

Section 1 Microeconomics: Answers to Test your understanding quantitative questions (Chapters 2–7)

Answers have been provided for all quantitative Test your understanding questions throughout the textbook.

Chapter 2 Competitive markets: demand and supply

Test your understanding 2.5 (page 35)

- 2 (a) Find at least 2 points on the curve and plot. For example:

$$\text{if } P = 2, Q_d = 70 - 7(2) = 70 - 14 \Rightarrow Q_d = 56; \text{ this gives the point } (56, 2)$$

$$\text{if } P = 3, Q_d = 70 - 7(3) = 70 - 21 \Rightarrow Q_d = 49; \text{ this gives the point } (49, 3)$$

$$\text{if } P = 4, Q_d = 70 - 7(4) = 70 - 28 \Rightarrow Q_d = 42; \text{ this gives the point } (42, 4)$$

The third point is to check that you are getting a straight line. (Recall that any point on a graph can be represented by (h, v) , where h is the value of the variable on the horizontal axis and v is the value of the variable on the vertical axis; see ‘Quantitative techniques’ chapter on the CD-ROM, page 8.)

However, the easiest way to plot a demand curve is to find the horizontal (Q) and vertical (P) intercepts, as these are the end-points of the demand curve:

Horizontal (Q) intercept: set $P = 0 \Rightarrow Q = 70 - 7(0) \Rightarrow Q = 70$ (this is simply the value of the parameter a in the function $Q_d = a - bP$)

Vertical (P) intercept: set $Q_d = 0 \Rightarrow 0 = 70 - 7P \Rightarrow 7P = 70 \Rightarrow P = 10$

The line joining the two intercepts is the D curve.

- (b) When $P = 2, Q_d = 70 - 7(2) = 70 - 14 \Rightarrow Q_d = 56$. Using the same method, you find that

$$\text{when } P = 5, Q_d = 35$$

$$\text{when } P = 8, Q_d = 14$$

- (c) This was done in part (a) above.

- (d) The graph of the D curve should cut the horizontal (Q) axis at $Q = 70$, and the vertical (P) axis at $P = 10$

- 3 (a) The new D curve will shift to the right by 15 units measured along the horizontal (Q) axis and will be parallel to the initial D curve.

(b) $Q_d = 85 - 7P$

(c) Vertical (P) intercept: set $Q_d = 0 \Rightarrow 0 = 85 - 7P \Rightarrow 7P = 85 \Rightarrow P = 12.14$

Horizontal (Q) intercept: set $P = 0: \Rightarrow Q = 85$ (this is the new value of the parameter a)

- 4 (a) The new D curve will shift to the left by 20 units measured along the horizontal (Q) axis and will be parallel to the initial D curve.
- (b) $Q_d = 50 - 7P$
- (c) Vertical (P) intercept: set $Q_d = 0 \Rightarrow 0 = 50 - 7P \Rightarrow 7P = 50 \Rightarrow P = 7.14$
 Horizontal (Q) intercept: $Q = 50$ (this is the new value of the parameter a).
- 5 (a) -7
- (b) You can easily graph the new D curve after answering (c) and (d) below. Knowing the vertical (P) intercept and the horizontal (Q) intercept, you can draw a line from $P = 14$ (where $Q = 0$) to $Q = 70$ (where $P = 0$).
- (c) $Q_d = 70 - 5P$
- (d) Vertical (P) intercept: set $Q_d = 0 \Rightarrow 0 = 70 - 5P \Rightarrow 5P = 70 \Rightarrow P = 14$
 Horizontal (Q) intercept: set $P = 0 \Rightarrow Q = 70$
 Note that when the slope changes, the horizontal (Q) intercept (or the value of the parameter a) does not change; you can also see this in your graph.
- (e) The absolute value of the slope decreases; therefore the D curve becomes steeper. This should be clear in your graph.

Test your understanding 2.6 (pages 37–8)

- 2 (a) You can find at least two points on the S curve and plot (as shown in Test your understanding 2.5, question 2(a) above, for the D curve). However, the easiest way to plot an S curve is by first seeing if the Q -intercept, or the value of c in the supply function $Q_s = c + dP$, has a positive or negative value. If $c > 0$, this means that the S curve begins from the horizontal (Q) axis; you should therefore find the horizontal intercept plus at least one more point, which will give you the S curve. If $c < 0$, this means that the S curve begins from the vertical (P) axis; you should therefore find the vertical intercept plus at least one more point, which will give you the S curve. (For an explanation of these points, see ‘Quantitative techniques’ chapter on the CD-ROM, page 22.)

In the question here, the horizontal intercept, or the value of c is negative ($c = -20$); therefore you should begin by finding the P -intercept:

$$\text{Set } Q_s = 0 \Rightarrow 0 = -20 + 10P \Rightarrow 10P = 20 \Rightarrow P = 2$$

To find a second point, you should use a value of $P > 2$ to solve for Q_s (since any $P < 2$ gives a negative value for Q_s , which is not of interest):

$$\text{If } P = 3, Q_s = -20 + 10(3) = -20 + 30 \Rightarrow Q_s = 10; \text{ this is point } (10, 3)$$

$$\text{If } P = 4, Q_s = -20 + 10(4) = -20 + 40 \Rightarrow Q_s = 20; \text{ this is point } (20, 4)$$

(The third point is to check that you are getting a straight line.)

- (b) When $P = 3$, $Q_s = 10$
 When $P = 4$, $Q_s = 20$
 When $P = 6$, $Q_s = 40$
- (c) Vertical (P) intercept: set $Q_s = 0 \Rightarrow P = 2$ (this was found above)
 Horizontal (Q) intercept: set $P = 0 \Rightarrow Q = -20$ (this is simply the value of the parameter c)
 The horizontal intercept of $Q = -20$ does not appear in the graph.
- (d) The non-negative intercept is the vertical (P) intercept, which is $P = 2$ (this is what your graph should show).
- 3 (a) The new S curve will shift to the right by 15 units measured along the horizontal (Q) axis, and will be parallel to the initial S curve.
- (b) $Q_s = -5 + 10P$
- (c) Vertical (P) intercept: set $Q_s = 0 \Rightarrow 0 = -5 + 10P \Rightarrow 10P = 5 \Rightarrow P = \frac{1}{2}$
 Horizontal intercept: set $P = 0 \Rightarrow Q_s = -5$ (this is the new value of the parameter c)
 The horizontal (Q) intercept of $Q = -5$ does not appear in the graph.
- 4 (a) The new S curve will shift to the left by 15 units measured along the horizontal axis, and will be parallel to the initial S curve.
- (b) $Q_s = -35 + 10P$
- (c) Vertical (P) intercept: set $Q_s = 0 \Rightarrow 0 = -35 + 10P \Rightarrow 10P = 35 \Rightarrow P = 3.5$
 Horizontal (Q) intercept: set $P = 0 \Rightarrow Q_s = -35$ (this is the new value of the parameter c)
 The horizontal (Q) intercept of $Q = -35$ does not appear in the graph.
- 5 (a) +10
- (b) To graph the new function, you need to first find the new S function (also asked for in part (c) below). This is $Q_s = -20 + 15P$
 Find the vertical (P) intercept by setting $Q_s = 0 \Rightarrow 0 = -20 + 15P \Rightarrow 15P = 20 \Rightarrow P = 1.33$
 To find a second point on the new S curve, find a Q for any value of $P > 1.33$ (since if $P < 1.33$ a negative Q results). If $P = 2$, $Q_s = -20 + 15(2) = -20 + 30 \Rightarrow Q_s = 10$. You now have 2 points that allow you to plot the curve. (You might want to find a third point as a check.) Note that when the slope changes, the horizontal (Q) intercept (or the value of the parameter c) does not change.

(c) $Q_s = -20 + 15P$

(d) Vertical (P) intercept: set $Q_s = 0 \Rightarrow P = 1.33$ (see above)

Horizontal (Q) intercept: set $P = 0 \Rightarrow Q_s = -20$

The horizontal intercept does not appear in the graph.

(e) The value of the slope increases, therefore the S curve becomes flatter.

(f) You must first find the new S function (also asked for in part (g) below). This is
 $Q_s = -20 + 8P$

Find the vertical (P) intercept by setting $Q_s = 0 \Rightarrow 0 = -20 + 8P \Rightarrow 8P = 20 \Rightarrow P = 2.5$

To find a second point on the new S curve, find a Q for any $P > 2.5$ (since if $P < 2.5$ a negative Q results). If $P = 4$, $Q_s = -20 + 8(4) = -20 + 32 \Rightarrow Q_s = 12$. You now have two points that allow you to plot the curve. (You might want to find a third point as a check.) Again you can see that when the slope changes, the horizontal (Q) intercept (or the value of the parameter c) does not change.

(g) $Q_s = -20 + 8P$

(h) The value of the slope has decreased; therefore the S curve becomes steeper.

Test your understanding 2.7 (page 39)

1 (a) Setting Q_d equal to Q_s :

$$500 - 2P = -100 + 2P \Rightarrow 600 = 4P \Rightarrow P = 150$$

Using the demand equation to solve for Q , you will get:

$$Q_d = 500 - 2(150) = 500 - 300 = 200$$

(You can also use the supply equation; you will get the same answer.)

Therefore the equilibrium P is \$150 and equilibrium Q is 200 thousand units per week.

(b) If you are given a price range for which to plot curves (as in this question), this makes plotting easier.

Demand curve:

When $P = \$50$: $Q_d = 500 - 2(50) = 500 - 100 \Rightarrow Q_d = 400$ (thousand units per week)

When $P = \$200$: $Q_d = 500 - 2(200) = 500 - 400 \Rightarrow Q_d = 100$ (thousand units per week)

You now have the two end-points of the D curve: (400,50) and (100,200).

Supply curve:

$$\text{When } P = \$50: Q_s = -100 + 2(50) = -100 + 100 = 0 \Rightarrow Q_s = 0$$

$$\text{When } P = \$200: Q_s = -100 + 2(200) = -100 + 400 = 300 \text{ (thousand units per week)}$$

You now have the two end-points of the S curve: (0,50) and (300,200).

The D and S curves are plotted in Figure 1, showing equilibrium P and Q .

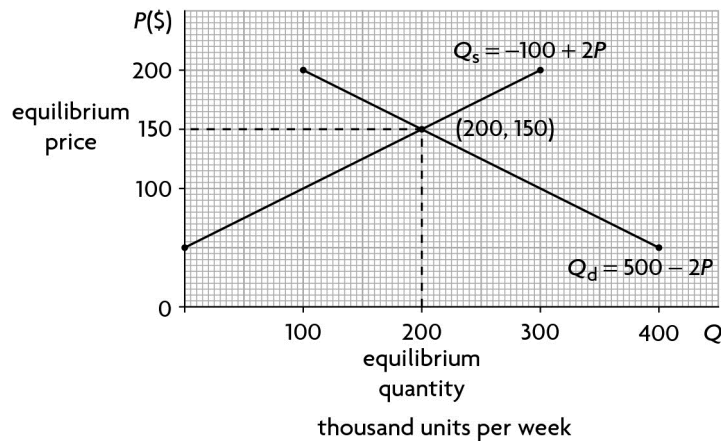


Figure 1

(c) When $P = \$190$:

$$Q_d = 500 - 2(190) = 500 - 380 = 120$$

$$Q_s = -100 + 2(190) = -100 + 380 = 280$$

There is excess supply (a surplus) of $280 - 120 = 160$ (thousand units per week).

When $P = \$170$:

use the same method as above to answer.

When $P = \$125$:

$$Q_d = 500 - 2(125) = 500 - 250 = 250$$

$$Q_s = -100 + 2(125) = -100 + 250 = 150$$

There is excess demand (a shortage) of $250 - 150 = 100$ (thousand units per week).

When $P = \$85$:

use the same method as above to answer.

(d) See textbook, page 30.

2 (a) $Q_d = 800 - 2P$; $Q_s = 200 + 2P$

To plot, you can use your graph from question 1 above (Figure 1) and simply shift the D and S curves by 300 (thousand) units toward the right, as in Figure 2.

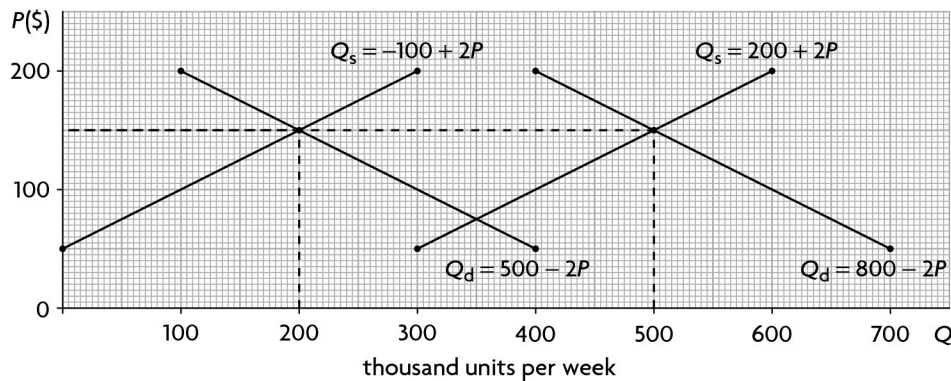


Figure 2

(b) $800 - 2P = 200 + 2P \Rightarrow 600 = 4P \Rightarrow P = 150$

Using the demand equation to solve for Q :

$$Q = 800 - 2(150) = 800 - 300 = 500$$

Therefore equilibrium P is \$150 and equilibrium Q is 500 thousand units per week.

- (c) Because both D and S increased by 300 thousand units per week. While an increase in D alone would have raised the price, or an increase in S alone would have lowered the price, the combined effect of an increase in both D and S by the same amount cancelled out the effects on price, leaving it unchanged, while increasing equilibrium Q by the full amount of the increase in both D and S .

3 (a) To find P : $27 - 0.7P = -5 + 0.9P \Rightarrow 32 = 1.6P \Rightarrow P = 20$

Using the demand equation to find Q : $Q = 27 - 0.7(20) = 27 - 14 = 13$

Therefore equilibrium $P = €20$ and equilibrium $Q = 13$ million units per month.

- (b) Since you know the equilibrium price and quantity, you can use this information to plot both curves; the point of equilibrium is a point on both the D and S curves. You therefore only need to find one more point on each curve, which could be the vertical (P) intercept for each one (note that in the case of the supply curve, since $c = -5$, you know the horizontal intercept is negative; therefore the supply curve begins on the vertical (P) axis).

Vertical (P) intercept for the demand curve:

$$\text{Set } Q = 0: 0 = 27 - 0.7P \Rightarrow 0.7P = 27 \Rightarrow P = 38.57$$

Vertical (P) intercept for S curve:

$$\text{Set } Q = 0: 0 = -5 + 0.9P \Rightarrow 0.9P = 5 \Rightarrow P = 5.55$$

The two curves are plotted in Figure 3 (the P -intercept values have been rounded off for simplicity).

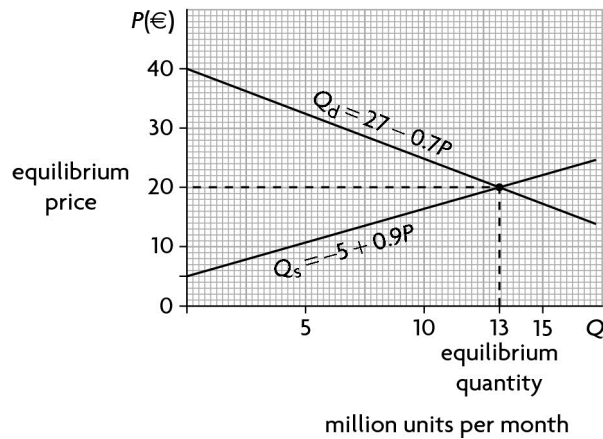


Figure 3

(c) When $P = €10$:

$$Q_d = 27 - 0.7(10) \Rightarrow 27 - 7 = 20 \text{ (million units per month)}$$

$$Q_s = -5 + 0.9(10) \Rightarrow -5 + 9 = 4 \text{ (million units per month)}$$

There is excess demand (a shortage) of $20 - 4 = 16$ million units per month.

When $P = €15$:

use the same method as above to find the answer.

When $P = €25$:

$$Q_d = 27 - 0.7(25) \Rightarrow 27 - 17.5 = 9.5 \text{ (million units per month)}$$

$$Q_s = -5 + 0.9(25) \Rightarrow -5 + 22.5 = 17.5 \text{ (million units per month)}$$

There is excess supply (a surplus) of $17.5 - 9.5 = 8$ million units per month.

When $P = €30$:

use the same method as above to find the answer.

(d) $Q_d = 27 - 0.9P$

(e) The absolute value of the slope increased; therefore the new D curve is flatter compared to the initial D curve.

(f) $Q_s = -5 + 0.7P$

(g) Since the value of the slope fell, the new S curve will be steeper compared to the initial S curve.

Chapter 3 Elasticities

Test your understanding 3.1 (page 48)

$$3 \quad \% \Delta Q = \frac{120 - 100}{100} \times 100 = 20\%$$

$$\% \Delta P = \frac{12 - 16}{16} \times 100 = -25\%$$

$PED = -0.8$; taking the absolute value, $PED = 0.8$

$$4 \quad PED = \frac{-8\%}{10\%} = -0.8; \text{ taking the absolute value, } PED = 0.8$$

Test your understanding 3.2 (page 53)

$$4 \quad (a) \quad \text{From a to b: } PED = \frac{-10/80}{5/10} = \frac{-1/8}{1/2} = \frac{-2}{8} = -0.25; \text{ taking the absolute value, } PED = 0.25$$

$$(b) \quad \text{From c to d: } PED = \frac{-10/50}{5/25} = \frac{-1/5}{1/5} = -1.0; \text{ taking the absolute value, } PED = 1.0$$

$$(c) \quad \text{From e to f: } PED = \frac{-10/20}{5/40} = \frac{-1/2}{1/8} = \frac{-8}{2} = -4; \text{ taking the absolute value, } PED = 4.0$$

(d) At high prices and low quantities, demand is price elastic (the absolute value of $PED > 1$); at low prices and large quantities, demand is price inelastic (the absolute value of $PED < 1$). At the mid-point of the demand curve, PED is unit elastic (the absolute value of $PED = 1$). The explanation for this relates to how PED is calculated, and is explained on page 50 of the textbook.

Test your understanding 3.5 (pages 61–62)

$$4 \quad XED = 0.7 = \frac{x}{5\%} \Rightarrow 0.7 \times 5\% = 3.5\%; \text{ there will be a } 3.5\% \text{ increase.}$$

6 (a) The goods in each pair are substitutes.

(b) B and C are stronger substitutes than A and B.

- (c) The demand curve for good B will shift to the right (demand increases) in response to an increase in the price of both A and C. Draw a demand curve for good B and show two rightward shifts. The large shift is caused by an increase in the price of good C, and the smaller one by an increase in the price of good A.
- 7 (a) The goods in each pair are complements.
- (b) E and F are stronger complements than D and E.
- (c) The demand curve for E will shift left (demand decreases) in response to an increase in prices of both D and F. Draw a demand curve for good E, and show two leftward shifts. The larger shift is caused by an increase in the price of good F, and the smaller one by an increase in the price of good D.

Test your understanding 3.6 (page 65)

3 (a) Pizza: $YED = \frac{4/8}{200/1000} = \frac{1/2}{1/5} = \frac{5}{2} = 2.5$

Cheese sandwiches: $YED = \frac{-5/15}{200/1000} = \frac{-1/3}{1/5} = \frac{-5}{3} = -1.67$

- (b) Pizzas are normal goods; cheese sandwiches are inferior goods.
- (c) The demand curve for pizzas shifts to the right; the demand curve for cheese sandwiches shifts left.
- 4 (a) Good A: $\frac{10\%}{15\%} = 0.67$; income-inelastic.
- (b) Good B: $\frac{20\%}{15\%} = 1.33$; income-elastic.
- (c) Good A is a necessity; good B is a luxury.

Test your understanding 3.7 (page 69)

- 5 (a) First week: $PES = 0$

(b) Second week: $PES = \frac{2000/10000}{5/10} = \frac{1/5}{1/2} = \frac{2}{5} = 0.4$

(c) Third week: $PES = \frac{8000/10000}{5/10} = \frac{4/5}{1/2} = \frac{8}{5} = 1.6$

- 6 (a) The longer the time period, the larger the *PES*.
- (b) See Figure 3.12 (textbook, page 68).

Chapter 4 Government intervention

Test your understanding 4.2 (page 79)

- 2 (a) You are given two points on each curve (vertical intercept and point of intersection), and so you can plot the two curves directly and identify their point of intersection (equilibrium *P* and *Q*; see Figure 4 below). (Remember that any point can be represented by (*h*,*v*), where *h* = the value of the variable measured on the horizontal axis, and *v* = the value of the variable measured on the vertical axis).
- (b) Label the axes (\$ and tonnes per day). The tax of \$2 per tonne shifts the *S* curve upward by \$2, measured along the vertical axis (see Figure 4). After the tax is imposed:

price paid by consumers is $P = \$5$

price received by producers is $P = \$3$

new equilibrium quantity is $Q = 4$ tonnes per day

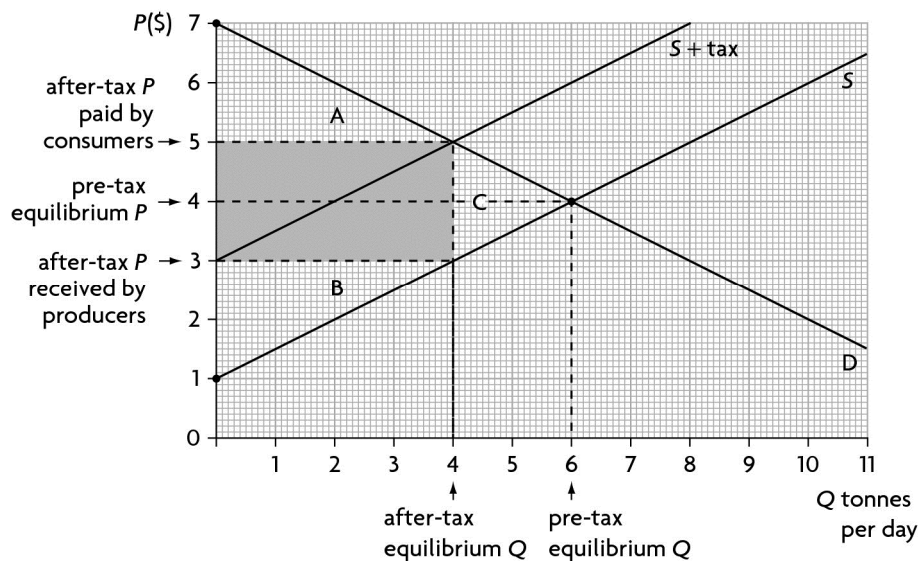


Figure 4

- (c) The price paid by consumers increases by \$1 (from \$4 to \$5) whereas the tax is \$2 per tonne. The reason the price paid by consumers increases by less than the tax per tonne is that part of the tax is paid by producers (\$1 per tonne).

(d) *Consumer expenditure:*

Before the tax: $\$4 \times 6 \text{ tonnes} = \24 per day

After the tax: $\$5 \times 4 \text{ tonnes} = \20 per day

Consumer expenditure fell by \$4 per day.

Firm revenue:

Before the tax: $\$4 \times 6 \text{ tonnes} = \24 per day

After the tax: $\$3 \times 4 \text{ tonnes} = \12 per day

Firm revenue fell by \$12 per day.

Government revenue:

Increased due to the tax by $\$2 \text{ per tonne} \times 4 \text{ tonnes per day} = \8 per day

Consumer surplus:

Before the tax: $\frac{(7-4) \times 6}{2} = \frac{18}{2} = \9

After the tax: $\frac{(7-5) \times 4}{2} = \frac{8}{2} = \4

Consumer surplus decreased by \$5 ($= \$9 - \4)

Producer surplus:

Before the tax: $\frac{(4-1) \times 6}{2} = \frac{18}{2} = \9

After the tax: $\frac{(3-1) \times 4}{2} = \frac{8}{2} = \4

Producer surplus decreased by \$5 ($= \$9 - \4)

Welfare loss (deadweight loss):

Is equal to $\frac{(5-3) \times (6-4)}{2} = \frac{2 \times 2}{2} = \2

(e) In Figure 4:

Triangle A = consumer surplus after the tax

Triangle B = producer surplus after the tax

Shaded rectangle = government revenue

Triangle C = welfare (deadweight) loss

(f) Post-tax supply function:

$$Q_s = -2 + 2(P - 2) = -2 + 2P - 4 = -6 + 2P \Rightarrow Q_s = -6 + 2P$$

To find the new equilibrium price and quantity, solve for P and Q using the demand function and the new supply function:

$$14 - 2P = -6 + 2P \Rightarrow 4P = 20 \Rightarrow P = \$5 \text{ is the new equilibrium price, which is the post-tax price paid by consumers.}$$

Post-tax price received by producers = post-tax price paid by consumers minus tax per unit = $\$5 - \$2 = \$3$

New equilibrium quantity: using the demand function, $Q_d = 14 - 2P \Rightarrow Q_d = 14 - 2(5) = 14 - 10 = 4$, i.e. 4 tonnes per day. The same result can be obtained using the post-tax supply function. (Note that to solve for Q , you must use $P = \$4$, which is the equilibrium price, or **price paid by consumers**.)

These results match the graph (Figure 4).

3 (a) $10 - \frac{1}{10}P = -2 + \frac{1}{10}P \Rightarrow 12 = \frac{2P}{10} \Rightarrow 2P = 120 \Rightarrow P = 60$

Substituting into the supply equation: $Q = -2 + \frac{1}{10}(60) = -2 + 6 = 4$

Therefore equilibrium $P = \$60$ and equilibrium $Q = 4$ units

Knowing equilibrium P and Q , it is only necessary to find one point on the D and one point on the S curve in order to plot them. You can find the P -intercept for each one. (Note that in the case of the S curve, since the Q -intercept is negative, this means that the S curve begins at a point on the P axis; see the explanation in Test your understanding 2.6, question 2 above, for an explanation.)

Demand curve:

Set $Q_d = 0$: $0 = 10 - \frac{P}{10} \Rightarrow \frac{P}{10} = 10 \Rightarrow P = 100$ is the P -intercept of the D curve.

Supply curve:

Set $Q_s = 0$: $0 = -2 + \frac{P}{10} \Rightarrow \frac{P}{10} = 2 \Rightarrow P = 20$ is the P -intercept of the S curve.

(b) New, post-tax supply function:

$$Q_s = -2 + \frac{1}{10}(P - 20) = -2 + \frac{P}{10} - \frac{20}{10} = -2 + \frac{P}{10} - 2 = -4 + \frac{P}{10}$$

Therefore $Q_s = -4 + \frac{1}{10}P$ is the new supply function.

To find the new equilibrium price and quantity, solve for P and Q using the demand function and the new supply function:

$$10 - \frac{1}{10}P = -4 + \frac{1}{10}P \Rightarrow 14 = \frac{2P}{10} \Rightarrow 140 = 2P \Rightarrow P = \$70 \text{ is the}$$

new equilibrium price, which is the post-tax price paid by consumers.

Post-tax price received by producers = post-tax price paid by consumers minus tax per unit = $\$70 - \$20 = \$50$

New equilibrium quantity: substitute $P = \$70$ into the demand function or new supply function. Using the demand function,

$$Q_d = 10 - \frac{1}{10}P \Rightarrow Q_d = 10 - \frac{1}{10}(70) = 10 - 7 = 3 \text{ units}$$

- (c) Using the same method as in question 2 above, you should find the following:

Consumer expenditure:

Fell by \$30

Firm revenue:

Fell by \$90

Government revenue:

Increased by \$60 due to the tax

Consumer surplus:

Reduced by \$35

Producer surplus:

Reduced by \$35

Welfare (deadweight) loss:

Is equal to \$10

Test your understanding 4.5 (page 88)

- 3 (a) You are given two points on each curve (vertical intercept and point of intersection), and so you can plot the two curves directly and identify their point of intersection (equilibrium P and Q ; see Figure 5 below).
- (b) Label the axes (£ and tonnes per day). The subsidy of £2 per tonne shifts the S curve downward by £2, measured along the vertical axis (see Figure 5). After the subsidy is granted:
- price paid by consumers is $P = £3$
- price received by producers is $P = £5$
- new equilibrium quantity is $Q = 8$ tonnes per day

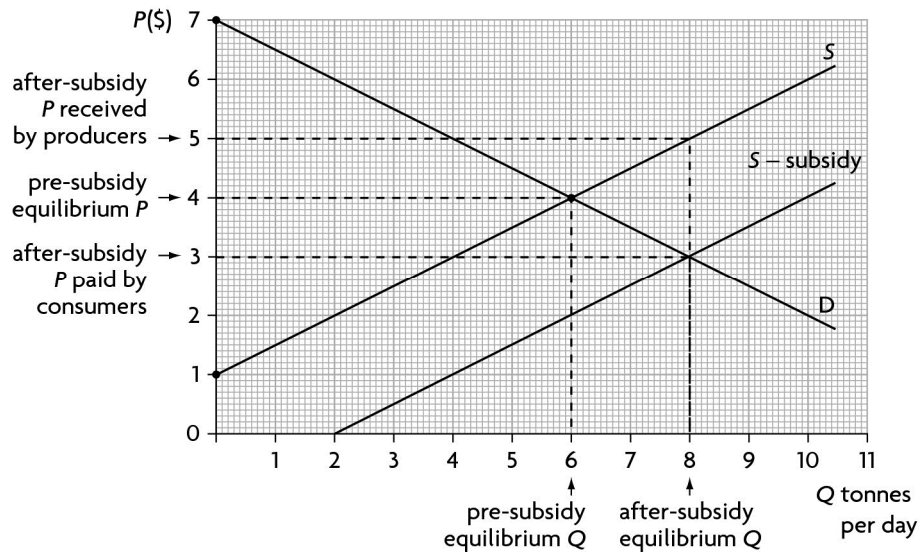


Figure 5

(c) *Consumer expenditure:*

Before the subsidy: £4 × 6 tonnes = £24 per day

After the subsidy: £3 × 8 tonnes = £24 per day

There is no change in consumer expenditure (but note that consumers now pay a lower price and buy a larger quantity).

Firm revenue:

Before the subsidy: £4 × 6 tonnes = £24 per day

After the subsidy: £5 × 8 tonnes = £40 per day

Firm revenue increased by £16 per day

Government expenditure:

Is £2 per tonne × 8 tonnes per day = £16 per day

Consumer surplus:

Before the subsidy: $\frac{(7-4) \times 6}{2} = \frac{18}{2} = £9$

After the subsidy: $\frac{(7-3) \times 8}{2} = \frac{32}{2} = £16$

Consumer surplus increased by £7 (= £16 – £9)

Producer surplus:

$$\text{Before the subsidy: } \frac{(4-1) \times 6}{2} = \frac{18}{2} = \text{£9}$$

$$\text{After the subsidy: } \frac{(5-1) \times 8}{2} = \frac{32}{2} = \text{£16}$$

Producer surplus increased by £7 (= £16 – £9)

Welfare (deadweight) loss:

$$\text{Is equal to } \frac{(5-3)(8-6)}{2} = \frac{2 \times 2}{2} = \text{£2}$$

(d) Post-subsidy supply function:

$$Q_s = -2 + 2(P + 2) = -2 + 2P + 4 \Rightarrow Q_s = 2 + 2P$$

To find the new equilibrium price and quantity, solve for P and Q using the demand function and the new supply function:

$$14 - 2P = 2 + 2P \Rightarrow 12 = 4P \Rightarrow P = 3, \text{ i.e. } P = \text{£3 is the new equilibrium price, and is the price paid by consumers.}$$

Post-subsidy price received by producers = price paid by consumers plus subsidy per tonne = £3 + £2 = £5

New equilibrium quantity: substitute $P = 3$ into the demand function or the new supply function and solve for Q . Using the demand function:

$$Q = 14 - 2(3) = 14 - 6 = 8, \text{ i.e. 8 tonnes per day}$$

The results match the graph (Figure 5).

$$4 \quad (a) \quad 10 - \frac{1}{10}P = -2 + \frac{1}{10}P \Rightarrow 12 = \frac{2P}{10} \Rightarrow 2P = 120 \Rightarrow P = 60$$

$$\text{Substituting into the supply equation: } Q = -2 + \frac{1}{10}(60) = -2 + 6 = 4$$

Therefore equilibrium $P = \text{£60}$ and equilibrium $Q = 4$ units

(b) The new supply function with a subsidy is found by:

$$Q_s = -2 + \frac{1}{10}(P + 20) = -2 + \frac{P}{10} + \frac{20}{10} = -2 + \frac{P}{10} + 2 = \frac{P}{10}; \text{ therefore}$$

$$Q_s = \frac{P}{10} \text{ is the new supply function.}$$

To find the new equilibrium price and quantity, use the demand function and new supply function to solve for P and Q :

$$10 - \frac{1}{10}P = \frac{P}{10} \Rightarrow 10 = \frac{2P}{10} \Rightarrow 2P = 100 \Rightarrow P = 50; \text{ therefore equilibrium } P, \text{ which is the price paid by consumers, is £50.}$$

The new price received by producers is equal to the price of consumers plus the subsidy per unit:

$$£50 + £20 = £70$$

To find the new equilibrium quantity, substitute $P = £50$ into the demand function or the new supply function. Using the new supply function:

$$Q = \frac{P}{10} = \frac{50}{10} = 5 \text{ units}$$

- (c) Although this question does not ask for a graph, it is very useful to draw a diagram (it does not have to be drawn to scale) showing the values of the variables required to answer all the question parts. You need the following values:

- pre-subsidy equilibrium price = £60
- pre-subsidy equilibrium quantity = 4 units
- post-subsidy price paid by consumers = £50
- post-subsidy price received by producers = £70
- post-subsidy equilibrium quantity = 5 units
- P -intercept of demand curve = £100 (found by setting $Q_d = 0$: $0 = 10 - \frac{P}{10} \Rightarrow P = 100$)
- P -intercept of pre-subsidy supply curve = £20 (found by setting $Q_s = 0$: $0 = -2 + \frac{P}{10} \Rightarrow P = 20$).

You can now draw a diagram as in Figure 4.11 in the textbook (page 87) putting in these numbers.

Now using the same method as in question 3 above, you should find the following:

Consumer expenditure:

Increased by £10

Firm revenue:

Increased by £110

Government expenditure:

Increased by £100 due to the subsidy

Consumer surplus:

Increased by £45

Producer surplus:

Increased by £45

Welfare (deadweight) loss:

Is equal to £10

Test your understanding 4.7 (page 92)

- 2 (a) At a price of £4 per unit, Q demanded is 32.5 thousand units per week, and Q supplied is 7.5 thousand units per week. There is therefore a shortage of 25 thousand units per week ($= 32.5 \text{ thousand} - 7.5 \text{ thousand}$).

- (b) *Consumer expenditure:*

Before the price ceiling: $\text{£}8 \times 20 \text{ thousand} = \text{£}160 \text{ thousand per week}$

After the price ceiling: $\text{£}4 \times 7.5 \text{ thousand} = \text{£}30 \text{ thousand per week}$

Consumers spend £130 thousand per week less.

- (c) *Producer revenue:*

The change in producer revenue is the same as the change in consumer expenditure, and therefore falls by £130 thousand per week.

Test your understanding 4.9 (page 96)

- 2 (a) At a price of £30 per unit, Q demanded is 20 thousand kg per week and Q supplied is 100 thousand kg per week. There is therefore a surplus of 80 thousand kg per week ($100 \text{ thousand} - 20 \text{ thousand}$).

- (b) *Consumer expenditure:*

Before the price floor: $\text{£}20 \times 60 \text{ thousand} = \text{£}1200 \text{ thousand per week}$ (or £1.2 million)

After the price floor: $\text{£}30 \times 20 \text{ thousand} = \text{£}600 \text{ thousand per week}$ (or £0.6 million)

Therefore consumer expenditure falls by £600 thousand per week (or £0.6 million).

- (c) *Producer revenue:*

Before the price floor: $\text{£}20 \times 60 \text{ thousand} = \text{£}1200 \text{ thousand per week}$ (or £1.2 million)

After the price floor: $\text{£}30 \times 100 \text{ thousand} = \text{£}3000 \text{ thousand per week}$ (or £3 million)

Therefore producer revenue increases by £1800 thousand per week (or £1.8 million).

- (d) *Government expenditure:*

Is equal to the price at the price floor (£30) times the quantity purchased by the government, which is the amount of the surplus (80 thousand kg per week; see part (a)):

$\text{£}30 \times 80 \text{ thousand} = \text{£}2400 \text{ thousand per week}$ (or £2.4 million)

Chapter 6 The theory of the firm I: Production, costs, revenues and profit

Test your understanding 6.1 (pages 143–44)

5

Units of variable input	<i>TP</i>	<i>MP</i>	<i>AP</i>
0	0	0	0
1	10	10	10.00
2	22	12	11.00
3	35	13	11.67
4	46	11	11.50
5	54	8	10.80
6	59	5	9.83
7	61	2	8.71
8	60	–1	7.50

- 6 (a) Using Figure 6.1 (textbook, page 141) as a guide, plot the total product curve in one diagram, and the average product and marginal product curves in another diagram below. Make sure you label your diagrams correctly.
- (b) The law of diminishing returns (see textbook, page 142).
- (c) Because the short run is defined as the period when at least one input is fixed, and the law shows what happens to the marginal product of a variable input that is added to a fixed input.
- (d) With 4 units of variable input (show in your diagram); this is when the marginal product begins to fall.
- (e) With 8 units of variable input (show in your diagram); this is when the marginal product becomes negative.
- (f) See textbook, page 141.

7

Units of variable input	<i>TP</i>	<i>MP</i>	<i>AP</i>
0	0	–	0
1	3	3	3.00
2	8	5	4.00
3	12	4	4.00
4	15	3	3.75
5	17	2	3.40
6	17	0	2.83
7	16	–1	2.29
8	13	–3	1.62

8 Use the same methods as in question 6 above to answer questions (a)–(c).

9 First find *TP* (by multiplying *AP* times units of variable input) and then find *MP*.

Units of variable input	<i>TP</i>	<i>MP</i>	<i>AP</i>
0	0	0	–
1	4	4	4.00
2	10	6	5.00
3	13	3	4.33
4	15	2	3.75
5	16	1	3.20
6	15	–1	2.50

Test your understanding 6.4 (page 150)

1 Units of variable input and *TP* are taken from Test your understanding 6.1, page 143.

- *TFC* is given in the problem, and is constant for all units of output.
- *TVC* arises from the use of labour, which costs \$2000 per worker per month. You therefore multiply \$2000 by the number of workers (units of variable input).
- *TC* is the sum of *TFC* and *TVC*.
- *AFC* is *TFC* divided by units of output (*TP*).
- *AVC* is *TVC* divided by units of output (*TP*).
- *ATC* is *TC* divided by units of output (*TP*); it can also be obtained by adding *AFC* to *AVC*.

- MC is the change in TC divided by the change in TP (remember it is the cost of producing one additional unit of output, Q). MC is found by dividing ΔTC by ΔTP . Alternatively, it can be found by dividing ΔTVC by ΔTP (the results are identical). For example, in the case of 2 units of variable input, ΔTC (or ΔTVC) = \$2000, and ΔTP = 12 units of output (= 22 – 10); therefore $MC = \frac{\$2000}{12} = \166.7

Units of variable input*	TP (units of output, Q)*	TFC (\$)	TVC (\$)	TC (\$)	AFC (\$)	AVC (\$)	ATC (\$)	MC
0	0	1500	0	1500	-	-	-	-
1	10	1500	2000	3500	150.0	200.0	350.0	200.0
2	22	1500	4000	5500	68.2	181.8	250.0	166.7
3	35	1500	6000	7500	42.9	171.4	214.3	153.8
4	46	1500	8000	9500	32.6	173.9	206.5	181.8
5	54	1500	10 000	11 500	27.8	185.2	213.0	250.0
6	59	1500	12 000	13 500	25.4	203.4	228.8	400.0
7	61	1500	14 000	15 500	24.6	229.5	254.1	1000.0

* Test your understanding 6.1, page 143.

- 2 Your graphs should have the general shapes shown in Figure 6.2(c) and (d) (textbook, page 148). Note that it is very difficult to plot such numbers accurately, and for the purposes of this exercise you can round off to the nearest whole number to plot. (In an exam, you will be asked to draw simpler graphs.)
- 5
 - (a) The vertical distance between TC and TFC represents TVC .
 - (b) The vertical distance between TC and TVC represents TFC .
- 6
 - (a) The vertical distance between ATC and AFC is AVC .
 - (b) The vertical distance between ATC and AVC is AFC .
- 10
 - (a) Insurance premiums are a fixed cost; therefore AFC and ATC would shift downward.
 - (b) Wage rates are a variable cost; therefore AVC , ATC and MC would shift downward.

Test your understanding 6.6 (pages 157–58)

2 Important note: The Quantity figures in this question should be in units (not thousand units).

Price (\$)	Quantity (units)	TR (\$)	MR (\$)	AR (\$)
5	0	0	0	0
5	1	5	5	5
5	2	10	5	5
5	3	15	5	5
5	4	20	5	5

3 Your graphs should have the same general shapes as in Figure 6.7 (textbook, page 156).

4 Important note: The Quantity figures in this question should be in units (not thousand units).

Price (\$)	Quantity (units)	TR (\$)	MR (\$)	AR (\$)
8	2	16	–	8
7	3	21	5	7
6	4	24	3	6
5	5	25	1	5
4	6	24	-1	4
3	7	21	-3	3
2	8	16	-5	2

5 Your graphs should have the same general shape as in Figure 6.8 (textbook, page 157).

- 6 (a)** They differ because the data in question 3 refer to a firm that has no control over price, therefore price is constant for all levels of output, while the data in question 5 refer to a firm that has some control over price, therefore price changes for different levels of output.
- (b)** When the firm has no control over price, price is constant for all units of output. This occurs when a firm is producing under highly competitive conditions. When the firm has some control over price, there is a negative relationship between price and quantity, so that as price falls, quantity increases (and vice versa). This occurs when conditions in the market are less competitive and the firm has some market power.
- (c)** Price and average revenue are the same, in both the cases where the firm has no control over price and the cases where the firm has some control over price.

- 7 Important note:** The Quantity figures in this question should be in units (not thousand units).

Since AR is the same as price, you can use the AR figures to calculate TR , and then MR .

Quantity (units)	AR (\$)	TR (\$)	MR (\$)	Price (\$)
1	20	20	20	20
2	18	36	16	18
3	16	48	12	16
4	14	56	8	14
5	12	60	4	12
6	10	60	0	10

- 8 Important note:** The Quantity figures in this question should be in units (not thousand units).

Since you are given MR , you can calculate TR , and then use TR and Q to find AR and therefore P .

Quantity (units)	MR (\$)	TR (\$)	AR (\$)	Price (\$)
1	14	14	14	14
2	12	26	13	13
3	10	36	12	12
4	8	44	11	11
5	6	50	10	10
6	4	54	9	9

Test your understanding 6.7 (page 161)

- 6** Adding together implicit plus explicit costs, you find that the firm had total costs of \$35 000 + \$75 000 = \$110 000
- (a) The firm earned normal profit in 2010 when $TC = TR$
- (b) The firm considered shutting down in 2011, because $TC > TR$
- (c) The firm earned supernormal profit of \$40 000 (= \$150 000 – \$110 000) in 2009.
- (d) Economic profit:
- 2009: \$40 000 (= \$150 000 – \$110 000)
- 2010: 0 (= \$110 000 – \$110 000)
- 2011: – \$15 000 (= \$95 000 – \$110 000)

- (e) The firm reached its break-even point in 2010, when it was earning normal profit and economic profit of zero.

Test your understanding 6.8 (pages 163–64)

- 3 Use the information in the question to calculate TR and economic profit for each level of output.

Q (units)	P (\$)	TR (\$)	TC (\$)	Economic profit (\$)
1	5	5	15	–10
2	5	10	18	–8
3	5	15	20	–5
4	5	20	21	–1
5	5	25	23	+2
6	5	30	26	+4
7	5	35	30	+5
8	5	40	35	+5
9	5	45	41	+4
10	5	50	48	+2

- (a) Profit is maximum when the firm produces 7 or 8 units of output.
- (b) Profit = \$5.
- (c) Make a graph plotting TC and TR on the vertical axis and Q on the horizontal axis; it should have the same general shape as Figure 6.10 (a) (textbook, page 162).

Profit is maximum where the difference between TR and TC is largest.

- (d) When $Q = 3$, the firm makes a loss of \$5 (negative economic profit).

When $Q = 6$, the firm earns economic profit of \$4.

When $Q = 10$, the firm earns economic profit of \$2.

4 You can find MR and MC from the information in question 3.

Q (units)	MR (\$)	MC (\$)
1	5	*
2	5	3
3	5	2
4	5	1
5	5	2
6	5	3
7	5	4
8	5	5
9	5	6
10	5	7

* You cannot calculate MC for the first unit of output because to do that you need to know TFC (see the table in question 1 of Test your understanding 6.4, where you can see that MC is calculated as the change in TC after TFC has been subtracted; this is why MC is actually the change in TVC divided by the change in Q).

- (a) The firm maximises profit where $MR = MC$; this is where $Q = 8$ units of output.
- (b) See Figure 6.

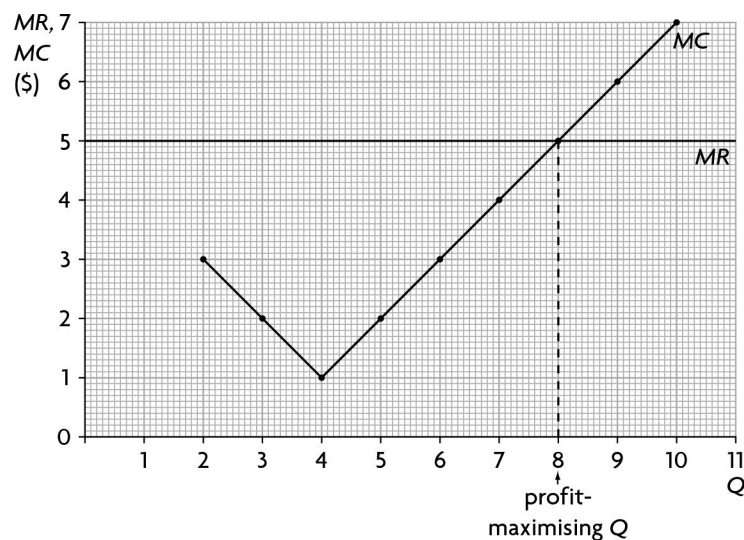


Figure 6

- (c) The profit-maximising level of output is the same. (Note that you must use the larger of the two values found by the TR and TC approach; see the note in the textbook, page 164.)

5

Q (units)	P (\$)	TR (\$)	TC (\$)	Economic profit (\$)
1	10	10	15	-5
2	9	18	18	0
3	8	24	20	+4
4	7	28	21	+7
5	6	30	23	+7
6	5	30	26	+4
7	4	28	30	-2
8	3	24	35	-11

- (a) The firm maximises profit by producing 4 or 5 units of output.
- (b) It will make profit of \$7.
- (c) Make a graph plotting TC and TR on the vertical axis and Q on the horizontal axis; it should have the same general shape as Figure 6.11 (a) (textbook, page 162). Profit is maximum where the difference between TR and TC is largest.
- (d) When $Q = 2$, the firm earns normal profit (zero economic profit).
- When $Q = 3$, the firm earns economic profit of \$4.
- When $Q = 8$, the firm makes a loss of \$11 (negative economic profit).

6 You can find MR and MC from the information in question 5.

Q (units)	MR (\$)	MC (\$)
1	10	*
2	8	3
3	6	2
4	4	1
5	2	2
6	0	3
7	-2	4
8	-4	5

* See the note at the bottom of the table in question 4 above.

- (a) The firm maximises profit when $MR = MC$, or when it produces 5 units of output.

(b) See Figure 7.

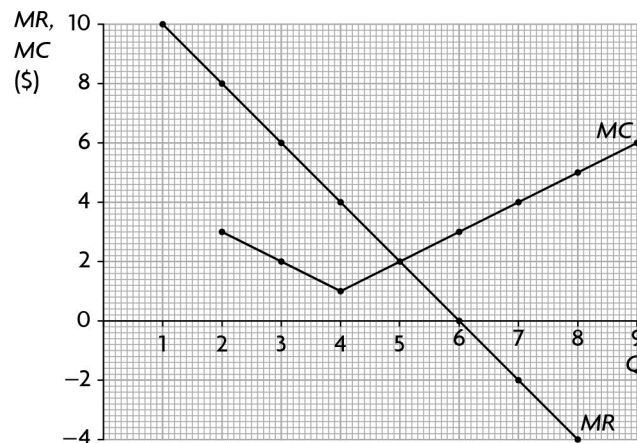


Figure 7

(c) The profit-maximising level of output is the same. (Note that you must use the larger of the two values found by the *TR* and *TC* approach; see the note in the textbook, page 164.)

Chapter 7 Theory of the firm II: Market structures

Test your understanding 7.2 (pages 174–75)

- 5 To answer this question you must compare price with *ATC* and/or *AVC*.
- (a) $ATC = AFC + AVC = \$2 + \$6 = \$8$. Since $P = \$9$, $P > ATC$, therefore the firm makes positive economic (supernormal) profit, and so will continue to operate in the short run.
 - (b) $ATC = AFC + AVC = \$3 + \$12 = \$15$. Since $P = \$13$, $P < ATC$, and so the firm is making a loss. However, $P > AVC$, therefore the firm will continue to operate in the short run (the reason is that as long as $P > AVC$, its loss is smaller than its fixed costs, and so it is better off producing rather than shutting down).
 - (c) $ATC = AFC + AVC = \$5 + \$12 = \$17$. Since $P = \$17$, $P = ATC$, and the firm is earning normal profit (zero economic profit). It will therefore continue to operate in the short run.
- 6
- (a) Profit per unit = $P - ATC = \$9 - \$8 = \$1$
 Total profit (supernormal profit) = profit per unit \times number of units sold = $\$1 \times 200$ units = \$200
 - (b) Loss per unit = $ATC - P = \$15 - \$13 = \$2$
 Total loss = loss per unit \times number of units sold = $\$2 \times 250$ units = \$500
 - (c) Zero profit/loss per unit; zero total profit or total loss.

- 7 (a) $P = MR = €6$. By the $MR = MC$ profit-maximisation rule, the firm will produce 9 units of output. At this level of output, $ATC = €4.44$. Therefore profit per unit $= P - ATC = €6.00 - €4.44 = €1.56$. Total profit $= \text{profit per unit} \times \text{number of units sold} = €1.56 \times 9 = €14.04$
- (b) $P = MR = €4$. By the $MR = MC$ profit-maximisation (loss-minimisation) rule, if the firm produces, it will produce 7 units of output.¹ At this level of output $ATC = €4.14$; therefore $P < ATC$, and the firm would be making a loss. However, since $AVC = €3.28$, it follows that $P > AVC$; therefore the firm will produce the 7 units. Loss per unit $= ATC - P = €4.14 - €4.00 = €0.14$, and total loss $= \text{loss per unit} \times \text{number of units sold} = €0.14 \times 7 = €0.98$.
- (c) $P = MR = €2$. By the $MR = MC$ profit-maximisation (loss-minimisation) rule, if the firm produces, it will produce 5 units of output.² At this level of output, $ATC = €4.40$; therefore the firm would be making a loss since $P < ATC$. Also, at this level of output $AVC = €3.20$; therefore $P < AVC$. Therefore the firm should not produce at all. As long as it remains in the short run, it will be making a total loss that will be equal to its total fixed costs.
- (d) Your graph should show the curves with the same general shape as in Figure 6.2(d), (textbook, page 148). The break-even price is at minimum ATC (where ATC is intersected by MC) and the shut-down price is minimum AVC (where AVC is intersected by MC (since the firm is in the short run)).

Test your understanding 7.4 (pages 178–79)

- 4 To answer this question, you must first calculate total cost, and then find ATC and AVC by dividing by Q .

Q (units)	TVC (\$)	TFC (\$)	TC (\$)	ATC (\$)	AVC (\$)
1	6	4	10	10.00	6.00
2	9	4	13	6.50	4.5
3	11	4	15	5.00	3.67
4	12	4	16	4.00	3.00
5	14	4	18	3.60	2.80
6	17	4	21	3.50	2.83
7	21	4	25	3.57	3.00
8	26	4	30	3.75	3.25
9	32	4	36	4.00	3.55

Short-run shut-down price = \$2.80 (where $P = \text{minimum } AVC$)

Break-even price = \$3.50 (where $P = \text{minimum } ATC$)

¹ Note that there are two levels of output where $P = MC$ (1 unit and 7 units). When this occurs, the firm will choose to produce the larger quantity of output, which is 7 units.

² As in part (b) above, there are more than two levels of output where $P = MC$ (3 units and 5 units). The firm will choose the larger quantity, or 5 units.

Test your understanding 7.7 (page 188)**5 (a)**

<i>Q</i> (units)	Price (\$)	<i>TR</i> (\$)	<i>MR</i> (\$)	<i>ATC</i> (\$)	<i>MC</i> (\$)
1	10	10	10	14.0	4
2	9	18	8	8.5	3
3	8	24	6	6.3	2
4	7	28	4	5.0	1
5	6	30	2	4.4	2
6	5	30	0	4.2	3
7	4	28	-2	4.1	4
8	3	24	-4	4.3	5

- (b) By the $MR = MC$ rule, the profit-maximising level of output is 5 units (where $MR = MC = \$2$).
- (c) 5 units of output will be sold at \$6 per unit.
- (d) Profit per unit = $P - ATC = \$6 - \$4.4 = \$1.6$. Total profit = profit per unit \times number of units sold = $\$1.6 \times 5 = \8.0
- (e) Your graph should show the curves with the same general shapes as in Figure 7.11(a) (textbook, page 186).
- 6** (b) The revenue-maximising monopolist produces output Q where $MR = 0$ (where total revenue is maximum). In the table in question 5, $MR = 0$ at 6 units of output, which will be sold at \$5 per unit.
- (c) In question 5, you found that the profit-maximising monopolist will produce 5 units of output, which will be sold at \$6 per unit. Therefore the revenue-maximising monopolist produces a larger quantity of output and sells it at a lower price, compared with the profit-maximising monopolist.