

INSTITUTE OF ACTUARIES OF INDIA
EXAMINATIONS

23rd November 2024

**CM2 - Financial Engineering and Loss Reserving
(Paper A)**

Time allowed: 3 Hours 15 Minutes

Total Marks: 100

Q. 1) In which form of market can investor derive the benefit of Insider Trading?

1. Weak form Efficient Markets
2. Semi-strong form Efficient Markets
3. Strong form Efficient Markets
4. All of the above

[1.5 Marks]

Q. 2) In accordance to the expected utility theorem, which axiom implies that the investors are consistent in their rankings of outcomes.

1. Comparability
2. Certainty equivalence
3. Transitivity
4. Independence

[1.5 Marks]

Q. 3) An approach to modelling Credit Risk that uses observed market statistics such as credit ratings is:

1. Structural models
2. Intensity-based models
3. Reduced-form models
4. The Merton models

[1.5 Marks]

Q. 4) According to Bernartzi and Thaler's behavioral finance approach to the equity premium puzzle, the puzzle can be explained by:

1. Investors' irrational behaviour and overconfidence.
2. Efficient markets hypothesis and rational expectations.
3. The risk-free rate being too low.
4. The equity risk premium being too high.

[1.5 Marks]

Q. 5) The type of risk which is avoidable through proper diversification.

1. portfolio risk
2. systematic risk
3. Specific risk
4. total risk

[1.5 Marks]

Q. 6) According to the capital-asset pricing model (CAPM), a security's expected (required) return is equal to:

1. The risk-free rate.
2. The risk-free rate plus a market risk premium.
3. The market risk premium.
4. The expected dividend yield.

[1.5 Marks]

Q. 7) The risk-free security has a beta equal to _____ , while the market portfolio's beta is equal to _____ .

1. one; more than one.

2. one; less than one.
3. zero; one.
4. less than zero; more than zero.

[1.5 Marks]

Q. 8) Consumer X has a higher income than Consumer Y but they have identical preferences and pay the same prices for the goods which they consume. If they both maximise utility then:

1. The marginal utility from each good consumed will be higher for X than for Y and X will have a higher total utility.
2. The marginal utility from each good consumed will be higher for X than for Y and X will have a lower total utility.
3. The marginal utility from each good consumed will be lower for X than for Y and X will have a higher total utility.
4. The marginal utility from each good consumed will be lower for X than for Y and X will have a lower total utility.

[1.5 Marks]

Q. 9) The efficient frontier is the set of _____ portfolios that offers the highest expected return for a defined level of risk on the lowest risk for a given level of expected return.

1. Minimum
2. maximum
3. optimal
4. regular

[1.5 Marks]

Q. 10) The Cameron-Martin-Girsanov theorem in stochastic calculus relates to:

1. Change of measure in the context of Brownian motion.
2. The pricing of American options.
3. The behavior of jump processes.
4. The convergence of stochastic processes.

[1.5 Marks]

Q. 11) A European put option allows the holder to

1. buy the underlying asset at the striking price on or before the expiration date.
2. sell the underlying asset at the striking price on or before the expiration date.
3. potentially benefit from a stock price increase.
4. sell the underlying asset at the striking price on the expiration date.

[1.5 Marks]

Q. 12) The Cameron-Martin-Girsanov theorem is used to change the measure in such a way that the new measure Q is absolutely continuous with respect to the original measure P. This means:

1. Q and P assign zero probability to the same events
2. Q is equivalent to P
3. Q and P are mutually exclusive
4. Q and P have the same probability density function

[1.5 Marks]

Q. 13) What is in the money (ITM) call option contract?

1. Spot price is greater than strike price

2. Spot price is Lower than strike price
3. Spot price is equal to strike price
4. None of these

[1.5 Marks]

Q. 14) Which of the following is a measure of total consumer surplus?

1. Marginal utility minus the price of the good.
2. The total utility consumers get from the consumption of the good.
3. The total utility consumers get from consumption of the good less the total expenditure on the good.
4. Marginal utility times the price of the good.

[1.5 Marks]

Q. 15) Which of the following is NOT implied by the principle of diminishing marginal utility of income:

1. Total utility increases at a decreasing rate as income increases.
2. Marginal utility increases at a decreasing rate as income increases.
3. Marginal utility decreases at an increasing rate as income falls.
4. Total utility decreases at an increasing rate as income increases.

[1.5 Marks]

Q. 16) Diminishing marginal utility of income implies:

1. people are risk lovers.
2. people are risk averse.
3. people are risk diversifiers.
4. people are risk neutral.

[1.5 Marks]

Q. 17) In ruin theory, the Cramer-Lundberg model assumes:

1. The surplus process follows a geometric Brownian motion.
2. The surplus process follows an arithmetic Brownian motion.
3. The surplus process follows a Poisson process.
4. The surplus process follows a compound Poisson process.

[1.5 Marks]

Q. 18) What is out of the money (OTM) put option contract?

1. Spot price is lower than strike price
2. Spot price is greater than strike price
3. Spot price is equal to strike price
4. None of these

[1.5 Marks]

Q. 19) What is intrinsic value of a derivative?

1. Intrinsic value is the difference between the price of underlying asset and the strike price
2. Intrinsic value is the difference between the price of underlying asset and the futures price
3. Intrinsic value is the difference between the spot price and interest rate
4. none of these

[1.5 Marks]

Q. 20) Which of the following is a key property of a Wiener process (standard Brownian motion)?

1. The process has continuous but non-differentiable paths.
2. The process has discontinuous paths.
3. The process is deterministic.
4. The process is bounded.

[1.5 Marks]

Q. 21) Which of the following is NOT a Martingale (a stochastic process)?

1. $X_t = W_t$, where W_t is a Wiener process
2. $X_t = e^{\mu t + \sigma W_t}$, where μ and σ are constants, and W_t is a Wiener process
3. $X_t = X_0 + W_t$, where W_t is a Wiener process
4. $X_t = W_t^2 - t$, where W_t is a Wiener process

[1.5 Marks]

Q. 22) Please read the given statement and then select the right option as your answer:
"It is possible for a futures contract to be underlying asset for an options contract"

1. TRUE
2. FALSE
3. Partially true
4. Not sure

[1.5 Marks]

Q. 23) If call option has a strike price of Rs 1210/- and the current market price of the underlying asset is Rs.1320/- and option premium is Rs.200, then what will be the time value.

1. Rs. 70
2. Rs. 90
3. Rs. 110
4. Rs. 140

[1.5 Marks]

Q. 24) What is Black -Scholes model?

1. This model is used to calculate a theoretical price of options using the five key determinants of an option price
2. This model is used to calculate impact of volatility on option premium
3. This model is used to calculate changes in option price with change in price of underlying asset
4. None of these

[1.5 Marks]

Q. 25) What is the foremost requirement for Chain ladder method to start?

1. Loss development factor
2. Cumulative development factor
3. Reserves
4. Incremental Triangle of claims development

[1.5 Marks]

Q. 26) Which is the correct formula giving Total Reserves?

1. Ultimate Claims – Premiums
2. Premium – Paid Claims
3. Ultimate Claims – Incurred Claims

4. Cumulative claims – Incremental Claims

[1.5 Marks]

Q. 27) Given the following cumulative claims data in a run-off triangle for a particular line of business, estimate the claims reserve for accident year 2018 using the Chain-Ladder method:

Accident Year	1	2	3
2016	100,000	150,000	180,000
2017	120,000	180,000	
2018	140,000		

Calculate the following:

- Development factors
- Projected cumulative claims for accident year 2018 at Development Year 3
- Estimated claims reserve for accident year 2018 (i.e., projected claims beyond the known values).

Options:

1. Development factors: 1.50, 1.20; Projected cumulative claims: 252,000; Estimated claims reserve: 112,000
2. Development factors: 1.25, 1.20; Projected cumulative claims: 210,000; Estimated claims reserve: 70,000
3. Development factors: 1.50, 1.33; Projected cumulative claims: 280,000; Estimated claims reserve: 140,000
4. Development factors: 1.50, 1.25; Projected cumulative claims: 262,500; Estimated claims reserve: 122,500

[2 Marks]

Q. 28) Given the Black-Scholes formula for a European call option:

$$C = S_0 N(d_1) - K e^{-rT} N(d_2)$$

where

$$d_1 = \frac{\ln(S_0/K) + (r + \sigma^2/2)T}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

If $S_0 = 50$, $K = 45$, $r = 0.05$, $\sigma = 0.2$, and $T = 1$, what is the value of d_1 ?

1. 0.875
2. 0.625
3. 0.575
4. 0.525

[2 Marks]

Q. 29) The _____ efficient market hypothesis assumes that the rates of return on the market should be independent; past rates of return have no effect on future rates.

1. Semi-strong form Efficient Markets
2. Strong form Efficient Markets
3. Weak form Efficient Markets
4. All of the above

[2 Marks]

Q. 30) _____ is a linear relationship between expected return and systematic risk (Beta) on which both portfolios and individual securities can lie.

1. Capital Market Line
2. Target Market Line
3. Diversified Market Line
4. Security Market Line

[2 Marks]

Q. 31) A stock has a beta (β) of 1.2. The risk-free rate (r_f) is 3%, and the expected return on the market (r_m) is 8%. Using the CAPM equation, calculate the expected return on the stock.

1. 7.5%
2. 8.6%
3. 9.0%
4. 9.6%

[2 Marks]

Q. 32) A statistical measure of how likely extreme values are to appear (ie those in the tails of the distribution) is:

1. Skewness
2. Kurtosis
3. Shortfall probabilities
4. Tail Value at Risk

[2 Marks]

Q. 33) Which of the following form may not result in credit risk?

- A. Principle and/or interest amount may not be repaid in the case of direct lending
- B. In case of guarantees or letter of credit, fund may not be forth coming from the constituents upon crystallisation of the liability
- C. Insurance companies intermediaries selling policies on behalf of Insurance Company and not passing the premium to the company
- D. Providing information to the regulators on financial adequacy

1. A, B and C only
2. A, C and D only
3. B and C only
4. D only
5. A only

[2 Marks]

Q. 34) Adverse selection means that:

1. The taking out of an insurance policy makes it more likely that the insured against event will occur than if no insurance policy is taken out.
2. Insurance companies tend to select only good risk customers.

3. Bad risk customers are able to obtain insurance on the same terms as good risk customers.
4. People who know they are particularly bad risks are more inclined to take out insurance than those who know they are good risks

[2 Marks]

Q. 35) Consider the iso-elastic utility function $U(c) = \frac{c^{1-\theta}}{1-\theta}$. If $c = 100$ and $\theta = 0.5$, what is the utility $U(c)$?

1. 20
2. 15
3. 18
4. 30

[2 Marks]

Q. 36) An insurance company offers two levels of coverage for car insurance: Basic and Premium. For policyholders with Basic coverage (coverage amount: Rs.10,000), the average number of claims per year is 1.5. For policyholders with Premium coverage (coverage amount: Rs.20,000), the average number of claims per year increases to 2.5 due to moral hazard.

The average cost per claim is Rs.5,000.

Calculate the expected annual cost per policyholder for both Basic and Premium coverage and determine the effect of moral hazard.

Options:

1. Basic coverage: Rs.7,500; Premium coverage: Rs.12,500; Effect of moral hazard: Rs.2,500
2. Basic coverage: Rs.7,500; Premium coverage: Rs.12,500; Effect of moral hazard: Rs.5,000
3. Basic coverage: Rs.7,500; Premium coverage: Rs.17,500; Effect of moral hazard: Rs.5,000
4. Basic coverage: Rs.7,500; Premium coverage: Rs.17,500; Effect of moral hazard: Rs.10,000

[2 Marks]

Q. 37) An explanation of risk aversion is that:

1. the marginal utility of an extra pound of income decreases as more income is received
2. the marginal utility of an extra pound of income increases as more income is received
3. there will always be some individuals willing to take risks while others will be unwilling to take risks regardless of the pay offs
4. investors will only take an increased risk if the marginal utility of risk over the price of risk rises

[2 Marks]

Q. 38) Given below are the main characteristics of an investment:

- Issued by commercial undertakings and other bodies.
- Entitle holders to receive all net profits of the company in the form of dividends after interest on loans and other fixed interest holders has been paid.
- Higher expected returns than for most other asset classes
- Risk of capital losses
- Returns can be variable.
- Lowest ranking form of finance.
- Low initial running yield but coupons should increase with inflation.

- Marketability varies according to size of company.
- Voting rights in proportion to number held.

Which asset has all the above characteristics:

1. Bonds
2. Derivatives
3. Equities
4. Hedge Funds

[2 Marks]

Q. 39) An insurance company has underwritten a portfolio of policies with an expected total claim amount of Rs.10,000,000 for the next year. The company enters into a proportional reinsurance agreement where it cedes 40% of the risk to a reinsurer. The reinsurer charges a ceding commission of 5% on the ceded premium, and the total premium collected by the insurer for the portfolio is Rs.12,000,000.

Calculate the following:

The amount of premium ceded to the reinsurer

The ceding commission

The net premium retained by the insurer after ceding the reinsurance premium and commission

Options:

1. Ceded premium: Rs.4,800,000; Ceding commission: Rs.240,000; Net premium retained: Rs.7,440,000
2. Ceded premium: Rs.4,800,000; Ceding commission: Rs.240,000; Net premium retained: Rs.7,560,000
3. Ceded premium: Rs.5,000,000; Ceding commission: Rs.250,000; Net premium retained: Rs.7,250,000
4. Ceded premium: Rs.5,000,000; Ceding commission: Rs.250,000; Net premium retained: Rs.7,750,000

[2 Marks]

Q. 40) Which of the model is “A stochastic process used to model interest rates. It is a one-factor model that assumes the short-term interest rate follows the stochastic differential equation:---- numerical

$$dr_t = \alpha(\theta - r_t) dt + \sigma dW_t$$

where:

- r_t is the short-term interest rate at time t ,
- α is the speed of mean reversion,
- θ is the long-term mean or equilibrium interest rate,
- σ is the volatility of the interest rate,
- dW_t is a Wiener process or Brownian motion.

1. The Vasicek Model
2. The Hull-White Model
3. The Cox, Ingersoll, and Ross Model

4. Ho and Lee Model

[2 Marks]

Q. 41) A random sample of 200 pairs of observations (x, y) from a discrete bivariate distribution (X, Y) is as follows:

the observation $(-2, 2)$ occurs 50 times
 the observation $(0, 0)$ occurs 90 times
 the observation $(2, -1)$ occurs 60 times.

The sample correlation coefficient for these data is:

1. -0.843
2. +0.864
3. -0.975
4. -0.768

[3 Marks]

Q. 42) A random sample of fifty claim amounts (Rs.) arising in a particular section of an insurance company's business are displayed below in a stem and leaf plot:

15	14678
16	0233368889
17	0000001233457888
18	3456779
19	0257
20	0
21	3
22	07
23	
24	
25	3
26	
27	3
28	8
29	
30	
31	2

Stem unit = 100

Leaf unit = 10

The sum of the fifty amounts (before rounding) is Rs. 92780. The mean and median claim amounts is:

1. 1855.60, 1657
2. 1855.60, 1735
3. 1855.40, 1546
4. 1786.30, 1657

[3 Marks]

Q. 43) Claim amounts are modelled as an exponential random variable with mean Rs.1,000. The probability that one such claim amount is greater than Rs.5,000 is:

1. .0657
2. .0056
3. .0067

4. .0765

[3 Marks]

Q. 44) Given below is a sample claims development data. Each row in the triangle represents an accident year cohort which defines a cohort of claims. The columns represent development years.

Accident Year	Cumulative claim payments				
	Development Year				
	0	1	2	3	4
2008	786	1,410	2,216	2,440	2,519
2009	904	1,575	2,515	2,796	
2010	995	1,814	2,880		
2011	1,220	2,142			
2012	1,182				

Using the delay triangle above, what is:

a. Assuming an inflation of 5% going forward, the total amount of claims paid in 2013 in respect of accidents that occurred in 2010 is:

1. 466.79
2. 647.89
3. 786.22
4. 644.77

[3 Marks]

b. the total amount of claims paid during AY 2012 and 2011 is:

1. 1182, 2142
2. 3530, 3203
3. 11519, 13543
4. 5087, 4065

[3 Marks]

c. Determine the Ultimate amount of claims paid in respect of accidents that occurred in AY 2012.

1. 3687.705
2. 3807.102
3. 2100.963
4. 3332.034

[3 Marks]

Q. 45) A national survey research company in India has past data which indicate that the interview time for a consumer opinion study has a standard deviation of 6 minutes. The size of the sample that should be taken if the company requires a 99% confidence interval for the mean interview time to be within +2 minutes is:

1. 50
2. 86
3. 74
4. 60

[3 Marks]

Q. 46) A consumer has a utility function given by $U(W) = \sqrt{W}$, where W is the wealth of the consumer. The consumer currently has a wealth of Rs.100,000. The consumer faces a potential loss of Rs.20,000 with a probability of 0.1. Using utility theory, calculate the maximum premium the consumer is willing to pay for insurance against this loss.

1. 4876.56
2. 3425.99
3. 2365.76
4. 1591.73

[3 Marks]

Q. 47) A claim size distribution is modelled using a simple distribution with density of the Form:

$$f(x) = \begin{cases} k(100-x), & 0 \leq x \leq 100 \\ 0, & \text{otherwise} \end{cases}$$

$$k = 0.0002$$

The mean of this claim size distribution is:

1. 33.33
2. 44.45
3. 23.56
4. 55.55

[3 Marks]

Q. 48) An insurer has a layered excess of loss reinsurance arrangement as follows:

Layer 1: Retention limit of Rs.50,000 and coverage up to Rs.150,000.

Layer 2: Coverage from Rs.200,000 to Rs.400,000.

Layer 3: Coverage from Rs.400,000 to Rs.700,000.

Consider the following three claims:

Claim 1: Rs.120,000

Claim 2: Rs.350,000

Claim 3: Rs.600,000

What are the payments by the primary insurer and each reinsurer for these claims?

1.
 - a. Primary Insurer: Rs.100,000
 - b. Layer 1 Reinsurer: Rs.170,000
 - c. Layer 2 Reinsurer: Rs.200,000
 - d. Layer 3 Reinsurer: Rs.600,000

- 2.

- a. Primary Insurer: Rs.150,000
 - b. Layer 1 Reinsurer: Rs.370,000
 - c. Layer 2 Reinsurer: Rs.350,000
 - d. Layer 3 Reinsurer: Rs.200,000
- 3.
- a. Primary Insurer: Rs.100,000
 - b. Layer 1 Reinsurer: Rs.170,000
 - c. Layer 2 Reinsurer: Rs.350,000
 - d. Layer 3 Reinsurer: Rs.300,000
- 4.
- a. Primary Insurer: Rs.100,000
 - b. Layer 1 Reinsurer: Rs.200,000
 - c. Layer 2 Reinsurer: Rs.150,000
 - d. Layer 3 Reinsurer: Rs.320,000

[3 Marks]

Q. 49) You have been given the expected return on three securities, 1, 2 and 3,

Asset	Expected return
Security 1	6.2%
Security 2	4.9%
Security 3	7.1%

and the variance/covariance matrix for these securities.

Variance/covariance matrix	Security 1	Security 2	Security 3
Security 1	0.38%	0.25%	0.15%
Security 2	0.25%	0.20%	0.27%
Security 3	0.15%	0.27%	1.10%

You have also been given the weights invested in each of these three securities in 2 portfolios, A and B.

Portfolios	Security 1	Security 2	Security 3
Portfolio A	33.3%	0.0%	66.7%
Portfolio B	14.9%	7.5%	77.6%

The portfolios are made up of only these three securities and no other assets are held.

Calculate the expected return and variance of the return on each of the two portfolios A and B.

1.

	Expected Return	Variance
Portfolio A	7.80%	0.50%
Portfolio B	3.20%	0.75%

2.

	Expected Return	Variance
Portfolio A	6.80%	0.50%
Portfolio B	6.00%	0.75%

3.

	Expected Return	Variance
Portfolio A	7.80%	2.00%
Portfolio B	3.20%	1.10%

4.

	Expected Return	Variance
Portfolio A	6.80%	0.60%
Portfolio B	6.80%	0.74%

[3 Marks]
