H. Profit

1. Using Figure 1, show that the competitive firm with these cost curves will not produce strictly between 0 and 10 units of output in the long run; also show that it might produce somewhere between 0 and 10 units of output in the short run.

2. Below Figure 3, draw a graph with Figure 3's average revenue, marginal revenue, long run average cost, long run marginal cost, optimal level of output, and the amount of profit. Show the optimal level of output and the amount of profit in Figure 3 too.

3. A firm produces corn Q from water W and fertilizer F. Suppose the firm's production function has no region of increasing returns; it has diminishing returns everywhere. Also, suppose the firm is in the short run, with F as the fixed input.

   (a) Sketch the total product of water curve (Q on the vertical axis, $W|_F$ on the horizontal axis). Explain what this has to do with diminishing returns.

   (b) Derive from this the variable cost curve. Do not give a long explanation; a couple of phrases are enough.

   (c) From your variable cost curve, derive the marginal cost curve and the average variable cost curve. Put these two curves on the same graph, and make the graph rather big.

   (d) On the graph you just drew, draw in the average total cost curve, given the following two hints: the average total cost curve is U-shaped, and when average total cost is at a minimum, it equals marginal cost. (If you were not able to figure out how the marginal cost and average variable cost curves should look, make a guess.)

   (e) Suppose this is a competitive firm, and price is a little below the minimum point of average total cost.

      i. Answering (i) is optional, so its type is small: Using the graph you drew in part (d), sketch the graph of "total revenue minus variable costs" versus quantity. Label the value/values of Q at which this curve reaches a (local) minimum or maximum; relate these points to something going on in the graph from part (d).

      ii. Sketch the graph of profit versus quantity. Where is marginal profit equal to zero?

iii. What is the optimal quantity for the firm?

4. A firm produces corn Q from water W and fertilizer F. Suppose the firm's production function has an initial region of increasing returns, but that it does obey the Law of Diminishing Returns. Also, suppose the firm is in the short run, with F as the fixed input.

   (a) Sketch the total product of water curve (Q on the vertical axis, $W|_F$ on the horizontal axis). Explain what this has to do with diminishing returns.

   (b) Derive from this the variable cost curve. Do not give a long explanation; a couple of phrases are enough.

   (c) From your variable cost curve, derive the marginal cost curve and the average variable cost curve. Put these two curves on the same graph, and make the graph rather big.

   (d) On the graph you just drew, draw in the average total cost curve, given the following two hints: the average total cost curve is U-shaped, and when average total cost is at a minimum, it equals marginal cost. (If you were not able to figure out how the marginal cost and average variable cost curves should look, make a guess.)

   (e) Suppose this is a competitive firm, and price is a little below the minimum point of average total cost.

      i. Answering (i) is optional, so its type is small: Using the graph you drew in part (d), sketch the graph of "total revenue minus variable costs" versus quantity. Label the value/values of Q at which this curve reaches a (local) minimum or maximum; relate these points to something going on in the graph from part (d).

      ii. Sketch the graph of profit versus quantity. Where is marginal profit equal to zero?

      iii. What is the optimal quantity for the firm?

5. This question involves drawing eight graphs, so you might not want to make each graph huge.

   (a) Sketch, on one graph, the marginal cost curve, average variable cost curve, and (short run) average total cost curve when diminishing returns begins immediately. (Hint: in this case the average total cost curve is U-shaped but the marginal cost curve and the average variable cost curve are always upward-sloping.)

In the parts of this question which follow, I will refer to the bottom of the average total cost curve as a (really, $\$a$/bushel) and the bottom (lowest point) of the marginal cost curve as b (really, $\$b$/bushel). Also, in the parts of this question which follow, assume that the firm is competitive.

(b) Underneath the graph you sketched in part (a), sketch a graph of total profit versus quantity if the market price is above a.

(c) Re-draw the graph you sketched in part (a), then underneath it sketch a graph of total profit versus quantity if the market price is equal to a.

(d) Re-draw the graph you sketched in part (a), then underneath it sketch a graph of total profit versus quantity if the market price is between a and b.

(e) Re-draw the graph you sketched in part (a), then underneath it sketch a graph of total profit versus quantity if the market price is below b.

As always, explain your answers.

6. This question involves drawing eight graphs, so you might not want to make each graph huge. As always, explain your answers.

(a) Sketch, on one graph, the marginal cost curve, average variable cost curve, and average total cost curve when each of these curves is U-shaped.

In the parts of this question which follow, I will refer to the bottom of the average variable cost curve as a (really, $\$a$/bushel) and the bottom of the marginal cost curve as b (really, $\$b$/bushel). Also, in the part of this question which follow, assume that the firm is competitive.

(b) Underneath the graph you sketched in part (a), sketch a graph of total profit versus quantity if the market price is a.

(c) Re-draw the graph you sketched in part (a), then underneath it sketch a graph of total profit versus quantity if the market price is between a and b.

(d) Re-draw the graph you sketched in part (a), then underneath it sketch a graph of total profit versus quantity if the market price is below b.

(e) Re-draw the graph you sketched in part (a), then underneath it sketch a graph of total profit versus quantity if the market price is exactly b.

7. This question involves drawing six graphs, so you might not want to make each graph huge. As always, explain your answers.

   (a) Sketch, on one graph, the marginal cost curve and average cost curve when the production function has decreasing returns to scale.

   In the parts of this question which follow, I will refer to the bottom of the average cost curve as a (really, \$$a$/bushel). Also, in the parts of this question which follow, assume that the firm is competitive.

   (b) Underneath the graph you sketched in part (a), sketch a graph of total profit versus quantity if the market price is above a.

   (c) Re-draw the graph you sketched in part (a), then underneath it sketch a graph of total profit versus quantity if the market price is a.

   (d) Re-draw the graph you sketched in part (a), then underneath it sketch a graph of total profit versus quantity if the market price is below a.

8. This question involves drawing eight graphs, so you might not want to make each graph huge.

   (a) Sketch, on one graph, the marginal cost curve and average cost curve for a firm which has first increasing and then decreasing returns to scale.

   In the parts of this question which follow, I will refer to the bottom of the average cost curve as a (really, \$$a$/bushel) and the bottom of the marginal cost curve as b (really, \$$b$/bushel). Also, in the parts of this question which follow, assume that the firm is competitive.

   (b) Underneath the graph you sketched in part (a), sketch a graph of total profit versus quantity if the market price is above a.

   (c) Re-draw the graph you sketched in part (a), then underneath it sketch a graph of total profit versus quantity if the market price is a.

(d) Re-draw the graph you sketched in part (a), then underneath it sketch a graph of total profit versus quantity if the market price is between a and b.

(e) Re-draw the graph you sketched in part (a), then underneath it sketch a graph of total profit versus quantity if the market price is below b.

As always, explain your answers.

9. A firm produces an output Q which sells for a price of \$20 per unit regardless of what the firm does. The firm's short-run costs are as follows:

- Fixed Cost $= 50$
- Variable Cost $= 0.1Q^2 + 10Q$
- Marginal Cost $= 0.2Q + 10$.

What output should the firm produce? Do not forget to consider the possibility that the firm might choose $Q = 0$.

10. A firm has marginal costs $MC(Q) = Q$. It divides its total output, Q, into the amount it sells in Tasmania (Q_T) and the amount it sells in Las Vegas (Q_{LV}); hence, $Q = Q_T + Q_{LV}$. The marginal revenue curve in Tasmania is

$$MR_T(Q_T) = 1 - Q_T\,,$$

and the marginal revenue curve in Las Vegas is

$$MR_{LV}(Q_{LV}) = 1 - 2Q_{LV}\,.$$

Show that the firm decides to produce 3/5 unit, 2/5 for Tasmania and 1/5 for Las Vegas.

11. A firm has one plant with marginal costs $MC(Q)$, where Q is the firm's total production. It sells in two markets, A and B, each with its own demand curve and marginal revenue curve $MR_A(Q_A)$, $MR_B(Q_B)$ (where Q_A is the firm's sales in market A and Q_B is its sales in market B). What is the algebraic relationship between:

(a) Q, Q_A, and Q_B?

(b) $MR_A(Q_A)$ and $MR_B(Q_B)$?

(c) $MC(Q)$ and $MR_A(Q_A)$?

(d) $MC(Q)$ and $MR_B(Q_B)$?

Now suppose a firm has two plants, 1 and 2, with marginal costs $MC_1(Q_1)$ and $MC_2(Q_2)$ (where Q_1 is the quantity produced in plant 1 and Q_2 is the quantity produced in plant 2). The firm sells in one market which has a marginal revenue curve of $MR(Q)$, where Q is the firm's total sales. What is the algebraic relationship between:

(e) Q, Q_1, and Q_2?

(f) $MC_1(Q_1)$ and $MC_2(Q_2)$?

(g) $MR(Q)$ and $MC_1(Q_1)$?

(h) $MR(Q)$ and $MC_2(Q_2)$?

Very briefly explain why all your answers are correct.

12. A competitive firm's production function yields isoquants as in Figure 1. It faces the following prices for water W, fertilizer F, and corn Q:

$$P_w = 1$$
$$P_f = 2$$
$$P = 3.$$

(a) If the firm wishes to produce 1 bushel of corn, approximately what W and F will it buy?

(b) If the firm wishes to produce 1 bushel of corn, approximately what will it spend on inputs?

(c) Answer questions (a) and (b) for 3 bushels of corn.

(d) Sketch a graph of total revenue versus quantity, for quantity between 0 and 4.

(e) If $C(q)$ is the cost function of the firm, use the answers to parts (a)–(c) to graph $C(1)$ and $C(3)$ on the graph in part (d). Does an output of 1 bushel or an output of 3 bushels yield higher profits?

13. A farmer uses water (W) and fertilizer (F) to produce corn (Q). Three isoquants are given in Figure 1. Suppose that the price of water is \$2/gallon and the price of fertilizer is \$1/pound.

(a1) If the farmer wishes to produce 10 bushels of corn, how much W and F will he buy? What will his total costs be? (Answer to the second question: about \$50.)

(a2) If the farmer wishes to produce 20 bushels of corn, how much W and F will he buy? What will his total costs be? (Answer to the second question: about \$80.)

(a3) If the farmer wishes to produce 30 bushels of corn, how much W and F will he buy? What will his total costs be? (Answer to the second question: about \$120.)

(b1) Suppose the farmer has made a commitment to buy exactly 40 pounds of fertilizer no matter what. Now how much W will he buy if he wants to produce 10 bushels of corn? What are his total costs? (Answer to the second question: about \$55.)

(b2) Suppose the farmer has made a commitment to buy exactly 40 pounds of fertilizer no matter what. Now how much W will he buy if he wants to produce 20 bushels of corn? What are his total costs? (Answer to the second question: about \$80.)

(b3) Suppose the farmer has made a commitment to buy exactly 40 pounds of fertilizer no matter what. Now how much W will he buy if he wants to produce 30 bushels of corn? What are his total costs? (Answer to the second question: about \$140.)

(c) Sketch 4 points on the farmer's long run total cost curve (for $Q = 0$, 10, 20, and 30). Also sketch 4 points on the farmer's short run total cost curve when F is fixed at 40 lbs. (for $Q = 0$, 10, 20, and 30). [Hint: you can do this even if you could not do parts (a)–(b), using the answers to (a)–(b) that I have given you.]

Based on the answer to part (c), also answer the following.

(d) Suppose the price of corn is \$5/bushel. Which of the following levels of output would the above firm prefer to produce in the long run: 0, 10, 20, or 30 bushels?

Hint: One way to start working this problem is to use your answers to part (c) to fill in the following table:

Q	TR	TC	π
0			
10			
20			
30			

(e) Answer part (d) for the short run instead of the long run. The hint from part (d) also helps for this question.

14. A firm produces corn C (measured in bushels) from water W (measured in gallons) and fertilizer F (measured in pounds) according to a production function whose isoquants are graphed in Figure 2. A consumer gets utility from consumption of corn and consumption of soda pop SP (measured in cans); his indifference curves are given in Figure 3. Denote the consumer's income by I, and denote prices by P. Then if

$$
\begin{aligned}
P_F &= \$3/\text{lb} \\
P_W &= \$1/\text{gal} \\
P_{SP} &= \$4/\text{can} \\
I &= \$24,
\end{aligned}
$$

find the equilibrium price and quantity of corn, assuming that the firm and the consumer behave competitively, even though there is only one of each. (It turns out you get the same P_C even if there are many identical firms and the same number of identical consumers, so we are just making the problem easier to work out by assuming only one of each).

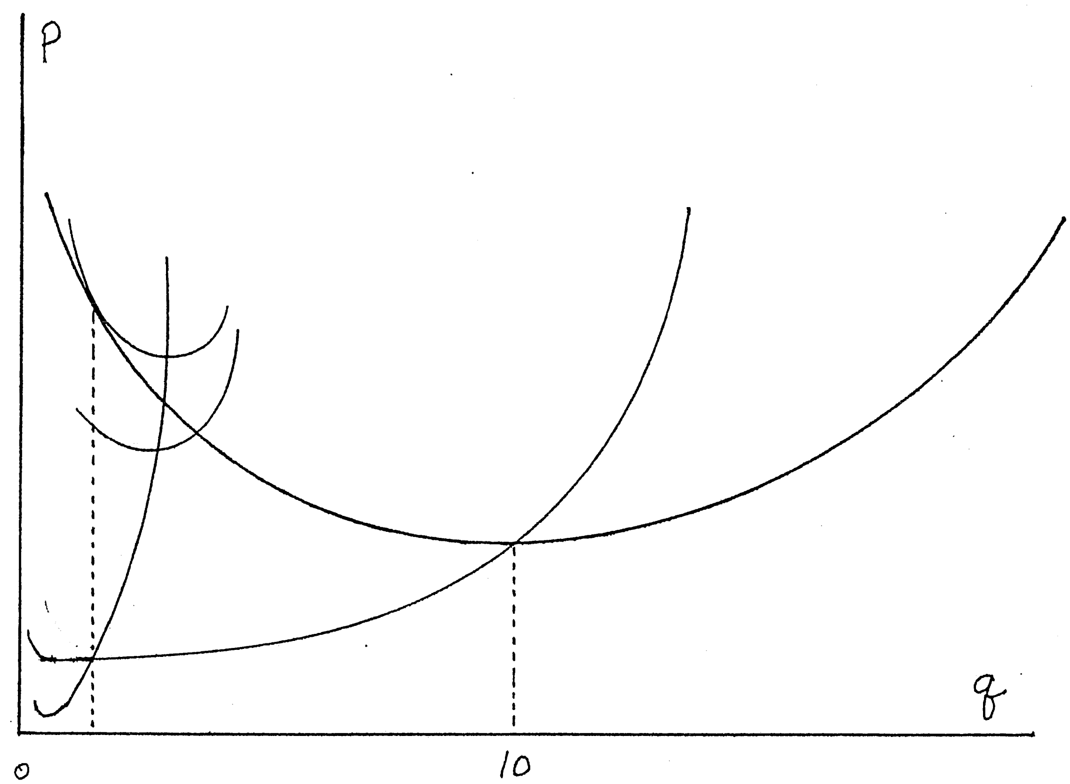
Here is one way of doing this. Copy this table on your answer sheet, then fill in the first three columns from Fig. 2.

Q_C, bu.	W, gal.	F, lbs.	TC, \$	ΔQ_C, bu.	ΔTC, \$	MC, \$/bu.
0				—	—	—

Then fill out the rest of the table. (It is also possible to skip columns 2 and 3, if you are clever.) Round things off to the nearest 1¢ or 10¢, or even to the nearest \$1 if it is close or if you do not have a calculator. Next, use Fig. 3 to fill in a table like this on your answer sheet:

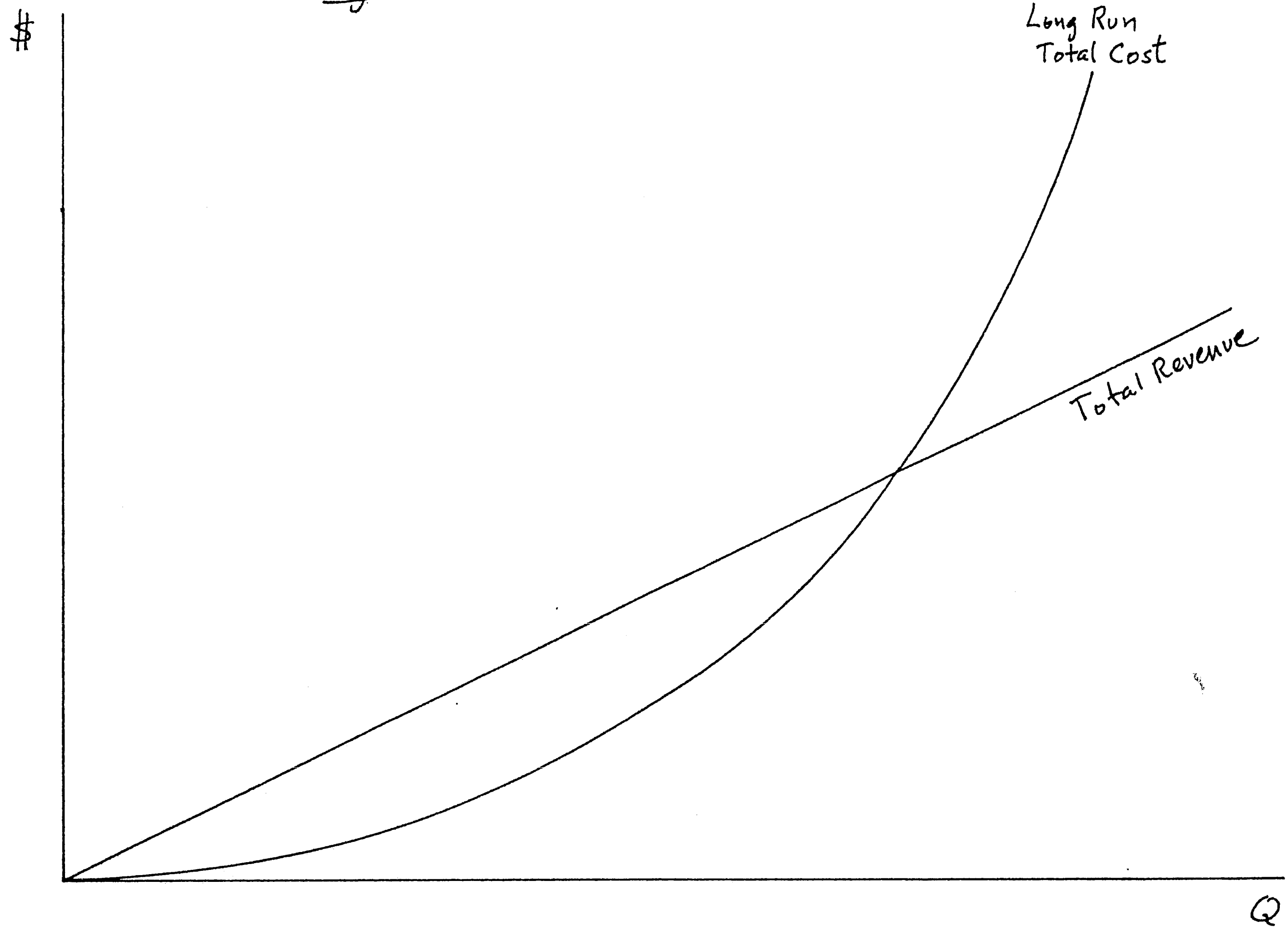
Q_C, bu.	P_C, \$

Finally, draw a graph in which you show supply and demand, and from this get the answer. Do not bother to check the shut-down rule.



Question 1's Fig. 1

Figure 3



Question 2's Fig. 3

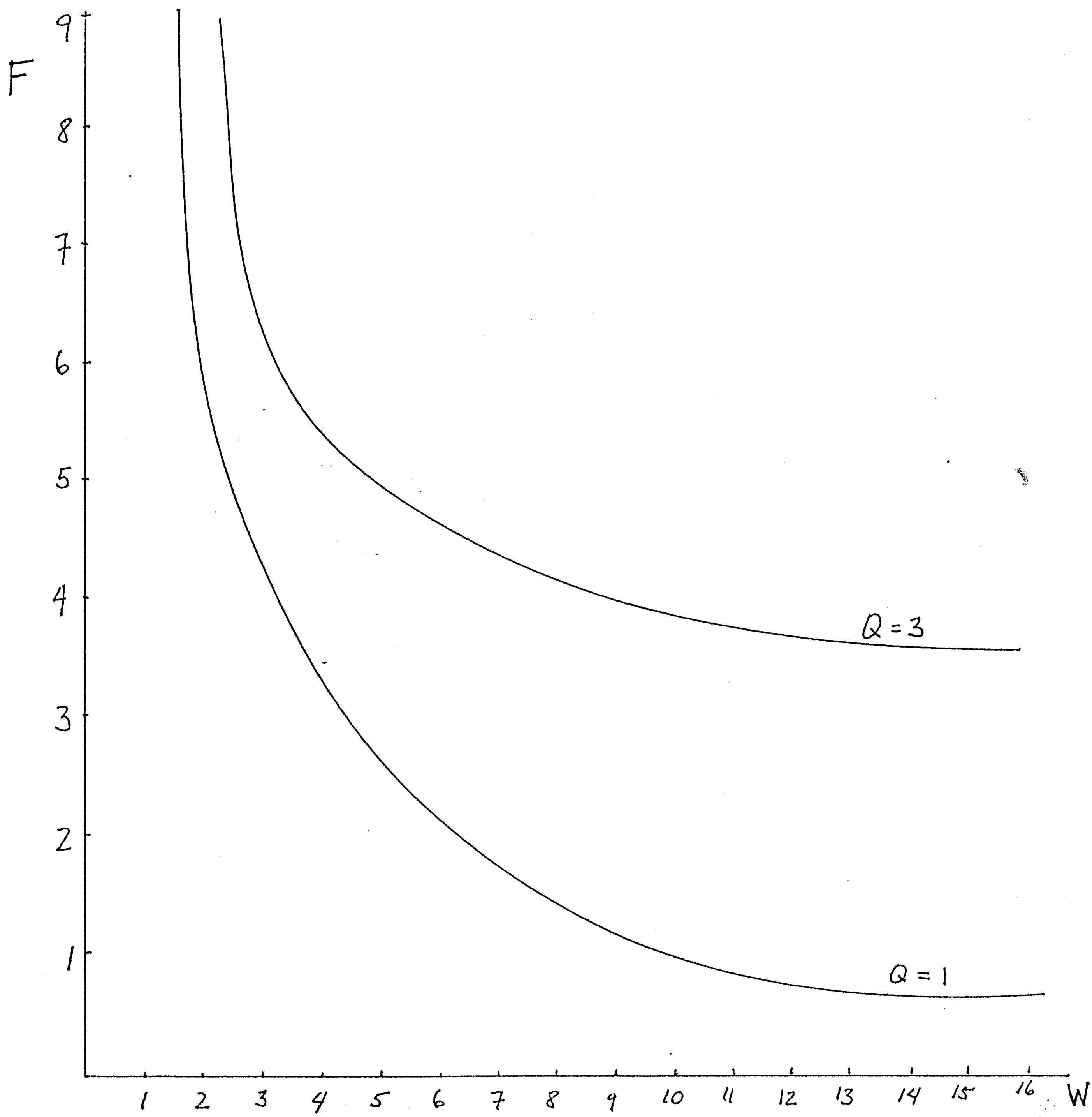
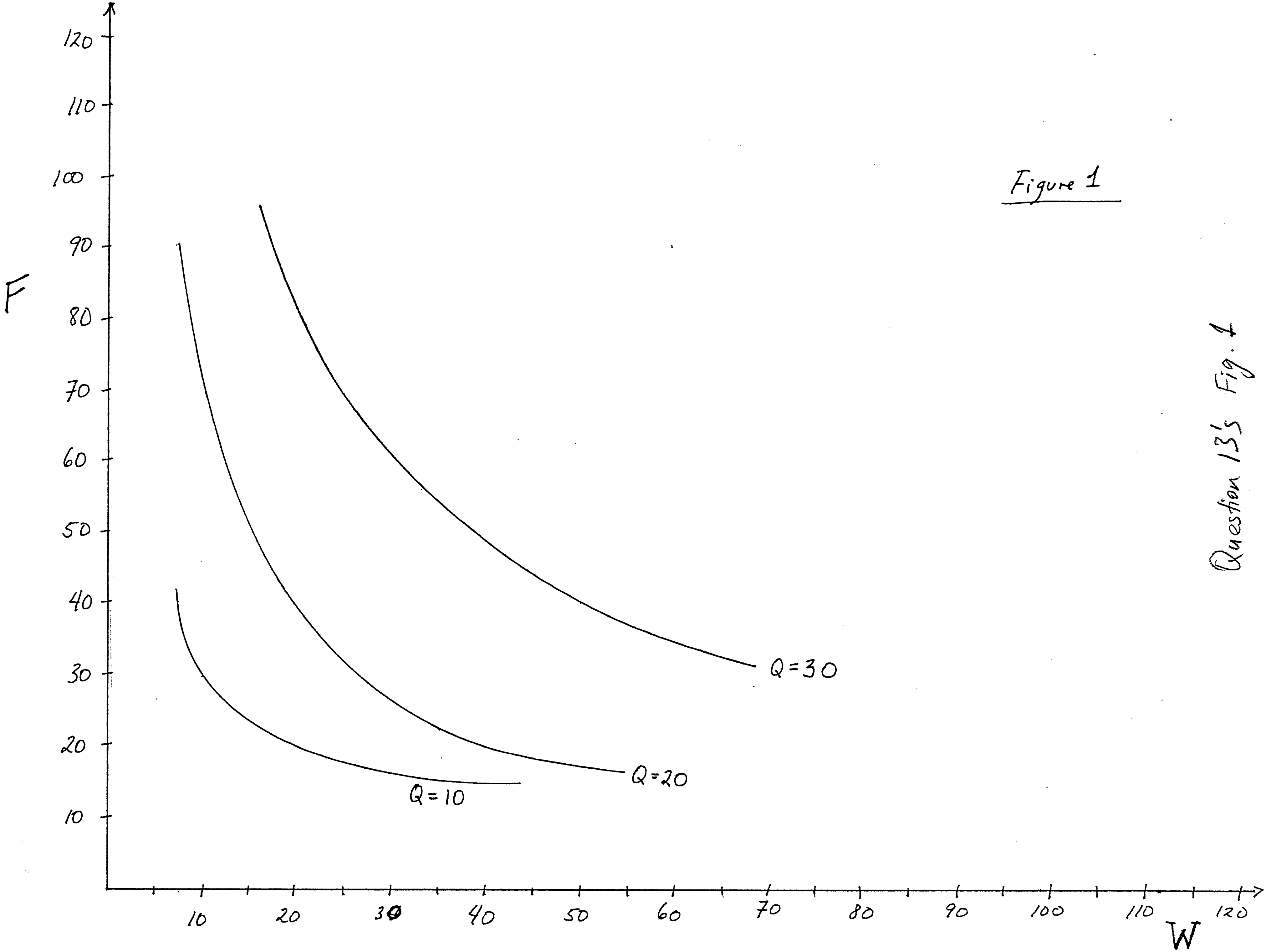


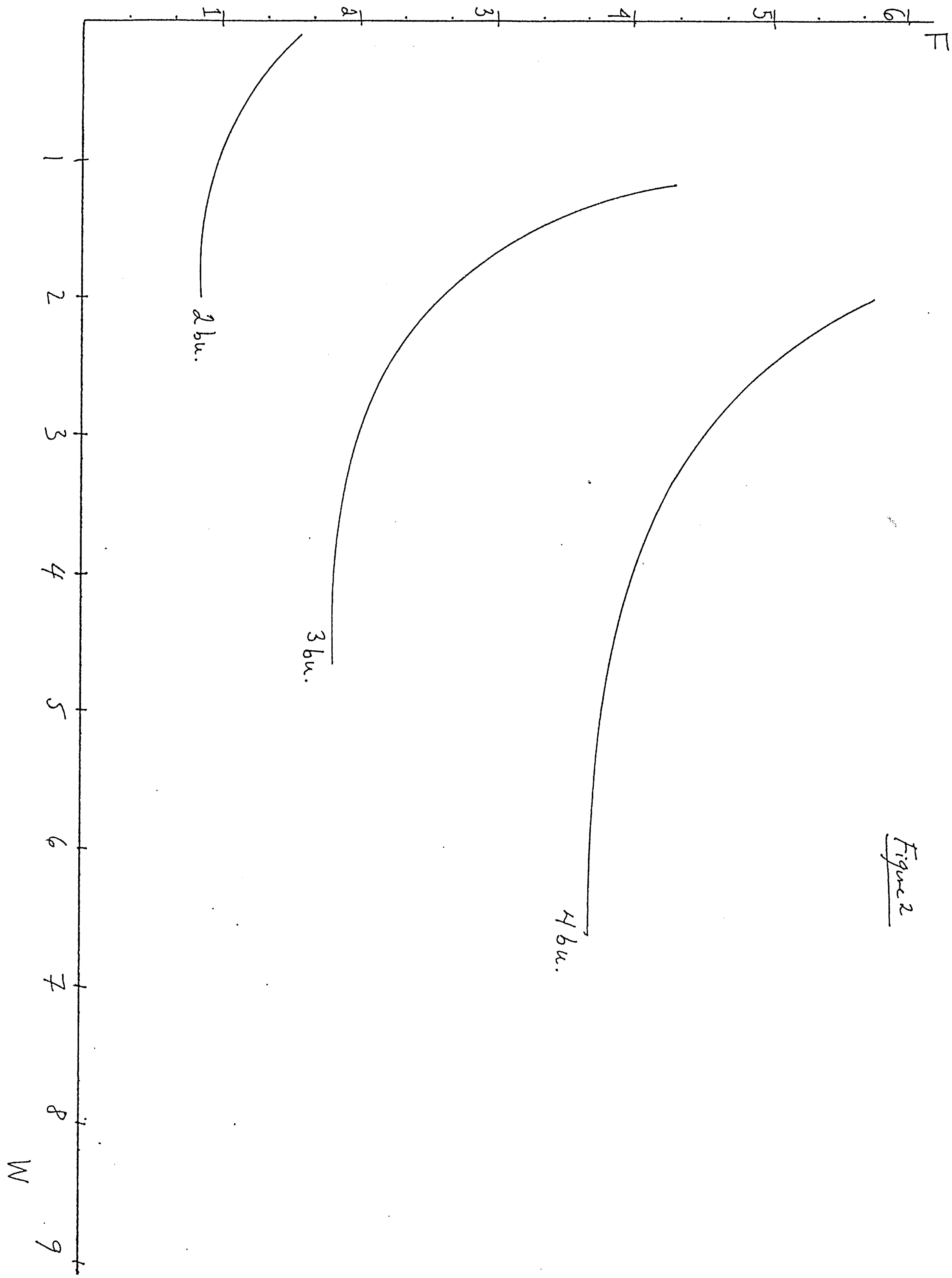
Fig. 1

Question 12's Fig. 1

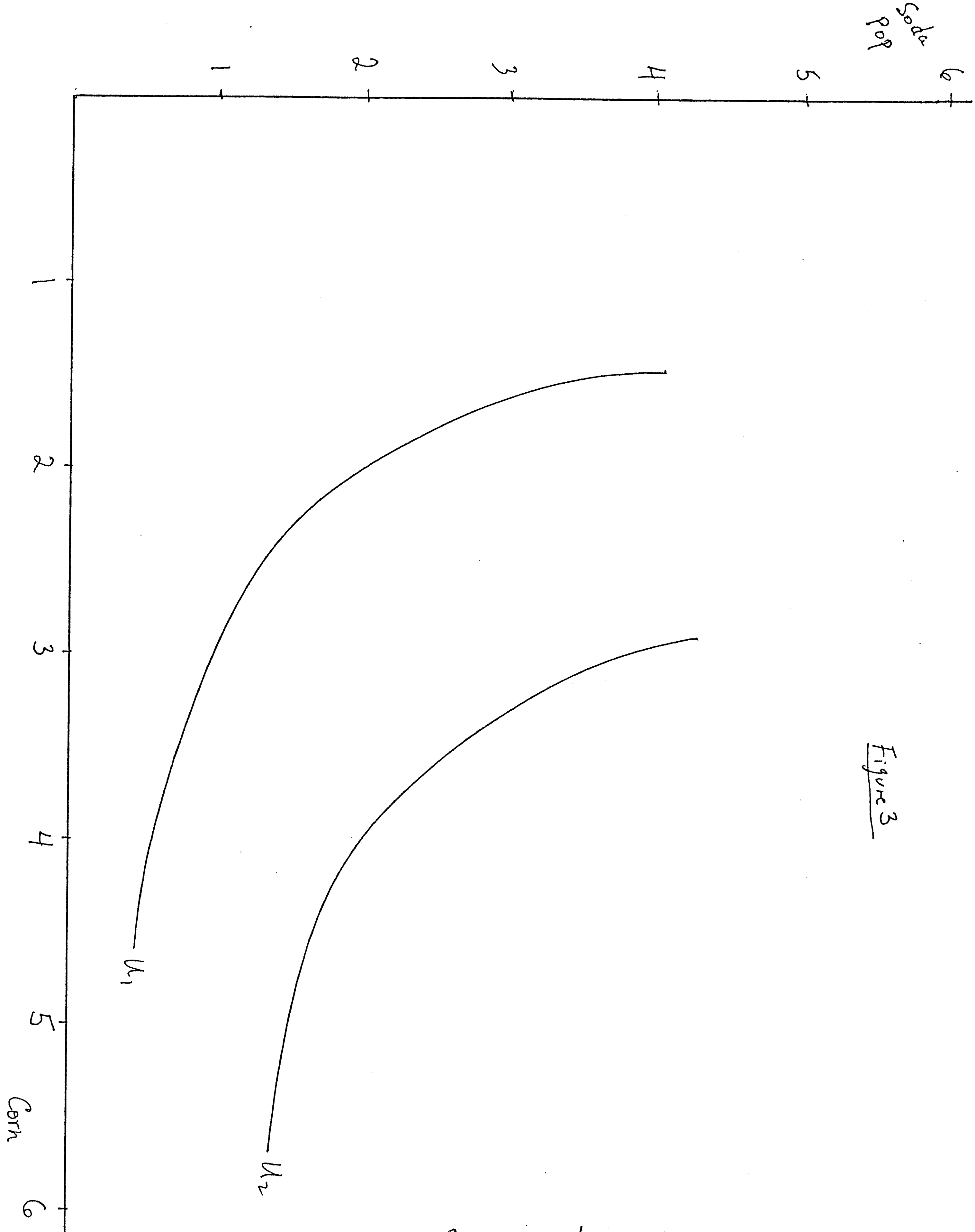
Figure 1



Question 13's Fig. 1



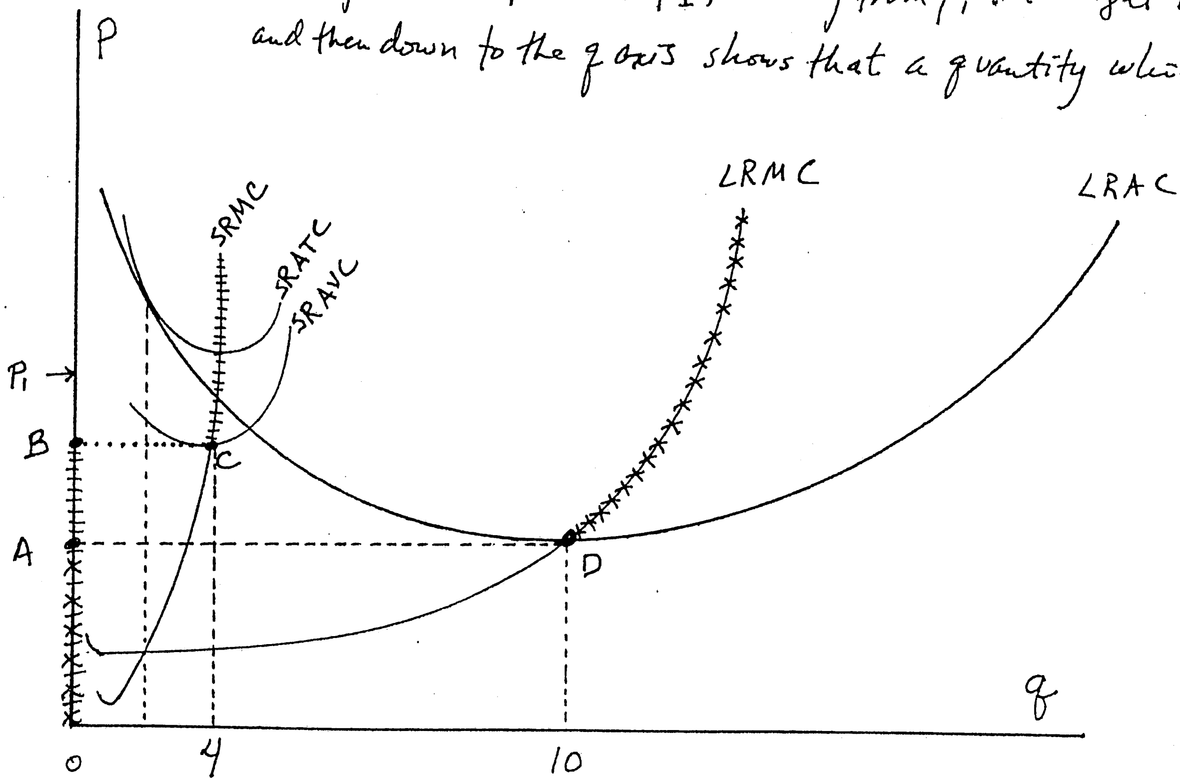
Question 14's Fig 2



Question 14's Fig. 3

Answers

① The SR supply curve goes from 0 to B, then skips to C, and follows the SRMC curve from there. The LR supply curve goes from 0 to A, then skips to D, and follows the LRMC curve from there. Quantities between A and D (between 0 and 10) will not be observed in the long run, while quantities between B and C (between 0 and, say, 4) will not be observed in the short run. Hence quantities larger than 4 and less than 10 may be produced in the short run but will not be produced in the long run. For example, at a price of P_1, tracing from P_1 to the right to SRMC and then down to the q axis shows that a quantity which is



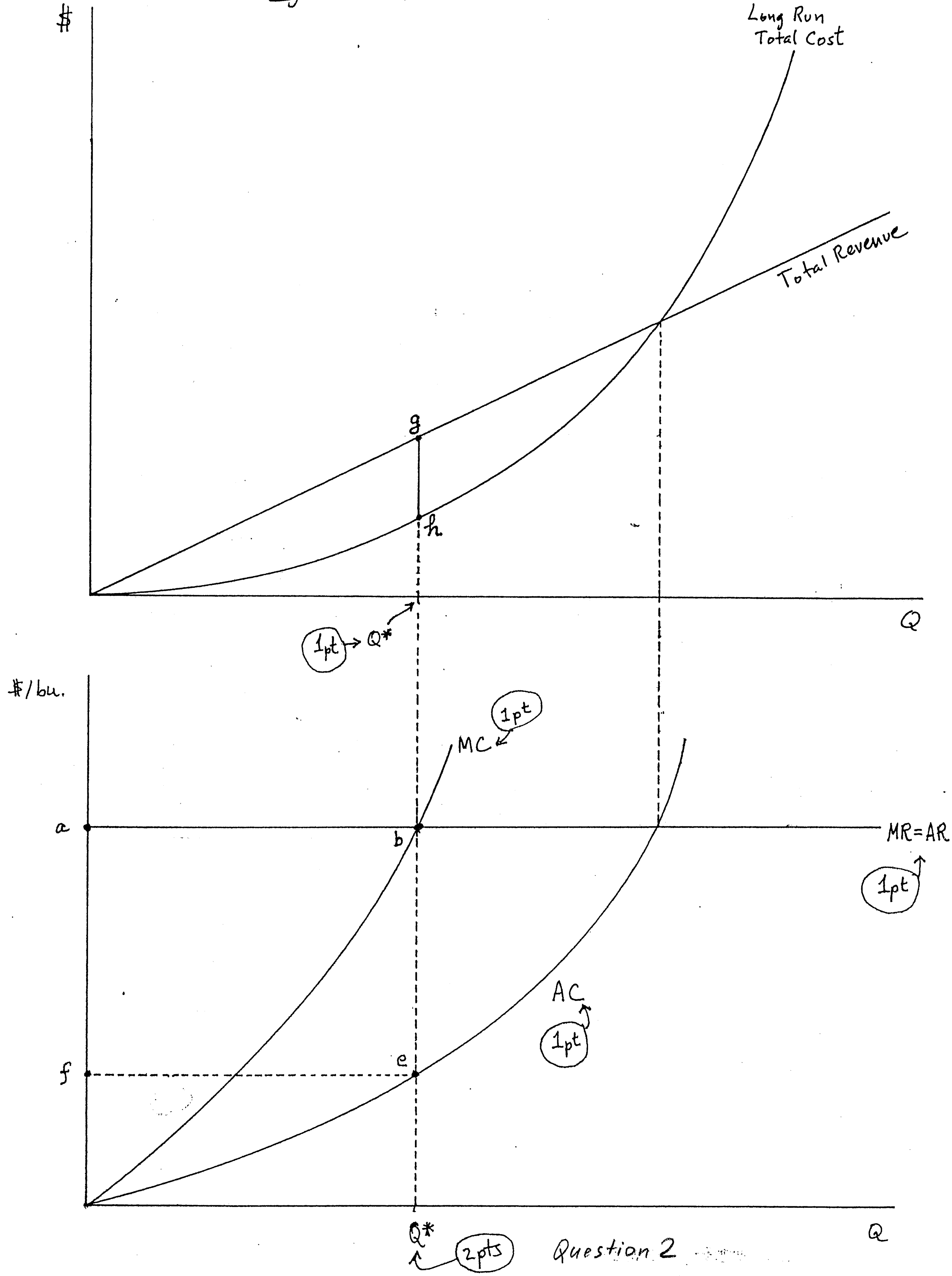
just slightly larger than 4 will be produced. There is no way to get this firm to produce such a quantity in the long run: at a price just above A, q is slightly bigger than 10; at a price just below A, q = 0; at at a price of A, q = 0 or q = 10.

5 curves @ 3 pts/curve = 15 pts
SR S curve, 5 pts
LR S curve, 5 pts
Gaps and explanation, 8 pts

Note: Other explanations are possible and will get full credit if they are correct.

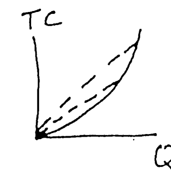
Question 2.

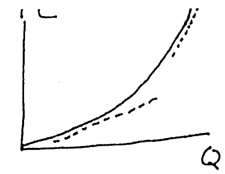
Figure 3

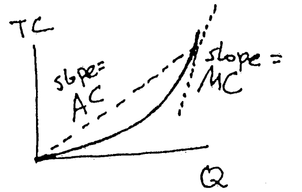


Question 2

(2) Since Total Revenue is a line from the origin, MR = AR and MR is constant.

Since LRTC is convex, LRAC is rising (lines like the dotted ones 

increa. in slope), LRMC is rising (lines like the dotted ones 

increase in slope), and LRMC is above LRAC since LRAC is rising (you can also show this using the graph: 

).

Setting MR = MC for profit maximization (point b) results in an optimal quantity of Q^*. Profit is $\pi = \frac{\pi}{Q^*} \cdot Q^* =$ Avg. Profit $\cdot\, Q^* = (AR - AC)\, Q^* =$

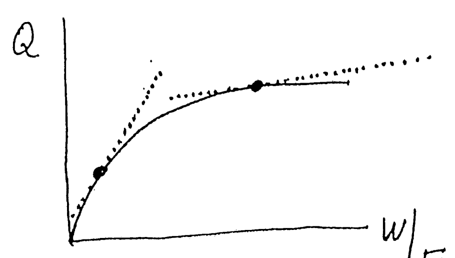
2 pts

the rectangle abef. Profit in Figure 3 is the line gh, corresponding to Q^*,

2 pts

where the distance between TR and TC is the greatest.

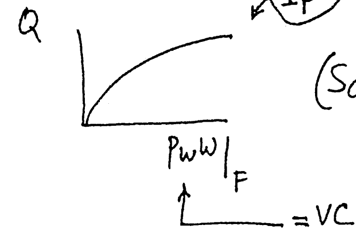
labels on axes : 1pt
labels on curves : 1pt

(3) a) 

This shows diminishing returns because: (a) it is concave; or (b) because its slope, the marginal product of water, always falls (see the dotted lines, whose slope represents the marginal product of water).

4 pts

b)



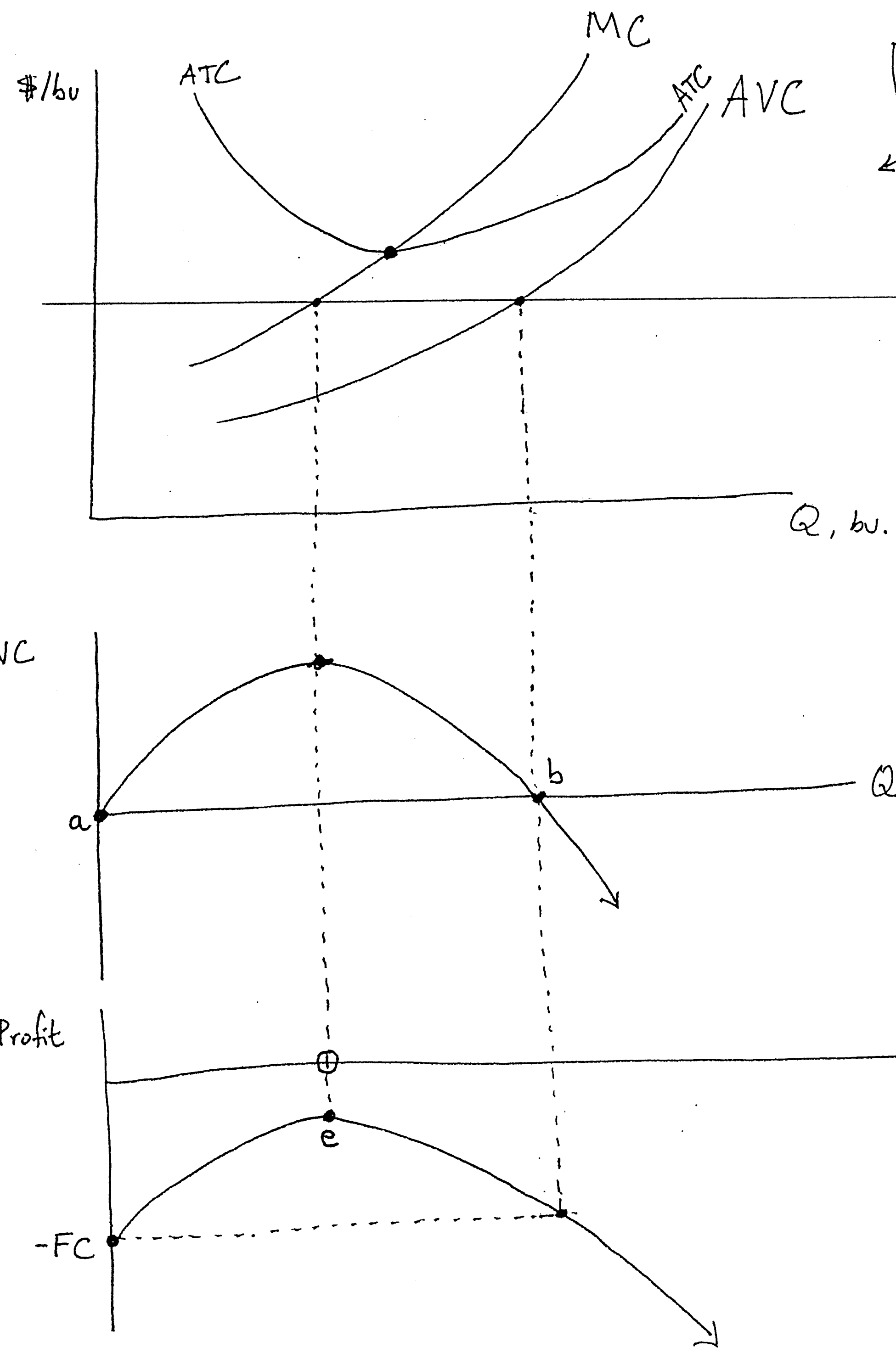
1pt

(Same shape as before, just shrunk or expanded horizontally.)

← Rotating the top graph about a 45° line, we get this shape.

4pts

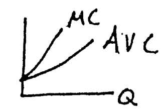
Graphs for (C) (d) (e)



U-shape for ATC: 1pt
ATC = MC at ATC's minimum: 1pt

Explanations for (c) (d) (e), see over →

(5pts)

c) The dotted lines on the VC versus Q graph show that AVC is rising. The dashed lines on that graph show that MC is (4pts) rising. Since the dashed lines are steeper than their corresponding dotted ones, MC > AVC. Hence 

, (2pts) as shown on the previous page. You did not have to indicate that MC = AVC at Q = 0.

(3pts)

d) ATC has to be larger than AVC because you get ATC from AVC by adding average fixed costs to AVC. But average fixed costs are $\frac{FC}{Q}$ where "FC" is fixed costs, so as Q gets large, this gets close to zero: therefore as Q gets large, the gap between AVC and ATC gets small. This results in 

as shown on page 3.

e) Price and marginal and average revenue are as shown on p. 3. (2pts)

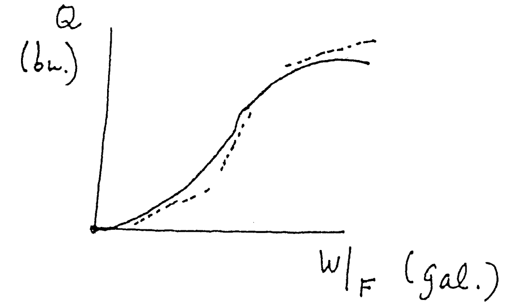
(i) Since TR = 0 at Q = 0 and VC = 0 at Q = 0, TR − VC = 0 at Q = 0. This gives point a (2pts) on the graph on p. 3. Since TR − VC = (AR − AVC) Q, where AR = AVC one has TR − VC = 0; this (2pts) gives point b. To the left of b, AR > AVC, so TR − VC is positive between a and b. (3pts) To the right of b, AR < AVC, so TR − VC is negative. (2pts)

(ii) This graph has the same (1pt) shape as in (i), just moved down by the amount of the fixed costs FC. Price is always less than ATC, so profit is always negative, (2pts) even at point e.

(1pt)

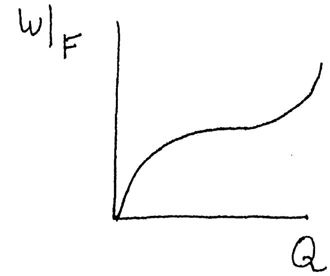
(iii) The Q corresponding to point e is optimal, because it is the highest profit. Another way to see this is that at that Q, MR = MC and P > AVC, so the firm will not shut down.

(4) a)

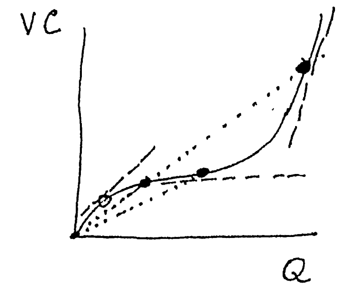


This shows first increasing and then diminishing returns. This is because: (a) it is first convex and then concave; or (b) because its slope, the marginal product of water (which is the slope of the dotted lines), first rises but then begins to fall. The Law of Diminishing Returns says that total product curves eventually become concave; this is equivalent to saying that marginal product curves eventually fall. (This allows total product curves to always be concave or marginal product curves to fall everywhere.)

b)



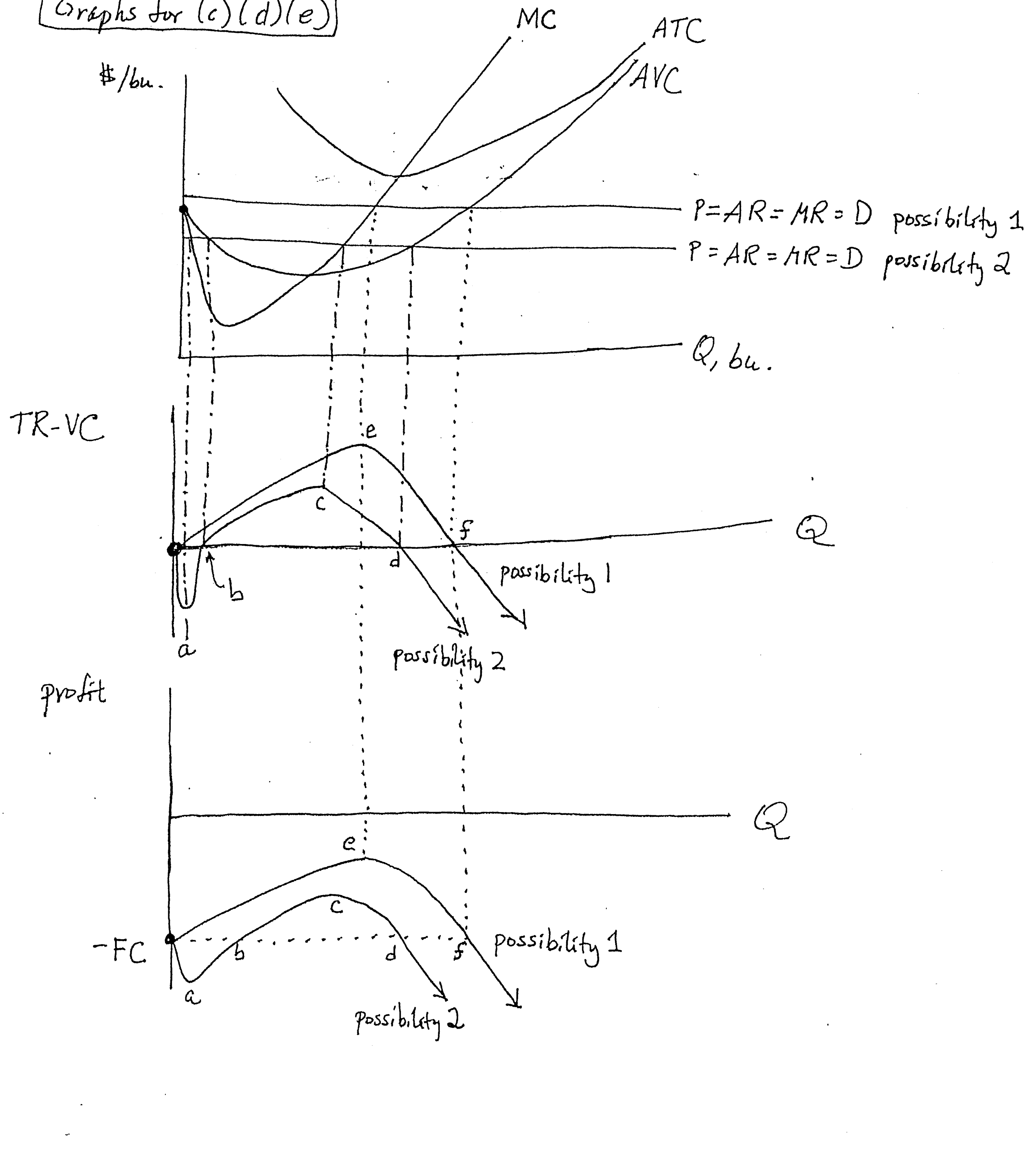
⇒



$VC = p_w \, w|_F$ so the second graph is just a vertical expansion or contraction of the first.

Rotated 45°.

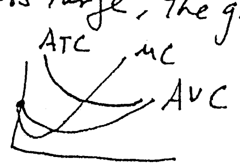
$\boxed{\text{Graphs for (c)(d)(e)}}$



c) The dotted lines on the VC versus Q graph show that AVC first falls and then rises. The dashed lines on that graph show that MC first falls and then rises. The dashed lines start out being flatter than the dotted lines (meaning MC < AVC), but eventually the dashed lines become steeper than the corresponding dotted lines (MC > AVC). Hence

as shown on the previous page. You did not have to indicate that MC = AVC at Q = 0.

d) ATC has to be larger than AVC because you get ATC from AVC by adding average fixed costs to AVC. But average fixed costs are $\frac{FC}{Q}$ where "FC" is fixed costs, so as Q gets large, this gets close to zero: therefore as Q gets large, the gap between AVC and ATC gets small. This result in



as shown on p. 2.

e) Price and marginal and average revenue are as shown on p. 2. There are two general possibilities for the location of this line; both are shown.

(i) Since TR = 0 at Q = 0 and VC = 0 at Q = 0, TR − VC = 0 at Q = 0. This is shown on p. 2 by the TR − VC curves beginning at the origin.

Since $TR - VC = \frac{TR - VC}{Q} \cdot Q = (AR - AVC)\, Q$, one has

$$TR - VC \begin{Bmatrix} < 0 \\ = 0 \\ > 0 \end{Bmatrix} \text{ if } \begin{Bmatrix} AR < AVC \\ AR = AVC \\ AR > AVC \end{Bmatrix}.$$ See points b and d on p. 2 for possibility 2, and point f for possibility 1. Also, since the slope of $TR - VC$ is $MR - MC$, one has

$$TR - VC \begin{Bmatrix} \uparrow \\ \text{constant} \\ \downarrow \end{Bmatrix} \text{ if } \begin{Bmatrix} MR > MC \\ MR = MC \\ MR < MC \end{Bmatrix}.$$ This gives rise to points a, c, and e on p. 2, as well as to the graphs' basic shapes.

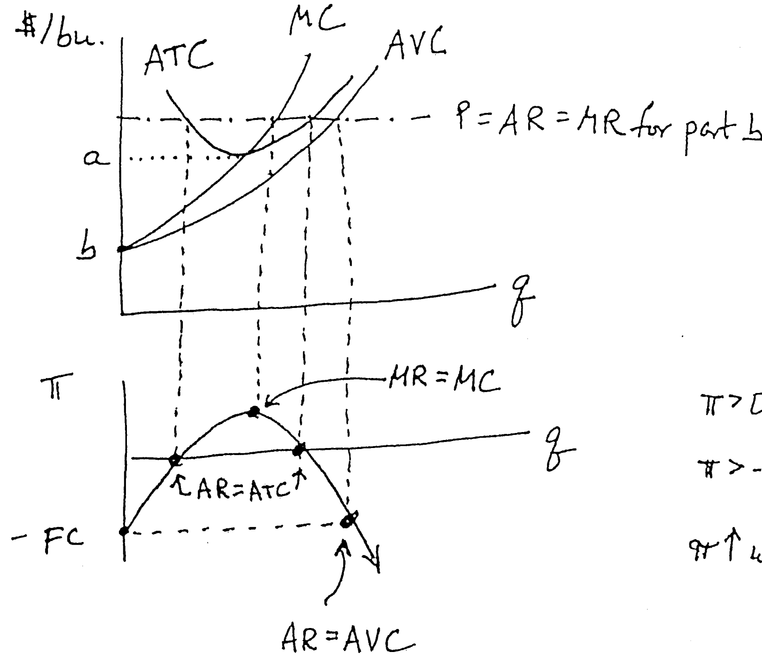
(ii) This graph has the same shape as in (i), just moved down by the amount of the fixed costs FC. Price is always less than ATC, so profit is always negative. Marginal profit is zero at point e or at points a and c.

(iii) The Q corresponding to point e (possibility 1) or point c (possibility 2) is optimal, because it is the highest profit. Another way to see this is that at these points, $MR = MC$ and $P = AR > AVC$, so the firm will not shut down.

Part:	a	b	c	d	e(i)	e(ii)	e(iii)
Points:	1	1	1	1	1	2	1

5

a)



b)

marginal cost MC
average total cost ATC
average variable cost AVC
profit π (for part b)

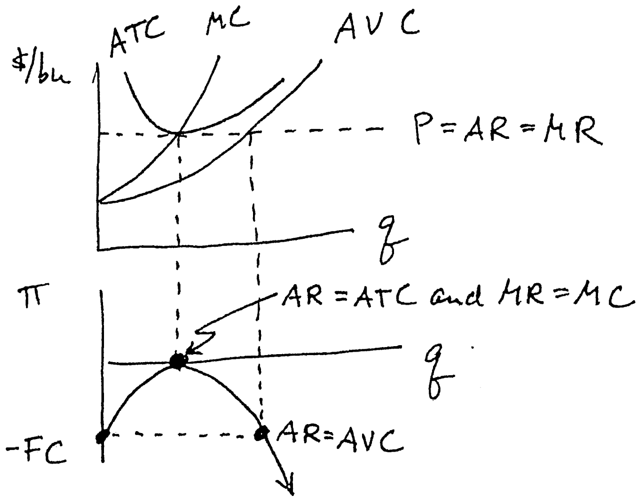
$\pi > 0$ when $AR > ATC$

$\pi > -FC$ when $AR > AVC$

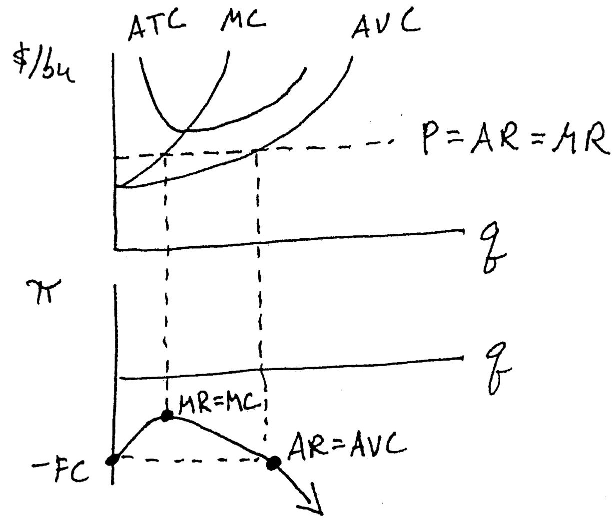
$\pi \uparrow$ when $MR > MC$

a) 4 pts
b) 8 pts

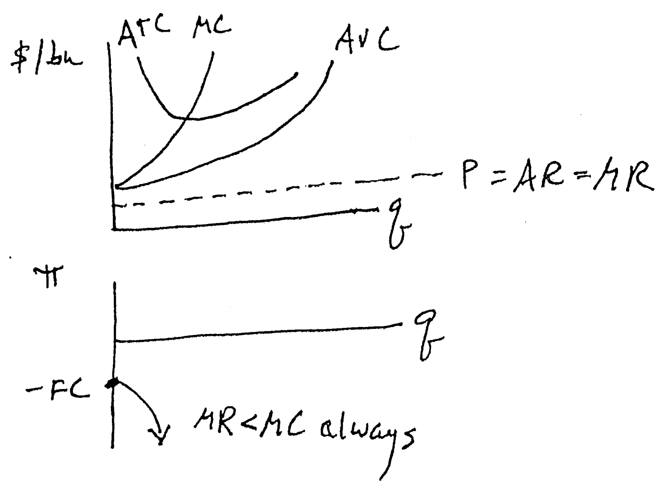
c)



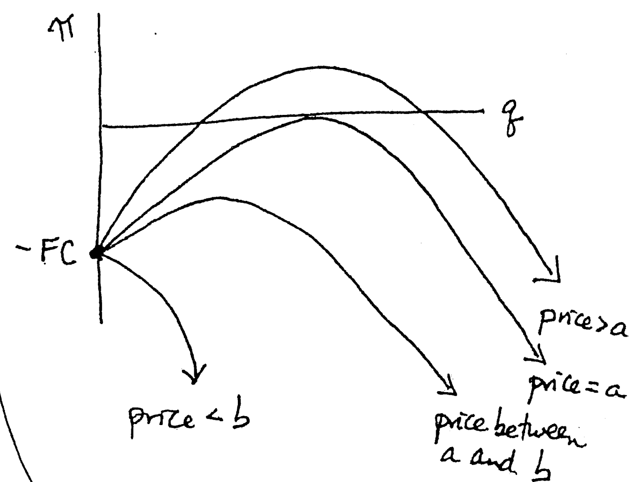
d)



e)



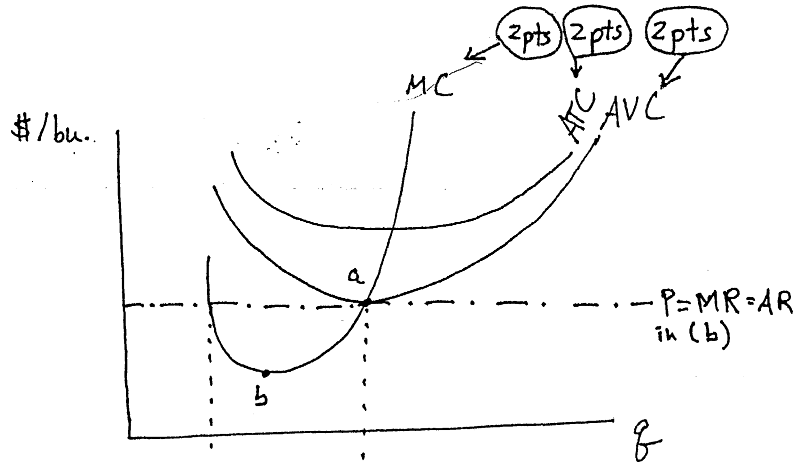
Optional Summary:



c) 8pts
d) 8pts
e) 5pts

(6)

a)



marginal cost MC

average variable cost AVC

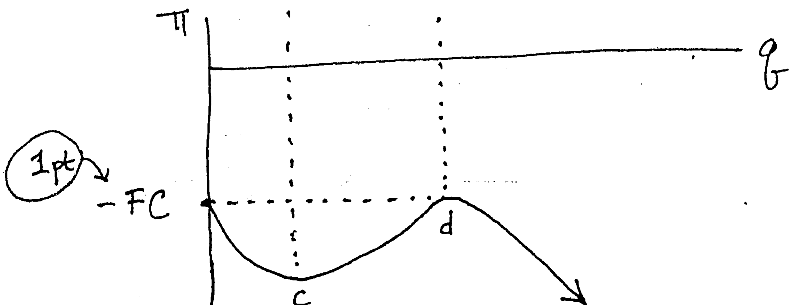
average total cost ATC

MC goes through the bottom of AVC

and ——— " ——— ATC

b) market price shown by -·-·-·- in (a)

π: profit



For all q, $AR < ATC \Rightarrow \pi < 0$.

At c and d, $MR = MC$ so $M\pi = 0$.

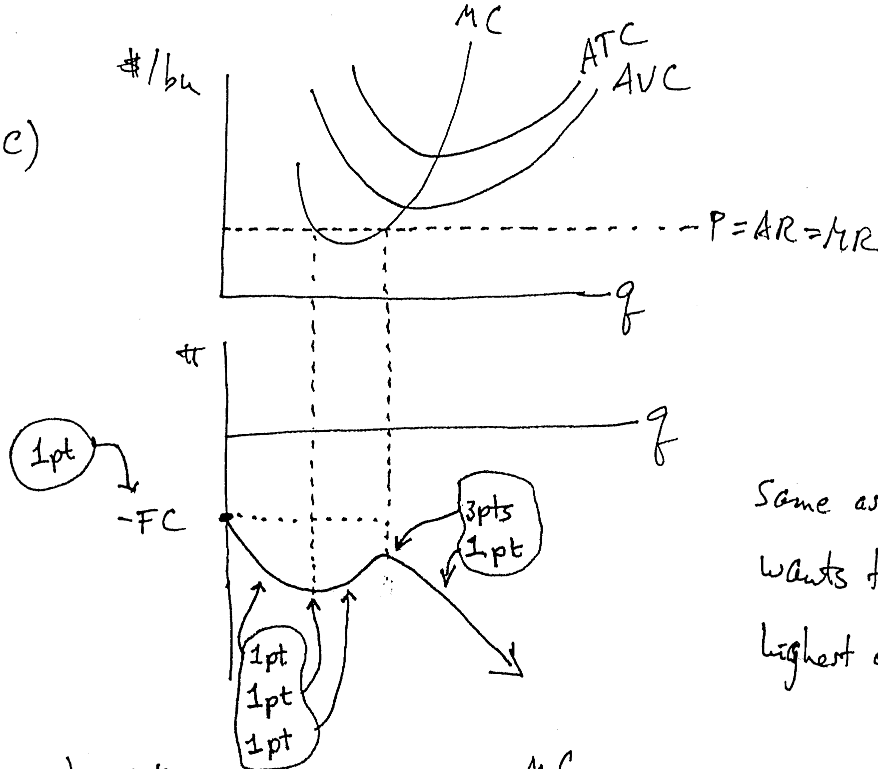
Between c and d, $MC < MR$ so $M\pi > 0$ ($\pi(q)$ upward sloping). Elsewhere, $M\pi < 0$, $\pi(q)$ downward sloping.

At $q = 0$, $\pi = -FC$.

At d, firm makes same profit as at $q = 0$ (because at price \$a/bu., the firm is indifferent between shutting down – which is $q = 0$ and $\pi = -FC$ – and producing). So at d, $\pi = -FC$.

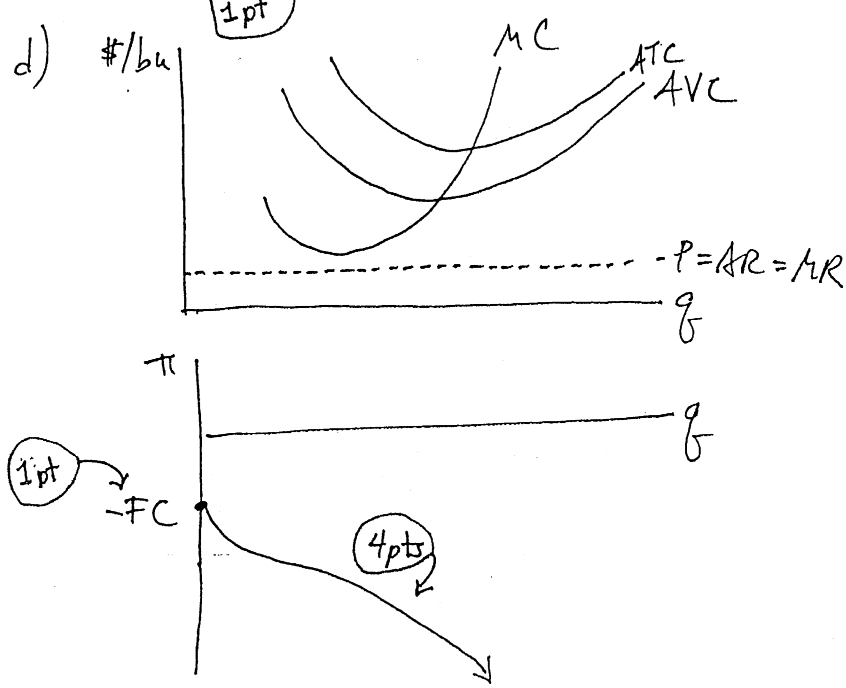
graph between 0 and c	: 2 pts
" at c	: 2 pts
" between c and d	: 2 pts
" at d	: 2 pts
" beyond d	: 2 pts

c)



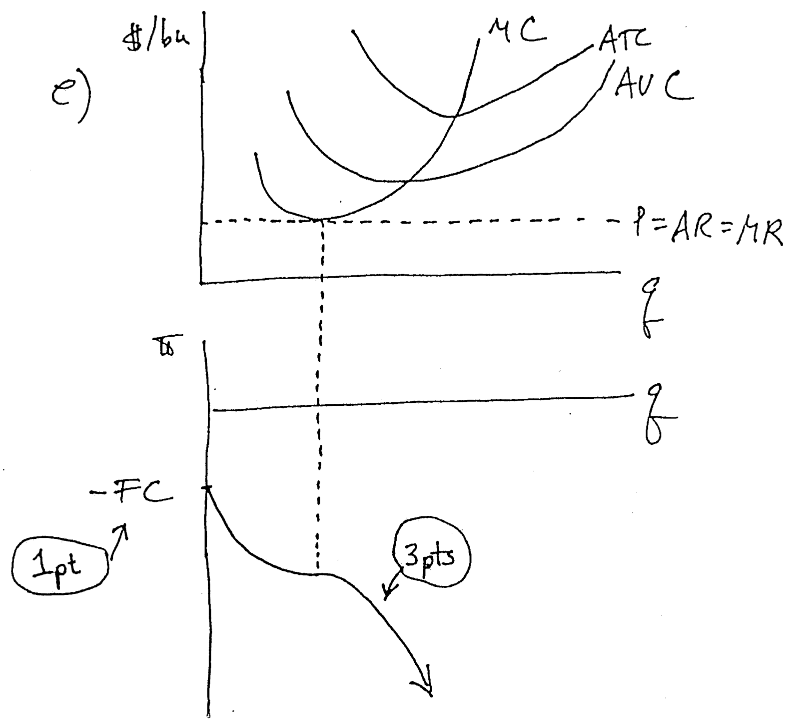
Same as (b) except firm definitely wants to shut down, so profit is highest at q=0.

d)



For all q,
MR < MC ⇒ Mπ < 0.

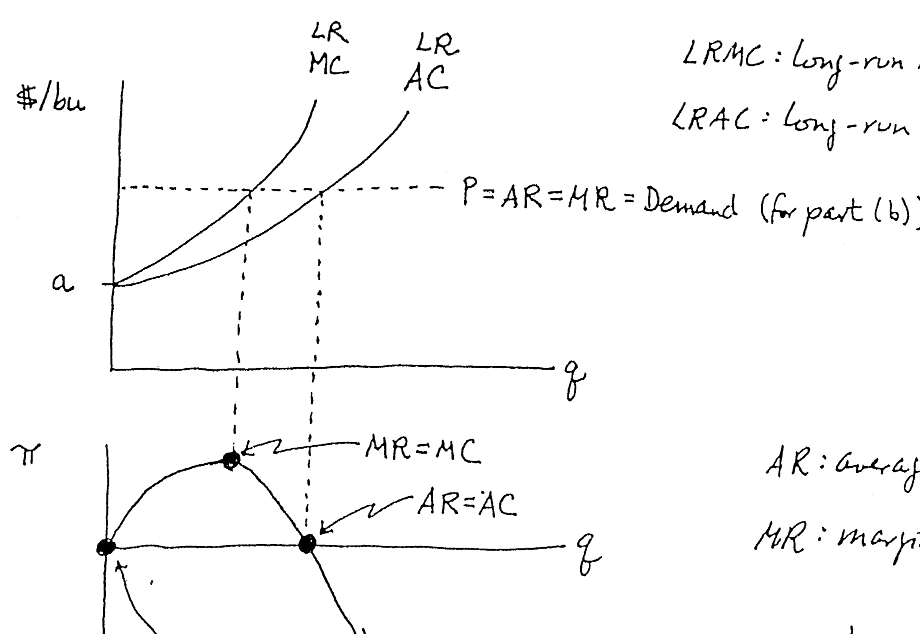
e)



$MR < MC$ (and so $\Delta\pi < 0$) except at the dotted line, where $MR = MC$ (so $\Delta\pi = 0$).

(7)

a)



b)

LRMC: long-run marginal cost

LRAC: long-run average cost

AR: average revenue

MR: marginal revenue

$\pi > 0$ when $AR > AC$

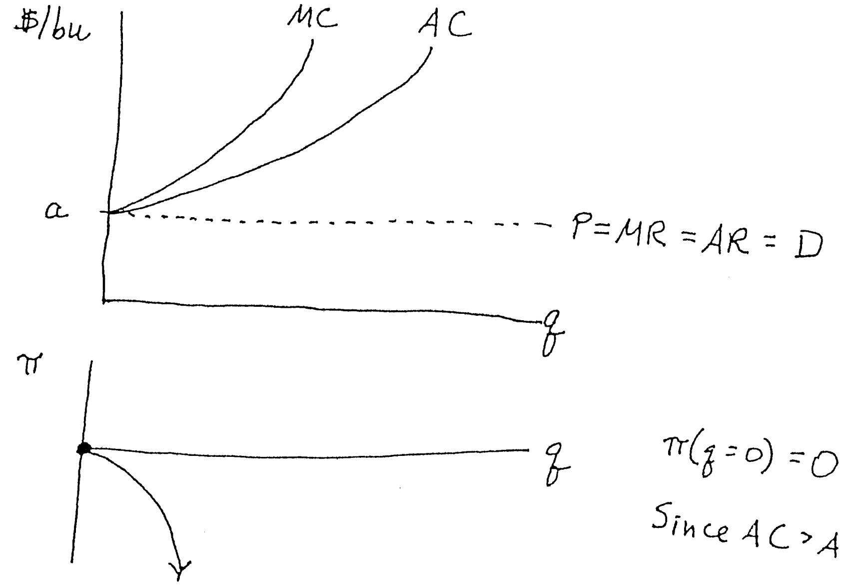
$\pi < 0$ when $AR < AC$

$\pi\uparrow$ when $MR > MC$

$\pi\downarrow$ when $MR < MC$

In the long run, fixed costs = 0 so $\pi(q=0) = 0$.

c)

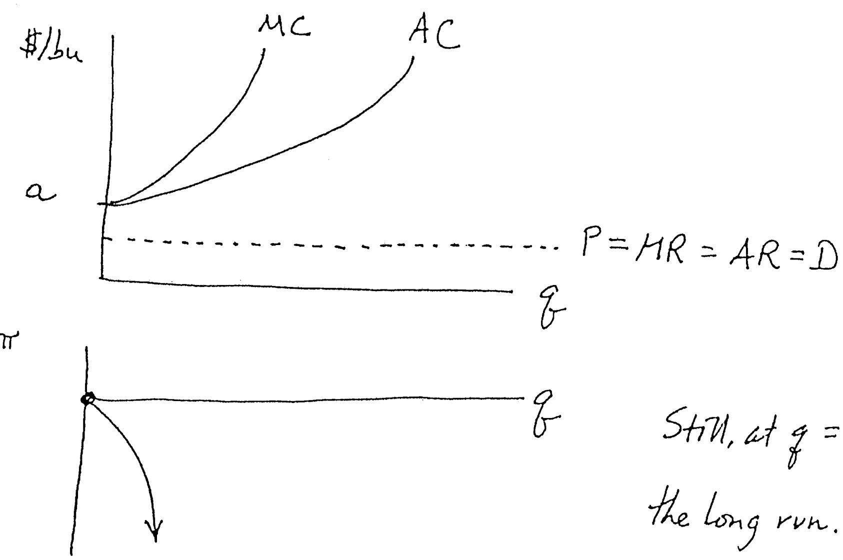


$\pi(q=0)=0$

Since $AC > AR$ for all $\underbrace{q}_{\text{positive}}$, $\pi < 0$ for all $q > 0$.

Since $MC > MR$ for all $q > 0$, π is falling for all $q > 0$. At $q = 0$, $MC = MR$ so $\pi(q)$ is flat.

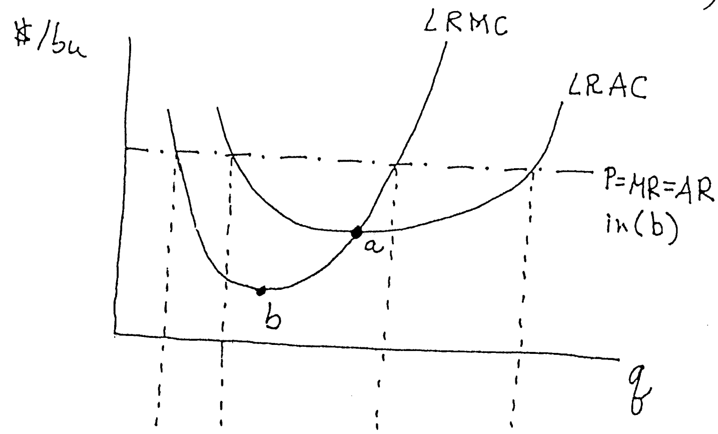
d)



2 points each for (a), (b), (c), and (d).

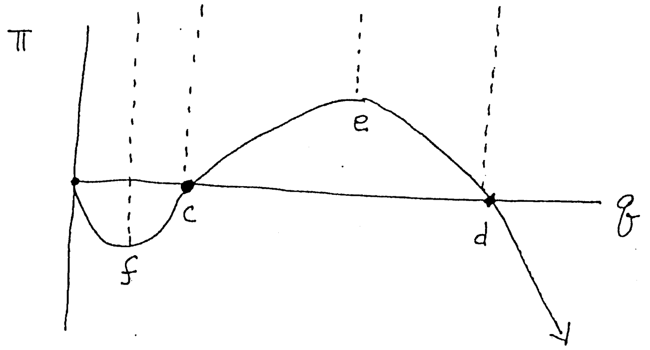
Still, at $q=0$, $\pi=0$ because this is the long run. The facts that $AC > AR$ for all $q > 0$ and $MC > MR$ for all $q > 0$ mean that π is negative and falling for all $q > 0$, as in part (c). At $q = 0$, $MC > MR$ so $\pi(q)$ at $q = 0$ is not flat but downward-sloping.

(8) a) "returns to scale" ⇒ this is a long-run situation (diminishing "returns" would indicate a short-run situation)



MC goes through the bottom of AC

b) market price shown by —·—·—· in (a)



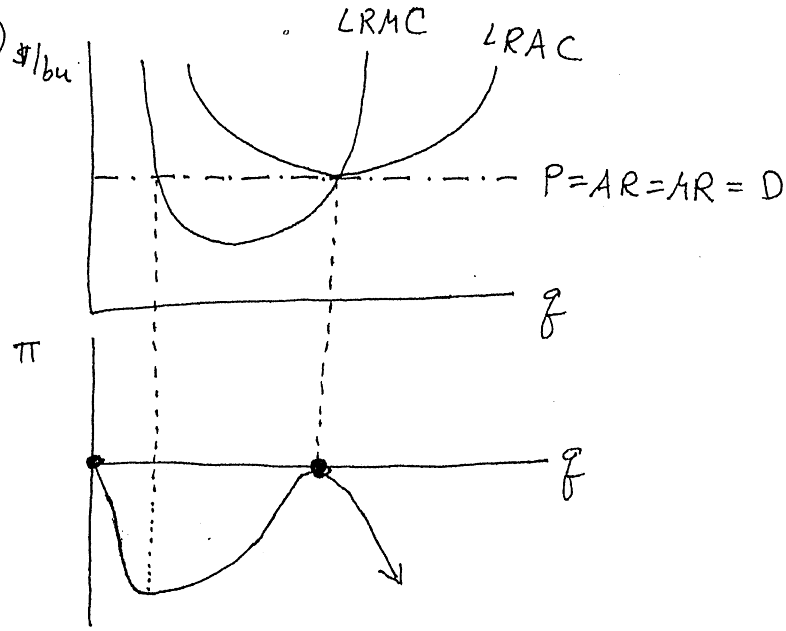
π: profit

At c and d, AR = AC so π = 0.
Between c and d, AR > AC so π > 0. Everywhere else, AR < AC so π < 0.

At e and f, MR = MC so Mπ = 0.
Between e and f, MR > MC so Mπ > 0 (π rises). Everywhere else, MR < MC so Mπ < 0 (π falls).

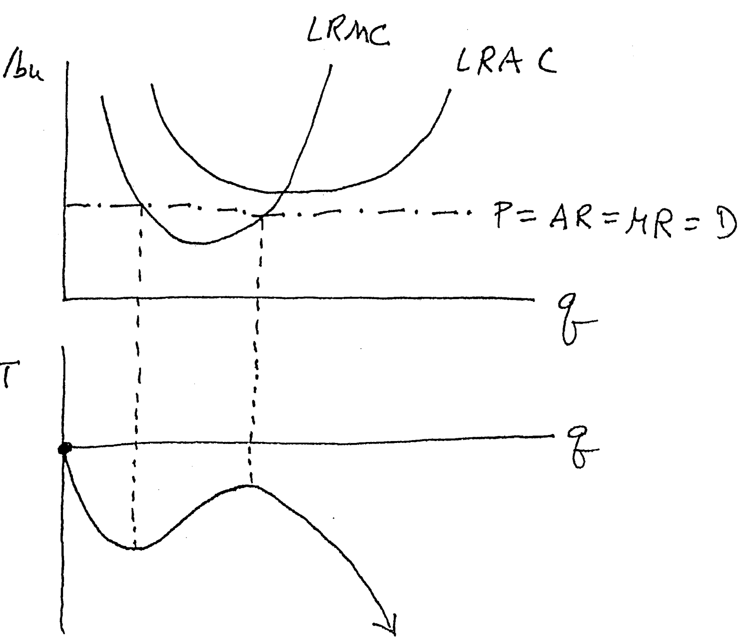
Since this is the long run, at q = 0 one has π = 0.

c)



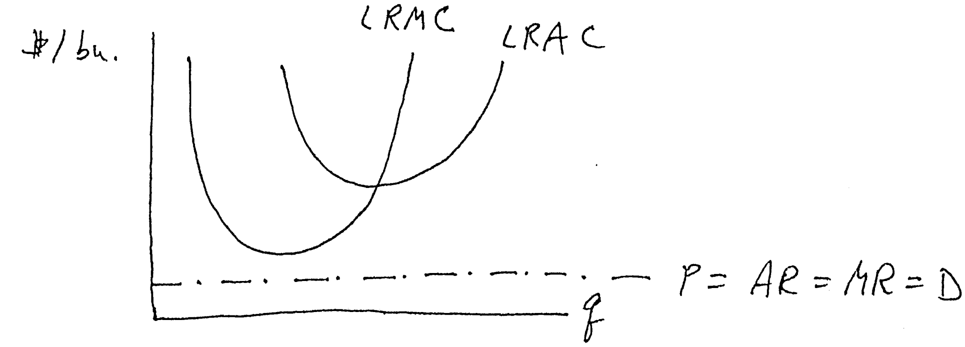
Similar to (b) except the highest profit the firm can make is zero.

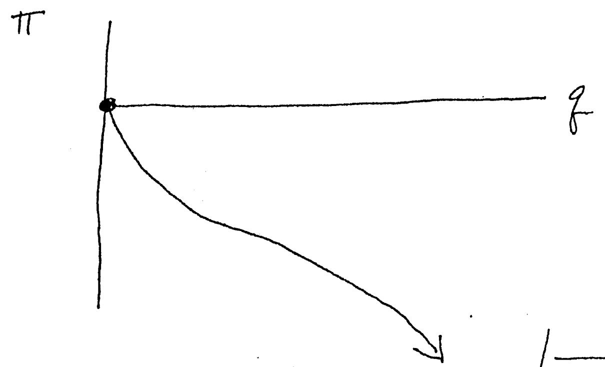
d)



Vertical dotted lines show where MR=MC.

e)





MR < MC always

	Points
a	2
b	2
π in c	2
π in d	2
π in e	1

9

\$20 = P = MR due to the assumption of competition (i.e., the firm thinks the price it receives is unaffected by its actions)

	points
MR = MC	3
Q = 50	2
check shutdown	3

Set MR = MC : $20 = 0.2Q + 10$

$$\frac{10}{0.2} = Q \Rightarrow Q = \frac{100}{2} = 50.$$

Now check to make sure the firm does not want to shut down. There are two ways to do this:

(i) Is P > AVC? $P = 20$

$$AVC(Q=50) = \frac{VC(Q=50)}{50} = \frac{0.1(50)^2 + 10(50)}{50}$$

$$= 0.1(50) + 10 = 5 + 10 = 15.$$

So P > AVC : the firm should not shut down. Hence Q = 50, as found above.

(ii) Find π at $Q = 50$:

$$TC(Q=50) = FC + VC(Q=50)$$
$$= 50 + [0.1(50)^2 + 10(50)]$$
$$= 50 + 250 + 500 = 800.$$
$$TR(Q=50) = PQ = 20(50) = 1000.$$
$$\pi(Q=50) = 1000 - 800 = \$200.$$

Find π at $Q = 0$: $TC(Q=0) = FC = 50$

$$TR(Q=0) = 0$$
$$\pi(Q=0) = 0 - 50 = -\$50.$$

Since \$200 > -\$50, profit is bigger if $Q > 0$ ($Q = 50$) than if $Q = 0$. So the firm should not shut down.

(10) $MR_T = MR_{LV}$: $1 - Q_T = 1 - 2Q_{LV}$

$$\boxed{Q_T = 2Q_{LV}.}$$

$MR = MC$:

$$1 - Q_T = Q_T + Q_{LV}$$ or: $1 - 2Q_{LV} = Q_T + Q_{LV}$ (etc.)

$$= Q_T + \tfrac{1}{2}Q_T$$
$$1 = \tfrac{5}{2}Q_T$$
$$\boxed{\tfrac{2}{5} = Q_T}$$
$$\therefore \boxed{Q_{LV} = \tfrac{1}{2}Q_T = \tfrac{1}{5}}.$$

(11) a) $Q = Q_A + Q_B$ production = sales

b) $MR_A(Q_A) = MR_B(Q_B)$ else you should sell more where MR is higher and less whe it's lower

3pts

3pts.

c) $MC(Q) = MR_A(Q_A)$

d) $MC(Q) = MR_B(Q_B)$

just the "$MR=MC$" rule. Which MR? They're equal by (b), so it doesn't matter.

e) $Q = Q_1 + Q_2$ sales = production

f) $MC_1(Q_1) = MC_2(Q_2)$ else you should produce more where MC is lower and less wh it's higher

3pts

3pts.

g) $MR(Q) = MC_1(Q_1)$

h) $MR(Q) = MC_2(Q_2)$

just the "$MR=MC$" rule. Which MC? They're equal by (f), so it doesn't matter.

$MR=MC$ comes from profit-maximization.

(12) a. slope of isocost line $= -p_W/p_F = -1/2$

The isocost line closest to the origin but still touching $Q=1$ touches it at approximately $W = 5\frac{1}{4}$ gal, $F = 2\frac{1}{2}$ lbs. (See also next page!)

isocost line: 7pts
W: 1pt
F: 1pt

b) $TC = p_W W + p_F F = (1)(5\frac{1}{4}) + (2)(2\frac{1}{2}) = 5\frac{1}{4} + 5 = \$10.25$ ← 2pts

c) $W = 4\frac{1}{4}$, $F = 5\frac{1}{4}$

isocost line: 7pts
W: 1pt
F: 1pt

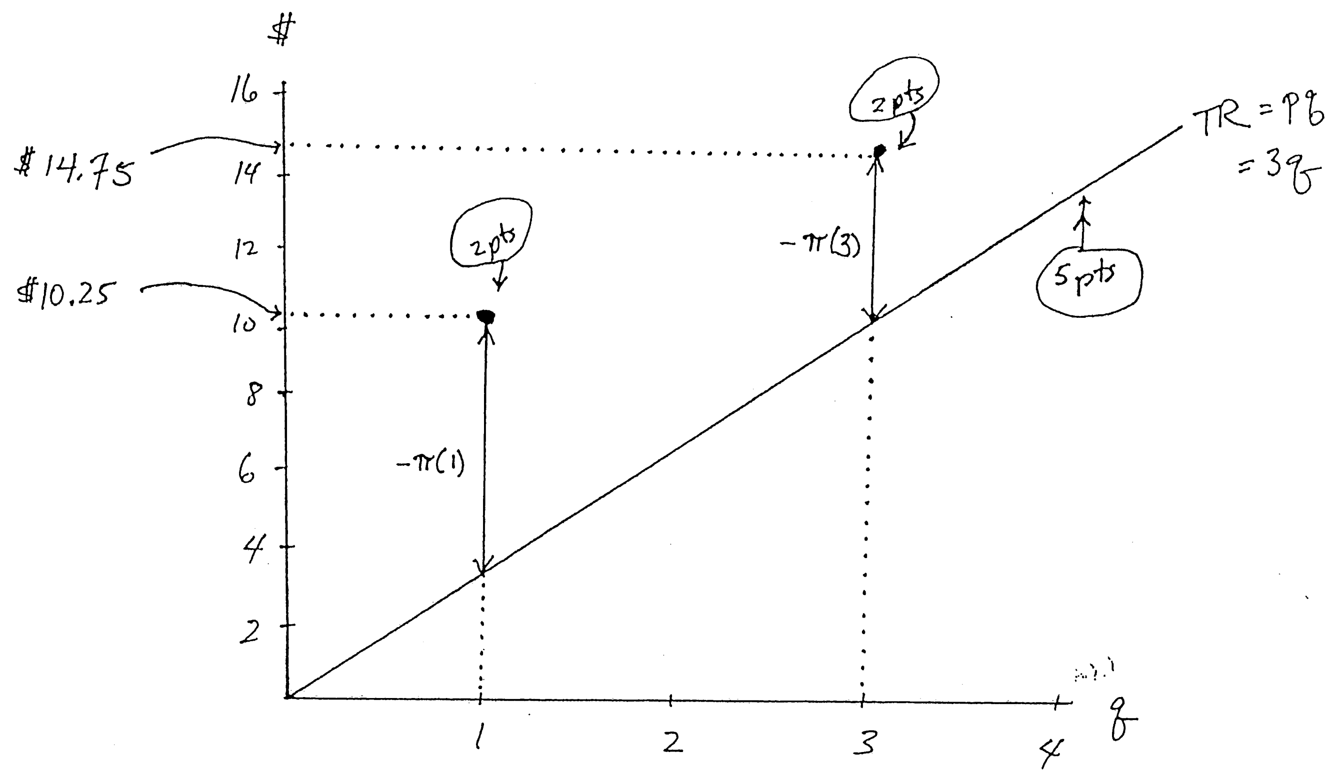
$TC = p_W W + p_F F = (1)(4\frac{1}{4}) + (2)(5\frac{1}{4}) = 4\frac{1}{4} + 10\frac{1}{2} = \$14.75$ ← 2pts

d) See below.

e) At $Q=1$, $TC = \$10.25$, $TR = 3Q = \$3$, so $\pi = 3 - 10.25 = -\$7.25$

At $Q=3$, $TC = \$14.75$, $TR = 3Q = \$9$, so $\pi = 9 - 14.75 = -5.75$

So $Q=3$ is better than $Q=1$. ← 2 pts (need not figure this out; just use the graph)



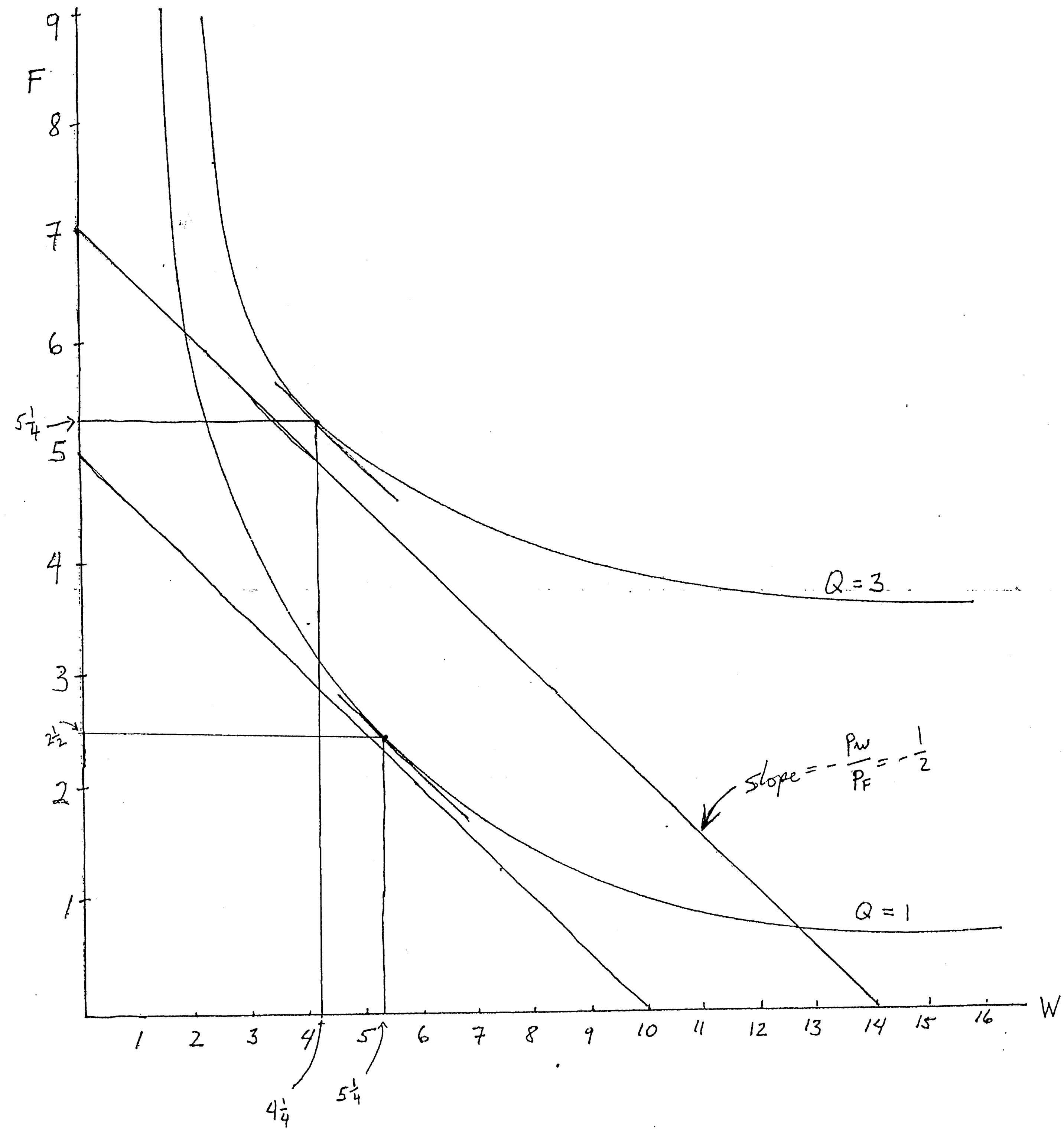


Fig. 1

Question 12

(13) slope of isocost lines $= -\frac{p_W}{p_F} = -2$

Let "$\doteq$" mean "is approximately equal to." See graph, two pages from now.

a1) $W \doteq 10$ $F \doteq 30$

$$C = p_W W + p_F F \doteq 2(10) + 1(30) = 50.$$

isocost: 2 points
W, F: 2 "
cost: 1 point

a2) $W \doteq 20$ $F \doteq 40$

$$C = p_W W + p_F F \doteq 2(20) + 1(40) = 80.$$

isocost: 2 points
W, F: 2 points
cost: 1 point

a3) $W \doteq 25$ $F \doteq 70$

$$C = p_W W + p_F F \doteq 2(25) + 1(70) = 120.$$

isocost: 2 points
W, F: 2 points
cost: 1 point

b1) $F = 40$ $W \doteq 7\frac{1}{2}$

$$C = p_W W + p_F F \doteq 2(7\tfrac{1}{2}) + 1(40) = 55.$$

F: 1 point
W: 3 points
cost: 1 point

b2) $F = 40$ $W \doteq 20$

$$C = p_W W + p_F F \doteq 2(20) + 1(40) = 80.$$

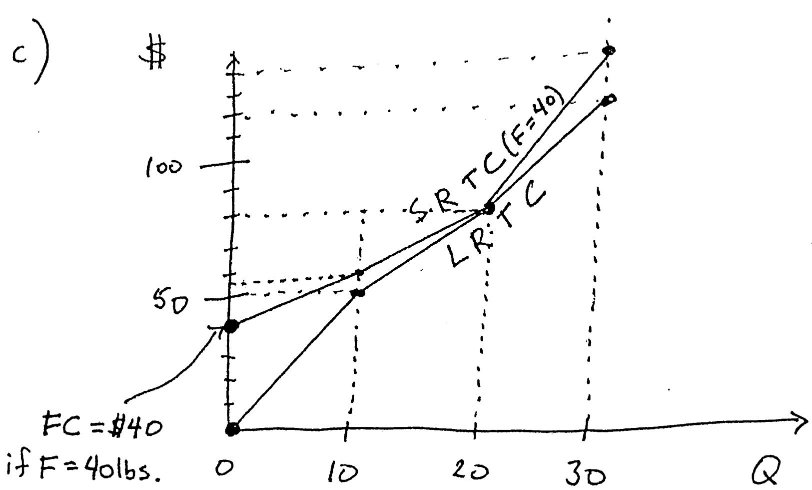
F: 1 point
W: 3 points
cost: 1 point

b3) $F = 40$ $W \doteq 50$

$$C = p_W W + p_F F \doteq 2(50) + 1(40) = 140.$$

F: 1 point
W: 3 points
cost: 1 point

c)



SRTC: 5 points
LRTC: 5 points

d)

Q	TR	TC	π
0	0	0	0
10	50	50	0
20	100	80	+20
30	150	120	+30

Long Run

← choose Q = 30

1 point for each entry in table (12 points total)

3 points for correct Q

e)

Q	TR	TC	π
0	0	40	-40
10	50	55	- 5
20	100	80	+20
30	150	140	+10

Short Run, F = 40

choose Q = 20

1 point for each entry in table,

3 points for correct Q

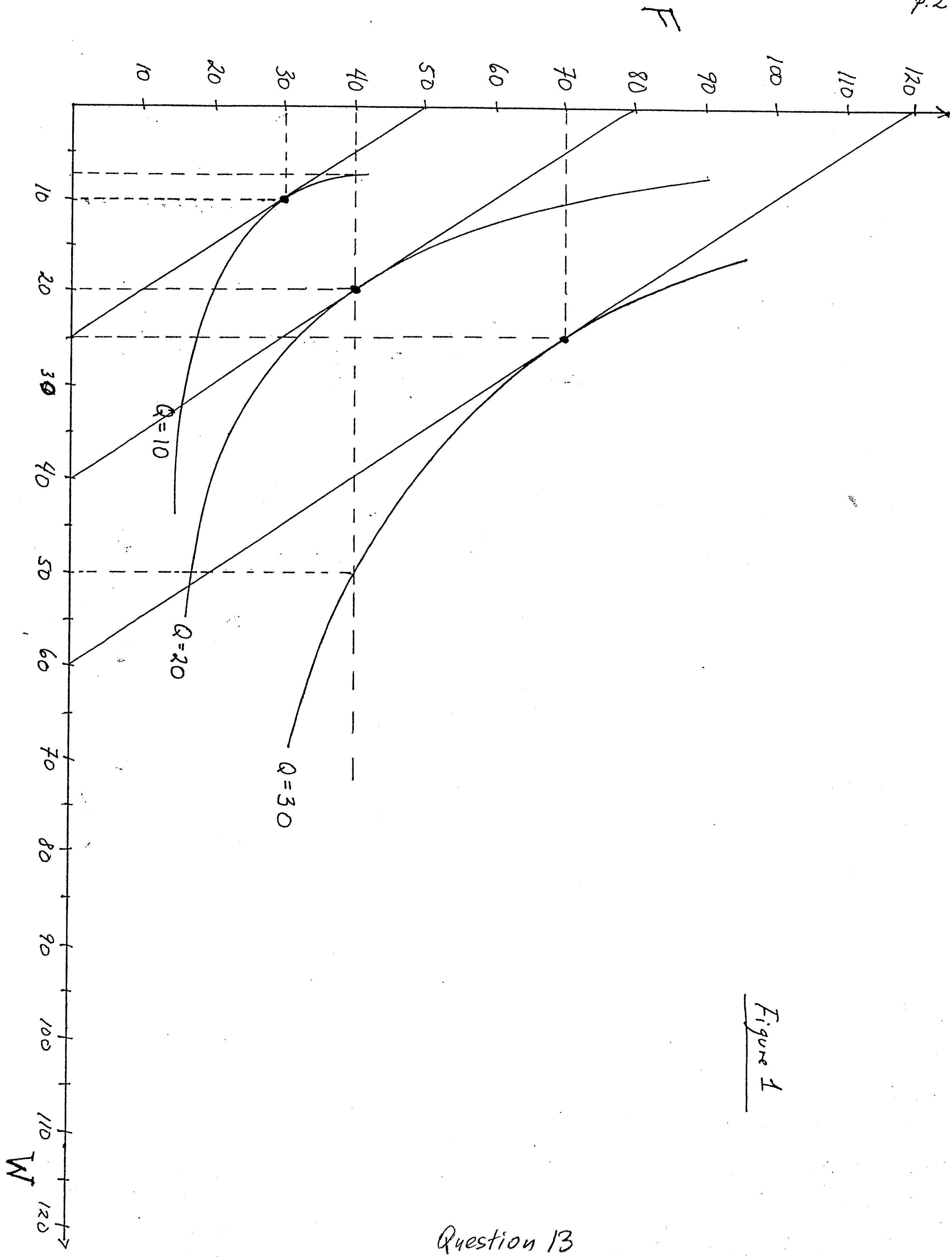


Figure 1

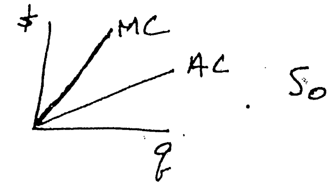
Question 13

14

Q_c	W	F	TC	ΔQ	ΔTC	$MC = \Delta TC / \Delta Q$
0	0	0	0 1pt.	—	—	—
2	1	1	$1 \cdot 1 + 3 \cdot 1 = 4$	2	4	2
3	3	2	$1 \cdot 3 + 3 \cdot 2 = 9$ 2pts each	1	5	5 2pts. each
4	4	4	$1 \cdot 4 + 3 \cdot 4 = 16$	1	7	7

Optional Notes: The way to skip columns 2 and 3 will be illustrated by looking at TC_1 in Fig. 2. With TC_1 dollars, you could buy 4 gal. of Water and 0 lb. F or 0 gal. W and $1\frac{1}{3}$ lb. F. Both of these choices would cost $\$4$ $(= 1\cdot 4 + 3\cdot 0 = 1\cdot 0 + 3\cdot 1\frac{1}{3})$. So all points on the ~~B~~ cost line TC_1 must cost $\$4$, which <u>is</u> the entry in the fourth column of the table. Similarly, with TC_3 dollars you can buy $5\frac{1}{3}$ lb. F and 0 gal. W, so $TC_3 = 5\frac{1}{3}$ lb. $\times$ $\$3$/lb. $= \$16$.

By the way, you might notice that $TC = Q^2$. Then for those of you who know calculus, $MC = 2Q$. So exact figures for the last column are 0, 4, 6, 8 instead of –, 2, 5, 7. Also, $TC = Q^2 \Rightarrow AC = Q$, like this:



. So the entire MC curve is above AC, and hence the entire MC curve is the firm's supply curve. So the shut-down rule, which you were allowed to ignore, will always say "do not shut down" unless $P = 0$.

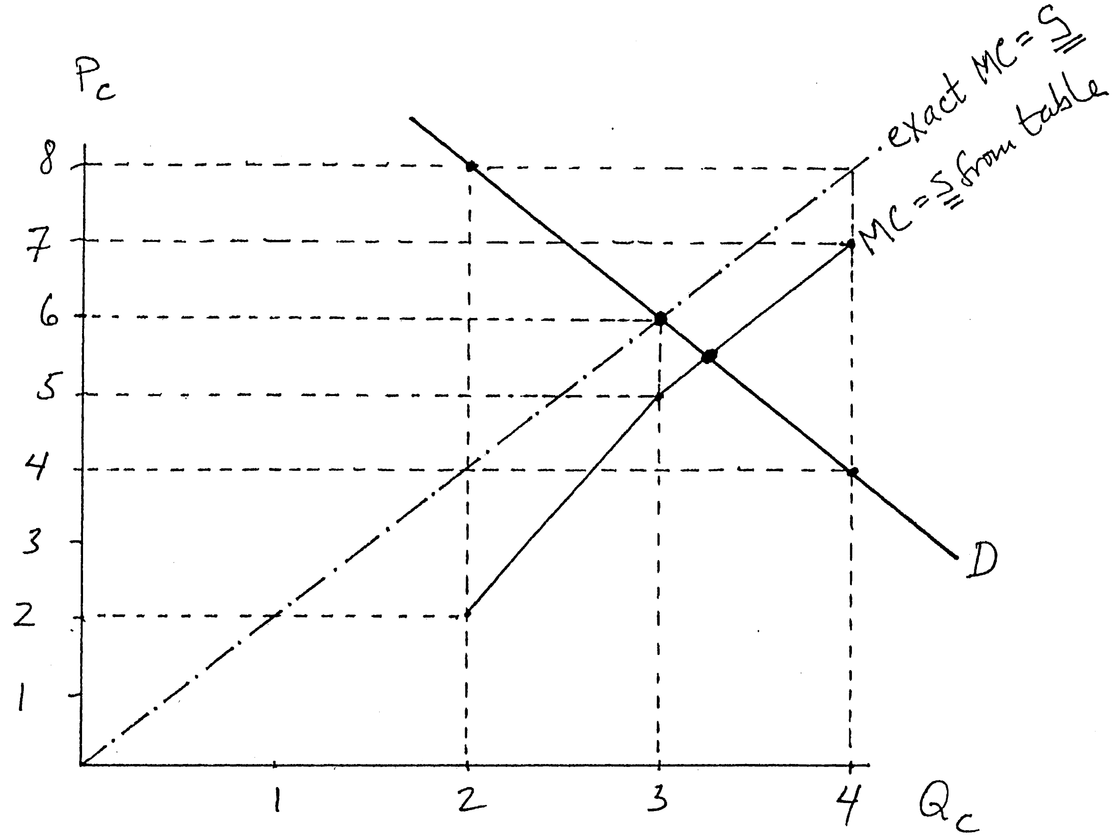
<u>End of Optional Notes.</u>

For the consumer, look at Fig. 3. Since $I = \$24$ and $P_{SP} = \$4$/can, we know that one point on the budget line (or "budget constraint") is 6 cans of SP and zero bu. of corn. If his budget line is BL_1, he could afford $SP = 0$, $C = 3$; so BL_1 must have $P_C = \frac{24}{3} = \$8$. For BL_2, he could afford $SP = 0$, $C = 6$, so there $P_C = \frac{24}{6} = \$4$. Thus we get:

Q_C	P_C
2	8
4	4

2pts 10pts

. This is the D curve. We get the S curve from the MC curve, since $S = MC$ ignoring the shut-down rule. Hence



S = MC : 7pts

D curve : 3pts

Using the approximate MC from the table, S = D at $P_c \approx \$5\frac{1}{2}$ and $Q_c \approx 3\frac{1}{4}$ bu.

Using the exact MC as explained in the optional notes, equilibrium occurs exactly at $P_c = \$6$, $Q_c = 3$ bu.

1pt

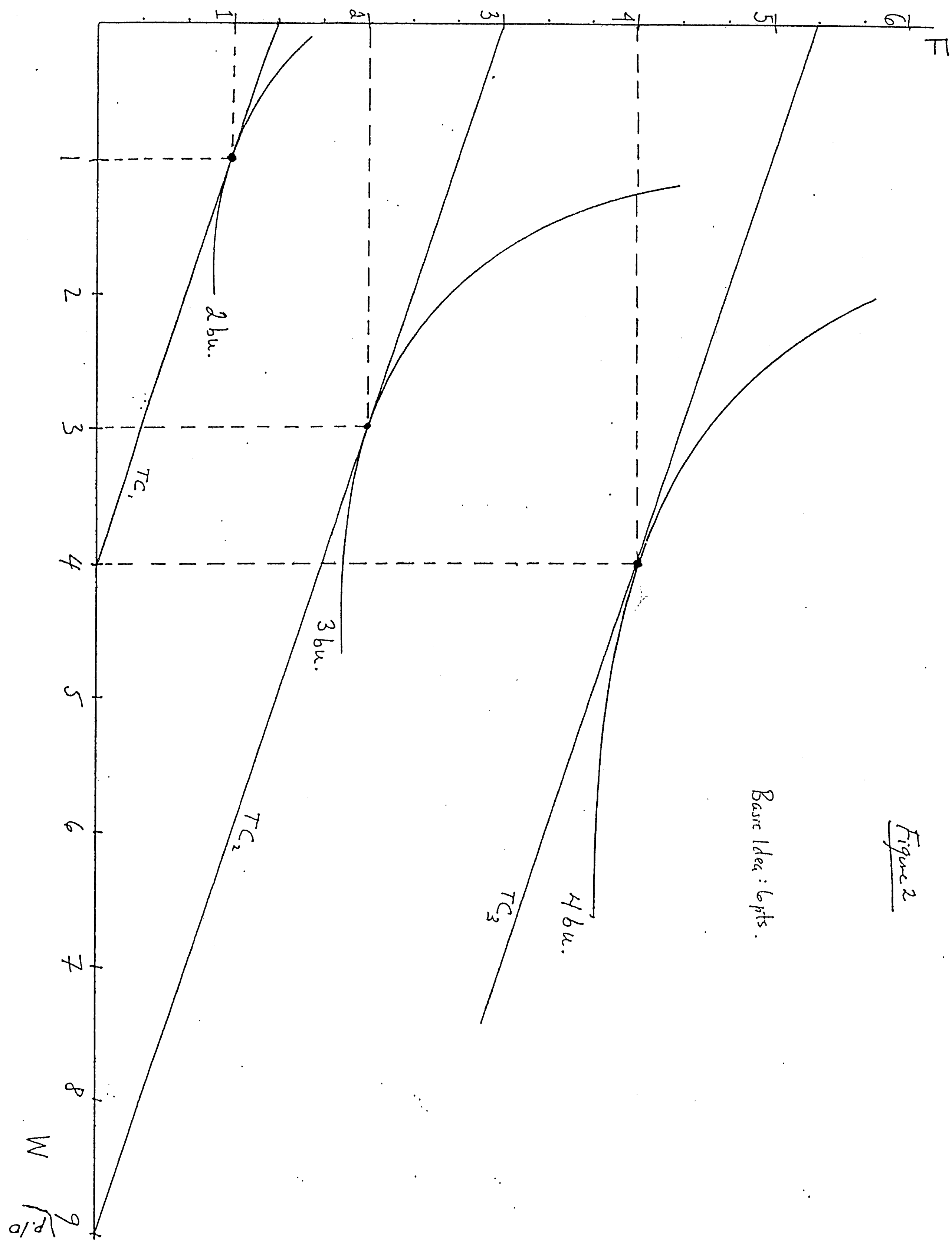
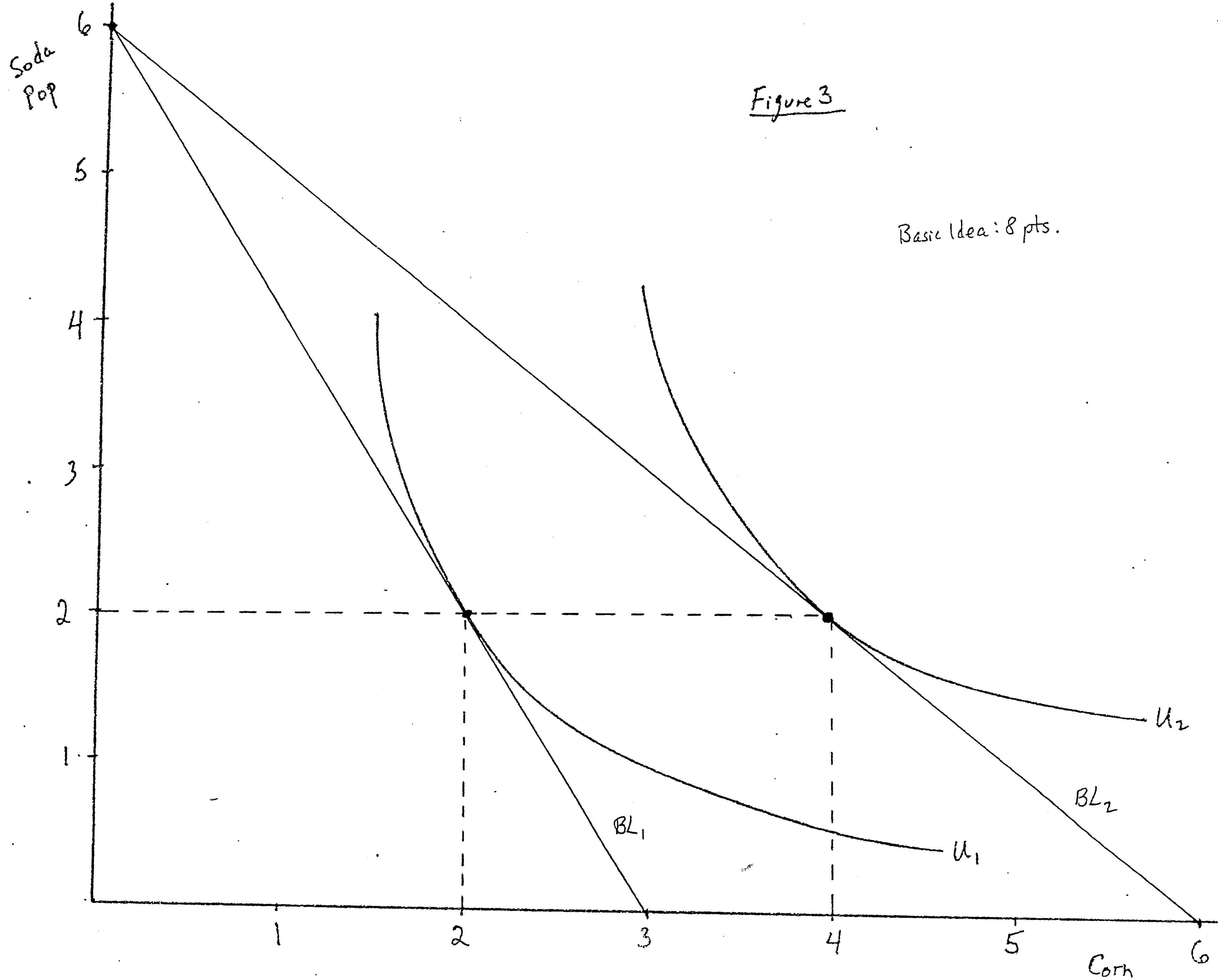


Figure 2
Basic Idea : 6pts.
F
W
1
2
3
4
5
6
7
8
9
2bu.
3bu.
4bu.
TC_1
TC_2
TC_3
p.10

Question 14

Figure 3

Basic Idea: 8 pts.



Question 14