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Long Division w/ Polynomials

Use this guide to help you with the process of dividing a linear expression into a polynomial with a higher degree. We will utilize the [**Divide – Distribute – Subtract – Drop**] technique.
Given $f(x) = x^3 + 3x^2 - 10x - 24; f(-2) = 0$

- Go through our factoring strategies first. Look for GCF's, # of terms, check to see if we can factor in another way before we take the polynomial long division route.

- Given $f(-2) = 0$, we write this as a linear expression and we know $(x + 2)$ is a factor of the polynomial.

$x+2\overline{)x^3+3x^2-10x-24}$	**Step 1**: Make sure the polynomial is written in standard form (exponents are in descending order). If any terms are missing, use a zero to fill in the missing term (this will help with the spacing). In this case, the problem is ready as is.
$\begin{array}{r} x^2 \\ x+2\overline{)x^3+3x^2-10x-24} \end{array}$	**Step 2**: <u>Divide</u> the term with the highest power inside the division symbol by the term with the highest power outside the division symbol. In this case, we have x^3 divided by x which is x^2.
$\begin{array}{r} x^2 \\ x+2\overline{)x^3+3x^2-10x-24} \\ \underline{-(x^3+2x^2)} \end{array}$	**Step 3**: <u>Distribute</u> (or multiply) the answer obtained in the previous step by the polynomial in front of the division symbol. In this case, we need to multiply x^2 and x + 2.
$\begin{array}{r} x^2 \\ x+2\overline{)x^3+3x^2-10x-24} \\ \underline{-(x^3+2x^2)} \\ 1x^2-10x \end{array}$	**Step 4**: <u>Subtract</u> and <u>drop</u> down the next term.
$\begin{array}{r} x^2+x \\ x+2\overline{)x^3+3x^2-10x-24} \\ \underline{-(x^3+2x^2)} \\ 1x^2-10x \end{array}$	**Step 5**: <u>Divide</u> the term with the highest power after the subtraction by the term with the highest power outside the division symbol. In this case, we have $1x^2$ divided by x which is x.

$x^2 + x$ $x+2 \overline{) x^3 + 3x^2 - 10x - 24}$ $\underline{- (x^3 + 2x^2)}$ $1x^2 - 10x$ $\underline{- (1x^2 + 2x)}$	**Step 6**: Distribute (or multiply) the answer obtained in the previous step by the polynomial in front of the division symbol. In this case, we need to multiply x and x + 2.
$x^2 + x$ $x+2 \overline{) x^3 + 3x^2 - 10x - 24}$ $\underline{- (x^3 + 2x^2)}$ $1x^2 - 10x$ $\underline{- (1x^2 + 2x)}$ $-12x - 24$	**Step 7**: Subtract and drop down the next term.
$x^2 + x - 12$ $x+2 \overline{) x^3 + 3x^2 - 10x - 24}$ $\underline{- (x^3 + 2x^2)}$ $1x^2 - 10x$ $\underline{- (1x^2 + 2x)}$ $-12x - 24$	**Step 8**: Divide the term with the highest power after the subtraction by the term with the highest power outside the division symbol. In this case, we have -12x divided by x which is -12.
$x^2 + x - 12$ $x+2 \overline{) x^3 + 3x^2 - 10x - 24}$ $\underline{- (x^3 + 2x^2)}$ $1x^2 - 10x$ $\underline{- (1x^2 + 2x)}$ $-12x - 24$ $\underline{- (12x - 24)}$ 0	**Step 9**: Distribute (or multiply) the answer obtained in the previous step by the polynomial in front of the division symbol. In this case, we need to multiply -12 and x + 2. **Step 10**: Subtract and notice a remainder of zero and there are no more terms to drop down.

We now have $x^3 + 3x^2 - 10x - 24 = (x+2)(x^2 + x - 12)$.
Since the remaining polynomial is a quadratic with 3 terms, we can factor and find the linear factors (not always possible).

$$x^3 + 3x^2 - 10x - 24 = (x+2)(x^2 + x - 12) = \boldsymbol{(x+2)(x-3)(x+4)}.$$