SMU
SINGAPORE MANAGEMENT UNIVERSITY

AY 2023-24 Term 2 Final Examinations

Date / Start Time	26 April 2024 / 2:30pm
Course	**QF206 - Quantitative Trading Strategies**
Groups	G1
Instructor	Assistant Professor Liu Peng
Total number of pages (including this instruction sheet)	6

INSTRUCTIONS TO CANDIDATES

1 The time allowed for this examination paper is **2 hours**.

2 This is a closed-book exam.

3 This examination paper contains a total of **21** questions and comprises **15 MCQs and 6 open questions**.

4 You are required to answer **ALL** questions on the exam booklet, including MCQ and open questions.

Each MCQ has 2 points.

1. For trend-following strategy and momentum trading strategy, whose entry point is controllable with respect to market conditions?
   A. Trend following
   B. Momentum trading
   C. Both
   D. Neither

Answer: A
Trend following strategies actively wait for a clear trend to establish before entering a position, meaning they can control their entry point based on market conditions, like identifying a trend breakout or a specific price level.

Other options are incorrect:
B: Momentum trading often focuses on reacting to existing price movements quickly, meaning the entry point is less controllable as it might be triggered by sudden price changes.
C: Since trend following allows for controlled entry based on market conditions, while momentum trading is more reactive, only trend following has a controllable entry point.
D: This is incorrect because trend following strategies explicitly aim to control entry points by waiting for defined trend signals.

2. You are given a time series of daily closing prices for a particular stock. To perform a monthly performance analysis, you decide to compute the monthly returns from these daily prices. Assume no dividends are paid. Which of the following formulas represents the correct method for calculating the total return for a given month? (select all that apply)

A) $R_m = \left(\frac{\sum_{i=\text{first day}}^{\text{last day}} P_i}{\text{Number of days in month}} - P_{\text{first day}} \right) \times 100\%$

B) $R_m = \left(\frac{P_{\text{last day}} - P_{\text{first day}}}{P_{\text{first day}}} \right) \times 100\%$

C) $R_m = \prod_{i=\text{first day}+1}^{\text{last day}} \left(1 + \frac{P_i - P_{i-1}}{P_{i-1}} \right) - 1$

D) $R_m = \sum_{i=\text{first day}+1}^{\text{last day}} \left(\frac{P_i - P_{i-1}}{P_{i-1}} \right) \times 100\%$

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# Example daily closing prices for a month (5 days for simplicity)
prices = [100, 102, 101, 104, 103]  # first day = 100, last day = 103
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Option A: 2.0000%
Option B: 3.0000%
Option C: 3.0000% (correct)
Option D: 3.0284%

Explanation
Option B gives the simple total return over the period.
Option C gives the correct compounded (cumulative) return.
Option D gives the sum of daily returns (approximate for small returns, not exact for compounding).
Option A is incorrect (uses average price, not return).

3. When analyzing financial time series data using pandas in Python, one often uses the rolling() and agg() functions to compute statistics over the data. What is the primary distinction between the rolling() and agg() functions in the context of financial time series analysis?
   A. rolling() is used for applying a single statistical function sequentially over a fixed-size moving window of time (e.g., 30-day rolling mean), whereas agg() is used for calculating grouped statistics (e.g., monthly averages) without considering a moving window.
   B. rolling() applies a function across a moving window based on time periods, useful for moving averages or volatility measures, while agg() applies one or more functions across an entire time series or within groups based on specific time intervals like months or quarters.
   C. rolling() is only capable of computing the moving average, whereas agg() is employed for more complex calculations like weighted averages and exponential moving averages specific to financial time series.
   D. rolling() is exclusively for intraday trading analysis, whereas agg() is used for end-of-day summary statistics.

The primary distinction between rolling() and agg() in pandas for financial time series analysis lies in their application scope. rolling() computes statistics over a sliding window, making it suitable for analyzing trends and volatility across time. In contrast, agg() calculates statistics across entire time series or grouped intervals, which is useful for summary statistics. Therefore, option B accurately describes this difference.

4. In momentum trading strategies, lookback and lookahead windows play distinct roles in the formulation and evaluation of a strategy. Considering these roles, which of the following statements is incorrect regarding lookback and lookahead windows in the development and application of momentum trading strategies?
   A. A lookback window is employed to determine the momentum indicator, typically using the past price changes, while a lookahead window is considered a methodological error in strategy development as it implies access to future information.

Answer: C
While it's true that you want a lookback window long enough to capture momentum but short enough to stay responsive, there is no valid way to "use" a lookahead window without introducing future-data leakage — any lookahead by definition peeks at tomorrow's prices and thus can't provide legitimate signals.

B. A lookback window of a momentum trading strategy might be optimized using historical data to maximize performance metrics, whereas a lookahead window, even if unintentionally included, can lead to overfitting and unrealistic performance expectations due to information leakage from the future.
C. The length of the lookback window should be sufficiently long to capture the relevant momentum effect, but not so long that the strategy cannot adapt to changing market conditions, while the lookahead window, if used correctly, can provide predictive signals that are not based on past data.
D. Utilizing a lookahead window in live trading is considered a malpractice as it implies trading on information not yet available, whereas optimizing the length of the lookback window is a standard practice in developing momentum strategies to capture the most predictive period of price movement.

5. When analyzing the risk characteristics of a financial asset, max drawdown is a critical measure used to gauge the largest potential loss from peak to trough over a specified period. If you were to compare the max drawdown on a daily basis with that on a monthly basis for the same asset, which of the following statements is most accurate?
   A. The daily max drawdown is generally higher than the monthly max drawdown, as it captures the intra-day volatility which is not reflected in monthly closing prices.
   B. The monthly max drawdown is generally higher than the daily max drawdown, as it accounts for cumulative price movements over a longer period and can therefore capture larger market swings.
   C. Daily and monthly max drawdowns are statistically identical since the daily drawdowns are subsumed within the monthly periods, making their magnitudes equivalent.
   D. Neither daily nor monthly max drawdowns can be compared directly, as they are dependent on the frequency of trading within the portfolio and unrelated to the time period over which they are measured.

6. When considering the risk-free rate in the context of investment analysis, which of the following statements best reflects the concept of max drawdown as it applies to the risk-free rate?
   A. The max drawdown for the risk-free rate is the maximum observed decrease from the peak interest rate offered by government securities within a given year.
   B. Since the risk-free rate is a theoretical construct that assumes no loss, the max drawdown is inherently zero as there are no fluctuations in the rate of return.
   C. The max drawdown for the risk-free rate can vary similarly to equities and bonds, depending on the interest rate environment and fiscal policy changes.
   D. The risk-free rate often has a significant max drawdown during economic downturns due to the increased likelihood of government defaults and the volatility of bond prices.

Answer: B
A "drawdown" measures the peak-to-trough loss of an investment. A truly risk-free instrument, by definition, cannot suffer a loss, so its drawdown is zero.

7. An investor decides to construct an equal-weight portfolio of four assets. According to Modern Portfolio Theory (MPT), which of the following statements is true regarding the risk and return characteristics of this equal-weight portfolio?
   A. The portfolio's risk is simply the average of the individual risks of the four assets since they are equally weighted.
   B. The portfolio's expected return is the average of the expected returns of the four assets, weighted equally.

Answer: D
Diversification benefit: The key principle of Modern Portfolio Theory (MPT) is that by holding a diversified portfolio of assets, an investor can reduce their overall risk even if the individual assets are risky.
Negative correlation: When assets are not perfectly correlated (meaning their prices do not move in exactly the same direction), their risks can offset each other within a portfolio, leading to a lower overall risk than the average risk of the individual assets.
Why other options are incorrect:
A: This is not true unless the assets are perfectly correlated. When assets are uncorrelated or negatively correlated, the portfolio's risk will be lower than the simple average of individual risks due to diversification.
B: This statement is correct. The expected return of a portfolio is indeed the weighted average of the expected returns of the individual assets. However, the question asks about the risk, not the expected return.
C: This is incorrect. While diversification does reduce risk, it doesn't bring the portfolio's risk down to the level of the least risky asset. The risk reduction depends on the degree of correlation between the assets. A portfolio with perfectly correlated assets would not benefit from diversification and would have a risk equal to the average risk of the individual assets.

C. The portfolio's risk is equal to the risk of the least risky asset in the portfolio due to the diversification effect.
D. The portfolio's risk is always lower than the average risk of the individual assets due to the diversification benefits, assuming the assets are not perfectly correlated.

8. In the domain of financial portfolio optimization, predictive and prescriptive analytics are utilized to maximize returns and minimize risks. How do these models interact to aid an investment manager in portfolio construction?
   A. Predictive models suggest the assets to be included in the portfolio, while prescriptive models are used to predict future market conditions affecting those assets.
   B. Prescriptive models simulate various market scenarios, which predictive models then use to determine the potential future performance of the portfolio.
   C. Predictive models forecast future asset prices and returns, which are inputs for prescriptive models that determine the optimal asset allocation to maximize the Sharpe ratio.
   D. There is no interaction; predictive models are used after portfolio optimization to validate the prescriptive model's asset allocation decisions.

   Answer: C
   We first use predictive analytics to get return forecasts, then feed those into a prescriptive (optimization) engine to pick weights that best trade off risk and return.

9. Which of the following options is false?
   A. Which of the following is correct about dark pools:
   B. The volume of trade executed is certain.
   C. Trading on a dark venue will reduce market impact.
   D. Dark pools offer real-time price discovery similar to public exchanges.

   Answer: D
   Dark pools conceal order details until after execution, so they do not contribute to continuous, public price discovery the way lit venues do.

10. In the trading market, liquidity is a measure of how easily an asset can be bought or sold without causing a significant price change. While several market participants contribute to liquidity, which of the following statements best represents the role of buyers and sellers as opposed to market makers or brokers/dealers in providing liquidity?
    A. Buyers and sellers provide liquidity by placing orders, which directly creates the market depth necessary for trades to occur, independent of the actions of market makers or brokers/dealers.
    B. Market makers and brokers/dealers are the true providers of liquidity because they alone have the capacity to place large volume orders that create the market.
    C. Buyers and sellers do not contribute to market liquidity since their trades are dependent on the prices set by market makers and brokers/dealers.
    D. Buyers and sellers are considered incidental to market liquidity; the primary contribution comes from the quotes provided by market makers and brokers/dealers.

    Answer: A
    Every limit order from any participant adds depth ("liquidity"), not just quotes from designated market makers.

11. The limit order book contains a complete picture of the liquidity in the market. True or false?
    A. True
    B. False

12. Which of the following statements is true regarding the execution of trades and price formation in a limit order book environment?

    A) A trade occurs only if a buy order's bid price meets or exceeds a sell order's ask price, with the trade executing at the midpoint between the highest bid and lowest ask.

    B) The highest bid price, P_1^{bid}, and lowest ask price, P_2^{ask}, define the bid-ask spread, and no trades occur within this range in a perfectly liquid market.

    C) The quantity of shares represented by q_3^{ask} at price P_3^{ask} will always be traded before q_2^{ask} at price P_2^{ask}, assuming a descending order book.

    D) If a buyer places a market order, it will be executed at the lowest ask price, P_2^{ask}, for the quantity available at this price, before moving to the next available ask price.

    Answer: D
    Market orders "walk the book," filling against resting asks in ascending-price order.

13. A trader executed four trades throughout the day at different prices and volumes. The details of the trades are as follows:
    - Trade 1: 100 shares bought at $50 per share
    - Trade 2: 150 shares bought at $52 per share
    - Trade 3: 200 shares bought at $51 per share
    - Trade 4: 50 shares bought at $53 per share

    Calculate the VWAP for these trades and select the correct answer from the options below.

    A. $51.20
    B. $51.30
    C. $51.80
    D. $52.00

    Answer: B

    # VWAP formula: sum(price * volume) / sum(volume)
    total_value = sum(shares * price for shares, price in trades)
    total_shares = sum(shares for shares, price in trades)
    vwap = total_value / total_shares

    Short calculation process:
    - Total value = 100*50 + 150*52 + 200*51 + 50*53 = 5000 + 7800 + 10200 + 2650 = 25650
    - Total shares = 100 + 150 + 200 + 50 = 500
    - VWAP = 25650 / 500 = 51.30

14. If a portfolio has a daily Sharpe ratio of 0.05, how would you annualize this Sharpe ratio to reflect a yearly Sharpe ratio, assuming there are 252 trading days in a year?
    A. Multiply the daily Sharpe ratio by the square root of 252.
    B. Multiply the daily Sharpe ratio by 252 directly.
    C. Divide the daily Sharpe ratio by the square root of 252.
    D. Divide the daily Sharpe ratio by 252.

    Answer: A
    Based on the Sharpe ratio formula, annualizing both the return and the standard deviation results in the annualized Sharpe ratio.

15. An investment analyst is tasked with estimating the parameters for the covariance matrix of a portfolio consisting of 100 assets. How many unique parameters, including variances and covariances, must the analyst estimate in total?
    A. 100
    B. 5050
    C. 10000
    D. 9900

    Answer: B
    Recall that the covariance matrix is symmetric, meaning the total number of unique entries is the max total number of non-zero entries of a lower/upper triangular matrix, i.e., 1 + 2 + ... + 100 = 100 * 101/2 = 5050

16. (15) Suppose we have two assets whose prices are x1 and x2, respectively.
    - (5) Assume a linear regression model to form the relationship x2=a*x1+b, where a>0. What is the correlation between x1 and x2?
    - (5) Assume asset 1 has mean return μ_1 and variance σ_1^2, asset 2 has mean return μ_2 and variance σ_2^2, and the correlation between the two assets is ρ. What is the portfolio risk and return?
    - (5) Now suppose we have d assets with $\mu_i = \mu$ and $\sigma_i = \sigma$ for all assets and $\rho_{ij} = 0$ for all $i \neq j$. We have one portfolio with all weight in the first asset, and another portfolio with equal weights in all assets. Calculate the risk and return for both portfolios and discuss the benefit of diversification.

17. (15) The following questions test a basic understanding of trading concepts:
    - (5) Explain long and short positions and characterize their return and risk profile.
    - (5) What is the average return for an investment fund with a 20% return in year 1 and -10% in year 2?
    - (5) For the second sub-question, what is the average return if we know 1 million dollars is invested in year 1 and 10 million dollars in year 2?

18. (10) We have worked with simple returns on many occasions.
    - (5) Discuss its definition and interpretation.
    - (5) What is its lower bound?

19. (10) For a portfolio of N risky assets under the mean-variance optimization framework, show:
    - (5) How portfolio risk can be calculated
    - (5) Why diversification helps generate a portfolio whose risk is lower than the weighted sum of individual risk.

20. (10) Exponential smoothing average is a popular technique in processing time series data.
    - (5) Provide the equation for the exponential smoothing average and explain how it works.
    - (5) Show the weights of all raw values sum to one.

21. (10) An investor is considering two assets for a portfolio, Asset 1 and Asset 2. The annual returns, variances, and the correlation coefficient between the two assets are as follows:
    - Expected return of Asset 1: 7%, Variance of Asset 1: 9%
    - Expected return of Asset 2: 10%, Variance of Asset 2: 16%
    - Correlation coefficient between Asset 1 and Asset 2: 0.5

    Assuming the investor wants to construct a minimum variance portfolio with these two assets, what are the weights of Assets 1 and 2 in this portfolio?

    (hint: use first-order condition to obtain a closed-form solution on portfolio weights)