G R A D E  1 2  P R E - C A L C U L U S  
M A T H E M A T I C S  (4 0 S )

Midterm Practice Exam
Answer Key
**Instructions**

The midterm examination will be weighted as follows:

- Modules 1–4 100%

Time allowed: 3 hours

**Note:** You are allowed to bring the following to the exam: pens/pencils (2 or 3 of each), blank paper, a ruler, a scientific calculator, and your Midterm Exam Resource Sheet. Your Midterm Exam Resource Sheet must be handed in with the exam. You will receive your Midterm Exam Resource Sheet back from your tutor/marker with the next module work that is submitted for marking.

Show all calculations and formulas used. Use all decimal places in your calculations and round the final answers to the correct number of decimal places. Include units where appropriate. Clearly state your final answer.
General Marking Principles

- Concepts learned in Grade 12 are worth 1 mark each. Concepts learned earlier (unless they are retaught under the curriculum, e.g., absolute value, reciprocals) are worth 0.5 mark each.
- Some errors are deducted only once (e.g., not putting arrowheads on graphs).
- Errors are followed through (e.g., if an arithmetic error is made in the first line, it is still possible for the student to receive nearly full marks).
- Many types of communication errors receive a 0.5 mark deduction, but 0.5 mark is the maximum communication error deduction for the entire exam.
Answer all questions to the best of your ability. Show all your work.

Long-Answer Questions (100 marks)

1. Given the sketch of $f(x)$ drawn below, show each transformation algebraically and graphically. State the domain and range of each function.

   \[ y = \frac{1}{2} f(x) - 2 \]  
   \( (3 \text{ marks}) \) (Module 2, Lesson 3)

   **Answer:**

   **Graphically:**

   \[ (x, y) \rightarrow \left( x, \frac{1}{2} y - 2 \right) \]

   Domain: \( \{ x \in \mathbb{R} \} \)

   Range: \( \{ y \geq -2.5 \} \)

   \( (1 \text{ mark for algebraic notation}) \)
   \( (1 \text{ mark for graph}) \)
   \( (0.5 \text{ mark for domain}) \)
   \( (0.5 \text{ mark for range}) \)
b) \( y = f\left(\frac{1}{2}(x + 4)\right) \)  \((3 \text{ marks})\) (Module 2, Lesson 3)

**Answer:**

**Graphically:**

- Domain: \( \{ x \in \mathbb{R} \} \)
- Range: \( \{ y \geq -1 \} \)

**Algebraically:**

- \((x, y) \rightarrow (2x - 4, y)\)

(1 mark for algebraic notation)
(1 mark for graph)
(0.5 mark for domain)
(0.5 mark for range)
2. The $y$-intercept of the function $g(x)$ is 4. What would the new $y$-intercept be for each of the following functions? (4 × 1 mark each = 4 marks)

a) $y = -2g(x)$ (Module 3, Lesson 1)
   
   **Answer:**
   Vertical reflection and stretch by 2.
   
   $4 \rightarrow -8$

b) $y = g(x) + 1$ (Module 2, Lesson 1)
   
   **Answer:**
   Vertical shift up 1.
   
   $4 \rightarrow 5$

c) $y = g(3x)$ (Module 2, Lesson 2)
   
   **Answer:**
   Horizontal stretch would not affect the $y$-intercept; it would be an invariant point at $(0, 4)$.

d) $y = g(-x)$ (Module 3, Lesson 2)
   
   **Answer:**
   Horizontal reflection would not affect the $y$-intercept; it would be an invariant point at $(0, 4)$.  


3. Use the graph of the function drawn below to sketch \( y = \frac{1}{f(x)} \). (2 marks)  
(Module 2, Lesson 5)

Answer:

(0.5 mark for asymptote at \( y = 0 \))  
(0.5 mark for asymptote at \( x = 2 \))  
(0.5 mark for graph on right side of \( x = 2 \))  
(0.5 mark for graph on left side of \( x = 2 \))
4. Using the sketch of \( f(x) \), sketch the following.

   a) \( y = -3f(x) \) \hspace{1cm} (2 marks) (Module 3, Lesson 1)

   Answer:

   \begin{figure}[h]
   \centering
   \includegraphics[width=\textwidth]{figure.png}
   \caption{(1 mark for vertical stretch)
   (1 mark for reflection over \( x \)-axis)}
   \end{figure}
b) \( y = f(-2x) \)  
(2 marks) (Module 3, Lesson 2) 
Answer:

(1 mark for horizontal compression)  
(1 mark for horizontal reflection)

c) \( y = f^{-1}(x) \)  
(2 marks) (Module 3, Lesson 3) 
Answer:

(1 mark for correct points after switching x- and y-coordinates)  
(1 mark for correct shape)
5. In how many ways can you order 13 songs in a playlist if
   a) there are no restrictions? (1 mark) (Module 1, Lesson 2)
      
      Answer:
      \[ 13! = 6,227,020,800 \]

   b) your favourite song must be first? (2 marks) (Module 1, Lesson 2)
      
      Answer:
      \[ 1 \times 12 \times 11 \times 10 \times 9 \times 8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 = 479,001,600 \]

      (1 mark for 12!)
      (1 mark for restricting first place)

6. How many distinct ways can 4 green cups, 2 blue cups, and 1 red cup be arranged on a
   shelf? (2 marks) (Module 1, Lesson 3)

   Answer:
   \[ \frac{7!}{4!2!} = 105 \]

   (0.5 mark for 7!)
   (0.5 mark for 4! in denominator)
   (0.5 mark for 2! in denominator)
   (0.5 mark for final answer)
7. Four men and five women are on a parent council committee. In how many ways can a five-member subcommittee be formed if the women must have a majority on this subcommittee? (4 marks) (Module 1, Lesson 4)

Answer:
Case 1: 5 women  \( \binom{5}{5} = 1 \)
Case 2: 4 women and 1 man  \( \binom{5}{4} \cdot \binom{4}{3} = 5(4) = 20 \)
Case 3: 3 women and 2 men  \( \binom{5}{3} \cdot \binom{4}{2} = 10(6) = 60 \)
1 + 20 + 60 = 81

(1 mark for each case \times 3)
(1 mark for addition of cases)

8. Evaluate each of the following using factorial notation. Show your work. (4 \times 2 marks each = 8 marks)

a) \( 3P_2 \) (Module 1, Lesson 2)
Answer: \[
\frac{3!}{(3-2)!} = \frac{3!}{1!} = 6 \quad \text{or} \quad 3 \cdot 2 = 6
\]

Mark break down for all:
(1 mark for set up)
(1 mark for answer)

b) \( 5P_2 \)
Answer: \[
\frac{5!}{(5-2)!} = \frac{5!}{3!} = \frac{5 \cdot 4 \cdot 3}{3} = 5 \cdot 4 = 20 \quad \text{or} \quad 5 \cdot 4 = 20
\]

c) \( 7C_3 \) (Module 1, Lesson 4)
Answer: \[
\frac{7!}{(7-3)!3!} = \frac{7!}{4!3!} = \frac{7 \cdot 6 \cdot 5}{3 \cdot 2 \cdot 1} = 35
\]

d) \( 6C_2 \)
Answer: \[
\frac{6!}{(6-2)!2!} = \frac{6!}{4!2!} = \frac{6 \cdot 5}{2 \cdot 1} = 15
\]
9. Solve without using a calculator. (3 marks) (Module 1, Lesson 4)

\( n + 3 P_2 = 20 \)

Answer:

\( n + 3 P_2 = 20 \)

Use \( n P_r = \frac{n!}{(n - r)!} \)

where \( n = n + 3 \)

\( r = 2 \)

\( \frac{(n + 3)!}{(n + 3 - 2)!} = 20 \)

Simplify the denominator:

\( \frac{(n + 3)!}{(n + 1)!} = 20 \)

Expand the factorials and simplify: \( (0.5 \text{ mark for expanding factorials}) \)

\( \frac{(n + 3)(n + 2)(n + 1)!}{(n + 1)!} = 20 \)

\( (n + 3)(n + 2) = 20 \)

Expand and simplify: \( (1 \text{ mark for expanding and simplifying}) \)

\( n^2 + 5n + 6 = 20 \)

\( n^2 + 5n + 6 - 20 = 0 \)

\( n^2 + 5n - 14 = 0 \)

Factor and solve: \( (1 \text{ mark for factoring and solving}) \)

\( (n + 7)(n - 2) = 0 \)

\( n = -7 \)

\( n = 2 \)

\( n \) cannot equal \(-7\) since you cannot take the factorial of a negative number

\( n = 2 \) \( (0.5 \text{ mark for solving for } n) \)
10. Given the following row of Pascal’s Triangle, determine the next row. (1 mark)
(Module 1, Lesson 5)

\[
\begin{array}{cccccccccccc}
1 & 11 & 55 & 165 & 330 & 462 & 462 & 330 & 165 & 55 & 11 & 1 \\
\end{array}
\]

Answer:

\[
\begin{array}{cccccccccccc}
1 & 12 & 66 & 220 & 495 & 792 & 924 & 792 & 495 & 220 & 66 & 12 & 1 \\
\end{array}
\]

To determine the next row of Pascal’s Triangle, start by adding a 1 as the first and last term in the row. Then, determine the middle terms by adding the two values that are diagonally above the term. For example, the second term in this row of Pascal’s Triangle is found by adding 1 to 11. The third term in this row is found by adding 11 to 55, and so on.

11. Write and simplify the last term of the expansion of \( 2 \left( 2 + \frac{2}{x^2} \right)^4 \). (3 marks)
(Module 1, Lesson 5)

Answer:

There are 5 terms.

\[ t_5 = \binom{4}{4} (2)^0 \left( \frac{2}{x^2} \right)^4 = 1 \left( \frac{16}{x^8} \right) = \frac{16}{x^8} \]

(1 mark for \( n = 4, \ k = 4 \))

(0.5 mark for \( 2^0 \))

(0.5 mark for \( \left( \frac{2}{x^2} \right)^4 \))

(0.5 mark for final coefficient)

(0.5 mark for final variable)
12. Expand and simplify \((2x - 3)^4\) using the Binomial Theorem. (4 marks)

(Module 1, Lesson 5)

Answer:

\[
(2x - 3)^4 = \binom{4}{0}(2x)^4(-3)^0 + \binom{4}{1}(2x)^3(-3)^1 + \binom{4}{2}(2x)^2(-3)^2 + \binom{4}{3}(2x)^1(-3)^3 + \binom{4}{4}(2x)^0(-3)^4
\]

\[
= 1(16x^4)(1) + 4(8x^3)(-3) + 6(4x^2)(9) + 4(2x)(-27) + 1(81)
\]

\[
= 16x^4 - 96x^3 + 216x^2 - 216x + 81
\]

(2 marks for the first line
0.5 mark for pattern of powers
0.5 mark for \(\binom{n}{r}\) pattern
1 mark for five terms)

(1 mark for exponent laws)
(1 mark for correct coefficients)
13. For the function \( y = x^3 - 3x^2 - x + 3 \), find the following:

a) the zeros of the function if you know that \((x + 1)\) is a factor of the polynomial

\(\text{(4 marks)}\) (Module 4, Lesson 3)

Answer:
\[ y = x^3 - 3x^2 - x + 3 \]

\((x + 1)\) is a factor so use synthetic division for \(x = -1\)

\[(1 \text{ mark for Factor Theorem)}\]

\[
\begin{array}{c|cccc}
-1 & 1 & -3 & -1 & 3 \\
 & & -1 & 4 & -3 \\
\hline
 & 1 & -4 & 3 & \color{red}{0} \\
\end{array}
\]

\[(1 \text{ mark for synthetic division)}\]

\[\therefore y = x^3 - 3x^2 - x + 3 = (x + 1)(x^2 - 4x + 3) = (x + 1)(x - 3)(x - 1)\]

\[y = (x + 1)(x - 3)(x - 1)\] \[(1 \text{ mark for correct factors)}\]

Zeros: \(x = -1, 3, \text{ and } 1\) \[(1 \text{ mark for correct zeros)}\]

b) left-right behaviour \( (1 \text{ mark)} \) (Module 4, Lesson 1)

Answer:
Left/Right Behaviour: Points down to the left and points up to the right

c) the \(y\)-intercept of the function \( (1 \text{ mark)} \) (Module 4, Lesson 1)

Answer:
\(y\)-intercept: 3
d) the sketch of the graph of the function (2 marks) (Module 4, Lesson 4)
Answer:

(0.5 mark for positive polynomial cubic or cubic consistent with previous work (end behaviour))
(1 mark for correct x-intercepts)
(0.5 mark for y-intercept)
14. Graph a quartic that has roots of $-1$ and $+2$ and a root with multiplicity 2 at $+1$. The function equation has a leading coefficient of $-3$. (3 marks) (Module 4, Lesson 4)

Answer:
x-intercepts at $-1, +2, +1$. Then, $y = -3(x + 1)(x - 2)(x - 1)^2$.

Graph falls in Quadrants III and IV.

Graph is tangent to x-axis at $x = +1$.

$y$-intercept at $(-3)(+1)(-2)(-1)^2$

$= (-3)(-2)$

$= +6$

(1 mark for end behaviour)
(1 mark for behaviour at x-intercept)
(1 mark for y-intercept)
15. If \( f(x) = \frac{1}{x - 3} \) and \( g(x) = |x| \), determine the equation and graph of \( h(x) = g(f(x)) \).

State the domain and range. \((5 \text{ marks})\) (Module 2, Lesson 5)

Answer:

\[
h(x) = g\left(\frac{1}{x-3}\right) = \left|\frac{1}{x-3}\right| \quad (1 \text{ mark for correct } h(x))
\]

(marks for correct graph:
- 1 mark for understanding the effect of absolute value;
- 2 marks for \( f(x) = \frac{1}{x-3} \):
  (0.5 mark for vertical asymptote at \( x = 3 \);
  0.5 mark for horizontal asymptote at \( y = 0 \);
  0.5 mark for right side;
  0.5 mark for left side)

Domain: \( \{x \mid x \neq 3, x \in \mathbb{R}\} \) \quad (0.5 mark)

Range: \( \{y \mid y > 0, y \in \mathbb{R}\} \) \quad (0.5 mark)
16. Consider the graphs of \( f(x) \) and \( g(x) \) below. Use these graphs to sketch \( (g - f)(x) \).

(3 marks) (Module 2, Lesson 4)

**Answer:**

<table>
<thead>
<tr>
<th>( x )</th>
<th>( f(x) )</th>
<th>( g(x) )</th>
<th>( (g - f)(x) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>8</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>5</td>
<td>4</td>
<td>-1</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>
(1 mark for restricting the domain)
(1 mark for \((g - f)(x)\) values)
(1 mark for correct graph)
17. The following graph represents a transformation of $f(x) = |x|$. Write an equation for the new absolute value function. (2 marks) (Module 2, Lesson 3)

Answer:
This function has been shifted 2 units to the right and either stretched vertically by a factor of $\frac{1}{2}$ or compressed horizontally by a factor of $\frac{1}{2}$. The resulting function could be

$$y = f\left(\frac{1}{2} (x - 2)\right) = \left|\frac{1}{2} (x - 2)\right| \text{ or } y = \frac{1}{2} f(x - 2) = \frac{1}{2} |x - 2|$$

(1 mark for horizontal compression value of $\frac{1}{2}$ or vertical stretch by $\frac{1}{2}$)

(0.5 mark for correct horizontal shift)

(0.5 mark for correct placement of absolute value)
18. The graph of a function $f(x)$ is drawn below.

a) Reflect the graph of $f(x)$ in the line $y = x$ to achieve the graph of $g(x)$. (1 mark)
(Module 3, Lesson 3)

Answer:
b) Write the equation of the new function \( g(x) \) in terms of \( f(x) \). (1 mark)  
(Module 3, Lesson 3)  

Answer:  
\[ g(x) = f^{-1}(x) \]

c) Reflect the graph of \( f(x) \) in the x-axis to achieve the graph of \( h(x) \). (1 mark)  
(Module 3, Lesson 1)  

Answer:  
![Graph of h(x)](image)

d) Write the equation of the new function \( h(x) \) in terms of \( f(x) \). (1 mark)  
(Module 3, Lesson 1)  

Answer:  
\[ h(x) = -f(x) \]
19. A function contains the ordered pairs \((-1, 0), (0, 6), \) and \((-3, 7)\). What are the corresponding ordered pairs if this function is reflected through the following lines? (3 × 1 mark each = 3 marks)
   a) \(y = 0\) (x-axis)  
   Answer:
   \((-1, 0), (0, -6), (-3, -7)\)
   
   b) \(x = 0\) (y-axis)  
   Answer:
   \((1, 0), (0, 6), (3, 7)\)
   
   c) \(y = x\)  
   Answer:
   \((0, -1), (6, 0), (7, -3)\)
20. For each of the following relations, determine if they are one-to-one functions. Explain your reasoning. (2 \times 1 \text{ mark each} = 2 \text{ marks})
(Module 3, Lesson 4)

(a) 

Answer:
Yes, \( f(x) \) is a function because it passes the vertical line test. The inverse of \( f(x) \), \( f^{-1}(x) \) is also a function because \( f(x) \) is one-to-one.

(b) 

Answer:
Yes, \( f(x) \) is a function because it passes the vertical line test. The inverse of \( f(x) \) is not a function because it does not pass the horizontal line test. If you restrict the domain of \( f(x) \) to be \( \{x \mid -2 \leq x \leq 0\} \), then \( f^{-1}(x) \) would be a function.
21. Show algebraically that the functions $f$ and $g$ are inverses of each other. (2 marks)  
(Module 3, Lesson 4)

\[ f(x) = \sqrt{4x-1} \quad g(x) = \frac{x^2 + 1}{4} \]

**Answer:**

**Method 1**

\[
f(g(x)) = \sqrt{4\left(\frac{x^2 + 1}{4}\right) - 1} \quad g(f(x)) = \frac{\left(\sqrt{4x-1}\right)^2 + 1}{4}
\]

\[
= \sqrt{x^2 + 1 - 1} \quad = \frac{4x - 1 + 1}{4}
\]

\[
= \sqrt{x^2} \quad = \frac{4x}{4}
\]

\[
= x \quad = \frac{4}{4}
\]

(0.5 mark for writing both compositions)  
(1 mark for simplifying)

As $f(g(x))$ and $g(f(x))$ both equal $x$, $f(x)$ and $g(x)$ are inverses of each other. (0.5 mark)

**Method 2**

\[
y = \sqrt{4x-1}
\]

\[
x = \sqrt{4y-1} \quad (0.5 \text{ mark for switching } x \text{ and } y)
\]

\[
x^2 = 4y - 1
\]

\[
x^2 + 1 = 4y
\]

\[
\frac{x^2 + 1}{4} = y \quad (1 \text{ mark for solving for } y)
\]

\[
\therefore f(x) \text{ and } g(x) \text{ are inverses of each other.} \quad (0.5 \text{ mark})
\]
22. Find $f^{-1}(x)$ algebraically. Graph $f^{-1}(x)$. Consider the domain and range of $f^{-1}(x)$. (3 marks)

$$f(x) = (x - 6)^2, \ x \leq 6$$

Answer: (Module 3, Lesson 4)

$$y = (x - 6)^2, \ x \leq 6 \ and \ y \geq 0$$

Represent inverse as:

$$x = (y - 6)^2 \quad (0.5 \text{ mark for switching } x \ and \ y)$$

$$\pm \sqrt{x} = y - 6 \quad (0.5 \text{ mark for solving})$$

$$\pm \sqrt{x} + 6 = y$$

$$f^{-1}(x) = -\sqrt{x} + 6, x \geq 0 \ and \ y \leq 6 \ (1 \text{ mark for correct sign of radical considering restriction on range})$$

(1 mark for the graph)
23. Given that \( f(x) = |2x - 1| \) and \( g(x) = x^3 - 1 \), find the following.  
(3 \times 1 \text{ mark each} = 3 \text{ marks}) (Module 2, Lesson 5)

a) \( f(f(x)) \)
   
   \[ f(f(x)) = 2\left(2\left|2x-1\right|\right)-1 \]
   
   Answer:

b) \( g(g(-1)) \)
   
   \[ g(g(-1)) = g((1)^3 - 1) = g(-1-1) = g(-2) = (-2)^3 - 1 = -9 \]
   
   Answer:

   c) \( f(g(2)) \)
   
   \[ (g(2)) = f((2)^3 - 1) = f(8-1) = f(7) = 2\times7 - 1 = 14 - 1 = 13 \]
   
   Answer:

24. Given: \( f(x) = x^3 \) and \( g(x) = x - 2 \) (Module 2, Lesson 5)

   a) Determine \( f(g(x)) \) and describe the graph of \( f(g(x)) \) in terms of a transformation of \( f(x) \).  
   (2 \text{ marks})
   
   \[ f(g(x)) = (x-2)^3 \]  
   (1 mark for equation)

   It is the graph of \( f(x) \) shifted 2 units to the right.  
   (1 mark for description)

   b) Determine \( g(f(x)) \) and describe the graph of \( g(f(x)) \) in terms of a transformation of \( f(x) \).  
   (2 \text{ marks})
   
   \[ g(f(x)) = x^3 - 2 \]  
   (1 mark for equation)

   It is the graph of \( f(x) \) shifted 2 units down.  
   (1 mark for description)
25. For each of the following polynomials, determine whether it is divisible by \( x - 2 \). Show your work. (2 \( \times 2 \) marks each = 4 marks) (Module 4, Lesson 3)
   
a) \( f(x) = -x^4 + x^3 - 8x^2 + 6 \)
   
   **Answer:**
   
   \[
   f(2) = (2)^4 + (2)^3 - 8(2)^2 + 6 \\
   = 16 + 8 - 32 + 6 \\
   = -34
   \]
   
   This polynomial is not divisible by \( x - 2 \), as the remainder does not equal zero.
   
   (1 mark for correct, consistent conclusion)

b) \( g(x) = -x^3 + x^2 - 5x + 14 \)
   
   **Answer:**
   
   \[
   g(2) = -(2)^3 + (2)^2 - 5(2) + 14 \\
   = -8 + 4 - 10 + 14 \\
   = 0
   \]
   
   This polynomial is divisible by \( x - 2 \), as the remainder equals zero.
   
   (1 mark for conclusion)

26. Divide, using long division or synthetic division, and write in the form given by the division algorithm. (3 marks) (Module 4, Lesson 2)

\[(2x^3 - 4x^2 - 12x - 14) \div (x - 4)\]

**Answer:**

\[
\begin{array}{cccc}
  & 2 & -4 & -12 & -14 \\
  \hline
  & 8 & 16 & 16 \\
  \hline
  & 2 & 4 & 4 & 2
\end{array}
\]

\[\therefore 2x^3 - 4x^2 - 12x - 14 = (2x^2 + 4x + 4)(x - 4) + 2\]

(1 mark for final division statement)
27. Factor \( g(x) = x^4 + 2x^3 - 20x^2 - 66x - 45 \) completely. (5 marks) (Module 4, Lesson 3)

\[ g(x) = x^4 + 2x^3 - 20x^2 - 66x - 45 \]

Possible rational roots: \( \pm1, \pm3, \pm5, \pm9, \pm15, \pm45 \)  

(1 mark for strategy)

Test \( x = -1 \): \[ g(-1) = (-1)^4 + 2(-1)^3 - 20(-1)^2 - 66(-1) - 45 \]
\[ = 1 - 2 - 20 + 66 - 45 \]
\[ = 0 \]

\( \therefore x = -1 \) is a root and \((x + 1)\) is a factor

\( \therefore g(x) = (x + 1)(q(x)) \)

\[ \begin{array}{c|cccc} \hline -1 & 1 & 2 & -20 & -66 & -45 \\ \hline \ & -1 & -1 & 21 & 45 \\ \hline & 1 & 1 & -21 & -45 & 0 \\ \end{array} \]

(1 mark for synthetic division)

\( \therefore q(x) = x^3 + x^2 - 21x - 45 \) and

\( g(x) = (x + 1)(x^3 + x^2 - 21x - 45) \)

Test \( x = -3 \) in \( q(x) \): \[ q(-3) = (-3)^3 + (-3)^2 - 21(-3) - 45 \]
\[ = -27 + 9 + 63 - 45 \]
\[ = 0 \]

\( \therefore x = -3 \) is a root and \((x + 3)\) is a factor

\( \therefore g(x) = (x + 1)(x + 3)(p(x)) \)

\[ \begin{array}{c|cccc} \hline -3 & 1 & 1 & -21 & -45 \\ \hline \ & -3 & 6 & 45 \\ \hline & 1 & -2 & -15 & 0 \\ \end{array} \]

(1 mark for synthetic division)

\( \therefore p(x) = x^2 - 2x - 15 \) and

\( g(x) = (x + 1)(x + 3)(x^2 - 2x - 15) \)

\( \therefore g(x) = (x + 1)(x + 3)(x + 3)(x - 5) \) or

\( \therefore g(x) = (x + 1)(x + 3)^2(x - 5) \)  

(1 mark)