MAT.HS.PT.4.0CORN.A.412

Sample Item ID:	MAT.HS.PT.4.0CORN.A.412
Title:	Corn
Grade:	HS
Primary Claim:	**Claim 4: Modeling and Data Analysis** Students can analyze complex, real-world scenarios and can construct and use mathematical models to interpret and solve problems.
Secondary Claim(s):	Claim 1: Concepts and Procedures Students can explain and apply mathematical concepts and interpret and carry out mathematical procedures with precision and fluency. Claim 2: Problem Solving Students can solve a range of well-posed problems in pure and applied mathematics, making productive use of knowledge and problem-solving strategies. Claim 3: Communicating Reasoning Students can clearly and precisely construct viable arguments to support their own reasoning and to critique the reasoning of others.
Primary Content Domain:	Number and Quantity
Secondary Content Domain(s):	Geometry, Statistics, Algebra
Assessment Target(s):	4 A: Apply mathematics to solve problems arising in everyday life, society, and the workplace. 4 D: Interpret results in the context of a situation. 4F: Identify important quantities in a practical situation and map their relationships (e.g. using diagrams, two-way tables, graphs, flowcharts, or formulas). 1 C: Reason quantitatively and use units to solve problems. 1 N: Build a function that models a relationship between two quantities. 1 P: Summarize, represent, and interpret data on a single count or measurement variable. 2 A: Apply mathematics to solve well-posed problems arising in everyday life, society, and the workplace. 2 B: Select and use appropriate tools strategically. 2 C: Interpret results in the context of a situation.
Standard(s):	N-Q.1,N-Q.2, S-ID.6, G-MG.3, G-SRT.8, 7.RP.2, 7.EE.3, A-CED.1, 7.RP.1

HS Mathematics Sample PT Form Claim 4

Mathematical Practice(s):	1, 2, 3, 4, 5, 6
DOK:	4
Item Type:	PT
Score Points:	20
Difficulty:	H
How this task addresses the "sufficient evidence" for this claim:	The student uses concept of number and quantity, geometry, and statistics to provide rationale for the recommendation made regarding on- or off-site storage of harvested corn. The work is supported by the calculations.
Target-specific attributes (e.g., accessibility issues):	Accommodations may be necessary for students who have challenges with language processing, vision, or fine motor skills.
Stimulus/Source:	http://www.extension.iastate.edu/agdm/crops/html/a2-35.html http://www.extension.iastate.edu/agdm/wholefarm/pdf/c2-24.pdf http://www.ksre.ksu.edu/library/agec2/mf2474.pdf http://www.michigan.gov/documents/Vol1-27GrainBinsandTanks_120836_7.pdf http://www.ces.purdue.edu/extmedia/gq/gq-3.html
Notes:	
Task Overview:	Students will research the price of corn and the costs associated with rental storage and grain bin storage, as well as the costs associated with drying corn to remove moisture so that it can be stored. A recommendation will then be made based on this analysis as to what type of corn storage method a farmer should use.
Teacher preparation / Resource requirements:	Resource requirements: Video access. Up to two days prior to the administration of this task, the teacher will provide class time to watch pretask videos. They may be watched as a class or individually. The teacher will also require students to perform a "prework" task in which they will research current prices of corn and liquid propane gas.
Teacher Responsibilities During Administration:	After the prework, the teacher will find the average of the prices for corn and gas that have been submitted by the students. These averages will be the numbers used in Session 1. The teacher should check for feasibility. During Session 1, the students will record values of certain quantities on a note sheet that will be needed for work during Session 2. After Session 1, the teacher will collect the note sheets from the students and return them to the students the following day. The students will need these responses to continue work on the second day. Monitor individual student work as necessary.
Time Requirements:	Excluding the prework, the task will be completed in two 60-minutes sessions. Parts A through C will be completed during Session 1 and Parts D and E will be completed during Session 2.

Prework:

Students will watch two short videos describing the harvesting and storing of corn for market. These videos will assist students, especially those unfamiliar with the work on a farm, by giving them a snapshot of this process. They may also supplement the reading load of these tasks for ELLs.

Here are some examples of ones that might be used:

- http://www.youtube.com/watch?v=1jhuNDuLaps
- http://www.youtube.com/watch?v=iddFy6A9uHg

Students will also be asked to research the current cost of corn and of LPG (liquid propane gas).

Your Assignment:

In this task you will assume the role of consultant for a farmer. You will analyze the options available to the farmer for handling the storage of shelled field corn (shown in the pictures above). In the past, the farmer has sold the corn as it was harvested, and did not store the corn to be sold in the future. The farmer has increased the number of acres used to grow corn, and now is exploring the cost of storing the corn until after the harvest is complete and then selling it. You will analyze two storage options available to the farmer for storing the grain that is harvested.

- The corn can be stored in grain bins constructed on the farm.
- The corn can be stored in rental storage close to the farm.

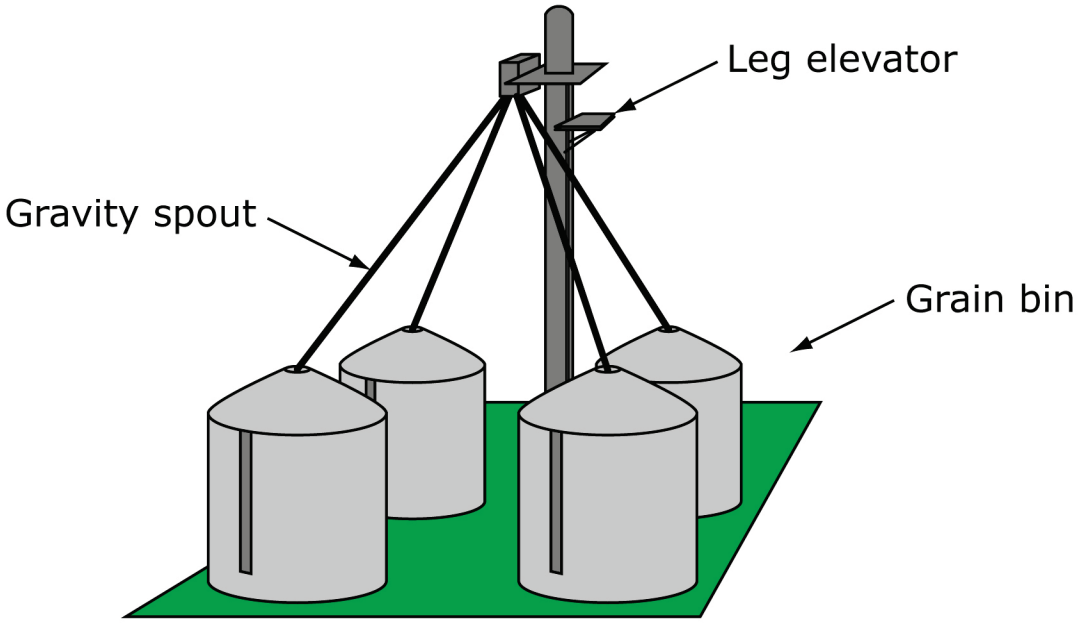
Following the tasks, you will recommend which type of storage the farmer should use.

Corn Storage

Session 1

Part A

Your first job is to determine the most efficient cost for constructing 4 grain bins which can be used to store the harvested corn. A leg elevator, which moves the corn from ground level into the bins, must also be built. The bins must be able to hold the 132,000 bushels of corn from the harvest. Each bin should include a ventilated floor, fan and heat. A cost table for building various size bins is shown below.



Cost of Grain Bins

				Add for			
Diameter (feet)	**Height (feet)**	**Capacity (bushels)**	**Cost Without Floor ($)**	**Concrete Floor ($)**	**Steel Floor ($)**	**Ventilated Floor ($)**	**Fan and Heat ($)**
30	19	10,775	11,525	1,650	1,130	4,250	2,950
	24	13,625	16,000	1,775	1,130	4,250	2,950
	32	18,175	20,100	1,975	1,130	4,250	2,950
33	24	16,475	17,725	2,050	1,320	5,100	3,025
	27	18,550	20,050	2,100	1,320	5,100	3,025
	32	21,975	24,950	2,550	1,320	5,100	3,025
36	24	19,625	21,575	2,575	1,540	6,000	3,075
	27	22,075	23,475	2,675	1,540	6,000	3,075
	32	26,150	26,100	2,775	1,540	6,000	3,075
	40	32,700	28,925	2,950	1,540	6,000	3,075
42	27	30,050	28,450	3,650	2,065	8,100	3,225
	32	35,600	32,525	3,875	2,065	8,100	3,225
	40	44,500	39,650	4,075	2,065	8,100	3,225
	48	53,425	47,200	4,400	2,065	8,100	3,225
48	27	39,250	41,150	4,775	2,640	10,450	3,350
	32	46,500	48,900	5,050	2,640	10,450	3,350
	40	58,150	55,000	5,300	2,640	10,450	3,350
	48	69,775	61,650	5,750	2,640	10,450	3,350

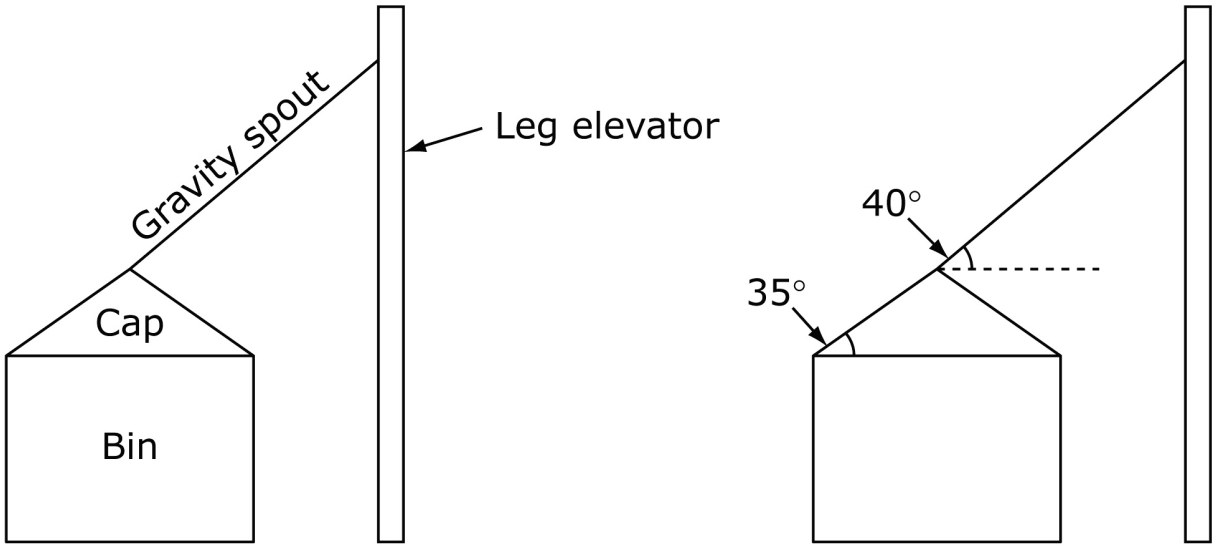
All 4 bins must have the same capacity.

The bins must be built to the following specifications.

- The height listed in the table does not include the height of the conical cap on top of the bin. The cap forms a 35^{o} angle with the base.
- The distance from the outer edge of the bins to the leg elevator will be 15 feet.
- A gravity spout is placed so that it runs from the top of the cap to a point that is 2 feet below the top of the elevator leg. To account for certain moisture content the gravity

spouts will slope 40 degrees to the horizontal.

- The average cost involved in the construction of the leg elevator is $15,000 plus $125 for every foot in height.
- The gravity spouts cost $20 per foot.



Find the most efficient cost of the construction. Be sure to include the bins (caps are included in the price), gravity spouts, and leg elevator.

Part B

When corn is harvested, the moisture content varies, but is typically above the level desired for selling or storing corn, so the corn must be dried. The moisture content is given as a percent that represents the proportion of the weight of the corn that is from water. For example, if you had 40 lbs of corn at 25% moisture content, it would consist of 10 lbs of water and 30 lbs of dry material. As corn dries, the amount of water decreases, but the amount of dry material stays the same, so the percent of weight from water will decrease.

The final moisture contents for various purposes are as follows:

- 15.5% to sell at market
- 14.0% to store at a rental storage facility
- 13.5% to store in grain bins constructed on the farm

There is a cost for drying corn to 15.5% moisture to be able to sell it at market, but there is extra cost to dry it below 15.5%. This extra cost is a cost of storage since it must be paid only if the grain is to be stored and not sold at market.

Assuming corn is harvested at an initial moisture content of 20% and you use LP gas as fuel for your dryer, use the information in tables 1 and 2 below to calculate the extra cost per bushel of drying corn to a final moisture content of 14% and 13.5%. Justify your answer mathematically and show all the steps in your calculation. You can use the regression tool in the spreadsheet provided if necessary. The BTUs required to dry corn to a final moisture content of 15.5% and 13.5% are not in the table but can be found using the provided regression tool.

Energy (BTU's) Required to Dry a Bushel of Wet Corn

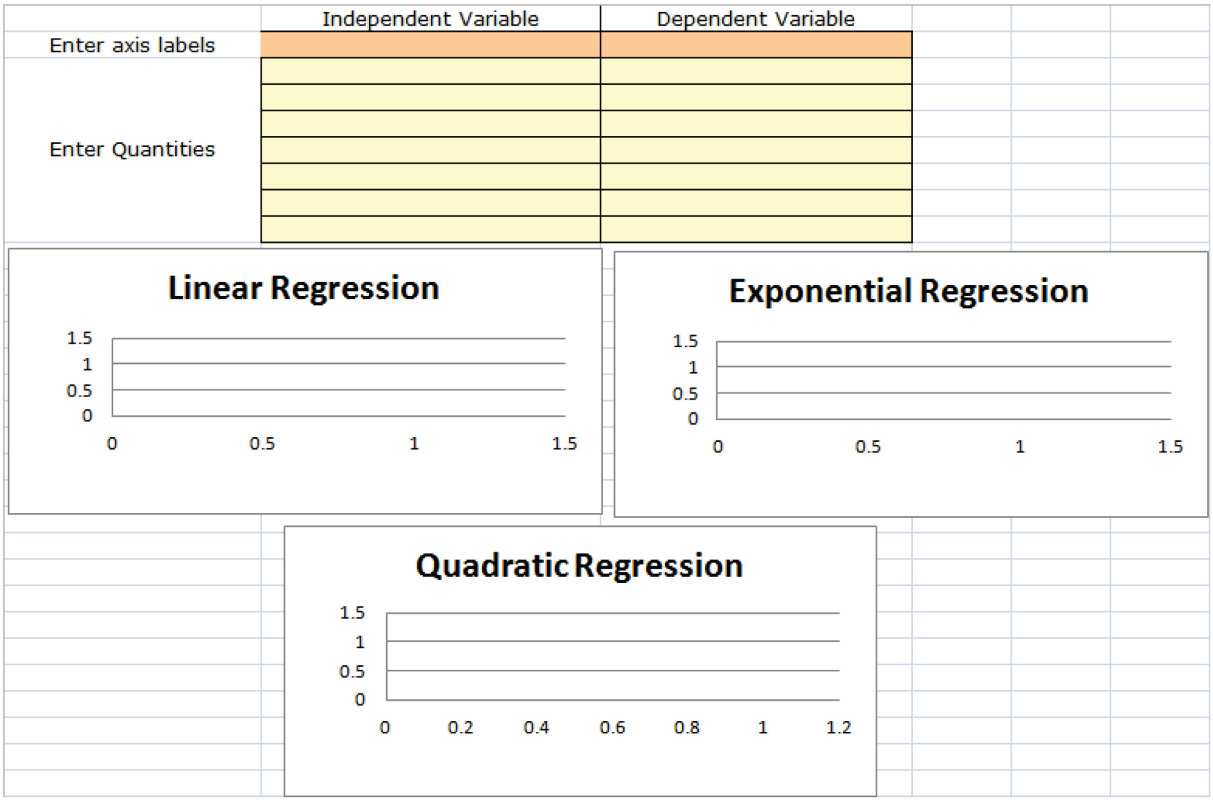
Final Moisture Content	**Initial Moisture Content**					
	20%	22%	24%	26%	28%	30%
17%	5,625	8,744	11,714	14,487	17,086	19,545
16%	7,522	10,596	13,506	16,241	18,784	21,188
15%	9,579	12,589	15,447	18,118	20,624	22,978
14%	11,635	14,582	17,388	19,994	22,463	24,768
13%	13,878	16,774	19,528	22,088	24,486	26,744

Energy Content (BTU's) per Unit of Fuel

Fuel Type	Unit	BTU's per Unit of Fuel
Oil	Gallon	140,000
LP gas	Gallon	92,000
Electricity	kWh	3,414
Natural gas	Cubic foot	1,000

To use the regression tool below, enter labels for the axes and pairs of independent and dependent variable values in the spreadsheet.

Regression Tool:



Enter your final answers:
Extra cost to dry 1 bushel of corn to 14% = _____
Extra cost to dry 1 bushel of corn to 13.5% = _____
(Record these values on your note sheet; you will need them in a later part.)

Part C

Corn is composed of dry material and water (moisture). For example, corn at 16% moisture would be composed of 84% dry material. At 15.5% moisture, one bushel of corn weighs 56 pounds. Complete the table below to show the amounts of dry material for 56 pounds of corn at each of the moisture levels. Show all work to get the values.

Moisture Level	Amount of Dry Material (pounds)
15.5%	
14%	
13.5%	

Enter the average price per bushel of corn that you found during the prework in the blank below.
Corn at 15.5% moisture sells for $_____ per bushel.

What is the price per pound for the dry material in 56 pounds of corn at 15.5% moisture? Show all work, and round your answer to the thousandths place.

At this rate of dollars per pound of dry material, what is the value, in dollars, of the dry material in 56 pounds of 14% corn

and in 56 pounds of 13.5% moisture corn? Show all work.

When 56 pounds of corn is sold at market, the buyer receives more dry material if the corn has lower moisture content. This means that there is a cost to the farmer of drying corn for storage, since each bushel sold will contain more dry material than it would have at higher moisture content. This cost is called the shrinkage cost.

For 56 pounds of corn sold:
Shrinkage Cost = value of dry material – selling price

Find the shrinkage costs when corn is sold at 14% moisture and at 13.5% moisture. Show all work.

Enter your final answers.
Shrinkage cost, per bushel, for selling corn at 14% = _____
Shrinkage cost, per bushel, for selling corn at 13.5% = _____
(Record these values on your note sheet; you will need them in a later part.)

Session 2

Part D

In this part, you will calculate the total rental cost of storing 132,000 bushels of corn at a grain elevator close to the farm, which is called rental storage. The farmer provides you with the following information.

- In January, February, and August, 2 truckloads of corn can be transported to market each day to be sold.
- In March, April, May, June, and July, 1 truckload of corn can be transported to market each day to be sold.
- Each truck the farm uses for transporting corn holds 600 bushels of corn.
- On average, corn is transported to market 20 days each

month.

- The farmer only transports and sells grain beginning in January.
- The cost for storing grain is $0.09 per bushel for 3 months and then $0.02 per bushel for each additional month past 3 months.
- The monthly storage cost for corn stored past 3 months is calculated based on the amount of corn in rental storage at the beginning of the month.
- From past experience, the farmer estimates the following percentages of corn harvested each month.

Month	Percent of Crop Harvested and Put in Storage
September	20%
October	40%
November	30%
December	10%

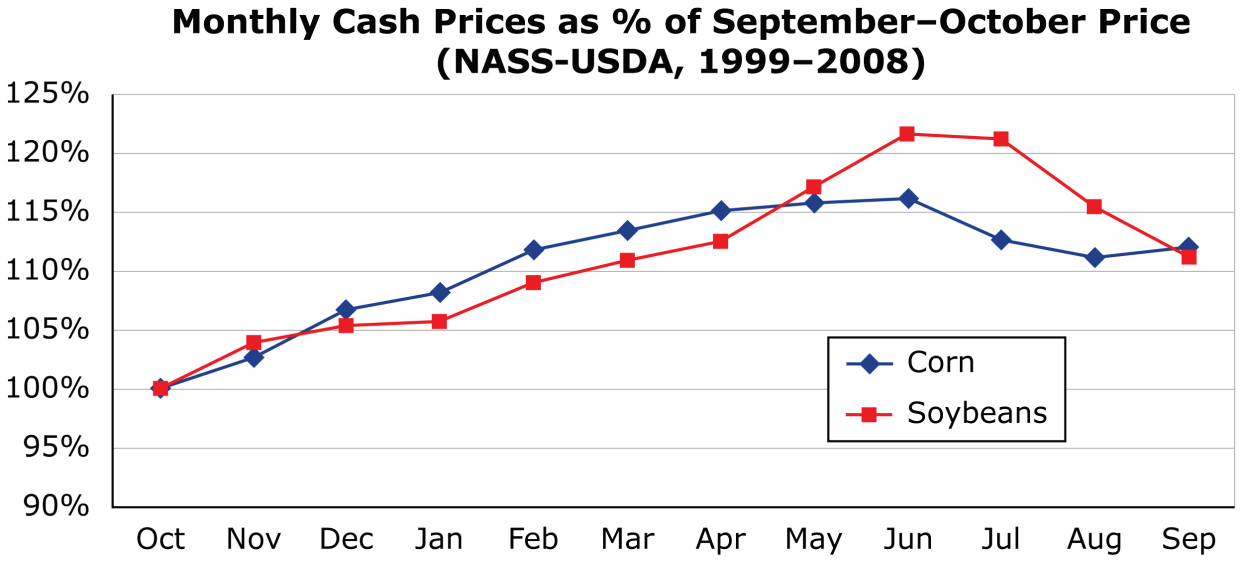
Enter the necessary amounts in the provided spreadsheet to calculate the total rental cost of storing the corn at a grain elevator close to the farm. Amounts can only be entered in cells that are shaded yellow.

Cost to store 1 bushel for 3 months=						
Cost to store 1 bushel for each month past the initial 3 months=						
Number of bushels =						
Month	Percent of Crop Put in Storage	Number of Bushels That It Is Possible to Transport	Percent of Crop Removed From Storage	Number of Bushels Removed From Storage During Month	Number of Bushels Remaining In Storage at End of Month	Cost of Rental Storage
September						$0.00
October						$0.00
November						$0.00
December						$0.00
January			#DIV/0!	#DIV/0!	#DIV/0!	$0.00
February			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
March			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
April			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
May			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
June			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
July			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
August			#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
			Total Cost of Rental Storage=			#DIV/0!

Part E

In this part, you will analyze the cost of building grain bins to store corn on the farm. Based on the time series plot below, the farmer thinks that it might be more cost effective to build grain bins rather than paying for rental storage. Storing corn in grain

bins on the farm will enable the farmer to sell corn to many possible buyers at times during the year when the price of corn will be higher than it is at harvest time.



Calculate the average increase in selling price ($ per bushel) that the farmer receives by selling corn during the months of January through August rather than selling all of the corn at harvest. The average increase in selling price ($ per bushel) is $0.20 more for grain stored in the farmer's bins than for grain stored in rental storage because rental storage charges a fee to remove grain to sell elsewhere.

Use the results of your calculations and any other necessary information to enter values in the spreadsheet below to calculate the cost for storing corn in grain bins and in rental storage. You will be provided with the note sheet on which you recorded the **current** cost per bushel of corn that you found in your prework, and the results of your calculations from previous parts.

Grain Storage Investment Comparison

Ag Decision Maker -- Iowa State University Extension

Place the cursor over cells with red triangles to read comments.
Enter your input values in yellow shaded cells.

Storage Type	Corn: On-farm Investment	Corn: Rental Storage
Number of bushels stored	1,000 bu.	1,000 bu.
Total cost of bin construction ($)		
bin(including floor, fan, heat), spouts, leg elevator	$ 1,000	
additional augers, fans, conveyers, etc.	$ 5,000	
Useful life for bin (years)	25 years	
Useful life for augers, fans, conveyers (years)	10 years	
Interest rate for financing initial investment (%)	4.6%	
Average moisture at harvest (%)	20.0%	20.0%
Moisture level for storage (%)	13.5%	14.0%
Extra handling cost ($ per bu.)	$ 0.015	
Extra transportation cost ($ per bu.)	$ 0.050	
Quality loss for on-farm storage (%)	1.0%	
Fans, total horsepower	10 hp	
Hours fans will run, total	1440 hrs	
Electricity rate ($ per KWH)	$ 0.1000	
Add'l hours per month spent managing & handling grain	5.00	
Labor value ($ per hour)	$ 10.00	
Commercial storage charges		
Minimum charge or base rate ($ per bu.)		$0.2100
Base period (months)		3 months
Rate per month after base period ($ per bu. per month)		$0.0280
Expected September-October cash selling price of corn ($ per bu.)	$ 6.00	$ 6.00
Average increase in selling price ($ per bu.)	$ 0.20	$ -
Short-term interest rate (%)	7.00%	7.00%
Average length of storage (months)	7 months	7 months

	On-farm Investment	Rental Storage
Fixed costs		
Interest and depreciation on investment	$ 703	
Repairs (estimated at 1.5% of initial investment)	$ 90	
Insurance and taxes (estimated at 1% of investment)	$ 60	
Total fixed costs ($ per year)	$ 853	
Fixed costs ($ per bu.)	$ 0.85	
Variable costs ($ per bu.)		
Storage rental charge or service fee		$ 0.322
Interest on grain inventory	$ 0.253	$ 0.245
Extra drying cost for corn		
Extra shrinkage cost for corn		
Extra handling and transportation cost	$ 0.065	
Quality deterioration	$ 0.060	
Electricity cost	$ 1.152	
Extra labor cost	$ 0.350	
Total cost of storage	**$ 2.73**	**$ 0.57**
Less selling price advantage	$ 0.200	$ -
Net cost of storage ($ per bu.)	**$ 2.53**	**$ 0.57**

Based on your analysis of the information in the spreadsheet, explain what recommendation you would make to the farm manager about what type of storage is best. Explain how you arrived at your recommendation.

Sample Top-Score Response:

Session 1

***Part A* (use *n* = 132,000 for number of bushels of corn)**

1. First, I need to decide which bins to buy. If the company needs 4 bins that will hold 132,000 bushels, then $\frac{132,000}{4} = 33,000$. The smallest bins that hold this capacity are those that hold 35,600 bushels. The dimensions for those bins are 42' by 32' (diameter by height) and will each cost $32,525. If we include the floor ($8100) and fan/heat ($3225), then each bin will cost $43,850.

2. Next, I need to find the height of the leg elevator. Its height is the sum of the bin height (32'), the cap height (*x*), the vertical distance from the top of the cap to the entry point for the gravity spout (y), and the remaining distance to the top of the leg elevator (2').

   To solve for *x*: $\tan 35 = \frac{x}{21}$ $x \approx 14.70$ and to solve for *y*: $\tan 40 = \frac{y}{36}$ $y \approx 30.21$

   Total height of the leg elevator is 32 + 14.70 + 30.21 + 2 = 78.91 ft.

3. Next is the length of each gravity spout (*z*). Using the Pythagorean Theorem (student may choose to use right triangle trigonometry), $36^2 + 30.21^2 = z^2$, and solved for *z*. I found the length of one gravity spout to be approximately 47 ft. Since there are four of them, we will need 188 feet.

4. Finally, I now have enough information to find the total cost of the project:

   Bins are 4($43,850) = $175,400.

   Leg elevator is $15,000 + $125(78.91), which is $24,863.75.

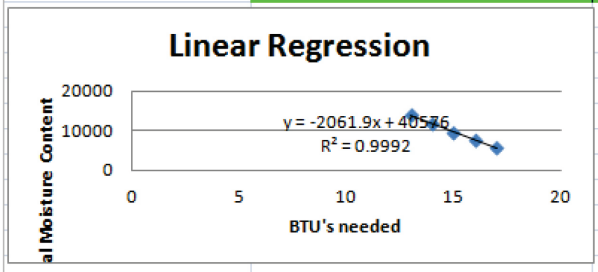
   The **gravity spouts** are $20(188) or $3,760.00.

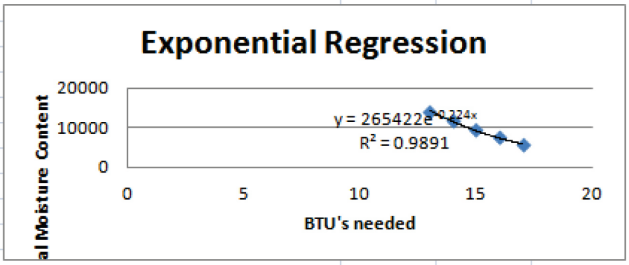
   Grand total cost of the project is **$204,023.75.**

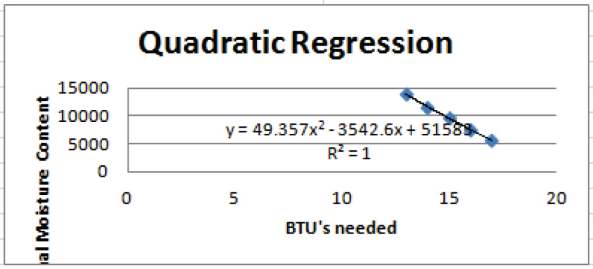
Part B
Cost of drying corn (Assuming LP Gas costs $2.18 per gallon)

Finding BTU's needed to dry corn –

	Independent Variable	Dependent Variable
Enter axis labels	Final Moisture Content	BTU's needed
Enter Quantities	17	5625
	16	7522
	15	9579
	14	11635
	13	13878







Since the quadratic regression has the highest r-squared value, I will use that equation to calculate the number of BTU's needed to dry one bushel of corn from 20% to 15.5% and to 13.5%.

Quadratic regression equation: $y = 49.357x^2 - 3542.6x + 51583$

BTU's needed for 15.5%: $y = 49.357(15.5)^2 - 3542.6(15.5) + 51583 = 8{,}531$ BTU's

BTU's needed for 14% (From table):11,635 BTU's

BTU's needed for 13.5%: $y = 49.357(13.5)^2 - 3542.6(13.5) + 51583 = 12{,}753$ BTU's

Finding per bushel cost –

For 15.5%: $8{,}531 \text{ BTU's} \cdot \frac{1 \text{ gallon}}{92{,}000 \text{ BTU's}} \cdot \frac{\$2.18}{1 \text{ gallon}} = \$0.202$ per bushel

For 14%: $11{,}635 \text{ BTU's} \cdot \frac{1 \text{ gallon}}{92{,}000 \text{ BTU's}} \cdot \frac{\$2.18}{1 \text{ gallon}} = \$0.276$ per bushel

For 13.5%: $12{,}753 \text{ BTU's} \cdot \frac{1 \text{ gallon}}{92{,}000 \text{ BTU's}} \cdot \frac{\$2.18}{1 \text{ gallon}} = \$0.302$ per bushel

Extra cost to dry 1 bushel of corn to 14% = cost to dry to 14% - cost to dry to 15.5%
= \$0.276 - \$0.202
= \$0.074

Extra cost to dry 1 bushel of corn to 13.5% = cost to dry to 13.5% - cost to dry to 15.5%
= \$0.302 - \$0.202
= \$0.100

Part C

Shrinkage cost (Assuming market price of $6.40 per bushel)
Finding the weight of the dry material in 56 lbs of corn –
For 15.5% moisture content (84.5% dry material):
Weight of dry material $= 56(.845) = 47.32$ pounds
For 14% moisture content (86% dry material):
Weight of dry material $= 56(.86) = 48.16$ pounds
For 13.5% moisture content (86.5% dry material):
Weight of dry material $= 56(.865) = 48.44$ pounds
Finding price per pound of dry material for corn at 15.5% moisture content –

$$\frac{\$6.40}{47.32 \text{ lbs of dry material}} = \$0.135 \text{ per lb of dry material}$$

Finding the value of the dry material in 56 lbs of corn at 14% and 13.5% moisture content –

For 14%: $48.16 \text{ lb of dry material} \bullet \frac{\$0.135}{1 \text{ lb of dry material}} = \$6.514$

For 13.5%: $48.44 \text{ lb of dry material} \bullet \frac{\$0.135}{1 \text{ lb of dry material}} = \$6.551$

Finding shrinkage cost –
Shrinkage cost, per bushel, for selling corn at 14%: Value of dry material – selling price
$\$6.514 - \$6.40 = \$0.114$
Shrinkage cost, per bushel, for selling corn at 13.5%: Value of dry material – selling price
$\$6.551 - \$6.40 = \$0.151$

Session 2

Part D

The information provided in part D gives the following values that can be directly entered into the spreadsheet.
Cost to store 1 bushel of corn for 3 months in rental storage: $0.09
Cost to store 1 bushel for each month past the initial 3 months: $0.02
Percent of crop put in storage: September (20%), October (40%), November (30%), December (10%)

The following information can be found on the student's note sheet from the previous day's work.
Number of bushels of corn harvested: 132,000

The number of bushels that can possibly be transported must be calculated.

For January, February, and August: $\frac{2 \text{ truckloads}}{1 \text{ day}} \times \frac{20 \text{ days}}{1 \text{ month}} \times \frac{600 \text{ bu.}}{1 \text{ truckload}} = \frac{24,000 \text{ bu.}}{\text{month}}$

For March, April, May, June, July: $\frac{1 \text{ truckloads}}{1 \text{ day}} \times \frac{20 \text{ days}}{1 \text{ month}} \times \frac{600 \text{ bu.}}{1 \text{ truckload}} = \frac{12,000 \text{ bu.}}{\text{month}}$

Entering all of these values into the spreadsheet results in a total cost of $23,160 for rental

storage to store the season's 132,000 bushels of harvested corn.

Cost to store 1 bushel for 3 months=			0.09			
Cost to store 1 bushel for each month past the initial 3 months=						0.02
Number of bushels of corn harvested =		132,000				
Month	Percent of Crop Put in Storage	Number of Bushels That It Is Possible to Transport	Percent of Crop Removed From Storage	Number of Bushels Removed From Storage During Month	Number of Bushels Remaining In Storage at End of Month	Cost of Rental Storage
September	20					$2,376.00
October	40					$4,752.00
November	30					$3,564.00
December	10					$1,188.00
January		24,000	0.18182	24,000	108,000	$2,640.00
February		24,000	0.18182	24,000	84,000	$2,160.00
March		12,000	0.09091	12,000	72,000	$1,680.00
April		12,000	0.09091	12,000	60,000	$1,440.00
May		12,000	0.09091	12,000	48,000	$1,200.00
June		12,000	0.09091	12,000	36,000	$960.00
July		12,000	0.09091	12,000	24,000	$720.00
August		24,000	0.18182	24,000	0	$480.00
				Total Cost of Rental Storage=		$23,160.00

Part E

The students will use the current selling price for 1 bushel of shelled corn, which they will find in the pre-work session. Suppose this price was $6.40, and the price was found when the test is taken in the month of March. Using the provided graph for the "Monthly cash prices as % of September-October price," it is possible to determine a likely value for the selling price at harvest time in September-October as follows.

The March price of corn, on average, is about 114% of the October price. This means that $\$6.40 = 1.14(\text{October price})$, or $\text{October price} = \frac{\$6.40}{1.14} \approx \$5.61$. So based on the monthly cash prices in the graph, on average, we would expect that the price at harvest would be about $5.61. This value can be placed into the spreadsheet for the "Expected September-October selling price" on line 35.

The "Average increase in selling price" must also be calculated and put into the spreadsheet. To do this, we must use the information in the provided time series plot, and

also the values for the percent of crop removed in each month from January to August from the spreadsheet in part D.

Month	**Percent of Crop Removed, *r*, (from spreadsheet in part D)**	**Monthly Cash Price, *p*, as % of Sept.–Oct. Price (estimated from graph)**	***r* × *p* (as a decimal)**
January	18.18%	108%	0.1963
February	18.18%	112%	0.2036
March	9.09%	114%	0.1036
April	9.09%	115%	0.1045
May	9.09%	116%	0.1054
June	9.09%	116%	0.1054
July	9.09%	113%	0.1027
August	18.18%	111%	0.2018
		Total =	1.1233

So when different percentages of corn are sold at different percentages of the Sept.-Oct. selling price, the weighted average for the corn sold is approximately 1.1233 times the Sept.-Oct. selling price, or in other words the average increase in selling price is about 12.33% higher than the harvest price. The average increase in selling price is thus approximately $\$5.61(0.1233) = \$0.6917$. This value can be entered for the "Average increase in selling price" on line 36 of the spreadsheet below.

Five other values must be obtained from the student's note sheet from the previous day's work. These values are the following.
Total cost of constructing the grain bins: $203,991.25 (from part A on day 1)
Extra cost to dry 1 bu. to 13.5% moisture (for grain bin): $0.10 (from part C on day 1)
Extra cost to dry 1 bu. to 14% moisture (for rental storage): $0.074 (from part C on day 1)
Shrinkage Cost for selling corn at 14% moisture (for rental storage): $0.114 (from part C on day 1)
Shrinkage Cost for selling corn at 13.5% moisture (for grain bins): $0.151 (from part C on day 1)

These five values must be entered into the spreadsheet on the appropriate lines.

Grain Storage Investment Comparison

Ag Decision Maker -- Iowa State University Extension

Place the cursor over cells with red triangles to read comments.
Enter your input values in yellow shaded cells.

Storage Type	Corn: On-farm Investment	Corn: Rental Storage
Number of bushels stored	**132,000 bu.**	132,000 bu.
Total cost of bin constrution ($)		
bin(including floor, fan, heat), spouts, leg elevator	**$ 204,024**	
additional augers, fans, conveyers, etc.	$ 5,000	
Useful life for bin (years)	25 years	
Useful life for augers, fans, conveyers (years)	10 years	
Interest rate for financing initial investment (%)	4.6%	
Average moisture at harvest (%)	20.0%	20.0%
Moisture level for storage (%)	13.5%	14.0%
Extra handling cost ($ per bu.)	$ 0.015	
Extra transportation cost ($ per bu.)	$ 0.050	
Quality loss for on-farm storage (%)	1.0%	
Fans, total horsepower	10 hp	
Hours fans will run, total	1440 hrs	
Electricity rate ($ per KWH)	$ 0.1000	
Add'l hours per month spent managing & handling grain	5.00	
Labor value ($ per hour)	$ 10.00	
Commercial storage charges		
Minimum charge or base rate ($ per bu.)		$0.0900
Base period (months)		3 months
Rate per month after base period ($ per bu. per month)		$0.0200
Expected September-October cash selling price of corn ($ per bu.)	**$ 5.61**	$ 5.61
Average selling price advantage ($ per bu.)	**$ 0.69**	$ 0.49
Short-term interest rate (%)	7.00%	7.00%
Average length of storage (months)	7 months	7 months

Fixed costs	On-farm Investment	Rental Storage
Interest and depreciation on investment	$ 14,534	
Repairs (estimated at 1.5% of initial investment)	$ 3,135	
Insurance and taxes (estimated at 1% of investment)	$ 2,090	
Total fixed costs ($ per year)	$ 19,759	
Fixed costs ($ per bu.)	$ 0.15	
Variable costs ($ per bu.)		
Storage rental charge or service fee		$ 0.170
Interest on grain inventory	$ 0.257	$ 0.249
Extra drying cost for corn	$ 0.100	$ 0.074
Extra shrinkage cost for corn	$ 0.151	$ 0.114
Extra handling and transportation cost	$ 0.065	
Quality deterioration	$ 0.056	
Electricity cost	$ 0.009	
Extra labor cost	$ 0.003	
Total cost of storage	**$ 0.79**	**$ 0.61**
Less selling price advantage	$ 0.692	$ 0.492
Net cost of storage ($ per bu.)	**$ 0.10**	**$ 0.12**

Recommendation: Based strictly on cost, the best recommendation to make to the farmer would be to build the grain bins and use them for storage, since the net cost for rental storage is $0.12 per bushel and the net cost for grain bin storage is $0.10 per bushel, which is lower. However, other considerations might convince the farmer to accept the higher cost.

Scoring Notes:

Scoring Rubric:

Responses to Part A will receive 0-4 points based on the following:

4 points: The student demonstrates a thorough understanding of the 3 major concepts assessed in this part: complete investigation of choice in size of the bins; use of right triangle trigonometry (or Pythagorean Theorem) to calculate missing heights; and a combination of strategies used in earlier grades (linear functions and proportional relationships) to analyze costs.

3 points: The student demonstrates a thorough understanding of 2 of the 3 major concepts assessed in this part and a limited understanding of the 3rd. This limited understanding could be an inappropriate choice for the size of the bins by picking one that doesn't hold enough, OR the student will demonstrate a thorough understanding of all 3 of the major concepts assessed in this part with minor arithmetic errors.

2 points: The student demonstrates a thorough understanding of 1 of the 3 major concepts assessed in this part and a limited understanding of the other two. A student receiving 2 points for this part may thoroughly determine the correct size of the bins but makes significant errors in the other two parts.

1 point: The student demonstrates a limited understanding of all of the 3 major concepts assessed in this part OR a thorough understanding of 1 of the 3 concepts and little to no understanding of the other 2. A student receiving 1 point for this part may thoroughly determine the correct size of the bins but only be able to guess at a cost for the rest of the project based on conjecture.

0 points: The student demonstrates little to no understanding of any of the 3 major concepts assessed in this part.

Responses to Part B will receive 0-4 points based on the following:

4 points: The student has a thorough understanding of how to analyze a real-world scenario to identify important quantities and use units to solve problems. The student has a thorough understanding of how to select and use a regression model in the context of the data. The student enters the values for final moisture content as the independent variable and the values for the number of BTU's needed to dry from 20% moisture content as the dependent variable. The student identifies that the quadratic regression is the best fit or explains that another type of regression is close enough to a perfect fit that the level of error would be negligible. The student uses the chosen regression function to find the number of BTU's needed to dry the corn to 15.5% and to 13.5% moisture content. The student shows how the units of the quantities lead to the calculation for the total cost per

bushel of drying corn and then subtracts to find the extra cost for drying corn to 14% and to 13.5%.

3 points: The student has an adequate understanding of how to analyze a real-world scenario to identify important quantities and use units to solve problems. The student has a thorough understanding of how to select and use a regression model in the context of the data. The student enters the values for final moisture content as the independent variable and the values for the number of BTU's needed to dry from 20% moisture content as the dependent variable. The student identifies that the quadratic regression is the best fit or explains that another type of regression is close enough to a perfect fit that the level of error would be negligible. The student uses the chosen regression function to find the number of BTU's needed to dry the corn to 15.5% and to 13.5% moisture content. The student shows how the units of the quantities lead to the calculation for the total cost per bushel of drying corn but forgets to subtract to find the extra cost for drying corn to 14% and to 13.5%.

2 points: The student has a solid understanding of how to analyze a real-world scenario to identify important quantities and use units to solve problems. The student has a limited understanding of how to select and use a regression model in the context of the data. The student either does not correctly use the regression spreadsheet to identify the best model for the data, or uses a model other than the quadratic one without explaining why it is acceptable in the context. The student uses the values they identified (which may be incorrect) for the number of BTU's needed to dry the corn to each level and shows how the units of the quantities lead to the calculation for the total cost per bushel of drying corn and then subtracts to find the extra cost for drying corn to 14% and to 13.5%.

1 point: The student has some understanding of how to analyze a real-world scenario to identify important quantities and use units to solve problems. The student has a limited understanding of how to select and use a regression model in the context of the data. The student either does not correctly use the regression spreadsheet to identify the best model for the data, or uses a model other than the quadratic one without explaining why it is acceptable in the context. The student uses the values they identified (which may be incorrect) for the number of BTU's needed to dry the corn to each level and shows how the units of the quantities lead to the calculation for the total cost per bushel of drying corn but forgets to subtract to find the extra cost for drying corn to 14% and to 13.5%. **OR** The student has limited understanding of how to analyze a real-world scenario to identify important quantities and use units to solve problems. The student has a solid understanding of how to select and use a regression model in the context of the data. The student enters the values for final moisture content as the independent variable and the values for the number of BTU's needed to dry from 20% moisture content as the dependent variable. The student identifies that the quadratic regression is the best fit or explains that another type of regression is close enough to a perfect fit that the level of error would be negligible. The student does not use the values they identified (which are correct) for the number of BTU's needed to dry the corn to each level to show how the units of the quantities lead to the calculation for the total cost per bushel of drying.

0 points: The student has limited understanding of how to analyze a real-world scenario to identify important quantities and use units to solve problems. The student has a limited understanding of how to select and use a regression model in the context of the data. The student either does not correctly use the regression spreadsheet to identify the best model for the data, or uses a model other than the quadratic one without explaining why it is acceptable in the context. The student either does not identify the number of BTU's needed

to dry the corn to each level or does not use the values they identified (which are incorrect) to show how the units of the quantities lead to the calculation for the total cost.

Responses to Part C will receive 0-4 points based on the following:

4 points: The student has a thorough understanding of how to analyze a real-world scenario to calculate rates and use units to solve problems. The student uses the percent of moisture content to calculate the weight of the dry material in 56 lbs of corn at each moisture level. The student uses the current price of corn to calculate the value of the dry material in the corn at the market standard moisture level of 15.5%. The student uses the calculated rate to find the value of the dry material in 56 lbs of each of the dryer corns. The student compares the value of the dry material in each of the dryer corns to the selling price to find the cost of shrinkage.

3 points: The student has some understanding of how to analyze a real-world scenario to calculate rates and use units to solve problems. The student uses the percent of moisture content to calculate the weight of the dry material in 56 lbs of corn at each moisture level. The student uses the current price of corn to calculate the value of the dry material in the corn at the market standard moisture level of 15.5%. The student uses the calculated rate to find the value of the dry material in 56 lbs of each of the dryer corns. The student does not compare the value of the dry material in each of the dryer corns to the selling price to find the cost of shrinkage.

2 points: The student has incomplete understanding of how to analyze a real-world scenario to calculate rates and use units to solve problems. The student uses the percent of moisture content to calculate the weight of the dry material in 56 lbs of corn at each moisture level. The student uses the current price of corn to calculate the value of the dry material in the corn at the market standard moisture level of 15.5%. The student does not use the calculated rate to find the value of the dry material in 56 lbs of each of the dryer corns, and so cannot compare the value of the dry material in each of the dryer corns to the selling price to find the cost of shrinkage.

1 point: The student has limited understanding of how to analyze a real-world scenario to calculate rates and use units to solve problems. The student uses the percent of moisture content to calculate the weight of the dry material in 56 lbs of corn at each moisture level. The student does not use the current price of corn to calculate the value of the dry material in the corn at the market standard moisture level of 15.5%. The student cannot find the value of the dry material in 56 lbs of each of the dryer corns, and so cannot compare the value of the dry material in each of the dryer corns to the selling price to find the cost of shrinkage.

0 points: The student has no understanding of how to analyze a real-world scenario to calculate rates and use units to solve problems. The student does not use the percent of moisture content to calculate the weight of the dry material in 56 lbs of corn at each moisture level. The student therefore cannot find the value of the dry material and the cost of shrinkage.

Responses to Part D will receive 0-4 points based on the following:

4 points: The student has a thorough understanding of how to analyze a real-world scenario to calculate rates and use units to solve problems. The student correctly calculates

the number of bushels of corn that can be transported to market for the block of months January, February, August, and separately for the block of months March, April, May, June, July. The student identifies the appropriate information to enter into the provided spreadsheet, enters this information into the spreadsheet, and records the value of $23,160 for the total cost of transportation.

3 points: The student has some understanding of how to analyze a real-world scenario to calculate rates and use units to solve problems. The student fails to correctly calculate the amount of corn transported for one of the block of months, but correctly calculates it for the other block of months. The student identifies the appropriate information to enter into the provided spreadsheet, enters this information into the spreadsheet, and records a value for the total cost of transportation that is correct except for the use of the one incorrect number.

2 points: The student has incomplete understanding of how to analyze a real-world scenario to calculate rates and use units to solve problems. The student fails to correctly calculate the amount of corn transported for both of the blocks of months. The student identifies the appropriate information to enter into the provided spreadsheet, enters this information into the spreadsheet, and records a value for the total cost of transportation that is correct except for the use of the two incorrect numbers.

1 points: The student has limited understanding of how to analyze a real-world scenario to calculate rates and use units to solve problems. The student fails to correctly calculate the amount of corn transported for both of the blocks of months. The student enters some information correctly into the spreadsheet, but not all correct information, and thus records an incorrect number for the total cost of transportation.

0 points: The student has no understanding of how to analyze a real-world scenario to calculate rates and use units to solve problems. The student fails to perform any calculation correctly, and fails to enter any correct information into the spreadsheet.

Responses to Part E will receive 0-4 points based on the following:

4 points: The student has a thorough understanding of how to analyze a real-world scenario to read information on a graph, set up a simple linear equation and solve for an unknown value, and reason quantitatively using percents. The student uses the current selling price of corn and the provided time series plot to correctly calculate the estimated selling price of corn at harvest time in October. The student also correctly calculates the "Average selling price advantage" by using the percent of crop removed and sold each month and the monthly cash price during that month to multiply percents and then calculate an average percent above the October price. These values and values from the previous day are all entered correctly into the spreadsheet, and then the student makes a recommendation about what type of storage to use and gives valid reasons for the recommendation.

3 points: The student has some understanding of how to analyze a real-world scenario to read information on a graph, set up a simple linear equation and solve for an unknown value, and reason quantitatively using percents. The student correctly calculates the "Average selling price advantage" by using the percent of crop removed and sold each month and the monthly cash price during that month to multiply percents and then calculate an average percent above the October price. However, the student fails to use the current selling price of corn and the provided time series plot to correctly calculate the

estimated selling price of corn at harvest time in October. These values and values from the previous day are all entered correctly into the spreadsheet, and then the student makes a recommendation about what type of storage to use and gives valid reasons for the recommendation.

2 points: The student has some understanding of how to analyze a real-world scenario to read information on a graph, set up a simple linear equation and solve for an unknown value, and reason quantitatively using percents. The student uses the current selling price of corn and the provided time series plot to correctly calculate the estimated selling price of corn at harvest time in October. However, the student fails to correctly calculate the "Average selling price advantage" by using the percent of crop removed and sold each month and the monthly cash price during that month to multiply percents and then calculate an average percent above the October price. These values and values from the previous day are all entered correctly into the spreadsheet, and then the student makes a recommendation about what type of storage to use and gives valid reasons for the recommendation.

1 points: The student has limited understanding of how to analyze a real-world scenario to read information on a graph, set up a simple linear equation and solve for an unknown value, and reason quantitatively using percents. The student fails to use the current selling price of corn and the provided time series plot to correctly calculate the estimated selling price of corn at harvest time in October. The student also fails to correctly calculate the "Average selling price advantage" by using the percent of crop removed and sold each month and the monthly cash price during that month to multiply percents and then calculate an average percent above the October price. The student makes a recommendation about what storage to use, but the recommendation is made based on incorrectly calculated numbers from the spreadsheet.

0 points: The student has no understanding of how to analyze a real-world scenario to read information on a graph, set up a simple linear equation and solve for an unknown value, and reason quantitatively using percents. Any calculations made are incorrect, and no recommendation is made or a recommendation is made but no reasoning is given to justify it.