

BALTIMORE CITY
PUBLIC SCHOOLS

Bernard C. “Jack” Young
Mayor, City of Baltimore

Linda Chinnia
Chair, Baltimore City Board of
School Commissioners

Dr. Sonja Brookins Santelises
Chief Executive Officer

Senior Project *Mathematics*

Dates	Pages
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You're in the Driver's Seat

Project and template for BCPS Spring 2020 Senior Mathematics

Project Components:

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Project Overview

The premium that an auto insurance company charges for a policy is dependent on many factors including driving record, number of years of driving experience, age, whether the driver is the principal operator of the vehicle, and whether the driver has had driver training. These factors are encoded in the Safe Driver Insurance Plan (SDIP) step and the rate class assigned to a driver on a policy. The task in this project is to investigate real data from an insurance company to discover the relationships between the driver demographics and the premiums.

This is a six-week project containing six components. Each week a project component will be finalized and submitted by students with all portions answered completely including necessary work and graphical displays. Each project component contains resources and practice exercises to help understand what is being asked. The resources and practice exercises are **optional**, but strongly recommended.

Weekly Plan

- Week 1:** Read the Project Overview pages completely, focusing specifically on the background information. Engage in focused class time and complete Question 1.
- Week 2:** Review feedback from your teacher from Week 1. Make any corrections or additions as needed. Engage in focused class time and complete Question 2.
- Week 3:** Review feedback from your teacher from Week 2. Make any corrections or additions as needed. Engage in focused class time and complete Question 3.
- Week 4:** Review feedback from your teacher from Week 3. Make any corrections or additions as needed. Engage in focused class time and complete Question 4.
- Week 5:** Review feedback from your teacher from Week 4. Make any corrections or additions as needed. Engage in focused class time and complete Question 5.
- Week 6:** Review feedback from your teacher from Week 5. Make any corrections or additions as needed. Engage in focused class time and complete Question 6. Be sure to turn in **all** project parts!

Technology

This project will require the use of technology, particularly the use of a graphing calculator as well as the ability to access websites for the additional resources and practice exercises that may contain video and dynamic question sets.

Desmos – <https://www.desmos.com/> - click “Start Graphing.” This web-based calculator is free to use, it can accept data that you input as a table and create regression lines and calculate correlation coefficients.

TI-84 Plus CE – Texas Instruments has made its emulator software for the TI-84 available for free for six months. Use the website <https://education.ti.com/en/resources/online-learning-program> and proceed with the technology that is appropriate for you. Note that there is a Chromebook app available as well.

The Problem

You are provided with some sample data obtained from First Stage Insurance Agency. Your job is to analyze the data to answer the following questions.

1. **Do drivers with higher SDIP steps have a higher incident of claims?**

Does the percent of policies that have claims against them increase as the SDIP step increases? Plot these variables against each other and determine the best-fit line and correlation coefficient.

- a. Extension 1: Does the equation of the line, or the correlation factor change when the scatter plot is made for each rate class separately?

2. **How does policy premium vary with SDIP step?**

Given the average policy premium for each SDIP, can you find the best-fit curve? How does your curve compare to the rule used by the insurance companies for SDIP credits and penalties?

3. **Which SDIP steps yield the largest profit for the insurance company?**

Graph the net profit, average profit per policy, average loss per policy, and average loss per claim vs. SDIP level. What does each of the graphs tell you about where the insurance companies make their money? Which drivers are paying too much or too little?

4. **Are the adjustments per rate class fair?**

Drivers with less than three years of experience can get a discount if they have had driver training. Do drivers who have had driver training have fewer claims? Is the company giving a fair discount? What about other rate classes? Are senior citizens being charged fairly? Which rate class is paying too much, and which is not paying their share? How would you adjust the rates?

5. **What is the actual price of a speeding ticket?**

While the cost of the ticket may hurt in the short term, the major cost to the driver is the increase in the insurance premiums. Investigate how much the ticket really costs considering the increased premiums.

6. **How does the new point system work?**

The process of assigning drivers “steps” was replaced with a system based on surcharge points added based on the amount and type of traffic incidents. The more surcharge points a driver accumulates, the higher his or her insurance premiums will be.

Areas of Application:

- Percentages
- Graphing & scatterplots
- Data analysis & statistics
- Linear regression & correlation coefficients
- Exponential growth & decay

Vocabulary:

Related to Car Insurance:

- **SDIP:** Safe Driver Insurance Plan (Massachusetts) assigns a step number to each driver based on their driving record. The steps range from 9 to 35. Drivers are initially assigned an SDIP of 15. This SDIP is reduced by 1 for every year of incident-free driving.
- **Insurance:** A way to protect an individual from unforeseen financial loss. An individual pays an estimated amount of losses before any losses have occurred. This money paid to a company is then used to pay for any losses that **do** occur.
- **Premium:** The consideration paid for a contract of insurance for a particular time period. This is usually stated as a yearly amount (ex. \$1200 per year) and individuals most often pay monthly (ex. \$100 per month).
- **Policy:** The contract set up for the individual that the insurance company agrees to carry out in the case of an accident.
- **Claim:** In the event that an accident occurs to a policyholder, this person must report the event to the company in order to receive the benefits of the policy.
- **Claim cost:** the amount the company pays out to settle a claim.
- **Profit:** for an insurance company, this would be the total amount gained from customer premiums (revenue) **minus** the total amount paid in claims (losses). Also called **net profit**.
- **Principal Operator:** The person who will be operating the vehicle most or all the time.
- **Occasional Operator:** A person who is not the principal operator. For example, State Farm qualifies “occasional” as someone unmarried, under 21, who operates the car less than 25% of the time.

Related to Mathematics:

- **Scatterplot:** a type of data display that shows the relationship between two numerical variables.
- **Linear Regression:** a **linear** approach to modeling the relationship between a response (or dependent or “y” variable) and one or more explanatory variables (or independent or “x” variables).
- **Correlation Coefficient:** is a statistical measure of the strength of the relationship between the relative movements of two variables. The values range between -1.0 (strong, perfectly negative) and 1.0 (strong, perfectly positive). As values get closer to zero, the strength is weaker, with zero being no correlation at all.
- **Simple Interest:** In the case of our problem, it is the increase or decrease based linearly on step 15.
- **Compounding:** Dealing with insurance premiums, compounding means calculating interest on both the base premium plus previous interest.

Standard

Standard	Description	Project Portion
F-LE.A.1	Distinguish between situations that can be modeled with linear functions and with exponential functions. F-LE.A.1a: Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals. F-LE.A.1b: Recognize situations in which one quantity changes at a constant rate per unit interval relative to another. F-LE.A.1c: Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another.	W2
F-LE.A.3	Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function.	W2
F-IF.A.2	Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.	W2
F-IF.B.4	For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. <i>Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity</i>	W1, W2, W3
A-CED.A.1	Create equations and inequalities in one variable and use them to solve problems. <i>Include equations arising from linear and quadratic functions, and simple rational and exponential functions.</i>	W2
A-SSE.A.1	Interpret expressions that represent a quantity in terms of its context.* A-SSE.A.1a: Interpret parts of an expression, such as terms, factors, and coefficients. A-SSE.A.1b: Interpret complicated expressions by viewing one or more of their parts as a single entity. <i>For example, interpret $P(1 + r)^n$ as the product of P and a factor not depending on P.</i>	W2, W6
S-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).	W4
S-ID.B.6	Represent data on two quantitative variables on a scatter plot and describe how the variables are related. S-ID.B.6a: Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models. S-ID.B.6c: Fit a linear function for a scatter plot that suggests a linear association.	W1, W2
S-ID.C.7	Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.	W1
S-ID.C.8	Compute (using technology) and interpret the correlation coefficient of a linear fit.	W1, W2
N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.	W1, W2, W3, W4, W5, W6
N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.	W1, W2, W3, W4, W5, W6
N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.	W1, W2, W3, W4, W5, W6

Materials:

- Background information about SDIP, steps, and rate class codes (p.8).
- Data including the number of policies, number of policies that reported losses, and total monetary losses incurred at each SDIP level and rate class. This information is found in the spreadsheet "[*You're in the Driver's Seat.xls*](#)"
 - Also included where necessary with each question.
- Questions 1 – 6 to facilitate the project.
- Vocabulary to support language use (p.5).
- Suggested approach and solutions (separate files for teachers only).
- Additional resources for the mathematical concepts and similar exercises (included within each question and on the teachers only files).
- **The project is divided into six separate questions, each in a separate document. All accompanying exercises/data/solutions/tutorials are included. During week 1, students should read the project in its entirety, organize data they will use, and be able to answer questions about what they are being asked to do as well as tackle Question 1. Each week thereafter students should tackle 1 question per week.**
- **The background information should be used with each of the activities.**

Background Information:

The SDIP Step System

The Safe Driver Insurance Plan (SDIP) assigns a step number to each driver based on their driving record. The steps range from 9 to 35. Drivers are initially assigned an SDIP of 15. This SDIP is reduced by 1 for every year of incident-free driving. If a driver has three consecutive years of incident free driving and their step is over 14, it is reduced to 14 at the end of the three-year period. Once a driver is involved in an accident in which they are at fault, or receives a ticket for a violation, the SDIP is increased 2 to 5 steps according to the severity of the accident or violation. This is summarized in the table below.

Surchargeable Incident	Increase in SDIP Level
Major Traffic Violation (i.e., D.U.I.)	5
Major At-Fault Accident (claim over \$2,000)	4
Minor At-Fault Accident (claim over \$500 to \$2,000)	3
Minor Traffic Violation (i.e., speeding)	2

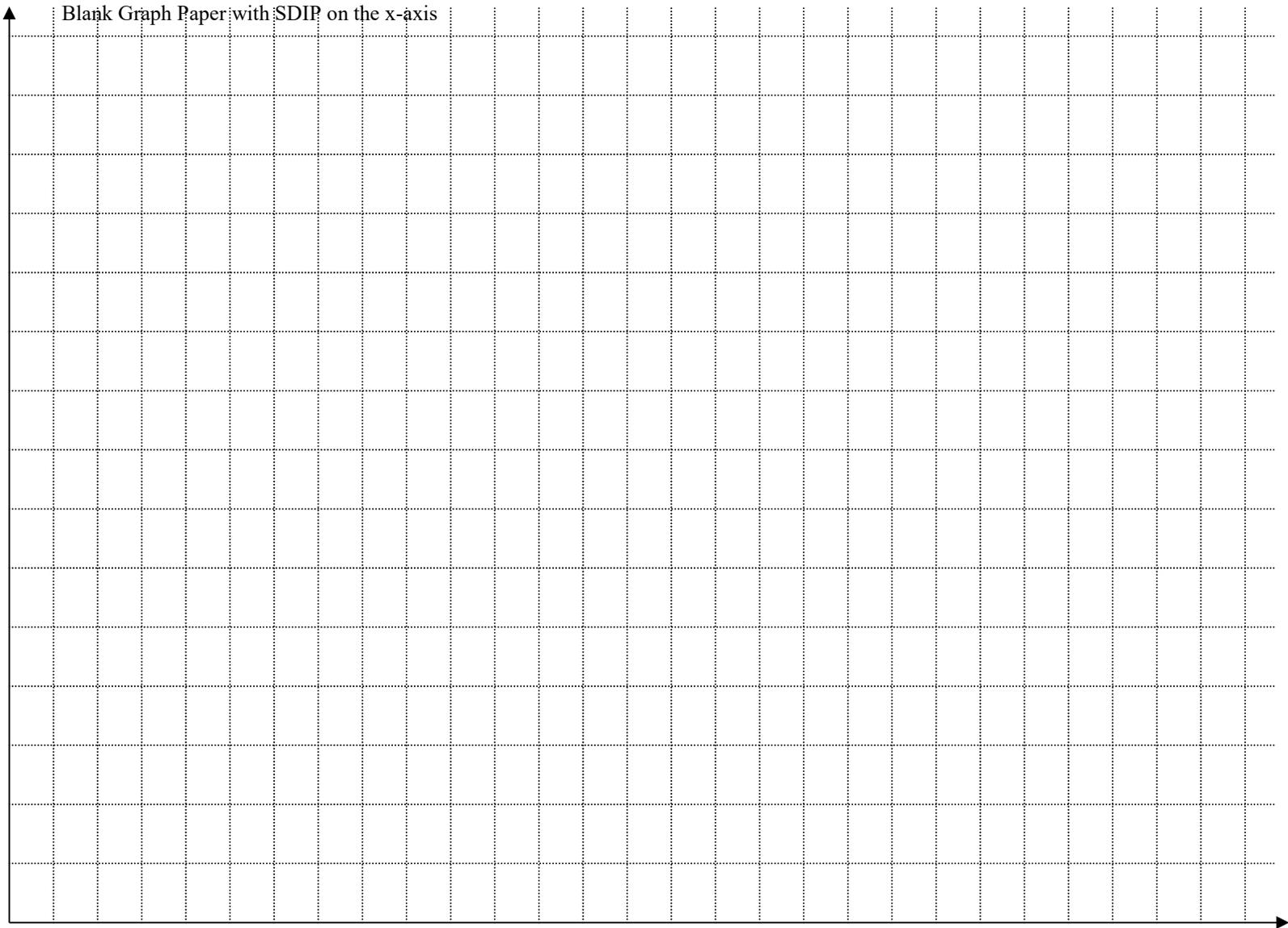
From http://www.mass.gov/doi/Consumer/WaysToSave_SDIP.html

The insurance premium charged by the insurance company depends on the driver's SDIP level. The premiums are defined based on step 15. For every step less than 15 the premium is reduced by 7%; for every step above 15, it is increased by 7%. However, for experienced operators the premium increases by 10% for each step over 19.

Rate Class Definitions

Each driver is assigned a rate class according to the following table. The information in which the insurance company is interested is dependent on the number of years of experience of the driver. For drivers with at least 6 years of experience there are only two classes dependent on the driver's age. For drivers with less than 6 years of experience, the insurance company is interested to know whether the driver is the principal user of the automobile, or whether they are the occasional user of someone else's car, typically their parents. A discount is given for drivers that have had driver training, but this discount only applies to drivers with less than three years experience.

Years of Driving Experience		
Less than 3 years	At least 3 but less than 6	At least 6 years
20 – Principal Operator No driver training	17 – Principal Operator	10 – Under 65 years old
21 – Occasional operator No driver training	18 – Occasional Operator	15 – At least 65 years old
25 – Principal Operator with driver training		
26 – Occasional Operator with driver training		



SDIP Level

Question 1: Do drivers with higher SDIP steps have a higher incident of claims?

Complete the exercises below then circle back to provide a complete answer to this question.

Exercises:

1. Complete the table of values on the next page to compute the percent of policies with claims for each SDIP step.
2. Prepare a scatterplot of the percent of policies with claims vs. their SDIP levels.
Scatterplots must have labeled axes and consistent scales

Independent (x) variable: _____ Dependent (y)
variable: _____

-You may print the graph provided **in the Project Overview** to complete the scatterplot by hand. When finished, take a picture and submit it with the other Question 1 artifacts.

-You may use graphing software to prepare your scatterplot. Here are tutorials to use the software. Save an image of your scatterplot.

Desmos:

-Enter data: <https://learn.desmos.com/tables> (don't connect the dots)

-Adjust graphing window: <https://learn.desmos.com/graph-settings>

TI-84 Plus CE:

-Enter data: <https://learnit.hoonuit.com/2760/learnit/97478>

-Create scatterplot: <https://learnit.hoonuit.com/2760/learnit/97479>

3. Find a line of best fit. Interpret the equation of the line in the context of the problem. If SDIP step increases by 1, what change in the percent of policies with claims does the line predict?



Desmos: <https://learn.desmos.com/regressions>

TI-84 Plus CE: <https://learnit.hoonuit.com/2760/learnit/97480>

Line of best fit: _____

Interpretation of the slope:

Interpretation of the y-intercept:

4. Calculate the correlation coefficient to test whether the relationship between the variables is linear.



Correlation coefficient: https://youtu.be/ugd4k3dC_8Y

The correlation coefficient is denoted by the variable “r”.

*Diagnostics must be turned on in the TI-84 (<https://youtu.be/wQkHFqaOU2w>) and the linear regression process run again to obtain the value of r.

State the correlation coefficient and what it signifies in relation to the data and the line of best fit:

Do you think a linear model is appropriate for this data set?

Exercise 1 – Line of Best Fit Table

SDIP Level	Number of Policies	Number of Policies with Claims	Percent with Claims	Number of Policies without Claims	Percent without Claims
9	152039	13305			
10	37857	3938			
11	7053	813			
12	3698	415			
13	20521	2364			
14	14485	1766			
15	14314	1802			
16	3185	452			
17	2998	406			
18	2664	388			
19	1885	300			
20	1231	205			
21	965	161			
22	762	133			
23	622	104			
24	460	65			
25	344	69			
26	250	41			
27	203	31			
28	151	29			
29	127	31			
30	78	19			
31	72	15			
32	50	11			
33	41	8			
34	33	2			
35	100	18			

Extension 1: Does the %Claims vs. SDIP relationship vary with rate class?

The following tables give the information used in the previous exercise broken down by rate class.

*Choose a single rate class and repeat the previous 4 exercises – find the percent of policies with claims for each SDIP step, plot these two variables against each other, find the correlation coefficient, and find a line of best fit.

*Comment on the regression line and the goodness of fit for this plot. For the rate class you chose, is the correlation coefficient higher or lower than for the entire data set? Suggest a reason for any changes in goodness of fit.

Table: Number of Policies by SDIP and Rate Class

SDIP	RC 10	RC 15	RC 17	RC 18	RC 20	RC 21	RC 25	RC 26	Total
09	118621	32784	236	146	11	43	9	189	152039
10	33723	3188	585	229	5	22	18	87	37857
11	5385	233	851	489	12	9	38	36	7053
12	2092	70	801	566	21	10	70	68	3698
13	15182	3222	628	681	100	60	227	421	20521
14	10186	1745	443	367	170	134	469	971	14485
15	8860	785	624	269	381	321	849	2225	14314
16	2422	110	289	179	12	21	53	99	3185
17	1990	278	227	136	27	25	101	214	2998
18	1760	215	165	98	39	25	117	245	2664
19	1324	98	119	69	24	18	59	174	1885
20	922	38	115	72	9	7	15	53	1231
21	702	44	80	56	7	7	26	43	965
22	559	39	56	33	6	8	18	43	762
23	467	30	60	29	3	2	11	20	622
24	362	10	41	23	2	1	6	15	460
25	258	10	36	20	2	3	5	10	344
26	195	11	26	8	1	0	4	5	250
27	152	7	23	13	0	0	3	5	203
28	122	8	8	7	0	1	4	1	151
29	98	6	10	6	0	0	3	4	127
30	61	7	4	2	0	1	2	1	78
31	47	3	11	7	2	0	2	0	72
32	39	1	3	5	0	1	1	0	50
33	31	3	2	4	0	0	1	0	41
34	28	2	1	0	0	0	0	2	33
35	73	0	10	9	1	1	5	1	100
Total	205661	42947	5454	3523	835	720	2116	4932	266188

Table: Number of Policies with Claims by SDIP and Rate Class

SDIP	RC 10	RC 15	RC 17	RC 18	RC 20	RC 21	RC 25	RC 26	Total
09	10337	2894	28	13	1	5	1	26	13305
10	3484	360	57	22	0	0	4	11	3938
11	615	28	109	51	2	1	4	3	813
12	233	9	101	51	3	1	9	8	415
13	1691	391	90	98	12	9	18	55	2364
14	1232	208	57	40	24	19	62	124	1766
15	946	77	83	38	71	53	163	371	1802
16	331	11	50	28	3	7	7	15	452
17	248	54	33	18	1	9	8	35	406
18	240	41	29	16	6	3	21	32	388
19	197	16	20	8	7	1	13	38	300
20	145	3	26	14	1	2	2	12	205
21	123	9	7	9	2	1	1	9	161
22	91	11	6	7	1	3	4	10	133
23	84	6	6	3	0	0	1	4	104
24	48	1	8	5	0	0	0	3	65
25	48	2	9	7	0	1	0	2	69
26	33	2	1	1	0	0	1	3	41
27	24	1	4	2	0	0	0	0	31
28	23	4	0	1	0	1	0	0	29
29	19	3	6	1	0	0	0	2	31
30	15	1	2	1	0	0	0	0	19
31	9	1	1	4	0	0	0	0	15
32	8	1	1	0	0	0	1	0	11
33	6	1	0	1	0	0	0	0	8
34	2	0	0	0	0	0	0	0	2
35	14	0	2	2	0	0	0	0	18
Total	20246	4135	736	441	134	116	320	763	26891

Question 2: How does the policy premium vary with SDIP?

Complete the exercises below then circle back to provide a complete answer to this question.

Exercises:

The following table gives the average premium charged by SDIP and rate class.

1. Graph the Grand Total premium vs. SDIP and describe the relationship between SDIP step and Grand Total premium. (A blank cell indicates that no policy holders had that particular combination of SDIP and rate class).



SDIP	RC 10	RC 15	RC 17	RC 18	RC 20	RC 21	RC 25	RC 26	Grand Total
09	\$697.46	\$536.26	\$720.24	\$703.74	\$832.92	\$808.87	\$447.29	\$818.79	\$662.91
10	\$800.95	\$641.30	\$951.78	\$852.18	\$1,107.70	\$931.84	\$924.36	\$871.93	\$790.48
11	\$884.67	\$756.82	\$1,114.27	\$972.68	\$1,182.63	\$962.22	\$1,002.24	\$925.02	\$915.53
12	\$955.91	\$744.27	\$1,210.63	\$1,009.66	\$1,466.02	\$1,088.03	\$1,221.16	\$1,056.20	\$1,025.86
13	\$1,038.69	\$799.64	\$1,290.06	\$1,127.95	\$1,634.86	\$1,201.07	\$1,517.16	\$1,267.89	\$1,025.29
14	\$1,109.80	\$859.86	\$1,382.55	\$1,182.09	\$1,724.77	\$1,413.85	\$1,613.43	\$1,333.36	\$1,131.26
15	\$999.77	\$751.32	\$1,352.28	\$1,185.80	\$1,734.50	\$1,380.58	\$1,685.06	\$1,344.48	\$1,127.52
16	\$1,233.47	\$1,002.77	\$1,525.13	\$1,324.51	\$1,762.28	\$1,687.44	\$1,814.72	\$1,483.96	\$1,279.08
17	\$1,281.31	\$1,012.84	\$1,618.81	\$1,342.25	\$1,923.08	\$1,358.75	\$1,925.62	\$1,532.78	\$1,330.89
18	\$1,318.69	\$1,005.22	\$1,730.79	\$1,450.34	\$2,348.14	\$1,938.84	\$2,066.73	\$1,683.36	\$1,410.93
19	\$1,396.82	\$1,088.05	\$1,716.42	\$1,439.21	\$2,466.54	\$1,865.33	\$2,112.74	\$1,670.62	\$1,469.30
20	\$1,400.04	\$1,211.02	\$1,847.10	\$1,553.76	\$2,029.52	\$1,910.72	\$2,319.29	\$1,735.65	\$1,478.56
21	\$1,471.22	\$1,174.94	\$1,751.76	\$1,674.47	\$2,644.44	\$2,184.25	\$2,277.51	\$1,735.78	\$1,540.64
22	\$1,529.04	\$1,184.76	\$1,965.85	\$1,665.24	\$2,723.30	\$1,722.86	\$2,178.27	\$2,265.81	\$1,618.06
23	\$1,622.71	\$1,218.11	\$1,961.53	\$1,836.08		\$1,718.74	\$2,354.25	\$2,256.95	\$1,679.28
24	\$1,675.69	\$1,036.73	\$2,152.11	\$1,806.79	\$3,203.36		\$2,257.17	\$2,144.60	\$1,752.32
25	\$1,731.15	\$1,684.34	\$2,390.99	\$2,239.74		\$2,089.40	\$2,631.50	\$2,674.51	\$1,871.80
26	\$1,748.07	\$1,616.22	\$2,433.39	\$2,193.81			\$4,284.89	\$2,836.91	\$1,901.67
27	\$1,723.36	\$2,253.22	\$2,271.74	\$1,879.19				\$1,272.12	\$1,805.10
28	\$1,880.16	\$1,466.26	\$2,321.80	\$1,603.70		\$2,304.43		\$1,606.06	\$1,891.22
29	\$1,917.25	\$2,017.58	\$2,742.10	\$1,462.48			\$3,415.49		\$2,028.99
30	\$2,063.58	\$1,410.94	\$3,042.50				\$2,048.46		\$2,083.03
31	\$2,250.77		\$2,753.35	\$2,126.92			\$2,760.95		\$2,377.04
32	\$2,369.13			\$785.25		\$2,214.67			\$2,195.29
33	\$2,210.48	\$2,683.76		\$2,169.39					\$2,264.50
34	\$2,452.55							\$3,780.20	\$2,642.22
35	\$2,134.83		\$2,584.86	\$1,790.08			\$3,181.47	\$4,661.22	\$2,324.01
Grand Total	\$820.71	\$594.24	\$1,322.00	\$1,146.45	\$1,772.55	\$1,385.80	\$1,699.97	\$1,371.51	\$820.50

2. Fit a regression line to the data, using the “Grand Total” column to include all rate classes. You may submit just 1 graph including the regression line and your scatterplot from Exercise 1 (copy the graph paper from the Project Overview if needed). The resources for creating scatterplots, regression lines, and correlation coefficients are all included on the Question 1 document.



Regression line: _____

How strong is the linear relationship between Grand Total average premium and SDIP?

3. The insurance manual (www.aib.org) indicates that the collision insurance premiums are based on a step of 15 and then the premium is reduced by 7% for every step below 15 and increased by 7% for each step above 15. For steps above 19 a 10% increase is applied per step. □

Simple Interest (the number of SDIP steps away from 15 takes the place of t for time):

<https://youtu.be/r3-lyBGIJ98>

SDIP	Grand Total Actual	Grand Total Predicted
09	\$662.91	
10	\$790.48	
11	\$915.53	
12	\$1,025.86	
13	\$1,025.29	
14	\$1,131.26	
15	\$1,127.52	-----
16	\$1,279.08	
17	\$1,330.89	
18	\$1,410.93	
19	\$1,469.30	
20	\$1,478.56	
21	\$1,540.64	
22	\$1,618.06	
23	\$1,679.28	
24	\$1,752.32	
25	\$1,871.80	
26	\$1,901.67	
27	\$1,805.10	
28	\$1,891.22	
29	\$2,028.99	
30	\$2,083.03	
31	\$2,377.04	
32	\$2,195.29	
33	\$2,264.50	
34	\$2,642.22	
35	\$2,324.01	

Does the data for the average premium and SDIP step support the percent increase described here? If not, what could be some reasons for the difference?

*Be sure to include evidence, use the table included here to compare values.

4. Assume for this part that the data from the insurance manual for these 7% changes based on SDIP are to be *compounded*. This means that, for instance, the 7% change for step 17 would be based on the amount in step 16, not based upon the base amount from step 15.



Compound interest: <https://youtu.be/wf91rEGw88Q>

Calculate compound interest: <https://youtu.be/Rm6UdfRs3gw>

Decreasing compound interest: https://youtu.be/7IPBdVp8_90

Practice: <https://www.mathexpression.com/compound-interest-practice-3.html>

SDIP	Grand Total	Compounded Total
09	\$662.91	
10	\$790.48	
11	\$915.53	
12	\$1,025.86	
13	\$1,025.29	
14	\$1,131.26	
15	\$1,127.52	-----
16	\$1,279.08	
17	\$1,330.89	
18	\$1,410.93	
19	\$1,469.30	
20	\$1,478.56	
21	\$1,540.64	
22	\$1,618.06	
23	\$1,679.28	
24	\$1,752.32	
25	\$1,871.80	
26	\$1,901.67	
27	\$1,805.10	
28	\$1,891.22	
29	\$2,028.99	
30	\$2,083.03	
31	\$2,377.04	
32	\$2,195.29	
33	\$2,264.50	
34	\$2,642.22	
35	\$2,324.01	

Does the data offer evidence as to whether the 7% premium increase is compounded from step to step? Describe in detail using evidence from your table and/or graph.

Question 3: Which SDIP steps yield the largest profit for the insurance company?

Complete the data analysis below then circle back to provide a complete answer to this question.

The table on the following page includes the total losses for the insurance company, in dollars, for each SDIP.

Calculate the following information to complete the table.

- Net Profit
- Average Profit (divide net profit by number of policies)
- Average Loss per Policy (divide loss by number of policies).
- Average Loss per Claim (divide loss by number of claims)

Graph each of the four filled-in columns versus SDIP step. Comment on each graph and its importance. Using information from each of the four graphs, discuss which SDIP steps are most profitable for the insurance company, as well as possible reasons why this is the case (this will make up most or all of your response to the main question above).

You may graph each by hand, make additional copies of the graph paper from the **Project Overview**.

SDIP	Number of Policies	Number of Policies with Claims	Total Losses (\$)	Total Revenue (\$)	Net Profit (\$)	Average Profit (\$)	Average Loss per Policy (\$)	Average Loss per Claim (\$)
09	152039	13305	\$37,654,878.43	\$100,803,476.45				
10	37857	3938	\$10,777,694.89	\$29,915,929.29				
11	7053	813	\$2,213,576.82	\$6,452,137.66				
12	3698	415	\$1,612,912.91	\$3,789,145.36				
13	20521	2364	\$7,779,020.03	\$21,042,522.82				
14	14485	1766	\$5,241,657.04	\$16,372,229.62				
15	14314	1802	\$8,546,389.23	\$16,120,317.86				
16	3185	452	\$1,597,518.49	\$4,074,103.14				
17	2998	406	\$1,518,472.08	\$3,980,209.11				
18	2664	388	\$1,350,318.96	\$3,755,985.75				
19	1885	300	\$1,400,230.02	\$2,778,072.88				
20	1231	205	\$863,640.32	\$1,826,103.68				
21	965	161	\$532,077.43	\$1,487,431.26				
22	762	133	\$740,962.61	\$1,230,503.92				
23	622	104	\$494,380.54	\$1,045,546.65				
24	460	65	\$177,252.05	\$803,484.12				
25	344	69	\$385,187.15	\$632,160.04				
26	250	41	\$138,953.20	\$467,376.99				
27	203	31	\$130,758.06	\$376,444.35				
28	151	29	\$121,049.21	\$289,238.39				
29	127	31	\$150,813.45	\$249,984.87				
30	78	19	\$64,167.60	\$160,283.50				
31	72	15	\$60,063.70	\$163,413.08				
32	50	11	\$142,973.96	\$111,237.89				
33	41	8	\$20,209.78	\$93,343.15				
34	33	2	\$10,898.17	\$81,858.25				
35	100	18	\$216,079.76	\$234,089.22				

Question 4: Are the Adjustments per Rate Class Fair?

Complete the exercises below then circle back to provide a complete answer to this question.

The premium that is charged is based on the rate class, which is based on information about the driver such as years of experience, age, and whether the driver has had training. Are the rate class groups being charged fairly? Is there one group for which the company is making a larger profit than the others?

Years of Driving Experience		
Less than 3 years	At least 3 but less than 6	At least 6 years
20 – Principal Operator No driver training	17 – Principal Operator	10 – Under 65 years old
21 – Occasional operator No driver training	18 – Occasional Operator	15 – At least 65 years old
25 – Principal Operator with driver training		
26 – Occasional Operator with driver training		

Instructions:

The following table contains data for the money collected in premiums for over 50,000 policies, and the amount paid out in claims on those policies:

Rate Class	Number of Policies	Total Premiums	Total Paid in Claims
10	41132	\$33,757,280.07	\$12,122,040.87
15	8587	\$5,102,705.03	\$2,919,881.66
17	1091	\$1,442,306.62	\$806,040.06
18	704	\$807,101.33	\$338,086.09
20	167	\$296,015.03	\$162,556.03
21	145	\$200,941.28	\$122,953.84
25	424	\$720,787.34	\$268,433.45
26	987	\$1,353,681.14	\$451,079.33
Grand Total	53237	\$43,680,817.85	\$17,191,071.33

1) To determine the fairness of the premium adjustments made to each rate class, it is first necessary to formulate a mathematical definition of “fairness.” State a definition of “fairness” that would allow the data above to be used to answer the question.



If your definition of “fairness” includes data from Questions 1, 2, or 3, feel free to use that data here.

2) Prepare a graph that uses your definition of fairness to show whether the premiums charged to different rate classes are fair. Comment on your graph – how fair is the pricing or car insurance?



Some groups that may be interesting to compare are:

- Drivers with less than three years experience that have had driver training (rate classes 25 and 26) vs. those without driver training (rate classes 20 and 21). Note that the driver training discount applies only to drivers with less than three years experience.
- Drivers with less than three years experience vs. drivers with at least 6 years experience (but under 65).
- Experienced drivers over 65 and under 65.

If you have found that the premiums are not fairly determined, how should they be adjusted to make them fair?

Question 5: What is the Actual Price of a Ticket?

Getting pulled over for going 40 mph in a 30 mph speed zone usually results in a fifty dollar ticket. Is that all that ticket really costs you? Unfortunately, if this is your second ticket (the first ticket in Massachusetts does not affect your SDIP rating) for a minor moving violation (stop sign, speeding, etc.), the price of the ticket is just the beginning. This incident affects your insurance premium by changing your SDIP rating; the second ticket for a minor moving violation increases your SDIP rating by two steps. The increases in one's SDIP step for various types of violations are summarized in the table below.

*Recall from the Background Information that the SDIP decreases by 1 for every incident-free year.

**Also, if a driver has 3 consecutive years of incident-free driving and their step is over 14, it is reduced to 14 at the end of the 3 year period.

Surchargeable Incident	Increase in SDIP Level
Major Traffic Violation (i.e., D.U.I.)	5
Major At-Fault Accident (claim over \$2,000)	4
Minor At-Fault Accident (claim over \$500 to \$2,000)	3
Minor Traffic Violation (i.e., speeding)	2

From http://www.mass.gov/doi/Consumer/WaysToSave_SDIP.html

The table below gives the premium for an insurance policy at each SDIP level. Although premiums vary from person to person (because of the rate class they belong to), assume for this problem that premium is entirely determined by SDIP level. This information will be used to answer the questions on the next page.

SDIP Level	Premium
9	\$662.91
10	\$790.48
11	\$915.53
12	\$968.23
13	\$1,025.29
14	\$1,076.41
15	\$1,127.52
16	\$1,279.08
17	\$1,330.89
18	\$1,410.93
19	\$1,469.30
20	\$1,478.56
21	\$1,540.64
22	\$1,618.06
23	\$1,679.28
24	\$1,752.32
25	\$1,871.80
26	\$1,901.67
27	\$1,944.11
28	\$1,986.55
29	\$2,028.99
30	\$2,083.03
31	\$2,139.16
32	\$2,195.29
33	\$2,264.50
34	\$2,324.01
35	\$2,642.22

Using the information on the previous page, one can determine the impact in overall cost (ticket plus increase in premium) for several traffic violations.

For example, consider a new driver who receives a second \$50 ticket for a minor moving violation. [Click here](#) for a 45 second animation of the process.

- New drivers are automatically placed at an SDIP level of 15. Upon receiving a second \$50 ticket for a minor moving violation, the SDIP level would be 17.
- Therefore, the annual cost of the policy would go from \$1,127.52/year for SDIP level 15 to \$1,330.89/year for SDIP level 17, a difference of \$203.37.
- If the driver receives no additional tickets for the remainder of the year, the driver would move to SDIP level 16 for year 2 and would pay \$1,279.08 for that year.
- This is instead of \$1,076.41 for an SDIP level 14, the level that the driver would have been on year 2 if they had not received a ticket. The difference in the second year is \$202.67 (that is $1,279.08 - 1,076.41$).
- Therefore, over the two-year period following the ticket, the driver has had to pay an additional two-point penalty of \$406.04 ($\$203.37 + \202.67) plus \$50 for the ticket for a total cost of \$456.04.

Questions:

1. Consider the following scenarios in which a driver's SDIP step increases as a result of a driving incident.
 - a. What would be the total cost over two years for a driver at SDIP level 28 for a second \$50 minor moving violation ticket?
 - b. If a driver has a minor accident, the SDIP level increases by three levels. What would be the total policy increase in cost over three years for a driver at SDIP level 20 who was involved in a minor accident? (Assume no additional tickets or accidents over the next three years.)
 - c. Suppose a driver who is initially at SDIP step 11 has a major accident. A year later, the same driver is ticketed for speeding. If the driver commits no further violations, in how many years will the driver reach SDIP step 9, the lowest step? What is the driver's total increase in premiums during that time, compared to his premiums if he had had no incidents?

2. Is the “true cost” of traffic violations higher for those with higher SDIP steps?



*Choose one type of motor vehicle incident (major traffic violation, second minor traffic violation, major accident, or minor accident).

*Choose 4 driver levels, two lower, two higher (each of the SDIP steps goes from 9 to 35), compute the total cost of this incident as measured by increased insurance premiums (for this question, ignore the cost of the violation itself).

That is, compare the total premiums paid after the incident to the premiums paid if the incident had never happened. Assume that the driver has no further driving incidents. Make a table for each of the 4 driver levels you chose showing the effect of the incident on that driver. Comment on your findings.

Some useful things to keep in mind:

- After a single incident, a driver’s SDIP step and insurance premium will be higher for a number of years. To compute the *total* premium increase, you need to consider *every* year for which the premium is greater than if there had been no incident at all.
- If a driver’s SDIP step is still greater than 14 after three years of incident-free driving, the SDIP is automatically reduced to 14
- The maximum SDIP step is 35.

Question 6: How does the new point system work?

Circle back to provide a complete answer to this question after calculating the 4 driver premiums.

As of January 1, 2006, the state of Massachusetts revised its Safe Driver Insurance Plan (SDIP). The process of assigning drivers to “steps” based on their driving history was replaced with a system based on “surcharge points.” If a Massachusetts driver commits a moving violation or is at fault in an accident, then surcharge points are added to the driver’s record. The more surcharge points a driver has accumulated, the higher his or her car insurance premium will be.

The following rules outline the new SDIP system:

- Each type of incident has a number of surcharge points assigned to it. The point values are given in the table below. A driver is assigned a surcharge point total, which is simply the sum of the surcharge points for each driving incident.

Surchargeable Incident	Surcharge Points
Major Traffic Violation (i.e., D.U.I.)	5
Major At-Fault Accident (claim over \$2,000)	4
Minor At-Fault Accident (claim over \$500 to \$2,000)	3
Minor Traffic Violation (i.e., speeding)	2

From http://www.mass.gov/doi/Consumer/WaysToSave_SDIP.html

- The lowest possible total number of surcharge points is zero, and the total may not exceed 45.
- When examining a driver’s history, the insurance company only considers incidents that occurred in the past six years. Driving incidents older than six years old are removed from one’s driving record. The six-year period preceding the date your insurance policy will take effect is called the *policy experience period*.
- No surcharge points are assigned for any incidents in the sixth and oldest year of the policy experience period.
- If a driver has been incident-free for the past three years **and** has no more than three surchargeable incidents in the past five years, then the surcharge point value for each incident still on the driver’s record is decreased by 1.
- If a driver has at least five years of driving experience and has had no surchargeable incidents in the past five years, then the driver receives the Excellent Driver Discount. Drivers also receive this discount if their only surchargeable incident is *one* minor traffic violation that is at least three years old.
- If a driver has had no surchargeable incidents for the past six years (and has a least six years of driving experience), then the driver receives the Excellent Driver Discount Plus.
- A driver’s surcharge points – and discounts, if applicable – affect their insurance premium.

Changes in premium are based on a “base rate” and are determined as follows:

- For inexperienced drivers (less than six years of driving experience), each surcharge point causes an increase in premium equal to 7.5% of the base rate.
- For experienced drivers (at least six years experience), each surcharge point causes an increase in premium equal to 15% of the base rate.
- The Excellent Driver Discount results in a decrease in premium equal to 7% of the base rate.
- The Excellent Driver Discount Plus causes a decrease in premium equal to 17% of the base rate.

Instructions:

With all the new changes, each driver will want to compute the surcharge points to be sure of their own premiums. Your task is to choose any 3 drivers below to calculate their premium. Then, either use your own driving history, the driving history of someone in your family, or create your own driving history and calculate the premium that will be charged.

You will need to consider:

- Type and date of all surchargeable incidents in the past six years
- Number of years of driving experience
- The year for which the policy applies
- The “base rate” for the insurance premium

Using this information, you should compute the following:

- The driver’s total number of surcharge points
- The driver’s premium, considering surcharge points and any applicable discounts

Driver A

Policy year: 2006

Years of driving experience: 17

Base rate: \$900.00

Driving history:

2004: Minor At-Fault Accident

2003: Minor Traffic Violation

2000: Minor Traffic Violation

Driver C

Policy year: 2007

Years of driving experience: 11

Base rate: \$1,300.00

Driving history:

2005: Minor Traffic Violation

2004: Minor Traffic Violation, Minor At-Fault Accident

2003: Minor Traffic Violation

2002: Major Traffic Violation

Driver B

Policy year: 2008

Years of driving experience: 5

Base rate: \$1,150.00

Driving history:

2003: Minor Traffic Violation

Driver D

Policy year: 2009

Years of driving experience: 35

Base rate: \$850.00

Driving history:

No surchargeable incidents in policy experience period.

Note: Students who have experience with a computer programming language and would prefer to create a program or create a programmed Excel sheet may do so.

You're in The Driver's Seat – Project Rubric

This rubric will be applied to each of the six questions

Characteristic	5	4	3	2	1
Key Question	Student thoroughly addresses the key question including multiple details in the analysis	Student addresses the key question including 2 to 3 specific details in the analysis	Student generally provides a response to the key question only includes 1 specific detail in the analysis	Student provides minimal information in response to the key question and does not include specific details.	The student does not provide a response to the key question.
Visual Displays (i.e.- tables, charts, graphs, etc.)	The student provides all required informative visual displays that organize information related to the key question. In the case of no required visual displays, student work is evident, and it incorporates all considerations for the key question.	The student provides all but 1 informative visual displays that organize information related to the key question. In the case of no required visual displays, student work is evident, and it incorporates most considerations for the key question.	The student provides all but 2 informative visual displays that organize information related to the key question. In the case of no required visual displays, student work is evident, and it incorporates some considerations for the key question.	The student provides 1 informative visual display that organizes information related to the key question. In the case of no required visual displays, student work is evident, and it incorporates minimal considerations for the key question.	No visual displays are provided, or the student work does not incorporate any considerations for the key question.
Data Analysis	The student presents a complete analysis of the data required by the question with minimal errors.	The student presents a complete analysis of the data required by the question with moderate errors.	The student presents an analysis of the data required by the question, but it is incomplete.	The student presents a minimal analysis of the data required by the question.	No evidence of data analysis required by the question is provided.
Teacher Comments:					

Question 1: _____ **Question 2:** _____ **Question 3:** _____ **Question 4:** _____ **Question 5:** _____ **Question 6:** _____