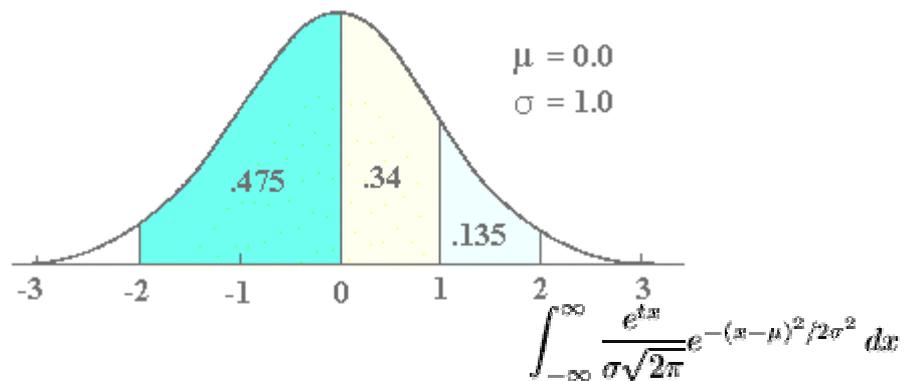


Interview Preparation: Quantitative Structuring

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INTERVIEW PREPARATION FOR JUNIOR QUANTITATIVE STRUCTURERS

This document is intended to provide a preparation framework ahead of interviews for junior structuring interviews. It is not meant to be exhaustive and more in-depth reading should be undertaken as part of the preparation process.

1) Introduction

The primary role of a Quant structurer is to act as a solutions provider in the preparation of transactions involving derivative financial products. This can be done through the creation of new products or the application of existing ones.

The responsibilities of a structurer can be summarised as follows:

- Create new products – primarily based on derivatives
- Enhance existing products
- Reverse-engineer product ideas seen in the market
- Create ideas for the Sales teams to engage the interest of customers
- Listen to customers' issues, and create a product or solution tailored to that customer
- Provide term sheets and materials to support the sales effort.
- Assist the front office Quants/Traders with modeling/execution of ideas

Typically structurers act as the interfacial connection between Financial Engineering (Quant Analytics), Traders and external customers. This fundamentally establishes the requirement of a structurer to be a strong mathematician. However to be better equipped to deal with the different responsibilities he may face, a structurer must have a strong personality and excellent communication skills. In addition to this, he must be business-focused with an appreciation of how derivatives can be used to enhance speculative trading strategies, arbitrage strategies and hedging strategies. Furthermore, there should be some level of comprehension of programming languages (namely C++ and VB) since the limitations of model implementation will be a dominant factor in evaluating product feasibility – there may also be a requirement for the structurer to get involved in actually programming some of the models that are developed.

Another key point to understand is that given the skill set of a structurer he may also act as a trader, because, in essence, a trader's responsibility will only differ in that he will actually get involved with execution of the trades.

A popular concept is that structurers should aim for a multi-asset philosophy, i.e. a single team covering all asset classes, split into smaller teams dedicated to each asset class, with the intention to create a cross-asset environment for cross fertilisation of ideas. Additionally this allows for comprehensive coverage of clients' needs

A multi-disciplinary team can provide better cross-asset tailored products more easily. Central to this is the aim of providing flexibility and efficient service. Hybrids increasingly appear to be the future of derivatives and such teams tend to be equipped to push development in that area.

2) Product knowledge

Derivatives fall into three main classes

- Options
- Swaps
- Futures/FRA's

There is a lot of jargon associated with the products that fall under these classifications, and it is important to be aware of this. During the interview you will be expected to demonstrate: some level of interest in different types of derivative products; and the capability to analyse them from a qualitative and quantitative perspective. There are literally hundreds (perhaps thousands - depending on how they are categorised) of different derivative products, and it would be an

inefficient use of one's time to attempt to learn the structure and nuances of each ahead of an interview, with the view of regurgitating this should the relevant questions come up. However, it is vital that you have an appreciation of the more important types of derivatives and how/why they are useful. An excellent introduction to the basics of derivatives is given by Stefan Bernstein in his book *Understand Derivatives in a Day*.

Also an understanding of the general derivatives markets (for example, the fact that swaps are by far the most popular type of derivative, in terms of quantity), and the ability to speak in-depth about a few key products that you yourself find genuinely interesting, would be advisable. The spectacular collapse of Bearings Bank in the 1990s which was triggered by a trader (Nick Leeson) writing uncovered put options on the Japanese Stock Index is an example of a case study that would be easy to find information on.

Typical product-related questions that have been asked at a junior structurer interview include:

- What is the price of a Forward?
- How do you hedge it?
- What is its delta?

For a European call:

- When is gamma the highest?
- How does the gamma moves with the volatility?
- What are the first and second derivatives in function of the strike?

Explain and calculate

- How can we build a digital?
- How is the vega at the barrier of an up and out Call?
- If we have an increase in volatility, how would the price move?
- Discuss the limitations of applying the original Black-Scholes approach to pricing an option?

3) Basic Maths:

It has been mentioned by a number of our clients that the failing of many junior candidates they interview is their lack of ability to solve problems using the fundamentals. For example, whilst 90%+ can apply Ito's lemma in the context of Black Scholes to calculate the price of an option where a stochastic process is involved, over half of these people are not able to solve it as an ODE once the stochastic component has been removed. This suggests two things;

i. They have merely learned the solution by memory; and/or

ii They are only aware of standard methodologies;

without understanding the fundamental mechanics of the model. What clients are looking for at the entry to 2 year level is strong competency on the basics and strong (almost intuitive) mathematical and logical problem solving skills that would suggest that in the future you will be capable of learning the difficult and complex processes applied to harder problems. If you slip up on the basics it's difficult to judge your potential of coping with the more challenging products or indeed your longer term potential to bring innovative ideas to the forum. We would therefore suggest that prior to interview you spend at least a 40-50% of your time consolidating your understanding of basic math applicable to quantitative finance and the rest revising programming and learning about the products and their structures. See Table 1 and Figure 1 for a fuller explanation of this).

Table I. Areas of maths which are fundamental for a Quant interview

Calculus:	Functions of a single variable: o Ordinary calculus o Ordinary differential equations o Solution methods o Basic numerical integration o Simple integral equations	Functions of two or more variables: o Partial differential calculus o Partial differential equations o Classification o The diffusion equation o Solution methods o Basic numerical methods	Matrices: o Matrix manipulation o Eigenvalues and eigenvectors o Exponentiation
Probability:	Elementary probability theory: o Distributions, discrete and continuous o First and second moments (mean and variance) o Higher moments (skew and kurtosis) o Important distributions o Several variables o Correlation o Central Limit Theorem	Elementary statistics: o Data representation o Regression o Confidence intervals o Hypothesis testing	Random walks: o Trinomial o Transition probability density functions o Deterministic equations from random behaviour

4) Basic Financial Maths:

You should then make sure you have mastered the basic math behind derivative pricing theory, for example, you understand Black Scholes and are able to not only solve the equation using at least two different methods but are able to discuss the application in a real world context. A complaint from clients is that some candidates are not “pragmatic” mathematicians – i.e. if they do have a good understanding of how an equation works they can often be too zealous about the equation itself rather than its application and practicality.

Example: When asking someone to price an option the “purists” dive straight into finding the solution with the most precision, however before attempting any question like this it is important to know the precision limits required as this may fundamentally change the approach one may take (speed vs precision optimization).

In terms of specific math look at: Markov Processes, Ito Processes, Ito’s Lemma, Wiener/Brownian Motion, PDEs, and Monte Carlo techniques. It goes without saying that you should understand the terminology and simple behavior of vanilla derivatives, for example, the relationship between derivative prices and their underlyings.

Finally, as a basic rule, ensure you are able to talk in depth about what you have put on your CV. Even if it is something you have not done for a few years make sure you are able to give a thorough overview of the projects you have done and that you can give a good summary of the considerations behind the technical decisions you made during these projects. Be prepared to be questioned on these and make sure you have re-familiarized yourself with the subject areas involved.

5) “Complex” Maths

“Complex” mathematical questions typically only contain complexity in the way that they are structured. Within an interview for an entry/junior level position, if you are presented with a highly complex problem the interviewer will often talk you through the approach to solving it giving you pointers where you get stuck. All you need to ensure is you have mastered the basics and that you are showing that you understand the approach being taught to you by the interviewer.

With regard to the more complex problems interviewers are looking for creativity in finding solutions. It is difficult to be creative with mathematical rules unless
i you know them well and therefore can apply them accurately; and
ii you have been actively applying them to a multitude of problems and therefore understand the different approaches to finding solutions.

Sample Questions on the basics

- Evaluate the following integrals

$$(a) \int_0^{\infty} x^2 e^{-x^2/2} .dx$$

$$(b) \int e^x \cos x .dx$$

$$(c) \int_0^t \frac{dt}{t^2 + 5t + 6}$$

- Solve the following ordinary differential equations for $y(x)$

$$(a) y'+6xy = 0, \quad y(0) = 1$$

$$(b) y''+y'-6y = 0, \quad y(0) = 1, \quad y'(0) = 0$$

- Solve the partial differential equation

$$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2}$$

- Find all eigenvalues and all (normalised) eigenvectors for the following matrix

$$\begin{pmatrix} 2 & 1 \\ 1 & 2 \end{pmatrix}$$

- Calculate $E[e^X]$, where X follows a Normal distribution $N(u, s)$ of mean u and standard deviation s .

- If

$$dX_t = a(X_{\infty} - X_t).dt + s.dW_t$$

and

f is a function of X and t ;

calculate df , where a, X_{∞} and s are constant.

What if the Brownian motion term in the above is 0 (i.e. $s.dW_t = 0$)?

- Write a probability density function for normal and log-normal distributions.
- You are dealt 13 cards randomly from a pack of 52. What is the probability your hand contains exactly 2 aces?

6) Programming Skills (C++ and Visual Basic)

Software development in C++ is one of the key technologies employed by global financial institutions, particularly due to its support of object-oriented programming. This has resulted in a minimum requirement for all quantitative professionals to have some appreciation of C++ modelling. In addition to this, the accessibility and “user-friendly” nature of VB/VBA has led to its increasing popularity. Ideally junior candidates for structuring will have used C++ and VB beyond a basic level (for example, implemented a PDE solver), and should have a deep understanding of core programming principles.

Sample questions (basic level C++):

- What is the difference between a pointer and a reference?
- When would you use a pointer/reference?

- What does it mean to declare a function or variable as *static*?
- What is a class?
- What is the difference between a struct and a class in C++?
- What is the purpose of a constructor/destructor?
- What is a constructor, destructor, default constructor, copy constructor?
- What does it mean to declare a member function as *virtual/static*?
- What is virtual inheritance?
- What is polymorphism?
- What is the most difficult program you have had to write?

7) Problem Solving Questions/Brainteasers.

It is likely that during the course of interviews you will be asked some “brainteaser” type questions designed to test your intuition for problem solving – such skills are vital for a structurer. The solutions are often mathematical but can also require simple logic or lateral thinking. Often there can be several solutions, some more optimized than others. Interviewers are looking to see your thought process in solving the problem and will usually require you to prove your answers.

Sample questions:

- What is the sum of all the numbers between 1 and 1000?
- How would you sum a series of 1 to n numbers? Demonstrate proof for this.
- You are given a set of balance scales which you are to use to measure eight balls. Seven of these balls have the same weight: the eighth ball is heavier than the rest. What is the minimum number of weighs you could perform to find the heaviest of the eight balls?
- Same as above but with 12 balls?
- To qualify for a race, you need to average 60 mph driving two laps around a 1 mile long track. You have some sort of engine difficulty the first lap so that you only average 30 mph during that lap; how fast do you have to drive the second lap to average 60 for both of them?
- A river is flowing downstream at 15 mph relative to the shore. A rowing team is practicing rowing and at first they row upstream (against the current). They can only go 1.5 mph relative to the shore at this rate. The guy at the back end of the boat is wearing a hat when they begin, but after a while his hat falls into the water (and floats) and it is 15 minutes before they notice it. They then instantaneously reverse direction and row back to catch up with the hat, rowing with the same strength or power they were rowing with before. How long will it take them to catch up with the hat as it is pushed downstream by the current?
- There are 10 open boxes containing 100 coins each. In 9 of these boxes the coins are made of gold, and in the other the coins are made of copper. You are given a large digital balance which can be used once only. Can you identify the box containing copper coins knowing the weight of both gold and copper coins?
- A bag contains a total of N balls with either blue or red colour. If five balls are randomly chosen from the bag, the probability is precisely $1/2$ that all five balls are blue. What's the smallest value of N for which this is possible? (Hint: Use different number of blue/red balls to get to the answer?)
- You are given 5 bags containing 100 coins each. The bags can contain coins of 3 different types that look identical. The first type weighs 9 grams, the second type 10 and the third type 11 grams. Each bag contains coins of equal weight but you do not know how many of the 5 bags are of the different types. (i.e. all 5 bags might well contain 9 gram coins as far as you are concerned). You are given a huge digital balance. How many times do you need to use the balance to clearly determine the type of coin contained in each bag?
- You are playing Russian roulette with a six chamber revolver, you load 2 bullets into the revolver in adjacent chambers. You spin the barrel place the gun to your head and pull the trigger, you don't shoot yourself. You now have the option of either spinning the barrel or pulling the trigger again, which do you take?

- You are in a boat on a lake, in the boat there is a suitcase, you throw this suitcase over the side of the boat. What happens to the level of the water in the lake? Does it rise, fall or stay the same?
- How many manhole covers are there in London?
- How many petrol stations are there in the UK?
- You are gambling on the roll of a fair six sided dice, in this game if you role a 1 you get \$1, if you role a 2 you get \$2 if you role a 3 you get \$3 and so on. What is the expected return after 100 roles of the dice.
(Note – there are a large number of variations on this game, you should spend some time looking at various dice games and probabilities).

If you wish to discuss any of this material further, please contact Gianna Tong or any of the other consultants listed below

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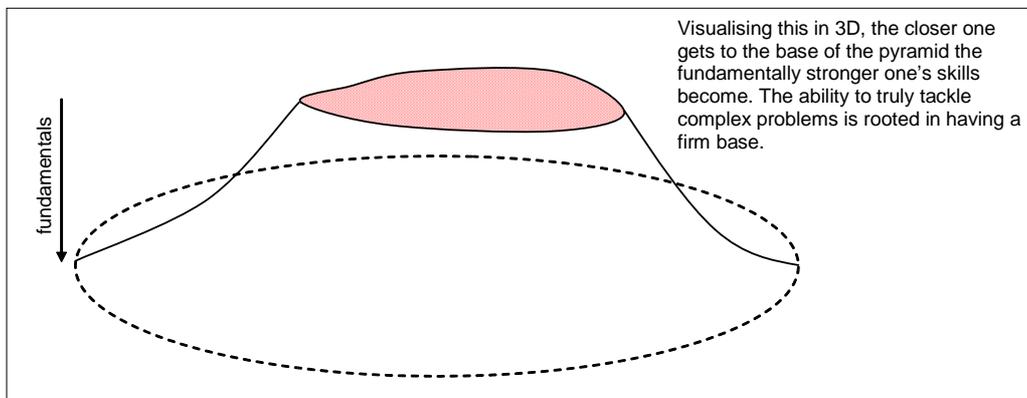
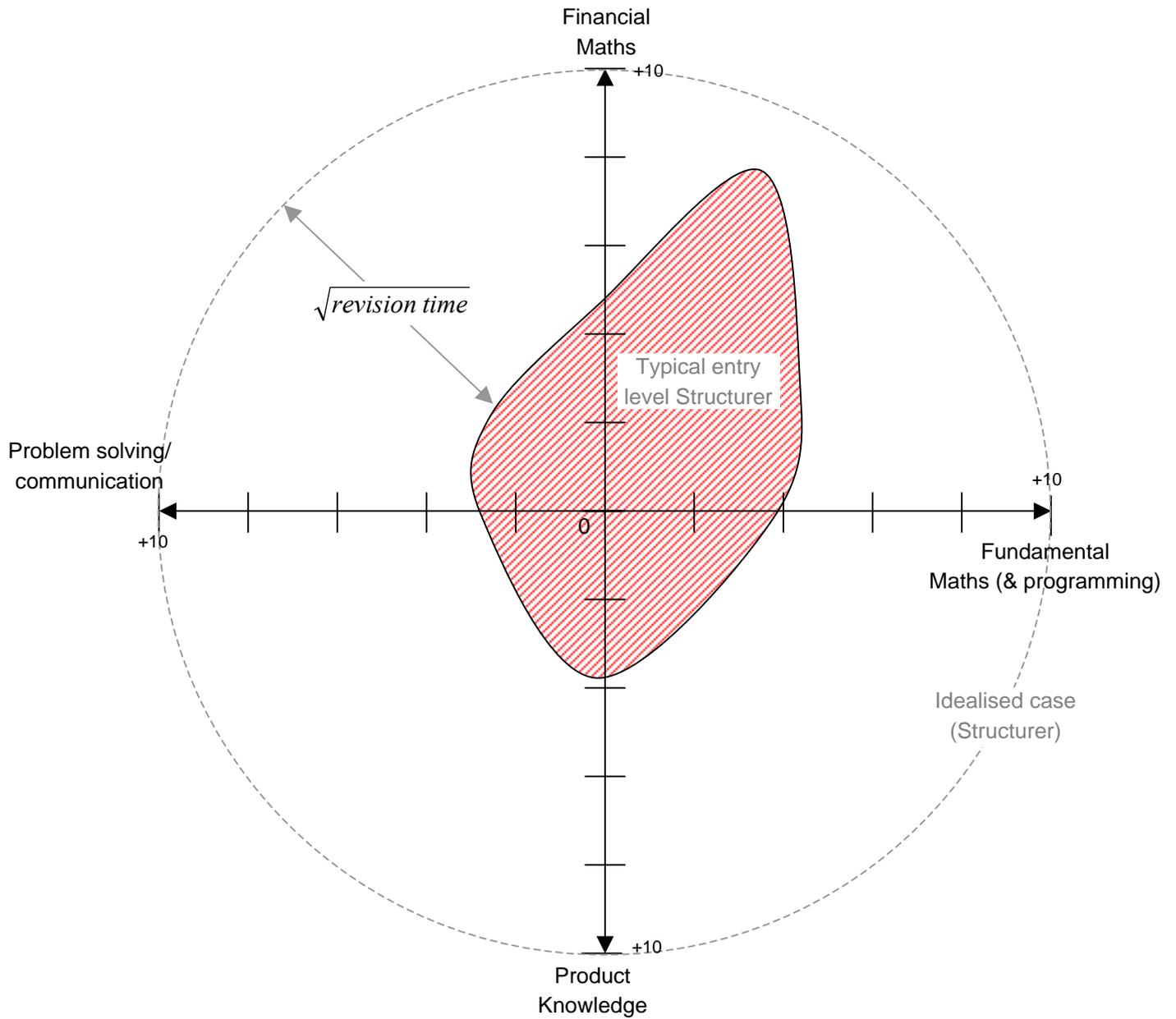


Figure 1: Skills mapping against revision space