Print your name and the name of your school on the lines above.

A separate answer sheet for Part I has been provided to you. Follow the instructions from the proctor for completing the student information on your answer sheet.

This examination has four parts, with a total of 37 questions. You must answer all questions in this examination. Record your answers to the Part I multiple-choice questions on the separate answer sheet. Write your answers to the questions in Parts II, III, and IV directly in this booklet. All work should be written in pen, except graphs and drawings, which should be done in pencil. Clearly indicate the necessary steps, including appropriate formula substitutions, diagrams, graphs, charts, etc. Utilize the information provided for each question to determine your answer. Note that diagrams are not necessarily drawn to scale.
The formulas that you may need to answer some questions in this examination are found at the end of the examination. You may remove this sheet from this booklet.

Scrap paper is not permitted for any part of this examination, but you may use the blank spaces in this booklet as scrap paper. A sheet of scrap graph paper is provided at the end of this booklet for any question for which graphing may be helpful but is not required. You may remove this sheet from this booklet. Any work done on this sheet of scrap graph paper will not be scored.

When you have completed the examination, you must sign the statement printed at the end of the answer sheet, indicating that you had no unlawful knowledge of the questions or answers prior to the examination and that you have neither given nor received assistance in answering any of the questions during the examination. Your answer sheet cannot be accepted if you fail to sign this declaration.

**Notice…**

A graphing calculator and a straightedge (ruler) must be available for you to use while taking this examination.

**DO NOT OPEN THIS EXAMINATION BOOKLET UNTIL THE SIGNAL IS GIVEN.**
Part I

Answer all 24 questions in this part. Each correct answer will receive 2 credits. No partial credit will be allowed. Utilize the information provided for each question to determine your answer. Note that diagrams are not necessarily drawn to scale. For each statement or question, choose the word or expression that, of those given, best completes the statement or answers the question. Record your answers on your separate answer sheet. [48]

1. The solution of $87e^{0.3x} = 5918$, to the nearest thousandth, is
   (1) 0.583       (3) 4.220
   (2) 1.945       (4) 14.066

2. A researcher randomly divides 50 bean plants into two groups. He puts one group by a window to receive natural light and the second group under artificial light. He records the growth of the plants weekly. Which data collection method is described in this situation?
   (1) observational study       (3) survey
   (2) controlled experiment     (4) systematic sample
3 If $f(x) = x^2 + 9$ and $g(x) = x + 3$, which operation would not result in a polynomial expression?

(1) $f(x) + g(x)$   (3) $f(x) \cdot g(x)$
(2) $f(x) - g(x)$   (4) $f(x) \div g(x)$
4 Consider the function \( p(x) = 3x^3 + x^2 - 5x \) and the graph of \( y = m(x) \) below.

Which statement is true?

(1) \( p(x) \) has three real roots and \( m(x) \) has two real roots.
(2) \( p(x) \) has one real root and \( m(x) \) has two real roots.
(3) \( p(x) \) has two real roots and \( m(x) \) has three real roots.
(4) \( p(x) \) has three real roots and \( m(x) \) has four real roots.
5 Which expression is equivalent to \( \frac{2x^4 + 8x^3 - 25x^2 - 6x + 14}{x + 6} \)?

   (1) \( 2x^3 + 4x^2 + x - 12 + \frac{86}{x + 6} \)
   (2) \( 2x^3 - 4x^2 - x + 14 \)
   (3) \( 2x^3 - 4x^2 - x + \frac{14}{x + 6} \)
   (4) \( 2x^3 - 4x^2 - x \)

6 Given \( f(x) = \frac{1}{2}x + 8 \), which equation represents the inverse, \( g(x) \)?

   (1) \( g(x) = 2x - 8 \)
   (3) \( g(x) = -\frac{1}{2}x + 8 \)
   (2) \( g(x) = 2x - 16 \)
   (4) \( g(x) = -\frac{1}{2}x - 16 \)

7 The value(s) of \( x \) that satisfy \( \sqrt{x^2 - 4x - 5} = 2x - 10 \) are

   (1) \( \{5\} \)
   (3) \( \{5, 7\} \)
   (2) \( \{7\} \)
   (4) \( \{3, 5, 7\} \)
8 Stephanie found that the number of white-winged crossbills in an area can be represented by the formula \( C = 550(1.08)^t \), where \( t \) represents the number of years since 2010. Which equation correctly represents the number of white-winged crossbills in terms of the monthly rate of population growth?

(1) \( C = 550(1.00643)^t \) \hspace{1cm} (3) \( C = 550(1.00643)^{12t} \)
(2) \( C = 550(1.00643)^{12t} \) \hspace{1cm} (4) \( C = 550(1.00643)^t + 12 \)

9 The roots of the equation \( 3x^2 + 2x = -7 \) are

(1) \(-2, -\dfrac{1}{3}\) \hspace{1cm} (3) \(-\dfrac{1}{3} \pm \dfrac{2i\sqrt{5}}{3}\)
(2) \(-\dfrac{7}{3}, 1\) \hspace{1cm} (4) \(-\dfrac{1}{3} \pm \dfrac{\sqrt{11}}{3}\)
10 The average depreciation rate of a new boat is approximately 8% per year. If a new boat is purchased at a price of $75,000, which model is a recursive formula representing the value of the boat \( n \) years after it was purchased?

\[
\begin{align*}
(1) \quad a_n &= 75,000(0.08)^n \\
(2) \quad a_0 &= 75,000 \\
\hspace{1cm} a_n &= (0.92)^n \\
(3) \quad a_n &= 75,000(1.08)^n \\
(4) \quad a_0 &= 75,000 \\
\hspace{1cm} a_n &= 0.92(a_n - 1)
\end{align*}
\]

11 Given \( \cos \theta = \frac{7}{25} \), where \( \theta \) is an angle in standard position terminating in quadrant IV, and \( \sin^2 \theta + \cos^2 \theta = 1 \), what is the value of \( \tan \theta \)?

\[
\begin{align*}
(1) \quad -\frac{24}{25} \\
(2) \quad -\frac{24}{7} \\
(3) \quad \frac{24}{25} \\
(4) \quad \frac{24}{7}
\end{align*}
\]
12 For \( x > 0 \), which expression is equivalent to \( \frac{\sqrt[3]{x^2} \cdot \sqrt{x^5}}{6\sqrt{x}} \)?

(1) \( x \)  
(2) \( \frac{3}{x^2} \)  
(3) \( x^3 \)  
(4) \( x^{10} \)

13 Jake wants to buy a car and hopes to save at least $5000 for a down payment. The table below summarizes the amount of money he plans to save each week.

<table>
<thead>
<tr>
<th>Week</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Money Saved, in Dollars</td>
<td>2</td>
<td>5</td>
<td>12.5</td>
<td>31.25</td>
<td>...</td>
</tr>
</tbody>
</table>

Based on this plan, which expression should he use to determine how much he has saved in \( n \) weeks?

(1) \( \frac{2 - 2(2.5^n)}{1 - 2.5} \)  
(2) \( \frac{2 - 2(2.5^{n-1})}{1 - 2.5} \)  
(3) \( \frac{1 - 2.5^n}{1 - 2.5} \)  
(4) \( \frac{1 - 2.5^{n-1}}{1 - 2.5} \)
14 Which expression is equivalent to \( x^6 y^4 (x^4 - 16) - 9(x^4 - 16) \)?

(1) \( x^{10} y^4 - 16x^6 y^4 - 9x^4 - 144 \)

(2) \( (x^6 y^4 - 9)(x + 2)^3(x - 2) \)

(3) \( (x^3 y^2 + 3)(x^3 y^2 - 3)(x + 2)^2(x - 2)^2 \)

(4) \( (x^3 y^2 + 3)(x^3 y^2 - 3)(x^2 + 4)(x^2 - 4) \)

15 If \( A = -3 + 5i, B = 4 - 2i, \) and \( C = 1 + 6i, \) where \( i \) is the imaginary unit, then \( A - BC \) equals

(1) \( 5 - 17i \)  \hspace{1cm} (3) \( -19 - 17i \)

(2) \( 5 + 27i \)  \hspace{1cm} (4) \( -19 + 27i \)
16 Which sketch best represents the graph of $x = 3^y$?
17 The graph below represents national and New York State average gas prices.

![Graph showing national and New York State average gas prices]

If New York State’s gas prices are modeled by $G(x)$ and $C > 0$, which expression best approximates the national average $x$ months from August 2014?

(1) $G(x + C)$
(2) $G(x) + C$
(3) $G(x - C)$
(4) $G(x) - C$
Data for the students enrolled in a local high school are shown in the Venn diagram below.

If a student from the high school is selected at random, what is the probability that the student is a sophomore given that the student is enrolled in Algebra II?

(1) $\frac{85}{210}$

(2) $\frac{85}{295}$

(3) $\frac{85}{405}$

(4) $\frac{85}{1600}$
19 If \( p(x) = 2\ln(x) - 1 \) and \( m(x) = \ln(x + 6) \), then what is the solution for \( p(x) = m(x) \)?

(1) 1.65  (3) 5.62
(2) 3.14  (4) no solution

20 Which function’s graph has a period of 8 and reaches a maximum height of 1 if at least one full period is graphed?

(1) \( y = -4\cos\left(\frac{\pi}{4}x\right) - 3 \)  (3) \( y = -4\cos(8x) - 3 \)
(2) \( y = -4\cos\left(\frac{\pi}{4}x\right) + 5 \)  (4) \( y = -4\cos(8x) + 5 \)

21 Given \( c(m) = m^3 - 2m^2 + 4m - 8 \), the solution of \( c(m) = 0 \) is

(1) \( \pm 2 \)  (3) \( 2i,2 \)
(2) \( 2, \text{ only} \)  (4) \( \pm 2i,2 \)
22 The height above ground for a person riding a Ferris wheel after \( t \) seconds is modeled by \( h(t) = 150\sin\left(\frac{\pi}{45} t + 67.5\right) + 160 \) feet.

How many seconds does it take to go from the bottom of the wheel to the top of the wheel?

(1) 10  (3) 90
(2) 45  (4) 150

23 The parabola described by the equation \( y = \frac{1}{12}(x - 2)^2 + 2 \) has the directrix at \( y = -1 \). The focus of the parabola is

(1) (2, -1)  (3) (2,3)
(2) (2,2)  (4) (2,5)
24 A fast-food restaurant analyzes data to better serve its customers. After its analysis, it discovers that the events $D$, that a customer uses the drive-thru, and $F$, that a customer orders French fries, are independent. The following data are given in a report:

$$P(F) = 0.8$$

$$P(F \cap D) = 0.456$$

Given this information, $P(F|D)$ is

(1) 0.344  
(2) 0.3648  
(3) 0.57  
(4) 0.8
Part II

Answer all 8 questions in this part. Each correct answer will receive 2 credits. Clearly indicate the necessary steps, including appropriate formula substitutions, diagrams, graphs, charts, etc. Utilize the information provided for each question to determine your answer. Note that diagrams are not necessarily drawn to scale. For all questions in this part, a correct numerical answer with no work shown will receive only 1 credit. All answers should be written in pen, except for graphs and drawings, which should be done in pencil. [16]

25 Over the set of integers, factor the expression $x^4 - 4x^2 - 12$.

Work space for question 25 is continued on the next page.
Express the fraction \( \frac{\frac{3}{2x^2}}{(16x^4)^\frac{1}{4}} \) in simplest radical form.

Work space for question 26 is continued on the next page.
27 The world population was 2560 million people in 1950 and 3040 million in 1960 and can be modeled by the function \( p(t) = 2560e^{0.017185t} \), where \( t \) is time in years after 1950 and \( p(t) \) is the population in millions. Determine the average rate of change of \( p(t) \) in millions of people per year, from \( 4 \leq t \leq 8 \). Round your answer to the nearest hundredth.

Work space for question 27 is continued on the next page.
Question 27 continued
28 The scores of a recent test taken by 1200 students had an approximately normal distribution with a mean of 225 and a standard deviation of 18. Determine the number of students who scored between 200 and 245.
29 Algebraically solve for $x$:

$$\frac{-3}{x + 3} + \frac{1}{2} = \frac{x}{6} - \frac{1}{2}$$
30 Graph \( t(x) = 3\sin(2x) + 2 \) over the domain \([0, 2\pi]\) on the set of axes below.
Question 30 continued

t(x)

x
31 Solve the following system of equations algebraically.

\[ x^2 + y^2 = 400 \]

\[ y = x - 28 \]

Work space for question 31 is continued on the next page.
Question 31 continued
Some smart-phone applications contain “in-app” purchases, which allow users to purchase special content within the application. A random sample of 140 users found that 35 percent made in-app purchases. A simulation was conducted with 200 samples of 140 users assuming 35 percent of the samples make in-app purchases. The approximately normal results are shown below.

Question 32 is continued on the next page.
Question 32 continued

Considering the middle 95% of the data, determine the margin of error, to the nearest hundredth, for the simulated results. In the given context, explain what this value represents.
Part III

Answer all 4 questions in this part. Each correct answer will receive 4 credits. Clearly indicate the necessary steps, including appropriate formula substitutions, diagrams, graphs, charts, etc. Utilize the information provided for each question to determine your answer. Note that diagrams are not necessarily drawn to scale. For all questions in this part, a correct numerical answer with no work shown will receive only 1 credit. All answers should be written in pen, except for graphs and drawings, which should be done in pencil. [16]

33 Solve the following system of equations algebraically for all values of $x$, $y$, and $z$.

$$
2x + 3y - 4z = -1 \\
x - 2y + 5z = 3 \\
-4x + y + z = 16
$$

Work space for question 33 is continued on the next page.
34 Evaluate $j(-1)$ given $j(x) = 2x^4 - x^3 - 35x^2 + 16x + 48$. Explain what your answer tells you about $x + 1$ as a factor.

Algebraically find the remaining zeros of $j(x)$.

Work space for question 34 is continued on the next page.
Determine, to the nearest tenth of a year, how long it would take an investment to double at a $3\frac{3}{4}$% interest rate, compounded continuously.
Question 35 continued
To determine if the type of music played while taking a quiz has a relationship to results, 16 students were randomly assigned to either a room softly playing classical music or a room softly playing rap music. The results on the quiz were as follows:

Classical: 74, 83, 77, 77, 84, 82, 90, 89
Rap: 77, 80, 78, 74, 69, 72, 78, 69

John correctly rounded the difference of the means of his experimental groups as 7. How did John obtain this value and what does it represent in the given context? Justify your answer.
Question 36 continued

To determine if there is any significance in this value, John rerandomized the 16 scores into two groups of 8, calculated the difference of the means, and simulated this process 250 times as shown below.

![Histogram of difference of means for Classical vs. Rap music]

Question 36 is continued on the next page.
Question 36 continued

Does the simulation support the theory that there may be a significant difference in quiz scores? Explain.
37 A major car company analyzes its revenue, \( R(x) \), and costs \( C(x) \), in millions of dollars over a fifteen-year period. The company represents its revenue and costs as a function of time, in years, \( x \), using the given functions.

\[
R(x) = 550x^3 - 12,000x^2 + 83,000x + 7000
\]

\[
C(x) = 880x^3 - 21,000x^2 + 150,000x - 160,000
\]

Question 37 is continued on the next page.
The company’s profits can be represented as the difference between its revenue and costs. Write the profit function, $P(x)$, as a polynomial in standard form.
Question 37 continued

Graph \( y = P(x) \) on the set of axes below over the domain \( 2 \leq x \leq 16 \).
Question 37 continued

Over the given domain, state when the company was the least profitable and the most profitable, to the nearest year. Explain how you determined your answer.
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Scrap Graph Paper — This sheet will not be scored.
High School Math Reference Sheet

<table>
<thead>
<tr>
<th>Conversion</th>
<th>Equivalent Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch = 2.54 centimeters</td>
<td>1 kilometer = 0.62 mile</td>
</tr>
<tr>
<td>1 meter = 39.37 inches</td>
<td>1 pound = 16 ounces</td>
</tr>
<tr>
<td>1 mile = 5280 feet</td>
<td>1 pound = 0.454 kilogram</td>
</tr>
<tr>
<td>1 mile = 1760 yards</td>
<td>1 kilogram = 2.2 pounds</td>
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<tr>
<td>1 mile = 1.609 kilometers</td>
<td>1 ton = 2000 pounds</td>
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<td>1 cup = 8 fluid ounces</td>
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<td>1 quart = 2 pints</td>
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<td></td>
<td>1 gallon = 3.785 liters</td>
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<tr>
<td></td>
<td>1 liter = 0.264 gallon</td>
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<tr>
<td></td>
<td>1 liter = 1000 cubic centimeters</td>
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<table>
<thead>
<tr>
<th>Geometry</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triangle</td>
<td>$A = \frac{1}{2}bh$</td>
</tr>
<tr>
<td>Parallelogram</td>
<td>$A = bh$</td>
</tr>
<tr>
<td>Circle</td>
<td>$A = \pi r^2$</td>
</tr>
<tr>
<td>Circle</td>
<td>$C = \pi d$ or $C = 2\pi r$</td>
</tr>
<tr>
<td>General Prisms</td>
<td>$V = Bh$</td>
</tr>
<tr>
<td>Pythagorean Theorem</td>
<td>$a^2 + b^2 = c^2$</td>
</tr>
<tr>
<td>Quadratic Formula</td>
<td>$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$</td>
</tr>
<tr>
<td>Arithmetic Sequence</td>
<td>$a_n = a_1 + (n - 1)d$</td>
</tr>
<tr>
<td>Geometric Sequence</td>
<td>$a_n = a_1 r^n - 1$</td>
</tr>
<tr>
<td>Geometric Series</td>
<td>$S_n = \frac{a_1 - a_1 r^n}{1 - r}$ where $r \neq 1$</td>
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</tbody>
</table>

The Reference Sheet is continued on the next page.
### Reference Sheet — concluded

<table>
<thead>
<tr>
<th>Cylinder</th>
<th>$V = \pi r^2 h$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sphere</td>
<td>$V = \frac{4}{3} \pi r^3$</td>
</tr>
<tr>
<td>Cone</td>
<td>$V = \frac{1}{3} \pi r^2 h$</td>
</tr>
<tr>
<td>Pyramid</td>
<td>$V = \frac{1}{3} Bh$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Radians</th>
<th>1 radian $= \frac{180}{\pi}$ degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees</td>
<td>1 degree $= \frac{\pi}{180}$ radians</td>
</tr>
</tbody>
</table>

**Exponential Growth/Decay**

$A = A_0 e^{k(t - t_0)} + B_0$