# ECN 275/375 – Natural resource and environmental economics
## 12:15-15:15 April 6, 2021

All help aids allowed except assistance from others.
This test consists of 3 questions, for a total score of 100 points.
All questions are to be answered. You may answer in English or Norwegian.

**In the case that you find a question unclear, or you are uncertain about what is meant, state your extra assumptions needed to be able to answer the question.**
**When I submit my answers on this exam, I confirm that I have worked alone on my answers and not cooperated with others. I am aware that cooperation with others is to be considered an attempt or a contribution to cheat.**
**I am aware of the consequences of cheating (Ch. 39, Academic regulations for NMBU).**

**Your name:** NN

## Question 1 (30 points)

Forestry and forest conservation.

(a) Consider a forest operation where the only source of income are timber harvest sales. Formulate a single rotation even aged stand equation that reflects the *expected income stream per hectare* of a forest operation when planting takes place once an area is clear cut (think of this as the rotation has already started). Assume planting is profitable. Explain the terms entering your equation and the reason for your choice of formulation. **(10 points)**

**Answer:**
Start writing your answer here

From the environmental economics part of this course we know that in a uniform price conservation procurement auction, optimal bids in the auction equal net present foregone profits (opportunity values) of the forest operation.

(b) Take a single rotation perspective and assume that $0 < t < T$, where $T$ is already determined. Explain why the size of the optimal bid decreases with decreasing $t$. A formula may help you to clarify your argument. **(10 points)**

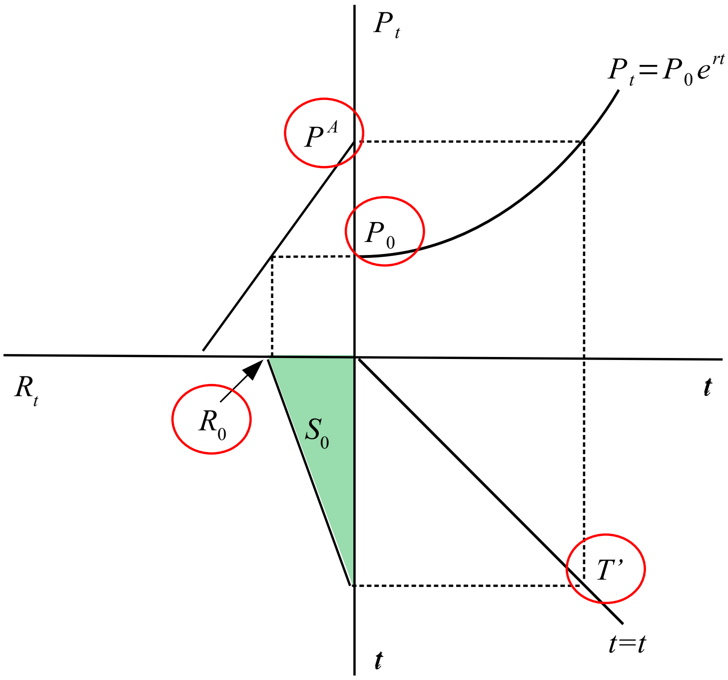
**Answer:**
Start writing your answer here

(c) Suppose conservation contracts are awarded for eternity. Assume that conservation contracts are only awarded to forests equal to or older than the optimal rotation age, $T$. Explain why the necessary size of the lump sum compensation then needs to equal $\pi_T + \pi_{2T} e^{-rT} + \pi_{3T} e^{-2rT} + \ldots = \sum_{x=1}^{\infty} \pi_{xT} e^{-(x-1)rT}$, where $\pi_t$ is profits at time $t$. **(10 points)** (Clarifying comment: You only need to explain reasons for left side formulation of the equal sign, but understanding the right hand side may make it easier for you to explain the compensation scheme).

**Answer:**
Start writing your answer here

## Question 2 (30 points)

The graph below illustrates a standard mining problem of a non-renewable resource in a fully competitive market. Assume that demand does not change over time until a perfect substitute is in place and demand is determined by the price of the substitute. Also assume mining costs are so small that we can disregard those.




(a) (i) Explain the meaning of the terms within the red circles. (ii) Explain why the mining profile in the graph is optimal. **(10 points).**

**Answer:**

(i) Start writing your answer here

(ii) Start writing your answer here

(b) Assume that at time $T^B < T'$ a backstop technology that is a perfect substitute for the resource will be available with a market price $P^B < P^A$. This is known with certainty at time $T^N: 0 < T^N < T^B$. Explain verbally what happens, draw the new price path, and make other adjustments in the graph to make it approximately consistent. Clearly indicate when any adjustments take place. **(10 points)**

**Answer:**

Start writing your answer here

(c) Suppose that in stead of the full certainty case in (b), the arrival time, $T^B \geq T'$, of the backstop technology is uncertain, where $T'$ is the earliest estimate for the arrival of the backstop technology. Also, assume that as the arrival time gets closer, mining firms gain more precise information about the true arrival time, $T^B$. Briefly explain how that would affect mining firms' mining profile. **(10 points)**

**Answer:**

Start writing your answer here

## Question 3 (40 points)

Harvest-effort models are frequently used to analyze the profitability properties of fisheries.

(a) (i) Formulate a profit maximizing harvest-effort model with harvest as a function of effort and a linear cost for effort. Specify the terms in your model. (ii) Derive the condition for the open-access equilibrium from your formula in general terms, and explain the reasoning behind and implications from your mathematical formulation of the open-access equilibrium. **(10 points)**

**Answer:**

(i) Start writing your answer here

(ii) Start writing your answer here

(b) (i) Derive the profit maximizing effort and ensuing harvest level from your model in (a), and provide a brief verbal explanation for the solution. (ii) Draw the open-access equilibrium from (a) and the profit maximizing equilibrium you have just found in the same harvest-effort graph. **(10 points)**

**Answer:**

(i) Start writing your answer here

(ii) Start writing your answer here

Suppose a new harvest technology becomes available that lowers the per unit costs of effort.

(c) (i) Explain why a large cost savings technology leads to higher effort and less harvest for the open access fishery regime. (ii) Explain that any cost saving technology leads to both increased effort and harvest for a profit maximizing fishery regime. **(10 points)**

**Answer:**

(i) Start writing your answer here

(ii) Start writing your answer here

(d) In open access fishery regimes like in (c), increased efforts due to lower per unit effort costs reduce long run harvests. What insights does this provide for the sustainability of open access fisheries? **(10 points)**

**Answer:**

Start writing your answer here