Homework 2
ASTR 513 - Computational and Statistical Methods for Astrophysics

Due: Monday, Sept 18, 11.59pm, submit via d2l

Problem 1: You can use examples for the explanations below

- Derive Bayes Theorem.
- Explain Bayes's theorem in the context of inference, i.e. when going from data space to model (parameter) space. What are the ingredients? How are they obtained? What is difficult about priors?
- For a multivariate Gaussian likelihood function, explain the ingredients. How are they obtained?

Problem 2: Use python + colab + Markdown for the following tasks:

- Choose 5 different probability density functions
- For each of the 5, draw from the distributions and create histograms with two different types of binning; plot both the histogram and the true pdf
- Name the relevant parameters that determine the function and explain their role (e.g., what aspect of the distributions shape do they control or what quantity do they represent in a use case)
- For 2 of the distributions, give closed form expressions (if they exist) of the moments of the pdf (only up to 4th moment if applicable); for up to 3rd order compare to the estimated moments from the histogram data
- For 2 of the distributions, find an astronomical use case (paper) and include the link. Answer the following questions:
  - What is the astro problem that is addressed in the paper (2 sentences)
  - What quantity is the random variable? What is the underlying population?
  - What pdf is used and what moments are computed?
  - What is the (a) statistical result of the paper?
  - How are errors computed? What determines statistical power of the experiment? What are important systematic uncertainties.