EISENHOWER PROJECT

TRUCKING TEAM

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June 13, 2001

INTRODUCTION

Over the past year members of the "trucking team" have worked together to create exercises and problems related to the trucking industry that can be solved using mathematical techniques. Team members have brought many different viewpoints and goals to the table as we have worked on this project. This is in part due to varied backgrounds – industry member, university student, middle school instructor, high school instructors, and university instructors. As we have prepared this material we have dealt with issues such as mathematical content, real-world application, and retention of knowledge. We have also kept the Wisconsin Education Standards as a guiding document.

The exercises and problems are designed for students at the middle school level and above. At least one solution is provided for each exercise. Different mathematical techniques and sub disciplines are represented in the material including algebra, geometry, probability, and statistics. In some solutions both technologically aided numerical solutions and analytic solutions are provided. Presently we have organized the material into three categories – Short Exercises, Medium Exercises, Long Exercises – based on the estimated time that it will take to provide a solution to the exercise or problem.

The material that you will find in this manuscript is still in a rough stage. In most cases each exercise is essentially unique in comparison to the others; i.e., typically an exercise was not created and then cloned by changing the numbers. While a good deal of the material has been classroom tested by one or more of the authors, you are the first individuals that will have the opportunity to look at and incorporate this material into the curriculum. We hope that you would share your thoughts on the completed material – content, organization, level of difficulty, multiple exercises of the same nature, missing concepts, web version, etc.

As the material begins to be used and reviewed by individuals such as you, we intend to create additional material as well as refine the current material. Your input is crucial to the overall success of this project. Any input that you can provide will be highly valued. Please submit your comments to the following address

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Thank you for your interest in this project.

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SHORT EXERCISES

How many miles did the driver drive?

Truck driver 1 started at Green Bay and drove 121 miles to Milwaukee. Once he/she arrived in Milwaukee he/she remembered that he/she was suppose to drop off some cargo in Sheboygan. Sheboygan is 63 miles from Milwaukee. The driver had to drive back to Sheboygan.

1. How many total miles did the driver travel?

2. If the driver had remembered to stop first in Sheboygan and then proceeded to Milwaukee, how many miles would he/she have driven?

3. How many extra miles did the driver travel because of his/her mistake?

Solution

Note: This exercise is not completely well defined.

1. The total number of miles driven by the driver depends on whether or not the route distance ends when he/she arrived in Sheboygan or if he/she then had to go back to Milwaukee. In the first scenario the driver drove 123 + 63 = 184 miles. In the second scenario the driver drove 123 + 2(63) = 247 miles.

2. 121 miles.

3. The driver drove either 63 or 126 extra miles depending on the scenario. If the driver were going straight back to Green Bay after dropping the Milwaukee load it is possible that the mistake cost no extra miles.

Day	1	2	3	4	5	6	7	8
Miles	352	489	525	540	352	599	283	600

The above table displays the number of miles a driver traveled on a particular trip.

1. Identify the maximum and minimum number of miles the driver traveled in any one day.

2. Calculate the range in the number of daily miles the driver drove throughout the trip.

3. Find the mean, median, and the mode of the daily miles traveled by the driver.

Solution

To determine many of the results asked for here, it is advantageous to first order the mileage values from smallest to largest:

283 352 352 489 525 540 599 600

1. The maximum mileage on a single day was 600 miles. The minimum mileage on a single day was 283 miles.

2. The range of miles that the driver drove is the difference of the maximum and minimum mileages; i.e., $600 - 283 = 317$ miles.

3. The mean distance traveled is $\dfrac{283+352+352+489+525+540+599+600}{8} = 467.5$ miles.

   The median distance traveled is $\dfrac{489+525}{2} = 507$ miles.

   The mode of the distances traveled is 352 miles.

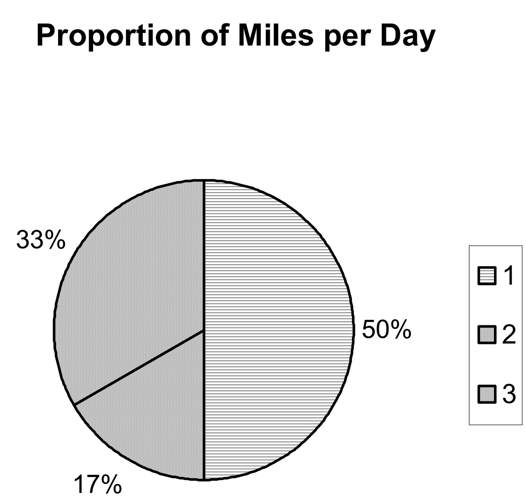
1. A driver traveled a total of 1500 miles on his/her trip. The first day he/she drove 750 miles. The second day the driver traveled only 250 miles. The last day he/she drove ____ miles. (You fill in the blank.)

2. Illustrate the proportion of miles driven each day by drawing a circle graph of the entire trip.

Solution

1. The last day the driver drove $1500 - 750 - 250 = 1500 - (750 + 250) = 500$ miles.

2. The proportions of miles driven on each day are $\frac{750}{1500} = 0.50$, $\frac{250}{1500} = 0.17$, and $\frac{500}{1500} = 0.33$.



1. The regular day for a truck driver starts at 8:00 pm and is followed by 8 hours of travel time. What time does the shift end?

2. The driver is on duty Monday – Friday for a 40-hour workweek. The salary for the driver is $18.00/hour. Drivers are allowed to work an extra 3 hours a day for overtime. Therefore any hours over 40 hours a week, the driver gets paid one and one-half times the standard rate. What would this hourly rate be?

3. Given this driver's time log, how much does the driver make for the week?

Monday	Tuesday	Wednesday	Thursday	Friday
8 hrs	10 hrs	11 hrs	9 hrs	10 hrs

4. If the driver traveled these same hours for a complete month, how much would the driver make in a month?

Solution

1. The driver's shift will end at 4:00 am.
2. The overtime-hourly rate is $1.5 \times \$18.00 = \$27.00$.
3. First we determine the number of regular hours and the number of overtime hours that the driver worked:

	Monday	Tuesday	Wednesday	Thursday	Friday	Total
	8 hrs	10 hrs	11 hrs	9 hrs	10 hrs	
Regular hrs	8 hrs	8 hrs	8 hrs	8 hrs	8 hrs	40 hrs
Overtime hrs		2 hrs	3 hrs	1 hr	2 hrs	8 hrs

   Now we find that his weekly earnings are $\$18.00 \times 40 + \$27.00 \times 8 = \$936.00$.

4. Assuming that a month has exactly four weeks in it, the driver would earn $4 \times \$936.00 = \$3744.00$.

Given the following traveling time log for a driver:

Day 1	Day 2	Day 3
4 hours at 65 mph	6 ½ hours at 70 mph	5 hours at 70 mph
30 min at 35 mph	1 ½ hours at 45 mph	1 ½ hours at 35 mph
2 hours at 15 mph		45 min at 25 mph
2 ½ hours at 70 mph		2 ¾ hours at 65 mph
Day 4	Day 5	
7 hours at 65 mph	4 hours at 75 mph	
2 hours at 59 mph	3 hours at 65 mph	
	2 hours at 50 mph	

1. How many miles did the driver travel during this week?

2. How many total hours was the driver on the road?

3. What was the driver's average speed in miles per hour?

Solution

1. The total number of miles traveled is given by:

$$4(65)+0.5(35)+2(15)+2.5(70)+6.5(70)+1.5(45)+$$
$$5(70)+1.5(35)+0.75(25)+2.75(65)+7(65)+2(59)+4(75)+3(65)+2(50)=2773$$

2. The total number of hours the driver drove is given by:

$$4+0.5+2+2.5+6.5+1.5+5+1.5+0.75+2.75+7+2+4+3+2=45$$

3. The driver's average speed in miles per hour is:

$$\frac{2773}{45}=61.6$$

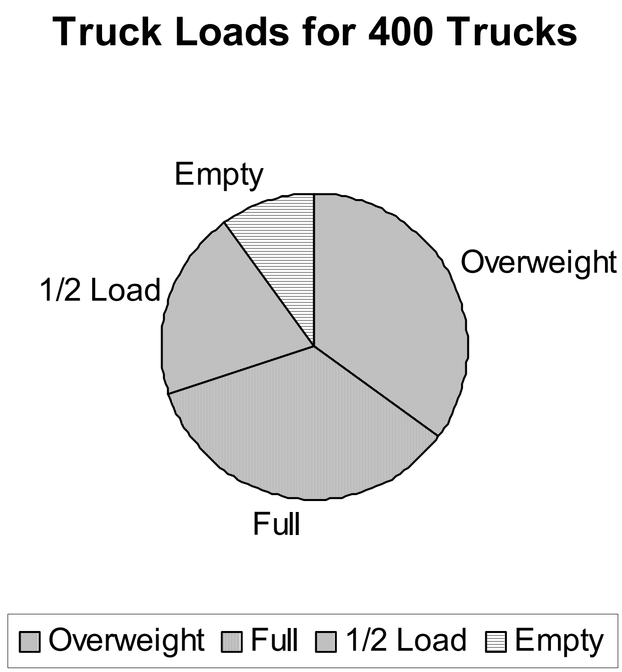
A trucking company receives a $300 bonus if the shipments are delivered early. In order to get the shipment to the receiving company early a driver must put in 15 hours of overtime at a pay rate of time and a half. If the driver's regular rate were $18/hour, would it be profitable for the trucking company to get the shipment to the receiving company early?

Solution

Based on the given information, it would not be profitable for the company to get the shipment to the company early. The 15 hours of overtime would cost the trucking company $15(1.5\times\$18.00)=\$405.00$. Since this amount exceeds the $300 bonus obtained from an early delivery the trucking company would experience a net lose of $105.00.

Based on the following pie chart, about how many of the 400 trucks carry a half load?

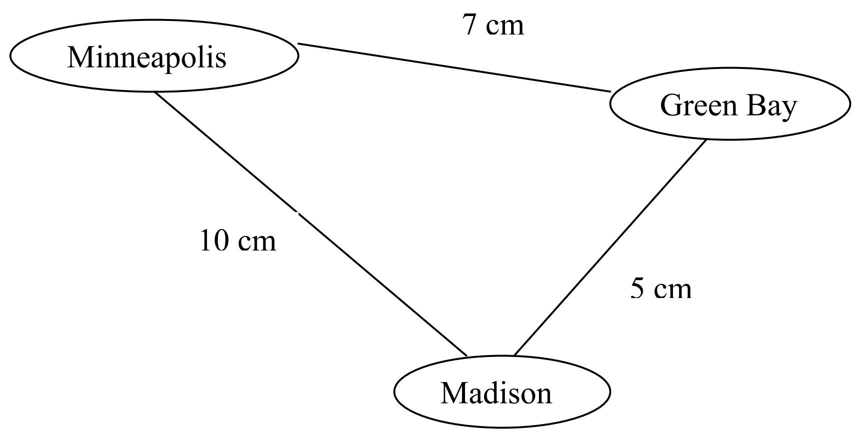
a. 20
b. 40
c. 80
d. 100



Solution

It appears that slightly less than 1/4 of the pie chart corresponds to 1/2-load situations. Since 1/4 of 400 loads is 100 loads we conclude that the correct response is c. 80 loads.

Assuming that 1 cm = 40 mi, how many miles long is the route from Green Bay to Madison to
Minneapolis to Green Bay?



Solution

The total route distance on the map is $5+10+7=22$ cm. Using the conversion factor of 1 cm = 40 mi, we find the total route mileage to be $22(40)=880$ miles.

A trucker drove from International Falls where the temperature was -32°F to St. Louis where the temperature was 44°F. What was the change in temperature?

Solution

The change in temperature is $44° - (-32°) = 76°$ F.

If diesel fuel sells for $1.89 a gallon and it cost $100 to fill the tank of a truck, approximately how many gallons of fuel were used to fill the tank?

a. 20
b. 40
c. 54
d. 75

Solution

$\frac{100}{1.89} \approx \frac{100}{2} = 50$, so approximately 50 gallons, answer c. $\frac{100}{1.89} = 52.9$ is the actual answer.

Which unit would you use to measure the amount of fuel in an Schneider National truck?

a. Liters
b. Kilograms
c. Millimeters
d. Square centimeters

Solution

The unit most likely used for measuring the amount of fuel in an Schneider National truck is liters. Answer a.

Harry drives a truck for Acme Trucking at the pay rate of $15/hour during the week and $20/hour during the weekend or on a holiday. If he worked only 8-hour days and earned $520, what combination of weekday and weekends/holidays did Harry drive?

a. 2 weekdays, 1 weekend/holiday
b. 3 weekdays, 1 weekend/holiday
c. 2 weekdays, 1 weekend/holiday
d. Not possible

Solution

Answer b. is correct since $\$15(3)(8)+\$20(1)(8)=\$520$.

What, most likely, would be parallel to the front axle of a truck?

a. Door handle
b. Front bumper
c. Steering wheel
d. Tire

Solution

All four of the responses are possible. The door handle of the driver or passenger door would be parallel to the front axel when the door is open 90°. Also a rear trailer door handle might be parallel to the front axle. The front bumper is clearly parallel to the front axel. The steering wheel is embedded in a plane that is parallel to the front axel. Finally, the spare tire is typically parallel to the front axle.

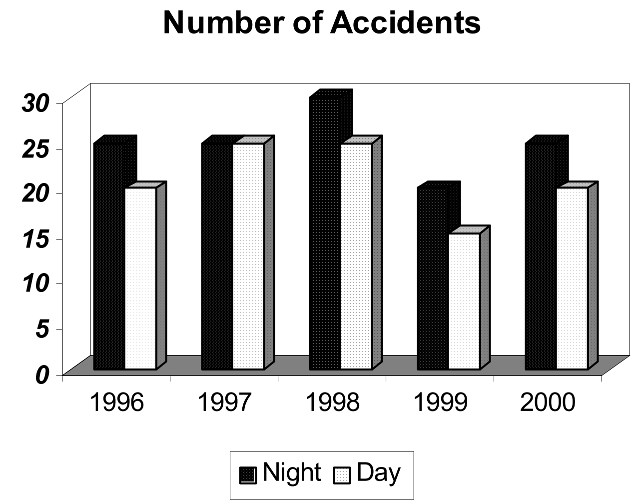
A truck was driving on an icy road when a deer ran out on the road in front of it. In trying to miss the deer, the driver skidded 50 feet before rolling over and landing upside down in the ditch. Which best describes the movement of the truck?

a. Turn
b. Turn and slide
c. Slide and flip
d. Turn and flip

Solution

This is clearly a case of slide and flip. Answer c.

Based on the following chart



1. About how many accidents occurred during the day in 1998?

2. What was the average number of accidents per year that had occurred at night?

3. In what year did three-fourths as many accidents occur during the day as at night?

Solution

1. Approximately 25 accidents occurred during the day in 1998.

2. The average number of accidents per year that had occurred at night is
$$\frac{25+25+30+20+25}{5}=25.$$

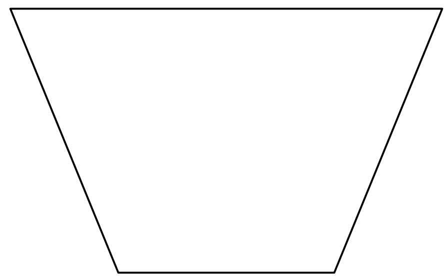
3. In 1999 there were 3/4 as many accidents during the day (15) as during the night (20).

There are five trucks sitting in a parking lot. Melissa's boss forgot to tell her which truck to take. She has the key. What is the probability she chooses the right truck? The wrong truck?

Solution

The probability that Melissa chooses the right truck is $\frac{1}{5} = 0.2$. The probability that Melissa chooses the wrong truck is $\frac{4}{5} = 0.8$ (or $1 - 0.2 = 0.8$).

The parking lot at Yellow Freight is set up so that five trucks can be parked in the first row, two more in the second row, and two more in each successive row thereafter. How many trucks can fit in the first six rows?



Solution

The number of trucks that can fit in the first six rows is $5+7+9+11+13+15=60$.

A truck holds a maximum of 8,000 pounds. What must you know about the boxes you are trying to load on it to determine how many will fit in the truck? (Discuss: weight, length, size, density, stackability, etc.)

Solution

Clearly the total weight of the boxes must not exceed 8,000 pounds. The total dimensions of the packing plan must not exceed any of the dimensions of the truck. Etc.

My truck traveled 110 miles in 115 minutes. About how fast was I going?

a. 1 mph
b. 55 mph
c. 65 mph
d. 70 mph

Solution

Since 60 mph = 1 mile per minute, 110 miles in 115 minutes must be just less than 60 mph, therefore the truck was going about 55 mph on average. Answer b.

You are traveling from Minneapolis to Chicago, a distance of 400 miles. You traveled x miles before lunch and y miles after lunch. How many more miles do you have left to travel?

a. $400 + x - y$
b. $400 - x + y$
c. $400 - x - y$
d. $400 + x + y$

Solution

The remaining number of miles is given by c. $400 - x - y$.

Together my two trucks hold 600 boxes. One truck had 50 more boxes than the other. How many boxes were on each truck?

Solution

Let x represent the number of boxes on one truck and $x+50$ the number of boxes on the other truck. Then $x+(x+50)=600$ or $2x=550$. Thus $x=275$ and $x+50=325$.

Your delivery route goes from Chicago to Minneapolis to Green Bay. This route forms a triangle. Your next route will be from Chicago to Minneapolis to another city. If these two triangular routes were close to being congruent, which of these would be the other city?

a. Phoenix
b. Miami
c. Boston
d. St. Louis

Solution

The other city is d. St. Louis.

1. You drive a refrigerated truck. The outside wall of the truck is 20ft by 8ft by 12ft. The inside wall is 19ft by 7ft by 11ft. What is the volume of coolant between the walls?

   a. 4 ft^3
   b. 457 ft^3
   c. 23 ft^3
   d. 1728 ft^3

2. What shape is each of these walls?

Solution

1. The volume of coolant that can fit between the walls is $(20)(8)(12) - (19)(7)(11) = 457$ cubic feet. So the answer is b.

2. Each wall is a rectangle.

1. If a truck tire has a radius of 18 inches, how far does the tire travel in one revolution?

    a. 56.52 inches
    b. 36 inches
    c. 11.46 inches
    d. None of the above

2. How many revolutions will the tire make in a mile.

Solution

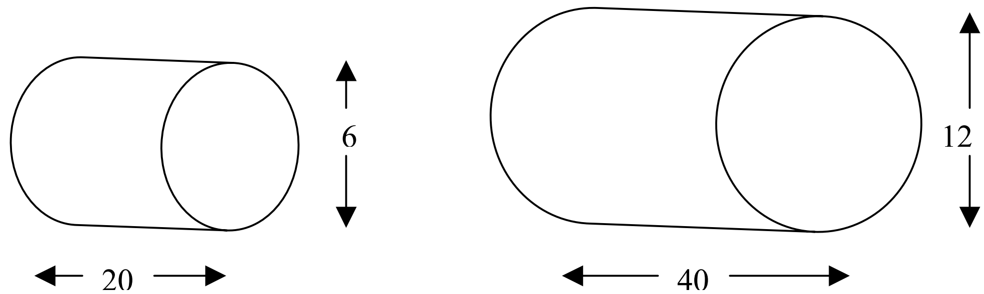
1. Using the formula for the circumference of a circle $C = 2\pi r$. We obtain $2\pi 18 \approx 113$ inches. The answer is d. none of the above.
2. A mile equals 5280 feet or $5280 \times 12 = 63360$ inches. Therefore the tire will make $\frac{63360}{113} \approx 561$ revolutions in a mile.

The cost of shipping bicycles by truck is \$8 per bike. The cost of shipping motorcycles is \$22 per bike. If you have a full load, you get a 15% discount. How much money would be saved on a full load of 25 bicycles and 10 motorcycles? Explain how you arrived at your answer.

Solution

By taking 15% of the shipping cost of 25 bicycles and 10 motorcycles we find $0.15[25(8)+10(22)] = \$63$ to be the savings.

If cylindrical two gasoline tanks have the following dimensions (in feet), how many times more gasoline does the larger tank hold? Show all of your work.



Solution

Using the volume for a cylinder $V = \pi r^2 h$ we find the ratio of the larger tank volume to the smaller tank volume to be $\frac{V_L}{V_S} = \frac{\pi(6)^2 40}{\pi(3)^2 20} = 8$. So the larger tank can hold 8 times more gasoline than the smaller tank.

Widgets can be shipped by rail, truck, or plane. They can be shipped either bulk or packaged. They can use either the express or standard rate of travel. How many different combinations are possible for shipping the widgets. Show all the possibilities.

Solution

There are $3 \times 2 \times 2 = 12$ different shipping combinations. Explicitly they are given by the following twelve ordered triples:

(rail, bulk, express)	(truck, bulk, express)	(plane, bulk, express)
(rail, bulk standard)	(truck, bulk, standard)	(plane, bulk, standard)
(rail, packaged, express)	(truck, packaged, express)	(plane, packaged, express)
(rail, packaged, standard)	(truck, packaged, standard)	(plane, packaged, standard)

John needed to make a map of the state of Wisconsin to show truck locations at any given time. He bought 5 square feet of poster board to make a map. Which size of poster board did he buy? (1 inch = 2.54 cm)

a. 65 centimeters by 100 centimeters
b. 2 feet by 3 feet
c. 24 inches by 30 inches
d. 1 yard by 1 yard

Explain how you determined the size of poster board that John purchased.

Solution

By computing the areas of the regions described in the four potential answers we can determine the size of poster board John purchased. b. is easiest to compute $2 \times 3 = 6$ square feet. d. is straight forward also, since 1 yd = 3 ft we have $3 \times 3 = 9$ square feet here. In c. we change the dimensions from inches to feet to get 2 feet by 2.5 feet and observe that $2 \times 2.5 = 5$ square feet as desired. So the answer is c.

Lori can load a truck in 6 hours. Lisa can load it in 8 hours. How long would it take them to load it together? Explain.

Solution

Let x represent the number of hours that it will take for Lori and Lisa to load the truck together – assuming no synergetic or anti-synergetic effects. Then $\frac{1}{6}+\frac{1}{8}=\frac{1}{x}$, $\frac{7}{24}=\frac{1}{x}$, or $x=\frac{24}{7}$ hr; i.e, approximately 3 hr 25 min.

A trucker worked 6 ¼ hours on Monday and has to work 40 hours for the week. He can set his own schedule for Tuesday through Friday, but the number of hours is never a whole number and no two days are the same. How many hours did the trucker work each day? Show that your answer works.

Solution

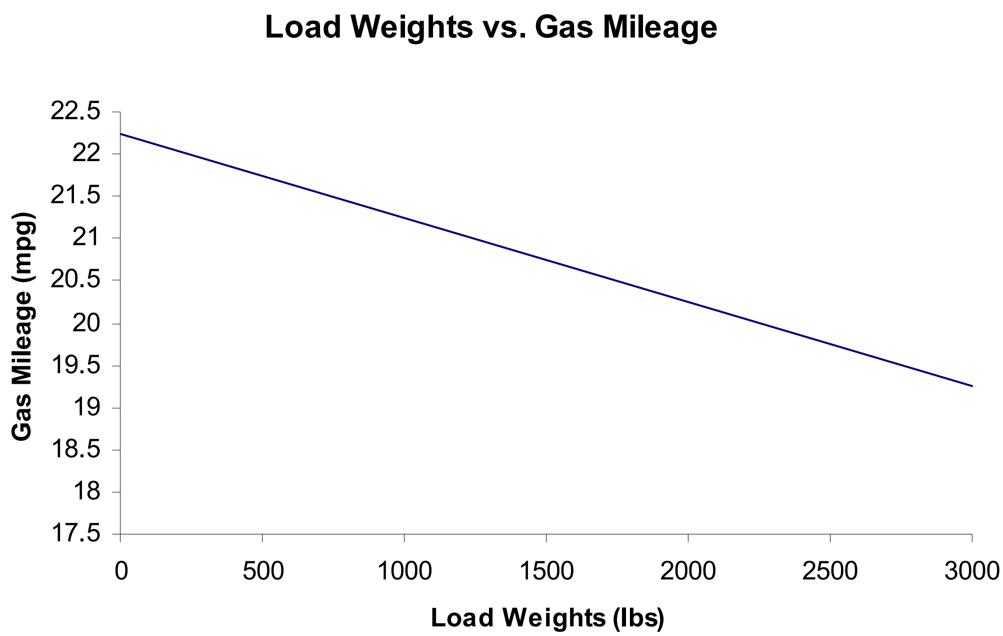
There are many schedules that will satisfy the given constraints; one such solution is given by:

Monday	Tuesday	Wednesday	Thursday	Friday
6 1/4	8 3/4	7 1/4	8 1/2	9 1/4

MEDIUM EXERCISES

Topic: Graph Interpretation and estimation

The graph below illustrates the relationship between the Load Weight of a mid-size truck and its Gas Mileage when traveling at an average rate of 55 mph.



1. Estimate the gas mileage of a truck with a load of:
   a. 0 lbs.
   b. 1000 lbs.
   c. 2500 lbs
   d. 5000 lbs
   e. 12,000 lbs

2. What is the approximate rate of change in gas mileage as the load weight increases from:
   a. 0 lbs. to 500 lbs.
   b. 1000 lbs to 2500 lbs.
   c. 5000 lbs to 12,000 lbs.
   d. Comment on these rates of change.

Solution

1. Based on the graph for the load weights in a. through c., the approximate gas mileage values are
   a. 22.25 mpg
   b. 21.25 mpg
   c. 19.75 mpg

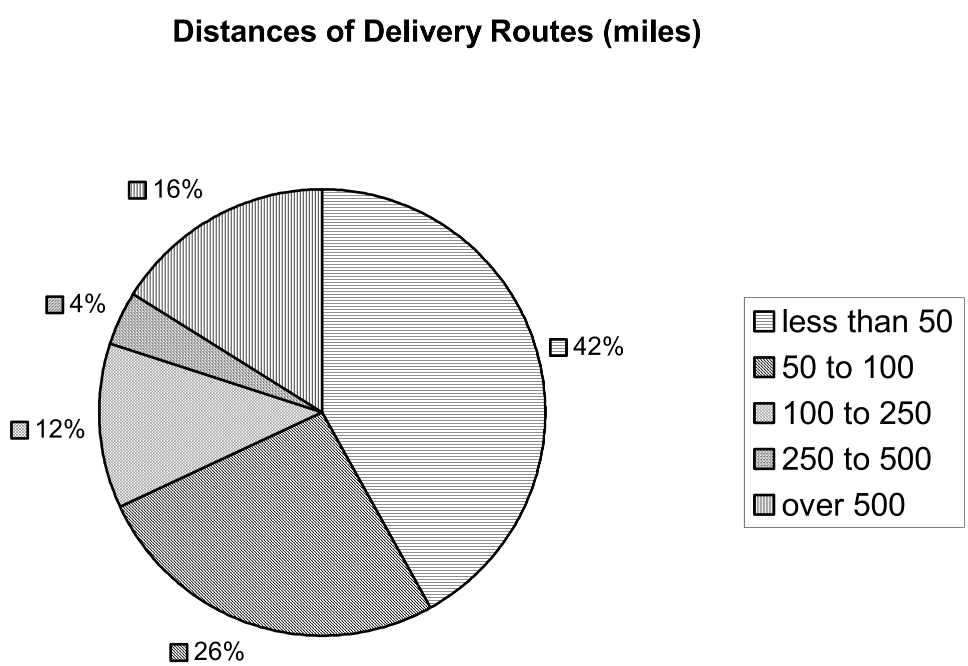
   The graph could be extended to make approximations for d. and e. or we could observe that the weight mileage relation appears to be linear and then determine a linear relation based on two of the above answers. Using the points $(0, 22.25)$ and $(2500, 19.75)$ we find $y - 22.25 = \frac{19.75 - 22.25}{2500 - 0}(x - 0)$ or $y = -.001x + 22.25$.

   d. Here we predict gas mileage to be $y = -.001(5000) + 22.25 = 17.25$ mpg
   e. Here we predict gas mileage to be $y = -.001(12{,}000) + 22.25 = 10.25$ mpg

2. Using the gas mileage values found in exercise 1. We have
   a. $\frac{21.75 - 22.25}{500 - 0} = -.001$
   b. $\frac{19.75 - 21.25}{2500 - 1000} = -.001$
   c. $\frac{10.25 - 17.25}{12000 - 5000} = -.001$
   d. All of the average rate of change values are the same – this is because the load weight – gas mileage relation is linear.

Topic: Graph interpretation and percentages

Schneider trucking compiled data on the distance between the loading and delivery destinations for 150,000 truck routes. The results of this study are presented in the chart below.



1. What percentage of the routes is between 50 and 250 miles?

2. How many routes were between 250 and 500 miles?

3. BONUS: Approximate the mean distance of all the routes.

Solution

1. 26% + 12% = 38% of the routes are between 50 and 250 miles.

2. 4% of 150,000 routes are between 250 and 500 miles; i.e., $0.04 \times 150{,}000 = 6000$ routes.

3. To approximate the mean distance of all routes first compute the number of routes corresponding to each pie slice in the chart. Second pick an average distance to represent all routes in each distance category – here we have used the midpoint distance for all except the final category. The last category presents a problem because we do not have a maximum route length; i.e., this category is not bounded based on the data provided. Denote this last average value by x

Length of Route	Percentage of Routes	Number of Routes	Route Category Average
less than 50	42%	63,000	25
50 – 100	26%	39,000	75
100 – 250	12%	18,000	175
250 – 500	4%	6,000	375
over 500	16%	24,000	x

Now the approximated mean distance is

$$\bar{x} = \frac{63{,}000(25) + 39{,}000(75) + 18{,}000(175) + 6{,}000(375) + 24{,}000x}{150{,}000} = 66 + 0.16x$$

If the final route length class is approximated by 750 miles, then $\bar{x} = 66 + 0.16(750) = 186$ miles; if the final class is approximated by 1500 miles then $\bar{x} = 66 + 0.16(1500) = 306$ miles, etc.

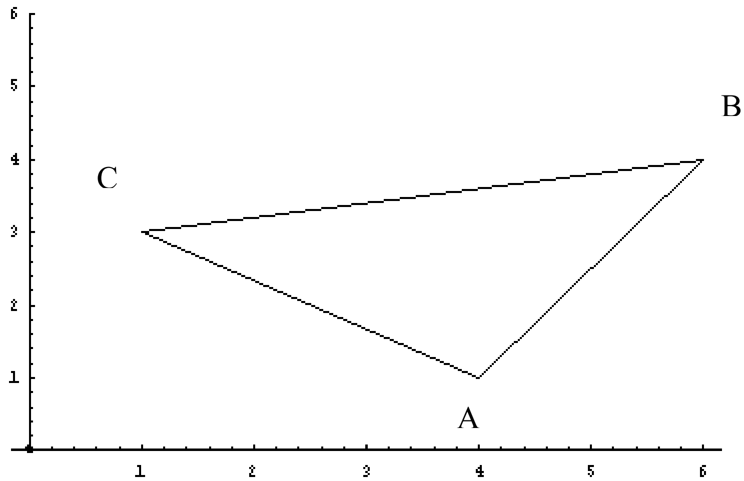
You are a member of a trucking company and have been given a route for a driver. The driver starts at point A and proceeds in a straight line to point B, then on to point C, and finally back to point A.

1. Supposing that the points A, B, and C can be represented by the coordinates (4,1), (6,4), and (1,3) respectively, on a piece of graph paper, indicate the route the driver will take. Identify and label the points the driver will travel to.

2. The driver has asked you to calculate how many miles he/she will be traveling on the entire trip. You need to look at the plotted route and use the conversion factor of 1 cm = 45 miles to calculate the mileage between the points.

3. Pick three or more cites on a state map and construct a coordinate system corresponding to the distance units on the map.
4. Repeat exercises 1. and 2. for the cities you have chosen.
5. Using the map calculate the actual highway distances for each part of the trip as well as the overall trip length. Then compare to the "as the crow flies distances" you have computed.

Solution



2. Using the standard distance formula we have

$$d(A,B)=\sqrt{(6-4)^2+(4-1)^2}=\sqrt{13}$$

$$d(B,C)=\sqrt{(6-1)^2+(4-3)^2}=\sqrt{26}$$

$$d(C,A)=\sqrt{(4-1)^2+(1-3)^2}=\sqrt{13}$$

   So the total distance based on the graph coordinates is $d=\sqrt{13}+\sqrt{26}+\sqrt{13}=2\sqrt{13}+\sqrt{26}$. Now, assuming that 1 unit on the graph = 1 cm, the distance traveled is $d=45(2\sqrt{13}+\sqrt{26})\approx 554$ miles.

3. Assuming the driver is on the road for x hours between points A and B, y hours between points B and C, and z hours between points C and A, the average miles per hour that the driver maintained is given by $\frac{554}{x+y+z}$.

1. The trailer the truck driver is pulling is 48 ft long $\times$ 8 ft wide $\times$ 12 ft high. The driver must load the cargo into the bed of the truck. If each piece of cargo is 6 ft $\times$ 2 ft $\times$ 3 ft, how many pieces of cargo fit into the trailer?

2. If the trailer was 50 ft long $\times$ 10 ft wide $\times$12 ft high, how many more pieces of cargo could be loaded into the trailer?

Solution

1. Notice that each piece of cargo takes up a volume of $6\times2\times3 = 36$ cubic feet and the volume of the trailer is $48\times8\times12 = 4608$ cubic feet. The upper bound on the number of pieces of cargo that can fit in the trailer is given by $\frac{4608}{36} = 128$ pieces. In this exercise it is possible to actually fit 128 pieces of cargo into the trailer. One way to do this is to place each piece of cargo so that the 6 ft dimension is parallel the 48 ft dimension of the trailer, the 2 ft dimension is parallel to the 8 ft dimension, and the 3 ft dimension is parallel to the 12 ft dimension.

2. Here the trailer has a volume of $50\times10\times12 = 6000$ cubic feet. The upper bound on the number of pieces can be determined by considering the ratio $\frac{6000}{36} = 166.67$. Hence no more than 166 pieces of cargo could fit into the trailer. Again there exists a packing scheme that allows the upper bound to be obtained. This time we set cargo so that the 3 ft dimension is parallel the50 ft dimension, the 2 ft dimension is parallel the 10 ft dimension, and the 6 ft dimension is parallel the 12 ft dimension. In this way we fill a $48\times10\times12$ section of the trailer with 160 pieces of cargo. There is still a $2\times10\times12$ section of the trailer available for cargo. This remaining section can hold 6 additional pieces of cargo by positioning them with the 6 ft cargo dimension parallel the 12 ft dimension of the remaining space and the 3 ft dimension parallel the 10 ft dimension.

   Finally, we note that the larger trailer can hold $166 - 128 = 38$ more pieces of cargo than the smaller trailer can.

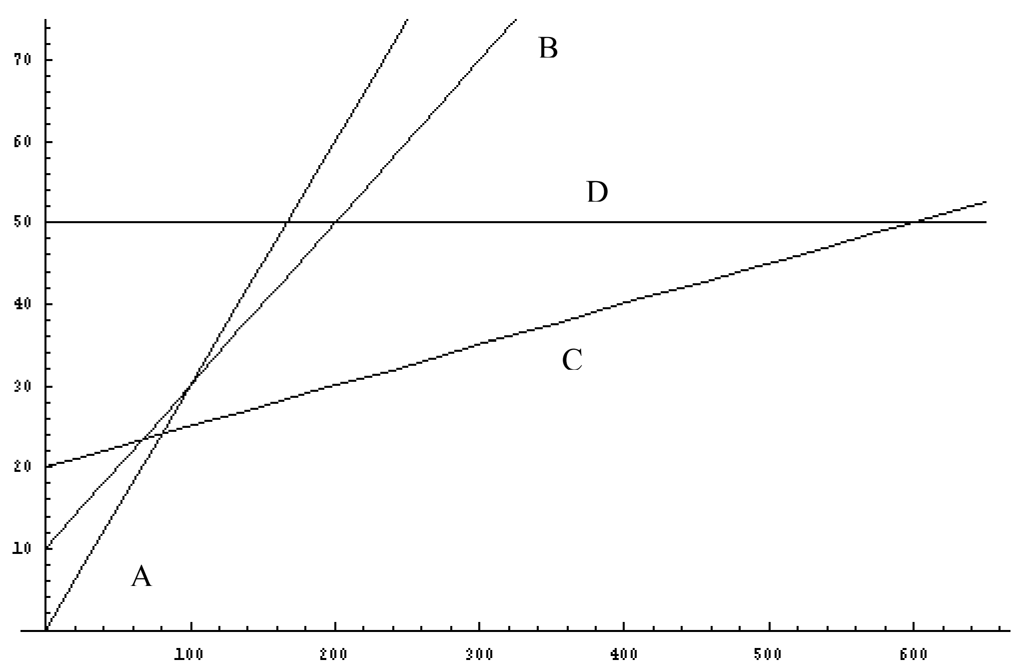
You want to have a cell phone in your truck. Four companies offer the following plans

Company	Rate
A	\$ 0/month plus 30¢/min
B	\$10/month plus 20¢/min
C	\$20/month plus 5¢/min
D	\$50/month

Which company would you choose? Why?

Solution

Graphing the total rates per month for a single month as a function of minutes spent on the phone yields



The most cost effective choice is the plan that bounds the bottom of all the above graphs. For usage under 80 minutes a month company A is the least expensive. For usage between 80 minutes and 600 minutes a month company C is the least expensive. For usage over 600 minutes a month company D is the least expensive.

An accident prevention policy was put into effect. The chart below shows the last five months of data.

Month	Number of Accidents
1	320
2	290
3	345
4	315
5	370
6	?

1. Based on this information, how many accidents would you predict for the sixth month? Explain your reasoning.

2. Is the accident prevention plan working? Why or why not?

Solution

1. Using the first 5 months of data, we can check to see if there is a linear trend by computing the linear correlation coefficient r. Here $r = 0.65$. Since the critical value for the correlation coefficient based on $n = 5$ ordered pairs is 0.878, the given data is not linearly correlated. In this situation the best prediction for the six month is given by the mean of the previous five months; i.e., $\frac{320+290+345+315+370}{5} = 365.5$. Thus 366 accidents would be predicted to occur during the sixth month.

2. There is no way to answer this question because we do not know when the accident prevention plan was put into effect.

John used a scale of 1 inch = 25 miles to make his map. De Pere, WI and Eagle River, WI are 6 ½ inches apart. Your truck averages 40 mph. Assuming that John can make a straight-line trip, about how many hours will it take to drive from De Pere to Eagle River? Show all of your work. Using a map determine the actual driving distance between the two cities. Compare the actual distance to the straight-line distance.

Solution

The distance traveled is $25 \times 6.5 = 162.5$ miles. The number of hours it will take to drive from De Pere to Eagle River is $\frac{162.5}{40} = 4.0625$. It will take about 4 hours for the trip.

Your boss wants you to fence in a parking lot for your trucks along the Fox River, which will be the eastern boundary. He purchased 2000 feet of fencing to be used to enclose as large a parking lot as possible. The parcel of land is large enough to accommodate a parking lot of any size. Describe its shape and dimensions.

Solution

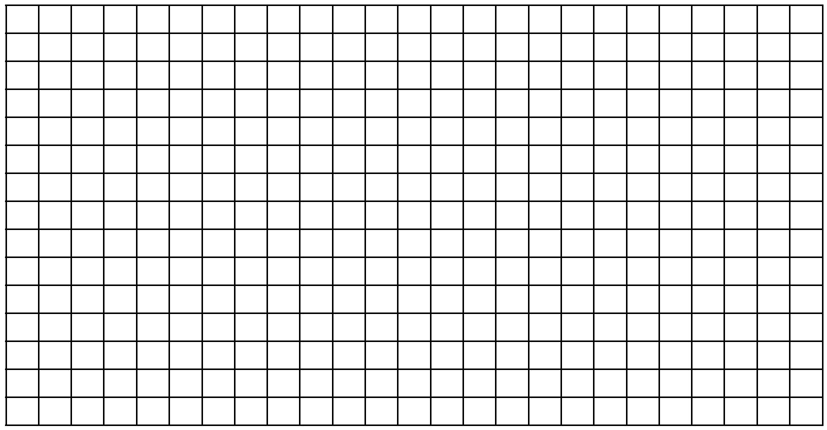
The largest possible lot that can be made will place the 2000 feet of fencing in the shape of a semi-circle with the river as the diameter. The radius of the semi-circle will satisfy $\pi r = 2000$; i.e., $r \approx 636.6$ ft. The area of the enclosed region will be $A = \frac{\pi r^2}{2} \approx 636{,}620$ square feet.

Now the company might find it inconvenient to park vehicles in such a lot. So they may be more inclined to build a rectangular lot. If this is the case we could let x represent the length parallel the river and y the width of the lot. Then the area of the lot will satisfy $A = xy$ where $x + 2y = 2000$. Solving the constraint equation for x and substituting into the area formula yields

$$A = (2000 - 2y)y = -2y^2 + 2000y = -2(y^2 - 1000y + 500^2) + 2(500^2) = -2(y - 500) + 500000$$

The maximum area for a rectangular lot is 500,000 square feet (136,620 square feet less than the semi-circular lot) and has dimensions 1000 ft by 500 ft.

The grid below represents the floor of the inside of your truck. Each square represents 1 square foot. You only have 120 square feet of room to load. Draw a rectangle with that area. Shade in a portion of your rectangle so that the perimeter of your shaded region is between 30 and 40 feet.

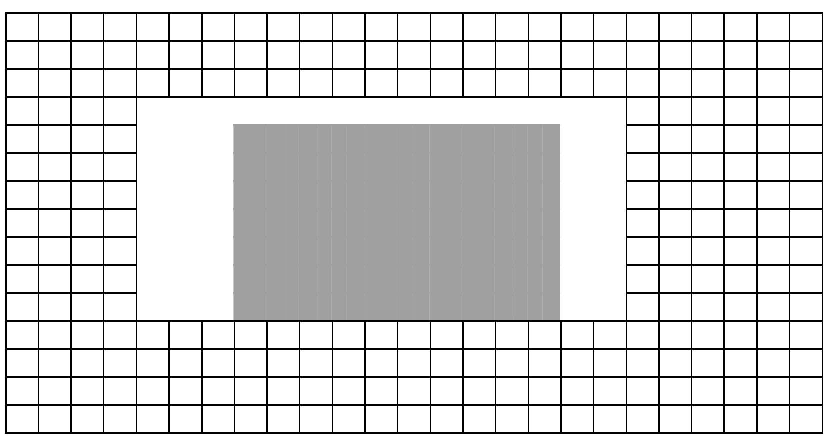


1. What is the area of your shaded region?

2. What percent of your rectangle is shaded?

Solution

Since the perimeter is to be between 30 and 40 feet, the length and width of the region will need to satisfy $15 \le l + w \le 20$. If we set $l = 10$ and $w = 7$, then we will have a satisfactory region identified:



1. The area of the shaded region is $10 \times 7 = 70$ square feet.

2. The percentage of the room to load taken up by the rectangle is $\frac{70}{120} \approx 58\%$.

LONG EXERCISES

TOPIC: Mean, median, mode, and standard deviation for grouped data and confidence intervals for the mean.

A trucking company is in the process of securing a contract to purchase tires for its trucks. A study was conducted to determine which brand of tire is likely to last the longest. The number of miles it traveled before 100 tires from each brand failed is given in the table below.

Number of miles a tire lasted until failure

Brand A			Brand B		
Miles	(Average)	Frequency	Miles	(Average)	Frequency
0-1000	(500.0)	3	0-1000	(500.0)	7
1001-5000	(3000.5)	11	1001-5000	(3000.5)	15
5001-9000	(7000.5)	6	5001-9000	(7000.5)	18
9001-13000	(11000.5)	41	9001-13000	(11000.5)	25
13001-17000	(15000.5)	10	13001-17000	(15000.5)	20
17001-21000	(19000.5)	23	17001-21000	(19000.5)	3
Over 210001	(25000.0)	6	Over 210001	(25000.0)	12
	Total	100		Total	100

1. Calculate the mean, median, mode, and standard deviation for each brand of tire.

2. Create a 90% confidence interval for each mean calculated in problem 1.

Discussion: A decision will be made to contract with a specific tire company for three years. The following information is known:

a. The price of the tires is approximately the same for both companies.

b. The probability of an accident occurring due to tire failure is 7%.

3. Which brand of tire should be purchased if safety is the main concern of the company? (A tire will be replaced before it fails.) Explain your answer.

4. Which brand of tire should be purchased if cost is the main concern of the company? (A tire will be replaced after it fails.) Explain your answer.

5. Which brand should be purchased if both safety and cost are of equal concern to the company? Explain your answer.

Solution

1. Using the following formulas for frequency table data we can determine the sample mean and sample standard deviations for the two data sets

$$\bar{x} = \frac{\sum f_i x_i}{n} \text{ and } s = \sqrt{\frac{n\sum f_i \cdot x_i^2 - \left(\sum f_i x_i\right)^2}{n(n-1)}}$$

Here f_i represents class frequency, x_i represents class average or mark, and n represents the total sample size. Applying the formulas to the Brand A data yields

$$\bar{x}_A = \frac{3(500)+11(3000.5)+6(7000.5)+41(11000.5)+10(15000.5)+23(19000.5)+6(25000)}{100}$$

$$= \frac{1264545.5}{100} = 12645$$

$$s_A = \sqrt{\frac{100[3(500)^2 + 11(3000.5)^2 + \cdots + 6(25000)^2] - (1264545.5)^2}{100(99)}} = 6087$$

Applying the formulas to the Brand B data yields

$$\bar{x}_B = 11065 \text{ and } s_B = 7023$$

By looking at the cumulative frequency in each class it is clear that the median class for each brand of tire is the 9001 – 13000 mile class.

Similarly the modal class for each brand tire is the 9001 – 13000 mile class.

2. Assuming that the data sets are essentially normally distributed, the 90% confidence intervals for the means found above can be computed using the formula

$$\bar{x} \pm 1.645\frac{s}{\sqrt{n}}$$

$$\bar{x}_A \pm 1.645\frac{s_A}{\sqrt{n}} = 12645 \pm 1.645 \cdot \frac{6087}{\sqrt{100}} = 12645 \pm 1001 \text{ or } (11644, 13656)$$

$$\bar{x}_B \pm 1.645\frac{s_B}{\sqrt{n}} = 11065 \pm 1.645 \cdot \frac{7023}{\sqrt{100}} = 11065 \pm 1155 \text{ or } (9910, 12220)$$

3. Brand A tires should be purchased if safety is the main concern – here you want the maximum mileage before retiring a tire <u>prior</u> to having it fail. Based on the confidence intervals for the mean mileage before tire failure, it is unlikely that a Brand A tire would fail before 11644 miles whereas it is possible that a brand B tire would fail after 9910 miles.

4. Brand A tires should also be purchased if cost is the main concern – here you want the maximum mileage before tire failure. Based on the confidence intervals for mean mileage before tire failure it would not be unlikely that a Brand A tire would last 13656 miles before failure, on the other hand, it is likely that a Brand B tire would have failed by 12220 miles.

5. Based on either criteria, safety or cost, Brand A tires seem to be the best choice.

Topic: Writing linear equations and linear regression.

Over the past month a trucking company has compiled data on the relationship between a vehicle's rate and gasoline mileage. (See chart 1).

Chart 1. Study of Rate vs. Gas Mileage

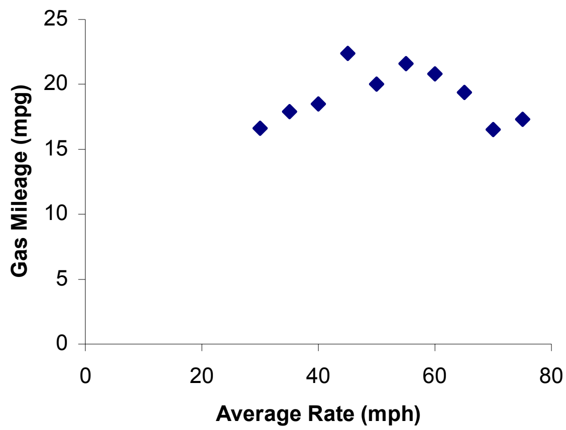
Rate vs. Gas Mileage Study

Average Rate (mph)	Gasoline Mileage (mpg)
30	16.6
35	17.9
40	18.5
45	22.4
50	20.0
55	21.6
60	20.8
65	19.4
70	16.5
75	17.3

1. Plot these data on a coordinate plane using the horizontal axis for Average Rate and the vertical axis for Gasoline Mileage.
2. Choose two points from the graph and write the equation of the line that contains these points.
3. Repeat step 2 using two different points.
4. Use linear regression to determine the equation of the best-fit line for this data.
5. Predict the gas mileage for a truck that travels 58 mph using each of the equations created in steps 2-4. Compare the results.
6. **Discussion**: What are the limitations that restrict the rate and gas mileage of the trucks? Does a linear equation adequately describe this relationship? What rate would produce the maximum gas mileage?
7. **Enrichment**: Using software such as Mathematica, or a calculator, create second and third degree equations to describe this relationship. Predict the gas mileage for a vehicle traveling at 58 mph using each of these equations. Determine the optimal rate and maximum gas mileage using each equation. In your opinion which equation is the most accurate at modeling this set of data? Explain your answer.

Solution

1.



2. The points $(30, 16.6)$ and $(35, 17.9)$ yield the line $y - 16.6 = \frac{17.9 - 16.6}{35 - 30}(x - 30)$ or $y = .26x + 8.80$.
3. The points $(30, 16.6)$ and $(75, 17.3)$ yield the line $y - 16.6 = \frac{17.3 - 16.6}{75 - 30}(x - 30)$ or $y = 0.016x + 16.13$.
4. Using a TI-85 calculator yields the linear regression line with equation $y = -0.00267x + 19.24$. Additionally the linear correlation coefficient is $r = -0.0193$. The correlation coefficient indicates that the linear regression model is not appropriate for this data set.
5. Predictions using the linear relations found in the previous three exercises are
   a) $y = .26(58) + 8.80 = 23.88$ mpg
   b) $y = .016(58) + 16.13 = 17.06$ mpg
   c) $y = -.00267(58) + 19.24 = 19.09$ mpg
6. Limitations that restrict the rate and gas mileage of trucks include: vehicle design, load carried, driver behavior, weather, terrain, etc. As noted in 4., the linear model is not appropriate to describe the data. Based on the linear model the slower the truck is driven the higher the gas mileage.
7. Using a TI-85 calculator yields the quadratic regression equation $y = -.009x^2 + .979x - 4.599$. The quadratic model takes on its maximum value when $y' = -.018x + .979 = 0$; i.e., when $x = 54.39$ mph. The predicted maximum value is then 22.02 mpg. These results can also be found by completing the square in the quadratic equation.

   Using a TI-85 calculator yields the cubic regression equation $y = 7.44 \times 10^{-5} x^3 - .021x^2 + 1.567x - 13.939$. The cubic model takes on its maximum value when $y' = 2.232 \times 10^{-4} x^2 - 042x + 1567 = 0$; i.e., when $x = 51.29$ mph or $x = 136.88$ mph. Clearly the latter solution is not sensible and we would predict that the maximum takes place when the average rate is 51.29 mph. The corresponding fuel consumption is 21.23 mpg.

Based on the scatter diagram and the fact that the cubic coefficient is so close to zero, I would choose the quadratic model for this data set.

KEEP ON TRUCKIN'

Wisconsin Standards:

Content Standard A: Students will draw on a broad body of mathematical knowledge and apply a variety of mathematical skills and strategies, including reasoning, oral and written communication, and the use of appropriate technology, when solving mathematical, real-world and non-routine problems.

Performance Standard A8.1E: Use reasoning abilities to evaluate strategies.

Performance Standard A8.2: Communicate logical arguments clearly to show why a result makes sense.

Performance Standard A8.4D: Develop effective oral and written presentations that include clear organization of ideas and procedures.

Content Standards D: Students will select and use appropriate tools (including technology) and techniques to measure things to a specified degree of accuracy. They will use measurements in problem-solving situations.

Performance Standard D8.4D: Determine measurements indirectly using geometric formulas to derive lengths, areas, and volumes of common figures.

Task Overview: Students are asked to move x pounds worth of freight from one city to another. They will initially figure out the maximum volume that their truck will hold. They will use mileage and weight comparisons in order to ensure a maximum profit for their company.

Time Required: 4 x 45 minutes.

Prior Knowledge: MPG and Volume formula.

Note: Unit might be extended to include a field trip and/or a guest speaker.

Activity 1: Design a maximum load of a semi-trailer.

Benchmark: A8.1E, A8.2, A8.4D, D8.4D

Material/Resources: Calculator, rectangular shaped candy bars and a small cardboard box to put them in. (Make sure box is not a perfect fit for the candy bars.)

Sequence: Given a semi-trailer with dimensions of length 58 feet, width 11 feet, and height 12 feet, students will compute how many boxes of length 4 feet, width 3 feet, and height 4 feet can be put inside. They will include a diagram showing the loading pattern. They must include the weight of the load of boxes. Each box weighs 2 pounds per cubic foot. Upon completion of this activity, the teacher will use the candy bars to show how some of the boxes needed to be placed inside the truck for maximum capacity. (Number of candy bars should meet or exceed the number of students in the class.)

Note: Activities 1, 2, and 3 must be corrected before doing activity 4. Activities 1, 2, and 3 will be done in groups of 2 or 3. Activity 4 will be done alone. Assessment will be on Activity 4 only.

Evaluation: **_X_ formative summative**

Homework: None

Exemplary Responses: 154 boxes (11 in a stack by 14 stacks). 14,784 pounds (154 boxes at 96 pounds each).

Activity 1

You are a member of a trucking company. It is your job to make sure that your truck carries as much freight as possible. Your trailer size is: length 58 feet, width 11 feet, and height 12 feet. The boxes you are to load are: length 4 feet, width 3 feet, and height 4 feet. Each box weighs 2 pounds per cubic foot. Your job is to get as many boxes in the truck as possible.

You must include:
1) A diagram showing the loading pattern of the boxes.
2) The number of boxes that you were able to fit in the truck.
3) The total weight of the boxes.

Solution

Compare with exemplary responses.

First we can determine an upper bound for the number of boxes that could fit into the trailer. The trailer has a volume of $58 \times 11 \times 12 = 7656$ cubic feet. Each box has a volume of $4 \times 3 \times 4 = 48$ cubic feet. The upper bound for the number of boxes that can fit in the trailer found by computing $\frac{7656}{48} = 159.5$; i.e., no more than 159 boxes can fit into the trailer.

There exists an arrangement such that 158 boxes can be positioned in the trailer. First notice that $4(13) + 3(2) = 58$ so that on the floor along the left wall 15 boxes can be positioned making a row 4 feet wide – 13 boxes are positioned with the 3 foot dimension going up and 2 boxes are positioned with the 3 foot dimension parallel the 58 foot dimension. The trailer being 12 feet high can accommodate a stack of four boxes in the first 13 positions and 3 boxes in the last two. Thus a total of $13(4) + 2(3) = 58$ boxes can go from floor to ceiling along the left wall with a constant width of 4 feet. Another 58 boxes can go next to these. At this point there are 116 boxes in the trailer and a rectangular region of size $58 \times 3 \times 12$ unfilled. In this region 42 additional boxes can be place in 3 rows of 14. Hence $116 + 42 = 158$ boxes can be positioned in the trailer.

Each box weighs $2 \times 48 = 96$ pounds, so the total weight of the load is $158 \times 96 = 15168$ pounds.

Activity 2: Calculate the profit made on a particular delivery.

Benchmark: A8.1E, A8.2, A8.4D, D8.4D

Materials/Resources: Calculator, price of diesel fuel

Sequence: Calculate the cost of delivering 80 snow blowers at a weight of 126 pounds to a point 3000 miles away. Calculations will be done based on a price of $1.60 per gallon of diesel fuel. An empty trailer will get 20 MPG (miles per gallon) and fuel efficiency will decrease by 1 MPG for every 1000 pounds of cargo. Assume that you will make $20 for every snow blower you deliver. How much money will you make?

What if you deliver only 79 snow blowers? What will your profit be?

What did you learn from this second problem?

Is 79 snow blowers the best amount to take for maximum profit?

Evaluation: **_X_ formative summative**

Homework: None

Exemplary Responses: 80 snow blowers will take in $1600, get 9 MPG, fuel cost $533.33, profit $1066.67. 79 snow blowers will take in $1580, get 10MPG, fuel cost $480, profit $1100. Sometimes a full load is not your best option. It depends on how much weight you can carry and the size of the boxes.

Activity 2

You are the member of a trucking company. It is your job to calculate the profit you will make on a particular delivery.

1) Calculate the cost of delivering 80 snow blowers at a weight of 126 pounds each to a point 3000 miles away. Calculations will be done based on a price of $1.60 per gallon of diesel fuel. An empty trailer will get 20 MPG (miles per gallon) and fuel efficiency will decrease by 1 MPG for every 1000 pounds of cargo. Assume that you will make $20 for every snow blower you deliver. How much money will you make? Include all calculations you did to arrive at your answer.

2) What if you deliver only 79 snow blowers? What will your profit be? Include all the calculations you did to arrive at your answer.

3) Does your answer surprise you? Explain.

Solution

Compare with exemplary responses.

80 snow blowers weigh $80(126) = 10080$ pounds. The fuel efficiency is $20 - \dfrac{10080}{1000} = 9.92$ mpg. The profit derived by transporting the snow blowers at \$20 per unit is $20(80) - \left(\dfrac{3000}{9.92}\right)1.60 = \$1116.13$.

79 snow blowers weigh $79(126) = 9954$ pounds. The fuel efficiency is $20 - \dfrac{9954}{1000} = 10.046$ mpg. The profit derived by transporting the snow blowers at \$20 per unit is $20(79) - \left(\dfrac{3000}{10.046}\right)1.60 = \$1102.20$.

In this case carrying an additional snow blower increases your profit by \$13.93. Clearly carrying 79 snow blowers will not maximize your profit. To determine the number of snow blowers to carry for a maximum profit under the assumption that they all fit in the trailer, we let x denote the number of snow blowers to be transported and look at the following profit function:

$$p(x) = 20x - \left(\frac{3000}{20 - \dfrac{126x}{1000}}\right)1.60 = 20x - \frac{4800000}{20000 - 126x}$$

Notice that the number of snow blowers cannot exceed 158 because at this point the gas mileage becomes zero. Differentiating the profit function yields:

$$p'(x) = 20 - \frac{4800000(126)}{(20000 - 126x)^2}$$

Solving $p'(x) = 0$ yields the maximum number of snow blowers $x = 115$. The corresponding profit is $p(115) = \$1428.86$.

Evaluating $p(1), p(2), \cdots, p(157)$ and selecting the largest profit can find the same result.

Activity 3: Make a complete round trip and figure out the maximum profit that can be made.

Benchmark: A8.1E, A8.2, A8.4D, D8.4D

Materials/Resources: Calculator, map, price of diesel fuel, worksheet

Sequence: Students will make one complete trip from Green Bay to Chicago to Minneapolis to Green bay figuring out the maximum profit they can make.

Evaluation: **_X_ formative summative**

Homework: None

Exemplary Responses: Green Bay to Chicago: 66 boxes, 6600 pounds, 14 MPG, $22.86 fuel cost, $1650 taken in, $1627.14 profit. Chicago to Minneapolis: 266 boxes, 11970 pounds, 9 MPG, $71.11 fuel cost, $1330 taken in, $1258.89 profit. Minneapolis to Green Bay: 88 boxes, 7040 pounds, 13 MPG, $36.92 fuel cost, $1760 taken in, $1723.08 profit.

Activity 3

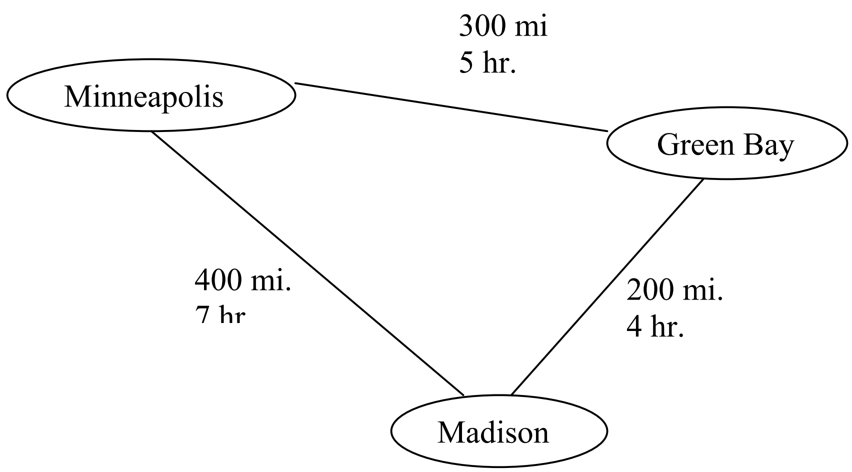
Over the Short Haul

You are the logistics department manager for a northern Wisconsin trucking company. It is your task to design a route for a driver that will produce a maximum profit for your company.

Included in your final plan should be the following:

A. A diagram showing the complete route with an overnight stop indicated.
B. Specifications for loading the truck that will include the loading pattern and total weight for each route if necessary.
C. Computations to show the MPG and fuel cost for each route.
D. Total profit for each route.
E. Total profit for the entire trip.

- You will transport goods from Green Bay to Chicago, Chicago to Minneapolis, and Minneapolis back to Green Bay.
- You are allowed two days of travel.
- The driver is allowed ten hours of driving time per day.
- The trailer has a weight capacity of 12,000 lbs.
- The dimensions of the trailer are $11' \times 12' \times 58'$.
- When the trailer is empty, the tractor has a fuel efficiency of 20 MPG and loses 1 MPG for every incremental increase of 1000 lbs of load. Cost of fuel at this time is $1.60.



City	Minneapolis	Green Bay	Chicago
Product	Gophers	Football Helmets	Cow Pies
Size of Boxes (ft.)	$3 \times 4 \times 7$	5×5×4	1×1×1
Unit Weights #s	80	100	45
Fee per Unit	$20	$25	$5

Solution

Compare with exemplary responses

Profit for the Green Bay to Chicago route is given by

$$p(x) = 25x - \left(\frac{200}{20 - \frac{100x}{1000}} \right) 1.60$$

It can be shown that maximum profit occurs for $x = 188$ boxes. On the other hand the maximum number of boxes that can be carried based on the weight restriction is $\frac{12000}{100} = 120$ boxes. Furthermore, the maximum number of boxes that can be carried based on volume is bounded by $\frac{11 \times 12 \times 58}{5 \times 5 \times 4} = 76.56$. So no more than 76 boxes can fit in the trailer. Here the maximum profit will occur for the load with the greatest number of boxes that can be fit in the trailer.

There exists a packing arrangement that allows for 68 boxes to be carried. Against the back wall of the trailer set six boxes, three on three, with the four foot dimension along the back of the truck and the five foot dimension going up. Repeat this pattern until 60 boxes have been loaded. At this point there will be a $11 \times 12 \times 8$ region left to be loaded. Eight additional boxes can be placed in this region, place the remaining boxes so that the four-foot box dimension is parallel the remaining eight-foot dimension in the trailer.

With 68 boxes on board the total load weight is 6800 pounds, the fuel efficiency is $20 - \frac{6800}{1000} = 13.2$ mpg, the fuel cost is $\frac{200}{13.2} 1.60 = \$24.24$, \$1700 is taken in, and the profit is \$1675.76.

For the Chicago to Minneapolis route it can be shown that transporting 360 boxes achieves the maximum profit, with no weight or space limitation. This value is obtained by analyzing the profit function

$$p(x) = 5x - \left(\frac{400}{20 - \frac{45x}{1000}} \right) 1.60 .$$

The maximum number of boxes that can be shipped based on volume constraints is clearly 7656 boxes. Here the limiting factor turns out to be weight, the maximum number of boxes that can be shipped based on weight is 266 boxes for 11970 pounds of load.

Evaluating the profit function when $x = 266$, yields \$1250.30. Here the truck will get $20 - \frac{11970}{1000} = 8.03$ mpg and the fuel cost is $\frac{400}{8.03}(1.60) = \$79.70$.

The driver needs to stop the first day no earlier two hours past Chicago and no later than six hours past Chicago in order to complete the trip in two days and not exceed the ten driving hours per day limit.

Using similar analysis to that used for the first two stages of the trip, it can be shown that the maximum profit for the Minneapolis to Green Bay stage occurs when 90 boxes are transported. A packing scheme exists for 90 boxes having a total weight of 7200 pounds, the truck will obtain 12.8 mpg, fuel cost will be \$37.50, \$1800 will be taken in, and the profit will be \$1762.50.

The total profit for the complete route is $\$1675.76 + \$1250.30 + 1762.50 = \$4688.56$.

Activity 4: Students will design a 6-day route that will make them the highest profit.

Benchmark: A8.1E, A8.2, A8.4D, D8.4D

Materials/Resources: Calculator, map, worksheet

Sequence: The student is a logistics department manager for a northern Wisconsin trucking company. It is their job to design a route for a pair of drivers that will produce a maximum profit for their company. A list of what is needed and what limitations are put on the drivers is included in the worksheet.

Evaluation: **formative _X_ summative**

Homework: None

Scoring Tools:

SCORING RUBRIC	Organization, Planning, Mathematical Accuracy, and Explanation
4 points	Organization and planning reflect a highly systematic approach. In addition, the diagrams and computations reflect accurate results. Explanation is fairly clear, but thinking process is easy to follow.
3 points	Information is organized and plan is used to create a schedule. Virtually no computational errors with accurate conclusions. Explanation is fairly clear, but thinking process is not always easy to follow.
2 points	A rudimentary plan is used but is inadequate to the complexity of the situation. Some computational errors, but allowing largely for accurate conclusions. Explanation is attempted, but difficult to follow.
1 point	No organization or plan in evidence. Many computational errors made. Little or no explanation is given, or is impossible to follow.

Exemplary Responses: A computer generated diagram or an actual map with routes and stops clearly indicated. Complete diagram of loading pattern and total weight computation with checks to see it doesn't exceed 12,000 pounds. MPG and fuel costs shown for each route. Total profit for each route. Total profit for entire trip is within $500 of the highest in the class.

Activity 4

Over the Long Haul

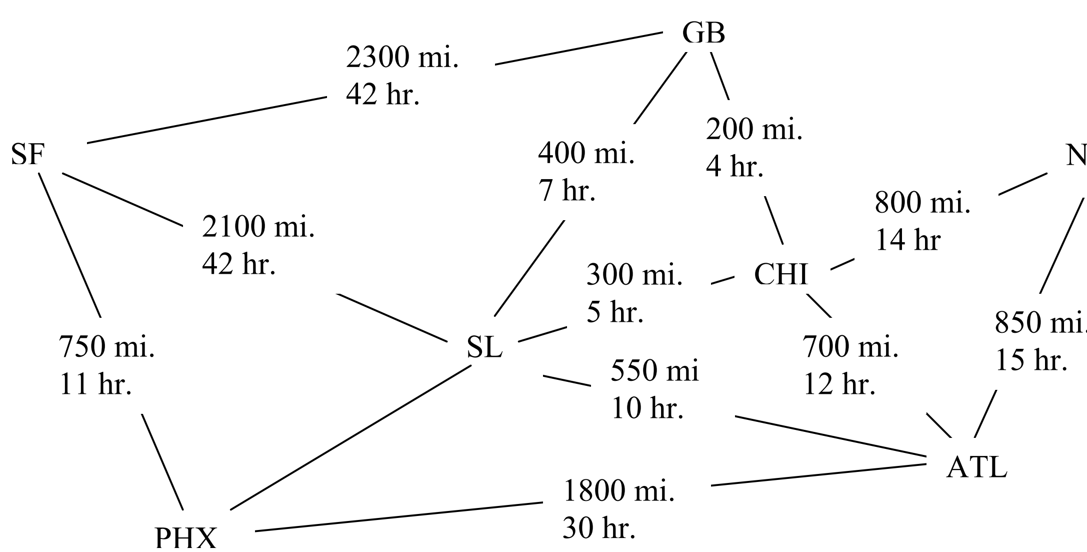
You are the logistics department manager for a northern Wisconsin trucking company. It is your task to design a route for a pair of drivers that will produce a maximum profit for your company.

Included in your final plan should be the following:

A. A diagram showing the complete route with all overnight stops indicated.
B. Specifications for loading the truck that will include the loading pattern and total weight for each route.
C. Computations to show MPG and fuel cost for each route.
D. Total profit for each route.
E. Total profit for the entire trip.

- Products can be loaded in any city and shipped to any other city.
- You are allowed six days of travel and must start in Green Bay and return to Green Bay.
- Each driver is allowed ten hours of driving time per day.
- The trailer has a weight capacity of 12,000#.
- The dimensions of the trailer are $10' \times 12' \times 60'$.
- An empty trailer gets 22 MPG and loses 1 MPG for every increment of 1000#. Cost of fuel at this time is $1.50.

Here are the route and times that are available for your use. Map is not drawn to scale.



City	San Francisco	Phoenix	St. Louis	Chicago	Green Bay	Atlanta	New York
Product	Rice a Roni	Sundials	Beans	Harleys	Toilet Paper	Coca Cola	Ticker Tape
Size of Boxes (ft)	3×4×5	2×2×2	Bulk	10×10×10	5×5×5	3×3×2	Bulk
Unit Weight (#s)	150	15	NA	2000	200	300	NA
Negotiated Fee per Unit	$40	$6	$.20 per #	$100	$20	$50	$.25 per#

Solution

The shipping load for maximum profit out of each city was computed based on weight limitations, volume limitations, and maximizing the profit function with no weight or volume limitations. The results are

	San Francisco	Phoenix	St. Louis	Chicago	Green Bay	Atlanta	New York
# of boxes	80 Weigh out	800 Weigh out	NA Weigh out	6 Weigh out	48 Cube out	40 Weigh out	NA Weigh out
MPG	10	10	10	10	12.4	10	10

Profit for each route was computed using

Profit = (fee per unit)(# of units) – (fuel cost per gallon)(miles in route)/(mpg)

Profit per hour along each route was computed since there is a restriction of a total of 120 driving hours. The route profit results are

From \ To	San Francisco	Phoenix	St. Louis	Chicago	Green Bay	Atlanta	New York
San Francisco		3088 (281)	2885 (69)		2855 (68)		
Phoenix	4686 (426)		4575 (169)			4530 (151)	
St. Louis	2085 (50)	2175 (81)		2355 (471)	2340 (374)	2318 (232)	
Chicago			555 (111)		570 (142)	495 (41)	480 (34)
Green Bay	682 (16)		912 (130)	935 (233)			
Atlanta		1730 (58)	1918 (192)	1895 (158)			1873 (124)
New York				2880 (205)		2873 (191)	

Based on a cursory look at the above table, recalling that there is a 120-hour time constraint, that good route in terms of profit would be to begin in Green Bay travel and to Chicago, repeat the route from Chicago to St. Louis to Chicago eleven times, and return from Chicago back to Green Bay. This scenario uses 118 hours and nets a profit of $935+11(555+2355)+570=\$33,515$. Finally, I would recommend that the drivers should stop the truck every 5 hours for a 1-hour break over the six days (sleeping done on the road).