Heard on The Street:
Quantitative Questions from Wall Street Job Interviews

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Preface

THIS BOOK IS A MUST READ! It is the first and the original book of quantitative questions from finance job interviews. Painstakingly revised over 15 years and 12 editions, *Heard on The Street* has been shaped by feedback from many hundreds of readers. With 50,000 copies in print, it is unmatched by any competing book.

This revised 12^{th} edition contains over 175 quantitative questions collected from actual job interviews in investment banking, investment management, and options trading. The interviewers use the same questions year-after-year, and here they are—with solutions! These questions come from all types of interviews (corporate finance, sales and trading, quant research, etc.), but they are especially likely in quantitative capital markets job interviews. The questions come from all levels of interviews (undergraduate, MS, MBA, PhD), but they are especially likely if you have, or almost have, an MS or MBA. This edition also includes over 125 non-quantitative actual interview questions, giving a total of more than 300 actual finance job interview quesitons. There is also a section on interview technique—based on my experiences interviewing candidates for the world's largest institutional asset manager and also based on feedback from interviewers worldwide.

This book bridges the considerable gap between the typical finance education and the knowledge required to successfully answer quantitative finance job interview questions. The considerable gap arises because Wall Street interviewers must separate the "wolves" from the "sheep." The sheep are confined by the boundaries of their education; the wolves are not. The interview questions reach beyond these boundaries in order to separate the two classes of interviewees. Hence the gap. Of course, most interviewers are wolves. Unfortunately, many interviewees are sheep. The butchering that takes place has been described to me as "horrific." That is why you need this book.

I bridge the above-mentioned gap by presenting quantitative questions from actual finance job interviews. I could not find even one of these questions in any of the three-dozen other "interview books" at a large US bookstore. My solutions and advice are carefully designed to sharpen your quantitative skills. My advice is based on my experiences as a frontline teaching assistant for MBA students at MIT, as a finance professor at Indiana University, and as the former head of a quant research team for the world's largest institutional asset manager.

My intended audience includes interviewees (wolves and sheep alike) seeking employment at Wall Street or other finance-related firms; their interviewers, who need to weed out the hapless sheep; university professors who want to "spice up"

finance courses with Wall Street job interview questions (both for fun and to show the importance of the basic concepts on The Street); students of finance who want to fill in some gaps; and finally, doctoral students in need of entertainment during periods of downtime.

Many of the questions collected and presented here are "classics" that appear year-after-year without fail. However, this book is definitely not for people who just want "The Answers" to such questions. Such people are the archetypal sheep in wolves' clothing, and they are quickly identified as such in an interview. To benefit from this book, you must make a serious investment of your time.

I thank MIT students, MIT faculty, and people on "The Street" who have supplied me with information. I thank Olivier Ledoit, Cecily Lown, Bingjian Ni, Eva Porro, and Juan Tenorio for their constructive criticism. This book was written and edited in 1995 while commuting to and from MIT on the subways and buses of the Massachusetts Bay Transit Authority (MBTA).

TFC/MIT/1995

I updated this book while working as a professor at Indiana University (IU). I thank all the people thanked above (especially Olivier Ledoit). I also thank Sean Curry and The MathWorks Inc for a free copy of MATLAB (used to check answers and draw figures), MBA Style Magazine (`www.mbastyle.com`) for horror stories, Andres Almazan, Tom Arnold, Mary Chris Bates, Klara Buff, Alex Butler, Victor W. Goodman, Tim Hoel, Taras Klymchuk, Victor H. Lin, Marianne Lown, Alan J. Marcus, David Maslen, Marc Rakotomalala, Jason Roth, Yi Shen, Valeri Smelyansky, Dahn Tamir, Paul Turner, and students (MBA and undergraduate) at each of MIT, UCLA, and IU.

TFC/IU/1996–2000

I updated this book while working as Head of Quantitative Active Equity Research (UK/Europe) at the world's largest institutional asset manager. I now also thank Jinpeng Chang, Mark Rubinstein, Alex Vigodner, and Nick Vivian.

TFC/London/2001–2003

I updated this book again after accepting the Chair in Finance at Otago University in New Zealand. I now also thank Giulio Agostini, Scott Chaput, Chun Han, Alessio Farhadi, Vince Moshkevich, Katie Price, Wolfgang Prymas, Naoki Sato, Mikhail Voropaev, and Thomas C. Watson.

The 10th, 11th and 12th Editions contain many new questions and improved answers to old ones. I particularly thank the interviewers at top firms who freely shared their most recent questions with me for inclusion in this book. I now also thank David Alexander, Armen Anjargholi, Edward Boyce, Jun Chung, Nate Coehlo, Richard Corns, Robin Grieves, Patrick de Man, Alexander Joura, Charles Hallion, James Hirschorn, Philip Koop, Steve Lee, Stuart O'Neill, Bryan Rasmussen, Ashish Saxena, Torsten Schöneborn, Adam Schwartz, Yirong Shen, Ian Short, Olaf Torne, and Simon West.

TFC/OU/2004–2009

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Introduction

This book first appeared in 1995 with questions collected from students after interviews. Nowadays the interviewers at top firms frequently send me their new questions directly! For example, one interviewer at a big-name New York investment bank sent me the bank's latest full written quantitative interview test with three dozen questions (and answers)! Like this book, the test questions are in sections (pure quant, stats, finance, etc). I can, however, find only a few to include that differ in nature from what is here already.

I used to wonder why interviewers at top firms supply me with their interview questions to put in a book to sell to their job candidates. Now I understand that they do not mind if the questions are public knowledge because job candidates who make a serious investment of time in revising the questions deserve to be hired!

All of the quantitative questions are accompanied by detailed solutions. The questions are split into four categories: Purely Quantitative and Logic, Derivatives, Other Financial Economics, and Statistics (chapters 1, 2, 3, and 4, respectively). The solutions appear in Appendices A, B, C, and D, respectively. Chapter 5 presents non-quantitative questions from actual interviews (with selected solutions in Appendix E). In the text, a name followed by a year (e.g., "Girsanov [1960]") refers to a work cited in the References (following the appendices).

If you are interviewing for option jobs and you need a review book to complement the interview questions here, then you should buy my other book: *Basic Black-Scholes*, Crack (2009). See the advertisement on the last page of this book for details, or go directly to `www.BasicBlackScholes.com`. Note that *Basic Black-Scholes* started its life as an extended appendix to this book, but was carved out as a book in its own right in 2004; it is now in its revised second edition. Given that the original aim of that book was to help interview candidates, the writing style should be more suited to your interview preparation than most competing books.

Questions in This Book

The questions in this book were collected by me from interviewees, interviewers, and others. I have taken the liberty of rewording them for maximum clarity because, unlike in an interview, you have no opportunity to ask me for clarification. Sometimes I give only part of a question that was asked; sometimes I combine related questions into a larger one. I remain faithful to the original problem statement

wherever possible.

I often add a footnote to a question. The footnote contains a slight variation on the question. Unless otherwise indicated, these "footnote questions" are made up by me and are not actual job interview questions. All other questions come from actual job interviews (even the "condom question").

Many of the questions require a serious investment of your time. Knowing the answer is not enough in and of itself. If my answer is not clear after several readings, then consult the references I give.

Interviewees should attempt these questions without peeking at the answers. Mastering the problem-solving process gets you the job. This may mean spending days with a problem before you figure it out. Looking at the answer tells you how I did it; it does not tell you how to solve problems by yourself. The path of greatest resistance bears the highest rewards!

Interviewers can use these questions as they stand. However, I strongly encourage you to push candidates very hard for the underlying understanding. Ask them to explain the answer, not to simply solve the problem. This differentiates those who understand the problem from those who merely know the answer. The good ones meet the challenge; the bad ones do not. Many people can solve problems, but only a few genuinely understand what they are doing.

Will the questions in this book become obsolete or dated? The answer is no, for two reasons: First, many of the questions are "classics" that appear consistently year-after-year; and second, the body of quantitative skills required to solve these questions has remained unchanged for three decades. Even if some of the questions change, the skills required to solve them do not. It is these skills that my book promotes. For these reasons, it follows that these questions are genuinely timeless.[1]

Sometimes the classification of a question (and, therefore, the chapter it should be in) is by no means clear. For example, some of the financial economics questions look like statistics questions, and I have placed questions on stochastic calculus in the derivatives chapter instead of the statistics chapter.

Some questions have more than one solution technique. The "right answer" is the wrong answer if you use a "brute-force" approach and completely miss an elegant alternative (I often give both techniques).

Some questions are more difficult than others. I have labelled difficult questions with two stars "(**)" and very difficult questions with three stars "(***)." By default, all other questions deserve one star. For the two-star or three-star questions, your approach, rather than your solution, may be of more importance. You should be able to set up a general framework for a solution. If you can solve such questions on the spot, you are doing well.

Some of the questions are at a low level, and you may think it beneath your dignity to answer them. I have, however, interviewed people who claim to have degrees in finance, economics, statistics or mathematics, who cannot answer basic

[1] At first glance, some questions may seem dated (e.g., "Suppose that IBM is trading at $75 per share ..."). However, I could easily have made it "Stock XYZ" (contrary to the original wording), and you would not have noticed. Where possible, I retain the original wording for authenticity.

finance, economics, statistics, or mathematics questions, respectively. If you think the basic questions are beneath you, then prove it by walking through them like a hot knife through butter. If you cannot answer the basic questions, however, either because you are rusty on the basics, or simply never understood them, then why should anyone hire you? No one will want to put you in front of their traders, other team members, or clients who will have basic questions.

Knowledge of C (but probably not C++) is required for some types of quantitative Wall Street interviews (in such cases, C++ may be required for the job itself). I used to have a few C questions in my book without solutions, but I now think it is in your best interest to simply recommend Mongan, Suojanen and Giguère (2007) to you.

You must have already heard all the ordinary interview advice (cover letters, appearance, comments on previous employers, use of bad language, chewing gum, researching people who will interview you, researching the firm, knowing your strengths and weaknesses, and so on); if not, then see Fry (2009). To answer the type of questions in this book, however, you may need the *extraordinary* advice in the next section.

The Interview

Will They Ask me These Questions?

Yes; you must assume that they will. You can hope for the best, but you must prepare for the worst. Some firms use the first round of interviews to get to know you with soft and non-quantitative questions. In this case, a second round typically follows with quantitative questions. Other firms use a quantitative first round to screen applicants up front. However, some firms ask no quantitative questions. There is thus a chance that you will see no quantitative questions. In this unlikely event, my quantitative questions will have increased your IQ, and my non-quantitative questions (chapter 5) will have been of most assistance.

On the non-quantitative front, many interviewees have been asked, "Where did the Dow close yesterday?" or "Where did the Nikkei close?" or "Where is the long bond?" In addition to current knowledge, you should also know how these (and other) basic economic variables have changed over the recent past, and where they are relative to all-time highs and lows—see chapter 5 for more examples. Even if you are very busy interviewing with many firms, you must not be found ignorant on such basic market knowledge.

ATQ!

"ATQ" stands for "Answer The Question!" Let us suppose that I am the interviewer and that I have little patience. I am busy. Damn busy! I have a deadline for my boss on a project that is due tonight (he is in an earlier time zone). I just walked away from the stack of work on my desk, and the computer simulation I desperately need to see the results of just so that I can talk to you. Spending 30 minutes with

you means I get home at 10:30PM instead of 8:00PM, because I have to finish my project, and I will miss the last direct train. I earn $250,000, $500,000, $1M, or more per annum. I got my job and kept it because I am efficient and I understand time management. I want to hire a good person, but if you waste my time then I will crucify you; perhaps not to your face, but to my colleagues, both at this firm, and at competing firms thinking of interviewing you.

I know from past experience that people with good resumes are not necessarily knowledgeable in their claimed area of expertise. If you have a degree in finance, or mathematics, or whatever, and cannot answer a basic question in that area, then how the heck can I let you answer the phone when our traders call, or stick you in front of a client, or take you to a meeting with the portfolio managers, or have you join me in a conference call with my boss? That is, how can I hire you if you cannot answer basic questions? I know that there will come a time in this interview or the next when I have to push you to answer some quantitative questions, so that I can see what you understand and what you do not. Some of them will be basic, some of them not. I need to know the limits of your knowledge, and I cannot find them by asking soft wishy-washy questions about your resume.

If I ask you a question, then answer the damn question! If you know the answer, then tell me it. If you do not know the answer, but can work it out, then tell me that and outline the steps; I may be happy with that, and then not need to see the full derivation. If you have only a passing knowledge of the area, or no hope whatsoever of answering the question, then I need you to say so directly, and without wasting my time, so that I can ask you other questions. I need to know the boundaries of your abilities, and to find them I must ask you a mix of questions including ones that you cannot answer at all. Do not waste my time by floundering around and, in effect, drowning yourself in your own ignorance.

For example, suppose it is a bond trading job and I ask you whether the curvature in the plot of bond price versus yield to maturity is caused by changing Macaulay duration as yield changes. Let us suppose that you know the answer, but instead of giving it to me directly, you say:

"Well, that's an interesting question. We know that for a standard coupon-bearing bond with no embedded options, the plot of bond price versus yield to maturity is downward sloping and concave up. Let me draw that on the whiteboard here (draws picture). As yield rises, other things being equal, bond price falls, but the dollar rate at which the bond price falls actually decreases as yield to maturity rises. That is, the slope becomes less negative. Changing slope means that there is curvature, and sure enough the plot is concave up. Now, some people may think, naively, that the slope of the plot is just the Macaulay duration of the bond. Now, it is well known that as yield to maturity rises, other things being equal, the Macaulay duration of a standard coupon-bearing bond with no embedded options falls. So, these people would deduce, naively and incorrectly, that as yield to maturity rises, the changing slope is simply a reflection of changing Macaulay duration. However, the simple fact that the Macaulay duration of a standard coupon-bearing bond with no embedded options is positive, and that the slope of our plot is negative, tells us that the slope is not the Macaulay duration. It is not the negative of the Macaulay duration either, and we can see

that by looking at the case of a zero-coupon bond. Suppose we plot bond price versus yield to maturity for a ten-year zero with no embedded options. The plot is downward sloping and concave up as before, with slope becoming less negative as yield to maturity rises, but the duration is 10 years regardless of the yield—because it is a zero. That is, where the slope is of large magnitude, the Macaulay duration is ten; where the slope is of intermediate magnitude, the Macaulay duration is ten; where the slope is of small magnitude, the Macaulay duration is ten. Thus, slope does not equal Macaulay duration, or negative Macaulay duration, and the curvature of the plot cannot simply be a reflection of changing Macaulay duration. Now, the slope of the plot of the price of the standard coupon-bearing bond versus its yield to maturity is *a function of Macaulay duration, but it is also a function of bond price and yield to maturity. If we write down the slope explicitly, we see that it is* $-\frac{D}{(1+r)}P$*, where* D *is Macaulay duration,* P *is bond price, and* r *is yield. If we look at numerical examples, we can see however, that the duration does not change very much with changing yield. Indeed, as already mentioned, it does not change at all in the case of a zero, and low-coupon bonds are not that different from zeroes. Rather, it is the bond price that changes significantly with changing yield, and it is this that causes changes in the slope, thus producing curvature. Sure enough, in the case of a coupon-bearing bond, the changing Macaulay duration contributes to the change in slope, and thus to the curvature, but its contribution to curvature is much less important than the contribution of changing bond price. So,* no, *it is not changing Macaulay duration, but rather, changing price, that drives the change in slope, thus creating curvature."*

Well, you just spent two and one-half minutes of my valuable time saying that. That is ten percent of your interview time. In your favor, you got to the correct answer, which is "no," but in so doing you gave me so many words that I ceased caring whether you knew the answer or not. I did figure out, however, that if you were working on my team, I could not take you to a presentation to clients because you would take *for bloody ever* to answer their questions and bore the pants off them in the process. I also figured out that you really like hearing the sound of your own voice. You may well be someone who does not realize that time is money, that that money belongs to my clients, or to the firm, and that that money has a heck of a lot of zeros on the end of it.

You should have just answered "No, changing bond price drives changing slope and creates curvature." You should then add that "Changing Macaulay duration contributes marginally to curvature for a coupon bearing bond, but not at all in the case of a zero." If the question has a "yes" or "no" answer, and you know the answer, then the first word out of your mouth should be "yes," or "no," respectively. Anything else means you are not getting to the point, and you are wasting my time and your golden opportunity! Obviously, you support your assertion immediately with more words, but answer the question first! ATQ!

I have had people talk a full ten minutes or more before coming anywhere near allowing me to detect whether they know the answer or not. After the first minute I have already decided that you are in the wrong building, and I am thinking about the stack of work on my desk. I stopped caring about your answer back in the first chapter of your saga. I am about to cancel the next person on your interview

schedule because I value his or her time almost as much as I value my own. Unlike me, you get to go home early today.

To repeat, if the answer is "yes," and you know it, then say so! If the answer is "no," and you know it, then say so! You can add words after that, to support your answer, but for God's sake, get to the point! Suppose you are on a date with a person you find exceptionally attractive, and you are dancing, and this person says, "Do you want to kiss me?" Are you going to talk to them for ten minutes about how you arrive at your decision or are you going to get to the point? Similarly, you must have had a professor at college who when asked a question from the audience mid-lecture would take five minutes giving his answer. When he got to the end of it you did not know what the answer was he had given, and you just wished he would shut up and move on. He invariably followed it up with "Is that clear now?" and no one dared say "no," for fear he would talk more about it. The bottom line is, answer the question! Remember ATQ, or even *ATFQ!*, if it helps hammer it into your skull.

If you do not know the answer, but know enough to try to work it out, than say something like "Hmmm. I do not know, but I think I can work it out. I know that the slope is given by $-\frac{D}{(1+r)}P$, where D is duration, P is price, and r is yield. I am not sure how much of the change in slope is explained by changes in each of D and P, but I do know that a zero has fixed D, so I suspect that changing P is more important than changing D." That is fine. You told me you did not know, and then you tried to work it out. That differs from knowing, but failing to tell me until the end of a saga.

If a question is not clear, be sure to ask for clarification. For example, "Is it a straight bond with no embedded options?," "Are there coupons?," etc.

If the interviewer tells you that your answer is incorrect when you know it is correct, and if you are dead sure of your answer, then defend yourself to the hilt. Interviewers make mistakes, and you can earn their respect (and a job) by tactfully correcting them. Good people want you to do that in practice, though probably not in front of their colleagues.

Other Advice

You are not just interviewing for the job that was advertised. There are other openings in the firm that have not yet been advertised (and may never be advertised), and there are openings in other firms that your interviewer knows about because he or she knows people there. There will also be other openings at the interviewing firm in the future. If they like you and your CV, but do not think you are suited to that one job, they may recommend you strongly to another team leader within their firm or even at another firm. The implication of this is that if you discover quickly that you are not suited to the position advertised, or the firm, then you should steer the interview toward your strengths and ask the interviewer to keep you in mind for other positions. He or she may even tell you of another opening.

This works in reverse also. If your interview is awful, the interviewer will happily pass that information to other people who ask about you, or even without being

asked if you really suck.

The finance community is small and interwoven and corporate memory is long. If you interviewed at the firm before, your interviewer probably knows about it and will talk to the people you talked to. Indeed, if you worked/interviewed/studied anywhere in the world, the interviewer can find a former colleague, interviewer, adviser etc, of yours, who is known to them and who can assess you. Your resume may have circulated widely within the firm, both in its local offices and overseas, before you set foot in the building or pick up the phone. Indeed, your resume might have circulated so widely that no one informs HR, and no one even remembers where your resume came from; that can explain why you never got any response, not even a rejection.

Your resume is a starting point. Do not inflate it. You *will* be asked about it. When a resume arrives on the desk of the interviewer, he or she looks at it and tries to figure out in advance some questions to ask. If you write on your resume that you took an option pricing class, and got an "A," then if the interviewer is an option pricing nut, you just guaranteed that the interview is going to get hot. If the area is a weakness for you, then do not make yourself a target. If you want to advertise that you took the class, then that is fine, but prepare yourself for incoming questions. ...and make sure your resume is proofread by people for whom English is their first language!

I received three cover letters that stand out in my mind. One from a young woman applying for a junior quant position who stated that she had "a lot of love to give," one from a graduate of Rutgers who seemed to think I was sufficiently stupid not to have heard of Rutgers and felt the need to describe the school in great detail, and one from someone saying that they had always wanted to work in investment banking (when I was working for an asset management company). Remember that you have sent your CV and cover letter out to act as your ambassador in your absence!

Be upbeat and enthusiastic. Even if the market is bad, and you are out of work. People like people who like them; it is that simple. If you tell me a tale of woe, all I can think is that "99% of your life is what you make it, and if your life sucks, you suck." Why would I want you sitting next to me at the office all day?

Do not smoke just before your interview. Get a stop smoking patch or something similar. The same goes for garlic for 24 hours before your interview. It stinks! Similarly, no one likes shaking hands with a limp dead fish. If your hands drip like a leaky faucet, then put your hand in your pocket (warm and dry), or palm down on you lap right up until you get up to shake hands. It is simple but effective.

Intelligent or genuinely humorous small talk is fine, but do not make a fool of yourself. For example, one guy came back a week later for a second round interview with me. I went to greet him in the foyer, and he looked at me blankly. Then he suddenly said "I remember you!" and "This is for the quant position, right?" Those were his first words!

Cover letters go in the garbage can, and e-mails are deleted. Make sure your e-mail address and phone number are on your resume. Similarly, buy an answering

machine and check it often. If HR cannot find you quickly, then someone else can interview for your job before you.

Finally, and one candidate told me this was the most valuable advice in the book, the ex-post probability that you get the job is either zero or one. If you prepare as though it is zero, then it will be. If you prepare as though it can be one, then you can make it so.

Story: A reader sent me the following e-mail: "...I bought your book... ...I just opened it to the first problem and was somewhat taken back by your solution. If you worked out the math, you would know that your answer is wrong. If you do not want to work out the math, then you could qualitatively grasp the mistake like so: ... ...Of course, to be quantitatively correct, you have to do the math. Always do the math... ...Hopefully, not too many interviewers have read this answer—or there will be lots of poor quants that will be turned away for being smart. Sincerely, YT."

Like many an overconfident quant, YT jumped into the math without *thinking* about the problem. Just as a pickpocket bumps you from the left while his accomplice takes money out of your right pocket, many of these questions are set up to distract you, and they are easier than they look.

I sent YT a tactful e-mail telling him politely why he was mistaken and why no math was needed. I even gave him a challenge quant question to solve to save face, but he did not respond. I think that his failure to respond was because he was unable to handle any criticism or admit his mistake (that would be consistent with his condescending e-mail). This is not what employers are looking for! Suppose an interviewer pushes you so hard or so far that you supply the wrong answer to a quant question. If the interviewer points out your mistake (and they do not always) then you should behave like a team member who is happy to accept constructive criticism. Do not get defensive, do not supply any BS; just take it and roll with the punches.

Please feel free to send me e-mails with queries, corrections, alternative solutions, but especially with new interview questions. The errata (with corrections and comments) can be found at the website below.

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Chapter 1

Purely Quantitative & Logic Questions

The only prerequisites for answering the questions in this chapter are elementary quantitative skills and common sense. Many questions in this chapter have two solution techniques: an elegant technique requiring little or no computation and a "hammer-and-tongs" brute-force approach. The technique you choose is revealing. Solutions for this chapter appear in Appendix A.

Question 1.1: You are given two glass jugs. Each contains the same volume, V, of liquid. One jug contains pure alcohol, and the other jug contains pure water. A modest quantity, Q, of water is poured from the water jug into the alcohol jug, which is then thoroughly mixed. The same modest quantity, Q, of (now diluted) alcohol is then poured back into the water jug to equalize the volumes of the jugs at their initial levels.

The initial concentration of alcohol in the alcohol jug equals the initial concentration of water in the water jug (at 100%). What is the relationship between the final concentrations of alcohol in the alcohol jug and water in the water jug?[1]

Question 1.2: What is the sum of the integers from 1 to 100?[2]

Question 1.3: (**) You are given a set of scales and 12 marbles. The scales are of the old balance variety. That is, a small dish hangs from each end of a rod that is balanced in the middle. The device enables you to conclude either that the contents of the dishes weigh the same or that the dish that falls lower has heavier contents than the other.

The 12 marbles appear to be identical. In fact, 11 of them are identical, and one is of a different weight. Your task is to identify the unusual marble and

[1] This is not a chemistry problem. Please ignore the fact that mixing a volume V_1 of water with a volume V_2 of alcohol results in a total volume less than $V_1 + V_2$.

[2] More generally, what is the sum of the integers from 1 to n?

discard it. You are allowed to use the scales three times if you wish, but no more. Note that the unusual marble may be heavier than the others, or it may be lighter; you do not know which. You are asked to both identify it and determine whether it is heavy or light.

Question 1.4: Interviewer: "You are a bug sitting in one corner of a *cubic* room. You wish to walk (no flying) to the extreme opposite corner (the one farthest from you). Describe the shortest path that you can walk. Be sure to mention direction, length, and so on."

Question 1.5: Picture a $10 \times 10 \times 10$ "macro-cube" floating in mid-air. The macro-cube is composed of $1 \times 1 \times 1$ "micro-cubes," all glued together. Weather damage causes the exposed (outermost) layer of micro-cubes to become loose. This outermost layer falls to the ground. How many micro-cubes are on the ground?

> **Story:** One candidate for a futures trading position in Chicago was asked: "Would you rather be beaten up, beat someone up, or run around the block naked?" The last response did not get him the job. My wife was horrified to hear this story. Welcome to Chicago!

Question 1.6: A mythical city contains 100,000 married couples but no children. Each family wishes to "continue the male line," but they do not wish to overpopulate. So, each family has one baby per annum until the arrival of the first boy. For example, if (at some future date) a family has five children, then it must be either that they are all girls, and another child is planned, or that there are four girls and one boy, and no more children are planned. Assume that children are equally likely to be born male or female.

Let $p(t)$ be the percentage of *children* that are male at the end of year t. How is this percentage expected to evolve through time?

Question 1.7: How many degrees (if any) are there in the angle between the hour and minute hands of a clock when the time is a quarter past three?

Question 1.8: What is the first time after 3PM when the hour and minute hands of a clock are exactly on top of each other?

Question 1.9: There are 100 light bulbs lined up in a row in a long room. Each bulb has its own switch and is currently switched off. The room has an entry door and an exit door. There are 100 stockbrokers lined up outside the entry door. Each bulb is numbered consecutively from 1 to 100. Each stockbroker is numbered consecutively from 1 to 100.

Broker number 1 enters the room, switches on *every* bulb, and exits. Broker number 2 enters and flips the switch on every *second* bulb (turning off bulbs 2, 4, 6, ...). Broker number 3 enters and flips the switch on every *third* bulb

(changing the state on bulbs 3, 6, 9, ...). This continues until all 100 brokers have passed through the room.

What is the final state of bulb number 64? Is it illuminated or dark?

Question 1.10: Exactly the same set-up as Question 1.9, with a different final question: How many of the light bulbs are illuminated after the 100th person has passed through the room, and which light bulbs are they?

Question 1.11: Your bedroom sock drawer contains eight red socks and 11 blue socks that are otherwise identical. The light is broken in your bedroom, and you must select your socks in the dark. What is the minimum number of socks you need to take out of your drawer and carry into your (well-lit) living room to guarantee that you have with you at least a matching pair to choose from?

> **Story:** One of my students was asked to "Describe the best boss you have ever had." Watch out for the opposite question: "Describe the worst boss you have ever had." Your answer may indicate disloyalty to a (former) employer.

Question 1.12: You and I are to play a competitive game. We shall take it in turns to call out integers. The first person to call out "50" wins. The rules are as follows:

1. The player who starts must call out an integer between one and 10, inclusive;
2. A new number called out must exceed the most recent number called by at least one and by no more than 10. For example, if the first player calls out "nine," then the range of valid numbers for the opponent is 10 to 19, inclusive.

Do you want to go first, and if so, what is your strategy?

Question 1.13: You are to open a safe without knowing the combination. Beginning with the dial set at zero, the dial must be turned counter-clockwise to the first combination number, (then clockwise back to zero), and clockwise to the second combination number, (then counter-clockwise back to zero), and counter-clockwise again to the third and final combination number, whereupon the door shall immediately spring open. There are 40 numbers on the dial, including the zero.

Without knowing the combination numbers, what is the maximum number of trials required to open the safe (one trial equals one attempt to dial a full three-number combination)?

Question 1.14: **(**)** You are given a set of scales and 90 coins (this question is similar to Question 1.3). The scales are of the old balance variety. That is, a small dish hangs from each end of a rod that is balanced in the middle. The device enables you to conclude either that the contents of the dishes weigh

the same or that the dish that falls lower has heavier contents than the other. You must pay $100 every time you use the scales.

The 90 coins appear to be identical. In fact, 89 of them are identical, and one is of a different weight. Your task is to identify the unusual coin and to discard it while minimizing the maximum possible cost of weighing.[3] What is your algorithm to complete this task? What is the most it can cost to identify the unusual coin (assuming your strategy minimizes the maximum possible cost)?

Note that the unusual coin may be heavier than the others, or it may be lighter. You are asked to both identify it and determine whether it is heavy or light.[4]

Question 1.15: (***) Suppose that the function $f(z)$ is complex valued in the complex plane. Suppose also that $f(z)$ is both bounded and entire. Prove that $f(z)$ must be a constant.[5]

Question 1.16: I have dropped 10,000 ants randomly onto a ruler that is one meter (i.e., 100 centimeters) long. The ants are of negligible size and mass. Each ant walks at a steady pace of one centimeter per second in a straight line in some random direction. The ants are all from the same colony and possess an inherited vision problem: they have peripheral vision only. This means that they can collide with each other if they meet head on (if they meet, but not head on, then one ant will just crawl over the other and neither will pause their steady pace). If two ants do collide head on, however, then they each turn around instantly and head back the way they came at their steady pace. With so many ants in one small space, a single ant may experience multiple collisions before it walks off of the ruler. So, how long must you wait to be sure that all the ants have walked off of the ruler?

Question 1.17: You start with a single lily pad sitting on an otherwise empty pond. You are told that the surface area of the lily pad doubles every day and that it will take 30 days for the single lily pad to cover the surface of the pond.[6]

If instead of one lily pad you start with eight lily pads (each identical in characteristics to the original single lily pad), how many days will it take for the surface of the pond to become covered?

[3] A slightly different task is to minimize the expected cost of weighing. Minimizing the expected cost of weighing does not necessarily minimize the maximum possible cost. This is a subtle distinction that you should not overlook.

[4] Does the answer change if you must identify the coin without saying whether it is heavy or light?

[5] Recall that an "entire" function is a function that is analytic in the entire finite complex plane. Thus, $f(z)$ may be represented by an everywhere-convergent power series: $f(z) = \sum_{n=0}^{\infty} a_n z^n$ (Holland [1973, p5]).

[6] The student who was asked this question says that his interviewer used the number 30. However, he suggested that I use the number 3,000 to make it more complicated. What is wrong with saying that it takes 3,000 days for the lily pad to cover the pond?

Question 1.18: Another lily pad problem. There are 27 lily pads on a pond. Each of the lily pads is one square foot in area. The pond is 6,000 square feet in area. Each lily pad doubles its size every day. How long until the pond is covered in lily pads?

> **Story:** A student of mine was taken to a room and asked to choose a place to sit at a long oval-shaped table. He chose a place at random. Later the interviewer asked why he had chosen that spot. I think the intent was to see if he was a leader (sitting at the head) or a follower (sitting at the side).

Question 1.19: Interviewer: "Alright, you're from MIT; you must be a quantitative type of person." Interviewee: (confidently, after a slight pause) "Yes indeed." Interviewer: "Give me the decimal equivalent of $\frac{13}{16}$ and of $\frac{9}{16}$."

Question 1.20: A snail is climbing up a 10-foot pole. It climbs up by three feet every day. Each night it sleeps. While sleeping, it slides down by one foot. When does it reach the top of the pole?

Question 1.21: (*) A windowless room contains three identical light fixtures, each containing an identical light bulb. Each light fixture is connected to one of three switches outside of the room. Each bulb is switched off at present. You are outside the room, and the door is closed. You may flip any of the external switches in any manner you choose. After this, you must take your hands off the switches and then you may go into the room and do as you please (but you will not be allowed to damage anything or touch the switches again). How can you tell which switch goes to which light?

Question 1.22: Inside of a dark closet are five hats: three blue and two red. Three smart men go into the closet, and each selects a hat in the dark and places it unseen upon his head. Each man knows both that the closet contains three blue hats and two red and that the other two men have the same knowledge.

Once outside the closet, no man can see his own hat. The first man looks at the other two, thinks, and says, "I cannot tell what color my hat is." The second man hears this, looks at the other two, and says, "I cannot tell what color my hat is either." The third man is blind. The blind man says, "Well, I know what color my hat is." What color is his hat, and how does he know?

Question 1.23: (**) Find the smallest positive integer that leaves a remainder of 1 when divided by 2, a remainder of 2 when divided by 3, a remainder of 3 when divided by 4, ... and a remainder of 9 when divided by 10.

> **Story:** 1. During the interview, an alarm clock went off from the candidate's briefcase. He took it out, shut it off, apologized, and said he had to leave for another interview. 2. An applicant came in wearing only one shoe. She explained that the other shoe was stolen off her foot in the bus.
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Question 1.24: There are two motorcyclists on a single lane road. They are 25 miles apart. At a signal, they start moving toward each other with constant speeds. The first motorcyclist rides at 20 mph; the second rides at 30 mph. When the signal goes off, a fly on the helmet of the first motorcyclist is startled and starts flying toward the second motorcyclist at 40 mph. When the fly reaches the second motorcyclist (now moving toward the first), he immediately reverses course and flies back to the first motorcyclist. When the fly gets back to the first motorcyclist, he reverses course again. The fly continues to fly backwards and forwards between the two motorcyclists until they all collide. How many miles will the fly have traveled before his life is extinguished?

Question 1.25: A, B, C, D, E, F, G, H, and I, are the nine integers from one to nine (not necessarily in order). They satisfy the following constraints:

$$\begin{aligned} A+B+C+D &= 20, \\ B+C+D+E+F &= 20, \\ D+E+F+G+H &= 20, \quad \text{and} \\ F+G+H+I &= 20 \end{aligned}$$

What values are taken by each of A to I?

> **Story:** Instead of being asked her greatest weakness, one of my students was asked: "Why shouldn't we hire you?" It is pretty difficult to maneuver your way out of that one!

Question 1.26: Prove that the area of a triangle is given by

$$A = \sqrt{s(s-a)(s-b)(s-c)},$$

where a, b, and c are the side lengths, and $s \equiv \frac{a+b+c}{2}$ is half the perimeter.[7]

Question 1.27: A very large number, N, of people arrive at a convention. There are exactly N single rooms in the hotel where the convention takes place. Each guest is given a numbered key for a specific room. Before they even go upstairs, they are all invited to a large party in the banquet hall. To gain admittance to the hall, they have to give up their keys to a doorman. At the end of the evening, the guests are not sober enough to recall their room numbers, so the doorman simply hands out the keys randomly. Each guest ends up spending the night in a random room. What is the probability that at least one guest ends up in the room to which he or she was originally assigned?

[7] Mark Rubinstein kindly pointed out to me that this is "Heron's Formula."

Question 1.28: A small boat is floating in a swimming pool. The boat contains a very small but very heavy rock. If the rock is tossed out of the boat into the pool, what happens to the water level in the pool?

Question 1.29: (**) In a certain matriarchal town, the women all believe in an old prophecy that says there will come a time when a stranger will visit the town and announce whether any of the men folk are cheating on their wives. The stranger will simply say "yes" or "no," without announcing the number of men implicated or their identities. If the stranger arrives and makes his announcement, the women know that they must follow a particular rule: If on any day following the stranger's announcement a women deduces that her husband is not faithful to her, she must kick him out into the street at 10AM the next day. This action is immediately observable by every resident in the town. It is well known that each wife is already observant enough to know whether any man (except her own husband) is cheating on his wife. However, no woman can reveal that information to any other. A cheating husband is also assumed to remain silent about his infidelity.

The time comes, and a stranger arrives. He announces that there are cheating men in the town. On the morning of the tenth day following the stranger's arrival, some unfaithful men are kicked out into the street for the first time. How many of them are there?

Question 1.30: In front of you are three poles. One pole is stacked with 64 rings ranging in weight from one ounce (at the top) to 64 ounces (at the bottom). Your task is to move all the rings to one of the other two poles so that they end up in the same order. The rules are that you can move only one ring at a time, you can move a ring only from one pole to another, and you cannot even temporarily place a ring on top of a lighter ring.

What is the minimum number of moves you need to make to achieve the task?

> **Story:** Here are some common thinking questions from section 5.5: "How many McDonald's fast food outlets are there in the US? How many gas stations are there in the US? How many elevators are there in the US?"

Question 1.31: Solve the following ordinary differential equation (ODE):

$$u'' + u' + u = 1$$

> **Story:** One of my students went to an interview with a big-name Wall Street firm in New York. He was interviewed by five quantitative guys in a row. Each interview was one hour, and there were absolutely no breaks. He had to work through multiple quantitative problems on their blackboard. They gave him no lunch. He was exhausted and starving by the end. He was swearing black and blue about the "&@!#@$%'s" when he got back. He said "The Russian" was the worst.

Question 1.32: Assume that the random variables X and Y are Normally distributed: $X \sim \mathcal{N}(\mu_X, \sigma_X^2)$, and $Y \sim \mathcal{N}(\mu_Y, \sigma_Y^2)$. The correlation between X and Y is ρ. How can you choose constants a and b such that you minimize the variance of the random variable sum $S = aX + bY$ under the constraints that $a + b = 1$, $0 \leq a \leq 1$, and $0 \leq b \leq 1$?[8]

Question 1.33: Suppose there is a straight coastline and a lighthouse that is $L = 3$ miles away from the coast. The light revolves at one revolution per minute. How fast is the beam of light traveling along the coastline? When the beam is $3L$ away from the coastal point closest to the light, how fast is the light traveling along the coast?

Question 1.34: I have a 20×20 chessboard and a very large box of identical cubes. Each square on the chessboard is the same size as the face of any cube. I am going to arrange piles of cubes on the chessboard in a special pattern. I align one edge of the board so it is running north–south. I start at the northwest corner by placing one cube on that square. Whenever I step to the south or the east, I place a pile of cubes containing one more cube than in the previous square. This produces the pattern in figure 1.1. How many cubes in total are there on the chessboard?

1	2	3	4	$\cdots$	19	20
2	3	4	5	$\cdots$	20	21
3	4	5	6	$\cdots$	21	22
4	5	6	7	$\cdots$	22	23
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$
19	20	21	22	$\cdots$	37	38
20	21	22	23	$\cdots$	38	39

Figure 1.1: Number of Cubes on Each Square of a 20×20 Chessboard (Q)

[8] Another version of this question asked in interviews is: "You are driving around with one wheel on the gravel and one wheel on the pavement. The variance of the gravel and pavement surfaces are described by σ_G^2 and σ_P^2. Whereabouts on the axle should you sit between $x = 0$ (right over the wheel on the gravel) and $x = 1$ (right over the wheel on the pavement) if you want the most comfortable ride?"

Question 1.35: You are standing at the centre of a circular field of radius R. The field has a low wire fence around it. Attached to the wire fence (and restricted to running around the perimeter) is a large, sharp-fanged, hungry dog who likes to eat any humans he can catch. You can run at speed v. Unfortunately, the dog can run four times as fast, at $4v$. The dog will do his best to catch you if you try to escape the field. What is your running strategy to escape the field without feeding yourself to the dog?

Question 1.36: Please prove that the following relationship holds:

$$\int_{-\infty}^{+\infty} e^{-x^2} dx = \sqrt{\pi}$$

Question 1.37: What is $\int \sec\theta d\theta$ equal to?[9]

Question 1.38: Does the infinite sum $\sum_{n=1}^{\infty} e^{-\sqrt{n}}$ converge?

> **Story:** One interviewee told me that the interviewers aim to put you under as much pressure as possible, and that "you never know when they are going to bring out the guy in the chicken suit."

Question 1.39: We are to play a game on a table in the next room. We each have an infinite bag of identical quarters (i.e., American 25-cent pieces). We will take it in turns to put one quarter on the table. Quarters may not overlap on the table. When there is no room left on the table to put another quarter, the winner is the last person to put a quarter on the table. Let me tell you that there does exist a strategy for winning and that this strategy is independent of the size of the table.

1. What is the shape of the table?
2. Do you start?
3. What is your strategy for winning?
4. Is there any case where this does not work?

Question 1.40: One analyst (John) is talking to another (Mary) while working on a deal book at 2AM. Mary learns that John's sister has three children. "How old are the children?" asks Mary. "Well," replies John, "the product of their ages is 36." Mary thinks for a while and says, "I need more information." "Hmmm, the sum of their ages is the same as this figure right here," says John pointing at the spreadsheet. "Still not enough information," says Mary after thinking for a minute. "The eldest is dyslexic," says John. How old are the children?

[9] Similarly, you could see questions on integrals (or derivatives) of $\sin\theta$, $\cos\theta$, $\tan\theta$, $\cot\theta$, and $\operatorname{cosec}\theta$.

Question 1.41: What are $\sum_{k=1}^{n} k^2$, and $\sum_{k=1}^{n} k^3$?

Question 1.42: You are given eight balls. They appear identical, but one is heavier than the rest. As in the previous ball questions, you have a pair of scales. How do you find the heavy ball?

Question 1.43: **(***)** You have 52 playing cards (26 red, 26 black). You draw cards one by one. A red card pays you a dollar. A black one fines you a dollar. You can stop any time you want. Cards are not returned to the deck after being drawn. What is the optimal stopping rule in terms of maximizing expected payoff? Also, what is the expected payoff following this optimal rule?[10]

Question 1.44: You have a chessboard (8×8) plus a big box of dominoes (each 2×1). I use a marker pen to put an "X" in the squares at coordinates (1,1) and (8,8)—a pair of diagonally opposing corners. Is it possible to cover the remaining 62 squares using the dominoes without any of them sticking out over the edge of the board and without any of them overlapping? You must not damage the board or the dominoes in the process or do anything weird like standing them on their ends—just answer the question.[11]

Question 1.45: One of my students interviewed with some folks who "wanted to get an idea of his comfort with formulae and with explaining things to clients." They asked why it is that if p is a prime number greater than 3, then $p^2 - 1$ is always divisible by 24 with no remainder.

Question 1.46: You are bidding B for a firm whose unknown true value is uniformly distributed between 0 and 1. Although you do not know the true value S of the firm, you do know that as soon as people learn that you have made a bid this news will cause the value to double to $2S$. Your bid, however, will be accepted only if it is at least as large as the original value of the firm. How do you bid so as to maximize your expected payoff?

Question 1.47: You have a string-like fuse that burns in exactly one minute. The fuse is inhomogeneous, and it may burn slowly at first, then quickly, then slowly, and so on. You have a match, and no watch. How do you measure exactly 30 seconds?

Question 1.48: You have two string-like fuses. Each burns in exactly one minute. The fuses are inhomogeneous, and may burn slowly at first, then quickly, then slowly, and so on. You have a match, and no watch. How do you measure exactly 45 seconds?

Question 1.49: How many places are there on the Earth where you can walk one mile south, one mile east, one mile north, and end up exactly where you started? Assume the Earth is a perfect sphere, that your compass bearing is constant on each leg of the walk, that all parts of the Earth are able to be walked upon, and that your feet are arbitrarily small.

Question 1.50: How many consecutive zeroes are there at the end of 100! (100 factorial). For example, 12!=479,001,600 has two consecutive zeroes at the end.

Question 1.51: This is an absolute classic. A king demands a tax of 1,000 gold sovereigns from each of 10 regions of his nation. The tax collectors for each region bring him the requested bag of gold coins at year end. An informant tells the king that one tax collector is cheating and giving coins that are consistently 10% lighter than they should be, but he does not know which collector is cheating. The king knows that each coin should weigh exactly one ounce. How can the king identify the cheat by using a weighing device exactly once?

Question 1.52: Again, an absolute classic. You hire a man to work in your yard for seven days. You wish to pay him in gold. You have one gold bar with seven parts—like a chocolate bar. You wish to pay him one gold part per day, but you may snap the bar in only two places. Where do you snap the bar so that you may pay him at the end of each day, and so that on successive days he may use what you paid him previously to make change?

Question 1.53: Why are images in a mirror flipped horizontally and not vertically? For example, although I wear my wristwatch on my left wrist, and my reflection wears his on his right wrist, my reflection is not standing on his head.

Question 1.54: **(**)** I am told this is a genuine finance interview question. It had to be a trading interview, because no one but a trader would ask this in an interview. I considered transforming the question, but left it as is for authenticity. Avert your eyes if you are easily offended!

How can three men and one women have mutually safe heterosexual intercourse with just two condoms? Assume that no condom can break or leak, and that you cannot wash a used one.[12]

Question 1.55: Consider a grid. You start at coordinate $(0, 0)$ and move one step at a time, eventually arriving at coordinate $(5, 5)$. With each step you may move only one step east or one step north but never diagonally. How many paths are there from $(0, 0)$ to $(5, 5)$?

Question 1.56: Six friends go out to lunch. The bill is \$132.67. They decide to add a 20% tip and split the total six ways evenly. What does each person pay?

[10] Try the same question with four cards (two red, two black).

[11] Naoki Sato has suggested a follow up question. Place an "X" on two squares: one black, and one white. Can you cover the remaining squares with dominoes? See Answer 1.44 for the solution.

[12] With one man and three women, the answer is of similar type, but different. This question also appears in Derman (2004, p104), which is probably how it drifted to Wall Street.

Question 1.57: You walk into a pizza shop. They sell three sizes of pizza: small, medium, and large. All are perfectly circular, have the same thickness, and have the same density of toppings. The price of a large pizza is equal to the price of a medium pizza plus the price of a small pizza: $P_L = P_M + P_S$. You see a group of your friends already sitting in the pizza store and they have just had one of each size pizza delivered to their table plus they have been given one empty box to take any leftovers home in. Each of their pizzas has been pre-cut into (perfect) sixths. Their box is a (perfect) square. You are looking at your friends' uneaten pizzas and are trying to choose between ordering one large pizza for yourself or ordering one medium plus one small for yourself. The cost is the same, but how can you determine which choice gives better value?[13]

Question 1.58: Find all of the roots to the equation $x^6 = 64$ (including the complex roots).

Question 1.59: A rock is dropped from the top of the Empire State Building. At what speed does it hit the ground, and how long does it take to get there?

Question 1.60: Please express the integral $f(x) = \int_{t=x}^{\infty} e^{-a\frac{t^2}{2}+bt} dt$ in terms of $N(x)$ (i.e., the cumulative Standard Normal).

Question 1.61: What is $\lim_{x\to\infty} \left(\sqrt{x^2+x} - x\right)$?

Question 1.62: How do you differentiate x^x with respect to x?

Question 1.63: Finally, can the mean of any two consecutive prime numbers ever be prime?

> **Story:** She threw up on my desk and immediately started asking questions about the job, like nothing had happened.
>
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[13] In the original question the pizza was not cut, there was no box, but you had a knife. I retained the spirit of the question but modified it because it was not, strictly speaking, able to be solved.

Chapter 2

Derivatives Questions

A prerequisite for answering the questions in this chapter is knowledge of basic option pricing theory. I strongly recommend my book *Basic Black-Scholes: Option Pricing and Trading* (Crack [2009]) as the best resource. It provides a firm foundation in Black-Scholes option pricing, with practical advice about option trading. See the advertisement on the last page of this book, or go directly to `www.BasicBlackScholes.com`. Solutions for this chapter appear in Appendix B.

Question 2.1: All Black-Scholes assumptions hold. Assume no dividends. The stock price is \$100. The riskless interest rate is 5% per annum. Consider a one-year European call option struck at-the-money (i.e., strike equals current spot). If the volatility is zero (i.e., $\sigma = 0$), what is the call worth? After valuing the call, please tell me how to hedge the call (assuming you sold it).

Question 2.2: Two standard options have exactly the same features, except that one has long maturity, and the other has short maturity. Which one has the higher gamma?

Question 2.3: All Black-Scholes assumptions hold. Assume no dividends. Consider a standard European call and a standard European put on the same stock. Assume that each option has the same maturity, and is struck at-the-money (i.e., strike equals current spot). For the sake of simplicity, assume that the interest rate is zero. Draw the payoff diagrams for each option (i.e., terminal payoff to option versus level of underlying).

The put has limited downside potential and no upside; the call has unlimited upside and no downside. Given the random direction of the stock price movements between now and expiration, the disparity in potential payoffs seems to suggest that the call should be worth more than the put. However, put-call parity says that this is not so. Verify the put-call parity implications and reconcile them with the seemingly disparate potential payoffs.

Question 2.4: For a standard European call option, draw the graph of the "delta" as a function of current stock price, $S(t)$.

Question 2.5: Assume a Black-Scholes world without dividends. Consider a standard European call struck at-the-money (i.e., strike equals current spot) with one year to maturity. If the interest rate is $r = 0.06$, is the option's delta greater or less than 0.5? What does it depend on?

Question 2.6: Assume a Black-Scholes world with continuous dividends. Consider a standard European call struck at-the-money (i.e., strike equals current spot) with one year to maturity. If the interest rate is $r = 0.06$, and dividends are at rate $\rho = 0.03$, can you tell whether the option's delta is greater or less than 0.5? What does it depend on?

Question 2.7: You are long a call option on MITCO stock. You have delta hedged your position. You hear on the radio that the CEO of MITCO has just been arrested for running a massive Ponzi scheme. The stock price plunges \$10. How do you adjust your hedge (qualitatively)? That is, do you borrow and buy stock or sell stock and lend? Explain carefully.

> **Story:** Some recent questions include "What do you think an investment banker does?" Not only that, but "Do you understand the hours investment bankers work and why?" Some of these folks look like Hell when you meet them. Are you sure about this career choice?

Question 2.8: How do you calculate an option's delta?[1]

Question 2.9: Explain very carefully the terms $N(d_1)$ and $N(d_2)$ that appear in the standard Black-Scholes European call option pricing formula without dividends.[2]

Question 2.10: Consider the European digital option (or "binary option") that pays a constant H if the stock price is above strike price X at expiration and zero otherwise. What is the price of this option, and how is it related to the price of the standard Black-Scholes European call option? Explain carefully.[3]

Question 2.11: Consider the European digital option (or "binary option") that pays H if the stock price is above strike price X at expiration and zero otherwise. How does the price of this option vary with volatility (that is, what is $\frac{\partial C}{\partial \sigma^2}$)? Intuitively? Rigorously? Explain carefully.

[1] Answer for a standard European call option (with and without dividends), and for an option with no closed-form solution (e.g., a plain vanilla American-style put or an exotic).

[2] Now use this explanation to deduce the standard Black-Scholes European put option pricing formula—if you can. Confirm that the pricing formulae verify the put-call parity relationship (with $D = 0$):$S(t) + p(t) = c(t) + Xe^{-r(T-t)} + D$.

[3] This is the "cash-or-nothing" digital option. You should also be able to answer this question for the "asset-or-nothing" digital option (which gives you the asset if $S(T) > X$ and nothing otherwise).

Question 2.12: Compare the "delta" of a standard European call option and the delta of a barrier option, for example a "down-and-out" call option.[4]

Question 2.13: (**) This is an applied theoretical option pricing problem taken from a telephone interview. You are given three time series of continuously compounded returns on an industry sector index: the ISI50. The time series are daily, weekly, and monthly over the same time period.[5] You are to price a standard European call option written on the level of the ISI50 with one month to expiration.

You decide to use the trusty Black-Scholes model. You observe all input variables except for the volatility term σ^2. Unsure of which of your three time series to use to estimate the volatility term, you calculate the sample volatility of each time series. You figure that the estimators $(\hat{\sigma}_d^2, \hat{\sigma}_w^2, \hat{\sigma}_m^2)$ should be related as $\hat{\sigma}_m^2 \approx 4\hat{\sigma}_w^2$, $\hat{\sigma}_m^2 \approx 20\hat{\sigma}_d^2$, and $\hat{\sigma}_w^2 \approx 5\hat{\sigma}_d^2$. You could thus get the monthly volatility either explicitly from the monthly estimate or implicitly from the weekly or daily estimates. You think the daily data are most reliable (they have the most observations).

You find, much to your horror, that $\hat{\sigma}_m^2 > 4\hat{\sigma}_w^2$, $\hat{\sigma}_m^2 > 20\hat{\sigma}_d^2$, and $\hat{\sigma}_w^2 > 5\hat{\sigma}_d^2$. Further investigation reveals that these differences are highly statistically significant. Your statistical observation is thus that the monthly volatility implicit in the daily and weekly time series is significantly smaller than the monthly volatility in the monthly time series.

How do you price the option? Explain your reasoning carefully.[6]

Question 2.14: Consider a plain vanilla American call option on a non-dividend-paying stock. The price of the call is $C(t)$ at time t. The "intrinsic value" of the call is $\max[S(t) - X, 0]$ (where $S(t)$ is stock price at time t, and X is exercise price). The excess of call value over intrinsic value is the "time value" of the option.[7]

Draw a graph of the time value, $C(t) - \max[S(t) - X, 0]$, versus $S(t)$. Explain carefully the different aspects of the plot.

Question 2.15: It is 10 months since you sold a one-year European call option to a customer. You have been delta-hedging your exposure to the written call

[4] Is the answer different for an up-and-out call? Explain carefully. Incidentally, who would buy an up-and-out call? Well, suppose you expect only limited upside on a security. If you wish to participate in this upside without paying for what you consider to be very unlikely further price appreciation, then an up-and-out-call could be just what you want (see Derman and Kani [1993, pp3–4]).

[5] Feel free to assume that one week is exactly five days, one month is exactly 20 days, and that there are no missing observations or exchange holidays.

[6] Hint: Begin by explaining how and why your statistical observations could arise. What went wrong? Ask yourself whether Black-Scholes pricing is still applicable. If not, where do you turn?

[7] Perhaps a more natural definition of intrinsic value is $\max[S(t) - Xe^{-r(T-t)}, 0]$ (Merton [1973, p145]; Merton [1992, p260]; Smith [1976, p11]). What would the plot of time value versus $S(t)$ look like with this definition of intrinsic value?

since it was sold. The option is now well in-the-money, and the delta of your replicating portfolio is correspondingly high (at around 0.90, say).

Suppose that you watch the underlying stock price falling gently over the last two months of the life of the option. As the stock price falls over this time period, what happens to the delta of the replicating portfolio? That is, are you buying stocks or selling stocks as you watch the stock price fall? You may have to describe different possible scenarios—be clear on the assumptions you make.

> **Story:** A student of mine was asked "How would you value yourself?" That is, put a dollar figure on your value using discounted cash flow analysis.

Question 2.16: What do you know about jump processes and jump diffusion processes? Explain when the pricing formula for a call option written on an asset whose price level follows a jump process can and cannot be derived using the Black-Scholes/Merton no-arbitrage technique.[8]

Question 2.17: This question concerns the standard European call option on a non-dividend-paying stock. You are asked to draw three closely related graphs as follows:

1. Please draw the graph of call price at maturity (time T) versus terminal stock price, $S(T)$.
2. Please draw the graph of call price at time t versus the futures price $F(t,T)$. The futures price $F(t,T)$ is observed at time t, prior to maturity. The futures contract and the option both mature at the same date T.[9]
3. Now draw the graph of call price versus stock price at time t, prior to maturity.

Explain carefully the relationships between the three graphs.

Question 2.18: Consider two European call options on the same underlying stock. The options have the same strike price. Assume constant interest rates. One option matures in one year; the other option matures in four years. Suppose that you put $\sigma = 15\%$ into the Black-Scholes formula to value the one-year option. What value of σ do you put into the Black-Scholes formula to value the four-year option? Assume that you set $T-t = 1$ in the Black-Scholes formula in both cases (i.e., one unit of time equals four years in the second case but only one year in the first case).

[8] Describe the form of the pricing formula for a European call option written on a stock whose price level follows a jump diffusion process (using Merton's notation): $\frac{dS}{S} = (\alpha - \lambda k)dt + \sigma dZ + dq$, where $dq = 0$ if the "Poisson event" (i.e., the jump) does not occur, $dq = (Y-1)$ if the jump does occur, $(Y-1)$ is a spike producing a finite jump in stock price from S to SY, α is the instantaneous expected rate of return on the stock, σ^2 is the instantaneous variance or returns assuming no jump occurs, dZ is a standard Wiener process, λ is the number of arrivals that you expect per unit time, $k \equiv E(Y-1)$ where E is the expectation operator over the random variable Y, and dZ is assumed independent of the Poisson process dq (see Merton [1992, p313]).

[9] Futures on single stocks have been traded in the US since 2002. See `www.OneChicago.com` for details.

Question 2.19: (***) The Black-Scholes formula is derived assuming the stock price process $S(t)$ follows a geometric Brownian motion: $dS(t) = \mu S(t)dt + \sigma S(t)dw(t)$, where $w(t)$ is a standard Brownian motion. Suppose instead that a stock price process $\mathcal{S}(t)$ follows an arithmetic Brownian motion: $d\mathcal{S}(t) = \mu dt + \sigma_A dw(t)$. Derive the pricing formula for a call option on $\mathcal{S}(t)$. Please assume that the option is at-the-money [i.e., $\mathcal{S}(t) = \mathcal{X}$], that the riskless interest rate $r = 0$, and that the stock pays no dividends.

> **Story:** "One cocky job candidate interviewed with several male managers at a major bank before being ushered into an interview with a female manager. He sat across from her, put his feet on her desk and said, 'Get me a Coke.' "
>
> MICHAEL ZWELL
> Michael Zwell & Associates, Chicago
>
> "Doomed Days: The Worst Mistakes Recruiters Have Ever Seen,"
> *The Wall Street Journal*, February 25, 1995, pR4.
> Reprinted by permission of *The Wall Street Journal*
>

Question 2.20: Interviewer: "You are fully familiar with Black-Scholes pricing aren't you?" Interviewee: (confidently, after a slight pause) "Yes indeed." Interviewer: "What is the value of a three-month at-the-money (i.e., $S = X$) call option on a \$100 stock when the implied vol is 40? Please assume $r = 0$ (it is the least important ingredient anyway) and assume also that the stock pays no dividends. You have 10 seconds to perform the calculation in your head. Now tell me how your answer changes if it is instead a put."

Question 2.21: A customer calls up and wants a price on a European 100-day call option. You quote \$100. He calls back a minute later and wants a quote on the same option but with 200 days to maturity. How does the second price quote compare to the first price quote? Explain carefully.

Question 2.22: Assume a Black-Scholes world. You have a one-year European call option on a stock. There are no dividends, the interest rate is assumed to be zero, and the option is struck at-the-money (i.e., strike equals current spot). The current spot is \$100. The standard deviation of terminal stock price (conditional on current stock price) is \$10.[10] Is the call price closer to \$1, \$5, or \$10?[11]

[10] It follows that the standard deviation of continuously compounded returns is approximately 10% per annum.

[11] If the standard deviation is \$20 per annum, is the call price closer to \$5, \$10, or \$20?

Question 2.23: You hold a 100-day European call option on a stock with implied volatility 20. Suppose that you know right now that tomorrow the implied volatility will increase to 25, but that after that it will return to 20 for the remainder of its life. What extension to the life of the call would produce the same change in the present value of the call as the above-mentioned single-day increase in volatility (assuming a constant implied volatility at 20)? That is, other things being equal, what change in the term to maturity is equivalent to the quoted one-day change in the implied volatility? Explain carefully.

Question 2.24: You are long a straddle with a strike of \$25. The underlying is at \$25. The straddle costs you \$5 to enter. What price movement are you looking for in the underlying?

Question 2.25: You are considering two contracts: a Eurodollar *futures* contract, with six months to maturity, selling at 5%, settled on three-month LIBOR, marked-to-market every day; and a Eurodollar *forward* contract, with six months to maturity, selling at 5%, settled on three-month LIBOR at maturity.

1. Which contract do you prefer (or are you indifferent)?
2. Do you think there is a mis-pricing?
3. If you go long one and short the other, which one should be long, and which one should be short (or are you indifferent)?

Question 2.26: You are to value a call option using Monte-Carlo simulation. Is it better to simulate the geometric Brownian motion (GBM) process for the call itself, or the GBM process for the underlying?

Question 2.27: Suppose that you hold a long position in mortgage-backed securities. If you are expecting a bond market rally, would you be better off with positive convexity or negative convexity?

> **Story:** There is the old story of the candidate who flew to London for an interview. At the interview, the interviewer excused himself for a few minutes. However, before leaving he asked the interviewee to open a window. Once alone, the interviewee discovered that all the windows were sealed shut. Great! Michael Lewis (in his excellent book Liar's Poker) talks about this technique in use on Wall Street (Lewis, 1990, p27). He suggests that one desperate interviewee threw a chair through Lehman's 43rd floor window in Manhattan!

Question 2.28: What is wrong with the following strategy for hedging a short call option: buy one share if the stock price exceeds the strike, and sell the share if the stock price falls below the strike?

Question 2.29: How fresh is your stochastic calculus? What can you tell me about $\int_0^T w(t)dt$, where $w(t)$ is a standard Brownian motion?

Question 2.30: What can you say about $\int_0^T w(t)dw(t)$, where $w(t)$ is a standard Brownian motion?

Question 2.31: (**) Suppose that IBM is trading at \$75 per share. What does it cost to construct a derivative security that pays exactly one dollar when IBM hits \$100 for the first time? Explain carefully the construction of the security. You may ignore IBM's dividends, assume a riskless interest rate of zero, assume all assets are infinitely divisible, ignore any short sale restrictions, and ignore any taxes or transactions costs.

> **Story:** "During his interview with me, a candidate bit his fingernails and proceeded to bleed onto his tie. When I asked him if he wanted a Band-Aid, he said that he chewed his nails all the time and that he'd be fine. He continued to chew away."
>
> AUDREY W. HELLINGER
> Chicago Office of Martin H. Bauman Associates, New York
>
> "Doomed Days: The Worst Mistakes Recruiters Have Ever Seen,"
> *The Wall Street Journal*, February 25, 1995, pR4.
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Question 2.32: (**) The payoff to a European-style "power call" is given by $\max(S^\alpha - X, 0)$. Derive the price of a European power call option using Black-Scholes pricing.[12,13]

> **Story:** "If we offer you a job right now, will you take it?" is often used by firms who will not make you an offer unless they know you will say yes.

Question 2.33: Why do you get a "smile" effect when you plot implied volatilities of options against their strike prices?

Question 2.34: Is the price of a double-barrier, knock-out option (i.e. one with both up-and-out and down-and-out barriers) just the price of an up-and-out plus the price of a down-and-out?

Question 2.35: Describe the analytical procedure for deriving (using calculus) the values of European digital asset-or-nothing and digital cash-or-nothing options.

[12] Try drawing the payoff diagrams for the cases $\alpha > 1$ and $\alpha < 1$. Add the current call value as a function of stock price to your diagrams.

[13] Jarrow and Turnbull (1996, p175) describe a "powered option" with payoff $[S(T) - X]^2$ if $S(T) \geq X$ and zero otherwise. I give the general result for the case $[S(T) - X]^\alpha$ in the solutions. Try to derive it before you peek at my solutions.

Question 2.36: Consider an American-style double-barrier "out-in" call option. There is an out barrier above the current stock price (an "up barrier") and an in barrier below the current stock price (a "down barrier"). This option has a payoff only if all three of the following events happen: first, the stock price path includes a fall in price below the down barrier (i.e., the option is "knocked in"); second, the stock price path does not include a rise in price above the up barrier (i.e., the option is not "knocked out"); and third, the option is exercised when the stock price is above the strike (i.e., the option is in-the-money at exercise). This option is both path-dependent and American-style. Is there an easy technique for valuing the option?

Question 2.37: Suppose gold prices follow a Gaussian process.[14] The current price of gold is \$400. The riskless interest rate is zero. The volatility of gold in dollar terms is σ = \$60 per annum. What is the value today of a digital cash-or-nothing option that pays \$1 million in six months if the price of gold is at or above \$430?

> **Story:** Here is a quirky thinking question from section 5.5: "How many ping-pong balls can you fit in a jumbo jet (e.g., Boeing 747)?"

Question 2.38: (**) What is the value of a perpetual (i.e., potentially infinitely lived) American put option?

Question 2.39: Let "L" denote the three-month US dollar LIBOR rate. Consider an interest rate swap arrangement where Party A pays L to Party B, and Party B pays $24\% - 2 \times L$ to Party A. Can you reverse engineer this deal and express it in simpler terms?

Question 2.40: If an option is at-the-money, about how many shares of stock should you hold to hedge the option?

Question 2.41: Compare the price of an option on a stock if the stock price follows mean reversion versus if the stock price does not.

Question 2.42: When can hedging an options position make you take on more risk?

Question 2.43: How do you hedge a written put on a stock if you can neither short any stock nor use options on any stock?

Question 2.44: Another pizza question! You order a pizza for six people. The diameter of the pizza is 12 inches. What would the diameter have to be to feed eight people? Yes, this is a derivatives question.

Question 2.45: When do you want to be short a put option on IBM stock?

[14] This is an arithmetic Brownian motion. The future price of gold is thus assumed to be Normally distributed (not Lognormally as per Black-Scholes).

Question 2.46: You own two pieces of land—a huge field in Arizona and a tiny piece of beach in Florida. The field in Arizona is idle; you have no plans to develop the land in any way. The tiny beach in Florida is very popular. In fact, it is so popular that you charge a small entrance fee for beachgoers.

The government has offered to buy the Arizona field for \$1 million. Your neighbor has offered to buy the Florida beach for \$1 million as well. Other things being equal, which piece of land has the higher forward price?

Question 2.47: You have 30 days of "representative" stock price data. How do you calculate historical volatility $\hat{\sigma}^2$ to use in Black-Scholes?

Question 2.48: Suppose a "top issuer" (i.e., highest-rated financial institution used as a reference in setting the swap curve) issues a corporate bond for itself valued at 100. The issuer then re-prices this bond using the swap curve. What price do they get (100, above 100, or below 100)? To clarify, they fix the coupon rate of the bond so that it is priced at par, and then they try pricing this same bond by discounting those previously set coupons using the swap curve. Is the answer par, above par, or below par?

Question 2.49: Suppose I don't know any mathematics. How do you explain to me why you use the riskless rate instead of the required return on the stock to derive the Black-Scholes formula?

Question 2.50: Are you better off using implied standard deviation or historical standard deviation to forecast volatility?

Question 2.51: According to Black-Scholes, which is more valuable: a European call option that is 10% out-of-the-money, or a European put option that is 10% out-of-the-money?

Question 2.52: Why are theta and gamma of opposite signs? Are they always of opposite signs?

Question 2.53: Suppose that the riskless rate is zero. Suppose that a stock is at \$100, and one year from now will be at either \$130, or \$70, with probabilities 0.80 and 0.20 respectively. There are no dividends. What is the value of a one-year European call with strike \$110?

Question 2.54: (**) Find a formula for the European-style "product call" with payoff $\max(S_1 \times S_2 - X, 0)$, where S_1 and S_2 are the prices of assets following geometric Brownian motions with correlated random increments. All other Black-Scholes assumptions apply.

Question 2.55: Are Asian options cheaper or more expensive than plain vanilla European-style options?

> **Story:** One of my students was asked to "Describe the best party you have ever been to." She said this big-name Wall Street investment bank was looking for "fun loving" people.

Question 2.56: When can a plain vanilla American-style call be treated as a European-style one? When can a plain vanilla American-style put be treated as a European-style one?

Question 2.57: How many nodes are there in a recombining binomial tree with N time steps? How many nodes are there in a non-recombining binomial tree with N time steps?

Question 2.58: You have inside information that a foreign stock will rise for sure. You can legally trade in the foreign market without being subject to any insider trading rules. You can trade the stock, a forward on the stock, futures on the stock, or options on the stock. Assume interest rates are zero, there are no transactions costs, the exchange rate will not move, and there are no restrictions on trading the derivatives. What trade should you put on if you can only go long these instruments?

Question 2.59: (**) A call option is priced at c today. What is the expected price tomorrow?

Question 2.60: (**) If in Question 2.59 you answered that the expected call price tomorrow is higher than today's call price, then how do you reconcile your answer with time decay? That is, how do you reconcile a positive expected return with negative theta?

> **Story:** A friend in the City of London was interviewing a candidate for a position on a credit derivatives quant team. On asking the candidate why he moved out of theoretical physics, he replied: "Why does a bank robber rob a bank?" After asking him several probabilistic dice questions, the candidate replied: "I can't be bothered with this shit." On asking him why he left his previous job, he replied: "Because they were a bunch of wankers"—which translates to "jerk-offs" for those readers in the United States. This is a true story!

Chapter 3

Other Financial Economics Questions

As a prerequisite to answering the questions in this chapter, it is expected that you have completed an introductory course in financial economics (or equivalent independent study). You also need a good deal of common sense. Solutions for this chapter appear in Appendix C.

Question 3.1: Consider the following game: a player tosses a fair coin until a head appears; if the head occurs on the k^{th} toss, the player gets a payoff of $\$2^k$, and the game ends.[1]

1. What is the fair value of the game? That is, what is the expected payoff to a player?
2. A very important customer is on the line and wants you to quote him a bid-ask spread for exactly one play of the game. "Hurry up, I haven't got all day!" You have 15 seconds.

Question 3.2: If the standard deviation of continuously compounded annual stock returns is 10%, what is the standard deviation of continuously compounded four-year stock returns?

Question 3.3: From the term-structure of interest rates, you see that the five-year spot rate is 10% per annum and the 10-year spot rate is 15% per annum. What is the implied forward rate from year 5 to year 10?

Question 3.4: Explain carefully the difference between the "yield" on a bond and the "rate of return" on a bond.

Question 3.5: What is "chaos theory"? Can you use it to predict stock returns? If so, how?

[1] This game is over 250 years old and is known as the "St. Petersburg Game." It is quoted by Daniel Bernoulli ([Latin version 1738]; [English translation 1954]).

> **Story:** One of my students who got a job at a large mutual fund company described his firm's working environment as follows: "Dig a hole, fill the hole with water, fill the water with sharks, and promote anything that crawls out alive."

Question 3.6: Draw the graph of bond price versus yield-to-maturity. Why is the curve convex?[2]

Question 3.7: The Capital Asset Pricing Model (CAPM) says that the plot of $E(r)$ versus β is an upward sloping line through $(0,\ r_f)$ and $[1,\ E(r_M)]$ (i.e., the Security Market Line [SML]). Suppose, however, that when you plot average returns against estimated betas you find something else. Which of the following two scenarios is most likely?

1. An upward sloping curve beginning at $(0,\ r_f)$, wholly above the theoretical SML, initially more steep than the SML, but eventually roughly parallel to the SML
2. An upward sloping curve beginning at $(0,\ r_f)$, wholly below the theoretical SML, initially less steep than the SML, but eventually roughly parallel to the SML

Which CAPM assumptions (if any) are violated by the above two scenarios?

Question 3.8: From the term-structure of interest rates, you see that the two-year spot rate is 7.60% per annum, and the one-year spot rate is 7.15% per annum.

What is the implied forward rate for the second year?

Question 3.9: Consider a six-month forward contract on a 10-year riskless discount (zero-coupon) bond.

1. Is the bond selling at a forward premium or a forward discount?
2. Does your answer change if the bond is a riskless *coupon* bond (assume the coupon rate exceeds the current risk-free rate)?

Question 3.10: You believe that the yield curve is going to steepen very soon. It may be a fall in short-term rates, a rise in long-term rates, or some combination of these. What strategy should you pursue in the bond market to position yourself to profit from your beliefs?

> **Story:** Many people are asked: "Are you married? Do you have children? What does your spouse do? How is your family? Where were you born? How old are you?" These are all illegal interview questions in the US. Although illegal, you should be prepared to answer these questions.

[2] Can you give economic intuition for this convexity? What about mathematical intuition?

Question 3.11: Define "duration" and "convexity." Describe their properties and uses.

Question 3.12: Describe briefly the GARCH(1,1) model in qualitative terms. Now write down the formal GARCH(1,1) model and explain each term carefully.[3]

Question 3.13: You have a long position in a \$100 million 30-year bond. What can you do to limit your exposure to only \$50 million?

Question 3.14: (**) You hold an 8% coupon, 30-year, \$1,000 par, Mexican Brady bond. Interest rates in Mexico do not change. Interest rates in the US increase by 1%. What is the change in the price of your bond? Make any necessary assumptions.

Question 3.15: You construct a yield curve for (coupon-bearing) treasuries. A particular five-year corporate zero-coupon bond has a default risk premium of 1% over the level of your treasuries yield curve at the five-year mark. You believe that the yield curve is going to flatten in such a way that the default risk premium of the five-year corporate zero remains constant (short-term rates rise, long-term rates fall, and the yield on the five-year coupon-bearing treasury and five-year corporate zero remain unchanged).

What strategy should you pursue using the five-year zero-coupon corporate bond and treasuries to position yourself to profit from your beliefs?

Question 3.16: The five-year interest rate is 10%, and the 10-year interest rate is 15%. You conclude that the forward rate from year 5 to year 10 is approximately 20%. Explain, *using plain English*, why the forward rate has to be *higher* than the 20% approximate value mentioned above.

Question 3.17: Here is a simple game. You get to toss a fair coin now. If it is heads, you get seven dollars 18 months from now. If it is tails, you lose two dollars immediately. The one-year interest rate is 12% per annum. The two-year interest rate is 18% per annum.

How much are you prepared to pay to play this game?

Question 3.18: There are 20 traders in a room. They trade in 100 stocks. They trade for their own accounts and only amongst themselves—it is a "closed economy." Halfway through their morning trading session, a group of SEC officials arrives and announces that one of the traders has inside information on one stock and has been trading on it. The trader is not yet identified. The SEC officials seat themselves in the room to watch. What happens to trading volume after the SEC announcement? Explain carefully.

[3] Note that GARCH is an acronym for Generalized AutoRegressive Conditional Heteroskedasticity. How do you estimate the model? Why was it introduced?

> **Story:** One interviewee was asked, "If you are holding a dinner party, and you can invite any three dead people (presumably resurrected), who would you choose? Please do not choose any relatives." Give it some thought.

Question 3.19: Two stocks have the same expected return. One has standard deviation of returns of 20%, and the other has standard deviation of returns of 30%. The correlation between their returns is 50%. How do I allocate money between these so as to minimize my risk.

Question 3.20: The same question as Question 3.19 but with variance or returns 10% and 40%, respectively, and correlation 50%.

> **Story:** A student interviewing with Goldman, Sachs was asked how he would move Mount Fuji. One of my colleagues suggested the answer "Call Mohammed."

Chapter 4

Statistics Questions

The only prerequisites for answering the statistics questions in this chapter are elementary statistical skills. Solutions for this chapter appear in Appendix D.

Question 4.1: Consider the following game. The player tosses a die once only. The payoff is \$1 for each "dot" on the upturned face. Assuming a fair die, at what level should you set the ticket price for this game?

Question 4.2: I will roll a single die no more than three times. You can stop me immediately after the first roll, or immediately after the second, or you can wait for the third. I will pay you the same number of dollars as there are dots on the single upturned face on my last roll (roll number three unless you stop me sooner). What is your playing strategy?[1]

Question 4.3: (**) Two sealed envelopes are handed out. You get one and your competitor gets the other. You understand that one envelope contains m dollars, and the other contains $2m$ dollars (where m is unstated).[2]

1. *If* you peek into your envelope, you see \$X. However, you do not know whether your opponent has $\$2X$ or $\$\frac{1}{2}X$. *Without peeking*, what is your expected benefit to switching envelopes? What is your opponent's expected benefit to switching envelopes (assuming your opponent sees \$Y)? Should you switch? If you do, do you do it again for the same reason (assuming neither of you peeked)?
2. Suppose that you both peek into your envelopes initially. What is the payoff to switching? Should you switch? If you do, do you do it again for the same reason?

[1] If you were running this game, how much would you charge players for repeated plays of the game? Suppose instead an amended game is played: I roll a single die three times without pause, and the payoff to the player is the maximum of the three rolls. What is the expected payoff to the player? Can you tell up front whether the original or amended game has the higher expected payoff?

[2] This problem is over 40 years old and is known as the "Exchange Paradox."

Question 4.4: You have three children, but only one apple. You want to toss a fair coin to determine which child gets the apple. You want each child to be equally likely to get the apple. What is your strategy?

Question 4.5: A follow up question to Question 4.4: What is the expected number of tosses needed to complete this strategy?

Question 4.6: They call this the "World Series" problem in the US. Sports teams "A" and "B" are to play each other until one has four wins and is declared the series winner. You have \$100 to bet on Team A to win the series. You are, however, only allowed to bet on individual games, not the final outcome directly, and, you must bet a positive amount on each game. So, if Team A wins the series, you must walk away with \$200, but if Team A loses the series, you must walk away with zero, and you must do so having placed a non-zero bet on every game. Your best assessment is that Team A has a 70% chance of winning any game and Team B has a 30% chance. How do you place your bets?

Question 4.7: You and I are to play a game. You roll a die until a number other than a one appears. When such a number appears for the first time, I pay you the same number of dollars as there are dots on the upturned face of the die, and the game ends. What is the expected payoff to this game?

Question 4.8: You are dealt exactly two playing cards from a well-shuffled standard 52-card deck. The standard deck contains exactly four Kings. What is the probability that both of your cards are Kings?

> **Story:** I spoke with a gay contact at a big-name Wall Street investment bank. I told him that some of my students were about to fly out to New York to interview. He told me: "Make sure they have nice suits, good hair-cuts, and wear their wedding rings."

Question 4.9: (**) This is one version of the famous "Let's Make a Deal" or "Monty Hall" game show question. There are three doors. You know that there is a prize behind one of them, and nothing behind the other two. The game show host tells you that you shall receive whatever is behind the door of your choice. However, before you choose, he promises that rather than immediately opening the door of your choice to reveal its contents, he will open one of the other two doors to reveal that it is empty. He will then give you the option to switch your choice. You may assume that the host is totally impartial—not malicious in any way.

You choose Door 3. He opens Door 2 and reveals that it is empty. You now know that the prize lies behind either Door 3 or Door 1. Should you switch your choice to Door 1?

I strongly recommend that you not look at the answer until you have done your best.

Question 4.10: (**) Exactly the same question as the previous one, except that when it comes time for the host to reveal an empty door, he instead selects someone from the audience who chooses randomly and by chance chooses a door that is revealed to be empty. Should you switch?

Question 4.11: You are presented with two empty jars and 100 marbles on a table. There are 50 white marbles and 50 black marbles. You are to put all 100 of the marbles into the two jars in any way you choose. I will then blindfold you. I will shake the jars up to ensure good mixing, and I will rearrange the placing of the jars on the table so that you do not know which one is which. You may then request either the "left-hand" or the "right-hand" jar. You get to choose exactly one jar, you are allowed to withdraw at most one marble from the jar, and you do not get a second chance if you are unhappy with your choice.

How many of each color marble should you place in each jar to maximize the probability that your blindfolded random draw obtains a white marble?[3]

Question 4.12: (***) Your name is Mr. 10. You are standing in a field with two opponents: Mr. 30 and Mr. 60. Each of you has a gun and plenty of ammunition. Each of you is in clear sight of the others and well within firing range. The goal is to maximize the probability of survival. Unfortunately, you are not a very good shot. If you take a shot at one of your opponents, you have only a 10% chance of killing him. Mr. 30 is a better shot; he has a 30% chance of killing whomever he shoots at. Mr. 60 is even better; he has a 60% chance of killing his target. You take turns shooting in a pre-arranged order: first you, then Mr. 30, then Mr. 60, and then through this cycle again and again until only one person remains.

You get to shoot first. At whom do you shoot?[4]

Question 4.13: Basketball! Your team is down two points, you are the best player, and you have the ball. There are only a few seconds left before the buzzer. You can take a shot from three-point land or move up and take one from two-point land. Historically, you have a 40% probability of getting the shot in from three-point land and a 70% probability of getting the shot in from two-point land.

Should you try for the three-point shot (a certain win if you make it), or should you try for the two-point shot? Note that a two-pointer produces a tie and puts you into overtime. We assume your team has a fifty-fifty chance of winning in overtime.

[3] Can you answer the same question except that you are to *minimize* the probability of a white marble? Does minimizing the probability of a white marble maximize the probability of a black one?

[4] Does the answer change if the order is first you, then Mr. 60, then Mr. 30, then you, and so on?

Question 4.14: I will spin a fair roulette wheel with only five sections. Four of the five sections pay \$1; the fifth pays \$5.

1. If the cost is \$1.50 per spin, and you may play as often as you want, should you play the game?
2. If the cost is \$1.50 per spin, and you may play exactly once, should you play the game?

> **Story:** It is many years ago now, but I know of a well-qualified MIT student who got a job offer of \$X from a well known firm (a good offer at that time). He declined, telling them that they had misjudged him. They called him back a couple of days later and offered him $\$X \times 1.67$ instead! Amazing! He took the job.

Question 4.15: If you like gambling and you like betting on the outcome of sports matches, then you may like the "parlay card." A parlay card lets you bet on the outcomes of more than one match. In order to win a parlay bet, you must be correct on each of the matches you bet upon. Parlay cards offer big payoffs if you are right on every match (some even offer a payoff for "almost wins").

Suppose that your bookie will give you 10-to-1 odds for a parlay bet that covers four sports matches (with no almost wins). Should you take the bet?[5]

Question 4.16: What is the standard deviation of $(1, 2, 3, 4, 5)$?

Question 4.17: Welcome to your interview. Sit in this chair. Excuse me while I tie your arms and legs to the chair. Thank you. Now we are going to play "Russian roulette." I have a revolver with six empty chambers. Watch me as I load the weapon with two contiguous rounds (i.e., two bullets side-by-side in the cylindrical barrel). Watch me as I spin the barrel. I am putting the gun against your head. Close your eyes while I pull the trigger. Click! This is your lucky day: you are still alive! Our game differs from regular Russian roulette because I am not going to add any bullets to the barrel before we continue, and I am not going to give you the gun.

My question for you: I am going to shoot at you once more before we talk about your resume. Do you want me to spin the barrel once more, or should I just shoot?

Question 4.18: You have a large jar containing 999 fair pennies and one two-headed penny. Suppose you pick one coin out of the jar and flip it 10 times and get all heads. What is the probability that the coin you chose is the two-headed one?

[5] Should you take the bet if the odds are 25-to-1?

Question 4.19: Four cards are shuffled and placed face down in front of you. Their faces (hidden) display the four elements: water, earth, wind, and fire. You are to turn the cards over one at a time until you either win or lose. You win if you turn over water and earth. You lose if you turn over fire. What is the probability that you win?

> **Story:** "In his first meeting with me, a candidate made himself a little too comfortable. Not only did he liberally pepper his conversation with profanities, he also pulled his chair right up to the edge of my desk and started examining papers and knickknacks."
>
> NINA PROCT
> Martin H. Bauman Associates, New York
>
> "Doomed Days: The Worst Mistakes Recruiters Have Ever Seen,"
> *The Wall Street Journal*, February 25, 1995, pR4.
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Question 4.20: Two players A and B play a marble game. Each player has both a red and a blue marble. They present one marble to each other. If both present red, A wins \$3. If both present blue, A wins \$1. If the colors do not match, B wins \$2. The winnings come from an external source, not from the other player.

Is it better to be A, or B, or does it matter?

Question 4.21: A coin-making machine produces pennies. Each penny is manufactured to have a probability P of turning up heads. However, the machine draws P randomly from the uniform distribution on $[0, 1]$ so P can differ for each coin produced. A coin pops out of the machine. You flip it once, and it comes up heads. Given this information, what is the (conditional) distribution function $F_{P|H}(p)$ for the probability of a head for that coin (where "H" denotes conditioning on the head)?

What is the (conditional) distribution function for the probability of a head if you flip the coin 1,000 times and get 750 heads?

> **Story:** One of my MIT students was exceptionally well qualified. He was also one of the nicest guys I have ever met. He was quiet and soft-spoken. He was very understated (the kind of guy you might not notice). His starting salary at a big-name Wall Street firm was about four times the average MIT starting salary that year. The moral of the story: I don't care how hot you think you are—brains wins.

Question 4.22: Suppose that X is distributed normal with mean 0 and variance σ^2. What is $E(e^X)$?

Question 4.23: Two games are offered to you. In Game One, you roll a die once and you are paid \$1 million times the number of dots on the upturned face of the die. In Game Two, you roll a die one million times. For each roll you are paid \$1 times the number of dots on the upturned face of the die. You are risk averse. Which game do you prefer?

> **Story:** 1. Took a brush out of my purse, brushed his hair and left. 2. Pulled out a Polaroid camera and snapped a flash picture of me. Said he collected photos of everyone who interviewed him. Interview Horror Stories from Recruiters
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>

Question 4.24: What is the expected number of tosses of an unfair coin needed to get two heads in a row (assume probability p of a head)? Same question with three heads in a row.

Question 4.25: In a survey of 1,000 people, 60% said they would vote for Candidate A for president (and 40% said they would vote for someone else). How can you calculate a margin of error on the 60% estimate?

Question 4.26: A disease occurs with probability 0.5% in the population. There is a test for the disease. If you have the disease, the test returns a positive for sure. If you do not have the disease, the test returns a false positive 7% of the time. A random stranger is given the test and it returns a positive. What is the probability that the stranger has the disease?

Question 4.27: How many different ways can you invest \$20,000 into five funds in increments of \$1,000? For example, one way to do it is

$$(\$0;\ \$4,000;\ \$1,000;\ \$2,000;\ \$13,000).$$

Question 4.28: (**) You are making chocolate chip cookies. You add N chips randomly to the cookie dough, and you randomly split the dough into 100 equal cookies. How many chips should go into the dough to give a probability of at least 90% that every cookie has at least one chip?

Question 4.29: You will roll a fair die until the game stops. The game stops when you get a 4, 5, or 6. For every number 1, 2, or 3 you have thrown your score increases by +1. If the game stops with a 4 or 5, you get paid the accumulated score. If the game stops with a 6 you get nothing. What is the expected payoff of this game?

Question 4.30: Take a stick and break it randomly into three pieces (i.e., two randomly placed breaks on the stick). What is the probability you can form a triangle from the pieces?

Question 4.31: (**) A variation on the previous question: What is the expected length of the longest piece?[6]

Question 4.32: I tell you that I have two children and that one of them is a girl (I say nothing about the other). What is the probability that I have two girls? Assume that boys and girls are equally likely to be born and that the gender of one child is independent of gender of another.

Question 4.33: I tell you that I have two children and that one of them is a girl (I say nothing about the other). You knock on my front door and you are greeted by a girl who you correctly deduce to be my daughter. What is the probability that I have two girls? Compare and contrast your answer to the answer to the previous question. Assume that boys and girls are equally likely to be born and that the gender of one child is independent of gender of another.

> **Story:** "Every morning I see job candidates who spend a day here. I talk to them, answer questions about our company, tell them whom they'll interview with, and send them off. At the end of the day, when they come back, I determine whom they'd most like to work for, brief them on employee benefits, and tell them what happens next. I went through the morning ritual recently with one young candidate and then told him I'd see him about 4P.M. 'I don't want to come back here,' he said, quite emphatically. 'I've already talked to a guy I know who has been here before, and he told me everything you're going to tell me.' "
>
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>
> "Doomed Days: The Worst Mistakes Recruiters Have Ever Seen,"
> *The Wall Street Journal*, February 25, 1995, pR4.
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>

[6] ...and what about the expected length of the shortest piece? ...or the medium piece?

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Chapter 5

Non-Quantitative Questions

You probably picked this book up for the same reason I wrote it: you like solving quantitative problems. If you are anything like me, you probably hate those invasive, wishy-washy, touchy-feely, namby-pamby, non-quantitative interview questions that you cannot solve using mathematics. If you have prepared for the quantitative questions, but you are dreading those wishy-washy, non-quantitative ones, then you need to read this chapter.[1]

Some of these questions have a single correct answer (great!). Others are roughly what you might expect in some sort of Freudian couch session after having been arrested for machine-gunning all the bag boys in your local supermarket. Some of the questions depend upon knowledge of financial management; others depend upon how many drinks you had at that last party you went to (and you might not get the job if you didn't have any drinks at the last party or if you do not go to parties).

Questions are broken into five categories: Questions About You, Questions About Your Job Awareness, Questions About the Markets or The Economy, Questions About Financial Management, and "Thinking Questions." In the rare cases where I deem an answer necessary, the question is labelled with an "**(A)**," and its suggested answer appears in Appendix E.

This chapter benefited very much from interview questions collected by second-year MBA students at MIT's Sloan School of Management.

5.1 Questions about You

Question 5.1.1: Tell me about yourself.

Question 5.1.2: Walk me through your resume.

[1] As mentioned in the introductory chapter, you can buy interview books containing general non-quantitative questions. However, these books do not cover finance-related non-quantitative questions or the quirky questions unique to investment banking interviews. Of these interview books, I recommend Fry (2009). He presents non-quantitative questions and weighs up good and bad responses.

Question 5.1.3: What are your career goals? How do you plan to achieve those goals?

Question 5.1.4: What do you see yourself doing in five years? Is this different from what you imagined when you entered the degree program at your college (if so, how so)?

Question 5.1.5: Describe your life experiences, explaining any major decisions you have made to date.

Question 5.1.6: What two or three accomplishments have given you particular satisfaction over your lifetime?

Question 5.1.7: Tell me in detail what you did while working for this company that appears on your resume.

Question 5.1.8: How would you value yourself? "Value" here means in financial terms.

Question 5.1.9: How do you evaluate your success or the success of others?

Question 5.1.10: How would you describe yourself? How would your friends describe you? How would a former supervisor describe you?

Question 5.1.11: What is your greatest strength?

Question 5.1.12: Describe a situation where you have successfully sold your ideas.

Question 5.1.13: What is your greatest weakness?

Question 5.1.14: What areas of your performance need improvement?

Story: "During a lunch interview with me, a candidate ordered a bowl of French onion soup. When he started to eat the layer of cheese on top, it became stringy, and with his hands he tried to pull the strings of cheese apart. He pulled at those strings of cheese for a l–o–n–g time."

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"Doomed Days: The Worst Mistakes Recruiters Have Ever Seen,"
The Wall Street Journal, February 25, 1995, pR4.
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Question 5.1.15: Why shouldn't we hire you? The interviewee described this to me as a tough spin on the traditional "what is your greatest weakness" question.

Question 5.1.16: Tell me something you tried but ended up quitting on.

Question 5.1.17: What is the biggest risk you have taken in your life?

Question 5.1.18: Rate yourself on a scale of 1 to 10 on the type of risk taker you are. Tell me why and give examples to support your claims.

Question 5.1.19: Tell me about a goal you set for yourself in the past that turned out to be either too easy or too hard to achieve. What did you learn from the situation?

Question 5.1.20: What distinguishes you from other candidates we might hire?

Question 5.1.21: What do you do for fun?

Question 5.1.22: Describe the best party you have ever been to.

Question 5.1.23: What is the biggest investment mistake you have ever made?

Question 5.1.24: Tell me about a time when you had to deal with a highly ambiguous situation. What did you do? How did you deal with it?

Question 5.1.25: Please describe an ethical dilemma you have faced at work, and tell me how you handled the situation.

Question 5.1.26: How good are your writing skills? Please give me some convincing evidence.

Question 5.1.27: If you could go on a cross-country car trip with any three people, who would you choose?

Question 5.1.28: If you were holding a dinner party, and you could invite any three dead people (presumably resurrected), who would you choose? Please do not choose any relatives.

Question 5.1.29: Why did you decide to apply to your MBA college? Did you apply to other MBA programs (if so, which ones and why)?

Question 5.1.30: What do you do if the "picture-in-picture" does not work on your television? Yes, one of my students was asked this in a banking interview!

Question 5.1.31: How would you evaluate your experiences at your MBA college?

Question 5.1.32: What are the strengths and weaknesses of your MBA program?

Question 5.1.33: Describe a situation in which you had to make a decision based on very little information.

Question 5.1.34: Tell me about a situation when you were chosen as a leader by the members of your group.

Question 5.1.35: Repeat the conversation that you had with your team mates when things did not go well in your group.

Question 5.1.36: What have you enjoyed most about your experiences at your MBA college? What would you change?

Question 5.1.37: What is your GPA at your college? What about your GMAT score?

Question 5.1.38: Which courses did you enjoy most at your MBA college (and why)?

Question 5.1.39: How has your course work at your MBA college helped you to develop skills relevant to this job?

Question 5.1.40: What has been most difficult for you at your MBA college, and how have you dealt with it?

Question 5.1.41: How much of your education did you personally fund?

Question 5.1.42: How do you spend your time outside of school and work? How do you balance your life?

Question 5.1.43: Are you married? Do you have children? What does your spouse do? How is your family? Where were you born? How old are you? These are all illegal questions in Canada and the US. Most questions about family background, religion, marital status, and so on are illegal. Although illegal, you should be prepared to answer these questions.

Question 5.1.44: Describe your typical day.

Question 5.1.45: Are you innately intelligent, or do you have to work really hard?

> **Story:** A student of mine interviewing at Goldman, Sachs was asked to draw a picture of himself! They gave him pencil and paper, and he drew a picture (into his picture he also drew books, friends, and other goofy stuff to indicate that he was not retarded).

Question 5.1.46: At interview end: "Is there anything important you have not had a chance to tell me?"

Question 5.1.47: At interview end: "Do you have any questions you would like to ask me?" You must have questions; Candidates with no questions appear unmotivated/uninterested. That is no way to end the interview!

> **Story:** Let me give some unorthodox advice.
>
> **1.** A colleague and I were interviewing a candidate for a quant equities job in London. After a few questions about his CV, we asked him a simple quant question. He was extremely uncomfortable. He declared it to be "not a proper interview," and to our amazement, he walked out the door! He made two fatal mistakes. First, walking out meant he was a quitter. Nobody likes quitters. Second, he should have attempted an answer because even if he was not suited to quant equities at my firm, we had vacancies in other areas and we knew of vacancies at other firms, and we would have passed his CV on if we thought he was talented—but not if we thought he was a quitter. It is in the interviewer's best interests to pass good CVs around the firm and to a network of contacts outside of it because the favor will be returned eventually. Remember, you are never interviewing for that one job only! If the interview is going badly, then be positive and focus on your strengths even if they are not strengths for that job!
>
> **2.** I was being interviewed for a practitioner job I really wanted. I was up to about the fifth person on my schedule for the day. From the moment this guy set eyes on me across the table I could tell he did not want to hire me. He was 100% negative and actually looked angry! I can read upside down, and, without him noticing, I quickly read the questions he had written on my CV across the table from me. I addressed his questions before he even asked them. That surprised him! I turned the conversation toward the markets and found some common ground. He became interested. I made a tasteful joke. He smiled. When our half-hour was up, he was 100% positive and I know he recommended that I be hired. There was nothing unethical about this manipulation of interview/interviewer: I love the markets, wanted the job, and thought the firm was a great fit for me.
>
> **3.** The two stories above are about losing and winning, respectively. I think a difference between these outcomes is mental preparation. I was given an inexpensive book called *The Dirty Dozen* by Sergeant Major (Ret.) Lawrence A. Jordan. Sergeant Major Jordan served a 24-year Special Operations career with the U.S. Army Rangers and Special Forces. His book is about dirty fighting techniques, and chapter 2, *The Winning Mind*, is about mental preparation for life-or-death hand-to-hand combat in self defense. Although it is unorthodox of me to write this, I recommend that you read *The Winning Mind* chapter of *The Dirty Dozen* for interview preparation. If you can stomach it, it may give you just the edge you need.

5.2 Questions about Your Job Awareness

Question 5.2.1: How does this position in this company fit into your career development plans? What other career options are you considering?

Question 5.2.2: Why do you want to work for this employer?

Question 5.2.3: Sell yourself to me. Prove to me that you are someone I should seriously consider for our firm.

Question 5.2.4: What motivates you to put forth your best effort? What type of work environment brings out your best effort?

Question 5.2.5: What rewards do you seek from work? What rewards do you seek from this particular job (or company)?

Question 5.2.6: Why are you not better matched with Firm X (our competitor)?

Question 5.2.7: Do you have any geographical preferences? What are your thoughts about travel or relocation?

Question 5.2.8: What do you see yourself contributing to our organization, both in the short term and in the long term?

Question 5.2.9: What other companies are you interviewing with, and how do we compare?

Question 5.2.10: **(A)** What do you think of our tombstone in today's *Wall Street Journal*?

Question 5.2.11: Why fixed income rather than equities?

Question 5.2.12: What do you think it takes to be successful in this position (or this organization)?

Question 5.2.13: Why do you want to work as a trader?

Question 5.2.14: What do you think traders do?

Question 5.2.15: If you were in my position, interviewing candidates for this position, what qualities would you seek? How would you evaluate candidates?

Question 5.2.16: Describe the best boss you have ever had. How would you define the qualities of a good manager?

Question 5.2.17: What do you think an investment banker does?

Question 5.2.18: Do you understand the hours investment bankers work and why?

Story: "We had narrowed our search for a senior-level executive at a major financial institution to three candidates and felt that one in particular was the best choice in terms of experience and background. We prepped all three for their interviews with the company's general counsel, but we really spent time prepping the top candidate. When he got into the interview, it suddenly seemed he'd come from another planet. He asked about his office furniture, his expense-account allowances and health-care plan. He asked nothing whatsoever about the functions of the job and his qualifications for it. I sat there in horror."

ARNOLD M. HUBERMAN
Arnold Huberman Associates, New York

"Doomed Days: The Worst Mistakes Recruiters Have Ever Seen,"
The Wall Street Journal, February 25, 1995, pR4.
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Question 5.2.19: Describe how you build relationships in a new job.

Question 5.2.20: Imagine you have received three job offers. How will you decide which one to accept?

Question 5.2.21: If you were to get two other job offers in addition to one from us, from which firms would they most likely come, would you take them, and why?

Question 5.2.22: Some people say investment banking is not value adding. How do you refute that?

Question 5.2.23: If we offer you a job right now, will you take it?

Question 5.2.24: **(A)** With your abilities, you seem to not fit in this position (or this firm). Perhaps you should consider a job in ...

5.3 Questions about the Markets or the Economy

Question 5.3.1: Where is the DOW, or S&P500, or NIKKEI, or FTSE, or Hang Seng, or....? How does it compare now to where it has been over the last two years? Where do you see it two weeks from now (or six months from now)?

Question 5.3.2: Where is the JPY, or GBP, or CAD, or EUR, or....? How does it compare now to where it has been over the last two years? Where do you see it two weeks from now (or six months from now)?

Question 5.3.3: What is LIBOR, and what is today's LIBOR rate?[2]

Question 5.3.4: Why invest in a particular market (e.g., Korea, Russia, Germany)?

Question 5.3.5: How would the following affect interest rates: A relative of Saddam Hussein starts making trouble in the Middle East; there is another Asian currency crisis; Monica Lewinsky (alleged mistress of the US president Clinton) hits the headlines again as the alleged mistress of the current US president.

Question 5.3.6: **(A)** When inflationary fears arise, the government has two forms of macroeconomic policy to try to slow the economy down. Name these and explain them in a few words.

Question 5.3.7: What stock do you recommend and why?

Question 5.3.8: What sector should I be short? What sector should I be long?

Question 5.3.9: Tell me about a stock you like or hate and why.

Question 5.3.10: What should be the (CAPM) beta for Intel Corp.?

Question 5.3.11: Where do you think the US economy will go over the next year?

Question 5.3.12: **(A)** What are the "Dow Jones Dogs"?

Question 5.3.13: Tell me how the Dow Jones Industrial Average is calculated.

Question 5.3.14: Draw the yield curve showing 3M, 6M, 1YR, 2YR, 5YR, 10YR, 30YR rates.

Question 5.3.15: Do you think the stock market is efficient (in an EMH sense)? A very popular question for asset management.

Question 5.3.16: Suppose you are actively investing to beat the market. Are there more opportunities (i.e., inefficiencies) in the S&P500 or in the 500 largest stocks in Europe?

Question 5.3.17: What is a black swan? What do black swans mean for the use of VaR and other conventional statistical methods employed in quantitative finance? This obviously refers to Nissam Taleb's book *The Black Swan: The Impact of the Highly Improbable.*

[2] They probably mean the benchmark three- or six-month US dollar LIBOR rates, but they might not say that. There are several different dimensions here: you should understand the distinction between USD LIBOR and GBP LIBOR, between three-month USD LIBOR and six-month USD LIBOR, between LIBOR (London InterBank Offered Rate) and EURIBOR (Euro Interbank Offered Rate), and between euro LIBOR and EURIBOR. If you do not, look in your favorite investments book, or use a WWW search engine.

5.4 Financial Management Questions

Question 5.4.1: How would you value a company? (This is a very popular question.)

Question 5.4.2: Suppose that the S&P500 index has a P/E ratio of 20. How would you value a manufacturing company with earnings of one million dollars?

Question 5.4.3: What key financial ratios do you look at when trying to determine a firm's financial health from its balance sheet?

Question 5.4.4: Why do pharmaceutical companies increase drug prices when they come off patent protection?

Question 5.4.5: Describe the CAPM.

Question 5.4.6: Can a company function without working capital?

Question 5.4.7: What happens to a company's balance sheet if the company buys an asset? Walk me through the steps.

Question 5.4.8: **(A)** When is a motor vehicle this is owned by the company not recorded on the balance sheet as PPE (physical plant and equipment)?

Question 5.4.9: How would you market this financial product (e.g., a structured note)?

Question 5.4.10: Imagine you are giving a presentation to a client and they tell you your numbers are wrong. What would you do?

Question 5.4.11: How do you use DCF to value a skyscraper in order to sell it? You need to come up with current revenue, costs, net income, estimates of future cash flows, and a discount rate.

Question 5.4.12: Kirk Kekorian attempted to force Chrysler to rid itself of what he called "excess cash"—through higher dividends and a stock buy back. What do you think of this?

Question 5.4.13: How would you market this company to our clients?

Question 5.4.14: Have you ever had to fire someone? If so, how did you handle this situation?

Question 5.4.15: Forecast the income statement for Duracell for this year.

Question 5.4.16: **(A)** In the calculation of free cash flow (i.e., FCF), does the level of long-term debt matter?

Question 5.4.17: How do you calculate VaR (i.e., Value at Risk)?

Question 5.4.18: Have you heard of LTCM?

Question 5.4.19: What is the difference between default risk and prepayment risk?

Question 5.4.20: What is kurtosis?

5.5 Thinking Questions

These "thinking questions" lie between quantitative and non-quantitative. Most of these questions have in common that they have some sort of precise solution. However, if you know exactly how many McDonald's outlets there are in the US (one of the questions) and say so directly, then you have missed the point. The interviewer wants you to work the answer out and describe your reasoning. These are thus "thinking questions," not calculation ones.

Question 5.5.1: If a cannonball is dropped in the deepest part of the Earth's oceans, how long will it take to reach the ocean floor?

Question 5.5.2: **(A)** How many McDonald's fast food outlets are there in the US?

Question 5.5.3: How many gas stations are there in the US?

Question 5.5.4: **(A)** You are in a jail cell alone stripped of your possessions. It is Friday afternoon, and you desperately need a cigarette. How do you force the guard to give you one?

Question 5.5.5: How many elevators (i.e., "lifts" if you are British) are there in the US?

Question 5.5.6: How would you value an option on (famous basketball player) Michael Jordan?

Question 5.5.7: **(A)** I toss a coin 100 times and get 100 heads in a row. What is the probability that the next outcome will be a head?

Question 5.5.8: How many ping-pong balls can you fit in a jumbo jet (e.g., Boeing 747)?

Question 5.5.9: How would you move Mount Fuji?

Question 5.5.10: **(A)** How do you weigh a jet aeroplane without using scales?

Question 5.5.11: You have a five-gallon jar and a three-gallon jar. You can have as much water as you want. How do you put exactly four gallons into the five-gallon container? This is too easy for me to supply an answer.

Question 5.5.12: Estimate the annual demand for car batteries.

Question 5.5.13: What would you estimate to be the size of the racquetball market in the US?

Question 5.5.14: You are to build a plant for Coors to serve all beer customers in the state of Ohio. How large would you build it? That is, specifically how many cans (of the new wide-mouth variety) do you anticipate being demanded for the year?

Question 5.5.15: Why do beer cans have tapered tops and bottoms?

Question 5.5.16: **(A)** Explain why aeroplanes can fly.

Question 5.5.17: How many fish are there in the Earth's oceans?

Question 5.5.18: How many barbers are there in Chicago?

Question 5.5.19: What is $\sqrt{204,000}$?

Question 5.5.20: **(A)** Finally, why are manhole covers round?

> **Story:** I was telephone-interviewing a candidate for an active equity research job in London. His job would be the creation, testing, and implementation of strategies for beating the market. I asked him if he could draw upon his considerable experience in the markets to suggest to me a strategy he had heard of for beating the market. There was a very long pause (at least 20 seconds), after which he answered simply "no." What did he think I was going to ask him about?!