AGEC 641 Spring 2023
MID-TERM EXAMINATION

Answer 5 of the first 6 questions. Take the other question home along with question #7 and turn them in on Saturday, March 11, 2023, by 5 pm by emailing
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1. (10 points) Suppose you are approached by an individual who has set up and solved an LP of a producer in a country where the work was done in $ and now needs the answer in another currency.
   The individual proposes to do one of two things:
   Procedure A. Multiply the solution information for the objective function, decision variables, shadow prices and reduced costs by the exchange rate and report those results as the answer (making no modification to the model).
   Procedure B. Multiply the objective function coefficients by the exchange rate and solve the modified model then use the consequent solution as the regional answer.
   Using the properties of an LP solution what is the effect of procedure A on the resultant solution information for the problem and would it yield the same results as would the solution under procedure B?

2. (10 points) Suppose you have the problem

$$\begin{array}{llll} \max\ (50\text{-}X)\,X & & -\,2Y & \\ & X & -(10\text{-}Y)Y & \leq 0 \\ & X & & \leq 50 \\ & X, & Y & \geq 0 \end{array}$$

   Set up an LP approximation ranging from X between 20 and 28, and Y between 0 and 8.

3. (10 points) Given the problem

$$\begin{array}{lrcrcl} \text{Min} & 3\,x1 & + & 2\,x2 & & \\ \text{s.t.} & x1 & + & 3\,x2 & \leq & 10 \\ & 2\,x1 & + & x2 & \geq & 4 \\ & x1 & - & x2 & = & 1 \\ & x1 & & & \geq & 0 \end{array}$$

   write its dual

4. (12 points) The word reduced cost is commonly used in the context of linear programming.
   (a) What is the definition of the term?
   (b) What is mathematical expression for determining the reduced cost?
   (c) Discuss the relationship between reduced costs for basic variables and the value of the optimal shadow prices.
5. (8 points) In the GAMS code below, a simple resource allocation question, please identify the errors in the bonded lines. The errors are not limited to syntax errors. Note, there are no problems with the numbers.

```
set    process       types of production processes   /x1,x2,x3/
```

```
       resource      types of resources                    /constrain1,constrain2/
;
parameter
       price(process)        product prices by process /x1 3,x2 2,x3 0.5/
       prodcost(process)     cost by process           /x1 0 ,x2 0, x3 0/
       resoravail(resource)  resource availability     /constrain1 10 ,constrain2 3/
;
table resouruse(resource,process) resource usage
                         x1       x2       x3
        constrain1        1        1        1
        constrain2        1       -1
;
positive variables   production(process) items produced by process;
variables            profit                          totalprofit;
equations           objt                             objective function (profit)
                          available(resource)     resources available;

objt.. profit=L=sum(process,(price(process)-prodcost(process))*production(process)) ;
available(resource).. sum(resource, resouruse(resource,process)*production(process))  =g=
                                  resoravail(resource);

model resalloc /objt,available/;
solve resalloc using lp max profit;
```

The list file gives the following error report

```
  19  objt.. profit=L=sum(process,(price(process)-prodcost(process))*production(process)) ;
  20  available(resource).. sum(resource, resouruse(resource,process)*production(process))
=g=
****                                    $125                        $149                $149
**** 125  Set is under control already
**** 149  Uncontrolled set entered as constant
  21                                    resoravail(resource);
  22
  23  model resalloc /objt,available/;
  24  solve resalloc using lp max profit;
****                                    $257
**** 257  Solve statement not checked because of previous errors

**** 4 ERROR(S)   0 WARNING(S)
```

6. (18 points) Develop a general formulation of a problem where a profit maximizing firm can manufacture N types of goods via a joint production process with K different processing alternatives at R different locations drawing upon firm purchase of F different purchased and use of Z fixed inputs which have maximum availabilities. Assume these products are sold to G customers that have three steps demand curve with limited prices can be sold for the two sets of higher prices and can receive products from any of the R locations where the cost of moving the goods between R and G is fixed per unit.

7. (32 points) Fred's integrated farm produces corn, soybeans and pigs. Fred wishes to know how much of each of these to grow. Technical data follows

Fred can plow for corn or soybeans (assume the same process for both) in either March, April, May June, October, November, and December. Plowing is done at 3 acres per hour with 1.1 people and 1 tractor.
Planting corn is in April or May with harvesting in October or November. Soybeans are planted in May or June with harvesting in September or October. Data are

	Acres/hour	Workers/hour	Tractors/hour	Fuel Cost	Input Cost

				per hour	(seeds, etc.)
Corn Planting	5	1.1	1	3	140
Corn Harvest	2	2.2	0.5	6	
Soybean Planting	5	1.1	1	3	120
Soybean Harvest	4	2.2	0.5	3	

The yield in bushels if planting soybeans after soybeans and corn after corn are

		Corn		Soybeans	
		Month of Planting		Month of Planting	
		April	May	May	June
Harvest Month	October	150	130	45	50
	November	140	135	50	60

If Fred plants corn after soybeans, the yield of corn can increase by 10%. If Fred plants soybeans after corn, the input cost of soybeans increases by 10%.

In addition to corn and soybeans, Fred also has pigs. Fred runs a continuous production system in which he buys sows (mature females) in the months Jan. and July. He uses sows for 3 to 4 pregnancy cycles. The sows have two pregnancy cycles per year. The first cycle is in May and birth yields 8 live pigs. The second cycle is in October with 7 live pigs born. The sow can be sold one month after the last birth month in the year depending on how long the sow will be kept (3-4 cycles in total). Baby Pigs are kept 4 months after birth and are then sold. Resource usage per month for labor, cost, feed and soybean meals by month follows:

	Labor hrs /animal	Cost incurred /animal	Feed (lb) /animal	Soybean Meal (lb) /animal
Sows				
Month of birth	0.5	2	250	100
Month of purchase	0.3	100	300	
Other months	0.1	1	300	
Month of sale	0.4	50	300	
Baby pigs				
Month 1	0.2	6	30	
Month 2	0.1	5	60	
Month 3	0.1	5	90	
Month 4	0.3	5	120	

Sows are sold for $100 after 3 cycles, and $90 after 4 cycles.
Pigs are sold for $75.
Sow and Pig feed is made up out of corn and soybeans which are either farm grown or purchased. One pound of feed must have 3 unit of calories and 1 unit of protein. Corn has 20 units of protein, and 200 units of calories per bushel. Soybeans has 100 units of protein, and 150 units of calories per bushel. 1 bushel of corn weighs 56 lbs., and 1 bushel of soybeans weighs 60 lbs.
Soybeans can also be crushed to 46 lbs of soybean meals and 14 lbs of soybean oil per bushel. The cost of the soybean crushed is $0.5 per bushel of soybean. No cost needed for mix feed.

Limited by the cost of leasing machine and labor, the farm decides to only crush soybeans and make feed in December.

The farm must store the feed and have storage large enough to supply all needs. Storage costs $.10 per bushel per month for corn and soybeans and $0.01 per pound for feed and soybean meal. The soybean oil cannot be stored and needs to be sold once made.
The farm can sell soybean at $8/bu, corn at $4/bu, soybean meal at $0.1/lb, and soybean oil at $0.3/lb in December only. The prices of corn, and soybean will be 10% higher if purchased from the market. And the farm can only purchase corn, and soybeans in May and August.

The farm has 600 acres, 1 tractor and 3 workers who work 10 hours per day, 20 days per month year-round.

Formulate an equilibrium profit maximizing LP for this problem to determine acreage by crop, sows to buy, the number of cycles to keep the sows, the feed mix and the required storage.