Practice problems 1 -- Solutions
Revised: October 11, 2001

1. (a) $Q = 10, P = $6.75
   (b) new $Q = 6, new $P = $5.25
   (c) If demand remained constant but supply decreased, the equilibrium price would increase. If demand remained constant but supply increased, the equilibrium price would decrease. If both demand and supply increased simultaneously, the new equilibrium would depend upon the ratio at which the two variables increased.
   (d) A flatter supply curve would imply a greater change in output and a smaller change in price.

2. (a) The tariff will shift the supply function upward, leading to a higher price and lower output. The extent of the price and output effects will depend on the slope of the demand curve. A very elastic (flat) demand curve implies that most of the effect will be on the output level. A very inelastic (steep) demand curve implies that most of the effect will be on price.

   Demand elasticity, in turn, depends on the nature of the product. For example, are there good substitutes for European cashmere products? In particular, if the tariff is imposed on European exporters only than it is likely that other alternative sources will become very competitive. This would imply that the demand for European cashmere products is very elastic and the impact of the tariff is primarily to reduce imports from Europe.

   (b) The answer depends, again, on the value of demand elasticity. Consider the extreme when the demand curve is flat. In this case, consumer surplus is zero both with and without the tariff. The cost of the tariff is entirely borne by European exporters, who now earn a lower margin (same price but lower net price) on a lower output level.

   Consider now the opposite extreme, that of a perfectly inelastic (vertical) demand curve. In this case, the tariff is entirely borne by consumers. European exporters continue to make the same profits: if the initial price was $p$, they now sell for $p + t$ and receive a net price of $(p + t) - t = p$.

   We conclude that a tariff on European cashmere sweaters is a useful retaliatory measure only if the U.S. demand is sufficiently elastic. The answer to (a) suggests that this is indeed the case.

3. One would expect demand to increase as a result of the NEJM article. In the short-run, supply is fixed. We would therefore observe a move along the supply curve, with both price and output going up. The extent of the price hike would depend on the steepness of the supply curve: the steeper the short-run supply curve is, the greater the price increase.
In the long-run, one would expect the supply function to expand, as new producers enter the market and existing producers expand their capacity. Assuming that demand is kept at the same level, this would correspond to a movement along the demand curve, with output going up and price going down.

To summarize: We would expect price to go up in the short-run, then back down in the long-run, possibly to almost the same level as the initial level. As to output, we would expect it to go up, with a greater increase in the long-run than in the short run.

4. (a) The supply curve of molybdenum is obtained by ordering the different possible sources by increasing value of marginal cost and then computing cumulative capacity (supply). Unfortunately, we do not have information about the marginal cost of non-AMAX mines. The best we can do is to assume that they have a marginal cost similar to AMAX’s, say, $4.50. We thus get the following values:

<table>
<thead>
<tr>
<th>Source</th>
<th>Cost ($/lb)</th>
<th>Capacity (M lbs)</th>
<th>Cumulative capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base metals by-product</td>
<td>0.50</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>AMAX Climax mine</td>
<td>4.00</td>
<td>49</td>
<td>124</td>
</tr>
<tr>
<td>AMAX Henderson mine</td>
<td>4.50</td>
<td>43</td>
<td>167</td>
</tr>
<tr>
<td>Rest of the world mines</td>
<td>4.50</td>
<td>60</td>
<td>227</td>
</tr>
</tbody>
</table>

Obviously, if capacity expansion takes place, then the supply curve will change.

(b) Without capacity expansion, a demand of 200 M lbs a year implies an equilibrium price of about 4.50. Even if capacity expansion takes place, it is likely that equilibrium price would remain at the same level. This is because expansion would take place at marginal cost levels greater than 4.50.

(c) It is possible (and it fact happened) that speculators have increased molybdenum inventories, so that, in the short run, demand is greater than 200 and price is pushed up.

(d) No. As it turns out, over the objections of its economics consultants, AMAX did go forward with the proposed investments. The price of molybdenum peaked in 1980 at an average price of $9.36/lb and then fell substantially. The U.S. Geological Survey lists the following average prices for molybdenum for the next few years:

<table>
<thead>
<tr>
<th>Year</th>
<th>Price ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>9.36</td>
</tr>
<tr>
<td>1981</td>
<td>6.40</td>
</tr>
<tr>
<td>1982</td>
<td>4.10</td>
</tr>
<tr>
<td>1983</td>
<td>3.64</td>
</tr>
<tr>
<td>1984</td>
<td>3.56</td>
</tr>
<tr>
<td>1985</td>
<td>3.33</td>
</tr>
<tr>
<td>1986</td>
<td>2.92</td>
</tr>
</tbody>
</table>

As of mid 1982 AMAX was running its molybdenum operations at less than 50% of capacity. The expanded Henderson and Climax mines closed temporarily in early 1983.

More recently, in 1997 the price for molybdenum was around $4.50/lb; in 1998 it was around $4.00/lb. Demand (market offtake) is about 100,000 metric tons per year -- not much
more than the 200 million pounds circa 1979. About 70% of molybdenum supply apparently comes through the copper refining by-product process. For further current information, see http://www.amm.com/ref/moly.htm and http://minerals.usgs.gov/minerals/pubs/commodity/molybdenum/470399.pdf

5. There are three opportunity costs:
   - The salary you could earn if you do not quit [$46k]
   - The interest income your savings could earn if you do not cash in [($200k)(0.06) = $12k]
   - The rent your building could earn if you do not use it for your restaurant [($2.5k)(12 months) = $30k]

There are four direct costs:
   - Maintaining the equipment [$4k]
   - Food [$50k]
   - Hiring extra help [$40k]
   - Utilities and supplies [$14k]

Note that the $200 k cost of the equipment is not an economic cost because it is essentially reversible. That is, you can always sell the equipment for its current market value as long as you maintain it. Only the interest you would have earned on the money tied up in the equipment and the cost to maintain it are economic costs.

Adding up opportunity and direct costs yields $196k. This is the break-even revenue for first year of operations.

6. (a) The train will imply a SW shift in the demand for air travel on the NY-Boston route. The shift would be most significant if the train were to take 2h:55m as initially planned. According to Vranich, the difference between plan and reality is significant; as things stand, the shift in demand will probably not be very significant.

   (b) The demand shift implies a decrease in output and price in the air travel market. In the short-run, the supply of air travel is likely to be fairly inelastic (flights are already scheduled). One would expect the impact of the demand shift to be felt mainly in the form of lower fares. In the long run, the price effect is likely to be less significant (more elastic supply). The main effect will be less air travel (and more train travel) on the NY-Boston route.

   (c) The important thing to keep in mind is that the cost of developing the train is essentially sunk. That being the case, the train should be deployed if it brings benefits with respect to the existing one. Even though, according to Vranich, the additional benefit is very small, so is the cost, too.

   Notice however that, if the cost corresponds to the actual train cars, then it is possible that they may be used elsewhere in the country. The cost would then not be sunk and should be taken into account.

7. (a) Total cost is 400K+10x25K = 650K. Average cost per ATM is thus 65K. (Answer would be different if only a part of the overhead cost can be allocated to Internet services.) Marginal cost per ATM is 25K. Strictly speaking, this is not MC since no. of ATMs is not a continuous variable.
(b) I will assume that the overhead cost is a fixed cost at the bank level, that is, so long as the bank remains open the cost must be paid. The answer would be different if a fraction of the overhead cost could be saved were all ATMs shut down.

In the short run, that is, given that the yearly lease for the ATMs has already been paid, no ATM should be shut down. I am assuming there is no operation cost in addition to the yearly lease. Given this assumption, the revenue is positive (and would be lost), whereas the marginal cost is zero, since the lease is a sunk cost.

In the long run, the lease is not a sunk cost. Given that, I would shut down the ATMs for which marginal cost is lower than marginal revenue: the two least profitable ATMs.

(c) If 50% of the lost revenue is picked up by other ATMs, then the “opportunity cost” of shutting down an ATM is not the current revenue but rather one half of that current revenue. Now it is worth shutting down the medium demand ATMs as well (the ones with $30,000 revenue): marginal cost is 25K whereas lost revenue is only 15K (possibly a little more since we will have shut down the least profitable ATMs and picked up some of that lost revenue).

The above applies to the long-run. In the short-run (i.e., given that the yearly lease has already been paid), it is still optimal not to shut down any of the ATMs.

8. (a) The $5 million you originally spent for the land, plant, and equipment is a sunk expenditure and thus not an economic cost. However, there is a “user cost of capital” associated with the land, plant and equipment, based on its current market value of $8 million and your cost of funds and the rate of depreciation or appreciation of the asset over the planning horizon. Your (opportunity) cost of investing $8 million for one year is $800,000, but these assets will appreciate by $480,000 over the year, giving a (net) user cost of capital of $320,000. (The depreciation rate is 6%). This is a fixed cost of making DRAM’s, to which we must add the other fixed costs of $500,000 to get a combined fixed cost of $820,000 for the year. The variable costs are a constant $4 per chip, so the cost function is $C(Q) = 820,000 + 4Q$, in the range of $0 < Q < 10,000,000$. (One could also report that $C(0) = 0$, by definition, and that $C(Q)$ is infinite for $Q > 10,000,000$, since your maximum capacity is ten million chips per year. Of course, in practice there would likely be a way to push production beyond “rated capacity,” at some cost penalty, but that is beyond the scope of this problem.)

(b) The average cost function is $AC(Q) = 820,000/Q + 4$, again up to ten million chips per year. This declines with Q, so the minimum AC is achieved at full capacity utilization. At ten million chips per year, the fixed costs come to $0.082 per chip, so average costs are $4.082 per chip. This is your minimum average cost, and thus the minimum price at which it makes sense to stay open for the year.

9. (a) The user cost of capital corresponding to the machine is given by 8% times $200,000 plus $(200,000-50,000)$, or simply $166,000. Divided by 100,000t this gives $1.66/t. Adding labor costs of $2.2/t, this gives a total of $3.86/t, the average cost. Marginal cost is $2.2/t up to 100,000t/year, infinity thereafter. The profit margin is therefore $6-$2.2=$3.8/t (up to 100,000t).

(b) We are considering the option of continuing to produce tomato pulp versus the
option of producing unprocessed tomato. There are two opportunity costs that need to be accounted for. First, by selling tomato pulp the farmer is foregoing the chance of selling unprocessed tomato. This opportunity cost amounts to the margin on unprocessed tomato, or $2.1/t. The second opportunity cost is that of the machine -- the user cost of capital. Since the machine is now worth only $50,000 and will last for one more year, the user cost of capital is given by $50,000 plus 8% times $50,000, or $54,000, which corresponds to $.54/t. The average economic profit, that is, including all imputed costs is, $5 (price) - 2.2 (labor) - .54 (cost of capital) - 2.1 (margin on unprocessed tomato) = $.16. Since this is positive, the firm should continue operating the machine and sell tomato pulp.

(c) By a calculation analogous to the one above, we conclude that the farmer is better off by switching to unprocessed tomato.

10. This problem is all about determining the economic cost of staying in business. The answer will depend on whether some of the expenses were already paid for the fourth year or not.

   Advertising: the $3m from the past three years are sunk. Assuming that advertising is necessary to stay in business, than $1 per year is an economic cost. I will assume that I have still not paid this for the fourth year.

   Servers. The crucial question is whether there is a market for these. I would have thought so, since this is normally standard equipment. Given that this type of equipment depreciates very rapidly, my guess is that either I pay $500,000 for the year or I sell the stuff for more or less the same amount. It follows that $500,000 is an economic cost.

   The wage bill is an economic cost. I am assuming that you can give your workers relatively short notice. (If this were Europe, things might be different; you might have to consider a large chunk of the wage bill a sunk cost, at least for the year.)

   Overhead is an economic cost. Again, I am assuming you have still not make any significant commitments for the current year.

   Finally, the $800,000 in rent payments are an economic cost insofar as I can leave the building on short notice. Typically, for these kinds of leases I would expect at least a six month notice, so I will consider $400,000 the relevant economic cost ($800,000 minus rent payments corresponding to the next six months, which I would have to pay even if I were to close now).

   All of this adds up to EC = $1m + $500,000 + $1m + $300,000 + $400,000 = $3.2m

   It follows that the optimal decision is to close down now. As mentioned above, if some of the expenses for Year 4 have already been made (e.g., half the advertising budget) then the decision would be reversed, as economic cost would fall below $3m. In that case, the optimal decision would be to close down at the end of the year.

11. (a) The fixed cost is given by 10 machines times $100k per machine; plus general overhead, $200k; plus the basic wage bill, which you pay regardless of how much you produce, $5m. Total is $6.2m

   The marginal cost has several components. Regarding labor, marginal cost is zero up to what can be produced with 40 hours of work. This is because you are going to pay
the basic wage bill regardless of how much you actually produce. For extra hours, the labor marginal cost is based on the hourly rate of $30/hour. Specifically, 40 hours/week times 50 weeks/year times 10 machines times 100 units/machine hour gives 200,000 units. Extra hours allow the factory to double production, so the maximum would be 400,000.

The other component of marginal cost is the input necessary for each component. It costs $5 for the first 100,000 units, $7 thereafter. Pulling all this together, we have that marginal cost is $5 for Q<100,000, $7 for 100,000<Q<200,000, and $37 (=30+7) for Q>200,000.

(b) If the market price is $15, then the optimal output level is 200,000. This is the highest level of Q such that price is greater or equal to marginal cost.

12. (a) When you watch a video, you are likely to want to eat popcorn. In fact, there are few times when you will eat popcorn other than when you what a video. We then conclude that video rentals and popcorn are complementary products. This implies that the indifference curves are square shaped. A decrease in prices or an income increase imply an increase in the consumption of popcorn and video rentals in the same proportion.

(b) CDs and audiotapes are alternative means of recording music. We thus have two substitute products, though less than perfect substitutes (different levels of sound quality, different degrees of convenience, etc). The indifference curves are likely to be between the extremes of (a) and a flat line (perfect substitutes). An increase in the price of CDs should then imply a decline in the demand for CDs and, most likely, an increase in the demand for audiotapes. An increase in income is likely to imply an increase in both demands.

(c) For the purpose of heating, electricity and heating fuel are very close substitutes. The situation would be similar to (b) only that the indifference curves are flatter.

13. (a) An increase in price to 110 leads to an estimate of elasticity of \( \frac{575-590}{110-105} \frac{105}{590} = -.53 \). An decrease in price to 100 leads to an estimate of elasticity of \( \frac{600-590}{100-105} \frac{105}{590} = -.355 \). We conclude that the value of the demand elasticity is somewhere between -.35 and -.53.

(b) Generally speaking, elasticity does not need to be constant at all levels of price. Simple calculations show that elasticity is not constant for this particular demand function. For example, a price change from $100 to $105 (5% increase) implies a decrease in demand from 600 to 590 (1.6% decrease), thus an elasticity of -.333. A price increase from 115 to 120 (4.3%) implies a decrease in demand from 550 to 510 (7.3%), thus an elasticity of -1.673.

(c) We would expect the quantity of phones demanded to increase at all price levels when the price of Internet access, a complementary product, decreases. However, it would be difficult to determine what the change in demand elasticity would be at any given point.
14.  (a) False. An increase in the price of gas implies a movement along the demand curve for gas.
   (b) True. The percent change in revenue is equal to the percent change in price times \((1+e)\). If \(e\) is greater than one in absolute value, then \((1+e)\) is less than zero.
   (c) False. \(A\) and \(B\) are complements if the cross-price elasticity is negative, so that an increase in the price of \(A\) leads to a decrease in the demand for \(B\) (and vice-versa).
   (d) In the short-run, fixed costs are sunk and should therefore be ignored in the process of decision making. If revenues exceed variable costs, then the firm should not shut down in the short run. In the long-run, however, the firm should shut down if its revenues do not cover its total costs. In summary, the sentence is true as it applies to the long run, but not the short run.
   (e) False. If \(A\) and \(B\) are complements, then an increase in the price of \(A\) implies a decrease in the demand for \(B\).
   (f) False. There is no reason why the demand elasticity should remain constant over time. In fact, the demand elasticity may very well be different for different levels of demand, and thus vary in time as quantity demanded varies.

15. Optimal monopoly pricing leads to the following relation between the price, marginal cost, and demand elasticity: \((p-MC)/p = 1/e\), where \(p\) is price, \(MC\) is marginal cost, and \(e\) is the elasticity of demand. In this problem, we have \((p-MC)/p=(100-40)/100\) or \(0.6\), which is greater than \(1/e=1/2=0.5\). This tells us that the price/cost margin is too high, so a lower price \($80\) would be optimal. It would be a mistake to use \(AC\) rather than \(MC\) for the purposes of calculating the price/cost margin.

16. A demand elasticity of 10 implies that AT&T's demand is very elastic. In fact, the author of the study that produced this estimate computes the welfare loss due to AT&T's market power to be less than 1% of sales volume.

17. (a) Given the elasticity of demand for long-distance, the optimal price is given by \(p = MC \times e/(e-1)\). The optimal price is thus \((0.05) \times 2 / 1 = .10\). Sprint should raise its price from 0.08 to 0.10.
   (b) The demand curve in this case has constant elasticity. The general formula for demand with constant elasticity is \(q=AQ^{-e}\), where \(A\) is a positive constant. We can find \(A\) in this problem by substituting \(p\) and \(Q\) (\(p=8\); \(Q=200\)) into the formula. The result is that \(A=12,800\). Substituting the optimal value \(p=.10\) into the above, \(q=(12,800)(.10)^{-2}\), gives 128 million minutes a day.
   The contribution to fixed cost is \(128(.10-.05) = $6.4m\). Repricing yields higher profits of $400,000 per day.

18. (a) (i) It is correct to say that development costs should not be taken into account. However, the fact that price is greater than average variable cost does not necessarily imply that such price is optimal.
   (ii) Optimal price is \(p = MC/(1+1/e)\). Given \(e=-2\) (which is confirmed by the above demand data), we have \(p = 2\) \(MC\). Marginal cost is \$7.2, so it follows that \(p = 14.4\). That’s an increase of 44% with respect to current price, so 10% would not be
(iii) Development costs are a sunk cost. They should therefore be ignored in the firm’s decision making. The only exception is the possibility of bankruptcy. If, taking into account the interest the firm is paying as well as other costs, the firm is losing money even when it sets price at the optimal level, then the firm would be better off by declaring bankruptcy.

(b) I would create two different versions of the software, one of greater value than the other one. If necessary, I would disable some of the functions from the full version and call that the “student version”. I would then price the student version at a lower price, so that each version would be purchased by the respective type of consumer. In order for this to work, I would need to make sure that there is no incentive for the high-valuation consumers to purchase the low-quality version instead of the high-quality version. In other words, I would need to check that the “incentive-compatibility” constraint is satisfied. This may imply that the full-version price is lower than the willingness to pay by high-valuation consumers.

19. (a) \[
\frac{22-25}{11-10} \times \frac{10/25}{} = \frac{-30/25}{} = -1.2
\]
(b) \%\ var in D = \%\ var in P \times \text{elasticity} = \frac{(12-11)}{11} \times (-1.2) = 9.1(-1.2) = -10.9\%. \text{ Final value of } D = 22 (1-10.9\%) = 19.6. \text{ Since } |e| \text{ is greater than one, we would expect revenue to decrease.}
(c) \[p = \frac{MC}{1+1/e} = 2/(1-1/1.2) = 12. \text{ This assumes that elasticity is constant for all values of } q.\]
(d) One would expect demand to decrease, as substitute products (generics) appear in the market.
(e) It’s hard so say what would happen to the demand elasticity. In fact, empirical evidence shows that branded drugs’ prices sometimes increase, sometimes decrease, following patent expiry. This suggests that there is no clear, unambiguous pattern of the effect of generics on demand elasticity.

20. (a) First notice that \[
\frac{(60-50)}{50} = 20\%. \text{ Second, } -30\%/20\% = -1.5. \text{ We conclude the elasticity is } -1.5.
\]
(b) It makes sense to assume printing costs are proportional to printing costs. If printing costs are 20\% of total production, or \[25\% \times 24m = 6m. \text{ Total circulation per year is } 200k \times 300, \text{ or } 60m. \text{ Dividing } 6m \text{ by } 60m, \text{ we get } 10c \text{ per copy.}
\]
(c) \[MR = p \times (1+1/e) = 50c \times (1-1/1.5) = 50c \times (1-.666) = 16.666c.\]
(d) Marginal revenue is greater than marginal cost; you should therefore decrease price (in order to increase circulation).
(e) \[p \times (1+1/e) = MC \text{ implies } p \times (.333) = 10, \text{ or simply } p = 10/(.333) = 30c.\]

21. (a) False: markets with lower demand elasticity (e.g., water) tend to have a high consumer surplus.
(b) True: since price is constant, price is the only component of marginal revenue.
(c) Ambiguous. The sentence is true in the case of perfect competition. However, there are competitive markets (i.e., markets where firms are price takers) where simultaneously entry and exit may take place.
(d) False: natural monopoly is the situation where total costs are minimized when there is only one active firm.
(e) False: prices should be lower the greater the absolute value of the demand elasticity.
(f) False: price should be greater the greater the level of marginal cost.
(g) True.

22. Light bulbs are a generally used homogeneous good. External suppliers enjoy economies of scale and specialization and supply the entire industry. In contrast, the plastic exterior cover must be custom-designed and manufactured for each make and model. Because it requires more Relationship Specific Investment (RSI), it is more likely to be made in-house.

23. Jet engines are marvelously idiosyncratic. The knowledge, tools and parts needed to service one family (brand) of engines do not transfer fully across brands. One firm does not typically service each airport because the economies of scale (across brands) are small and the economies of specialization (within brand) are large. The only thing worse for an airline than an AOG (an aircraft sitting on the ground with a broken engine) is an aircraft flying with a broken engine or two. To ensure their reputation and revenues and to avoid ex post hold up, airlines demand before purchasing an aircraft that engine makers pre-commit capital to ensure that parts and service are available at major stations world-wide. Because the skills to do this are RSIs, and because the engine owner's reputation is at stake, to sell engines and credibly commit to keeping them running, each manufacturer must provide service and support at major stations.

Subcontracting would be difficult because of the RSI required (the subcontractor would fear hold-up) and because a poor subcontractor would impose a negative externality on the manufacturer. When the jet goes down, the manufacturer's reputation will suffer on a scale beyond any contractual penalty a subcontractor could likely be held to, so the work is not usually subcontracted. In addition, the manufacturers benefit directly from direct feedback within the firm on the performance of the engines they produce. This information may flow more readily within the firm than across firms.

Some airlines with sufficient scale do perform their own routine engine maintenance at their own maintenance bases. However, the airlines cannot efficiently do emergency engine repairs away from an airline's main bases. While there are enough GE engines going through Karachi International Airport to justify an on-site GE technical support staff, most airlines do not have enough flights through Karachi to justify the investment. The economies of scale in non-routine work are site and engine specific, not generally airline specific.

24. Refer to the lectures on the vertical and horizontal boundaries of the firm.

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