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About the Charles A. Dana Center at The University of Texas at Austin

The Dana Center develops and scales math and science education innovations to support educators, administrators, and policy makers in creating seamless transitions throughout the K–14 system for all students, especially those who have historically been underserved.

We work with our nation’s education systems to ensure that every student leaves school prepared for success in postsecondary education and the contemporary workplace—and for active participation in our modern democracy. We are committed to ensuring that the accident of where a student attends school does not limit the academic opportunities he or she can pursue. Thus, we advocate for high academic standards, and we collaborate with local partners to build the capacity of education systems to ensure that all students can master the content described in these standards.

Our portfolio of initiatives, grounded in research and two decades of experience, centers on mathematics and science education from prekindergarten through the early years of college. We focus in particular on strategies for improving student engagement, motivation, persistence, and achievement.

We help educators and education organizations adapt promising research to meet their local needs and develop innovative resources and systems that we implement through multiple channels, from the highly local and personal to the regional and national. We provide long-term technical assistance, collaborate with partners at all levels of the education system, and advise community colleges and states.

We have significant experience and expertise in the following:

- Developing and implementing standards and building the capacity of schools, districts, and systems
- Supporting education leadership, instructional coaching, and teaching
- Designing and developing instructional materials, assessments, curricula, and programs for bridging critical transitions
- Convening networks focused on policy, research, and practice

The Center was founded in 1991 at The University of Texas at Austin. Our staff members have expertise in leadership, literacy, research, program evaluation, mathematics and science education, policy and systemic reform, and services to high-need populations. We have worked with states and education systems throughout Texas and across the country. For more information about our programs and resources, see our homepage at www.utdanacenter.org.

About the Dana Center Mathematics Pathways

The Dana Center Mathematics Pathways (DCMP) is a systemic approach to improving student success and completion through implementation of processes, strategies, and structures based on four fundamental principles:

1. Multiple pathways with relevant and challenging mathematics content aligned to specific fields of study
2. Acceleration that allows students to complete a college-level math course more quickly than in the traditional developmental math sequence
3. Intentional use of strategies to help students develop skills as learners
4. Curriculum design and pedagogy based on proven practice

The Dana Center has developed curricular materials for three accelerated pathways—*Statistical Reasoning*, *Quantitative Reasoning*, and *Reasoning with Functions I* and *Reasoning with Functions II* (a two-course preparation for Calculus). The pathways are designed for students who have completed arithmetic or who are placed at a beginning algebra level. All three pathways have a common starting point—a developmental math course that helps students develop foundational skills and conceptual understanding in the context of college-level course material.

In the first term, we recommend that students also enroll in a learning frameworks course to help them acquire the strategies—and tenacity—necessary to succeed in college. These strategies include setting academic and career goals that will help them select the appropriate mathematics pathway.

In addition to the curricular materials, the Dana Center has developed tools and services to support project implementation. These tools and services include an implementation guide, data templates and planning tools for colleges, and training materials for faculty and staff.

Acknowledgments

The development of the Dana Center Mathematics Pathways curricular materials began with the formation of the **DCMP Curricular Design Team**, who set the design standards for the curricular materials of individual DCMP courses. The team members are:

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The Dana Center then convened faculty from each of the DCMP codevelopment partner institutions to provide input on key usability features of the instructor supports in curricular materials and pertinent professional development needs. Special emphasis was placed on faculty who need the most support, such as new faculty and adjunct faculty. The **Usability Advisory Group** members are:

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1.D	1.D	Functions <i>Identify when one quantity is a function of another quantity</i> <i>Identify when one quantity is not a function of another quantity</i>	10	9	20	1.D
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Lesson 2: Working with Inputs and Outputs						
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2.B	2.B	Processes <i>Identify input values (independent variable) and output values (dependent variable) of functions described with words, formulas, tables, and graphs</i>	24	19	34	2.B
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Lesson	Preview Assignment	Lesson Title and Description	In-Class Activities with Answers	In-Class Activities (Student)	Lesson Planning Suggestions	Practice Assignment
Lesson 3: Exploring Linear, Exponential, and Periodic Models						
3.A	3.A	Linear Population Growth <i>Write a linear function, given its starting value and rate of change</i> <i>Determine whether a linear function is increasing or decreasing from its graph, or from a table of values</i> <i>Use and interpret function notation</i>	41	31	49	3.A
3.B	3.B	Models of Exponential Growth and Decay <i>Find the percent rate of change of an exponential function</i> <i>Write a formula for an exponential function, given its starting value and percent rate of change</i> <i>Calculate the average rate of change of a function over a given interval</i> <i>Determine whether an exponential function is increasing or decreasing from its equation, from its graph, or from a table of values</i>	47	37	54	3.B
3.C	3.C	Models With Periodic Functions <i>Identify the period of a periodic function</i> <i>Use the period to predict future values of a periodic function</i> <i>Identify intervals over which a periodic function is increasing or decreasing</i> <i>Calculate the average rate of change of a periodic function over a given interval</i> <i>Interpret and use function notation</i>	51	41	61	3.C
3.D	3.D	Comparing Linear, Exponential, and Periodic Functions <i>Decide whether a given function appears to be linear, exponential, or periodic</i> <i>Predict future behavior of linear, exponential, and periodic functions</i>	55	45	66	3.D
3.E	-	Forming Effective Study Groups <i>Describe how to form and conduct an effective study group</i> <i>Identify key characteristics of effective study groups</i>	61		71	-

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Lesson 4: Exploring Logarithmic Models						
4.A	4.A	Introduction to Piecewise Defined Functions <i>Graph a piecewise defined function, given data tables and/or algebraic descriptions of the function on two or more intervals</i> <i>Write the equation of a piecewise defined function, given the equations that describe its behavior on each interval</i>	63	51	76	4.A
4.B	4.B	Interpreting the Behavior of Logarithmic Functions <i>Use various representations of a new function to calculate its average rate of change over different intervals</i>	67	55	81	4.B
4.C	-	Interpreting the Behavior of Logarithmic Functions (Continued) <i>Use various representations of a logarithmic function to calculate its average rate of change on given intervals</i>	73	59	87	4.C
4.D	4.D	Investigating Other Functions <i>Calculate and interpret average rates of change on given intervals</i>	78	63	91	4.D
Lesson 5: Modeling Constant Change						
5.A	5.A	Linear Functions and Equations <i>Identify a linear relationship using rate of change</i> <i>Use information about constant rate of change and initial value to write a linear equation</i>	83	67	97	5.A
5.B	5.B	Linear Functions and Equations (Continued) <i>Identify linear relationships using multiple representations, including graphical representations, tabular representations, and verbal descriptions</i> <i>Create new functions by using the output values of one function as the input values to a second function</i>	88	71	102	5.B

Lesson	Preview Assignment	Lesson Title and Description	In-Class Activities with Answers	In-Class Activities (Student)	Lesson Planning Suggestions	Practice Assignment
5.C	5.C	Straight Talk About Lines <i>Use the slope-intercept formula to find the equation of a line, given information about the slope and vertical intercept of that line</i> <i>Use the point-slope formula to find the equation of a line, given information about the slope of that line and a point lying on the line</i>	94	75	108	5.C
5.D	5.D	Straight Talk About Lines (Continued) <i>Use information about two points on a line to find the equation for that line</i> <i>Use information about a point on a line and its slope to find the equation of the line</i>	99	79	113	5.D
Lesson 6: Making Predictions with Lines						
6.A	6.A	Slope and Intercept <i>Determine the sign of the slope and vertical intercept of a linear function based on the graph of the function</i> <i>Determine the relative sizes of the slope and vertical intercept of a linear function based on the graph of the function</i> <i>Graphically estimate the solution of a linear equation</i>	104	83	118	6.A
6.B	6.B	Golfing on the Moon <i>Determine the exact formula for reversing a linear formula</i>	109	87	124	6.B
6.C	6.C	Finding Intersections of Lines <i>Determine the exact intersection point of two lines</i>	112	89	129	6.C
6.D	6.D	Graphing With Technology <i>Plot functions using a graphing calculator or app</i> <i>Adjust the viewing window to see the important features of the graph</i> <i>Calculate specific output values of a function using a graphing device</i> <i>Find the coordinates of important points on a graph using a graphing device</i>	115	91	135	6.D
Lesson 7: Modeling with Two Lines						
7.A	7.A	Solving Systems of Linear Equations Graphically <i>Find the intersection of two lines using graphing technology</i>	119	95	143	7.A

Lesson	Preview Assignment	Lesson Title and Description	In-Class Activities with Answers	In-Class Activities (Student)	Lesson Planning Suggestions	Practice Assignment
7.B	7.B	Determining the Number of Solutions <i>Determine the number of solutions of a system of two linear equations</i>	123	99	148	7.B
7.C	7.C	Solving Systems Using Substitution <i>Use substitution to solve a system of linear equations algebraically</i>	129	103	155	7.C
7.D	7.D	Elimination by Addition <i>Solve a system of equations using elimination by addition</i>	133	107	160	7.D
7.E	7.E	Maximum Heart Rate <i>Solve a system of equations using an appropriate method</i> <i>Interpret the solution of a system within the given context</i>	138	111	164	7.E
Lesson 8: Using Matrices to Find Solutions (Optional)						
8.A	8.A	Matrices and Linear Systems <i>Represent a linear system with a matrix</i> <i>Reconstruct a linear system from a matrix</i>	141	113	168	8.A
8.B	8.B	Row Echelon Form <i>Set up a linear system to solve an application problem</i> <i>Use row operations to put a matrix into row echelon form</i> <i>Solve a linear system from a matrix in row echelon form</i>	145	117	173	8.B
8.C	8.C	Strategies for Solving Linear Systems <i>Use row operations to put an augmented matrix into row echelon form</i> <i>Interpret linear systems that have no solutions or infinitely many solutions</i>	149	121	177	8.C
Lesson 9: Modeling with Curves						
9.A	9.A	Quadratic Functions <i>Multiply two linear factors to obtain a formula for a quadratic function in standard form</i> <i>Compute the first and second differences of a function</i> <i>Interpret the first and second differences of a function in the context of a problem</i>	152	123	181	9.A

Lesson	Preview Assignment	Lesson Title and Description	In-Class Activities with Answers	In-Class Activities (Student)	Lesson Planning Suggestions	Practice Assignment
9.B	9.B	Properties of Quadratic Functions <i>Use graphing technology to find the vertex and intercepts of a quadratic function</i> <i>Use graphing technology to find the input values that correspond to a given output value</i> <i>Interpret quadratic functions in the context of a model</i>	158	127	187	9.B
9.C	9.C	Unit Cost <i>Recognize quadratic functions by their numerical and graphical properties</i> <i>Show that a function is a quadratic by simplifying its formula</i> <i>Apply the quotient rule for exponents</i>	164	133	192	9.C
Lesson 10: Shifting, Scaling, and Inverting Quadratic Functions						
10.A	10.A	Transformations of Quadratic Functions <i>Apply shifts and scales to a quadratic function to fit a model</i> <i>Locate the vertices and horizontal intercepts of certain quadratic functions</i>	169	137	197	10.A
10.B	10.B	Composing and Inverting Transformations <i>Apply a sequence of transformations to a quadratic function</i> <i>Invert a sequence of transformations</i> <i>Identify a sequence of transformations to get from one quadratic function to another</i>	174	141	204	10.B
10.C	10.C	Modeling With Quadratic Functions <i>Translate between the different forms of a quadratic function</i> <i>Choose the appropriate form of a quadratic function to answer questions about a model</i>	179	145	210	10.C
10.D	10.D	Solving Quadratic Equations <i>Solve quadratic equations using the quadratic formula</i> <i>Factor quadratic expressions</i>	182	147	215	10.D
10.E	10.E	Rates of Change and Total Change <i>Deriver a formula for a function that represents the area under a line</i> <i>Interpret total change and rate of change in the context of a model</i>	187	151	220	10.E

Lesson	Preview Assignment	Lesson Title and Description	In-Class Activities with Answers	In-Class Activities (Student)	Lesson Planning Suggestions	Practice Assignment
Lesson 11: Exploring Inverse Relationships						
11.A	11.A	Reversing a Quadratic Function <i>Write a formula for the inverse of a function of the form $f(x)=ax^2$ Graph the resulting square root function</i>	190	153	225	11.A
11.B	11.B	The Inverse of a Linear Function <i>Use composition to decide whether two linear functions are inverses of one another Find the inverse of a linear function Use tabular data to discuss the existence of inverse functions</i>	195	157	230	11.B
11.C	11.C	The Inverse of a Quadratic Function <i>Identify ways to restrict the domain of a quadratic function in order to make it one-to-one Find the inverse of a quadratic function (given an appropriate domain restriction)</i>	199	161	237	11.C
11.D	11.D	What Is a Meter? <i>Find the inverse of a square root function</i>	204	165	243	11.D
11.E	11.E	How Fast? <i>Estimate the instantaneous rate of change for a given function</i>	210	169	250	11.E

Lesson	Preview Assignment	Lesson Title and Description	In-Class Activities with Answers	In-Class Activities (Student)	Lesson Planning Suggestions	Practice Assignment
Lesson 12: Modeling with Power Functions						
12.A	12.A	Introduction to Power Functions <i>Evaluate and graph power functions</i> <i>Compare and contrast different power functions</i>	215	173	255	12.A
12.B	12.B	Introduction to Power Functions (Continued) <i>Evaluate power functions with negative exponents</i> <i>Describe changes in inputs and outputs of power functions</i> <i>Solve equations involving power functions</i>	220	177	261	12.B
12.C	12.C	Illuminance <i>Identify graphs of power functions</i> <i>Compute and describe the rate-of-change behavior functions with negative integer exponents</i> <i>Solve equations involving power functions</i>	225	181	267	12.C
Lesson 13: Working with Volume and Optimization Models						
13.A	13.A	Graphing Polynomial Functions <i>Use a graphing calculator or app to view the graphs of polynomials, setting viewing windows appropriately</i> <i>Use a graphing calculator or app to investigate the features of the graph of a polynomial</i>	229	185	272	13.A
13.B	13.B	Building Polynomial Models <i>Given a list of roots, construct a formula for a polynomial with those roots</i> <i>Apply shifts and scales to fit a polynomial to a model</i> <i>Multiply polynomials</i>	233	189	278	13.B
13.C	13.C	Optimization <i>Construct a polynomial function to model the volume of certain objects</i> <i>Use models to decide what the optimal dimensions of a container should be</i>	237	193	283	13.C
13.D	13.D	Strategies for Factoring Polynomials <i>Find factors of a polynomial</i> <i>Convert a polynomial from standard form to factored form</i>		197	288	13.D

Lesson	Preview Assignment	Lesson Title and Description	In-Class Activities with Answers	In-Class Activities (Student)	Lesson Planning Suggestions	Practice Assignment
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14.B	14.B	Average Rates of Change (Continued) <i>Derive a formula for a function given the average rate of change of a polynomial function</i>	249	205	298	14.B
14.C	14.C	Modeling with Polynomial Functions <i>Use a graphing calculator or app to investigate the graphs of polynomial functions, choosing an appropriate viewing window</i> <i>Make decisions by interpreting a polynomial model</i>	252	207	303	14.C
14.D	14.D	Modeling with Polynomial Functions (Continued) <i>Compose functions in the context of a model</i> <i>Calculate or estimate the total change of a quantity given a graph of its rate of change versus time</i>	256	209	308	14.D
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15.A	15.A	Fractional Exponents <i>Rewrite an expression that contains radicals by using fractional exponents</i> <i>Apply the rules of exponents to simplify an expression containing fractional exponents</i> <i>Evaluate and interpret expressions written with fractional exponents</i>	262	213	313	15.A
15.B	15.B	Functions With Fractional Exponents <i>Evaluate and interpret simple expressions containing fractional exponents</i> <i>Find an inverse for a function with fractional exponents</i>	267	217	318	15.B
15.C	15.C	Graphs of Functions With Fractional Exponents <i>Identify and describe properties of a graph, such as increasing or decreasing, or opening upward or downward, using intervals in the domain</i>	271	221	324	15.C

Lesson	Preview Assignment	Lesson Title and Description	In-Class Activities with Answers	In-Class Activities (Student)	Lesson Planning Suggestions	Practice Assignment
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16.B	16.B	End Behavior of Rational Functions <i>Describe the behavior of a rational function for large input values</i>	282	229	336	16.B
Lesson 17: Exploring Asymptomatic Behavior						
17.A	17.A	Vertical Asymptotes <i>Locate the vertical asymptotes on the graph of a rational function using algebra</i> <i>Interpret the behavior of a rational function near its vertical asymptotes in the context of a model</i>	289	231	342	17.A
17.B	17.B	Behavior Near Vertical Asymptotes <i>Find the vertical asymptotes and zeros of a rational function using algebra</i> <i>Interpret the behavior of a rational function on intervals near its vertical asymptotes and holes in the context of a model</i>	293	235	347	17.B
17.C	17.C	Vertical Asymptotes vs. Holes <i>Find all the discontinuities of a rational function and determine which ones correspond to vertical asymptotes</i> <i>Interpret the meaning of vertical asymptotes and holes in the context of a model</i>	299	239	352	17.C
17.D	17.D	Strategies for Understanding Vertical Asymptotes <i>Determine the behavior of the graph of a function on both sides of a vertical asymptote using algebra</i> <i>Sketch the graphs of rational functions near vertical asymptotes without using a calculator or app</i> <i>Find a formula for a rational function to match a given graph</i>	303	243	357	17.D

Lesson	Preview Assignment	Lesson Title and Description	In-Class Activities with Answers	In-Class Activities (Student)	Lesson Planning Suggestions	Practice Assignment
Lesson 18: Modeling with Rational Functions						
18.A	18.A	You're Getting Very Sleepy... <i>Use the leading terms in the numerator and denominator of a rational function to predict the long-term behavior of the function</i> <i>Use limit notation to describe the behavior of a rational function for large values of its input</i>	309	247	363	18.A
18.B	18.B	Reducing Pollution <i>Write an equation for the horizontal asymptote of a rational function</i>	313	251	370	18.B
18.C	18.C	Food Costs <i>Use the equation of a rational function to determine whether the graph of the function has a horizontal asymptote, a slant asymptote, or neither of these</i> <i>If a rational function's graph has a slant asymptote, find the slope of this asymptote</i>	319	255	379	18.C
Lesson 19: Exploring Graphs of Rational Functions						
19.A	19.A	Graphing Rational Functions <i>Identify common limitations in computer-generated graphs of rational functions</i>	324	259	385	19.A
19.B	19.B	Extreme Values of Rational Functions <i>Create a hand-drawn graph with non-constant scale that shows all the features of a rational function</i>	328	263	390	19.B
19.C	19.C	Drug Concentration <i>Use data points to match a model to date</i> <i>Use a model to make predictions</i>	333	267	397	19.C
19.D	19.D	Special Relativity <i>Compute the relative velocity of an object under special relativity</i>	336	269	403	19.D
Lesson 20: Understanding Addition and Composition of Rational Functions						
20.A	20.A	Composition of Rational Functions <i>Compose two functions when one or both of the functions is a rational function</i>	339	273	408	20.A
20.B	20.B	Adding It All Up <i>Add two rational expressions by finding a common denominator</i>	347	287	415	20.B

Lesson	Preview Assignment	Lesson Title and Description	In-Class Activities with Answers	In-Class Activities (Student)	Lesson Planning Suggestions	Practice Assignment
20.C	20.C	Adding Rational Functions <i>Add rational functions to form a new rational function</i>	349	279	421	20.C
20.D	20.D	Adding Rational Functions (Continued) <i>Add two rational functions by finding the lowest common denominator Use graphs and other approaches to explore</i>	353	281	426	20.D
Lesson 21: Comparing Graphs of Functions						
21.A	21.A	Exponential Functions – Revisited <i>Graph exponential functions Identify and compare graphs of exponential functions based on their growth/decay rates</i>	359	285	433	21.A
21.B	21.B	Other Forms of Exponential Functions <i>Calculate the value of an exponential function with a formula involving the number e, particularly when the independent variable has a negative value Reason graphically about rates of change of exponential functions</i>	365	289	439	21.B
21.C	21.C	Comparing Exponential and Linear Functions <i>Reinforcing the basic distinction between exponential and linear models: constant rate of change vs. constant percentage change</i>	371	295	445	21.C
Lesson 22: Interpreting Change in Exponential Models						
22.A	22.A	Half-life and Decay Models <i>Find a formula to measure the average rate of change of an exponential function Classify the behavior of a function that calculates the average rate of change of an exponential function</i>	376	299	451	22.A
22.B	22.B	Doubling Time and Growth Models <i>Write a formula for the average rate of change of an exponential function</i>	379	303	457	22.B

Lesson	Preview Assignment	Lesson Title and Description	In-Class Activities with Answers	In-Class Activities (Student)	Lesson Planning Suggestions	Practice Assignment
22.C	22.C	Comparing Exponential Functions <i>Use information about the constants a and C to describe the shape of the graph of $y = Ca$</i> Compare two exponential functions using information about the initial values and the bases	382	305	462	22.C
Lesson 23: Exploring Other Exponential Models						
23.A	23.A	Newton's Law of Cooling <i>Describe how the temperature of an object is decreasing using newton's Law of Cooling</i>	388	309	469	23.A
23.B	23.B	Drug Accumulation and Exponential Models <i>Check that a function's average rate of change agrees with a given scenario</i>	392	311	474	23.B
23.C	23.C	Surge Functions <i>Calculate the value of a function that contains an exponential factor (surge function)</i> <i>Reason and make decisions in the context of practical applications of surge functions</i>	395	315	480	23.C
Lesson 24: Analyzing Linear Approximations of Exponential Models						
24.A	24.A	Linear Approximations of Exponential Functions <i>Find a formula $f(x)$ for an exponential function given a line tangent to the graph of f and $x = 0$</i> <i>Interpret exponential functions and their linear approximations in the context of a model</i>	399	319	485	24.A
24.B	24.B	Compound Interest <i>Use an exponential model for compound interest to answer questions and make decisions</i>	403	323	491	24.B

Lesson	Preview Assignment	Lesson Title and Description	In-Class Activities with Answers	In-Class Activities (Student)	Lesson Planning Suggestions	Practice Assignment
Lesson 25: Exploring Logistic Growth and Oscillation						
25.A	25.A	The Logistic Function <i>Estimate the carrying capacity parameter for a logistic growth model, based on existing data that represents the early stages of population growth</i>	407	327	496	25.A
25.B	25.B	Decaying Oscillations <i>Determine a formula for an exponential function to match given data</i>	409	329	502	25.B
25.C	25.C	Decaying Oscillations (Continued) <i>Find a formula for a vertically shifted exponential function that matches given data</i>	412	331	509	25.C
25.D	25.D	Charging and Discharging Capacitors <i>Determine the formula for a function composition</i>	416	333	514	25.D
Lesson 26: Inverting Exponential Functions						
26.A	26.A	Inverse Exponentials <i>Estimate input and output values for the inverse of exponential functions Sketch a graph of an inverse to an exponential function</i>	419	337	518	26.A
26.B	26.B	Logarithms <i>Compute the output of logarithm functions</i>	423	339	523	26.B
26.C	26.C	Graphing Logs <i>Graph a logarithm function by hand</i>	427	343	530	26.C
26.D	26.D	Log Laws <i>Use laws of logarithms to expand a single logarithm into a sum or difference of logarithms</i>	431	345	535	26.D
26.E	26.E	Logarithmic Scales <i>Compare inputs and outputs of logarithmic functions Use the laws of logarithms to simplify expressions</i>	436	349	541	26.E

Lesson	Preview Assignment	Lesson Title and Description	In-Class Activities with Answers	In-Class Activities (Student)	Lesson Planning Suggestions	Practice Assignment
Lesson 27: Solving Exponential and Logarithmic Equations						
27.A	27.A	Savings Bonds <i>Solve exponential equations</i> <i>Use the compound interest formula to calculate the doubling time for an investment</i> <i>Estimate the doubling time using the “rule of 72”</i>	441	353	547	27.A
27.B	27.B	How Do You Rank? <i>Solve exponential equations arising from logistic models and interpret the results</i>	446	357	553	27.B
27.C	27.C	Earthquake! <i>Solve equations containing one logarithmic expression</i>	449	359	559	27.C
27.D	27.D	Extraneous Solutions <i>Solve equations containing more than one logarithmic expression</i>	453	363	565	27.D

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