

# **Appendix D**

## **Item Descriptions Developed During the TIMSS Advanced 2008 Benchmarking**

### **Advanced Mathematics**

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#### **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**

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### **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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