In all the following f = F' and g = G'. 1. **Product Rule**. Given F, f, G, g find Fg + fG **Example:** If  $F = (x^2 + 1)^3, G = (2x + 7)^3, f = 3(x^2 + 1)^2, g = 6(2x + 7)^2$ Find Fg + fG and factor your answer completely.

2. Quotient Rule Given *F*, *f*, *G*, *g* find  $(F/G)' = \frac{fG-Fg}{G^2}$ Example:  $F = (x^2 + 1)^m$   $G = (x^2 + x)^n$   $f = 2mx(x^2 + 1)^{m-1}$   $g = 2n(x + 1)(x^2 + x)^{n-1}$ . 3. Given *F*(*x*) and *f*(*x*) = *F'*(*x*). Find *F*(*a*), *F*(*b*), *f*(*a*), *f*(*b*), and  $\frac{F(b)-F(a)}{b-a}$ . 4. Rewrite  $\frac{x^n + 1 + x^m \sqrt{x}}{x^k}$  without radical signs. Rewrite  $\frac{x^n + 1 + x^m \sqrt{x}}{x^k}$  without negative exponents . 5. Implicit differentiation : Solve  $3y^2D + y^3x = (x^2 - 1)D + x$  for *D*. 6. Given *F*(*x*) and *f*(*x*), • Eind equation of line through (*a*, *F*(*a*)) with slop

• Find equation of line through (a, F(a)) with slope f(a).

• Solve 
$$y - F(a) = f(a)(x - a)$$
 for  $y$ 

• Solve 
$$\frac{y-F(a)}{x-a} = f(a)$$
 for  $y$ .

7. a) Let x = a and x = b (with a < b) be the solutions of u(x) = v(x). Find F(b) - F(a). b) Let x = a and x = b and x = c (with a < b < c) be the solutions of u(x) = v(x). Find F(b) - F(a) + F(b) - F(c).8. Given F. simplify the difference quotient  $\frac{F(a+h)-F(a)}{b}$ 9. Given f (a first or second derivative) a) Solve f(x) = 0. b) In what intervals is f(x) positive? negative? 10. Given F, find and simplify  $\frac{F(b)-F(a)}{b-a}$ 11. Suppose  $F(x) = x^3 + bx^2 + cx + d$  and  $f(x) = 3x^2 + 2bx + c$ If F(1) = 0 and F(2) = 4 and f(2) = 3. find F(x), f(x), f(a), etc. 12. Order of operations problems such as •  $3x(x+1)^2 - x^2(3-2x)$ . • Given f(x) = x + 1 and q(x) = 2 - x find f(x) - 2q(x) - f(x)q(x).

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1. Warmup for Product rule Let  $F = A^3$ ;  $G = B^3$ ;  $f = 3A^2$ ; and  $g = 6B^2$ . Find Fg + fG and factor your answer completely.

Stanley Ocken Sabbatical Notes : Calculus Preparation

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Substitute the given polynomials into Fg + fG

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Substitute the given polynomials into Fg + fG  $A^{3}(6B^{2}) + (3A^{2})(B^{3})$ 

Recognize as sum of two terms

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Substitute the given polynomials into Fg + fG  $A^{3}(6B^{2}) + (3A^{2})(B^{3})$ Recognize as sum of two terms  $= A^{3}(6B^{2}) + (3A^{2})(B^{3})$ Rewrite each term with constant at left

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1. Warmup for Product rule Let  $F = A^3$ ;  $G = B^3$ ;  $f = 3A^2$ ; and  $g = 6B^2$ . Find Fg + fG and factor your answer completely.

**Solution:** Scroll slowly. Try each step before you look at the answer.

Substitute the given polynomials into Fg + fGRecognize as sum of two terms Rewrite each term with constant at left Pull out common factor 3  $A^3(6B^2) + (3A^2)(B^3)$  $= A^3(6B^2) + (3A^2)(B^3)$ 

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1. Warmup for Product rule Let  $F = A^3$ ;  $G = B^3$ ;  $f = 3A^2$ ; and  $g = 6B^2$ . Find Fq + fG and factor your answer completely.

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 $A^{3}(6B^{2}) + (3A^{2})(B^{3})$  $= 3A^2 (2A^{3-2}B^2 + B^3)$ 

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Substitute the given polynomials into Fg + fG  $A^3(6B^2)$ Recognize as sum of two terms  $= A^3(6B^2)$ Rewrite each term with constant at left  $= 6A^3B^2$ Pull out common factor 3  $= 3(2A^3E)$ Pull out the lowest common power  $A^2$  of  $A = 3A^2$  (2A) Pull out lowest common power  $B^2$  of  $B = 3A^2B^2$ Subtract exponents

$$A^{3}(6B^{2}) + (3A^{2})(B^{3})$$
  
=  $A^{3}(6B^{2}) + (3A^{2})(B^{3})$   
=  $6A^{3}B^{2} + 3A^{2}B^{3}$   
=  $3(2A^{3}B^{2} + A^{2}B^{3})$   
=  $3A^{2}(2A^{3-2}B^{2} + B^{3})$   
=  $3A^{2}B^{2}(2A^{3-2} + B^{3-2})$ 

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 $A^{3}(6B^{2}) + (3A^{2})(B^{3})$  $= A^{3}(6B^{2}) + (3A^{2})(B^{3})$  $= 6A^{3}B^{2} + 3A^{2}B^{3}$  $= 3A^2 (2A^{3-2}B^2 + B^3)$  $= 3A^2B^2 (2A^{3-2} + B^{3-2})$  $= 3A^2B^2 (2A^1 + B^1)$ 

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 $= A^{3}(6B^{2}) + (3A^{2})(B^{3})$  $= 6A^{3}B^{2} + 3A^{2}B^{3}$  $= 3A^2 (2A^{3-2}B^2 + B^3)$  $= 3A^2B^2 (2A^{3-2} + B^{3-2})$  $= 3A^2B^2 (2A^1 + B^1)$  $= 3A^2B^2(2A+B)$ 

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**Solution:** This problem was obtained by substituting  $x^2 + 1$  for A and 2x + 7 for B in the warmup problem. This problem seems harder, simply because there are more symbols.

Substitute the given polynomials into Fg + fG

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**Solution:** This problem was obtained by substituting  $x^2 + 1$  for A and 2x + 7 for B in the warmup problem. This problem seems harder, simply because there are more symbols.

Substitute the given polynomials into Fg + fG  $(x^2 + 1)^3(6(2x + 7)^2) + (3(x^2 + 1)^2)((2x + 7)^3)$ 

Recognize as sum of two terms =

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Substitute the given polynomials into Fg + fG  $(x^2 + 1)^3(6(2x + 7)^2) + (3(x^2 + 1)^2)((2x + 7)^3)$ Recognize as sum of two terms  $= (x^2 + 1)^3(6(2x + 7)^2) + (3(x^2 + 1)^2)((2x + 7)^3)$ 

Rewrite each term with constant at left =

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**Solution:** This problem was obtained by substituting  $x^2 + 1$  for A and 2x + 7 for B in the warmup problem. This problem seems harder, simply because there are more symbols.

 $(x^{2}+1)^{3}(6(2x+7)^{2}) + (3(x^{2}+1)^{2})((2x+7)^{3})$ Substitute the given polynomials into Fa + fG $= (x^{2}+1)^{3}(6(2x+7)^{2}) + (3(x^{2}+1)^{2})((2x+7)^{3})$ Recognize as sum of two terms  $= 6(x^{2}+1)^{3}(2x+7)^{2} + 3(x^{2}+1)^{2}(2x+7)^{3}$ Rewrite each term with constant at left  $= 3 \left( 2(x^{2}+1)^{3}(2x+7)^{2} + (x^{2}+1)^{2}(2x+7)^{3} \right)$ Factor out common factor 3 Factor  $(x^2 + 1)^2$  from both terms.  $= 3(x^{2}+1)^{2} (2(x^{2}+1)^{3-2}(2x+7)^{2}+(2x+7)^{3})$  $= 3(x^{2}+1)^{2}(2x+7)^{2} \left(2(x^{2}+1)^{3-2}+(2x+7)^{3-2}\right)$ Factor  $(2x+7)^2$  from both terms.  $= 3(x^{2}+1)^{2}(2x+7)^{2} (2(x^{2}+1)^{1}+(2x+7)^{1})$ Subtract exponents Expand the remaining factor =

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 $(x^{2}+1)^{3}(6(2x+7)^{2}) + (3(x^{2}+1)^{2})((2x+7)^{3})$ Substitute the given polynomials into Fa + fG $= (x^{2}+1)^{3}(6(2x+7)^{2}) + (3(x^{2}+1)^{2})((2x+7)^{3})$ Recognize as sum of two terms  $= 6(x^{2}+1)^{3}(2x+7)^{2} + 3(x^{2}+1)^{2}(2x+7)^{3}$ Rewrite each term with constant at left  $= 3 \left( 2(x^{2}+1)^{3}(2x+7)^{2} + (x^{2}+1)^{2}(2x+7)^{3} \right)$ Factor out common factor 3 Factor  $(x^2 + 1)^2$  from both terms.  $= 3(x^{2}+1)^{2} (2(x^{2}+1)^{3-2}(2x+7)^{2}+(2x+7)^{3})$  $= 3(x^{2}+1)^{2}(2x+7)^{2} (2(x^{2}+1)^{3-2}+(2x+7)^{3-2})$ Factor  $(2x+7)^2$  from both terms.  $= 3(x^{2}+1)^{2}(2x+7)^{2}(2(x^{2}+1)^{1}+(2x+7)^{1})$ Subtract exponents  $= 3(x^{2}+1)^{2}(2x+7)^{2}((2x^{2}+2)+(2x+7))$ Expand the remaining factor  $= 3(x^{2}+1)^{2}(2x+7)^{2}(2x^{2}+2x+9)$ Collect the remaining factor

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**Solution:** This problem was obtained by substituting  $x^2 + 1$  for A and 2x + 7 for B in the warmup problem. This problem seems harder, simply because there are more symbols.

 $(x^{2}+1)^{3}(6(2x+7)^{2}) + (3(x^{2}+1)^{2})((2x+7)^{3})$ Substitute the given polynomials into Fq + fG $= (x^{2}+1)^{3}(6(2x+7)^{2}) + (3(x^{2}+1)^{2})((2x+7)^{3})$ Recognize as sum of two terms  $= 6(x^{2}+1)^{3}(2x+7)^{2} + 3(x^{2}+1)^{2}(2x+7)^{3}$ Rewrite each term with constant at left  $= 3 \left( 2(x^{2}+1)^{3}(2x+7)^{2} + (x^{2}+1)^{2}(2x+7)^{3} \right)$ Factor out common factor 3 Factor  $(x^2 + 1)^2$  from both terms.  $= 3(x^{2}+1)^{2} (2(x^{2}+1)^{3-2}(2x+7)^{2}+(2x+7)^{3})$  $= 3(x^{2}+1)^{2}(2x+7)^{2} (2(x^{2}+1)^{3-2}+(2x+7)^{3-2})$ Factor  $(2x+7)^2$  from both terms.  $= 3(x^{2}+1)^{2}(2x+7)^{2}(2(x^{2}+1)^{1}+(2x+7)^{1})$ Subtract exponents  $= 3(x^{2}+1)^{2}(2x+7)^{2}((2x^{2}+2)+(2x+7))$ Expand the remaining factor Collect the remaining factor  $= 3(x^2+1)^2(2x+7)^2(2x^2+2x+9)$ To be sure the boxed answer is completely factored, use the Quadratic polynomial factoring criterion to see if  $2x^2 + 2x + 9$  factors.

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This problem was a bit much. On the next slide, we show how to use abbreviations to make it easier to handle.

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Using abbreviations Let  $F = (x^2 + 1)^3$ ;  $G = (2x + 7)^3$ ;  $f = 3(x^2 + 1)^2$ ; and  $g = 6(2x + 7)^2$ . Find Fg + fG and factor your answer completely.

Stanley Ocken Sabbatical Notes : Calculus Preparation

Using abbreviations Let  $F = (x^2 + 1)^3$ ;  $G = (2x + 7)^3$ ;  $f = 3(x^2 + 1)^2$ ; and  $g = 6(2x + 7)^2$ . Find Fg + fG and factor your answer completely. Solution: Substitute  $A = x^2 + 1$  and B = 2x + 7 in F, g, f, G to get  $F = A^3, G = B^3, f = 3A^2, g = 6B^2$ . Substitute the abbreviations into Fg + fG

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In calculus, some expression names are written with a prime. For example, f and f' could be the names of different polynomials, as in the next example.

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In calculus, some expression names are written with a prime. For example, f and f' could be the names of different polynomials, as in the next example.

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Stanley Ocken Sabbatical Notes : Calculus Preparation

**Solution:** Substitute the given polynomials into  $\frac{f'g-fg'}{q^2}$ 

1. Preparation for Quotient rule: Let  $f = (x^2 + 1)^4$ ;  $g = 2(2x + 7)^3$ ,  $f' = 8x(x^2 + 1)^3$ , and  $g' = 6(2x + 7)^2$ . Find  $\frac{f'g - fg'}{g^2}$  and rewrite your answer as a completely reduced fraction.

Solution: Substitute the given polynomials into  $\frac{f'g-fg'}{g^2}$   $\frac{(8x(x^2+1)^3)(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ 

Recognize as sum of two terms

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Solution: Substitute the given polynomials into  $\frac{f'g-fg'}{g^2}$ Recognize as sum of two terms  $= \frac{8x(x^2+1)^3(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ 

Rewrite each term with constant at left

Solution: Substitute the given polynomials into  $\frac{f'g-fg'}{g^2}$  $\frac{(8x(x^2+1)^3)(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ Recognize as sum of two terms $= \frac{8x(x^2+1)^3(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ Rewrite each term with constant at left $= \frac{16x(x^2+1)^3(2x+7)^3-6(x^2+1)^4(2x+7)^2}{2^2((2x+7)^3)^2}$ 

Pull out common factor 2 from numerator

Solution: Substitute the given polynomials into  $\frac{f'g-fg'}{g^2}$  $\frac{(8x(x^2+1)^3)(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ Recognize as sum of two terms $= \frac{8x(x^2+1)^3(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ Rewrite each term with constant at left $= \frac{16x(x^2+1)^3(2x+7)^3-6(x^2+1)^4(6(2x+7)^2)}{2^2((2x+7)^3)^2}$ Pull out common factor 2 from numerator $= \frac{2(8x(x^2+1)^3(2x+7)^3-3(x^2+1)^4((2x+7)^2))}{4(2x+7)^6}$ 

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Cancel constant factor from numerator and denominator

1. Preparation for Quotient rule: Let  $f = (x^2 + 1)^4$ ;  $g = 2(2x + 7)^3$ ,  $f' = 8x(x^2 + 1)^3$ , and  $g' = 6(2x + 7)^2$ . Find  $\frac{f'g - fg'}{a^2}$  and rewrite your answer as a completely reduced fraction.

Solution: Substitute the given polynomials into  $\frac{f'g-fg'}{g^2}$  $\frac{(8x(x^2+1)^3)(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ Recognize as sum of two terms $= \frac{8x(x^2+1)^3(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ Rewrite each term with constant at left $= \frac{16x(x^2+1)^3(2x+7)^3-6(x^2+1)^4(2x+7)^2}{2^2((2x+7)^3)^2}$ Pull out common factor 2 from numerator $= \frac{2(8x(x^2+1)^3(2x+7)^3-3(x^2+1)^4((2x+7)^2))}{4(2x+7)^6}$ Cancel constant factor from numerator and denominator $= \frac{2(8x(x^2+1)^3(2x+7)^3-3(x^2+1)^4((2x+7)^2))}{4(2x+7)^6}$ 

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Solution: Substitute the given polynomials into  $\frac{f'g-fg'}{g^2}$  $\frac{(8x(x^2+1)^3)(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ Recognize as sum of two terms $= \frac{8x(x^2+1)^3(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ Rewrite each term with constant at left $= \frac{16x(x^2+1)^3(2x+7)^3-6(x^2+1)^4(2x+7)^2}{2^2((2x+7)^3)^2}$ Pull out common factor 2 from numerator $= \frac{2(8x(x^2+1)^3(2x+7)^3-3(x^2+1)^4((2x+7)^2))}{4(2x+7)^6}$ Cancel constant factor from numerator and denominator $= \frac{\frac{1}{2}(8x(x^2+1)^3(2x+7)^3-(x^2+1)^4(3(2x+7)^2))}{4(2x+7)^6}$ 

Pull out least power  $(x^2+1)^3$  of  $x^2+1$  from both terms.

 $\frac{(8x(x^2+1)^3)(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ **Solution:** Substitute the given polynomials into  $\frac{f'g-fg'}{a^2}$  $=\frac{8x(x^2+1)^3(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ Recognize as sum of two terms  $=\frac{16x(x^2+1)^3(2x+7)^3-6(x^2+1)^4(2x+7)^2}{2^2((2x+7)^3)^2}$ Rewrite each term with constant at left  $=\frac{2(8x(x^2+1)^3(2x+7)^3-3(x^2+1)^4((2x+7)^2))}{4(2x+7)^6}$ Pull out common factor 2 from numerator  $=\frac{2\left(8x(x^2+1)^3(2x+7)^3-(x^2+1)^4(3(2x+7)^2)\right)}{4(2x+7)^6}$ Cancel constant factor from numerator and denominator  $=\frac{(x^2+1)^3 \left(8x(2x+7)^3-(x^2+1)(3(2x+7)^2)\right)}{2(2x+7)^6}$ 

Pull out least power  $(x^2 + 1)^3$  of  $x^2 + 1$  from both terms.

1. Preparation for Quotient rule: Let  $f = (x^2 + 1)^4$ ;  $g = 2(2x + 7)^3$ ,  $f' = 8x(x^2 + 1)^3$ , and  $g' = 6(2x+7)^2$ . Find  $\frac{f'g-fg'}{a^2}$  and rewrite your answer as a completely reduced fraction.  $\frac{(8x(x^2+1)^3)(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ **Solution:** Substitute the given polynomials into  $\frac{f'g-fg'}{a^2}$  $=\frac{8x(x^2+1)^3(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ Recognize as sum of two terms  $=\frac{16x(x^2+1)^3(2x+7)^3-6(x^2+1)^4(2x+7)^2}{2^2((2x+7)^3)^2}$ Rewrite each term with constant at left  $=\frac{2(8x(x^2+1)^3(2x+7)^3-3(x^2+1)^4((2x+7)^2))}{4(2x+7)^6}$ Pull out common factor 2 from numerator  $=\frac{\frac{4(8x(x^2+1)^3(2x+7)^3-(x^2+1)^4(3(2x+7)^2))}{4(2x+7)^6}}{4(2x+7)^6}$ Cancel constant factor from numerator and denominator  $=\frac{(x^2+1)^3(8x(2x+7)^3-(x^2+1)(3(2x+7)^2))}{2(2x+7)^6}$ Pull out least power  $(x^2 + 1)^3$  of  $x^2 + 1$  from both terms.  $=\frac{(x^2+1)^3(2x+7)^2(8x(2x+7)-(x^2+1)(3))}{2(2x+7)^6}$ Pull out least power  $(2x + 7)^2$  of 2x + 7 from both terms.

1. Preparation for Quotient rule: Let  $f = (x^2 + 1)^4$ ;  $g = 2(2x + 7)^3$ ,  $f' = 8x(x^2 + 1)^3$ , and  $g' = 6(2x+7)^2$ . Find  $\frac{f'g-fg'}{a^2}$  and rewrite your answer as a completely reduced fraction.  $\frac{(8x(x^2+1)^3)(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ **Solution:** Substitute the given polynomials into  $\frac{f'g-fg'}{a^2}$  $=\frac{8x(x^2+1)^3(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ Recognize as sum of two terms  $=\frac{16x(x^2+1)^3(2x+7)^3-6(x^2+1)^4(2x+7)^2}{2^2((2x+7)^3)^2}$ Rewrite each term with constant at left  $=\frac{2(8x(x^2+1)^3(2x+7)^3-3(x^2+1)^4((2x+7)^2))}{4(2x+7)^6}$ Pull out common factor 2 from numerator  $=\frac{2\left(8x(x^2+1)^3(2x+7)^3-(x^2+1)^4(3(2x+7)^2)\right)}{4(2x+7)^6}$ Cancel constant factor from numerator and denominator  $=\frac{(x^2+1)^3(8x(2x+7)^3-(x^2+1)(3(2x+7)^2))}{2(2x+7)^6}$ Pull out least power  $(x^2 + 1)^3$  of  $x^2 + 1$  from both terms.  $=\frac{(x^2+1)^3(2x+7)^2(8x(2x+7)-(x^2+1)(3))}{2(2x+7)^6}$ Pull out least power  $(2x+7)^2$  of 2x+7 from both terms.  $=\frac{(x^2+1)^3(2x+7)^2(16x^2+56x-(3x^2+3))}{2(2x+7)^6}$ Cancel powers of 2x + 7 and rewrite the remaining factor

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1. Preparation for Quotient rule: Let  $f = (x^2 + 1)^4$ ;  $g = 2(2x + 7)^3$ ,  $f' = 8x(x^2 + 1)^3$ , and  $g' = 6(2x+7)^2$ . Find  $\frac{f'g-fg'}{a^2}$  and rewrite your answer as a completely reduced fraction.  $\frac{(8x(x^2+1)^3)(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ **Solution:** Substitute the given polynomials into  $\frac{f'g-fg'}{a^2}$  $=\frac{8x(x^2+1)^3(2(2x+7)^3)-(x^2+1)^4(6(2x+7)^2)}{(2(2x+7)^3)^2}$ Recognize as sum of two terms  $=\frac{16x(x^2+1)^3(2x+7)^3-6(x^2+1)^4(2x+7)^2}{2^2((2x+7)^3)^2}$ Rewrite each term with constant at left  $=\frac{2(8x(x^2+1)^3(2x+7)^3-3(x^2+1)^4((2x+7)^2))}{4(2x+7)^6}$ Pull out common factor 2 from numerator  $=\frac{\frac{4(8x(x^2+1)^3(2x+7)^3-(x^2+1)^4(3(2x+7)^2))}{4(2x+7)^6}}{4(2x+7)^6}$ Cancel constant factor from numerator and denominator  $=\frac{(x^2+1)^3(8x(2x+7)^3-(x^2+1)(3(2x+7)^2))}{2(2x+7)^6}$ Pull out least power  $(x^2 + 1)^3$  of  $x^2 + 1$  from both terms.  $=\frac{(x^2+1)^3(2x+7)^2(8x(2x+7)-(x^2+1)(3))}{2(2x+7)^6}$ Pull out least power  $(2x+7)^2$  of 2x+7 from both terms.  $=\frac{(x^2+1)^3(2x+7)^2(16x^2+56x-(3x^2+3))}{2(2x+7)^6}$ Cancel powers of 2x + 7 and rewrite the remaining factor  $= \frac{(x^2+1)^3(16x^2+56x-3x^2-3)}{2(2x+7)^{6-2}}$ Distribute the minus sign

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Note: the Quadratic polynomial factoring criterion assures us that  $13x^2 + 56x - 3$  does not factor because  $b^2 - 4ac = 56^2 - 4(13)(-3) = 3292$  is not a perfect square.

Working with abbreviations: Let  $f = (x^2 + 1)^4$ ;  $g = 2(2x + 7)^3$ ,  $f' = 8x(x^2 + 1)^3$ , and  $g' = 6(2x + 7)^2$ . Find  $\frac{f'g - fg'}{g^2}$  and rewrite your answer as a completely reduced fraction.

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Substitute into 
$$\frac{f'g-fg'}{g^2}$$

Stanley Ocken Sabbatical Notes : Calculus Preparation

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Substitute into 
$$\frac{f'g - fg'}{g^2}$$
  $\frac{(8xA^3 \cdot 2B^3) - A^4(6B^2)}{(2B^3)^2}$ 

Recognize as sum of two terms

Working with abbreviations: Let  $f = (x^2 + 1)^4$ ;  $g = 2(2x + 7)^3$ ,  $f' = 8x(x^2 + 1)^3$ , and  $g' = 6(2x + 7)^2$ . Find  $\frac{f'g - fg'}{g^2}$  and rewrite your answer as a completely reduced fraction. Solution: Scroll slowly. Try each step in the left column before you click to see the answer. Substitute A for  $x^2 + 1$  and B for 2x + 7 to get  $f = A^4$ ;  $g = B^3$ ,  $f' = 8xA^3$ , and  $g' = 6B^2$ .

Rewrite each term with constant at left

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Recognize as sum of two terms

Rewrite each term with constant at left

$$= \frac{8xA^3 \cdot 2B^3 - A^4(6B)}{(2B^3)^2}$$
$$= \frac{16xA^3B^3 - 6A^4B^2}{2^2(B^3)^2}$$

Pull out common factor 2 from numerator

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 $=\frac{2(8xA^3B^3-3A^4B^2)}{4B^6}$ 

Working with abbreviations: Let  $f = (x^2 + 1)^4$ ;  $g = 2(2x + 7)^3$ ,  $f' = 8x(x^2 + 1)^3$ , and  $q' = 6(2x + 7)^2$ . Find  $\frac{f'g-fg'}{c^2}$  and rewrite your answer as a completely reduced fraction. Solution: Scroll slowly. Try each step in the left column before you click to see the answer. Substitute A for  $x^2 + 1$  and B for 2x + 7 to get  $f = A^4$ ;  $q = B^3$ ,  $f' = 8xA^3$ , and  $q' = 6B^2$ . Substitute into  $\frac{f'g - fg'}{g^2}$   $\frac{(8xA^3 \cdot 2B^3) - A^4(6B^2)}{(2B^3)^2}$ Recognize as sum of two terms  $=\frac{8xA^3 \cdot 2B^3 - A^4(6B^2)}{(2B^3)^2}$  $=\frac{16xA^3B^3-6A^4B^2}{2^2(B^3)^2}$ Rewrite each term with constant at left  $=\frac{2(8xA^3B^3-3A^4B^2)}{4B^6}$ 

Pull out common factor 2 from numerator

Cancel before continuing

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 $\label{eq:pullow} \mbox{Pull out lowest common power } A^3 \mbox{ of } A$ 

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$$\frac{f(b) - f(a)}{b - a} = \frac{f(x + h) - f(x)}{(x + h) - x} = \frac{f(x + h) - f(x)}{h}$$

$$= \frac{1}{h} \left( (x + h) - (x + h)^2 - (x - x^2) \right)$$

$$= \frac{1}{h} \left( x + h - (x^2 + 2hx + h^2) - x + x^2 \right)$$

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3. In each of the following, find  $\frac{f(b)-f(a)}{b-a}$  and rewrite your answer as a polynomial or as a reduced fraction. Go slowly through the slide and write down the answer to each part before you move ahead.

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$$= -\frac{1}{h} \left( (x - h) - (x - h)^2 - (x - x^2) \right)$$

$$= -\frac{1}{h} \left( x - h - (x^2 - 2hx + h^2) - x + x^2 \right)$$

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$$= \frac{1}{h} \left( h - 2hx - h^2 \right)$$

$$= \frac{1}{h} \left( h - 2hx - h^2 \right)$$

$$= \frac{1}{h} \left( h (1 - 2x - h) \right) = \boxed{-2x + 1 - h}$$

3.3 Let  $f(x)=\frac{1}{x}; a=x, b=x+h.$  Then  $\frac{f(b)-f(a)}{b-a}=$ 

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Stanley Ocken Sabbatical Notes : Calculus Preparation

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$$3.4 \text{ Let } f(x) = \frac{x}{2x + 3}; a = x, b = x + h.$$
 Then  

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$$= \frac{2x^2+3x+2hx+3h-(2x^2+2xh+3x)}{h(2x+3+2h)(2x+3)}$$

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3 Find  $\frac{f(b)-f(a)}{b-a}$  and rewrite your answer as a polynomial or as a reduced fraction. Go slowly through the slide and write down the answer to each part before you move ahead.

3.3 Let 
$$f(x) = \frac{1}{x}; a = x, b = x + h$$
. Then  

$$\frac{f(b) - f(a)}{b - a} = \frac{f(x+h) - f(x)}{(x+h) - x} = \frac{f(x+h) - f(x)}{h}$$

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$$= \frac{1}{h} \left(\frac{1}{x+h} - \frac{1}{x}\right)$$

$$= \frac{1}{h} \left(\frac{1}{x+h} - \frac{1}{x} - \frac{1}{x} \cdot \frac{x+h}{x+h}\right)$$

$$= \frac{1}{h} \left(\frac{x}{(x+h)x} - \frac{x+h}{x(x+h)}\right)$$

$$= \frac{1}{h} \left(\frac{x-(x+h)}{x(x+h)}\right) = \frac{1}{h} \cdot \frac{x-x-h}{x(x+h)}$$

$$= \frac{1}{h} \cdot \frac{x}{x(x+h)} = \boxed{\frac{-1}{x(x+h)}}$$

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$$f(x) = \frac{x}{2x+3}$$
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$$= \frac{1}{h} \left( f(x+h) - f(x) \right)$$

$$= \frac{1}{h} \left( \frac{x+h}{2x+2h+3} - \frac{x}{2x+3} \right)$$

$$= \frac{1}{h} \left( \frac{x+h}{2x+2h+3} \cdot \frac{2x+3}{2x+3} - \frac{x}{2x+3} \cdot \frac{2x+2h+3}{2x+2h+3} \right)$$

$$= \frac{1}{h} \left( \frac{x(2x) + x(3) + h(2x) + h(3)}{(2x+3+2h)(2x+3)} - \frac{x(2x) + x(2h) + x(3)}{(2x+3+2h)(2x+3)} \right)$$

$$= \frac{2x^2 + 3x + 2hx + 3h - (2x^2 + 2xh + 3x)}{h(2x+3+2h)(2x+3)}$$

$$= \frac{2x^2 + 3x + 2hx + 3h - (2x^2 - 2xh - 3x)}{h(2x+3+2h)(2x+3)}$$

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$$= \frac{3x^2}{h(2x+3+2h)(2x+3)} = \boxed{\frac{3}{(2x+3+2h)(2x+3)}}$$

3.5 Let  $f(x) = \sqrt{x}$ ; a = x, b = x + h. Then  $\frac{f(b) - f(a)}{b - a} =$ 

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Stanley Ocken Sabbatical Notes : Calculus Preparation

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$$= \frac{1}{h} \cdot \left( \frac{\sqrt{x} - \sqrt{x+h}}{\sqrt{x}\sqrt{x+h}} \right) \cdot \frac{\sqrt{x} + \sqrt{x+h}}{\sqrt{x+\sqrt{x+h}}}$$

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$$= \frac{1}{h} \cdot \left( \frac{1}{\sqrt{x+h}} \frac{\sqrt{x}}{\sqrt{x}} - \frac{1}{\sqrt{x}} \frac{\sqrt{x+h}}{\sqrt{x+h}} \right)$$

$$= \frac{1}{h} \cdot \left( \frac{\sqrt{x} - \sqrt{x+h}}{\sqrt{x}\sqrt{x+h}} \right) \cdot \frac{\sqrt{x} + \sqrt{x+h}}{\sqrt{x} + \sqrt{x+h}}$$

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$$= \frac{\sqrt{x+h} - \sqrt{x}}{h} \cdot \frac{\sqrt{x+h} + \sqrt{x}}{\sqrt{x+h} + \sqrt{x}}$$

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$$= \frac{(\sqrt{x+h})^2 - (\sqrt{x})^2}{h(\sqrt{x+h} + \sqrt{x})}$$

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Stanley Ocken Sabbatical Notes : Calculus Preparation

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Stanley Ocken Sabbatical Notes : Calculus Preparation

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