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so multiplying a fraction by x has the same effect as multiplying the numerator of the fraction by x.

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Addition

Case 1: Same Denominator:

To add two fractions with the same denominator, *add the numerators together*, i.e.,

$$\frac{a}{h} + \frac{b}{h} = \frac{a+b}{h}$$

(Consider: two-sixths of a pizza plus one-sixth of a pizza equals three-sixths, or one-half of a pizza.)

Case 2: Different Denominators:

For fractions with different denominators, say $\frac{a}{b}$ and $\frac{c}{d}$, we must first alter the fractions to have a **common denominator**, say $h = bd$. We do this by multiplications by 1, where we write 1 as an appropriate fraction:

$$\frac{a}{b} + \frac{c}{d} =$$

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We have thus derived the basic addition formula:

$$\frac{a}{b} + \frac{c}{d} = \frac{ad + bc}{bd}$$

The formula is easily remembered as “cross-multiplication”:

$$\frac{a}{b} \bowtie \frac{c}{d} \rightarrow \frac{ad + bc}{bd}$$

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which would normally be done with fewer steps displayed:

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and this only works if we know that 7 is a common factor of 1197 and 980. Not many of us have this information at our finger tips!

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$$\frac{a}{b}-\frac{c}{d}=\frac{a}{b}+\frac{-c}{d}=\frac{ad+b(-c)}{bd}=\frac{ad-bc}{bd},$$

so we have the subtraction formula $\frac{a}{b}-\frac{c}{d}=\frac{ad-bc}{bd}$

Example 9:

$$\frac{5}{7}-\frac{3}{4}=\frac{5}{7}+\frac{-3}{4}=\frac{5(4)+7(-3)}{7(4)}=\frac{20-21}{28}=-\frac{1}{28}$$

Factorization can again be used to simplify subtraction calculations:

Example 10:

$$\frac{5}{12}-\frac{3}{28}=\frac{5}{3(4)}-\frac{3}{4(7)}=\frac{1}{4}\left(\frac{5}{3}-\frac{3}{7}\right)=\frac{1}{4}\left(\frac{5(7)-3(3)}{3(7)}\right)=$$

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Division

To divide $\frac{a}{b}$ by $\frac{c}{d}$, we remember that $\frac{c}{d} \cdot \frac{d}{c} = \frac{cd}{cd} = 1$,

and multiply by 1 in a special form:

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Example 11: $\frac{\frac{2}{3}}{\frac{5}{4}} = \left(\frac{2}{3}\right)\left(\frac{4}{5}\right) = \frac{8}{15}$

Example 12: $\frac{\frac{2}{3} + \frac{4}{7}}{\frac{5}{7} + \frac{3}{4}} =$

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Example 12: $\frac{\frac{2}{3} + \frac{4}{7}}{\frac{5}{7} + \frac{3}{4}} = \frac{\frac{14+12}{21}}{\frac{20+21}{28}} =$

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To divide $\frac{a}{b}$ by $\frac{c}{d}$, we remember that $\frac{c}{d} \cdot \frac{d}{c} = \frac{cd}{cd} = 1$,

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Our basic division formula is thus

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Thus, to simplify the quotient of two fractions, we multiply numerator by the inverse of the denominator," i.e.,

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Be careful not to confuse what is divided by what: the expression $\frac{\frac{a}{b}}{c}$ is ambiguous:

Does it mean: $\frac{\left(\frac{a}{b}\right)}{c}$ or $\frac{a}{\left(\frac{b}{c}\right)}$?

These two expressions mean very different things:

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and

$$\frac{a}{\left(\frac{b}{c}\right)} =$$

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$$\frac{a}{\left(\frac{b}{c}\right)} = \frac{\left(\frac{a}{1}\right)}{\left(\frac{b}{c}\right)} =$$

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and

$$\frac{a}{\left(\frac{b}{c}\right)} = \frac{\left(\frac{a}{1}\right)}{\left(\frac{b}{c}\right)} = \left(\frac{a}{1}\right)\left(\frac{c}{b}\right) = \frac{ac}{b}$$

Example 13:

$$\frac{\left(\frac{1}{2}\right)}{3} =$$

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Example 14:

$$\frac{1}{\left(\frac{2}{3}\right)} =$$

Example 13:

$$\frac{\left(\frac{1}{2}\right)}{3} = \left(\frac{1}{2}\right)\left(\frac{1}{3}\right) = \frac{1}{6}$$ (Remember that pizza?)

Example 14: $$\frac{1}{\left(\frac{2}{3}\right)} = \frac{3}{2}$$