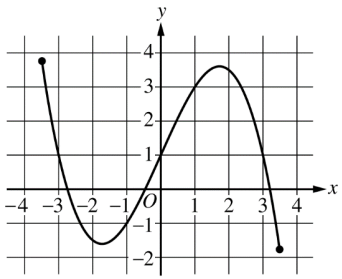
Question 1: Function Concepts
Part A: Graphing calculator required — 6 points



Graph of f

The figure shows the graph of the function f on its domain of $-3.5 \le x \le 3.5$. The points $(-3, 1)$, $(0, 1)$, and $(3, 1)$ are on the graph of f. The function g is given by $g(x) = 2.916 \cdot (0.7)^x$.

Model Solution	Scoring

(A) (i) The function h is defined by $h(x) = (g \circ f)(x) = g(f(x))$. Find the value of $h(3)$ as a decimal approximation, or indicate that it is not defined.
(ii) Find all values of x for which $f(x) = 1$, or indicate that there are no such values.

(i) $h(3) = g(f(3)) = g(1) = 2.041$	Value	**1 point**
(ii) From the graph, $f(x) = 1$ when $x = -3$, $x = 0$, and $x = 3$.	Values	**1 point**

General Scoring Notes for Question 1 Parts (A), (B), and (C):

- Decimal approximations must be correct to three places after the decimal point by rounding or truncating. Decimal values of 0 in final digits need not be reported ($2.000 = 2.00 = 2.0 = 2$).
- A **decimal presentation error** occurs when a response is complete and correct, but the answer is reported to fewer digits than required.
- The first decimal presentation error in Question 1 does not earn the point. For each additional part of Question 1 that requires a decimal approximation and contains a decimal presentation error, the response is eligible to earn the point.

Scoring notes:

- The first point is earned for a correct decimal approximation of 2.041.
- The second point does not require supporting work.

- A response that does not earn either point in Part (A) is eligible for **partial credit** in Part (A) if the response has one criteria from the first column AND one criteria from the second column. Partial credit response is scored **0-1** in Part (A).

First Column	Second Column
Correct value in (i) that is not expressed as a decimal approximation	Only one correct value in (ii) with no incorrect values included
Correct value in (i) with a decimal presentation error	Only two correct values in (ii) with no incorrect values included

(B) (i) Find all values of x, as decimal approximations, for which $g(x) = 2$, or indicate that there are no such values.
(ii) Determine the end behavior of g as x increases without bound. Express your answer using the mathematical notation of a limit.

(i) $g(x) = 2 \Rightarrow 2.916(0.7)^x = 2$ $x = 1.057$	Value	**1 point**
(ii) As x increases without bound, the output values of g get arbitrarily close to 0. Therefore, $\lim_{x \to \infty} g(x) = 0$.	End behavior with limit notation	**1 point**

Scoring notes:

- The first point is earned for a correct decimal approximation of 1.057. No incorrect values may be included.
- The second point requires a correct limit statement with four components: "lim," "$x \to \infty$," the function g, and 0. Examples that earn the point include:
  - $\lim_{x \to \infty} g(x) = 0$ OR $\lim_{x \to \infty} g = 0$
  - $\lim_{x \to \infty} g(x) \to 0$ OR $\lim_{x \to \infty} g \to 0$
  - $\lim_{x \to \infty} g(x)$ 0 OR $\lim_{x \to \infty} g$ 0

  If the response includes an additional, complete limit statement (e.g., $\lim_{x \to -\infty} g(x) = \infty$), the value of the limit must be correct.

- A response that does not earn either point in Part (B) is eligible for **partial credit** in Part (B) if the response has one criteria from the first column AND one criteria from the second column. Partial credit response is scored **1-0** in Part (B).

First Column	**Second Column**
Correct answer in (i) that is not expressed as a decimal approximation	Correct end behavior statement in (ii) without use of limit notation
Correct value in (i) with a decimal presentation error	Correct end behavior statement in (ii) with incorrect limit notation
	Correct limit statement in (ii) that is missing "$x \to \infty$"

(C) (i) Determine if f has an inverse function.
(ii) Give a reason for your answer based on the definition of a function and the graph of $y = f(x)$.

(i) f does not have an inverse function on its domain of $-3.5 \le x \le 3.5$.	Answer	**1 point**
(ii) There are output values of f that are not mapped from unique input values; for example, $f(-3) = f(0) = f(3) = 1$.	Reason	**1 point**

Scoring notes:

- The first point is earned for a correct answer.
- Both points may be earned in (ii) provided there is no incorrect response in (i).
- The second point requires an implicit or explicit reference to the definition of a function AND support for the reason by referencing specific function values.
- A response such as "f does not have an inverse function because $f(-3) = f(0) = 1$" OR "f does not have an inverse function because there are two input values mapped to 1" earns both points.
- A response such as "f is not one-to-one" OR "f fails the horizontal line test" OR "There are output values that are not mapped from unique input values" is not sufficient to earn the second point.
- The second point cannot be earned if there are any errors in Part (C) (ii).
- A response that indicates that f **has** an inverse function in Part (C) (i) without a reason in Part (C) (i) <u>combined</u> with a response in Part (C) (ii) that provides both the correct answer <u>and</u> a correct reason is scored **0-1**.

Total for question 1 6 points