Show **all** of your work on this assignment and answer each question fully in the given context.

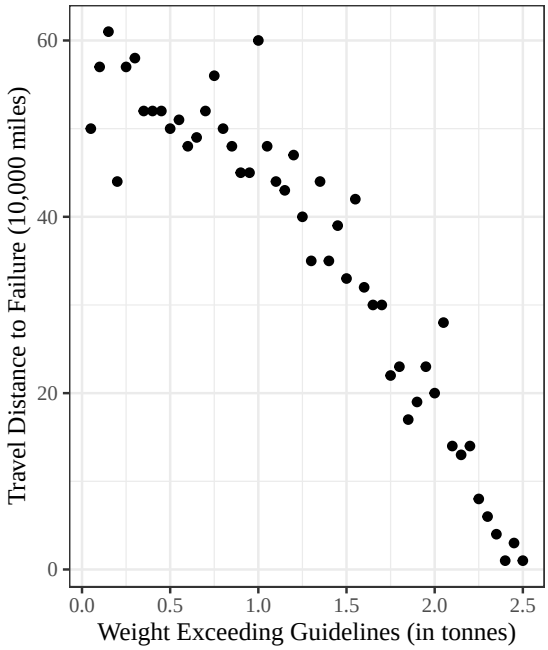
**If you cannot submit your homework in the class, you can drop it at my office door in 3220 Snedecore Hall by Thursday at 03:30 PM.**

In this homework, you CAN use JMP to plot the data or calculate coefficients of regression model whenever it is asked in the question.

Please staple your assignment and write your name !

1. The major cause of axel failure in freight trucks is when shippers exceed the recommended weight limits that can be handled by the axels. Issues resulting from these failures have been becoming more frequent as shippers try to cut corners, leading members of the state's Department of Transportation to ask one of their civil engineers to look into the available data and better advise them on the relationship between excessive weight and axel failure.

   A company manufacturing axels provides the engineer with data gathered from conducting experiments loading axels with excessive weight and simulating traveling conditions. The data consists of two columns, **excessive weight (in tonnes)** is the amount of weight over the limit that was placed on the axel, and **distance to failure (in tens of thousands of miles)** is the simulated distance to the axel's failure.




   Here are some summaries of the data:

$$\sum_{i=1}^{50} x_i = 64 \qquad \sum_{i=1}^{50} x_i^2 = 107$$

$$\sum_{i=1}^{50} y_i = 1795 \qquad \sum_{i=1}^{50} y_i^2 = 79777$$

$$\sum_{i=1}^{50} x_i y_i = 1699$$

(a) Using the summaries above, fit a linear relationship between **weight exceeding guidelines** (x) and **travel distance to failure** (y).[10 pts]

(b) Write the equation of the fitted linear relationship. [5 pts]

(c) Find and interpret the value of $R^2$ for the fitted linear relationship.[5 pts]

(d) Using the fitted line, provide a predicted value of travel distance to failure when the weight exceeding the guidelines is 3.4 tonnes.[5 pts]

(e) If the observed travel distance is 0.37 when the weight exceeding the guidelines is 3.4, what is the residual? Based on the sign of the residual, explain if we are overfitting or under fitting.[5 pts]
Hint: You have already achieved the predicted value of travel distance when the weight exceeding the guideline is 3.4 in part (d).

The JMP output below comes from fitting a quadratic model using $x$ and $x^2$.

**Response Distance to Failure**

**Summary of Fit**

| | |
|---|---|
| RSquare | REDACTED |
| RSquare Adj | REDACTED |
| Root Mean Square Error | 5.281589 |
| Mean of Response | 0.16 |
| Observations (or Sum Wgts) | 50 |

**Analysis of Variance**

| Source | DF | Sum of Squares | Mean Square | F Ratio |
|---|---|---|---|---|
| Model | 2 | 13229.647 | 6614.82 | 237.1314 |
| Error | 47 | 1311.073 | 27.90 | Prob > F |
| C. Total | 49 | 14540.720 | | <.0001* |

**Parameter Estimates**

| Term | Estimate | Std Error | t Ratio | Prob>\|t\| |
|---|---|---|---|---|
| Intercept | 16.27602 | 2.333507 | 6.97 | <.0001* |
| Weight Exceeding Limit | 4.6604349 | 4.221593 | 1.10 | 0.2752 |
| (Weight Exceeding Limit)^2 | -10.2775 | 1.604983 | -6.40 | <.0001* |

(f) Write the equation of the fitted quadratic relationship. [5 pts]

(g) Find and interpret the value of $R^2$ for the fitted quadratic relationship.[5 pts]

(h) Using the fitted quadratic relationship, provide a predicted value of travel distance to failure when the weight exceeding the guidelines is 3.4 tonnes.[5 pts]

2. **[Ch. 4.1 Exercise 3, pg. 140]** The article "Polyglycol Modified Poly (Ethylene Ether-Carbonate) Polyols by Molecular Weight Advancement" by R. Harris (*Journal of Applied Polymer Science*, 1990) contains some data on the effect of reaction temperature on the molecular weight of resulting poly polyols. The data for eight experimental runs at temperature 165°C and above are as follows (see website for 'polyols.csv'):

| Pot temperature (°C) | Average molecular weight |
|---:|---:|
| 165 | 808 |
| 176 | 940 |
| 188 | 1183 |
| 205 | 1545 |
| 220 | 2012 |
| 235 | 2362 |
| 250 | 2742 |
| 260 | 2935 |

Use a statistical package (JMP or 'R') to help you complete the following (plots and computation):

(a) What fraction of the observed raw variation in molecular weight of resulting poly polyols ($y$) is accounted for by a linear equation in reaction temperature ($x$)?[5 pts]
hint: The question asks for the coefficient of determination.

(b) Fit a linear relationship $y \approx \beta_0 + \beta_1 x$ to these data via least squares. Then explain how the average mulecular weight changes if pot temperature increases for a 1°C ?[5pts]

(c) Compute and plot residuals from the linear relationship fit in b). Discuss what they suggest about the appropriateness of that fitted equation.[10 pts]
**Note:** You should provide both residual plots vs. experimental variable and normal QQ-plot vs. residual quantiles to see if the assumptions of the model are met.

(d) Based on your analysis of these data, what average molecular weight would you predict for an additional reaction run at 188°C? At 200°C? Why would or wouldn't you be willing to make a similar prediction of average molecular weight if the reaction is run at 70°C?[6 pts]
Hint: You may consider extrapolation and/or intrapolation.

3. **[Ch. 4.2, Exercise 1, pg. 161]** Return to problem 2, (Exercise 3 of Section 4.1 on pg. 140 of the textbook).

(a) Fit a quadratic relationship $y \approx \beta_0 + \beta_1 x + \beta_2 x^2$ to the data via least squares.[5 pts]

(b) Provide the value of $R^2$ and interpret that.[5 pts]

(c) Plot residuals against the experiemntal variable and normal QQ-plot and discuss if the assumptions of the model are met.[5 pts]

Total: 86 pts