SOCIETY OF ACTUARIES
Exam FETE
Financial Economic Theory and Engineering Exam (Finance/ERM/Investment)

Exam FETE

MORNING SESSION

Date: Thursday, October 30, 2008
Time: 8:30 a.m. – 11:45 a.m.

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This examination has a total of 120 points. It consists of a morning session (worth 60 points) and an afternoon session (worth 60 points).

   a) The morning session consists of 10 questions numbered 1 through 10.

   b) The afternoon session consists of 10 questions numbered 11 through 20.

   The points for each question are indicated at the beginning of the question. Questions 1 - 2 pertain to the Case Study, which is enclosed inside the front cover of this exam booklet.

2. Failure to stop writing after time is called will result in the disqualification of your answers or further disciplinary action.

3. While every attempt is made to avoid defective questions, sometimes they do occur. If you believe a question is defective, the supervisor or proctor cannot give you any guidance beyond the instructions on the exam booklet.

Written-Answer Instructions

1. Write your candidate number at the top of each sheet. Your name must not appear.

2. Write on only one side of a sheet. Start each question on a fresh sheet. On each sheet, write the number of the question that you are answering. Do not answer more than one question on a single sheet.

3. The answer should be confined to the question as set.

4. When you are asked to calculate, show all your work including any applicable formulas.

5. When you finish, insert all your written-answer sheets into the Essay Answer Envelope. Be sure to hand in all your answer sheets since they cannot be accepted later. Seal the envelope and write your candidate number in the space provided on the outside of the envelope. Check the appropriate box to indicate morning or afternoon session for Exam FETE.

6. Be sure your written-answer envelope is signed because if it is not, your examination will not be graded.

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Exam FETE-Front Cover

****BEGINNING OF MORNING EXAMINATION****
Financial Economic Theory & Engineering – Finance/ERM/Investment

Questions 1 and 2 pertain to the Case Study

1. *(6 points)* LifeCo's CEO is exploring securitization for their Traditional Life block. Traditional Life has total death benefits of $1 billion and this year's expected dollar value of claims is $10 million.

(a) *(1 point)* Describe the potential benefits of insurance securitization for both LifeCo and its investors.

(b) *(2 points)* Recommend a securitization structure for the funding of LifeCo's XXX reserves on its term life block of business. Support your recommendation.

(c) *(3 points)* Construct a risk transfer securitization for the full Traditional Life block that will ensure a maximum mortality impact of 1% of reported liabilities.

Questions 1 and 2 pertain to the Case Study

2. *(7 points)* LifeCo will be launching a new equity linked life insurance product in the near future. The Chief Investment Officer and Chief Information Officer of LifeCo are proposing to use the existing investment strategy and administration system, respectively, of the equity linked GIC product for the new equity linked life insurance product.

(a) Describe the considerations for the crediting method of an equity linked life insurance product.

(b) Determine the feasibility of these two proposals by the Chief Investment Officer and Chief Information Officer.

(c) Recommend changes to LifeCo's Asset Liability Management Policy Statement to incorporate the new equity linked life insurance product.

3. *(5 points)* You are given a constant maturity swap (CMS) with the following:

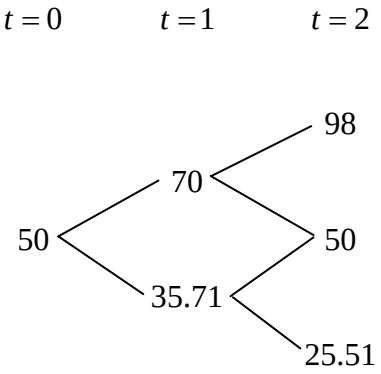
Notional principal	$100 million
Maturity	3 years
Pay	6% fixed rate
Receive	10-year swap rate
Payment frequency, fixed leg	annual
Payment frequency, floating leg	annual
Floating leg payment amount	Based on previous payment date swap rate
Term structure	Flat at 6% per annum, annual compounding
Options on 10-year swaps: implied volatility	18%
1-year caplet implied volatility	25%
Correlation between each cap rate and each swap rate	0.5

(a) *(3 points)* Calculate the convexity adjustment to the forward swap rate in terms of basis points per year.

(b) *(1 point)* Determine the 10-year swap rate in 2 years time for the purpose of valuing the CMS swap.

(c) *(1 point)* Calculate the net cash flow at the 2 year point.

4. *(6 points)* The company is considering launching a new product that will require an initial investment of \$150 and will have cashflows for the next two time periods of:



You are given:

WACC	9%
Risk-free rate	5%
Probability of up movement	0.50
Up movement factor	$(u) = 1.4$

At time $t = 1$ or $t = 2$ the company may forgo the current and projected cash flows, abandon the project, and sell the research findings for 55.

(a) *(1 point)* Describe a real option and list the three key assumptions for pricing real options.

(b) *(1 point)* Compare and contrast Net Present Value and Real Option analysis as decision making tools.

(c) *(4 points)* Calculate the value of the project at $t = 0$ and recommend whether or not the company should go ahead with the project.

5. *(6 points)*

(a) Outline the steps to value mortgage backed securities using Monte Carlo simulation.

You are using the Heath-Jarrow-Morton (HJM) model to simulate the behavior of interest rates.

(b) Show that $v(t,T,\Omega)=\frac{\sigma}{\lambda}\left(e^{-\lambda(T-t)}-1\right)$, where σ and λ are constant, is a proper function for bond price volatility.

(c) Define the instantaneous forward rate process given by the HJM model when the bond price volatility is as given in (b).

(d) Explain why the LIBOR Market model is superior to the HJM model.

6. *(6 points)* The Republic of Seatopia currently regulates financial services industry capital adequacy with risk-based capital calculations based on factors applied to book value of assets, reserves, and other quantities reported in annual statements. The Meritocratic Order of Theory-Happy Radical Actuaries is considering recommending a new approach to risk-based capital for Seatopia, with minimum RBC calculated as Value at Risk at a 95^{th} percentile level for an entire company's business.

(a) Compare the use of factor-based RBC calculations versus a Value at Risk-based calculation.

(b) Explain the dangers of using VaR to measure RBC.

(c) Recommend approaches for RBC which address some of the problems of using VaR to determine risk-based capital.

7. *(7 points)* Assume that Y_t denotes the log return on a stock index S_t, i.e. $Y_t = \ln\left(S_t / S_{t-1}\right)$.

In the country of Sunnydale, econometricians have noticed three characteristics of the log return process:

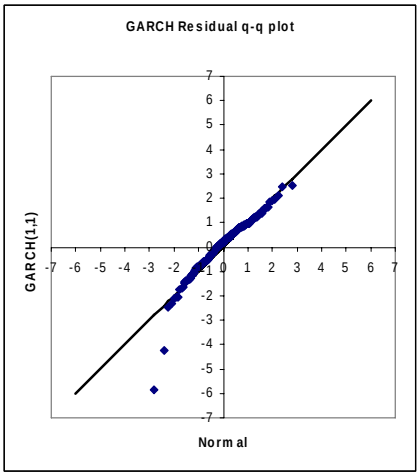
(i) The volatility of the process is stochastic
(ii) The process exhibits volatility clustering
(iii) High volatility is associated with poor returns

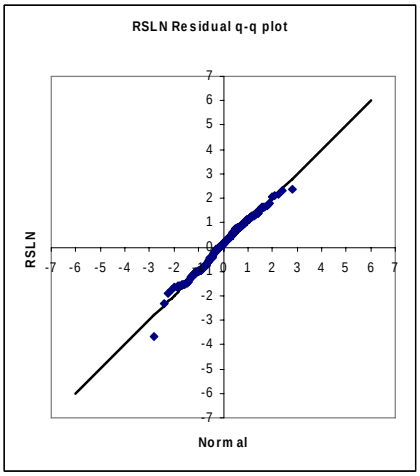
(a) For each of the models for the log return listed below, describe which, if any, of these three characteristics is captured, and explain briefly how the model achieves this.

(i) Independent lognormal model
(ii) GARCH(1,1) model
(iii) Regime Switching Lognormal Model with two regimes
(iv) AAA stochastic log-volatility model (SLV)

The actuary of Sunnydale Life Insurance Company is modeling the liabilities for a portfolio of variable annuity policies. The q-q plots of residuals for 200 observations of monthly returns are given below, assuming the GARCH(1,1) model and the RSLN (2) model for the underlying return process.

(b) Recommend one of these models, and give your reasons for your answer.





8. *(7 points)* Adam, a 55-year old entrepreneur, is the sole owner of HillTop, a modestly profitable and unlevered firm. Conservatively run, HillTop's unlevered risk is $\beta_u = 0.7$ and Adam is in the 28% tax bracket. He is considering converting his business into a corporation that would provide his 27-year old nephew and his nephew's two friends equal ownership with him (i.e., each with 25% ownership in HillTop).

You are given:

HillTop's new corporate tax rate, at 50% leverage	40.0%
k_b = the risk-free rate of return	4.0%
Market rate of return	8.0%
β_L	1.3

(a) Calculate the weighted average cost of capital for HillTop before and after the incorporation.

(b) Determine the increase or decrease in EBIT that the new corporation requires to support a 10% increase in the current value of the firm.

(c) Describe the pros and cons of incorporating HillTop.

(d) Evaluate the points in (c) and recommend to Adam whether or not to incorporate.

9. *(6 points)* At CLG Manufacturing Company, managers are compensated based on the following incentive schedule:

$$M = 0.1 \times V_0 \times (1+r) + \begin{cases} 0.15 \times V_1 & \text{if} \quad V_1 > D \\ 0.15 \times V_1 - C & \text{if} \quad V_1 \le D \end{cases}$$

Where:

- V_0 and V_1 are the values of the firms at time 0 and 1, respectively.
- C is the penalty imposed on the manager if $V_1 < D$.
- D is the face value of debt issued by the firm at time 0.

Assume that:

- At time 1, "good" firms are worth 250 and "bad" firms are worth 150.
- There is no uncertainty in the market and pricing is risk neutral.
- Managers know the true quality of their firms and their compensation is known to investors.
- Managers act to maximize their compensation.
- The risk-free rate is 10%.
- Investors perceive that the firm is a good one if $D > 150$.

(a) *(1 point)* Define information asymmetry in financial markets.

(b) *(1 point)* Explain how a company's management can signal value to financial markets.

(c) *(4 points)* Calculate the minimum cost of false signaling that has to be imposed on management to ensure that all managers signal correctly.

10. *(4 points)* Your company has just sold a European put option on 10,000 USD for a premium paid in Japanese Yen.

You are given the following:

- The time to maturity $T = 180$ days
- Yen risk-free interest rate $r_j = 0.4988\%$ per annum, continuously compounded
- USD risk-free interest rate $r_u = 4.97\%$ per annum, continuously compounded
- The current exchange rate is $Q = 120$ Yen/USD
- The strike price of the option is 117 Yen/USD
- The volatility of the exchange rate is 10%
- Assume there are 365 days in a year

(a) Calculate the option premium received, based on the Black-Scholes currency option formula.

Your company plans to hedge the short put position using the option premium received.

A hedge portfolio will be purchased such that its value in Yen will approximately equal the value of the put option at each point in time.

To hedge the put option, you buy Y units of USD and invest the balance of the portfolio at Yen money market rate.

(b) Express the change in hedge portfolio value (dX) in Yen in terms of Y, the change in exchange rate (dQ), Q, r_u, r_j, and dt.

(c) Calculate Y using the Black-Scholes currency option formula.

(d) Assume one day has passed and the exchange rate is now 120.127, with interest rates and exchange rate volatility unchanged. Calculate dX and X_1 (the current value of X).

****END OF EXAMINATION****
Morning Session

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Exam FETE

AFTERNOON SESSION

Date: Thursday, October 30, 2008
Time: 1:30 p.m. – 4:45 p.m.

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This afternoon session consists of 10 questions numbered 11 through 20 for a total of 60 points. The points for each question are indicated at the beginning of the question. There are no questions that pertain to the Case Study in the afternoon session.

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11. *(3 points)* You are working as a quant in an investment firm. One morning, you receive an email from your boss.

> *"I just got this modified Black Scholes equity index option model from a contact on Wall Street. She told me this is the model they use for option pricing. Please review the model. I think we should replace our existing model with this new one and start using it immediately."*

(a) Describe the 3 major categories of model and identify which of these your boss has received.

(b) Explain the types of model risk.

(c) Recommend ways to mitigate potential model risk.

12. *(7 points)* Two companies, NorthSouth and PropRed, are competing in the market of a product with total annual sales of $100 million dollars. For simplicity, assume that each company can only make two kinds of effort, a maximum effort at a cost of $25 million and a minimum effort at a cost of $10 million. It is expected that they will split the sales 50-50 if both make the same kind of effort; otherwise the company with minimum effort can barely capture a sale of $10 million to cover its cost.

To compete against each other, both companies may use the following two strategies in different market environments:

The Tit-for-Tat Strategy

1. Start by making minimum effort;
2. then, in period *n* choose the action that the other player chose in period $(n-1)$.

The Grim Strategy

1. Start by making minimum effort;
2. continue to make minimum effort unless some player has chosen to make maximum effort, in which case choose to make maximum effort forever.

(a) Describe the game by identifying the players, actions, and payoffs (sales net of costs), assuming that it is non-repeated.

(b) Demonstrate that if the game is *non-repeated*, action: (NorthSouth's effort, PropRed's effort) = (make maximum effort, make maximum effort) is the only dominant strategy.

(c) Demonstrate that if the game is *finitely-repeated*, a Nash equilibrium must be the strategy profile of the "always-make-maximum-effort" strategy.

(d) Define a subgame Nash perfect equilibrium

(e) Demonstrate that if the game is *infinitely-repeated*, the Tit-for-Tat Strategy is not a subgame perfect Nash equilibrium when the discount factor used in present value of payoffs calculation is close to 1.

(f) Determine the range of discount factors used in the present value of payoffs calculation in the *infinitely-repeated* game so that the Grim Strategy as defined above, when played by both players, is a subgame perfect Nash equilibrium.

13. *(6 points)* ABC Insurance will have future earnings with a present value of either 100 or 200, with equal probability. ABC has 100 outstanding shares with a total value of 50. It has outstanding debt with a total value of 100.

ABC Insurance is considering two options to expand into a new product line.

Project A is a riskless transaction in which ABC acquires XYZ Insurance, which already has market share. The capital cost is 200 and the projected cash flows have a present value of 240.

Project B is risky and involves developing market share organically with limited experience in the new product. The capital cost is 200 and the present value of earnings will be either 40 or 310, with equal probability.

The firm issues new (junior) nonconvertible debt with a face value of 200 prior to making its project selection with the hope of financing the project, which has a cost of 200. Assume the transaction cost in the event of bankruptcy is 100.

The earnings from the projects are independent of those from existing operations.

(a) Calculate for each of Projects A and B:

(i) the Net Present Value
(ii) the Value of the Firm
(iii) the Value of the Old Debt
(iv) the Value of the New Debt
(v) the Value of the Equity

(b) ABC's bondholders assume that Project B will be chosen.

Determine:
(i) the price they should pay for the new debt issue.
(ii) the additional capital that ABC's shareholders must contribute to fund the project.

(c) Instead of issuing nonconvertible debt with a face value of 200, ABC issues convertible debt for 200, convertible to 200 shares.

For Project A:
(i) Explain the features and implications of using convertible debt.
(ii) Determine the value of the firm at which the conversion option will be exercised.
(iii) Calculate the value of the convertible debt issued.

14. *(5 points)* The MPC Boat Manufacturing Company has recently implemented a new risk management system. MPC's three business units can be characterized as follows:

Business Unit (BU)	BU's Influence on Capital Received	BU's Ability to Forecast Its CaR Needs
A (Stinkpots)	Strong	Strong
B (Sailboats)	Strong	Moderate
C (Canoes)	None	Low

At the business unit level, the following have been determined:

Business Unit (BU)	**A**	**B**	**C**
Correlation with A	1	-0.3	0.7
Correlation with B	-0.3	1	0.2
Correlation with C	0.7	0.2	1
Individual CaR	150	300	400
Total Diversified CaR after Removal	475	400	300
Covariance with Total MPC Returns	140	160	100
Correlation with Total MPC Returns	0.145	0.289	0.723
Standard Deviation of Returns	70	40	10

Variance of MPC Total returns is 191.2

(a) Calculate the allocation of diversified Total CaR to A, B, and C under the following methods:

(i) Splitting the diversification benefits equally ("split method")
(ii) Marginal CaR
(iii) Internal beta

In order to make top management capital budgeting decisions, and as a standard to evaluate its business units and business unit manager incentives, MPC uses the following:

(i) Risk-adjusted performance measure = Return on CaR
(ii) Business unit level measure of CaR = Internal beta

(b) Results based solely on these measures have led to counterintuitive allocation decisions. Propose a change so MPC avoids this problem.

15. *(8 points)* Eyrie Insurance issues a single premium variable annuity with a guaranteed annuity option. At age 65 the contract holder may annuitize the variable annuity proceeds at a conversion rate guaranteed to be no less than a pre-specified rate, g, for an annuity payable monthly in advance for life.

At time $t = 0$ the single premium of \$1,000 is invested in a stock with price process S_t. Management charges of 0.5% of the fund value are deducted at the start of each month. Let F_t denote the separate account fund value at time *t*. Let $a_{65}(t)$ denote the value at *t* of an annuity of 1 per year payable monthly in advance to a life aged 65. Assume the annuitization option matures at time *n* when the policyholder reaches age 65.

(a) Derive a function for the option payoff for the annuity guarantee in terms of S_t, g, and $a_{65}(t)$.

(b) Describe the risks which affect the value of this option.

(c) Assess, briefly, the problems involved in hedging each of the risks in (b).

(d) Analyze how the payoff function for the option would change if annuitization is mandatory.

Suppose now that the annuitization is based not on the fund value at maturity, but on the greater of:

(i) the fund value, and
(ii) the accumulated value of the original premium with interest at 6% per year.

(e) Derive the revised option payoff formula.

(f) Assess, briefly, the additional risks faced by the insurer under the new contract design in (e).

16. *(7 points)* You are an actuary in the Treasury area for the Fishtale Insurance Company. Your liabilities have the following distributions of risk.

Health	
Loss	Probability
-	50%
400	40%
800	10%

Life	
Loss	Probability
-	98%
1,000	2%

Assuming all risks are independent gives the following distribution:

Health	Life	Total Loss	Joint Probability
-	-	-	49.0%
400	-	400	39.2%
800	-	800	9.8%
-	1,000	1,000	1.0%
400	1,000	1,400	0.8%
800	1,000	1,800	0.2%

(a) Calculate the amount of capital Fishtale requires based on VaR(99%).

(b) Calculate the amount of capital Fishtale requires based on CTE(98%).

(c) Calculate the capital allocation for each line of business, assuming proportional allocation at VaR(99%)

(d) Calculate the capital allocation for each line of business using the percentile layer method, based on a VaR(99%) risk measure.

A consultant has proposed a *new method* of capital allocation:

Given that the loss from Health is denoted L_H, the loss from Life is denoted L_L, and the total loss is $TL = L_H + L_L$, then the allocation to line *i* is

$$E\left[L_i \mid TL > VaR(98\%)\right] \text{ for } i \in \{H,L\}$$

(e) Calculate the total capital requirement at CTE(98%) and allocate this to each line using the *new method*.

(f) Recommend a capital allocation method for the Fishtale Insurance Company.

17. *(7 points)* Your company, Great South Life is considering an acquisition of Apple Life, a small company which specializes in equity indexed annuities. Great South Life has decided to pay the appraisal value plus a $2 million premium for Apple Life.

Two methods of financing the deal are proposed:

(i) Finance the deal through debt at a cost of 7%, after tax
(ii) Issue additional shares, with investment banking fees of $1,000,000.

You are given the following information:

Net income for Great South Life before acquisition	$10,000,000
Net income for Apple Life before acquisition	$2,000,000
After tax revenue and cost synergies	$1,000,000
Goodwill amortization period	4 years
Number of shares of Great South Life before acquisition	1,000,000
Number of shares of Apple Life before acquisition	200,000

Projected financial statement values (in $ thousands) for Apple Life:

Income Statement	2008	2009	2010	2011	2012
Premiums	6,000	6,900	7,900	9,000	11,000
Investment Income	3,000	3,300	3,600	4,000	4,400
Death Benefits	100	110	120	130	140
Surrender Benefits	500	550	600	660	730
Expenses	400	420	440	470	510
Commissions	120	170	220	270	320
Taxes	400	400	400	400	400

Balance Sheet	12/31/2007	12/31/2008	12/31/2009	12/31/2010	12/31/2011	12/31/2012
Required capital	3,200	3,584	4,042	4,640	5,320	6,090
Tax Reserve	48,300	51,000	56,100	61,400	67,600	77,200
GAAP Reserve	49,500	52,200	57,500	63,000	69,300	78,900
Statutory Reserve	50,000	55,000	60,500	66,400	72,800	79,500

17. (continued)

Current Capital Structure for Apple Life:

Asset Class	% of asset class	Expected after tax return
Debt	30%	5%
Equity	70%	10%

(a) Determine the appraisal value using the discounted cash flow approach. Assume all cash flows occur at the end of each year. Show all work.

(b) Explain the advantages and disadvantages of financing through debt versus through equity.

(c) Assume that 200,000 new shares would need to be issued under the equity financing method. Determine which method of financing would generate the higher earnings per share for the combined company. Show all work.

18. *(8 points)* BigCo is a large multiline insurance company competing in a niche market with SpecialtyCo. BigCo is planning its marketing strategy for the coming year.

BigCo has had difficulty maintaining the profitability of its product line and its market share in the face of SpecialtyCo's focused competition. In addition, senior managers at BigCo in this product line are being actively recruited by SpecialtyCo. However, not all senior management in the market are key; a number of these employees are ineffective managers whose defections would have little or no effect on business results.

BigCo's CEO is considering three options:

(i) Exit the market and surrender it to SpecialtyCo.

(ii) Appear to exit the market and "allow" non-key management to defect to SpecialtyCo; then exploit known shortcomings in the defecting executives.

(iii) Continue business as usual.

Exiting the market has a payoff of $(-5, 10)$ to (BigCo, SpecialtyCo). Business as usual has a 0.1 probability of success and a payoff of $(10, -5)$. Failure results in a payoff of $(-10, 10)$.

If BigCo exits the market, there is a significant probability $(\alpha = 0.5)$ that some senior management will defect to SpecialtyCo and, if these are truly key employees, their inside knowledge will provide a significant competitive advantage for SpecialtyCo.

SpecialtyCo can capitalize on these defections in a number of ways:

(i) Absorb the new talent and continue its own business as usual with enhanced capabilities; this has a payoff $(-5, 15)$ if these defectors are key; $(5, -5)$ if they are not.

(ii) Decide to exploit the newly recruited talent and their inside knowledge to expand outside its traditional niche market to the detriment of BigCo:

- If properly implemented and successful, this has payoff $(-15, 22)$.
- If SpecialtyCo recruits are not truly key, BigCo will take advantage of SpecialtyCo with positive results; this has a payoff of $(5, -8)$.

In fact, BigCo has secretly provided lucrative compensation packages to executives it knows to be key management to ensure that no key defections are possible whether it exits the market or not.

18. **(continued)**

(a) Diagram this situation as a game in extensive form.

(b) Determine the dominant strategy for BigCo given the information it has available. Support your answer.

SpecialtyCo is unsure whether the staff it is recruiting are truly key for BigCo and is unaware of BigCo's secret deal to retain key managers.

(c) Determine the range of the probability that the recruited staff are key employees for SpecialtyCo's exploit option to dominate business as usual if BigCo exits the market, given the information available to SpecialtyCo.

Now, the newly appointed CEO of BigCo has reservations about the effectiveness of the secret staff retention arrangement. She is worried that even with the arrangement some of the key managers may still decide to defect to SpecialtyCo due to moral hazard. The CRO states that the problem is not moral hazard but adverse selection.

(d) Define the 'Moral Hazard with Hidden Action' and the 'Adverse Selection' categories of asymmetric information models.

(e) Analyze which, if either, of these models is relevant to BigCo's situation.

19. *(5 points)* Your firm has only three independent one-year projects available. You are given the following project payoffs, by ending state, at the end of one year:

State	Probability	Project 1	Project 2	Project 3
1	1/3	40	40	0
2	1/3	0	50	30
3	1/3	0	0	34

You also have the following information:

(i) The market value of Project 1 is 10.
(ii) The market value of Project 2 is 25.
(iii) The one-year risk free rate of interest is 10%.
(iv) The weighted average cost of capital (WACC) is 15%.

(a) Calculate the market value of Project 3.

(b) Given that the funding cost of each project is the market value, determine whether each project should be funded and explain why or why not.

Assume you plan to invest solely in Project 1, and will finance this investment by means of a one-year note. Your firm has no other liabilities.

(c) Calculate the amount of risk capital required to insure the value of the firm's net assets against a loss in value relative to the risk-free rate.

20. *(4 points)* You are given information for a bank with the following balance sheet and off-balance sheet items:

(Amounts in Millions)

Balance Sheet	Asset Risk Capital Weight (%)	12/2007
Cash	0	5
FNMA Insured Mortgages	0	30
Municipal Bonds	20	15
Non-Insured Mortgages	50	20
Corporate Bonds	100	50
Stocks	100	10
Real Estate	100	20

Off Balance Sheet Items	Counterparty Risk Capital Weight (%)	Credit Conversion Factor (%)	12/2007
Bankers Acceptance (Non-OECD Bank)	50	100	5
6-month revolving loan (Non-OECD Bank)	50	0	25
3-year call option on S&P 500 stock index, notional=10, original term 3 years, remaining term 2 years	50	100	0.5

Other Factors:

Equity option add-on factor	0.10
Minimum Capital Requirement (% of risk-weighted assets)	8%

(a) *(1 point)* Calculate the minimum amount of capital required for the bank to be in compliance with the original 1988 BIS Accord. Show all work.

(b) *(3 points)*

(i) Identify and explain problems with the methodology used to compute required capital under the rules of the original Accord for specific balance sheet and off-balance sheet items.

(ii) Explain solutions which have been proposed to address these problems.

****END OF EXAMINATION****
Afternoon Session