CHAPTER 2

OPTIMIZATION TECHNIQUES AND NEW MANAGEMENT TOOLS

Multiple-Choice Questions

1. Use the information in the table below to determine the average total cost of producing 4 units of output.

Output	0	1	2	3	4	5	6	7	8
Cost	10	11	13	16	20	25	31	38	48

A. 20
B. 4
C. 5
D. 2.5

Answer: C

2. Use the information in the table below to determine the average variable cost of producing 5 units of output.

Output	0	1	2	3	4	5	6	7	8
Cost	10	11	13	16	20	25	31	38	48

A. 25
B. 15
C. 5
D. 3

Answer: D

3. Use the information in the table below to determine the average fixed cost of producing 2 units of output.

Output	0	1	2	3	4	5	6	7	8
Cost	10	11	13	16	20	25	31	38	48

A. 13
B. 6.5
C. 5
D. 2

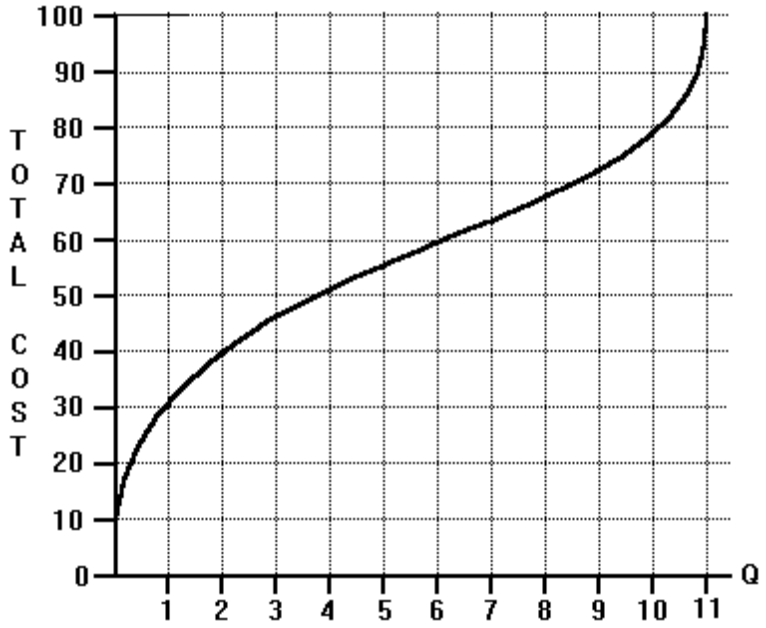
Answer: C

4. Use the information in the table below to determine the marginal cost of producing the sixth unit of output.

Output	0	1	2	3	4	5	6	7	8
Cost	10	11	13	16	20	25	31	38	48

A. 6
B. 31
C. 6/31
D. 31/6

Answer: A



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5. Refer to the total cost graph. What is average total cost equal to when Q = 6?

A. 60
B. 50
C. 10
D. 5

Answer: C

6. Refer to the total cost graph. What is average variable cost equal to when Q = 2?

A. 15
B. 20
C. 30
D. 40

Answer: A

7. Refer to the total cost graph. At approximately what level of output is average total cost at a minimum?

A. 0
B. 5
C. 8
D. 10

Answer: D (Use a ray drawn from the origin)

8. Refer to the total cost graph. What is average fixed cost equal to when Q = 5?

A. 2
B. 10
C. 11
D. 55

Answer: A

9. Refer to the total cost graph. What is the marginal cost of producing the second unit of output?

A. 40
B. 30
C. 20
D. 10

Answer: D

10. Refer to the total cost graph. Which of the following levels of output is closest to the inflection point?

A. 2
B. 5
C. 10
D. 11

Answer: B

11. If marginal cost (MC) is $12 and average variable cost (AVC) is $10, then AVC

A. is at a minimum.
B. is at a maximum.
C. is increasing.
D. is decreasing.

Answer: C

12. If marginal cost (MC) is $10 and average variable cost (AVC) is $10, then AVC

A. is at a minimum.
B. is at a maximum.
C. is increasing.
D. is decreasing.

Answer: A

13. If marginal cost (MC) is $10 and average variable cost (AVC) is $12, then AVC

A. is at a minimum.
B. is at a maximum.
C. is increasing.
D. is decreasing.

Answer: D

14. Use the information about marginal cost (MC) and marginal revenue (MR) that is presented in the table below to determine the profit maximizing level of output.

Output	1	2	3	4	5	6	7	8	9
MC	10	11	13	16	20	25	31	38	48
MR	50	45	40	35	30	25	20	15	10

A. 1
B. 3
C. 6
D. 9

Answer: C

15. Use the information about marginal revenue (MR) that is presented in the table below to determine the total revenue when output is equal to 6.

Output	1	2	3	4	5	6	7	8	9
MR	50	45	40	35	30	25	20	15	10

A. 25
B. 30
C. 150
D. 225

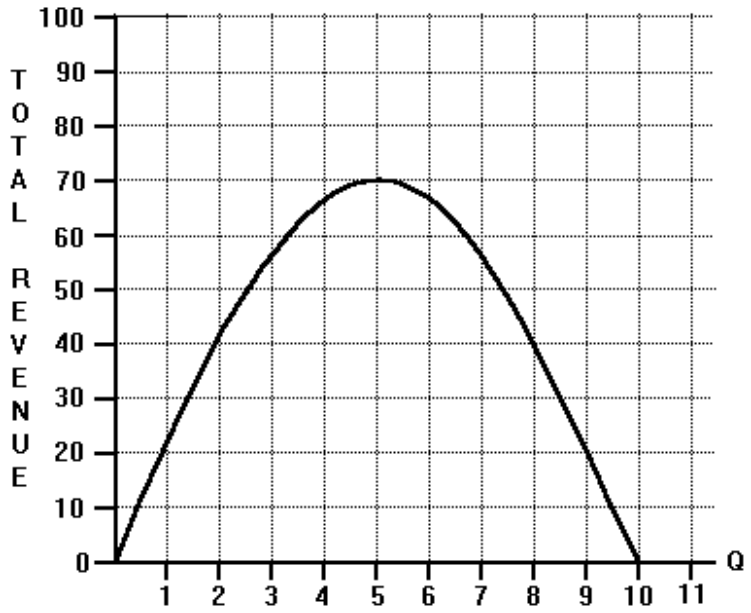
Answer: D

16. Use the information about marginal revenue (MR) that is presented in the table below to determine the level of output that maximizes total revenue.

Output	1	2	3	4	5	6	7	8	9
MR	50	40	30	20	10	0	-10	-20	-30

A. 1
B. 6
C. 9
D. There is not enough information to determine the answer.

Answer: B



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17. Refer to the total revenue graph. The level of output where marginal revenue is equal to zero is

    A. 0
    B. 2
    C. 5
    D. 10

Answer: C

18. Refer to the total revenue graph. Marginal revenue is decreasing when output is equal to

    A. 2
    B. 5
    C. 7
    D. All of the above are correct.

Answer: D

19. Refer to the total revenue graph. If marginal cost is equal to 10 at all levels of output, then which of the following output levels will yield the highest level of profit?

A. 2
B. 4
C. 5
D. 7

Answer: B

20. Suppose that a firm's total revenue function is defined as $TR=200Q-20Q^2$. What is average revenue equal to when one unit of output is produced?

A. 180
B. 20
C. 200
D. 220

Answer: A

21*. Relationships between economic variables can be expressed in the form of

A. a graph.
B. an equation.
C. a table.
D. any of the above.

Answer: D

22*. The optimal solution to a problem is best defined as the solution that

A. is superior to any other possible solution.
B. costs less than any other possible solution.
C. generates more revenue than any other possible solution.
D. corresponds to the inflection point on a total product or total cost curve.

Answer: A

23*. Differential calculus can be used to solve problems in cases where economic relationships are expressed in the form of

A. a graph.
B. a table.
C. an equation.
D. any of the above.

Answer: C

24*. Average cost is defined as

A. total cost divided by marginal cost.
B. total cost divided by total output.
C. total output times cost per unit.
D. total output times marginal cost.

Answer: B

25*. The marginal cost when output=10 is equal to

A. the slope of a line drawn tangent to the total cost curve where output=10.
B. the total cost of 10 units of output divided by 10.
C. the average cost of 10 units of output.
D. the slope of a ray drawn from the origin to the point on the total cost curve where output=10.

Answer: A

26*. If a firm's total revenue function is a straight line that begins at the origin, then

A. marginal revenue is zero.
B. average revenue is zero.
C. marginal revenue is equal to average revenue.
D. all of the above are true.

Answer: C

27*. If marginal revenue is equal to zero, then

A. total revenue is zero.
B. average revenue is zero.
C. total revenue is at a maximum or a minimum.
D. average revenue is at a maximum or a minimum.

Answer: C

28*. If average cost is at a minimum, then

A. it is equal to marginal cost.
B. total cost is also at a minimum.
C. profit is at a maximum.
D. all of the above are true.

Answer: A

29*. The level of output where a straight line drawn from the origin is tangent to the total cost curve is where

A. total cost is at a minimum.
B. average cost is equal to marginal cost.
C. profit is at a maximum.
D. all of the above are correct.

Answer: B

30*. The economic concept that corresponds most closely to a "derivative" in calculus is the concept of

A. an average value.
B. a total value.
C. a marginal value.
D. economic profit.

Answer: C

31*. The marginal principle asserts that, in general, when net benefit is maximized

A. total benefit will be equal to total cost.
B. average benefit will be equal to average cost.
C. marginal benefit will be equal to marginal cost.
D. average cost will be above total cost but below average benefit.

Answer: C

32*. When total revenue is at a maximum

A. average revenue is at a maximum.
B. marginal revenue is at a maximum.
C. average revenue is equal to zero.
D. none of the above are correct.

Answer: D

33*. If both average cost (AC) and marginal cost (MC) are U shaped, then

A. AC will reach a minimum at a level of output that is less than that at which MC reaches a minimum.
B. the total cost curve will be a straight line.
C. AC will reach a minimum at a level of output that is greater than that at which MC reaches a minimum.
D. both AC and MC will reach a minimum at the same level of output.

Answer: C

34*. If a firm's marginal revenue is greater than its marginal cost, then the firm should

A. increase output to increase profit.
B. decrease output to increase profit.
C. keep output the same.
D. collect additional information before taking any action.

Answer: A

35*. If a firm's average cost is equal to its average revenue, then

A. profit is at a maximum.
B. profit is at a minimum.
C. profit is equal to zero.
D. the firm is in equilibrium.

Answer: C

36*. The inflection point refers to the point on a total cost curve where

A. average cost is at a minimum.
B. average cost is at a maximum.
C. marginal cost is at a minimum.
D. marginal cost is at a maximum.

Answer: C

37*. If an average curve has a negative slope, then the corresponding

A. marginal curve is below the average curve.
B. total curve has a negative slope.
C. marginal curve is above the average curve.
D. total curve has a positive slope.

Answer: A

38*. If a firm's total cost curve is defined by a straight line that has a positive intercept that is equal to fixed costs, then

A. average cost is equal to marginal cost for all levels of output.
B. average cost is negatively sloped and marginal cost is horizontal.
C. both average cost and marginal cost are negatively sloped, but they are not equal to each other.
D. both average cost and marginal cost are horizontal, and average cost is below marginal cost at all levels of output.

Answer: B

39*. If a firm is producing a level of output where marginal cost is equal to marginal revenue, then

A. profit is at a maximum if marginal cost has a negative slope and marginal revenue is horizontal.
B. profit is at a minimum if marginal cost has a negative slope and marginal revenue is horizontal.
C. profit is at a maximum if average revenue is greater than average cost.
D. profit is at a minimum if average revenue is greater than average cost.

Answer: B

40*. The optimal amount of pollution to society is where

A. the total cost of pollution is equal to zero.
B. the total benefit of pollution is equal to zero.
C. the marginal benefit of pollution equals the marginal cost of pollution.
D. there is no pollution at all.

Answer: C

True-False Questions

1*. Economic relationships can be expressed as equations, graphs, and schedules.

Answer: T

2*. If an economic relationship is complex, it must generally be expressed as an equation.

Answer: T

3*. Differential calculus can be applied directly to the graph of an economic relationship.

Answer: F

4*. The optimal solution to a problem refers to the best solution.

Answer: T

5*. For any given total function, the total is always larger than the average and the average is always larger than the marginal.

Answer: F

6*. The form of the relationship between total, average, and marginal functions is the same whether it is applied to total revenue, product, cost, or profit.

Answer: T

7*. Total cost is equal to average cost times marginal cost.

Answer: F

8*. Average revenue is equal to marginal revenue between zero units of output and one unit of output.

Answer: T

9*. If total cost is increasing, marginal cost is positive.

Answer: T

10*. If total revenue is decreasing, average revenue is negative.

Answer: F

11*. If total profit is at a maximum, marginal profit is zero.

Answer: T

12*. The concept that corresponds most closely to the derivative is the concept of an average value.

Answer: F

13*. Marginal cost is plotted (as an approximation) halfway between successive units of output.

Answer: T

14*. If an average value is equal to its corresponding marginal value, the average value must be at either a maximum or a minimum.

Answer: T

15*. Average revenue reaches a maximum at the same level of sales that total revenue reaches a maximum.

Answer: F

16*. Marginal revenue reaches a maximum at the same level of output that total revenue reaches a maximum.

Answer: F

17*. If a straight line that is tangent to total cost passes through the origin of a graph, then the slope of the line is equal to average cost at the point of tangency.

Answer: T

18*. If a straight line that is tangent to total cost passes through the origin of a graph, then the slope of the line is equal to marginal cost at the point of tangency.

Answer: T

19*. If a straight line that intersects a total cost line passes through the origin of a graph, then the slope of the straight line is equal to marginal cost at the point of intersection.

Answer: F

20*. If a firm's marginal revenue is negative, then total revenue will decrease if the firm sells more output.

Answer: T

21*. The slope of a tangent to a total curve is equal to the marginal value at the point of tangency.

Answer: T

22*. The inflection point refers to the point where a marginal curve has a slope of zero.

Answer: T

23*. The point where a total value changes from increasing at an increasing rate to increasing at a decreasing rate is called the inflection point.

Answer: T

24*. The point where a total value changes from increasing at a decreasing rate to increasing at an increasing rate is called the inflection point.

Answer: T

25*. If a marginal value is greater than its corresponding average value, the average value must be decreasing.

Answer: F

26*. If an average value is greater than its corresponding marginal value, the average value must be decreasing.

Answer: T

27*. If a marginal value is greater than its corresponding average value, the marginal value must be decreasing.

Answer: F

28*. If a firm is producing a level of output where marginal profit is equal to zero, then the level of output is optimal.

Answer: T

29*. If a firm's total cost curve is a straight line, then its marginal cost curve will be defined by a horizontal straight line.

Answer: T

30*. If a firm's total cost curve is a straight line, then its average total cost curve will also be a straight line.

Answer: F

31*. If a firm's total cost curve is an upward-sloping straight line, then its average total cost curve will slope upward.

Answer: F

32*. A firm's total profit is generally at a maximum when total revenue is at a maximum.

Answer: F

33*. A firm's total profit is generally at a maximum when total cost is at a minimum.

Answer: F

34*. A firm's total profit is generally at a maximum when the firm's average revenue curve is above its average cost curve and the vertical distance that separates the two curves is at a maximum.

Answer: F

35*. A firm's total profit is generally at a maximum when the firm's total revenue curve is above its total cost curve and the vertical distance that separates the two curves is at a maximum.

Answer: T

36*. A firm should continue to increase an activity so long as the marginal revenue from the activity exceeds the marginal cost of the activity.

Answer: T

37*. A firm should continue to increase an activity so long as the total revenue from the activity exceeds the total cost of the activity.

Answer: F

38*. If marginal revenue is equal to marginal cost, profit must be at a maximum.

Answer: F

39*. If total cost is equal to total revenue, then profit is equal to zero.

Answer: T

40*. The optimal amount of pollution is found where the marginal benefit of pollution is equal to the marginal cost of pollution.

Answer: T

Problems

1. A firm's demand function is defined as Q = 14-2P. Use this function to calculate total revenue when price is equal to 3 and when price is equal to 4. What is marginal revenue equal to between P=3 and P=4?

   Solution:

   Q = 14 - (2)(4) = 6 so total revenue is (6)(4) = $24

   Q = 14 - (2)(3) = 8 so total revenue is (8)(3) = $24

   Marginal revenue is 0.

2. A firm's demand function is defined as Q = 30 - P. Use this function to calculate total revenue when price is equal to 5 and when price is equal to 6. What is marginal revenue equal to between P=5 and P=6?

   Solution:

   Q = 30 - 5 = 25 so total revenue is (25)(5) = $125

   Q = 30 - 6 = 24 so total revenue is (24)(6) = $144

   Marginal revenue is $19.

3. A firm's demand function is defined as Q = 30 - 2P. Use this function to calculate total revenue when price is equal to 10 and when price is equal to 11. What is marginal revenue equal to between P=10 and P=11?

   Solution:

   Q = 30 - (2)(10) = 10 so total revenue is (10)(10) = $100

   Q = 30 - (2)(11) = 8 so total revenue is (8)(11) = $88

   Marginal revenue is negative $6.

4. Use the production relationship between total product (Q) and units of labor (L) employed that is presented in the table below to calculate the average and marginal product of labor when Q = 5.

L	1	2	3	4	5	6	7	8	9
Q	3	7	13	17	20	22	23	23	22

   Solution:

   Average product = 20/5 = 4

   Marginal product = 20 - 17 = 3

5. Use the total cost (TC) schedule that is presented in the table below to calculate average total cost, average variable cost, average fixed cost, and marginal cost when output (Q) is equal to 5.

Q	0	1	2	3	4	5	6	7	8	9
TC	5	7	8	10	14	20	28	38	50	72

   Solution:

   Average total cost = 20/5 Average variable cost = (20-5)/5 = 3

   Average fixed cost = 5/5 = 1 Marginal cost = (20 - 14)/(5 - 4) = 6

6. Use the total cost (TC) schedule that is presented in the table below to determine the optimal rate of production when the firm can sell all of the output it produces at a price of $10 per unit. Also determine the level of profit (or loss) that the firm will experience at this level of output.

Q	0	1	2	3	4	5	6	7	8	9
TC	5	7	8	10	14	20	28	38	50	72

Solution:

Q	1	2	3	4	5	6	7	8	9
MC	2	1	2	4	6	8	10	12	22

The firm should produce Q=7. Its profit will be (7)(10) - 38 = $32.

7. Use the total cost (TC) schedule that is presented in the table below to determine the optimal rate of production when the firm can sell all of the output it produces at a price of $6 per unit. Also determine the level of profit (or loss) that the firm will experience at this level of output.

Q	0	1	2	3	4	5	6	7	8	9
TC	15	17	18	20	24	30	38	48	60	82

Solution:

Q	1	2	3	4	5	6	7	8	9
MC	2	1	2	4	6	8	10	12	22

The firm should produce Q=5. Its profit will be (5)(6) - 30 = 0.

8. Use the demand schedule that is presented in the table below to determine the optimal rate of production and price when the firm has a constant marginal cost of $10 per unit.

Quantity	1	2	3	4	5	6	7	8	9	10
Price	80	60	48	40	34	29	25	20	15	10

Solution:

Quantity	1	2	3	4	5	6	7	8	9	10
TR	80	120	144	160	170	174	175	160	135	100
MR	80	40	24	16	10	4	1	-15	-25	-35

The firm should produce Q=5.

9. Use the demand schedule that is presented in the table below to determine the optimal rate of production and price when the firm has the following marginal cost function: MC = 1 + Q/2.

Quantity	1	2	3	4	5	6	7	8	9	10
Price	80	60	48	40	34	29	25	20	15	10

Solution:

Quantity	1	2	3	4	5	6	7	8	9	10
TR	80	120	144	160	170	174	175	160	135	100
MR	80	40	24	16	10	4	1	-15	-25	-35
MC	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6

The firm should produce Q=6.

10. A firm's demand function is Q = 16 - P and its total cost function is defined as $TC = 3 + Q + 0.25\ Q^2$. Use these two functions to form the firm's profit function and then determine the level of output that yields the profit maximum. What is the level of profit at the optimum?

Solution:

$TR = 16Q - Q^2$ so $Profit = (16Q - Q^2) - (3 + Q + 0.25Q^2) = -3 + 15Q - 1.25Q^2$

Using calculus: dProfit/dQ = 15 - 2.5 Q = 0 implies Q = 6 and the second derivative is -2.5, which implies that Q =6 is a maximum.

Profit = -3 + (15)(6) - (1.25)(36) = 42

An alternative method of solution can be applied by noting that MC = 1 + Q/2 and MR = 16 - 2Q and then setting the two equal to each other.

11. A firm's demand function is defined as Q = 20-2P. Use this function to calculate total revenue when price is equal to 3 and when price is equal to 4. What is marginal revenue equal to between P=3 and P=4?

Solution:

Q = 20 - (2)(4) = 12 so total revenue is (12)(4) = $48

Q = 20 - (2)(3) = 14 so total revenue is (14)(3) = $42

Marginal revenue is (48-42)/(12-14) = -3.

12. A firm's demand function is defined as Q = 40 - P. Use this function to calculate total revenue when price is equal to 5 and when price is equal to 6. What is marginal revenue equal to between P=25 and P=26?

Solution:

Q = 40 - 25 = 15 so total revenue is (15)(25) = $375

Q = 40 - 26 = 14 so total revenue is (14)(26) = $364

Marginal revenue is (375-364)/(15-14)= 11.

13. A firm's demand function is defined as Q = 100 - 5P. Use this function to calculate total revenue when price is equal to 10 and when price is equal to 12. What is marginal revenue equal to between P=10 and P=12?

Solution:

Q = 100 - (5)(10) = 50 so total revenue is (10)(50) = $500

Q = 100 - (5)(12) = 40 so total revenue is (12)(40) = $480

Marginal revenue is (500-480)/(50-40) = 2.

14. Use the production relationship between total product (Q) and units of labor (L) employed that is presented in the table below to calculate the average and marginal product of labor when Q = 4.

L	1	2	3	4	5	6	7	8	9
Q	2	5	11	16	20	22	23	23	22

Solution:

Average product = 16/4 = 4

Marginal product = 16 - 11 = 5

15. Use the total cost (TC) schedule that is presented in the table below to calculate average total cost, average variable cost, average fixed cost, and marginal cost when output (Q) is equal to 4.

Q	0	1	2	3	4	5	6	7	8	9
TC	3	6	8	11	15	20	26	34	55	70

Solution:

Average total cost = 15/4 = 4.25 Average variable cost = (14-3)/4 = 2.75

Average fixed cost = 3/4 = 0.75 Marginal cost = (15 - 11)/(4 - 3) = 4

16. Use the total cost (TC) schedule that is presented in the table below to determine the optimal rate of production when the firm can sell all of the output it produces at a price of $6 per unit. Also determine the level of profit (or loss) that the firm will experience at this level of output.

Q	0	1	2	3	4	5	6	7	8	9
TC	3	6	8	11	15	20	26	34	55	70

Solution:

Q	1	2	3	4	5	6	7	8	9
MC	3	2	3	4	5	6	8	11	15

The firm should produce Q=6. Its profit will be (6)(6) - 26 = $10.

17. Use the total cost (TC) schedule that is presented in the table below to determine the optimal rate of production when the firm can sell all of the output it produces at a price of $8 per unit. Also determine the level of profit (or loss) that the firm will experience at this level of output.

Q	0	1	2	3	4	5	6	7	8	9
TC	15	17	18	20	24	30	38	48	60	82

Solution:

Q	1	2	3	4	5	6	7	8	9
MC	2	1	2	4	6	8	10	12	22

The firm should produce Q=6. Its profit will be (6)(8) - 38 = 10.

18. Use the demand schedule that is presented in the table below to determine the optimal rate of production and price when the firm has a constant marginal cost of $16 per unit.

Quantity	1	2	3	4	5	6	7	8	9	10
Price 80	60	48	40	34	29	25	20	15	10	

Solution:

Quantity	1	2	3	4	5	6	7	8	9	10
TR	80	120	144	160	170	174	175	160	135	100
MR	80	40	24	16	10	4	1	-15	-25	-35

The firm should produce Q=4.

19. Use the demand schedule that is presented in the table below to determine the optimal rate of production and price when the firm has the following marginal cost function: MC = 1 + Q.

Quantity	1	2	3	4	5	6	7	8	9	10
Price 80	60	48	40	34	29	25	20	15	10	

Solution:

Quantity	1	2	3	4	5	6	7	8	9	10
TR	80	120	144	160	170	174	175	160	135	100
MR	80	40	24	16	10	4	1	-15	-25	-35
MC	2	3	4	5	6	7	8	9	10	11

The firm should produce Q=5.

20. A firm's demand function is $Q = 40 - 2P$ and its total cost function is defined as $TC = 100 + 2Q + 0.25\ Q^2$. Use these two functions to form the firm's profit function and then determine the level of output that yields the profit maximum. What is the level of profit at the optimum level of output?

Solution:

$TR = 20Q - 0.5Q^2$
so Profit = $(20Q - 0.5Q^2) - (100 + 2Q + 0.25Q^2) = -100 + 18Q - 0.75Q^2$

Using calculus: $dProfit/dQ = 18 - 1.5\ Q = 0$ implies $Q = 12$ and the second derivative is -1.5, which implies that $Q = 12$ is a maximum.

Profit = $-100 + (18)(12) - (0.75)(144) = 8$

An alternative method of solution can be applied by noting that $MC = 2 + Q/2$ and $MR = 20 - Q$ and then setting the two equal to each other.