Homework 5: Self-Review of the Midterm Exam

ECON 341: Natural Resource Economics

Name: _____

Redo each question or subpart where you lost credit. Show your reasoning and briefly explain each correction. Label any extra pages with the question number. Hand in this worksheet before the final exam begins at **8:30 a.m. on Wednesday, December 9, 2026**.

I. Multiple choice

1. Maintained fishing effort is already above the effort that produces MSY. On the sustainable catch and effort curve, moving still farther beyond that effort tends to:

A. increase sustainable catch without limit.
B. leave the maintained fish stock unchanged.
C. eliminate all real fishing costs.
D. reduce sustainable catch as the maintained stock falls.

2. Under Hotelling's benchmark, the expected growth rate of net resource price exceeds the market interest rate. A forward-looking private owner has an incentive to:

A. extract more today and invest the proceeds.
B. delay extraction.
C. ignore future net prices.
D. remain indifferent between extracting now and later.

3. A pollution loss occurs only in the distant future. A higher discount rate, with the future loss unchanged, gives that loss:

A. a larger present value.
B. the same present value.
C. a smaller present value.
D. a negative physical size.

4. Under Hartwick's rule and its substitution assumptions, which action helps maintain consumption as a nonrenewable resource is depleted?

A. Invest all scarcity rent in other forms of productive capital.
B. Consume all scarcity rent immediately.
C. Invest only the interest earned on scarcity rent.
D. Preserve every unit of the resource underground.

5. A cheaper substitute permanently reduces a mineral's value below its extraction cost. Which outcome can be economically optimal?

A. Extract the entire deposit because leaving ore unused always wastes resources.
B. Stop extraction while some ore remains underground.
C. Increase extraction because the mineral is now less valuable.
D. Ignore extraction costs when deciding whether to continue mining.

II. Fill in the blanks

Write a word or phrase in each blank.

1. The property-right characteristic that makes the owner receive the benefits and bear the costs of resource use is _____; the characteristic that allows rights to be voluntarily transferred from one owner to another is _____.

2. The largest fish stock the environment can support without fishing, where net natural growth is zero, is the _____.

3. A defined community excludes outsiders and enforces rules for its members' resource use. This property regime is _____.

4. Benefiting from a public good while relying on others to pay for its provision is called _____.

5. Maximizing the sum of current and discounted future net benefits concerns _____; deciding how benefits and costs should be shared across generations concerns _____; leaving future generations no worse off than the present generation concerns _____.

III. Short answers

Aim for **2 to 4 sentences per answer**.

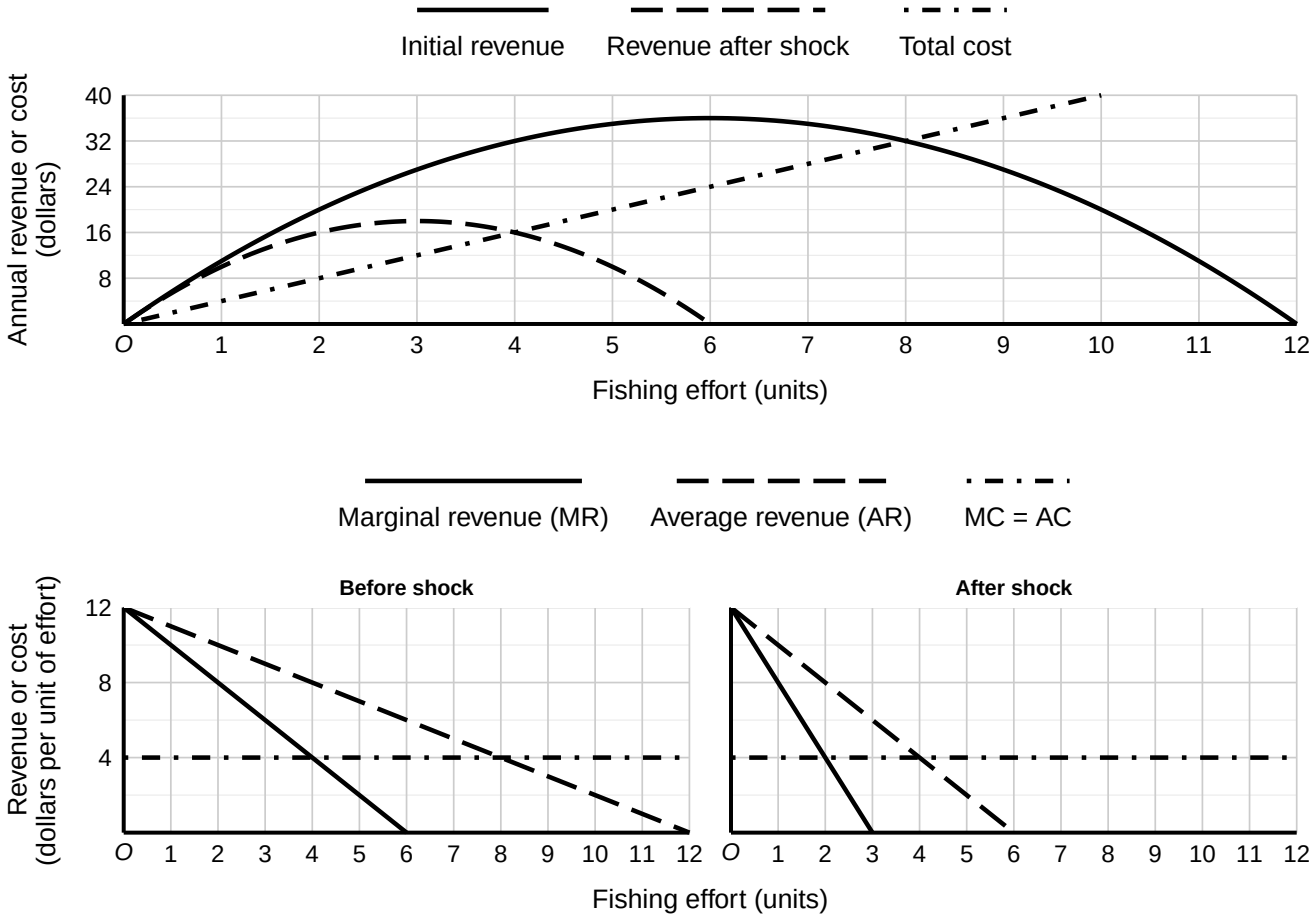
1. A **myopic private owner** extracts a scarce nonrenewable resource, ignoring both extraction pollution and future net benefits. Assume the socially efficient allocation includes both current and future extraction. Would a per-unit tax equal to marginal external pollution damage achieve efficiency? Explain your answer.

2. An efficient allocation gives the current generation \$120 in net benefits and the future generation \$80, with no saving or transfers. These amounts are **undiscounted**. Does it also meet the sustainability criterion? Explain how the two criteria differ.

IV. Analytical question: a fishery growth shock

Slower natural growth changes sustainable revenue as shown. Fish price is **$2 per ton**, real effort costs are unchanged, and there are no other external damages. For Questions 1 and 2, compare steady states. AR and MR are average and marginal revenue from effort; AC and MC are average and marginal cost.

Curves are distinguished by line type, as shown in the legend below.



1. Identify each **initial effort** and briefly state its graph criterion.

Target	Initial effort	Graph criterion
Static efficient	_____	_____
MSY	_____	_____
Open access (OA)	_____	_____

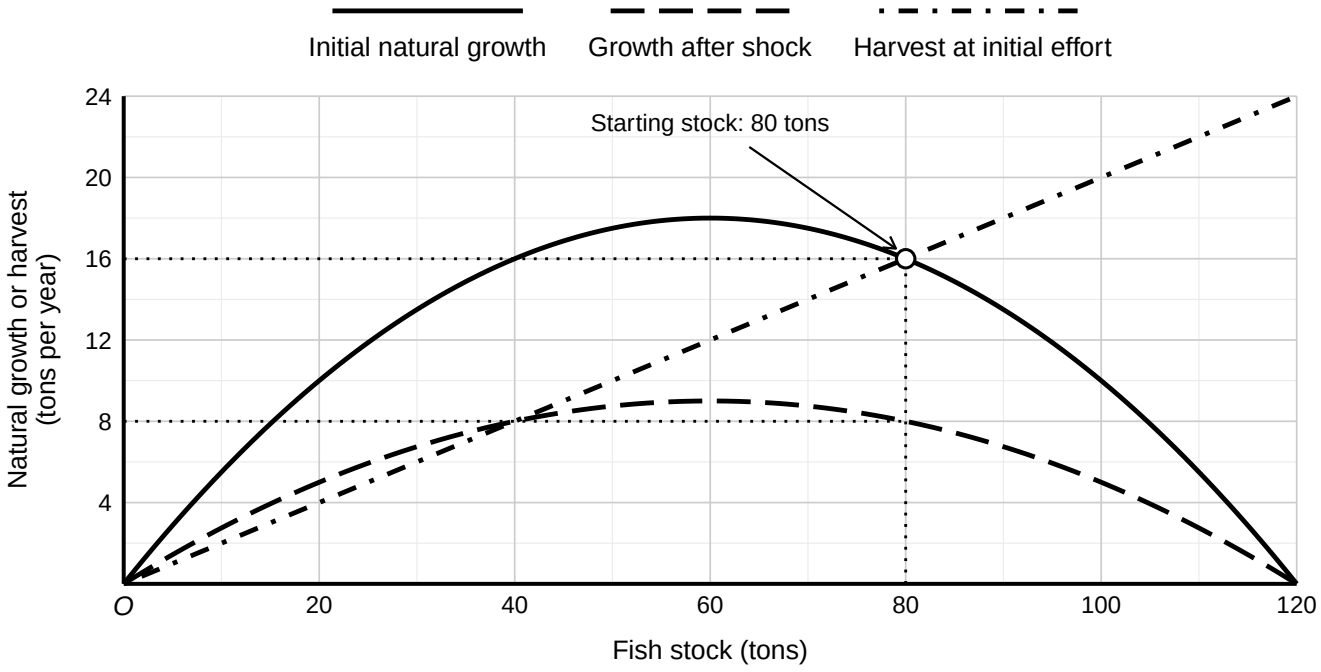
2. After the shock, what effort corresponds to each target?

Static efficient: _____ MSY: _____ OA: _____

IV. A fishery growth shock (continued)

3. The graph below shows the same fishery at its old efficient effort, $E = 4$, and starting stock of **80 tons**. Immediately after growth slows, effort and stock are unchanged. Does the stock begin to rise or fall? Use the growth and harvest values to explain.

Curves are distinguished by line type, as shown in the legend below.



V. Analytical question: allocation over time

Allocate a **60-ton deposit** between today (Q_1) and ten years from now (Q_2), with $Q_1 + Q_2 = 60$. There is no pollution. Private marginal net benefits, in dollars per ton, are

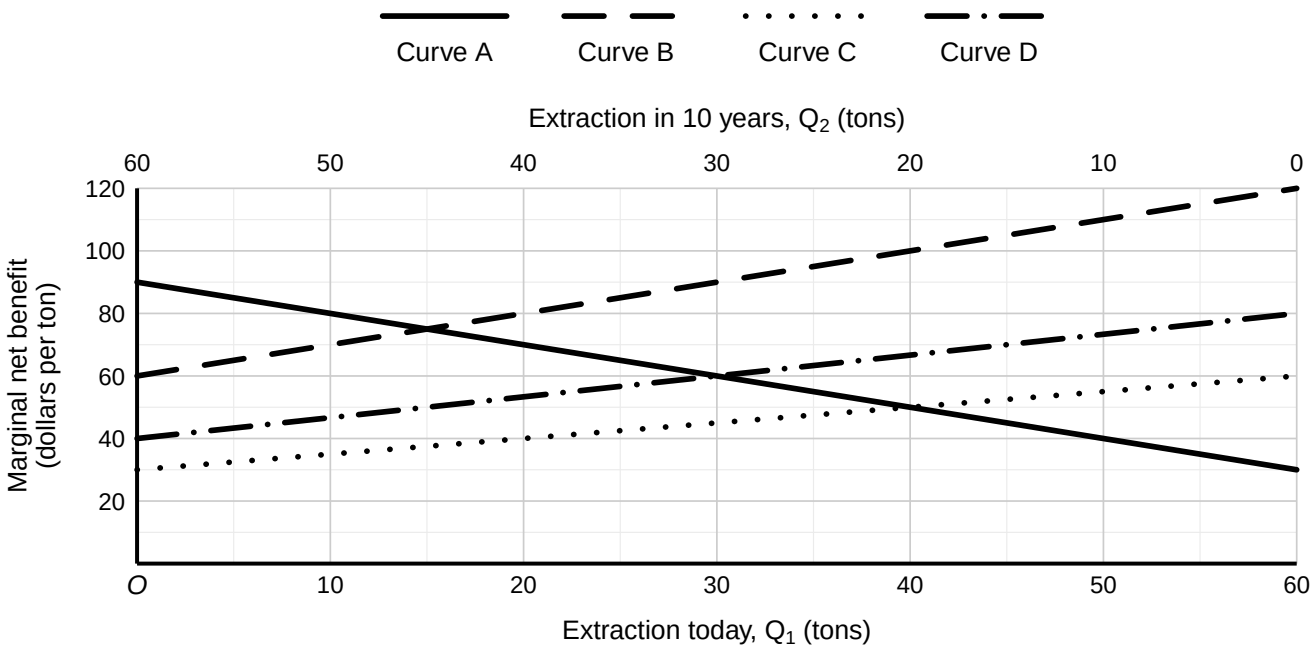
$$MNB_1 = 90 - Q_1, \qquad MNB_2 = 120 - Q_2 \quad \text{(undiscounted)}.$$

For an amount X_t in t years, $PV(X_t) = X_t/(1+r)^t$. Let r_p be the owner's **market interest rate** and r_s the **social discount rate**. Use these ten-year discounting factors:

$$\frac{1}{(1+r_p)^{10}} = \frac{1}{2}, \qquad \frac{1}{(1+r_s)^{10}} = \frac{2}{3}.$$

The **forward-looking owner** uses r_p; society uses r_s. Each maximizes the **sum of net benefit today and discounted net benefit in ten years** at the respective rate. The top axis shows $Q_2 = 60 - Q_1$; both discounted future MNB curves are given.

Curves are distinguished by line type, as shown in the legend below.



1. Identify curves A–D. Write a name or formula in each blank.

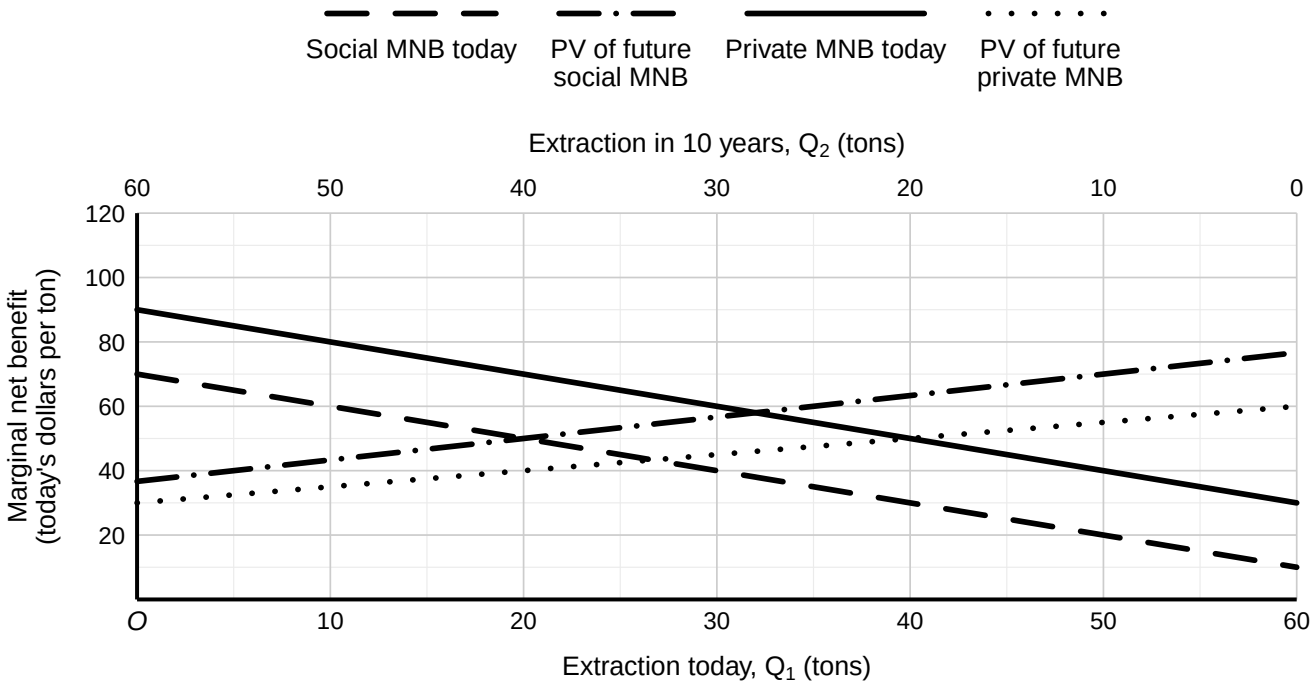
A: _____ B: _____
C: _____ D: _____

2. Shade society's loss from the owner's allocation. Explain why shifting extraction to the future improves the outcome and where this shift should stop. **Do not calculate the size of the area.**

VI. Analytical question: extraction and pollution

Use Part V's deposit, marginal net benefits, and discounting factors. Extraction causes **$20 of external damage per ton today** and **$5 per ton in ten years**, at the time of extraction. In Questions 1 and 2, the owner is forward-looking as in Part V and does not pay for this damage. Present values use r_p for private MNB and r_s for social MNB.

Curves are distinguished by line type, as shown in the legend below.



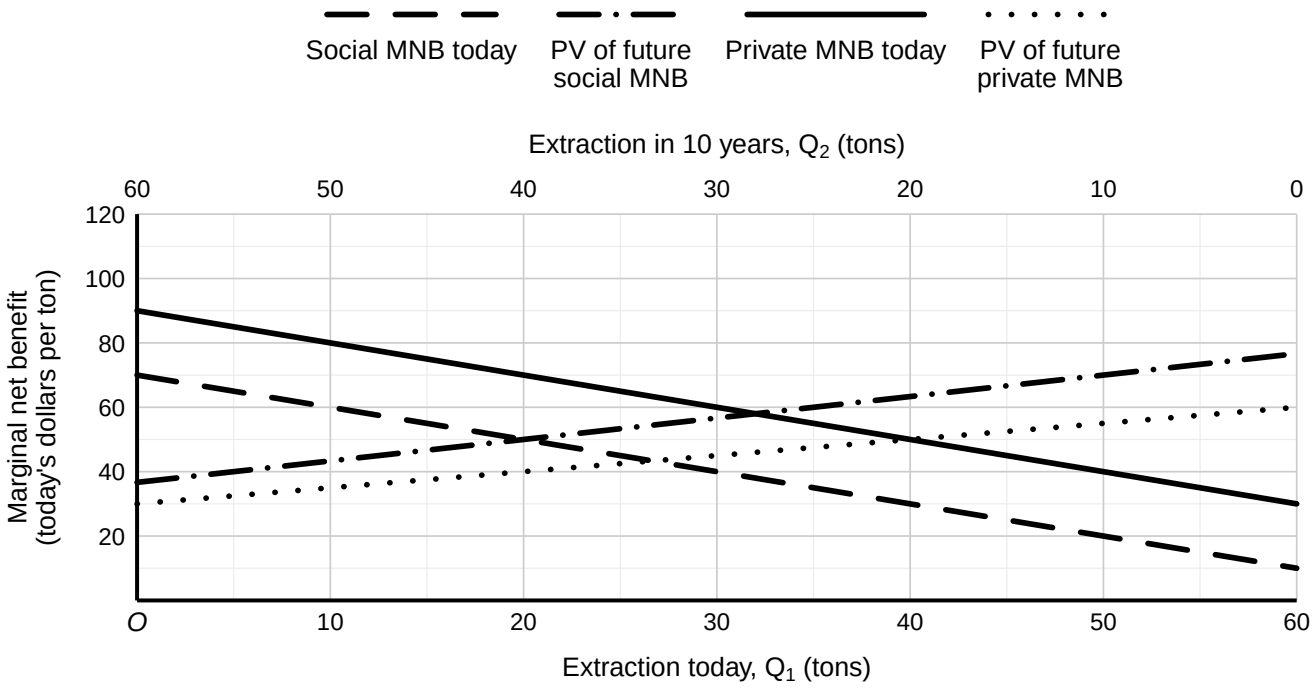
1. Mark the allocation optimal for society and label Q_1^* and Q_2^*. Shade the welfare loss if the owner instead extracts **40 tons today**. **Do not calculate the size of the area.**

2. Compare society's allocation between the two periods with Part V. Would pollution change that allocation? Why?

VI. Extraction and pollution (continued)

3. A **myopic private owner** considers only today's private net benefits, ignoring future benefits and pollution. **Before any tax, how many tons would this owner extract today?** What **per-ton corrective tax on extraction today** would induce society's optimal allocation? **Draw the tax-adjusted current private** MNB **curve on the graph below** and mark the owner's extraction after tax.

Curves are distinguished by line type, as shown in the legend below.



VI. Extraction and pollution (continued)

4. An innovation reduces today's external marginal cost from **\$20 to \$5**, with no change in extraction costs or future damage. Add the new current social MNB curve to the graph below. Compared with Question 1 in Part VI, does society's optimal current extraction rise or fall? **Do not calculate the extraction quantity.**

Curves are distinguished by line type, as shown in the legend below.

