Homework 1: Solutions
Environmental Economics: ECO 403

Question 1 (12 points).

a. The allocation is efficient. We cannot make Luke better off without making Dave worse off.

b. The allocation is not efficient. We can give the one remaining frisbee to either Dave or Luke and get a Pareto preferred allocation.

c. Dave likes frisbees more than cleats, whereas Luke is indifferent between the two. So if Luke trades a small amount of frisbees for an equal amount of cleats, he is equally well off, but Dave is better off. Dave was willing to give up twice as many cleats to get frisbees, but only had to give up and equal amount. Therefore when Luke trades a small amount of frisbees for an equal amount of cleats, we have a Pareto preferred allocation.

Question 2 (20 points).

For the table, Ralph saves \$5 million by installing the upgrade, but he must pay \$1 million for the generator and give \$3 million to his customers, so his net benefit is $\$5 - \$3 - \$1 = \$1$ million. For the control equipment, Ralph pays \$7 and gets no benefits, so his net benefit is -\$7.

A total of $0.2+0.1 = 0.3$ million households split the \$3 million in savings evenly. That works out to $\frac{\$3}{0.3} = \$10$ per household (both upwind and downwind). Total surplus from upgrading the equipment is $0.2 \cdot \$10 = \$2$ million for the downwind households and \$1 million for the upwind households.

For the pollution control equipment, the downwind households receive \$40 of benefits each if Ralph installs the equipment. Total benefits for the downwind households are then $\$40 \cdot 0.2 = \$8$ million. The upwind households do not care about pollution control and therefore get zero either way. The table is thus:

		Surplus per person				total surplus (Millions)			
Group	Number	upgrade	not	control	not	upgrade	not	control	not
Ralph	1	\$1 M	0	-\$7 M	0	\$1	0	-\$7	0
downwind households	0.2 M	\$10	0	\$40	0	\$2	0	\$8	0
upwind households	0.1 M	\$10	0	0	0	\$1	0	0	0
total surplus						\$4	0	\$1	0

a. Yes. Looking at the last row, $\$4 > 0$. The surplus from upgrading is greater than the surplus from not upgrading, so upgrading is efficient.

b. Yes. $\$1 > 0$. The surplus from installing the control equipment is greater than the surplus from not installing, so installing the control equipment is efficient.

c. NSR requires Ralph to install the control equipment *if* he upgrades. Upgrading then becomes a losing proposition for Ralph ($\$1 - \$7 = -\$6$ for upgrading, versus 0 for not upgrading). Therefore, Ralph does not install the upgrade and does not install the control equipment.

   An easy Pareto preferred allocation results by simply repealing NSR (there exist many Pareto preferred allocations). In this case, Ralph installs the upgrade ($\$1 > 0$), but does not install the control equipment. Looking at column 7 and 8, all are better off versus NSR where neither the upgrade nor the control equipment is installed.

d. All will vote unanimously against NSR. Voting for NSR is equivalent to getting zero, whereas all households and Ralph get positive benefits without NSR, since Ralph upgrades.

e. To get an efficient allocation, we need to have both the upgrade and the control equipment installed. An easy way to accomplish this is to tax the downwind households a total of \$7 million, and use the proceeds to reimburse Ralph for installing the equipment (perhaps give Ralph a subsidy or tax credit for installing the control equipment). Ralph will install the upgrade on his own, and total surplus will be $\$1 - \$7 + \$7 \text{ tax credit } = \$1$ for Ralph, $\$2 + \$8 - \$7 \text{ in taxes } = \$3$ for the downwind households, and $\$1 + 0 = \$1$ for the upwind households. Total surplus in this case is $\$1 + \$3 + \$1 = \$5$, equal to the maximum possible (from the last row, upgrading and installing gives a total surplus of $\$4 + \$1 = \$5$).

   Many studies have shown that there exist many old, coal fired power plants (especially in the Midwest) that are not being upgraded due to NSR. Since newer equipment tends to use less energy and emit less, even without the pollution control equipment, it is likely that NSR actually increases pollution.

Question 3 (12 points).

a. Production for firm one is $E_1 = \min(2, 1) = 1$ and for firm two $E_2 = \min(1, 2) = 1$. So two units are produced in total. But more could be produced by moving a unit of capital from firm one to two or a unit of labor from firm two to firm one. In the former case, production would be $E_1 = \min(1, 1) = 1$ and $E_2 = \min(2, 2) = 2$. A Pareto preferred allocation can then be achieved by giving the extra good to anyone.

b. The allocation is efficient. Production cannot be increased beyond 5.

c. The allocation is also efficient. Firm one has an extra unit of capital. But moving the unit of capital from one firm to another does not increase production.

Question 4 (20 points).

I drew the Edgeworth box with Dave in the lower left corner. The negative of the price ratio, or the slope of the budget line is $-p_f/p_s = -15/3 = -5$. Next, according to the problem, Dave starts with 4 filters and 6 cups of coffee. There is a total of 11 filters and 10 cups of coffee. So I have carefully drawn the endowment point, labeled 'A' on the graph, with the total available goods drawn as the size of the box. Next, Dave's MRS is -7 and Aaron's is -4, so at 'A', Aaron's slope is steeper.

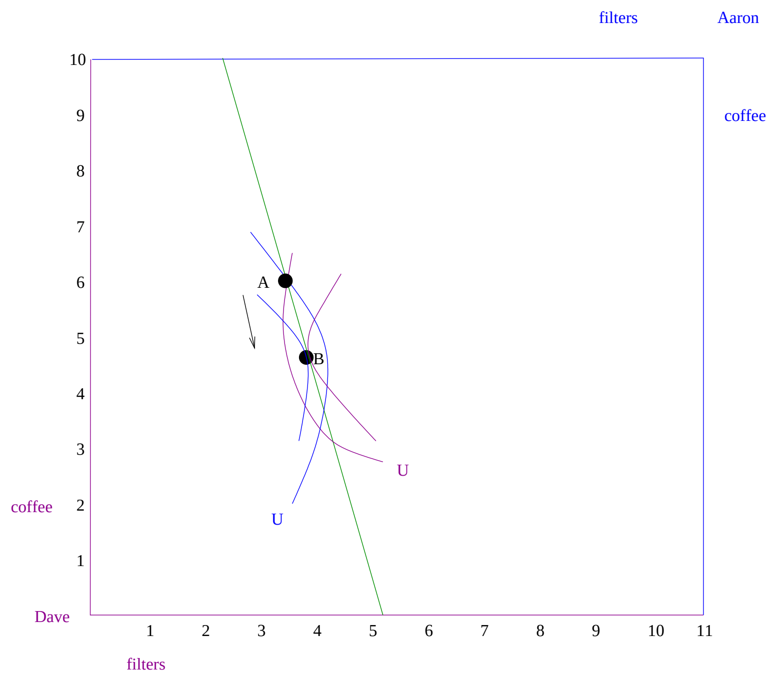

Figure 1: Edgeworth Box for Dave and Aaron.

a. Aaron's MRS indicates he is indifferent between 4 cups of coffee and one filter. However, the price ratio indicates if he sells 1 filter he has enough money to buy 5 cups of coffee. Therefore, Aaron can sells filters and buys coffee, and is better off.

b. At the market equilibrium, the MRS for both Aaron and Dave equals the price ratio (point B on the graph). Therefore, both Aaron and Dave will have an MRS of -5 at the market equilibrium.

Question 5 (20 points).

a. The slope of the iso profit line is also the negative of the price ratio (-5). At the market equilibrium, the marginal rate of transformation, $-\frac{5}{2}f$, equals the price ratio. Setting these two equal implies:

$$-\frac{5}{2}f = -5 \quad \rightarrow \quad f = 2. \tag{1}$$

Next, from the production possibilities frontier:

$$C = 8 - \frac{5}{4}f^2 = 8 - \frac{5}{4}2^2 = 3 \tag{2}$$

So 2 filters and 3 cups of coffee are produced.

b. Profits are revenues less costs. Revenues equal prices times quantities, so:

$$\pi = \$15 \cdot 2 + \$3 \cdot 3 - \$20 = \$19. \tag{3}$$

Here is a graph of the problem.

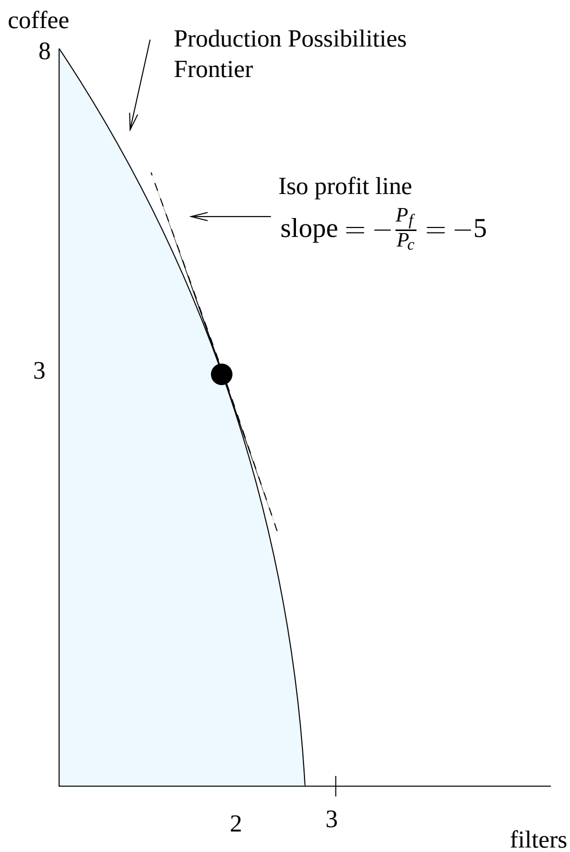

Figure 2: Production Possibilities set.

Question 6 (16 points).

a. Efficiency requires the MRTS to be equal across firms. Since the MRTS are not equal, removal of waste is not efficient.

Firm A has $MRTS^A_{LK} = .75$. That means that firm A can get the same production by reducing labor by one and adding 0.75 movers, or equivalently reducing labor by 4 and adding 3 movers. Firm J has $MRTS^J_{LK} = .25$. That means that firm J can get the same production by reducing labor by one and adding 0.25 mover, or equivalently reducing labor by 4 and adding one mover. Clearly firm J is more productive with movers: 1 mover is equivalent to 4 units of labor for J, while at firm A 3 movers is equivalent to 4 units of labor. Therefore, we want firm J to add movers and reduce labor.

b. Profit maximization requires the MRTS to equal the price ratio which is $\frac{w}{P_M} = \frac{1}{2}$. Since MRTS is 0.75, firm A is not maximizing profits. From the isocost line, firm A can increase labor by one and decrease movers by 0.5 without changing it's costs. Firm A could therefore reduce movers by 3 and add 6 units of labor (since $3/6 = 0.5$). But then production must go up, since production stays constant when we replace 3 movers with 4 units of labor. So firm A should increase labor and reduce movers to increase profits.

c. Conversely, if firm J increases movers by 1 and decreases labor by 4, production stays constant. Firm J saves $4 \cdot \$1 = \$4$ in labor costs, and pays an extra $1 \cdot \$2 = \$2$ in earth moving costs for a net savings of \$2. Since production stayed the same but costs fell, profits rose.