SUID:

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Exam 3
Spring 2016

DO NOT OPEN THIS EXAM UNTIL YOU ARE TOLD TO DO SO.

Instructions

1. Write your SUID in the upper right corner of this exam. Do NOT write your name.

2. SHOW ALL YOUR WORK. Answers without supporting work will receive little or no credit.

3. There are 120 points on the exam and you'll have 180 minutes to complete it. Be sure to budget your time accordingly.

4. Some questions provide a blank table you can use to organize your calculations. Be sure to label the columns clearly. Where applicable, show the equation for the column in the bottom row of the table. The tables may have more rows or columns than you need.

5. Do all your work on the exam. If you need extra space, write on the backs of the pages. However, if you do write an answer on the back of a page, *be sure you've noted that near the question*.

6. Some helpful PV formulas:

$$PV = \frac{B_t}{(1+r)^t} \qquad\qquad PV = \frac{B}{r}$$

Question 1 (15 points)

A city with aging infrastructure wants to reduce the number of times each year that storm water causes its sewer system to overflow and release raw sewage into a nearby lake. The overflows violate water quality standards and the city is being fined $1 million per year. It is considering two options. The conventional approach ("C") would be to upgrade the wastewater treatment plant. That would cost $2 million per year and take 5 years (years 1-5). In year 6, the fines would cease. A new unconventional approach ("U") would be to change land use around the city to cause storm water to filter into the soil rather than ending up in the sewer system (an approach known as "green infrastructure"). It would cost $500,000 per year but take 20 years (years 1-20). In year 21, the fines would cease. In addition, the changes would make the city more attractive and produce an additional benefit of $1 million per year starting in year 21.

Please calculate the net present value of each plan and indicate which one is best. The city uses an interest of 5% in present value calculations.

Question 2 (15 points)

A growing coastal community that gets its water from wells is concerned that rising sea levels will cause salt water to contaminate its water supply (a problem known as "salt water intrusion"). However, contamination is not certain: it depends on features of local geology that aren't completely understood. The chance of contamination ("C") is believed to be 25%; otherwise there will be no contamination ("N"). The community is evaluating two options, "S" and "L". Option S would be a small project focused on contamination and L would be a larger general purpose upgrade. Information about the options is given in the table below.

Option	Cost	Benefit in C	Benefit in N
S	$4 million	$20 million	$8 million
L	$12 million	$8 million	$20 million

In addition, an engineering company could analyze the local geology for $1 million. The study would determine for certain whether or not contamination will occur. The test could be carried out before the community would need to decide whether to do S or L.

Please determine the community's best plan of action. You may assume it wants to choose the approach with the highest expected value. Also, please note that this problem only involves one time period and no present value calculations are needed.

Question 3 (15 points)

A large city would like to upgrade its downtown streets. It is considering two options: a conventional ("C") upgrade and an alternative ("A") that would be designed to be more suitable than C for self-driving cars. However, there are no self-driving cars in the city now and no one is sure there will be any in the future. To keep things simple, suppose that everyone agrees that the prospects for self-driving cars will become clear in year 5, and that there is a 20% chance they will work well and be adopted starting in year 6 (state "S"); otherwise, normal cars will continue to be used (state "N"). Both C and A would take 5 years to construct (years 1-5) and would produce benefits starting in year 6. The city could also wait for 5 years until it's known whether S or N will occur and then proceed with the upgrade (everything would be delayed by 5 years: construction would occur in years 6-10 and benefits would start in 11). The annual construction costs and benefits are given below:

Option	Construction Cost	Benefit in S	Benefit in N
C	$25 million/year	$20 million/year	$20 million/year
A	$50 million/year	$60 million/year	$10 million/year

Please determine what the city should do. You may assume that it uses a 5% interest rate in present value calculations and wants to pick the option with the highest expected net present value.

Question 4 (15 points)

Errors in medical care are the third largest cause of death in the United States after heart disease and cancer. One action that could help would be improved record keeping in hospitals. Suppose that the government is considering giving $1 billion in grants to hospitals to upgrade record keeping technology (in year 0). However, it is not clear how much the upgrade will help. There is a 70% change it will be highly helpful ("H") and would provide $100 million in benefits each year forever starting in year 1. However, there is a 30% change it would only be moderately helpful ("M") and produce $20 million in benefits each year. However, a trial of the system could be run for $100 million that would indicate for sure whether H or M would occur. To keep things simple you may assume the results would be available in year 0 before the decision must be made on the grant program. Finally, any money spent on the project would need to be raised via a tax that creates $0.25 of deadweight loss for each dollar of revenue collected.

Using an interest rate of 5%, please determine the government's best course of action and give its expected value.

Question 5 (15 points)

A non-profit organization provides information to low income clients about claiming the Earned Income Tax Credit (EITC) on their income tax forms. It has total costs given by the following equation: TC = 1000 + 10*Q, where Q is the number of clients it serves. The demand for its services is given by the equation P = 480 – 4*Q, and there are no other organizations nearby providing a similar service. The organization wishes to serve as many people as possible without running a deficit.

What price should the organization charge and how many people will it be able to serve? How much profit will it earn? As a hint, the value of Q is between 112 and 122, inclusive.

Question 6 (15 points)

Suppose a profit-maximizing firm is considering a research project to develop a more efficient car engine that would have much better fuel economy. If it succeeds, the annual demand for the engine would be given by $P = 380 – 2*Q$ and production costs would be given by $TC = 80*Q$. Assuming the firm is able to develop the engine, what price would it charge and what quantity would it produce in each year during the time it is a monopolist? What profits will it earn each year? As a hint, the quantity will be between 72 and 82.

Variable

Equation

Question 7 (15 points)

Now suppose that the research project to develop the engine in Question 6 would cost $110,000 which would be paid in year 0. However, there is only a 25% chance the project would succeed. You may assume the project could be carried out in year 0 and, if it succeeds, the profits from Question 6 would begin to arrive in year 1. The firm would be a monopolist for 20 years (years 1-20) after which other firms would enter the market, the price would fall to $80, and the firm's profits would drop to 0.

Please calculate the expected net present value of the research project assuming that the firm uses an interest rate of 5% in present value calculations. Should the firm undertake it?

Question 8 (15 points)

Now suppose the engine would create a positive externality by lowering emissions of carbon dioxide and other pollutants. To keep things simple, suppose the external benefit is $4000 a year during the patent period and $8000 a year after the patent expires. (It doesn't depend on Q and is just $4000 in year 1, $4000 in year 2, ..., $8000 in year 21, and so on). Please compute the sum of consumer surplus and the external benefit in a typical year during the patent period and a typical year after the patent expires. Then compute the expected present value of those benefits (that is, CS plus the externality) if the firm undertook the project. You may assume that after the patent expires other firms enter the market and the price drops to $80. Please use a 5% interest rate in present value calculations.

Question 8, continued.

Finally, suppose the government is considering a partnership with the firm. Under the partnership, the government would pay $90,000 of the development cost in year 0. In exchange, the government would receive 20% of the profits on the engine if the firm succeeds in developing it. If the development project fails, the government does not receive any payment from the firm.

Would the partnership induce the firm to undertake the project? Assuming for simplicity that the government only cares about consumer surplus, externalities, and its payments to or from the firm (that is, assuming it doesn't care about the firm's profits), what is its expected value from the partnership?