Financial Instruments
Bus 35100 Spring 2013
John Heaton

Midterm

INSTRUCTIONS:

- There are 4 questions. Question 1: 20 points, Question 2: 20 points, Question 3: 30 points, Question 4: 20.
- You have 90 minutes to complete the exam. The number of points for each question are exactly equal to the number of minutes you should spend on the question.
- The questions cover various aspects of the class material. Read all the questions and start from those that you feel more comfortable with.
- Answer all questions as well as you can.
- Do not get hung up on calculations. Sometimes, just setting up an equation or providing a good intuitive argument will be sufficient for partial credit Remember to keep moving!
- Approximate all your calculations to **2 decimal points**.
- **You must write your answers on this midterm. Use back pages for any calculations. No other piece of paper, besides your formula sheet, is allowed.**

Honor Code: I pledge my honor that I have not violated the Honor Code during this examination.

Name and ID number (Please print clearly):_____

Signature:_____

Problem 1. (20 points) True-False Questions (there are 4 of them). *Grade depends on completeness of answer.*

(a) (5 points) Suppose that you write a European call option on a stock. Since you are now implicitly short the stock, you hedge your exposure to the stock by buying an equivalent number of shares of the stock.

(b) XYZ airlines is committed to buying one million barrels of jet fuel next quarter. XYZ can hedge this position by going long futures contracts for one million barrels of oil.

(c) Option contracts may increase in value as they approach maturity.

(d) The current price of a security is given by the expected future price of that security discounted using the risk-adjusted required rate of return. A forward contract to buy that same security locks in the price at which you buy the security at maturity. Since risk is eliminated, the forward price reflects only the risk-free return. For this reason, the forward price of a security must be lower than the expected future price.

Problem 2. (20 points) Binomial trees. Suppose that stock JCH, whose current price is \$100, can either increase by $u = 1.05$ or decrease by $d = 1/(1.05)$ per year for the next 2 years. The continuously-compounded interest rate is 2% per year.

(a) (15 points) Suppose that you are *long* a call option that gives you the option to buy *100* shares JCH stock in two years at a strike price of \$95. How would you hedge your exposure to the price of JCH stock over the life of the option? What is the current price of your option position?

Extra space for problem 2.(a)

(b) (5 points) Consider a *binary* option on JCH stock that has maturity of two years. Under this option contract the holder of the option receives a share of JCH stock if in two years (maturity of the option) the stock is trading between \$85 and \$95. According to your assumptions, what would be an appropriate price for this option? (Hint: notice that I just asked you to price the option. No hedging required!)

Problem 3. (**30 points**) A few years ago your company a bond denominated in Euros. The bond has a face value of 1 million Euros and pays semi-annual coupons at an annual rate of 6%. You just made a coupon payment and the bond has one year left to maturity. In other words you owe a coupon payment in 6 months and payments of coupon along with principal in 1 year.

The current exchange rate is 1.3 dollars per Euro (USD/Euro). The current LIBOR rates (in continuously compounded units) are:

Maturity	USD	Euro
6 months	2%	2%
1 year	2.5%	3%

(a) (10 points) You would like to hedge your exposure to the Euro using forward contracts. How many and what maturities of forward contracts would you use? What would be the forward price of these contracts?

Extra space for problem 3.(a)

(b) (10 points) Suppose the day after you signed your forward contract in part (a) above, the spot exchange rate between dollars and Euros move to 1.29 dollars per Euro (USD/Euro). Yields in the LIBOR market are now:

Maturity	USD	Euro
6 months (less a day)	2%	2%
1 year (less a day)	2.5%	3.1%

What would be the new values of the forward contracts you signed in part (a)? (Assume that there are 360 days in a year.)

Extra space for problem 3.(b)

(c) (10 points) Let's return to the setting of part (a) where you owe a coupon payment in six months, and coupon and principal payments in one year. An investment bank offers you a contract where they will pay your Euro obligation under your bond obligation. In return, you will owe the bank US dollar denominated payments on a bond with one year to maturity, face value of $1.29 million, and semiannual coupon payments at an annual rate of 6%. Would you enter into this contract to hedge your exposure to the Euro? Why or why not?

Extra space for problem 3.(c)

Problem 4. (**20 points**) Through your investment in an index fund you are currently long 1,000 units of the S&P500. In addition, you are long a put option on the S&P500. The terms of this put option are:

- Underlying index: S&P500.
- Number of units of the underlying index: 750.
- Strike price of the put option (per unit of underlying): $1,000.
- Maturity of the put option: 2 years.

(a) (5 points) Why might you be holding the put option contract along with the S&P 500 index?

(b) (15 points) Make the following assumptions:

- Current value of the S&P500: \$1,200
- Risk-free rate: 1% continuously compounded.
- Dividend yield for the S&P500: 0%.
- Volatility of the S&P500: 30%. This will be constant over the life of the option.

Under these assumptions, what should be the value of your portfolio? What is the delta of your portfolio with respect to the S&P500?

Extra space for problem 4.(b)

Cumulative Normal Distribution

$\Phi(x) = \int_{-\infty}^{x} \frac{e^{-y^2/2}}{\sqrt{2\pi}} dy$

x	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998

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Fall 2022
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- The allotted time on Canvas is 120 minutes. It should take you approximately 90 minutes to complete the exam. The number of points for each question are exactly equal to the number of minutes you should spend on the question. This should give you plenty of time to upload your solution.
- You are to submit a "pdf" file. **NO EXCEL** files. You may submit the exam in a format of your choosing including printing the version with space given and scanning your solutions.
- **NOTE: solutions without justification** (i.e. formulas showing what you calculated) will receive **no credit**. In other words: **show your work**.
- The questions cover various aspects of the class material. Read all the questions and start from those that you feel more comfortable with.
- Answer all questions as well as you can.
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Problem 1. (15 points) True-False Questions (there are 3 of them). *Grade depends on completeness of answer.*

(a) (5 points) In a foreign exchange forward contract, the value of the forward contract is always positive.

(b) It is possible to calculate the swap rate S of a swap on *any* underlying factor X_t (e.g. exchange rates, golds, oil) with spot rate X_t and net cash flows $X_t - S$ from the current forward rates $F_{t,T}$ on the factor itself

(c) The current exchange rate between the United States and Canada is 1.02 US dollars per Canadian dollar. The one-year forward exchange rate is 1.03 US dollars per Canadian dollar. The market must be expecting that over the next year the US dollar will depreciate relative to the Canadian dollar.

Problem 2. (25 points) Binomial trees. Suppose that stock XYZ, whose current price is \$50, can either increase by $u = 1.1$ or decrease by $d = 1/(1.1)$ each year over the next 2 years. The continuously-compounded interest rate is 1% per year.

(a) (10 points) What is the no-arbitrage price of a European put option with strike price of \$48 and maturity of 2 years.

(b) (5 points) Consider now an 2-year *look-back* call option on the stock with a strike price of \$50. With this option, at maturity the buyer as the option to pay the strike price and receive the *maximum* value the stock achieves during the life of the option. What should be the price of this option?

(c) (10 points) You sold the option in point (b) to the client. You decide to hedge against the short position by going long the underlying, that is, *the option from part (a)*. What is your hedging position at time 0? Make sure to describe both the position in the underlying and in bonds.

Problem 3. (**20 points**) You run a firm that has operations in Great Britain. In each of the next two years you expect to generate earnings of 10 million British pounds (BPD). You would like to hedge the exchange rate risk you face.

The current exchange rate is 1.6 US dollars per British pound (USD/BPD). The current LIBOR rates (in continuously compounded units) are:

Maturity	USD	BPD
1 year	2%	3%
2 years	3%	3%

(a) (10 points) What are the implied one- and two-year forward exchange rates between US dollars and British pounds? How would you use these forward contracts to hedge your exchange rate risk?

(b) (10 points) Instead of using the forward contracts you would like to use a two-year exchange rate swap with a fixed rate of exchange during the life of the swap. If the terms of this contract are fare, at what rate would you swap pounds for dollars in

each of the next two years? How does this swap rate compare to the forward rates you calculated in part (b) above? Explain (in words only) the relationship between the forward rates and the swap rate.

Problem 4. (30 points) Consider the following properties of a "Capital Protected Note":

- Maturity: 4 years
- Issue Price: \$1,000
- Principal \$1,000
- Interest: 0
- Principal Protection 100%
- Payoff at maturity: Principal plus Supplementary Redemption Amount (SRA), if positive, where:

$$SRA = \text{Final Index Value - Initial Index Value}$$

- Index: S&P500 which has a current value of \$1000.

Make the following assumptions:

- The 4-year (c.c.) interest rate is 2%.
- The dividend yield of the S&P500 will be 0%. over the next 4 years (no dividends!).
- The volatility of the S&P500 will be 15% over the life of the note.

(a) (10 points) What should be the price of the Capital Protected Note? Is it properly priced? What is the Delta of the Note?

(b) (5 points) Suppose that you sold the Capital Protected Note? What initial positions in a 4-year European PUT option and the S&P500 could you use to hedge your exposure to the S&P500 and replicate the payoff to the Capital Protected Note?

(c) (10 points) Instead of using the put option and the S&P500 from part (b), you would like to hedge your sale of the Capital Protected Note using a 1-year at-the-money call option on the S&P500. According to the Black-Scholes model, what is the delta of this option? How many of the short dated call options would you have to hold to hedge your exposure to changes in the S&P500?

(d) (5 points) If immediately after you enter into the hedging positions of part (b), the S&P500 increases in price. Describe *in words* the directions in which you would have to change your positions and why. (Intuition only, no calculations here).

Cumulative Normal Distribution

$\Phi(x) = \int_{-\infty}^{x} \frac{e^{-y^2/2}}{\sqrt{2\pi}} dy$

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2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9997
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998

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- You are to submit a "pdf" file. **NO EXCEL** files. **NO CHAT GPT OUTPUT!!**. You may submit the exam in a format of your choosing including printing the version with space given and scanning your solutions.
- **NOTE: solutions without justification** (i.e. formulas showing what you calculated) will receive **no credit**. In other words: **show your work**.
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1. **(10 points)** True-False (there are 2 questions here). *Grade depends on completeness of answer.*

   (a) (5 points) As long as we can sell the underlying options before maturity a short-straddle has little risk exposure.

   (b) (5 points) Under the assumptions of the Black-Scholes model, the Sharpe ratio of option investing is the same on the sharpe ratio of the underlying stock.

2. **(40 points) Binomial trees.** Suppose that the current per share price of JCH incorporated is §100. JCH does not currently pay a dividend and is not expected to pay a dividend over the next year. The risk-free yield curve is flat with 2% yields (in continuously compounded rates annual rates) for all maturities over the next year and the yield curve is not expected to change over the course of the next year.

   You have a developed a binomial model for the dynamics of JCH over the next year with 2 periods (6 months each). In each period an analyst forecasts that the stock will go either "up" or "down" where the probability of the "up" state in each period is 60%. Over the next 6-months the stock will either increase in price by 20% or decrease in price by 10% (i.e. to $\$100 \times (1 - 0.1) = \$90$. **HOWEVER,** over the second 6-month period (from time 0.5 to time 1) the stock with then either increase in price by 15% or decrease by 5%.

   (a) (5 points) What might explain the analysts differing assumptions for the size of the up and down moves in each of the six-month periods?

   (b) (7 points) Create and report the two-period binomial tree implied by these assumptions.

   (c) (8 points) What are the risk-neutral probabilities (from the perspective of now: time 0) of reaching the different possible stock values in a year under the assumptions of the tree? Compare these probabilities to the analyst's probabilities? Why might there be differences?

   (d) Consider now a long position in two options

   - A European call option with one-year to maturity and strike price of 120.
   - A European put option with one-year to maturity and strike price of 100.

   i. (5 points) Ignoring the binomial assumptions, sketch the *payoff* diagram for the position at maturity in the two options. Given this diagram, explain why might you want to take the long position in the two options?

   ii. (5 points) Using the risk-neutral probabilities you calculated in part 2c (i.e. no hedging yet!) calculate the implied price of the long position in the two options.

   iii. (10 points) Suppose that the position in the two options is trading for §1 more than you calculated in part 2(d)ii, show in *detail* how you would take advantage of this difference. In particular calculate all of the positions you would take at each node of the binomial tree.

3. (20 points) Make the Black-Scholes assumptions about a stock price. In addition assume the following:

   - The current stock price is §50.
   - The standard deviation of the stock return is 30% (annualized).
   - The expected return on the stock is 15% in continuously-compounded annual units.
   - The risk-free rate is 5% in continuously-compounded annual units.
   - The stock will not pay dividends over the next year.

   (a) (5 points) Suppose that you sold an at-the-money put option on the stock with one year to maturity (360 days) and where the put option is for 1,000 share of the stock. Under the assumptions above what should be the price of this option and how would you hedge this position using stocks and bonds today?

   (b) (5 points) Suppose that you maintain the position from part 3a over the first full day but after a day the stock price has dropped to §40. If all of the other assumptions stay the same except that there are now 259 days to maturity, what is the value of hedge position? How would this compare to the new price of the options you sold? Did the hedge work well? Why or why not?

   (c) (10 points) Suppose you want to track the value of the put option better by adding an additional position at time zero. This additional position is an at-the-money put option (again on 1000 units of the stock) with maturity of 6 months. Calculate the positions you would take at time zero in the underlying, the bond and the 6-month option to better hedge your position.

4. (10 points)

   (a) (5 points) Today is time zero and the current exchange rate is 1.2 US dollars per Euro. There is swap contract trading today at a price of zero under which in 6 months and in one year you exchange a fixed 1.209 dollars for each euro (the "swap" rate). Suppose that the 6 month forward exchange rate is 1.206 dollars for each euro and that the 6-month and 1-year risk-rates in US dollars are 5% and 6% respectively (in continuously compounded annualized rates). What should be the forward rate for exchanging US dollars into Euros with a maturity of one year?

   (b) (5 points) Suppose that you enter into the swap contract above to *sell* dollars for Euros. Right after you signed the contract suppose the spot exchange rate moves to 1.15 US dollars per Euro but there are no changes in the US and Euro yield curves. What would be the value of your swap position?