Q1. Suppose Humphrey and Matilda live together. Humphrey currently smokes 20 packs of cigarettes per month; Matilda hates the smoke. They currently have no agreement restricting smoking. Their only joint expense is monthly rent, which they split 50:50. Draw an Edgeworth box with two goods – smoke and rental payments. Make up some reasonable indifference curves. Show the initial endowment. What Pareto efficient points might result from bargaining to restrict smoke ? How does the graph show what price per pack Matilda might pay to buy down Humphrey’s smoking (i.e., show the relative prices on your figure)? How would your answers change if the status quo is that the two have an agreement for no smoking and Humphrey would *like to smoke* as much as 20 packs per month ? He must seek Matilda’s permission to do so.

(Hint : For Matilda, redefine Humphrey’s smoking as smoke reduction.)

Q2. Consider an airport that produces noise that decays as the distance (*d*), in kilometres, from the airport increases: *N(d) = 1/d2*. Fritz works at the airport. Fritz’s damage from noise is $1 per unit of noise and is associated with where Fritz lives. His costs of commuting are $1 per kilometre (each way). The closest he can live to the airport is *d* = 0.1 km.

1. Write an expression for Fritz’s total costs (noise and transportation).
2. What is the distance Fritz will live from the airport in the absence of compensation for the noise ? What are his total costs ?
3. Suppose Fritz is compensated for his damage, wherever he may live. How close to the airport will he choose to live ? How much will he be compensated ?

Q3. Consider an air basin with only two consumers, Huck and Matilda. Suppose Huck’s demand for air quality is given by $q\_{H}=1-p$, where *p* is Huck’s marginal willingness to pay for air quality. Similarly, Matilda’s demand is given by $q\_{M}=2-2p$. Air quality can be supplied according to $q=p$ where p is the marginal cost of supply.

1. Graph the aggregate demand for air quality along with individual demands.
2. What is the efficient amount of air quality?

Q4. Two types of consumers (workers and retirees) share a community with a polluting factory. The pollution is non rival and non-excludable. The total damage to workers is *p2* where *p* is the amount of pollution and the total damage to retirees is *3p2*. Thus marginal damage to workers is *2p* and marginal damage to retirees is *6p*. The factory saves *20p – p2* by polluting *p*, for a marginal savings of *20 – 2p*.

1. Find the aggregate marginal damage for the public bad.
2. Graph the marginal savings and aggregate marginal damage curves with pollution on the horizontal axis.
3. How much will the factory pollute in the absence of any regulation or bargaining? What is this society’s optimal level of pollution ?
4. Starting from the uncontrolled level of pollution calculated in part (c), find the marginal willingness to pay for pollution abatement, *A*, for each consumer class. (Abatement is reduction in pollution; zero abatement would be associated with the uncontrolled level of pollution.) Find the aggregate marginal willingness to pay for abatement.
5. Again starting from the uncontrolled level of pollution, what is the firm’s marginal cost of pollution abatement ? What is the optimal level of *A*?
6. Are the problems of optimal provision of public bad (pollution) and the public good (abatement) equivalent ? Explain why or why not.

Q5. Consider the problem of carbon dioxide emissions. We will abstract away from the problem slightly, assuming there are polluters and consumers in two regions, the OECD (O) and the rest of the world (R). Suppose the marginal cost of controlling CO2 emissions is $10 per ton of emissions. Let the marginal willingness to pay for pollution reduction be *13 – Q* for region O and *12 – 2Q* for region R, where *Q* is the amount of pollution reduction. The United Nations is considering two proposed methods for controlling CO2 emissions, both involving polluters paying for the damage they cause. Proposal A involves the polluters paying damages to each region for the pollution generated. Proposal B involves the polluters in each region independently negotiating pollution reductions, assuming the other region is not undertaking pollution reduction.

1. Graph the marginal abatement cost and the total marginal willingness to pay schedules. What is the socially efficient level of emission reductions, *Q* ?
2. How much total pollution reduction will occur under proposal A and what will be the total compensation received by regions O and R ? If those payments were instead placed in the general coffers of the UN, would the outcome be any different from an efficiency point of view ? Why or why not ?
3. How much pollution would be generated under proposal B ? Explain any differences between this answer and the answer to parts (a) and (b).