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. Unless otherwise indicated, use an interest rate of 5% in PV calculations and assume the decision maker is risk neutral and cares only about maximizing EV in calculations involving uncertainty.

7. 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)

Because cities often have a lot of pavement and other dark surfaces, and have relatively few trees, they are usually warmer than surrounding areas, a phenomenon known as the urban heat island effect. Suppose the government of a city in a warm climate expects that climate change will exacerbate the urban heat island effect faced by its residents. It is considering a package of actions (A) to mitigate the problem, including changes to land use regulations, expanding the number of trees and parks, and painting roofs and other surfaces white.

To keep things simple, you can assume A could be carried out immediately and would cost $500 million in year 0. Because warming is gradual, however, it would not have any effect right away. However, it would reduce heat-related damages by $20 million in years 11-20 and by $100 million from year 21 on forever. To pay for the policy, the city would issue a $500 million bond (B) in year 0, would pay $30 million in coupon payments in years 1-20, and would repay the $500 million in year 20.

Please determine: ☐ the NPV of the package of actions A, ☐ the NPV of the bond B, ☐ the NPV of the overall project, and ☐ indicate whether the city should go ahead. The city uses an interest rate of 5% in PV calculations.

Question 2 (15 points)

Suppose a small community is concerned about the risk of a wildfire. It believes there is a 5% chance a fire might occur, and if it does, the fire would cause $200 million in damages. It is considering two policies:

Policy B would be a mandatory change in the building code requiring owners to install fire-resistant materials on their roofs. It would cost $5 million but would protect many of the buildings. If a fire occurs, the damage would be reduced to $60 million.

Policy V would be an educational campaign asking people to reduce the potential fuel for a fire by voluntarily trimming the brush around their houses. It would cost $1 million but its impact is uncertain. If compliance is high (H), it would reduce the damage from a fire to $100 million but if compliance is low (L) it would have no effect. The community believes that the chance of H is 40% and the chance of L is 60%.

Please determine which policy, if any, the community should adopt. To keep things simple, treat this as a one-time decision with no time dimension: no PV calculations are needed.

Question 3 (15 points)

Many governments are very concerned about risks raised by the development of AI and are considering regulating it. At the same time, the technology has great potential for good and regulation could stifle its development. This question explores the tradeoffs. To keep things simple, we'll ignore the costs and benefits to the firms developing the technology and focus only on the positive or negative externalities AI could produce.

Suppose that in the absence of regulation (BAU), tech firms working in the area have a 10% chance of successful (S) development of advanced AI and a 90% chance of failure (F). If the development is successful, there's a 50% chance it will be a positive outcome (P) creating $1 trillion ($1000 billion) in benefits. However, there's also a 50% chance it will be a negative outcome (N) that creates $500 billion of damages. If the development is a failure (F) it will not produce any externalities. The government is considering the two policies below.

Policy R would heavily regulate AI development. It would raise the chance of a positive outcome (P) to 90%. It would have no direct cost but by limiting the creativity of developers, it would lower the chance of success (S) to 5% and reduce the value of the positive payoff (P) to $500 billion. The payoff of a negative outcome (N) would remain a $500 billion loss.

Policy T would be a $20 billion research project. It would infallibly reveal whether the AI would be positive (P) or negative (N) early in the process before it's clear whether it will succeed or fail. If the test reports N would occur, the government would ban AI and development would cease. If the test reports P, development would be allowed to continue. All probabilities and payoffs would be the same as their BAU values.

Please determine which policy, if any, the government should pursue.

Question 4 (15 points)

Suppose a community expects to grow substantially due to the arrival of a major new employer. It is concerned about the cost of housing and is considering two policies, C and M, for expanding the amount of affordable housing.

Policy C is a conventional approach that would build a new residential neighborhood. Construction would cost $30 million a year in years 1-3 and the project would begin producing $10 million in benefits a year forever starting in year 4.

Policy M would build a mixed use neighborhood that contains both homes and small commercial areas. It would be more expensive and take longer to build than C: construction would cost $40 million a year in years 1-5. It is also uncertain how successful it would be. There's a 40% chance it would be highly successful (H) and produce $20 million a year in benefits forever starting in year 6. However, there's a 60% chance it would have low (L) success and produce only $10 million a year.

Finally, a consulting firm could be hired to conduct a test (**T**) that would determine whether M would have high or low success. The firm is infallible and the test could be conducted in year 0 before construction begins.

Please determine the maximum the community would be willing to pay for the test. The community uses an interest rate of 5% in PV calculations.

Question 5 (15 points)

A nonprofit organization provides accounting services to small businesses in low income areas. It has total costs given by the following equation: $TC = 1000 + 20Q^2$ where Q is the number of businesses it serves. It believes the demand for its service is given by $WTP = 5000 - 10Q$, 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 160 and 170, inclusive.

Question 6 (15 points)

Suppose a profit-maximizing firm is considering a research project to develop a new battery technology that wouldn't require cobalt or other hard-to-obtain minerals. If it succeeds, it would face an annual demand given by $WTP = 20100 - 200 * Q$, and production costs would be given by $TC = 100 * Q$. Assuming that the firm is able to develop the technology, 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 46 and 56, inclusive.

Question 7 (15 points)

Now suppose the project in question 6 involves two stages. The first is developing the chemistry (C) of the new battery. That would cost $1 million (paid in year 0) and has a 30% chance of success. If C succeeds, the firm would then need to develop a new manufacturing process (M) to build the batteries. That would cost an additional $1 million and would have a 50% chance of success. If C and M both succeed, profits 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 price would fall to $100 and the firm's profits would drop to 0. If either C or M fails, the project fails and the firm would earn no profits in any year.

(a) Using an interest rate of 5%, please: ☐ calculate the PV of the monopoly profit if the project succeeds; ☐ calculate the EV of the research project as a whole; and ☐ determine whether the firm would undertake the research.

Question 7, continued.

(b) Now suppose the new batteries would each create a positive externality of $2000 by using some materials recycled from old batteries. Please calculate: ☐ the external benefits and consumer surplus produced each year during and after the patent period. Then, using an interest rate of 5%, calculate ☐ the PV of the external benefits and CS that would be generated if the firm successfully develops and manufactures the battery.

Question 8 (15 points)

Finally, suppose the government is considering offering a $4 million prize to the firm if it successfully develops and sells the battery. Please: ☐ determine whether the prize would change the firm's decision. Then, using an interest rate of 5%, ☐ determine the government's expected NPV payoff assuming it only cares about the externalities, consumer surplus, and its own payments under the policy (that is, it doesn't care about the firm's profits). Finally, ☐ determine the minimum prize that would induce the firm to undertake the project. Please be sure to show your work.

Have a great break!

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