Math 439: Fall 2021 Final Exam

Instructions: There will be two questions to the exam, each containing multiple parts. Responses to the questions should be in report form. If you are asked to provide a final model, explain the steps you went through to reach that model, cite relevant output throughout your explanation and then provide the final model.

Problem 1: In an anti-gravitation field theoretical physicists hypothesize the height (a.k.a. position) of an inanimate object released 10 meters above the ground at time = 0 is P(t) = 4.8\*t^3 – 9.8\*t^2 + 5 for t:0<t<3. However, measurement of the position is very difficult inside of the gravitation field as most position sensors require gravitational balance to function. The scientists have assumed that they are accurately measuring position with small normally distributed errors centered around zero with constant variance. In the data file: antigravity.csv you will find 200 position measurements for this experiment.

1. Begin by developing the best model that you can. More important than prediction in this process will be an interpretation of the final model. Document your progression towards the final model and provide the final model when finished. (30 points)
2. Based on your final model residual diagnostics, do you believe that the scientists assumptions on the behavior of the measurement errors is justifiable. Provide relevant graphical output if you feel it is necessary. (10 points)
3. Challenge Question: Design a hypothesis/set of hypotheses for testing whether the theoretical model proposed by the Physicists is potentially valid. Is there evidence that their model is incorrect? (10 points)

Problem 2: There is very strong statistical literature covering the rate at which earthquakes occur within a spatio-temporal window. However, there is relatively little statistical literature (beside some generic and basic pdf estimation) on the sizes or magnitudes of earthquakes. After downloading the eqmag.csv dataset and reading it into R you will find a single numerical response (magnitude), three numerical predictors (fault\_depth, fault\_angle, fault\_length) and one categorical predictor (volcano). fault\_depth measures the depth of the nearest neighboring fault to the earthquake, fault\_angle measures the angle of the nearest fault to the occurring earthquake and fault-length represents the length of the nearest fault. Volcano is a binary categorical variable that is a 1 if the earthquake is in close proximity to a volcano and a 0 if the earthquake wasn’t in close proximity to a volcano.

1. Determine your best fitting model for predicting earthquake magnitude based on information about it’s neighboring fault. The goal of this research is future prediction. Document your progression towards a final model and provide your final model. (25 points)
2. Compute and interpret the overall R^2 for your final model (10 points)
3. I just bought a Summer home in close proximity to a volcano near a fault that is 1.6 miles deep and 67 miles long. The angle between the fault and my house is 13 degrees. If an earthquake were to occur at my house, what do you predict the magnitude of the earthquake would be? (15 points).