TMUA PRACTICE SET

Transformations Part A Practice 1 Solutions

Time limit: none — work at your own pace

Calculators: not permitted

Format: 10 multiple-choice questions

This is a TMUA-style practice set, intended for familiarisation with a specific topic.

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Question 1

The curve $y = f(x)$, where $f(x) = x^2 + x - 2$, undergoes the following transformations in order: a horizontal translation by $+2$, a vertical stretch by factor 3, a reflection in the y-axis, and a vertical translation by -4. Which of the following is the equation of the transformed curve?

A $y = 3x^2 - 9x - 4$

B $y = 3x^2 + 9x - 4$

C $y = 3x^2 + 9x - 12$

D $y = 3x^2 - 15x + 8$

Solution 1

Answer: B

A horizontal translation by $+2$ replaces x by $x - 2$. After the vertical stretch, reflection in the y-axis and final vertical translation, the equation is

$$y = 3f(-x-2) - 4.$$

Now $f(-x-2) = (-x-2)^2 + (-x-2) - 2 = x^2 + 3x$, so

$$y = 3(x^2 + 3x) - 4 = 3x^2 + 9x - 4.$$

Question 2

The curve $y = f(x)$, where $f(x) = x^3 - x + 2$, undergoes the following transformations in order: a reflection in the x-axis, a horizontal stretch by factor 2, a horizontal translation by -1, and a vertical translation by $+3$. Which of the following is the equation of the transformed curve?

A $y = -\dfrac{(x-1)^3}{8} + \dfrac{x-1}{2} + 1$

B $y = -8(x+1)^3 + 2(x+1) + 1$

C $y = -\dfrac{(x+1)^3}{8} + \dfrac{x+1}{2} - 5$

D $y = -\dfrac{(x+1)^3}{8} + \dfrac{x+1}{2} + 1$

Solution 2

Answer: D

The reflection first gives $y = -f(x)$. A horizontal stretch by factor 2 replaces x by $x/2$, and the translation by -1 then replaces x by $x+1$. Hence the final equation is

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

Substituting the definition of f gives

$$y = -\left(\frac{(x+1)^3}{8} - \frac{x+1}{2} + 2\right) + 3 = -\frac{(x+1)^3}{8} + \frac{x+1}{2} + 1.$$

Question 3

The curve $y = f(x)$, where $f(x) = 2x^2 - 3x + 1$, undergoes the following transformations in order: a reflection in the line $x = 2$, a vertical stretch by factor $1/2$, a vertical translation by $+5$, and a reflection in the line $y = 1$. Which of the following is the equation of the transformed curve?

A $\quad y = -x^2 + \dfrac{13}{2}x - \dfrac{27}{2}$

B $\quad y = -x^2 + \dfrac{13}{2}x - \dfrac{29}{2}$

C $\quad y = -x^2 + \dfrac{13}{2}x - \dfrac{7}{2}$

D $\quad y = -x^2 + \dfrac{5}{2}x - \dfrac{9}{2}$

Solution 3

Answer: A

Reflection in $x = 2$ replaces x by $4-x$. Just before the final reflection, the equation is $y = \frac{1}{2}f(4-x)+5$. Reflection in $y = 1$ replaces the entire current output y by $2 - y$, so the final equation is

$$y = 2 - \left(\frac{1}{2}f(4-x) + 5\right) = -\frac{1}{2}f(4-x) - 3.$$

Since $f(4-x) = 2x^2 - 13x + 21$, this becomes

$$y = -x^2 + \frac{13}{2}x - \frac{27}{2}.$$

Question 4

The curve $y = f(x)$, where $f(x) = x^3 + 2x^2 - x$, undergoes the following transformations in order: a horizontal stretch by factor 0.5, a reflection in the y-axis, a horizontal translation by $+3$, and a reflection in the x-axis. Which of the following is the equation of the transformed curve?

A $y = -(-2x-6)^3 - 2(-2x-6)^2 + (-2x-6)$

B $y = -\left(\frac{3-x}{2}\right)^3 - 2\left(\frac{3-x}{2}\right)^2 + \frac{3-x}{2}$

C $y = -(6-2x)^3 - 2(6-2x)^2 + (6-2x)$

D $y = -(2x-6)^3 - 2(2x-6)^2 + (2x-6)$

Solution 4

Answer: C

A horizontal stretch by factor 0.5 replaces x by $2x$. Reflection in the y-axis then replaces x by $-x$, giving $f(-2x)$. Translating this curve horizontally by $+3$ gives

$$y = f(-2(x-3)) = f(6-2x).$$

The final reflection in the x-axis gives $y = -f(6-2x)$. Using the definition of f,

$$y = -(6-2x)^3 - 2(6-2x)^2 + (6-2x).$$

Question 5

The curve $y = f(x)$, where $f(x) = x^2 - 4x + 3$, undergoes the following transformations in order: a vertical translation by $+2$, a reflection in the x-axis, a horizontal translation by -3, and a reflection in the line $x = -1$. Which of the following is the equation of the transformed curve?

A $y = -x^2 + 2x - 2$

B $y = -x^2 - 2x - 2$

C $y = -x^2 - 2x + 2$

D $y = -x^2 - 6x - 10$

Solution 5

Answer: B

After the first three transformations, the equation is $y = -f(x+3) - 2$. Reflection in the line $x = -1$ replaces x in this entire current function by $-2 - x$. Therefore

$$y = -f((-2 - x) + 3) - 2 = -f(1 - x) - 2.$$

Since $f(1 - x) = (1 - x)^2 - 4(1 - x) + 3 = x^2 + 2x$, the final equation is

$$y = -x^2 - 2x - 2.$$

Question 6

Let $f(x) = x^2 + 3x - 1$ and $g(x) = 2(x-4)^2 + 6(x-4) + 3$. Which of the following sequences of transformations maps the graph of $y = f(x)$ to the graph of $y = g(x)$?

A A horizontal translation by -4, followed by a vertical stretch by factor 2, then a vertical translation by $+5$

B A horizontal translation by $+4$, followed by a vertical translation by $+5$, then a vertical stretch by factor 2

C A horizontal stretch by factor 4, followed by a vertical stretch by factor 2, then a vertical translation by $+5$

D A horizontal translation by $+4$, followed by a vertical stretch by factor 2, then a vertical translation by $+5$

Solution 6

Answer: D

Looking at $g(x)$, it is clear that $g(x) = 2f(x-4) + k$ for some constant k. Now

$$2f(x-4) + k = 2(x-4)^2 + 6(x-4) - 2 + k.$$

Comparing this with $g(x) = 2(x-4)^2 + 6(x-4) + 3$ gives $-2 + k = 3$, so $k = 5$. Therefore

$$g(x) = 2f(x-4) + 5.$$

This corresponds to a horizontal translation by $+4$, followed by a vertical stretch by factor 2, then a vertical translation by $+5$. Hence the correct answer is **D**.

Question 7

Let $f(x) = x^3 - 2x$ and $g(x) = -(2-x)^3 + 2(2-x) - 4$. Which of the following sequences of transformations maps the graph of $y = f(x)$ to the graph of $y = g(x)$?

A A reflection in the line $x = 1$, followed by a reflection in the line $y = -2$

B A reflection in the line $x = -1$, followed by a reflection in the line $y = -2$

C A reflection in the line $x = 1$, followed by a vertical translation by -4

D A reflection in the line $x = 1$, followed by a reflection in the x-axis, then a vertical translation by -2

Solution 7

Answer: A

The expression for $g(x)$ appears to contain $f(2-x)$, since

$$f(2-x) = (2-x)^3 - 2(2-x).$$

Replacing x by $2-x$ corresponds to a reflection in the line $x = 1$.

We can now write $g(x) = -f(2-x) - 4$. The form of this expression, together with the options, suggests that the second transformation is a reflection in a line $y = b$. Such a reflection transforms y into $2b - y$, so we require

$$2b - f(2-x) = -f(2-x) - 4.$$

Hence $2b = -4$, giving $b = -2$. Therefore the transformations are a reflection in the line $x = 1$, followed by a reflection in the line $y = -2$. Hence the correct answer is **A**.

Question 8

Let $f(x) = 2x^2 + x - 3$ and $g(x) = 4x^2 - x + \frac{5}{2}$. Which of the following sequences of transformations maps the graph of $y = f(x)$ to the graph of $y = g(x)$?

A A reflection in the y-axis, a horizontal stretch by factor 2, a vertical stretch by factor 0.5, then a vertical translation by $+4$

B A reflection in the y-axis, a horizontal stretch by factor 0.5, a vertical stretch by factor 2, then a vertical translation by $+4$

C A reflection in the y-axis, a horizontal stretch by factor 0.5, a vertical stretch by factor 0.5, then a vertical translation by $+4$

D A reflection in the y-axis, a horizontal stretch by factor 0.5, a vertical stretch by factor 0.5, then a vertical translation by -4

Solution 8

Answer: C

To obtain the leading term $4x^2$ from the transformations given, the correct sequence can only be C or D.

The first three transformations in either of these options produce

$$\frac{1}{2}f(-2x) = \frac{1}{2}\left(8x^2 - 2x - 3\right) = 4x^2 - x - \frac{3}{2}.$$

To obtain $g(x) = 4x^2 - x + \frac{5}{2}$, we must then translate vertically by $+4$, since $-\frac{3}{2} + 4 = \frac{5}{2}$. Therefore the correct answer is **C**.

Question 9

Let $f(x) = x^3 + x^2 - 1$ and $g(x) = -\frac{(x+2)^3}{27} - \frac{(x+2)^2}{9} + 2$. Which of the following sequences of transformations maps the graph of $y = f(x)$ to the graph of $y = g(x)$?

A A horizontal translation by -2, followed by a horizontal stretch by factor 3, a reflection in the x-axis, then a vertical translation by $+1$

B A horizontal stretch by factor 3, followed by a horizontal translation by -2, a reflection in the x-axis, then a vertical translation by $+1$

C A horizontal stretch by factor 3, followed by a horizontal translation by $+2$, a reflection in the x-axis, then a vertical translation by $+1$

D A horizontal stretch by factor 3, followed by a horizontal translation by -2, a vertical translation by $+1$, then a reflection in the x-axis

Solution 9

Answer: B

The cubic and square terms in $g(x)$ suggest the expression $f\left(\frac{x+2}{3}\right)$, since

$$f\left(\frac{x+2}{3}\right) = \frac{(x+2)^3}{27} + \frac{(x+2)^2}{9} - 1.$$

The replacement of x by $\frac{x+2}{3}$ corresponds to a horizontal stretch by factor 3, followed by a horizontal translation by -2.

Comparing the expression above with $g(x)$, we have

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

Thus the curve is then reflected in the x-axis and translated vertically by $+1$. Hence the correct answer is **B**.

Question 10

Let $f(x) = x^3 - x + 1$ and $g(x) = (x-5)^3 - x + 5$. Which of the following sequences of transformations maps the graph of $y = f(x)$ to the graph of $y = g(x)$?

A A reflection in the line $y = 2$, followed by a reflection in the line $x = 3$, a horizontal translation by $+1$, then a vertical translation by -3

B A vertical translation by -3, followed by a reflection in the line $y = 2$, a horizontal translation by $+1$, then a reflection in the line $x = 3$

C A reflection in the line $y = -2$, followed by a horizontal translation by $+1$, a reflection in the line $x = 3$, then a vertical translation by -3

D A reflection in the line $y = 2$, followed by a horizontal translation by $+1$, a reflection in the line $x = 3$, then a vertical translation by -3

Solution 10

Answer: D

The cubic term $(x-5)^3$ in $g(x)$ suggests that the horizontal transformations produce $f(5-x)$. From the options, this is obtained by a horizontal translation by $+1$, followed by a reflection in the line $x = 3$. This rules out A, leaving B, C and D.

To distinguish between them, there are a few ways, on this occassion, we will just test one point. Consider the point $(2, 7)$ on $y = f(x)$, since $f(2) = 7$. Under the horizontal translation by $+1$, its x-coordinate becomes 3, and reflection in $x = 3$ leaves it unchanged.

We now track its y-coordinate under each remaining option. In B, it becomes $7 - 3 = 4$, then $4 - 4 = 0$ after reflection in $y = 2$. In C, reflection in $y = -2$ gives $-4 - 7 = -11$, followed by the vertical translation to -14. In D, reflection in $y = 2$ gives $4 - 7 = -3$, followed by the vertical translation to -6.

Finally,

$$g(3) = (3-5)^3 - 3 + 5 = -6.$$

Therefore only D maps $(2, 7)$ to a point on $y = g(x)$, so the correct answer is **D**.