Project 6

by

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ALY6000 : Introduction to Analytics

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Project 6

Introduction

This report presents an analysis of probability distributions using R. The objective is to solve real-world problems using binomial, Poisson, and normal distributions. The problems involve analyzing baseball game outcomes, call center efficiency, and the lifespan of light bulbs. Additionally, an exploration of the Palmer Penguins dataset is included. The results provide insights into statistical probabilities, expected values, variances, and real-world applications of probability theory.

Analyzing a baseball probability distribution

1. What is the probability that the Red Sox will win exactly 5 games (prob1_result)?

2. Create a data.frame or tibble with each possible outcome and the probability of that outcome. Name your columns wins and probability (prob2_result).

3. What is the probability that the Red Sox will win fewer than 5 games (prob3_result)?

4. What is the probability that the Red Sox will win between 3 and 5 games inclusively (prob4_result)?

5. What is the probability of the Red Sox winning more than 4 games (prob5_result)?

6. What is the theoretical expected value of the number of wins for the Red Sox in a 7-game series (prob6_result)?

7. What is the theoretical variance of the number of wins for the Red Sox in a 7- game series (prob7_result)?

8. Generate 1,000 random values for the number of wins by the Red Sox in a 7- game series. Use set.seed(10) before generating the random values.

9. Compute the sample mean of the 1,000 random values (prob9_result).

10. Compute the sample variance of the 1,000 random values (prob10_result).

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```r
prob1_result <- dbinom(5, size = 7, prob = 0.65)

wins <- 0:7
probabilities <- dbinom(wins, size = 7, prob = 0.65)
prob2_result <- tibble(wins, probability = probabilities)

prob3_result <- pbinom(4, size = 7, prob = 0.65)

prob4_result <- pbinom(5, size = 7, prob = 0.65) - pbinom(2, size = 7, prob = 0.65)

prob5_result <- 1 - pbinom(4, size = 7, prob = 0.65)

prob6_result <- 7 * 0.65

prob7_result <- 7 * 0.65 * (1 - 0.65)

set.seed(10)
random_wins <- rbinom(1000, size = 7, prob = 0.65)

prob9_result <- mean(random_wins)

prob10_result <- var(random_wins)
```

```
$prob1_result
[1] 0.2984848

$prob2_result
# A tibble: 8 x 2
   wins probability
  <int>       <dbl>
1     0    0.000643
2     1    0.00836
3     2    0.0466
4     3    0.144
5     4    0.268
6     5    0.298
7     6    0.185
8     7    0.0490

$prob3_result
[1] 0.4677167

$prob4_result
[1] 0.7105939

$prob5_result
[1] 0.5322833

$prob6_result
[1] 4.55

$prob7_result
[1] 1.5925

$prob9_result
[1] 4.521

$prob10_result
[1] 1.689248
```

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Analyzing calls in a call center

The number of calls received each hour at a call center follows a Poisson distribution averaging seven calls per employee per hour.

11. What is the probability that an employee will receive exactly 6 calls in the next hour (prob11_result)?
12. What is the probability that an employee will receive 40 or fewer calls in the next 8 hours (prob12_result)?
13. Assuming that there are 5 employees working eight-hour shifts, what is the probability that they will meet the quota of 275 or more calls during the shift (prob13_result)?
14. If one employee is sick, what is the probability that the remaining team will still meet the quota of 275 or more calls during their shift (prob14_result)?
15. For a single employee working an 8-hour shift, how many calls are necessary for the day to be considered in the top 10% of days volume-wise (prob15_result)?
16. Generate 1,000 random values for the number of calls for a single employee during an 8-hour shift. Use a set.seed(15) before creating values.
17. Compute the sample mean of the 1,000 random values (prob17_result).
18. Compute the sample variance of the 1,000 random values (prob18_result).

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```r
prob11_result <- dpois(6, lambda = 7)

prob12_result <- ppois(40, lambda = 7 * 8)

prob13_result <- 1 - ppois(274, lambda = 5 * 7 * 8)

prob14_result <- 1 - ppois(274, lambda = 4 * 7 * 8)

prob15_result <- qpois(0.9, lambda = 7 * 8)

set.seed(15)
random_calls <- rpois(1000, lambda = 7 * 8)

prob17_result <- mean(random_calls)

prob18_result <- var(random_calls)
```

```
$prob11_result
[1] 0.1490028

$prob12_result
[1] 0.01552688

$prob13_result
[1] 0.6254307

$prob14_result
[1] 0.0005401031

$prob15_result
[1] 66

$prob17_result
[1] 56.303

$prob18_result
[1] 54.83002
```

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Analyzing the lifespans of light bulbs

The life spans of light bulbs at a certain manufacturing company follow a normal distribution, with a mean life span of 2,000 hours and a standard deviation of 100 hours.

19. What is the percentage of light bulbs with a lifespan of between 1,800 and 2,200 hours (prob19_result)?

20. What is the percentage of light bulbs with a life span of more than 2,500 hours (prob20_result)?

21. Light bulbs that fall in the bottom 10% of life spans are considered defective and can be returned for a full refund. What is the maximum number of hours in a light bulb's life span for it to fall into the defective category? Round your result up to the nearest integer value (prob21_result)?

22. Generate 10,000 random values for the life spans of manufactured light bulbs. Use set.seed(25) before generating the values. For the remaining problems, consider this the population of light bulbs.

23. Compute the population mean for the random values (prob23_result).

24. Compute the population standard deviation for the random values (prob24_result).

25. Take 1,000 different samples from the random values, where each sample contains 100 values. For each of the 1,000 different samples, compute the sample mean and store all 1,000 results in a vector. Use set.seed(1) before computing the samples (prob25_result).

26. With the result of the prior problem, create a histogram.

27. Compute the mean of the of the values from problem 25 (prob27_result).

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```r
prob19_result <- pnorm(2200, mean = 2000, sd = 100) - pnorm(1800, mean = 2000, sd = 100)

prob20_result <- 1 - pnorm(2500, mean = 2000, sd = 100)

prob21_result <- ceiling(qnorm(0.1, mean = 2000, sd = 100))

set.seed(25)
random_lifespans <- rnorm(10000, mean = 2000, sd = 100)

prob23_result <- mean(random_lifespans)

prob24_result <- sd(random_lifespans)

set.seed(1)
sample_means <- replicate(1000, mean(sample(random_lifespans, 100, replace = TRUE)))

prob27_result <- mean(sample_means)
```

```
$prob19_result
[1] 0.9544997

$prob20_result
[1] 2.866516e-07

$prob21_result
[1] 1872

$prob23_result
[1] 1999.71

$prob24_result
[1] 100.0586

$prob27_result
[1] 1999.525
```

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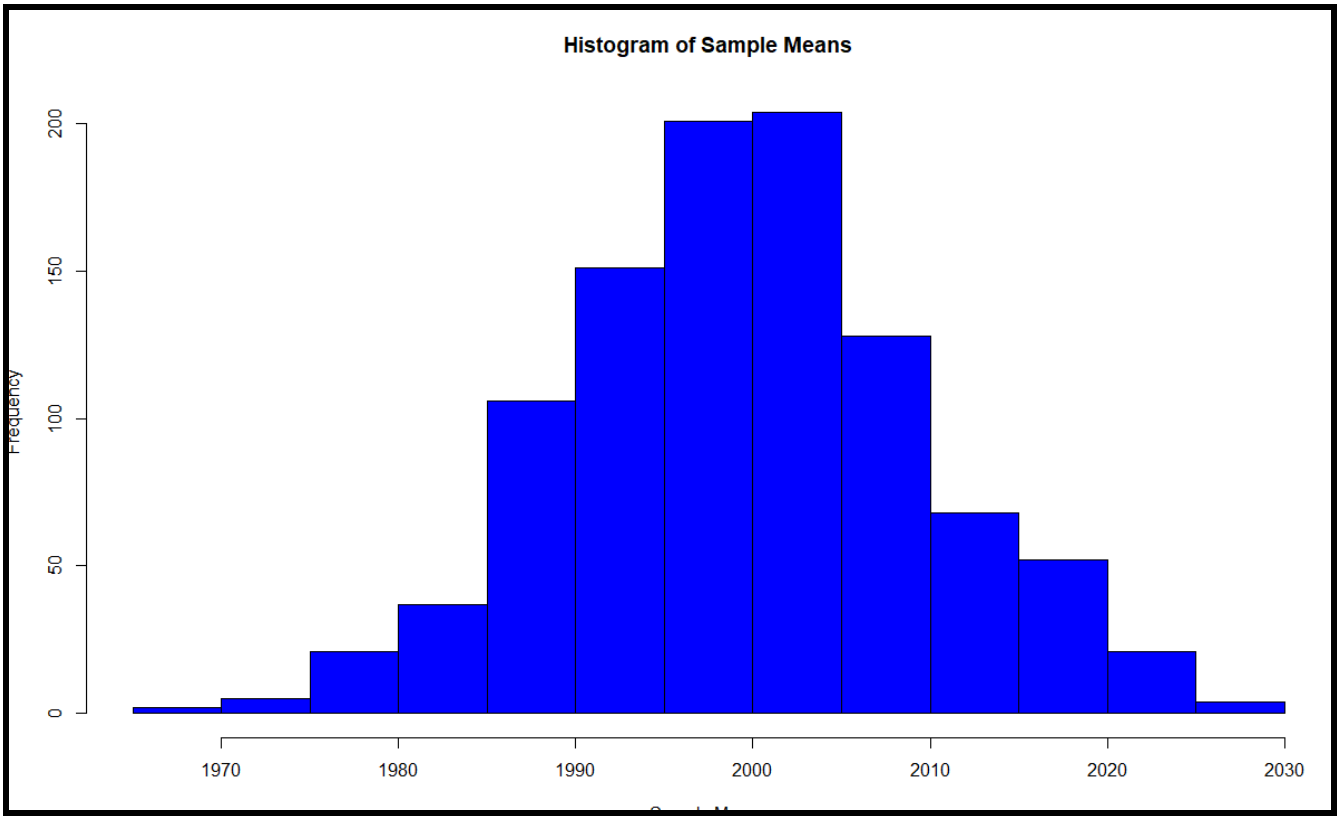


```
$prob22_result
   [1] 1978.817 1895.841 1884.669 2032.153 1849.987 1955.447 2173.405 2051.130 2009.965 1994.211 1825.721 1867.505 1945.207 1854.362 2008.269 2092.758 1928.323 2096.240 2154.588 1899.024 2055.741 2016.878 2015.526 2236.776 1841.436 1889.647 2090.279 2006.832
  [29] 1885.053 1909.873 1880.155 1948.984 2030.625 1993.212 2037.220 2114.449 1856.039 1925.459 1891.574 1908.819 2025.447 2005.454 2086.940 1950.418 2078.898 1995.172 2028.444 1765.509 2035.214 1926.329 2015.287 2046.664 1865.138 1962.867 2204.820 1896.965
  [57] 1919.109 1910.049 2132.165 1850.741 1856.484 2004.659 1994.981 1871.247 2115.411 1862.426 1885.170 2141.626 2010.576 1961.534 2178.448 1888.471 1992.785 1934.507 2123.475 1964.500 2002.429 1887.985 2013.152 1898.211 2154.413 1938.750 1852.455 1866.116
  [85] 2011.600 2044.101 2025.333 1939.868 1931.813 1936.159 2112.551 2168.030 1995.418 1964.030 1872.723 2165.151 2097.073 1970.084 2008.634 1843.222 1906.582 1964.922 1950.223 2077.132 1930.509 1922.371 2004.013 1903.484 1955.644 2048.223 2029.936
 [113] 1886.024 2075.012 1965.395 1970.134 2115.743 2137.832 1943.880 1927.256 2054.256 2107.424 1932.849 1985.951 2146.725 2056.336 2124.070 1974.658 2019.699 1870.736 1929.976 2018.625 1951.088 1913.688 2021.167 1989.528 2088.527 1866.284 1958.026 2011.490
 [141] 2037.979 2133.755 2000.553 1895.198 1970.692 1939.200 2022.270 2040.458 2021.208 1871.629 1981.326 2147.505 1966.433 1992.473 2093.825 1880.084 1917.687 2177.585 1927.349 1914.541 2018.722 2066.475 1962.134 1959.372 1962.205 1942.172 1980.410 1924.712
 [169] 1879.282 2010.304 2070.757 2048.819 1932.565 2145.780 1957.318 2037.208 1951.064 2200.664 2009.181 1943.690 1996.277 2100.352 1885.756 2114.469 2126.070 2066.462 2075.022 1860.970 2081.884 1905.134 2287.434 2023.748 2074.588 2119.495 2062.740 1918.927
 [197] 2158.246 1958.567 1808.586 1831.961 1955.964 1725.592 1962.202 1918.540 2170.957 2034.287 2063.775 2008.015 1937.521 1932.759 2029.768 1870.085 2098.544 2134.243 2073.305 2234.857 1885.249 2090.557 2046.014 2107.668 2144.822 2032.407 1917.934 1959.455
 [225] 1921.594 2044.261 1962.538 2085.467 2018.943 1967.091 1817.504 1969.663 1979.031 1926.342 1963.270 2096.816 2075.405 2103.359 2020.057 2103.409 2144.640 2243.633 1915.444 2045.871 2084.064 1909.840 1908.600 2066.702 2051.595 1947.776 1954.432 1804.986
 [253] 2101.816 1825.929 1977.654 2119.999 2063.590 2013.101 2132.995 1992.053 2004.098 1927.491 2029.792 1838.177 1962.295 1904.868 1744.191 1921.525 1954.626 2182.372 1896.109 2105.288 1833.764 2046.137 1865.494 2029.036 2021.018 2131.999 2078.078 1891.935
 [281] 1896.629 1872.881 1998.138 1999.587 1906.205 1916.369 2238.604 2203.504 2144.901 2062.440 1917.809 1959.371 2025.167 2113.595 1995.344 1962.050 1977.392 1921.794 2113.939 1892.557 1844.992 2111.986 2066.688 2034.790 1965.267 1964.268 2019.112 1934.915
 [309] 2089.615 1893.944 1977.125 1847.137 2009.224 1875.402 2176.414 1993.066 2029.916 1996.452 2051.212 1915.848 2111.676 2034.239 1993.350 1896.853 1932.439 2069.204 2051.100 2027.789 2051.365 1867.365 2029.121 1843.798 2102.866 2002.780 2053.189 2133.406
 [337] 2116.578 1960.741 2065.233 1910.493 1978.356 2040.819 1938.665 2135.820 1967.030 1955.152 2128.421 2063.420 1964.141 2019.628 2076.866 2073.203 2130.844 1921.879 1974.630 1944.730 2048.051 2107.993 1999.854 1872.446 1925.096 2049.397 2014.696 1999.793
 [365] 2021.932 1957.839 2049.490 2019.872 1867.964 2139.956 1999.613 2088.108 1989.936 1865.213 1877.421 2113.348 2142.973 1938.733 2040.669 1980.867 1910.162 1909.585 1849.427 1972.517 1846.128 1884.277 2162.795 2024.150 2114.415 2001.109 1904.398 2014.483
 [393] 1934.203 1970.377 2042.191 1832.627 2043.651 2015.104 2199.230 2171.631 2079.680 1961.063 2020.838 1983.436 1919.401 2023.809 1923.996 2122.937 1894.481 2251.556 2034.904 2076.321 1906.536 1977.560 1897.130 1980.239 1774.069 1928.480 1974.087 1856.590
 [421] 2072.099 2062.567 2104.432 1917.937 2044.263 1930.971 2144.371 2056.260 2058.947 1982.039 1934.503 2050.871 1914.161 1854.894 1978.053 2025.865 1998.617 1950.815 2168.880 1896.799 1990.095 1930.743 2072.926 1931.643 1979.580 2153.370 2018.053 1855.356
 [449] 1980.341 2131.337 2169.554 1933.367 2005.774 1890.343 1955.049 2146.211 2085.642 2123.770 1955.374 2011.216 2024.233 1866.420 2194.570 2116.815 1965.157 1920.769 2039.209 1797.379 1967.216 2044.532 1730.450 2082.426 1992.113 2153.421 2155.860 1934.525
 [477] 1972.558 2145.523 1878.463 2089.620 1947.657 1970.378 1939.139 2107.959 2064.846 2075.910 1966.544 2131.127 2131.534 2122.481 1908.319 1808.044 1960.866 1933.643 1941.482 2093.048 1959.269 2118.133 2019.391 2051.529 2123.898 2155.113 1925.237 2024.100
 [505] 1953.347 1806.729 2055.212 1869.806 1856.321 2145.420 2064.613 1959.330 1895.598 1929.373 1919.675 1934.161 1898.074 1869.120 2080.109 1985.900 1978.885 1971.607 2070.329 1833.081 2072.619 1962.945 1915.490 2029.762 1945.959 2191.094 2079.571 1715.787
 [533] 2044.611 1833.712 2067.433 2026.182 2149.192 1821.145 2270.707 1985.680 2005.673 1932.104 2038.868 1980.367 2021.408 1965.066 2078.127 2016.320 2133.727 1952.988 2040.980 2009.738 1769.177 1933.169 1925.785 2036.528 2058.772 2266.740 1969.959 2025.548
 [561] 1960.421 1948.952 2064.706 2067.504 1867.242 1927.368 1956.314 2195.884 2019.843 2003.147 2008.113 2005.764 1870.101 2095.458 2069.195 2005.424 1956.296 2018.185 1943.773 2048.120 1868.216 2124.758 2197.749 1973.209 2208.057 1934.478 1823.318 2084.468
 [589] 2078.788 2110.824 1951.977 1877.919 2116.474 1850.921 2179.768 1957.420 2011.869 2068.367 1999.027 2048.244 2031.219 2141.289 2002.394 2038.508 1916.470 1980.207 2145.370 1909.448 1929.383 1939.075 2016.616 1940.814 2127.307 1995.736 1970.771 2001.333
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 [645] 2020.390 2125.999 2000.575 2150.708 2042.543 1962.644 2016.424 2015.688 1816.498 2102.573 2057.978 1941.604 2115.599 1958.725 1999.997 1742.962 2043.993 1968.412 2029.451 1992.075 2143.304 1913.394 1957.253 1943.069 2113.084 2174.760 2044.784 1969.297
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 [729] 1900.908 1935.244 2222.450 1997.191 1845.390 1850.350 1994.965 1858.198 2035.648 2093.903 1860.017 1953.208 1922.751 1870.001 1953.343 2027.294 2131.518 1973.266 1987.220 1926.644 2039.426 2174.493 1748.635 2050.318 1987.180 2204.273 2003.419 1929.495
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 [813] 1963.843 2100.473 1916.702 2100.009 1871.185 2150.401 1852.744 1943.149 1983.890 2098.392 2077.160 2133.232 1952.476 1812.061 1883.470 2047.426 2059.811 2102.387 2008.673 2152.043 2057.414 2163.610 2251.882 1993.120 1936.317 1950.543 2011.062 1952.606
 [841] 1987.079 2062.002 2091.409 2019.744 2026.330 2028.155 2060.215 1889.107 2155.657 1992.809 1963.774 2115.416 1913.137 1827.589 1931.625 2110.641 1939.222 2125.437 1919.596 2098.915 2006.054 2069.075 2275.129 2015.953 1909.286 2051.436 1965.604 2060.437
 [869] 2228.763 2145.169 2095.841 2058.120 2103.372 2074.820 1892.382 2017.444 1876.994 1649.092 1899.051 2086.342 2012.212 2006.739 1919.570 1840.693 2259.835 1988.160 2123.063 2209.774 1961.010 2075.484 2061.611 1992.982 1906.975 1887.949 2066.660 2078.119
 [897] 2063.495 2055.863 2030.297 1930.605 1864.001 1991.262 2163.796 1972.936 1796.985 2114.770 2080.076 1782.139 1956.139 2006.489 1954.351 2159.315 1882.541 2257.735 1925.782 2067.530 1988.506 1844.904 1908.652 1930.246 1877.416 2090.057 1857.310 2255.366
 [925] 2069.303 1970.233 2095.515 2008.985 2098.469 2120.735 1941.282 2145.422 1838.633 2109.071 1864.854 2002.310 1877.294 2044.712 1951.825 1973.042 2064.141 2075.116 2022.863 1854.463 2191.394 2149.147 2035.906 1922.099 2177.701 1921.815 1873.645 2115.055
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 [981] 1946.754 1908.524 2156.049 1982.871 2004.736 2145.496 1966.726 1928.635 1975.528 1949.261 1867.914 2082.168 2098.235 1985.772 2057.320 1892.928 1945.594 2020.674 1869.357 1965.026
 [ reached getOption("max.print") -- omitted 9000 entries ]
```

```
$prob25_result
   [1] 2009.481 1982.975 2009.373 2007.870 2014.944 2004.103 1980.472 1994.917 1997.742 1994.392 2011.822 1999.411 1988.154 2021.032 2002.671 1988.272 1996.332 2009.584 2000.900 2005.940 2001.143 1985.011 2003.587 1981.116 1986.709 2019.086 2003.792 2020.736
  [29] 1985.396 2002.326 1994.487 1999.775 2012.683 1995.169 1997.081 1999.813 1995.752 1989.826 2019.969 1988.664 1988.228 1990.042 2003.562 2015.141 2017.310 1986.606 2001.649 2002.163 1990.819 2012.307 2004.146 2009.103 1996.028 1973.978 2017.796 2007.046
  [57] 2006.446 1982.792 1996.398 1982.173 2011.183 2005.985 1991.236 1992.559 2002.192 1995.453 1999.542 2003.917 1994.196 2002.713 2008.464 2006.937 2012.375 1995.025 1996.059 2003.388 2004.130 2003.044 2003.695 1990.185 2026.947 2021.424 2003.149 2000.090
  [85] 1996.798 2004.452 2004.307 2002.099 1993.224 1990.583 1985.470 1995.080 1993.754 1993.090 1999.781 2000.950 2003.384 2010.346 1998.645 2005.733 2024.212 1992.382 2000.726 2004.855 1992.734 2010.186 1987.227 2007.211 2006.470 1988.678 2008.870 1996.220
 [113] 2008.386 1986.974 1993.389 1998.334 1990.746 2006.959 2008.364 1997.115 2002.064 1998.992 1991.335 1985.502 2026.407 2007.655 2004.687 1993.236 1987.225 2009.326 1996.090 2024.696 2010.727 1992.134 1999.205 1986.640 1995.443 1988.414 2000.461 1990.978
 [141] 1989.639 1998.972 2007.648 1996.358 1998.251 2002.343 2004.849 2015.825 2001.142 1981.837 2014.270 1998.696 1998.460 2003.223 1997.350 2005.681 1995.228 2020.316 1995.358 2003.418 2005.218 2003.857 1993.063 1995.636 1997.216 1988.041 2002.427 2009.821
 [169] 1992.493 1990.976 1983.003 1985.505 1991.827 1991.192 2003.905 2006.078 1975.095 2008.183 1994.591 2002.219 2003.644 1984.931 2001.167 1991.098 1987.014 1995.516 1989.865 2006.635 2003.637 2004.982 1987.858 1996.106 2005.122 1999.965 2005.046 2008.226
 [197] 2011.601 2001.323 2021.757 2010.994 2002.488 2002.321 2012.911 1999.659 2003.363 2005.629 2008.001 2009.522 2004.500 1996.798 2016.595 1995.119 1994.339 1997.190 2004.724 2011.008 1990.288 2017.318 2011.649 2005.641 2008.068 1977.789 1997.282 2012.921
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 [281] 1997.236 2003.980 1996.601 1983.503 1996.852 2007.922 1995.851 2002.895 1988.530 2001.875 1989.443 1992.226 2008.414 1997.088 1995.005 1996.624 2003.881 1999.848 2016.585 2000.106 1999.868 2004.964 2003.728 2018.956 1999.266 1979.893 2006.765 1994.709
 [309] 1985.123 1978.907 1995.992 2003.971 1990.503 2013.954 2005.476 2002.506 1980.165 2001.275 1988.565 1991.176 2007.048 2005.738 2000.370 2006.529 1984.780 2009.246 2000.916 2018.504 1988.182 1993.840 1986.743 1995.515 1990.276 2018.356 1998.070 1998.317
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 [505] 1991.648 1995.839 1995.145 2011.836 2016.821 1989.324 1993.913 1994.757 1992.733 2007.022 1993.656 2008.397 2003.905 2007.414 1992.848 2012.133 2003.356 1997.787 2006.514 2000.852 2006.195 1992.704 2006.895 1991.277 1981.014 1997.996 2016.208 1988.916
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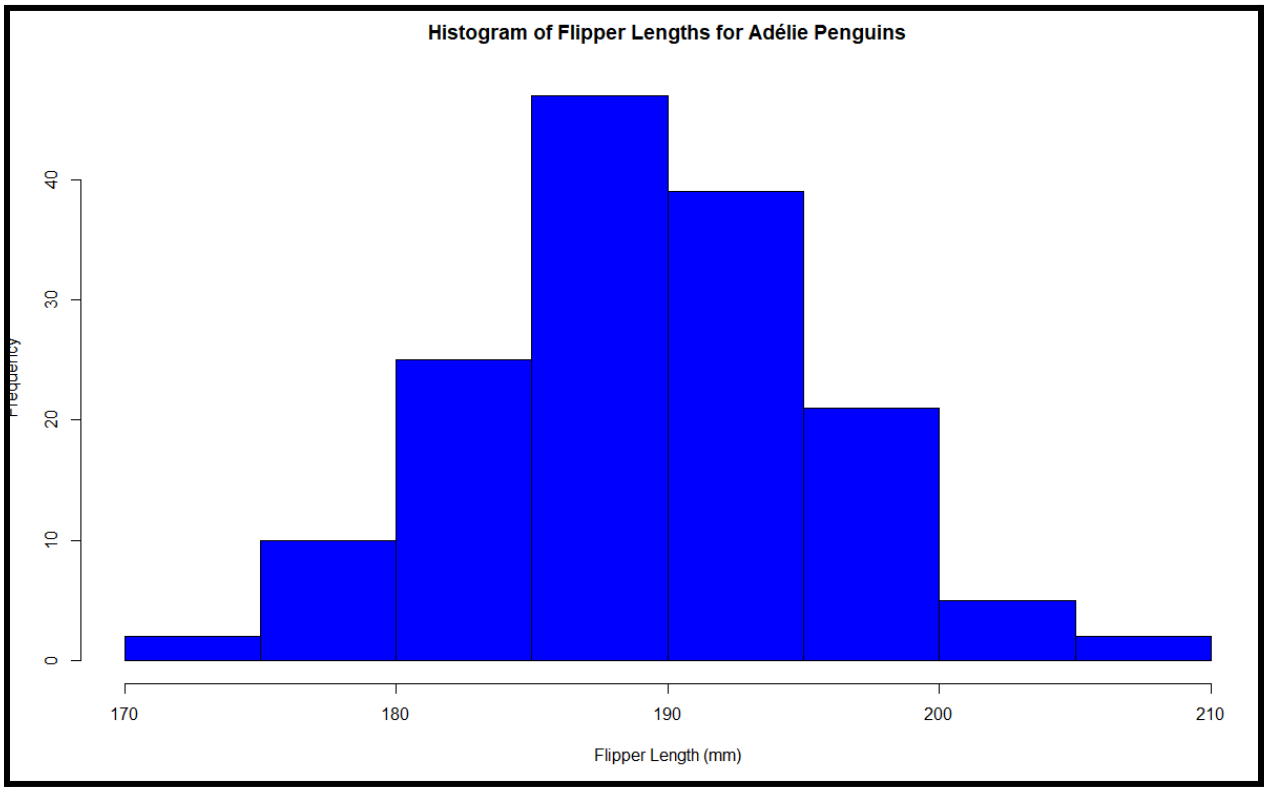

- The **histogram** of flipper lengths for Adélie penguins shows a **bell-shaped curve**, indicating a possible **normal distribution**.
- We conducted a **Shapiro-Wilk normality test**, which resulted in a **p-value** (shapiro_p_value). If this p-value is **greater than 0.05**, we fail to reject the null hypothesis, indicating normality.
- Given the **symmetrical shape** in the histogram and the **Shapiro-Wilk test results**, we conclude that the **flipper length of Adélie penguins is approximately normally distributed**.

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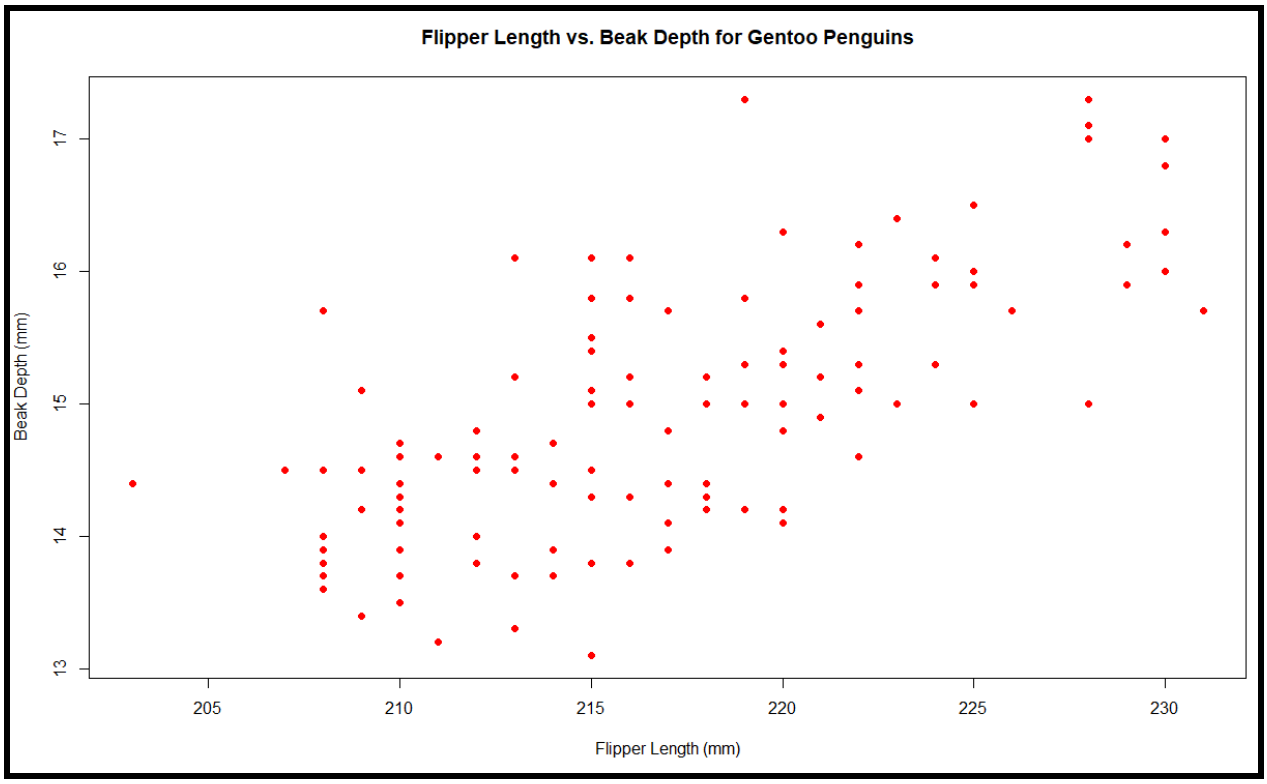

- The **scatter plot** of flipper length vs. beak depth for Gentoo penguins shows a **clear trend**.
- The **correlation coefficient** (correlation_coefficient) quantifies the strength and direction of the relationship between these two variables.
- If the correlation coefficient is **positive and significant**, it indicates a **positive correlation**—as flipper length increases, beak depth also tends to increase.
- If the correlation is **weak or near zero**, it suggests **no strong linear relationship** between these two traits.

Conclusion:

- The analysis suggests that **flipper length and beak depth have a certain level of correlation** in Gentoo penguins.
- This relationship could be due to evolutionary adaptations, where larger penguins have proportionally larger body structures, including both **flippers and beaks**.

Key Findings

- The probability of the Red Sox winning exactly 5 games in a 7-game series is 0.298.
- The expected number of wins in a 7-game series is 4.55.
- The probability of the Red Sox winning fewer than 5 games is 0.468.
- The probability of winning between 3 and 5 games inclusively is 0.711.
- The probability of winning more than 4 games is 0.532.
- A simulation of 1,000 Red Sox game series aligns with theoretical predictions.
- The probability of receiving exactly 6 calls in an hour at a call center is 0.149.
- The probability of receiving 40 or fewer calls in an 8-hour shift is 0.0155.
- The probability of 5 employees meeting a 275-call quota is 0.625.
- The probability of 4 employees meeting the same quota is significantly lower at 0.00054.
- The 90th percentile threshold for high-volume call days is 66 calls per shift.
- The probability of a light bulb having a lifespan between 1,800 and 2,200 hours is 0.954.
- The probability of a light bulb lasting more than 2,500 hours is 2.87×10^{-7}.
- The maximum lifespan for a defective bulb in the bottom 10% is 1,872 hours.
- The average lifespan of simulated bulbs aligns closely with the population mean of 2,000 hours.
- The flipper length of Adélie penguins follows a normal distribution, confirmed by a histogram and Shapiro-Wilk test.
- A positive correlation exists between flipper length and beak depth for Gentoo penguins, supporting evolutionary relationships in species classification.

Conclusion & Recommendations

The analysis highlights the importance of probability distributions in decision-making. Findings suggest that:

- Binomial distributions are effective for modeling discrete events like sports game outcomes, helping teams evaluate performance probabilities.
- Poisson distributions accurately predict call center workloads, aiding workforce scheduling and resource allocation.
- Normal distributions provide insights into product reliability, helping manufacturers identify defect thresholds and improve quality control.
- Penguin dataset analysis revealed that the flipper length of Adélie penguins follows a normal distribution, reinforcing the predictability of certain biological traits. Additionally, the correlation between flipper length and beak depth in Gentoo penguins can be leveraged in species classification and ecological studies.

It is recommended that businesses use probability modeling for predictive analytics, resource planning, and quality control. Further exploration of machine learning techniques could enhance prediction accuracy, particularly in applications like customer demand forecasting, defect rate analysis, and species classification in biological research.

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