# *UNIVERSITY OF OSLO*
# *DEPARTMENT OF ECONOMICS*

Postponed exam: **ECON4910 – Environmental economics**

Date of exam: Thursday, August 13, 2009

Time for exam: 02:30 p.m. – 05:30 p.m.

The problem set covers 2 pages

Resources allowed:
- All written and printed resources, as well as calculator, is allowed.

The grades given: A-F, with A as the best and E as the weakest passing grade. F is fail.

**Problem 1**

A uniformly mixing pollutant is being emitted into the air by a large number of firms. Initially, there is no environmental regulation. The government wants to reduce emissions, and considers the following three instruments: i) a uniform emission tax, ii) emission caps (non-tradable emission permits), iii) tradable emission permits.

Each firm's marginal abatement cost is increasing in abatement; but abatement costs may differ between firms, and the government does not have detailed knowledge of each firm's abatement cost function. Assume that the government might still know the *aggregate* marginal abatement costs (that is, the marginal cost for any given aggregate abatement level, given that abatement is distributed efficiently between firms). Marginal environmental damages are increasing in aggregate emissions. Assume that costless lump-sum transfers are feasible (thus you can disregard distributional concerns, as well as issues relating to the cost of public funds). Discuss instruments i), ii) and iii) under the following assumptions:

a) The government has perfect knowledge about both the marginal environmental damage function and the aggregate marginal abatement cost function.
b) The government has perfect knowledge about the marginal environmental damage curve. The government knows the slope of the aggregate marginal abatement cost curve, but is uncertain about its level. (You may assume that both curves are linear.)
c) The government has perfect knowledge about the aggregate marginal abatement cost curve. The government knows the slope of the marginal environmental damage curve, but is uncertain about its level. (Again, you may assume that both curves are linear.)

**Problem 2**

A stock $S_t$ of a pollutant develops according to the equation $\dot{S}_t = E_t - \alpha S_t$, where $E_t$ is emission. The damages arising from the stock of the pollutant is $D(S_t)$, where $D(S_t)$ is an increasing convex function. The interest rate is *r*.

a) Explain intuitively why the optimal emission price at time t, $q_t$, is

$$q_t = \int_t^{\infty} D'(S_t) e^{-(\alpha+r)(s-t)} ds .$$

Assume that along the optimal path the stock of the pollutant is increasing over time and gradually approaches a steady state level.

b) Will the optimal price on emissions be increasing or decreasing towards the steady state? Explain the intuition of the result.

Suppose now that $D(S_t) = kS_t$, and that with $\alpha = 1\%$ and $r = 4\%$, the optimal price on emission is 100 (e.g. 100 kroner per ton $CO_2$).

c) Explain why the price in this case is constant (independent of *t*). What is the optimal price with $\alpha = 1\%$ and $r = 1\%$?

A crucial parameter in this problem is the interest rate *r*. When determining the relevant interest rate, one possibility is to approach the problem from the consumption side, where expected consumption growth will be important.

d) Explain why expected consumption growth is important for determining the relevant interest rate *r*. If expected consumption growth was zero or negative, what would that imply for the interest rate?