The Katz School

Workshop in Probability and Statistics

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1 About the Statistics Workshop...

Purpose:

This workshop is part of the course: BQOM 2401 Statistical Analysis.

HW #1 is related to the workshop material. Also the midterm exam will include questions from the workshop material

Format:

- Three lectures of two hours each.

Content:

- Introduction to Probability Theory – foundation for Statistics.

2 Probability - Experiments, Outcomes, and Events

We always talk about the probability of an ***Event***.

Probability is a number between 0 and 1 (inclusive). How do we obtain (calculate) the probabilities of the events that are of interest to us.

Events of Interest:

1. What's the probability that the fed will reduce the short-term interest rates at the next scheduled meeting?
2. What's the probability that the price of XYZ stock will go up today?
3. What's the probability that it will rain tomorrow?
4. What's the probability of a heart when you pull a card at random from a standard deck of cards?

Subjective Probability

Objective Probability

Empirical

Mathematical

Experiment: is any process that is observable and has uncertain outcomes.

1. The weather tomorrow.
2. The price of XYZ stock at the end of the day.
3. Flip a coin

Sample Point is the most B***asic Outcome*** of the experiment.

1. Flip a coin; Head or Tail are the basic outcomes.
2. Throw a Dice; an even number or an odd number is NOT a simple outcome, so is not a sample point.

The ***Sample Space*** of an experiment is the collection of all its sample points(outcomes).

An ***Event*** is a specific collection of one or more outcomes (sample points).

1. An even number on the throw of a dice.
2. Fed raises the short-term interest rates.

2.1 Urns, balls, dice and real life examples

1. I want to build a portfolio of 4stocks from the Dow 30 stocks. Le us say the Dow 30 stocks can be classified as "Technology" (10) and "Non Technology" (20) stocks. Let us say that among the "Non Technology" stocks 18 pay dividends and among the "Technology" stocks only 4 pay dividends. I want to build a portfolio of 4 stocks that contain no more than 2 "Technology" stocks and at least 3 of the 4 stocks should pay dividends. How many different portfolios can I build?

   Equivalent experiment with urns and balls: I have an urn that contains 20 red balls and 10 blue balls. Among the red balls, 18 have stripes and 2 have dots. Among the blue balls, 4 have stripes and 2 have dots.

2. Katz has 60 faculty members, 35 Full Professors (4 women), 12 Associate Professors (3 women), and 13 Assistant Professors (2 women). How many different committees of 5 can be formed if ....

   Equivalent experiment with urns and balls: I have an urn that contains 35 red balls, 12 blue balls, and 13 white balls. Among the red balls, 4 have stripes. Among the blue balls, 3 have stripes and among the white balls 2 have stripes. If I take 5 balls at random, ...

2.2 *Sample Space, Outcomes, Events: Definition*

How do we calculate the probabilities of events? (Subjective or Objective)

Context: Experiment, sample space (outcomes), events (sets)

Experiment: Throw a Dice
Sample Space: S=(1,2,3,4,5,6)
A = (1,2,3); B= (4,5,6); C = (2,4,6); D = (1,3,5); E =(1,2,3,4)

Complimentary event of A, denoted as A^c or $\overline{A}$, contains every outcome in the sample space except the outcomes that are in the event A.

Union of Two Events, (A ∪ B), contains all the sample points that are either in A or in B or both.

(A ∪ C) =

(C ∪ E)=

Intersection of Two Events, (A ∩ B), contains all the sample points that are common to both A and B events.

(A ∩ B) =

(A ∩ C) =

Mutually Exclusive Events: two or more events are mutually exclusive if they do NOT have any common outcomes (sample points), i.e. their intersection is zero (null set).

All Exhaustive Events: Two or more events are said to be all exhaustive if their union is the set of all possible outcomes.

Mutually Exclusive and All Exhaustive Events.

2.3 Rules for Calculation of Probabilities.

A simple definition of the ***probability of an event*** is the sum of the probabilities of all the outcomes included in the event.

If the experiment results in equally likely outcomes, then

P (Event) = (The number of outcomes in the event)/ (The total number of outcomes in the experiment)

2.3.1 Counting Rules

1. If an experiment has n trials and each trial has $k_1, k_2, \ldots k_n$ outcomes. The total number of outcomes in the experiment is $k_1 . k_2 . k_3 \ldots k_n$.

   Example: An automobile manufacture makes cars in 5 exterior colors, 4 interior colors and 3 styles (two door, four door and station wagon). How many different automobiles are there?

2. If an experiment consists of n trials and each trial has k outcomes, the total number of outcomes is $k.k.k \ldots k = k^n$.

   Example: Flip a coin 5 times. How many outcomes are there?

3. ***Permutations:*** the arrangement of r objects from n objects (order is important)

$$n^P r = \frac{n!}{(n-r)\,!}$$

Special cases:

a) Arrange all n object (r = n) $n^P n = n\,!$
b) r = 1 $n^P 1 = n$
c) Arrange 0 objects (r = 0) $n^P 0 = 1$

4. ***Combinations:*** The selection of r objects from n objects (<u>order is not important</u>)

$$n^c r = \binom{n}{r} = \frac{n!}{(n-r)\ !\ r\ !}$$

Special cases:

a) Select all n objects (r = n) $\binom{n}{n} = 1$

b) Select 1 object (r = 1) $\binom{n}{1} = n$

c) Select 0 objects (r = 0) $\binom{n}{0} = 1$

2.3.2 Problems on Counting Rules

1. In how many ways can 8 people be seated on a bench if only 3 seats are available?

2. How many different committees of 3 members can be formed selecting from a total of 10 members?

3. How many four digit numbers can be formed with the <u>nine</u> digits 1, 2,...,9 if

   (a) Repetitions are allowed?

   (b) Repetitions are not allowed?

   (c) Last digit must be an even number and repetitions are not allowed.

4. The Dean of Katz wanted to form a committee of 4 people to review the current curriculum. A group of 10 people volunteered to serve on the committee. Assuming that all 10 are equally qualified,

   (a) How many different committees of 4 people can be formed from these 10 people?

   (b) If each committee needs to have chairman (among the 4 members), how many different committees can be formed?

   (c) Of the 10 people volunteered, 3 are Assistant Professors. The dean wants to include at most one Assistant Professor on the committee. How many different committees can be formed? (Assume no chairman is required).

5. A garage door opener has a code of 5 digits. Each digit is set to be 0 or 1. (For example 01100 is a valid code). You set your code when the garage door was installed. Recently, because of old age or whatever, you forgot the code. How many attempts should you make before you are sure you can open the garage?

6. How many tickets should be bought in the Pennsylvania Lotto Lottery game to guarantee a winner? (6 balls are drawn from 48 balls without replacement and one other ball is drawn from another set of 48 balls. The winner has to match all 6 plus the super ball number).

7. We have 3 Astrology books, 4 Biology books, and 5 Chemistry books.

   a) In how many ways can these books be arranged if there are no restrictions?

   b) In how many ways can these books be arranged if the books in each subject matter have to stand together?

   c) What if the books in each subject matter are identical?

2.3.3 Probability Rules

1. Axiom **$0 \leq P(E_i) \leq 1$**

2. If $E_1, E_2, .. E_k$ are mutually exclusive, all exhaustive, then $\sum_{i=1}^{k} P(E_i) = 1$

3. $P(A \cup B) = P(A) + P(B) - P(A \cap B)$

4. If A and B are independent
   $P(A \cap B) = P(A) . P(B)$

   P (Two heads in a row) = $P(H_1 \cap H_2) = P(H_1). P(H_2) = 1/2 . 1/2 = 1/4$.

5. Conditional Probability (Bayes' Rule; Revised Probability)

$$P(A / B) = \frac{P(A \cap B)}{P(B)}$$

6. If $P(A/B) = P(A)$ (or $P(B/A) = P(B)$), then we say that A and B are independent.

2.3.4 Problems on Probability

1. In a small town 60% of the people buy morning paper, 30% of the people buy the evening paper, and 20% of the people buy both the papers.

   a) What proportion of the people do not buy any newspaper?

   b) If a citizen of that town buys the morning paper, what is the probability that he also buys an evening paper?

2. One hundred shoppers at a large suburban shopping center were asked two questions: (1) Did you shop at department store X during the past two weeks? (2) Did you see an ad for department store X during the last two weeks? The responses are summarized below:

	Shopped at X	Did not shopped at X
Saw ad	50	13
Did not see ad	12	25

A person was chosen at random from the one hundred people.

a) What is the probability that this person saw the ad?

b) What is the probability that this person shopped at X?

c) Given that the person saw the ad, what is the probability that he/she shopped at X?

d) Are the two events "Did not see ad" and "did not shop at X" mutually exclusive?

e) Are they independent (the events in part d)?

3. Consider a bag that has 4 red balls, and 6 green balls. Among the red balls, 1 has stripes and 3 have dots. Among the green balls, 2 have stripes and 4 have dots. You pick a ball at random. Define the following events:

- R - a red ball is drawn
- G - a green ball is drawn
- S - a striped ball is drawn
- D - a dotted ball is drawn

4. A bag contains 5 red balls and 3 white balls. Two balls are drawn at random without replacement.

   a) What is the probability that both are red?

   b) What is the probability that one of them is red and the other is white?

   c) What are the answers to parts a) and b) if the sampling is done with replacement?

5. Box I contains 4 white balls and 3 green balls. Box II contains 2 white and 7 green balls. A box is chosen at random and a ball is drawn from that box.

   a) What is the probability that the ball is white?

   b) If the sampled ball is white, what is the probability that it came from Box I? (Bayes Theorem)

6. A small company has two manufacturing plants producing the same products. Plant A produces 70% of the products and Plant B produces the remaining 30%. The defect rate at Plant A is 5% and the corresponding value at Plant B is 4%.

   a) What proportion of the product manufactured by that company is defective?

   b) A randomly selected item is found to be defective. What is the probability that this defective item was produced at Plant B?

3 Random Variables

3.1 Random Variables and Probability Distributions

1. A ***Random Variable*** (RV) assigns a numerical value for every outcome of the experiment.

   Examples:
   1. The outcomes on the roll of a dice.
   2. The outcomes on the flip of a coin are not a RV.
   3. The sum of the numbers on the roll of two dice.

2. ***Discrete RV*** and ***Continuous RV***

3. ***Probability Mass Function*** (pmf)/ ***Probability Density Function*** (pdf)

4. ***Cumulative Distribution Function*** (cdf) or (cmf)

   $$F(x) = P(X \le x)$$

5. ***Expected Value;*** $E(X) = \mu$

   $$\mu = \sum_i x_i P(X = x_i)$$

6. ***Variance;*** σ^2

   $$\sigma^2 = \sum_i (x_i - \mu)^2 P(X = x_i)$$

3.1.1 Problems on Random Variables

1. The number of desktop computers sold /day, denoted by X, by a local Radio Shack store has the following distribution.

X	2	3	4	5
P (X = x)	0.1	0.3	0.4	0.2

   a) Draw the pmf of X.

   b) What is the cmf of X ?

   c) What is expected value of X?

   d) What is the variance and standard deviation of X?

2. Discrete Random Variable - consider throwing two dice simultaneously (or one dice two times sequentially). Let the random variable X be the sum of the numbers (dots) on the two dice. For example, this is a game where you pay some money to play and you will be paid back the sum of the dots on the two dice. Let us look at the distribution of X.

4 Special Probability Distributions

4.1 Binomial Distribution

1. The Experiment consists of ***n*** (known) trials.

2. Each trial results in one of ***two*** outcomes (called success and failure).

3. The probability of success on any trial ***p*** is constant.

4. The trials are ***independent.***

If X = the number of successes, then X is a Binomial random variable with parameters n and p. (Mean = n.p, variance = n. p. (1-p)).

$$P(X = x) = \binom{n}{x} p^x (1-p)^{n-x} \; ; x = 0, 1, 2, \ldots, n$$

Tables are available for these probabilities or cumulative probabilities.

Example 1: A production process is known to produce 10% defectives. A sample of 8 is taken from a large lot. Let X be the number of defectives in the sample. X is Binomial with n = 8, p = 0.10.

Example 2: n = 10; p = 0.80

P (X = 4) =

P (X ≤ 2) =

4.2 *Poisson Distribution*

A very useful discrete distribution for describing randomly occurring events is Poisson distribution. In queuing models, the number of arrivals in a unit time is usually assumed to be Poisson distributed. Poisson distribution has ***one parameter*** λ, which is also its ***mean*** and its ***variance***. The probability mass function is given by

$$P(X = x) = \frac{e^{-\lambda}\lambda^{x}}{x!}, \text{ for } x = 0, 1, 2, \ldots.$$

For a given λ, most textbooks provide tables of pmf or cmf.

Example: Let the mean number of arrivals at a gas station be 2 per minute. The arrivals are distributed according to Poisson distribution.

In this case, λ = mean arrival rate = 2

P (X = 1) = 0.406 - 0.135 = 0.271, (from table)

P (X = 3) =

P (X = 5) =

4.2.1 *The Relationship between Poisson Distribution and Exponential Distribution*

There is a very interesting and useful relationship between the Poisson and Exponential random variables. Note that Poisson distribution is a discrete distribution and the Exponential distribution is a continuous distribution. If the arrivals are Poisson distributed with mean λ, then the inter-arrival time (the time between arrivals; a continuous random variable) follows an exponential distribution with mean $(1/\lambda)$.

Continuous Random Variables

Continuous Random Variables (Continued)

Continuous Random Variables (Continued)

Expectations of Functions of Random Variables

Let X be the random variable representing the scores on the first exam of the statistics course. Let μ_x be the mean and σ_x^2 be the variance of the exam scores. (Example $\mu_x = 75$ and $\sigma_x^2 = 36$).

Let $Y = a + X$

a) What are the mean and variance of Y?

E (Y) =

Var (Y) =

Let $Y = b\,X$

b) What are the expected value and variance of Y?

E (Y) =

Var (Y) =

Let $Y = a + b\,X$

c) What are the mean and variance of Y?

E (Y) =

Var (Y) =

A special case: ***Standardized RV.***

Let $Q = X - \mu_x$

d) What are the mean and variance of Q?

E (Q) =

Var (Q) =

Let $Z = Q/\sigma_x$

e) What are the mean and variance of Z?

E (Z) =

Var (Z) =

$$Z = \frac{X - \mu}{\sigma}$$

5 Summary

We covered the following topics in this Statistics Workshop:

1. ***Probability***
   - We talked about the nature of objective and subjective probabilities;
   - We defined **experiments, outcomes** and **events**;
   - To help us calculate the total number of outcomes in an experiment, we introduced the **multiplication rule, permutations** and **combinations**;
   - We defined **mutually exclusive** events, **all exclusive** events, **complementary events** $(\bar{A})$, **union** of events $(A \cup B)$, and **intersection** of events $(A \cap B)$
   - We gave you the following formulae/rules;
     1. $P(A \cup B) = P(A) + P(B) - (A \cap B)$
     2. If A and B are mutually exclusive, then $P(A \cap B) = 0$
     3. $P(A/B) = P(A \cap B)/P(B)$
     4. If $P(A/B) = P(A)$, then A and B are independent
     5. If A and B are independent, then $P(A \cap B) = P(A) \, . \, P(B)$
   - We talked about using **tree diagram** to do problems dealing with conditional probabilities (also Bayes's Theorem)

2. ***Random Variables***

   A RV assigns a numerical value for every outcome of the experiment. RV's are of two types: **discrete** and **continuous**. All RV's have probability distributions. Discrete probability distributions are called **Probability Mass Functions** and continuous probability distributions are called **Probability Density Functions.**

   For all RV's (where *a* and *b* are constants)

   $E(a + bX) = a + b\,E(X)$
   $Var(a + bX) = b^2\,Var(X)$
   $E(X \pm Y) = E(X) \pm E(Y)$
   $Var(X + Y) = Var(X) + Var(Y) + 2\,cov(X, Y)$
   $cov(X, Y) = 0$, if X and Y are uncorrelated.

3. ***Special Probability Distributions***

   Binomial Distribution
   Poisson Distribution
   Normal Distribution

6 Recitation Problems

6.1 General probability distribution problems

1. An employee for a vending concession at a baseball stadium must choose between working behind the hot dog counter and receiving a fixed sum of $100 for the evening, or working around the stands selling beer on a commission basis. If the latter is chosen, the employee can make $180 on a warm night, $140 on a moderate night, $90 on a cool night and $30 on a cold night. At this time of year, the probabilities of a warm, moderate, cool, or cold night are .1, .3, .4, and .2, respectively.

   a) Determine the mean (expected) value to be earned by selling beer that evening.

   b) Compute the standard deviation.

   c) Which product should the employee sell? Why?

3. The director of a large employment agency wishes to study various characteristics of its job applicants. A sample of 200 applicants has been selected for analysis. Seventy applicants have had their job for at least 5 years; 80 of the applicants are college graduates; 25 of the college graduates have had their current jobs at least 5 years.

a) What is the probability that an applicant chosen at random

1) Is a college graduate?

2) Is a college graduate and has held the current job less than 5 years?

3) Either is a college graduate or has held the current job at least 5 years?

b) Given that a particular employee is a college graduate, what is the probability that he or she has held the current job less than 5 years?

c) Determine whether being a college graduate and holding the current job for at least 5 years are statistically independent.

6.2 *Binomial distribution problems*

1. Suppose that warranty records show that the probability that a new car needs a warranty repair in the first 90 days is .05. If a sample of three new cars is selected, what is the probability that:
    a. None needs a warranty repair?
    b. At least one needs a warranty repair?
    c. More than one needs a warranty repair?

2. An important part of the customer service responsibilities of a natural gas utility company concerns the speed with which calls relating to no heat in a house can be serviced. Suppose that one service variable of importance refers to whether or not the repair person reaches the home within a two-hour period. Past data indicates that the likelihood is .60 that the repair person reaches the house within a two-hour period.
    a. If a sample of five service calls for "no heat" is selected, what is the probability that the repair person will arrive at
        i. All five houses within a two hour period?
        ii. At least three houses within a two hour period?
    b. Find the probability that the repair person will arrive at zero, one, and two houses and plot the histogram for the probability distribution.

6.3 Poisson distribution problems

1. The average number of claims per hour made to the Gecko Insurance Company for damages or losses incurred in car accidents is 2.4. What is the probability that in any given hour
   a. Fewer than three claims will be made?
   b. Exactly three claims will be made?
   c. Three or more claims will be made?
   d. More than three claims will be made?

2. Based on past records, the average number of two-car accidents in a Pittsburgh police precinct is 0.7 per day. What is the probability that there will be at least two but no more than five accidents in this precinct on any given day?

Additional Probability Problems

1.29 In how many ways can 10 people be seated on a bench if only 4 seats are available?

1.34 Five red marbles, two white marbles, and three blue marbles are arranged in a row. If all the marbles of the same color are not distinguishable from each other, how many different arrangements are possible?

1.40 How many different salads can be made from lettuce, escarole, endive, watercress and chicory?

1.41 From 7 consonants and 5 vowels, how many words can be formed consisting of 4 different consonants and 3 different vowels? The words need not have meaning.

1.52 A box contains 5 red and 4 white marbles. Two marbles are drawn successively from the box without replacement and it is noted that the second one is white. What is the probability that the first is also white?

3.107 The probability that an Avon salesperson sells beauty products to a prospective customer on the first visit to the customer is 0 .4. If the salesperson fails to make the sale on the first visit, the probability that the sale will be made on the second visit is .65. The salesperson never visits a prospective customer more than twice.

a.) What is the probability that the salesperson will make a sale to a particular customer?

b.) Given that a customer made a purchase, what is the probability that he made it on the first visit?

3.112 A small brewery has two bottling machines. Machine A produces 75% of the bottles and machine B produces 25%. One out of every 20 bottles filled by A is rejected for some reason, while one out of every 30 bottles from B is rejected. What proportion of bottles is rejected? What is the probability that a randomly selected bottle comes from machine A, given that it is accepted?

1 To develop programs for business travelers staying at convention hotels, a major hotel chain commissioned a study of executives who play golf. The study revealed that 55% of the executives admitted they had cheated at golf. Also, 20% of the executives admitted they had cheated at golf and had lied in business. Given an executive who had cheated at golf, what is the probability that the executive also had lied in business?

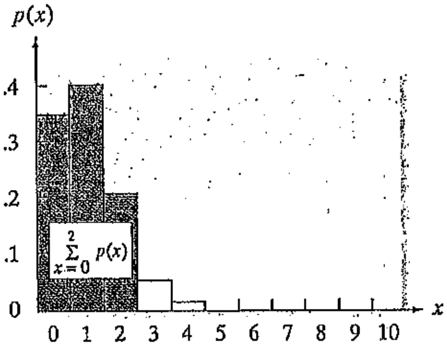
2 A country welfare agency employs 10 welfare workers who interview prospective food stamp recipients. Periodically the supervisor selects, at random, the forms completed by 2 workers to audit for illegal deductions. Unknown to the supervisor, 3 of the workers have regularly been giving illegal deductions to applicants. What is the probability that both of the 2 workers chosen have been giving illegal deductions?

3 An urn holds 5 white and 3 black marbles. If two marbles are drawn at random without replacement and X denotes the number of white marbles, (a) find the probability distribution for X and (b) graph the distribution.

4 A and B play a game in which they alternately toss a pair of dice. The one who is first to get a total of 7 wins the game. Find the probability that (a) the one who tosses first will win the game, (b) the one who tosses second will win the game.

Table I Binomial Probabilities

Binomial cumulative Probabilities.



Tabulated values are $\sum_{x=0}^{k} p(x)$. (Computations are rounded at the third decimal place.)

a. $n = 5$

k \ p	.01	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95	.99
0	.951	.774	.590	.328	.168	.078	.031	.010	.002	.000	.000	.000	.000
1	.999	.977	.919	.737	.528	.337	.188	.087	.031	.007	.000	.000	.000
2	1.000	.999	.991	.942	.837	.683	.500	.317	.163	.058	.009	.001	.000
3	1.000	1.000	1.000	.993	.969	.913	.812	.663	.472	.263	.081	.023	.001
4	1.000	1.000	1.000	1.000	.998	.990	.969	.922	.832	.672	.410	.226	.049

b. $n = 6$

k \ p	.01	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95	.99
0	.941	.735	.531	.262	.118	.047	.016	.004	.001	.000	.000	.000	.000
1	.999	.967	.886	.655	.420	.233	.109	.041	.011	.002	.000	.000	.000
2	1.000	.998	.984	.901	.744	.544	.344	.179	.070	.017	.001	.000	.000
3	1.000	1.000	.999	.983	.930	.821	.656	.456	.256	.099	.016	.002	.000
4	1.000	1.000	1.000	.998	.989	.959	.891	.767	.580	.345	.114	.033	.001
5	1.000	1.000	1.000	1.000	.999	.996	.984	.953	.882	.738	.469	.265	.059

c. $n = 7$

k \ p	.01	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95	.99
0	.932	.698	.478	.210	.082	.028	.008	.002	.000	.000	.000	.000	.000
1	.998	.956	.850	.577	.329	.159	.063	.019	.004	.000	.000	.000	.000
2	1.000	.996	.974	.852	.647	.420	.227	.096	.029	.005	.000	.000	.000
3	1.000	1.000	.997	.967	.874	.710	.500	.290	.126	.033	.003	.000	.000
4	1.000	1.000	1.000	.995	.971	.904	.773	.580	.353	.148	.026	.004	.000
5	1.000	1.000	1.000	1.000	.996	.981	.937	.841	.671	.423	.150	.044	.002
6	1.000	1.000	1.000	1.000	1.000	.998	.992	.972	.918	.790	.522	.302	.068

d. $n = 8$

k \ p	.01	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95	.99
0	.923	.663	.430	.168	.058	.017	.004	.001	.000	.000	.000	.000	.000
1	.997	.943	.813	.503	.255	.106	.035	.009	.001	.000	.000	.000	.000
2	1.000	.994	.962	.797	.552	.315	.145	.050	.011	.001	.000	.000	.000
3	1.000	1.000	.995	.944	.806	.594	.363	.174	.058	.010	.000	.000	.000
4	1.000	1.000	1.000	.990	.942	.826	.637	.406	.194	.056	.005	.000	.000
5	1.000	1.000	1.000	.999	.989	.950	.855	.685	.448	.203	.038	.006	.000
6	1.000	1.000	1.000	1.000	.999	.991	.965	.894	.745	.497	.187	.057	.003
7	1.000	1.000	1.000	1.000	1.000	.999	.996	.983	.942	.832	.570	.337	.077

(continued)

Table I *(continued)*

e. $n = 9$

k \ p	.01	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95	.99
0	.914	.630	.387	.134	.040	.010	.002	.000	.000	.000	.000	.000	.000
1	.997	.929	.775	.436	.196	.071	.020	.004	.000	.000	.000	.000	.000
2	1.000	.992	.947	.738	.463	.232	.090	.025	.004	.000	.000	.000	.000
3	1.000	.999	.992	.914	.730	.483	.254	.099	.025	.003	.000	.000	.000
4	1.000	1.000	.999	.980	.901	.733	.500	.267	.099	.020	.001	.000	.000
5	1.000	1.000	1.000	.997	.975	.901	.746	.517	.270	.086	.008	.001	.000
6	1.000	1.000	1.000	1.000	.996	.975	.910	.768	.537	.262	.053	.008	.000
7	1.000	1.000	1.000	1.000	1.000	.996	.980	.929	.804	.564	.225	.071	.003
8	1.000	1.000	1.000	1.000	1.000	1.000	.998	.990	.960	.866	.613	.370	.086

f. $n = 10$

k \ p	.01	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95	.99
0	.904	.599	.349	.107	.028	.006	.001	.000	.000	.000	.000	.000	.000
1	.996	.914	.736	.376	.149	.046	.011	.002	.000	.000	.000	.000	.000
2	1.000	.988	.930	.678	.383	.167	.055	.012	.002	.000	.000	.000	.000
3	1.000	.999	.987	.879	.650	.382	.172	.055	.011	.001	.000	.000	.000
4	1.000	1.000	.998	.967	.850	.633	.377	.166	.047	.006	.000	.000	.000
5	1.000	1.000	1.000	.994	.953	.834	.623	.367	.150	.033	.002	.000	.000
6	1.000	1.000	1.000	.999	.989	.945	.828	.618	.350	.121	.013	.001	.000
7	1.000	1.000	1.000	1.000	.998	.988	.945	.833	.617	.322	.070	.012	.000
8	1.000	1.000	1.000	1.000	1.000	.998	.989	.954	.851	.624	.264	.086	.004
9	1.000	1.000	1.000	1.000	1.000	1.000	.999	.994	.972	.893	.651	.401	.096

g. $n = 15$

k \ p	.01	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95	.99
0	.860	.463	.206	.035	.005	.000	.000	.000	.000	.000	.000	.000	.000
1	.990	.829	.549	.167	.035	.005	.000	.000	.000	.000	.000	.000	.000
2	1.000	.964	.816	.398	.127	.027	.004	.000	.000	.000	.000	.000	.000
3	1.000	.995	.944	.648	.297	.091	.018	.002	.000	.000	.000	.000	.000
4	1.000	.999	.987	.838	.515	.217	.059	.009	.001	.000	.000	.000	.000
5	1.000	1.000	.998	.939	.722	.403	.151	.034	.004	.000	.000	.000	.000
6	1.000	1.000	1.000	.982	.869	.610	.304	.095	.015	.001	.000	.000	.000
7	1.000	1.000	1.000	.996	.950	.787	.500	.213	.050	.004	.000	.000	.000
8	1.000	1.000	1.000	.999	.985	.905	.696	.390	.131	.018	.000	.000	.000
9	1.000	1.000	1.000	1.000	.996	.966	.849	.597	.278	.061	.002	.000	.000
10	1.000	1.000	1.000	1.000	.999	.991	.941	.783	.485	.164	.013	.001	.000
11	1.000	1.000	1.000	1.000	1.000	.998	.982	.909	.703	.352	.056	.005	.000
12	1.000	1.000	1.000	1.000	1.000	1.000	.996	.973	.873	.602	.184	.036	.000
13	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.995	.965	.833	.451	.171	.010
14	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.995	.965	.794	.537	.140

(continued)

Table I *(continued)*

h. $n = 20$

k \ p	.01	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95	.99
0	.818	.358	.122	.012	.001	.000	.000	.000	.000	.000	.000	.000	.000
1	.983	.736	.392	.069	.008	.001	.000	.000	.000	.000	.000	.000	.000
2	.999	.925	.677	.206	.035	.004	.000	.000	.000	.000	.000	.000	.000
3	1.000	.984	.867	.411	.107	.016	.001	.000	.000	.000	.000	.000	.000
4	1.000	.997	.957	.630	.238	.051	.006	.000	.000	.000	.000	.000	.000
5	1.000	1.000	.989	.804	.416	.126	.021	.002	.000	.000	.000	.000	.000
6	1.000	1.000	.998	.913	.608	.250	.058	.006	.000	.000	.000	.000	.000
7	1.000	1.000	1.000	.968	.772	.416	.132	.021	.001	.000	.000	.000	.000
8	1.000	1.000	1.000	.990	.887	.596	.252	.057	.005	.000	.000	.000	.000
9	1.000	1.000	1.000	.997	.952	.755	.412	.128	.017	.001	.000	.000	.000
10	1.000	1.000	1.000	.999	.983	.872	.588	.245	.048	.003	.000	.000	.000
11	1.000	1.000	1.000	1.000	.995	.943	.748	.404	.113	.010	.000	.000	.000
12	1.000	1.000	1.000	1.000	.999	.979	.868	.584	.228	.032	.000	.000	.000
13	1.000	1.000	1.000	1.000	1.000	.994	.942	.750	.392	.087	.002	.000	.000
14	1.000	1.000	1.000	1.000	1.000	.998	.979	.874	.584	.196	.011	.000	.000
15	1.000	1.000	1.000	1.000	1.000	1.000	.994	.949	.762	.370	.043	.003	.000
16	1.000	1.000	1.000	1.000	1.000	1.000	.999	.984	.893	.589	.133	.016	.000
17	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.996	.965	.794	.323	.075	.001
18	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.999	.992	.931	.608	.264	.017
19	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.999	.988	.878	.642	.182

i. $n = 25$

k \ p	.01	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95	.99
0	.778	.277	.072	.004	.000	.000	.000	.000	.000	.000	.000	.000	.000
1	.974	.642	.271	.027	.002	.000	.000	.000	.000	.000	.000	.000	.000
2	.998	.873	.537	.098	.009	.000	.000	.000	.000	.000	.000	.000	.000
3	1.000	.966	.764	.234	.033	.002	.000	.000	.000	.000	.000	.000	.000
4	1.000	.993	.902	.421	.090	.009	.000	.000	.000	.000	.000	.000	.000
5	1.000	.999	.967	.617	.193	.029	.002	.000	.000	.000	.000	.000	.000
6	1.000	1.000	.991	.780	.341	.074	.007	.000	.000	.000	.000	.000	.000
7	1.000	1.000	.998	.891	.512	.154	.022	.001	.000	.000	.000	.000	.000
8	1.000	1.000	1.000	.953	.677	.274	.054	.004	.000	.000	.000	.000	.000
9	1.000	1.000	1.000	.983	.811	.425	.115	.013	.000	.000	.000	.000	.000
10	1.000	1.000	1.000	.994	.902	.586	.212	.034	.002	.000	.000	.000	.000
11	1.000	1.000	1.000	.998	.956	.732	.345	.078	.006	.000	.000	.000	.000
12	1.000	1.000	1.000	1.000	.983	.846	.500	.154	.017	.000	.000	.000	.000
13	1.000	1.000	1.000	1.000	.994	.922	.655	.268	.044	.002	.000	.000	.000
14	1.000	1.000	1.000	1.000	.998	.966	.788	.414	.098	.006	.000	.000	.000
15	1.000	1.000	1.000	1.000	1.000	.987	.885	.575	.189	.017	.000	.000	.000
16	1.000	1.000	1.000	1.000	1.000	.996	.946	.726	.323	.047	.000	.000	.000
17	1.000	1.000	1.000	1.000	1.000	.999	.978	.846	.488	.109	.002	.000	.000
18	1.000	1.000	1.000	1.000	1.000	1.000	.993	.926	.659	.220	.009	.000	.000
19	1.000	1.000	1.000	1.000	1.000	1.000	.998	.971	.807	.383	.033	.001	.000
20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.991	.910	.579	.098	.007	.000
21	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.998	.967	.766	.236	.034	.000
22	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.991	.902	.463	.127	.002
23	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.998	.973	.729	.358	.026
24	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	.996	.928	.723	.222

Poisson Cumulative Prob.

Table 6 Cumulative Poisson Probabilities

	Mean Arrival Rate λ									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0	.9048	.8187	.7408	.6703	.6065	.5488	.4966	.4493	.4066	.3679
1	.9953	.9825	.9631	.9384	.9098	.8781	.8442	.8088	.7725	.7358
2	.9998	.9989	.9964	.9921	.9856	.9769	.9659	.9526	.9371	.9197
3	1.0000	.9999	.9997	.9992	.9982	.9966	.9942	.9909	.9865	.9810
4	1.0000	1.0000	1.0000	.9999	.9998	.9996	.9992	.9986	.9977	.9963
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	.9999	.9998	.9997	.9994
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	.9999
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

	Mean Arrival Rate λ									
	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
0	.3329	.3012	.2725	.2466	.2231	.2019	.1827	.1653	.1496	.1353
1	.6990	.6626	.6268	.5918	.5578	.5249	.4932	.4628	.4337	.4060
2	.9004	.8795	.8571	.8335	.8088	.7834	.7572	.7306	.7037	.6767
3	.9743	.9662	.9569	.9463	.9344	.9212	.9068	.8913	.8747	.8571
4	.9946	.9923	.9893	.9857	.9814	.9763	.9704	.9636	.9559	.9473
5	.9990	.9985	.9978	.9968	.9955	.9940	.9920	.9896	.9868	.9834
6	.9999	.9997	.9996	.9994	.9991	.9987	.9981	.9974	.9966	.9955
7	1.0000	1.0000	.9999	.9999	.9998	.9997	.9996	.9994	.9992	.9989
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	.9999	.9999	.9998	.9998
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

	Mean Arrival Rate λ									
	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
0	.1225	.1108	.1003	.0907	.0821	.0743	.0672	.0608	.0550	.0498
1	.3796	.3546	.3309	.3084	.2873	.2674	.2487	.2311	.2146	.1991
2	.6496	.6227	.5960	.5697	.5438	.5184	.4936	.4695	.4460	.4232
3	.8386	.8194	.7993	.7787	.7576	.7360	.7141	.6919	.6696	.6472
4	.9379	.9275	.9162	.9041	.8912	.8774	.8629	.8477	.8318	.8153
5	.9796	.9751	.9700	.9643	.9580	.9510	.9433	.9349	.9258	.9161
6	.9941	.9925	.9906	.9884	.9858	.9828	.9794	.9756	.9713	.9665
7	.9985	.9980	.9974	.9967	.9958	.9947	.9934	.9919	.9901	.9881
8	.9997	.9995	.9994	.9991	.9989	.9985	.9981	.9976	.9969	.9962
9	.9999	.9999	.9999	.9998	.9997	.9996	.9995	.9993	.9991	.9989
10	1.0000	1.0000	1.0000	1.0000	.9999	.9999	.9999	.9998	.9998	.9997
11	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	.9999	.9999
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

	Mean Arrival Rate λ									
	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0
0	.0450	.0408	.0369	.0334	.0302	.0273	.0247	.0224	.0202	.0183
1	.1847	.1712	.1586	.1468	.1359	.1257	.1162	.1074	.0992	.0916
2	.4012	.3799	.3594	.3397	.3208	.3027	.2854	.2689	.2531	.2381
3	.6248	.6025	.5803	.5584	.5366	.5152	.4942	.4735	.4532	.4335
4	.7982	.7806	.7626	.7442	.7254	.7064	.6872	.6678	.6484	.6288
5	.9057	.8946	.8829	.8705	.8576	.8441	.8301	.8156	.8006	.7851
6	.9612	.9554	.9490	.9421	.9347	.9267	.9182	.9091	.8995	.8893
7	.9858	.9832	.9802	.9769	.9733	.9692	.9648	.9599	.9546	.9489
8	.9953	.9943	.9931	.9917	.9901	.9883	.9863	.9840	.9815	.9786

(continued)

Table 6 Cumulative Poisson Probabilities (*Continued*)

	Mean Arrival Rate λ									
	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0
9	.9986	.9982	.9978	.9973	.9967	.9960	.9952	.9942	.9931	.9919
10	.9996	.9995	.9994	.9992	.9990	.9987	.9984	.9981	.9977	.9972
11	.9999	.9999	.9998	.9998	.9997	.9996	.9995	.9994	.9993	.9991
12	1.0000	1.0000	1.0000	.9999	.9999	.9999	.9999	.9998	.9998	.9997
13	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	.9999	.9999
14	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

	Mean Arrival Rate λ									
	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
0	.0166	.0150	.0136	.0123	.0111	.0101	.0091	.0082	.0074	.0067
1	.0845	.0780	.0719	.0663	.0611	.0563	.0518	.0477	.0439	.0404
2	.2238	.2102	.1974	.1851	.1736	.1626	.1523	.1425	.1333	.1247
3	.4142	.3954	.3772	.3594	.3423	.3257	.3097	.2942	.2793	.2650
4	.6093	.5898	.5704	.5512	.5321	.5132	.4946	.4763	.4582	.4405
5	.7693	.7531	.7367	.7199	.7029	.6858	.6684	.6510	.6335	.6160
6	.8786	.8675	.8558	.8436	.8311	.8180	.8046	.7908	.7767	.7622
7	.9427	.9361	.9290	.9214	.9134	.9049	.8960	.8867	.8769	.8666
8	.9755	.9721	.9683	.9642	.9597	.9549	.9497	.9442	.9382	.9319
9	.9905	.9889	.9871	.9851	.9829	.9805	.9778	.9749	.9717	.9682
10	.9966	.9959	.9952	.9943	.9933	.9922	.9910	.9896	.9880	.9863
11	.9989	.9986	.9983	.9980	.9976	.9971	.9966	.9960	.9953	.9945
12	.9997	.9996	.9995	.9993	.9992	.9990	.9988	.9986	.9983	.9980
13	.9999	.9999	.9998	.9998	.9997	.9997	.9996	.9995	.9994	.9993
14	1.0000	1.0000	1.0000	.9999	.9999	.9999	.9999	.9999	.9998	.9998

	Mean Arrival Rate λ									
	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0
0	.0061	.0055	.0050	.0045	.0041	.0037	.0033	.0030	.0027	.0025
1	.0372	.0342	.0314	.0289	.0266	.0244	.0224	.0206	.0189	.0174
2	.1165	.1088	.1016	.0948	.0884	.0824	.0768	.0715	.0666	.0620
3	.2513	.2381	.2254	.2133	.2017	.1906	.1800	.1700	.1604	.1512
4	.4231	.4061	.3895	.3733	.3575	.3422	.3272	.3127	.2987	.2851
5	.5984	.5809	.5635	.5461	.5289	.5119	.4950	.4783	.4619	.4457
6	.7474	.7324	.7171	.7017	.6860	.6703	.6544	.6384	.6224	.6063
7	.8560	.8449	.8335	.8217	.8095	.7970	.7841	.7710	.7576	.7440
8	.9252	.9181	.9106	.9027	.8944	.8857	.8766	.8672	.8574	.8472
9	.9644	.9603	.9559	.9512	.9462	.9409	.9352	.9292	.9228	.9161
10	.9844	.9823	.9800	.9775	.9747	.9718	.9686	.9651	.9614	.9574
11	.9937	.9927	.9916	.9904	.9890	.9875	.9859	.9841	.9821	.9799
12	.9976	.9972	.9967	.9962	.9955	.9949	.9941	.9932	.9922	.9912
13	.9992	.9990	.9988	.9986	.9983	.9980	.9977	.9973	.9969	.9964
14	.9997	.9997	.9996	.9995	.9994	.9993	.9991	.9990	.9988	.9986

	Mean Arrival Rate λ									
	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0
0	.0022	.0020	.0018	.0017	.0015	.0014	.0012	.0011	.0010	.0009
1	.0159	.0146	.0134	.0123	.0113	.0103	.0095	.0087	.0080	.0073
2	.0577	.0536	.0498	.0463	.0430	.0400	.0371	.0344	.0320	.0296
3	.1425	.1342	.1264	.1189	.1118	.1052	.0988	.0928	.0871	.0818

Table 6 Cumulative Poisson Probabilities (*Continued*)

	MEAN ARRIVAL RATE λ									
	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0
4	.2719	.2592	.2469	.2351	.2237	.2127	.2022	.1920	.1823	.1730
5	.4298	.4141	.3988	.3837	.3690	.3547	.3406	.3270	.3137	.3007
6	.5902	.5742	.5582	.5423	.5265	.5108	.4953	.4799	.4647	.4497
7	.7301	.7160	.7017	.6873	.6728	.6581	.6433	.6285	.6136	.5987
8	.8367	.8259	.8148	.8033	.7916	.7796	.7673	.7548	.7420	.7291
9	.9090	.9016	.8939	.8858	.8774	.8686	.8596	.8502	.8405	.8305
10	.9531	.9486	.9437	.9386	.9332	.9274	.9214	.9151	.9084	.9015
11	.9776	.9750	.9723	.9693	.9661	.9627	.9591	.9552	.9510	.9467
12	.9900	.9887	.9873	.9857	.9840	.9821	.9801	.9779	.9755	.9730
13	.9958	.9952	.9945	.9937	.9929	.9920	.9909	.9898	.9885	.9872
14	.9984	.9981	.9978	.9974	.9970	.9966	.9961	.9956	.9950	.9943

	MEAN ARRIVAL RATE λ									
	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0
0	.0008	.0007	.0007	.0006	.0006	.0005	.0005	.0004	.0004	.0003
1	.0067	.0061	.0056	.0051	.0047	.0043	.0039	.0036	.0033	.0030
2	.0275	.0255	.0236	.0219	.0203	.0188	.0174	.0161	.0149	.0138
3	.0767	.0719	.0674	.0632	.0591	.0554	.0518	.0485	.0453	.0424
4	.1641	.1555	.1473	.1395	.1321	.1249	.1181	.1117	.1055	.0996
5	.2881	.2759	.2640	.2526	.2414	.2307	.2203	.2103	.2006	.1912
6	.4349	.4204	.4060	.3920	.3782	.3646	.3514	.3384	.3257	.3134
7	.5838	.5689	.5541	.5393	.5246	.5100	.4956	.4812	.4670	.4530
8	.7160	.7027	.6892	.6757	.6620	.6482	.6343	.6204	.6065	.5925
9	.8202	.8096	.7988	.7877	.7764	.7649	.7531	.7411	.7290	.7166
10	.8942	.8867	.8788	.8707	.8622	.8535	.8445	.8352	.8257	.8159
11	.9420	.9371	.9319	.9265	.9208	.9148	.9085	.9020	.8952	.8881
12	.9703	.9673	.9642	.9609	.9573	.9536	.9496	.9454	.9409	.9362
13	.9857	.9841	.9824	.9805	.9784	.9762	.9739	.9714	.9687	.9658
14	.9935	.9927	.9918	.9908	.9897	.9886	.9873	.9859	.9844	.9827
15	.9972	.9969	.9964	.9959	.9954	.9948	.9941	.9934	.9926	.9918
16	.9989	.9987	.9985	.9983	.9980	.9978	.9974	.9971	.9967	.9963
17	.9996	.9995	.9994	.9993	.9992	.9991	.9989	.9988	.9986	.9984
18	.9998	.9998	.9998	.9997	.9997	.9996	.9996	.9995	.9994	.9993
19	.9999	.9999	.9999	.9999	.9999	.9999	.9998	.9998	.9998	.9997
20	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	.9999	.9999	.9999	.9999

	MEAN ARRIVAL RATE λ									
	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0
0	.0003	.0003	.0002	.0002	.0002	.0002	.0002	.0002	.0001	.0001
1	.0028	.0025	.0023	.0021	.0019	.0018	.0016	.0015	.0014	.0012
2	.0127	.0118	.0109	.0100	.0093	.0086	.0079	.0073	.0068	.0062
3	.0396	.0370	.0346	.0323	.0301	.0281	.0262	.0244	.0228	.0212
4	.0940	.0887	.0837	.0789	.0744	.0701	.0660	.0621	.0584	.0550
5	.1822	.1736	.1653	.1573	.1496	.1422	.1352	.1284	.1219	.1157
6	.3013	.2896	.2781	.2670	.2562	.2457	.2355	.2256	.2160	.2068
7	.4391	.4254	.4119	.3987	.3856	.3728	.3602	.3478	.3357	.3239
8	.5786	.5647	.5507	.5369	.5231	.5094	.4958	.4823	.4689	.4557
9	.7041	.6915	.6788	.6659	.6530	.6400	.6269	.6137	.6006	.5874
10	.8058	.7955	.7850	.7743	.7634	.7522	.7409	.7294	.7178	.7060

(*continued*)

Home Work # 1

1. How many different basketball lineups can be made from a team of ten men if all ten men can play any position? How many lineups are possible if the team contains two centers, four guards, and four forwards, and the lineup must include one center, two guards, and two forwards?

2. Sears advertises that the customer can select one of the possible frequency codes on an automatic garage-door opener by setting nine switches in one of two positions (e.g., + or -).
   a) How many different codes might a burglar have to try before being assured of finding the correct one (the answer 'all of them' is not sufficient)? What is the probability that the burglar will be right on one randomly selected try?
   b) Suppose the burglar knows that eight of the nine switches are set on + and one on -. What is now the probability of his being correct on one randomly selected try?

3.
   a) The President of the U.S.A. is scheduled to visit three different countries. In how many different orders can these three countries be visited? Draw the tree diagram.
   b) In how many different orders can the President visit three countries if there are ten possible countries that could be visited?
   c) How many different combinations of three countries could be visited if there is a list of ten possible countries to visit (order isn't important)?

4. How many different permutations are there of the ten letters in the word 'statistics'?

5. Wendy's hamburger chain advertises that you can order your hamburger with any one of 256 different combinations of toppings. How many different toppings will you get if you order your burger with 'everything,' assuming each topping (such as tomato) is either on or off?

6. The following data describe certain characteristics of the students enrolled at a university.

	Men	Women	Over 21
Freshmen	1325	1100	125
Sophomores	1200	900	175
Juniors	900	850	325
Seniors	725	775	950
Graduates	1350	875	2225

   a) How many students are enrolled in this university
   b) What is the probability that a student selected 'at random' will be a woman?
   c) What is the probability that a student selected at random will be a senior?
   d) Calculate P(sophomore $\cap$ male) and P(sophomore | male)

7. In a certain city it is known that one-fourth of the people leave their keys in their cars. The police chief estimates that five percent of the cars with keys left in the ignition will be stolen, but that only one percent of the cars without keys left in the ignition will be stolen. What is the probability that a car stolen in this city had the keys in the ignition?

8. Three airlines serve a small town. Airline A has 50% of all the scheduled flights, airline B has 30%, and airline C has the remaining 20%. Their on- time rates are 80%, 65% and 40%, respectively. A plane has left on time. What is the probability that it was airline B?

9. Eight helicopters were part of the April 25, 1980, ill-fated attempt by the U.S. to rescue the Iranian hostages. At least six helicopters had to be operational for the mission to continue.
   a) Suppose that the probability of failure for each helicopter during the mission is 0.10, and failures are independent of one another. What is the probability that three or more of the helicopters will fail?
   b) What is the expected numbers of failed aircrafts?

10. A barbershop has on the average ten customers arriving between 8:00 and 9:00 each morning that it is open. Customers arrive according to the Poisson distribution.
    a) What is the probability that the barbershop will have exactly ten customers between these hours on a given morning?
    b) What is the probability that the barbershop will have more than twelve customers?
    c) What is the probability that the barbershop will have fewer than six customers?