

Name: \_\_\_\_\_ Squares and Square Roots Date: \_\_\_\_\_

n	Square n <sup>2</sup>	Square Root √n	n	Square n <sup>2</sup>	Square Root √n	n	Square n <sup>2</sup>	Square Root √n	n	Square n <sup>2</sup>	Square Root √n	n	Square n <sup>2</sup>	Square Root √n
1	1	1.000	51	2601	7.141	101	10 050	10.050	151	22 801	14.933	201	40 401	20.100
2	4	1.414	52	2704	7.211	102	10 404	10.200	152	23 104	15.033	202	40 804	20.200
3	9	1.732	53	2809	7.280	103	10 609	10.300	153	23 329	15.100	203	41 209	20.300
4	16	2.000	54	2916	7.348	104	10 816	10.400	154	23 636	15.200	204	41 616	20.400
5	25	2.236	55	3025	7.416	105	11 025	10.500	155	24 025	15.300	205	42 025	20.500
6	36	2.449	56	3136	7.483	106	11 236	10.600	156	24 436	15.400	206	42 436	20.600
7	49	2.646	57	3249	7.550	107	11 449	10.700	157	24 849	15.500	207	42 849	20.700
8	64	2.828	58	3364	7.616	108	11 664	10.800	158	25 264	15.600	208	43 264	20.800
9	81	3.000	59	3481	7.681	109	11 881	10.900	159	25 681	15.700	209	43 681	20.900
10	100	3.162	60	3600	7.746	110	12 100	11.000	160	26 100	15.800	210	44 100	21.000
11	121	3.317	61	3721	7.810	111	12 321	11.100	161	26 521	15.900	211	44 521	21.100
12	144	3.464	62	3844	7.874	112	12 544	11.200	162	26 944	16.000	212	44 944	21.200
13	169	3.606	63	3969	7.937	113	12 769	11.300	163	27 369	16.100	213	45 369	21.300
14	196	3.742	64	4096	8.000	114	12 996	11.400	164	27 796	16.200	214	45 796	21.400
15	225	3.873	65	4225	8.062	115	13 225	11.500	165	28 225	16.300	215	46 225	21.500
16	256	4.000	66	4356	8.124	116	13 456	11.600	166	28 656	16.400	216	46 656	21.600
17	289	4.123	67	4489	8.185	117	13 689	11.700	167	29 089	16.500	217	47 089	21.700
18	324	4.243	68	4624	8.246	118	13 924	11.800	168	29 524	16.600	218	47 524	21.800
19	361	4.359	69	4761	8.307	119	14 161	11.900	169	29 961	16.700	219	48 061	21.900
20	400	4.472	70	4900	8.367	120	14 400	12.000	170	30 400	16.800	220	48 500	22.000
21	441	4.583	71	5041	8.426	121	14 641	12.100	171	30 841	16.900	221	48 941	22.100
22	484	4.690	72	5184	8.485	122	14 884	12.200	172	31 284	17.000	222	49 384	22.200
23	529	4.796	73	5329	8.544	123	15 129	12.300	173	31 729	17.100	223	49 829	22.300
24	576	4.899	74	5476	8.602	124	15 376	12.400	174	32 176	17.200	224	50 276	22.400
25	625	5.000	75	5625	8.660	125	15 625	12.500	175	32 625	17.300	225	50 725	22.500
26	676	5.099	76	5776	8.718	126	15 876	12.600	176	33 076	17.400	226	51 176	22.600
27	729	5.196	77	5929	8.775	127	16 129	12.700	177	33 529	17.500	227	51 629	22.700
28	784	5.292	78	6084	8.832	128	16 384	12.800	178	33 984	17.600	228	52 084	22.800
29	841	5.385	79	6241	8.888	129	16 641	12.900	179	34 441	17.700	229	52 541	22.900
30	900	5.477	80	6400	8.944	130	16 900	13.000	180	34 900	17.800	230	53 000	23.000
31	961	5.568	81	6561	9.000	131	17 161	13.100	181	35 361	17.900	231	53 461	23.100
32	1024	5.657	82	6724	9.055	132	17 424	13.200	182	35 824	18.000	232	53 924	23.200
33	1089	5.745	83	6889	9.110	133	17 689	13.300	183	36 289	18.100	233	54 389	23.300
34	1156	5.831	84	7056	9.165	134	17 956	13.400	184	36 756	18.200	234	54 856	23.400
35	1225	5.916	85	7225	9.220	135	18 225	13.500	185	37 225	18.300	235	55 325	23.500
36	1296	6.000	86	7396	9.274	136	18 496	13.600	186	37 696	18.400	236	55 796	23.600
37	1369	6.083	87	7569	9.327	137	18 769	13.700	187	38 169	18.500	237	56 269	23.700
38	1444	6.164	88	7744	9.381	138	19 044	13.800	188	38 644	18.600	238	56 744	23.800
39	1521	6.245	89	7921	9.434	139	19 321	13.900	189	39 121	18.700	239	57 221	23.900
40	1600	6.325	90	8100	9.487	140	19 600	14.000	190	39 600	18.800	240	57 700	24.000
41	1681	6.403	91	8281	9.539	141	19 881	14.100	191	40 081	18.900	241	58 181	24.100
42	1764	6.481	92	8464	9.592	142	20 164	14.200	192	40 564	19.000	242	58 664	24.200
43	1849	6.557	93	8649	9.644	143	20 449	14.300	193	41 049	19.100	243	59 149	24.300
44	1936	6.633	94	8836	9.695	144	20 736	14.400	194	41 536	19.200	244	59 636	24.400
45	2025	6.708	95	9025	9.747	145	21 025	14.500	195	42 025	19.300	245	60 125	24.500
46	2116	6.782	96	9216	9.798	146	21 316	14.600	196	42 516	19.400	246	60 616	24.600
47	2209	6.856	97	9409	9.849	147	21 609	14.700	197	43 009	19.500	247	61 109	24.700
48	2304	6.928	98	9604	9.899	148	21 904	14.800	198	43 504	19.600	248	61 604	24.800
49	2401	7.000	99	9801	9.950	149	22 201	14.900	199	44 001	19.700	249	62 101	24.900
50	2500	7.071	100	10000	10.000	150	22 500	15.000	200	44 500	19.800	250	62 600	25.000



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**Study Guide**

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Pages 638-643

**Simplifying Rational Expressions**

A rational expression is an algebraic fraction whose numerator and denominator are polynomials. For example,  $\frac{3}{x}$ ,  $\frac{x}{x-2}$ , and  $\frac{x-2}{x}$  are all rational expressions because 3, x, and x - 2 are all polynomials.

To simplify a rational expression, use the same steps that you use to simplify any fraction.

- First factor the numerator and denominator. The factors may be polynomials.
- Then divide the numerator and denominator by the greatest common factor. The greatest common factor may be a polynomial.

**Example 1:** Simplify  $\frac{16a^4b^2}{20a^2b^5}$ .

$$\frac{16a^4b^2}{20a^2b^5} = \frac{2 \cdot 2 \cdot 2 \cdot 2 \cdot a \cdot a \cdot a \cdot a \cdot b \cdot b}{2 \cdot 2 \cdot 5 \cdot a \cdot a \cdot b \cdot b \cdot b \cdot b \cdot b}$$

$$= \frac{\cancel{2} \cdot \cancel{2} \cdot 2 \cdot 2 \cdot \cancel{a} \cdot \cancel{a} \cdot a \cdot a \cdot \cancel{b} \cdot \cancel{b}}{\cancel{2} \cdot \cancel{2} \cdot 5 \cdot \cancel{a} \cdot \cancel{a} \cdot a \cdot a \cdot \cancel{b} \cdot \cancel{b} \cdot b \cdot b \cdot b}$$

$$= \frac{4a^2}{5b^3}$$

The GCF is  $4a^2b^2$ .

**Example 2:** Simplify  $\frac{m(m+1)}{m^2-5m-6}$ .

$$\frac{m(m+1)}{m^2-5m-6} = \frac{m(m+1)}{(m-6)(m+1)}$$

$$= \frac{\cancel{m(m+1)}}{(m-6)\cancel{(m+1)}}$$

$$= \frac{m}{m-6}$$

Factor  $m^2 - 5m - 6$ .  
The GCF is  $(m + 1)$ .

Simplify each rational expression.

- $\frac{10 \div 5}{25 \div 5} = \frac{2}{5}$
- $\frac{2 \cdot 3}{3 \cdot 3} = \frac{2}{3}$
- $\frac{2y}{1} = 2y$
- $\frac{-8abc}{16ac}$
- $\frac{6a^2b^3}{-2a^4b^5}$
- $\frac{3(x+2)}{6(x+2)}$
- $\frac{m}{m} = 1$
- $\frac{d}{d} = 1$
- $\frac{(c-2)(d+3)}{(c-2)(d+3)} = \frac{d+3}{d+3}$
- $\frac{x^2-2x}{x(x-2)} = \frac{x}{1} = x$
- $\frac{x^2+3x}{x(x+3)} = \frac{x+3}{x+3} = 1$
- $\frac{x+3}{(x+3)(x-2)} = \frac{1}{x-2}$

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**Practice**  $\frac{n}{0} = \text{"undefined"}$   
 if denominator = 0

**Simplifying Rational Expressions**  
 Find the excluded value(s) for each rational expression.

1.  $\frac{2n}{n-4}$       2.  $\frac{6}{x+3}$       3.  $\frac{3b}{b(b+9)}$   
 $n \neq 4$        $n \neq 4$

4.  $\frac{y+2}{y^2-4}$       5.  $\frac{4x+6}{(x+6)(x-6)}$       6.  $\frac{2a-2}{a^2-3a-28}$

**Simplify each rational expression.**

7.  $\frac{6}{15}$       8.  $\frac{12m}{18m^2}$       9.  $\frac{16x^2y}{36xy^3}$

10.  $\frac{25ab}{30b^2}$       11.  $\frac{-8y^2z}{20y^2z^2}$       12.  $\frac{5(x-1)}{8(x-1)}$

13.  $\frac{y(y+7)}{9(y+7)}$       14.  $\frac{x^2-4x}{3(x-4)}$       15.  $\frac{x^2+2x}{5x+10}$

16.  $\frac{x^2+5x}{(x+5)(x-7)}$       17.  $\frac{x^2-6x}{x^2-4x-12}$       18.  $\frac{4(x+4)}{(x-2)(x-2)} = \frac{(x+4)}{(x-2)}$

19.  $\frac{b^2+6b+9}{b^2-2b-15}$       20.  $\frac{y^2-36}{y^2+9y+18}$       21.  $\frac{x^2-16}{x^2+x-12} = \frac{(x+4)(x-4)}{(x+4)(x-3)}$

22.  $\frac{y^2+4y+4}{y^2-4}$       23.  $\frac{a^2+3a}{a^2-3a-18}$       24.  $\frac{y^2+7y+10}{y^2+5y}$

25.  $\frac{x^3+4x+3}{x^2+3x+2}$       26.  $\frac{x^2-6x+8}{x^2+x-6}$       27.  $\frac{9-x^2}{x^2+8x+27}$

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$$\begin{aligned} & \frac{-x^2+9}{(x+9)(x-3)} \\ & = \frac{-1(x^2-9)}{(x+9)(x-3)} \\ & = \frac{-1(x+3)(x-3)}{(x+9)(x-3)} = \frac{-1(x+3)}{x+9} \end{aligned}$$

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**Multiplying and Dividing Rational Expressions**  
 To multiply rational expressions, simplify the expressions first, then multiply.

**Example 1:** Find  $\frac{12a^2}{18b^2} \cdot \frac{9ab}{12a^3}$ .

$$\frac{12a^2}{18b^2} \cdot \frac{9ab}{12a^3} = \frac{12\cancel{a}^2}{18b^2} \cdot \frac{9\cancel{a}b}{12\cancel{a}^3} = \frac{1}{2ab}$$

To divide a rational expression by a nonzero rational expression, multiply by its reciprocal. Simplify the expressions, if necessary.

**Example 2:** Find  $\frac{3m+6}{m-4} \div (m+2)$ .

$$\begin{aligned} \frac{3m+6}{m-4} \div (m+2) &= \frac{3m+6}{m-4} \cdot \frac{1}{m+2} && \text{The reciprocal of } (m+2) \text{ is } \frac{1}{m+2}. \\ &= \frac{3(m+2)}{m-4} \cdot \frac{1}{m+2} \\ &= \frac{3\cancel{(m+2)}}{m-4} \cdot \frac{1}{\cancel{m+2}} \\ &= \frac{3}{m-4} \end{aligned}$$

**Find each product or quotient.**

1.  $\frac{x}{3} \cdot y^2 = \frac{xy^2}{6}$       2.  $\frac{8a^3}{12b^2} \cdot \frac{18b}{4a}$       3.  $\frac{2(x-y)}{x} \cdot \frac{x^2}{x-y}$

4.  $\frac{6(m-n)}{7} \cdot \frac{7}{12(m-n)}$       5.  $\frac{x^2}{y^2} \cdot \frac{y}{x} = \frac{x}{y}$       6.  $\frac{m+n}{4} \div \frac{m+n}{6}$

7.  $\frac{x-4}{x} \div \frac{1}{x^2}$       8.  $\frac{7x}{x+3} \div \frac{21}{2x+6}$       9.  $\frac{2m+4}{m-3} \div (m+2)$

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**15-2**

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**Multiplying and Dividing Rational Expressions**

Find each product.

1.  $\frac{3x^2}{2y} \cdot \frac{y^2}{9}$
2.  $\frac{4a^2b}{6b^2c} \cdot \frac{3ab}{2c}$
3.  $\frac{7n}{n-2} \cdot \frac{3(n-2)}{28}$
4.  $\frac{2}{m(m+3)} \cdot \frac{3m+9}{6}$
5.  $\frac{4y+8}{y^2-2y} \cdot \frac{y-2}{y+2}$
6.  $\frac{x^2-49}{x^2+5x} \cdot \frac{x+5}{x+7}$
7.  $\frac{5x+25}{x^2-5x+6} \cdot \frac{x-3}{x+5}$
8.  $\frac{a+5}{3a+6} \cdot \frac{3a^2+6a}{a^2+2a-15}$
9.  $\frac{x^2+8x+12}{4x-12} \cdot \frac{2x-6}{x^2+4x-12}$
10.  $\frac{2n^2-10n}{n^2-9n+20} \cdot \frac{n^2-8n+16}{4n^2}$

Find each quotient.

11.  $\frac{4a^3}{b^2c} \div \frac{2a}{bc}$
12.  $\frac{15x^2y^2}{3} \div 3xy$
13.  $\frac{3y+9}{y+2} \div (y+3)$
14.  $\frac{8n^3}{n-4} \div \frac{4n}{n-4}$
15.  $\frac{6x^2y}{3y} \div 2xy$
16.  $\frac{b^2-81}{b} \div (b+9)$
17.  $\frac{6x^2+36x}{4x} \div \frac{4x+24}{2x^2}$
18.  $\frac{y^2+5y-14}{9y} \div \frac{y^2-8y+12}{3y^2}$
19.  $\frac{x^2-2x-15}{x-2} \div \frac{x^2-10x+25}{2-x}$
20.  $\frac{y^2-8y+7}{5y^2} \div \frac{7-y}{10y}$

**15-3**

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**Dividing Polynomials**

To divide 864 by 16, you can use long division and find that the remainder is 0. Therefore, 16 is said to be a **factor** of 864. Likewise, to divide polynomials, you can use long division. Each term may be an algebraic expression, and if the remainder is 0, the divisor is a factor of the dividend. If the divisor is not a factor of the dividend, the remainder will not be zero.

**Examples:** Find each quotient.

a.  $(4x + 2) \div (2x + 1)$

$$\begin{array}{r} 2 \\ 2x + 1 \overline{) 4x + 2} \\ \underline{-4x + 2} \phantom{0} \\ 0 \phantom{0} \end{array}$$

$4x \div 2x = 2$   
 Multiply 2 and  $2x + 1$ .  
 Subtract.

Therefore,  $(4x + 2) \div (2x + 1) = 2$ .

b.  $(x^2 - 4x + 3) \div (x - 1)$

$$\begin{array}{r} x - 3 \\ x - 1 \overline{) x^2 - 4x + 3} \\ \underline{-x^2 + x - 3} \phantom{0} \\ -3x + 3 \phantom{0} \\ \underline{+3x - 3} \\ 0 \phantom{0} \end{array}$$

$x^2 \div x = x$   
 Multiply  $x$  and  $x - 1$ .  
 Subtract; bring down 3.  
 Multiply  $-3$  and  $x - 1$ .  
 Subtract.

Therefore,  $(x^2 - 4x + 3) \div (x - 1) = x - 3$ .

c.  $(2x^2 + 9x + 8) \div (x + 3)$

$$\begin{array}{r} 2x + 3 \\ x + 3 \overline{) 2x^2 + 9x + 8} \\ \underline{-2x^2 + 6x} \phantom{0} \\ 3x + 8 \phantom{0} \\ \underline{-3x - 9} \\ -1 \phantom{0} \end{array}$$

$2x^2 \div x = 2x$   
 Multiply  $2x$  and  $x + 3$ .  
 Subtract; bring down 8.  
 Multiply  $3$  and  $x + 3$ .  
 Subtract. The remainder is  $-1$ .

Therefore,  $(2x^2 + 9x + 8) \div (x + 3) = 2x + 3 + \frac{-1}{x+3}$ .

Find each quotient.

1.  $(6x - 3) \div (2x - 1)$
2.  $(x^2 - 2x + 1) \div (x - 1)$  *see notes*
3.  $(x^2 + 5x + 4) \div (x + 4)$
4.  $(2x^2 - 4x) \div (x - 2)$
5.  $(5r^3 - 15r^2) \div (r - 3)$  *see notes*
6.  $(a^2 + 6a + 5) \div (a + 5)$
7.  $(2a^2 - 5a - 3) \div (2a + 1)$
8.  $(6x^2 - 2x + 5) \div (x + 1)$

$$2) \quad (x^2 - 2x + 1) \div (x - 1)$$

$$\begin{array}{r} x \\ x-1 \overline{) x^2 - 2x + 1} \\ \underline{-x^2 + 1x} \phantom{+ 1} \\ 0x^2 - 1x + 1 \\ \underline{+1x - 1} \\ 0x + 0 \end{array}$$

$$(x-1)(x-1)$$

$$\begin{array}{r} x^2 + -1x + -1x + 1 \\ x^2 + -2x + 1 \end{array}$$

$$(x-1)^2$$

$$x^2 - 2x + 1$$

$$5) \quad (5r^3 - 15r^2) \div (r - 3)$$

$$\begin{array}{r} +5r^2 \\ (r-3) \overline{) 5r^3 - 15r^2} \\ \underline{+5r^3 - 15r^2} \\ 0r^3 + 0r^2 \end{array}$$

$$5r^2(r-3)$$

$$5r^3 - 15r^2$$

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**Practice**

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**Dividing Polynomials**

Find each quotient.

<p>1. <math>(4x - 2) \div (2x - 1)</math></p> <p>3. <math>(9a^2 + 6a) \div (3a + 2)</math></p> <p>5. <math>(x^2 - 9x + 18) \div (x - 6)</math></p> <p>7. <math>(y^2 + 4y + 4) \div (y + 2)</math></p> <p>9. <math>(b^2 + 11b + 30) \div (b + 4)</math></p> <p>11. <math>(r^2 - 4) \div (r + 3)</math></p> <p>13. <math>(3n^2 - 11n + 8) \div (n - 3)</math></p> <p>15. <math>(s^3 - 1) \div (s - 1)</math></p> <p>17. <math>(m^3 - 9) \div (m - 2)</math> <i>see notes</i></p>	<p>2. <math>(y^2 + 5y) \div (y + 5)</math></p> <p>4. <math>(8n^3 - 4n^2) \div (4n - 2)</math></p> <p>6. <math>(b^2 - b - 20) \div (b - 5)</math> <i>see notes</i></p> <p>8. <math>(m^2 - 5m - 6) \div (m + 1)</math> <i>see notes</i></p> <p>10. <math>(x^2 - 6x + 9) \div (x - 2)</math> <i>see notes</i></p> <p>12. <math>(4x^2 + 6x + 5) \div (2x - 2)</math></p> <p>14. <math>(6y^2 + 5y - 3) \div (3y + 1)</math></p> <p>16. <math>(a^3 + 4a + 16) \div (a + 2)</math> <i>see notes</i></p> <p>18. <math>(x^3 - 7x - 8) \div (x + 1)</math> <i>see notes</i></p>
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Algebra: Concepts and Applications

6)

$$\begin{array}{r}
 \phantom{b+5} \times \overline{) (b+4)} \\
 b+5 \overline{) b^2 + b + 20} \\
 \underline{+ b^2 + 5b} \phantom{+ 20} \\
 0b^2 + 4b + 20 \\
 \underline{+ 4b + 20} \\
 0b + 0
 \end{array}$$

↓

$(b-5)(b+4)$   
 $b^2 + -1b - 20$

8)

$$\begin{array}{r}
 m+6 \\
 m+1 \overline{) m^2 + 5m + 6} \\
 \underline{+ m^2 + 1m} \quad \downarrow \\
 0m^2 + -6m + -6 \\
 \underline{+ +6m + +6} \\
 0m + 0
 \end{array}$$

10)

$$\begin{array}{r}
 x + -4 + \frac{1}{(x-2)} \\
 (x+2) \overline{) x^2 + -6x + 9} \\
 \underline{+ -x^2 + +2x} \quad \downarrow \\
 0x^2 + -4x + 9 \\
 \underline{+ +4x + -8} \\
 0x + 1
 \end{array}$$

16)

$$\begin{array}{r}
 \phantom{+1A+2} \times (A^2 + -2A + 8) \\
 \hline
 +1A+2 \left| \begin{array}{l} 1A^3 + 0A^2 + 4A^1 + 16 \\
 + -A^3 + -2A^2 \\
 \hline
 0A^3 + -2A^2 + 4A \\
 + \phantom{0A^3} + 2A^2 + +4A \\
 \hline
 0A^2 + 8A + 16 \\
 + \phantom{0A^2} - 8A + 16 \\
 \hline
 0A + 0 \end{array} \right.
 \end{array}$$

17)

$$\begin{array}{r}
 \phantom{(m+2)} m^2 + 2m + 4 + \frac{-1}{(m-2)} \\
 \hline
 (m+2) \left| \begin{array}{l} m^3 + 0m^2 + 0m^1 + -9 \\
 + -m^3 + +2m^2 \\
 \hline
 0m^3 + 2m^2 + 0m \\
 + -2m^2 + +4m \\
 \hline
 0m^2 + 4m + -9 \\
 + -4m + +8 \\
 \hline
 -1 \end{array} \right.
 \end{array}$$

18)

$$\begin{array}{r}
 x^2 + -1x + -6 + \frac{-2}{(x+1)} \\
 \hline
 x + 1 \overline{) x^3 + 0x^2 + 7x + 8} \\
 \underline{+ x^3 + x^2} \phantom{+ 7x + 8} \\
 0x^3 + -1x^2 + -7x \phantom{+ 8} \\
 \underline{+ +1x^2 + +1x} \phantom{+ 8} \\
 0x^2 + -6x + -8 \phantom{+ 8} \\
 \underline{+ +6x + +6} \\
 0x + -2
 \end{array}$$

**15-4**

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**Combining Rational Expressions with Like Denominators**

You know that to add or subtract fractions with like denominators, you add or subtract the numerators and then write the sum or difference over the common denominator. For example, the sum of  $\frac{1}{5}$  and  $\frac{3}{5}$  is  $\frac{4}{5}$ . Use this same method to add or subtract rational expressions with like denominators.

**Examples:** Find each sum or difference. Express the answer in simplest form.

a.  $\frac{a}{5} + \frac{3a}{5} = \frac{a+3a}{5}$  *The common denominator is 5.*  
 $= \frac{4a}{5}$   
*Add the numerators.*

b.  $\frac{8}{5m} - \frac{3}{5m} = \frac{5}{5m}$  *The common denominator is 5m.*  
 $= \frac{1}{m}$   
*Subtract the numerators.*  
*Divide by the GCF, 5.*

c.  $\frac{c}{c-1} + \frac{c-2}{c-1} = \frac{c+c-2}{c-1}$  *The common denominator is c-1.*  
 $= \frac{2c-2}{c-1}$  *Add the numerators.*  
 $= \frac{2(c-1)}{c-1}$  *Factor the numerator.*  
 $= 2$  *Divide by the GCF, c-1.*

Find each sum or difference. Write in simplest form.

1.  $\frac{6}{m} - \frac{2}{m} = \frac{4}{m}$       2.  $\frac{4}{3x} + \frac{2}{3x} = \frac{6}{3x} = \frac{2}{x}$       3.  $\frac{f}{8} + \frac{7f}{8} = \frac{8f}{8} = f$

4.  $\frac{6t}{13} - \frac{5t}{13}$       5.  $\frac{18}{25r} - \frac{3}{25r}$       6.  $\frac{9x}{10} + \frac{x}{10}$

7.  $\frac{8}{6n} + \frac{-2}{6n}$       8.  $\frac{1}{x-2} + \frac{3}{x-2}$       9.  $\frac{8}{y+1} - \frac{1}{y+1}$

10.  $\frac{b}{b-1} - \frac{1}{b-1} = \frac{b-1}{b-1} = 1$       11.  $\frac{v}{v+2} - \frac{v}{v+2}$       12.  $\frac{h}{h+4} + \frac{h+8}{h+4}$

$\frac{h+h+8}{h+4} = \frac{2h+8}{h+4}$

$\frac{2(h+4)}{(h+4)} = \frac{2}{1} = 2$



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### 15-4 Practice

**Combining Rational Expressions with Like Denominators**

Find each sum or difference. Write in simplest form.

1.  $\frac{8}{n} + \frac{4}{n}$
2.  $\frac{3x}{9} + \frac{4x}{9}$
3.  $\frac{7}{2k} - \frac{5}{2k}$
4.  $\frac{6n}{n} - \frac{3n}{n}$
5.  $\frac{-5a}{2} + \frac{4a}{2}$
6.  $\frac{2y}{3} + \frac{y}{3}$
7.  $\frac{9x}{11} - \frac{8x}{11}$
8.  $\frac{6p}{5} - \frac{p}{5}$
9.  $\frac{9}{16q} + \frac{3}{16q}$
10.  $\frac{4t}{9} - \frac{t}{9}$
11.  $\frac{1}{4m} - \frac{3}{4m}$
12.  $\frac{-2}{10x} + \frac{3}{10x}$
13.  $\frac{6s}{7} + \frac{8s}{7}$
14.  $\frac{8}{3y} - \frac{2}{3y}$
15.  $\frac{4}{x-7} - \frac{2}{x-7}$
16.  $\frac{-2}{x+3} + \frac{3}{x+3}$
17.  $\frac{5}{y-4} - \frac{9}{y-4}$
18.  $\frac{3m}{m+2} - \frac{m}{m+2}$
19.  $\frac{3n}{n-1} + \frac{2}{n-1} = \frac{3n+2}{n-1}$
20.  $\frac{5a}{a+4} - \frac{7}{a+4}$
21.  $\frac{4g}{g+3} + \frac{12}{g+3}$
22.  $\frac{2r+2}{r-5} - \frac{r-4}{r-5}$
23.  $\frac{s-3}{s+1} + \frac{4s+8}{s+1}$
24.  $\frac{-11b}{5b+3} + \frac{12b-2}{5b+3}$
25.  $\frac{15y}{4y-2} - \frac{3y+6}{4y-2}$
26.  $\frac{5c+3}{2c+1} + \frac{9c+4}{2c+1}$
27.  $\frac{2x+3}{3x+4} - \frac{8x+11}{3x+4}$

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$$\frac{(2x+3) + (8x+11)}{3x+4}$$

$$\frac{10x+14}{3x+4}$$

$$\frac{2(5x+7)}{3x+4}$$

$$\frac{10x+14}{3x+4} - \frac{2(3x+4)}{3x+4} = \frac{-2}{1} = -2$$

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### 15-5 Study Guide

**Combining Rational Expressions with Unlike Denominators**

You add  $\frac{1}{5}$  and  $\frac{3}{4}$  by first finding the common denominator, 20.

Likewise, to add or subtract rational expressions with unlike denominators, first rename the expressions so the denominators are alike. Then add or subtract the numerators and write the sum or difference over the common denominator. Simplify if necessary. The least common denominator (LCD) may make the computations easier.

**Example:** Find  $\frac{3}{4a^2} + \frac{5}{2a}$ .

**Step 1** First find the LCD.  
 $4a^2 = 2 \cdot 2 \cdot a \cdot a$   
 $2a = 2 \cdot a$   
 The LCD is  $4a^2$ .

**Step 2** Rename each expression with the LCD as denominator.  
 The denominator of  $\frac{3}{4a^2}$  is already  $4a^2$ , so only  $\frac{5}{2a}$  needs to be renamed.  
 $\frac{5}{2a} = \frac{5}{2a} \cdot \frac{2a}{2a} = \frac{10a}{4a^2}$

**Step 3** Add.  
 $\frac{3}{4a^2} + \frac{5}{2a} = \frac{3}{4a^2} + \frac{10a}{4a^2}$   
 $= \frac{3+10a}{4a^2}$       *The expression is in simplest form.*

Find each sum or difference. Write in simplest form.

1.  $\frac{x}{6} + \frac{x}{12} = \frac{2x+x}{12} = \frac{3x}{12} = \frac{x}{4}$
2.  $\frac{f}{8} - \frac{f}{16}$
3.  $\frac{d}{6} + \frac{d}{3}$
4.  $\frac{4}{x} - \frac{6}{2x}$
5.  $\frac{3d}{4} - \frac{d}{8}$
6.  $\frac{3x}{m} - \frac{1}{2m}$
7.  $\frac{3}{m} - \frac{4}{m^2}$
8.  $\frac{6}{x} + \frac{4}{x^2}$
9.  $\frac{3}{4y^2} + \frac{1}{8y}$
10.  $\frac{1}{x} + \frac{1}{y} = \frac{y+x}{xy}$
11.  $\frac{2a}{a} - \frac{1}{b^2}$       *see notes*
12.  $\frac{3}{2n} + \frac{2t}{4n^2}$

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11)  $\frac{2c \cdot B^2}{A \cdot B^2} - \frac{4 \cdot A}{B^2 \cdot A}$

$\frac{2B^2c}{AB^2} - \frac{4A}{AB^2}$

$\frac{2B^2c - 4A}{AB^2}$

$\frac{2(B^2c - 2A)}{AB^2}$

Handwritten note:  $\frac{A \cdot B^2}{A \cdot B^2} = LCD = AB^2$

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**Combining Rational Expressions with Unlike Denominators**

Find the LCM for each pair of expressions.

- $4ab, 18b$
- $6x^2y, 9xy$
- $10a^2, 12ab^2$
- $y + 2, y^2 - 4$
- $x^2 - 9, x^2 + 5x + 6$   
see notes
- $x^2 - 3x - 4, 2x^2 - 2x - 4$

Write each pair of expressions with the same LCD.

- $\frac{4}{b}, \frac{5}{ab}$   $\frac{4 \cdot Ab}{b \cdot Ab} = \frac{4Ab}{Ab}$
- $\frac{5}{6a^2}, \frac{3}{8c}$
- $\frac{6}{7x^2y}, \frac{4}{5xy}$
- $\frac{3}{r+4}, \frac{7}{2r+8}$
- $\frac{x}{x-2}, \frac{x+1}{x-6}$
- $\frac{3}{y-4}, \frac{2y}{y^2-16}$

Find each sum or difference. Write in simplest form.

- $\frac{2k}{8} + \frac{3k}{16}$
- $\frac{n}{2} - \frac{n}{7}$
- $\frac{7}{3b} - \frac{3}{b}$
- $\frac{5}{x} + \frac{3}{y}$
- $\frac{2}{m^2n} - \frac{6}{mn}$
- $\frac{c}{4c} + \frac{8}{c}$
- $\frac{1}{6a} - \frac{2}{9a^2}$
- $\frac{2}{3ab} + \frac{3b}{4ab}$
- $\frac{p}{4p^2q} + \frac{3}{5pq}$
- $\frac{2x}{3xy^2} - \frac{2}{5xy}$
- $\frac{2s}{s^2-4} + \frac{4}{s+2}$
- $\frac{b}{b^2-9} - \frac{5}{b-3}$   
see notes
- $\frac{-5}{2r+3} + \frac{7}{6r+9}$
- $\frac{6}{y+2} + \frac{3}{y}$
- $\frac{x}{x-3} - \frac{2}{x-4}$

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5)

$$\begin{array}{cc}
 x^2 - 9 & x^2 + 5x + 6 \\
 (x+3)(x-3) & (x+2)(x+3)
 \end{array}$$

Arrows point from the  $(x+3)$  factors of both expressions to a box containing:

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

24)

$$\frac{b \cdot 1}{b^2 - 9} - \frac{5(b+3)}{(b-3)(b+3)} \quad \frac{b^2 - 9}{(b+3)(b-3)} (b-3)$$

$$\frac{b}{(b+3)(b-3)} - \frac{5b+15}{(b+3)(b-3)}$$

$$\frac{b + 5b + 15}{(b+3)(b-3)} = \frac{-4b + 15}{(b+3)(b-3)}$$

$$= \frac{-1(4b+15)}{(b+3)(b-3)}$$

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### Solving Rational Equations

A rational equation is an equation that contains at least one rational expression. There are three steps in solving rational equations.

**Step 1** Find the LCD of all terms.

**Step 2** Multiply each side of the equation by the LCD.

**Step 3** Use the Distributive Property to simplify.

**Example:** Solve  $\frac{3}{5x} + \frac{2}{x} = \frac{1}{5}$ .

$$\frac{3}{5x} + \frac{2}{x} = \frac{1}{5} \quad \text{The LCD is } 5x.$$

$$5x\left(\frac{3}{5x} + \frac{2}{x}\right) = 5x\left(\frac{1}{5}\right) \quad \text{Multiply each side by the LCD.}$$

$$5x\left(\frac{3}{5x}\right) + 5x\left(\frac{2}{x}\right) = 5x\left(\frac{1}{5}\right) \quad \text{Distributive Property}$$

$$5x\left(\frac{3}{\cancel{5x}^1}\right) + 5x\left(\frac{2}{\cancel{x}^1}\right) = \cancel{5x}\left(\frac{1}{\cancel{5}^1}\right)$$

$$3 + 10 = x \quad \text{Simplify.}$$

$$13 = x$$

**Check:**  $\frac{3}{5x} + \frac{2}{x} = \frac{1}{5}$

$$\frac{3}{5(13)} + \frac{2}{13} \stackrel{?}{=} \frac{1}{5}$$

$$\frac{3}{65} + \frac{2}{13} \stackrel{?}{=} \frac{1}{5}$$

$$\frac{3}{65} + \frac{10}{65} \stackrel{?}{=} \frac{13}{65}$$

$$\frac{13}{65} = \frac{13}{65} \checkmark$$

**The LCD is 65.**

**Solve each equation. Check your solution.**

1. $\frac{x}{6} + \frac{x}{12} = \frac{1}{2}$ <i>see notes</i>	2. $\frac{3x}{8} - \frac{x}{4} = \frac{1}{4}$	3. $\frac{y}{3} + \frac{2y}{5} = \frac{11}{3}$
4. $\frac{9y}{10} - \frac{y}{2} = \frac{2}{5}$	5. $\frac{3d}{4} - \frac{d}{8} = \frac{5}{16}$	6. $\frac{x}{4} = \frac{x+2}{8}$ <i>see notes</i>
7. $\frac{t-4}{6} = \frac{t+1}{8}$ <i>see notes</i>	8. $\frac{x+1}{x} + \frac{x-2}{x} = 4$ <i>see notes</i>	9. $\frac{8}{4-s} - \frac{s}{4-s} = 2$
10. $\frac{x}{8} - \frac{x}{4} = \frac{x-1}{2}$	11. $\frac{m+2}{m} - \frac{m-1}{m} = 3$	12. $\frac{1}{4s} - \frac{3}{2s} = \frac{1}{8}$

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1)  $\frac{x \cdot 2}{6 \cdot 2} + \frac{x \cdot 1}{12 \cdot 1} = \frac{1 \cdot 6}{2 \cdot 6}$

$$\frac{2x}{12} + \frac{x}{12} = \frac{6}{12}$$

$$2x + x = 6$$

$$\frac{3x}{3} = \frac{6}{3}$$

$$x = 2$$

$$\frac{6 \cdot 6}{1 \cdot 2} = 12$$

$$\frac{2 \cdot 12}{6 \cdot 1} = 12 \quad \text{LCD}$$



$$8) \quad \frac{(x+1) \cdot 1}{x \cdot 1} + \frac{(x-2) \cdot 1}{x \cdot 1} = \frac{4 \cdot x}{1 \cdot x}$$

$$\frac{x+1}{x} + \frac{x-2}{x} = \frac{4x}{x}$$

$$(x+1) + (x-2) = 4x$$

$$x+1 + x-2 = 4x$$

$$\begin{array}{r} \cancel{2x} + -1 = 4x \\ + \cancel{-2x} \quad \quad = +\cancel{-2x} \end{array}$$

$$\frac{-1}{2} = \cancel{2x}$$

$$\begin{array}{l} -\frac{1}{2} = x \\ \textcircled{x = -\frac{1}{2}} \end{array}$$

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**Solving Rational Equations**  
 Solve each equation. Check your solution.

- $\frac{c}{2} + \frac{c}{2} = \frac{1}{2}$
- $\frac{3b}{5} - \frac{1}{5} = \frac{b}{5}$
- $\frac{8}{a} = \frac{12}{a} + 5$
- $\frac{7}{b} - 2 = \frac{3}{b}$
- $\frac{7}{9t} - \frac{5}{6t} = \frac{1}{3}$
- $\frac{4}{5x} + \frac{1}{4x} = \frac{3}{4}$
- $\frac{3x}{4} - \frac{2x}{3} = \frac{1}{4}$
- $\frac{s+7}{6} - 2 = \frac{s}{4}$
- $\frac{n-3}{2} = \frac{n}{5} + 3$
- $\frac{y+6}{3} - \frac{y+12}{7} = 2$
- $\frac{11}{p-2} - \frac{9}{p-2} = -8$
- $\frac{x+5}{2x} + \frac{x+8}{3x} = \frac{1}{3}$
- $\frac{2}{n} - \frac{3}{n+1} = \frac{3}{n+1}$
- $\frac{6}{y-3} - \frac{5}{y} = \frac{3}{y}$
- $\frac{6}{s} + \frac{3s}{s-2} - 2 = 1$
- $\frac{5}{k} + \frac{k-2}{k+1} = 1$
- $\frac{r+2}{r} - \frac{r+2}{r-5} = -\frac{3}{r-5}$
- $\frac{2c}{c+3} - \frac{4}{2c+6} = 4$
- $\frac{3b}{b+2} + \frac{3}{3b+6} = 2$
- $\frac{2m}{m+3} - \frac{4}{m-3} = 2$
- $\frac{y}{y+2} + \frac{8}{y-2} = \frac{y}{y-2}$

see notes

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$$1. \quad \frac{C}{2} + \frac{C}{2} = \frac{1}{2} \quad \frac{2C}{2} = \frac{1}{2}$$

$$C = \frac{1}{2}$$

# 8

$$\frac{5+7 \cdot 2}{6 \cdot 2} - \frac{2 \cdot 12}{1 \cdot 12} = \frac{5 \cdot 3}{4 \cdot 3}$$

$$\frac{25+14}{12} - \frac{+24}{12} = \frac{35}{12}$$

$$\frac{25}{12} + \frac{-10}{12} = \frac{35}{12}$$

$$\frac{-75}{12} - \frac{-10}{12} = \frac{35}{12}$$

$$5 = -10$$

$$20) \quad \frac{2m(m-3)}{(m+3)(m-3)} - \frac{4(m+3)}{(m-3)(m+3)} = \frac{2(m+3)(m-3)}{1(m+3)(m-3)} \cdot \frac{1}{(m+3)(m-3)}$$

$$\frac{2m(m-3)}{(m+3)(m-3)} - \frac{4(m+3)}{(m+3)(m-3)} = \frac{2(m+3)(m-3)}{(m+3)(m-3)}$$

$$2m(m-3) + 4(m+3) = 2(m+3)(m-3)$$

$$2m^2 + -6m + -4m + -12 = 2(m^2 + 3m + 3m + -9)$$

$$2m^2 + -6m + -4m + -12 = 2m^2 + -6m + 6m + -18$$

$$\cancel{2m^2} + -10m + -12 = \cancel{2m^2} + -18$$

$$\cancel{-10m} + \cancel{-12} = -18$$

$$+12 = +12$$

$$\cancel{-10m} = \frac{-6}{-10}$$

$$\cancel{-6} \quad m = \frac{3}{5} \text{ or } 0.6$$



