Multiplication and expansion of polynomials

A. PRODUCT NOTATION

In algebra we agree:

- To **leave out** the "×" **signs** between any multiplied quantities provided that at least one of them is an unknown (letter)
- To write **numerals (numbers) first** in any product
- Where products contain two or more letters, we write them in **alphabetical order**

For example:

- $3a$ is used rather than $3 \times a$ or $a3$
- $2ab$ is used rather than $2ba$

ALGEBRAIC PRODUCTS

The **product** of two or more factors is the result obtained by multiplying them together

Consider the factors $-3x \quad and \quad 2x^2$. Their product $-3x \times 2x^2$ can be simplified by following the steps below:

- Step 1: Find the product of the signs.
- Step 2: Find the product of the numerals or numbers.
- Step 3: Find the product of the variables or letters.

So. $-2x \times 3x^2 = -6x^3$

$- \times + = -$

$3 \times 2 = 6$

$x \times x^2 = x^3$

For $-2x$, the sign is $-$, the numeral is 2, and the variable is x

EXAMPLE 1

Simplify the following products:

a) $-3 \times 4x$	b) $2x \times -x^2$	c) $-4x \times -2x^2$
a) $-3 \times 4x$ $= -12x$	b) $2x \times -x^2$ $= -2x^3$	c) $-4x \times -2x^2$ $= 8x^3$

EXERCISE 1

Write the following algebraic products in simplest form:

a) $c \times b$	b) $a \times 2 \times b$	c) $y \times xy$	d) $pq \times 2q$
e) $2 \times 3x$	f) $4x \times 5$	g) $-2 \times 7x$	h) $3 \times -2x$
i) $2x \times x$	j) $3x \times 2x$	k) $-2x \times x$	l) $-3x \times 4$
m) $-2x \times (-x)$	n) $-3x \times x^2$	o) $-x^2 \times (-2x)$	p) $3d \times (-2d)$
q) $(-a)^2$	r) $(-2a)^2$	s) $2a^2 \times a^2$	t) $a^2 \times (-3a)$

EXERCISE 2

Simplify the following:

a) $2 \times 5x + 3x \times 4$	b) $5 \times 3x - 2y \times y$	c) $3 \times x^2 + 2x \times 4x$
d) $a \times 2b + b \times 3a$	e) $4 \times x^2 - 3x \times x$	f) $3x \times y - 2x \times 2y$
g) $3a \times b + 2a \times 2b$	h) $4c \times d - 3c \times 2d$	i) $3a \times b - 2c \times a$

- Multiplication is often written using the multiplication sign or cross symbol "×" between the factors:

$$a \times b$$

- In algebra multiplication is sometimes denoted by a middle dot

$$a \cdot b$$

- In algebra, multiplication involving variables is often written as a juxtaposition

$$ab$$

- This notation can also be used for quantities that are surrounded by parentheses

$$(a)(b)$$

EXERCISE 3

Simplify the following:

a) $(2y) \cdot (3z)$	b) $(-5ab^2c) \cdot (4a^3c) \cdot (b^2c)$	c) $(3xy^2) \cdot (-5x^2yz)$
d) $(12xy) \cdot (6x^2) \cdot (x^2y^3)$	e) $(-3x^3y) \cdot (-2y^6x^5)$	f) $(-4x^7y3z^6) \cdot (3z^3y^2x^5)$

B. THE DISTRIBUTIVE LAW

Consider the expression $2(x+3)$. We say that 2 is the coefficient of the expression in the brackets. We can expand the brackets using the distributive law:

$$a(b+c) = ab + ac$$

The distributive law says that we must multiply the coefficient by each term within the brackets, and add the results.

EXAMPLE 2

Expand the following:

a) $3(4x+1)$ b) $2x(5-2x)$ c) $-2x(x-3)$

a)	b)	c)
$3(4x+1)$ $= 3\times 4x + 3\times 1$ $= 12x + 3$	$2x(5-2x)$ $= 2x\times 5 + 2x\times(-2x)$ $= 10x - 4x^2$	$-2x(x-3)$ $= (-2x)\times x + (-2x)\times(-3)$ $= -2x^2 + 6x$

With practice, we do not need to write all of these steps.

EXAMPLE 3

Expand and simplify:

a) $2(3x-1)+3(5-x)$ b) $x(2x-1)-2x(5-x)$

a)	b)
$2(3x-1)+3(5-x)$ $= 6x - 2 + 15 - 3x$ $= 3x + 13$	$x(2x-1)-2x(5-x)$ $= 2x^2 - x - 10x + 2x^2$ $= 4x^2 - 11x$

Notice in b) that the minus sign in front of $2x$ affects **both** terms inside the following brackect

EXERCISE 4

Expand and simplify:

a) $3(x+1)$	b) $2(5-x)$	c) $-(x+2)$	d) $x(x+3)$
e) $-3(x+2)$	f) $-2(x-y)$	g) $x(2x-1)$	h) $2x(x^2-x-2)$
i) $1+2(x+2)$	j) $13-(4(x+3)$	k) $3(x-6)+2$	l) $x(x-1)+x$
m) $2x(3-x)+x^2$	n) $4x-5x(2x-3)$	o) $7x^2-4x(x+2)$	p) $3a(b-a)+5a^2$

EXERCISE 5 Expand and simplify:		
a) $3(x-5)+2(5+x)$	b) $2a+(5a-7b)$	c) $2a-(3a-6b)$
d) $3(y+2)+5(4-y)$	e) $6(x-2)-4(3x+5)$	f) $4x-3(2-3x)$
g) $2x^2-x(3x-2)$	h) $2x(4x-3)-3x(5x+3)$	i) $-3x^2(x^3-4)$
j) $a^2(5ab-a^2)$	k) $3x^3(2x^4-4x^3)$	l) $-4x^2(2x-5)-2x(3x^2-x)$

C. THE PRODUCT $(a+b)(c+d)$

$$(a+b)(c+d)=ac+ad+bc+bd$$

To remember → FOIL rule

ac = is the product of First terms of each bracket
ad = is the product of Outer terms of each bracket
bc = is the product of Inner terms of each bracket
bd = is the product of Last terms of each bracket

EXAMPLE 4

Expand and simplify:

a) $(x+2)(x+3)$ b) $(2x+3)(3x-5)$

a)

$(x+2)(x+3)$

$=x^2+3x+2x+6$

$=x^2+5x+6$

b)

$(2x+3)(3x-5)$

$=6x^2-10x+9x-15$

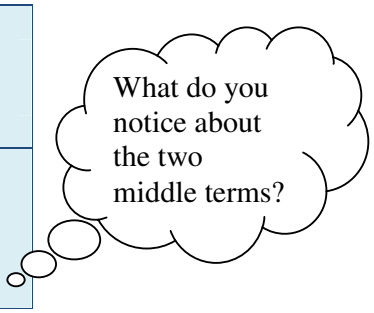
$=6x^2-x-15$

EXERCISE 6 Expand and simplify:		
a) $(x-6)(x+7)$	b) $(x+3)(x-2)$	c) $(x+5)(x-5)$
d) $(2y+2)(4y-6)$	e) $(x-2)(1-3x)$	f) $(6x-1)(6x-1)$
g) $(4-6x)(3x-2)$	h) $(4x-3)(5+3x)$	i) $(x-3)(x^3-4)$
j) $(2x^2-5x)(3x^2+4x)$	k) $(3x^3+4x^2)(2x^2-5x)$	l) $(5x-4)(7x+5)$

EXAMPLE 5

Expand and simplify:

a) $(x+5)(x-5)$	b) $(4x-3)(4x+3)$
a) $(x+5)(x-5)$ $= x^2-5x+5x-25$ $= x^2-25$	b) $(4x-3)(4x+3)$ $= 16x^2+12x-12x-9$ $= 16x^2-9$

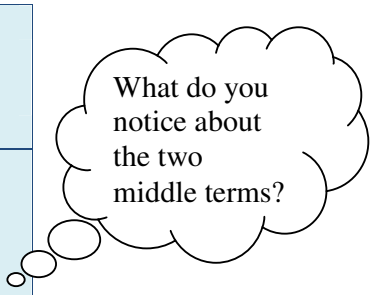


EXERCISE 7 Expand and simplify:		
a) $(x-6)(x+6)$	b) $(x+3)(x-3)$	c) $(2x+5)(2x-5)$
d) $(4y+6)(4y-6)$	e) $(3x-2)(2+3x)$	f) $(6x+1)(6x-1)$

EXAMPLE 6

Expand and simplify:

a) $(2x+5)^2$	b) $(4x-3)^2$
a) $(2x+5)^2$ $= (2x+5)(2x+5)$ $= 4x^2+10x+10x+25$ $= x^2+20x+25$	b) $(4x-3)^2$ $= (4x-3)(4x-3)$ $= 16x^2-12x-12x+9$ $= 16x^2-24x+9$



EXERCISE 8 Expand and simplify doing the product:		
a) $(x+6)^2$	b) $(x-3)^2$	c) $(2x-5)^2$
d) $(4y-3)^2$	e) $(3-2x)^2$	f) $(6x+a)^2$

D. DIFFERENCE OF TWO SQUARES

If a^2 and b^2 are perfect squares then $a^2 - b^2$ is called the **difference of two squares**

Notice that $(a+b)(a-b) = a^2 \underbrace{-ab+ab}_{\text{The middle two terms add to zero}} - b^2 = a^2 - b^2$

Thus, $(a+b)(a-b) = a^2 - b^2$

EXAMPLE 7

Expand and simplify:

a) $(3x+5)(3x-5)$ b) $(4x-3y)(4x+3y)$

a) $(3x+5)(3x-5)$	b) $(4x-3y)(4x+3y)$
$= (3x)^2 - (5)^2$	$= (4x)^2 - (3y)^2$
$= 9x^2 - 25$	$= 16x^2 - 9y^2$

EXERCISE 9

Expand and simplify using the rule $(\boldsymbol{a+b})(\boldsymbol{a-b}) = \boldsymbol{a^2 - b^2}$:

a) $(x-6)(x+6)$	b) $(x+3)(x-3)$	c) $(2x+5)(2x-5)$
d) $(4y+6)(4y-6)$	e) $(3x-2)(2+3x)$	f) $(6x+1)(6x-1)$
g) $(2x-1)(2x+1)$	h) $(2x+3y)(2x-3y)$	i) $(2x^2+5)(2x^2-5)$
j) $(4y^2+6)(4y^2-6)$	k) $(3x-2y)(2y+3x)$	l) $(6x+a)(6x-a)$
m) $(4x^3+5y)(4x^3-5y)$	n) $(3a^2+b)(3a^2-b)$	o) $(2yx^2+4z)(2yx^2-4z)$

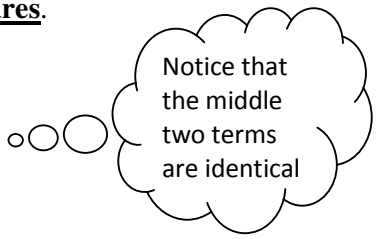
E. PERFECT SQUARES EXPANSION

$(a+b)^2$ and $(a-b)^2$ are called **perfect squares**.

Notice that $(a+b)^2 = (a+b)(a+b)$

$= a^2 + ab + ab + b^2$ using FOIL

$= a^2 + 2ab + b^2$



Thus, we can state the perfect square expansion rule:

$$(a+b)^2 = a^2 + 2ab + b^2$$

We can remember the rule as follows:

Step 1: Square the **first term**.
Step 2: Add twice the products of the **first** and **last terms**.
Step 3: Add on the square of the **last term**.

Notice that $(a-b)^2 = (a-b)(a-b)$

$= a^2 - ab - ab + b^2$ using FOIL

$= a^2 - 2ab + b^2$

So, we can state:

$$(a-b)^2 = a^2 - 2ab + b^2$$

EXAMPLE 8

Expand and simplify:

a) $(5x+3)^2$ b) $(6-4x)^2$

a) $(5x)^2 + 2 \cdot 5x \cdot 3 + 3^2$
$= 25x^2 + 30x + 9$

b) $6^2 - 2 \cdot 6 \cdot 4x + (4x)^2$
$= 36 - 48x + 16x^2$

EXERCISE 10

Expand and simplify using the perfect square expansion rule:

a) $(x+6)^2$	b) $(x-3)^2$	c) $(2x-5)^2$
d) $(4y-3)^2$	e) $(3-2x)^2$	f) $(6x+a)^2$
g) $(3x+4)^2$	h) $(2a-b)^2$	i) $(7+2a)^2$
j) $(12y-3x)^2$	k) $(3z-4x)^2$	l) $(25x-2xy)^2$

EXAMPLE 9

Expand and simplify:

a) $(3x^2+5)^2$ b) $6-(4+3x)^2$

a) $(3x^2+5)^2$
$= (3x^2)^2 + 2 \cdot 3x^2 \cdot 5 + 5^2$
$= 9x^4 + 30x^2 + 25$

b) $6-(4+3x)^2$
$= 6-(4^2 + 2 \cdot 4 \cdot 3x + (3x)^2)$
$= 6-(16 + 24x + 9x^2)$
$= 6 - 16 - 24x - 9x^2$
$= -10 - 24x - 9x^2$

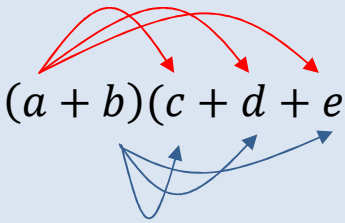
Notice the use of square brackets in the second line. These remind us to change the signs inside them when they are removed

EXERCISE 11 Expand and simplify:		
a) $(x^2+4)^2$	b) $(2a-b^2)^2$	c) $(7^2+2a^2)^2$
d) $(5y-3x^2)^2$	e) $(2z^2-3z)^2$	f) $(2x^2-5y^2)^2$
g) $(x^3-2x)^2$	h) $(2a^3-4a^2)^2$	i) $(2x^3-6x)^2$

EXERCISE 12 Expand and simplify:	
a) $3x+1-(x+4)^2$	b) $5x-3+(x-2)^2$
c) $(x+1)(x-1)-(x+4)^2$	d) $(x+3)(x-3)-(x-2)^2$
e) $(2x-3)^2+(x+5)(x-5)$	f) $(3x+2)^2-(x+4)(x-4)$
g) $(3x+2)(3x-2)-(5-x)^2$	h) $(2x+9)(2x-9)-(4x-6)^2$
i) $(x-7)^2+(x+8)^2$	j) $(4x+2)^2-(x-9)^2$

F. FURTHER EXPANSION

In this section we will expand more complicated expressions by repeated use of the expansion laws.
Consider the expansion of $(a+b)(c+d+e)$



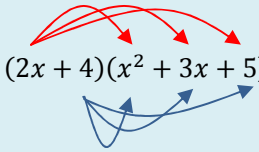
$$(a+b)(c+d+e)=ac+ad+ae+bc+bd+be$$

Notice that there are 6 terms in this expansion and that **each term within the first bracket is multiplied by each term in the second**

2 terms in the first bracket × 3 terms in the second bracket = 6 terms in the expansion

EXAMPLE 9

Expand and simplify: $(2x+4)(x^2+3x+5)$



$(2x+4)(x^2+3x+5) = 2x^3+6x^2+10x+4x^2+12x+20$

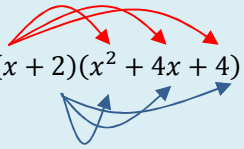
$= 2x^3+10x^2+22x+20$ {Collecting like terms}

EXAMPLE 10

Expand and simplify: $(x+2)^3$

$(x+2)^3 = (x+2)(x+2)^2$

$= (x+2)(x^2+4x+4)$



$= (x+2)(x^2+4x+4)$ {each term within the first bracket is multiplied by each term in the second bracket}

$= x^3+4x^2+4x+2x^2+8x+8$

$= x^3+6x^2+12x+8$ {Collecting like terms}

EXAMPLE 11

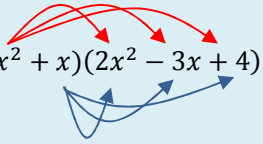
Expand and simplify:

a) $x(x+1)(2x^2-3x+4)$ b) $(x+2)(x-3)(x+3)$

Always look for ways to make your expansions simpler. In b) we can use the difference of two squares

a)

$x(x+1)(2x^2-3x+4)$



$= (x^2+x)(2x^2-3x+4)$

$= 2x^4-3x^3+4x^2+2x^3-3x^2+4x$

$= 2x^4-x^3+x^2+4x$ {Collecting like terms}

b) $(x+2)(x-3)(x+3)$

$= (x+2)(x-3)(x+3)$

$= (x+2)(x^2-9)$ {difference of two squares}

$= x^3-9x+2x^2-18$

$= x^3+2x^2-9x-18$

EXERCISE 13 Expand and simplify:	
a) $(x+3)(x^2+x+5)$	b) $(2x-4)(3x^2-5x+2)$
c) $(3x-1)(5x^2+4x-6)$	d) $(4x+3)(6x^2-2x-8)$
e) $(x-2)^3$	f) $(2x+3)^3$
g) $(2x+1)^3$	h) $(3x-2)^3$
i) $x(x+3)(x+3)$	j) $x(x-3)(x+1)$
k) $2x(x-4)(x+4)$	l) $(x+2)(x-2)(2x+3)$
m) $-3x(2x-1)(x+2)$	n) $x(1-3x)(2x+5)$
o) $2x^2(x-1)^2$	p) $(3x-2)(x-2)(x+1)$
q) $(x-3)(1-x)(2x-2)$	r) $(x-1)(x-2)(x+2)$

HARDER EXTENSION

EXERCISE 14 Expand and simplify:	
a) $(x^4+3x^3)(4x^5+2x^4+5x^3)$	b) $(3x^3-2x^2)(x^4-3x^3-5x^2-1)$
c) $(2x^4+x^3+3x^2-2)(x^3-3x+1)$	d) $(x^4-7x^3+x^2-1)(x^3+4x^2-6x+2)$

G. THE BINOMIAL EXPANSION

Consider $(a+b)^n$. We note that:

- $a+b$ is called a binomial as it contains two terms
- Any expression of the form $(a+b)^n$ is called a power of a binomial
- The binomial expansion of $(a+b)^n$ is obtained by writing the expression without brackets.

Now $$\begin{aligned}(\boldsymbol{a+b})^{\boldsymbol{3}} &= (\boldsymbol{a+b})(\boldsymbol{a+b})^{\boldsymbol{2}} \\ &= (\boldsymbol{a+b})\left(\boldsymbol{a^2+2ab+b^2}\right) \\ &= \boldsymbol{a^3+2a^2b+ab^2+ba^2+2ab^2+b^3} \\ &= \boldsymbol{a^3+3a^2b+3ab^2+b^3}\end{aligned}$$

So, the binomial expansion of

$$(a+b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$$

Doing the same process with

$$\begin{aligned}(a-b)^3 &= (a-b)(a-b)^2 \\ &= (a-b)\left(a^2 - 2ab + b^2\right) \\ &= a^3 - 2a^2b + ab^2 - ba^2 + 2ab^2 - b^3 \\ &= a^3 - 3a^2b + 3ab^2 - b^3\end{aligned}$$

So, the binomial expansion of

$$(a-b)^3 = a^3 - 3a^2b + 3ab^2 - b^3$$

EXAMPLE 12

Expand and simplify using the binomial expansion:

a) $(x+2)^3$ b) $(2x-4)^3$

a) {Using $(a-b)^3 = a^3 - 3a^2b + 3ab^2 - b^3$}

We substitute $a = x$ and $b = 2$

$\therefore\ (x+2)^3 = x^3 + 3x^2 2 + 3x2^2 + 2^3$

$= x^3 + 6x^2 + 12x + 8$

We use brackets to assist our substitution

b) {Using $(a-b)^3 = a^3 - 3a^2b + 3ab^2 - b^3$}

We substitute $a = (2x)$ and $b = 4$

$\therefore\ (2x-4)^3 = (2x)^3 - 3(2x)^2 4 + 3(2x)4^2 - 4^3$

$= 8x^3 - 48x^2 + 96x - 64$

b) {Using $(a+b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$}

We substitute $a = (2x)$ and $b = (-4)$

$\therefore\ (2x-4)^3 = (2x)^3 + 3(2x)^2(-4) + 3(2x)(-4)^2 + (-4)^3$

$= 8x^3 - 48x^2 + 96x - 64$

EXERCISE 15

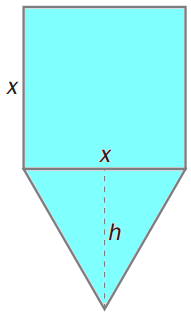
Use the binomial expansion for $(a+b)^3$ or $(a-b)^3$ to expand and simplify:

a) $(x+1)^3$	b) $(3x-2)^3$	c) $(x-5y)^3$
d) $(2x+3)^3$	e) $(4a-6)^3$	f) $(2x^2+1)^3$
g) $(x^3-2x)^3$	h) $(a^3-4a^2)^3$	i) $(3x^3+x)^3$

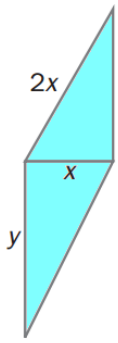
EXERCISE 15 (Extension)

Find, in terms of x, the surface area of the following figures:

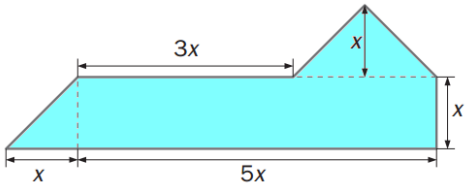
a)



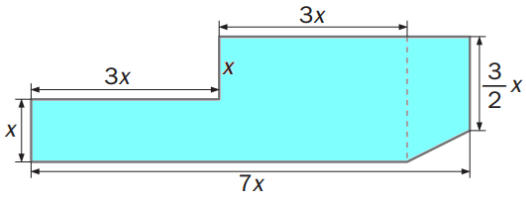
b)



c)



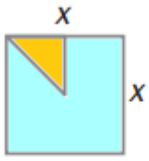
d)



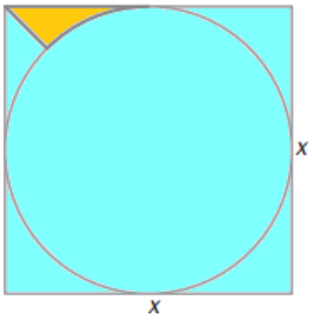
EXERCISE 16 (Extension)

Find, in terms of x, the surface area of the orange zone of the following figures:

a)



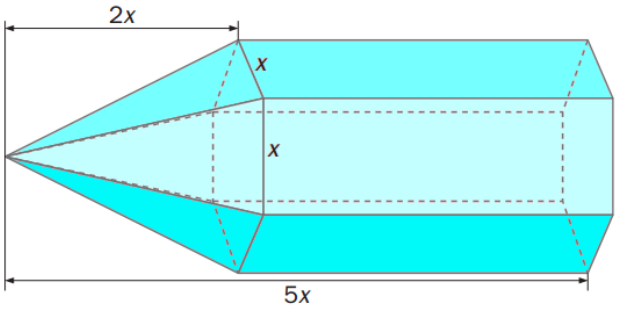
b)



EXERCISE 17 (Extension)

Find, in terms of x, the volume of the following figure:

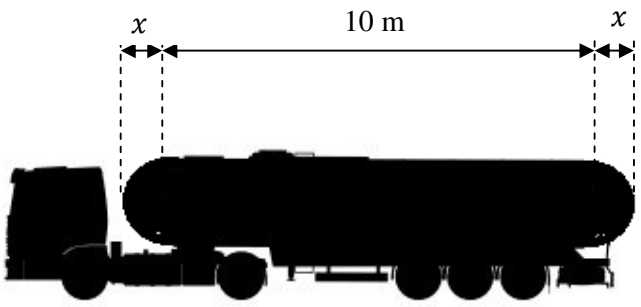
a)



EXERCISE 18 (Extension)

a) Find, in terms of $\boldsymbol{x}$, the surface area and the volume, of the following cylindrical water tank trailer, with hemispherical endings.

b) Find the surface and volume if $\boldsymbol{x} = \mathbf{3}$ m.



EXERCISE 19 (Review)

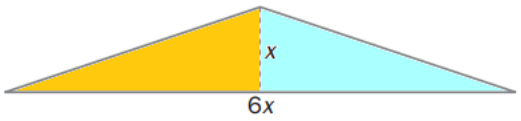
a) Expand and simplify:

1. $4x \cdot 8$
2. $6x \cdot 2x^2$
3. $2x \cdot 5x^3 \cdot (-3x^2) \cdot x$
4. $(-4x)(-7x)$
5. $5x^2y \cdot (-3y^2x^3)$
6. $x(5x - 6)$
7. $4 - 2(2x + 3)$
8. $2(x - 6) + 3(2 - x)$
9. $5(2x - 3) - 8(4x - 7)$
10. $3x^2(4x^5 - 7x^2)$
11. $-6x^2(3x - 4) - 3x(5x^2 - 2x)$
12. $(3x + 2)(x - 4)$
13. $(x - 5)^2$
14. $(3x + 4)^2$
15. $(2x - 6)^2$
16. $(2x - 6)(2x + 6)$
17. $(x - 5)(x + 5)$
18. $x(x - 3)(x + 3)$

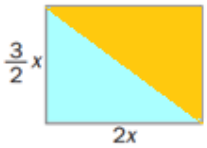
19. $-5x(x+2)(x-2)$
20. $-(x+3)^2$
21. $(2x-5)(x-1)(x+1)$
22. $(x-5)(x-1)(x-1)$
23. $(x-1)^3$
24. $5+2x-(x+2)^2$
25. $(3x-2)(x^2-2x+7)$
26. $(x-1)(x+2)(x-3)$
27. $x(x+2)^3$
28. $(x^2+1)(x+1)(x-1)$
29. $(x+5)(x-5)(2x+3)$
30. $(2x^3-x^2)(3x^4-x^2+5x-2)$
31. $(3x-4)^3$

b) Find, in terms of x, the surface area of the orange zone of the following figures:

1.



2.



KEY POINTS

Useful products: (In Spanish: "productos notables")

$$a(b+c) = ab + ac$$
$$(a+b)(c+d) = ac + ad + bc + bd$$
$$(a+b)(a-b) = a^2 - b^2$$
$$(a+b)^2 = a^2 + 2ab + b^2$$
$$(a-b)^2 = a^2 - 2ab + b^2$$
$$(a+b)^3 = a^3 + 3a^2b + 3ab^2 + b^3$$
$$(a-b)^3 = a^3 - 3a^2b + 3ab^2 - b^3$$

Expansion and factorisation relation:

$$(a+b)^2 = a^2 + 2ab + b^2$$

Expansion → (left to right)

Factorisation ← (right to left)

Note: $\boldsymbol{a^2 + b^2}$ cannot be factorised.

$\boldsymbol{a^2 - b^2}$ is the **difference of squares**

MORE EXERCISES TO PRACTICE AT HOME:

EXERCISE 20

1) Simplify, by collecting like terms

a $7x + 3y^3 - 2xy + 2xy - 5x - 6y^3$

b $2x^2 - 4xy + 3y^2 - (8x^2 - 2xy + 6y^2)$

c $(2x^3 + 5x) - (3x^2 + 2x) + (x^3 - 6x) - (x + 4x^2)$

d $5ab + 6a^2b - 7ab^2 + 2a^2b - 3ab$

2) Expand and simplify

a $(x+1)^2$	**b** $(x+2)^2$	**c** $(2x+1)^2$
d $(x-5)^2$	**e** $(x+1)(x+2)$	**f** $(x+3)(x+4)$
g $(x+3)(x-4)$	**h** $(x-2)(x+1)$	**i** $(2x+1)(x+1)$
j $(x-4)(3x-2)$	**k** $(4x-3)(4x+3)$	**l** $(x-2)(x+2)$

3) Expand and simplify

a $(2a+1)(a-3)$ **b** $(4d+3e)(d+2e)$ **c** $(2-x)(3-4x)$

d $(8-7w)(8w-7)$ **e** $(3l-5)(3l+5)$ **f** $(3x+4)^2$

g $(2h+5)(2h-7)$ **h** $(5x+7)(2x-3)$ **i** $(2x+1)(3x+4)$

j $(2-7x)(2+7x)$ **k** $(2y-3)^2$ **l** $(b^2+4)(4-b^2)$

m $(x-1)^3$ **n** $\left(a^{\frac{1}{2}}-b^{\frac{1}{2}}\right)\left(a^{\frac{1}{2}}+b^{\frac{1}{2}}\right)$

4) Given that, $f(x)=x^2+3x-1$, and $g(x)=x^3-2x^2+5$, find

a $f(x)+g(x)$ **b** $f(x)-g(x)$ **c** $f(x)g(x)$

d $(x+1)f(x)$ **e** $(f(x))^2$ **f** $3xf(x)-2g(x)$

5) If $f(x)$ and $g(x)$ are polynomials of degree 7 and 8 respectively, state the degree of

a $f(x)+g(x)$ **b** $(f(x))^2$ **c** $f(x)g(x)$

6) Find the coefficient of the x^2 term in these expansions. (Do not work out all the terms.)

a $(x^2+2x-1)(x^2+3x+4)$ **b** $(2x^2-x+4)(x^2+x+3)$

c $(x^3-2x+2)(4x^2+3x-1)$ **d** $(4-x-x^2)(2+x-x^2)$

7) Given that $f(x)=3x^2-x+2$, and $g(x)=7x^4-2x^3+x^2+1$, find

a $f(x)+g(x)$ **b** $f(x)-2g(x)$ **c** $f(x)g(x)$ **d** $x^3f(x)+xg(x)$

8) Find the coefficient of the x^3 term in these expansions.

a $(x^4+3x^2-2x+1)(x^3-2x^2+x-7)$

b $(2x^3-x^2+5x-4)(-x^3+4x^2+2x+1)$

9) Expand and simplify

a $(7x^2+5x-1)(6x^3-3x^2+2x+4)$ **b** $(x^2+2xy+y^2)(x^2-2xy+y^2)$

c $(y^3+3y^2-2y-2)(4y^4-2y+7)$ **d** $(u^3+v^2-2w)^2$

e $(3xy+1)(2x^2-3y)$ **f** $(2x+1)(3x-1)(2x+7)$