University of Kentucky, Physics 335
Laboratory #1, Rev. A, due Friday, 2023-09-01

The purpose of this lab is to *theoretically* and *experimentally* quantify the distribution of the random variable X representing **Monopoly rolls**: the sum of two thrown dice. Perform and analyze the experiment in pairs, but submit your own separate assignment with all plots and calculations.

1. Theoretical estimation of the **Parent Distribution**

a) Identify the *sample space* of possible outcomes labeled by $x = x_1 + x_2$, where x_i is the number of each die, and the *probability* $P(x)$ for each individual outcome (the *events*).

b) What assumptions went into this model?

c) Draw step plot of the *distribution* $P(x)$, labeling your axes in the figure, spanning the entire width of your sheet.

d) Calculate the mean μ, median $\mu_{1/2}$, mode μ_{max}, standard deviation σ, and average deviation α of this distribution.

e) Draw the *central values* as ticks and *deviations* as error bars on the abscissa of your plot, on separate lines with (μ, σ) and $(\mu_{1/2}, \alpha)$ together and μ_{max} alone.

2. Experimental measurement of a **Sample Distribution**

a) Perform an experiment to estimate $P(x)$ by throwing a pair of dice $N = 25$ times and recording each sum x_i for $i = 1 \ldots 20$.

b) Histogram the number of occurrences of each value of x in a *frequency table*.

c) Plot the the *sample distribution* $P_M(x)$ of $\{x_i\}$, normalized (divide by N) to approximate the *parent distribution* $P(x)$ Plot this distribution as a disconnected solid dot for each value of x.

d) Recalculate the sample mean $\bar{x}$, median $x_{1/2}$, mode x_{max}, standard deviation s, and average deviation a of your sample distribution, dividing by $N - 1$ instead of N for the deviations.

e) Plot the *central values* and *deviations* as before with a solid dot on the tick.

3. Calculation of the **Combined Distribution**

a) Add up the histograms from each group to obtain the combined sample distribution $P_C(x)$, and plot it on the same graph with open squares.

b) Recalculate and plot the same *central values* and *deviations* as before with an open square on the tick.

c) Qualitatively compare the plots and statistics of the parent, sample, and combined distributions. [*bonus: How do the error bars relate to the difference between the different ticks?*]

4. In the game **Monopoly**, each player rolls two dice to advance their piece around the board.

a) How often does a player leave jail and end on free parking without passing it (ignoring the effects of cards, and rolling again on doubles)?

b) In light of your analysis please discuss this heat map of the number of landings on each space of a Monopoly board. Why aren't all spaces visited equally?