AAE 320 Fall 2020 **Exam #1** **Name: KEY**

1) (6 pts.) *Based on material covered in class*, are these True or False? Mark your answer.

a) T_X_ F___ The number of dairy herds in Wisconsin has been declining the last 2-3 years at a more rapid rate than in previous years.

b) T_X_ F___ In Wisconsin, about 75% of all the farmers have less than $100,000 of agricultural sales annually.

c) T_X_ F___ Wisconsin has the second largest processed vegetable industry in the U.S. in terms of the annual value of production.

d) T_X_ F___ Based on budgets examined in class for Wisconsin and other states, the full cost of production for a dairy cow exceeds $4,600 per year.

e) T_X_ F___ Most value in the U.S. food system is generated after the farmer, so farmers receive only a small part of the money when someone buys food.

f) T_X_ F___ Based on materials covered in class, farming is the most capital intensive part of the U.S. food supply chain.

2) (10 pts.) Short answer

a) (1 pt) What is Wisconsin's largest fruit crop in terms of the annual value produced each year?

Cranberries

b) (1 pt) In the context of dairy farming, is a milk cow male or female?

Female

c) (2 pt) In the context of dairy farming, what is the difference between a heifer and a cow?

Heifer is a female that has not yet had a calf/given birth, a cow has had a calf/given birth

d) (2 pt) In the context of dairy farming, what is the difference between a bull and a steer?

Both are males, but a steer has been castrated

e) (4 pt) A field of corn can be harvested for corn silage or for grain. Briefly explain how corn silage differs from grain corn in terms of what is harvested and how it is stored.

In terms of what is harvested, for silage, most of the plant biomass is harvested and chopped up, while for grain, only the corn kernels are harvested. In terms of storage, silage is fermented by storing in some way to be anaerobic (no oxygen): a large pile covered in plastic, a large plastic bag, or a silo, while corn grain is dried and stored in a grain bin or similar to remain dry.

3) (10 pts.) You manage a small organic vegetable farm. This table reports how many sacks of potatoes are dug, cleaned, and ready for sale in one day with different numbers of workers.

Workers Hired	Sacks/Day	Marginal Product	Value of Marginal Product
1	25	--	--
3	65	20	400
5	99	17	340
7	121	11	220
9	139	9	180

a) (2 pts) Using some numbers from this table, show in the space below how to calculate the Marginal Product for <u>one</u> example, and then fill in the Marginal Product column in the table above.

MP = ΔQ/ΔX = (65 – 25) / (3 – 1) = 40/2 = 20

b) (2 pts) Potatoes sell for $20/Sack. Using numbers from this table, show in the space below how to calculate the Value of Marginal Product for <u>one</u> example, and then fill in the Value of Marginal Product column in the table above.

VMP = P x MP = 20 x 20 = 400

c) (2 pts) If wages, taxes, materials, etc. cost you $250/day to hire a worker, what is the profit maximizing number of workers to hire? Note, you may need to interpolate between entries. You do not have to get an integer for an answer, round to the nearest tenth.

The number of workers where the VMP = r (the cost of hiring a worker), or $250.
Linear interpolation:

Workers	VMP
5	340
6.5	250
7	220

Workers = 5 + (250 – 340) x (7 – 5)/(220 – 340) = 5 + 90 x (2/120) = 6.5
<u>Hire 6.5 workers</u>

d) (2 pts) Wisconsin is an important state for potato production. In 2018, what was Wisconsin's rank among U.S. states in terms of potato production? What percentage of the total US potato production was produced in Wisconsin?

WI is <u>third</u> in potato production after ID and WA and produced <u>6%</u> of U.S. potato in 2018.

4) (16 pts.) You have been planting corn following corn in a field, but want to look at a corn-soybean rotation. For your current system, you would plant corn in 2021 and again in 2022 in the field. For the alternative system, you would switch the field to soybeans in 2021 and then corn in 2022. For corn following soybeans in 2022, your cost will decrease and yield will increase compared to corn following corn, but you have to plant soybeans in the field in 2021.

For your current system, in 2021 your estimated cost is $658 per acre to grow corn following corn, you expect an average yield of 192 bushels per acre and your expected corn price is $3.50 per bushel. For 2022, your estimated cost is $663 per acre to grow corn following corn, you expect an average yield of 195 bushels per acre and your expected corn price is $3.35.

If you switch to a corn-soybean rotation, your estimated cost is $444 per acre to grow soybeans in 2021, you would get 53 bushels per acre and your expected soybean price is $8.50 per bushel. In 2022, your estimated cost is $604 per acre to grow corn following soybeans, you expect a yield of 200 bushels per acre and your expected corn price remains $3.35.

Use the given information to conduct a partial budget analysis of switching to a corn soybean rotation for the field for 2021 and 2022. I have provided two empty partial budget tables to use. The first will be for switch the field to soybeans in 2021 versus planting corn following corn. The second table will be for planting corn following soybeans in 2022 versus planting corn following corn. Calculate the benefits and costs and the net benefit for each year, show your calculations in the tables provided. Round to the nearest cent.

<table>
<tr><th colspan="2">Benefits of switching to soybeans in 2021 versus staying with corn following corn</th><th colspan="2">Costs of switching to soybeans in 2021 versus staying with corn following corn</th></tr>
<tr><td colspan="2">Additional Revenues
What new revenue will be generated?

2021 Soybean Revenue
= 53 bu/ac x $8.50/bu = $450.50/ac</td><td colspan="2">Additional Costs
What new costs will be added?

2021 Soybeans following Corn Costs
= $444/ac</td></tr>
<tr><td colspan="2">Costs Reduced
What costs will be eliminated?

2021 Corn following Corn Costs
= $658/ac</td><td colspan="2">Revenues Reduced
What revenues will be lost?

2021 Corn following Corn Revenue
= 192 bu/ac x $3.50/bu = $672/ac</td></tr>
<tr><td>Total Benefits</td><td>$450.50 + $658 = $1,108.50</td><td>Total Costs</td><td>$444 + $672 = $1,116</td></tr>
<tr><td colspan="3">Total Benefits – Total Costs = Net Benefit</td><td>$1,108.50 – $1,116 = –$7.50/ac</td></tr>
</table>

Benefits of switching to corn following soybeans in 2022 versus staying with corn following corn		**Costs of switching to corn following soybeans in 2022 versus staying with corn following corn**	
Additional Revenues What new revenue will be generated? 2022 Corn following Soybean Revenue = 200 bu/ac x $3.35/bu = $670/ac		Additional Costs What new costs will be added? 2022 Corn following Soybeans Costs = $604/ac	
Costs Reduced What costs will be eliminated? 2022 Corn following Corn Costs = $663/ac		Revenues Reduced What revenues will be lost? 2022 Corn following Corn Revenue = 195 bu/ac x $3.35/bu = $653.25/ac	
Total Benefits	$670 + $663 = $1,333	Total Costs	$604 + $653.25 = $1,257.25
Total Benefits – Total Costs = Net Benefit			$1,333 – $1,257.25 = $75.75/ac

a) (2 pts) Based on your results, looking only at 2021, is it more profitable to switch the field to soybeans or to stay with corn following corn?

The estimated net benefit for switching for 2021 is –$7.50/ ac, so it is more profitable to stay with corn following corn.

b) (2 pts) Based on your results, looking only at 2022, is it more profitable to switch to growing corn following soybeans in the field or to stay with growing corn following corn?

The estimated net benefit for switching for 2022 is $75.75/ ac, so it is more profitable to switch to corn following soybeans.

c) (2 pts) Based on your results, what is the average net benefit in $ per acre across both years for switching to a corn-soybean rotation in the field versus continuing to grow corn following corn? **Briefly** explain whether you would or would not recommend switching to the corn-soybean rotation for a farmer wanting to maximize the average net benefit over both years.

Over the two years, the average net benefit is (–$7.50 + $75.75)/2 = $68.25/2 = $34.13/ac. If the goal is to maximize the average net benefit over both years, the gains are larger from switching to the corn-soybean rotation than with staying with a continuous corn rotation. The small losses for 2021 are more than made up for in the large gains in 2022 so that over both years, the farmer is better off switching.

d) (4 pts) The numbers used for this problem are adapted from Iowa State University crop budgets (https://www.extension.iastate.edu/agdm/crops/html/a1-20.html) presented in class. As discussed in recorded presentations and class lectures, give one reason why costs of production are lower and one reason why yields are higher for corn following soybeans compared to corn following corn?

On the cost side, the budgets show that the corn following corn has higher costs mostly due to needing to use more nitrogen fertilizer and having to use an insecticide compared to the corn following soybeans does not have. The other cost differences are smaller and largely due to having a large yield for corn following soybean (more grain to haul and dry, removing more phosphate and potash in the grain, etc.). Why yield is larger is due to less insect and disease pressure in rotated systems – the insect and disease life cycles are broken up, such as for corn rootworm, the number one corn pest.

5) (9 pts.) Chicks starting at 8 oz fed the following corn and soybean meal rations gain 40 oz and are ready to sell as broilers in 12 weeks.

Ground Corn (lbs) (**Y**)	Soybean Meal (lbs) (**X**)	Marginal Rate of Technical Substitution
2.0	7.9	---
3.2	5.5	0.5
5.2	3.9	1.25
7.4	3.1	2.75

a) (3 pts) Using numbers from this table, show in the space below how to calculate the Marginal Rate of Technical Substitution between ground corn and soybean meal for the second row in the table and then fill in the missing entries in the table above. Round the MRTS to the nearest thousandth (3 places to the right of the decimal).

MRTS = $-\Delta Y/\Delta X$
Do it one of these two ways, depending on if Corn is X or Y
If Corn = Y: MRTS = –(3.2 – 2.0)/(5.5 – 7.9) = 1.2/2.4 = 0.5

(If Corn = X: MRTS = –(5.5 – 7.9)/(3.2 – 2.0) = 2.4/1.2 = 2.0)

b) (3 pts) If ground corn costs $0.08/lb and soybean meal costs $0.16/lb, what is the profit maximizing amount of each to feed? Note, you may need to interpolate between entries. Round the optimal amounts to the nearest tenth of a pound (1 place to the right of the decimal).

MRTS = $-\Delta Y/\Delta X$ = price ratio r_x/r_y, or price of soybean meal divided by price of ground corn = 0.16 / 0.08 = 2.0

Corn	Soy	MRTS
5.2	3.9	1.25
		2.0
7.4	3.1	2.75

Corn = 5.2 + (2.0 – 1.25) x (7.4 – 5.2)/(2.75 – 1.25)
= 5.2 + 0.75 x (2.2/1.5) = **6.3**

Soy = 3.9 + (2.0 – 1.25) x (3.1 – 3.9)/(2.75 – 1.25)
= 3.9 – 0.75 x (0.8/1.5) = **3.5**

6) (20 pts.) Corn yield as a function of the nitrogen fertilizer rate is $Q = 165 + 0.9N - 0.003N^2$, where yield Q is total bushels of corn per acre and the nitrogen application rate N is in pounds of N per acre. The corn price is $3 per bushel. You have two options for nitrogen fertilizer: 1) urea that is 45% N and sold for $360 per ton and urea-ammonium nitrate (UAN) that is 32% N and sold for $300 per ton.

a) (2 pts) What are the prices in <u>$ per pound of nitrogen</u> for the urea and UAN fertilizers? Which is the lower cost source for nitrogen?

Urea: $\frac{\$360}{1 \text{ ton of Fert.}} x \frac{1 \text{ ton of Fert.}}{2{,}000 \text{ pounds of Fert.}} x \frac{1 \text{ pound of Fert.}}{0.45 \text{ pounds of N}} = \frac{\$0.40}{1 \text{ pound of N}}$

UAN: $\frac{\$300}{1 \text{ ton of Fert.}} x \frac{1 \text{ ton of Fert.}}{2{,}000 \text{ pounds of Fert.}} x \frac{1 \text{ pound of Fert.}}{0.32 \text{ pounds of N}} = \frac{\$0.46875}{1 \text{ pound of N}} \frac{\$0.47}{1 \text{ pound of N}}$

Urea is the lowest corn source of nitrogen

b) (10 pts) Using the price for lowest cost nitrogen source you identified in part a, what is the economically optimal nitrogen rate for corn? Set up and solve this economic problem using calculus and the given information. Check the second order condition. Round to four digits to the right of the decimal while doing algebra and then round your final answer to the nearest tenth of a pound per acre.

Set up: $\pi(N) = 3(165 + 0.9N - 0.003N^2) - 0.4N$

FOC: $d\pi/dN = 3(0.9 - 0.006N) - 0.4 = 0$

Solve FOC:
$3(0.9 - 0.006N) = 0.4$
$0.9 - 0.006N = 0.4/3 = 0.1333$
$0.9 - 0.1333 = 0.7667 = 0.006N$
$N = 0.7667 / 0.006 = 127.7833 = 127.8$ pounds of N pe racre

SOC: $d^2\pi/dN^2 = 3(-0.006) = -0.018 < 0$ passes SOC for maximum

c) (2pts) At the nitrogen rate you derived in part b, what is the corn yield in bushels per acre?
$Q = 165 + 0.9N - 0.003N^2 = 165 + 0.9(127.8)N - 0.003(127.8)^2 = 231.0$ bushels per acre

d) (2 pts) Besides the cost of nitrogen, other costs are $650/acre. What are net returns ($ per acre)?
$\pi(N) = 3(231) - 0.4N - 650 = -0.4N - 650 = 693 - 0.4(127.8) - 6510 = -\$8.12$/ac

e) (4 pts) You should have gotten a negative value in part d. Data show that farmers commonly go through times when they earn below average returns for their work and assets (land). Based on class discussion and materials, briefly list/describe <u>three</u> things a farmer can do to improve profits in times of low margins?
Multiple options are possible:

- Optimize variable input costs: fertilizer, herbicide, seed, …
- Outsource activities that others can do at lower cost (partial budget analysis)
- Sell machinery, keep older machinery, share machinery, do custom work
- Use yield monitors to find unprofitable parts of fields and stop farming them
- Reduce operating loan by switching to crops with lower per acre costs: soybean, wheat…
- Negotiate lower land rents, or shift to flex leases
- Develop a marketing plan
- Accept below normal returns to survive for future profits
- Add to off-farm income to cover family expenses
- Refinance operating loan or rolling line of credit back into the farm mortgage

7) (7 pts.) *Based on material covered in class*, are these True or False? Mark your answer.

a) T___ F_X_ The hypoxic (dead) zone in the Gulf of Mexico caused by Midwestern nutrient pollution is fairly unique and rarely seen elsewhere in the world.

b) T___ F_X_ In Wisconsin, private well contamination by nitrates typically only occurs in the few wells near large animal feeding operations.

c) T___ F_X_ Wisconsin law regulates how much fertilizer a farmer can apply and when it can be applied.

d) T_X_ F___ Wisconsin Nutrient Management Plans are strategies to help farmers maximize their returns from nutrients while protecting water quality.

e) (3 pts) Cover crops came up in this course in our discussion around Nitrogen in Agriculture and in Problem Set #1. Write a brief paragraph that a) explains what a cover crop is, b) examples of what types of crops are used as cover crops in the Midwest and c) the types of benefits that cover crops generate.

a) Wikipedia states that "*cover crops are plants that are planted to cover the soil rather than for the purpose of being harvested*" which is fairly accurate: soil cover and generally not for direct harvest, though in many places they are used sometimes for forage (grazed or chopped) when needed. Problem Set #1 had links to cover crop resources, including this SARE page: https://www.sare.org/resources/cover-crops/. This web page states that "*A cover crop is a plant that is used primarily to slow erosion, improve soil health, enhance water availability, smother weeds, help control pests and diseases, increase biodiversity and bring a host of other benefits to your farm*," which again focuses on the function of the crop and its benefits.

b) The SARE page also has several examples of cover crops under legume (red clover, crimson clover, vetch, peas, beans) and non-legume: cereals (rye, wheat, barley, oats, triticale), forage grasses (annual ryegrass) and broadleaf species (buckwheat, mustards and brassicas, including the forage radish), plus a link to more resource lists. Literally almost any crop can a cover crop, if manage appropriately (for soil cover and non-harvest). During the 2019 wet spring with lot of prevented pant acres, I helped facilitate having corn and soybeans declared as cover crops for WI farmers: https://aae.wisc.edu/pdmitchell/wp-content/uploads/sites/15/2019/09/Corn-or-Soy-as-Cover-Crop-Update.pdf.

c) The SARE definition in part a explains many of the standard cover crop benefits: "*A cover crop is a plant that is used primarily to slow erosion, improve soil health, enhance water availability, smother weeds, help control pests and diseases, increase biodiversity and bring a host of other benefits to your farm*" to which several note increased crop yields in the long-term.

8) (22 pts.) Corn yield is $Y = 70 + 3N - 0.05N^2 + 2K - 0.3K^2 + 0.2NK$, where Y is corn yield as bushels per acre, N is pounds of nitrogen fertilizer per acre and K is pounds of potassium per acre. The corn price is \$3 per bushel, the price of nitrogen fertilizer is \$0.4 per pound, and the price of potassium fertilizer is \$0.3 per pound.

a) (15 pts) What is the profit maximizing amount of nitrogen (N) and potassium (K) to use per acre to grow corn (Y)? You do not need to convert prices to set up the profit function. Round to four digits to the right of the decimal while doing algebra and then round your final answer to the nearest tenth of a pound per acre. Be sure to check the second order conditions.

Set up: $\pi = 3(70 + 3N - 0.05N^2 + 2K - 0.3K^2 + 0.2NK) - 0.4N - 0.3K$

FOCs:
$d\pi/dN = 3(3 - 0.1N + 0.2K) - 0.4 = 0$
$d\pi/dK = 3(2 - 0.6K + 0.2N) - 0.3 = 0$

Solve FOCs:

$3(3 - 0.1N + 0.2K) = 0.4$ — There are multiple solution paths.
$3 - 0.1N + 0.2K = 0.4/3 - 0.1333$ — This is one way to solve it.
$3 - 0.1333 + 0.2K = 0.1N$
$2.8667 + 0.2K = 0.1N$
$N = 28.667 + 2K$ — Substitute this into the 2nd FOC

$3(2 - 0.6K + 0.2N) = 0.3$ — First simplify the 2nd FOC
$2 - 0.6K + 0.2N = 0.1$
$2 - 0.6K + 0.2(28.667 + 2K) = 0.1$
$2 - 0.6K + 5.7334 + 0.4K = 0.1$
$7.6334 - 0.2K = 0$
$7.6334 = 0.2K$
$K = 7.6334/0.2 =$ **38.167 = 38.2**

$N = 28.667 + 2K$
$N = 28.667 + 2(38.167) =$ **105.0**
Alternative rounding: $N = 28.667 + 2(38.2) = 105.067 =$ **105.1**

SOC:
$d^2\pi/dN^2 = 3(-0.1) = -0.3 < 0$ passes
$d^2\pi/K^2 = 3(-0.6) = -1.8 < 0$ passes
$d^2\pi/dNdK = 3(+0.2) = 0.6$
$(-0.3)(-1.8) - (-0.6)^2 = 0.54 - 0.36 = 0.18 > 0$ passes

b) (2 pts) At these optimal N and K rates in part a, what is corn yield?

$Y = 70 + 3N - 0.05N^2 + 2K - 0.3K^2 + 0.2NK$
$Y = 70 + 3(105) - 0.05(105)^2 + 2(38.2) - 0.3(38.2)^2 + 0.2(105)(38.2) = 274.578 =$ **274.6**

If use N = 105.1, you get the same answer once round: Y = 274.5915 = 274.6

c) (2 pts) Suppose you do not trust your calculus and decided to put a little more on and increase your application rates in part a by 10%. Multiply your answers in part a for N and K by 1.1 to increase them by 10%. What would corn yield be if you used these 10% higher N and K rates? Your answer should be far less than a 1 bu/ac difference from the yield on part b and not a detectable difference for farms; the crop would look fine in either case.

N = 1.1 x 105.0 = **115.5** (= **115.6** if use 105.1)
K = 1.1 x 38.2 = **42.0**

$Y = 70 + 3N - 0.05N^2 + 2K - 0.3K^2 + 0.2NK$
$Y = 70 + 3(115.5) - 0.05(115.5)^2 + 2(42) - 0.3(42)^2 + 0.2(115.5)(42) = 274.4875 =$ **274.5**

If use N = 115.6, you get the same answer once round:
$Y = 70 + 3(115.6) - 0.05(115.6)^2 + 2(42) - 0.3(42)^2 + 0.2(115.5)(42) = 274.472 =$ **274.5**

d) (3 pts) Suppose instead you reduced your N and K application rates by 10-20% to save money and reduce losses to surface and groundwater. What are the classic visually apparent symptoms of a corn crop that is deficient in Nitrogen? What about deficient in Potassium?

Based on "The More-On Principle" lecture, the classic nitrogen deficiency symptoms for corn are yellowing of the leaves, especially at the tips and up the **center rib** of the leaf. Potassium deficiency in corn is also yellowing, but on the **edges** and tips of the corn leaves. I have pasted an image showing the classic N and K deficiency patterns for corn leaves.