1. Analysis of externalities

Here are the demand and supply schedules for a paper factory:

<table>
<thead>
<tr>
<th>Price per ton ($)</th>
<th>70</th>
<th>90</th>
<th>110</th>
<th>130</th>
<th>150</th>
<th>170</th>
<th>190</th>
<th>210</th>
<th>230</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity demanded (m tons)</td>
<td>100</td>
<td>90</td>
<td>80</td>
<td>70</td>
<td>60</td>
<td>50</td>
<td>40</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Quantity supplied (m tons)</td>
<td>10</td>
<td>30</td>
<td>50</td>
<td>70</td>
<td>90</td>
<td>110</td>
<td>130</td>
<td>150</td>
<td>170</td>
</tr>
</tbody>
</table>

The factory dumps dirty water into a river, which imposes an external cost of $60 per ton of paper produced.

a. Graph the demand and supply curves, the marginal external cost curve, and the marginal social cost curve.
b. On the graph in a., show the market equilibrium price and quantity, and the socially optimal price and quantity.
c. Show and explain the effects on the market price and quantity of the government imposing a tax of $60 per ton of paper produced.
d. Which, if any, of the following would produce the same result as in c.? Explain.
   i. The government charges the firm for the external costs it imposes (an effluent charge).
   ii. The government requires the firm to eliminate the pollution it causes.
   iii. The government puts in place a costless system that allows individuals who suffer from the pollution to sue the firm for the harm caused by the pollution.

2. International externalities

Many externalities are international. For instance, so much water is diverted from the Colorado River (in the U.S.) that essentially no water flows into Mexico (where the river reaches the sea).

a. Give three further examples of international externalities.
b. Why can international externalities not be solved by appropriate taxation and regulation?
c. Briefly, what alternative methods are there for tackling international externalities?

3. Market for Lemons

A thousand used cars are for sale in Boston. Some of the cars are of good quality ("plums"), and some are not ("lemons"), but the buyer cannot tell the difference between the two qualities; of course the seller knows whether the car is a lemon or a plum. Suppose that consumers are willing to pay $4,000 for a lemon and $6,400 for a plum; and sellers are willing to sell a lemon for $3,500 and a plum for $5,600.

a. If there is a 40% chance that a car is a lemon, how many cars will be sold? And what is the maximum consumer surplus in this case.
b. If there is a 10% chance that a car is a lemon, how many cars will be sold? And what is the maximum consumer surplus in this case?
4. **Public goods**

Suppose 20 people live on a street and that each of them is willing to pay $2 for each extra streetlight, regardless of the number of streetlights provided. If the cost of providing $x$ streetlight is given by $c(x) = x^2$, what is the Pareto efficient number of streetlights to provide?

5. **Complementary goods**

Your computer needs an operating system (OS; price $p_1$) and application software (App; price $p_2$). The demand for the combination is given by $Q = 600 - 20P$, where $P = P_1 + P_2$. The marginal costs are zero.

   a. Find the optimal price and quantity if the OS and App are provided by separate firms.
   b. Find the optimal price and quantity if the OS and App are provided by a single integrated firm.
   c. What broader conclusion do you draw from your answers to a. and b.?

6. **Fishing**

Let $E$ be the days of effort put into fishing. The total cost of the effort is given by $TC = 120 \times E$.

The total revenue earned from fishing will depend on the amount of effort, and is given by $TR = 600 \times E - 20 \times E^2$.

   a. What is the biological maximum sustainable total revenue from this fishery?
   b. If the fishery is closed access, how much effort will be made to fish? What will the profit be? The value of fish caught?
   c. If the fishery is open access, how much effort will be made to fish? What will the profit be? The value of fish caught?
   d. Technological innovation lowers the cost of fishing, so now the cost function is $TC = 80 \times E$. Find the answers to b. and c. given this new cost function.

   [Hint: You will need to find $MC$ and $MR$. To get $MR$, find the derivative of $TR$. The templates we saw in class may help.]