Assignment 1

(1) In a certain random experiment, let $A$ and $B$ be two events such that $P(A) = 0.7$, $P(B) = 0.5$, and $P((A \cup B)') = 0.1$, show that

(a) $P(A \cap B) = 0.30$
(b) $P(A|B) = 0.60$
(c) $P(B|A) = \frac{3}{7}$
(d) $P(A \cap B) = 0.30 \neq 0.7 \times 0.5 = P(A)P(B)$.
(e) $A$ and $B$ are not independent events.

(2) In a certain random experiment, let $C$ and $D$ be two events such that $P(C) = 0.8$, $P(D) = 0.4$, and $P((C \cup D)') = 0.12$, show that

(a) $P(C \cap D) = 0.32$
(b) $P(D|C) = 0.40$
(c) $P(C|D) = 0.80$
(d) $P(C \cap D) = 0.32 = 0.8 \times 0.4 = P(C)P(D)$.
(e) $C$ and $D$ are independent events.

(3) The grip strengths at the end of a health dynamics course for 15 male students were

$$\begin{align*}
58 & \quad 52 & \quad 46 & \quad 57 & \quad 52 & \quad 45 & \quad 65 & \quad 71 & \quad 57 & \quad 54 & \quad 48 & \quad 58 & \quad 35 & \quad 44 & \quad 53
\end{align*}$$

Find the mean, variance and standard deviation of these 15 grip strengths.

(4) If $P(A) = 0.4$, $P(B) = 0.5$, and $P(A \cap B) = 0.3$, find (a) $P(A \cup B)$, (b) $P(A \cap B')$, (c) $P(A' \cup B')$.

(5) A typical American roulette wheel used in a casino has 38 slots that are numbered 1, 2, \cdots, 35, 36, 0, 00 respectively. The 0 and 00 are colored as green. Half of the remaining slots are red and half are black. Also, half of the integers between 1 and 36 inclusive are odd, half are even. A ball is rolled around the wheel and ends up in one of the 38 slots; we assume that each slot has equal probability of $1/38$ and we are interested in the number of the slots in which the ball falls.

(a) What is the sample space $S$.
(b) Let $B = \{0, 00\}$, what is $P(B)$?
(c) Let $C = \{14, 15, 17, 18\}$, what is $P(C)$?
(d) Let \( D = \{ x \in S \mid x \text{ is odd} \} \), what is \( P(D) \)?

(6) Prove that

(a) \[ \binom{n}{k} = \binom{n-1}{k} + \binom{n-1}{k-1} \]

(b) \[ \sum_{k=0}^{n} (-1)^k \binom{n}{k} = 0 \]

(c) \[ \sum_{k=0}^{n} \binom{n}{k} = 2^n \]

(7) Let an experiment be drawing five cards at random without replacement from a deck of 52 poker cards. The sample size is then \( C(52, 5) = 2,598,960 \). Find the size of the following events.

(a) Four of a kind (four cards of equal face value and one card of a different value).

(b) Full house (one pair and one triple of cards with equal face value).

(c) Three of a kind (three equal face values plus two cards of different values).

(d) Two pairs (two pairs of equal face value plus one card of a different value).

(e) One pair (one pair of equal face value plus three cards of different values).

(8) A box contains four marbles numbered 1 through 4. The marbles are selected one at a time without replacement. A match occurs if marble numbered \( k \) is the \( k \)th marble selected. Let the event \( A_i \), denote a match on the \( i \)th draw, \( i=1,2,3,4 \).

(a) Find \( P(A_i) \), for \( i=1,2,3,4 \).

(b) Find \( P(A_i \cap A_j) \), where 1 \( \leq i < j \leq 4 \).

(c) Find \( P(A_i \cap A_j \cap A_k) \), where 1 \( \leq i < j < k \leq 4 \).

(d) Find \( P(A_1 \cup A_2 \cup A_3 \cup A_4) \).

(e) Extend this exercise so that there are \( n \) marbles in the box. Show that the probability of at least one match is

\[ P(A_1 \cup A_2 \cup \cdots \cup A_n) = 1 - \frac{1}{2!} + \frac{1}{3!} - \frac{1}{4!} + \cdots + \frac{(-1)^{n+1}}{n!} \]

\[ = 1 - \left(1 - \frac{1}{2!} + \frac{1}{3!} - \frac{1}{4!} + \cdots + \frac{(-1)^n}{n!} \right) \]

(f) What is the limit of this probability as \( n \) increases without bound?
Consider a random experiment of casting a pair of unbiased six-sided dice and let the r.v. X equal the smaller of the outcomes if they are different and the common value if they are equal.

(a) Find the probability mass function (p.m.f.) of r.v. X.
(b) Draw a probability histogram.
(c) Find the expectation and variance of r.v. X.

The number of defects on a printed circuit board is a random variable (r.v.) X with the probability mass function (p.m.f.) given by

\[ P(X = i) = \frac{\gamma}{(i + 1)}, \quad i = 0, 1, 2, 3, 4 \]

(a) Compute the constant \( \gamma \).
(b) Compute the mean of X.
(c) Compute the variance of X.

Bean seeds from supplier A have 85% germination rate and those from supplier B have a 75% germination rate. A seed packaging company purchases 40% of their bean seeds from supplier A and 60% from supplier B and mixes these seeds together.

(a) Find the probability that a seed selected at random from the mixed seeds will germinate, say \( P(G) \).
(b) Given that a seed germinates, find the probability that the seed was purchased from supplier A.
(c) Given that a seed germinates, find the probability that the seed was purchased from supplier B.

Some ornithologists were interested in the clutch size of the common gallinule. They observed the number of eggs in each of 117 nests which are listed below.

| 7 5 13 7 7 8 9 9 9 8 8 9 7 7 |
| 5 9 7 7 4 9 8 8 10 9 7 8 8 7 |
| 9 7 7 10 8 7 9 7 10 8 9 7 11 10 9 |
| 9 4 8 6 8 9 9 9 8 8 5 8 8 9 9 |
| 14 10 8 9 9 8 7 9 7 9 10 10 7 6 |
| 11 7 7 6 9 7 7 6 8 9 4 6 9 8 9 |
| 7 9 9 9 8 8 8 9 9 9 8 10 9 9 |
| 8 5 7 8 7 6 7 7 7 6 5 9 |

(a) Construct a frequency table for these data.
(b) Draw a histogram.
(c) What is the mode (the typical clutch size)?

(13) The following data give the ACT math and ACT verbal scores, say, \((x, y)\), for 15 students:

\[
\begin{array}{cccc}
(16,19) & (18,17) & (22,18) & (20,23) \\
(25,21) & (21,24) & (23,18) & (24,18) \\
(27,29) & (28,24) & (30,24) & (27,23) \\
\end{array}
\]

(a) Verify that \(\bar{x} = 23.8\), \(\bar{y} = 21.8\), \(s_x^2 = 22.457\), \(s_y^2 = 11.600\), \(r = 0.626\).
(b) Find the equation of the best fitting line.
(c) Plot the 15 points and the line on the same graph.

(14) The final scores of 59 students taking CS3332 course in Fall, 1999 are listed below.

\[
\begin{array}{cccccccc}
61 & 72 & 77 & 58 & 67 & 70 & 76 & 70 & 83 \\
42 & 58 & 49 & 74 & 65 & 55 & 90 & 80 & 31 \\
53 & 82 & 90 & 51 & 48 & 55 & 84 & 70 & 48 \\
61 & 76 & 70 & 70 & 66 & 50 & 80 & 73 & 77 \\
71 & 99 & 66 & 63 & 63 & 52 & 54 & 80 & 67 \\
52 & 83 & 62 & 60 & 61 & 86 & 61 & 70 & 73 \\
\end{array}
\]

(a) Find the order statistics of this set of data.
(b) Find the 25th, 75th percentiles, and the median.
(c) Find five-number summary of these data.
(d) Draw a box-and-whisker diagram.