

ChE 150: Green Engineering
HW-MLA : Environmental and Pollution Economics (due: 03/02/06)

1. Each year, approximately 45,000 people lose their lives in automobile accidents in the U.S. (population 281 million, 2000 census). How many fatalities would be expected over a three-day weekend in the Rochester greater area (population 1 million)?
 2. Problem 6, page 61, Chapter 2 in Green Engineering: Environmentally Conscious Design of Chemical Processes (Arnold et al.)
 3. Problem 2, page 458, Chapter 13 in Green Engineering: Environmentally Conscious Design of Chemical Processes (Rosselot, Allen)
 4. In today's climate of ever-increasing gasoline prices it is difficult to convince drivers that driving is misleadingly cheap. Consider the following statistics and assumptions:
 - U. S. drivers consume about 172.0×10^9 gallons of gasoline per year.
 - Including automobiles, buses, and trucks, there are $\sim 229.60 \times 10^6$ registered vehicles in the U.S.
 - Americans drive about 4.478×10^{12} kilometers per year.
 - Americans pay $\sim \$ 1.4 \times 10^{12}$ annually for their cars (gas, maintenance, etc)
 - The cost of traffic congestion ranges from \$ 44 - 190×10^9 per year due to lost time, idle fuel losses—assume an average value of this range for calculations.
 - In 1997, the last year that published statistics were available, 13.8 million motor accidents killed over 43,000 drivers. The FHWA's estimates the cost of accidents is about $\$ 350 \times 10^9$ per year.
 - Americans pay about $\$ 140 \times 10^9$ annually for commercial and private passenger insurance, and the insurance companies cover about $\$ 110 \times 10^9$ per year in losses and adjusted expenses.
 - The shadow price of CO₂ emission costs range from \$ 20 to 1000 per ton of carbon (not CO₂). Use \$ 50 per ton for part 1 below.
 - Assume the density of gasoline is 0.73 g/cm^3 .
 - The elemental composition of gasoline is 89 % C and 11 % H. Nominally, the C in gasoline is converted to CO₂ through combustion with oxygen: $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$.
- a. Showing all conversions and calculations, using both a *per mile* and *per gallon* basis, determine the following:
 - the internal costs of owning an automobile
 - the external costs due to traffic congestion
 - the external costs due to accidents
 - the external costs due to CO₂ emission.
 - b. In Rochester, the cheapest grade of gas costs $\sim \$2.50$ per gallon; about 31 % is due to taxes. If gas taxes were raised to cover the externalities discussed in problem 1, how much would gasoline cost? Subtract out the amount that insurance companies cover, i.e. don't double count any external costs
 - c. Taxes on gasoline are one way to "internalize" externalities, list another method and comment on how fair they would be at distributing cost burdens.
 - d. List at least two negative externalities that were not included in the above calculations and list one positive externality.