

Appendix D

Item Descriptions Developed During the TIMSS Advanced 2008 Benchmarking

Advanced Mathematics

Items at Intermediate International Benchmark (475)

Algebra

- | | |
|-------|--|
| M2_01 | Rationalizes the denominator in an expression |
| M6_02 | Solves a rational inequality with linear numerator and denominator |

Calculus

- | | |
|-------|--|
| M1_01 | Determines the expression of a function of a function in a simple case |
| M1_04 | Determines the limit of a rational function in x where the numerator and denominator are both quadratic as x tends to infinity |
| M2_03 | Determines the sign of a rational function with numerator and denominator in factored form |

- M3_05 Recognizes from its graph the points where a function is not continuous
- M4_05 Finds the second derivative of a simple function
- M6_04 Determines the limit of a rational function where the numerator and denominator are both quadratic
- M6_05 Differentiates an exponential function with a simple trigonometric exponent
- M6_06 Differentiates a rational function where the numerator and denominator are both linear
- M6_08 Integrates a function of the form $\frac{ax^2 + b}{cx}$

Geometry

- M1_08 Uses properties of an isosceles right triangle to determine the length of a given median
- M2_08 Calculates the difference between vectors in coordinate form
- M3_01 Identifies the three-dimensional figure traced out by a line rotating around another line
- M3_06 Draws and labels the image of a triangle under reflection
- M5_08 Identifies coordinates of the fourth vertex of a parallelogram when three vertices are given

Items at High International Benchmark (550)

Algebra

- M1_02 Analyzes a piecewise-defined function consisting of linear segments to identify its graph
- M1_03 Compares two models given in a word problem by solving a quadratic inequality

- M1_09 Identifies the points with integer coordinates on a graph of a function of the form $y = \frac{a}{x}$
- M4_01 Determines the term in a geometric sequence having a given value
- M4_04 Analyzes steps in a given solution of a simple logarithmic equation and identifies an error
- M5_02 Identifies two constants in a rational function given two points on its graph
- M5_05 Solves a word problem by finding the distance between the points at which a parabola intersects the x -axis
- M6_03 Identifies the graph that represents the relationship between the volume of a sphere and its diameter

Calculus

- M1_06 Differentiates a function of the form $\frac{a}{\sqrt{bx+c}}$
- M2_05 Differentiates an exponential function where the exponent is a simple polynomial
- M3_04 Evaluates the definite integral of a function of the form $y = \frac{ax+b}{x^2}$
- M4_06 Analyzes the graph of a function to determine the sign of its derivative
- M6_07 Justifies a statement about slopes at two points on the graph of a trigonometric function
- M7_06 Analyzes properties of a function and its first and second derivatives to identify its graph
- M7_07 Determines the points of intersection with the x -axis of a simple function of the fourth degree

Geometry

- M1_07 Finds the sum of the slopes of the three sides of an equilateral triangle with one side along the x -axis

M2_07	Identifies the equation of a line through a given point and perpendicular to a given line
M4_09	Evaluates the shortest path between opposite vertices on the surface of a cube
M4_10	Solves a word problem about height given the distance and angle of elevation
M4_11	Uses properties of vectors to analyze equivalence of conditions involving the sum and difference of two vectors
M6_09	Identifies the equation of a circle given its graph
M6_10	Uses basic properties of sine and cosine functions to determine the number of possible solutions of a simple trigonometric equation
M7_10	Identify solutions of a trigonometric equation of the form $\sin(ax)=b$

Items at Advanced International Benchmark (625)

Algebra

M2_02	Calculates the cube of a complex number given in trigonometric form
M3_07	Apply the concept of limit in a word problem about regular polygons
M4_02	Solves a word problem about the number of permutations
M4_03	Solves a word problem comparing dimensions of two cylindrical containers given their volumes
M5_01	Given the first three terms, calculates the sum of an infinite geometric series
M5_03	Solves a straightforward logarithmic equation

- M6_01 Given the first and third terms, calculates the sum of an infinite geometric series
- M7_01 Solves a word problem by finding a certain term of a geometric sequence
- M7_03 Determines the coefficients of a quadratic function given the points of intersection between the graph and the axes
- M7_04 Finds the minimum of a function of a function

Calculus

- M3_05 Recognizes from its graph the points where a function is not differentiable
- M5_06 Given the graph of the derivative of a function, determines the x -values of the maximum point and the point of inflection of the function
- M7_05 Solves a multi-step word problem involving distance as a function of time
- M7_07 Determines the maximum and minimum points of a simple function of the fourth degree
- M7_08 Calculates the definite integral given the graph of a function and the areas between the curve and the x -axis

Geometry

- M2_09 Given two points, identifies an equation that represents the set of all points twice as far from one of the given points as from the other
- M2_10 Uses vector sums and differences to express a relationship among three vectors shown in a figure
- M3_09 Based on the coordinates of the vertices of a given quadrilateral (which is a parallelogram), proves that the diagonals of that particular quadrilateral bisect each other

- M5_09 Given functions of the form $y=a \sin(bx+c)$, compares amplitudes and periods
- M6_11 Solves a multi-step word problem involving trigonometric ratios to identify the length of a side of a regular polygon inscribed in a circle
- M7_11 Given two points on a line and a triangle in a Cartesian plane, uses mathematical properties to determine whether the line is parallel to a side of the triangle

Items above Advanced International Benchmark (625)

Algebra

- M3_08 Specifies the essential steps of a proof by induction
- M5_04 Given one imaginary root, identifies the constant term of a third-degree polynomial with known coefficients
- M7_02 Rationalizes an expression where the denominator is a complex number

Calculus

- M2_06 Maximizes the volume of a cylinder given a relationship between its height and diameter
- M4_07 Solves a multi-step word problem by maximizing the profit given a quadratic cost function and the unit selling price
- M4_08 Calculates the area between the graphs of a linear and a quadratic function
- M5_05 Solves a multi-step word problem by calculating the area between two intersecting parabolas whose equations are given

- M5_07 Determines the vertical line that divides a specified area between a parabola and the x -axis into equal parts
- M7_09 Identifies the indefinite integral of an exponential function where the exponent is a linear polynomial

Geometry

- M3_06 Draws and labels the image of a triangle under rotation
- M5_10 Calculates the two possible lengths of a side of a triangle given an angle and the lengths of two sides that do not include the angle

Physics

Items at Intermediate International Benchmark (475)

Mechanics

- P1_05 Calculates falling distance from rest, assuming negligible air resistance
- P3_03 Uses the relationship between wave speed and wavelength to calculate the wavelength
- P4_02 Identifies a basic property of circular motion, given constant speed
- P7_02 Identifies forces acting on a body thrown up into the air

Electricity and Magnetism

- P1_04 Recognizes the circuit showing resistances that corresponds to given conditions
- P3_01 Orders types of electromagnetic radiation by wavelength
- P4_06 Identifies the meaning of the symbols in a formula

P5_01 Identifies a given range of wavelengths

Heat and Temperature

P2_05 Recognizes a process of energy transfer

P4_08 Applies knowledge of the gas and energy laws in a meteorological situation

P6_02 Selects the best explanation of the greenhouse effect

P7_07 Relates specific heat capacities of different materials to observed phenomena

Atomic and Nuclear Physics

P2_01 Identifies a correct statement about black lines in the spectrum of light

P2_07 Recognizes a statement consistent with the photoelectric effect

P4_10 Identifies the number of protons and neutrons in given isotopes

P7_10 Recognizes the number of neutrons in a nucleus, given its atomic notation

P7_11 Selects the best description of an atomic nucleus

Items at High International Benchmark (550)

Mechanics

P1_01 Interprets oscilloscope readings with regard to pitch and loudness of sounds

P1_03 Applies Newton's Laws to recognize the tension in a string connecting hanging objects

P2_04 Derives an expression for the speed of an object moving in a vertical circular path

- P4_03 Recognizes a situation where mechanical energy is transformed into heat
- P6_04 Applies the energy law to calculate the maximum compression of a spring

Electricity and Magnetism

- P4_04 Recognizes the direction of the electric force on a charged object in an electric field
- P4_05 Applies understanding of series and parallel connections of resistors to compare total resistances
- P5_03 Applies Ohm's Law and the Joule's law to solve a problem about resistance
- P5_04 Recognizes paths of particles in a magnetic field
- P7_05 Draws an arrow from a certain point showing the direction of an electric field from two point charges

Heat and Temperature

- P5_07 Applies knowledge of specific heat to solve a problem of transfer of energy
- P6_03 Identifies the type of electromagnetic radiation related to the temperature of a heat-emitting body

Atomic and Nuclear Physics

- P1_02 Uses the law of radioactive decay to calculate the half-life of a radioactive element
- P6_10 Recognizes that the nucleus of an atom is very small relative to the size of the entire atom

Items at Advanced International Benchmark (625)

Mechanics

- P3_07 Uses a graph of experimental data about a falling object to calculate the value of acceleration due to gravity.
- P4_01 Selects the graph that best represents variation of potential energy of a moving body
- P5_05 Solves a problem by using the characteristics of free fall
- P7_01 Applies Newton's third law of motion to compare the size of forces
- P7_04 Interprets a graph and applies the definition of momentum to solve a problem

Electricity and Magnetism

- P1_06 Applies Coulomb's law to find a point where the net force from two charges on a third charge is zero
- P1_09 Analyzes changes in ammeter and voltmeter readings in a complex circuit diagram
- P2_06 Identifies the direction of the force on a current-carrying conductor in a given magnetic field
- P2_08 Analyzes a complex circuit diagram to solve a power consumption problem
- P5_02 Interprets a current-by-resistance graph to calculate the internal resistance of a battery
- P6_06 Identifies mutual electric forces acting on two charged particles
- P6_09 Recalls that glass absorbs ultraviolet light

Heat and Temperature

- P4_07 Applies the gas laws to solve a straightforward problem

- P5_08 Applies coefficients of linear expansion to compare the lengths of two rods of different materials
- P6_01 Applies knowledge of heat conduction in different materials
- P7_08 Identifies the range of temperatures at which electromagnetic radiation is visible

Atomic and Nuclear Physics

- P2_03 Applies knowledge of how Rutherford's scattering experiment worked
- P2_09 Recognizes the effect of a nuclear reaction on the atomic and mass numbers of an atom
- P4_11 Completes the equation for a nuclear reaction
- P5_11 Applies knowledge of radioactive decay in the solution of word problems
- P6_11 Recognizes a basic explanation of beta decay in a radioactive isotope
- P7_12 Writes the symbol for a particular atomic nucleus given the number of its protons and neutrons

Items above Advanced International Benchmark (625)

Mechanics

- P2_02 Applies Newton's third law to identify forces on two interacting spring balances
- P5_06 Demonstrates knowledge of the most fundamental principle of relativity
- P6_05 Uses Newton's second law and the law of gravity to solve a problem involving planetary motion

P7_03 Uses the law of conservation of momentum to formulate and solve a multi-step word problem

Electricity and Magnetism

- P3_04 Applies the principle of equilibrium of electrical and gravitational forces acting on a charged object to calculate the electric field strength
- P3_06 Shows that the period of revolution of a charged particle in a magnetic field is independent of its speed
- P6_07 Demonstrates understanding of the effect of two point charges on a third charge when the positions of the first two charges are interchanged
- P6_08 Recognizes that a laser beam can cause damage because the beam stays highly concentrated
- P7_06 Describes a procedure to demonstrate electromagnetic induction

Heat and Temperature

- P3_02 Calculates final temperature when two materials of different temperatures are brought together
- P4_09 Interprets a nonroutine problem situation and explains that an object in temperature equilibrium gains heat at the same rate as it loses it
- P5_09 Applies knowledge of light absorption in a problem situation about observed color
- P5_10 Interprets a nonroutine problem situation and relates wavelengths of light to the temperature of the emitting body

P7_09 Interprets a complex problem situation and applies the gas laws and Dalton's law of mixtures to calculate pressure

Atomic and Nuclear Physics

P3_05 Applies Einstein's equation for the photoelectric effect to explain whether electrons will be emitted from different metals



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Lynch School of Education, Boston College



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