NAME:__________________________________

**Question #1 – Optimal Allocation of Land (16.67 points)**

Identify three factors that can produce an increase in the bid rent function for agriculture. In addition, explain why the slope of the bid rent function is negative. Finally, use the following bid rent functions to identify the optimal allocation of land: $X_{RD}=80-C$, $X_{AG}=60-0.6C$ and $X_{WD}=5-0.016C$, where RD denotes residential development, AG represents agricultural activities and WD is wilderness. Depict the bid rent functions and calculate the range for which a landowner decides to (1) construct a residential development, (2) dedicate her land to agricultural activities and (3) keep the land in its natural state.

1) Domestic population growth increases the domestic demand for food
2) Opening of exports markets for agriculture that increase the foreign demand for local crops
3) New planting or harvesting technologies that lower the cost and increase the profitability of farming
4) Lower agricultural transport costs

The slope of the bid rent function is downward sloping because the costs of transporting both goods and people lowers net benefits per acre more for distant locations.

![Graph showing bid rent functions](image)

$X_{RD}=X_{AG}$

80-C=60-0.6C

20=0.4C

C=50

Hence from [0-50] the landowner will decide to construct a residential development.

$X_{AG}=X_{WD}$

60-0.6C =5-0.016C

55=0.584C

C=94.18

Hence from (50-94.18] the landowner will decide to develop agricultural activities.

and from (94.18-312.5] the landowner will keep her land in its natural state.
Question #2 - Variable Charge Rate Structures (16.66 points)

Compare the Uniform Rate Structure versus the Inverted Block Rate Structure. Identify the main differences and discuss why the inverted block rate structure is an efficient price system. Use a graph to describe each charge structure.

Uniform Rate:
- The cost per unit of consumption does not increase or decrease with additional units of consumption
- From a scarcity point of view is the worst possible form of pricing
- The marginal cost of additional water is zero
- No incentives to conserve. It is an inefficient price system

![Uniform Rate Graph](image1)

Inverted Block Rate:
- The cost increases with additional units of consumption
- Efficient price system since promotes water conservation by ensuring that the MC of consuming additional water is high
- Incentives to conserve
- Fair

![Inverted Block Rate Graph](image2)
Question #3 – Single Rotation versus Infinite Rotation (16.66 points)
Discuss the main differences between the single rotation model and the infinite rotation model. In addition, explain how the optimal rotation time is affected when there is a change in the interest rate, \( i \), in the planting cost, \( k \), and in the net price, \( p \).

**Single rotation**
It does not allow re-plantation. The optimal rotation period that maximizes the present value of profits occurs when:

\[
i = \frac{p \times dS_T}{p \times S_T}
\]

The present value of profits is maximized when the rate of growth of the net value of the resource stock is equal to the private discount rate.

**Infinite rotations**
It allows re-plantation. The optimal rotation period that maximizes the present value of profits occurs when:

\[
i + \frac{it}{p \times S_T} = \frac{p \times dS_T}{p \times S_T}
\]

Where \( i + \frac{it}{p \times S_T} \) is the rate of interest that could be earned on the capital tied up in the growing timber plus the interest that could be earned on the capital tied up in the site value of the land.

<table>
<thead>
<tr>
<th>Change in Optima Rotation Time</th>
<th>( i )</th>
<th>( k )</th>
<th>( p = P - c )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( dT/di &lt; 0 )</td>
<td></td>
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<tr>
<td>( dT/dk &gt; 0 )</td>
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<td></td>
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<tr>
<td>( dT/dp &lt; 0 )</td>
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\( dT/di < 0 \) means that the interest rate and the optimal rotation period are negatively related.

\( dT/dk > 0 \) means that the planting cost and the optimal rotation period are positively related.

\( dT/dp < 0 \) means that the net price and the optimal rotation period are negatively related.
Regulation of the natural gas industry in the United States has historically been a tumultuous ride, resulting in dramatic changes in the industry over the past 30 or more years. In November of 1978, at the peak of the natural gas supply shortages, Congress enacted legislation known as the Natural Gas Policy Act (NGPA), as part of broader legislation known as the National Energy Act (NEA). Realizing that those price controls that had been put in place to protect consumers from potential monopoly pricing had now come full circle to hurt consumers in the form of natural gas shortages, the federal government sought through the NGPA to revise the federal regulation of the sale of natural gas. Assume that the demand and supply for natural gas are $P_d=50-0.85q$ and $P_s=2+0.15q$, respectively. Before the NGPA was enacted the government had a price control policy equal to $3 per barrel. Analyze how this price control affects the consumer surplus (Use a graph to represent your results). Finally, assume that the firm is able to adjust its cost structure and, hence, the new supply is $P^*_s=0.0542q$. Identify the new quantity demanded and consumer surplus. Discuss the effects of the price control policy on the consumer surplus in the short and long run when the firm is able to adjust its cost structure.

Assume that the demand and supply for natural gas are $P_d=50-0.85q$ and $P_s=2+0.15q$ respectively. Before the NGPA was enacted the government had a price control policy equal to $3 per barrel. Analyze how this price control affects the consumer surplus (Use a graph to represent your results).

Equilibrium without Price Control:

Supply=Demand

$50-0.85q=2+0.15q$

$q=48$ and $P=50-0.85\times48=9.2$

Equilibrium with Price Control:

$2+0.15q=3$

Quantity supplied is $q_s=6.67$ and the price consumers are willing to pay is $P=50-0.85\times6.67=44.33$. Note that the quantity demanded when $P=3$ is $q_d=55.29$. Therefore there is a shortage of $(55.29-6.67)\ 48.62$ barrels.

Graphically:
CS (without PC): (50-9.2)x48/2=979.2

CS(with PC): (50-44.33)*6.67/2 + (44.33-3)*6.67=18.91+275.67=294.58

Hence a price control reduces the consumer surplus.

Finally, assume that the firm is able to adjust its cost structure and the new supply is \( P^* = 0.0542q \). Identify the new quantity demanded and consumer surplus. Discuss the effects of the price control policy on the Consumer Surplus in the short and long run when the firm is able to adjust its cost structure.

New Equilibrium with Price Control:

\[
0.0542q = 3
\]

\[
q = 55.29
\]

Quantity supplied is \( q_s = 55.35 \) and the price consumers are willing to pay is \( P = 3 \). Therefore there is no shortage when the firm adjusts its cost structure.

Graphically:

Note that consumer surplus is higher when the firm adjust is production process and is able to produced the entire quantity demanded when the price is $3.

In the short run consumers will be better-off when the firm adjusts its cost structure. However, natural gas is a Depletable resource and every period will be more expensive to extract this Depletable resource, hence the supply curve will shift upward, as a consequence the CS decreases on the long run.
Question #5 – Virgin Ore versus Recycled Materials (16.67 points)
Assume that a good can be produced using virgin ore at a marginal cost given by $MC_1 = 0.7q_1$ or it can be produced with recycled materials at a marginal cost given by $MC_2 = 10 + 0.2q_2$.

a) If the inverse demand curve is given by $P = 15 - 0.4(q_1 + q_2)$, how many units of the product would be produced with virgin ore and how many units with recycled materials?
b) If the inverse demand curve is $P = 30 - 0.4(q_1 + q_2)$, what would your answer be?
c) Illustrate your answer on a clearly labeled graph.

a) $0.7q_1 = 15 - 0.4q_1$
   $1.1q_1 = 15$
   $q_1 = 13.63$

$10 + 0.2q_2 = 15 - 0.4q_2$
$0.6q_2 = 5$
$q_2 = 8.3$

b) $0.7q_1 = 30 - 0.4q_1$
   $1.1q_1 = 15$
   $q_1 = 27.27$

$10 + 0.2q_2 = 30 - 0.4q_2$
$0.6q_2 = 20$
$q_2 = 33.33$
Question #6 – Population (16.67 points)
As in any market with a negative externality, reducing demand (the marginal benefits of children) or raising the marginal costs of children can move the equilibrium toward the economically efficient number of children. Identify three factors that might increase the marginal cost of children (an upward shift of the marginal cost) and three factors that might decrease the marginal benefits of children (a downward shift of the marginal benefit).

Marginal Costs:
1. One of the main components of the cost of children is the opportunity cost of the mother’s time
2. As societies urbanize and industrialize, housing space becomes more expensive due to concentrated demands in specific locations.
3. The cost of education

Marginal Benefits:
1. The shift from agriculture to an industrialized economy reduces the productivity of children.
2. A decrease in infant mortality/
3. If woman’s status is no longer defined by the number of children, the MB may decrease.
4. When alternative means of providing for old-age security are developed. The MB from additional children decreases.