1) Marginal emissions control costs (abatement costs) for the two firms are MC_1 = $200q_1$ and MC_2 =$100q_2$. With no controls at all, each firm would be emitting 20 units of emissions. Thus e_1 = e_2 = 20, and total emissions (without controls) will be 40 units.

a. A total reduction in emissions of 21 units is necessary, which must be allocated across the two firms. What is the cost-effective allocation?

b. Suppose a regulator wanted to total reduction in emissions of 21 units by using an emission fee system. What fee (or tax) would need to be imposed? Show graphically.

c. Now suppose that each firm contributes differently to the ambient level of pollution at a receptor site. The ambient standard is 27 ppm. The transfer coefficient for firm 1 is 2.0 ppm/unit and the transfer coefficient for firm 2 is 1.0 ppm/unit.

   What is the cost-effective reduction of the two firms?

   How many permits will be allocated? What will be the price of the permits?

2) Consider an industry with two firms with different marginal control costs for abatement. The marginal costs of firm 1 and 2 are given as MC_1 = $0.3q_1$ and MC_2 =$0.5q_2$, respectively. q_1 and q_2 are abated emissions. With no regulation, the two firms would emit 20 units of emissions each. The firm's transfer coefficients are a_1 = 1.5 and a_2 = 1.0.

a) Without regulation, what is the ambient pollution concentration at the receptor (ppms)?

b) The ambient standard is 12 ppm, so 12 ambient permits would be issued. How would permits be allocated in a cost effective way?

3) Two identical firms benefit from polluting. A firm's marginal benefit from polluting an amount e are given by $24 - 3e$. The two firms differ in their impact on ambient pollution concentrations. Three units of emissions from firm 1 result in one unit of ambient pollution at the receptor site. Firm 2 has three times the impact on the ambient environment from the same amount of emissions.

a) What are the transfer coefficients of the two firms?
b) If the goal is to reach an ambient pollution concentration of 6 ppm at the receptor site, what is the cost effective level of emissions of the two firms? How many permits will be issued and what is the permit price?