Assessment Report
For
Department of Mathematics & Statistics

(2013-14 Academic Year) (December 19, 2013)

(Assessment Period Covered) (Date Submitted)

Includes Assessment Reports for the Instructional Programs listed below:

<table>
<thead>
<tr>
<th>Title of Degree Program</th>
<th>Degree Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor of Science in Mathematics</td>
<td>Bachelor</td>
</tr>
</tbody>
</table>

Submitted By: Narendra Kumar Govil, Associate Chair
(Department or Unit Representative)
Assessment Report
For

Bachelor of Science in Mathematics
(Instructional Degree Program)

Academic Year 2013-14
(Assessment Period Covered)

Bachelor
(Degree Level)

December 19, 2013
(Date Submitted)

NOTE: There should be one form B for each degree program offered by your department.

Expected Outcomes of this Degree Program:
*When they complete this degree program, students will be able to . . .*

1. Mathematical Analysis

   When the students complete this degree program, they will be able to demonstrate to have acquired the understanding of the concepts in Mathematical Analysis, in topics including, Properties of Real Number System, Topology of Cartesian Spaces, and Convergence of Sequences. Besides, students will also learn to develop Elementary Proof Techniques.

2. Abstract Algebra

   When the students complete this degree program, they will be able to demonstrate to have acquired the understanding of the concepts in Abstract Algebra, in topics including, Basic Group Theory, Properties of Groups, Homomorphisms, and Isomorphisms of Abelian Groups.

3. <Brief description>
   <Full description>

4. <Brief description>
   <Full description>

5. <Brief description>
   <Full description>

6. <Brief description>
   <Full description>

*If you wish to record additional expected outcomes, simply cut and paste one of the boxes above.*
Assessment Report
For

Bachelor of Science in Mathematics
(Instructional Degree Program)

Bachelor
(Degree Level)

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NOTE: There should be at least one form C for each expected outcome listed on form B. If you used more than one assessment method to gather information about an expected outcome, there should be one form C for each assessment method. Thus, if you studied three outcomes during the year and used two means of assessment to gather information about each outcome, you would provide a total of six different copies of form C.

Expected Outcome Brief Description:
Students will demonstrate an understanding of concepts in Mathematical Analysis, in topics including, Properties of Real Number System, Topology of Cartesian Spaces, and Convergence of Sequences. Besides, students will also learn to develop Elementary Proof Techniques.

Assessment Method, Brief Description:
Common Examination on Items

Assessment Method, Full Description:
The Chair of the department Dr. T.Y. Tam set up an Assessment Committee of the department for the purpose of assessing the programs, comprising of the faculty N.K. Govil (Chair), Ziqin Feng (Co-chair), Dmitry Glotov (Member), Erkan Nane (Member) and Jessica McDonald (Member). This committee then identified some concepts in Mathematical Analysis that the committee thought every undergraduate student majoring in Mathematics must know before graduation. Also, this committee helped in making a test having minimum of two questions on each of these concepts, which was then used to find learning outcomes to test the understanding of different concepts in Mathematical Analysis, that have been identified by the committee.

The students were given this test at the end of the Fall Semester 2013 in the course on “Analysis” and the data concerning the performance in these tests was collected and analyzed. The total number of students who took this test for learning outcome “Understanding of Concepts in Mathematical Analysis” was 10, and every undergraduate student majoring in Mathematics is required to take this test at some stage because the course where these concepts are covered is a required course for graduation. A copy of the Test is appended at the end of this form, as Appendix 1.

The data, along with its analysis, concerning the performance in this test is given in the next section, which is on “Assessment Method, Findings”.

Form C
Assessment Method, Findings:

In the table given below, the data (and its analysis) is obtained on the basis of test given to students. Test items, 1 and 2, are on the concept, Real Number System; test items, 3 and 4, are on the concept, Topology of Cartesian spaces, and so on. The average proportion of students answering test items 1 and 2 correctly is 60%. See the Appendix 2 for more detailed findings of the assessment.

<table>
<thead>
<tr>
<th>Topics</th>
<th>Test Items Addressing This Learning Goal</th>
<th>Average Proportion of Students Answering These Questions Correctly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Number System</td>
<td>1 and 2</td>
<td>60%</td>
</tr>
<tr>
<td>Topology of Cartesian Spaces</td>
<td>3 and 4</td>
<td>60%</td>
</tr>
<tr>
<td>Convergence of Sequences</td>
<td>5, 6, and 7</td>
<td>53%</td>
</tr>
<tr>
<td>Elementary Proof Techniques</td>
<td>8, 9 and 10</td>
<td>35%</td>
</tr>
</tbody>
</table>

Based on the table given above we find that the students appear to be strong in “Topology of Cartesian Spaces” and “Real Number System”, not so strong in “Convergence Spaces”, while weak in “Elementary Proof Techniques”.

Assessment Method, Use of Findings for Improvement:

The findings obtained and mentioned in the above section on “Assessment Method, Findings” were discussed with the members of the committee and agreed upon that the instructors teaching these concepts in future will be told of these finding and advised to take measures for correcting this by

(i) Spending more time on the topics, “Elementary Proof Techniques” and “Convergence of Sequences” where students appear to be not so strong or are weak.

(ii) Provide longer office hours, and encourage students to seek help during the office hours.

Also, the committee will place a request to the department chair to provide some Graduate Teaching Assistants who could provide extra help to students in “Convergence of Sequences” and “Elementary Proof Techniques”, where the students are not so strong or weak.

Any Additional Comments?

Appendix 1. Test used for the Assessment:

Appended below is the copy of the test prepared with the help of the Department Assessment Committee, and used for the purpose of assessment.

Please explain your answer for the true or false questions. If the statement is ‘true’, explain the reason; if the statement is ‘false’, give a counterexample.
I. Real Number System
1. State the Archimedean Property.
2. (True or False) Every non-empty set of rational numbers which has an upper bound has a supremum which is also a rational number.

II. Topology of Cartesian Spaces
3. (True or False) If a subset of the Cartesian Space is not open, then the subset is closed.
4. State the Heine-Borel Theorem.

III. Convergence of Sequences
5. (True or False) If a sequence is bounded, then it is convergent.
7. (True or False) If \(|x_n|\) is a convergent sequence in the set of real numbers, then \((x_n)\) is also convergent.

IV. Elementary Proof Techniques
8. By using the definition of convergence, prove that \(\lim_{n \to \infty} \frac{1}{n} = 0\).
9. Prove that every convergent sequence is bounded.
10. Prove that the sequence \((-1)^n\) is divergent.

Appendix 2. Table with Detailed Data:
Given below is the table consisting of the data (and its analysis) collected on the basis of scores obtained by the students in the test. In this table, s1, s2, s3,…refer to Student # 1, Student # 2, Student # 3, and so on. For example Student #1 obtained a score of 1 on Question # 1, score of 0.5 on Question # 2, a score of 1 on Question # 3, and so on, and thus obtaining average of 65% in all the questions. Similarly looking at the first two rows (shaded in purple) of the table we find that all the students obtained an average of 60% on the concept of “Real Number System” (covered by Questions 1 and 2), an average of 60% on the concepts of “Topology of Cartesian Spaces” (covered by Questions 3 and 4, and shaded in yellow), an average of 53% on the concepts of “Convergence of Sequences” (covered by Questions 5, 6, and 7, and shaded in green), and 35% on the concepts of “Elementary Proof Techniques” (covered by Questions 8, 9, and 10, and shaded in red). This data has been summarized in the Table given above in the Section on “Assessment Method, Findings”.

<table>
<thead>
<tr>
<th>Questions</th>
<th>s1</th>
<th>s2</th>
<th>s3</th>
<th>s4</th>
<th>s5</th>
<th>s6</th>
<th>s7</th>
<th>s8</th>
<th>s9</th>
<th>s10</th>
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<td>1</td>
<td>1</td>
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</tr>
</tbody>
</table>

| Real Number System | 60% |
| Topology of Cartesian Spaces | 60% |
| Convergence of Sequences | 53% |
| Elementary Proof Techniques | 35% |
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Students will demonstrate an understanding of concepts in Abstract Algebra, in topics including, Basic Group Theory, Properties of Groups, Homomorphisms, and Isomorphisms of Abelian Groups.

Assessment Method, Brief Description:
Common Examination on Items

Assessment Method, Full Description:
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The students were given this test towards the end of Fall Semester 2013 in the course on “Abstract Algebra” and the data concerning the performance in these tests was collected and analyzed. The total number of students who took this test for learning outcome “Understanding of Concepts in Abstract Algebra” was 9, and every undergraduate student majoring in Mathematics is required to take this test at some stage because the course where these concepts are covered is a required course for graduation. A copy of the Test is appended at the end of this form, as Appendix 1.

The data, along with its analysis, concerning the performance in this test is given in the next section, which is on “Assessment Method, Findings”. Form C
Assessment Method, Findings:

In the table given below, the data (and its analysis) is obtained on the basis of test given to students. Test items, 1 and 2, are on the concept, Basic Group Theory; test items, 3, 4, 5 and 6, are on the concept, Properties of Groups, and so on. The average proportion of students answering test items 1 and 2 correctly is 61%. See the Appendix 2 for more detailed findings of the assessment.

<table>
<thead>
<tr>
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<th>Test Items Addressing This Learning Goal</th>
<th>Average Proportion of Students Answering These Questions Correctly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Group Theory</td>
<td>1 and 2</td>
<td>61%</td>
</tr>
<tr>
<td>Properties of Groups</td>
<td>3, 4, 5 and 6</td>
<td>86%</td>
</tr>
<tr>
<td>Homomorphisms</td>
<td>7 and 8</td>
<td>61%</td>
</tr>
<tr>
<td>Isomorphisms of Abelian Groups</td>
<td>9 and 10</td>
<td>72%</td>
</tr>
</tbody>
</table>

Based on the table given above we find that the students appear to be strong in “Properties of Groups” and “Isomorphisms of Abelian Groups”, while not so strong in “Homomorphisms”, and “Basic Group Theory”.

Assessment Method, Use of Findings for Improvement:

The findings obtained and mentioned in the above section on “Assessment Method, Findings” were discussed with the members of the committee and agreed upon that the instructors teaching these concepts in future will be told of these finding and advised to take measures for correcting this by

(i) Spending more time on the topics, “Basic Group Theory” and “Homomorphisms” where students appear to be not so strong.

(ii) Provide longer office hours, and encourage students to seek help during the office hours.

Also, the committee will place a request to the department chair to provide some Graduate Teaching Assistants who could provide extra help to students in “Homomorphisms” and “Basic Group Theory”, where the students are not so strong.

Any Additional Comments?

Appendix 1. Test used for the Assessment:

Appended below is the copy of the test prepared with the help of the Department Assessment Committee, and used for the purpose of assessment.

I. Basic Group Theory

1. Every binary operation is associative. Form C True False
2. A non-empty subset of a group $G$ is a subgroup if it is closed with respect to the binary operation on $G$. True False

II. Properties of Groups

3. All cyclic groups are Abelian. True False
4. Every group with more than one element has at least two normal subgroups. True False
5. Every subgroup of $G$ is normal if $G$ is Abelian. True False
6. There are no simple Abelian groups. True False

III. Homomorphisms

7. Two groups are isomorphic if they have the same order. True False
8. Every normal subgroup is the kernel of a homomorphism between groups. True False

IV. Isomorphisms of Abelian Groups

9. The real numbers under addition are isomorphic to the non-zero real numbers under multiplication. True False
10. Two cyclic groups are isomorphic if they have the same order. True False

Appendix 2. Table with Detailed Data:

Given below is the table consisting of the data (and its analysis) collected on the basis of scores obtained by the students in the test. In this table, $s_1$, $s_2$, $s_3$, …refer to Student # 1, Student # 2, Student # 3, and so on. For example Student #1 obtained a score of 0 on Question # 1, score of 0 on Question # 2, a score of 0 on Question # 3, a score of 1 on Question # 4, and so on, and thus obtaining average of 50% in all the questions. Similarly looking at the first two rows (covered in purple) of the table we find that all the students obtained an average of 61% on the concept of “Basic Group Theory” (covered by Questions 1 and 2), an average of 86% on the concepts of “Property of Groups” (covered by Questions 3, 4, 5 and 6), an average of 61% on the concepts of “Homomorphisms” (covered by Questions 7 and 8), and 72% on the concepts of “Isomorphisms of Abelian Groups” (covered by Questions 9 and 10). This data has been summarized in the Table given above in the Section on “Assessment Method, Findings”.

<table>
<thead>
<tr>
<th>Questions</th>
<th>$s_1$</th>
<th>$s_2$</th>
<th>$s_3$</th>
<th>$s_4$</th>
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Form C