Name:	Date: Period:
4.8 Factoring Polynomials (3+ Degre	
Engage: Cubic Identities	
1. What is the volume of a cube with side length	n equal to 4? 43 = 64
2. What is the volume of a cube with side length	
b. Now use the distributive property to n simplify your answer.	to find the area of the base of the cube. $= X^{2} + 2 \cdot x \cdot 4 + 4^{2} = X^{2} + 8x + 16$ of PST nultiply the area of the base by the height $(x + 4)$ and
$(x+4)(x^2+8x+16) = x$	3+8x2+16x+4x2+32x+64
= X	$3+12x^2+48x+64$
4. What is the volume of a cube with side length determine this.	the equal to $x + y$? Use the same steps as in Step 3 to $+ 3x^2y + 3xy^2 + y^3$
5. So the identify for a binomial cube is: $(x + y)$	$^{3} = X^{3} + 3x^{2}y + 3xy^{2} + y^{3}$
6. Determine the following identity: $(x - y)$ Explain or show how you came up with	$^{3} = \frac{\chi^{3} - 3\chi^{2} + 3\chi u^{2} - u^{3}}{4 + 3\chi u^{2} - u^{3}}$
	$3 - 3x^2y + 3xy^2 - y^3$
	equivalent to the sum of two cubes by exploring the
following expressions: a. Simplify $(x + 2)^3$. b.	Simplify $x^3 + 2^3$
$x^3 + 3x^2 \cdot 2 + 3x \cdot (2)^2 + 2^3$	[x3,0]
$x^3 + 6x^2 + 12x + 8$	
c. Is your answer to part a equivalent to	your answer in part b? NO
d. Simplify $(x + 2)(x^2 - 2x + 4) = x^3$	-2x2+4x+2x2-4x+8
\times_3	+8
e. Is your answer to part b equivalent to	your answer in part d? <u>Yes</u>

f. Your answers to part b and d should be equivalent. They illustrate two more commonly used polynomial identities:

The Sum of Cubes (SOC): $a^3 + b^3 = (a + b)(a^2 - ab + b^2)$

The Sum of Cubes (SOC): $a^3 + b^3 = (a+b)(a^2 - ab + b^2)$ The Difference of Cubes (DOC): $a^3 - b^3 = (a-b)(a^2 + ab + b^2)$ SAME OPPOSITE (AWAYS)

	Difference of Cubes (DOC)		St	teps & Notes	Sum of Cubes (SOC)			
	$a^3 - b^3 = (a - b)(a^2 - b^2)$				a^3+b^3	=(a+b)(a+b)	$a^2 - ab + b^2)$	(
	1. $x^3 - 8$	Perfect	Cube	1) Factor out the GCF, if any.	3. $27x^3 +$	- 1		
34	1x3 18	Cube	Root	GOF, II arry.	\$27x3	3 1		
Ť		1 1	1	2) Find the cube	3x	1		
13	X 2	8	2	root of the first term and the cube root	a b	7 2		
	$(x-2)(x^2+x\cdot 2+2^3)$	27	3	of the last term.	(3x+1)	$((3x)^2 -$	3x·1 +12)	
1	$(x-2)(x^2+2x+4)$	64	4		((3x+1)	(9x2-3)	1(1+)	
	2. $2000x^3 - 686$	125	. 5	2) Substitute cube roots into the	4. 512x3	$\pm 125v^3$	y y	
	QCF:3	216	6	formulas to the left.				
	2(1000x3-343)	343	7	Pay attention to the	₹512x3			-
	· •	512	8	signs. SOP.	8x	5y		
_	\$ 1000 x3 \$ 343	729	9	Be sure to simplify the squares, if	***************************************		313 37	
7	10x +7.4 x		10	necessary.	(8x+5	1)(64x2-	-40xy+25	v2)
	2(10x-7)(100x2+70x	1000		3	Commence of the last			
D	-ciox-valcox i iox	777/	11.4	XXIII				
	1 19 19				2			
1	Disc		(0.00	· · · · · · · · · · · · · · · · · · ·				4
	Difference of	of Square) and Sum of So		OS) Revis	ited	113 12 1
	1) 8			$^2 = (a+b)(a-b)$			X	
	12	19 7 BX	$a^2 + b^2$	= (a + bi)(a - b)	i) 4- ONL	FOR QUE	DE ATTCE	
	5. $3x^4 - 3$	When to Use: Look		to Use: Look for	6. $36x^4$ -	$-25v^2$	PERIO	\dashv
			perfec	ct squares minus or	0.00%	All Alleria	Wall W	
	100.3			ot squares minus or	The second secon			
	gof:3		plus p	erfect squares.	J36x4	125u2		
	Y		plus p Reme	perfect squares. ember variables with	136x4	V25y2		
	3 (x4-1)	F+ NX	plus p Reme even	perfect squares. ember variables with exponents are all	36x4 6x2	$\sqrt{25y^2}$ $5y$		-
	Y	3 + WX	plus p Reme even	perfect squares. ember variables with	6X2	5y"	· ·	
	3 (x4-1) 	:	plus p Reme even o perfec	perfect squares. ember variables with exponents are all	6X2	5y"	-5u) [
	3 (x4-1) 	12, 1	plus p Reme even o perfect	perfect squares. ember variables with exponents are all ct squares. es check for GCF 1st.	6x ² +		-5y)	
	3 (x4-1)	X 1 1×3 1	plus p Reme even of perfect Alway Be ca	perfect squares. Ember variables with exponents are all ct squares. Ex check for GCF 1st. Exercial using the sum of	6x ² +	5y"	-5y)	
	3 (x ⁴ -1) 	X 1 1× 1	plus p Reme even o perfect Alway Be ca	perfect squares. Ember variables with exponents are all ct squares. It is check for GCF 1st. It is reful using the sum of these formula: this is	6x ² +	5y"	-5y)	
	3 (x4-1) 	1)(×-1) 1×3 1×3	plus p Reme even of perfect Alway Be ca square strictly	perfect squares. Ember variables with exponents are all ct squares. Ex check for GCF 1st. Exercial using the sum of	6x ² +	5y"	-5y)	
	3 (x ⁴ -1) 	1)(x-1) 1×3 1	plus p Reme even of perfect Alway Be ca square strictly expre	perfect squares. Ember variables with exponents are all ct squares. Ex check for GCF 1st. Exercial using the sum of these formula: this is the for quadratic essions.	6x ² +	5y"	-54)	
	3 (x ⁴ -1) 		plus p Reme even o perfect Alway Be ca squar strictly expre	perfect squares. Ember variables with exponents are all ct squares. It should be sum of the sum of	6x ² +	5y"	<u>-54)</u>	
	$ \begin{array}{c cccc} 3 & (x^{4}-1) \\ \hline & x^{2} & 1 \\ 3 & (x^{2}+1) & (x^{2}-1) \\ \hline & 3 & (x+i)(x-i) & (x+i) $		plus p Reme even of perfect Alway Be ca square strictly expre Quac + bx ⁿ +	perfect squares. The squares with exponents are all ct squares. The squares of the squares of the square of the s	$(6x^{2})$ $(6x^{2}+4)$ $(xx^{n}-q)$	5y)(6x ²	-5y)	
	3 (x ⁴ -1) 		Plus p Reme even o perfect Alway Be ca square strictly expre Quac + bx ⁿ + When	perfect squares. Ember variables with exponents are all ct squares. It should be sum of the sum of	$(6x^{2})$ $(6x^{2}+4)$ $(xx^{n}-q)$	5y)(6x ²	-5y) J	
	$3(x^{4}-1)$ x^{2} $3(x^{2}+1)(x^{2}-1)$ $3(x+i)(x-i)(x+1)$ $7. x^{4}-4x^{2}-45$		plus p Reme even o perfect Alway Be ca square strictly expre Quac + bx ⁿ + When expre terms	perfect squares. The exponents are all exponents. The exponents are formula: this is a for quadratic exions. I ratic Form (QF) $\mathbf{c} = (\mathbf{m} \mathbf{x}^{\mathbf{n}} - \mathbf{p})(\mathbf{k} \mathbf{n})$ to Use: A polynomial ssion that has three and one of the terms is a perfect that the exponent is a perfect	$6x^{2}$ $(6x^{2}+$ $9.2x^{6}-$	5y)(6x ²	-54)] 3]-6 ³⁰ /5	
	$3(x^{4}-1)$ $x^{2} = 1$ $3(x^{2}+1)(x^{2}-1)$ $3(x+i)(x-i)(x+1)$ $7. x^{4}-4x^{2}-45$ $(x^{2}-9)(x^{2}+5)$		Plus p Reme even o perfect Alway Be ca square strictly expre Quac + bx ⁿ + When expre terms consti	perfect squares. The ember variables with exponents are all ct squares. The exponents are all ct squares. The exponents are some of the square of the exponent of the exponen	$6x^{2}$ $(6x^{2}+$ $9.2x^{6}-$	5y)(6x ²	3 -6 30 5	
	$3(x^{4}-1)$ $x^{2} = 1$ $3(x^{2}+1)(x^{2}-1)$ $3(x+i)(x-i)(x+1)$ $7. x^{4}-4x^{2}-45$ $(x^{2}-9)(x^{2}+5)$		Plus p Reme even o perfect Alway Be ca square strictly expre Quac + bx ⁿ + When expre terms consta it two	perfect squares. The exponents are all exponents. The exponent is a square of the exponent is a square of the terms is a square of the terms is a square of the exponent times the other	$6x^{2}$ $(6x^{2}+$ $9.2x^{6}-$	5y)(6x ²	3 -6 -30 3 -6 -5	
	$3(x^{4}-1)$ $x^{2} = 1$ $3(x^{2}+1)(x^{2}-1)$ $3(x+i)(x-i)(x+1)$ $7. x^{4}-4x^{2}-45$ $(x^{2}-9)(x^{2}+5)$		Plus p Reme even o perfect Alway Be ca square strictly expre Quac + bx ⁿ + When expre terms consti	perfect squares. The exponents are all exponents. The exponent is a square of the exponent is a square of the terms is a square of the terms is a square of the exponent times the other	$6x^{2}$ $(6x^{2}+$ $9.2x^{6}-$	5y)(6x ²	-54) 3 -6 -30 5 1 -2 -1	2
0	$3(x^{4}-1)$ x^{2} $3(x^{2}+1)(x^{2}-1)$ $3(x+i)(x-i)(x+1)$ $7. x^{4}-4x^{2}-45$ $(x^{2}-9)(x^{2}+5)$ x^{2} y^{2} y^{2} y^{2} y^{2}		Plus p Reme even o perfect Alway Be ca square strictly expre Quac + bx ⁿ + When expre terms consta it two expor	perfect squares. The ember variables with exponents are all ct squares. The exponents are all ct squares. The exponents are all ct squares. The exponent is so that the exponent is a contract of the terms is a contract of the exponent times the other nent.	$6x^{2}$ $(6x^{2}+$ $9.2x^{6}-$	5y)(6x ²	3 -6 30/5	
<u> </u>	$3(x^{4}-1)$ $x^{2} = 1$ $3(x^{2}+1)(x^{2}-1)$ $3(x+i)(x-i)(x+1)$ $7. x^{4} - 4x^{2} - 45$ $(x^{2}-9)(x^{2}+5)$ $\sqrt{x^{2}} = \sqrt{9}$ $x = 3$	ax ²ⁿ - 45/5	Plus p Reme even o perfect Alway Be ca square strictly expre Quac + bx ⁿ + When expre terms consta it two expor	perfect squares. The exponents are all exponents. The exponent is a square of the exponent is a square of the terms is a square of the terms is a square of the exponent times the other	$6x^{2}$ $(6x^{2}+$ $9.2x^{6}-$	5y)(6x ²	3 -6 -30 5	
SEL	$3(x^{4}-1)$ $x^{2} = 1$ $3(x^{2}+1)(x^{2}-1)$ $3(x+i)(x-i)(x+1)$ $7. x^{4} - 4x^{2} - 45$ $(x^{2}-9)(x^{2}+5)$ $\sqrt{x^{2}} = \sqrt{9}$ $x = 3$ $(x+3)(x-3)(x^{2}+1)$	ax ²ⁿ - 45/5	Alway Be ca square strictly expre Quac + bx ⁿ + When expre terms constr it two export	perfect squares. In the squares are all contents are squares. In the squares are all contents are squares. In the squares are all contents are squares. In the squares are all contents are squares are all contents are all contents are all contents are all contents. In the squares are all contents are all contents are all contents are all contents. In the squares are all contents are all contents are all contents are all contents.	$(6x^{2}+6x^{3}-q)$ $(6x^{2}+6x^{3}-3)$ $(x^{3}-3)$	5y)(6x ² x ³ -15 2x ³ +5)	3 -6 -30 5 1 -2 -1	
erms	$3(x^{4}-1)$ $x^{2} = 1$ $3(x^{2}+1)(x^{2}-1)$ $3(x+i)(x-i)(x+1)$ $7. x^{4} - 4x^{2} - 45$ $(x^{2}-9)(x^{2}+5)$ $\sqrt{x^{2}} = \sqrt{9}$ $x = 3$	ax ²ⁿ - 45/5	Plus p Reme even o perfect Alway Be ca square strictly expre Quac + bx ⁿ + When expre terms consta it two export Alway Facto it were	perfect squares. In the expression as if ea quadratic but has been described by the exponents are all content of the exponents are all content of the exponent of the exponent of the exponent of the expression as if ea quadratic but then	$(6x^{2}+6x^{3}-q)$ $(6x^{2}+6x^{3}-3)$ $(x^{3}-3)$	5y)(6x ²	3 -6 30 5 1 -2 -1 5	
	$3(x^{4}-1)$ $x^{2} = 1$ $3(x^{2}+1)(x^{2}-1)$ $3(x+i)(x-i)(x+1)$ $7. x^{4} - 4x^{2} - 45$ $(x^{2}-9)(x^{2}+5)$ $\sqrt{x^{2}} = \sqrt{9}$ $x = 3$ $(x+3)(x-3)(x^{2}+1)$	ax ²ⁿ - 45/5	plus p Reme even o perfect Alway Be ca square strictly expre Quac + bx ⁿ + When expre terms consta it two export Alway Facto it were make	perfect squares. In the expression as if ea quadratic but her the expression as if ea quadratic but her the expression as if ea quadratic but her expression as if ea quadratic but her sure that you have	$(6x^{2}+6x^{3}-q)$ $(6x^{2}+6x^{3}-3)$ $(x^{3}-3)$	5y)(6x ² x ³ -15 2x ³ +5)	3 -6 30/5 1) -2/-1	
	3 (x ⁴ -1) x^2 3 (x^2 +1)(x^2 -1) 3 (x+i)(x-i)(x+ 7. x^4 - 4 x^2 - 45 (x^2 -9)(x^2 +5) $\sqrt{x^2}$ $\sqrt{9}$ x 3 (x+3)(x-3)(x^2 +1 8. 2 x^4 + 34 x^2 + 140 9 Cf: 2	ax ²ⁿ - 45/5	Plus p Reme even o perfect Alway Be ca square strictly expre Quac + bx ⁿ + When expre terms constrict two export Alway Facto it were make the co	perfect squares. In the expression as if e a quadratic but her that you have brief that you have that	$(6x^{2}+6x^{3}-q)$ $(6x^{2}+6x^{3}-3)$ $(x^{3}-3)$	5y)(6x ² x ³ -15 2x ³ +5)	3 -6 30/5 1) -2 -1 5	
	$3(x^{4}-1)$ $x^{2} = 1$ $3(x^{2}+1)(x^{2}-1)$ $3(x+i)(x-i)(x+1)$ $7. x^{4} - 4x^{2} - 45$ $(x^{2}-9)(x^{2}+5)$ $\sqrt{x^{2}} = \sqrt{9}$ $x = 3$ $(x+3)(x-3)(x^{2}+1)$	ax ²ⁿ - 45/5	Plus p Reme even o perfect Alway Be ca square strictly expre Quac + bx ⁿ + When expre terms consta it two export Alway Facto it were make the co export	perfect squares. In the expression as if ea quadratic but here that you have breef to the expression as if ea quadratic but then sure that you have breef to the expression as if ea quadratic but then sure that you have breef to the expression as if ea quadratic but then sure that you have breef to the expression as if ea quadratic but then sure that you have breef to the expression as if ea quadratic but then sure that you have breef to the expression as if each that you have breef to the expression as if each that you have breef to the expression as if each that you have breef to the expression as if each that you have breef to the expression as if each that you have breef to the expression that the expression as if each that you have breef to the expression that the expression as if each that you have breef to the expression that the expression as if each that you have breef that you have breef to the expression that the expression as if each that you have breef that yo	$(6x^{2}+6x^{3}-q)$ $(6x^{2}+6x^{3}-3)$ $(x^{3}-3)$	5y)(6x ² x ³ -15 2x ³ +5)	3 -6 -30/5 1) -2 -1 -10/2	
	3 (x ⁴ -1) x^2 3 (x^2 +1)(x^2 -1) 3 (x+i)(x-i)(x+ 7. x^4 - 4 x^2 - 45 (x^2 -9)(x^2 +5) $\sqrt{x^2}$ $\sqrt{9}$ x 3 (x+3)(x-3)(x^2 +1 8. 2 x^4 + 34 x^2 + 140 9 Cf: 2	ax ²ⁿ - 45/5	Plus p Reme even o perfect Alway Be ca square strictly expre Quac + bx ⁿ + When expre terms consta it two export Alway Facto it were make the co export	perfect squares. In the expression as if e a quadratic but her that you have brief that you have that	$(6x^{2}+6x^{3}-q)$ $(6x^{2}+6x^{3}-3)$ $(x^{3}-3)$	5y)(6x ² x ³ -15 2x ³ +5)	3 -6 -30/5 1 -2 -1 -10/2	
	3 (x ⁴ -1) x^2 3 (x^2 +1)(x^2 -1) 3 (x+i)(x-i)(x+ 7. x^4 - 4 x^2 - 45 (x^2 -9)(x^2 +5) $\sqrt{x^2}$ $\sqrt{9}$ x 3 (x+3)(x-3)(x^2 +1 8. 2 x^4 + 34 x^2 + 140 9 Cf: 2 2 (x^4 +17 x^2 + 70	ax ²ⁿ -45/2	Plus p Reme even o perfect Alway Be ca square strictly expre Quac + bx ⁿ + When expre terms consta it two export Alway Facto it were make the co export	perfect squares. In the expression as if ea quadratic but here that you have breef to the expression as if ea quadratic but then sure that you have breef to the expression as if ea quadratic but then sure that you have breef to the expression as if ea quadratic but then sure that you have breef to the expression as if ea quadratic but then sure that you have breef to the expression as if ea quadratic but then sure that you have breef to the expression as if each that you have breef to the expression as if each that you have breef to the expression as if each that you have breef to the expression as if each that you have breef to the expression as if each that you have breef to the expression that the expression as if each that you have breef to the expression that the expression as if each that you have breef to the expression that the expression as if each that you have breef that you have breef to the expression that the expression as if each that you have breef that yo	$(6x^{2}+6x^{3}-q)$ $(6x^{2}+6x^{3}-3)$ $(x^{3}-3)$	5y)(6x ² x ³ -15 2x ³ +5)	-54)] 3 -6-30/5 1 -2-1 -10/2	
	3 (x ⁴ -1) x^2 3 (x^2 +1)(x^2 -1) 3 (x+i)(x-i)(x+ 7. x^4 - 4 x^2 - 45 (x^2 -9)(x^2 +5) $\sqrt{x^2}$ $\sqrt{9}$ x 3 (x+3)(x-3)(x^2 +1 8. 2 x^4 + 34 x^2 + 140 9 Cf: 2	ax ²ⁿ -45/2	plus p Reme even o perfect Alway Be ca square strictly expre Quac + bx ⁿ + When expre terms consta it two export Alway Facto it were make the cc export paren	perfect squares. In the expression that has three in the exponent times the other nent. If the expression as if ea quadratic but then sure that you have prect variable nent in the others.	$(6x^{2}+6x^{3}-q)$ $(6x^{2}+6x^{3}-3)$ $(x^{3}-3)$	5y)(6x ² x ³ -15 2x ³ +5)	3 -6 30/5 1 - 2 - 1 - 10/2	
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3 lerms	3 (x ⁴ -1) x^2 3 (x^2 +1)(x^2 -1) 3 (x+i)(x-i)(x+ 7. x^4 - 4 x^2 - 45 (x^2 -9)(x^2 +5) $\sqrt{x^2}$ $\sqrt{9}$ x 3 (x+3)(x-3)(x^2 +1 8. 2 x^4 + 34 x^2 + 140 9 Cf: 2 2 (x^4 +17 x^2 + 70	ax ²ⁿ -45/2	Plus p Reme even o perfect Alway Be ca square strictly expre Quac + bx ⁿ + When expre terms consta it two expor Alway Facto it were make the cc expor paren Che	perfect squares. In the expression that has three in the exponent times the other nent. If the expression as if ea quadratic but then sure that you have prect variable nent in the others.	$(6x^{2}+6x^{3}-q)$ $(6x^{2}+6x^{3}-3)$ $(x^{3}-3)$	5y)(6x ² x ³ -15 2x ³ +5)	3 -6 -30 5 1 - 2 -1 -10 -10 -10 -10 -10 -10 -10 -10 -10	

	Grouping (GRP) When to Use: when the expression has four terms and the degree is 3 or higher. There must be some proportionality between the pairs of terms.
	11. Factor $x^3 - 2x^2 + 5x - 10$
	$(x^{2}-2x^{2})+(5x-10)$
	qcf: X2 gcf:5
10	$x^{2}(x-2) + 5(x-2)$
Terms	$(x-2)(x^2+5)$
4	12. Factor $x^3 + 2x^2 - 9x - 18$
	$\frac{(x^3+2x^2)+(-9x-18)}{9cf:x^2}$
	$x^{2}(x+2) - 9(x+2)$
	$(x+2)(\underbrace{x^2-q}_{\text{DOS}}) \stackrel{\sqrt{x^2}}{x} \stackrel{\sqrt{q}}{3}$
	(X+2)(X+3)(X-3)
Note	s: If the 2nd and 4th terms have ennesite

Notes: If the 2nd and 4th terms have opposite signs, you will need to factor out a negative GCF from the second pair of terms.

If the binomials in the parentheses in Step 3 do not match then check your GCFs or this expression cannot be factored by grouping.

Steps & Notes

Binomial Cubed (BC)

 $a^{3} + 3a^{2}b + 3ab^{2} + b^{3} = (a+b)^{3}$ $a^{3} - 3a^{2}b + 3ab^{2} - b^{3} = (a-b)^{3}$

Grouping

1) Group the first two terms and the last two terms.

2) Factor the GCF out of both pairs.

3) The binomial in the parentheses should match and will be one factor and the common factors together make the second binomial.

4) If one of the factors can be factored further, keep factoring until complete.

Binomial Cubed

1) Find the cube roots of

the first and last terms.

2) Determine if the formula holds for the middle term.

3) Make a binomial of the cube roots and cube it.

13. Factor $x^3 - 15x^2 + 75x - 125$ Vist à lost terms are perfect cubes $\sqrt[3]{x^3}$ $\sqrt[3]{x^3}$ $\sqrt[3]{x^3}$ $\sqrt[3]{x^3}$ $\sqrt[3]{x^3}$

1 Check middle terms

Is $3 \cdot x^2 \cdot 5 = 15x^2$? Yes (2nd) against 18 $3 \cdot x \cdot 5^2 = 75x$? Yes (3rd) the formula

 $(x-5)^3$

14. Factor $8x^3 + 36x^2 + 54x + 27$

₹8×3 2×

and tenem (3a2b) Is 3·(2x)23 = 36x2? Yes 3rd term (3ab2) Is 3·2x·32 = 54x? Yes

(2X+3)3