College Readiness and Remediation Free Standards Recommendations:

Report to the Ohio College Readiness Advisory Committee

Composite Recommendations of:
English Language Arts Faculty Panel
Math / Science Faculty Panel
Ready for College Subgroup of Ohio Board of Regents Completion Task Force

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Foreword

House Bill 153 of the 129th Ohio General Assembly amended Section 3345.061 (F) of the Ohio Revised Code with the following:

Section 3345.061 (F) *Not later than December 31, 2012, the presidents, or equivalent position, of all state institutions of higher education, or their designees, jointly shall establish uniform statewide standards in mathematics, science, reading, and writing each student enrolled in a state institution of higher education must meet to be considered in remediation-free status. The presidents also shall establish assessments, if they deem necessary, to determine if a student meets the standards adopted under this division. Each institution is responsible for assessing the needs of its enrolled students in the manner adopted by the presidents. The board of trustees or managing authority of each state institution of higher education shall adopt the remediation-free status standard, and any related assessments, into the institution's policies. The chancellor shall assist in coordinating the work of the presidents under this division.*

To provide the chancellor's assistance of this work, the Academic Affairs Division of the Ohio Board of Regents invited faculty members from colleges and universities throughout Ohio to convene for the purposes of developing recommendations for:

1.) Uniform statewide standards in mathematics, science, reading, and writing; and

2.) Assessments to determine if a student meets the standards to be considered remediation-free.

The recommendations included in this report reflect the collaborative work of an English Language Arts panel, a Math and Science Panel, and the Ready for College subgroup of the Ohio Board of Regents Completion Task Force. The content area panels were each comprised of higher education and secondary faculty members from public and private institutions throughout Ohio. The Ready for College subgroup was comprised of postsecondary faculty from public two- and four-year institutions throughout Ohio.

The content panels analyzed data reflecting the historical performance of Ohio students in non-credit remedial college coursework and first level credit bearing coursework. Panel members gathered information on current placement practices of higher education institutions in Ohio and the perceived effectiveness of those practices. In addition, panel members performed a review of the existing body of research on effective placement practices.

The Ready for College subgroup analyzed best practices throughout Ohio and the United States in developing its recommendations.

The report is organized as follows:

- Recommendations for College Readiness and Remediation-Free Guarantee
    - Expectations for College Readiness in English Language Arts Literacies
    - Assessment to Determine College Readiness/Remediation-Free Status in English Language Arts Literacies
    - Expectations for College Readiness in Math and Science
    - Assessment to Determine College Readiness / Remediation-Free Status in Math and Science
    - Assessing Cognitive and Non-Cognitive Skills
- Recommendations Beyond Scope of ORC 3345.061(F)
    - Policy and Practice Recommendations for Student Success

Section I:
Recommendations for College Readiness and Remediation-Free Guarantee

General Principles

The Remediation Free Guarantee

In establishing college readiness expectations and assessment threshold scores to deem a student exempt from institutional placement testing for the purposes of remediation, the recommended expectations and related assessments included in this document provide a threshold that institutions may not exceed. **While institutions are allowed to set assessment threshold scores lower than the measures detailed in this document, they are not allowed to set assessment threshold scores higher than the recommendations herein.** Further, a student who achieves a score lower than the threshold score need not be placed automatically into remediation. It is strongly recommended that institutions design and implement placement procedures for students scoring below assessment threshold scores to further assess the student, utilizing multiple measures to determine the optimal plan to accelerate the student's enrollment in and successful completion of credit-bearing courses. Such measures could include review of high school grade point average, performance on new State assessments as they are adopted, particularly end-of-course assessments in high school, a writing assessment, a review of previous college work, and assessment of non-cognitive skills.

It is further recommended that aggregate assessment results be used to inform collaborative and continuous improvement efforts for both educator preparation programs and discipline-specific content preparation provided by colleges of arts and sciences. It is further recommended that assessment results be used to inform secondary school curriculum and instruction to align high school and post-secondary student expectations and requirements for successful student transition. It is essential that high school curriculum and teaching practices be developed that better ensure that all students who earn a high school diploma are prepared for immediate entry into colleges or careers.

Remediation-Free Guarantee Parameters

It is recommended that a student's demonstration of college readiness, as measured by her/his highest-scoring performance on an administration of an assessment exam be valid for two years from the completion of that assessment. After two years, institutions may require students to repeat an assessment to determine the currency of their college readiness.

Use of Multiple Measures

It is strongly recommended that colleges and universities employ multiple assessment measures to determine optimal placement for student success. College and career readiness should include evaluation of key academic and non-academic risk factors. Effective placement procedures

are those that consider high school performance, ACT scores, previous college experience, and the essential inclusion of non-cognitive assessments.

Effective Models for Student Academic Support

It is strongly recommended that institutional policies and practices provide innovative models of remedial design, including supplemental instruction, co-enrollment in credit-bearing courses in other disciplines, enrollment in credit-bearing courses that are integrated with academic support services or employ innovative teaching practices, or refresher courses delivered in a module format, and other delivery methods that produce successful outcomes for students (Roderick, M., Nagaoka, J., Coca, V., 2009).

Recommended Expectations for College Readiness in English Language Arts Literacies:

Reading, Writing, Speaking, and Listening

To prepare for post-secondary education and the world of work, students must be given opportunities to become competent communicators and critical thinkers. Students need to integrate reading, writing, speaking, viewing, listening, and applying technology creatively in a variety of contexts on a regular basis. Learning in the English language arts is an active and on-going process and should occur throughout the curriculum—at all levels and in all subject areas—and beyond the classroom setting. In short, success in post-secondary education and in the workplace entails both preparation in and ability in all of the areas noted in the recommendations.

The College Readiness Expectations in English provide a statement of the knowledge and skills that enable students to succeed in making the transition directly into first year, college-level, non-remedial courses. Representatives from higher education and secondary education reviewed these standards in April 2011 and found general alignment with the Common Core State Standards.

Reading

Key Ideas and Details

A. Understand that reading is a strategic process of constructing meaning from texts.

B. Actively engage texts, autonomously applying skills and strategies that are appropriate for the demands of the texts and their purposes for reading.

C. Formulate and clearly express complex ideas related to texts, citing evidence to support inferences and interpretations.

D. Think critically and creatively about the texts they read, often drawing upon their personal experiences and knowledge to enhance comprehension.

E. Analyze and interpret fiction and non-fiction texts (including expository and persuasive essays) and work-related documents such as manuals, memos, letters, and business plans.

F. Determine and comprehend the central themes of a text and analyze their development. Summarize the key supporting details and ideas.

G. Analyze how and why individuals, events, and ideas develop and interact over the course of a text.

H. Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

I. Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

J. Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.

Craft and Structure

A. Employ pre-reading strategies to identify features of text that aid comprehension (e.g., informational).

K. Understand and use text formatting features (table of contents, glossaries, navigation bars) to effectively locate and acquire information in a variety of texts.

L. Differentiate between fact and opinion.

M. Employ vocabulary-building strategies while reading various texts.

N. Evaluate an author's purpose and point of view by analyzing the use of language, style, and point of view found in the text.

O. Demonstrate an understanding that the writer's choice of language shapes meaning.

P. Evaluate an author's rhetorical and argumentative strategies.

Q. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

R. Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.

Integration of Knowledge and Ideas

A. Read and respond orally and in writing to texts representing a variety of genres, authors, cultures, and historical periods.

S. Establish and apply criteria for selecting and evaluating the credibility of print and multimodal texts for a range of purposes, including research.

T. Use features, (e.g., pie charts, bar graphs, pictures) to enhance, emphasize, and clarify comprehension of print, and multimodal, or oral texts across the curriculum.

Range of Reading and Level of Text Complexity

A. Actively engage texts, autonomously applying skills and strategies that are appropriate for the demands of the texts and their purposes for reading.

B. Skillfully read a wide range of increasingly complex texts, print and multimodal.

Writing

Text Types and Purposes

A. Independently and ethically produce writing that meets the needs of a particular purpose and audience, appropriate for academic and work-related documents.

B. Select from a repertoire of processes and modes to develop writing for purposes such as persuasion, explanation, research, or personal expression.

C. Use style, voice and organizational structures which are transparent and appropriate for the rhetorical purpose and audience.

D. Adept at responding in writing to diverse texts and formats, synthesizing, critiquing and analyzing those texts.

E. Adapt writing strategies for audience, purpose, and type of task.

F. Produce texts that convey an argument that is organized, coherent, fully developed, and rhetorically appropriate in support of a thesis.

G. Produce writing that exhibits word choices that convey intended meaning.

Production and Distribution of Writing

A. Independently and ethically produce writing that meets the needs of a particular purpose and audience, appropriate for academic and work-related documents.

B. Draft, revise, and edit writing autonomously.

C. Adapt writing strategies for audience, purpose, and type of task.

D. Use reflective strategies for critiquing and evaluating their own and others' writing.

E. Employ sentences of varying lengths and structures which are as appropriate to audience, purpose, and context.

F. Use appropriate conventions of the English language, including grammar and usage, punctuation, capitalization, and spelling.

Research to Build and Present Knowledge

A. Employ the research writing skills of evaluating sources and integrating them in support of a thesis.

B. Accurately and correctly quote, paraphrase, and summarize material from another text to avoid unintentional plagiarism.

C. Properly cite sources, using a generally accepted citation system such as MLA or APA.

Speaking, Viewing and Listening

Comprehension and Collaboration

A. Listen actively and speak effectively in a variety of academic and work-related situations.

B. Listen carefully, take notes as needed, and not interrupt other speakers when engaged in group or committee work.

C. Deliver a clearly organized message when contributing to the group or committee work.

D. Take notes while listening to lectures or participating in other forms of information gathering and uses the notes to review and reflect on learning.

E. Know how to identify and accommodate cultural differences in communication styles and strategies.

F. Analyze and synthesize information gathered from a variety of sources.

C. Summarize information heard into another form of communication, e.g., rephrase statements, summarize a speech, and paraphrase an oral reading.

D. Evaluate and respond to a speaker's message.

E. Use viewing skills and strategies to understand and interpret visual media.

F. Support and clarify written and oral presentations with visual media resources, including electronic technologies.

G. Recognize and respect cultural and language differences in both formal and informal speaking situations.

H. Interpret and evaluate a speaker's rhetorical strategies and evidence.

I. Employ appropriate non-verbal strategies to enhance communication.

J. Summarize information heard into another form of communication, rephrase statements, summarize a speech, or paraphrase an oral reading.

K. Understand the impact that visual media has on society.

L. Set criteria and evaluate the technology techniques used to influence economic, political, cultural, social, and aesthetic decision-making.

Presentation of Knowledge and Ideas

A. Present successfully to an audience, recognizing the needs of an audience for visual as well as auditory messages.

B. Deliver a clearly organized message when contributing to the group or committee work.

C. Speak fluently, enunciating clearly with appropriate rate and volume.

D. Speak effectively and listen actively in diverse communicative contexts.

E. Express ideas, thoughts, and concerns effectively in both formal and informal speaking situations, e.g., conversations, discussion, presentations, collaborative groups, one-on-one interactions, debates, negotiations, and interviews.

F. Employ appropriate non-verbal strategies to enhance communication.

G. Recognize and evaluate techniques used in visual media to influence opinions, decision-making, and cultural perceptions.

H. Use images to convey meaning, often in conjunction with written or oral presentations.

I. Use visual media or computer technology to communicate effectively with a variety of audiences for a variety of purposes.

J. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Recommended Assessments to Determine College Readiness / Remediation-Free Status in English Language Arts Literacies

English Assessments for Placement into English Composition

Assessment	Threshold Score*
ACT	18 English Exam
SAT	440 Writing
ACCUPLACER	88 English; 70 Sentence Skills

The COMPASS and ASSET English Exams are not recommended to assess student writing skills. These exams solely measures editing and reading comprehension skills and do not assess college-ready writing skills. Research has shown that the COMPASS English Exam has minimal predictive validity in placing students for success in English Composition (Hughes, K., Scott-Clayton, 2011).[1] It is recommended that institutions administer an authentic writing assessment to determine optimal placement for student success.

Reading Assessments for Placement into All First Level Transfer Credit-Bearing College Courses

Assessment	Threshold Score*
Enhanced ACT Reading Score	21
COMPASS	87
SAT Reading Score	450
ACCUPLACER Reading Scale Score[2]	102
ASSET Reading Skills Score	45

*Admitted students achieving or exceeding the English and Reading scores on this page are guaranteed exemption from placement into non-credit remedial courses on the basis of English Language Arts (ELA) literacies and are guaranteed exemption from requisite institutional placement testing for purposes of remedial placement based on ELA literacies.

[1] Hughes, K., Scott-Clayton, J., 2011. Assessing developmental assessment in community colleges. *Community College Research Center*, February, 2011, CCRC Working Paper No. 19.

[2] The College Board does not provide or support concordances for Accuplacer. This concordance is from the Southern West Virginia Community and Technical College.

It is critical to understand that institutions are not required to place students scoring below the threshold score into remedial courses. Students scoring below the threshold score are subject to institutional placement procedures to gain eligibility to enroll in credit-bearing courses. Such procedures could include review of high school grade point average, a writing assessment, and a review of previous college work.

It is recommended that institutional policies provide innovative, effective models of academic support for students scoring below the threshold scores, including supplemental instruction, co-enrollment in credit-bearing courses, and/or refresher courses delivered in a module format.

Recommended Expectations for College Readiness in Math and Science:

Biology, Chemistry, Computer Science, Engineering, Geology, and Physics

College students in Ohio pursue a large and diverse range of academic majors related to the sciences and mathematics. Attempting to specify recommendations for each of these majors would be an extremely difficult task, particularly since the requirements for majors vary among the higher education institutions in the State. So instead, the faculty panel has developed recommendations for each of the common introductory courses in the natural sciences: biology, chemistry, physics, and geology. Recommendations are also provided for computer science and for engineering. Although these recommendations were not required by this legislation, the panel believes that these recommendations will be helpful for students, parents, teachers, and other stakeholders for advising students about how to prepare for these other closely related fields. Guidance counselors, academic advisors, and teachers can use these recommendations to advise students how to best prepare for college by determining which college courses they will likely need to complete based on the student's intended academic major in college.

The recommendations are divided into three sections: 1) Recommendations regarding learning skills needed by all students; 2) Recommendations regarding knowledge and skills needed by students who plan to only take general education science courses that are not intended for science majors; 3) Recommendations regarding knowledge and skills needed by students who plan to take science courses that are designed for students majoring in the natural and health sciences.

These recommendations are based, in part, on the Ohio College Ready Standards for Science that have been developed by the Ohio Department of Education, and also on the Mathematical Expectations for College Readiness 2011 developed by the Ohio Board of Regents with mathematics faculty.

The Ohio College Ready Standards specify what K-12 students in Ohio are expected to know and be able to do in each of the grade levels from Kindergarten through grade 8 and provide syllabi and model curricula for six high school science courses: the two required courses, biology and physical science, and four advanced courses: chemistry, physics, environmental science, and physical geology. These standards specify certain science facts, concepts, and relationships that students need to know, but also emphasize the importance of students achieving an understanding and mastery of the process and practice of science. It is notable that the list of facts, concepts, and relationships that students are expected to master in these standards is shorter than in the previous Ohio science standards. A feature of the revised standards that the panel considers valuable is their clear and explicit description of the depth of understanding that students are expected to achieve for the high school curriculum topics. This will be a useful tool in efforts to

establish more uniform high school instruction throughout the state so that all students are provided a level of instruction that will enable them to be well prepared for college level study in the natural sciences.

Indeed, the faculty panel strongly recommends that measures are enacted to ensure that all schools offer the quality and level of instruction to make it possible for all students to meet these expectations. Those measures would include a system of assessment, accountability, and resource allocation that ensures that coursework is sufficiently rigorous, thorough, and supportive, and teaching is of sufficient quality to meet all students' learning needs. The Ohio College Ready Standards (now known as the "Ohio New Learning Standards: K-12 Science"). provide a strong foundation on which to base those measures.

The recommendations in this document include a set of learning skills that the panel considers essential for success in college level coursework. Many students are currently enrolling in college science courses lacking these skills and they are at a severe disadvantage for success. For students to uniformly be able to succeed at the college level and meet expectations, it is essential that they have these important and essential skills.

The panel's recommendations build on the Mathematical Expectations for College Readiness 2011 which provides a well-organized, concise, yet thorough description of the mathematics knowledge and skills that students need to be prepared for college. The faculty panel is aware that it is possible for students to understand and to be able to demonstrate abstract math skills without being able to apply those within the scientific disciplines. Thus, the faculty panel indicates that it is not only sufficient for students to master the mathematics expectations, but to be prepared to succeed in college science classes, they also need to be able to apply these math skills within the context of the science disciplines, meaning that students can actually use those math skills to solve problems, develop and use models, and describe phenomena in the sciences.

The faculty panel believes that students who master this entire set of expectations should be well prepared for a high level of success in the first level of college coursework in the sciences. We, therefore, urge the development of valid and reliable assessments that not only provide summative, but also useful formative assessment, at every stage of a student's K-12 education, so that students can progress smoothly and consistently towards this complete level of mastery.

College-Level Learning Skills Required for All Students

To be fully prepared for college level coursework, students should be competent and capable, self-regulated, college-level learners. Such learners are able to:

A. Learn science using a variety of sources including, but not limited to:

1. Standard college-level science textbooks;
2. Inquiry-based laboratory experiences that engage students in asking valid scientific questions and gathering and analyzing information;
3. Well-reasoned and evidence-based discussions of science principles, concepts and problems with well-prepared peers and faculty;
4. Well-organized lectures delivered at an appropriate cognitive level for first-year STEM college students by college faculty; and
5. Other appropriate sources of science information in the popular press and in other sources such as research reports and summaries that are at an appropriate cognitive level for first-year college students.

B. Reliably and accurately assess their learning and take effective action to remediate their deficiencies, prior to instructor-administered summative assessments; and

C. Persist in their learning despite encountering initial difficulty in mastering challenging material and seek and use alternative learning strategies when they find that their initial strategies are not as effective as desired, so that they consistently meet their learning goals and achieve the targeted learning outcomes.

Science Content Knowledge and Science and Mathematics Skills Needed by Students Who Will Only Enroll in General Education Natural Science Courses for Non-Science Majors

Science Content Knowledge

General education science courses are designed with lower level expectations for students' prior knowledge of the content in specific natural science disciplines than science courses intended for college students majoring in the natural sciences. To be well prepared for these courses, students should satisfactorily complete the Ohio graduation requirements for science and mathematics, meeting all of the expectations specified in the New Ohio Learning Standards: K-12 Science for each of those courses. The Ohio graduation requirement specifies that students must satisfactorily complete the following high school science courses: biology, physical science, and one advanced science course. Students who master the science content and process skills specified in the Ohio Career and College-Ready Standards model curricula for three science courses should have sufficient content knowledge and science process skills to be ready to learn what is expected in general education courses that meet the Ohio Transfer Assurance Guidelines (TAG) and are designed for students to achieve TAG learning outcomes.

Science Mathematics Skills

Students also should be able to consistently demonstrate mastery of the first five Recommendations in "Mathematical Expectations for College Readiness 2011" within science contexts. Students should be able to demonstrate mastery of these processes, concepts, functions, applications, and operations by creating models of physical realities related to those models. Students should also be able to use the models they create to reliably and consistently solve problems dealing with the concepts and relationships described in the Syllabus and Model Curriculum of the Ohio Revised Science Standards for the science courses that they have taken in high school. These students do not need to be able to demonstrate the "Additional Expectations for Calculus."

Rationale

Since general education science courses for non-science majors presume relatively low-level science content knowledge, the exact science content that students have mastered is not as critical as it is for science majors. However, that does not mean that these students need not have mastered or used any science content. If students completely lack familiarity with the nature of scientific knowledge and some of the core scientific content, they would have a very weak ability to construct new knowledge in the sciences. Thus, to be prepared to learn science content at the level expected in college non-majors science courses, students need mastery of some general science concepts and the following scientific processes so that they are proficient at constructing new science knowledge and understanding:

A. Identify questions and concepts that guide scientific investigations;
B. Design and conduct scientific investigations;
C. Use technology and mathematics to improve investigations and communications;
D. Formulate and revise explanations and models using logic and evidence (critical thinking);
E. Recognize and analyze explanations and models; and
F. Communicate and support a scientific argument.

This level of mastery should be accomplished by satisfactory completion of three high school science courses as defined by the syllabi and model curricula of the New Ohio Learning Standards: K-12 Science.

Science Content Knowledge and Science and Mathematics Skills Needed by Students Who Will Take Natural Science Courses Intended for Those Majoring in the Natural and Health Sciences

To be prepared to succeed in college-level courses in the natural sciences at Ohio universities and colleges, in addition to the College-Level Learning Skills defined above, students should know and be able to do the following:

A. Consistently demonstrate mastery of the learning outcomes defined by the Syllabus and Model Curriculum of the New Ohio Learning Standards: K-12 Science for the high school level course corresponding to the college course that they will be taking. This means that students who will take the introductory biology course intended for science majors should have mastered the learning outcomes defined by the Syllabus and Model Curriculum for biology, those planning to take the introductory chemistry course for science majors should have mastered the learning outcomes defined by the Syllabus and Model Curriculum for chemistry, and those planning to take the introductory physics course for science majors should have mastered the learning outcomes defined by the Syllabus and Model Curriculum for physics. Those students planning to study Geology or Environmental Science in college should have mastered the learning outcomes for chemistry since college-level geology and environmental science courses typically expect students to have mastered this chemistry content knowledge. They need not have mastered the learning outcomes for high school Physical Geology. Although that course would convey an advantage to those high school students who complete it, the content in that course need not have been previously mastered for students to be adequately prepared for first-year geology courses in college and if a student has to choose between high school Chemistry and high school Physical Geology, they will be better prepared for college-level geology courses by completing the high school Chemistry course.

B. Consistently demonstrate mastery of the first five Recommendations in "Mathematical Expectations for College Readiness 2011" within science contexts, meaning that students can demonstrate these skills in creating models of physical realities within those contexts and use those models to reliably and consistently solve problems dealing with the concepts and relationships described in the Syllabus and Model Curriculum of the New Ohio Learning Standards for the type of science course that they plan to take in college. Students who are planning to major in chemistry, physics, engineering or other majors that require calculus within the first two years of college should be able to consistently demonstrate their mastery of the "Additional Expectations for Calculus." Problem solving skills are absolutely essential for college-level work in the sciences. So

facility with this aspect of mathematics within the specific science disciplines that students will be studying is critical for student success at the college level.

C. Write effectively in a technical scientific style consistent with the discipline, at a level appropriate for college level work.

D. Communicate technical scientific information with appropriate visual and graphical tools.

E. Work together with peers to design a solution to a multifaceted, complex problem involving science inquiry or technology or engineering design.

An Additional Recommendation for Students Planning to Major in a Field of Engineering

In addition to the above expectations, students planning to major in a field of engineering should also be able to analyze products, devices, machines and systems in order to discover the principles on which they are based.

Recommended Mathematical Expectations for College Readiness 2011

A large percentage of Ohio college freshmen find that they are not "ready" for entry level college coursework. In mathematics, 32% of Ohio's recent graduates enrolling at Ohio public colleges or universities in fall 2008 took remedial mathematics during their first year of college.[3] Reducing the number and percentage of students taking remedial mathematics courses is challenging. Nonetheless, an important first step is to define clearly the mathematical expectations for students who enter two- and four-year colleges. These expectations should help guide college and high school faculty, and, most importantly, assist students and their parents in planning secondary and postsecondary coursework.

Defining the mathematics and statistics students need to know as they enter college may sound simple. In fact, it is a challenging endeavor, requiring those who undertake it to examine the nature of mathematics and pedagogy and think seriously about the mathematics that will be needed in the future by all students. Certainly, students who will take calculus as entering freshmen require a different level of preparation and competence than students who take introductory credit-bearing courses. The first part of this document describes the standards for the latter group. Also included are the additional expectations for incoming college students who wish to enroll directly into college calculus courses. These expectations are drawn from the pre-calculus outcomes in the Mathematics Transfer Assurance Guide.

This document is a revision of a set of expectations first articulated in 2006. The work, done under the auspices of the Ohio Board of Regents and the Ohio Department of Education, involved both higher education faculty and high school mathematics teachers. These revised expectations are consistent with the Common Core State Standards for Mathematics that have been adopted by Ohio, and in no way should be viewed as replacing those standards.

The panel creating this document made a conscious effort to limit the content to the essential mathematics needed for successful completion of entry-level college mathematics courses. This document represents minimal expectations. Thus, this document omits some traditional and appealing concepts that would provide an enriched mathematics background. It is understood and expected that many secondary students will learn more mathematics than is reflected here. Students intending to pursue mathematically intensive programs and careers after high school would benefit from a more comprehensive and rigorous study of mathematics. The panel believes, however, that the core expectations outlined in this document will provide students with a sufficient knowledge base for success; and it is essential that students have more than a passing

[3] http://regents.ohio.gov/perfrpt/hs_2008/hs_trans_HS_rpt_AU08.pdf.

acquaintance with these ideas. Students must retain this foundation well beyond the confines of any one course and be able to apply these concepts and skills to both routine and non-routine problems, drawn from a variety of contexts.

Expectation 1: Mathematical Processes

Mathematical processes are intertwined with content. In the best of all worlds they would be intertwined to the point that it is unnecessary to mention them. However, in addition to essential numeric, algebraic, geometric and data skills, students need to possess mathematical process skills in order to be successful in post-secondary education. These skills include communication, reasoning and using technology—but perhaps most important are problem solving skills. Students should have frequent experiences with rich mathematical problems that engage them in problem solving—a process deeper than that of practicing a new technique on a classified category of word problems. Problem solving should contribute to the development of mathematical habits of mind (e.g., perseverance, questioning, independence, reflection, connecting) and develop an appreciation for and a disposition toward problem solving as the paramount aim of learning mathematics.

Students are expected to:

A. Solve Problems

1. Use a variety of problem solving strategies;
2. Reflect on and analyze their own problem solutions and the solutions of others;
3. Connect ideas in a variety of context; and
4. Solve complex, non-routine and multi-step problems that may require student formulation of problems and/or sustained thought and effort.

B. Communicate with Mathematical Ideas

1. Use correct mathematical terminology and notation;
2. Show a logical progression of thought, clearly and coherently, orally and in writing;
3. Read mathematical material with understanding and independence;
4. Use appropriate degrees of precision based upon problem context; and
5. Use exact answers (e.g., $\sqrt{}$ or π) when appropriate.

C. Reason Mathematically

1. Understand the need for proof in mathematics; recognize when a proof is required;
2. Understand the difference between a statement verified by proof and one illustrated by using examples;
3. Understand the meaning of logical terms (e.g., and, or, but, not, if … then); and
4. Understand the significance of and roles played by definitions, assumptions, theorems/propositions, examples, and counterexamples in mathematics.

D. Connect Mathematical Concepts

1. Connect mathematics with a variety of disciplines and workplace and everyday settings; and
2. Use connections among and within branches of mathematics (e.g., algebraic properties of a function and geometric properties of its graph).

E. Use Technology and other Tools Appropriately

1. Use a variety of tools to solve mathematical problems—ranging from common tools (e.g., rulers, protractors) to technology-enhanced tools (e.g., calculators, computers, spreadsheets);
2. Use technology to collect organize and analyze information with the goal of interpretation, presentation and argumentation and as motivation for proof; and
3. Use appropriate technology to enhance and support student learning.

Expectation 2: Number and Operations

Concepts from number and operations form the basis for understanding of algebra and work with symbols. Students should be proficient with arithmetic operations and their properties on integers, rational numbers and real numbers. They should demonstrate number sense and compute fluently, including mental methods, and make reasonable estimates. Students should possess a basic understanding of the real number system and the way the natural numbers, whole numbers, integers, rational numbers, and irrational numbers relate to one another.

Students are expected to:

A. Structure of the Number System

1. Understand and convert between different representations of numbers (decimal, percent, fraction, scientific notation, radicals…); and
2. Explain the effects of operations on the magnitudes of quantities and signs of numbers.

B. Operations

1. Perform arithmetic operations on various forms of real numbers;
2. Compute and explain the solutions to problems involving ratio, proportion, percent, scientific notation, square roots and numbers with integer and rational exponents; and
3. Apply and generalize properties of operations (including order of operations) as a foundation for algebra.

C. Estimation

1. Estimate the solutions to problems involving ratio, proportion, percent, scientific notation, square roots and numbers with integer and rational exponents.

Expectation 3: Algebra

Algebra continues to be the most fundamental prerequisite for success in college mathematics. Algebra provides a language and structure that allows students to create representations, model and generalize mathematical ideas. It is concerned with change, patterns and dealing with concepts at a more abstract level than in arithmetic. In addition to competence with manipulation of algebraic objects, students should be able to model and solve problems using a variety of algebraic methods.

Students are expected to:

A. Equations and Inequalities

1. Algebraically solve linear equations in one variable, including examples with no solution, one solution, and infinitely many solutions;
2. Solve systems of linear equations with two unknowns by graphing, substitution, and addition/elimination; including examples with no solution, one solution, and infinitely many solutions;

3. Solve quadratic equations by graphing, factoring, completing the square, and using the quadratic formula (including equations that have complex solutions);
4. Algebraically solve linear inequalities and represent solutions in multiple ways such as graphically, inequality notation, and interval notation;
5. Algebraically solve absolute value equations in the form $|Ax + B| = C$ and related absolute value inequalities and represent solutions in multiple ways;
6. Algebraically solve equations that include rational expressions or radicals including examples that generate extraneous solutions;
7. Solve for specified variables in literal equations; and
8. Solve exponential equations in one variable using logarithms.

F. Operations with Algebraic Objects

1. Perform operations with exponents and radicals, including laws of exponents, with both numerical and algebraic expressions;
2. Add, subtract, multiply and divide rational expressions by hand and identify values where they are undefined. (Limit numerators and denominators to monomial, linear and quadratic expressions);
3. Evaluate and simplify algebraic expressions; and
4. Add, subtract, multiply and divide polynomial expressions (limit divisors to monomial and linear expressions).

G. Graphing

1. Graph linear equations and inequalities and quadratic equations in two variables, with and without technology (limit quadratic equations to vertical and horizontal parabolas);
2. Graph common functions (e.g., absolute value, square root, linear, quadratic, rational, exponential, piecewise) with and without technology;
3. Read a graph to interpret solutions to an equation and identify and interpret characteristics such as intercepts, extrema, and rates of change;
4. Graph transformations of functions (limit transformations to vertical and horizontal shifts, reflections, and stretches); and

5. Interpret transformations of functions from both a graphical and algebraic perspective.

H. Functions and Applications

1. Define functions; determine whether a relationship between two variables (represented in a variety of ways) represents a function; identify, as appropriate for the context, both the domain and range of a function; and use function notation;
2. Describe how a change in one variable affects the value of a related variable, for example, problems involving direct and inverse variation;
3. Interpret sequences as functions whose domain is a subset of the whole numbers. Solve problems with arithmetic and geometric sequences;
4. Adjust the parameters of function families to model relationships between variables (function families include linear, quadratic, piecewise, absolute value, square root, power and exponential); and
5. Formulate equations or functions that model problems in a variety of contexts.

Expectation 4: Geometry

Geometry is the place where students learn about shapes and space. It is also a natural place for students to use careful deductive reasoning. Students analyze mathematical situations and solve problems using geometric objects and ideas.

Students are expected to:

A. Structure

1. Describe and explain the different roles of assumptions, definitions, theorems and proofs in the logical structure of geometry;
2. Use theorems about parallel and perpendicular lines, angles, congruent figures, similar figures, right triangles (e.g., Pythagorean Theorem), polygons, circles, polyhedrons, spheres, cylinders, and cones to solve problems;
3. Prove theorems about lines, angles, triangles, and parallelograms;
4. Use similarity to solve problems and to model proportional relationships; and

5. Use right triangle trigonometry to solve problems.

B. Geometric Representations

1. Represent geometric objects algebraically using coordinates (analytic geometry);
2. Use algebra to solve geometric problems;
3. Draw and define reflections, rotations, translations, and dilations of geometric objects and understand compositions of these transformations;
4. Define, describe, and identify reflectional and rotational symmetry; and
5. Express transformations algebraically (i.e., using coordinates).

C. Measurement

1. Explain that the geometric measures (length, perimeter, area, volume) depend on the choice of unit, and that measurements are approximations;
2. Explain the effect of a scale factor on length, perimeter, area, and volume;
3. Calculate the perimeter and area of common plane figures and the surface area and volume of solids;
4. Distinguish between exact and approximate values. Explain differences among accuracy, precision, and error, and describe how errors affect later calculations;
5. Solve problems involving measurement, including problems requiring a choice of scale and unit; and
6. Convert fluently from one measurement unit to another, within and across systems.

Expectation 5: Probability and Statistics

Statistics and probability form the basis for understanding situations involving variability. Beginning with questions, data are gathered, displayed, summarized, and interpreted in order to identify patterns and deviations from patterns and to make predictions. In a world increasingly inundated with data, it is essential that all students become familiar with ways data is used and misused.

Students are expected to:

A. Data Displays and Interpretation

1. Create and/or interpret graphical displays to describe sets of data (e.g., box-and-whisker, scatterplot, frequency distribution, normal distribution); and
2. Find and interpret measures of central tendency and variability for sets of data.

B. Representations and Use of Data

1. Use the context to determine appropriate way(s) to represent data, and understand the advantages and disadvantages of various representations;
2. Identify misuses of data;
3. Distinguish between correlation and causation; and
4. Understand the characteristics of well-designed studies (e.g., lack of bias, sampling methods, randomness) in order to interpret results.

C. Probability Concepts

1. Use the fundamental counting principle to determine the number of possible outcomes;
2. Compute probability of compound events, independent events, and simple dependent events; and
3. Compare experimental and theoretical results for simple experiments.

Additional Expectations for Calculus

The expectations outlined above will help assure that students are ready for college. If a student plans to enroll in a calculus course upon entering college that student should also have facility with the following which are drawn from the Ohio Board of Regents description of a Pre-calculus Course (TMM002). The codes in parentheses indicate Pre-calculus outcomes that are already included or partially included among the expectations for all students.

A. Functions

1. Represent functions verbally, numerically, graphically and algebraically, including linear, quadratic, polynomial, rational, root/radical/power,

piecewise-defined, exponential, logarithmic, trigonometric and inverse trigonometric functions (3.C.2, 3.C.3, except logarithmic and trigonometric functions);

2. Determine whether an algebraic relation or given graph represents a function (3.D.1);
3. Perform transformations of functions—translations, reflections and stretching and shrinking (3.C.4, 3.C.5);
4. Perform operations with functions—addition, subtraction, multiplication, division and composition;
5. Analyze algebraic structure and graph of a function, including those listed in 1.1 to determine the intercepts, domain, range, intervals on which the function is increasing, decreasing or constant, the vertex of a quadratic function, asymptotes, whether the function is one-to-one, whether the graph has symmetry (even/odd), etc. and given the graph of the function to determine possible algebraic definitions. (3.C.3; 3.D.1, 2,4);
6. Find inverse of functions listed in 1.1 and understand the relationship of the graph of a function to that of its inverse;
7. Use the Remainder and Factor Theorems for polynomial functions; and
8. Use functions, including those listed in 1.1 to model a variety of real-world problem solving applications (3.D.4).

B. Equations/Systems

1. Understand the difference between an algebraic equation of one, two or more variables and a function, and the relationship among the solutions of an equation in one variable, the zeros of the corresponding function, and the coordinates of the x-intercepts of the graph of that function;
2. Determine algebraically and graphically whether the graph of an equation exhibits symmetry;
3. Solve a variety of equations, including polynomial, rational, exponential, and logarithmic, trigonometric and inverse trigonometric, including equations arising in application problems. (3.A.1,3,5,6, except logarithmic and trigonometric equations);

4. Solve a system of linear equations graphically and algebraically by substitution and elimination and solve application problems that involve systems of linear equations. (3.A.2);
5. Identify and express the conics (quadratics in two variables) in standard rectangular form, graph the conics, and solve applied problems involving conics; and
6. Solve polynomial and rational inequalities graphically and algebraically.

C. Sequences/Series

1. Represent sequences verbally, numerically, graphically and algebraically, including both the general form and recursively (3.D.3);
2. Write series in summation notation, and represent sequences of partial sums verbally, numerically and graphically; and
3. Identify and express the general term of arithmetic and geometric sequences, and find the sum of arithmetic and geometric series (3.D.3).

D. More Trigonometry

1. Express angles in both degree and radian measure;
2. Define the six trigonometric functions in terms of right triangles and the unit circle;
3. Solve right and oblique triangles in degrees and radians for both special and non-special angles, solve application problems that involve right and oblique triangles (4.A.5);
4. Verify trigonometric identities by algebraically manipulating trigonometric expressions using fundamental trigonometric identities, including the Pythagorean, sum and difference of angle, double-angle and half-angle identities; and
5. Solve a variety of trigonometric and inverse trigonometric equations, including those requiring the use of the fundamental trigonometric identities listed in 4.4, in degrees and radians for both special and non-special angles. Solve application problems that involve such equations.

E. Vectors

1. Represent vectors graphically in both rectangular and polar coordinates and understand the conceptual and notational difference between a vector and a point in the plane;
2. Perform basic vector operations both graphically and algebraically—addition, subtraction and scalar multiplication; and
3. Solve application problems using vectors.

Recommended Assessments to Determine College Readiness / Remediation-Free Status in Math and Science

In establishing threshold scores to deem a student exempt from institutional placement testing for the purposes of remediation, the recommended expectations and related assessment provide a threshold that institutions may not exceed. While it is recommended that institutions be allowed to set the threshold scores lower than the measures detailed below, these recommendations specify that they not be allowed to set the threshold scores higher than those listed below. Thus students achieving higher scores than specified below would be guaranteed they would not be placed in remedial, non-credit-bearing courses for the specific fields indicated. However, individual institutions can decide which students scoring below these levels would be placed in remedial courses.

It is strongly recommended that in designing remediation placement procedures for students scoring below the threshold scores, that institutions further assess student preparation utilizing multiple measures to determine the optimal plan to accelerate the student's enrollment in and completion of credit-bearing courses. Such measures could include review of high school grade point average, a writing assessment, and a review of previous college work.

It is further recommended that institutional policies provide innovative models of support for students scoring below the threshold scores, including supplemental instruction, co-enrollment in credit-bearing courses, refresher courses delivered in a module format, and other delivery methods that produce successful outcomes for students.

English Assessments

Assessment	**Threshold Score***
ACT	18 English Exam
SAT	440 Writing
ACCUPLACER	88 English; 70 Sentence Skills

Reading Assessments

Assessment	**Threshold Score***
Enhanced ACT Reading Score	21
COMPASS	87
SAT Reading Score	450

ACCUPLACER Reading Scale Score[4]	102
ASSET Reading Skills Score	45

Math Assessments

Assessment	**Threshold Score**
ACT Math Sub-Score	24**

*Admitted students achieving or exceeding these scores are guaranteed exemption from placement into non-credit remedial courses on the basis of English Language Arts (ELA) literacies and are guaranteed exemption from requisite institutional placement testing for purposes of remedial placement based on ELA literacies.

**Admitted students who score 24 or higher on the Math Composite ACT (or equivalent SAT Math sub-score) are guaranteed exemption from placement into non-credit remedial courses and exemption from requisite institutional placement testing for remedial placement. The previously established Ohio placement policy that set a minimum threshold of an ACT mathematics sub-score of 22 remains in effect and institutions should continue to reach a score of 22 at a minimum for placement in non-remedial first-college level mathematics courses. An ACT mathematics sub-score of 24, however, guarantees a student placement in a degree applicable, credit-bearing mathematics and statistics courses, without a placement test, that are recognized for transfer.

It is critical to understand that institutions are not required to place students scoring below the threshold score into remedial courses. Students scoring below the threshold score are subject to institutional placement procedures to gain eligibility to enroll in credit-bearing courses. Such procedures should include review of high school grade point average and other assessments, and a review of previous college work. Institutions should develop placement procedures and practices that are best suited for the specific resources that they have available to promote student success, tailored for the specific student populations that they serve.

Science Assessments for STEM Majors

To assess a prospective STEM major's preparedness for success in college level courses, it is important to assess their math abilities, reading comprehension, and science reasoning skills. The Math and Science Panel does not recommend setting a threshold score for the ACT Science exam, as the focus of this assessment is on science reasoning and not science content, thereby making the assessment redundant to the reading comprehension assessment.

[4] The College Board does not provide or support concordances for Accuplacer. This concordance is from the Southern West Virginia Community and Technical College.

For STEM majors, there is significant advantage in mastering some core chemistry content to be considered ready for the first college level chemistry courses. To determine whether students are ready for success in college level science courses for majors, an assessment is needed to determine if they have mastered the science content; however, such an assessment that is appropriate, readily available for use at the high school level, and affordable is not currently available. The Ohio Department of Education plans to institute end-of-course assessments for Physical Science and Biology high school courses to be administered in 2014-15 and will likely develop end-of-course assessments for Chemistry and Physics courses subsequently. The Math and Science Panel recommends that these end-of-course assessments be adopted as indicators as soon as they are available.

Until better assessments of science content knowledge are available, the Math and Science Panel recommends that campuses be allowed to use their own assessments of science content to supplement the other sources of information such as ACT scores, high school grade point average (GPA), and other indicators of college readiness in determining the college readiness in science for STEM majors.

Assessing College Readiness in Cognitive and Non-Cognitive Skills

In addition to mastery of content knowledge, to be college ready in the 21st century, students must demonstrate mastery of cognitive learning strategies, responsibility for their own learning, time management, study skills and habits, critical thinking abilities and non-cognitive skills required for postsecondary success. Mastery of these skills is included as a key part of a multi-faceted college readiness definition for Ohio students.

It is recommended that colleges and universities administer **authentic assessments** of college readiness in order to ensure students are best positioned for success when beginning their postsecondary experiences. Authentic assessments confront students with the kinds of problems they will encounter as college students and subsequently as professionals and engaged citizens. In authentic assessments, students are required to draw upon a wide variety of skills, accessing and drawing meaning from multiple information sources to develop cogent responses (Austin, 2010)[5]. Authentic assessments must be based on a multi-faceted definition of college readiness, and if used effectively, can help reform the placement process in colleges and universities.

Multiple-Measure Assessment Approach

College and work readiness in math, reading, and writing must be determined through the use of multiple-measure assessment approaches that include evaluation of key academic and non-academic risk factors. Effective placement relies on effective assessment of student learning and performance on tasks directly related to the tasks students will be doing in the courses into which they are placed. Effective assessment practices must consider multiple measures, including but not limited to high school performance, ACT scores, previous college experience, and non-cognitive assessments.

Assessing Non-Cognitive Skills

Non-cognitive skills include a range of behaviors that reflect greater student self-awareness, self-monitoring, and self-control—study skills, work habits, time management, help-seeking behavior, and social problem-solving skills. Meeting the developmental demands of college requires behavioral, problem-solving, and coping skills that allow students to successfully manage new environments and the new academic and social demands of college[6].

[5] Austin, J. (2010). Creating an Academy of Learning: Authentic Assessment, Peer Review, and the College and Work Readiness Assessment. Independent School, 69(3).

[6] S. Bowles and H. Gintis, Schooling in Capitalist America: Educational Reform and the Contradictions of Economic Life (New York: Basic Books, Inc., 1976); S. Bowles and H. Gintis, "The Inheritance of Inequality," Journal of Economic Perspectives 16 (2002): 3–30; Farkas, "Racial Disparities and Discrimination in Education" (see note 13); J. Heckman and A. B. Krueger, Inequality in America: What Role for Human Capital Policies (MIT Press, 2003).

It is strongly recommended that institutions implement **authentic assessments** of students' non-cognitive skills among the multiple measures employed to determine optimal placement for student persistence and success.

Available assessments of non-cognitive skills include the Noel-Levitz College Student Inventory (CSI) and integrated assessment, and the Grit-S Assessment (Duckworth, A., & Quinn, P., 2009). Duckworth, Peterson, Matthews, and Kelly (2007) introduced the construct of grit, defined as trait-level perseverance and passion for long-term goals, and showed that grit predicted achievement in challenging domains over and beyond measures of talent.

In addition to non-cognitive assessments, advising software packages such as MapWorks are available through *Educational Benchmarking* to support individualized academic planning to support persistence and completion.

Section II:
Recommendations Beyond Scope of ORC *Section 3345.061 (F)*

Policy and Practice Recommendations for Student Success

Continuous Improvement Across the P-20 Continuum

Postsecondary institutions in Ohio prepare the majority of educators for the state's elementary and secondary schools. Given the importance of this role in the P-20 continuum, it is strongly recommended that aggregate student assessment results be used to inform collaborative and continuous improvement efforts for both educator preparation programs and discipline-specific content preparation provided by colleges of arts and sciences. It is further recommended that assessment results be used to inform secondary school curriculum and instruction to align high school and post-secondary student expectations and requirements for successful student transition.

High School / Higher Education Alignment

It is recommended that postsecondary institutions and secondary schools adopt and implement policies and practices that encourage and support collaboration between postsecondary faculty and high school faculty to assure alignment of the expectations for students moving from secondary to post-secondary education. A shared understanding of the content taught and skills developed at each educational level will support educator efforts to support students in a successful transition to and through the next level of learning.

It is recommended that the summer writing workshops bringing together high school and postsecondary writing faculty be reinstituted.

High School Assessments

It is recommended that the state implement common end-of-course and end-of-year assessments to measure student mastery of course outcomes and preparation for college and that the assessment outcomes be utilized to inform educational plans for high school students as they prepare for college and careers. These individualized plans should include course selection and sequencing, supplemental instruction, and academic major/career exploration.

It is recommended that the Early Math Placement Test be reinstituted for all Ohio students

Increasing College Knowledge among High School Students

Sociological researchers emphasize that in addition to measured qualifications, a student's college readiness will be shaped by whether he or she has the information, resources, and skills necessary to effectively navigate the college admission process—college knowledge. College knowledge may contribute to significant disparities in college readiness by income and race and ethnicity, with low-income and minority students facing barriers to college access beyond their qualifications and point to the importance of understanding the college application process, the

financial aid system, and the range of choices within the postsecondary system, as well as being able to navigate these complex processes and systems. Successfully enrolling in college requires such knowledge, which high schools can support by providing norms, information, and guidance about college to their students (Roderick, M., Nagaoka, J., Coca, V., 2009).[7]

It is recommended that high schools and postsecondary institutions collaborate to provide college information to students beginning in the middle grades, and sustaining the effort throughout the high school years. It is recommended that these strategies engage parents and guardians in the communication efforts.

Placement Test Preparation

It is recommended that postsecondary institutions that employ placement exams implement mandatory preparation experiences for placement testing. The preparation sessions should consist of orientation-to-the-test information and a review of math concepts involved in the tests prior to placement testing.

Placement Summit

The recommendations contained within this report constitute expectations and assessment thresholds for a statewide remediation-free guarantee for students. Beyond a remediation-free guarantee, there is a need for an improved statewide placement policy for postsecondary institutions in Ohio. Currently (2012), placement policies throughout the state are widely varied due to the variety of institutional missions across the state.

It is recommended that the Ohio Board of Regents coordinate a statewide placement summit to document current placement policies across institutions and to explore what resources and ideas might be shared to support student success.

[7] Roderick, M., Nagaoka, J., & Coca, V., 2009. College readiness for all: The challenge for urban high schools. *The Future of Children*, 19:1.