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Multivariable Calculus

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**MATLAB Reflection Paragraphs**

Project 1: For this project, we were tasked with importing a large dataset, and doing something useful with it. The data that I imported was from the 2010 Population Census Data. This dataset consisted of many variables such as population, number of housing units, total area, land area, water area, population density, and housing unit density for all 50 states. It total, there were 350 distinct data-points. I decided that I would take this data and perform descriptive and relationship analysis statistics among each variable. I imported the data through an excel spreadsheet into MATLAB. First, I had to convert the table of data into an array so that I could actually analyze the data with statistical functions. For each variable, I calculated the means, standard deviations, medians, and interquartile ranges. This way, I could have all of these descriptive statistics right with each visual representation of the data. To best visualize the distributions of each variable, I employed the function “histfit.” This function creates a histogram of the data with a bell curve indicating where the mean is. Histfit best utilizes the descriptive statistics utilized and allows the patterns of the data to be observed easily. Along with the histograms for each variable, I calculated the five number summaries using “prctile” which include the minimum, 25th percentile, median, 75th percentile, and the maximum values. After doing this for each variable, I created a new table containing every standardized value for every variable and state using “normalize”. Using these values, I created a boxplot of every variable side-by-side so that the distributions for each variable could be analyzed. Also, you can easily see the number of outliers for each variable which are depicted by red crosses. The boxplots are also visual representations of the five number summaries while including outliers in the data. After all of the descriptive statistical calculations were performed, I then proceeded to analyze the correlations between certain variables. The relationships I analyzed were between population and population density, housing units and housing density, land area and housing units, and population and housing units. To calculate the least squares regression line between each variable, I had to first find the slope and y-intercept for each line. The x variable had to be padded against a series of ones, and then the line had to be calculated using “\”, which will give the y-intercept and slope for the line. Then I scattered the points and held on the line going through all of the data-points. Then I calculated the coefficient of determination and correlation (r2 and r) using the statistical formula. Then determine the degree of correlation, I set up an if loop to determine whether the relationships were weak, moderate, or strong between the variables. Once I had calculated the relationships between the variables and the descriptions of each distribution, I had successfully completed the project.

Project 3: For my freestyle project, I decided to calculate the least squares regression line by method of least squares. In our multivariable calculus textbooks, the method of least squares is included in a section referring to applications of multivariable extrema and finding maximums. Unfortunately, we were not able to learn this method due to time constraints. However, I decided that it would be a good idea to learn this method for myself. Since I am currently taking AP Statistics, I have learned a lot about linear regression models and its uses. Although, I have not really considered the formula and how it is calculated. Since the formula is quite a lengthy process, it would be much easier using MATLAB as a tool and to see how it works. I started off the project by creating a random matrix of ten coordinates which all x and y values between zero and five. From there, you have to find the sum of the x values, the sum of the y values, the sum of x times y for all ten coordinates, and the sum of x squared for all coordinates. Then, calculated the slope and y-intercept using the formula in the textbook. I plotted all the points on a scatterplot showing the least squares regression line amongst the coordinates. After that, I decided to create a residual plot of the data to visualize how the method of least squares seeks to minimize the vertical distance between the actual and predicted values. This way, I could fully see how the least squares regression line can be applied to real life models.

Project 4: For my problem for chapter 11, I chose number 87 on page 796. For this problem, you were given a point and a plane, and you had to find the distance between them. The point given was (0,0,0) and the plane was 2x + 3y + z = 12. First, you can see that the normal vector was [2,3,1] based on the coefficient of the plane. Then the vector between the point and the plane is [-6,0,0]. Then I took the dot product between the normal vector and the vector between the point and the plane. Then the distance between the point and plane is equal to the absolute value of the dot product of the vectors divided by the magnitude of the normal vector. For chapter 12, I chose number 41 on page 826. This problem asked to graph different polar transformations of similar graphs to see how each change affects the graph. The original plot was x = 2cos(t), y = 2sin(t), and z = 0.5t. I used plot3 for all of the transformations and held on each graph in different colors so the transformation could be visualized. For chapter 13, I chose two problems. I chose number 66 on page 930, and number 27 on page 946. For the first problem, the first part was graphing a 3D surface of a depth function, and for that I used “surf”. The next part was plugging in values and finding the depth at a certain point. Next, I had to take the partial derivatives of the function with respect to x and y to analyze the gradient in relation to each variable. Lastly, I had to find the moment where the rate of change was the largest and I calculated the gradient of the function and substituted in 1 and 0.5 for the x and y values for the moment of maximum change. Then for the other problem, I was asked to graph a multivariable function and find its extrema. So I used “isosurface” to plot, and I took various partial derivatives to find the points of extrema. Then depending on the derivative sign values, I created an if loop to analyze if each point is either a maximum, minimum, or saddle point. For chapter 14, I did number 57 on page 1022. For this, I was tasked with verifying the moment of inertia given for a cylinder. Doing this included taking triple integrals of functions. In order to take the triple integrals, I would have to use “int”, the integral function, 3 successive times to complete the triple integral. I had to do 3 total triple integrals in relation to each axis. These calculated the three different moments of inertia for each variable. Lastly, my chapter 15 problem was number 5 on page 1085. The task of this problem was to verify Green’s Theorem. First you are given an integral to evaluate over a curve for a certain region, and that integral has to equal the double integral of the partial derivatives of that region. For the curve, you had to parameterize the curve to into two separate parts and add up the integrals of each curve to find the integral of the total curve. So I substituted the parameterized derivatives into the xy functions to get the answer to the integral. Then for the region, I had to find the bounds of the region so that I could find the limits of integration. Then the integral was taken using the partial derivatives of the functions. If the integral for the region was equal to the integral for the curve, then Green’s Theorem was verified.