SUID:

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Exam 3
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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 potentially helpful formulas and equations:

$$\frac{1}{2}bh \qquad \frac{F_t}{(1+r)^t} \qquad \frac{F}{r}$$

Question 1 (15 points)

A small city is concerned about coastal erosion caused by sea level rise (a consequence of climate change). The city's shoreline has a scenic beach that currently produces $5 million of benefits every year. Immediately behind the beach is a residential area that currently produces $10 million of benefits each year. If nothing is done, erosion will completely eliminate the beach in year 21 and then eliminate the residential area in year 41. To keep things simple, you may assume that the benefits of the beach and residential area remain constant at $5 million and $10 million per year until they are eliminated, at which point they drop to $0.

The city is considering two policies, S and B, to address the erosion. Policy S would construct a seawall (concrete barrier) to protect the residential area. The seawall would cost $60 million in year 40 and would permanently prevent the loss of the residential area that would otherwise occur in year 41. However, it would do nothing to preserve the beach. Policy B would use land purchases and zoning changes to gradually move the residential area inland. It would cost the city $1 million per year forever starting in year 1 in land purchases. In addition, zoning changes would reduce the value of the residential area to $9 million starting in year 1. The policy would permanently protect both the beach and the residential area by moving the houses out of harm's way and allowing the beach to move inland.

Please calculate the net present value of each plan and then indicate which one is best. You may assume that the government uses an interest of 5% in present value calculations.

Question 2 (15 points)

A city facing a severe drought and short on drinking water is considering two policies, P and M. Policy P would raise water prices in order to reduce consumption. It would cost $6 million to implement because new meters and billing software would be required. If the public accepts the price increase (A), it would be very effective, producing a gross benefit of $30 million. However, the city is worried that the policy could be a public relations disaster and provoke a backlash (B). In that case, the city would have to back down on the price increase (not receive the $30 million benefit) and would also have to pay $2 million to settle lawsuits provoked by the policy. The city believes the chance of a backlash is 75%. Policy M, in contrast, would use a social media (M) campaign to change how people think about water use. It would send people carefully designed messages to nudge them toward using water more efficiently. Policy M would cost $2 million, would provide a gross benefit of $8 million, and there would be no chance of a backlash. Finally, the city could hire a consulting firm to carry out surveys and focus groups to determine whether or not the price policy would cause a backlash before the city has to choose which policy to implement.

Please determine the maximum the city would be willing to pay the consulting firm for the study. To keep things simple, you may assume that the firm is infallible. Please note that everything happens in one period so no PV calculations are needed.

Question 3 (15 points)

Many governments are concerned about interdependencies between different critical infrastructure systems, such electricity and water supplies: a failure in one system can cause cascading failures in others. For example, recent wildfires in parts of California caused unusually severe damage because the fires caused power outages, which caused water pumping stations to shut down, which cut off water supplies to firefighters.

Suppose that each year a community has a 10% risk of wildfire. If a fire occurs, there is a 10% chance the electrical system will fail. If that happens, there is currently a 100% chance of a water system failure. However, if the electrical system does *not* fail, there is still a 10% chance the fire would cause the water system to fail for other reasons. If the water system fails for any reason, the wildfire will cause $500 million in damage. If the water system does not fail, no damage will occur.

The community is considering upgrading its pumping stations by adding backup generators. If it goes ahead, the chance that the water system would fail if the electrical grid fails would drop from 100% down to 20%. All other probabilities above would remain the same.

(a) Please calculate the annual expected wildfire damage under business as usual, and then calculate it under the upgrade. How much does the upgrade reduce the annual expected damage?

Question 3, continued.

Now suppose that carrying out the upgrade would cost $6 million per year in years 1-5. The money would have to be raised via a tax that creates a deadweight loss of $0.25 for each $1 of revenue it raises. The improvement in the water system would begin in year 6 and go on indefinitely.

(b) Please calculate the upgrade's NPV and indicate whether the community should go ahead with it. You may assume the city is risk-neutral and uses an interest rate of 5% in present value decisions.

Question 4 (15 points)

An electric utility would like to reduce its costs by lowering its peak demand (when electricity generation is very expensive). It is considering two programs, B and N, that would encourage residential customers to cut back on their air conditioning use during the hottest days of the summer. However, it knows that households differ in how flexible they are in adjusting their thermostats. Twenty percent (20%) are highly flexible (type H) and would react strongly to a policy, while the remaining 80% have low flexibility (type L) and would react little. The utility's traditional approach would be to use a broad, one-size-fits-all policy (policy B). Policy B would cost the utility $90 per household. When applied to an H household it would produce a gross benefit to the utility of $300 but when applied to an L household the gross benefit would be only $50. However, a new policy (N) is available that is specifically tuned to the needs of H households. It would cost the utility $150 per household and would produce a gross benefit of $450 when applied to an H household but a $0 gross benefit when applied to an L household. (To make sure there is no confusion, please note that this problem is from the utility's point of view and all of the costs and benefits mentioned would be paid for or received by it.)

(a) Suppose that initially no information is available about the type of any given household. Which policy should the utility use, if any?

Question 4, continued.

(b) Now suppose that a large, detailed dataset (i.e., big data) is available that can be used to test whether any given household is type H or type L. If the utility uses the test, it could then apply policy B or N, or no policy at all, to the household. (To be clear, it can use different policies with different households.) The evaluation would cost $10 per household but would not be infallible. It has a 20% risk of reporting that a type-H household is type L, and 10% chance of reporting that a type-L household is type H.

Please determine whether the utility will use the test. If it does, how would it use the results?

Question 5 (15 points)

A non-profit organization provides legal and accounting services to low income residents of its county who want to start their own businesses. It has total costs given by the following equation: $TC = 7000 + Q^2$, where Q is the number of businesses it serves. It believes the demand for its advice is given by the equation $P = 3000 - 200 * Q$, and there are no other organizations nearby providing a similar service. The organization wishes to serve as many businesses as possible without running a deficit.

What price should the organization charge and how many businesses will it be able to serve? How much profit will it earn? As a hint, the value of Q is between 5 and 15, inclusive.

Question 6 (15 points)

Substances known as "adjuvants" have long been added to vaccines to boost the response of the immune system. However, a recent development has been adjuvant systems (AS for short) that combine several adjuvants to produce much stronger and longer lasting effects. For example, a new AS developed by GlaxoSmithKline is the key to a breakthrough vaccine against shingles, a very painful disease that affects about 30% of older adults. A single AS can be used with vaccines for multiple diseases, so a successful one can be very profitable. Suppose a profit-maximizing firm is considering a research project to develop a new AS. If it succeeds, the annual demand for the AS would be $P = 4400 - 100*Q$ and production costs would be given by $TC = 400*Q$. Assuming the firm is able to develop the AS, 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 17 and 27.

Question 7 (15 points)

Now suppose the research project in Question 6 would require two stages. The first stage is basic research. It would cost $150,000 and there is a 40% chance the firm would produce a potentially useful AS. However, before the firm could sell the AS, it would need to carry out a clinical trial to show that the new AS actually produces significantly better vaccines. The trial would cost $100,000 and the firm would have a 50% chance of success. If it succeeds, the firm would be able to sell the AS and would be a monopolist for 20 years (years 1-20). After that, other firms would enter the market, the price would fall to $400, and the firm's profits would drop to 0. If the clinical trial fails, no one will ever use the AS and sales will be zero.

(a) 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 7, continued.

(b) The government is interested in the potential consumer surplus the AS would produce. Using an interest rate of 5%, what is the PV of the CS that would be generated if the firm successfully developed a marketable AS? Be sure to consider both the period of the patent and the period after the patent expires and competitors enter the market. Finally, account for the fact that the project might not succeed by computing the expected CS.

Question 8 (15 points)

Finally, suppose the government proposes the following deal to the firm. It will provide the firm with a $150,000 loan to undertake the project. If the project succeeds in producing a marketable AS, the firm would be required to repay the $150,000 loan. However, the loan would be forgiven (the firm would not have to repay it) if the project ends for any reason other than producing a marketable AS.

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

In case you're curious, GlaxoSmithKline's actual AS cost far more to develop but is also expected to be much more profitable. The shingles vaccine alone is likely to earn a billion dollars a year, and the AS is expected to lead to new vaccines for malaria and other diseases.

Additional page for calculations
If you use this, please remember to indicate near the question that part of the answer is here.