Quantitative Reasoning
(mathematical thinking and problem solving)

- Graduation requirement 511 IAC 6-7.1-5
- Courses that count for quantitative reasoning
- Quantitative Reasoning (the course)
  - Definition, description
  - Content
  - College QR courses and dual credit opportunities

Core 40/Math Task Force
September 9, 2014
Graduation Requirements

511 IAC 6-7.1-4 Minimum required and elective credits . . .

(3) Four (4) mathematics credits must be earned after the student enters high school. Mathematics credits earned prior to entering grade 9 may meet specific course requirements but not the credit requirements for graduation. Such credits are considered elective mathematics credits. The purpose of taking mathematics courses before entering grade 9 is to give the student the opportunity to take an additional mathematics course in high school or take a challenging mathematics course in high school over an extended period of time. If the student completes any of the required mathematics courses before entering high school, the student must complete additional mathematics courses in high school. Mathematics credits must include two (2) credits in algebra I or integrated mathematics I unless a student has completed algebra I or integrated mathematics I before entering high school. A minimum of two (2) credits of the mathematics requirement shall be from the mathematics area of study. Two (2) credits may be from:

(A) business technology;
(B) family and consumer sciences;
(C) technology education; or
(D) career-technical;
courses having predominately mathematics content.

(4) A student who enters high school in the 2012-2013 school year or a subsequent school year must earn two (2) mathematics or quantitative reasoning credits during the student’s junior or senior year.

511 IAC 6-7.1-5 Core 40 diploma

Authority: IC 20-19-2-8; IC 20-30-5; IC 20-30-10-2
Affected: IC 20-30-4-2; IC 20-30-5-7

Sec. 5. (a) To be eligible for a Core 40 diploma, a student who enters high school in the 2006-2007 school year or a subsequent school year must complete a minimum of forty (40) high school credits. Thirty-four (34) of the credits shall be earned in the areas of study specified in subsection (b), and six (6) of the credits shall be earned from courses in these and other approved areas of study.

(b) The thirty-four (34) required credits consist of the following:

(3) Mathematics 6 credits

(c) Courses that may be counted toward the required credits prescribed in subsection (b) are subject to the following provisions:

(4) The mathematics requirement is subject to the following:

(A) Mathematics credits must include one (1) of the following course sequences:
   (i) Algebra I, geometry, and algebra II.
   (ii) Integrated mathematics I, integrated mathematics II, and integrated mathematics III.

(B) The student is recommended to earn two (2) mathematics credits during the student’s last year in high school. A student who takes mathematics in the senior year is better prepared for mathematics placement exams upon entering a postsecondary education program, an apprenticeship program, or the military. A student who takes mathematics in the senior year is:
   (i) less likely to require remedial mathematics courses following high school; and
   (ii) more likely to complete a postsecondary program.

(C) A student who enters high school prior to the 2012-2013 school year must earn either:
   (i) two (2) mathematics credits; or
   (ii) two (2) credits in physics;
during the student’s last two (2) years in high school.

(D) A student who enters high school in the 2012-2013 school year or a subsequent school year must earn six (6) mathematics credits after entering high school. Mathematics credits earned prior to entering grade nine (9) may meet specific course requirements and may count towards the credit requirements for a diploma, but six (6) mathematics credits must be earned while in high school.

(E) A student who enters high school in the 2012-2013 school year or a subsequent school year must be enrolled in a mathematics or quantitative reasoning course each year the student is enrolled in high school.

(Indiana State Board of Education; 511 IAC 6-7.1-5; filed Oct 20, 2005, 11:30 a.m.: 29 IR 803; filed Dec 21, 2010, 10:15 a.m.: 20110119-IR-511090383FRA; filed Jan 6, 2012, 10:24 a.m.: 20120201-IR-511110327FRA, eff Jul 1, 2012)
Quantitative Reasoning Graduation Requirement

For the Core 40, Academic Honors (AHD), and Technical Honors (THD) diplomas, students must take a mathematics course or a quantitative reasoning course each year they are enrolled in high school. For the General Diploma, students must earn two credits in a mathematics course or a quantitative reasoning course during their junior or senior year.

Quantitative Reasoning Defined

Quantitative reasoning is knowledge of and confidence with basic mathematical/analytical concepts and operations required for problem solving, decision making, economic productivity and real world applications. Quantitative reasoning will prepare students for an increasingly information-based society in which the ability to use and critically evaluate information, especially numerical information, is central to the role requirements of an informed citizen. Students should acquire the skills necessary to make rational decisions based on real data. Students will be able to report their conclusions in a precise and accurate manner using the language, tools, and symbolism of mathematics. Quantitative reasoning includes:

- mathematics, statistics, algorithms, and formal symbolic logic
- the process of making reasonable estimation, forming conclusion(s), judgment or inferences from quantitative information
- the recognition and construction of valid mathematical models that represent quantitative information
- the analysis and manipulation of models that represent quantitative information
- the drawing of conclusions, prediction or inferences on the basis of this analysis
- the assessment of the reasonableness of conclusions drawn from the data
## Guidelines for courses that count for quantitative reasoning

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Proficiency level</th>
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<tbody>
<tr>
<td><strong>Interpretation</strong>&lt;br&gt;Ability to explain information presented in mathematical forms (e.g., equations, graphs, diagrams, tables, words)</td>
<td>Provides accurate explanations of information presented in mathematical forms. Makes appropriate inferences based on that information. <em>For example, accurately explains the trend data shown in a graph and makes reasonable predictions regarding what the data suggest about future events.</em></td>
</tr>
<tr>
<td><strong>Representation</strong>&lt;br&gt;Ability to convert relevant information into various mathematical forms (e.g., equations, graphs, diagrams, tables, words)</td>
<td>Skillfully converts relevant information into an insightful mathematical portrayal in a way that contributes to a further or deeper understanding.</td>
</tr>
<tr>
<td><strong>Calculation</strong></td>
<td>Calculations attempted are essentially all successful and sufficiently comprehensive to solve the problem. Calculations are also presented elegantly (clearly, concisely, etc.)</td>
</tr>
<tr>
<td><strong>Application / Analysis</strong>&lt;br&gt;Ability to make judgments and draw appropriate conclusions based on the quantitative analysis of data, while recognizing the limits of this analysis</td>
<td>Uses the quantitative analysis of data as the basis for deep and thoughtful judgments, drawing insightful, carefully qualified conclusions from this work.</td>
</tr>
<tr>
<td><strong>Assumptions</strong>&lt;br&gt;Ability to make and evaluate important assumptions in estimation, modeling, and data analysis</td>
<td>Explicitly describes assumptions and provides compelling rationale for why each assumption is appropriate. Shows awareness that confidence in final conclusions is limited by the accuracy of the assumptions.</td>
</tr>
<tr>
<td><strong>Communication</strong>&lt;br&gt;Expressing quantitative evidence in support of the argument or purpose of the work (in terms of what evidence is used and how it is formatted, presented, and contextualized)</td>
<td>Uses quantitative information in connection with the argument or purpose of the work, presents it in an effective format, and explicates it with consistently high quality.</td>
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## Student outcomes from courses that count for quantitative reasoning

<table>
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<tr>
<th>Outcome</th>
<th>Description</th>
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<tbody>
<tr>
<td>Apply math to society</td>
<td>Students will understand how real-world problems and social issues can be analyzed using the power and rigor of mathematical and statistical models.</td>
</tr>
<tr>
<td>Understand math representations</td>
<td>Students will be able to evaluate representation and inferences that are based on quantitative information.</td>
</tr>
<tr>
<td>Interpret math models</td>
<td>Students will be able to interpret mathematical models such as formulas, graphs, and tables, and draw inferences from them.</td>
</tr>
<tr>
<td>Find math answers</td>
<td>Students will be able to estimate and check answers to mathematical problems in order to determine reasonableness, identify alternatives, and select optimal results.</td>
</tr>
<tr>
<td>Use math methods</td>
<td>Students will be able to use arithmetical, algebraic, geometric, and statistical methods to solve problems, but learn to recognize the limitations of mathematics and statistics as well.</td>
</tr>
</tbody>
</table>
Evaluation form for courses that count for quantitative reasoning

Course #: 

Course Title: 

Course Description: 

1. Course meets the Guidelines for a Quantitative Reasoning Course: ☐ Yes ☐ No 

2. Course meets criteria for Student Outcomes for a Quantitative Reasoning Course: ☐ Yes ☐ No 

3. What percentage of your class time will be spent on quantitative reasoning or mathematical topics? Percentage 

4. List the quantitative reasoning or mathematical topics you will be covering in the course: 

5. Give examples of how you will link quantitative reasoning or mathematical topics to non-mathematical disciplinary topics: 

6. What percentage of student assessment will be spent on quantitative reasoning or mathematical skills? Percentage 

7. Explain how a student’s quantitative reasoning proficiency will be evaluated and used in determining the final grade for your course: 

This course must be reviewed by a minimum of one discipline professional and one mathematics professional. 

Name of Reviewer: 
Discipline of Reviewer: 
Date: 

Name of Mathematics Professional Reviewer: 
Date: 

Core 40/Math Task Force 
September 9, 2014, IDOE
Quantitative Reasoning Courses
In November 2011, the State Board of Education passed new graduation requirements that affect incoming freshman in 2012-13.

- For the Core 40, Academic Honors (AHD), and Technical Honors (THD) diplomas, students must take a mathematics course or a quantitative reasoning course each year they are enrolled in high school.
- For the General Diploma, students must earn two credits in a mathematics course or a quantitative reasoning course during their junior or senior year.
- A quantitative reasoning course is a high school course that "advances a student's ability to apply mathematics in real world situations and contexts" and that "deepens a student's understanding of high school mathematics standards."
- The Indiana Department of Education will provide an annual review to determine the high school courses that meet these criteria.
- These courses have been determined to meet the criteria for quantitative reasoning courses for 2013-2014 and 2014-2015.

Advanced Placement (AP)
Biology, AP
Calculus AB, AP
Calculus BC, AP
Chemistry, AP
Computer Science A, AP
Environmental Science, AP
Macroeconomics, AP
Microeconomics, AP
Physics B, AP
Physics C, AP
Statistics, AP

Agriculture
Advanced Life Science, Animals
Agribusiness Management
Landscape Management

Business, Marketing, and Information Technology
Accounting
Business Math
Computer Programming I
Computer Programming II
Global Economics
Financial Services

Engineering and Technology
Aerospace Engineering
Civil Engineering and Architecture
Computer Integrated Manufacturing
Digital Electronics
Engineering Design and Development
Principles of Engineering

Family and Consumer Sciences
Advanced Life Science: Foods

International Baccalaureate (IB)
Chemistry Higher Level, IB
Chemistry Standard Level, IB
Computer Science Higher Level, IB
Computer Science Standard Level, IB
Economics Higher Level, IB
Economics Standard Level, IB
Further Mathematics Standard Level, IB
Mathematical Studies Standard Level, IB
Mathematics Higher Level, IB
Mathematics Standard Level, IB
Physics Higher Level, IB
Physics Standard Level, IB

Science
Chemistry I
Chemistry II
Integrated Chemistry-Physics
Physics I
Physics II

Social Studies
Economics

Trade and Industrial
Advanced Manufacturing II
Architectural Drafting and Design II
Construction Technology: Electrical II
Construction Technology: HVAC II
Electronics and Computer Technology II
Mechanical Drafting and Design II
Precision Machining I
Precision Machining II
Quantitative Reasoning (the course)

Timeline
March 2014 - Researched Quantitative Reasoning (the course) definition and requirements in higher ed
March/April 2014 - Researched role of quantitative reasoning and requirements in high school and higher ed
April 2014 - Reviewed high school courses that count as quantitative reasoning for alignment and math components
April 2014 - Shared mathematics standards and standards resource materials with Dana Center
May 2014 - Shared course materials from Ivy Tech, USI and ISU quantitative reasoning courses
August 2014 - Sent Dana Center draft proposal for Quantitative Reasoning (the course) to teachers for review

Next Steps
September 2014 - Share teacher reviews with the Dana Center
October 2014 - Refine course requirements for Quantitative Reasoning (the course) with the Dana Center
November/December 2014 - Create guidance and resources for teaching Algebra II in ways that would prepare students with knowledge and skills to be prepared for Quantitative Reasoning (the course)

Proposed Learning Outcomes for High School Quantitative Reasoning (the course)

Process standards for mathematics
Outcomes: Students will develop conceptual understanding of mathematical content. Students will synthesize and apply mathematical skills.
PS.1: Make sense of problems and persevere in solving them.
PS.2 Reason abstractly and quantitatively.
PS.3 Construct viable arguments and critique the reasoning of others.
PS.4 Model with mathematics.
PS.5 Use appropriate tools strategically.
PS.6 Attend to precision.
PS.7 Look for and make use of structure.
PS.8 Look for and express regularity in repeated reasoning.

Numeracy
Outcome: Students will develop number sense and the ability to apply concepts of numeracy to investigate and describe quantitative relationships and solve real-world problems in a variety of contexts.
N.1 Demonstrate an understanding of fractions, decimals, and percentages by representing quantities in equivalent forms, comparing the size of numbers in different forms and interpreting the meaning of numbers in different forms.
N.2 Solve problems involving calculations with percentages and interpret the results.
N.3 Demonstrate an understanding of large and small numbers by interpreting and communicating with different forms (including words, fractions, decimals, standard notation, and scientific notation) and compare magnitudes.
N.4 Use estimation skills, and know why, how, and when to estimate results.
N.5 Use dimensional analysis to convert between units of measurements and to solve problems involving multiple units of measurement.
N.6 Read, interpret, and make decisions about data summarized numerically.

**Proposed Learning Outcomes for High School Quantitative Reasoning (the course), continued**

**Number, Ratio, and Proportional Reasoning**
Outcome: Students will draw conclusions and/or make decisions based on analysis and critique of quantitative information using proportional reasoning. Students will also effectively justify conclusions and communicate about their conclusions in ways appropriate to the audience.
NRP.1 Solve real-life problems requiring interpretation and comparison of complex numeric summaries which extend beyond simple measures of center.
NRP.2 Solve real-life problems requiring interpretation and comparison of various representations of ratios, (i.e. fractions, decimals, rate, and percentages).
NRP.3 Distinguish between proportional and non-proportional situations, and, when appropriate, apply proportional reasoning.

**Modeling**
Outcome: Students will draw conclusions and/or make decisions by analyzing and/or critiquing mathematical models, including situations for which the student must recognize underlying assumptions and/or make reasonable assumptions for the model.
M.1 Analyze and critique mathematical models and be able to describe their limitations.
M.2 Use models, including models created with spreadsheets or other tools, to estimate solutions to contextual questions, identify patterns and identify how changing parameters affect the results.
M.3 Choose and create models for bivariate data sets, and use the models to answer questions and draw conclusions or make decisions.
M.4 Analyze real-world problem situations, and use variables to construct and solve equations involving one or more unknown or variable quantities.
M.5 The student uses a variety of network models represented graphically to organize data in quantitative situations, make informed decisions, and solve problems.

**Probabilistic reasoning to assess risk**
Outcome: Students will apply probabilistic reasoning to draw conclusions, to make decisions, to evaluate outcomes of decisions, and to critically evaluate statements involving risk and arguments based on probability.
P.1 Build a finite sample space to model the outcomes of real-world events by determining the nature and number of elements using counting techniques.
P.2 Evaluate claims based on empirical, theoretical, and subjective probabilities.
P.3 Use data displays and models to determine probabilities (including conditional probabilities) and use these probabilities to make informed decisions.

**Statistics**
Outcome: Students will draw conclusions or make decisions and communicate their rationale based on understanding, analysis, and critique of self-created or reported statistical information and statistical summaries.
S.1 Use statistical information from studies, surveys, and polls (including when reported in condensed form or using summary statistics) to make informed decisions.
S.2 Create and use visual displays of data.
S.3 Summarize, represent, and interpret data sets on a single count or measurement variable.
S.4 Use properties of distributions to analyze data and answer questions.