PLEASE READ THIS: Write your name and student ID on your bluebook. Each question should start on a new page and please mark clearly the question number. Try to answer all questions within the time limit. (There are 100 points in total.) You should always show your work when calculations are involved. Please take two minutes at the beginning of the exam to have a quick look at all the questions. Good luck!

A. True or False? Explain why in one to two sentences. And do not forget to correct the statement the way it should be if you say it is false.
[4 points each. Total: 20 points.]

1. Emission permits for nitrogen and sulfur oxides can be traded on a one-to-one basis without risk for hot spots occurring.

2. Social welfare is higher under a monopoly compared to a competitive market when the production of a private good entails a positive externality.

3. When the slope of the marginal environmental damage curve is relatively steeper than the slope of the marginal abatement cost curve, a quantity-based instrument will yield a smaller welfare loss when misjudging the marginal abatement cost curve than a price-based instrument.

4. A price-discriminating monopolist will provide the optimal level of an excludable public good.

5. The term for allowing new or expanding sources to start operations in a non-attainment area provided they acquire sufficient emission reduction credits from existing sources is netting.

B. Short question: please answer using not more than 5-6 sentences.
[20 points]

1. Polluters generally prefer command-and-control standards to economic incentives. Why? (Hint: draw a graph and discuss the intuition.)
C. Numerical problem solving  
[30 points each. Total: 60 points]

1. (Heterogeneity in abatement costs)  
[30 points]

Around a small lake there are several sources that let nitrate into the water: a wastewater treatment plant for the nearby city, and 10 dairy farms. The marginal abatement cost curves in USD for reducing nitrate emissions into water are:

The wastewater treatment plant: $50 + 50X$
Each dairy farm: $12X$

where $X=$ tons of nitrate reduction and we assume that each dairy farm has identical marginal costs of nitrate abatement.

The regional environmental protection agency has set a goal of reducing the nitrate concentration in the lake, and has issued an order to reduce nitrate emissions by 100 tons at the wastewater treatment plant. The dairy farms have strong lobbying power and have not been allocated any reduction target.

a) What is a point and non-point source in this context?

b) When comparing marginal abatement costs across sources, explain which is the most efficient in nitrate emissions reduction? (Draw a graph to explain if you’d like.)

c) Write down the condition for cost-effective abatement (put in the numbers that apply for this problem).

d) Solve for the cost-effective levels of abatement at each source. (Hint: in addition to the equation you’ve written in c) you need another equation to solve for it and it involves the overall abatement level.)

e) Now assume the regional EPA allows point/non-point source emission trading. This means that a point source may pay for emission reductions at non-point sources and count that towards its emission reduction goal. Assuming zero transaction costs, which sources would sell emission reductions and which buy? And how many tons would be exchanged in each transaction? (The overall emission reduction target remains 100 tons.)

f) What are the total cost savings from allowing trading?
2. (Technological change)  
[30 points]

Junior’s car is getting old and he’s thinking about replacing it. He asks for your advice as an economist. Junior likes his car and does not want to change brand or type of car but is simply considering whether to invest in the latest year model. His old car has a mileage of 24 miles per gallon (MPG) and the current year model of the same brand gets 40 miles per gallon. You can summarize the information in the following table:

<table>
<thead>
<tr>
<th></th>
<th>Old gas guzzler</th>
<th>The current year’s model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miles per gallon (h_i)</td>
<td>24</td>
<td>40</td>
</tr>
<tr>
<td>Yearly maintenance and insurance fees</td>
<td>$1000</td>
<td>$1000</td>
</tr>
<tr>
<td>Capital investment (annualized)</td>
<td>0</td>
<td>$3000</td>
</tr>
</tbody>
</table>

You also know the following: the gasoline price is $2 per gallon, Junior’s average speed is 60 miles per hour, and he values his time at $15 an hour. Junior has no necessity trips to make and his utility from driving is $u = 100\sqrt{m}$ where m=miles driven in one year. Assume that Junior decides to change car if the net benefit from doing so in the first year is positive.

a) The objective function that Junior should maximize is the following:

\[
\frac{100\sqrt{a_i h_i}}{A} - \left( \frac{2}{h_i} + \frac{15}{60} \right) a_i h_i - K_j
\]

Match each of the above terms with its economic explanation. Choose from the list below:

1) fixed capital investment cost
2) utility from driving
3) variable cost of driving per mile ($/mile)
4) miles driven (mileage)

b) Calculate the actual gas consumption (a) and mileage (m) to Junior when driving with the old gas guzzler and with the new car. Summarize the calculations in the following format:

<table>
<thead>
<tr>
<th></th>
<th>a_0=</th>
<th>a_1=</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline purchases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mileage (e_i=m_i)</td>
<td>m_0=</td>
<td>m_1=</td>
</tr>
</tbody>
</table>

c) Is there a rebound effect or not in the miles driven? Why, why not?
d) Calculate the net private benefits to Junior of 1) driving the old gas guzzler, and 2) driving the new car.

NPB₀ =
NPB₁ =
Will he change car?

e) What if the government introduces a policy to buy up old gas guzzlers in order to accelerate technological change: How much would they have to offer for Junior to hand in his car and buy the new one instead?

f) Junior lives and drives in the desert, so you can assume that the only pollution government is concerned about are the CO₂ emissions he’s creating by driving a car.

Let’s say the emissions function for CO₂ is \( z_i = \frac{(100 - h_i)}{100} * 3.6 * a_i \) (measured in pounds, lb). What shadow value of CO₂ emissions is implied by the technology subsidy that you calculated in e)? That is, calculate the minimum value per lb of CO₂ emissions that would justify the car scrapping subsidy. Hint: Use the values of \( a_0 \) and \( a_1 \) calculated in b) to get \( z_0 \) and \( z_1 \) (there is no need to redo the maximization problem).