Selection Assignment @ MathFinance2026

Procedure: Submit the solution files and your CV by **May 25 mid-night, 2026**. Fill up the *google form: forms.gle/m9qNgxMUf6uHFvfd7* with a link to the solution files and your CV. You can upload these to a folder in google drive / dropbox and share the link. DO CHECK that you have granted access for us to view the folder. We will finalize the list of selected participants by June 7, 2026.

The program includes online courses on probability, statistics, coding and stochastic calculus, designed to prepare you for industry roles. There will be a two-week onsite component followed by online sessions and self study. Do note that, the onsite session is going to be in CMI during June 20-July 5.

Submit your solution as a combination of latex file and Jupyter notebook.

Communication

1. Please briefly describe your PhD research in plain English, placing it in the context of recent developments in the field. Your explanation should be understandable to an intelligent non-specialist with approximately a 12th-grade science background.

2. Choose one of the following traded financial instrument from equities, foreign exchange (FX), or fixed income and credit (FICC) markets: Equity options (call/put options), Interest rate swaps, FX forwards or FX options, Credit default swaps, Futures contracts, Variance swaps.

   Write a one-page note explaining:

   - what the instrument is and how it works,
   - the typical use cases and market participants,
   - the main risks involved.

Combinatorics

1. Prove the following identities using words/combinatorial arguments.

$$\sum_{k=0}^{n} \binom{n}{k} = 2^n, \quad \binom{n}{k} = \binom{n-1}{k} + \binom{n-1}{k-1} \quad \text{and} \quad \sum_{r=k}^{n} \binom{r}{k} = \binom{n+1}{k+1}.$$

2. In how many ways can 8 people be seated around a circular table if two particular people must not sit next to each other?

3. A standard deck of 52 cards is shuffled.

   - What is the probability that all four aces appear consecutively?
   - What is the probability that no two aces are adjacent?

4. A rook starts at the bottom-left corner of an $m \times n$ grid and moves only right or up.

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- How many shortest paths are there to the top-right corner?
- One of the grid cells, (x, y) is blocked. Now how many shortest paths are there?

Probability

1. State the Central Limit Theorem. Prove it using (a) Moment generating functions and (b) Characteristic functions. Is there a difference between the two methods of proving it?

2. Take three independent normal random variables $X \sim N(0,1)$, $Y \sim N(0,1)$ and $Z \sim N(0,2)$ where $N(a,b)$ denotes a normal distribution with mean a and variance b. Compute the following probabilities:

   (a) $P(X > Y) :=$ the probability that $X > Y$.

   (b) $P(|X| > |Y|)$

   (c) $P(X > Z)$

   (d) $P(|X| > |Z|)$

Statistics

1. Perform the following tasks to investigate the distributional properties of human height using publicly available NHANES data.

2. Install Jupyter notebook. Get the height data from https://wwwn.cdc.gov/nchs/nhanes/continuousnhanes/default.aspx?BeginYear=2009.

3. Analyze the overall height distribution. A typical guess would that the distribution should be normal. Do you see that ?

4. One issue is because of gender. Download the demographic data and merge with height data. Now, plot the histogram of heights for different genders. Are the histograms normal now?

5. Extend your analysis of the dataset. This may include, for example, testing for normality using Q-Q plots or providing justification for why normality should not be expected. Based on your initial analysis, determine and carry out any further investigations that are appropriate and report your findings clearly.

Code of Conduct:

- You are allowed to refer to books and online materials.
- You can use chatgpt, but write the answers in your own language.
- You are NOT allowed to discuss with other people.