MATHEMATICS · GRADES 10-12

Linear programming basics

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you get the best result inside your limits, like a bakery making the most profit from the flour and time it has. You cannot make everything, so you have to choose the mix that earns the most while staying inside what you have. A bakery uses it to decide what to bake, a factory uses it to plan production, and anyone with limited time, money, or materials uses the same idea to get the most out of what they have.



Rule

The best value of a linear objective over a region always happens at a corner of the region.

Work out the objective at every corner and pick the biggest for a maximum or the smallest for a minimum.

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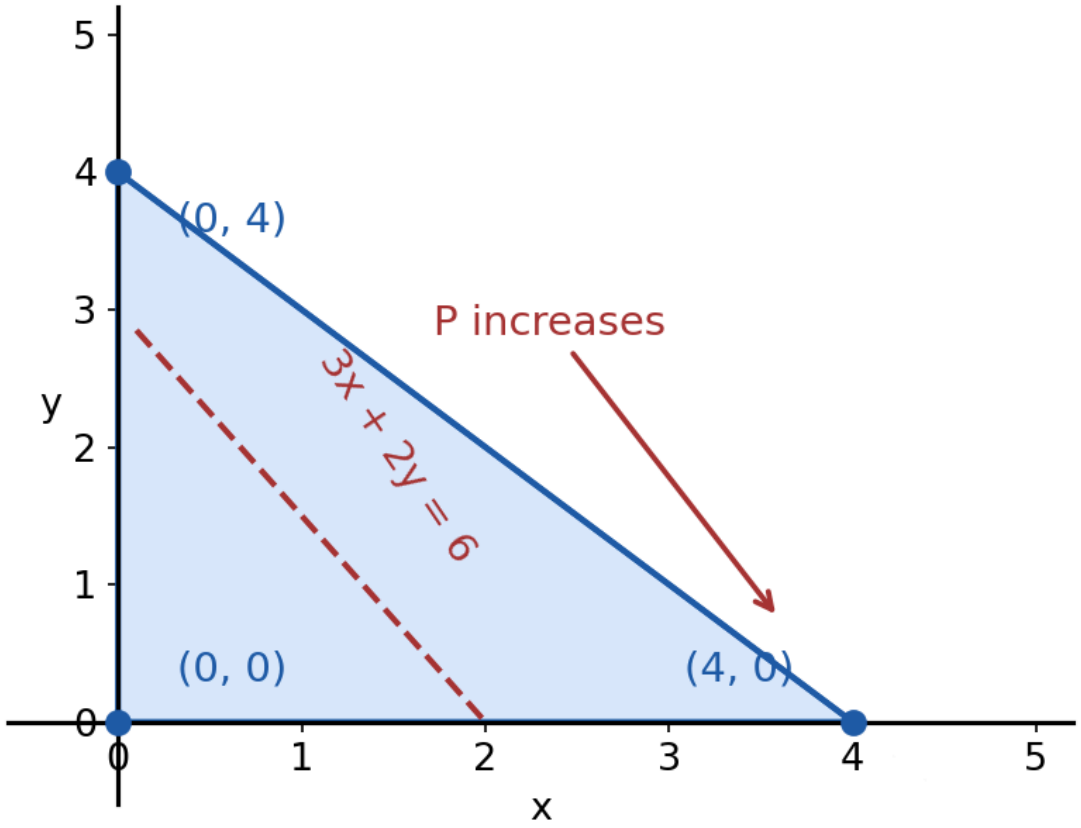
Worked examples

EXAMPLE 1

Q **Maximise P = 3x + 2y over the triangle with corners (0, 0), (4, 0), (0, 4). What is the maximum value of P, and at which corner does it happen?**



SOLUTION

Evaluate P at each corner: at (0, 0), P = 0; at (4, 0), P = 12; at (0, 4), P = 8.

Compare: 12 is the largest.

Maximum P = 12 at (4, 0)

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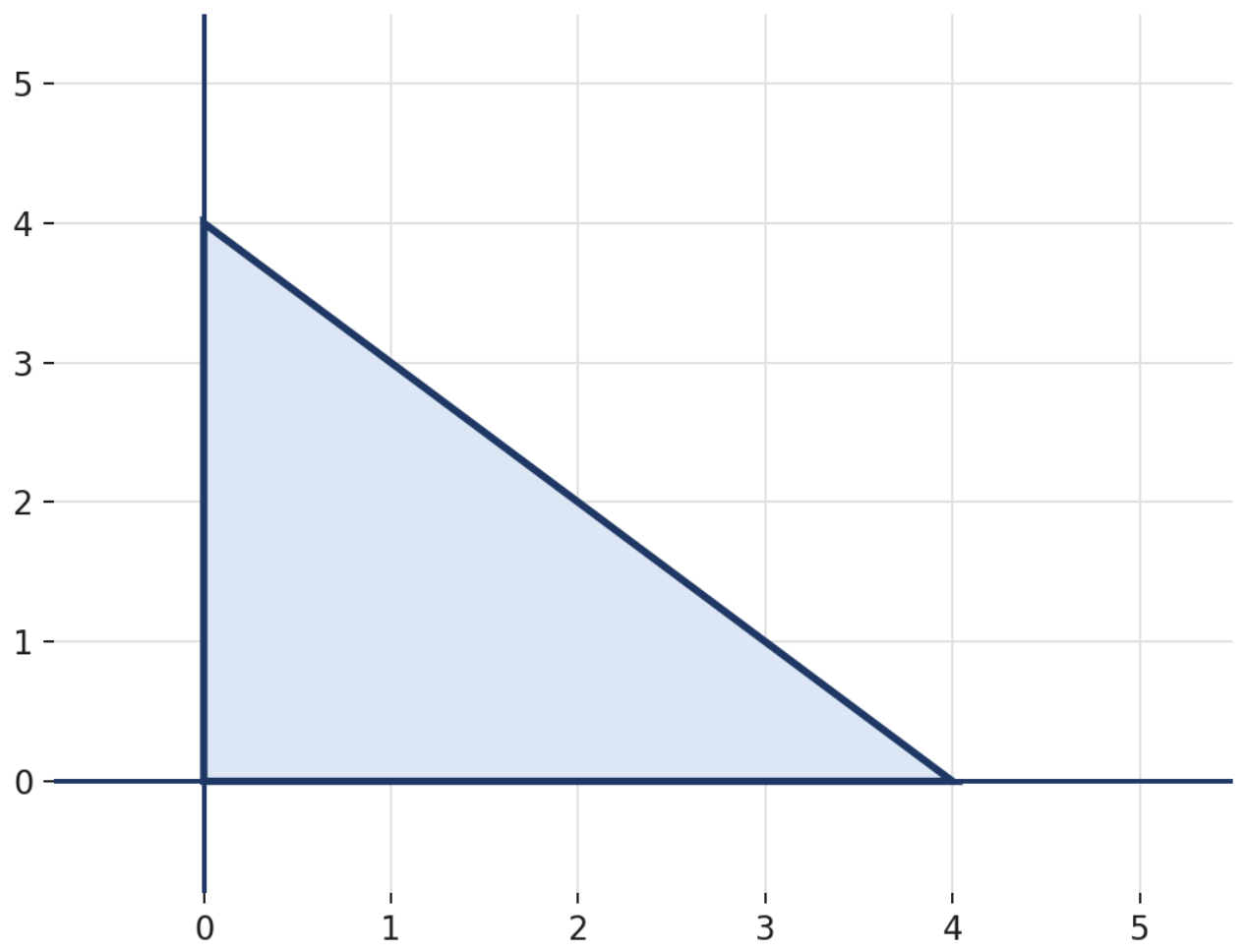
EXAMPLE 2

Q **Minimise C = x + 2y over the same triangle. What is the minimum value of C, and at which corner does it happen?**



SOLUTION

At (0, 0), C = 0; at (4, 0), C = 4; at (0, 4), C = 8.

Compare: 0 is the smallest.

Minimum C = 0 at (0, 0)

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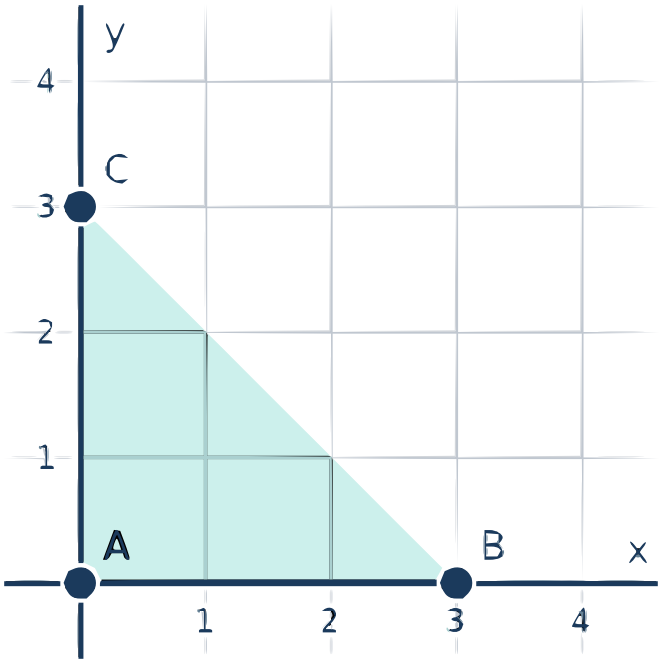
Practice questions

1 Profit is $P = x + y$, and the shaded region shows the possible mixes. What is the greatest profit, and at which corner does it happen?



- **A** 3, at (3, 0)
- **B** 0, at (0, 0)
- **C** 3, at (0, 0)
- **D** 6, at (3, 0)

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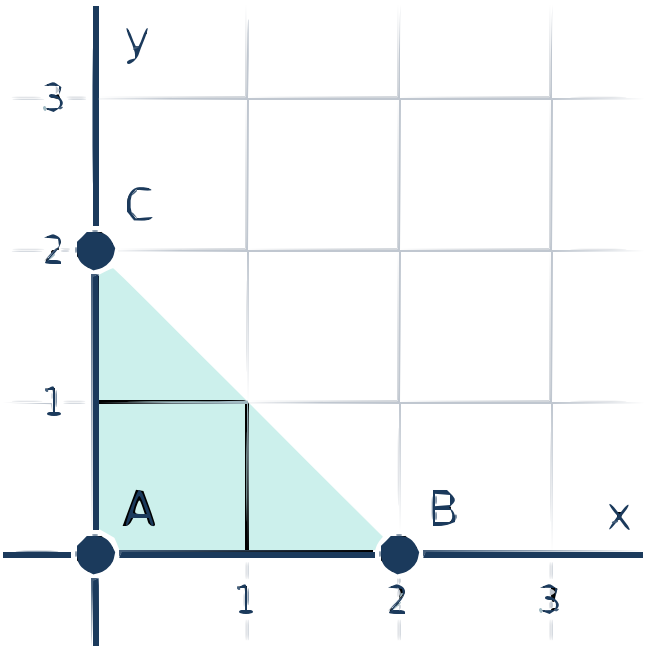
2 Profit is $P = 3x + y$, and the shaded region shows the possible mixes. What is the greatest profit, and at which corner does it happen?



A 2, at (0, 2)

B 6, at (2, 0)

C 0, at (0, 0)

D 6, at (0, 2)

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3 Why is checking the corners enough to find the best profit?

A. The best value is always in the middle of the region

B. The optimum of a linear function over a polygon always occurs at a corner

C. Only the corners on the x-axis need checking

D. The best value is always at (0, 0)

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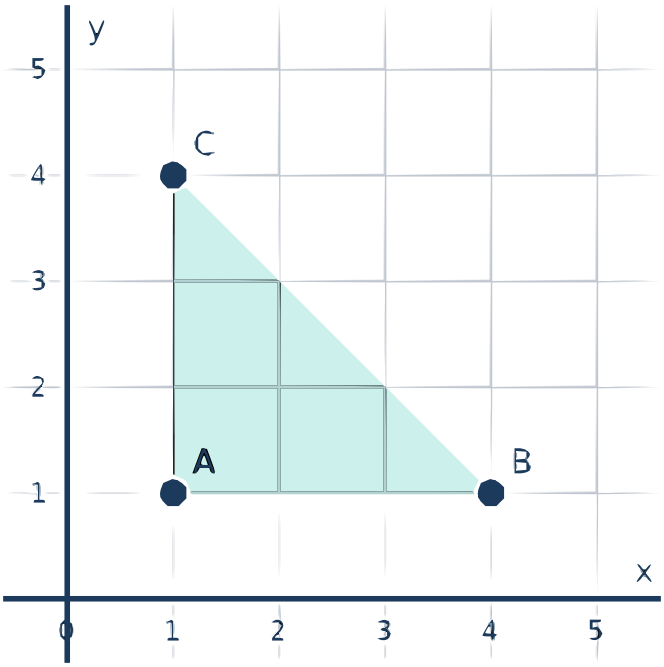
4 Cost is C = x + y, and the shaded region shows the possible mixes. What is the smallest cost, and at which corner does it happen?



- **A** 5, at (4, 1)
- **B** 5, at (1, 4)
- **C** 2, at (1, 1)
- **D** 2, at (4, 1)

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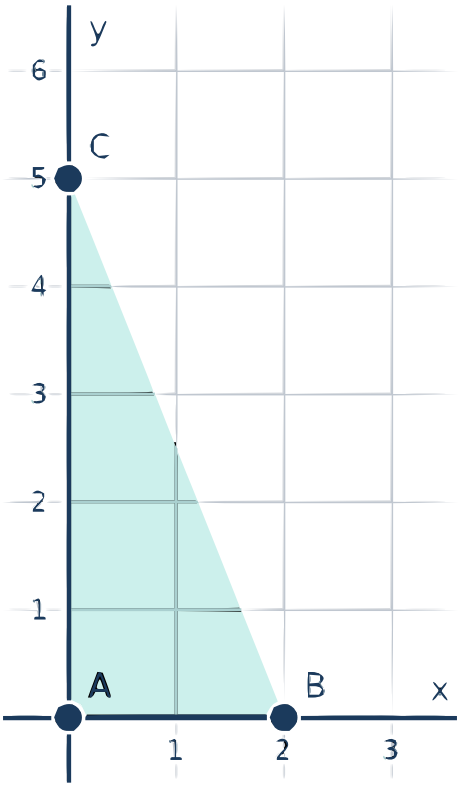
5 Profit is $P = 2x + y$, and the shaded region shows the possible routes. What is the greatest profit, and at which corner does it happen?



A 4, at (2, 0)

B 0, at (0, 0)

C 5, at (2, 0)

D 5, at (0, 5)

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6 **What is $P = 4x + y$ called in linear programming?**

- **A** The objective function
- **B** The constraint
- **C** The feasible region
- **D** The corner point

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7 **What are the conditions $x + y \leq 4$, with $x \geq 0$ and $y \geq 0$, called?**

- **A** Constraints
- **B** The objective function
- **C** The feasible region
- **D** The corner point

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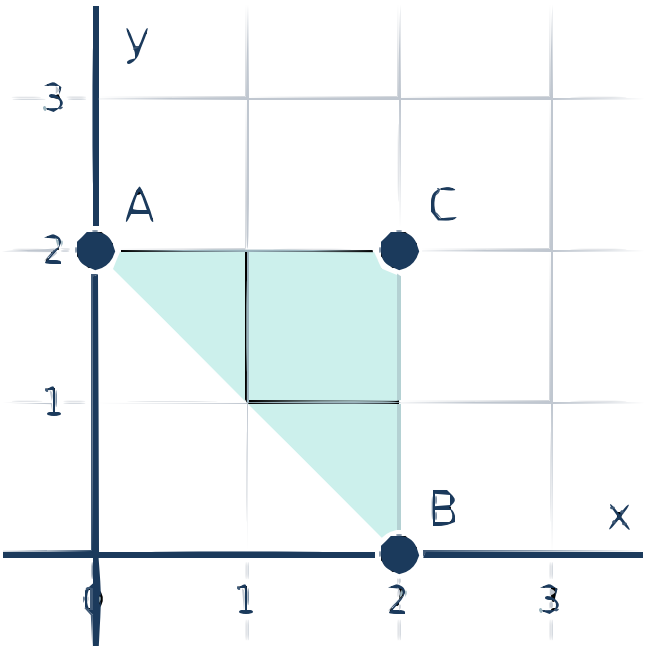
8 Cost is $C = x + 3y$, and the shaded region shows the possible orders. What is the smallest cost, and at which corner does it happen?



A 2, at (2, 0)

B 6, at (0, 2)

C 8, at (2, 2)

D 2, at (0, 2)

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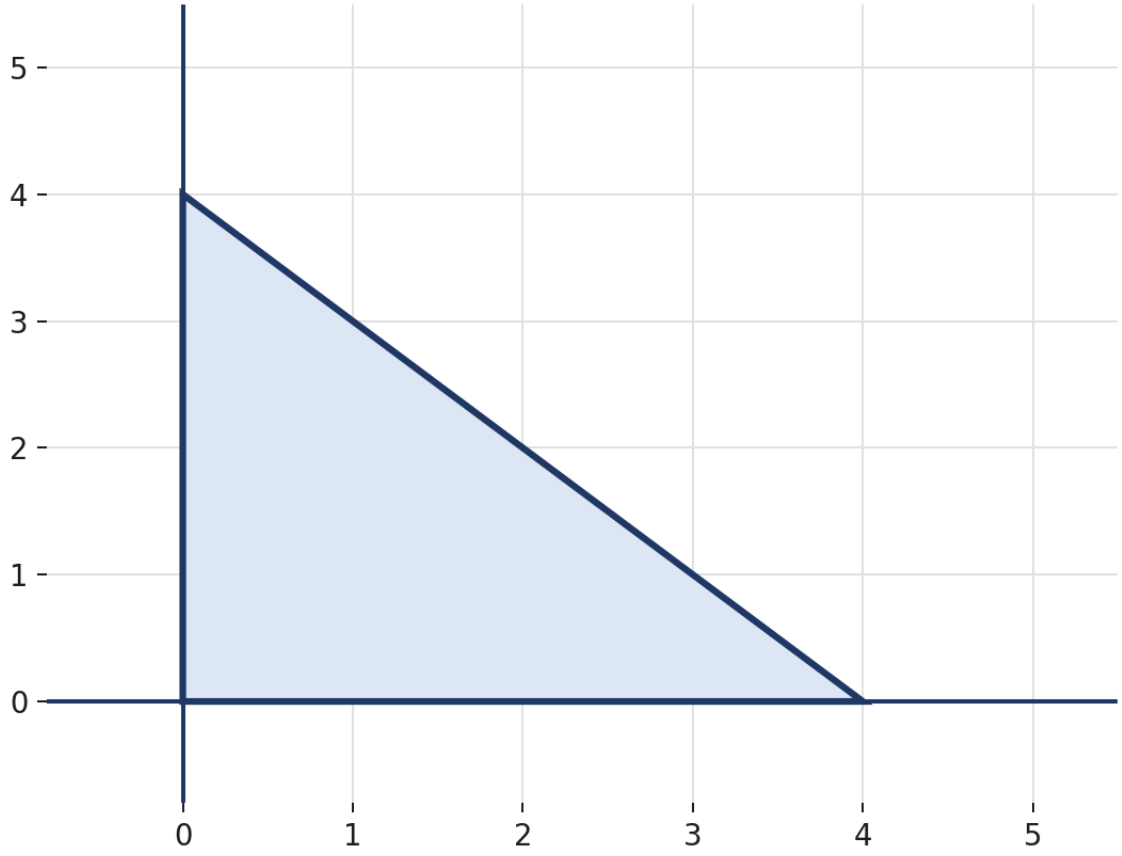
9 **Profit is $P = x + 4y$, and the shaded region shows the possible mixes. What is the greatest profit, and at which corner does it happen?**



A 4, at (4, 0)

B 0, at (0, 0)

C 16, at (4, 0)

D 16, at (0, 4)

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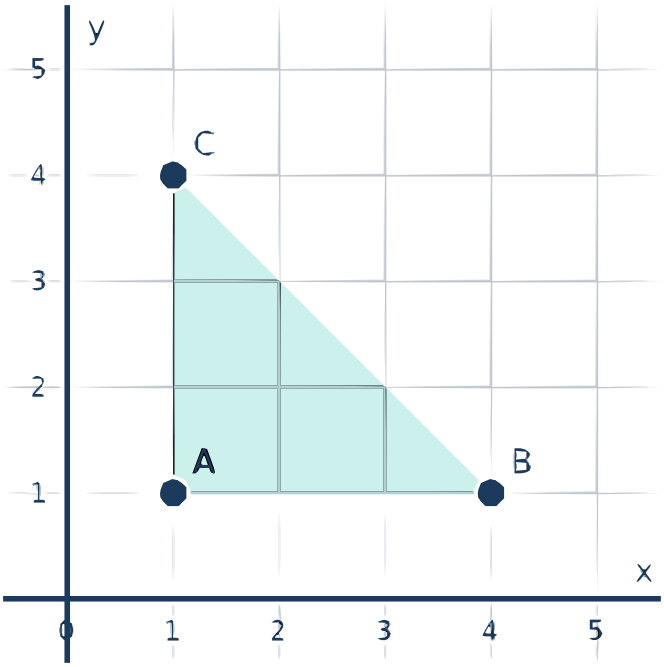
10 **Profit is $P = x + 3y$, and the shaded region shows the possible orders. What is the greatest profit, and at which corner does it happen?**



A 4, at (1, 1)

B 13, at (1, 4)

C 7, at (4, 1)

D 13, at (4, 1)

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ANSWER KEY

1. 3, at (3, 0)

2. 6, at (2, 0)

3. The optimum of a linear function over a polygon always occurs at a corner

4. 2, at (1, 1)

5. 5, at (0, 5)

6. The objective function

7. Constraints

8. 2, at (2, 0)

9. 16, at (0, 4)

10. 13, at (1, 4)

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