

I. Competitive Equilibrium

1. (a) Suppose a competitive industry consists of two firms. One has a U-shaped average cost curve that reaches a minimum of \$1; the other has a U-shaped average cost curve that reaches a minimum of \$2. Show that the aggregate supply curve has at least one “gap” in it.
(b) If the aggregate supply curve in a market has a “gap” in it, there might be no market equilibrium. Explain carefully why.
2. Using graphs, prove the following proposition: “Suppose an industry is composed of two non identical firms. (Call them A and B) The two firms are competitive, and each has a U-shaped average cost curve. Then it may be impossible for demand to equal supply.” Explain your answer thoroughly.
3. (a) A competitive industry has only two firms, *A* and *B*. On the basis of Figure 1, what is the graph of the industry supply curve? Be sure to label the important points of the graph with numbers.
(b) Explain what is going on in Figure 2. (That is, explain why the supply curve may look as it does and what market price and quantity might be).
4. (a) Under what circumstances is the Long Run Average Cost curve U-shaped? When the Long Run Average Cost curve is U-shaped, will the Long Run Supply curve have a gap in it?
(b) Under what circumstances is the Short Run Average Variable Cost curve U-shaped? When the Short Run Average Variable Cost curve is U-shaped, will the Short Run Supply curve have a gap in it?
(c) Under what circumstances is the Short Run Average Total Cost curve U-shaped? When the Short Run Average Total Cost curve is U-shaped, will the Short Run Supply curve have a gap in it?
5. (a) Prove that all short-run average total cost curves are U-shaped. Part of your answer should involve sketching a short-run total cost curve.
(b) If a firm’s production function has increasing returns to scale, is its average cost curve falling, constant, rising, or none of the above? Exactly why is this so?

- (c) What sort of returns to scale does a firm have to have in order for its long-run average cost curve to be U-shaped? Why?
 - (d) Graphically illustrate why U-shaped average cost curves might cause nonexistence of a competitive equilibrium.
6. A perfectly competitive firm has total costs TC of the form

$$TC = q^2 + 1$$

where q is the quantity of production by the firm. This implies a marginal cost curve of

$$MC = 2q.$$

- (a) If price is \$4, what are the firm's profits or losses? (Hint: this firm has a U-shaped average cost curve. Figure out where $AC = MC$ and sketch a graph of AC and MC .)
 - (b) Suppose the entire industry has only one other firm, which is identical to the first one. Sketch the market supply curve, giving the coordinates of at least two points on its rising portion.
7. Suppose there are 10 firms in a competitive industry, and each firm has a marginal cost curve

$$MC = q^2.$$

If the market demand curve is

$$P = 11 - Q,$$

find the equilibrium P and Q .

Hint. Depending on how you work the problem, it might come in handy to know that $x^2 + 10x - 11 = (x + 11)(x - 1)$, or that $x^2 + 100x - 1100 = (x + 110)(x - 10)$.

8. (a) Does Figure 2B represent an increasing-, decreasing-, or constant-cost industry? Why?
- (b) Suppose that the demand curve D in Figure 2B shifts downward to a new demand curve D' . (Draw D' .) Mark the new short-run equilibrium in Fig. 2B. Are the firm's profits in the new short-run equilibrium positive or negative or zero? Why?

- (c) Mark the new long-run equilibrium on Figure 2B. Draw the location of Figure 2A's average cost curve in the new long-run equilibrium. Explain how this makes sense in light of your answer to part (a).
 - (d) What are the firm's profits in the new long-run equilibrium? Why?
 - (e) Is the number of firms larger, smaller, or the same in the new long-run equilibrium compared with the old long-run equilibrium, or can you not tell? Why?
9. Using two diagrams, one for a typical firm and one for the industry as a whole, derive the shape of the very long run supply curve in a competitive increasing cost industry by assuming that an initial very long run equilibrium point is disturbed by a *fall* in demand. Assume that each firm has first increasing and then decreasing returns to scale.
 10. Suppose a decreasing-cost industry is in very long run equilibrium, and that the demand curve suddenly shifts *DOWN*. By showing what happens in the market and what happens to each individual firm, derive the slope of the very long run supply curve.
 11. By sketching a graph, show that one can have an increasing returns to scale firm in an increasing-cost industry, but that increasing returns to scale is inconsistent with very long run competitive equilibrium.
Also show that one can have a decreasing returns to scale firm in an increasing-cost industry, but that decreasing returns to scale is inconsistent with very long run competitive equilibrium.
 12. Is a production function of the form $Q = 3W^{1/3}F^{3/4}$ compatible with competitive very long run equilibrium? Why or why not?
If the production function were $Q = W^\alpha F^\beta$, then what values of α and β would be compatible with competitive very long run equilibrium?
 13. A competitive decreasing-cost industry is in long run competitive equilibrium at price P^* and quantity Q^* . Suppose the government establishes P^* as a price floor for this market. Why might the government be surprised at the very-long-run effect of its price floor if demand shifted down? Explain thoroughly with a graph. Be sure to include in your graph the initial and final short run supply curves if there is no

price floor, as well as all the other important curves. Trace out and explain the entire adjustment process if there were no price floor.

14. Suppose that for each firm in an industry, average costs are U-shaped and minimum average cost always occurs at $q = 1$. Also, take as given the following chart.

# Firms	Minimum Average Cost for each firm
5	15
10	10
15	15
20	20
25	25
30	40

(see Figure 1).

- (a) Sketch the very-long-run supply curve. Does this industry have constant-, increasing-, or decreasing-cost? What kinds of returns to scale does each firm have?
- (b) Give the very-long-run equilibrium price, quantity and number of firms if the market demand curve is given by $P = 20 - Q$. Sketch the market demand curve and explain your answer.
15. (a) Sketch the total revenue curve and the very long run total cost curve of a perfectly competitive firm with constant returns to scale, assuming that the firm shuts down in the long run.
- (b) Suppose that in this example, the price of the firm's output is \$2/bushel and its average costs are \$3/bushel. What is the algebraic expression for the firm's total profit curve (profit π versus quantity Q)? Is marginal profit equal to zero at the firm's optimal choice of Q ? If not, what is its marginal profit at the optimal Q ?
16. Suppose that wheat is produced under perfectly competitive conditions. Individual wheat farmers have average cost curves as in Figure 1. If the market demand curve is given by

$$Q_D = 72 - 4P,$$

what is the very long run equilibrium price of wheat? What is the very long run equilibrium quantity of wheat produced by each firm? How many firms are there in very long run equilibrium?

17. Suppose there are 10 identical firms in an industry. The total cost curve of each firm is $TC = \frac{1}{2}q^2 + wq$ and the marginal cost of each firm is $MC = q + w$, where q is the production of each firm and w is the wage rate of workers in this industry. Suppose $w = 1.9Q$ where Q is the total industry production.
- Is this an increasing-, decreasing-, or constant-cost industry? Why?
 - Give the algebraic equation of the industry supply curve. (This should be Q as a function of p with no w involved.)
 - Suppose quantity demanded is given by $Q^D = 6 - p$. Find the equilibrium price, market quantity, and wage rate.
18. Suppose the long-run average cost curve for one competitive firm is given by $LRAC = (q - 10)^2 + 1 + N$, where N is the number of firms in the industry. Figure 6 is a sketch of this.
- Is this a decreasing-, constant-, or increasing-cost industry, or can you not tell?
 - What is the very long run equilibrium price, supposing that N is known?
 - What is the very long run equilibrium quantity of this one firm, q ? What is the very long run equilibrium quantity for the whole industry of N firms if all the firms are identical?
 - Suppose the market demand curve is given by $P = 100 - Q$. Find the very long run equilibrium P , Q , and q , if all the firms are identical.

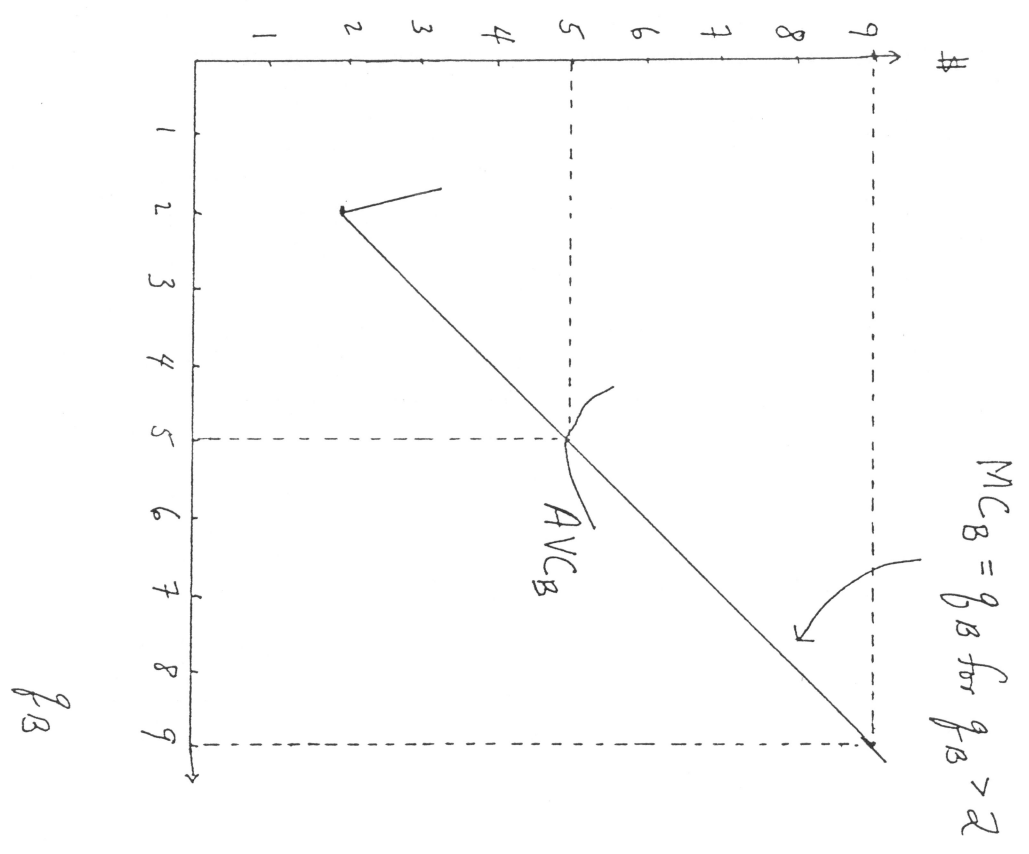
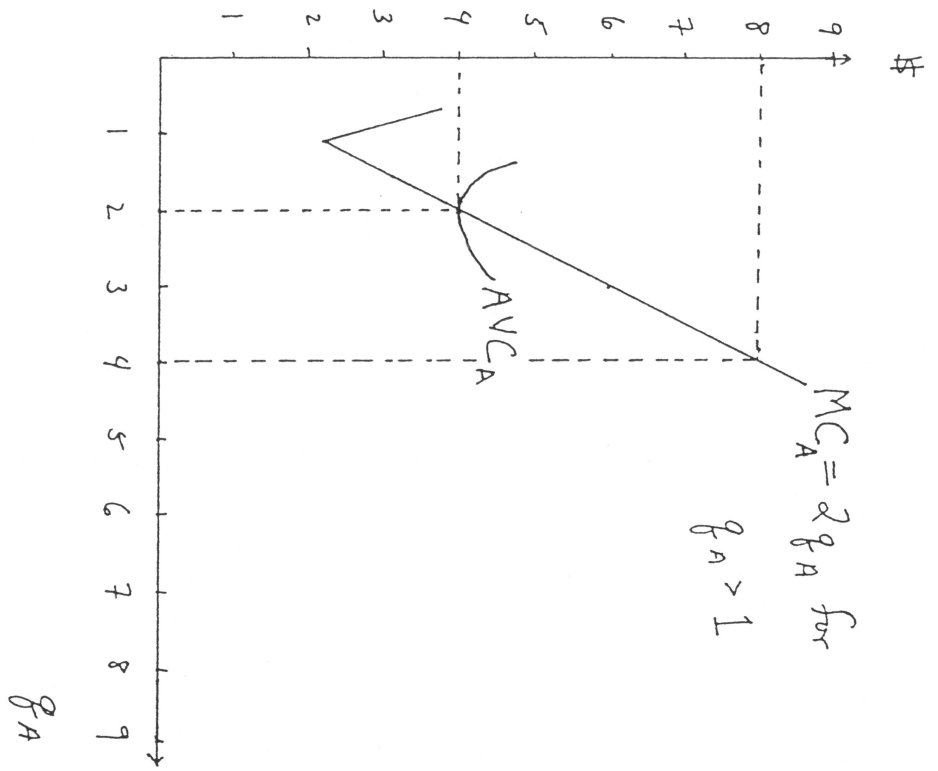


Fig. 1

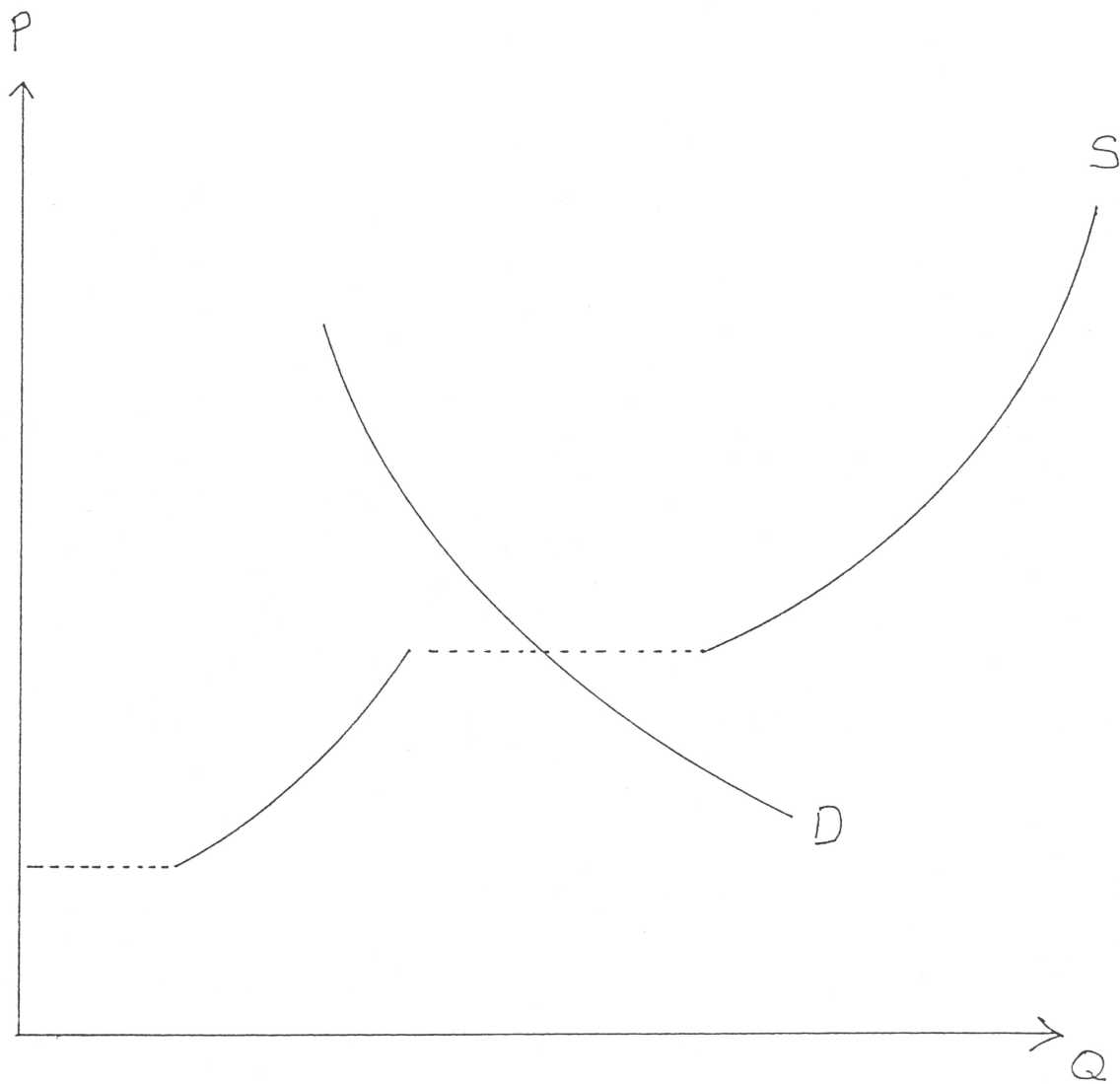
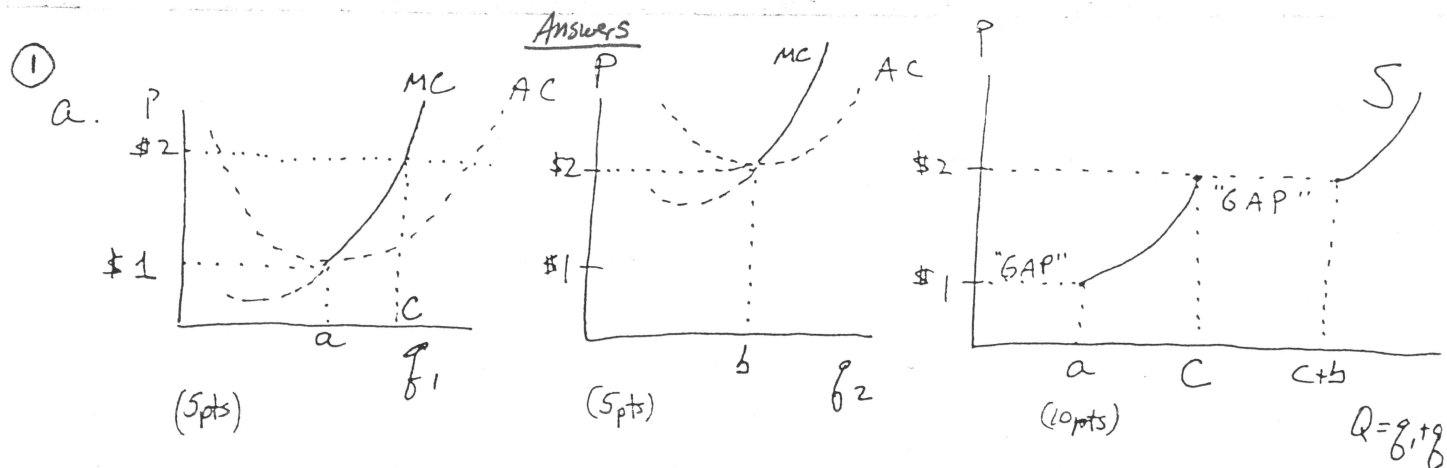


Fig. 2

Question 3's Fig. 2



This is a process of constructing the aggregate supply curve from the MC curves of two firms. At $p < \$1$, $q_1 = 0$ and $q_2 = 0$, so $Q = 0$. At $p = \$1$, $q_1 = 0$ or a and $q_2 = 0$, so $Q = 0$ or a . * Between $p = 1$ and $p = 2$, $q_2 = 0$ and q_1 is between a and c . At $p = 2$, $q_1 = c$ and $q_2 = 0$ or b , so $Q = c$ or $b + c$. Above $p = 2$, $q_1 > 0$ and $q_2 > 0$.

b. The market demand curve might go through the "gap":



At $p > 2$, $S > D$; at $p < 2$, $D > S$; at $p = 2$, either $S < D$ or $D < S$, depending on which point the firms choose to produce.

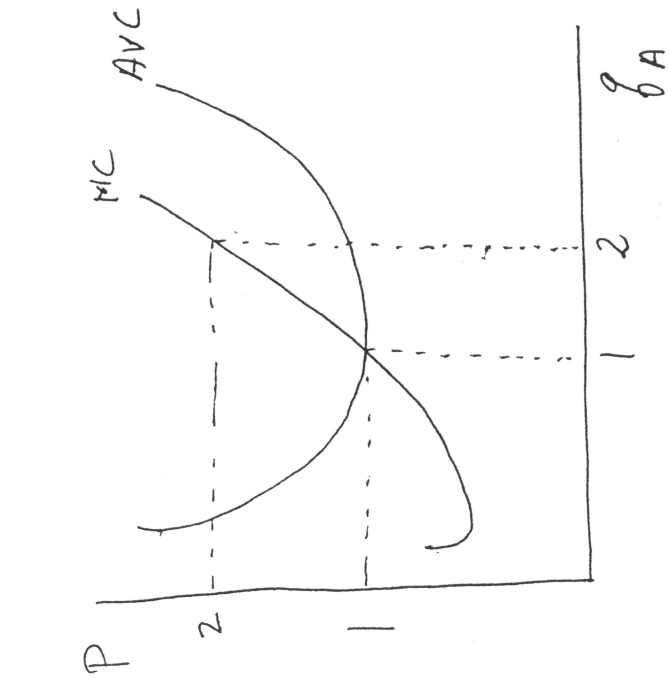
* Reason: To go from p to q , you know that p will equal MR (marginal revenue) — so MR is a horizontal line at p . Where this horizontal line intersects MC, that is the profit-maximizing q , unless that q results in $AC > p$. If it does result in $AC > p$, then some other q (perhaps $q = 0$) will be profit-maximizing.

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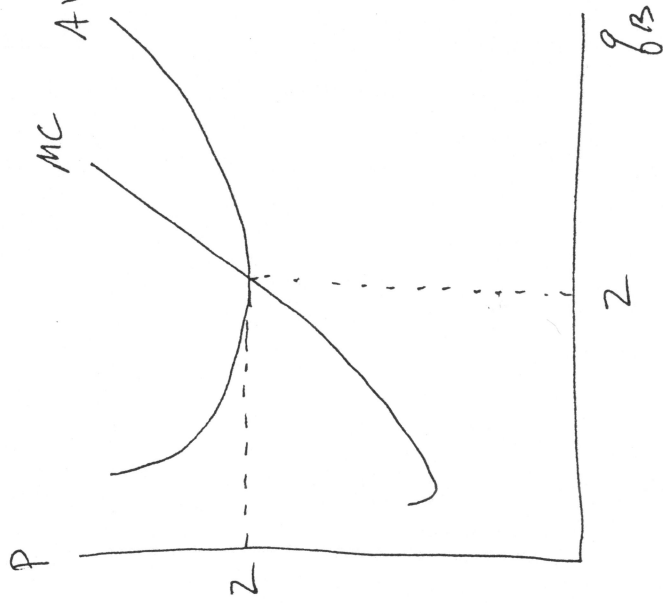
Given AVC curves as in the first two figures on the next page, Industry Supply looks as in last figure.* If the market demand curve is in the position shown, then there's no way to get supply equal to demand: At prices just under \$2, $q_A \approx 2$ and $q_B = 0$. At prices just over \$2, $q_A \approx 2$, $q_B \approx 2$, so $Q \approx 4$. At \$2 exactly, $q_A = 2$ and $q_B = 0$ or 2, so Q is 2 or 4. Hence there's no way to get a Q strictly between 2 and 4.

This is also true if the demand curve is in the gap between $Q=0$ and $Q=1$.

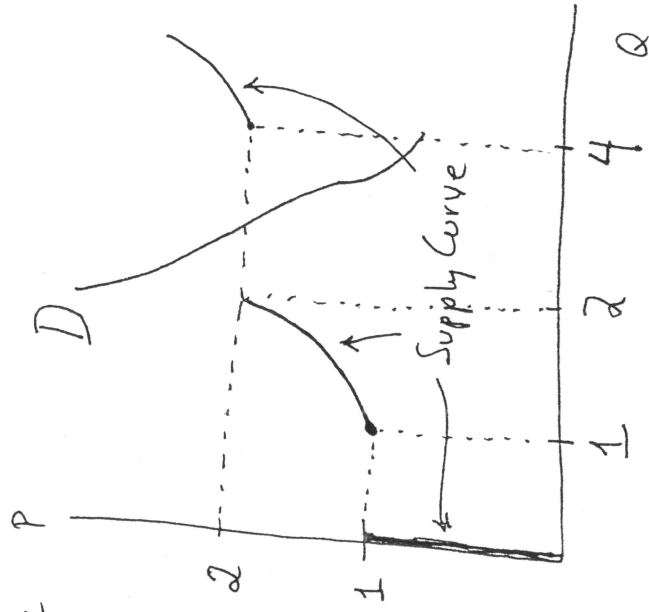
* For the reasoning, see the answer to the previous question.



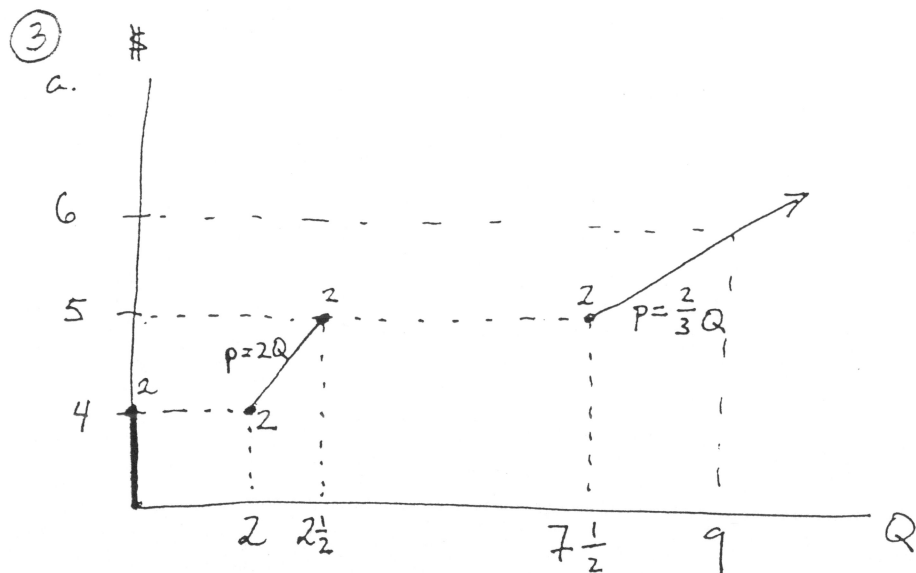
Firm A



Firm B



Industry



- b. U-shaped average costs: firms enter with a large minimum quantity once price hits min AC [10]

P will probably be at the "----" line, and Q at the L of this line since if a firm entered to bring Q to the R point on the line, it could not sell all its production. Q at the L of the line would be a permanent state of excess demand. [5]

The supply curve has a gap : { in the short run, when there is an initial region of increasing returns ;
in the long run, when there is an initial region of increasing returns to scale .

In both these cases, firms either produce zero or they produce at least a certain minimum quantity which is strictly positive.

Let $\hat{p}$ denote the price at which the D curve intersects the dotted line

in the figure given in the question.

If price were greater than $\hat{p}$

there would be excess supply. If price were less than $\hat{p}$ there would be excess demand.

At $\hat{p}$ there is either excess supply or excess demand. So there is no equilibrium price.

The best guess as to what would happen would be a price of $\hat{p}$ and production at the left end of the dotted line (permanent excess demand), because the opposite possibility — permanent excess supply — would lead to the absurdity of ever-increasing inventories. Another possibility is alternating in time between production at the left and right sides of the dotted line, but this wasn't discussed in class.