

Then

You simplified radical expressions.

Now

- Add and subtract radical expressions.
- Multiply radical expressions.

**ConceptSummary** Operations with Radical Expressions

Operation	Symbols	Example
addition, $b \geq 0$	$a\sqrt{b} + c\sqrt{b} = (a + c)\sqrt{b}$ like radicands	$4\sqrt{3} + 6\sqrt{3} = (4 + 6)\sqrt{3}$ $= 10\sqrt{3}$
subtraction, $b \geq 0$	$a\sqrt{b} - c\sqrt{b} = (a - c)\sqrt{b}$ like radicands	$12\sqrt{5} - 8\sqrt{5} = (12 - 8)\sqrt{5}$ $= 4\sqrt{5}$

**Examples 1-3** Simplify each expression.

1.  $3\sqrt{5} + 6\sqrt{5}$   $9\sqrt{5}$      
 2.  $8\sqrt{3} + 5\sqrt{3}$   $13\sqrt{3}$      
 3.  $\sqrt{7} - 6\sqrt{7}$   $-5\sqrt{7}$   
 4.  $10\sqrt{2} - 6\sqrt{2}$   $4\sqrt{2}$      
 5.  $4\sqrt{5} + 2\sqrt{20}$   $8\sqrt{5}$      
 6.  $\sqrt{12} - \sqrt{3}$   $\sqrt{3}$   
 7.  $\sqrt{8} + \sqrt{12} + \sqrt{18}$   
 $5\sqrt{2} + 2\sqrt{3}$      
 8.  $\sqrt{27} + 2\sqrt{3} - \sqrt{12}$   $3\sqrt{3}$      
 9.  $9\sqrt{2}(4\sqrt{6})$   $72\sqrt{3}$

5)  $4\sqrt{5} + 2\sqrt{20} = 4\sqrt{5}$   
 $\sqrt{4} \cdot \sqrt{5}$   
 $2 \cdot 2$   
 $4\sqrt{5} + 4\sqrt{5} = 8\sqrt{5}$

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4.  $10\sqrt{2} - 6\sqrt{2}$   $4\sqrt{2}$

5.  $4\sqrt{5} + 2\sqrt{20}$   $8\sqrt{5}$

6.  $\sqrt{12} - \sqrt{3}$   $\sqrt{3}$

7.  $\sqrt{8} + \sqrt{12} + \sqrt{18}$   
 $5\sqrt{2} + 2\sqrt{3}$

8.  $\sqrt{27} + 2\sqrt{3} - \sqrt{12}$   $3\sqrt{3}$

9.  $9\sqrt{2}(4\sqrt{6})$   $72\sqrt{3}$

Handwritten work for problem 8:

8  $\sqrt{27} = 3\sqrt{3}$

$3 \cdot 9 = 27$

$3 \cdot 3 = 9$

$2\sqrt{3} = 2\sqrt{3}$

$-\sqrt{12} = -2\sqrt{3}$

$2 \cdot 2 = 4$   
 $4 \cdot 3 = 12$

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7.  $\sqrt{8} + \sqrt{12} + \sqrt{18}$   
 $5\sqrt{2} + 2\sqrt{3}$

8.  $\sqrt{27} + 2\sqrt{3} - \sqrt{12}$   $3\sqrt{3}$

9.  $9\sqrt{2}(4\sqrt{6})$   $72\sqrt{3}$

⑦  $\sqrt{8} = 2\sqrt{2}$

4 2

⑨  $36\sqrt{12}$

2 2 3

$2\sqrt{2} + 2\sqrt{3} + 3\sqrt{2}$

⑧  $\sqrt{12} = 2\sqrt{3}$

2 2

$\sqrt{18} = 3\sqrt{2}$

4 3

9 2

3 3

## ConceptSummary Operations with Radical Expressions

Operation	Symbols	Example
multiplication, $b \geq 0, g \geq 0$	$a\sqrt{b}(f\sqrt{g}) = af\sqrt{bg}$ Radicands do not have to be like radicands.	$3\sqrt{2}(5\sqrt{7}) = (3 \cdot 5)(\sqrt{2 \cdot 7})$ $= 15\sqrt{14}$

10.  $4\sqrt{3}(8\sqrt{3})$  **96**

$32\sqrt{9} = 32 \cdot 3$

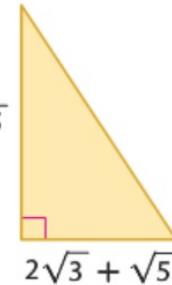
11.  $\sqrt{3}(\sqrt{7} + 3\sqrt{2})$   
 $\sqrt{21} + 3\sqrt{6}$

12.  $\sqrt{5}(\sqrt{2} + 4\sqrt{2})$   **$5\sqrt{10}$**

### Example 4

13. **GEOMETRY** The area  $A$  of a triangle can be found by using the formula  $A = \frac{1}{2}bh$ , where  $b$  represents the base and  $h$  is the height. What is the area of the triangle at the right?

$4\sqrt{3} + \sqrt{5}$



$2\sqrt{3} + \sqrt{5}$

$\frac{1}{2}(4\sqrt{3} + \sqrt{5})(2\sqrt{3} + \sqrt{5})$

	$4\sqrt{3}$	$\sqrt{5}$
$2\sqrt{3}$	$24$	$2\sqrt{15}$
$\sqrt{5}$	$4\sqrt{15}$	$5$

$\frac{29 + 6\sqrt{15}}{2}$

Practice and Problem Solving

Extra Practice is on page R10.

Examples 1-3 Simplify each expression. 18.  $12\sqrt{3} + \sqrt{2}$

14.  $7\sqrt{5} + 4\sqrt{5}$   $11\sqrt{5}$

16.  $3\sqrt{5} - 2\sqrt{20}$   $-\sqrt{5}$

18.  $7\sqrt{3} - 2\sqrt{2} + 3\sqrt{2} + 5\sqrt{3}$

20.  $\sqrt{6}(2\sqrt{10} + 3\sqrt{2})$   $4\sqrt{15} + 6\sqrt{3}$

22.  $5\sqrt{3}(6\sqrt{10} - 6\sqrt{3})$   $30\sqrt{30} - 90$

24.  $(3\sqrt{11} + 3\sqrt{15})(3\sqrt{3} - 2\sqrt{2})$

15.  $2\sqrt{6} + 9\sqrt{6}$   $11\sqrt{6}$

17.  $3\sqrt{50} - 3\sqrt{32}$   $3\sqrt{2}$

19.  $\sqrt{5}(\sqrt{2} + 4\sqrt{2})$   $5\sqrt{10}$

21.  $4\sqrt{5}(3\sqrt{5} + 8\sqrt{2})$   $60 + 32\sqrt{10}$

23.  $(\sqrt{3} - \sqrt{2})(\sqrt{15} + \sqrt{12})$

25.  $(5\sqrt{2} + 3\sqrt{5})(2\sqrt{10} - 5)$   $5\sqrt{5} + 5\sqrt{2}$

23.  $3\sqrt{5} + 6 - \sqrt{30} - 2\sqrt{6}$

24.  $9\sqrt{33} - 6\sqrt{22} + 27\sqrt{5} - 6\sqrt{30}$

Handwritten work for problem 23:

$\sqrt{45} = 3\sqrt{5}$  (with prime factorization of 45 shown as 3·3·5)

$\sqrt{24} = 2\sqrt{6}$  (with prime factorization of 24 shown as 2·2·2·3)

$\sqrt{36} = 6$  (with prime factorization of 36 shown as 2·2·3·3)

$\sqrt{9} = 3$  (with prime factorization of 9 shown as 3·3)

Problem 23:  $(\sqrt{3} - \sqrt{2})(\sqrt{15} + \sqrt{12})$

$\sqrt{3}$	$-\sqrt{2}$
$\sqrt{45}$	$-\sqrt{30}$
$\sqrt{36}$	$-\sqrt{24}$

Result:  $5\sqrt{5} + 5\sqrt{2}$

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Extra Practice is on page R10.

**Examples 1–3** Simplify each expression. 18.  $12\sqrt{3} + \sqrt{2}$

14.  $7\sqrt{5} + 4\sqrt{5}$   $11\sqrt{5}$

16.  $3\sqrt{5} - 2\sqrt{20}$   $-\sqrt{5}$

18.  $7\sqrt{3} - 2\sqrt{2} + 3\sqrt{2} + 5\sqrt{3}$

20.  $\sqrt{6}(2\sqrt{10} + 3\sqrt{2})$   $4\sqrt{15} + 6\sqrt{3}$

22.  $5\sqrt{3}(6\sqrt{10} - 6\sqrt{3})$   $30\sqrt{30} - 90$

24.  $(3\sqrt{11} + 3\sqrt{15})(3\sqrt{3} - 2\sqrt{2})$

15.  $2\sqrt{6} + 9\sqrt{6}$   $11\sqrt{6}$

17.  $3\sqrt{50} - 3\sqrt{32}$   $3\sqrt{2}$

19.  $\sqrt{5}(\sqrt{2} + 4\sqrt{2})$   $5\sqrt{10}$

21.  $4\sqrt{5}(3\sqrt{5} + 8\sqrt{2})$   $60 + 32\sqrt{10}$

23.  $(\sqrt{3} - \sqrt{2})(\sqrt{15} + \sqrt{12})$

25.  $(5\sqrt{2} + 3\sqrt{5})(2\sqrt{10} - 5)$   $5\sqrt{5} + 5\sqrt{2}$

23.  $3\sqrt{5} + 6 - \sqrt{30} - 2\sqrt{6}$

24.  $9\sqrt{33} - 6\sqrt{22} + 27\sqrt{5} - 6\sqrt{30}$

①  $3\sqrt{50} = 3(5\sqrt{2})$   
 $5 \cdot 10 = 15\sqrt{2}$   
 $5 \cdot 2$

$3\sqrt{32} = 3(4\sqrt{2})$   
 $8 \cdot 4 = 12\sqrt{2}$   
 $2 \cdot 4$