Mathematics and Statistics

EXECUTIVE SUMMARY: Last year, Math 113, 114, and 115 (Calculus I, II, Accelerated Calculus) were eliminated and replaced by a single course Math 118 (Calculus: Dynamics and Integration), though Math 105 (Applied Modeling with Calculus) absorbs some students who previously took Math 113. In fall 2015, Math 215 (Linear Algebra) will be taught in two flavors: one similar to past version in its focus on proofs (taught by Tecosky-Feldman) and one more applied (taught by Butler).

PLACEMENT TEST: The placement test in math and stats was mandatory for all entering students. Your advisees should have taken it – if they did not, please tell them to take the test online (there is a link on the department web page) and send an email to Rob Manning informing him that they have done so. The math and stats department uses the results of the test, together with SAT and Advanced Placement scores, to recommend appropriate entry courses in the calculus sequence and the statistics sequence. Even students with very high SAT and AP scores need to take the placement test, as well as students who think they may not take a mathematics course in their first semester.

POSSIBLE MATH PLACEMENT RESULTS (EXPLANATIONS BELOW):

<table>
<thead>
<tr>
<th>Course</th>
<th>Name</th>
<th>Fall/Spring</th>
<th>Instructors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 105</td>
<td>Applied Modeling with Calculus</td>
<td>Spring only</td>
<td>Tecosky-Feldman</td>
</tr>
<tr>
<td>Math 118</td>
<td>Calculus: Dynamics and Integration</td>
<td>Fall only (2)</td>
<td>Manning, French</td>
</tr>
<tr>
<td>Math 121</td>
<td>Multivariable Calculus</td>
<td>Fall(2)+Spring(2)</td>
<td>F: Lippel, French S: French, Davison</td>
</tr>
<tr>
<td>Math 215</td>
<td>Linear Algebra</td>
<td>Fall(2)+Spring(2)</td>
<td>F: Butler, Tecosky-Feldman S: Sabloff, Davison</td>
</tr>
</tbody>
</table>

Because the process is imprecise, some students are placed in “borderline” categories (e.g., 121/215). Such students should seek further advice, perhaps directly from the instructor, and be prepared to switch courses during the first few weeks if a choice seems wrong.

POSSIBLE STATISTICS PLACEMENT RESULTS (EXPLANATIONS BELOW):

<table>
<thead>
<tr>
<th>Course</th>
<th>Name</th>
<th>Fall/Spring</th>
<th>Instructors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 103</td>
<td>Introduction to Probability and Statistics</td>
<td>Fall+Spring</td>
<td>F: Miao S: Feinberg</td>
</tr>
<tr>
<td>Math 203</td>
<td>Statistical Methods and their Applications</td>
<td>Fall+Spring</td>
<td>F: Miao S: Butler</td>
</tr>
<tr>
<td>Math 286</td>
<td>Applied Multivariate Statistical Analysis</td>
<td>Not offered in 15-16; should be in 16-17</td>
<td></td>
</tr>
</tbody>
</table>

ADVICE FOR STUDENTS CONSIDERING A MAJOR OR MINOR IN MATH OR STATISTICS:

- Because of the sequential nature of math courses and prerequisites, it is strongly recommended that students considering a major start at the appropriate placement level during their first year.
• Math majors are strongly recommended to have taken Math 215 (Linear Algebra) and either Math 121 (Multivariable Calculus) or Math 216 (Advanced Calculus) by the end of their sophomore years.
• Math students interested in statistics should not take Math 103. They should take Math 203 instead, and it is best to have done this sometime during their first two years. Math 218 (Probability) is also strongly recommended, at some point during their first two years.

EXPLANATIONS OF EACH PLACEMENT CATEGORY (INCLUDING CORRESPONDING STATISTICS ADVICE):

Math 105 (Applied Modeling w/Calculus)

Math 105 assumes no previous background in calculus, so it’s somewhat like a typical “Calculus I” course, but with some different emphases: it has a major focus on “mathematical modeling” (how to take a real-world problem and explore it mathematically) and covers a few ideas from later calculus courses (a little multivariable calculus and differential equations). Thus, for students who will only take one calculus course, Math 105 provides a good window into how calculus can be used, including in real-world applications involving many variables.

Math 105 is offered in the spring only, since most students taking it can afford to wait (since they are not considering majors that need much math). If your advisee places at this level and has a strong desire to take calculus right away, they could consider BMC Math 101, a more traditional Calculus I course. In this situation, it pays to have a careful conversation with your advisee about their motivation, to see if there really is a strong reason to take Calculus I right away, or if it they could arrange to wait for Math 105 in the spring and thus separate calculus from other traditional “gateway” courses often taken in the first semester of college.

Statistics advice for this category: For most students who place into Math 105, the appropriate intro stats course is Math/Stat 103 (or the equivalent BMC Math 104), either in addition to Math 105, or instead of it if the student is not motivated to take calculus. Another possibility is to take intro statistics courses in economics, sociology, or psychology, if majoring in one of those areas. [Note that some students placing into Math 105 place into Math/Stat 203 based on previous experience.]

Math 105 (Applied Modeling w/Calculus) or 118 (Calculus: Dynamics and Integration)

For students in this category, their placement test provided a mixed message about whether they are ready for Math 118 (e.g., some self-reporting of calculus mastery but weaker scores on our placement questions). These students will particularly benefit from a detailed conversation with their advisor. Here are some key issues to consider (see above and below for more discussion of 105 and 118).

Math 118 is a good choice for students considering majors in Chemistry, Physics, Math, Economics, Computer Science and others who plan to take more calculus. If your advisee is in this category, it makes sense to strongly consider Math 118, since it will move the student forward toward their eventual math needs. On the other hand, students placed at this level may need some review to prepare for Math 118 (e.g., the materials at ds.haverford.edu/wp/math118) and should structure their semester to allow time for this review and for the support services for Math 118 throughout the semester.

In contrast, Math 105 is a good choice for students who took some calculus but it didn’t “stick”, particularly if they envision taking only one course in calculus and are not considering the majors listed above (e.g., their main motivation is to satisfy a Q or NA requirement).
Statistics advice for this category: For most students who place at this level, the appropriate intro stats course is Math/Stat 103 (or the equivalent BMC Math 104), either in addition to a calculus course, or instead of it if the student is not motivated to take calculus. If students first take calculus through Math 118, then Math/Stat 203 is the right starting level. Another possibility is to take intro statistics courses in economics, sociology, or psychology, if majoring in one of those areas. [Note that some students placing into calculus at this level place into Math/Stat 203 based on previous experience.]

**Math 118 (Calculus: Dynamics and Integration)**

This course is designed for students who have partial mastery of calculus from a previous course, but not enough to start in Math 121. It begins with topics that will be new for most students (discrete dynamical systems and differential equations) and that appear in many applied sciences. So, the course covers most topics that appear in a typical “Calculus II” course, but in a way that also reinforces key ideas from “Calculus I” and introduces new applications of derivatives and integrals. Thus, Math 118 serves as a good option for students with some exposure to calculus from a previous course, preparing them to continue on to multivariable calculus (our Math 121) if they so choose. Students placed at this level seem to have sufficient mastery of precalculus and derivatives that they will be ready for Math 118, but they are free to avail themselves of the review materials at ds.haverford.edu/wp/math118 if they are unsure, and they should certainly plan to use the support services available for Math 118 throughout the semester, as the newness of much of the material means students can not generally coast on their past experience.

Statistics advice for this category: For most students who place at this level, the appropriate intro stats course is Math/Stat 103 (or the equivalent BMC Math 104), if they choose to take statistics before Math 118, or instead of calculus. If a student first takes Math 118, then Math/Stat 203 is the right starting level. Another possibility is to take intro statistics courses in economics, sociology, or psychology, if majoring in one of those areas. [Note that some students placing into calculus at this level place into Math/Stat 203 or even Math/Stat 286 based on previous experience.]

**Math 121 (Multivariable Calculus)**

This course is for students who have had a full year of college-level calculus and know it “reasonably well” (i.e., well enough that repeating the material would be boring or non-productive).

Statistics advice for this category: If a student wants to take statistics at any point while at Haverford and has placed at the 121 level of calculus, then the appropriate intro stats course is Math/Stat 203 (not Math/Stat 103 or BMC Math 104). [In some cases, a student with a strong high school statistics background places past Math/Stat 203 into the more advanced Math/Stat 286.]

Math 121 (Multivariable Calculus) or Math 215 (Linear Algebra)

This placement level is for students who have mastered a full-year of college-level calculus and thus can choose between two starting courses that can be taken in either order (121 and 215). For students in this category, we felt we lacked full information to advise them which would be the appropriate choice, so that a detailed conversation with the advisor would be useful.

A useful rule of thumb is that starting with Math 215 is the right choice for students who like the study of math for its own sake, including (but not restricted to) those potentially considering math as a major. Math 215 gives the best window into the style of advanced courses in our major, and taking Math 215 allows a student to build up a network of math peers to work with in future courses. In
addition, starting in Math 215 allows students to take a linear-algebra-based multivariable calculus course Math 216 (or they can opt to take the more standard Math 121 even after taking Math 215).

Students whose motivation for taking math is more as a tool for other academic pursuits might be better served by starting with Math 121 (and then potentially taking Math 215 as the next course). Math 121 extends ideas from single-variable calculus to problems with several variables, so it will “resemble” a previous calculus course, whereas Math 215 looks very different.

Statistics advice for this category: If a student wants to take statistics at any point while at Haverford and has placed at this level of calculus, then the appropriate intro stats course is Math/Stat 203 (not Math/Stat 103 or BMC Math 104). [In some cases, a student with a strong high school statistics background places past Math/Stat 203 into the more advanced Math/Stat 286.]

Math 215 (Linear Algebra)
This is a sophomore-level course that is often taken by first-year students. It covers basic linear algebra and also introduces students to formal mathematical reasoning and rigorous proofs, although in Fall 2015, we are offering two flavors, one (taught by Butler) with a more applied flavor, while the other (taught by Tecosky-Feldman) has a more traditional emphasis on proofs. Math 215a continues into Math 216b, which covers multivariable calculus at a more advanced and theoretical level than Math 121a,b. Students continuing in mathematics should take either 121a,b or 216b, but not both.

We recommend Math 215a-216b only for those first-year students with a very strong interest in mathematics, mathematical physics or mathematical economics. Placement alone is not sufficient. We suggest that all students consult with the instructor or a member of the mathematics department before signing up for the course.

For other students with high placement, particularly those who only plan to take a semester or two of mathematics, Math 121a is an excellent alternative that fits well with the needs of many departments (for example, physics or chemistry). Such students will be very well prepared to take Math 215 as their next course if they decide to continue. Despite these warnings, strong students should not be discouraged from taking 215a-216b in their first year. It is a fundamental course in mathematics, and taking it early has many advantages for students thinking about majoring or taking more advanced courses in mathematics. Any student who has gotten a 5 on the BC Advanced Placement Test should be well-qualified for Math 215a, provided that his or her interest in mathematics is also very high.

Statistics advice for this category: If a student wants to take statistics at any point while at Haverford and has placed at this level of calculus, then the appropriate intro stats course is Math/Stat 203 (not Math/Stat 103 or BMC Math 104). [In some cases, a student with a strong high school statistics background places past Math/Stat 203 into the more advanced Math/Stat 286.]

Spring courses
Students who take 118 in the fall typically take 121 in the spring if continuing in calculus, or could take Stats 203 (the occasional student who does well in 118 is permitted to take 215 in the spring). Students who take 121 in the fall typically take 215 in the spring. Students who take 215 in the fall typically choose between 121 or 216 in the spring.

Majoring in mathematics
To be prepared for the mathematics major, a student should have completed Math 215 and either Math 121 or Math 216 by the end of the sophomore year. The reason is that math majors should be taking, or have taken Math 317-318 (Analysis) and Math 333-334 (Algebra) no later than their junior year, and both Math 215 and either Math 216 or 121 are prerequisites for these sequences. Students whose advanced placement permits them to take 215-216 as first year students may take analysis or algebra (or both) as sophomores. This adds flexibility to a student’s program, but is not absolutely necessary for majoring in mathematics.

Where to get help
Be sure that your advisees know about the Math Question Center and the Calculus Resource Center. These are two of the most important resources for students having difficulty with their math courses. The MQC is held in KINSC H011 and is staffed five evenings each week, Sunday through Thursday, from 7-9pm, while the CRC is held in the Office of Academic Resources (days and times to be announced in calculus courses).

The MQC is open to a broad audience of students, from those taking 100-level classes through those taking 300-level electives. In the MQC, students can find undergraduate tutors and often members of the math faculty who can give assistance with homework or other problems from coursework in any mathematics class. The CRC is open to students taking Math 105 and Math 118, and sometimes Math 121. We have found that different students feel more comfortable in different environments, so please encourage your advisees to try both the MQC and CRC if they need help. Further, many students come to the MQC or the CRC without questions, and use them as a “study hall” to work on their math courses with others, comfortable in knowing that help is there if needed.

Finally, the Office of Academic Resources provides tutoring for students that are having trouble in math (as well as other subjects). Be sure that students have first tried the MQC and/or CRC before seeking a tutor; there are evenings when the MQC is quiet and the staff can act as informal tutors, devoting most of their time to a small number of students. The students hired to staff the MQC and CRC are often among the best math tutors on campus.

Computer science/scientific computing?
Students interested in computer science should be reminded of the major or minor in computer science, or the concentration in scientific computing. The CS department urges potential majors to take CS 105 (Introduction to Computer Science) and CS 106 (Introduction to Data Structures) as early as possible. These courses also count toward the concentration in scientific computing. Students with a serious interest in computer science should definitely not take CS 100 (The World of Computing), which does not prepare students sufficiently for CS106.

What about math courses at Bryn Mawr?
In addition to Elements of Probability and Statistics (BMC 104), which is roughly equivalent to our Math/Stat 103, Bryn Mawr offers courses roughly equivalent to most of our standard calculus offerings:

<table>
<thead>
<tr>
<th>BMC</th>
<th>HC</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>105</td>
<td>(Calculus I, but BMC 101 is less about modeling)</td>
</tr>
<tr>
<td>102</td>
<td>118</td>
<td>(really, two quite different courses that both “finish” single-variable calculus)</td>
</tr>
<tr>
<td>201</td>
<td>121</td>
<td>(Multivariable Calculus)</td>
</tr>
<tr>
<td>203</td>
<td>215</td>
<td>(Linear Algebra)</td>
</tr>
<tr>
<td>104</td>
<td>103</td>
<td>(Intro Statistics)</td>
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