

Grade 12
Pre-Calculus Mathematics
Achievement Test

Booklet 1

January 2016



Soumoss!

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Manitoba Education and Advanced Learning
School Programs Division
Winnipeg, Manitoba, Canada

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Grade 12 Pre-Calculus Mathematics Achievement Test

DESCRIPTION

Time: 3 hours

Numbers and Marks by Question Type


	Selected Response	Constructed Response	Marks
Booklet 1*	-	13	29
Booklet 2	8	24	63
Total	8	37	92

* The first 4 questions in *Booklet 1* require a calculator.  You will have access to your calculator for the first 45 minutes of the test.

GENERAL DIRECTIONS

- Read all instructions carefully.
- The perforated *Formula Sheet* and the *Terminology Sheet* can be removed from the test booklet. No marks will be given for work done on these pages.
- The blank pages at the back of each booklet may be used as scrap paper, but must **not** be removed from the test booklet. No marks will be given for work done on these pages.
- Note that diagrams and graphs provided in the test booklets may not be drawn to scale.
- After 45 minutes, put away your calculator. Even though you may not have finished *Booklet 1*, *Booklet 2* will be distributed at this time. You may choose to continue working on *Booklet 1* or start working on *Booklet 2*, but you will no longer have access to your calculator.

Instructions

- There are 13 questions worth a total of 29 marks.
- Calculators (scientific or graphing) are allowed for the first 45 minutes of the test.
- A calculator icon  appears next to the questions that require a calculator.
- Write each solution in the space provided.
- For full marks, your answers must show all pertinent diagrams, calculations, and explanations.
- Graphing calculator solutions must include an explanation of how your final answer is obtained.
- Your solutions should be neat, organized, and clear.
- Some answers are to be given as decimal values. Rounding too early in your solution may result in an inaccurate final answer for which full marks will not be given.
- Express your answers as exact values or correct to the nearest thousandth (3 decimal places) unless instructed otherwise.

Formula Sheet

$$s = \theta r$$

$$\sin^2 \theta + \cos^2 \theta = 1$$

$$\tan^2 \theta + 1 = \sec^2 \theta$$

$$1 + \cot^2 \theta = \csc^2 \theta$$

$$\sin(\alpha - \beta) = \sin \alpha \cos \beta - \cos \alpha \sin \beta$$

$$\cos(\alpha - \beta) = \cos \alpha \cos \beta + \sin \alpha \sin \beta$$

$$\tan(\alpha - \beta) = \frac{\tan \alpha - \tan \beta}{1 + \tan \alpha \tan \beta}$$

$$\sin(\alpha + \beta) = \sin \alpha \cos \beta + \cos \alpha \sin \beta$$

$$\cos(\alpha + \beta) = \cos \alpha \cos \beta - \sin \alpha \sin \beta$$

$$\tan(\alpha + \beta) = \frac{\tan \alpha + \tan \beta}{1 - \tan \alpha \tan \beta}$$

$$\sin 2\alpha = 2 \sin \alpha \cos \alpha$$

$$\cos 2\alpha = \cos^2 \alpha - \sin^2 \alpha$$

$$\cos 2\alpha = 1 - 2 \sin^2 \alpha$$

$$\cos 2\alpha = 2 \cos^2 \alpha - 1$$

$$\tan 2\alpha = \frac{2 \tan \alpha}{1 - \tan^2 \alpha}$$

$$\log_a (MN) = \log_a M + \log_a N$$

$$\log_a \left(\frac{M}{N} \right) = \log_a M - \log_a N$$

$$\log_a (M^n) = n \log_a M$$

$$P(n, r) \text{ or } {}_n P_r = \frac{n!}{(n-r)!}$$

$$C(n, r) \text{ or } {}_n C_r = \frac{n!}{r!(n-r)!}$$

$$t_{k+1} = C_n^k a^{n-k} b^k$$

$$\text{For } ax^2 + bx + c = 0,$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Terminology Sheet

Some questions may contain directing words such as *explain, identify, and justify*. These words are defined below.

Evaluate: Find the numerical value.

Explain: Use words to provide the cause of or reason for the response, or to render the response more clear and understandable.

Sketch the graph: Provide a detailed drawing with key features of the graph that includes a minimum of 2 coordinate points.

Identify/Indicate: Recognize and select the answer by stating or circling it.

Justify: Show reasons for or give facts that support a position by using mathematical computations, words, and/or diagrams.

Solve: Give a solution for a problem or determine the value(s) of a variable.

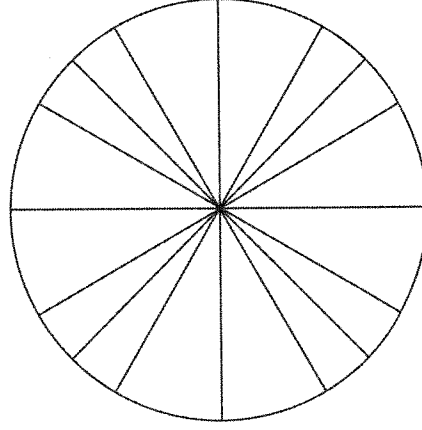
Verify: Establish the truth of a statement by substitution or comparison.

Determine: Use a mathematical formula, an algebraic equation, or a numerical calculation to solve a problem.

State: Give an answer without an explanation or justification.

Describe: Use words to provide the process or to report details of the response.

Unit Circle (can be used if needed)



Question 1

2 marks

101

A pizza with a diameter of 15 inches is cut into equal slices, each with a central angle of 36° . Determine the length of the crust on the outer edge of one slice of pizza.

$$S = \theta R$$

$$S = 36 \left(\frac{\pi}{180} \right) (7.5)$$

$$S = \frac{3\pi}{2} \text{ inches}$$

or

$$4.712 \text{ inches}$$

Question 2

a) 1 mark b) 2 marks

102
103

There are 9 girls and 7 boys in a math class from which a committee of 5 is to be chosen.

a) How many different committees of 5 can be formed if one of the boys, William, must be on the committee?

$$1 \cdot {}_{15}C_4 = 1365$$

b) How many different committees of 5 can be formed if there must be 2 girls and 3 boys on the committee?

$${}_{9}C_2 \cdot {}_{7}C_3 = 1260$$

Question 3

3 marks

104

Solve the following equation over the interval $[0, 2\pi]$:

$$\sin^2 \theta + 6 \sin \theta - 2 = 0$$

Not factorable!

Use quadratic formula.

$$\sin \theta = \frac{-6 \pm \sqrt{6^2 - 4(1)(-2)}}{2(1)}$$

$$\sin \theta = \frac{-6 \pm \sqrt{44}}{2}$$

↓

$$\sin \theta = 0.316624$$

$$\theta = 0.322109$$

$\theta = 0.322$
 $\theta = 2.819$

$$\sin \theta = -6.136624$$

No solution.

Question 4

4 marks

105

Solve:

$$6(5)^{3x+2} = 9^{2-x}$$

$$\log 6(5)^{3x+2} = \log 9^{2-x}$$

$$\log 6 + \log 5^{3x+2} = (2-x) \log 9$$

$$\log 6 + (3x+2) \log 5 = 2 \log 9 - x \log 9$$

$$\log 6 + 3x \log 5 + 2 \log 5 = 2 \log 9 - x \log 9$$

$$3x \log 5 + x \log 9 = 2 \log 9 - \log 6 - 2 \log 5$$

$$x(3 \log 5 + \log 9) = 2 \log 9 - \log 6 - 2 \log 5$$

$$x = \frac{2 \log 9 - \log 6 - 2 \log 5}{3 \log 5 + \log 9}$$

$$x = -0.288$$

$$x = -0.288$$

Note: A calculator is not required for the remaining test questions.

Question 3

3 marks

104

Solve the following equation over the interval $[0, 2\pi]$:

$$\sin^2 \theta + 6 \sin \theta - 2 = 0$$

Not factorable!

Use quadratic formula.

$$\sin \theta = \frac{-6 \pm \sqrt{6^2 - 4(1)(-2)}}{2(1)}$$

$$\sin \theta = \frac{-6 \pm \sqrt{44}}{2}$$

↓

$$\sin \theta = 0.316624$$

$$\theta = 0.322109$$

$\theta = 0.322$
 $\theta = 2.819$

Question 5

4 marks

106

Solve $(2 \sin \theta - 1)(\sin \theta + 1) = 0$ where $\theta \in \mathbb{R}$.

$$2 \sin \theta - 1 = 0$$

$$\sin \theta + 1 = 0$$

$$\sin \theta = \frac{1}{2}$$

$$\sin \theta = -1$$

$$\theta = \frac{\pi}{6} + 2\pi n$$

$$\theta = \frac{3\pi}{2} + 2\pi n$$

$$n \in \mathbb{I}$$

$$\frac{5\pi}{6} + 2\pi n$$

(or)

$$\theta = 30^\circ + 360^\circ n$$

$$\theta = 270^\circ + 360^\circ n$$

$$150^\circ + 360^\circ n$$

$$n \in \mathbb{I}$$

Question 6

1 mark

107

The roots of the polynomial equation $3(x-2)(x+1)^2 = 0$ are $x = 2$ and $x = -1$.Explain what these roots represent on the graph of $p(x) = 3(x-2)(x+1)^2$.

The roots represent
the x-intercepts of
the graph $p(x)$

Question 7

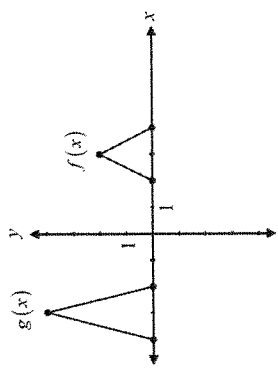
2 marks

1 mark

Question 8

Determine an equation for $g(x)$ as a transformation of $f(x)$.

A student must determine the factors of $5x^4 - 2x^3 + 4x - 1$. He used 5, -2, 4, and -1 as the coefficients of the polynomial when using synthetic division. Explain the student's error.



$$g(x) = \frac{2f(x+b)}{}$$

or

$$g(x) = 2f(-x)$$

The student did not
write the coefficient
of 0 for the term
 x^2 .

Question 9

2 marks

110

Describe the transformations of $y = f(x)$ when asked to sketch the graph of $y = -f(x - 4)$.

→ a reflection over the x-axis
 → horizontal translation of 4 units right

Question 10

3 marks

111

Prove the identity below for all permissible values of θ :

$$\sin \theta + \frac{\cos \theta}{\tan \theta} = \frac{1}{\cos \theta \tan \theta}$$

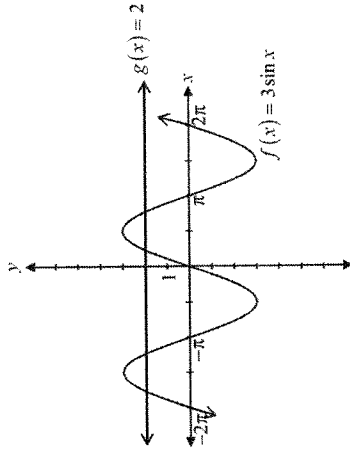
Left-Hand Side	Right-Hand Side
$\sin \theta + \frac{\cos \theta}{\frac{\sin \theta}{\cos \theta}}$	$\frac{1}{\cos \theta \frac{\sin \theta}{\cos \theta}}$
$\sin \theta + \cos \theta \left(\frac{\cos \theta}{\sin \theta} \right)$	$\frac{1}{\sin \theta}$
$\sin \theta + \frac{\cos^2 \theta}{\sin \theta}$	
$\frac{\sin^2 \theta + \cos^2 \theta}{\sin \theta}$	
$\frac{1}{\sin \theta}$	$\frac{1}{\sin \theta}$
	$\text{LHS} = \text{RHS}$

Question 11

1 mark

1.12

Describe how to use the graphs of $f(x) = 3 \sin x$ and $g(x) = 2$ to solve the equation $3 \sin x = 2$.



The solutions to this equation
is the x -coordinates of where
the 2 curves intersect.

Question 12

1 mark

1.13

A hockey arena has 5 doors.

Determine the number of ways that you can enter through one door but exit through a different door.

$$5 \cdot 4 = 20 \text{ ways}$$

Question 13

2 marks

134

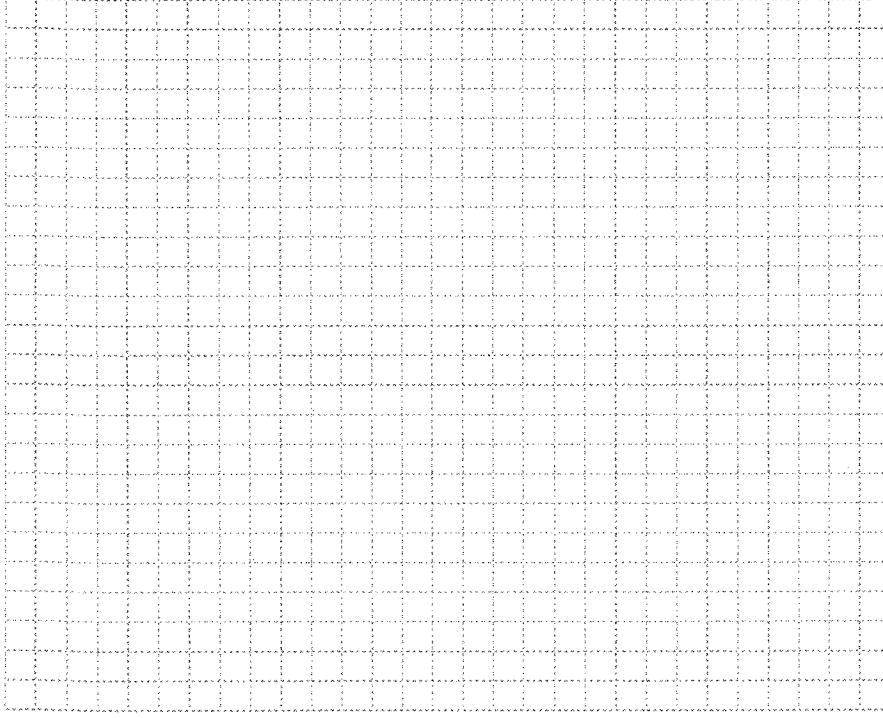
Given that $(x+3)$ is one of the factors, express $2x^3 + 7x^2 + 2x - 3$ as a product of factors.

$$\begin{array}{r|rrrr} -3 & 2 & 7 & 2 & -3 \\ & & -6 & -3 & 3 \\ \hline & 2 & 1 & -1 & 0 \end{array}$$

$$(x+3)(2x^2 + x - 1)$$

$$(x+3)(2x-1)(x+1)$$

No marks will be awarded for work done on this page.



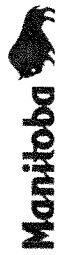
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Grade 12
Pre-Calculus Mathematics
Achievement Test

Booklet 2

January 2016



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Instructions

No marks will be awarded for work done on this page.

Selected Response Questions

- There are 8 questions worth a total of 8 marks.
- Calculators are **not** allowed for this part of the test.
- You may use the spaces beside each question for rough work.
- Provide only one answer per question.
- There is no penalty for guessing.
- Record your answers on the sheet provided.

Constructed Response Questions

- There are 24 questions worth a total of 55 marks.
- Calculators are **not** allowed for this part of the test.
- For full marks, your answer must show all pertinent diagrams, calculations, and explanations.
- Your solutions should be neat, clear, and well organized.
- Write each solution in the space provided.

Question 14 1 mark

Identify the maximum number of x-intercepts for a polynomial function of degree 3.

- a) 1
- b) 2
- c) 3
- d) 4

minimum would be 1

Question 15 1 mark

The graph of $y = f(x)$ contains the point (a, b) . The graph of $g(x)$ is a transformation of the graph of $f(x)$ and contains the point $(3a, b)$.

Identify the function that represents $g(x)$.

- a) $g(x) = f(3x)$
- b) $g(x) = 3f(x)$
- c) $g(x) = f\left(\frac{x}{3}\right)$
- d) $g(x) = \frac{1}{3}f(x)$

Question 16 1 mark

The angle 2.95 radians, in standard position, terminates in quadrant:

- a) I
- b) II
- c) III
- d) IV



Question 17 1 mark

Evaluate:

$$2 \sin \frac{\pi}{8} \cos \frac{\pi}{8}$$

- a) $\frac{1}{2}$
- b) $\frac{\sqrt{2}}{2}$
- c) 1
- d) $\sqrt{2}$

$$= \sin 2\left(\frac{\pi}{8}\right) = \sin \frac{\pi}{4}$$

Question 18 1 mark

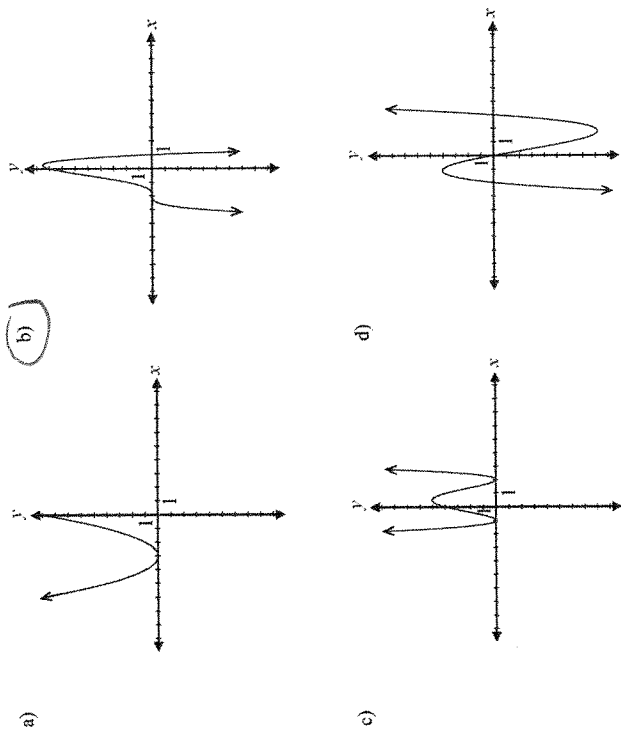
Identify which of the following represents the 5th term in the expansion of $(4x^2 - 2y^3)^{15}$.

- a) ${}_{15}C_5 (4x^2)^{10} (-2y^3)^5$
- b) ${}_{15}C_5 (4x^2)^{11} (-2y^3)^4$
- c) ${}_{15}C_4 (4x^2)^{10} (-2y^3)^5$
- d) ${}_{15}C_4 (4x^2)^{11} (-2y^3)^4$

Question 19

1 mark

Identify which of the following graphs of polynomial functions has a zero with a multiplicity of 3.



Question 20

1 mark

A non-permissible value of x for the function $f(x) = \frac{1}{\cos x + 1}$ is:

- a) -1
 - b) 0
 - c) π
 - d) $\frac{3\pi}{2}$
- $\cos x + 1 \neq 0$
 $\cos x \neq -1$
 $x \neq \pi$

Question 21

1 mark

Identify which of the following statements is true for the rational function $f(x) = \frac{4(x-1)(x-2)}{(x-1)(x+3)}$.

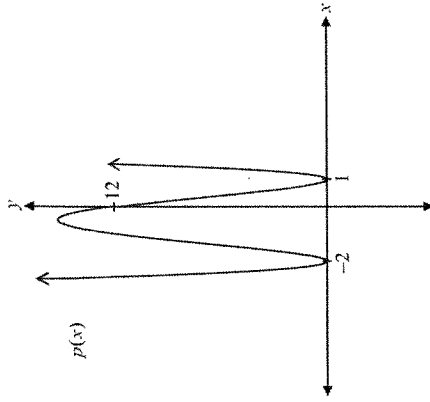
- a) The equation of the horizontal asymptote is $y = 4$.
- b) The equation of the vertical asymptote is $x = 1$.
- c) The y -intercept is 0 .
- d) There is a point of discontinuity (hole) when $x = 2$.

Question 22

3 marks

115

Determine the equation of the polynomial function, $p(x)$, represented by the graph.



$$p(x) = 3(x+2)^2(x-1)^2$$

$$y = a(x+2)^2(x-1)^2$$

$$12 = a(0+2)^2(0-1)^2$$

$$12 = 4a(1)$$

$$3 = a$$

Question 23

1 mark

116

Evaluate:

$$\log_4 2 = x$$

$$4^x = 2$$

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

$$2x = 1$$

$$x = \frac{1}{2}$$

$$\log_4 2 = \frac{1}{2}$$

Question 24

2 marks

117

Evaluate:

$$\left(\cos \frac{11\pi}{3}\right) \left(\csc \frac{11\pi}{6}\right)$$

$$\left(\frac{1}{2}\right) \left(-\frac{2}{1}\right)$$

$$= -1$$

Question 25

1 mark

118

Estimate the value of $\log_2 5$.

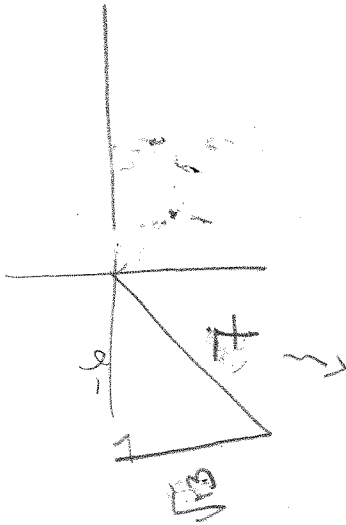
Justify your answer.

$$\log_2 4 = 2$$

$$\log_2 8 = 3$$

$$\therefore \log_2 5 \approx 2.3$$

If θ terminates in quadrant III and $\cos \theta = -\frac{6}{7}$, determine the exact value of $\tan \theta$.



$$(-6)^2 + b^2 = 7^2$$

$$b^2 = 49 - 36$$

$$b^2 = 13$$

$$b = \sqrt{13}$$

$$\tan \theta = \frac{\text{opp}}{\text{adj}}$$

$$\tan \theta = \frac{-\sqrt{13}}{-6}$$

$$\tan \theta = \frac{\sqrt{13}}{6}$$

Given $f(x) = x^2 + x - 4$ and $g(x) = \sqrt{x+5}$, Taz was asked to find $f(g(x))$.

Taz's solution:

$$\begin{aligned} f(g(x)) &= (\sqrt{x+5})^2 + x - 4 \\ &= x + 5 + x - 4 \\ &= 2x + 1, \quad x \geq -5 \end{aligned}$$

Describe the error in Taz's solution.

Taz must substitute

$g(x)$ in both terms

containing x in $f(x)$

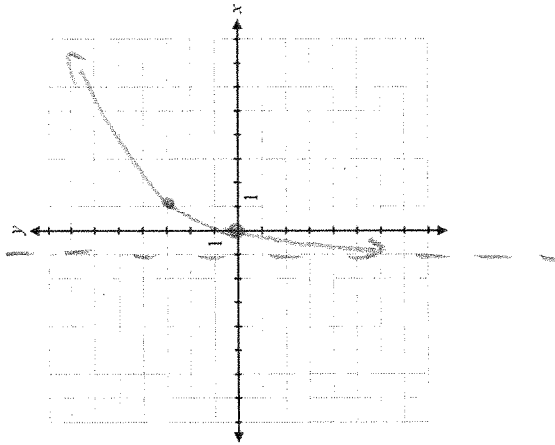
then simplify

Question 28

3 marks

121

Sketch the graph of the function $f(x) = 3 \log_2(x+1)$.



Question 29

1 mark

122

Write an equation of a rational function that would not have any vertical asymptotes.

Many solutions!

$$y = \frac{(x-2)(x+1)}{x-2}$$

or

$$y = \frac{4}{x^2+4}$$

Question 30

2 marks

123

Determine the exact value of $\tan 75^\circ$.

$$\tan 75^\circ = \tan(30^\circ + 45^\circ)$$

$$= \frac{\tan 30^\circ + \tan 45^\circ}{1 - \tan 30^\circ \tan 45^\circ}$$

$$= \frac{\frac{1}{\sqrt{3}} + 1}{1 - \frac{1}{\sqrt{3}} \cdot 1}$$

$$= \frac{1 + \sqrt{3}}{\sqrt{3} - 1}$$

$$= \frac{1 + \sqrt{3}}{\sqrt{3}} \cdot \frac{\sqrt{3}}{\sqrt{3} - 1}$$

$$= \frac{1 + \sqrt{3}}{\sqrt{3} - 1} \quad \text{or} \quad \frac{\sqrt{3} + 3}{3 - \sqrt{3}}$$

Question 31

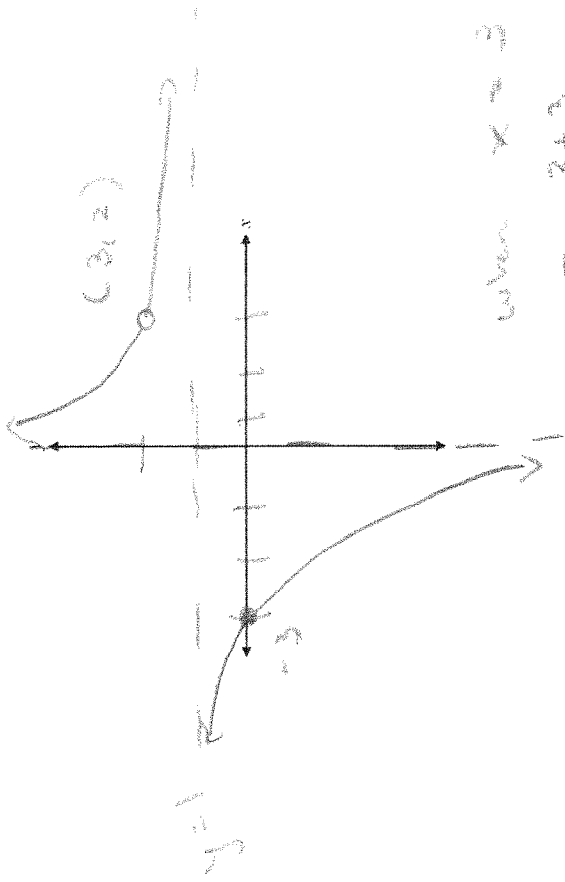
4 marks

124

Sketch the graph of the following function:

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

$$f(x) = \frac{x+3}{x}, \quad x \neq 3$$



when $x = 3$

$$y = \frac{3+3}{3}$$

$$y = 2$$

Question 32

2 marks

125

In the binomial expansion of $(\frac{1}{x^3} - 2x^2)^9$, determine which term contains x^3 .

ignore coefficients!

$$x^3 = (x^{-3})^{9-k} (x^2)^k$$

$$x^3 = x^{3k-27} x^{2k}$$

$$x^3 = x^{5k-27}$$

$$3 = 5k - 27$$

$$30 = 5k$$

$$6 = k$$

\therefore term 7

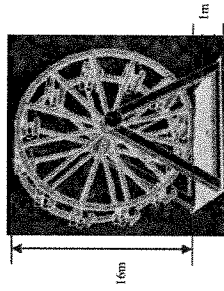
Question 33

4 marks

126

José and Dana get on a Ferris wheel, which is 1 metre off the ground. The diameter of the Ferris wheel is 16 metres. Their ride lasts for 4 minutes, in which time the Ferris wheel makes one revolution.

Determine the values of A, B, C, and D, if the sinusoidal function that models the situation is $h(t) = A \cos[B(t - C)] + D$, where h is the height at which José and Dana are located on the Ferris wheel, from the ground, in metres, and t is the time, in minutes.



$$A = \frac{8}{-8}$$

$$B = \frac{\pi/2}{2}$$

$$C = \frac{2}{0 \text{ or } 4}$$

$$D = \frac{9}{9}$$

cosine function!



$$b = \frac{2\pi}{\text{period}} = \frac{2\pi}{4} = \frac{\pi}{2}$$

Question 34

3 marks

127

Solve algebraically:

$${}_n P_3 = 4!(n-1)$$

$$\frac{n!}{(n-3)!} = 4!(n-1)$$

$$\frac{n(n-1)(n-2)(\cancel{n-3})!}{(\cancel{n-3})!} = 4!(n-1)$$

$$n(\cancel{n-1})(n-2) = 4!(n-1)$$

$$n(n-2) = 24$$

$$n^2 - 2n - 24 = 0$$

$$(n-6)(n+4) = 0$$

$$n=6 \quad n=-4$$

Question 35

2 marks

128

Given $f(x) = \frac{2}{x-1}$, determine the equation of the inverse, $f^{-1}(x)$.

$$y = \frac{2}{x-1}$$

$$x = \frac{2}{y-1}$$

$$y-1$$

$$x(y-1) = 2$$

$$y-1 = \frac{2}{x}$$

$$y = \frac{2}{x} + 1$$

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

or

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

Question 36

3 marks

129

Solve:

$$4 \log_3 2 - \frac{1}{3} \log_3 8 = \log_3 a$$

$$\log_3 2^4 - \log_3 8^{1/3} = \log_3 a$$

$$\log_3 16 - \log_3 \sqrt[3]{8} = \log_3 a$$

$$\log_3 \frac{16}{\sqrt[3]{8}} = \log_3 a$$

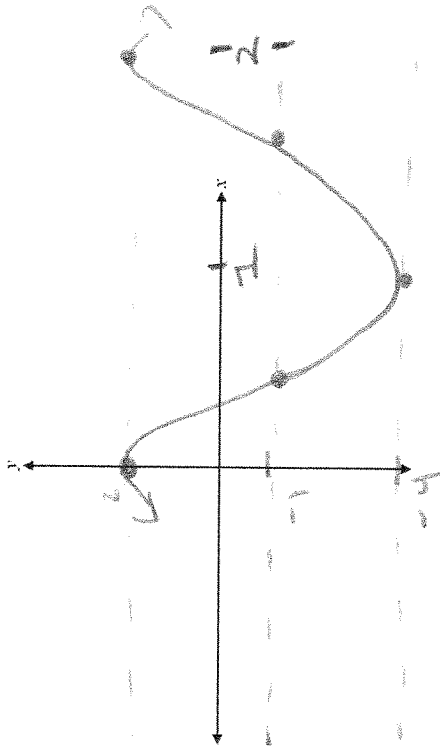
$$\frac{16}{2} = a$$

$$8 = a$$

Question 37

3 marks

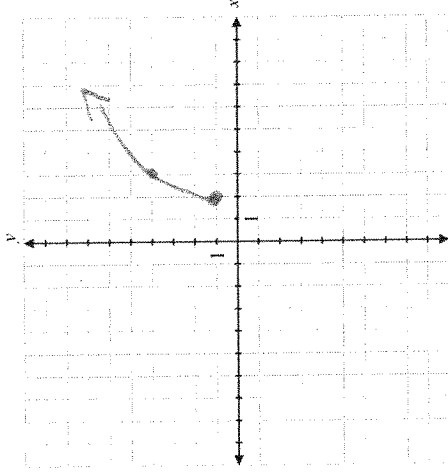
130

Sketch the graph of at least one period of the function $y = 3 \cos(\pi x) - 1$.

$$\text{period} = \frac{2\pi}{b} = \frac{2\pi}{\pi} = 2$$

Question 39

Sketch the graph of $f(x) = 3\sqrt{x-2} + 1$.



Question 38

Using the laws of logarithms, fully expand the expression:

$$\log_a \left(\frac{x^3}{y\sqrt{z}} \right)$$

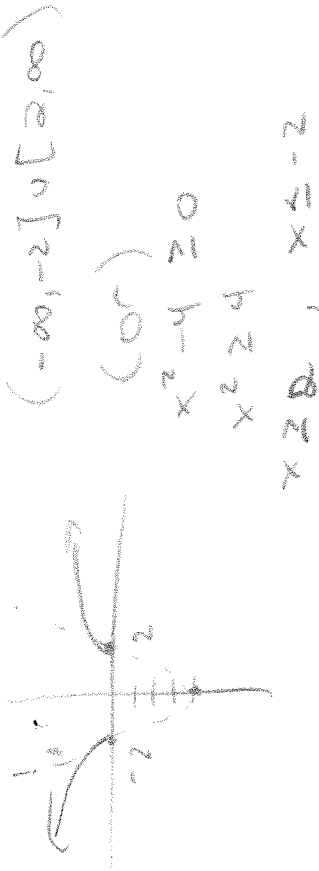
$$3 \log_a x - \log_a y - \frac{1}{2} \log_a z$$

Question 40

a) 1 mark b) 1 mark

133
134

a) Determine the domain of the graph of the function $f(x) = \sqrt{x^2 - 4}$.



b) Explain why the domain of $f(x) = \sqrt{x^2 - 4}$ is restricted.

The radicand can not be negative.
 (or)
 We can't take the square root of a negative number

Question 41

a) 1 mark b) 1 mark

135
136

Given the point $(-12, -18)$ on the graph of $f(x)$, determine the new points after the following transformations of $f(x)$.

a) $\frac{1}{f(x)}$

$$(x, y) \rightarrow (x, \frac{1}{y})$$

$$(-12, \frac{1}{-18})$$

b) $f(-x)+10$

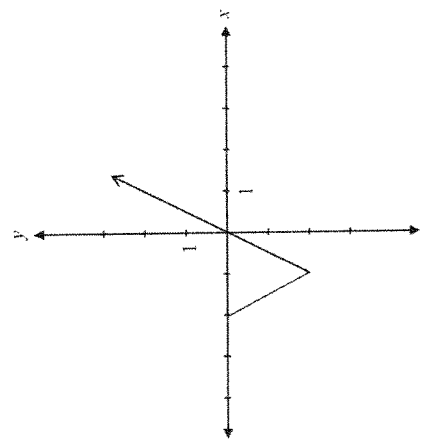
$$(x, y) \rightarrow (-x, y+10)$$

$$(12, -8)$$

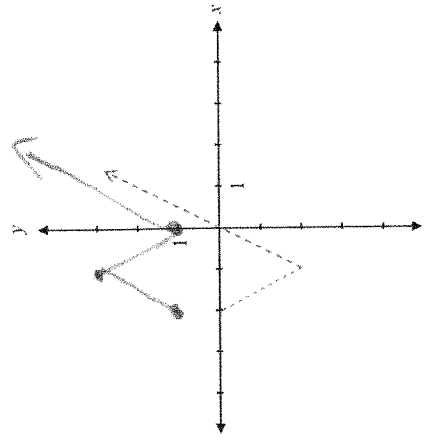
Explain why there is no solution for the equation $\csc \theta = -\frac{1}{2}$.

$\sin \theta = -2$
 The value of sine can't be less than -1.
 or
 The value of cosecant be between -1 and 1

Given the graph of $y = f(x)$,



sketch the graph of $y = |f(2x)| + 1$.



The graph of $f(x)$ has already been drawn for your reference. No marks will be awarded for the graph of $f(x)$.

Question 44

1 mark

1.39

Given $f(x) = 2^x + 1$, state the equation of the horizontal asymptote.

$$y = 1$$

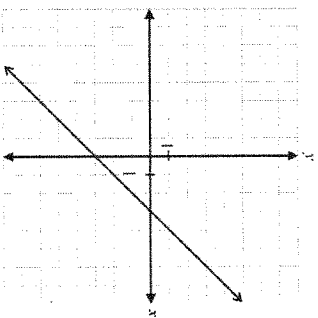
Question 45

2 marks

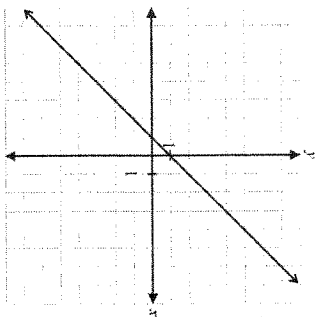
1.40

Given the following graphs of $f(x) = x - 3$ and $g(x) = x + 1$,

$f(x)$



$g(x)$



sketch the graph of $h(x) = (f \circ g)(x)$.

