

2011-12 Assessment of General Education Outcomes

Quantitative Reasoning (Full Report)

Office of Institutional Assessment and Evaluation

July, 2012

"Working together to create a culture of evidence-based decision making..."

Table of Contents

The Assessment of Quantitative Reasoning	1
College Algebra I	2
RESULTS: Across All Sections, by School/College, Student Classification and Gender	2
Results by School/College: College Algebra I	4
Results by Student Classification: College Algebra I	5
Descriptive Statistics by Student Classification: College Algebra I	7
Inferential Statistics by Student Classification: College Algebra I	8
Results by Gender: College Algebra I	9
College Algebra II	11
RESULTS: Across All Sections, by School/College and Student Classification	11
Results by School/College: College Algebra II	13
Results by Student Classification: College Algebra II	15
Descriptive Statistics by Student Classification: College Algebra II	16
Inferential Statistics by Student Classification: College Algebra II	18
Pre-Calculus	19
RESULTS: Across All Sections, by School/College and Student Classification	20
Results by School/College: Pre-calculus	20
Results by Student Classification: Pre-calculus	21
Descriptive Statistics by Student Classification: Pre-calculus	23
Inferential Statistics by Student Classification: Pre-calculus	25
The Economics of Student Drop-Out in Mathematics Courses	26
Summary	27
Appendix A. College Algebra I	28
Appendix B. College Algebra II	31
Appendix C. Pre-calculus	34



2011-12 Assessment of General Education Outcomes Quantitative Reasoning

The Assessment of Quantitative Reasoning

In Spring Semester 2012, the Office of Institutional Assessment and Evaluation (OIAE) consulted with chairs of the departmental final examination committees for College Algebra I, College Algebra II, and Pre-calculus for the purpose of deciding which questions on the final examinations would be used to measure the general education learning outcome, *quantitative reasoning*. To aid in the identification of questions that would be used to measure quantitative reasoning, committee chairs were given the general education competencies for quantitative reasoning as defined by the Mathematical Association of America (MAA). Chairs were asked to identify at least two questions on their respective final examination which measured students' ability to:

- Interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them;
- Represent mathematical information symbolically, visually, numerically, and verbally;
- Use arithmetical, algebraic, geometric and statistical methods to solve problems; and
- Estimate and check answers to mathematical problems in order to determine reasonableness, identify alternatives, and select optimal results.

The assessment of *quantitative reasoning* occurs each spring semester; therefore, the OIAE set three goals for this assessment activity for AY 2011-12: (1) to improve the measurement – reliability and validity – of quantitative reasoning as defined by the four competencies, (2) to glean information about student performance in mathematics based on student classification and gender so that appropriate interventions can be designed and implemented, and (3) to increase the response rate among professors who report their students' performance data. In the past, only one question was identified to measure each competency; however, to improve the measurement of the competencies, OIAE decided to collect data on two questions for each competency. This decision to collect more information has the effect of increasing the validity of inferences about the level of students' competency in quantitative reasoning. This decision also carried with it the probability that professors would have to devote more time to reporting student performance on eight questions instead of four – which could have a negative effect on the response rate. Therefore, the OIAE divided professors into two groups. Each group of professors was responsible for reporting student performance on only four questions on the final examination, where each question measured a different competency.

Thus, OIAE was able to (1) improve the measurement of quantitative reasoning by collecting more data on student performance without increasing the level of reporting effort required from

participating professors; and (2) disaggregate the student performance data by student classification and gender so that the results could be used to improve student learning.

The question number and point value, the statement of the question, and the related competency are presented in Tables 1, 9, and 15 for College Algebra I, College Algebra II and Pre-calculus, respectively. "Competent" performance was defined as earning a question or final examination score of at least 60%.

College Algebra I

The final examination for College Algebra I for Spring Semester 2012 consisted of 15 questions and a total score of 200 points. Table 1 presents the questions that were selected to measure each of two competencies. A copy of the College Algebra I final examination is in Appendix A.

RESULTS: Across All Sections, by School/College, Student Classification and Gender

Table 2 presents the results of student performance on the College Algebra I final examination for all sections by school or college. The results indicate that 242 of 363 or 67% of the enrollees had a final exam score and, therefore, were considered "valid cases" for these analyses. Thus, 121 or 33% of the students who did not have a final exam score either withdrew from the course, remained in the course but did not take the final exam, or took a different final exam because they were prospective graduates (seniors). Still, the retention rate for College Algebra I was low across all schools and colleges, ranging for 33% to 85%. Across all sections of College Algebra I, the results of data analyses on student performance indicate that for:

- Questions 3, 5, 6, and 12, which measured students' ability to (1) *interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them,* 79 of 130 valid cases or 60.8% of the students who took the final exam earned a question score of 60% or higher, and 79 of 188 or 42% of the original enrollees earned a score of 60% or higher.
- Questions 7, 8, 10 and 14, which measured students' ability to (*3*) *use arithmetical, algebraic, geometric and statistical methods to solve problems*, 86 of 106 valid cases or 81.1% of the students who took the final exam earned an question score of 60% or higher, and 86 of 177 or 48.6% of the original enrollees earned a score of 60% or higher.

Question # (Points)	Question Description	QR Competency Measured
3. (20pts)	 Let f(x) = (x - 1)² - 4. (a) Determine whether the graph of <i>f</i> opens up or down (b) Give the vertex (c) Find the x- and y- intercepts (d) Determine whether the function <i>f</i> is increasing and where it is decreasing. (e) Graph the function <i>f</i>. 	
5. (20pts)	 Consider the line with equation 5x-3y=15 (a) Graph the line and label the x- intercept and y- intercept. (b) Find the slope of the line (c) Is the point (60,95) on this line? Justify your answer. (d) Is this line perpendicular to the line passing through the points (2,-7) and (7,-11)? Justify your answer. 	(1) Interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them.
6. (10pts)	 (a) Find the equation to the circle with center (3,-2) and which passes through (3, 0). Graph the circle. (b) Find the center and radius of the circle x² + y²+4x-6y+12=0. Graph the circle. 	
12. (10pts)	Find the domain of each function. Give your answer in interval notation. (a) $f(x) = \sqrt{x+3}$ (b) $f(x) = \frac{x}{x^2+x-6}$	
7. (5pts)	Add the fractions and simplify. Leave your answer in factored form. $\frac{2x}{x^2-1} + \frac{3x}{x^2-2x+1}$	
8. (10pts)	Find all real solutions, if any, to $x+1 = \sqrt{x+3}$. (a) $2x^3=54$ (b) $6x^2-5x-6=0$	(3) Use arithmetical,
10. (10pts)	Solve each inequality, and give the solutions and interval notation. Also graph the solution set. (a) $-3 < 2x + 1 \le 4$ (b) $ 2x - 3 \le 4$	algebraic, geometric and statistical methods to solve problems
14. (15pts)	When a certain medicinal drug is administered to a patient, the number of milligrams remaining in the patient's bloodstream after <i>t</i> hours is modeled by $D(t) = 50e^{-0.2t}$	

Table 1. Questions and QR Competencies for College Algebra I Final Examination

For all questions on the final exam, 171 of 242 valid cases or 70.7% of the students earned a score of 60% or higher, and 171 of 366 or 46.7% of the original enrollees earned a score of 60% or higher.

Results by School/College: College Algebra I

Among students enrolled in College Algebra I, the largest representation of students was from the College of Arts and Science (N=224 of 363, 61.7%) and the smallest representation was from the School of Education (N=6 of 363, 1.7%).

The results indicate that the College of Nursing and Allied Health Sciences had the highest percentage of students who took the final examination and earned a total score of 60% or higher (N=13 of 17, 76.5%). The School of Education had the lowest percentage of students who took the final examination and earned a total score of 60% or higher (N=0 of 2, 0%); however, this may due small number of valid cases. The results for the other schools and colleges were College of Arts and Sciences (N=6 of 8, 75%), School of Business (N=17 of 26, 65.3%), and School of Communications (N=31 of 43, 72.1%).

Table 2 also presents the percentage of original enrollees in College Algebra I who earned a score of 60% or higher on the departmental final examination. Across all schools and colleges, the percentages ranged from 0% to 65%. At the institutional level, the percentage of original enrollees who earned a score of 60% or higher was 47.1%. This does not mean that only 47.1% of the original enrollees earned a passing grade (grade D or better) in College Algebra I. Rather, these results indicate that about 47% of the students were able to demonstrate the minimum level of competency on their College Algebra I final examination.

Student Classification	Number of Cases	Withdrew or No Score	Valid Cases	Item # & (QR Comp)	No. of Valid Cases Scoring 60% or Higher	Percent of Valid Cases Scoring 60% or Higher	Percent of Original Enrollees Scoring 60% or Higher
College of	116	38	78	3, 5, 6, & 12 (1)	47	60.2%	40.5%
Arts &	108	44	64	7, 8, 10 & 14 (3)	53	82.8%	49.1%
Sciences	224	78	146	Total Exam	104	71.2%	46.4%
College	6	2	4	3, 5, 6, & 12	3	75.0%	50.0%
Engineering, Architecture & Computer Science	5	1	4	7, 8, 10 & 14	4	100.0%	80.0%
	11	3	8	Total Exam	6	75.0%	54.5%
School of	3	2	1	3, 5, 6, & 12	0	0%	0%
	3	2	1	7, 8, 10 & 14	1	100.0%	33.3%
	6	4	2	Total Exam	0	0%	0%
College of	10	1	9	3, 5, 6, & 12	6	66.7%	60.0%
Nursing and Allied Health	10	2	8	7, 8, 10 & 14	6	75.0%	60.0%
Sciences	20	3	17	Total Exam	13	76.5%	65.0%
	20	3	17	3, 5, 6, & 12	12	70.6%	60.0%
School of Business	11	2	9	7, 8, 10 & 14	6	66.7%	54.5%
Dubinebb	31	5	26	Total Exam	17	65.3%	54.8%
School of	33	12	21	3, 5, 6, & 12	11	52.3%	33.3%
Communicati	38	18	20	7, 8, 10 & 14	16	80%	42.1%
ons	71	28	43	Total Exam	31	72.1%	43.7%
	188	58	130	3, 5, 6, & 12	79	60.8%	42.0%
Institutional Results	175	69	106	7, 8, 10 & 14	86	81.1%	49.1%
INCOULO	363	121	242	Total Exam	171	70.7%	47.1%

Table 2. Quantitative Reasoning for Spring Semester 2012 by School and College Algebra I Final Examination

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture and Computer Sciences, Education, Allied Health Sciences, School of Business, and School of Communications. (2) *Number of Cases* indicates the number of students on the official class roster. (3) *Withdrew or No Score* includes situations in which students withdrew from the class, did not take the final (including prospective graduating students), or did not answer the particular item. (4) *Valid Cases* indicate the number of cases included in the analysis for which there is a question or exam score. (5) Two students (freshman) did not choose school or college yet at the time when final exam was taken; their data are not included in this table.

Results by Student Classification: College Algebra I

Table 3 presents the results of student performance on the College Algebra I final examination for all classifications of students. Of the 366 students enrolled in the course, freshmen had the largest representation (N=222 of 366, 60.7%) and junior and seniors had the smallest representation (N=34 of 366, 9.3%). The results also indicate that freshmen had the

highest percentage of students who took the final examination and earned a total score of 60% or higher (N=123 of 165, 74.5%). Juniors had the lowest percentage of students who took the final examination and earned a total score of 60% or higher (N=10 of 19, 52.6%).

Student Classification	Number of Cases	Withdrew or No Score	Valid Cases	Item #	No. of Valid Cases Scoring 60% or Higher	Percent of Valid Cases Scoring 60% or Higher	Percent of Original Enrollees Scoring 60% or Higher
	117	27	90	3, ,5 ,6, & 12	60	66.7%	51.3%
Freshman	105	34	71	7, 8, 10, & 14	59	83.0%	56.2%
	222	57	165	Total Exam	123	74.5%	55.4%
Sophomore	34	11	23	3, ,5 ,6, & 12	11	47.8%	32.4%
	41	19	22	7, 8, 10, & 14	16	72.7%	39.0%
	75	29	46	Total Exam	31	67.4%	41.3%
	20	9	11	3, ,5 ,6, & 12	6	54.5%	30.0%
Junior	14	6	8	7, 8, 10, & 14	6	75.0%	42.9%
	34	15	19	Total Exam	10	52.6%	29.4%
	17	11	6	3, ,5 ,6, & 12	2	33.3%	11.8%
Senior	17	12	5	7, 8, 10, & 14	5	100%	29.4%
	34	22	12	Total Exam	7	58.3%	20.6%
Institutional	188	58	130	3, ,5 ,6, & 12	79	60.8%	42.0%
Results	177	71	106	7, 8, 10, & 14	86	81.1%	48.6%
ixcourto	365	123	242	Total Exam	171	70.7%	46.8%

Table 3. Quantitative Reasoning for Spring Semester 2012 by Student ClassificationCollege Algebra I Final Examination

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture & Computer Sciences, and Nursing and Allied Health Sciences. (2) *Number of Cases* indicates the number of "original enrollees" on the official class roster. (3) *Withdrew or No Score* includes situations in which students withdrew from the class, did not take the final (including perspective graduating students), or did not answer the particular item. (4) *Valid Cases* indicate the number of cases included in the analysis for which there is a question or exam score.

The results also indicate that retention rates for College Algebra I were low across all classifications and decreased as classification level increased (See "valid cases"): freshmen (N=123 of 165, 74.5%); sophomores (N=31 of 46, 67.4%); juniors (N=10 of 19, 52.6%); and seniors (N=7 of 12, 58.3%). Essentially, nearly one-fourth of all freshmen and two-thirds of all seniors who were enrolled in College Algebra did not have a departmental final examination score reported for them. The retention rate for seniors, however, may be somewhat underestimated since seniors who were prospective graduates took a final examination approximately one week before the departmental final examination was administered.

Figure 1 presents the percentage of *original enrollees* in College Algebra I who earned a score of 60% or higher on the departmental final examination by student classification -- the percentages ranged from 4.2% for seniors to 19.1% for freshmen.



Figure 1

Descriptive Statistics by Student Classification: College Algebra I

Table 4 provides descriptive statistics for the 242 valid cases who took the department final examination in College Algebra I in Spring Semester 2012. Valid cases are those students for whom a question or final examination score is reported. Raw scores on the final examination range from 0 to 200. Table 4 shows the percentage scores and range from 0% to 100%, for example, if the raw score is 80 (out of 200), the percentage score is 40% in Table 4. The highest mean score and lowest variability occurred among freshmen, M=69.6%, SD=20.2%, and the lowest mean score and highest variability occurred among seniors, M=57.5%, SD=27.2%. Observed scores ranged from 1.5% to 99%. Both of these extreme scores were earned by freshmen.

Classification	Valid N	Minimum	Maximum	Mean	Std. Dev.
Freshman	165	1.5%	99.0%	69.6%	20.2%
Sophomore	46	8.5%	91.0%	64.8%	21.3%
Junior	19	12.5%	97.5%	57.5%	27.2%
Senior	12	35.5%	89.5%	65.3%	17.9%
Institutional Results	242	1.5%	99.0%	67.5%	21.1%

Table 4. Descriptive Statistics for Algebra I by Student Classification (Percentages)Spring Semester 2012

Figure 2 presents the mean scores on the College Algebra I final examination by student classification for valid cases only. The graph shows that, overall, the mean scores for all student classifications -- freshmen, sophomores, juniors and seniors – were around 60% or a C grade.





Inferential Statistics by Student Classification: College Algebra I

F-Test and Post Hoc Analyses: An Analysis of Variance (ANOVA) was performed on the four mean percentage scores by student classification. The results of the *F*-test in Table 5 show that there is no statistically significant difference in the mean scores at 5% significant level for

freshmen, sophomores, juniors and seniors on the departmental final examination for College Algebra I, F(3,238)=2.31, p=.08.

by Student Classification in College Algebra I											
	Sum of Squares	df	Mean Square	F	Sig.						
Between Groups	3026.265	3	1008.755	2.306	.077						
Within Groups	104124.030	238	437.496								
Total	107150.295	241									

Table 5. ANOVA for Final Exam (Percentage) Score by Student Classification in College Algebra I

A Post Hoc analysis was also performed in order to examine pair-wise differences in mean performances by student classification. Table 6 shows that there are no statistically significant differences (p<.05) between the mean performances.

Table 6. Post Hoc Multiple Comparisons for Final Exam Percentage Scoresby Student Classification in College Algebra I, 2012

		Mean	Std.	- 	95% Co Inte	nfidence erval
(I) Classification	(J) Classification	Difference (I-J)	Error	Sig.	Lower Bound	Upper Bound
	Sophomore	4.79	3.51	.69	-4.71	14.29
Freshman	Junior	12.12	6.44	.37	-6.65	30.89
	Senior	4.32	5.38	.97	-12.32	20.97
	Freshman	-4.79	3.51	.69	-14.29	4.71
Sophomore	Junior	7.33	6.99	.89	-12.49	27.14
	Senior	47	6.03	1.00	-18.06	17.13
	Freshman	-12.12	6.44	.37	-30.89	6.65
Junior	Sophomore	-7.33	6.99	.89	-27.14	12.49
	Senior	-7.79	8.10	.92	-30.66	15.07
	Freshman	-4.32	5.38	.97	-20.97	12.32
Senior	Sophomore	.47	6.03	1.00	-17.13	18.06
	Junior	7.79	8.10	.92	-15.07	30.66

Note: "Tamhane"s T2" Post Hoc test is used, and equal variances are not assumed.

Results by Gender: College Algebra I

Of the 365 students enrolled in College Algebra I, 64.4% (N=235 of 365) were female and 35.6% (N=130 of 365) were male, thereby reflecting a ratio of females to males of almost 2:1. Table 7 shows that females performed much better on "use arithmetical, algebraic, geometric and

statistical methods to solve problems" (category 3) than "interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them" (category 3), while males only performed slightly better. Most likely because of the high attrition rates among females (N=70 of 235 or 30%) and males (N=53 of 135 or 39%), Table 7 shows that only 47.2% of females (N=111 of 235) and 46.2% of males (N=60 of 130) who originally enrolled in College Algebra I earned a score of 60% or higher on the final examination.

Gender	No. of Cases	Withdrew or No Score	Valid Cases	Item # & (QR Comp)	No. of Valid Cases Scoring 60% or Higher	Percent of Valid Cases Scoring 60% or Higher	Percent of Original Enrollees Scoring 60% or Higher
Female	119	34	85	3, 5, 6, & 12 (1)	47	55.3%	39.5%
	116	40	76	7, 8, 10 & 14 (3)	63	82.9%	54.3%
	235	70	165	Total Exam	111	67.3%	47.2%
Male	69	24	45	3, 5, 6, & 12	32	71.1%	46.4%
	61	31	30	7, 8, 10 & 14	23	76.7%	37.7%
	130	53	77	Total Exam	60	77.9%	46.2%

Table 7. Quantitative Reasoning for Spring Semester 2011 by GenderCollege Algebra I Final Examination

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture and Computer Sciences, Education, Nursing and Allied Health Sciences, Business, and Communications. (2) *Number of Cases* indicates the number of students on the official class roster. (3) *Withdrew or No Score* includes situations in which students withdrew from the class, students did not take the final (including perspective graduating students), or students did not answer the particular item. (4) *Valid Cases* indicate the number of cases included in the analysis for which there is a question or exam score.

Table 8 presents the results of an independent *t*-test performed on the mean percentage scores by gender. The results indicate that there is no significant effect by gender, t(240) = -1.15, p=.25. Females and males performed very similarly.

Gender	Valid N	Mean of Total Exam	Std. Dev.	t	df	Sig. (2-tailed)
Female	165	66.5%	20.9%	1 1 5	240	0.25
Male	77	69.8%	21.5%	-1.15	240	0.25

Table 8. Mean Comparison by Gender for College Algebra I, Spring Semester 2012

College Algebra II

The final examination for College Algebra II for Spring Semester 2011 consisted of 14 questions and each question is 20 points. Students were asked to answer any 10 questions with a total score of 200 points. Table 9 presents the questions that were selected to measure each of four competencies. Questions 3, 8, and 9 were selected to measure Competency 1, questions 10 to measure Competency 2, and questions 1, 4, 7, and 13 to measure Competency 3.

Since student can select any of 10 questions, "percent of original enrollees scoring 60% or higher" is not computed in table 10. A copy of the College Algebra II final examination is in Appendix B.

RESULTS: Across All Sections, by School/College and Student Classification

Table 10 presents the results of student performance on the College Algebra II final examination for all sections by school or college. The results indicate that 193 of 259 or 74.5% of the enrollees had a final examination score and were considered "valid cases" for these analyses. Thus, 193 or 25.5% of the students who did not have a final exam score either withdrew from the course, remained in the course but did not take the final exam, or took a different final exam because they were prospective graduates (seniors). Nevertheless, the retention rate for College Algebra II varied across schools and colleges, ranging from 69% among students enrolled in the College of Arts & Sciences to 100% among students enrolled in the School of Education. Across all sections of College Algebra II, the results of data analyses on student performance indicate that for:

- Questions 3, 8, and 9, which measured students' ability to (1) *interpret mathematical models such as formulas, graphs, tables, and schematics, and draw inferences from them,* 33 of 50 valid cases or 66% of the students who took the final exam earned a question score of 60% or higher.
- Question 10, which measured students' ability to (2) *represent mathematical information symbolically, visually, numerically, and verbally*, 20 of 34 valid cases or 58% of the students who took the final exam earned a question score of 60% or higher.
- Questions 1, 4, 7, and 13, which measured students' ability to (3) use arithmetical, algebraic, geometric and statistical methods to solve problems, 114 of 132 valid cases or 86% of the students who took the final exam earned an question score of 60% or higher.

For all questions on the final exam, 147 of 193 valid cases or 76% of the students earned a score of 60% or higher, and 147 of 259 or 57% of the original enrollees earned a score of 60% or higher.

Item # (Points)	Item Description	Competency Measured
3. (20 pts)	 The time required to double the amount of an investment of the interest rate r compounded continuously is given by t = ln 2/r where t is measured in years. (a) Write the exponential equation that gives A(t), the amount after t years. (b) Find the time required to double an investment at 6 percent interest. 	(1) Interpret mathematical models such as formulas, graphs, tables, and
8. (20 pts)	Find the equation for the hyperbola whose focus is at the point (0,1) and whose directrix is the line y=5	schematics, and draw inferences from them.
9. (20 pts)	Find the equation for the hyperbola that satisfies the given conditions: Foci: $(\pm 5; 0)$, vertices $(\pm 3; 0)$	
10. (20 pts)	Graph the region which satisfies the following inequalities. Be sure to identify the coordinates of each vertex. $x \ge 0$ $y \ge 0$ $2x + y \le 10$ $-2x + y \le 2$ $4x + 7y \le 28$	(2) Represent mathematical information symbolically, visually, numerically, and verbally.
1. (20 pts)	Find all rational zeros of the polynomial $P(x) = x^3 + 9x^1 - 108$.	
4 (20 pts)	The perimeter of the triangle is 72 inches. The length is 3.5 times as large as the width. Find the dimensions.	(3) Use arithmetical,
7. (20 pts)	Use Cramer's rule to solve the following system of equations: $4x-5y=3$, $3x-2y=1$.	statistical methods to solve problems
13. (20 pts)	Find the final amount in an annuity in which \$200 is deposited monthly for 10 years, interest is compounded monthly and the annual interest rate is 12 percent.	

Table 9. Questions and QR Competencies for College Algebra II Final Examination

Results by School/College: College Algebra II

Of the 259 students enrolled in College Algebra II, the largest representation of students was from the College of Arts and Science (N=123 of 259 or 47.5%) and the smallest representation was from the School of Education (N=4 of 259 or 1.5%).

The results indicate that the College of Nursing and Allied Health Sciences (CEACS) had the highest percentage of students who took the final examination and earned a total score of 60% or higher (N=19 of 21 or 90%). The School of Business had no students (68%) to earned a total score of 60% or higher.

Table 10 also presents the percentage of original enrollees in College Algebra II who earned a score of 60% or higher on the departmental final examination. Across all schools and colleges, the percentages ranged from 53% to 75%. At the institutional level, the percentage of original enrollees who earned a score of 60% or higher was 57%. This does not mean that only 57% of the original enrollees earned a passing grade (grade D or better) in College Algebra II. Rather, these results indicate that about one-third of the students were able to demonstrate the minimum level of competency on their College Algebra II final examination.

Student Classification	Number of Cases	Withdrew or No Score	Valid Cases	Item # & (QR Comp)	No. of Valid Cases Scoring 60% or Higher	Percent of Valid Cases Scoring 60% or Higher	Percent of Original Enrollees Scoring 60% or Higher
	28	7	21	3, 8, & 9 (1)	12	57%	NA
College of	28	11	17	10 (2)	8	47%	NA
Sciences	95	34	61	1, 4, 7, & 13 (3)	52	85%	NA
	123	38	85	Total Exam	67	79%	54%
College	2	2	0	3, 8, & 9	0	NA	NA
Engineering,	2	2	0	10	0	NA	NA
& Computer	3	0	3	1, 4, 7, & 13	2	66%	NA
Science	5	1	4	Total Exam	3	75%	60%
	3	0	3	3, 8, & 9	1	33%	NA
School of	3	0	3	10	3	100%	NA
Education	1	0	1	1, 4, 7, & 13	1	100%	NA
	4	0	4	Total Exam	3	75%	75%
	5	1	4	3, 8, & 9	4	100%	NA
College of Nursing and	5	2	3	10	2	66%	NA
Allied Health	22	6	16	1, 4, 7, & 13	16	100%	NA
Sciences	27	6	21	Total Exam	19	90%	70%
	23	8	15	3, 8, & 9	11	73%	NA
School of	23	14	9	10	6	66%	NA
Business	47	12	35	1, 4, 7, & 13	28	80%	NA
	70	16	54	Total Exam	37	68%	53%
	9	2	7	3, 8, & 9	5	71%	NA
School of	9	7	2	10	1	50%	NA
Communicati	21	5	16	1, 4, 7, & 13	15	93%	NA
	30	5	25	Total Exam	18	72%	60%
	70	20	50	3, 8, & 9	33	66%	NA
Institutional	70	36	34	10	20	58%	NA
Results	189	57	132	1, 4, 7, & 13	114	86%	NA
	259	66	193	Total Exam	147	76%	57%

Table 10. Quantitative Reasoning for Spring Semester 2012 by School and College

Note: (1) *Institutional Results* include Arts & Sciences, Engineering & Architecture, Education, Allied Health Sciences, School of Business, and School of Communications and exclude one student from Continuing Education. (2) *Number of Cases* indicates the number of students on the official class roster. (3) *Withdrew or No Score* includes situations in which students withdrew from the class, did not take the final (including perspective graduating students), or did not answer the particular item. (4) *Valid Cases* indicate the number of cases included in the analysis for which there is a question or exam score (5) Item 13 was optional, which could reduce the number of valid cases.

Results by Student Classification: College Algebra II

Table 11 presents the results of student performance on the College Algebra II final examination for all classifications of students. Of the 259 students enrolled in the course, freshmen had the largest representation (N=120 of 259 or 46.3%) and juniors had the smallest representation (N=31 of 259 or 12%). The results also indicate that seniors had the highest percentage of *students who took the final examination* and earned a total score of 60% or higher (N=10 of 12 or 83%). Juniors had the lowest percentage of students *who took the final examination* and earned a total score of 60% or higher (N=14 of 22 or 63%).

Student Classification	Number of Cases	Withdrew or No Score	Valid Cases	Item #	No. of Valid Cases Scoring 60% or Higher	Percent of Valid Cases Scoring 60% or Higher	Percent of Original Enrollees Scoring 60% or Higher
	38	7	31	3, 8, & 9	22	71%	NA
Frachman	38	17	21	10	15	71%	NA
Freshman	82	9	73	1, 4, 7, & 13	62	85%	NA
	120	13	107	Total Exam	88	82%	73%
Sophomore	18	7	11	3, 8, & 9	6	54%	NA
	18	10	8	10	3	37%	NA
	53	17	36	1, 4, 7, & 13	32	89%	NA
	71	19	52	Total Exam	35	67%	49%
	7	4	3	3, 8, & 9	2	66%	NA
T ·	7	4	3	10	1	33%	NA
Junior	24	7	17	1, 4, 7, & 13	14	82%	NA
	31	9	22	Total Exam	14	63%	45%
	7	2	5	3, 8, & 9	3	60%	NA
Sonior	7	5	2	10	1	50%	NA
Semor	30	24	6	1, 4, 7, & 13	6	100%	NA
	37	25	12	Total Exam	10	83%	27%
	70	20	50	3, 8, & 9	33	66%	NA
Institutional	70	36	34	10	20	59%	NA
Kesults	189	57	132	1, 4, 7, & 13	114	86%	NA
	259	66	193	Total Exam	147	76%	57%

Table 11. Quantitative Reasoning for Spring Semester 2012 by Student Classification College Algebra II Final Examination

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture & Computer Sciences, and Nursing and Allied Health Sciences. (2) *Number of Cases* indicates the number of "original enrollees" on the official class roster. (3) *Withdrew or No Score* includes situations in which students withdrew from the class, did not take the final (including perspective graduating students), or did not answer the particular item. (4) *Valid Cases* indicate the number of cases included in the analysis for which there is a question or exam score.

The results also indicate that retention rates for College Algebra II decreased as classification increased (See "valid cases"): freshmen (N=107 of 120 or 89.2%); sophomores (N=52 of 71 or 73.2%); juniors (N=22 of 31 or 71%); and seniors (N=12 of 37 or 32.4%).

Figure 3 presents the percentage of *original enrollees* in College Algebra II who earned a score of 60% or higher on the departmental final examination by classification -- the percentages ranged from 27% for seniors to 73% for freshmen.





Descriptive Statistics by Student Classification: College Algebra II

Table 12 provides descriptive statistics for the 193 valid cases who took the department final examination in College Algebra II in Spring Semester 2012. Valid cases are those students for whom a question or final examination score is reported. Raw scores on the final examination could range from 0 to 200. Observed raw scores ranged from 0 to 200. Table 12 shows the percentage scores and range from 0% to 100%, for example, if the raw score is 80 (out of 200), the percentage score is 40% in Table 12. The highest mean score occurred among seniors, M=74.5%, SD=28%; the lowest mean score occurred among juniors, M=62.7%, SD=24%.

Classification	Valid N	Minimum	Maximum	Mean	Std. Dev.
Freshman	107	0%	100%	75.3%	21.5%
Sophomore	52	0%	100%	66.2%	25.5%
Junior	22	10%	97.5%	62.7%	24.0%
Senior	12	0%	100%	75.4%	28.0%
Institutional Results	193	0%	100%	71.4%	23.6%

 Table 12. Descriptive Statistics for College Algebra II by Student Classification (Percentages)

 Spring Semester 2012

Figure 4 presents the mean scores on the College Algebra II final examination by student classification for valid cases only. The graph shows that freshmen were the only class to meet the minimum mean criterion performance of at least 60%. Specifically, the mean score for freshmen on the College Algebra II final examination is 63%. All other student classifications, sophomores, juniors and seniors, failed to meet the criterion score of 60% or higher with mean scores of 50.3%, 48.7%, and 47.3%, respectively.



Figure 4

Inferential Statistics by Student Classification: College Algebra II

F-Test and Post Hoc Analyses: An Analysis of Variance (ANOVA) was performance on the four mean scores by student classification. The results of the *F*-test in Table 13 show that there is a statistically significant difference in the mean scores for freshmen, sophomores, juniors and seniors on the departmental final examination for College Algebra II, F(3,189)=3.00, p=0.03.

	Sum of Squares	df	Mean Square	F	Sig.			
Between Groups	4870.296	3	1623.432	2.999	.032			
Within Groups	102312.918	189	541.338					
Total	107183.214	192						

Table 13. ANOVA for Final Exam Percentage Scores
by Student Classification in College Algebra II

A Post Hoc analysis was also performed in order to examine pair-wise differences in mean performances by student classification. Table 14 shows that there are no statistically significant differences between any two pairs of the mean performances by student classification. ANOVA result shows that there is only a three percent chance (i.e., statistically significant) that all mean scores for freshmen, sophomores, juniors and seniors are equal. However, the chance for each pair of mean scores to be equal is higher than 5%, i.e., statistically not significant.

 Table 14. Post Hoc Multiple Comparisons for Final Exam Percentage Scores

 by Student Classification in College Algebra II

		Mean	Std.		95% Confidence Interval	
	(J) Classification	Difference (I-J)	Error	Sig.	Lower Bound	Upper Bound
	Sophomore	9.08	4.10	.16	-1.95	20.11
Freshman	Junior	12.60	5.42	.16	-2.74	27.90
	Senior	101	8.34	1.00	-26.10	25.90
	Freshman	-9.08	4.10	.16	-20.11	1.95
Sophomore	Junior	3.50	6.13	.99	-13.40	20.40
	Senior	-9.18	8.81	.90	-35.73	17.37
	Freshman	-12.58	5.42	.16	-27.90	2.74
Junior	Sophomore	-3.508	6.13	.99	-20.40	13.40
	Senior	-12.68	9.50	.73	-40.47	15.11
Senior	Freshman	.10	8.34	1.00	-25.90	26.10
	Sophomore	9.18	8.81	.90	-17.37	35.73
	Junior	12.68	9.50	.73	-15.11	40.47

Note: Tamhane's T2 Post Hoc test is used, and equal variances are not assumed.

Pre-Calculus

The final examination for Pre-calculus for Spring Semester 2011 consisted of 14 questions and a total score of 200 points. Table 15 presents the questions that were identified to measure each of four competencies. A copy of the final examination is in Appendix C.

Item # (Points)	Item Description	Competency Measured	
4. (10 pts)	Express $\ln x - 2 \ln(x^2 + 1) - \frac{1}{2}\ln(x + 1)^2$ as a single logarithm		
8. (10 pts)	Given the trigonometric function $y=3\cos\left[2\left(x-\frac{\pi}{4}\right)\right]$ (a). Find the amplitude, period, and phase shift of the graph of the trigonometric function, if any. (b.) Graph the function, showing at least two periods.	(2) Represent mathematical	
9. (20 pts)	Verify the following trigonometric identities: (a) $\frac{1+\tan 2\theta}{\csc 2\theta} = \tan 2\theta$ (b) $(\cot x - \csc x) (\cos x + 1) = \sin x$	information symbolically, visually, numerically, and verbally.	
12. (10 pts)	Graph the feasible region and maximize the objective function $P(x,y)=12x + 6y \text{ subject to the constraints:} \begin{cases} x \ge 0 \\ y \ge 0 \\ 2x + 2y < 8 \\ 2x + 3y \le 12 \end{cases}$	•	
5. (20 pts)	Solve the following logarithmic equations: (a) $\ln(x - 2) = 2$ (b) $log_2x + log_2(x+2) = 3$.		
7. (20 pts)	Without using your calculator, find the exact values of the following expressions. You must show your work to get credit. (a) $\sin 75^{\circ}$ (b) $\cos -1\left(-\frac{\sqrt{3}}{2}\right)$ (c) $\sin^{-1}\left(\sin\frac{2\pi}{3}\right)$ (d) $\cos(\sin -1\frac{3}{5})$	(3) Use arithmetical,	
10. (20 pts)	Solve the trigonometric equation $4\cos^2\theta - 4\cos\theta + 1 = 0$ and list specific solutions.	and statistical methods to solve problems.	
14. (10 pts)	 The population of a certain country was given by the exponential model N(t)=260e^{0.007t} where N(t) is in millions and <i>t</i> is the number of years after 2000. (a) What as the population of the country in the year 2000? (b) In which year did the population reach 270 million? (c) What will be the size of the population in the year 2012? 	-	

Table 15. Questions and QR Competencies for Pre-calculus Final Examination

RESULTS: Across All Sections, by School/College and Student Classification

Table 16 presents the results of student performance on the Pre-calculus final examination for all sections by school or college. The results indicate that 149 of 181 or 82.3% of the enrollees had a final examination score and were considered "valid cases" for these analyses. Thus, 32 of 181 or 17.7% of the students who did not have a final exam score either withdrew from the course, remained in the course but did not take the final exam, or took a different final exam because they were prospective graduates (seniors). The retention rate for Pre-calculus varied across the three schools and colleges represented, ranging from 79.3% (N=23 of 29) among students enrolled in the College Engineering, Architecture & Computer Science to 100% (N=10 of 10) among students enrolled in the School of Business. Across all sections of Pre-calculus, the results of data analyses on student performance indicate that for:

- Questions 4, 8, 9, and 12, which measured students' ability to (2) *represent mathematical information symbolically, visually, numerically, and verbally*, 55 of 85 valid cases or 64.7% of the students who took the final exam earned a question score of 60% or higher, and 55 of 95 or 57.9% of the original enrollees earned a score of 60% or higher.
- Questions 5, 7, 10, and 14, which measured students' ability to (*3*) *use arithmetical, algebraic, geometric and statistical methods to solve problems*, 34 of 64 valid cases or 53.1% of the students who took the final exam earned an question score of 60% or higher, and 34 of 86 or 53.1% of the original enrollees earned a score of 60% or higher.

For all questions on the final examination, 90 of 149 valid cases or 60.4% of the students earned a score of 60% or higher, and 90 of 181 or 49.7% of the original enrollees earned a score of 60% or higher.

Results by School/College: Pre-calculus

Of the 181 students enrolled in Pre-calculus, the largest representation of students was from the College of Arts and Science (N=125 of 181 or 69.1%) and the smallest representation was from the School of Business (N=10 of 181 or 5.5%). No students from the School of Education were enrolled in Pre-calculus.

The results indicate that the College of Nursing and Allied Health Sciences had the highest percentage of *students who took the final examination* and earned a total score of 60% or higher (N=10 of 14 or 71.4%). The results for the College of Arts and Sciences, which had a much larger representation in Pre-calculus, were N=62 of 102 or 60.9%. In addition, only one half, (N=12 or 23 or 52.2%) of the students from the College of Engineering, Architecture and Computer Sciences who took the final examination earned a total score of 60% or higher.

Table 16 also presents the percentage of *original enrollees* in Pre-calculus who earned a score of 60% or higher on the departmental final examination. Across all schools and colleges, the percentages ranged from 41% to 60%. At the institutional level, the percentage of original enrollees who earned a score of 60% or higher was 50%. This does not mean that only 50% of the original enrollees earned a passing grade (grade D or better) in Pre-calculus. Rather, these

results indicate that about two-fifths of the students were able to demonstrate the minimum level of competency on their Pre-calculus final examination.

Student Classification	Number of Cases	Withdrew or No Score	Valid Cases	Item # & (QR Comp)	No. of Valid Cases Scoring 60% or Higher	Percent of Valid Cases Scoring 60% or Higher	Percent of Original Enrollees Scoring 60% or Higher
College of	75	9	66	4, 8, 9, & 12 (2)	45	68.1%	60.0%
Arts & Sciences	50	14	36	5, 7, 10 &14 (3)	18	50.0%	36.0%
	125	23	102	Total Exam	62	60.9%	49.6%
College	9	1	8	4, 8, 9, & 12	5	62.5%	55.6%
Architecture & Computer Science	20	5	15	5, 7, 10 &14	9	60.0%	45.0%
	29	6	23	Total Exam	12	52.2%	41.3%
College of	7	0	7	4, 8, 9, & 12	3	42.3%	42.8%
Nursing and Allied Health	10	3	7	5, 7, 10 &14	4	57.1%	40.0%
Sciences	17	3	14	Total Exam	10	71.4%	58.8%
	4	0	4	4, 8, 9, & 12	2	50.0%	50.0%
School of Business	6	0	6	5, 7, 10 &14	3	50.0%	50.0%
Dubinebb	10	0	10	Total Exam	6	60.0%	60.0%
	95	10	85	4, 8, 9, & 12	55	64.7%	57.9%
Institutional Results	86	22	64	5, 7, 10 &14	34	53.1%	39.5%
Repuid	181	32	149	Total Exam	90	60.4%	49.7%

Table 16. Quantitative Reasoning for Spring Semester 2012 by School and College Pre-calculus Final Examination

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture and Computer Sciences, Education, Allied Health Sciences, School of Business, and School of Communications. (2) *Number of Cases* indicates the number of students on the official class roster. (3) *Withdrew or No Score* includes situations in which students withdrew from the class, did not take the final (including prospective graduating students), or did not answer the particular item. (4) *Valid Cases* indicate the number of cases included in the analysis for which there is a question or exam score.

Results by Student Classification: Pre-calculus

Table 17 presents the results of student performance on the Pre-calculus final examination for all classifications of students. Of the 181 students enrolled in the course, freshmen had the largest representation (N=100 of 181 or 55.2%) and juniors had the smallest representation (N=20 of 181 or 11%). The results also indicate that freshmen had the highest percentage of *students who took the final examination* and earned a total score of 60% or higher (N=62 of 91 or

68.1%). Juniors had the lowest percentage of students *who took the final examination* and earned a total score of 60% or higher (N=4 of 12 or 33.3%).

Student Classification	Number of Cases	Withdrew or No Score	Valid Cases	Item #	No. of Valid Cases Scoring 60% or Higher	Percent of Valid Cases Scoring 60% or Higher	Percent of Original Enrollees Scoring 60% or Higher
	61	3	58	4, 8, 9, & 12	40	68.9%	65.6%
Freshman	39	6	33	5, 7, 10 &14	19	57.6%	48.7%
	100	9	91	Total Exam	62	68.1%	62.0%
Sophomore	23	3	20	4, 8, 9, & 12	14	70.0%	60.7%
	16	8	8	5, 7, 10 &14	3	37.5%	18.8%
	39	11	28	Total Exam	15	53.6%	71.8%
	7	3	4	4, 8, 9, & 12	0	0.0%	0.0%
Junior	13	5	8	5, 7, 10 &14	3	37.5%	61.5%
	20	10	12	Total Exam	4	33.3%	20.0%
	4	1	3	4, 8, 9, & 12	1	33.3%	25.0%
Senior	18	3	15	5, 7, 10 &14	9	60.0%	50.0%
	22	4	18	Total Exam	9	50.0%	40.9%
T T	95	10	85	4, 8, 9, & 12	55	64.7%	57.9%
Institutional Results	86	22	64	5, 7, 10 &14	34	53.1%	39.5%
Results	181	32	149	Total Exam	90	60.4%	49.7%

Table 17. Quantitative Reasoning for Spring Semester 2012 by Student Classification Pre-calculus Final Examination

Note: (1) *Institutional Results* include Arts & Sciences, Engineering, Architecture & Computer Sciences, and Nursing and Allied Health Sciences. (2) *Number of Cases* indicates the number of "original enrollees" on the official class roster. (3) *Withdrew or No Score* includes situations in which students withdrew from the class, did not take the final (including perspective graduating students), or did not answer the particular item. (4) *Valid Cases* indicate the number of cases included in the analysis for which there is a question or exam score.

The results also indicate that retention rates for Pre-calculus by student classification: freshmen (N=91 of 100 or 91%), sophomores (N=28 of 39 or 71.8%), juniors (N=12 of 20 or 60%), and seniors (N=18 of 22 or 81.8%) (See "valid cases").

Figure 5 presents the percentage of *original enrollees* in Pre-calculus who earned a score of 60% or higher on the departmental final examination by student classification -- the percentages ranged from 34.8% for seniors to 56.3% for juniors.



Figure 5

Descriptive Statistics by Student Classification: Pre-calculus

Table 18 provides descriptive statistics for the 149 valid cases who took the department final examination in Pre-calculus in Spring Semester 2012. Valid cases are those students for whom a final examination score is reported. Raw scores on the final examination could range from 0 to 200. Table 18 shows the percentage scores, which ranges from 10.5% to 96.5%. Table 18 presents the descriptive statistics for student performance by classification in percentage score units. The highest mean score occurred among freshmen, M=65.8%; the lowest mean score occurred among juniors, M=47.9%; and the highest variability occurred among seniors, SD=27.9%.

Classification	Valid N	Minimum	Maximum	Mean	Std. Dev.
Freshman	91	10.5%	96.5%	65.8%	20.2%
Sophomore	28	23%	91%	52.2%	18.0%
Junior	12	17.5%	85%	47.9%	21.5%
Senior	18	18%	91.5%	62.5%	27.9%
Institutional Results	149	10.5%	96.5%	62.2%	21.5%

Table 18. Descriptive Statistics for Pre-calculus by Student Classification (Percentages)Spring Semester 2012

Figure 6 presents the mean scores on the Pre-calculus final examination by student classification for valid cases only. The graph shows that sophomores and juniors failed to meet the minimum mean criterion score of 60%. Freshmen and seniors met the minimum mean criterion performance of at least 60%. Specifically, the mean scores for freshmen and seniors on the Pre-calculus final examination were 65.8% and 62.5%, respectively.



Figure 6

Inferential Statistics by Student Classification: Pre-calculus

F-Test and Post Hoc Analyses: An Analysis of Variance (ANOVA) was performance on the four mean scores by student classification. The results of the *F*-test in Table 19 show that there is a statistically significant difference in the mean scores for freshmen, sophomores, juniors and seniors on the departmental final examination for Pre-calculus, F(3, 145)=3.29, p=0.02.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4351.674	3	1450.558	3.286	.023
Within Groups	64002.669	145	441.398		
Total	68354.343	148			

Table 19. ANOVA for Final Exam Scores by Student Classification in Pre-calculus

The Post Hoc analysis and results in Table 20 shows that there are no statistically significant pair-wise differences between mean performances by student classification. ANOVA result shows that there is only a two percent chance (i.e., statistically significant) that all mean scores for freshmen, sophomores, juniors and seniors are equal. However, the chance for each pair of mean scores to be equal is higher than 5%, i.e., statistically not significant.

		Mean	Std.	-	95% Confidence Interval	
(1) Classification	(J) Classification	Difference (I-J)	Error	Sig.	Lower Bound	Upper Bound
	Sophomore	8.63	4.01	.20	-2.37	19.62
Freshman	Junior	17.90	6.58	.10	-2.28	38.08
	Senior	4.37	6.91	.99	-15.73	24.47
Sophomore	Freshman	-8.63	4.01	.20	-19.62	2.37
	Junior	9.27	7.09	.75	-11.69	30.23
	Senior	-4.26	7.41	.99	-25.34	16.82
	Freshman	-17.90	6.58	.10	-38.08	2.28
Junior	Sophomore	-9.27	7.09	.75	-30.23	11.69
	Senior	-13.53	9.06	.61	-39.21	12.15
Senior	Freshman	-4.37	6.91	.99	-24.47	15.73
	Sophomore	4.26	7.41	.99	-16.82	25.34
	Junior	13.53	9.06	.61	-12.15	39.21

Table 20. Post Hoc Multiple Comparisons for Final Exam Scoresby Student Classification in Pre-calculus

Note: Tamhane's T2 Post Hoc test is used, and equal variances are not assumed.

The Economics of Student Drop-Out in Mathematics Courses

During the 2009-10 year, the Office of Institutional Assessment and Evaluation began to estimate the cost of student drop-out in mathematics courses in terms of dollars and cents and in extended time-to-degree. In the 2010-11 report we noted, "There are costs to students and to the institution when students drop out of courses, fail to meet certain competencies or earn failing grades... oftentimes students have to re-enroll in a course and pay for it again...the cost to the institution is in additional salaries for professors and perhaps lower four-year graduation rates."

For Spring Semester 2011, (if these students had to re-enroll in these courses) we estimated that the potential cost in AY2010-11 dollars would be \$654,381 for College Algebra I, \$290,836 College Algebra II, \$92,684 for Pre-calculus, and \$1,037,901 for a total cost to students.

The Spring Semester 2012 estimated costs (for students whose grades were reported to OIAE and data were submitted in time and followed report requirement), in terms of tuition dollars for freshmen, sophomores, and juniors who either officially withdrew from a mathematics course or did not have a final examination score reported for them, are presented in Table 21. The table presents the cost for retaking the courses.

Course	No. of Students who Withdrew or did not have a final exam score	Number of Credit Hours per Course	Cost per Credit Hour*	Total Cost
College Algebra I				
Freshmen	57	3	\$799	\$136,629
Sophomores	29	3		69,513
Juniors	15	3		35,955
Sub-Total for CAI	101			\$242,097
College Algebra II				
Freshmen	13	4	\$799	\$41,548
Sophomores	19	4		60,724
Juniors	9	4		28,764
Sub-Total for CAII	41			\$131,036
Pre-calculus				
Freshmen	9	4	\$799	\$28,764
Sophomores	11	4		35,156
Juniors	10	4		31,960
Sub-Total for Pre-cal	30			\$95,880
TOTAL COST				\$469,013

Table 21. Cost for Retaking College Algebra I, College Algebra II, and Pre-calculus

*Undergraduate part-time rate per credit hour for AY2012-13.

Summary

The improvement of students' competencies in *quantitative reasoning*, as defined by performance in College Algebra I, College Algebra II and Pre-calculus, must begin with strategies to reduce the attrition rates in these courses. Students who officially withdrew from the courses, stop attending without officially withdrawing, or failed the courses (earn a grade of F) will have to re-take the courses in order to fulfill degree requirements and graduate. The estimated costs to the university in real dollars and cents for students to re-take these courses are cumulative and prohibitive. The costs are cumulative because each year the university must provide instructional resources for new entrants as well as for those returning students who must retake the courses. The costs are prohibitive because (1) they are high and could lead to increased student debt and time-to-degree, and (2) each year the university invests generously in professional developmental/remediation programs that are designed to prepare underprepared students for college level mathematics and reduce the rates of recidivism in the general education mathematics courses. Hence, while the awarding degrees is important, institutions are increasingly placing an equally important premium on student learning outcomes; that is, what students know and are able to do when they graduate. In fact, institutional effectiveness is being defined, in part, by the extent to which institutions are able to provide credible evidence that students are achieving the learning goals that institutions have set for themselves.

Disaggregating student performance data by school/college, student classification and gender allows university personnel to develop specific strategies for targeted student groups. Doing so demonstrates that a 'one size fits all' may not be an effective approach for improving student learning outcomes or achieving institutional goals. The data clearly show that too many freshmen are failing to persist and succeed in their mathematics courses.

Analyzing student performance data by competency also reveals areas of strength or weakness in the university's instructional programs. The analyses of student performance data for College Algebra I, College Algebra II and Pre-calculus suggest that students met the minimum competency in areas which measured procedural knowledge, such as solving problems; however, students failed to meet minimum competency in areas which measured higher order and critical thinking skills, such as interpreting mathematical models, drawing inferences, determining reasonableness of a solution, or selecting optimal results.

Faculty, academic advisors, peer counselors, student affairs personnel, university administrators, and most importantly, students themselves must work collaboratively to do what is necessary to improve students' competencies in *quantitative reasoning* (See Conclusions and Recommendations in the "Executive Summary).

Appendix A. College Algebra I





HOWARD UNIVERSITY Department of Mathematics College Algebra 1 - Math 006 Final Examination Tuesday, May 1, 2012

The Examination consists of two pages with a total of 200pts. Answer all questions. Show your work. No calculators allowed.

- 1. (15pts)
 - (a) Compute ||-3|-|2|
 - (b) Eliminate negative exponents, and simplify $\frac{a^3b^{-2}}{(b^3a)^{-3}}$
 - (c) Simplify 8^{2/3}9^{3/2}
- 2. (20pts) Factor completely
 - (a) $6x^2 + 5x 6$
 - (b) $8x^2 16x 24$
- 3. (20pts) Let $f(x) = (x 1)^2 4$.
 - (a) Determine whether the graph of f opens up or down.
 - (b) Give the vertex.
 - (c) Find the x- and y-intercepts.
 - (d) Determine where the function f is increasing and where it is decreasing.
 - (e) Graph the function f.
- 4. (20pts) Find the slope-intercept form of the equation of the line having the given characteristics.
 - (a) Slope = 4; passing through (-4, -4).
 - (b) Parallel to the line 3x + 3y 2 = 0; passing through (-5, -7).
 - (c) Perpendicular to the line 3x 2y + 4 = 0; passing through (2, -4).
 - (d) x intercept (3, 0) and y intercept (0, 5).
- 5. (20pts) Consider the line with equation 5x 3y = 15.
 - (a) Graph the line and label the x-intercept and y-intercept.
 - (b) Find the slope of the line.
 - (c) Is the point (60, 95) on this line? Justify your answer.
 - (d) Is this line perpendicular to the line passing through the points (2, -7) and (7, -11)? Justify your answer.
 - 1

2

- 6. (10pts)
 - (a) Find the equation to the circle with center (3, -2) and which passes through (3, 0). Graph the circle.
 - (b) Find the center and radius of the circle $x^2 + y^2 + 4x 6y + 12 = 0$. Graph the circle.
- 7. (5pts) Add the fractions and simplify. Leave your answer in factored form

$$\frac{2x}{x^2 - 1} + \frac{3}{x^2 - 2x + 1}$$

8. (10pts) Find all real solutions, if any, of each equation.

(a)
$$2x^3 = 54$$

- (b) $6x^2 5x 6 = 0$
- 9. (10pts) Find all real solutions, if any, to: $x + 1 = \sqrt{x + 3}$.
- 10. (10pts) Solve each inequality, and give the solution in interval notation. Also graph the solution set.
 - (a) $-3 < 2x + 1 \le 4$ (b) $|2x - 3| \le 4$
- 11. (10pts) A function f is defined by $f(x) = x^2 2x$. Find and simplify (a) f(-x)
 - (b) f(a)

 - (c) f(a+h)(d) f(a+h) f(a)(0

(d)
$$\frac{1}{h}$$

12. (10pts) Find the domain of each function. Give your answer in interval notation. (a) $f(x) = \sqrt{x+3}$ a.

(b)
$$f(x) = \frac{x}{x^2 + x - 6}$$

- 13. (5pts) Find the average rate of change between x = 1 and x = 4 for the function $f(x) = 3x^2 + 2.$
- 14. (15pts) When a certain medical drug is administered to a patient, the number of milligrams remaining in the patient's bloodstream after t hours is modeled by

$$D(t) = 50e^{-0.02t}$$

How many milligrams of the drug remain in the patient's bloodstream after 3 hours? Leave your answer in the form Ae^b .

15. (20pts) Find the functions
$$f \circ g$$
, $g \circ f$, if $f(x) = \sqrt{x}$ and $g(x) = \frac{2}{x-4}$.

Appendix B. College Algebra II





Howard University Math Department College Algebra II Final Exam

Spring 2012

Instructions: PLEASE PROVIDE STEP BY STEP EXPLANATIONS Time Limit 2 hours Please read the questions carefully before answering Each problem 20 points. Total 200 points.

ANSWER ANY 10

- 1. Find all rational zeros of the polynomial $P(x) = x^3 + 9x^2 108$.
- 2. Use the laws of logarithms to expand the following expressions and express all products as sums , quotients as differences and all powers as factors:
 - (a) $log_5(5x)$

5/1

- (b) $log_5[(x+1)(x+3)]$
- (c) $log_5\left[\frac{5}{x^2}\right]$
- (d) $log_5\left[\frac{x(x+1)^3}{x^2}\right]$
- 3. The time required to double the amount of an investment at the interest rate r compounded continuously is given by $t = \frac{ln2}{r}$ where t is measured in years.
 - (a) Write the exponential equation that gives A(t), the amount after t years.
 - (b) Find the time required to double an investment at 6 percent interest.
- 4. The perimeter of a rectangle is 72 inches. The length is 3.5 times as large as the width. Find the dimensions.
- 5. Solve the system using matrices with row operations (no credit for other methods). If there is more than one solution, list three of them. If the system has no solution, say that it is inconsistent.

$$x - 2y + 3z = 4$$
$$x - y + 2z = 7$$
$$y - z = 3$$

6. Find the Inverse of the following matrix :

$$\begin{bmatrix} 1 & -1 & -2 \\ -2 & 3 & 5 \\ 5 & -4 & -7 \end{bmatrix}$$

1

- 7. Use Cramers rule to solve the following system of equations: 4x 5y = 3, 3x 2y = 1.
- 8. Find the equation of the parabola whose focus is at the point (0,1) and whose directrix is the line y = 5.
- Find an equation for the hyperbola that satisfies the given conditions: Foci:(±5;0), vertices:(±3;0).
- 10. Graph the region which satisfies the following inequalities. Be sure to identify the coordinates of each vertex.

$$x \ge 0$$
$$y \ge 0$$
$$2x + y \le 10$$
$$-2x + y \le 2$$
$$4x + 7y \le 28$$

- 11. This problem concerns the sequence $3, 7, 11, 15, \dots$
 - (a) Find the common difference for the sequence.
 - (b) Find the fifth term of this sequence, i.e, a_5 .
 - (c) Find a formula for a_n in terms of n.
 - (d) Find the 100th term of this sequence, i.e, a_{100} .
- 12. Write the first two terms and the term containing x^8 in the expansion of $(x+y)^{20}$.
- 13. Find the final amount in an annuity in which \$ 200 is deposited monthly for 10 years, interest is compounded monthly and the annual interest rate is 12 percent.
- 14. There are four defective bulbs in a box of 50. If two bulbs are picked at random, what is the probability that both are defective?

Appendix C. Pre-calculus



PreCalculus (Math 007) Spring 2012 — Final Exam Howard University Department of Mathematics May 1, 2012

Name: .

This exam consists of 14 questions. Show all your work. No work, no credit. Good Luck!

20points 1. For the rational function

$$R(x) = \frac{2x - 4}{x^2 + x - 2}$$

- (a) find the domain and intercepts of the graph of R(x).
- (b) find the vertical asymptote(s) of the graph of R(x) if any.
- (c) find the horizontal asymptote(s) of the graph of R(x) if any.
- (d) sketch the graph of R(x) indicating clearly the intercepts and asymptotes.
- (e) find the range.

10points 2. Find the exact values of the following. You must show your work to get credit.

- (a) $\log_3 45 \log_3 5$ (b) $\ln \frac{1}{e}$
- 10points 3. Solve $e^{2x} e^x 12 = 0$.

10points 4. Express
$$\ln x - 2\ln(x^2 + 1) - \frac{1}{2}\ln(x + 1)^2$$
 as a single logarithm.

- 20points 5. Solve the following logarithmic equations:
 - (a) $\ln(x-2) = 2$.
 - (b) $\log_2 x + \log_2(x+2) = 3$.
- 10points 6. Find the values of the remaining five trigonometric functions of θ if sec $\theta = 3$ and θ is in Quadrant IV.
- 20points 7. Without using a calculator find the **exact values** of the following expressions. You must show your work to get credit.
 - (a) $\sin 75^{\circ}$ (b) $\cos^{-1}\left(-\frac{\sqrt{3}}{2}\right)$ (c) $\sin^{-1}(\sin\frac{2\pi}{3})$. (d) $\cos(\sin^{-1}\frac{3}{5})$.

10points 8. Given the trigonometric function

$$y = 3\cos\left[2\left(x - \frac{\pi}{4}\right)\right]$$

- (a) Find the *amplitude*, *period* and *phase shift* of the graph of the trigonometric function, if any.
- (b) Graph the function, showing at least two periods.

20points 9. Verify the following trigonometric identities:

(a)
$$\frac{1+\tan^2\theta}{\csc^2\theta} = \tan^2\theta$$

(b) $(\cot x - \csc x)(\cos x + 1) = \sin x$

20points 10. Solve the trigonometric equation $4\cos^2 \theta - 4\cos \theta + 1 = 0$ and list six specific solutions.

20points 11. For the following system of equations:

$$\begin{cases} x - y + 3z = 4\\ x + 2y - 2z = 10\\ 3x - y + 5z = 14 \end{cases}$$

- (a) Write the augmented matrix of the system.
- (b) Use row operations (Gaussian Elimination) and solve the system.
- 10 points 12. Graph the feasible region and maximize the objective function P(x, y) = 12x+6y subject to the constraints:

$$\begin{cases} x \ge 0, \\ y \ge 0, \\ 2x + y \le 8, \\ 2x + 3y \le 12 \end{cases}$$

10points 13. Solve for all possible triangles that satisfy a = 10, b = 16 and $m \angle A = 30^{\circ}$. Refer to the following figure.



- 10 points 14. The population of a certain country was given by the exponential model $N(t) = 260e^{0.007t}$ where N(t) is in millions and t is the number of years after 2000.
 - (a) What was the population of the country in the year 2000?
 - (b) In which year did the population reach 270 million?
 - (c) What will be the size of the population in the year 2012?