**Gribbin Brewing Problem**

Regional brewer Andrew Gribbin distributes kegs of his famous beer through three warehouses in the greater News York City area, with current supplies as shown in Figure 1.

On a Thursday morning, he has his usual weekly orders from his four loyal customers, as shown in Figure 2. Tracy Chapman, Gribbin’s shipping manager, needs to determine the most cost-efficient plan to deliver beer to these four customers, knowing that the costs per keg are different for each possible combination of warehouse and customer (see Figure 3). What is the optimal shipping plan?

|  |  |
| --- | --- |
| Warehouses | Supply |
| Hoboken | 80 |
| Bronx | 145 |
| Brooklyn | 120 |

Figure 1

|  |  |
| --- | --- |
| Bars | Demand |
| Der Ratkeller | 80 |
| McGoldrick's Pub | 65 |
| Night Train Bar & Grill | 70 |
| Stern Business School | 85 |

Figure 2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Ratkeller | McGoldrick's | Night Train | Stern |
| Hoboken | $4.64 | $5.13 | $6.54 | $8.67 |
| Bronx | $3.52 | $4.16 | $6.90 | $7.91 |
| Brooklyn | $9.95 | $6.82 | $3.88 | $6.85 |

Figure 3

**Sailboat Problem**

Sailco must determine how many sailboats to produce during each of the next four quarters. At the beginning of the first quarter, Sailco has an inventory of 10 sailboats.

Sailco must meet demand on time. The demand during each of the next four quarters is as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr |
| 40 | 60 | 75 | 25 |

For simplicity, assume that sailboats made during a quarter can be used to meet demand for that quarter. During each quarter, Sailco can produce up to 50 sailboats with regular-time employees, at a labor cost of $400 per sailboat. By having employees work overtime during a quarter, Sailco can produce unlimited additional sailboats with overtime labor at a cost of $450 per sailboat.

At the end of each quarter (after production has occurred and the current quarter’s demand has been satisfied,), a holding cost of $20 per sailboat is incurred.

Determine a production schedule to minimize the sum of production and inventory holding costs during the next four quarters.

**Surfs Up**

Surfs Up produces high-end surfboards. Their production facility can produce at most 50 boards per month. A challenge faced by Surfs Up is that their demand is highly seasonal. Demand exceeds production capacity during the warm summer months, but is very low in the winter months. To meet the high demand during the summer, Surfs Up typically produces more surfboards than are needed in the winter months and then carries inventory into the summer months. The production cost of a surfboard is $125. The boards are sold for $200. Because of storage cost and the opportunity cost of capital, each board held in inventory from one month to the next incurs a cost of $5 per board. Since demand is uncertain, Surfs Up would like to maintain an ending inventory (safety stock) of at least 10 boards during the warm months (May-September) and at least 5 boards during the other months (October-April). It is now the start of January and Surfs Up has 5 boards in inventory. The forecast of demand over the next 12 months is shown in the table below. Determine how many surfboards should be produced each month to maximize total profit.

**Forecasted Demand**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec |
| 10 | 14 | 15 | 20 | 45 | 65 | 85 | 85 | 40 | 30 | 15 | 10 |

**Project Funding Problem**

It is **January 1, 2008**. Director of Special Projects Rakesh Parameshwar has a planned $20.5 million project, which will require the following expected cash flows between 2008 and 2012:

|  |  |
| --- | --- |
| Date | Cash Requirement ($ millions) |
| 01-Jul-08 | 7.50 |
| 01-Jan-09 | 4.50 |
| 01-Jul-09 | 1.00 |
| 01-Jan-10 | 1.00 |
| 01-Jul-10 | 1.00 |
| 01-Jan-11 | 1.00 |
| 01-Jul-11 | 1.00 |
| 01-Jan-12 | 3.50 |

Rakesh turns to his Director of Financial Planning, Christine Reyling, and asks her to ensure that funding is available for the project. Christine is considering buying a portfolio of bonds, with cash flows from the bonds arranged to coincide with the needs of Rakesh’s project. The following bonds are available, and can be purchased in any quantity:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Maturity | 01-Jul-08 | 01-Jan-09 | 01-Jul-09 | 01-Jan-10 | 01-Jul-10 | 01-Jan-11 | 01-Jul-11 | 01-Jan-12 |
| Coupon | 7.00% | 7.50% | 6.75% | 0.00% | 10.00% | 9.00% | 10.25% | 10.00% |
| Price | 1.00 | 1.03 | 1.02 | 0.81 | 1.16 | 1.15 | 1.23 | 1.25 |

**Every 6 months**, starting 6 months from the current date and ending at the expiration date, each bond pays

0.5 \* (coupon rate)

At the expiration date the face value is paid. For example, the second bond pays

* $0.0375 on 01-Jul-08
* $1.0375 on 01-Jan-09

What is the minimum cost portfolio of these bonds that will meet the project’s requirements? Assume that any cash can be reinvested at an annual rate of 4%, and don’t worry about discounting.

**Funding a Pension Liability**

It is January 1, 2005 and you are managing a Pension Fund. You have a good idea of how much money you will need to pay out during each of the next 15 years. The payments in the following table must be made on January 1 of each year.

|  |  |
| --- | --- |
| **Year** | **Payment** |
| 2005 | $11,000 |
| 2006 | $12,000 |
| 2007 | $14,000 |
| 2008 | $15,000 |
| 2009 | $16,000 |
| 2010 | $18,000 |
| 2011 | $20,000 |
| 2012 | $21,000 |
| 2013 | $22,000 |
| 2014 | $24,000 |
| 2015 | $25,000 |
| 2016 | $30,000 |
| 2017 | $31,000 |
| 2018 | $31,000 |
| 2019 | $31,000 |

In order to finance these obligations, the following three bonds may be purchased on January 1, 2005 (all coupons are paid on January 1 of each year):

* Bond 1 costs $980 and pays $60 in 2006-2009 and $1060 in 2010.
* Bond 2 costs $970 and pays $65 in 2006-2015 and $1065 in 2016.
* Bond 3 costs $1050 and yields a $75 coupon in 2006-2018 and $1075 in 2019.

Payments from bonds are received in time to be used to meet pension liabilities. During each year you earn 4% interest on your cash. Given the bonds available for purchase today, you would like to find the least amount of money that must be set aside today to ensure that you can make all pension payments.

Build a spreadsheet model to help you determine the minimum amount of money you need to provision and the bonds to purchase on January 1, 2005 to ensure that you will meet all pension liabilities.

**Scheduling Professors**

Three professors must be assigned to teach six sections of finance. Each professor must teach two sections of finance, and each has ranked the six time periods during which finance is taught, as shown in the table below. A rating of 10 means that the professor wants to teach at that time, and a ranking of 1 means that he or she does not want to teach at that time.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | 9 A.M. | 10 A.M. | 11 A.M. | 1 P.M. | 2 P.M. | 3 P.M. |
| Professor l | 8 | 7 | 6 | 5 | 7 | 6 |
| Professor 2 | 9 | 9 | 8 | 8 | 4 | 4 |
| Professor 3 | 7 | 6 | 5 | 6 | 9 | 5 |

Preferences for Teaching Finance

Determine an assignment of professors to sections that maximizes the total satisfaction of the professors.

**Contract Bidding**

A company is taking bids on four construction jobs. Three contractors have placed bids on the jobs. Their bids (in thousands of dollars) are given in the table below. (A dash indicates that the contractor did not bid on the given job.)

Contractor 1 can do only one job, but contractors 2 and 3 can each do up to two jobs.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Job 1 | Job 2 | Job 3 | Job 4 |
| Contractor 1 | 50 | 46 | 42 | 40 |
| Contractor 2 | 51 | 48 | 44 | — |
| Contractor 3 | — | 47 | 45 | 45 |

Bids for Contractor Problem

Determine the minimum cost assignment of contractors to jobs.

Also answer the following questions:

1. What is the “cost” of restricting Contractor 1 to only one job?
2. How much more can Contractor 1 bid for Job 4 and still get the job?

**Bidding on Search Ads**

Daniel Refurbished Laptops is trying to decide how much to bid on different keywords on Google.

Daniel is running an advertising campaign that with a daily budget of $550 and is considering bidding

on four different keywords: “laptop”, “refurbished laptop”, “cheap laptop” and “used laptop”. Daniel’s

goal is to get as many clicks as possible given its ad budget.



The table below shows the expected number of clicks for a given keyword and ad slot.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **slot** | **"laptop"** | **"refurbished laptop"** | **"cheap laptop"** | **"used laptop"** |
| 1 | 1539 | 370 | 45 | 38 |
| 2 | 1099 | 264 | 32 | 27 |
| 3 | 785 | 189 | 23 | 19 |
| 4 | 561 | 135 | 16 | 14 |
| 5 | 401 | 96 | 12 | 10 |
| 6 | 286 | 69 | 8 | 7 |
| 7 | 204 | 49 | 6 | 5 |
| 8 | 146 | 35 | 4 | 4 |

The table below shows the cost per click for each keyword and ad slot.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **slot** | **"laptop"** | **"refurbished laptop"** | **"cheap laptop"** | **"used laptop"** |
| 1 | 6.73 | 1.29 | 0.59 | 0.93 |
| 2 | 6.72 | 0.95 | 0.58 | 0.85 |
| 3 | 2 | 0.8 | 0.56 | 0.84 |
| 4 | 1.7 | 0.79 | 0.55 | 0.7 |
| 5 | 1.56 | 0.78 | 0.51 | 0.58 |
| 6 | 1.42 | 0.77 | 0.42 | 0.46 |
| 7 | 1.13 | 0.57 | 0.4 | 0.43 |
| 8 | 0.95 | 0.54 | 0.39 | 0.4 |

Should Daniel bid in all four keywords? For the auctions that Daniel chooses to participate in, how

much should he bid on each keyword?

**Media Selection**

Assume Honda has decided it wants its September 2014 TV ads to be seen at least this many times by the following demographic groups:

* 100 million women 18-30
* 90 million women 31-40
* 80 million women 41-50
* 70 million women more than 50
* 100 million men 18-30
* 90 million men 31-40
* 80 million men 41-50
* 70 million men more than 50

(These numbers are usually determined by either the firm’s prior ad experiences or for a new product using the ad agency’s prior experience.)

Honda can advertise on *Oprah, Jeopardy!, the Late Show with David Letterman, Notre Dame Football, Saturday Night Live, The Simpsons, Seinfeld, ER, and Monday Night Football (MNF)*. The costs and demographic information for each show are shown in the figure below.



For example, a 30-second ad on *Oprah* reaches 6 percent of all women 18-30, and such. There are 20 million women 18-30, and so on (see row 4).

Honda is given the quantity discount schedule shown in the figure below. For example, 1 ad on *Oprah* costs $32,000, but 10 ads cost $170,000 (much less than 10 times the cost of a single ad).



Assume Honda can place at most 10 ads on a given show. Determine the cheapest way to meet its exposure goal. For simplicity, we make the following assumption. If one ad on a show generates *n* exposures to a group, then *m* ads generates *m\*n* exposures to a group. Such an assumption can be easily dropped for a slightly more sophisticated model.

The data is available at Media Data.xls.

You may use the vlookup function for this example to look up specific information located in a table of data. Here is how it works:

**VLOOKUP**(**lookup\_value**,**table\_array**,**col\_index\_num**,range\_lookup)

**Lookup\_value**    The value to search in the first column of the table array. Lookup\_value can be a value or a reference. If lookup\_value is smaller than the smallest value in the first column of table\_array, VLOOKUP returns the #N/A error value.

**Table\_array**    Two or more columns of data. Use a reference to a range or a range name. The values in the first column of table\_array are the values searched by lookup\_value. These values can be text, numbers, or logical values. Uppercase and lowercase text are equivalent.

**Col\_index\_num**    The column number in table\_array from which the matching value must be returned. A col\_index\_num of 1 returns the value in the first column in table\_array; a col\_index\_num of 2 returns the value in the second column in table\_array, and so on. If col\_index\_num is:

* Less than 1, VLOOKUP returns the #VALUE! error value.
* Greater than the number of columns in table\_array, VLOOKUP returns the #REF! error value.

**Range\_lookup**    A logical value that specifies whether you want VLOOKUP to find an exact match or an approximate match:

* If TRUE or omitted, an exact or approximate match is returned. If an exact match is not found, the next largest value that is less than lookup\_value is returned.
* If FALSE, VLOOKUP will only find an exact match. In this case, the values in the first column of table\_array do not need to be sorted. If there are two or more values in the first column of table\_array that match the lookup\_value, the first value found is used. If an exact match is not found, the error value #N/A is returned.

**Nobel Amazon**

Nobel Amazon sells books online. Management is trying to determine the best sites for the company’s warehouses. Five potential sites are under consideration. Most of the sales come from customers in the United States. The average weekly demand from each region of the county, the average shipping cost from each warehouse site to each region of the country, the fixed cost per week of each warehouse if it is operated, and the maximum capacity of each warehouse (if it is operated) are shown in the tables below. Determine which warehouse sites Nobel Amazon should operate and how books should be distributed from each warehouse to each region of the country to minimize total cost.

Warehouse: Fixed Cost and Capacity

|  |  |  |
| --- | --- | --- |
| Warehouse Site | Fixed Cost (per week) | Capacity (books/week) |
| Spokane, WA  Reno, NV  Omaha, NE  Harrisburg, PA  Jacksonville, FL | $40,000  $30,000  $25,000  $40,000  $30,000 | 20,000  20,000  15,000  25,000  15,000 |

Customer Demand in Each Region

|  |  |
| --- | --- |
| Region | Customer Demand |
| Northwest  Southwest  Midwest  Southeast  Northeast | 8,000  12,000  9,000  14,000  17,000 |

Average Shipping Cost ($/book)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Northwest | Southwest | Midwest | Southeast | Northeast |
| Spokane, WA  Reno, NV  Omaha, NE  Harrisburg, PA  Jacksonville, FL | 2.40  3.25  4.05  5.25  6.95 | 3.50  2.30  3.25  6.05  5.85 | 4.80  3.40  2.85  4.30  4.80 | 6.80  5.25  4.30  3.25  2.10 | 5.75  6.00  4.75  2.75  3.50 |

**Capital Budgeting**

Norwood Development is considering the potential of four different development projects. Each project would be completed in at most three years. The required cash outflow for each project is given in the table below, along with the net present value of each project to Norwood, and the cash that is available each year. Assume that any cash can be reinvested at an annual rate of 4%, and don’t worry about discounting

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Cash Outflow Required ($million)** | | | | **Cash Available  ($million)** |
|  | **Project 1** | **Project 2** | **Project 3** | **Project 4** |
| Year 1 | 9 | 7 | 6 | 11 | 28 |
| Year 2 | 6 | 4 | 3 | 0 | 13 |
| Year 3 | 6 | 0 | 4 | 0 | 10 |
| NPV | 30 | 16 | 22 | 14 |  |

Determine which project(s) should be undertaken to maximize the net present value.

**Togawa Steel Company**

Togawa Steel Company (TSC) manufactures structural beams of a standard length. The strength of a beam depends on its weight, and industry standards specify eight beam weights ranging from 50 pounds to 750 pounds. If a customer requests a given strength, then TSC may meet the demand by substituting a beam of greater strength. In this case, TSC incurs the material cost of providing the heavier beam. For every substitution, the incremental material cost is the difference in weight between the beam demanded and the beam supplied, multiplied by the variable cost of $2 per pound. If TSC decides to manufacture a particular weight, then it incurs a setup cost of $120,000. Determine which categories of steel beams to produce in order to minimize the total cost of production.

The beam weights and their demand requirements for the coming month are tabulated as follows

|  |
| --- |
| Category |
| 1 2 3 4 5 6 7 8 |
| Weight 50 100 150 200 250 400 500 750  Demand 1000 2000 400 800 1000 500 200 100 |

**Beat the Market**

A common goal of portfolio managers is to beat the market. If we assume that past performance is somewhat of an indicator of the future, then picking a portfolio that beat the market most often in the past might yield a portfolio that will more than likely beat the market in the future.

Consider a portfolio of five large stocks traded on the New York Stock Exchange (NYSE):

* + Disney (DIS)
  + Boeing (BA)
  + General Electric (GE)
  + Procter & Gamble (PG)
  + McDonald’s (MCD)

The quarterly performance (return) of each of these stocks over a six-year period (2001-2005) is shown in the template file. The performance of the market as a whole, as measured by the NYSE Composite Index, is also shown in the file.

What mix of these five stocks will yield a portfolio that is likely to beat the market in the future?

**Whartvard Business School**

The admissions committee for the Whartvard Business School will be making its decisions regarding which applicants to admit to its MBA program for the coming year. In addition to considering each applicant on his or her own merit, the committee also needs to take three policy guidelines into account. One guideline is that, although a relatively low GMAT total score should not disqualify an applicant if other factors are very positive, the average GMAT total score for the entire MBA class should be reasonably high. (About 85 percent of all individuals taking the GMAT receive a total score below 650, but Whartvard is such a selective school that it considers anything below 650 to be a low score.) A second guideline is that the number of men and number of women in the MBA class should not be too badly out of balance. The third guideline is that the class should include a substantial number of students who are at least 30 years old, since they bring considerable work experience and maturity into the mix. The committee now has divided both the male applicants and female applicants into three categories according to whether they have high, medium, or low GMAT total scores. The following table shows the number of applicants whose age is under 30 and at least 30 in each category.



The admissions committee has set four goals for this entering MBA class, in the following order of priority:

Goal 1: The entering class should include at least 240 students.

Goal 2: The entering class should have an average GMAT total score of at least 690.

Goal 3: The entering class should consist of at least 35 percent women.

Goal 4: At least 120 members of the entering class should be at least 30 years old.

Based on past experience, 60 percent of all applicants who are admitted will accept admission.

Determine approximately how many applicants to admit from each category.

**Pond Island Bank**

A trust officer at Pond Island Bank needs to determine what percentage of the bank’s investable funds to place in each of following investments.

|  |  |  |  |
| --- | --- | --- | --- |
| Investment | Yield | Maturity | Risk |
| A  B  C  D  E | 11.0%  8.0%  8.5%  10.0%  9.0% | 8 years  1 year  7 years  6 years  2 years | 5  2  1  5  3 |

The yield column represents each investment’s annual yield. The Maturity column indicates the number of years funds must be placed in each investment. The Risk column indicates an independent financial analyst’s assessment of each investment’s risk. The trust officer should not invest more than 40% of the funds in any of the five investments. In general, the trust officer wants to maximize the weighted average yield on the funds placed in these investments while minimizing the weighted average maturity and the weighted average risk.

**Savings Accumulation**

Lynn recently completed her MBA and accepted a job with a fast growing mobile telephone service company in Europe. Although she likes her job, she is also looking forward to retiring one day. To ensure that her retirement is comfortable, Lynn intends to put $4500 of her salary into a tax-sheltered retirement fund in the US each year. Lynn is not certain what annual rate of return this investment will earn, but she expects that the rate could be modeled appropriately as a normally distributed random variable with a mean of 10% and standard deviation of 2%.

1. If Lynn is 30 years old, how much money should she expect to have in her retirement fund at age 60?
2. What is the probability that Lynn will have more than $1 million in her retirement fund when she reaches age 60?

**Estimate NPV**

You have been asked to evaluate the following investment opportunity.

A small firm is available for purchase for $150,000, to be paid to the seller in five equal annual installments. The firm has been generating annual revenues of $100,000, with operating costs equal to 65% of revenues. Assume that the annual taxes will be 36% of net income, and that the discount rate is 10%.

Uncertainty Factors

* Actual revenues each year could be as low as $60,000 or as high as $125,000. The most likely amount is $100,000. Revenues in successive years are independent.
* Operating costs each year could be as low as 55% of revenues or as high as 75%, with any values in between being equally likely. Costs in successive years are independent.
* The tax rate in any year will be 36% with probability 0.4 and 40% with probability 0.6, depending on factors outside the buyer’s control and independent from year to year.

In the case of negative taxable income, the buyer will have other income, so the tax effects represented in the model will still hold.

Questions

1. Verify that this investment has an NPV of $12,131 if we leave out the uncertainty factors.
2. Build a simulation model to study the NPV of this investment including the uncertainty factors.
3. Estimate the probability that the NPV will be negative.
4. Estimate the probability of positive cash flow in all five years.

**Project Valuation**

Catch’em Corporation is considering development and introduction of a new mousetrap into the market and there is a significant technological uncertainty about the cost of product development and production, as well as market uncertainty about product’s success and the competitors’ actions.

Specifically, the VP of R&D expects the product development cost to be $30,000, with standard deviation of $5,000. The VP of production estimates that the production cost could be as low as $6 per unit, or as high as $8 per unit. Once produced, if the mousetrap does not become popular, the total sales can be expected to be 60,000 units at a price of $10 per unit. On the other hand, if the mousetrap does catch attention, the sales could be as high as 100,000 units. However, in that case, new competition can be expected to move in and drive the price down to $8 a unit. From the preliminary research, the marketing VP believes that there is a 60% chance that the mousetrap will be a hit.

**Development of a New Drug**

The pharmaceutical business deals with a very high degree of uncertainty. Over 90% of all products under development fail to come to market resulting in large losses. Products that do come to market can earn multibillion profits annually for 10-15 years (until their patent expires). Simulation is a natural tool to use in an effort to estimate whether a new product is worth developing.

Eli Daisy wants to determine whether a new drug, Niagara, is worth developing. Before coming to market Niagra must go through the following stages of development

* Initial R and D
* Preclinical Testing
* Testing I (first phase of clinical trials)
* Testing II (second phase of clinical trials)

Only after all development stages succeed can the drug be sold. If the drug fails at any stage, then development is terminated. A success at any stage leads us to pursue the next stage. We want to determine the risk adjusted NPV from this drug (15% discount rate per year is used) and get an idea of the key drivers of the drug’s profitability.

For each stage we will model the cost, probability of success and time required to complete the stage with a triangular random variable. We will also model the profit earned from the drug with a triangular random variable. Please see *Data of Development of New Drug.xls* for detailed information.

**Insurance Claims**

AzurAuto, a small insurance company, is trying to decide how much money to keep in liquid asset to cover auto insurance claims. The company holds some of the premiums it receives in interest bearing checking accounts and puts the rest into investments that are not quite as liquid, but generate a higher return. The company wants to study cash flows to determine how much money it should keep in liquid assets to pay claims. A review of the company’s data has shown the following:

* Repair bills per claim have a Normal distribution with a mean of $3000 and a standard deviation of $1000.
* The number of repair claims filed each week is distributed as follows:

|  |
| --- |
| No. of repair claims 1 2 3 4 5 6 7 8 9 |
| Probability 0.05 0.06 0.10 0.17 0.28 0.14 0.08 0.07 0.05 |

* In addition to repair claims, the company also receives claims for cars that have been “totaled”, that is, damaged beyond repair. On average, there is a 20% chance of occurrence of this type of claim in any week. Typically these claims cost anywhere from $3000 to $35000, the most common cost being around $18000.

1. Create a spreadsheet model of the total claims cost incurred by the company in any week.
2. Simulate the model with Crystal Ball to determine the average cost that the company should expect to pay each week.
3. Suppose that the company decides to keep $35000 cash on hand to pay claims. What is the probability that this amount would not be adequate to cover claims in any week?

**Transcontinental Airlines Overbooking**

Transcontinental Airlines has a daily flight (excluding weekends) from San Francisco to Chicago that is mainly used by business travelers. There are 150 seats available in the single cabin. The average fare per seat is $300. This is a nonrefundable fare, so no-shows forfeit the entire fare. The fixed cost for operating the flight is $30,000, so more than 100 reservations are needed to make a profit on any particular day.

For most of these flights, the number of requests for reservations considerably exceeds the number of seats available. The company’s management science group has been compiling data on the number of reservation requests per flight for the past several months. The average number has been 195, but with considerable variation from flight to flight on both sides of this average. Plotting a frequency chart for these data suggests that they roughly follow a bell-shaped curve. Therefore, the group estimates that the number of reservation requests per flight has a normal distribution with a mean of 195. A calculation from the data estimates that the standard deviation is 30.

The company’s policy is to accept 10 percent more reservation than the number of seats available on nearly all its flights, since roughly 10 percent of all its customers making reservations end up being no-shows. However, if its experience with a particular flight is much different from this, then an exception is made and the management science group is called in to analyze what the overbooking policy should be for that particular flight. This is what has just happened regarding the daily flight from San Francisco to Chicago. Even when the full quota of 165 reservations has been reached (which happens for most of the flights), there usually are a significant number of empty seats. While gathering its data, the management science group has discovered the reason why. Only 80 percent of the customers who make reservations for this flight actually show up to make the flight. The other 20 percent forfeit the fare (or, in most cases, allow their company to do so) because their plans have changed.

Now that the data have been gathered, the management science group decides to begin its analysis by investigating the option of increasing the number of reservations to accept for this flight to 190. If the number of reservation requests for a particular day actually reaches this level, then this number should be large enough to avoid many, if any, empty seats. Furthermore, this number should be small enough that there will not be many occasions when a significant number of customers need to be bumped from the flight because the number of arrivals exceeds the number of seats available (150). Thus, 190 appears to be a good first guess for an appropriate trade-off between avoiding many empty seats and avoiding bumping many customers.

When a customer is bumped from this flight, Transcontinental Airlines arranges to put the customer on the next available flight to Chicago on another airline. The company’s average cost for doing this is $150. In addition, the company gives the customer a voucher worth $200 for use on a future flight. The company also feels that an additional $100 should be assessed for the intangible cost of a loss of goodwill on the part of the bumped customer. Therefore, the total cost of bumping a customer is estimated to be $450.

The management science group now wants to investigate the option of accepting 190 reservations by using computer simulation to generate frequency charts for the following three measures of performance for each day’s flight.

1. The profit
2. The number of filled seats.
3. The number of customers denied boarding.

What number of reservations should be accepted to maximize the expected profit from the flight?

**Optimizing Liquidity**

You run an endowment fund for a university that currently has 1 billion in investments. You can make both liquid investments (stock and bond market) and illiquid investments (real estate and hedge funds).

You can only offload your illiquid investments once a year.

The university revenues this year will be distributed according to a normal distribution, with mean 400

million and standard deviation of 50 million. The university will also get donations, which will distributed uniformly between 100 and 250 million. The operating cost of the university is normally

distributed, with mean 650 million and standard deviation of 150 million.

Your predictions for how the three investments will behave over the next year are given in the table

below:

|  |  |  |
| --- | --- | --- |
| **Investment** | **Expected Return** | **Standard Deviation** |
| Liquid | 4% | 8% |
| Illiquid | 7% | 11% |

Suppose that if the university runs out of money during the year, it will lose the equivalent of 100

million dollars due to borrowing costs and bad publicity. How much of the endowment should be

invested in illiquid investments?

**Profitability Model for PPC Online Advertising**

Internet users who want to purchase a product often search the Internet for information on the product. In addition to showing search results, search engines also show paid ads relevant to the users’ search. Companies such as Yahoo and Google can, of course, charge advertisers to have their ads appear when users conduct a search.

When a search engine provider charges based on pay per click (PPC), the advertisers know that they are charged only when a search clicks through to their website. Because click-through should lead to sales, advertisers know they are getting some value for their payments. The first instance of PPC advertising was developed in 1996 by a division of Packard Bell NEC Corporation. Beginning in 2002, the AdWords system was used for PPC advertising.

The following example shows how an advertiser can estimate monthly profitability of PPC advertising. The following quantities are needed:

* **Cost per Click**: This is the cost the advertiser must pay for each click. Let’s assume a $1 cost per click.
* **Estimated Clicks per Day**: This is simply the daily number of clicks to their site expected by the advertiser. If you sign up for Google AdWords, Google’s Bid Simulator feature gives you an estimate of the number of clicks per day that can be obtained for a given cost per click. Assume the number of daily clicks generated from the ads can be any number between 100 and 200.
* **Conversion Rate**: This is the fraction of clicks that results in a sale. The conversion rate can easily be estimated from historical data. Assume the conversion rate follows a normal distribution with mean 6% and standard deviation 2%.
* **Profit per Sale**: This can easily be estimated from historical data. Assume the profit per sale is between $100 and $200, and most likely $130.

Simulate the profit per month from PPC advertising.