Module name: Digital Finance
Module code: COMP0164
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Term 1, 2 or 3: Term 2
Nature of assessment: Group

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Section A: Core Information

This assessment is marked out of	110 marks
% weighting of this assessment within the total module mark	70%
Academic misconduct (including plagiarism)	Academic Misconduct is any action or attempted action that may result in a student obtaining an unfair academic advantage. Refer to Academic Manual Section 9: Student Academic Misconduct Procedure - 9.2 Definitions.
Submission date & time	**16:00 (UK time) on 25 Mar 2022**
Penalty for late submission	Standard UCL penalties apply. Students should refer to https://www.ucl.ac.uk/academic-manual/chapters/chapter-4-assessment-framework-taught-programmes/section-3-module-assessment#3.12 If you encounter problems, issues, challenges which fall under the scope of Extenuating Circumstances, please apply to the Computer Science Department.
Submitting your assignment	The assignment MUST be submitted to the module submission link located within this module's Moodle 'Submissions' tab by the specified deadline. Submissions should be as both a pdf of your work and the jupyter notebook of your work. For questions 1-5 you should comment your python code and show your formulas and working steps in markdown. For the mini-essay responses, you should write these in markdown.
Anonymity of identity	Normally, all assignments are anonymous unless the nature of the assessment e.g. video, presentation, group work, is such that anonymity is not possible.

Section B: Coursework brief and requirements

This assignment will require you to apply what you have learnt in the lectures, tutorials and covered in the reading materials to answer six questions.

You should submit your answers as both a jupyter notebook written in python of your code and markdown, as well as an exact pdf copy.

For each question where a numerical answer is required, you should show the python code that you used to compute the answer and the relevant formulas and working steps to solve the problem. If you do not include each of these in your answers, you will only gain partial marks.

For any mini-essay question, you should write your answers in markdown and in full sentences (not bullet points). Any answers over the word limit of a question part will not be marked beyond the word limit.

[10 marks] are available for the structure, clarity, language, mathematical notion and overall presentation of your coursework. Please clearly mark each question and sub-questions.

Question 1 [16 marks]

Suppose that you are the Chief Investment Officer for a pension plan managing a global fund internally. An imaginary manufacturer, ABC company, is one of the fund's large holdings. Recently, ABC's CFO announced an investment of $100 million on a new business expansion project. The new project is planned to be financed with an $80 million public offering of 10-year debt and the remainder with an equity offering. You have collected the information necessary to evaluate this project in Exhibits 1 and 2.

Exhibit 1: Relevant Information for Analysis	
Equity risk premium	4.82%
Risk-free rate of interest	4.25%
Market value of ABC's debt	$900 million
Market value of ABC's equity	$2.4 billion
ABC's equity beta	1.3
ABC's before -tax cost of debt	9.25%
Corporate tax rate	37.5%

Exhibit 2: Estimated Project Financials			
	Year 1	Year 2	Year 3
Revenues	99.2	109.6	115.44
Operating Costs	32	36	38
Depreciation	16	16	16

a) Calculate the weighted average cost of capital of ABC prior to its new project investment. [3 marks]
b) Find ABC's asset beta prior to the new project. [2 marks]
c) If the new project has the same asset beta as the ABC company in b), find the project equity beta. [2 marks]
d) The formula for project after-tax free cash flow at a certain time t is given by

FCF = (Revenues – Operating Costs – Depreciation) * (1 – Tax Rate) + Depreciation

Use python functions to automatically calculate project FCFs and prove that the after-tax free cash flow generated for the next three years are $48 million, $52 million, and $54.4 million, respectively. [2 marks]

e) Find the project NPV and IRR with the next three years after-tax free cash flow given in d). [2 marks]

You also plan to update the fund's holdings with dividend-paying stocks. You begin by reviewing the characteristics of the following portfolio candidates:

DEF company is in the steel manufacturing sector with a required rate of return of 7.35%. You estimate that if the economy is booming, the company's current annual dividend of $0.65 per share will grow 12% a year for the next four years and then stabilize at a 3.5% growth rate a year indefinitely. However, if the economy falls into a recession, then DEF will not likely experience the elevated 12% short-run growth and instead will grow by 3.5% indefinitely.

GHI company is a mature company with a stable capital structure. The company had an EPS of $2 in 2021. The earnings in the next year without the additional planned investments are expected to remain at $2. The earnings retention ratio is 0.60. The company is expected to earn an ROE of 14% on its investments, and the required rate of return is 11%. Assume that all dividends are paid at the end of the year.

f) Use the discount dividend method and find the current value of company DEF stock under both economic conditions. [3 marks]
g) Calculate GHI company's sustainable growth rate, find the value of the company's stock at the beginning of 2022 and determine the company's present value of growth opportunities. [2 marks]

Question 2 [15 marks]

Suppose that you are a senior analyst at the fixed-income division of an investment bank. You have gathered relevant data about the fixed-income market and three bonds for further research. The information is summarised in Exhibits 1, 2 and 3.

Exhibit 1: Current Par Yield and Spot Rates		
Maturity	Par Rate	Spot Rate
1 year	2.50%	2.50%
2 years	2.99%	3.00%
3 years	3.48%	3.50%
4 years	3.95%	4.00%
5 years	4.37%	?
Note: Par and spot rates are based on annual-coupon bonds.		

Exhibit 2: Information for Selected Bonds			
Bond Name	Maturity	Coupon	Type of Bond
Bond A (Face value $1,000)	3 years	6.00% annual	Option-free
Bond B	3 years	4.40% annual	Callable at par on start of year 1 and year 2
Bond C	3 years	4.40% annual	Putable at par on start of year 1 and year 2

Exhibit 3: Binomial Interest Rate Tree, based on an estimated interest rate volatility of 10%, where ‘u’ represents an up move and ‘d’ represents a down move.		
Year 0	Year 1	Year 2
2.2500% (r)	3.5930% (ru node)	4.6470% (ruu node)
	2.9417% (rd node)	3.8046% (rud node)
		3.1150% (rdd node)

a) Based on Exhibit 1, find the five-year spot rate. [2 marks]
b) Use Exhibit 1 and the law of one price to calculate the forward rate of a one-year loan starting in three years. [1 mark]
c) Given spot rates for one-, two-, and three-year zero bonds, how many forward rates can be calculated? Please list the forward rates that can be calculated and briefly explain your answer. [3 marks]
d) Find the yield to maturity for Bond A. You should use the IRR formula method in python. [3 marks]
e) Based on Exhibit 3, assume an equal probability of interest rate going up and down at each node. Calculate the value of Bond B and Bond C with the binomial tree model. [3 marks]

f) All else being equal, explain the effect of a fall in interest rates on Bond B and Bond C. [2 marks]

g) All else being equal, which bond is most likely to increase in value if interest rate volatility is 15% rather than 10%? Briefly explain your answer. (Hint: consider the value of options) [1 mark]

Question 3 [19 marks]

Consider a stock that is trading at $100 today. The stock does not generate income / pay dividends. The stock is traded in a well-functioning market with no transaction costs and no restrictions on short sales. Both borrowing and lending can be done in unlimited amounts at the 2% risk-free rate.

a) What is the difference between forward contracts and futures contracts [answers should be no longer than 200 words] [4 marks]
b) Consider a futures contract on the stock with a maturity of one year. Suppose that the futures price is currently at $110. Are the futures fairly priced? Describe an arbitrage strategy that would allow you to make a riskless profit. [2 marks]
c) Same as question b) but suppose that the futures price is currently at $95. Describe your arbitrage strategy. [2 marks]

Suppose that you hold a long position on a European call option that has an underlying asset price of $57.03, strike price $55, risk-free rate 0.22%, volatility 32% and time to expiration 0.25. The underlying asset does not have any investment yield.

d) Value this call option. [1 mark]
e) Based on the BSM model, describe a portfolio that replicates the call option's payoff [1 mark]
f) Define a function to price the option with the binomial tree method. The function should take the number of steps (n) as one of the inputs. You should NOT use list comprehension in the function. [3 marks]
g) By setting n = 10, 50 and 100, compare and comment on the results under the two methods. [2 marks]

When buying two calls with the exercises price of x1 and x3 and selling two calls with the exercise price of x2, where x2=(x1+x3)/2, with the same maturity for the same stock, we call it a butterfly. Consider the following call options on the same stock in Exhibit 1.

Option Name	Strike Price	Call Premium (Price)
Call Option 1	50	10
Call Option 2	55	7
Call Option 3	60	5

h) Create a graphical representation of the butterfly strategy's payoff. [2 marks]
i) Why might an investor enter into such a strategy? [2 marks]

Question 4 [13 marks]

Suppose that you want to build a portfolio with the stocks (with tickers of) AAPL, GOOG, AMZN and FB. You plan to retrieve the relevant yahoo finance data with the 'yfinance' python module from 1st of Jan. 2017 to 31st of Dec. 2020 (inclusive).

a) Calculate the daily returns of these stocks. You should use the adjusted daily closing price. [1 mark]
b) Based on a), find the covariance matrix of these stocks. [1 mark]
c) Suppose that the four stocks are equally weighted, find the annualised portfolio expected returns and portfolio variance. [2 marks]
d) Find the efficient portfolio with the maximum Sharpe ratio. What is the corresponding Sharpe ratio? [2 marks]
e) Plot the efficient frontier. [3 mark]
f) Based on the concept of diversification, comment on the current portfolio. How can this portfolio be improved? [answers should be no longer than 200 words] [4 marks]

Question 5 [14 marks]

You are a life actuary of an insurance company. Today on 13 March 2022, a potential client, Alice, is looking to sign a permanent life insurance contract with your company. Alice, born on 28 October 1983, is a smoker with the health condition standard for her cohort with the same age, gender, and smoker status. You decide to apply the 2015 Valuation Basic Table (VBT) (www.soa.org/files/research/exp-study/2015-vbt-smoker-distinct-alb-anb.xlsx) for Alice's mortality evaluation with the Age Nearest Birthday (ANB) method for her age calculation. Your company applies the valuation interest rate of 3.5% for premium pricing.

a) Calculate Alice's annal unconditional survival rates $_np_x$ from now to age 42. [3 marks]
b) Calculate Alice's life expectancy in years (show one decimal place). [2 marks]
c) Calculate the probability that Alice dies exactly between 6 and 9 years from now (show five decimal places). [2 marks]
d) Calculate the minimum annual premium rate (premium as a fraction of death benefit) that your company should charge for Alice's cohort (show five decimal places). [3 marks]
e) What technologies can you apply to enable a closer prediction on the company's cash flow linked to this line of business of permanent life insurance? [answers should be no longer than 200 words] [4 marks]

Question 6 [23 marks]

You are a new analyst at a traditional brokerage and wealth management business. The business is traditional and focuses on stocks, bonds, derivatives and options for their customers and advisory. Your CEO asks you to think about ways in which your traditional firm could embrace new emerging technologies and business models in the future in a gradual way. Your CEO asks you to come back with answers to the following points, answering each question sub-part with no more than 400 words:

a) Describe what emerging technologies could be utilised and how they could be applied in the business infrastructure. [6 marks]
b) What type of new business models could you also look to if you were thinking of reinventing your business scope and why? [9 marks]
c) What new emerging financial products would be most suitable to add to complement the existing products of the business and why? [8 marks]

Section C: Assessment of this coursework

Within each section of this coursework, you may be assessed on the following aspects, as applicable and appropriate to this particular assessment, and should thus consider these aspects when fulfilling the requirements of each section:

- The accuracy of any calculations;
- The strengths and quality of your overall analysis and evaluation;
- Appropriate use of relevant theoretical models, concepts and frameworks;
- The rationale and evidence that you provide in support of your arguments;
- The credibility and viability of the evidenced conclusions/recommendations/plans of action you put forward;
- Structure and coherence of your considerations and reports;
- Appropriate and relevant use of, as and where relevant and appropriate, real world examples, academic materials and referenced sources. Any references should use either the Harvard OR Vancouver referencing system (see References, Citations and Avoiding Plagiarism)
- Academic judgement regarding the blend of scope, thrust and communication of ideas, contentions, evidence, knowledge, arguments, conclusions.
- Each part has requirements with allocated marks, maximum word count limits/page limits and where applicable, templates that are required to be used.

You are advised to refer to the UCL Assessment Criteria Guidelines, located at https://www.ucl.ac.uk/teaching-learning/sites/teaching-learning/files/migrated-files/UCL_Assessment_Criteria_Guide.pdf

Section D: Groupwork instructions

You should create your own groups in moodle (minimum 3, maximum 4). Each group member should contribute to the coursework equally. Only one person from each group needs to submit the various parts of the assignment.