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<td>2F</td>
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<td>3C</td>
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For any updates of this book, please refer to the subject homepage:


For mathematics problems consultation, please email to the following address:

[ltk.mathematics@gmail.com](mailto:ltk.mathematics@gmail.com)

For Maths Corner Exercise, please obtain from the cabinet outside Room 309
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</table>

Mark: _______
1.1A Basic Concepts of Significant Figures

In a number, the non-zero digit with the largest place value is called the first significant figure.
In general, all important digits of a number are called significant figures.

<table>
<thead>
<tr>
<th>The 1st significant figure</th>
<th>Number of significant figures</th>
</tr>
</thead>
<tbody>
<tr>
<td>485</td>
<td>4</td>
</tr>
<tr>
<td>5 003</td>
<td>5</td>
</tr>
<tr>
<td>2.701 3</td>
<td>2</td>
</tr>
<tr>
<td>0.009 6</td>
<td>9</td>
</tr>
</tbody>
</table>

Note that the bold digits are significant figures.

1. Complete the following table.

<table>
<thead>
<tr>
<th>The 1st significant figure</th>
<th>The 2nd significant figure</th>
<th>Number of significant figures</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) 517</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) 1 209</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) 9.362</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) 60.108</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) 0.876</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) 0.030 51</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.1B Rounding off to the Required Significant Figures

Step ①: Identify which digit is to be rounded.
Step ②: Examine the next digit to the right. Then, round off the number.
Step ③: State the degree of accuracy.

e.g. Round off 1 593 to 2 significant figures.

1 593 = 1 600, cor. to 2 sig. fig.
Example 1
Round off 64 257 to
(a) 2 significant figures,
(b) 3 significant figures,
(c) 4 significant figures.

Sol
(a) 64 257
= 64 000, cor. to 2 sig. fig.

(b) 64 257
= 64 300, cor. to 3 sig. fig.

(c) 64 257
= 64 260, cor. to 4 sig. fig.

Instant Drill 1
Round off 38 506 to
(a) 2 significant figures,
(b) 3 significant figures,
(c) 4 significant figures.

Sol
(a) 38 506
= __________, cor. to __________

(b) 38 506
= __________

(c) 38 506
= __________

2. Round off 50 903 to
(a) 1 significant figure,
(b) 2 significant figures,
(c) 4 significant figures.

3. Round off 277 041 to
(a) 2 significant figures,
(b) 3 significant figures,
(c) 5 significant figures.

4. In the table below, round off each number to the required degree of accuracy.

<table>
<thead>
<tr>
<th>Correct to</th>
<th>1 significant figure</th>
<th>2 significant figures</th>
<th>3 significant figures</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) 1 048</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) 69 463</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) 859 032</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the answers, which of the ‘0’s
(i) are significant figures?
(ii) are not significant figures?

Ex 1A 3(a)(b), 4(a)(b), 5, 6
Example 2
Round off 0.170 3 to
(a) 1 significant figure,
(b) 2 significant figures,
(c) 3 significant figures.

**Sol**
(a) \[0.170\ 3 \approx 0.2\], cor. to 1 sig. fig.
(b) \[0.170\ 3 \approx 0.17\], cor. to 2 sig. fig.
(c) \[0.170\ 3 \approx 0.170\], cor. to 3 sig. fig.

Instant Drill 2
Round off 0.060 35 to
(a) 1 significant figure,
(b) 2 significant figures,
(c) 3 significant figures.

**Sol**
(a) \[0.060\ 35 \approx 0.06\],
(b) \[0.060\ 35 \approx 0.060\],
(c) \[0.060\ 35 \approx 0.060\].

5. Round off 0.406 14 to
(a) 1 significant figure,
(b) 2 significant figures,
(c) 4 significant figures.

6. Round off 3.027 049 to
(a) 3 significant figures,
(b) 5 significant figures,
(c) 6 significant figures.

7. In the table below, round off each number to the required degree of accuracy.

<table>
<thead>
<tr>
<th>Correct to</th>
<th>1 significant figure</th>
<th>2 significant figures</th>
<th>3 significant figures</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) 2.955</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) 73.014 7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) −135.71</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

⊕ Ex 1A 3(c)(d), 4(c)(d), 7–9

e Ex 1A 10–12
**Example 3**

In each of the following, how many significant figures does the number 800 have?

(a) 800, correct to the nearest hundred

(b) 800, correct to the nearest ten

(c) 800, correct to the nearest integer

**Sol**

(a) \[800, \text{ cor. to the nearest hundred}, \text{ has 1}\]

(b) \[800, \text{ cor. to the nearest ten}, \text{ has 2}\]

(c) \[800, \text{ cor. to the nearest integer}, \text{ has 3}\]

**Instant Drill 3**

In each of the following, how many significant figures does the number 2500 have?

(a) 2500, correct to the nearest hundred

(b) 2500, correct to the nearest ten

(c) 2500, correct to the nearest integer

**Sol**

(a) \[2500, \text{ cor. to the nearest hundred}, \text{ has}\]

(b) \[2500, \text{ cor. to the nearest ten}, \text{ has}\]

(c) \[2500, \text{ cor. to the nearest integer}, \text{ has}\]

8. How many significant figures are there in each of the following numbers?

(a) 4520, correct to the nearest ten

(b) 78000, correct to the nearest thousand

(c) 6000000, correct to the nearest hundred

9. How many significant figures are there in each of the following numbers?

(a) 2.90, correct to the nearest 0.01

(b) 0.070, correct to 3 decimal places

(c) 0.00100, correct to 5 decimal places

**Example 4**

Oxygen will change into solid at \(-218.79^\circ\text{C}\). Round off this temperature to

(a) 2 significant figures,

(b) 3 significant figures.

**Sol**

(a) \[-218.79^\circ\text{C}, \text{ cor. to 2 sig. fig.}\]

(b) \[-218.79^\circ\text{C}, \text{ cor. to 3 sig. fig.}\]

**Instant Drill 4**

The population of a city is 909,316. Round off this population to

(a) 1 significant figure,

(b) 2 significant figures.

**Sol**

(a) \[909316, \text{ cor. to 1 sig. fig.}\]

(b) \[909316, \text{ cor. to 2 sig. figs.}\]
10. A highway is 5.448 1 km long. Round off this length to
   (a) 3 significant figures,
   (b) 4 significant figures.

11. A company’s bank balance was –$41 592 last month. Round off this balance to
   (a) 1 significant figure,
   (b) 3 significant figures.

‘Explain Your Answer’ Question

12. An observatory records a rainfall of 3.602 5 mm in a certain day.
   (a) Round off this amount of rainfall to
       (i) 2 significant figures,  
       (ii) 3 significant figures.
   (b) Mary claims that the approximate value in (a)(i) has the same degree of accuracy as that
       in (a)(ii). Do you agree? Explain your answer.

   (a) (i) 3.602 5 mm =
       (ii)
   (b) Since the approximate value in ______ has more significant figures than that in ______,
       the approximate value in ______ is more accurate.
      ∴ The claim is (agreed / disagreed).

Level Up Questions

13. Convert \(\frac{1}{7}\) into a decimal, correct to 3 significant figures.

14. The perimeter of a regular hexagon is 53.942 3 cm.
   (a) Round off this perimeter to 2 significant figures.
   (b) Use the approximate value in (a) to estimate the length of each side of the regular hexagon.
1 Approximation and Errors

Level 1

1. Write down the first significant figure of each of the following numbers.
   (a) 565                  (b) 20 102
   (c) 37.58                (d) 0.043 7

2. How many significant figures are there in each of the following numbers?
   (a) 144                  (b) 6 008
   (c) 0.030 6              (d) 50.021
   (e) 0.004 9              (f) 320.023

3. Round off the following numbers to 1 significant figure.
   (a) 471                  (b) 2 080
   (c) 0.543                (d) 0.057 6

4. Round off the following numbers to 2 significant figures.
   (a) 692                  (b) 84 508
   (c) 4.636 2              (d) 0.197 5

In each of the questions [Nos. 5–12] below, round off the number to
   (a) 2 significant figures,
   (b) 3 significant figures,
   (c) 4 significant figures.

5. 25 086                  6. 4 051 673                    7. 9.034 8
   8. 0.065 193

9. 0.732 95               10. 3.989 8                     11. −18.062
   12. −320.796

13. In each of the following, how many significant figures does the number 58 000 have?
   (a) 58 000, correct to the nearest integer
   (b) 58 000, correct to the nearest ten
   (c) 58 000, correct to the nearest hundred
   (d) 58 000, correct to the nearest thousand
14. How many significant figures are there in each of the following numbers?
   (a) 32.0, correct to the nearest 0.1
   (b) 40.08, correct to 2 decimal places
   (c) 0.106, correct to 3 decimal places
   (d) 0.007 00, correct to 5 decimal places

15. It is known that mercury changes into solid state at –38.829°C. Round off this temperature to
   (a) 2 significant figures,
   (b) 3 significant figures.

16. There are two buildings A and B. The height of building A is 235 m. The height of building B is 88 m
    higher than that of building A. Round off their heights to 2 significant figures.

17. The perimeter of a square is 46.07 cm. Find the length of each side of the square, correct to
    (a) 3 significant figures,
    (b) 4 significant figures.

18. It is known that the distance travelled by a butterfly in a day is 46 033 cm. Convert this distance to
    (a) m,
    (b) km.
    (Give the answers correct to 3 significant figures.)

   **Level 2**

19. State all possible number(s) of significant figures in each of the following approximate values.
    (a) 0.054
    (b) 620
    (c) 3 000
    (d) 0.085 0

20. Convert each of the following fractions into a decimal, correct to 4 significant figures.
    (a) \( \frac{1}{7} \)
    (b) \( 30 \frac{9}{16} \)
    (c) \( \frac{25}{18} \)
    (d) \( \frac{13}{111} \)

21. Evaluate \( 200 - \frac{3}{200} \) and give the answer correct to
    (a) 3 significant figures,
    (b) 4 significant figures.
22. In each of the following expressions, round off each number involved to 3 significant figures. Then, estimate the value of the expression.
   (a) $37.82 + 62.15$  
   (b) $475.36 - 123.78$

23. In each of the following expressions, round off each number involved to 1 significant figure. Then, estimate the value of the expression.
   (a) $5974 \times 3.18$  
   (b) $425 \div 7.83$

24. In the expression $210.53 \times 3.45 \div 6.97$, round off each number involved to 2 significant figures. Then, estimate the value of the expression.

25. In the expression $680.3 \div 19.95 + 349.8$, round off each number involved to 3 significant figures. Then, estimate the value of the expression.

26. After rounding off an integer $N$ to 2 significant figures, the approximate value 150 is obtained. Write down the greatest possible value of $N$.

27. An aeroplane takes 4 hours and 35 minutes to fly from Hong Kong to Tokyo. Convert this time to hours, correct to 3 significant figures.

28. In a sailing race, the finishing time of the champion team is 8 days 15 hours 48 minutes and 20 seconds. Convert this time to
   (a) days, correct to 3 significant figures,  
   (b) minutes, correct to 4 significant figures.

29. The following table shows the monthly expenditure of Carol in the second half year of 2015.

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<tr>
<th>Month</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenditure ($)</td>
<td>11 450</td>
<td>12 074</td>
<td>10 586</td>
<td>9 710</td>
<td>10 365</td>
<td>15 248</td>
</tr>
</tbody>
</table>

Find the total expenditure of Carol in the second half year of 2015.  
*(Give the answer correct to 4 significant figures.)*

30. A construction company plans to replace all the tiles in a shopping mall. The total floor area of the shopping mall is 75 120 m² and the total cost of the tiles required is $47 980 000.
   (a) Round off the total floor area and the total cost to 1 significant figure. Then, estimate the average cost of each m² of tile.
   (b) Round off the total floor area and the total cost to 2 significant figures. Then, estimate the average cost of each m² of tile.
   (c) Which estimation is more accurate, the one in (a) or the one in (b)? Explain your answer.
Consolidation Exercise 1A  (Answer)

1. (a) 5  (b) 2  
   (c) 3  (d) 4  
2. (a) 3  (b) 4  (c) 3  
   (d) 5  (e) 2  (f) 6  
3. (a) 500  (b) 2 000  
   (c) 0.5  (d) 0.06  
4. (a) 690  (b) 85 000  
   (c) 4.6  (d) 0.20  
5. (a) 25 000  (b) 25 100  (c) 25 090  
6. (a) 4 100 000  (b) 4 050 000  
   (c) 4 052 000  
7. (a) 9.0  (b) 9.03  (c) 9.035  
8. (a) 0.065  (b) 0.065  (c) 0.065  
9. (a) 0.73  (b) 0.733  (c) 0.733  
10. (a) 4.0  (b) 3.99  (c) 3.990  
11. (a) −18  (b) −18.1  (c) −18.06  
12. (a) −320  (b) −321  (c) −320.8  
13. (a) 5  (b) 4  
   (c) 3  (d) 2  
14. (a) 3  (b) 4  
   (c) 3  (d) 4  

15. (a) −39°C  (b) −38.8°C  
16. building A: 240 m, building B: 320 m  
17. (a) 11.5 cm  (b) 11.52 cm  
18. (a) 460 m  (b) 0.460 km  
19. (a) 2  (b) 2 or 3  
   (c) 1, 2, 3 or 4  
   (d) 3  
20. (a) −0.142 9  (b) 30.56  
   (c) 1.389  (d) 0.117 1  
21. (a) 200  (b) 200.0  
22. (a) 100  (b) 351  
23. (a) 18 000  (b) 50  
24. 105  
25. 384  
26. 154  
27. 4.58 h  
28. (a) 8.66 days  (b) 12 470 min  
29. $69 430  
30. (a) $625  (b) $640  (c) (b)
<table>
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<tr>
<th>Date</th>
<th>Task</th>
<th>Progress</th>
<th></th>
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</tr>
</tbody>
</table>
1.2A  Nature of Approximation in Measurement

The result obtained in measurement is not exact. It is only an approximate value.

1.2B  Errors

I. Absolute Error

In estimation or measurement, the difference between the actual value (i.e. exact value) and the approximate value is called the absolute error.

Case ①: If the actual value > the approximate value, then
absolute error = actual value – approximate value

Case ②: If the approximate value > the actual value, then
absolute error = approximate value – actual value

Note: Absolute error is always positive.

Example 1
Find the absolute errors in the following cases.

<table>
<thead>
<tr>
<th>actual value</th>
<th>approximate value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) 338</td>
<td>320</td>
</tr>
<tr>
<td>(b) 4.37 g</td>
<td>5 g</td>
</tr>
</tbody>
</table>

Sol (a) Absolute error = 338 – 320 ①
= 18

(b) Absolute error = (5 – 4.37) g ②
= 0.63 g

Instant Drill 1
Find the absolute errors in the following cases.

<table>
<thead>
<tr>
<th>actual value</th>
<th>approximate value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) 1 891</td>
<td>2 000</td>
</tr>
<tr>
<td>(b) 0.905 s</td>
<td>0.9 s</td>
</tr>
</tbody>
</table>

Sol (a) Absolute error = (    ) – (    )

(b) Absolute error = [(    ) – (    )] s

1. Complete the following table.

<table>
<thead>
<tr>
<th>Measured value</th>
<th>Absolute error</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Actual temperature = 26.25°C</td>
<td>[(    ) – (    )]°C</td>
</tr>
<tr>
<td>(b) Actual height = 16.38 cm</td>
<td></td>
</tr>
<tr>
<td>(c) Actual time = 44.691 s</td>
<td></td>
</tr>
</tbody>
</table>

Ex 1B 1–3
Example 2
Suppose the actual weight of a box of candy is 0.85 kg. Tom and John measure the weight of the box of candy as 0.8 kg and 1 kg respectively.

(a) Find the absolute errors of their measurements.

(b) Whose measurement is more accurate? Explain your answer.

Sol
(a) Absolute error of Tom’s measurement
    \[= (0.85 - 0.8) \text{ kg} = 0.05 \text{ kg}\]

Absolute error of John’s measurement
    \[= (1 - 0.85) \text{ kg} = 0.15 \text{ kg}\]

(b) \(\therefore\) 0.05 kg < 0.15 kg
    i.e. The absolute error of Tom’s measurement is less than that of John’s measurement.

\(\therefore\) Tom’s measurement is more accurate.

Instant Drill 2
Suppose the actual temperature of a classroom is 26.49°C. Amy and May measure the temperature of the classroom as 26°C and 26.5°C respectively.

(a) Find the absolute errors of their measurements.

(b) Whose measurement is more accurate? Explain your answer.

Sol
(a) Absolute error of Amy’s measurement
    \[= [(\quad) - (\quad)]^\circ \text{C} = \quad] \text{C}\]

Absolute error of May’s measurement
    \[= [(\quad) - (\quad)]^\circ \text{C} = \quad] \text{C}\]

(b) \(\therefore\) (\quad)°C < (\quad)°C
    i.e.

2. Suppose there are 473 biscuits in a can. Sam and Paul estimate the number of biscuits in the can as 450 and 500 respectively.

(a) Find the absolute errors of their estimations.

(b) Whose estimation is more accurate? Explain your answer.

3. The price of a vase is $3382. Mandy and Sandy estimate the price of the vase as $3200 and $3400 respectively.

(a) Find the absolute errors of their estimations.

(b) Whose estimation is more accurate? Explain your answer.
II. Maximum Error

Maximum absolute error (or maximum error) = \( \frac{1}{2} \times \text{scale interval on the measuring tool} \)

e.g. Use the ruler on the right in measurement.

Maximum error = \( \frac{1}{2} \times 1 \text{ cm} = 0.5 \text{ cm} \)

4. Complete the following table.

<table>
<thead>
<tr>
<th>Measuring tool</th>
<th>Scale interval</th>
<th>Maximum error</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Ruler</td>
<td>1 mm</td>
<td></td>
</tr>
<tr>
<td>(b) Measuring cylinder</td>
<td>10 mL</td>
<td></td>
</tr>
<tr>
<td>(c) Mechanical scale</td>
<td>0.4 kg</td>
<td></td>
</tr>
</tbody>
</table>

Lower limit of the actual value = measured value – maximum error
Upper limit of the actual value = measured value + maximum error
The possible range of the actual value is:

\[
\text{lower limit} \leq \text{actual value} < \text{upper limit}
\]

Example 3

The scale interval on a ruler is 1 cm. The length of a pencil is measured to be 10 cm by the ruler.

(a) Find the maximum error of the measurement.

(b) If the actual length of the pencil is \( x \) cm, find the possible range of \( x \).

\[ \text{Sol} \]

(a) Maximum error = \( \frac{1}{2} \times 1 \text{ cm} \)

\[ = 0.5 \text{ cm} \]

(b) Possible range of the actual length

\[
\begin{array}{c|c|c}
\text{Lower limit} & \text{Upper limit} \\
9 \text{ cm} & 10 \text{ cm} \\
10 \text{ cm} & 11 \text{ cm} \\
\end{array}
\]

Lower limit of the actual length

\[ = (10 - 0.5) \text{ cm} \]

\[ = 9.5 \text{ cm} \]

Upper limit of the actual length

\[ = (10 + 0.5) \text{ cm} \]

\[ = 10.5 \text{ cm} \]

\[ \therefore \text{The possible range of} \ x \text{ is} \]

\[ 9.5 \leq x < 10.5. \]

Instant Drill 3

The scale interval on a stopwatch is 0.1 s. Using this stopwatch, the measured time for Ada to finish a swimming event is 27.2 s.

(a) Find the maximum error of the measurement.

(b) If the actual time is \( a \) s, find the possible range of \( a \).

\[ \text{Sol} \]

(a) Maximum error = \( \frac{1}{2} \times 0.1 \text{ s} \)

\[ = \frac{1}{2} \text{ s} \]

(b) Possible range of the actual time

\[
\begin{array}{c|c|c}
\text{Lower limit} & \text{Upper limit} \\
( ) \text{ s} & 27.2 \text{ s} \\
27.2 \text{ s} & ( ) \text{ s} \\
\end{array}
\]

Lower limit of the actual time

\[ = [( ) - ( )] \text{ s} \]

\[ = \]

Upper limit of the actual time

\[ = [( ) + ( )] \text{ s} \]

\[ = \]

\[ \therefore \text{The possible range of} \ a \text{ is} \]

\[ 
\]
5. In the figure, the weight of the dumb-bell is measured to be 1.6 kg.
(a) Find the maximum error of the measurement.
(b) If the actual weight of the dumb-bell is $y$ kg, find the possible range of $y$.

(a) Scale interval of the weighing device = 

\[ \therefore \text{Maximum error} = \]

(b)

6. Samuel uses a measuring cup with a scale interval of 50 mL to measure the volume of a bottle of lemon tea. The result is 500 mL. Find the lower limit and the upper limit of the actual volume of the lemon tea.

7. The weight of a letter is measured as 8.12 g, correct to the nearest 0.02 g.
(a) Find the maximum error of this measured weight.
(b) If the actual weight of the letter is $x$ g, find the possible range of $x$.

‘Correct to the nearest 0.02 g’ can be regarded as the measuring tool with scale interval 0.02 g.

8. The thickness of a book is measured as 38 mm, correct to the nearest mm. Find the lower limit and the upper limit of the actual thickness of the book.
### 1.2C Relative Error

In measurement, the relative error is given by:
\[
\text{relative error} = \frac{\text{maximum error}}{\text{measured value}}
\]

- **Example 4**
  The length of Shing Mun River in Sha Tin is 7 km, correct to the nearest km. For this measured length, find
  (a) the maximum error,
  (b) the relative error.

  **Sol**
  (a) Maximum error = \( \frac{1}{2} \times 1 \text{ km} = 0.5 \text{ km} \)
  (b) Relative error = \( \frac{0.5 \text{ km}}{7 \text{ km}} = \frac{1}{14} \)

- **Instant Drill 4**
  The weight of a smartphone is 120 g, correct to the nearest 10 g. For this measured weight, find
  (a) the maximum error,
  (b) the relative error.

  **Sol**
  (a) Maximum error = \( \frac{1}{2} \times (\text{g}) = \)
  (b) Relative error = \( \frac{(\text{g})}{(\text{g})} = \)

- **9.** The volume of a cup is 250 mL, correct to the nearest 5 mL. Find the relative error.

- **10.** The time spent by Sunny to run along a path is 22.5 s, correct to the nearest 0.5 s. Find the relative error.

\[\Theta\] ExIB 9, 10
In estimation, 
\[
\text{relative error} = \frac{\text{absolute error}}{\text{actual value}}
\]

<table>
<thead>
<tr>
<th>Example 5</th>
<th>Instant Drill 5</th>
</tr>
</thead>
</table>
| There are 2 500 audience in a magic show. Neo estimates the number of audience as 2 600. Find, in Neo’s estimation,  
(a) the absolute error,  
(b) the relative error.  
**Sol**  
(a) Absolute error = 2 600 – 2 500  
= \( \frac{100}{2 500} \)  
(b) Relative error =  
= 0.04  
| A chef estimates that there are 42 dishes in a kitchen cabinet. If the actual number of dishes in the kitchen cabinet is 60, find, in the chef’s estimation,  
(a) the absolute error,  
(b) the relative error.  
**Sol**  
(a) Absolute error = (      ) – (      )  
=  
(b) Relative error =  
= |

11. Kelly estimates that there are 43 floors in a building. If there are only 40 floors in the building, find the relative error of her estimation.  

12. The price of a necklace is $13 800. Mr Chan estimates the price of the necklace as $12 000. Find the relative error of his estimation, correct to 2 significant figures.
### 1.2D Percentage Error

Percentage error = relative error \times 100%

<table>
<thead>
<tr>
<th>Example 6</th>
<th>Instant Drill 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>The length of a wire is 5.0 cm, correct to the nearest 0.5 cm. Find the percentage error of this length.</td>
<td>Sammy estimates that there are 600 words in an article. If the actual number is 500, find the percentage error of her estimation.</td>
</tr>
<tr>
<td><strong>Sol</strong> Maximum error = ( \frac{1}{2} \times 0.5 \text{ cm} )</td>
<td><strong>Sol</strong> Absolute error = ( ) – ( )</td>
</tr>
<tr>
<td>= 0.25 cm</td>
<td>=</td>
</tr>
<tr>
<td>Percentage error = ( \frac{0.25 \text{ cm}}{5.0 \text{ cm}} \times 100% )</td>
<td>Percentage error = ( ) \times 100%</td>
</tr>
<tr>
<td>= 5%</td>
<td>=</td>
</tr>
</tbody>
</table>

| 13. An engineer estimates that there are 28 000 seats in a stadium. If the actual number of seats is 27 950, find the percentage error, correct to 3 significant figures. | 14. The weight of a box of washing powder is \( (500 \pm 10) \text{ g} \). Find the percentage error. |
| 15. It is known that the height of a lighthouse is \( (32 \pm 0.2) \text{ m} \). Find the percentage error. | (500 – 10) g \leq \text{actual value} < (500 + 10) g, i.e. maximum error = 10 g |

| 16. The running time of a film is \( (186 \pm 6) \text{ minutes} \). Find the percentage error, correct to the nearest 0.1\%. |

Ω Ex 1B 12, 13
17. The weight of a packet of potato chips is measured as 42 g, correct to the nearest g.
   (a) Find the maximum error of the measurement.
   (b) Can the actual weight of the packet of potato chips be less than 40 g? Explain your answer.

(a) Maximum error =

(b) Lower limit of the actual weight =

. . . 40 g (> / = / <) 40 g
. . . The actual weight of the packet of potato chips (can / cannot) be less than 40 g.

18. The height of James is 160 cm, correct to the nearest 5 cm. If the actual height of Nick is 163 cm, is it possible that James is taller than Nick? Explain your answer.

Level Up Question

19. It is known that the monthly salary of Miss Cheung is $24 730. After rounding off her monthly salary to 2 significant figures, find
   (a) the absolute error,
   (b) the percentage error.

(Give the answers correct to 3 significant figures if necessary.)
1 Approximation and Errors

Level 1

1. In the figure, the size of $\angle AOB$ is measured by a protractor.
   (a) Find the size of $\angle AOB$, correct to the nearest 1°.
   (b) If the actual size of $\angle AOB$ is 110.2°, find the absolute error of the approximate value in (a).

2. In the figure, the length of a drumstick is measured by the given ruler.
   (a) Find the length of the drumstick, correct to the nearest 1 cm.
   (b) If the actual length is 38.97 cm, find the absolute error of the approximate value in (a).

3. The figure shows a reading on a mechanical scale.
   (a) Find the reading, correct to the nearest 0.5 kg.
   (b) If the actual weight is 5.38 kg, find the absolute error of the approximate value in (a).

4. Suppose the actual volume of a bottle of milk is 285.3 mL. Judy and Flora measure the volume of the milk as 285.5 mL and 286 mL respectively.
   (a) Find the absolute errors of their measurements.
   (b) Whose measurement is more accurate? Explain your answer.

5. There are 683 guests in a party. Aaron and Larry estimate the number of guests as 690 and 680 respectively.
   (a) Find the absolute errors of their estimations.
   (b) Whose estimation is more accurate? Explain your answer.

6. Complete the following table.
<table>
<thead>
<tr>
<th>Measuring tool</th>
<th>Scale interval</th>
<th>Maximum error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timer</td>
<td>1 s</td>
<td></td>
</tr>
<tr>
<td>Syringe</td>
<td>0.2 mL</td>
<td></td>
</tr>
<tr>
<td>Measuring tape</td>
<td>5 mm</td>
<td></td>
</tr>
</tbody>
</table>

7. Complete the following table.

<table>
<thead>
<tr>
<th>Measured value</th>
<th>Maximum error</th>
<th>Lower limit of actual value</th>
<th>Upper limit of actual value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) 57 cm</td>
<td></td>
<td>56 cm</td>
<td></td>
</tr>
<tr>
<td>(b) 24°C</td>
<td>0.1°C</td>
<td></td>
<td>500.5 mL</td>
</tr>
<tr>
<td>(c) 500 mL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) 0.05 kg</td>
<td>77.80 kg</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. In a zoo, the weight of an elephant is measured as 4 550 kg, correct to the nearest 10 kg.
   (a) Find the maximum error of the measured weight.
   (b) If the actual weight of the elephant is $x$ kg, find the possible range of $x$.

9. The figure shows a clinical thermometer.
   (a) Find the scale interval on this thermometer.
   (b) Using this thermometer, the body temperature of a man is measured as 36.3°C. If his actual body temperature is $x$°C, find the possible range of $x$.

10. The area of a park is 435 m$^2$, correct to the nearest m$^2$. For this measured area, find
    (a) the maximum error,
    (b) the relative error.

11. The length of a bridge is measured as 2 500 m, correct to the nearest 10 m. Find its relative error.

12. Mandy estimates that there are 234 words on a certain page of a book. If the actual number of words on this page is 240, find the relative error of Mandy’s estimation.

13. The volume of water in a bathtub is $(680 \pm 5)$ L. Find the percentage error of this measurement, correct to 2 significant figures.

14. The speed of a motorcycle is measured by the speedometer shown on the right. Find the percentage error of the measured speed, correct to the nearest 0.1%.
15. There were 5 648 vehicles passing through a tunnel yesterday.
   (a) Find the absolute error after rounding off the number of vehicles to
       (i) 2 significant figures,               (ii) 3 significant figures.
   (b) Which approximate value obtained in (a) is more accurate? Explain your answer.

16. The figure shows a sticker in a triangular shape. The base and the height are measured as 65 mm and 54 mm respectively. Both measurements are correct to the nearest mm.
   (a) Find the maximum error of each measurement.
   (b) Find the minimum possible area of the sticker.
   (c) If the actual area of the sticker is \( y \) mm\(^2\), find the possible range of \( y \).

17. In the polygon as shown, all the lengths are measured by the given ruler.
   (a) Find the maximum error of each measurement.
   (b) Find the minimum possible area of the polygon.
   (c) If the actual area of the polygon is \( x \) cm\(^2\), find the possible range of \( x \).

18. (a) The weight of a doll is measured as 54 g, correct to the nearest g. Find the minimum possible weight of the doll.
    (b) The weight of a robot is measured as 4.5 kg, correct to the nearest 0.5 kg.
        (i) Can the actual weight of the robot exceed 4 760 g? Explain your answer.
        (ii) Is it possible that the actual weight of the robot is equal to 90 times the actual weight of the doll in (a)? Explain your answer.

19. Ben measures the weight of 800 identical clips as 640 g and the relative error is \( \frac{1}{160} \). If the actual weight of each clip is \( x \) g, find the possible range of \( x \).

20. Mrs Chau estimates the price of an oil painting. The absolute error and the relative error of Mrs Chau’s estimation are $3 780 and \( \frac{18}{95} \) respectively. Is the price of the oil painting greater than $20 000? Explain your answer.

21. Last week, 36 924 people visited a theme park. After rounding off the number of people to 2 significant figures, find
    (a) the absolute error,
    (b) the percentage error, correct to the nearest 0.1%,
of the approximate value.

22. Gloria uses a measuring cylinder to measure the volume of some water. The result is shown on the right.
   (a) What is the reading on the measuring cylinder?
   (b) What is the maximum error of this reading?
   (c) What is the percentage error of this reading?
   (Give the answer correct to 2 significant figures.)

23. Two thermometers \(P\) and \(Q\) are used to measure the temperature in a laboratory. The scale interval of thermometer \(P\) is 2°C and the scale interval of thermometer \(Q\) is 0.1°C. Assume the actual temperature in the laboratory is 28.385°C. Complete the following table. (Give the answers correct to 3 significant figures if necessary.)

<table>
<thead>
<tr>
<th>Measured value (°C)</th>
<th>Absolute error (°C)</th>
<th>Relative error</th>
<th>Percentage error</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Thermometer (P)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Thermometer (Q)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

24. The volume of a bottle of oil is measured as 3.00 L, correct to the nearest 0.01 L. The volume of a can of coffee is measured as 260 mL, correct to the nearest mL.
   (a) Find the percentage errors of these two measured values.
   (Give the answers correct to 3 significant figures.)
   (b) Which measured value is more accurate? Explain your answer.

25. The measured weight of a bag of rice is 12 kg. The percentage error of this measurement is \(8 \frac{1}{3}\)%. 
   (a) Find the maximum error of the measurement.
   (b) Is it possible that the actual weight of the bag of rice is 10.8 kg? Explain your answer.

26. The International Commerce Centre is the tallest building in Hong Kong. The measured height of the building is 475 m with percentage error 2%.
   (a) Find the maximum error of the measurement.
   (b) Is it possible that the actual height of the building is 485 m? Explain your answer.
Consolidation Exercise 1B (Answer)

1. (a) $110^\circ$  (b) $0.2^\circ$

2. (a) $39 \text{ cm}$  (b) $0.03 \text{ cm}$

3. (a) $5.5 \text{ kg}$  (b) $0.12 \text{ kg}$

4. (a) Judy: $0.2 \text{ mL}$, Flora: $0.7 \text{ mL}$
   (b) Judy’s measurement

5. (a) Aaron: 7, Larry: 3
   (b) Larry’s estimation

6. (a) $0.5 \text{ s}$  (b) $0.1 \text{ mL}$  (c) $2.5 \text{ mm}$

7. (a) maximum error: $1 \text{ cm}$, upper limit: $58 \text{ cm}$
   (b) lower limit: $23.9^\circ \text{C}$, upper limit: $24.1^\circ \text{C}$
   (c) maximum error: $0.5 \text{ mL}$, lower limit: $499.5 \text{ mL}$
   (d) measured value: $77.85 \text{ kg}$, upper limit: $77.90 \text{ kg}$

8. (a) $5 \text{ kg}$  (b) $4.545 \leq x < 4.555$

9. (a) $0.1^\circ \text{C}$  (b) $36.25 \leq x < 36.35$

10. (a) $0.5 \text{ m}^2$  (b) $\frac{1}{870}$

11. $\frac{1}{500}$

12. $0.025$

13. $0.74\%$

14. $1.3\%$

15. (a) (i) 48  (ii) 2
   (b) (a)(ii)

16. (a) $0.5 \text{ mm}$  (b) $1725.375 \text{ mm}^2$
   (c) $1725.375 \leq y < 1784.875$

17. (a) $0.05 \text{ cm}$  (b) $15.56 \text{ cm}^2$
   (c) $15.56 \leq x < 16.57$

18. (a) $53.5 \text{ g}$
   (b) (i) no  (ii) no

19. $0.795 \leq x < 0.805$

20. no

21. (a) 76  (b) $0.2\%$

22. (a) $42 \text{ mL}$  (b) $1 \text{ mL}$  (c) $2.4\%$

23. | Measured value ($^\circ \text{C}$) | Absolute error ($^\circ \text{C}$) | Relative error | Percentage error |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) 28</td>
<td>0.385</td>
<td>0.0136</td>
<td>1.36%</td>
</tr>
<tr>
<td>(b) 28.4</td>
<td>0.015</td>
<td>0.000528</td>
<td>0.0528%</td>
</tr>
</tbody>
</table>

24. (a) oil: $0.167\%$, coffee: $0.192\%$
   (b) oil

25. (a) 1 kg  (b) no

26. (a) $9.5 \text{ m}$  (b) no
# F2A: Chapter 2A

<table>
<thead>
<tr>
<th>Date</th>
<th>Task</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lesson Worksheet</td>
<td>Complete and Checked ○  Problems encountered ○  Skipped ○  (Full Solution)</td>
</tr>
<tr>
<td></td>
<td>Book Example 1</td>
<td>Complete ○  Problems encountered ○  Skipped ○  (Video Teaching)</td>
</tr>
<tr>
<td></td>
<td>Book Example 2</td>
<td>Complete ○  Problems encountered ○  Skipped ○  (Video Teaching)</td>
</tr>
<tr>
<td></td>
<td>Book Example 3</td>
<td>Complete ○  Problems encountered ○  Skipped ○  (Video Teaching)</td>
</tr>
<tr>
<td></td>
<td>Consolidation Exercise</td>
<td>Complete and Checked ○  Problems encountered ○  Skipped ○  (Full Solution)</td>
</tr>
<tr>
<td></td>
<td>Maths Corner Exercise 2A Level 1</td>
<td>Complete and Checked ○  Problems encountered ○  Skipped ○  Teacher’s Signature ( )</td>
</tr>
<tr>
<td></td>
<td>Maths Corner Exercise 2A Level 2</td>
<td>Complete and Checked ○  Problems encountered ○  Skipped ○  Teacher’s Signature ( )</td>
</tr>
<tr>
<td></td>
<td>Maths Corner Exercise 2A Level 3</td>
<td>Complete and Checked ○  Problems encountered ○  Skipped ○  Teacher’s Signature ( )</td>
</tr>
<tr>
<td></td>
<td>Maths Corner Exercise 2A Multiple Choice</td>
<td>Complete and Checked ○  Problems encountered ○  Skipped ○  Teacher’s Signature ( )</td>
</tr>
<tr>
<td></td>
<td>E-Class Multiple Choice Self-Test</td>
<td>Complete and Checked ○  Problems encountered ○  Skipped ○  Mark: ________</td>
</tr>
</tbody>
</table>
2.1 Index Notation

(a) For any number \( a \) and any positive integer \( n \),
\[
a \times a \times a \times \cdots \times a = a^n. \quad \text{n times}
\]
(b) \( a^n \) is read as ‘\( a \) to the power \( n \)’ or ‘the \( n \)th power of \( a \)’.

Example 1
Use index notation to represent each of the following.

(a) the square of 8
(b) 10 to the power 6
(c) the 11th power of \( x \)

\( a \) is called the base and \( n \) is called the index.

\( ' \text{The square of 8' means '8 to the power 2'.} \)

\( ' \text{The cube of 7' means '7 to the power 3'.} \)

\( \cdot \) means the same as '×'.

\begin{align*}
\text{Sol (a)} & : \quad \text{The square of 8} = 8^2 \\
\text{(b)} & : \quad 10 \text{ to the power 6} = 10^6 \\
\text{(c)} & : \quad \text{The 11th power of } x = x^{11}
\end{align*}

Example 2
Use index notation to represent each of the following.

(a) \( 9 \times 9 \times 9 \times 9 \)
(b) \( 2 \times 2 \times 2 \times 3 \times 3 \times 3 \)
(c) \( (-6) \times (-6) \times (-6) \times (-6) \times (-6) \)
(d) \( \frac{7 \times 7 \times 7 \times 7}{4 \times 4} \)
(e) \( a \times a \times a \times a \times a \)
(f) \( x \times x \times x \times y \times y \)

\( \text{Sol (a)} : \quad 9 \times 9 \times 9 \times 9 = 9^4 \\
\text{(b)} : \quad 2 \times 2 \times 2 \times 3 \times 3 \times 3 \times 3 = 2^3 \times 3^4 \\
\text{(c)} : \quad (-6) \times (-6) \times (-6) \times (-6) \times (-6) = (-6)^5 \\
\text{(d)} : \quad \frac{7 \times 7 \times 7 \times 7}{4 \times 4} = \frac{7^4}{4^2} \\
\text{(e)} : \quad a \times a \times a \times a \times a = a^5 \\
\text{(f)} : \quad x \times x \times x \times y \times y = x^3 y^2
\)

Instant Drill 1
Use index notation to represent each of the following.

(a) the cube of 7
(b) 5 to the power 8
(c) the 23rd power of \( y \)

\( \text{Sol (a)} : \quad \text{The cube of 7} = 7^3 \\
\text{(b)} : \quad 5 \text{ to the power 8} = 5^8 \\
\text{(c)} : \quad \text{The 23rd power of } y = y^{23} \)

\( \Theta \text{ Ex 2A 1, 2} \)

Instant Drill 2
Use index notation to represent each of the following.

(a) \( 4 \times 4 \times 4 \times 4 \times 4 \)
(b) \( 7 \times 7 \times 7 \times 6 \times 6 \)
(c) \( b \times b \times b \)
(d) \( m \times m \times m \times m \times n \times n \)
(e) \( (-d) \times (-d) \times (-d) \)
(f) \( \frac{p \times p \times p}{q \times q \times q \times q \times q} \)

\( \text{Sol (a)} : \quad 4 \times 4 \times 4 \times 4 \times 4 = 4^5 \\
\text{(b)} : \quad 7 \times 7 \times 7 \times 6 \times 6 = 7^3 \times 6^2 \\
\text{(c)} : \quad b \times b \times b = b^3 \\
\text{(d)} : \quad m \times m \times m \times m \times n \times n = m^4 \times n^2 \\
\text{(e)} : \quad (-d) \times (-d) \times (-d) = (-d)^3 \\
\text{(f)} : \quad \frac{p \times p \times p}{q \times q \times q \times q \times q} = \frac{p^3}{q^5} \)
Use index notation to represent each of the following. [Nos. 1–12]

1. $5 	imes 5 	imes 5 	imes 5$

2. $7 	imes 7 	imes 10 	imes 10 	imes 10 	imes 10 	imes 10$

3. $(-2) 	imes (-2) 	imes (-2)$

4. $-(6 	imes 6 	imes 6)$

5. $8 	imes 8 	imes 8 	imes 8 	imes 9 	imes 9$

6. $\frac{11 \times 11}{3 \times 3 \times 3 \times 3 \times 3}$

7. $r \times r \times r \times r \times r \times r$

8. $2 \times 2 \times 2 \times d \times d \times d \times d \times d$

9. $h \times h \times h \times h \times k$

10. $(-f) \times (-f) \times (-f) \times (-f) \times (-f)$

11. $-(a \times a \times a \times a)$

12. $\frac{(-b) \cdot (-b) \cdot (-b)}{a \cdot a \cdot a \cdot a}$

Ex 2A 3–9
### Example 3
Without using a calculator, find the values of the following expressions.

(a) \(2^4\)

(b) \(-3^4\)

(c) \((-5)^3\)

**Sol**

(a) \(2^4 = 2 \times 2 \times 2 \times 2\)

\[= 16\]

(b) \(-3^4 = -(3 \times 3 \times 3 \times 3)\)

\[= -81\]

(c) \((-5)^3 = (-5) \times (-5) \times (-5)\)

\[= -125\]

### Instant Drill 3
Without using a calculator, find the values of the following expressions.

(a) \(4^3\)

(b) \(-5^3\)

(c) \((-2)^5\)

**Sol**

(a) \(4^3 = (\phantom{1}) \times (\phantom{1}) \times (\phantom{1})\)

\[= \phantom{1} \]

(b) \(-5^3 = -(\phantom{1} \times \phantom{1} \times \phantom{1})\)

\[= \phantom{1} \]

(c) \((-2)^5 = (-2) \times (-2) \times \phantom{1}\)

\[= \phantom{1} \]

---

Without using a calculator, find the values of the following expressions. **[Nos. 13–18]**

13. \(3^5\)

14. \((-5)^4\)

15. \(6(2)^3\)

16. \(-8(-3)^2\)

17. (a) \(6^3\)

(b) \(4^2\)

(c) \(6^3 + 4^2\)

18. (a) \(9^2\)

(b) \(2^5\)

(c) \(9^2 - 2^5\)

© Ex 2A 10–13, 16(a), (b)
19. In each of the following, are the two expressions equal in value? Explain your answer.

(a) \((-5)^3, 5^3\)

(b) \(-3^4, (-3)^4\)

(a) \((-5)^3 = 5^3 = \ldots\)

(b) \(-3^4 = \ldots\)

Level Up Questions

20. Use index notation to represent each of the following.

(a) \(3 \times 3 \times (-2) \times (-2) \times (-2)\)

(b) \((-4) \times 7 \times (-4) \times 7 \times (-4) \times 7 \times (-4)\)

(c) \(m \times (-n) \times (-n) \times (-n) \times m\)

21. Given that \(R = 4s - u^3\), find the value of \(R\) in each of the following cases.

(a) \(s = 8, u = -2\)

(b) \(s = \frac{1}{2}, u = 3\)
Level 1

Use index notation to represent each of the following. [Nos. 1–10]

1. (a) the square of 9  
   (b) the cube of \( m \)

2. (a) the 7th power of 4  
   (b) \( k \) to the power 8

3. (a) \( 5 \times 5 \times 5 \)  
   (b) \( 7 \times 7 \times 7 \)

4. (a) \( 3 \times 3 \times 3 \times 2 \)  
   (b) \( 4 \times 4 \times 4 \times 4 \times 6 \times 6 \)

5. (a) \( h \times h \)  
   (b) \( k \times k \times k \times k \times k \times k \)

6. (a) \( m \times p \times p \times p \)  
   (b) \( n \times n \times n \times n \times n \times n \times q \times q \)

7. (a) \((-3) \times (-3) \times (-3) \times (-3) \times (-3)\)  
   (b) \(-10 \times 10 \times 10 \times 10 \times 10\)

8. (a) \((-r) \times (-r) \times (-r) \times (-r)\)  
   (b) \(-s \times s \times s \times s \times s \times s \times s \times s\)

9. (a) \(4 \times 4 \times c \times c \times c\)  
   (b) \(9 \times 9 \times 9 \times d \times d\)

10. (a) \(\frac{2 \times 2 \times 2 \times 2}{3 \times 3 \times 3 \times 3 \times 3}\)  
    (b) \(\frac{8 \times 8 \times 8 \times 8}{a \times a \times a \times a \times a}\)

Without using a calculator, find the values of the following expressions. [Nos. 11–14]

11. (a) \(2^5\)  
    (b) \((-3)^2\)

12. (a) \((-4)^3\)  
    (b) \(-(-5)^3\)

13. (a) \(6(2^4)\)  
    (b) \(-2(-7^2)\)

14. (a) \(\frac{2}{(-10)^3}\)  
    (b) \(\frac{1}{(-3)^4}\)
Level 2

Use index notation to represent each of the following. [Nos. 15–16]

15. (a) \((-4) \times 7 \times (-4) \times 7 \times 7\)
   (b) \((-1) \times (-8) \times (-1) \times (-1) \times (-1) \times (-8)\)

16. (a) \(q \times (-p) \times (-p) \times q \times q \times (-p) \times q \times q\)
   (b) \((-h \times m \times h \times m \times h \times m\) \)

Without using a calculator, find the values of the following expressions. [Nos. 17–19]

17. (a) \(7^2 - 2^3\)
   (b) \(-6^2 + 5^2\)
   (c) \(3^4 - (-4)^2 + 2^5\)

18. (a) \((-1)^7 \times (-3)^3\)
   (b) \((\frac{1}{3})^3 \times 9^2\)
   (c) \(6^2 \times \left(-\frac{1}{2}\right)^4 \times (-1)^6\)

19. (a) \((-3)^3 + 2^4 \times 5^2\)
   (b) \(4^3 \times \left(-\frac{1}{2}\right)^5 + 3^2\)
   (c) \((-1)^5 - \left(-\frac{1}{6}\right)^3 \times 6^4\)

20. Given that \(P = m^3 - n^2\), find the value of \(P\) in each of the following cases.
    (a) \(m = 3, n = 4\)  
    (b) \(m = 1, n = 7\)  
    (c) \(m = -2, n = -1\)

21. Given that \(C = h^2 + k^5\), find the value of \(C\) in each of the following cases.
    (a) \(h = 4, k = 2\)  
    (b) \(h = 5, k = -2\)  
    (c) \(h = \frac{1}{3}, k = -1\)

22. Given that \(D = -(p^4 + 2q^3)\), find the value of \(D\) in each of the following cases.
    (a) \(p = -1, q = 2\)  
    (b) \(p = -2, q = -3\)  
    (c) \(p = -\frac{1}{2}, q = \frac{1}{4}\)
Consolidation Exercise 2A (Answer)

1. (a) $9^2$  (b) $m^3$
2. (a) $4^7$  (b) $k^3$
3. (a) $5^3$  (b) $7^4$
4. (a) $3^3 \times 2$  (b) $4^2 \times 6^2$
5. (a) $h^2$  (b) $k^7$
6. (a) $mp^3$  (b) $n^6q^2$
7. (a) $(-3)^5$  (b) $-10^6$
8. (a) $(-r)^4$  (b) $-s^7$
9. (a) $4^2c^3$  (b) $9^4d^2$
10. (a) $\frac{2^4}{3^6}$  (b) $\frac{8^4}{a^3}$
11. (a) 32  (b) 9
12. (a) $-64$  (b) 125
13. (a) 96  (b) 98
14. (a) $-\frac{1}{500}$  (b) $\frac{1}{81}$
15. (a) $(-4)^2 \times 7^3$  (b) $(-1)^4 \times (-8)^2$
16. (a) $(-p)^3q^5$  (b) $-h^4m^3$
17. (a) 41  (b) $-11$  (c) 97
18. (a) 27  (b) 3  (c) $\frac{9}{4}$
19. (a) 373  (b) 7  (c) 5
20. (a) 11  (b) $-48$  (c) $-9$
21. (a) 48  (b) $-7$  (c) $-\frac{8}{9}$
22. (a) $-17$  (b) 38  (c) $-\frac{3}{32}$
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2.2A Multiplication of Powers

If \( m \) and \( n \) are positive integers, then
\[
a^m \times a^n = a^{m+n}
\]

Apply to the powers with the SAME base only.

Example 1
Simplify the following expressions and express the answers in index notation.

(a) \( 8^2 \times 8^3 \)
(b) \( a^5 \times a \)
(c) \( y^7 \cdot y^{10} \)

Sol
(a) \( 8^2 \times 8^3 = 8^{2+3} = 8^5 \)
(b) \( a^5 \times a = a^{5+1} = a^6 \)
(c) \( y^7 \cdot y^{10} = y^{7+10} = y^{17} \)

Instant Drill 1
Simplify the following expressions and express the answers in index notation.

(a) \( 5^2 \times 5^6 \)
(b) \( e \times e^8 \)
(c) \( h^5 \cdot h^{13} \)

Sol
(a) \( 5^2 \times 5^6 = 5^{(2)+ (6)} = 5^8 \)
(b) \( e \times e^8 = e^{(1)+ (8)} = e^9 \)
(c) \( h^5 \cdot h^{13} = h^{5+13} = h^{18} \)

Simplify the following expressions and express the answers in index notation. [Nos. 1–4]

1. \( 6^3 \times 6^5 \)
2. \( y^4 \times y^2 \)
3. \( x^{12} \cdot x \)
4. \( r^5 \cdot r^2 \cdot r^8 \)

Ex 2B 1, 5
Example 2
Simplify the following expressions.
(a) \(5c^3 \times 2e^9\)
(b) \(m^2n \times 7m^{11}n^4\)

\[\text{Sol} (a)\quad 5c^3 \times 2e^9 \quad \Rightarrow \quad 10c^3e^9 \quad \Rightarrow \quad 10c^{12}\]

\[\text{Sol} (b)\quad m^2n \times 7m^{11}n^4 \quad \Rightarrow \quad 7m^2n \times m^{11}n^4 \quad \Rightarrow \quad 7m^{13}n^5\]

Instant Drill 2
Simplify the following expressions.
(a) \(4w^8 \times 10w^6\)
(b) \(a^3b^5 \times (–3a^2b^4)\)

\[\text{Sol} (a)\quad 4w^8 \times 10w^6 \quad \Rightarrow \quad 4 \times ( ) \times w^{( )} \times w^{( )} \quad \Rightarrow \quad ( ) \times w^{( )} \quad \Rightarrow \quad ( ) \times w^{( )} \quad \Rightarrow \quad \text{ } \]

\[\text{Sol} (b)\quad a^3b^5 \times (–3a^2b^4) \quad \Rightarrow \quad ( ) \times a^{( )} \times a^{( )} \quad \Rightarrow \quad ( ) \times a^{( )} \times \text{ } \]

Simplify the following expressions. [Nos. 5–8]

5. \((-3a^4) \times 2a^6\)
6. \(p^2q^5 \times pq^3\)

7. \((-x^6y^{10}) \times 5x^9y^3\)
8. \((-8m^4n^7) \times (–4m^5n^{13})\)

\(\text{Ex 2B} 6, 13(a), 14\)
2.2B Division of Powers

If \( m \) and \( n \) are positive integers and \( a \neq 0 \), then

\[
\begin{align*}
d^m \div a^n &= d^{m-n} \quad \text{(where } m > n) \\
d^m \div a^n &= \frac{1}{a^{m-n}} \quad \text{(where } m < n) 
\end{align*}
\]

**Example 3**

Simplify the following expressions and express the answers in index notation.

(a) \( 6^5 \div 6^2 \)

(b) \( t^8 \div t^3 \)

(c) \( 5^7 \div 5^{13} \)

(d) \( u^6 \div u^{10} \)

**Sol**

(a) \( 6^5 \div 6^2 = 6^{5-2} = 6^3 \)

(b) \( t^8 \div t^3 = t^{8-3} = t^5 \)

(c) \( 5^7 \div 5^{13} = \frac{1}{5^{13-7}} = \frac{1}{5^6} \quad \text{< 13} \)

(d) \( u^6 \div u^{10} = \frac{1}{u^{10-6}} = \frac{1}{u^4} \)

**Instant Drill 3**

Simplify the following expressions and express the answers in index notation.

(a) \( 7^9 \div 7^3 \)

(b) \( a^{12} \div a^8 \)

(c) \( 2^4 \div 2^{11} \)

(d) \( b^3 \div b^{15} \)

**Sol**

(a) \( 7^9 \div 7^3 = 7^{(9)-(3)} = \) 

(b) \( a^{12} \div a^8 = \)

(c) \( 2^4 \div 2^{11} = \frac{1}{2^{(11)-(4)}} = \frac{1}{2^7} \quad \text{< 11} \)

(d) \( b^3 \div b^{15} = \)

Simplify the following expressions and express the answers in index notation. [Nos. 9–12]

9. \( \frac{3^6}{3^4} \)

10. \( r^{17} \div r^7 \)

11. \( 10^8 \div 10^{19} \)

12. \( \frac{t^{15}}{t^{21}} \)

\( \text{Ex 2B 2, 7, 13(b)} \)
Example 4
Simplify the following expressions.
(a) 36w^8 ÷ 9w^2
(b) 12x^2y ÷ (-4xy^3)

Sol (a) 36w^8 ÷ 9w^2 = \frac{36w^8}{9w^2} = \frac{36}{9}w^{8-2} = 4w^6
(b) 12x^2y ÷ (-4xy^3) = \frac{12x^2y}{-4xy^3} = \frac{3x^{2-1}}{y^{3-1}} = \frac{3x}{y^2}

Instant Drill 4
Simplify the following expressions.
(a) 15d^8 ÷ 3d^4
(b) 63e^7f^3 ÷ 7e^{12}f^3

Sol (a) 15d^8 ÷ 3d^4 = \frac{15d^8}{( )} = \frac{5d^4}{( )}
(b) 63e^7f^3 ÷ 7e^{12}f^3 = 9e^{-5}f^{-3}

Simplify the following expressions. [Nos. 13–14]

13. (a) 18v^9 ÷ 6v^4
(b) \frac{-4x^2y^7}{32xy^2}

14. (a) \frac{24x^3}{8x^6}
(b) 25x^8y^{12} ÷ 15x^6y^{16}

Ex 2B 8, 9, 13(c), 15
### Example 5
Simplify the following expressions and express the answers in index notation.

(a) \((3^4)^5\)

(b) \((a^6)^2\)

**Sol** (a) \((3^4)^5 = 3^{4\times 5} = 3^{20}\)

(b) \((a^6)^2 = a^{6\times 2} = a^{12}\)

### Instant Drill 5
Simplify the following expressions and express the answers in index notation.

(a) \((5^3)^2\)

(b) \((y^4)^9\)

**Sol** (a) \((5^3)^2 = 5^{3\times 2} = 5^6\)

(b) \((y^4)^9 = y^{4\times 9} = y^{36}\)

Simplify the following expressions and express the answers in index notation. [Nos. 15–20]

15. \((11^7)^4\)

16. \((x^2)^7\)

17. \((y^8)^5\)

18. \(-4(y^9)^3\)

19. \(m^2(m^3)^6\)

20. \(\frac{(m^4)^8}{m^{14}}\)

≈ Ex 2B 3, 10
## 2.2D Powers of Products and Powers of Quotients

If \( n \) is a positive integer, then

\[
(ab)^n = a^n b^n
\]

### Example 6

Simplify the following expressions.

(a) \((xy)^7\)
(b) \((2a)^3\)
(c) \((u^2v^4)^6\)

**Sol**

(a) \((xy)^7 = x^7 y^7\)
(b) \((2a)^3 = 8a^3\)
(c) \((u^2v^4)^6 = (u^2)^6(v^4)^6 = u^{12}v^{24}\)

### Instant Drill 6

Simplify the following expressions.

(a) \((bc)^9\)
(b) \((5k)^2\)
(c) \((r^3s^8)^4\)

**Sol**

(a) \((bc)^9 = b^9 c^9\)
(b) \((5k)^2 = 25k^2\)
(c) \((r^3s^8)^4 = (r^3)^4 (s^8)^4 = r^{12} s^{32}\)

### Simplify the following expressions. [Nos. 21–24]

21. \((ab)^{12}\)

22. \((3x^2)^4\)

23. \((h^5k^{10})^6\)

24. \(3^n \times 5^n\)

\[d^n b^n = (ab)^n\]
If \( n \) is a positive integer, then
\[
\left(\frac{a}{b}\right)^n = \frac{a^n}{b^n} \quad \text{(where} \ b \neq 0)\]

---

**Example 7**

Simplify the following expressions.

(a) \( \left( \frac{h}{k} \right)^{10} \)

(b) \( \left( \frac{x^3}{4} \right)^2 \)

**Sol**

(a) \( \left( \frac{h}{k} \right)^{10} = \frac{h^{10}}{k^{10}} \)

(b) \( \left( \frac{x^3}{4} \right)^2 = \frac{(x^3)^2}{4^2} = \frac{x^{3\times2}}{16} = \frac{x^6}{16} \)

---

**Instant Drill 7**

Simplify the following expressions.

(a) \( \left( \frac{r}{s} \right)^8 \)

(b) \( \left( \frac{a^4}{3c^2} \right)^3 \)

**Sol**

(a) \( \left( \frac{r}{s} \right)^8 = \frac{r^{8}}{s^{8}} \)

(b) \( \left( \frac{a^4}{3c^2} \right)^3 = \frac{a^{4\times3}}{3^{3}c^{6}} \)

---

Simplify the following expressions. **[Nos. 25–30]**

25. \( \left( \frac{2}{a} \right)^5 \)

26. \( \left( \frac{r^7}{u^9} \right)^2 \)

27. \( \left( \frac{-3}{w^2} \right)^4 \)

28. \( \left( \frac{4x^6}{y^5} \right)^3 \)

---

\( \Theta \) Ex 2B 4(b), 12
29. \(5y^9 \div (y^2)^4\)

30. \(\left(\frac{a}{b}\right)^2 \times (ab)^3\)

**Level Up Questions**

Simplify the following expressions. [Nos. 31–32]

31. (a) \(a^2 \times 3a^5 \times (-4a^7)\)

(b) \(24y^9 \div 3y^2 \div y^4\)

(c) \((h^2k)^3 \times \left(\frac{6k}{h}\right)^2\)

32. \((9^5)(3^9)\)

- Convert the base of \(9^5\) to 3.
  - [Hint: \(9 = 3^2\).]
2 Manipulations and Factorization of Polynomials

**Level 1**

Calculate the following expressions and express the answers in index notation. **[Nos. 1–4]**

1. (a) $3^7 \times 3^2$  
   (b) $-6^4 \times 6^4$

2. (a) $5^8 \div 5$  
   (b) $\frac{2^6}{2^{11}}$

3. (a) $(7^4)^5$  
   (b) $(10^6)^3$

4. (a) $\frac{-8^4}{-2^4}$  
   (b) $(-6)^9 \times (-2)^9$

Simplify the following expressions. **[Nos. 5–18]**

5. (a) $p^2 \times p^3$  
   (b) $h^4 \times h^3$  
   (c) $m^3 \times (-m^6)$

6. (a) $2^6 \times 3^4$  
   (b) $4x^5 \times 3x^2$  
   (c) $-2y^5 \times (-5y)$

7. (a) $\frac{u^8}{u^6}$  
   (b) $v^3 \div v^7$  
   (c) $w^3 \div (-w^3)$

8. (a) $x^5 \div 2x^3$  
   (b) $\frac{6y^2}{3y^6}$  
   (c) $\frac{12(-z)^{11}}{9(-z)^8}$

9. (a) $(h^9)^3$  
   (b) $(k^2)^6$  
   (c) $[(-r)^4]^5$

10. (a) $(mn)^9$  
    (b) $(-3a)^3$  
    (c) $(pq^2)^4$

11. (a) $\left(\frac{c}{d}\right)^7$  
    (b) $\left(\frac{h}{-2}\right)^4$  
    (c) $\left(\frac{m^3}{4n}\right)^3$

12. (a) $t^4 \times 3t^3 \times 5t^5$  
    (b) $u^9 \div u^3 \div u^4$  
    (c) $20u^{12} \div v^3 \div 4v^6$

13. (a) $xy^3 \times x^3y^4$  
    (b) $4w^2z^5 \times 6w^7z^3$  
    (c) $(-9a^5b^2) \times (-3a^3b^4)$

14. (a) $h^7k^5 \div h^4k^3$  
    (b) $35p^9q^{11} \div 7pq^5$  
    (c) $18r^4s^5 \div (-6r^3s)$

15. $a^7 \times (-3a^2) \div (-a^2)$
16. $16b^{14} \div (b^2)^5$

17. $h^5 \div (gh)^3$

18. $m^2 \times \left( \frac{n}{m} \right)^3$

In each of the following, $a$ and $b$ are positive integers. Write down two sets of values for $a$ and $b$ such that the equality holds. [Nos. 19–23]

19. $7^a \times 7^b = 7^5$

20. $5^a \div 5^b = 5^3$

21. $(4^a)^b = 4^{18}$

22. $a^3 \cdot b^3 = 12^3$

23. $\frac{a^7}{b^7} = 5^7$

### Level 2

Simplify the following expressions. [Nos. 24–35]

24. (a) $-35r^a s^3 \div 5r^4 s^{11}$
   
   (b) $\frac{16t^{10}}{2t^2 \times 4t^5}$

25. (a) $(3^a)(27^b)$
   
   (b) $\frac{100^p}{10^q}$ (where $p > q$)

26. (a) $8^a \div 4^a$
   
   (b) $3 \times 9^b$

27. (a) $(x^2 \times 2x)^5$
   
   (b) $\left( \frac{g \times 3g^2}{-h^3} \right)^3$

28. (a) $\frac{(p^3 q^2)^5}{(p^2 q^3)^5}$
   
   (b) $(8a^3 b^2)^3 \div (-8a^3 b)^5$

29. (a) $\frac{36x^4}{(2y) \times (-3x)^2}$
   
   (b) $16h^2 \times \left( \frac{3h}{4k^2} \right)^3$

30. $\frac{125^a \times 5^m}{25^m}$ (where $n > m$)
31. \((3^{2n} \times 27^n)^3\)

32. \((-d)^3 \times (-6d)^2 \div 9d^4\)

33. \((-m^3n)^2 \times m^5n^3 \times mn^4\)

34. \((2x^k y)^4 \div \frac{(6x^3 y^2)^4}{(-3xy^2)^3}\)

35. \(20a^4b^5 \div (-5b^3) \div (-4a^2b^3)^2\)

36. It is given that \(p^m = 81\) and \(p^n = 27\), where \(m, n\) are positive integers and \(m > n\). Find the value of \(p^{m-n}\).

37. Given that \(a^r = 4\), where \(r\) is a positive integer, find the value of \(a^{3r}\).

38. Given that \(x^h = 2\) and \(x^k = 8\), where \(h\) and \(k\) are positive integers, find the value of \(x^{3h + k}\).

39. Given that \(x^k = 5\) and \(y^k = 2\), where \(k\) is a positive integer, find the value of \(\frac{1}{2} (xy^k)^k\).
Consolidation Exercise 2B (Answer)

1. (a) $3^9$  (b) $-6^8$
2. (a) $5^7$  (b) $\frac{1}{2^5}$
3. (a) $7^{20}$  (b) $10^{18}$
4. (a) $4^4$  (b) $12^9$
5. (a) $p^5$  (b) $h^7$  (c) $-m^{11}$
6. (a) $6r^{10}$  (b) $12x^7$  (c) $10y^8$
7. (a) $u^2$  (b) $\frac{1}{v^4}$  (c) $-\frac{1}{w^3}$
8. (a) $\frac{x^2}{2}$  (b) $\frac{2}{y^4}$  (c) $-\frac{4z^3}{3}$
9. (a) $h^{15}$  (b) $k^{12}$  (c) $r^{20}$
10. (a) $m^9n^9$  (b) $-27a^3$  (c) $p^4q^8$
11. (a) $e^7$  (b) $\frac{h^4}{16}$  (c) $\frac{m^9}{64n^{15}}$
12. (a) $15t^{11}$  (b) $u^2$  (c) $5v^3$
13. (a) $x^4y^7$  (b) $24w^8x^5$  (c) $27a^8b^6$
14. (a) $h^3k^2$  (b) $5p^3q^6$  (c) $-3r^2s^4$
15. $3a^5$
16. $16b^4$
17. $\frac{1}{g^3h}$
18. $\frac{n^3}{m}$
19. $a = 1, b = 4; a = 2, b = 3$
   (or other reasonable answers)
20. $a = 4, b = 1; a = 5, b = 2$
   (or other reasonable answers)
21. $a = 2, b = 9; a = 3, b = 6$
   (or other reasonable answers)
22. $a = 2, b = 6; a = 3, b = 4$
   (or other reasonable answers)
23. $a = 10, b = 2; a = 15, b = 3$
   (or other reasonable answers)
24. (a) $-\frac{7r^2}{s^8}$  (b) $2t^3$
25. (a) $3^a + 3^n$  (b) $10^{2p} - q$
26. (a) $2^a$  (b) $3^1 + 2b$
27. (a) $32x^{15}$  (b) $-\frac{27g^9}{h^{12}}$
28. (a) $\frac{p^5}{q^5}$  (b) $-64d^6b^9$
29. (a) $\frac{x^2}{2y^3}$  (b) $\frac{27h^5}{4k^6}$
30. $5^{3n} - m$
31. $3^{15n}$
32. $-4d^5$
33. $m^2n^3$
34. $-\frac{x^{11}y^{10}}{3}$
35. $-\frac{1}{4b^4}$
36. 3
37. 64
38. 64
39. 10
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<th>Progress</th>
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2.3A Basic Knowledge about Polynomials

(a) A **monomial** is an algebraic expression that consists of one single term. This term must be one of the following types:

<table>
<thead>
<tr>
<th>Monomial</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) A number</td>
<td>3, −4, 1/2</td>
</tr>
<tr>
<td>(ii) A variable with a positive integral index</td>
<td>x, y²</td>
</tr>
<tr>
<td>(iii) The product of a number and one or more variables, where each variable has a positive integral index</td>
<td>6x, −7x²y³</td>
</tr>
</tbody>
</table>

**Note:** \(\frac{1}{x}\) and \(\frac{2}{4-3y^2}\) are not monomials.

(b) A **polynomial** can be a monomial or a sum of monomials.

  e.g. \(3x, 2x - 1, 3x^2 + 5xy\)  

  The polynomial \(2x - 1\) has two terms: \(2x\) and \(-1\).

1. Determine whether each of the following algebraic expressions is a polynomial.

   (a) \(-5\)  
   (b) \(7x\)  
   (c) \(6x^2y^5\)  
   (d) \(\frac{xy}{z}\)  
   (e) \(\frac{2p^3}{8}\)  
   (f) \(\frac{4}{3}x + 5y\)  
   (g) \(5a + \frac{3a}{2b} - 4c\)  
   (h) \(\frac{a^3}{2} + \frac{2b^2}{5} - \frac{3c}{d}\)

Can you explain why some of the expressions here are not polynomials?

(a) In each term of a polynomial, a **coefficient** is the numerical value that is multiplied with the variable(s).

(b) A **constant term** is the term without variables.

  e.g. (i) The coefficient of the monomial \(-4x^2\) is \(-4\).

  (ii) For the polynomial \(5x^2 - 7x + 1\):

    Coefficient of the \(x^2\) term = 5
    Coefficient of the \(x\) term = \(-7\)
    Constant term = 1

θ Ex 2C 1
2. Complete the table below.

<table>
<thead>
<tr>
<th>Polynomial</th>
<th>Number of terms</th>
<th>Coefficient of the x term</th>
<th>Constant term</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) $9x + 4$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) $3x^2 - 5x - 11$</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(c) $-7x^3 + 8x - 6x^2$</td>
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</table>

2.3B Degree of a Polynomial

I. Monomials

Degree of a monomial = sum of the indices of all the variables

<table>
<thead>
<tr>
<th>Monomial</th>
<th>$x$</th>
<th>$y^2$</th>
<th>$x^2y^3$</th>
<th>$-5x^2y^4z^6$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree</td>
<td>0</td>
<td>1</td>
<td>2 + 3 = 5</td>
<td>2 + 4 + 6 = 12</td>
</tr>
</tbody>
</table>

When the monomial is a number, degree = 0.

3. Write down the degree of each of the following monomials.

(a) $\frac{1}{2}$  
(b) $3x$  
(c) $2x^5$

(d) $-xy$  
(e) $x^2y$  
(f) $8x^3y^4$

(g) $\frac{xyz}{4}$  
(h) $a^2bc^3$  
(i) $-4xyz^5$

(a) Degree of $\frac{1}{2} = \text{________}$

(b) Degree of $3x = \text{________}$

(c) Degree of $2x^5 = \text{________}$

(d) Degree of $-xy = ( \text{________} ) + ( \text{________} ) = \text{________}$

(e) Degree of $x^2y = ( \text{________} ) + ( \text{________} ) = \text{________}$

(f) Degree of $8x^3y^4 = ( \text{________} ) + ( \text{________} ) = \text{________}$

(g) Degree of $\frac{xyz}{4} = ( \text{________} ) + ( \text{________} ) + ( \text{________} ) = \text{________}$

(h) Degree of $a^2bc^3 = \text{________}$

(i) Degree of $-4xyz^5 = \text{________}$
II. Polynomials

Degree of a polynomial = degree of the term with the highest degree
e.g. Consider the polynomial \(-y^3 + 5y^2 + 3y - 4\).

<table>
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<tr>
<th>Term</th>
<th>Degree</th>
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<tr>
<td>(-y^3)</td>
<td>3</td>
</tr>
<tr>
<td>+5y^2</td>
<td>2</td>
</tr>
<tr>
<td>+3y</td>
<td>1</td>
</tr>
<tr>
<td>-4</td>
<td>0</td>
</tr>
</tbody>
</table>

\[\text{highest degree}\]

\[\therefore\] The degree of \(-y^3 + 5y^2 + 3y - 4\) is 3.

Example 1
Write down the degree of each of the following polynomials.
(a) \(8 + 5x - 3x^2\)
(b) \(9x^3y + x^5y^2\)

\[\text{Sol (a)}\]

\[
\begin{array}{c|c|c|c|c}
\text{Term} & \text{Degree} \\
\hline
8 & 0 \hline
+5x & 1 \hline
-3x^2 & 2 \hline
\end{array}
\]

\[\text{Degree: 0 + 1 + 2 = 3}\]

\[\therefore\] The term with the highest degree is \(-3x^2\) and its degree is 2.

\[\therefore\] The degree of \(8 + 5x - 3x^2\) is 2.

(b)

\[
\begin{array}{c|c|c|c|c}
\text{Term} & \text{Degree} \\
\hline
9x^3y & 3 + 1 \hline
+ x^5y^2 & 5 + 2 \hline
\end{array}
\]

\[\text{Degree: 3 + 1 + 5 + 2 = 7}\]

\[\therefore\] The term with the highest degree is \(x^5y^2\) and its degree is 7.

\[\therefore\] The degree of \(9x^3y + x^5y^2\) is 7.

Instant Drill 1
Write down the degree of each of the following polynomials.
(a) \(4x^2 - 8x\)
(b) \(y^3 - 5x^2y + 2xy^3\)

\[\text{Sol (a)}\]

\[
\begin{array}{c|c|c|c|c}
\text{Term} & \text{Degree} \\
\hline
4x^2 & 0 \hline
-8x & 1 \hline
\end{array}
\]

\[\text{Degree: 0 + 1 = 1}\]

\[\therefore\] The term with the highest degree is \(-8x\) and its degree is 1.

\[\therefore\] The degree of \(4x^2 - 8x\) is 1.

(b)

\[
\begin{array}{c|c|c|c|c}
\text{Term} & \text{Degree} \\
\hline
y^3 & 0 \hline
-5x^2y & 2 \hline
+ 2xy^3 & 3 \hline
\end{array}
\]

\[\text{Degree: 2 + 3 = 5}\]

\[\therefore\] The term with the highest degree is \(2xy^3\) and its degree is 5.

\[\therefore\] The degree of \(y^3 - 5x^2y + 2xy^3\) is 5.

Write down the degree of each of the following polynomials. [Nos. 4–7]

4. \(x^5 - 6x^3 + 7x^2 - 1\)
5. \(y - 5y^4 + 3y^2\)

6. \(mn^2 + 4m^7n - 5\)
7. \(8x^6 - 5x^4y^3 + x - 9\)

\(\Theta\) Ex 2C 3–7
Consider the polynomials $x^3 + x^2 + x + 1$ and $1 + y + y^2 + y^3$.

1. The terms of $x^3 + x^2 + x + 1$ are arranged in descending powers of $x$.
2. The terms of $1 + y + y^2 + y^3$ are arranged in ascending powers of $y$.

**Example 2**

Arrange the terms of each of the following polynomials in descending powers of $x$.

(a) $5x + 9 - 7x^2$
(b) $8x^2 + 7x + 4x^3 - 5$

**Sol**

(a) Arrange in descending powers of $x$: $-7x^2 + 5x + 9$
(b) Arrange in descending powers of $x$: $4x^3 + 8x^2 + 7x - 5$

**Example 3**

Arrange the terms of each of the following polynomials in ascending powers of $y$.

(a) $-4y + 9y^2 - 10$
(b) $6y^2 - 2y^3 + 1$

**Sol**

(a) Arrange in ascending powers of $y$: $-10 - 4y + 9y^2$
(b) Arrange in ascending powers of $y$: $1 + 6y^2 - 2y^3$

**Instant Drill 2**

Arrange the terms of each of the following polynomials in descending powers of $x$.

(a) $-9x + 3x^2 - 8$
(b) $4x^3 - 2x^5 - 6x + 1$

**Sol**

(a) Arrange in descending powers of $x$: ________________
(b) Arrange in descending powers of $x$: ________________

**Instant Drill 3**

Arrange the terms of each of the following polynomials in ascending powers of $y$.

(a) $-y - 6 + 2y^2$
(b) $7y^6 + 2y^3 + 4 - 10y^2$

**Sol**

(a) Arrange in ascending powers of $y$: ________________
(b) Arrange in ascending powers of $y$: ________________

For each of the polynomials in Nos. 8–9, arrange the terms in

(a) descending powers of $x$,
(b) ascending powers of $x$.

8. $8x + 10x^2 + x^4$
9. $5x^3 - x - 4 - 2x^6$

� Ex 2C 8, 9
# 2.3D Value of a Polynomial

## Example 4
Find the value of the polynomial $5x^2 - 8x + 6$ in each of the following cases.

(a) $x = 3$

(b) $x = -4$

**Sol**

(a) When $x = 3$,
the value of the polynomial
$\begin{align*}
5(3)^2 &- 8(3) + 6 \\
45 &- 24 + 6 \\
&= 27
\end{align*}$

(b) When $x = -4$,
the value of the polynomial
$\begin{align*}
5(-4)^2 &- 8(-4) + 6 \\
80 &+ 32 + 6 \\
&= 118
\end{align*}$

## Instant Drill 4
Find the value of the polynomial $-x^3 + 4x^2$ in each of the following cases.

(a) $x = 2$

(b) $x = -3$

**Sol**

(a) When $x = $ ____,
the value of the polynomial
$\begin{align*}
-( )^3 + 4( )^2 \\
&=
\end{align*}$

(b) When $x = $ ____,
the value of the polynomial
$\begin{align*}
&=
\end{align*}$

## Exercise 10
Find the value of the polynomial $y^2 + 6y - 18$ in each of the following cases.

(a) $y = 0$

(b) $y = 5$

## Exercise 11
Find the value of the polynomial $y^4 - 3y^3 + y^2 - 5$ in each of the following cases.

(a) $y = 2$

(b) $y = -1$

---

Ex 2C 10, 11
12. Consider the polynomial \(-x^3 - 6x^2 + 5x + 3\). Amy claims that the coefficient of the \(x^2\) term is greater than the constant term. Do you agree? Explain your answer.

The coefficient of the \(x^2\) term =
The constant term =
\[ \therefore \ ____ (> / = / <) ____ \]
\[ \therefore \quad \text{The claim is (agreed / disagreed).} \]

13. Peggy claims that if \(7x^2y^n\) is a monomial of degree 6, then the value of \(n\) is 6. Do you agree? Explain your answer.

14. Arrange the terms of the polynomial \(5a^2x^4 + 7ax^2 - 4a^3x^3\) in ascending powers of

(a) \(a\),

(b) \(x\).

(a)

\(5a^2x^4 + 7ax^2 - 4a^3x^3\)

(b)

\(5a^2x^4 + 7ax^2 - 4a^3x^3\)
2 Manipulations and Factorization of Polynomials

Level 1

1. Determine whether each of the following algebraic expressions is a polynomial.

(a) $x + 3$  
(b) $-9$  
(c) $\frac{4}{k} - 2k$  
(d) $\frac{x^2t}{6}$  
(e) $2x^2y^2 - 7 - \frac{4x}{y}$  
(f) $\frac{3}{5}x^3 + 2\frac{2}{3}xy + 1$

2. Complete the following table.

<table>
<thead>
<tr>
<th>Monomial</th>
<th>Coefficient</th>
<th>Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) $-3h$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) $\frac{1}{2}k^5$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) $5m^2n$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) $0.8r^3s^4$</td>
<td></td>
<td></td>
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3. Complete the following table.

<table>
<thead>
<tr>
<th>Polynomial</th>
<th>Number of terms</th>
<th>Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) $5 + 2x$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) $p^3 + 12pq^2 + q^3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) $hk^3 - h^2k^2$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) $4a - \frac{b}{2} - \frac{5}{8}c + 3de$</td>
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<td></td>
</tr>
</tbody>
</table>

For each of the polynomials in Nos. 4–7, write down
(a) the constant term,
(b) the term with the highest degree and its coefficient,
(c) the degree of the polynomial.

4. $-4ab + 3$  
5. $-6 + 3m^3 + 5m^2$

6. $5p^2q + 2pq^2 - pq^3$  
7. $2r^3s^4 + 9r^3s^3 - 3rs + 12$

8. Arrange the terms of each of the following polynomials in ascending powers of $x$.
(a) $2x - 3x^3 + 5$  
(b) $4x^2 + x^6 - 7x^3 - 1$

9. Arrange the terms of each of the following polynomials in descending powers of $y$.
(a) $6y^3 - 3 + 8y^4$  
(b) $-2y - 6y^5 + 7y^2$

10. Find the value of the polynomial $5x^3 - 9x + 8$ in each of the following cases.
11. Write down a monomial in variables $p$ and $q$ only where its degree is 5 and its coefficient is $-2$.

12. Karen claims that if $3x - 4xy^{a+2}$ is a binomial of degree 3, then the value of $a$ is 1. Do you agree? Explain your answer.

**Level 2**

13. Arrange the terms of the polynomial $-6a^3b + 5b^3 - ab^2 - 7a^2$ in ascending powers of each of the following variables.
   (a) $a$  
   (b) $b$

14. Arrange the terms of the polynomial $10 + 3m^2n^4 + 2m^3n - m^4n^3$ in descending powers of each of the following variables.
   (a) $m$  
   (b) $n$

15. Find the value of the polynomial $4p^3q^2 - 5p^4q + 7$ in each of the following cases.
   (a) $p = -2, q = 1$  
   (b) $p = -1, q = -4$

16. Find the value of each of the following polynomials when $x = \frac{1}{4}$ and $y = -\frac{3}{4}$.
   (a) $9x^2 + y^2 + 6xy$  
   (b) $x^3 + x^2y + \frac{xy^2}{3} + \frac{y^3}{27}$

**Explain** 17. Consider the polynomial $\frac{2}{3}x^4y^2 + \frac{4}{5}x^2y^n - 8$, where $n$ is a positive integer. Frank claims that if the degree of the polynomial is 6, then the value of $n$ must be 1, 2 or 3 only. Do you agree? Explain your answer.
Consolidation Exercise 2C (Answer)

1. (a) yes (b) yes (c) no
   (d) yes (e) no (f) yes

2. | Monomial | Coefficient | Degree |
<table>
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<tr>
<th></th>
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<tbody>
<tr>
<td>−3h</td>
<td>−3</td>
<td>1</td>
</tr>
<tr>
<td>( \frac{1}{2} ) ( k^3 )</td>
<td>( \frac{1}{2} )</td>
<td>3</td>
</tr>
<tr>
<td>5( m^n )</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>0.8( r^3s^4 )</td>
<td>0.8</td>
<td>7</td>
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3. | Polynomial | Number of terms | Degree |
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>5 + 2x</td>
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<td>1</td>
</tr>
<tr>
<td>( p^3 + 12p^2q + q^3 )</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>( hk^3 - h^3k^2 )</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>( 4a - \frac{b}{2} - \frac{5}{8} c + 3de )</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

4. (a) 3 (b) \(-4ab, -4\) (c) 2
5. (a) −6 (b) 3\( m^3, 3 \) (c) 3
6. (a) 0 (b) \(-pq^2, -1\) (c) 4
7. (a) 12 (b) 2\( r^3s^4, 2 \) (c) 7
8. (a) 5 + 2x − 3\x^3 \( \) (b) \(-1 + 4x^2 - 7x^3 + x^6 \)
9. (a) 8\( y^4 + 6y^3 - 3 \) (b) \(-6y^5 + 7y^2 - 2y \)
10. (a) −14 (b) 8 (c) 4
11. \(-2p^4q \) (or other reasonable answers)
12. no
13. (a) 5\( b^3 - ab^2 - 7a^2 - 6a^3b \)
    (b) \(-7a^2 - 6a^3b - ab^2 + 5b^3 \)
14. (a) \(-m^2n^3 + 2m^3n + 3m^2n^4 + 10 \)
    (b) 3\( m^2n^4 - m^n3 + 2m^n + 10 \)
15. (a) −105 (b) \(-37 \)
16. (a) 0 (b) 0
17. no
## F2A: Chapter 2D

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<th>Progress</th>
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|      |                  | ○ Problems encountered  
|      |                  | ○ Skipped  
|      | Book Example 12 | ○ Complete  
|      |                  | ○ Problems encountered  
|      |                  | ○ Skipped  
|      | (Video Teaching) |   
|      | Book Example 13 | ○ Complete  
|      |                  | ○ Problems encountered  
|      |                  | ○ Skipped  
|      | (Video Teaching) |   
|      | Book Example 14 | ○ Complete  
|      |                  | ○ Problems encountered  
|      |                  | ○ Skipped  
|      | (Video Teaching) |   
|      | Book Example 15 | ○ Complete  
|      |                  | ○ Problems encountered  
|      |                  | ○ Skipped  
|      | (Video Teaching) |   
|      | Book Example 16 | ○ Complete  
|      |                  | ○ Problems encountered  
|      |                  | ○ Skipped  
|      | (Video Teaching) |   
|      | Consolidation Exercise | ○ Complete and Checked  
|      |                  | ○ Problems encountered  
|      |                  | ○ Skipped  
|      | (Full Solution) |   
|      | Maths Corner Exercise 2D Level 1 | ○ Complete and Checked  
|      |                  | ○ Problems encountered  
|      |                  | ○ Skipped  
|      |                  | Teacher’s Signature   
|      | Maths Corner Exercise 2D Level 2 | ○ Complete and Checked  
|      |                  | ○ Problems encountered  
|      |                  | ○ Skipped  
|      |                  | Teacher’s Signature   
|      | Maths Corner Exercise 2D Level 3 | ○ Complete and Checked  
|      |                  | ○ Problems encountered  
|      |                  | ○ Skipped  
|      |                  | Teacher’s Signature   

**Teacher’s Signature:**

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<td>○ Problems encountered</td>
<td>○ Skipped</td>
<td>Mark:</td>
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2.4 Addition and Subtraction of Polynomials

In polynomials, like terms can be combined under addition or subtraction.

e.g. (i) \(2x + 3x = (2 + 3)x\)
\[= 5x\]
(ii) \(4y^2 – 7y^2 = (4 – 7)y^2\)
\[= –3y^2\]

**Example 1**

Simplify the following expressions.

(a) \(4x – 8 + x – 1\)

(b) \(2x^2 – 5x + 9 – x^2 – x – 4\)

Sol (a) \(4x – 8 + x – 1\)
\[= 4x + x – 8 – 1\] \(\checkmark\) Group like terms.
\[= 5x – 9\] \(\checkmark\) Combine like terms.

(b) \(2x^2 – 5x + 9 – x^2 – x – 4\)
\[= 2x^2 – x^2 – 5x – x + 9 – 4\]
\[= x^2 – 6x + 5\]

**Instant Drill 1**

Simplify the following expressions.

(a) \(5x + 7 – 2x + 3\)

(b) \(7x^2 + 4x – 3 – 3x^2 + 8x\)

Sol (a) \(5x + 7 – 2x + 3\)
\[=\]

(b) \(7x^2 + 4x – 3 – 3x^2 + 8x\)
\[=\]

Simplify the following expressions. [Nos. 1–2]

1. \(6x^2 – 5x + 1 – 4x^2 + 2x\)

2. \(xy + y^2 – 9xy + 3y^2\) \(\checkmark\) \(xy\) and \(-9xy\) are like terms.

Ex 2D 5–7
### Example 2
Simplify the following expressions.

(a) \((3x + 1) + (2x + 5)\)

(b) \((x - 6y) + (7x - 4y)\)

**Solution**

(a) \((3x + 1) + (2x + 5)\)

\[
\begin{align*}
&= 3x + 1 + 2x + 5 \\
&= 3x + 2x + 1 + 5 \\
&= 5x + 6
\end{align*}
\]

Alternative

\[
\begin{align*}
3x + 1 & \\
+ & 2x + 5 \\
\hline
5x + 6 & \\
3x + 2x & = 5x \\
1 + 5 & = 6
\end{align*}
\]

(b) \((x - 6y) + (7x - 4y)\)

\[
\begin{align*}
&= x - 6y + 7x - 4y \\
&= x + 7x - 6y - 4y \\
&= 8x - 10y
\end{align*}
\]

Alternative

\[
\begin{align*}
x - 6y & \\
+ & 7x - 4y \\
\hline
8x - 10y & \\
3x - 6y & = 3x \\
1 + 5 & = 6
\end{align*}
\]

### Instant Drill 2
Simplify the following expressions.

(a) \((8x - 3) + (x + 5)\)

(b) \((7x + 2y) + (4x - 3y)\)

**Solution**

(a) \((8x - 3) + (x + 5)\)

\[
\begin{align*}
&= 8x - 3 + x + 5 \\
&= 8x + x - 3 + 5 \\
&= 9x + 2
\end{align*}
\]

Alternative

\[
\begin{align*}
8x - 3 & \\
+ & x + 5 \\
\hline
9x + 2 & \\
8x + x & = 9x \\
-3 + 5 & = 2
\end{align*}
\]

(b) \((7x + 2y) + (4x - 3y)\)

\[
\begin{align*}
&= 7x + 2y + 4x - 3y \\
&= 7x + 4x + 2y - 3y \\
&= 11x - y
\end{align*}
\]

Alternative

\[
\begin{align*}
7x + 2y & \\
+ & 4x - 3y \\
\hline
11x - y & \\
7x + 4x & = 11x \\
2y - 3y & = -y
\end{align*}
\]

### Complete the following operations. [Nos. 3–5]

3. \(4a - 2c\) + \(3a - 4c\)

\[
\begin{align*}
&= 4a - 2c + 3a - 4c \\
&= 4a + 3a - 2c - 4c \\
&= 7a - 6c
\end{align*}
\]

4. \(9x - 6y\) + \(-3x + 4y\)

\[
\begin{align*}
&= 9x - 6y - 3x + 4y \\
&= 9x - 3x - 6y + 4y \\
&= 6x - 2y
\end{align*}
\]

5. \(-3u + 9v + 2w\) + \(-5u - 8v + w\)

\[
\begin{align*}
&= -3u + 9v + 2w - 5u - 8v + w \\
&= -3u - 5u + 9v - 8v + 2w + w \\
&= -8u + v + 3w
\end{align*}
\]

### Simplify the following expressions. [Nos. 6–9]

6. \((3 - 2x) + (11 - 5x)\)

\[
\begin{align*}
&= 3 - 2x + 11 - 5x \\
&= 3 + 11 - 2x - 5x \\
&= 14 - 7x
\end{align*}
\]

7. \((4x - y) + (9x + y)\)

\[
\begin{align*}
&= 4x - y + 9x + y \\
&= 4x + 9x - y + y \\
&= 13x
\end{align*}
\]
Example 3

Simplify the following expressions.

(a) \((4x - 7) - (2x + 1)\)

(b) \((3x - 5y) - (7y - 2x)\)

**Sol** (a) \((4x - 7) - (2x + 1)\)

\[
= 4x - 7 - 2x - 1
\]

\[
= 4x - 2x - 7 - 1
\]

\[
= 2x - 8
\]

Alternative

\[4x - 7\]

\(-\) \[2x + 1\]

\[2x - 8\]

\[
4x - 2x = 2x
\]

\[
-7 - (+1) = -7 - 1 = -8
\]

(b) \((3x - 5y) - (7y - 2x)\)

\[
= 3x - 5y - 7y + 2x
\]

\[
= 3x + 2x - 5y - 7y
\]

\[
= 5x - 12y
\]

Alternative

\[3x - 5y\]

\(-\) \[-2x + 7y\]

\[5x - 12y\]

Arrange the like terms in the same column.

Instant Drill 3

Simplify the following expressions.

(a) \((8y - 5) - (3y + 2)\)

(b) \((5x - 6y) - (y - x)\)

**Sol** (a) \((8y - 5) - (3y + 2)\)

\[
= 8y - 5 - (3y + 2)
\]

Alternative

\[
8y - 5
\]

\(-\) \[
\]

(b) \((5x - 6y) - (y - x)\)

\[
= 5x - 6y - (y - x)
\]

Alternative

Complete the following operations. [Nos. 10–12]

10. \(8a - 2c\)

\(-\) \(-3a + 4c\)

11. \(4x^2 - 5x - 3\)

\(-\) \(-3x^2 - 1\)

12. \(3xy - 7x - y\)

\(-\) \(-xy + 2x - 6y\)
Simplify the following expressions. [Nos. 13–16]

13. \((x - 9) - (2x + 10)\)

14. \((2x - 8y) - (9x - 5y)\)

15. \((3x^2 - 6x) - (7x - 4x^2)\)

16. \((2a - 3b - c) - (3a - 5b + c)\)

Level Up Questions

Simplify the following expressions. [Nos. 17–19]

17. \((14 - 2x + 8x^2) - (3x - 5x^2 + 2)\)

18. \((3 + 8x - 2x^2) + (4 - 7x^2 + 6x^3)\)

19. \((6a^2 + 5ac - 3c^2) - (9c^2 + 7ac - 2a^2)\)
2 Manipulations and Factorization of Polynomials

Level 1
Complete the following operations. [Nos. 1–4]

1. (a) \(3a + 2\) \(\text{b)} 2b - 4c\)
   \(+4a - 7\) \(+5b - 3c\)

2. (a) \(12d + 3\) \(\text{b) } -2e - 5f\)
   \(-4d - 6\) \(-11f\)

3. (a) \(8k^2 - 5k\) \(\text{b) } 9t^2 - 1\)
   \(+7k^2 + \underline{3}\) \(-5t^2 + 3t\)

4. (a) \(3x - 4y - 2\) \(\text{b) } 6mn - 4n\)
   \(+5x - y + 8\) \(-10mn - 2m + n\)

Simplify the following polynomials. [Nos. 5–6]

5. (a) \(2a^3 + 6a - 3a^3 - 4a\)
   \(\text{b) } 3x^3 - 8x^2 + 6x + x + 2x^2 + 5\)

6. (a) \(bc - 7ab + 3ac - 3bc + 9ab\)
   \(\text{b) } 3pq + 6pr - 4qr + 2pr - 2pq + pr\)

Simplify the following expressions. [Nos. 7–14]

7. (a) \((3x - 6) + (4x + 1)\)
   \(\text{b) } (8b + 3) + (2b - 9)\)

8. (a) \((2h - 1) - (7h + 2)\)
   \(\text{b) } (k + 6) - (8k - 7)\)

9. (a) \((9x - 2y) + (5x - y)\)
   \(\text{b) } (2w - 3z) + (-6w + 5z)\)

10. (a) \((4p - 6q) - (-p + 8q)\)
    \(\text{b) } (5m + n) - (-2m - 3n)\)

11. (a) \((2c^2 - 5) + (-5 - 2c^2)\)
    \(\text{b) } (3d - 4d^2) - (d^2 + 7d)\)

12. (a) \((3u - v + 2) + (u - 3v - 4)\)
    \(\text{b) } (2d + 5e - 6f) - (4d - 6f - 5e)\)

13. (a) \((-2p + 7qr) + (6p - 2qr)\)
    \(\text{b) } (-xy - 4xz) - (-8yz + 3xy)\)
14. (a) \((1 + z) + (3z - 6) + (9 + 5z)\)  
(b) \((m + 4n) - (6m - 3n) - (-3n - 8m)\)

**Level 2**

15. Complete the following operations.
(a) \(2a^3 - 6a^3 + 8a^2 + 7a + 3a^5 - 2a^4 + 4a^3 - 3a\)
(b) \(-4a^3 + 3a^2 + 2a + 8\)

Simplify the following expressions. [Nos. 16–18]

16. (a) \((m^3 + 3m - 5) + (4m^3 - 6m - 7)\)  
(b) \((2n^3 - 3n^2 - 5n + 8) + (2n - 4n^3 - 3 + 6n^2)\)

17. (a) \((4x^3 - 3x) - (x^2 - 2x^3 + 3)\)  
(b) \((3y - 1 - y^3) - (-5 - 3y + 2y^2 + 6y^3)\)

18. (a) \((3x + 5y - z) - (2y - 6x + 9z) + (-4z + 8y - 7x)\)  
(b) \((5t^3 - t + 2) + (8 - 3t^3 + 4t^2) - (t^4 - 2t^2 + 6t)\)

19. (a) Simplify \((3x^2 - 5x - 4) + (2x + 9 - 2x^2)\).
(b) Hence, find the value of the expression in (a) when \(x = 2\).

20. (a) Simplify \((4m^2 + 7mn - 3n^2) - (mn + 3m^2 + 8n^2)\).
(b) Hence, find the value of the expression in (a) when \(m = -5\) and \(n = 3\).

21. The figure on the right shows a triangle \(PQR\).
(a) Express the perimeter of \(\triangle PQR\) in terms of \(x\).
(b) If \(x = 6\), find the perimeter of \(\triangle PQR\).

22. There were \(k\) books in a shop. Yesterday, \((3k - 18)\) books were sold and the shopkeeper bought \((5k + 2)\) new books. Today, \((12 - k)\) books are sold. Express, in terms of \(k\),
(a) the total number of books sold yesterday and today,
(b) the number of books in the shop at the end of today.

23. Peter has \$(4x^2 + 2)\) and Tom has \$(9x - 7 - x^2)\).
(a) How much do they have altogether?
(b) Peter and Tom want to buy a toy together but the total amount they have is not enough. If the price of the toy is \$(5x^2 - 4x + 3)\), how much more do they need?

(Express the answers in terms of \(x\).)
Consolidation Exercise 2D (Answer)

1. (a) $7a - 5$
   (b) $-3b - 7c$
2. (a) $8d + 9$
   (b) $-2e + 6f$
3. (a) $k^2 - 5k + 3$
   (b) $4t^2 - 3t - 1$
4. (a) $8x - 5y + 6$
   (b) $-4mn + 2m - 5n$
5. (a) $-a^3 + 2a$
   (b) $3x^3 - 6x^2 + 7x + 5$
6. (a) $2ab + 3ac - 2bc$
   (b) $pq + 9pr - 4qr$
7. (a) $7x - 5$
   (b) $10b - 6$
8. (a) $-5h - 3$
   (b) $-7k + 13$
9. (a) $14x - 3y$
   (b) $-4w + 2z$
10. (a) $5p - 14q$
    (b) $7m + 4n$
11. (a) $-10$
    (b) $-5d^2 - 4d$
12. (a) $4u - 4v - 2$
    (b) $-2d + 10e$
13. (a) $4p + 5qr$
    (b) $-4xy - 4xz + 8yz$
14. (a) $4 + 9z$
    (b) $3m + 10n$
15. (a) $5a^3 - 2a^2 - 2a + 8a^2 + 4a$
    (b) $-9a^3 - a^2 + 3a^2 + 7a + 9$
16. (a) $5m^3 - 3m - 12$
    (b) $-2n^3 + 3n^2 - 3n + 5$
17. (a) $6x^3 - x^2 - 3x - 3$
    (b) $-7y^3 - 2y^2 + 6y + 4$
18. (a) $2x + 11y - 14z$
    (b) $-t^4 + 2t^3 + 6t^2 - 7t + 10$
19. (a) $x^2 - 3x + 5$
    (b) $3$
20. (a) $m^2 + 6mn - 11n^2$
    (b) $-164$
21. (a) $(x^2 + 8x - 14) m$
    (b) $70 m$
22. (a) $2k - 6$
    (b) $4k + 8$
23. (a) $(3x^2 + 9x - 5)$
    (b) $(2x^2 - 13x + 8)$
# F2A: Chapter 2E

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2.5 Multiplication of Polynomials

(A) Method of expansion

Distributive law of multiplication:
\[ x(a + b) = xa + xb \]
\[ (a + b)x = ax + bx \]

Alternatively,
\[ x \begin{array}{c}
    a \\
    \hline
    ax \\
    +b \\
    \hline
    bx
\end{array} \]

With the table above, we have:
\[ (a + b)x = ax + bx \]

Example 1
Expand the following expressions.

(a) \(5(6 + x)\)

(b) \((3x - 2)(-4x)\)

\[ \text{Sol} \ (a) \quad 5(6 + x) \]
\[ = 5(6) + 5(x) \]
\[ = 30 + 5x \]

\[ \text{Sol} \ (b) \quad (3x - 2)(-4x) \]
\[ = 3x(-4x) - 2(-4x) \]
\[ = -12x^2 + 8x \]

Instant Drill 1
Expand the following expressions.

(a) \(7(a - 3)\)

(b) \((2a + 1)(-6a)\)

\[ \text{Sol} \ (a) \quad 7(a - 3) \]
\[ = \]

\[ \text{Sol} \ (b) \quad (2a + 1)(-6a) \]
\[ = \]

Expand the following expressions. [Nos. 1–4]

1. \(-8(4 - 2y)\)

2. \(2a(a - 4)\)

3. \((-4x + 3)(5y)\)

4. \((6f - 5g)(-3f)\)
Product of two binomials:

\[(a + b)(c + d) = (a + b)c + (a + b)d = ac + bc + ad + bd\]

Example 2

Expand the following expressions.

(a) \((x - 2)(x + 3)\)

(b) \((x - 4)(x - 5)\)

Solution (a) \((x - 2)(x + 3)\)

\[= (x - 2)x + (x - 2)(3)\]
\[= x^2 - 2x + 3x - 6\]
\[= x^2 + x - 6\]

(b) \((x - 4)(x - 5)\)

\[= (x - 4)x - (x - 4)(5)\]
\[= x^2 - 4x - 5x + 20\]
\[= x^2 - 9x + 20\]

Alternatively,

\[
\begin{array}{c|c|c|c|c}
\text{x} & x^2 & -4x & -5x & +20 \\
\hline
\text{x} & \text{ } & \text{ } & \text{ } & \text{ } \\
\hline
\end{array}
\]

i.e. \((x - 4)(x - 5) = x^2 - 4x - 5x + 20\)

Instant Drill 2

Expand the following expressions.

(a) \((y + 2)(y - 6)\)

(b) \((y - 3)(y - 9)\)

Solution (a) \((y + 2)(y - 6)\)

\[= (\quad)(\quad) - (\quad)(\quad)\]
\[= \]

(b) \((y - 3)(y - 9)\)

Expand the following expressions. [Nos. 5–10]

5. \((x + 3)(x + 1)\)

6. \((x - 7)^2\)  \((x - 7)^2 = (x - 7)(x - 7)\)

7. \((2 + a)(8 + a)\)

8. \((x - 6)(2x + 6)\)

\[\Theta \text{ Ex 2E 6–9}\]

9. \((2p - 1)(4p - 5)\)

10. \((3r + 8)(3r - 2)\)

\[\Theta \text{ Ex 2E 10–19}\]
(B) Long multiplication

**Example 3**
Expand the following expressions by long multiplication.

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

**Sol (a)**
\[
\begin{array}{c}
\times \quad a + 2 \\
\hline
\hline
a^2 + 2a \\
\hline
+ \quad 5a + 10 \\
\hline
\hline
a^2 + 7a + 10 \\
\end{array}
\]

(b) \(2x + 3\)
\[
\begin{array}{c}
\times \quad x - 5 \\
\hline
\hline
2x^2 + 3x \\
\hline
+ \quad -10x - 15 \\
\hline
\hline
2x^2 - 7x - 15 \\
\end{array}
\]

**Instant Drill 3**
Expand the following expressions by long multiplication.

(a) \((y - 3)(y + 4)\)
(b) \((2r - 5)(r - 2)\)

**Sol (a)**
\[
\begin{array}{c}
\times \quad y - 3 \\
\hline
\hline
y - 3 \\
\hline
\hline
y + 4 \\
\end{array}
\]

(b) \(2\)
\[
\begin{array}{c}
\times \quad r - 2 \\
\hline
\hline
r - 2 \\
\end{array}
\]

Expand the following expressions by long multiplication. [Nos. 11–14]

11. \((x - 4)(x - 7)\)
\[
\begin{array}{c}
\times \quad x - 4 \\
\hline
\hline
x - 4 \\
\hline
\hline
x - 7 \\
\end{array}
\]

12. \((x - 1)(5x + 1)\)
13. \((6x - 2)(x + 1)\)
14. \((2x - 5)(3x - 7)\)

[Ex 2E 20–25]
Expand and simplify the following expressions. [Nos. 15–16]

15. \(5x(7 - 3x) + 6x\)

16. \(-3x(2x + 5) - (x - 8)\)

Level Up Questions

Expand the following expressions. [Nos. 17–18]

17. (a) \(3xy(2x + 4)\)
   
   (b) \((a^2 - 2ab)(-5ab)\)

18. (a) \((3x - 2y)(x + y)\)
   
   (b) \((x + 1)(x^2 + 2x - 1)\)
2 Manipulations and Factorization of Polynomials

**Consolidation Exercise 2E**

**Level 1**
Expand the following expressions by the method of expansion. [Nos. 1–4]

1. (a) $9(m + 5)$  
   (b) $(2n - 3)(-4)$

2. (a) $a(a + 2)$  
   (b) $-b(1 - 6b)$

3. (a) $2x(y - 1)$  
   (b) $-3y(4x + 7z)$

4. (a) $(h - 5g)(6h)$  
   (b) $(2k - 3n)(-k^3)$

Expand the following expressions by the method of expansion. [Nos. 5–14]

5. $(a + 3)(a + 5)$  
   6. $(b - 4)(b + 1)$

7. $(x + 2)^2$  
   8. $(9 + y)(y - 9)$

9. $(3m + 4)(m + 6)$  
   10. $(-5 + a)(5a - 1)$

11. $(-6 - n)(2 - 5n)$  
   12. $(4 - 7b)(8 - 3b)$

13. $(3r^2 + 2)(r - 1)$  
   14. $(2 - 3s^2)(1 + 4s)$

Expand the following expressions by long multiplication. [Nos. 15–20]

15. $(a + 8)(a + 1)$  
   16. $(b + 1)(b - 9)$

17. $(k - 4)(k - 5)$  
   18. $(h - 2)(-h + 5)$

19. $(2m + 7)(m - 4)$  
   20. $(2n - 3)(3n + 1)$

Expand and simplify the following expressions. [Nos. 21–22]

21. $12p + p(p - 5)$

22. $3(r - 4) - (5r - 7)r$

**Level 2**
Expand the following expressions by the method of expansion. [Nos. 23–28]

23. (a) $5xy(2x - 3y)$
   (b) $(x^2 - 2xy)(-4xy)$

24. (a) $-4(m^3 - 3m - 5)$
   (b) $(1 - 3n - 2n^2)(-3n)$

25. (a) $(h + k)(k - h)$
   (b) $(m + 2p)(-9m + 4p)$

26. (a) $(n - 3q)(2n - 5q)$
   (b) $(3r + 5)(6r - 7s)$

27. (a) $(y - 1)(y^2 + y + 1)$
   (b) $(x^2 - 2x + 4)(x + 2)$

28. (a) $(3m + 1)(m^2 - 5m + 6)$
   (b) $(2n^2 + 8n - 3)(4 - n)$

Expand the following expressions by long multiplication. [Nos. 29–30]

29. (a) $(a + 2b)(3a + 8b)$
   (b) $(-4p + 7q)(5p - 3q)$

30. (a) $(m^2 + 6m + 9)(m - 3)$
   (b) $(3n - 2)(-4 + 2n - n^2)$

31. (a) Expand $6x(2 - x^2)$.
   (b) Hence, simplify $(2x^2 + 12x + 8) - 6x(2 - x^2)$.

Expand and simplify the following expressions. [Nos. 32–35]

32. $2a(a - 1) + 3a(2a - 3)$
33. $-(n + 4)(3n - 2) - (8 - 3n^2)$

34. $(4b - 1)(2b - 5) - (5 - b^2 - 7b)$
35. $(m + 2)(m - 4)(4m - 1)$

36. A factory produced $(9r - 2)$ identical bricks last week. If the weight of each brick is $(2r + 5)$ kg, express the total weight of the bricks in terms of $r$ and arrange the terms in descending powers of $r$.

37. The figure on the right shows a pentagon $PQRST$.
   (a) Express the area of $PQRST$ in terms of $x$.
   (b) If $x = 2$, find the area of $PQRST$. 

![Diagram of a pentagon PQRST]
Consolidation Exercise 2E (Answer)

1. (a) $9m + 45$  (b) $-8n + 12$
2. (a) $a^2 + 2a$  (b) $-b + 6b^2$
3. (a) $2xy - 2x$  (b) $-12xy - 21yz$
4. (a) $6h^2 - 30gh$  (b) $-2k^4 + 3nk^3$
5.  $a^2 + 8a + 15$
6.  $b^2 - 3b + 15$
7.  $x^2 + 4x + 4$
8.  $y^2 - 81$
9.  $3m^2 + 22m + 24$
10.  $5a^2 - 26a + 5$
11.  $5n^2 + 28n - 12$
12.  $21b^3 - 66b + 32$
13.  $3r^3 - 3r^2 + 2r - 2$
14.  $2 + 8s - 3s^2 - 12s^3$
15.  $a^2 + 9a + 8$
16.  $b^2 - 8b - 9$
17.  $k^2 - 9k + 20$
18.  $-h^2 + 7h - 10$
19.  $2m^2 - m - 28$
20.  $6n^2 - 7n - 3$
21.  $p^2 + 7p$
22.  $-5r^2 + 10r - 12$
23.  (a) $10x^2y - 15xy^2$
    (b) $-4x^3y + 8x^2y^2$
24.  (a) $-4m^2 + 12m + 20$
    (b) $-3n + 9n^2 + 6n^3$
25.  (a) $k^2 - h^2$
    (b) $-9m^2 - 14mp + 8p^2$
26.  (a) $2n^2 - 11nq + 15q^2$
    (b) $18r^2 + 9rs - 35s^2$
27.  (a) $y^3 - 1$
    (b) $x^3 + 8$
28.  (a) $3m^3 - 14m^2 + 13m + 6$
    (b) $-2n^3 + 35n - 12$
29.  (a) $3a^2 + 14ab + 16b^2$
    (b) $-20p^2 + 47pq - 21q^2$
30.  (a) $m^3 + 3m^2 - 9m - 27$
    (b) $-3n^3 + 8n^2 - 16n + 8$
31.  (a) $12x - 6x^3$
    (b) $6x^3 + 2x^2 + 8$
32.  $8a^2 - 11a$
33.  $-10n$
34.  $9b^3 - 15b$
35.  $4m^3 - 9m^2 - 30m + 8$
36.  $(18r^2 + 41r - 10) \text{kg}$
37.  (a) $10x^2 + \frac{23}{2}x - 30$ cm\(^2\)
    (b) $33 \text{cm}^2$
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2.6 Factorization of Polynomials

Factorization is the process of converting a polynomial into the product of its factors. 
e.g. Consider the relation between \(x(x + 3)\) and \(x^2 + 3x\).

2.6A Taking out Common Factors

\[ ab + ac = a(b + c) \]

**Example 1**
Factorize the following expressions.

(a) \(5a + 5b\)
(b) \(-7x - 21\)
(c) \(3ah - 3ak\)

**Sol**
(a) \(5a + 5b = 5(a + b)\)
Check the answer: \(5(a + b) = 5a + 5b\)

(b) \(-7x - 21 = -7(x + 3)\)
Factors of 7x: 7, x
Factors of 21: 1, 3, 7, 21
\(\therefore\) The common factor is 7.

(c) \(3ah - 3ak = 3a(h - k)\)
Factors of 3ah: 3, a, h
Factors of 3ak: 3, a, k
\(\therefore\) The common factor is \(3 \times a\) (i.e. 3a).

**Instant Drill 1**
Factorize the following expressions.

(a) \(8x + 8y\)
(b) \(-12 - 2a\)
(c) \(4ax - 4cx\)

**Sol**
(a) \(8x + 8y\)

(b) \(-12 - 2a = (\phantom{1})(\phantom{1}) - 2a\)

(c) \(4ax - 4cx\)

Factorize the following expressions. [Nos. 1–10]

1. \(xy + 7x\)
2. \(-3d - 15\)
3. \(16e^2 + 8e\)  
\[e^2 = e \cdot e\] 

4. \(15f^2 - 12ef\)

5. \(-gh^2 - 2gh\)

6. \(5x^3 - 20x^2\)

7. \(2x + xy - 4xz\)

8. \(3h^2k + 2h^2 - 5h^2k^2\)

9. \((p + 4)q + (p + 4)r\)  
The common factor is \((   )\).

10. \(9(x - 2y) - 2(3x - 2y)\)

\(\Theta\) Ex 2F 5–10

\(\Theta\) Ex 2F 11–14

\(\Theta\) Ex 2F 15–17
2.6B Grouping Terms

**Example 2**

Factorize \(3a + 3b + ac + bc\).

**Sol**

\[
3a + 3b + ac + bc = 3(a + b) + c(a + b) = (a + b)(3 + c)
\]

- **Step 1**: Group the terms.
- **Step 2**: Take out the common factor in each group.
- **Step 3**: Take out the common factor (i.e. \(a + b\)) of the groups.

**Instant Drill 2**

Factorize \(ax + ay + 2x + 2y\).

**Sol**

\[
ax + ay + 2x + 2y = a(x + y) + 2(x + y) = (x + y)(a + 2)
\]

Factorize the following expressions. [Nos. 11–18]

11. \(m - n + rm - rn\)

\[
rm - rn = r(m - n)
\]

12. \(3x^2 - 2x + 3xy - 2y\)

13. \(ac + ab - 5c - 5b\)

\[
-5c - 5b = -5(c + b)
\]

14. \(x + x^2 - r - rx\)

15. \(x - y - ax + ay\)

\[
-ax + ay = -a(x - y)
\]

16. \(ar - 2a - 3r + 6\)

- \(Ex\ 2F\ 18–26\)

17. \(8u - 8v + cv - cu\)

Rearrange the terms if necessary.

18. \(rs - rk - ak + as\)

- \(Ex\ 2F\ 27, 28\)
19. Sofia claims that the two expressions \(xy + y - x - 1\) and \(xy - y + x - 1\) have the common factor \(x - 1\). Do you agree? Explain your answer.

\[\begin{align*}
xy + y - x - 1 &= \\
xy - y + x - 1 &= \\
\therefore\ &\text{The two expressions (have / do not have) the common factor } x - 1. \\
\therefore\ &\text{The claim is (agreed / disagreed).}
\end{align*}\]

20. Factorize \(2ac - 8bc + 10c^2\).

21. Factorize \(9m(x + y) - 6n(x + y)\).

22. Factorize \(3xy - 9y + 2x - 6\).

23. Factorize \(ax + y + x + ay\).

\[\begin{align*}
ax + y + x + ay &= ax + ay + \underline{\text{__________}} \\
&= 
\end{align*}\]

Rearrange the terms for grouping.
Manipulations and Factorization of Polynomials

**Level 1**

Factorize the following expressions. [Nos. 1–28]

1. \(6a - 6b\)  
2. \(7c + 14\)  
3. \(mn + m\)  
4. \(5q - pq\)  
5. \(3rs + 9rt\)  
6. \(-2uv - 2vw\)  
7. \(4x^2 - 8x\)  
8. \(9h^2 + 12hk\)  
9. \(7a^3 + a^4\)  
10. \(-m^2n^3 - m^3n^2\)  
11. \(8x + 4y - 12\)  
12. \(3d - de - df\)  
13. \(m^2 - 2mn - 3m\)  
14. \(3ab^3 - 5a^2b + b^2\)  
15. \(p(w + z) - q(w + z)\)  
16. \((7m + 9) + n(9 + 7m)\)  
17. \(2b(x - y) + a(x - y)\)  
18. \(uv - 11u + v - 11\)  
19. \(kr + ks + s + r\)  
20. \(a - b + ac - bc\)  
21. \(h + k - hx - kx\)  
22. \(wz + z + 6w + 6\)  
23. \(pn - qn - 4p + 4q\)  
24. \(5x + 15 - xy - 3y\)  
25. \(ab - 7b - ac + 7c\)  
26. \(m^n + m^2 - 2n - 2\)  
27. \(hx - hy - 4x + 4y\)  
28. \(3y - 8xy - 8xz + 3z\)
Factorize the following expressions. [Nos. 29–44]

29. $4pq - 12pr + 20ps$

30. $-9ab - 18a^2 - 3a$

31. $15m^2 + 10m^3 - 25m^5$

32. $8r^2s^2 - 20r^2s^3 + 24r^3s^2t$

33. $6x(2a - b) + 3y(2a - b)$

34. $(3k + 5)(m + n) - 4(n + m)$

35. $(3b - 7)(h + 2k) - 2b(h + 2k)$

36. $(m - n)(p + 2q) + (n - m)(3p - q)$

37. $4m - nk + 4n - mk$

38. $10pr - 4qs + 8pq - 5rs$

39. $8tu + t - 4r^2 - 2u$

40. $-4nk - n^2 - nh - 4hk$

41. $4pm - 4qm - 4rm - pn + qn + rn$

42. $ax - bx + 2cx - 2cy + by - ay$

43. $4x - 6 + (2x - 3)^2$

44. $(y + 7)(y - 7) + 21 - 3y$
Consolidation Exercise 2F (Answer)

1. $6(a - b)$
2. $7(c + 2)$
3. $m(n + 1)$
4. $q(5 - p)$
5. $3r(s + 3t)$
6. $-2v(u + w)$
7. $4x(x - 2)$
8. $3h(3h + 4k)$
9. $a^3(7 + a)$
10. $-m^2n^2(n + m)$
11. $4(2x + y - 3)$
12. $d(3 - e - f)$
13. $m(m - 2n - 3)$
14. $b^2(3ab - 5a^2 + 1)$
15. $(w + z)(p - q)$
16. $(7m + 9)(1 + n)$
17. $(x - y)(2b + a)$
18. $(v - 11)(u + 1)$
19. $(r + s)(k + 1)$
20. $(a - b)(1 + c)$
21. $(h + k)(1 - x)$
22. $(w + 1)(z + 6)$
23. $(p - q)(n - 4)$
24. $(x + 3)(5 - y)$
25. $(a - 7)(b - c)$
26. $(n + 1)(m^2 - 2)$
27. $(x - y)(h - 4)$
28. $(3 - 8x)(y + z)$
29. $4p(q - 3r + 5s)$
30. $-3a(3b + 6a + 1)$
31. $5m^2(3 + 2m - 5m^3)$
32. $4r^2s^2(2 - 5s + 6rt)$
33. $3(2a - b)(2x + y)$
34. $(m + n)(3k + 1)$
35. $(h + 2k)(b - 7)$
36. $(m - n)(3q - 2p)$
37. $(m + n)(4 - k)$
38. $(2p - s)(5r + 4q)$
39. $(4t - 1)(2u - t)$
40. $-(4k + n)(n + h)$
41. $(p - q - r)(4m - n)$
42. $(a - b + 2c)(x - y)$
43. $(2x - 3)(2x - 1)$
44. $(y - 7)(y + 4)$
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3.1A Meaning of Identities and the Tests for Identities

(a) For an equation in x, if ANY value of x can satisfy the equation, then the equation is called an identity.

(b) For an identity, the like terms on both sides must be the same.

e.g. \(2x = x + x\) is an identity.
\(3x = 1\) is not an identity.

Example 1
Prove that the equation \(x + 4x = 5x\) is an identity.

\[\text{L.H.S.} = x + 4x = 5x\]
\[\text{R.H.S.} = 5x\]
\[\therefore \text{L.H.S.} = \text{R.H.S.}\]
\[\therefore x + 4x \equiv 5x\]

To indicate an identity, we use the identity symbol ‘≡’ to replace ‘=’.

Instant Drill 1
Prove that the equation \(-6y = 2y - 8y\) is an identity.

\[\text{L.H.S.} = -6y\]
\[\text{R.H.S.} = \]
\[\therefore \text{L.H.S.} \quad \]
\[\therefore \quad \]

1. Prove that the equation \(2(x - 1) = 2x - 2\) is an identity.

\[\text{L.H.S.} = \]

2. Prove that the equation \(-12y + 8 = -4(3y - 2)\) is an identity.

Θ Ex 3A 1–4
### Example 2
Prove that the equation $3(2x + 1) - x = 5x + 7$ is not an identity.

**Sol**  
**Method 1**  
L.H.S. = $3(2x + 1) - x$  
\[= 6x + 3 - x\]  
\[= 5x + 3\]  
R.H.S. = $5x + 7$  
\[\therefore \text{ L.H.S.} \neq \text{R.H.S.}\]  
\[\therefore 3(2x + 1) - x = 5x + 7 \text{ is not an identity.}\]

**Method 2**  
When $x = 0$,  
L.H.S. = $3[2(0) + 1] - 0 = 3$  
R.H.S. = $5(0) + 7 = 7$  
\[\therefore \text{ L.H.S.} \neq \text{R.H.S.}\]  
\[\therefore 3(2x + 1) - x = 5x + 7 \text{ is not an identity.}\]

### Instant Drill 2
Prove that the equation $4x + 6 = 2(2x - 5) + 4$ is not an identity.

**Sol**  
**Method 1**  
L.H.S. = $4x + 6$  
R.H.S. =  
\[\therefore \text{ L.H.S.} \neq \text{R.H.S.}\]  
\[\therefore 4x + 6 = 2(2x - 5) + 4 \text{ is not an identity.}\]

**Method 2**  
When $x = \_\_\_$,  
L.H.S. =  
R.H.S. =  
\[\therefore \text{ L.H.S.} \neq \text{R.H.S.}\]  
\[\therefore 4x + 6 = 2(2x - 5) + 4 \text{ is not an identity.}\]

<table>
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<tr>
<th>3.</th>
<th>Prove that the equation $3(5x + 2) = 6(2x + 1)$ is not an identity.</th>
<th>4.</th>
<th>Prove that the equation $y^2 - 4 = (y - 2)^2$ is not an identity.</th>
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</table>
| **Method 1** | L.H.S. = | **Method 1** | L.H.S. =  
R.H.S. =  
R.H.S. = $(y - 2)^2$  
\[= (y - 2)(\quad )\]  
=  |
| **Method 2** | When $x = \_\_\_$,  
L.H.S. =  
R.H.S. =  | **Method 2** |  
| | | | |
Determine whether each of the following equations is an identity. **[Nos. 5–6]**

**5.** $5(2x + 4) = 10(1 + 2x)$

L.H.S. =

R.H.S. =

∴ L.H.S. (= / ≠) R.H.S.

∴

**6.** $(x + 3)(x - 2) = x^2 + x - 6$

L.H.S. = $(x + 3)(x - 2)$

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

= 

3.1B Finding Unknown Constants in an Identity

**Method 1:**
Consider an identity in $x$ with unknown constant(s).

**Step Θ:** Expand and simplify the two sides of the identity.

**Step Θ:** Compare the like terms on both sides.

e.g. Consider $Px + Q \equiv 6x - 4$, where $P$ and $Q$ are constants.

Comparing like terms on both sides, we have

$P = 6$

$Q = -4$

Example 3
If $4(x + 5) \equiv Ax + B$, where $A$ and $B$ are constants, find $A$ and $B$.

**Sol** L.H.S. = $4(x + 5)$

$= 4x + 20$

∴ $4x + 20 \equiv Ax + B$

Comparing like terms on both sides, we have

$A = 4$

$B = 20$

Instant Drill 3
If $Px^2 + Qx \equiv 7(x - 2)$, where $P$ and $Q$ are constants, find $P$ and $Q$.

**Sol** R.H.S. = $7(x - 2)$

∴

Comparing like terms on both sides, we have

$P = \underline{\hspace{2cm}}$

$Q = \underline{\hspace{2cm}}$
Find the unknown constants (denoted by capital letters) in each of the following identities.

[Nos. 7–8]

7. \(3(y + A) \equiv By - 3\)

8. \(5x(x + 2) + Px \equiv Qx^2 + 8x\)

**Method 2:**
Consider an identity in \(x\) with unknown constant(s).
Substitute a suitable value of \(x\) into the identity to find each unknown constant.

**Example 4**
If \((x - 2)(x + 1) \equiv x^2 + Ax + B\), where \(A\) and \(B\) are constants, find \(A\) and \(B\).

**Sol** For the identity
\[(x - 2)(x + 1) \equiv x^2 + Ax + B\],
when \(x = 0\),
\[(0 - 2)(0 + 1) = 0^2 + A(0) + B\]
\[\therefore \quad B = -2\]
when \(x = 2\),
\[(2 - 2)(2 + 1) = 2^2 + A(2) - 2\]
\[0 = 4 + 2A - 2\]
\[2A = -2\]
\[\therefore \quad A = -1\]

**Instant Drill 4**
If \((x - 1)(x - 3) \equiv x^2 + Px + Q\), where \(P\) and \(Q\) are constants, find \(P\) and \(Q\).

**Sol** For the identity
\[(x - 1)(x - 3) \equiv x^2 + Px + Q\],
when \(x = \_\_\_\_\_\_,\)
\[(\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_) = (\_\_\_\_\_\_\_\_\_)^2 + P(\_\_\_\_\_\_\_\_\_) + Q\]
\[\therefore \quad = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_]\]
when \(x = \_\_\_\_\_\_,\)
Find the unknown constants (denoted by capital letters) in each of the following identities.

[Nos. 9–10]

9. \((x + 4)(x - 2) \equiv x^2 + Ax + B\)

10. \((4y - 3)(y + 1) \equiv 4y^2 + Py + Q\)

---

Level Up Questions

11. Determine whether the equation \(5(3x + 1) + 3(x - 4) = 6(3x - 1)\) is an identity.

12. If \((x + 2)(x - A) \equiv x^2 + Bx - 20\), where \(A\) and \(B\) are constants, find \(A\) and \(B\).
3 Identities

Level 1

Prove that each of the following equations is an identity. [Nos. 1–4]

1. \(6(y - 2) = 6y - 12\)  
2. \(4(2x + 3) = 2(4x + 6)\)

3. \(9 - y^2 = (3 + y)(3 - y)\)  
4. \(x(x - 5) + 8x = x^2 + 3x\)

Prove that each of the following equations is not an identity. [Nos. 5–8]

5. \(5x - 2 = 5(x - 1) + 4\)  
6. \(3(5x + 2) = 5(3x + 1) + x\)

7. \(y(2 - y) + 5 = y^2 - 2y + 5\)  
8. \((y - 4)^2 = y^2 - 16\)

Determine whether each of the following equations is an identity. [Nos. 9–14]

9. \(2x + 5x = 11x - 4x\)  
10. \(-4(2y + 3) = -(8y - 12)\)

11. \(3(x + 2) - 5x = -2(x - 3)\)  
12. \(4y(4 - 2y) = 2y(4y - 7) - 2y\)

13. \((x - 5)^2 - 3x = x^2 - 13x - 25\)  
14. \((y + 5)(y - 7) + 35 = y^2 - 2y\)

Find the unknown constants \(P\) and \(Q\) in each of the following identities. [Nos. 15–24]

15. \(3x - 8 \equiv Px - Q\)  
16. \(6x + 1 \equiv P + Qx\)

17. \(5(x + P) \equiv Qx + 20\)  
18. \(4(3x - 2) + P \equiv Qx - 10\)

19. \(7y(y + 2) \equiv Py^2 + Qy\)  
20. \(y(4y + P) \equiv 6y - Qy^2\)

21. \((Px - 3)x - 2 \equiv -5x^2 - 3x + Q\)  
22. \(x^2 + Px - Q \equiv (x - 3)(x + 5)\)

23. \(Py^2 + 17y + Q \equiv (y + 4)(2y + 9)\)  
24. \((2y - 1)(3y - 4) \equiv 6y^2 - Py + Q\)

Level 2
Prove that each of the following equations is an identity. [Nos. 25–27]

25. \((7 - 3x)^2 = 9x^2 - 42x + 49\)

26. \(y(y + 11) + 30 = (y + 5)(y + 6)\)

27. \(4(7x - 6 + 3x^2) = (2x + 6)(6x - 4)\)

Prove that each of the following equations is not an identity. [Nos. 28–30]

28. \(3 - 4x(x - 2) = (3 - 2x)(2x - 1)\)

29. \((5y - 6)(3y + 5) + 3y = 15y^2 - 10y - 30\)

30. \(\frac{n}{2} + \frac{7 - n}{6} = \frac{4n + 7}{6}\)

Determine whether each of the following equations is an identity. [Nos. 31–34]

31. \((2p - 3)(p + 6) - 4p = (p + 2)(2p - 9)\)    32. \(4m - 3m(2m - 5) = -(4 - 3m)(2m + 9)\)

33. \((n - 2)^2 + n(5n - 6) = 2(3n - 2)(n - 1)\)  34. \(\frac{4x - 5}{18} - \frac{2 - x}{9} = \frac{2x - 3}{6}\)

Find the unknown constants (denoted by capital letters) in each of the following identities. [Nos. 35–42]

35. \((x + 3)(x + A) \equiv x^2 + Bx - 6\)    36. \((Ax - 3)(x - 2) \equiv 5x^2 + Bx + 6\)

37. \((Ax - B)(3x + 2) \equiv -6x^2 - 19x - 10\)    38. \((3x + 1)^2 - A \equiv 9x^2 - Bx - 3\)

39. \(4(x + 5) + 2(2x - 5) \equiv Ax^2 + Bx + C\)    40. \((8x + 2)(Ax - B) \equiv 24x^2 + Cx - 8\)

41. \(x(Ax - 4) - B \equiv (2x + C)^2 + 2\)    42. \((x - 4)(Ax - 1) \equiv 6x^2 + B(5x - 1) + C\)

43. It is given that \((x + A)(x + B) \equiv x^2 + x + C\), where \(A\), \(B\) and \(C\) are constants.

   (a) Express \(B\) in terms of \(A\). Hence, express \(C\) in terms of \(A\).

   (b) Write down two sets of possible values of \(A\), \(B\) and \(C\).
### Consolidation Exercise 3A (Answer)

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37. $A = -2, B = 5$  
38. $A = 4, B = -6$  
39. $A = 0, B = 8, C = 10$  
40. $A = 3, B = 4, C = -26$  
41. $A = 4, B = -3, C = -1$  
42. $A = 6, B = -5, C = -1$  
43. (a) $B = 1 - A, C = A - A^2$  
   (b) $A = 1, B = 0, C = 0;$  
   $A = 2, B = -1, C = -2$  
   (or other reasonable answers)
# F2A: Chapter 3B

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Mark:
3.2 The Difference of Two Squares Identity

\[ a^2 - b^2 \equiv (a + b)(a - b) \]

We can also write it as \((a + b)(a - b) \equiv a^2 - b^2\).

**Example 1**
Expand

(a) \((x + 4)(x - 4)\), \hspace{1cm} (b) \((3 - y)(3 + y)\).

**Sol** (a) \((x + 4)(x - 4)\) \hspace{1cm} \(a = x, b = 4\)
\[
= x^2 - 4^2 \\
= x^2 - 16
\]

(b) \((3 - y)(3 + y)\) \hspace{1cm} \(a = 3, b = y\)
\[
= 3^2 - y^2 \\
= 9 - y^2
\]

**Instant Drill 1**
Expand

(a) \((y - 7)(y + 7)\), \hspace{1cm} (b) \((8 + x)(8 - x)\).

**Sol** (a) \((y - 7)(y + 7)\)
\[
= (y - 7)^2 - (y + 7)^2 \\
= __________
\]

(b) \((8 + x)(8 - x)\)
\[
= (8 + x)^2 - (8 - x)^2 \\
= __________
\]

1. Expand \((10 + x)(10 - x)\).
2. Expand \((-2 + y)(-2 - y)\).

**Example 2**
Expand \((2n - 5)(2n + 5)\).

**Sol** \((2n - 5)(2n + 5)\)
\[
= (2n)^2 - 5^2 \\
= 4n^2 - 25
\]

\(4n^2 - 25 \equiv (2n)^2 = 2^2n^2\)

**Instant Drill 2**
Expand \((9x + 1)(9x - 1)\).

**Sol** \((9x + 1)(9x - 1)\)
\[
= (9x + 1)^2 - (9x - 1)^2 \\
= __________
\]

Expand the following expressions. [Nos. 3–8]

3. \((4a + 3)(4a - 3)\)

4. \((5 - 7h)(5 + 7h)\)
5. \((1 + 6x)(6x - 1) = (6x + \underline{\phantom{0}})(6x - 1) = \) \\
6. \((-5y + 2)(5y + 2) = \) \\

\[ \begin{align*}
5. & \quad (1 + 6x)(6x - 1) = (6x + \underline{\phantom{0}})(6x - 1) = \\
6. & \quad (-5y + 2)(5y + 2) = \\
7. & \quad (2x + 7)(x - 7) = 2((\underline{\phantom{0}})^2 - (\underline{\phantom{0}})^2) = \\
8. & \quad -(3k + 2)(3k - 2) = \\
\end{align*} \]

\[ \begin{align*}
\text{Example 3} \\
\text{Without using a calculator, find the values of the following expressions.} \\
(a) \quad & 78^2 - 22^2 \\
(b) \quad & 41 \times 39 \\
\text{Sol} (a) \quad & 78^2 - 22^2 = (78 + 22)(78 - 22) = 100 \times 56 = 5600 \\
\text{(b) } \quad & 41 \times 39 = (40 + 1)(40 - 1) = 40^2 - 1^2 = 1600 - 1 = 1599 \\
\end{align*} \]

\[ \begin{align*}
\text{Instant Drill 3} \\
\text{Without using a calculator, find the values of the following expressions.} \\
(a) \quad & 55^2 - 45^2 \\
(b) \quad & 28 \times 32 \\
\text{Sol} (a) \quad & 55^2 - 45^2 = (\underline{\phantom{0}} + \underline{\phantom{0}})(\underline{\phantom{0}} - \underline{\phantom{0}}) = (\underline{\phantom{0}})(\underline{\phantom{0}}) = \\
\text{(b) } \quad & 28 \times 32 = (\underline{\phantom{0}} - \underline{\phantom{0}})(\underline{\phantom{0}} + \underline{\phantom{0}}) = (\underline{\phantom{0}})^2 - (\underline{\phantom{0}})^2 = \\
\end{align*} \]

9. \(86^2 - 14^2 = \) \\
10. \(32^2 - 22^2 = \)
11. 59 × 61

12. 103 × 97

Level Up Questions

13. Expand \((5x - 9y)(5x + 9y)\).

14. Expand \((11 + m^2)(11 - m^2)\).

\[ (m^2)^2 = m^2 \times m^2 = m^4 \]

15. Without using a calculator, find the value of \(305^2 - 295^2\).
3 Identities

**Level 1**
Expand the following expressions. [Nos. 1–16]

1. \((p + 1)(p - 1)\)  
2. \((q + 6)(q - 6)\)

3. \((7 - r)(7 + r)\)  
4. \((-4 - m)(-4 + m)\)

5. \((5n + 1)(5n - 1)\)  
6. \((2n + 5)(2n - 5)\)

7. \((-6 + 3x)(-6 - 3x)\)  
8. \((7y - 8)(8 + 7y)\)

9. \((-9 + z)(9 + z)\)  
10. \((-5x + 3)(5x + 3)\)

11. \(8(a + 3)(a - 3)\)  
12. \(-5(b - 4)(b + 4)\)

13. \(4(5c + 2)(5c - 2)\)  
14. \(2(4k - 1)(4k + 1)\)

15. \(-9(3 + 2t)(3 - 2t)\)  
16. \(6(-4 + 3x)(-4 - 3x)\)

Without using a calculator, use the difference of two squares identity to find the values of the following expressions. [Nos. 17–22]

17. \(81^2 - 19^2\)

18. \(79^2 - 69^2\)

19. \(104^2 - 96^2\)

20. \(162^2 - 138^2\)

21. \(53 \times 47\)

22. \(95 \times 105\)

**Level 2**
Expand the following expressions. [Nos. 23–34]
23. \((2a + 5b)(2a - 5b)\)  
24. \((4c - 3d)(-4c - 3d)\)

25. \(\left(\frac{p}{2} - q\right)\left(q + \frac{p}{2}\right)\)  
26. \(\left(\frac{1}{5} + 2cd\right)\left(\frac{1}{5} - 2cd\right)\)

27. \(8(3m - 2n)(3m + 2n)\)  
28. \(-2(5x + 6y)(6y - 5x)\)

29. \(9\left(\frac{m}{3} + \frac{n}{9}\right)\left(\frac{m}{3} - \frac{n}{9}\right)\)  
30. \((k^2 + 8)(k^2 - 8)\)

31. \((4r^2 - 7)(7 + 4r^2)\)  
32. \((ab - 5)(-5 - ab)\)

33. \((3m + 9n)(m - 3n)\)  
34. \(\left(\frac{x}{2} + y\right)\left(\frac{y}{4} - \frac{x}{8}\right)\)

35. (a) Expand \((5a + 3b)(5a - 3b)\).  
    (b) Hence, expand \(15\left(\frac{3b}{5} + a\right)\left(\frac{5a}{3} - b\right)\).

36. (a) Expand \((2x + 7y)(7y - 2x)\).  
    (b) Hence, expand \(\left(x + \frac{7}{2}y\right)\left(y - \frac{2}{7}x\right)\).

Without using a calculator, use the difference of two squares identity to find the values of the following expressions. [Nos. 37–40]

37. \(4002^2 - 3998^2\)  
38. \(47.5^2 - 2.5^2\)

39. \(510 \times 490\)  
40. \(29\frac{1}{3} \times 30\frac{2}{3}\)

41. (a) Express \(497 \times 503\) in the form \(a^2 - b^2\).  
    (b) Hence, find the value of \(497 \times 503 - 499^2\).

42. (a) Express \(1004 \times 996\) in the form \(a^2 - b^2\).  
    (b) Hence, find the value of \(1001^2 - 1004 \times 996\).
Consolidation Exercise 3B (Answer)

1. \( p^2 - 1 \)
2. \( q^2 - 36 \)
3. \( 49 - r^2 \)
4. \( 16 - m^2 \)
5. \( 25n^2 - 1 \)
6. \( 4n^2 - 25 \)
7. \( 36 - 9x^2 \)
8. \( 49y^2 - 64 \)
9. \( z^2 - 81 \)
10. \( 9 - 25x^2 \)
11. \( 8a^2 - 72 \)
12. \( 80 - 5b^2 \)
13. \( 100c^2 - 16 \)
14. \( 32k^2 - 2 \)
15. \( 36r^2 - 81 \)
16. \( 96 - 54x^2 \)
17. \( 6200 \)
18. \( 1480 \)
19. \( 1600 \)
20. \( 7200 \)
21. \( 2491 \)
22. \( 9975 \)
23. \( 4a^2 - 25b^2 \)
24. \( 9d^2 - 16c^2 \)
25. \( \frac{p^2}{4} - q^2 \)
26. \( \frac{1}{25} - 4e^2d^2 \)
27. \( 72m^2 - 32n^2 \)
28. \( 50x^2 - 72y^2 \)
29. \( m^2 - \frac{n^2}{9} \)
30. \( k^4 - 64 \)
31. \( 16t^4 - 49 \)
32. \( 25 - a^2b^2 \)
33. \( 3m^4 - 27n^2 \)
34. \( \frac{y^2}{4} - \frac{x^2}{16} \)
35. (a) \( 25a^2 - 9b^2 \)
(b) \( 25a^2 - 9b^2 \)
36. (a) \( 49y^2 - 4x^2 \)
(b) \( \frac{7}{2}y^2 - \frac{2}{7}x^2 \)
37. \( 32000 \)
38. \( 2250 \)
39. \( 249900 \)
40. \( 899 \frac{5}{9} \)
41. (a) \( 500^2 - 3^2 \)
(b) \( 990 \)
42. (a) \( 1000^2 - 4^2 \)
(b) \( 2017 \)
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<th>Task</th>
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<th>Notes</th>
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|      | Book Example 11 | ○ Complete  
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○ Skipped | (Video Teaching) |
|      | Book Example 12 | ○ Complete  
○ Problems encountered  
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|      | Book Example 13 | ○ Complete  
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○ Skipped | (Video Teaching) |
|      | Book Example 14 | ○ Complete  
○ Problems encountered  
○ Skipped | (Video Teaching) |
|      | Consolidation Exercise | ○ Complete and Checked  
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○ Skipped | (Full Solution) |
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○ Problems encountered  
○ Skipped | Teacher’s Signature ( ) |
|      | Maths Corner Exercise 3C Level 2 | ○ Complete and Checked  
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|      | Maths Corner Exercise 3C Level 3 | ○ Complete and Checked  
○ Problems encountered  
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<td>Problems encountered</td>
<td>Skipped</td>
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### 3.3A Square of the Sum of Two Numbers

\[(a + b)^2 = a^2 + 2ab + b^2\]

#### Example 1
Expand

(a) \((x + 1)^2\),

**Sol** (a) \((x + 1)^2 = x^2 + 2(x)(1) + 1^2 = x^2 + 2x + 1\)

(b) \((4 + y)^2\),

**Sol** (b) \((4 + y)^2 = 4^2 + 2(4)(y) + y^2 = 16 + 8y + y^2\)

#### Instant Drill 1
Expand

(a) \((x + 6)^2\),

**Sol** (a) \((x + 6)^2 = (x + 6)^2 + 2( )( ) + ( )^2 = _______\)

(b) \((3 + y)^2\),

**Sol** (b) \((3 + y)^2 = (3 + y)^2 + 2( )( ) + ( )^2 = _______\)

---

1. Expand the following expressions.

(a) \((x + 2)^2 = ( )^2 + 2( ) + ( )^2 = _______\)

(b) \((x + 3)^2 = _______\)

(c) \((x + 5)^2 = _______\)

(d) \((x + 7)^2 = _______\)

(e) \((x + 9)^2 = _______\)

---

#### Example 2
Expand \((5y + 3)^2\).

**Sol** \((5y + 3)^2 = (5y)^2 + 2(5y)(3) + 3^2 = 25y^2 + 30y + 9\)

#### Instant Drill 2
Expand \((4 + 9x)^2\).

**Sol** \((4 + 9x)^2 = ( )^2 + 2( ) + ( )^2 = _______\)

---

2. Expand \((10a + 1)^2\).

3. Expand \((-3 + 8c)^2\).

---

Try to memorize the following square numbers.

<table>
<thead>
<tr>
<th>n^2</th>
<th>1</th>
<th>2^2 = 4</th>
<th>3^2 = 9</th>
<th>4^2 = 16</th>
<th>5^2 = 25</th>
<th>6^2 = 36</th>
<th>7^2 = 49</th>
<th>8^2 = 64</th>
<th>9^2 = 81</th>
<th>10^2 = 100</th>
<th>11^2 = 121</th>
<th>12^2 = 144</th>
</tr>
</thead>
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---

Ex 3C 1, 2, 5

Ex 3C 7, 8, 11, 14
3.3B  Square of the Difference of Two Numbers

\[(a - b)^2 \equiv a^2 - 2ab + b^2\]

**Example 3**
Expand
(a) \((x - 1)^2\),
(b) \((5 - y)^2\).

**Sol**
(a) \((x - 1)^2 = x^2 - 2(x)(1) + 1^2 = x^2 - 2x + 1\)
(b) \((5 - y)^2 = 5^2 - 2(5)(y) + y^2 = 25 - 10y + y^2\)

**Instant Drill 3**
Expand
(a) \((y - 7)^2\),
(b) \((3 - x)^2\).

**Sol**
(a) \((y - 7)^2 = a = ____ \quad b = ____\)
(b) \((3 - x)^2 = a = ____ \quad b = ____\)

4. Expand the following expressions.
(a) \((x - 2)^2 = ( )^2 - 2( ) ( ) + ( )^2 = ____
(b) \((x - 4)^2 = ____
(c) \((x - 6)^2 = ____
(d) \((x - 8)^2 = ____
(e) \((x - 10)^2 = ____

**Example 4**
Expand \((3 - 4r)^2\).

**Sol** \((3 - 4r)^2 = 3^2 - 2(3)(4r) + (4r)^2 = 9 - 24r + 16r^2\)

**Instant Drill 4**
Expand \((6y - 5)^2\).

**Sol** \((6y - 5)^2 = ( )^2 - 2( ) ( ) + ( )^2 = ____

5. Expand \((4 - 5x)^2\).

6. Expand \((-2c - 7)^2\).

∅ Ex 3C 3, 4, 6

∅ Ex 3C 9, 10, 12, 13
7. Expand \(2(x + 4)^2\).

\[
(\mathbf{a + b})^2 = \underline{\underline{}}
\]

\[
2(x + 4)^2 = 2[(x + 4)^2 + 2(x)(4) + (4)^2]
\]

8. Expand \(3(2 - 3n)^2\).

\[
(\mathbf{a - b})^2 = \underline{\underline{}}
\]

\[
3(2 - 3n)^2 = 3[(2 - 3n)^2 - 2(2)(3n) + (3n)^2]
\]

Example 5

Without using a calculator, find the values of the following expressions.

(a) \(31^2\)

(b) \(98^2\)

\[
\text{Sol} \ (\text{a}) \ 31^2 = (30 + 1)^2 = 30^2 + 2(30)(1) + 1^2 = 900 + 60 + 1 = 961
\]

\[
\text{Sol} \ (\text{b}) \ 98^2 = (100 - 2)^2 = 100^2 - 2(100)(2) + 2^2 = 10000 - 400 + 4 = 9604
\]

Instant Drill 5

Without using a calculator, find the values of the following expressions.

(a) \(105^2\)

(b) \(49^2\)

\[
\text{Sol} \ (\text{a}) \ 105^2 = (100 + \underline{\underline{}})^2
\]

\[
= (\underline{\underline{}})^2 + 2(\underline{\underline{}})(\underline{\underline{}}) + (\underline{\underline{}})^2
\]

\[
\text{Sol} \ (\text{b}) \ 49^2 = (50 - \underline{\underline{}})^2
\]

\[
= (\underline{\underline{}})^2 - 2(\underline{\underline{}})(\underline{\underline{}}) + (\underline{\underline{}})^2
\]

Without using a calculator, find the values of the following expressions. [Nos. 9–12]

9. \(53^2\)

10. \(202^2\)

11. \(39^2\)

12. \(67^2\)
13. Expand \((8x + 3y)^2\).

14. Expand \((5p - 12q)^2\).

15. (a) Prove that the equation 
\[(m + 1)^2 + (m - 1)^2 = 2(m^2 + 1)\]
is an identity.

(b) Using the result of (a), find the value of \(101^2 + 99^2\) without using a calculator.
3 Identities

**Level 1**
Expand the following expressions. [Nos. 1–20]

1. \((m + 3)^2\)  
2. \((5 + n)^2\)  
3. \((p - 7)^2\)  
4. \((9 - q)^2\)  
5. \((-x + 6)^2\)  
6. \((-1 + y)^2\)  
7. \((-8 - y)^2\)  
8. \((-x - 4)^2\)  
9. \((3a + 2)^2\)  
10. \((8b + 5)^2\)  
11. \((4k - 1)^2\)  
12. \((6t - 7)^2\)  
13. \((2 + 9r)^2\)  
14. \((5 - 3s)^2\)  
15. \((-8 - 3x)^2\)  
16. \((-2y + 7)^2\)  
17. \(3(h - 1)^2\)  
18. \(5(2 + k)^2\)  
19. \(2(5x + 6)^2\)  
20. \(4(3 - 4p)^2\)

Without using a calculator, use the perfect square identities to find the values of the following expressions. [Nos. 21–24]

21. \(62^2\)  
22. \(97^2\)  
23. \(201^2\)  
24. \(298^2\)

**Level 2**
Expand the following expressions. [Nos. 25–36]

25. \((3m + n)^2\)  
26. \((5a - 2b)^2\)  
27. \((-4x - 3y)^2\)  
28. \(\left(\frac{m + n}{7}\right)^2\)  
29. \(\left(\frac{r}{2} - 5x\right)^2\)  
30. \(\left(\frac{u}{5} + \frac{v}{6}\right)^2\)  
31. \(\frac{1}{3}(3h + 9k)^2\)  
32. \(-5(2x^2 - 3)^2\)  
33. \([4(3s - 1)]^2\)  
34. \([3(x + 6y)]^2\)  
35. \((8p^2 - 4q)^2\)  
36. \(6(mn + 2)^2\)

37. (a) Expand \((2 + m)^2\).
    (b) Hence, expand \((2 + m + 3n)^2\).

38. (a) Expand \((y - 3z)^2\).
    (b) Hence, expand \((x + y - 3z)(x - y + 3z)\).

Without using a calculator, use the perfect square identities to find the values of the following expressions. [Nos. 39–42]

39. \(598^2\)  
40. \(1003^2\)  
41. \(20.1^2\)  
42. \(79.9^2\)
Consolidation Exercise 3C (Answer)

1. \( m^2 + 6m + 9 \)  
2. \( 25 + 10n + n^2 \)  
3. \( p^2 - 14p + 49 \)  
4. \( 81 - 18q + q^2 \)  
5. \( x^2 - 12x + 36 \)  
6. \( 1 - 2y + y^2 \)  
7. \( 64 + 16y + y^2 \)  
8. \( x^2 + 8x + 16 \)  
9. \( 9a^2 + 12a + 4 \)  
10. \( 64b^2 + 80b + 25 \)  
11. \( 16k^2 - 8k + 1 \)  
12. \( 36t^2 - 84t + 49 \)  
13. \( 4 + 36r + 81r^2 \)  
14. \( 25 - 30s + 9s^2 \)  
15. \( 64 + 48x + 9x^2 \)  
16. \( 4y^2 - 28y + 49 \)  
17. \( 3h^2 - 6h + 3 \)  
18. \( 20 + 20k + 5k^2 \)  
19. \( 50x^2 + 120x + 72 \)  
20. \( 36 - 96p + 64p^2 \)  
21. \( 3 844 \)  
22. \( 9 409 \)  
23. \( 40 401 \)  
24. \( 88 804 \)  
25. \( 9m^2 + 6mn + n^2 \)  
26. \( 25a^2 - 20ab + 4b^2 \)  
27. \( 16x^2 + 24xy + 9y^2 \)  
28. \( m^2 + \frac{2mn}{7} + \frac{n^2}{49} \)  
29. \( \frac{r^2}{4} - 5rs + 25s^2 \)  
30. \( \frac{u^2}{25} + \frac{uv}{15} + \frac{v^2}{36} \)  
31. \( 3h^2 + 18hk + 27k^2 \)  
32. \( -20x^4 + 60x^2 - 45 \)  
33. \( 144x^2 - 96x + 16 \)  
34. \( 9x^2 + 108xy + 324y^2 \)  
35. \( 64p^4 - 64p^2q + 16q^2 \)  
36. \( 6m^2n^2 + 24mn + 24 \)  
37. (a) \( 4 + 4m + m^2 \)  
(b) \( 4 + 4m + m^2 + 12n + 6mn + 9n^2 \)  
38. (a) \( y^2 - 6yz + 9z^2 \)  
(b) \( x^2 - y^2 + 6yz - 9z^2 \)  
39. \( 357 604 \)  
40. \( 1 006 009 \)  
41. \( 404.01 \)  
42. \( 6 384.01 \)