Deadline: November 10, 2025 (11:59 pm)

Instructions:

- Each student is supposed to do the assignment individually.
- Students, please be advised that any form of cheating or plagiarism, including copying from peers or the internet, will result in 0 marks. The assignments will be screened through **Plagiarism Checker by Grammarly**.
- Please email your solutions to **puneet.pasricha@iitrpr.ac.in** by November 10, 2025 at 23h59. The subject of the e-mail should be **"MA634 Assignment Your Entry Number"**. Your solutions should be neatly presented. Attach Python codes named in the format **"Assignment_EntryNumber_Codes.py"** and a PDF file named **"Assignment_EntryNumber_Solutions.pdf"**. The Python codes should execute without any issues and should be well-commented.
- There will be a viva after the submission deadline is over. The dates will be announced later.

Objective

(i) Construct Global Minimum Variance (GMV), Mean–Variance Efficient (tangency), Equal-Weight (EW), and an "Active" portfolio (based on alpha significance), (ii) run a rolling 6-month formation / 3-month holding backtest from 2009–2022, (iii) evaluate performance, and (iv) estimate and backtest 99 % historical VaR at a 3-month horizon.

Data You will find two csv files on the google classroom.

- *Stocks_data.csv*: Daily closing prices for *50* Nifty 50 constituents from **2009-01-01** to **2022-12-31**. The last column contains the closing value of Nifty 50. If a stock has missing/partially observations in the analysis period, you can remove that stock.
- *market_Factor_risk_Free.csv*: Daily factors: columns `Date, MF, RF`, where `MF` is the market excess return (in percentage) and `RF` is the daily risk-free rate (decimal).

Problems Unless stated otherwise, use *daily* simple returns (not log returns) in raw series and compound appropriately when aggregating.

1. **(Common dates)** Match trading dates across the stock, index, and factor files and **retain only the intersection** of dates for all subsequent analysis.
2. **(Portfolio construction from formation window)** For any formation window, let $R_t \in \mathbb{R}^N$ be the vector of stock returns on day t for the available N stocks in that window. Estimate the sample mean $\hat{\mu} \in \mathbb{R}^N$ and covariance $\hat{\Sigma} \in \mathbb{R}^{N\times N}$. Create the following four portfolios,
   a) **Global Minimum Variance (GMV) portfolio**
   b) **Mean–Variance (Tangency) portfolio**
   c) **Equal-Weighted (EW) portfolio**
   d) **Active portfolio via alpha significance (formation window).** For each stock i, run the CAPM regression on *excess* returns (with all series in decimals) using formation-window data:

$$(R_{i,t} - RF_t) = \alpha_i + \beta_i \,\mathrm{MF}_t + \varepsilon_{i,t}.$$

   Test the significance (at 95 % confidence level) of α_i. Select stocks with *significant non-zero* alpha, and form an **Active** portfolio (see the lecture slides for details on active portfolio). If no stock qualifies in the formation period, choose the market portfolio.

3. Using the weights from the formation window, compute the realized portfolio return over the **holding-period** (no rebalancing during the holding period).

4. **(Rolling windows)** Begin with formation **Jan–Jun 2009** and holding **Jul–Sep 2009**. Shift the formation and holding **forward by 3 months** (rolling window): formation **Apr–Sep 2009**, holding **Oct–Dec 2009**; then **Jul–Dec 2009 / Jan–Mar 2010**; continue until the last holding period **Oct–Dec 2022**. For each window, compute the 3-month realized returns for the **five** portfolios: [GMV, MV, EW, Active, NIFTY50].

5. **(Return matrix)** Stack the window results into an $n \times 5$ matrix $\mathbf{R}$, where n is the number of rolling windows.

6. **(Performance reporting)**

   a) Plot **cumulative returns** of all five portfolios across windows by compounding the 3-month holding returns sequentially.

   b) Create a **performance table** reporting, for each portfolio: mean return, standard deviation, **Sharpe ratio** (use an annualized definition and state your risk-free convention), and **Information ratio** relative to Nifty 50. Clearly state annualization choices (e.g., 252 trading days/year; 3 months ≈ 63 trading days) and how you convert window returns to annualized figures (e.g., via log-returns).

   c) Briefly **discuss** the results (risk–return trade-offs, performance relative to Nifty 50, etc.).

7. **(Historical VaR backtest, 99 %)** For each window and each portfolio:

   a) Let t_0 be the portfolio formation date for a given window. At the end of each formation period, you have the portfolio weights. Let L be the *number of trading days* in the subsequent holding period (counted from t_0+1 through the holding-period end date, inclusive). All returns are in **decimals**. Estimate L-period (holding period) 99 % Value at Risk using the historical simulation method.

   b) Compare this VaR with the **realized** 3-month holding return to check if VaR is violated or not. Let $R_{p,\text{real}}^{(t_0,L)}$ be the realized holding-period return from t_0+1 to t_0+L. A VaR violation occurs if the realized loss exceeds VaR:

$$-R_{p,\text{real}}^{(t_0,L)} > \text{VaR}_{0,99}(L) \quad \Longleftrightarrow \quad R_{p,\text{real}}^{(t_0,L)} < -\text{VaR}_{0,99}(L).$$

   c) Produce a time-series plot of estimated VaR (as negative numbers) and realized holding returns, and report the **violation count** for each of the four portfolios you created.

Assumptions & Notes

- Unless otherwise specified: fully invested portfolios ($(\sum_{i=1}^{N} w_i = 1)$) where N is the number of stocks. State and justify any alternative bounds you use.
- Be explicit about return definitions (simple vs. log), compounding conventions, and annualization constants. Convert all returns to decimals; keep unit consistency.

Deliverables

1. A concise PDF report including: methodology summary, cumulative return plot, performance table, VaR vs. realized plot, and key takeaways.
2. Working code.
3. An $(n \times 5)$ CSV (or table in the appendix) of rolling 3-month holding returns with columns: GMV, MV, EW, Active, NIFTY50.