Symmetries and operations on functions Lesson #5

MAT 1375 Precalculus

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MAT 1375 - Precalculus

5. Symmetries and operations on functions 1/9

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Even functions

A function is even, if

$$f(-x) = f(x)$$
 for all x

Example: $f(x) = x^2$ Find f(2) = f(-2) = f(3) = f(-3) = f(-

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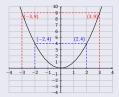
Even functions

A function is even, if

$$f(-x) = f(x)$$
 for all x

Example:
$$f(x) = x^2$$

Find $f(2) = 4$ $f(-2) = 4$
 $f(3) = 9$ $f(-3) = 9$



Even functions have graphs that are symmetric with respect to the *y*-axis.

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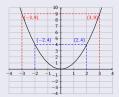
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Even functions have graphs that are symmetric with respect to the *y*-axis.

Odd functions

A function is odd, if

$$f(-x) = -f(x)$$
 for all x

Example: $f(x) = x^3$ Find f(2) = f(-2) =

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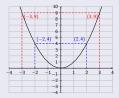
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Even functions have graphs that are symmetric with respect to the *y*-axis.

Odd functions

A function is odd, if

$$f(-x) = -f(x)$$
 for all x

Example: $f(x) = x^3$ Find f(2) = 8 f(-2) = -8



Odd functions have graphs that are symmetric with respect to the origin.

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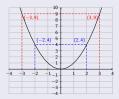
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Even functions have graphs that are symmetric with respect to the *y*-axis.

Odd functions

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Odd functions have graphs that are symmetric with respect to the origin.

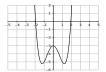
Note: If 0 is in the domain, then f(0) = f(-0) = -f(0), so that: f(0) = 0

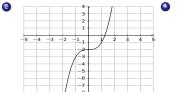
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Determine if the function is even, odd, or neither.

•
$$f(x) = x^4 - 3x^2 - 3$$
 • $f(x) = \frac{1}{x^3} - \frac{4}{x}$

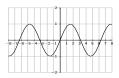
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$$f(x) = \frac{x^2+2}{x^4-3}$$





$$f(x) = x^3 + x^6$$





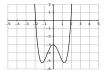
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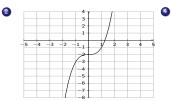
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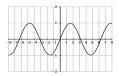






$$f(x) = x^3 + x^6$$





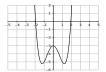
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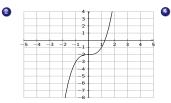
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$$f(x) = \frac{x^2+2}{x^4-3}$$

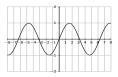






 $f(x) = x^3 + x^6$





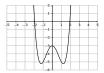
Neither

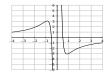
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Determine if the function is even, odd, or neither.

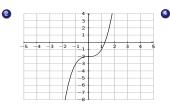
a $f(x) = x^4 - 3x^2 - 3$ **b** $f(x) = \frac{1}{x^3} - \frac{4}{x}$







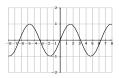
Even



Odd

$$f(x) = x^3 + x^6$$

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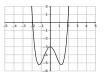
Neither

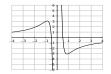
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Determine if the function is even, odd, or neither.

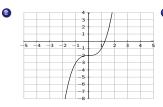
 $f(x) = x^4 - 3x^2 - 3$ 3 $f(x) = \frac{1}{x^3} - \frac{4}{x}$



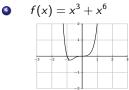






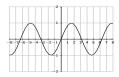


Odd



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5 $f(x) = \frac{x^2+2}{x^4-3}$



Neither

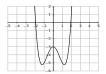
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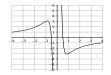
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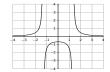
Determine if the function is even, odd, or neither.

a $f(x) = x^4 - 3x^2 - 3$ **b** $f(x) = \frac{1}{x^3} - \frac{4}{x}$

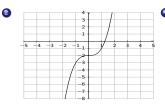




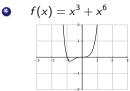




Even

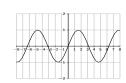


Odd



Even

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Neither

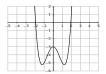
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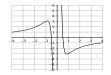
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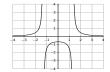
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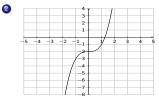




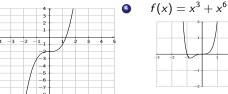




Even





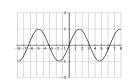


Neither

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Even

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Odd

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Neither

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• Let
$$f(x) = x^2 + 7x + 12$$
 and $g(x) = 2x - 6$.

• Find the sum
$$(f + g)(x) = f(x) + g(x)$$

• Find the difference
$$(f - g)(x) = f(x) - g(x)$$

• Find the product
$$(f \cdot g)(x) = f(x) \cdot g(x)$$

• Find the quotient
$$\frac{f}{g}(x) = \frac{f(x)}{g(x)}$$

• Find the quotient
$$\frac{g}{f}(x) = \frac{g(x)}{f(x)}$$

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• Let
$$f(x) = x^2 + 7x + 12$$
 and $g(x) = 2x - 6$.

• Find the sum
$$(f + g)(x) = f(x) + g(x)$$

= $(x^2 + 7x + 12) + (2x - 6) = x^2 + 9x + 6$

• Find the difference
$$(f - g)(x) = f(x) - g(x)$$

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$$(f + g)(x) = f(x) + g(x)$$

= $(x^2 + 7x + 12) + (2x - 6) = x^2 + 9x + 6$

• Find the difference
$$(f - g)(x) = f(x) - g(x)$$

= $(x^2 + 7x + 12) - (2x - 6) = x^2 + 5x + 18$

• Find the product
$$(f \cdot g)(x) = f(x) \cdot g(x)$$

• Find the quotient
$$\frac{f}{g}(x) = \frac{f(x)}{g(x)}$$

• Find the quotient
$$\frac{g}{f}(x) = \frac{g(x)}{f(x)}$$

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$$= (x^{2} + 7x + 12) \cdot (2x - 6)$$

= 2x³ - 6x² + 14x² - 42x + 24x - 72
= 2x³ + 8x² - 18x - 72

• Find the quotient
$$\frac{f}{g}(x) = \frac{f(x)}{g(x)}$$

• Find the quotient
$$\frac{g}{f}(x) = \frac{g(x)}{f(x)}$$

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• Find the difference
$$(f - g)(x) = f(x) - g(x)$$

= $(x^2 + 7x + 12) - (2x - 6) = x^2 + 5x + 18$

• Find the product
$$(f \cdot g)(x) = f(x) \cdot g(x)$$

= $(x^2 + 7x + 12) \cdot (2x - 6)$
= $2x^3 - 6x^2 + 14x^2 - 42x + 24x - 72$
= $2x^3 + 8x^2 - 18x - 72$

• Find the quotient
$$\frac{f}{g}(x) = \frac{f(x)}{g(x)} = \frac{x^2 + 7x + 12}{2x - 6}$$

• Find the quotient
$$\frac{g}{f}(x) = \frac{g(x)}{f(x)}$$

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• Find the product
$$(f \cdot g)(x) = f(x) \cdot g(x)$$

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= $2x^3 - 6x^2 + 14x^2 - 42x + 24x - 72$
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$$\frac{f}{g}(x) = \frac{f(x)}{g(x)} = \frac{x^2 + 7x + 12}{2x - 6}$$

• Find the quotient
$$\frac{g}{f}(x) = \frac{g(x)}{f(x)} = \frac{2x-6}{x^2+7x+12}$$

Domains:

$$D_f = D_g =$$

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• Let
$$f(x) = x^2 + 7x + 12$$
 and $g(x) = 2x - 6$.
• Find the sum $(f + g)(x) = f(x) + g(x)$ Domains
 $= (x^2 + 7x + 12) + (2x - 6) = x^2 + 9x + 6$ $D_{f+g} =$
• Find the difference $(f - g)(x) = f(x) - g(x)$
 $= (x^2 + 7x + 12) - (2x - 6) = x^2 + 5x + 18$ $D_{f-g} =$
• Find the product $(f \cdot g)(x) = f(x) \cdot g(x)$
 $= (x^2 + 7x + 12) \cdot (2x - 6)$
 $= 2x^3 - 6x^2 + 14x^2 - 42x + 24x - 72$
 $= 2x^3 + 8x^2 - 18x - 72$ $D_{f \cdot g} =$
• Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{g(x)} = \frac{x^2 + 7x + 12}{2x - 6}$ $D_{\frac{f}{g}} =$

• Find the quotient
$$\frac{g}{f}(x) = \frac{g(x)}{f(x)} = \frac{2x-6}{x^2+7x+12}$$

$$D_{\frac{g}{f}} =$$

 $D_{f \cdot g} =$

Domains: $D_{f+g} =$

Domains:

 $D_f = \mathbb{R}$ $D_g = \mathbb{R}$

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• Let
$$f(x) = x^2 + 7x + 12$$
 and $g(x) = 2x - 6$.
• Find the sum $(f + g)(x) = f(x) + g(x)$ Domains:
 $= (x^2 + 7x + 12) + (2x - 6) = x^2 + 9x + 6$ $D_{f+g} = \mathbb{R}$
• Find the difference $(f - g)(x) = f(x) - g(x)$
 $= (x^2 + 7x + 12) - (2x - 6) = x^2 + 5x + 18$ $D_{f-g} = \mathbb{R}$
• Find the product $(f \cdot g)(x) = f(x) \cdot g(x)$
 $= (x^2 + 7x + 12) \cdot (2x - 6)$
 $= 2x^3 - 6x^2 + 14x^2 - 42x + 24x - 72$
 $= 2x^3 + 8x^2 - 18x - 72$ $D_{f \cdot g} = \mathbb{R}$
• Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{g(x)} = \frac{x^2 + 7x + 12}{2x - 6}$ $D_{\frac{f}{g}} =$
• Find the quotient $\frac{g}{f}(x) = \frac{g(x)}{f(x)} = \frac{2x - 6}{x^2 + 7x + 12}$

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Domains: $D_f = \mathbb{R}$ $D_g = \mathbb{R}$

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 $D_{\frac{g}{f}} =$

• Find the quotient
$$\frac{g}{f}(x) = \frac{g(x)}{f(x)} = \frac{2x-6}{x^2+7x+12}$$

$$D_{f-g} = \mathbb{R}$$

$$D_{f \cdot g} = \mathbb{R}$$

$$2x - 6 = 0 \Rightarrow 2x = 6 \Rightarrow x = 3$$

$$D_{\frac{f}{g}} = \mathbb{R} - \{3\}$$

 $D_{\frac{g}{f}} =$

Domains: $D_{f+g} = \mathbb{R}$

Domains:

 $D_f = \mathbb{R}$ $D_g = \mathbb{R}$

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• Let
$$f(x) = x^2 + 7x + 12$$
 and $g(x) = 2x - 6$.
• Find the sum $(f + g)(x) = f(x) + g(x)$
 $= (x^2 + 7x + 12) + (2x - 6) = x^2 + 9x + 6$
• Find the difference $(f - g)(x) = f(x) - g(x)$
 $= (x^2 + 7x + 12) - (2x - 6) = x^2 + 5x + 18$
• Find the product $(f \cdot g)(x) = f(x) \cdot g(x)$
 $= (x^2 + 7x + 12) \cdot (2x - 6)$
 $= 2x^3 - 6x^2 + 14x^2 - 42x + 24x - 72$
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• Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{g(x)} = \frac{x^2 + 7x + 12}{2x - 6}$
• Find the quotient $\frac{g}{f}(x) = \frac{g(x)}{f(x)} = \frac{2x - 6}{x^2 + 7x + 12}$

Domains:

 $D_f = \mathbb{R}$ $D_g = \mathbb{R}$

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$$D_{f-g} = \mathbb{R}$$

$$D_{f\cdot g} = \mathbb{R}$$

$$2x - 6 = 0 \Rightarrow 2x = 6 \Rightarrow x = 3$$

$$D_{\frac{f}{g}} = \mathbb{R} - \{3\}$$

$$x^{2} + 7x + 12 = 0$$

$$\Rightarrow (x + 3)(x + 4) = 0$$

$$\Rightarrow x = -3 \text{ or } x = -4$$

$$\Rightarrow x = -3 \text{ or } x = -4$$
$$D_{\frac{g}{f}} = \mathbb{R} - \{-3, -4\}$$

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Domains: $D_{f+g} = \mathbb{R}$

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2 Let
$$f(x) = \frac{1}{x-5}$$
 and $g(x) = \sqrt{x-2}$.

• Find the sum
$$(f + g)(x) = f(x) + g(x)$$

Domains:
$$D_{f+\sigma} =$$

 $D_{f-g} =$

• Find the difference
$$(f - g)(x) = f(x) - g(x)$$

• Find the product
$$(f \cdot g)(x) = f(x) \cdot g(x)$$

• Find the quotient
$$\frac{f}{g}(x) = \frac{f(x)}{g(x)}$$

$$D_{f \cdot g} =$$

$$D_{\frac{f}{g}} =$$

Find the quotient
$$\frac{g}{f}(x) = \frac{g(x)}{f(x)}$$
 $D_{\frac{g}{f}} =$

Domains:

 $D_f = D_g =$

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$$= \frac{1}{x-5} + \sqrt{x-2}$$
• Find the difference $(f-g)(x) = f(x) - g(x)$
• Find the product $(f \cdot g)(x) = f(x) \cdot g(x)$
• Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{g(x)}$
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Domains:

 $D_f = D_g =$

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• Find the difference $(f-g)(x) = f(x) - g(x)$

$$= \frac{1}{x-5} - \sqrt{x-2}$$
• Find the product $(f \cdot g)(x) = f(x) \cdot g(x)$
D_{f-g} =
• Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{g(x)}$
D_f =
• Find the quotient $\frac{g}{f}(x) = \frac{g(x)}{f(x)}$
D_g =

Domains:

 $D_f = D_g =$

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Q Let
$$f(x) = \frac{1}{x-5}$$
 and $g(x) = \sqrt{x-2}$.
• Find the sum $(f+g)(x) = f(x) + g(x)$ Domains:
$$= \frac{1}{x-5} + \sqrt{x-2}$$
• Find the difference $(f-g)(x) = f(x) - g(x)$

$$= \frac{1}{x-5} - \sqrt{x-2}$$
• Find the product $(f \cdot g)(x) = f(x) \cdot g(x)$

$$= \frac{1}{x-5} \cdot \sqrt{x-2} = \frac{\sqrt{x-2}}{x-5}$$
• Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{g(x)}$
• Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{f(x)}$
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• Find the quotient $\frac{g}{f}(x) = \frac{g(x)}{f(x)}$

Domains:

 $D_f = D_g =$

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Q Let
$$f(x) = \frac{1}{x-5}$$
 and $g(x) = \sqrt{x-2}$.
• Find the sum $(f+g)(x) = f(x) + g(x)$ Domains:
$$= \frac{1}{x-5} + \sqrt{x-2}$$
• Find the difference $(f-g)(x) = f(x) - g(x)$

$$= \frac{1}{x-5} - \sqrt{x-2}$$
• Find the product $(f \cdot g)(x) = f(x) \cdot g(x)$

$$= \frac{1}{x-5} \cdot \sqrt{x-2} = \frac{\sqrt{x-2}}{x-5}$$
• Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{g(x)} = \frac{1}{x-5} \cdot \frac{1}{\sqrt{x-2}} = \frac{1}{x-5} \cdot \frac{1}{\sqrt{x-2}}$
• Find the quotient $\frac{f}{g}(x) = \frac{g(x)}{f(x)}$

$$= \frac{1}{x-5} \cdot \frac{1}{\sqrt{x-2}} = \frac{1}{(x-5) \cdot \sqrt{x-2}}$$
• Find the quotient $\frac{g}{f}(x) = \frac{g(x)}{f(x)}$

$$D_{\frac{g}{f}} = \frac{1}{x-5} \cdot \frac{1}{x-5} + \frac{1}{x-5} \cdot \frac{1}{x-5} + \frac{1}$$

Domains:

 $D_f = D_g =$

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Q Let
$$f(x) = \frac{1}{x-5}$$
 and $g(x) = \sqrt{x-2}$.
• Find the sum $(f+g)(x) = f(x) + g(x)$ Domains:
$$= \frac{1}{x-5} + \sqrt{x-2}$$
• Find the difference $(f-g)(x) = f(x) - g(x)$ $D_{f-g} = \frac{1}{x-5} - \sqrt{x-2}$
• Find the product $(f \cdot g)(x) = f(x) \cdot g(x)$ $= \frac{1}{x-5} \cdot \sqrt{x-2} = \frac{\sqrt{x-2}}{x-5}$ $D_{f-g} = \frac{1}{x-5} \cdot \sqrt{x-2} = \frac{\sqrt{x-2}}{x-5}$
• Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{g(x)} = \frac{\frac{1}{x-5}}{\sqrt{x-2}} = \frac{\frac{1}{x-5}}{\frac{\sqrt{x-2}}{1}}$ $D_{\frac{f}{g}} = \frac{1}{x-5} \cdot \frac{1}{\sqrt{x-2}} = \frac{1}{(x-5) \cdot \sqrt{x-2}}$
• Find the quotient $\frac{g}{f}(x) = \frac{g(x)}{f(x)} = \frac{\sqrt{x-2}}{\frac{1}{x-5}}$ $D_{\frac{f}{g}} = \sqrt{x-2} \cdot \frac{x-5}{1} = \sqrt{x-2} \cdot (x-5)$

Domains:

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Q Let
$$f(x) = \frac{1}{x-5}$$
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• Find the sum $(f+g)(x) = f(x) + g(x)$ Domains:
$$= \frac{1}{x-5} + \sqrt{x-2}$$
• Find the difference $(f-g)(x) = f(x) - g(x)$ $D_{f-g} = \frac{1}{x-5} - \sqrt{x-2}$
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• Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{g(x)} = \frac{\frac{1}{x-5}}{\sqrt{x-2}} = \frac{\frac{1}{x-5}}{\frac{\sqrt{x-2}}{1}}$ $D_{\frac{f}{g}} = \frac{1}{x-5} \cdot \frac{1}{\sqrt{x-2}} = \frac{1}{(x-5) \cdot \sqrt{x-2}}$
• Find the quotient $\frac{g}{f}(x) = \frac{g(x)}{f(x)} = \frac{\sqrt{x-2}}{\frac{1}{x-5}}$ $D_{\frac{f}{g}} = \sqrt{x-2} \cdot \frac{x-5}{1} = \sqrt{x-2} \cdot (x-5)$

Domains:

 $D_f = \mathbb{R} - \{5\}$ $D_g = [2, \infty)$



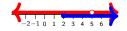
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Q Let
$$f(x) = \frac{1}{x-5}$$
 and $g(x) = \sqrt{x-2}$.
a Find the sum $(f+g)(x) = f(x) + g(x)$ and $f(x) = f(x) + g(x)$ and $f(x) = \frac{1}{x-5} + \sqrt{x-2}$
b Find the difference $(f-g)(x) = f(x) - g(x)$ and $f(x) = \frac{1}{x-5} - \sqrt{x-2}$
b Find the product $(f \cdot g)(x) = f(x) \cdot g(x)$ and $f(x) = \frac{1}{x-5} \cdot \sqrt{x-2} = \frac{\sqrt{x-2}}{x-5}$
c Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{g(x)} = \frac{1}{x-5} \cdot \frac{1}{\sqrt{x-2}} = \frac{1}{\frac{1}{x-5}} = \frac{1}{\frac{1$

Domains:

 $D_f = \mathbb{R} - \{5\}$ $D_g = [2, \infty)$



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Q Let
$$f(x) = \frac{1}{x-5}$$
 and $g(x) = \sqrt{x-2}$.
a Find the sum $(f+g)(x) = f(x) + g(x)$ and $f(x) = f(x) + g(x)$ and $D_{f+g} = [2,5) \cup (5,\infty)$.
b Find the difference $(f-g)(x) = f(x) - g(x)$ and $D_{f-g} = [2,5) \cup (5,\infty)$.
b Find the product $(f \cdot g)(x) = f(x) \cdot g(x)$ and $T_{x-5} - \sqrt{x-2}$.
c Find the product $(f \cdot g)(x) = f(x) \cdot g(x)$ and $T_{x-5} - \sqrt{x-2} = \frac{\sqrt{x-2}}{x-5}$.
c Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{g(x)} = \frac{1}{x-5} - \frac{1}{\sqrt{x-2}} = \frac{1}{x-5}$.
d Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{g(x)} = \frac{1}{x-5} - \frac{1}{\sqrt{x-2}} = \frac{1}{x-5}$.
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f Find the quotient $\frac{g}{f}(x) = \frac{g(x)}{x-2} = \frac{\sqrt{x-2} \cdot (x-5)}{x-5}$.
f Find the quotient $\frac{g}{f}(x) = \frac{g(x)}{f(x)} = \frac{\sqrt{x-2}}{x-5}$.
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f Find the quotient $\frac{g}{f}(x) = \frac{g(x)}{x-5} = \sqrt{x-2} \cdot (x-5)$.

Domains:

 $D_f = \mathbb{R} - \{5\}$ $D_g = [2, \infty)$



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5. Symmetries and operations on functions 5/9

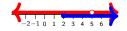
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Q Let
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 and $g(x) = \sqrt{x-2}$.
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 $= \frac{1}{x-5} - \sqrt{x-2}$
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 $= \frac{1}{x-5} \cdot \sqrt{x-2} = \frac{\sqrt{x-2}}{x-5}$
b Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{g(x)} = \frac{1}{x-5} \cdot \frac{1}{\sqrt{x-2}} = \frac{1}{\frac{1}{x-5}}$
c Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{g(x)} = \frac{1}{(x-5) \cdot \sqrt{x-2}}$
b Find the quotient $\frac{g}{f}(x) = \frac{g(x)}{g(x)} = \frac{\sqrt{x-2}}{1}$
c Find the quotient $\frac{g}{f}(x) = \frac{g(x)}{g(x)} = \frac{\sqrt{x-2}}{1}$
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Find the quotient
$$\frac{g}{f}(x) = \frac{g(x)}{f(x)} = \frac{\sqrt{x-2}}{\frac{1}{x-5}}$$
$$= \sqrt{x-2} \cdot \frac{x-5}{1} = \sqrt{x-2} \cdot (x-5)$$

Domains:

 $D_f = \mathbb{R} - \{5\}$ $D_{g} = [2, \infty)$



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 $D_{\frac{g}{f}} =$

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b Find the quotient $\frac{f}{g}(x) = \frac{f(x)}{g(x)} = \frac{1}{\frac{x-5}{\sqrt{x-2}}} = \frac{1}{\frac{x-5}{1}}$
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c Find the quotient $\frac{g}{f}(x) = \frac{g(x)}{f(x)} = \frac{\sqrt{x-2}}{\frac{1}{x-5}}$
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Domains:

 $D_f = \mathbb{R} - \{5\}$ $D_{g} = [2, \infty)$



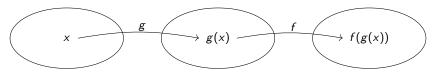
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 $(5) \cup (5, \infty)$

Composition

Use the output of the function g as an input for the function f:



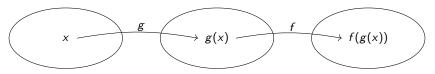
Definition

The composition $f \circ g$ is the function $(f \circ g)(x) = f(g(x))$. The domain of $f \circ g$ are all x for which g(x) is defined and then f(g(x)) is also defined.

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Composition

Use the output of the function g as an input for the function f:



Definition

The composition $f \circ g$ is the function $(f \circ g)(x) = f(g(x))$. The domain of $f \circ g$ are all x for which g(x) is defined and then f(g(x)) is also defined.

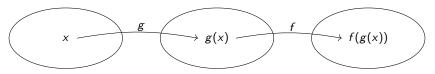
• $f(x) = 2x + 1$	2 $f(x) = \frac{x+1}{x+2}$	3 $f(x) = x^2 - 5x + 8$
$g(x)=x^2-5$	g(x) = x + 3	g(x) = x + 3
Evaluate:	Evaluate:	Evaluate:
$(f \circ g)(4) = f(g(4)) =$	$(f\circ g)(5)=f(g(5))=$	$(f \circ g)(x) = f(g(x)) =$

 $(f \circ g)(3) = f(g(3)) = (g \circ f)(5) = g(f(5)) =$

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Use the output of the function g as an input for the function f:



Definition

The composition $f \circ g$ is the function $(f \circ g)(x) = f(g(x))$. The domain of $f \circ g$ are all x for which g(x) is defined and then f(g(x)) is also defined.

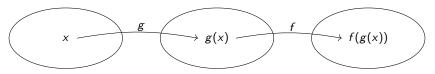
1	f(x) = 2x + 1	2	$f(x) = \frac{x+1}{x+2}$	
	$g(x) = x^2 - 5$		g(x) = x + 3	
	Evaluate:		Evaluate:	
	$(f \circ g)(4) = f(g(4)) = f(4^2 - 5)$		$(f \circ g)(5) = f(g(5)) =$	
	$= f(11) = 2 \cdot 11 + 1 = 23$			
	$(f \circ g)(3) = f(g(3)) =$		$(g \circ f)(5) = g(f(5)) =$	

•
$$f(x) = x^2 - 5x + 8$$

 $g(x) = x + 3$
Evaluate:
 $(f \circ g)(x) = f(g(x)) = 6$

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Use the output of the function g as an input for the function f:



Definition

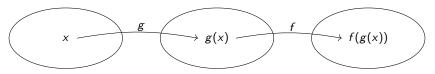
The composition $f \circ g$ is the function $(f \circ g)(x) = f(g(x))$. The domain of $f \circ g$ are all x for which g(x) is defined and then f(g(x)) is also defined.

1 f(x) = 2x + 12 $f(x) = \frac{x+1}{x+2}$ **3** $f(x) = x^2 - 5x + 8$ $g(x) = x^2 - 5$ g(x) = x + 3g(x) = x + 3Evaluate: Evaluate: Evaluate[.] $(f \circ g)(4) = f(g(4)) = f(4^2 - 5)$ $(f \circ g)(5) = f(g(5)) =$ $(f \circ g)(x) = f(g(x)) =$ $= f(11) = 2 \cdot 11 + 1 = 23$ $(f \circ g)(3) = f(g(3)) = f(3^2 - 5)$ $(g \circ f)(5) = g(f(5)) =$ $= f(4) = 2 \cdot 4 + 1 = 9$

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Use the output of the function g as an input for the function f:



Definition

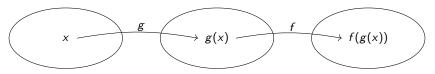
The composition $f \circ g$ is the function $(f \circ g)(x) = f(g(x))$. The domain of $f \circ g$ are all x for which g(x) is defined and then f(g(x)) is also defined.

1 f(x) = 2x + 12 $f(x) = \frac{x+1}{x+2}$ **3** $f(x) = x^2 - 5x + 8$ $g(x) = x^2 - 5$ g(x) = x + 3g(x) = x + 3Evaluate: Evaluate: Evaluate[.] $(f \circ g)(4) = f(g(4)) = f(4^2 - 5)$ $(f \circ g)(5) = f(g(5)) = f(5+3)$ $(f \circ g)(x) = f(g(x)) =$ $= f(11) = 2 \cdot 11 + 1 = 23$ $= f(8) = \frac{8+1}{8+2} = \frac{9}{10}$ $(f \circ g)(3) = f(g(3)) = f(3^2 - 5)$ $(g \circ f)(5) = g(f(5)) =$ $= f(4) = 2 \cdot 4 + 1 = 9$

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Use the output of the function g as an input for the function f:

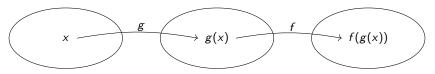


Definition

The composition $f \circ g$ is the function $(f \circ g)(x) = f(g(x))$. The domain of $f \circ g$ are all x for which g(x) is defined and then f(g(x)) is also defined.

1 f(x) = 2x + 12 $f(x) = \frac{x+1}{x+2}$ **3** $f(x) = x^2 - 5x + 8$ $g(x) = x^2 - 5$ g(x) = x + 3g(x) = x + 3Evaluate: Evaluate: Evaluate[.] $(f \circ g)(4) = f(g(4)) = f(4^2 - 5)$ $(f \circ g)(5) = f(g(5)) = f(5+3)$ $(f \circ g)(x) = f(g(x)) =$ $= f(11) = 2 \cdot 11 + 1 = 23$ $= f(8) = \frac{8+1}{8+2} = \frac{9}{10}$ $(f \circ g)(3) = f(g(3)) = f(3^2 - 5)$ $(g \circ f)(5) = g(f(5)) = g(\frac{5+1}{5+2})$ $= f(4) = 2 \cdot 4 + 1 = 9$ $= g(\frac{6}{7}) = \frac{6}{7} + 3 = \frac{27}{7}$ イロト イポト イヨト イヨト

Use the output of the function g as an input for the function f:



Definition

The composition $f \circ g$ is the function $(f \circ g)(x) = f(g(x))$. The domain of $f \circ g$ are all x for which g(x) is defined and then f(g(x)) is also defined.

f(x) = 2x + 1 $g(x) = x^{2} - 5$ Evaluate: $(f \circ g)(4) = f(g(4)) = f(4^{2} - 5)$ $= f(11) = 2 \cdot 11 + 1 = 23$ $(f \circ g)(3) = f(g(3)) = f(3^{2} - 5)$ $= f(4) = 2 \cdot 4 + 1 = 9$ $f(x) = \frac{x+1}{x+2}$ g(x) = x + 3Evaluate: $(f \circ g)(5) = f(g(5)) = f(5 + 3)$ $= f(8) = \frac{8+1}{8+2} = \frac{9}{10}$ $(g \circ f)(5) = g(f(5)) = g(\frac{5+1}{5+2})$ $= g(\frac{6}{7}) = \frac{6}{7} + 3 = \frac{27}{7}$

(a) $f(x) = x^2 - 5x + 8$ g(x) = x + 3Evaluate: $(f \circ g)(x) = f(g(x)) =$ = f(x + 3) $= (x + 3)^2 - 5(x + 3) + 8$ $= x^2 + 6x + 9 - 5x - 15 + 8$ $= x^2 + x + 2$

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Find the compositions and state their domains.

Image: f(x) = x^2 + 3x
 Image: f(x) = x^2 + 4x + 6

$$g(x) = x - 7$$
 $g(x) = 2x + 3$
 $(f \circ g)(x) =$
 $(f \circ g)(x) =$

5
$$f(x) = \frac{x+2}{x-5}$$

 $g(x) = x^2 + 4$
 $(f \circ g)(x) =$

$$f(x) = x^2 + 4x + 6$$

 $g(x) = 2x + 3$

 $(g \circ f)(x) =$

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MAT 1375 - Precalculus

5. Symmetries and operations on functions 7/9

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Find the compositions and state their domains.

•
$$f(x) = x^2 + 3x$$

 $g(x) = x - 7$
 $(f \circ g)(x) = f(g(x))$
 $= f(x - 7)$
 $= (x - 7)^2 + 3 \cdot (x - 7)$
 $= x^2 - 14x + 49 + 3x - 21$
 $= x^2 - 11x + 28$
Domain: $D = \mathbb{R}$
• $f(x) = \frac{x+2}{x-5}$
 $g(x) = x^2 + 4$

•
$$f(x) = x^2 + 4x + 6$$

 $g(x) = 2x + 3$
 $(f \circ g)(x) =$

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 $= x^2 - 14x + 49 + 3x - 21$
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Domain: $D = \mathbb{R}$
• $f(x) = \frac{x+2}{x-5}$
 $g(x) = x^2 + 4$
 $(f \circ g)(x) = f(g(x))$
 $= f(x^2 + 4)$
 $= \frac{x^2+4+2}{x^2+4-5} = \frac{x^2+6}{x^2-1}$

Domain:

Where is the denominator zero?

$$\begin{aligned} x^2 - 1 &= 0\\ (x+1)(x-1) &= 0 \Rightarrow x = \pm 1\\ \Rightarrow D &= \mathbb{R} - \{-1, +1\} \end{aligned}$$

•
$$f(x) = x^2 + 4x + 6$$

 $g(x) = 2x + 3$
 $(f \circ g)(x) =$

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Domain: $D = \mathbb{R}$
• $f(x) = \frac{x+2}{x-5}$
 $g(x) = x^2 + 4$
 $(f \circ g)(x) = f(g(x))$
 $= f(x^2 + 4)$
 $= \frac{x^2+4+5}{x^2+4-5} = \frac{x^2+6}{x^2-1}$

Domain:

Where is the denominator zero?

$$x^{2} - 1 = 0$$

(x + 1)(x - 1) = 0 \Rightarrow x = ± 1
 \Rightarrow D = $\mathbb{R} - \{-1, +1\}$

$$f(x) = x^{2} + 4x + 6$$

$$g(x) = 2x + 3$$

$$(f \circ g)(x) = f(g(x))$$

$$= f(2x + 3)$$

$$= (2x + 3)^{2} + 4 \cdot (2x + 3) + 6$$

$$= 4x^{2} + 12x + 9 + 8x + 12 + 6$$

$$= 4x^{2} + 20x + 27$$

Domain: $D = \mathbb{R}$

•
$$f(x) = x^2 + 4x + 6$$

 $g(x) = 2x + 3$
 $(g \circ f)(x) =$

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Find the compositions and state their domains.

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$$f(x) = x^2 + 3x$$

 $g(x) = x - 7$
 $(f \circ g)(x) = f(g(x))$
 $= f(x - 7)$
 $= (x - 7)^2 + 3 \cdot (x - 7)$
 $= x^2 - 14x + 49 + 3x - 21$
 $= x^2 - 11x + 28$
Domain: $D = \mathbb{R}$
• $f(x) = \frac{x+2}{x-5}$
 $g(x) = x^2 + 4$
 $(f \circ g)(x) = f(g(x))$
 $= f(x^2 + 4)$
 $= \frac{x^2 + 45}{x^2 + 45} = \frac{x^2 + 65}{x^2 - 1}$

Domain:

Where is the denominator zero?

$$x^{2} - 1 = 0$$

(x+1)(x-1) = 0 \Rightarrow x = ±1
 \Rightarrow D = $\mathbb{R} - \{-1, +1\}$

(a)
$$f(x) = x^{2} + 4x + 6$$

$$g(x) = 2x + 3$$

$$(f \circ g)(x) = f(g(x))$$

$$= f(2x + 3)$$

$$= (2x + 3)^{2} + 4 \cdot (2x + 3) + 6$$

$$= 4x^{2} + 12x + 9 + 8x + 12 + 6$$

$$= 4x^{2} + 20x + 27$$
Domain: $D = \mathbb{R}$
(a)
$$f(x) = x^{2} + 4x + 6$$

$$g(x) = 2x + 3$$

$$(g \circ f)(x) = g(f(x))$$

$$= g(x^{2} + 4x + 6)$$

$$= 2x^{2} + 4x + 6)$$

= 2 \cdot (x^{2} + 4x + 6) + 3
= 2x^{2} + 8x + 12 + 3
= 2x^{2} + 8x + 15

Domain: $D = \mathbb{R}$

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7/9

Find the compositions and state their domains.

Image: f(x) =
$$\sqrt{3 - 2x}$$
 Image: f(x) = $\frac{1}{x^2 - x - 12}$

 g(x) = 5 - 4x
 g(x) = 3x - 5

 (f \circ g)(x) =
 (g \circ f)(x) =

$$f(x) = \sqrt{3 - 2x}$$
$$g(x) = 5 - 4x$$
$$(g \circ f)(x) =$$

$$f(x) = \frac{1}{x^2 - x - 12}$$

$$g(x) = 3x - 5$$

$$(f \circ g)(x) =$$

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Find the compositions and state their domains.

(a)
$$f(x) = \sqrt{3 - 2x}$$

 $g(x) = 5 - 4x$
 $(f \circ g)(x) = f(g(x))$
 $= f(5 - 4x)$
 $= \sqrt{3 - 2 \cdot (5 - 4x)}$
 $= \sqrt{3 - 10 + 8x}$
 $= \sqrt{8x - 7}$

Domain:

$$8x - 7 \ge 0 \implies 8x \ge 7 \implies x \ge \frac{7}{8}$$
$$D = [\frac{7}{8}, \infty)$$
$$f(x) = \sqrt{3 - 2x}$$
$$g(x) = 5 - 4x$$
$$(g \circ f)(x) =$$

$$f(x) = \frac{1}{x^2 - x - 12}$$

$$g(x) = 3x - 5$$

$$(g \circ f)(x) =$$

$$f(x) = \frac{1}{x^2 - x - 12}$$

$$g(x) = 3x - 5$$

$$(f \circ g)(x) =$$

Find the compositions and state their domains.

$$f(x) = \sqrt{3 - 2x}$$

$$g(x) = 5 - 4x$$

$$(f \circ g)(x) = f(g(x))$$

$$= f(5 - 4x)$$

$$= \sqrt{3 - 2 \cdot (5 - 4x)}$$

$$= \sqrt{3 - 10 + 8x}$$

$$= \sqrt{8x - 7}$$

Domain:

9

$$8x - 7 \ge 0 \implies 8x \ge 7 \implies x \ge \frac{7}{8}$$

$$D = [\frac{7}{8}, \infty)$$

$$f(x) = \sqrt{3 - 2x}$$

$$g(x) = 5 - 4x$$

$$(g \circ f)(x) = g(f(x))$$

$$= g(\sqrt{3 - 2x})$$

$$= 5 - 4 \cdot \sqrt{3 - 2x}$$
Domain:

$$\begin{array}{l} 3-2x\geq 0 \quad \Rightarrow -2x\geq -3 \quad \Rightarrow x\leq \frac{3}{2} \\ D=(-\infty,\frac{3}{2}] \end{array}$$

•
$$f(x) = \frac{1}{x^2 - x - 12}$$

 $g(x) = 3x - 5$
 $(g \circ f)(x) =$

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$$f(x) = \frac{1}{x^2 - x - 12}$$

$$g(x) = 3x - 5$$

$$(f \circ g)(x) =$$

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Find the compositions and state their domains.

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$$f(x) = \sqrt{3 - 2x}$$

$$g(x) = 5 - 4x$$

$$(f \circ g)(x) = f(g(x))$$

$$= f(5 - 4x)$$

$$= \sqrt{3 - 2 \cdot (5 - 4x)}$$

$$= \sqrt{3 - 10 + 8x}$$

$$= \sqrt{8x - 7}$$

Domain:

9

$$8x - 7 \ge 0 \implies 8x \ge 7 \implies x \ge$$
$$D = \begin{bmatrix} \frac{7}{8}, \infty \end{bmatrix}$$
$$f(x) = \sqrt{3 - 2x}$$
$$g(x) = 5 - 4x$$
$$(g \circ f)(x) = g(f(x))$$
$$= g(\sqrt{3 - 2x})$$
$$= 5 - 4 \cdot \sqrt{3 - 2x}$$
Domain:

 $\begin{array}{ll} 3-2x\geq 0 & \Rightarrow -2x\geq -3 & \Rightarrow x\leq \frac{3}{2} \\ D=(-\infty,\frac{3}{2}] \end{array}$

$$f(x) = \frac{1}{x^2 - x - 12}$$

$$g(x) = 3x - 5$$

$$(g \circ f)(x) = g(f(x))$$

$$= g(\frac{1}{x^2 - x - 12}) = 3 \cdot \frac{1}{x^2 - x - 12} - 5$$

$$= \frac{3}{x^2 - x - 12} - \frac{5(x^2 - x - 12)}{x^2 - x - 12}$$

$$= \frac{3 - 5x^2 + 5x + 60}{x^2 - x - 12} = \frac{-5x^2 + 5x + 63}{x^2 - x - 12}$$

Domain:

10

$$x^{2} - x - 12 = 0$$

$$\Rightarrow (x + 3)(x - 4) = 0 \quad \Rightarrow x = -3, x = 4$$

$$D = \mathbb{R} - \{-3, 4\}$$

$$f(x) = \frac{1}{x^{2} - x - 12}$$

$$g(x) = 3x - 5$$

$$(f \circ g)(x) =$$

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Find the compositions and state their domains.

$$f(x) = \sqrt{3 - 2x}$$

$$g(x) = 5 - 4x$$

$$(f \circ g)(x) = f(g(x))$$

$$= f(5 - 4x)$$

$$= \sqrt{3 - 2 \cdot (5 - 4x)}$$

$$= \sqrt{3 - 10 + 8x}$$

$$= \sqrt{8x - 7}$$

Domain:

9

$$8x - 7 \ge 0 \implies 8x \ge 7 \implies x \ge \frac{7}{8}$$
$$D = [\frac{7}{8}, \infty)$$
$$f(x) = \sqrt{3 - 2x}$$
$$g(x) = 5 - 4x$$
$$(g \circ f)(x) = g(f(x))$$
$$= g(\sqrt{3 - 2x})$$
$$= 5 - 4 \cdot \sqrt{3 - 2x}$$

Domain:

$$\begin{array}{l} 3-2x\geq 0 \quad \Rightarrow -2x\geq -3 \quad \Rightarrow x\leq \frac{3}{2}\\ D=(-\infty,\frac{3}{2}] \end{array}$$

$$f(x) = \frac{1}{x^2 - x - 12}$$

$$g(x) = 3x - 5$$

$$(g \circ f)(x) = g(f(x))$$

$$= g(\frac{1}{x^2 - x - 12}) = 3 \cdot \frac{1}{x^2 - x - 12} - 5$$

$$= \frac{3}{x^2 - x - 12} - \frac{5(x^2 - x - 12)}{x^2 - x - 12}$$

$$= \frac{3 - 5x^2 + 5x + 63}{x^2 - x - 12} = \frac{-5x^2 + 5x + 63}{x^2 - x - 12}$$

Domain:

10

$$\begin{aligned} x^2 - x - 12 &= 0 \\ \Rightarrow (x+3)(x-4) &= 0 \quad \Rightarrow x = -3, x = 4 \\ D &= \mathbb{R} - \{-3, 4\} \end{aligned}$$

$$f(x) = \frac{1}{x^2 - x - 12} = \frac{1}{(x+3)(x-4)} g(x) = 3x - 5 (f \circ g)(x) = f(g(x)) = f(3x - 5) = \frac{1}{((3x-5)+3) \cdot ((3x-5)-4)} = \frac{1}{(3x-2)(3x-9)}$$

Domain:

$$3x - 2 = 0 \text{ or } 3x - 9 = 0$$

$$\Rightarrow x = \frac{2}{3} \text{ or } x = 3 \quad \Rightarrow D = \mathbb{R} - \{\frac{2}{3}, 3\}$$

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MAT 1375 - Precalculus

5. Symmetries and operations on functions 9/9

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