Using OERs and WeBWorK to Support Student Success in Mathematics

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OER Resources for STEM

Name	URL	Cost	Description
CoCalc	cocalc.com	free (optionally pay)	portal to computer algebra system and programming environments (Python/scipy/numpy, Octave, R (statistics), …) provides classroom environment for teaching with computers
GeoGebra	geogebra.org	free	classroom-oriented software for geometry and algebra
Desmos	desmos.com	free	intuitive calculator and grapher

OER Resources for STEM

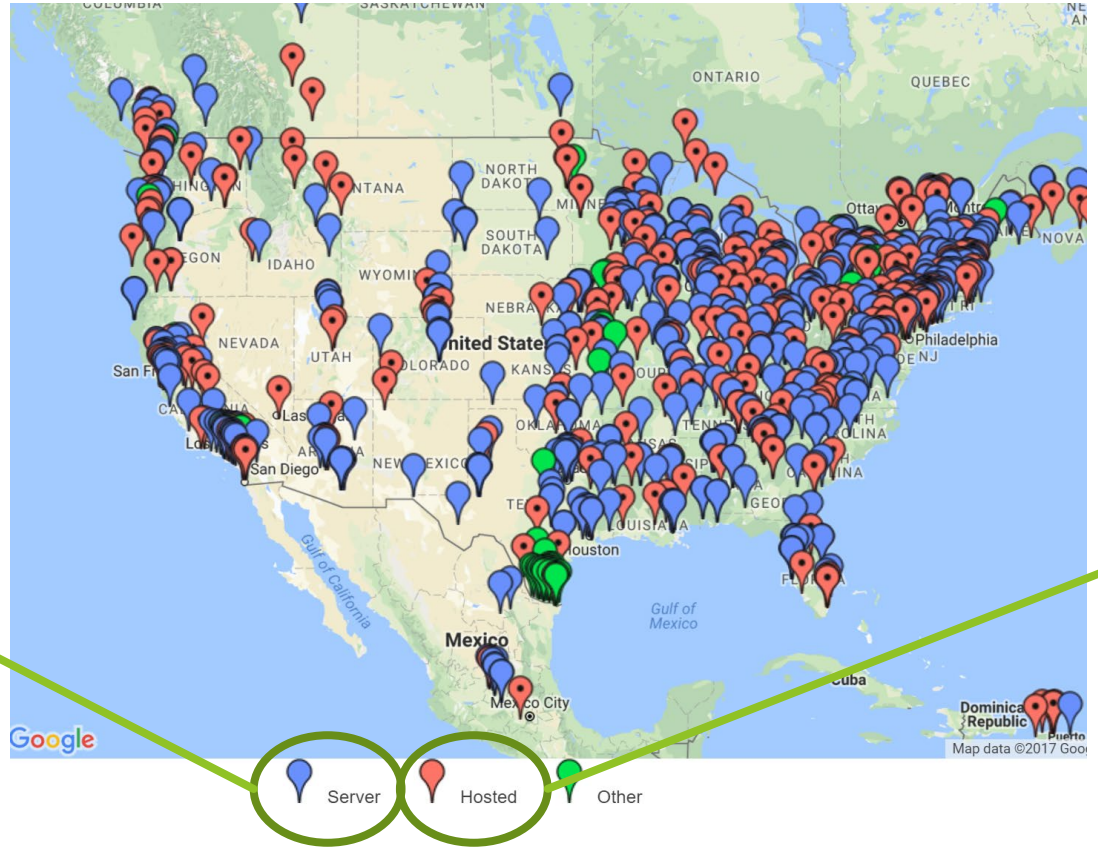
Name	URL	Cost	Description
AIM Math	aimmath.org	free	reviews of free math textbooks
PreTeXT	mathbook.pugetsound.edu	free	PreTeXT system for producing math texts that are readable on many different platforms
WeBWorK	webwork.maa.org	free	free online homework system (mainly math)

Obstacles to Adoption of OER for Mathematics

- Most commercially published textbooks have an (optional) online platform that lets students do homework, take quizzes, remediate skills (sometimes), etc.
- Some faculty are reluctant to adopt OER for Math because of a lack of online HW systems.
- Some free books now have partnered with 3rd party online HW systems, but for a fee to students. (Example: OpenStax & XYZ Homework)

WeBWorK can help meet these needs!

- WeBWorK is an open-source online homework system for math and science classes.



Institutions can host their own server (free for institution and for students)

Or pay a fee per class for MAA hosting (fee is paid by the institution, the platform is still free to students)

What is WeBWorK?

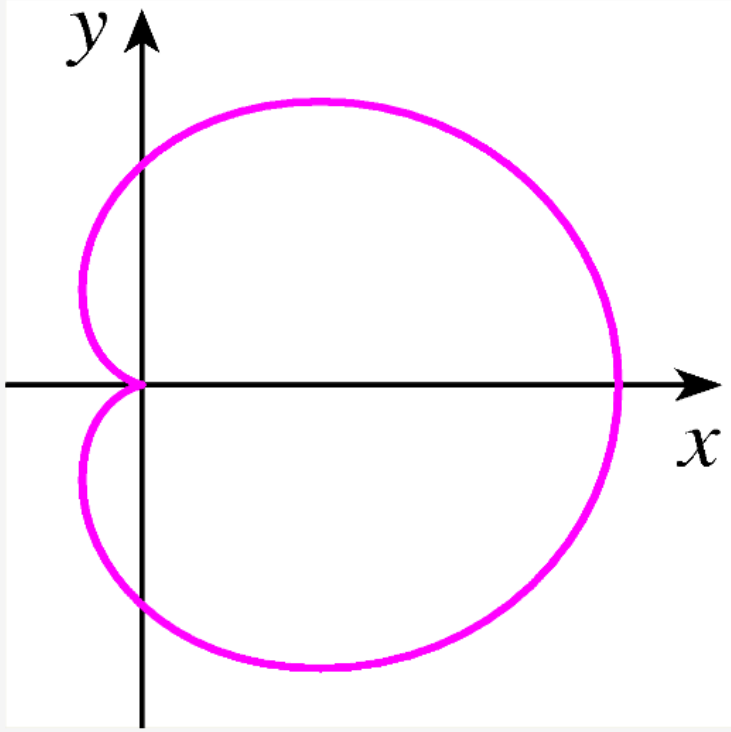
- Free, Open Source: http://webwork.maa.org
- Web-based system for delivering and grading math homework problems
- Grading is done by the system.
- Students receive immediate feedback.
- Works in ordinary web-browser, no plug-ins or other software are required.

Example problem:

Use implicit differentiation to find an equation of the line that is tangent to the curve

$$x^2 + y^2 = (2x^2 + 2y^2 - x)^2$$

at the point $(0, 1/2)$.



(cardioid)

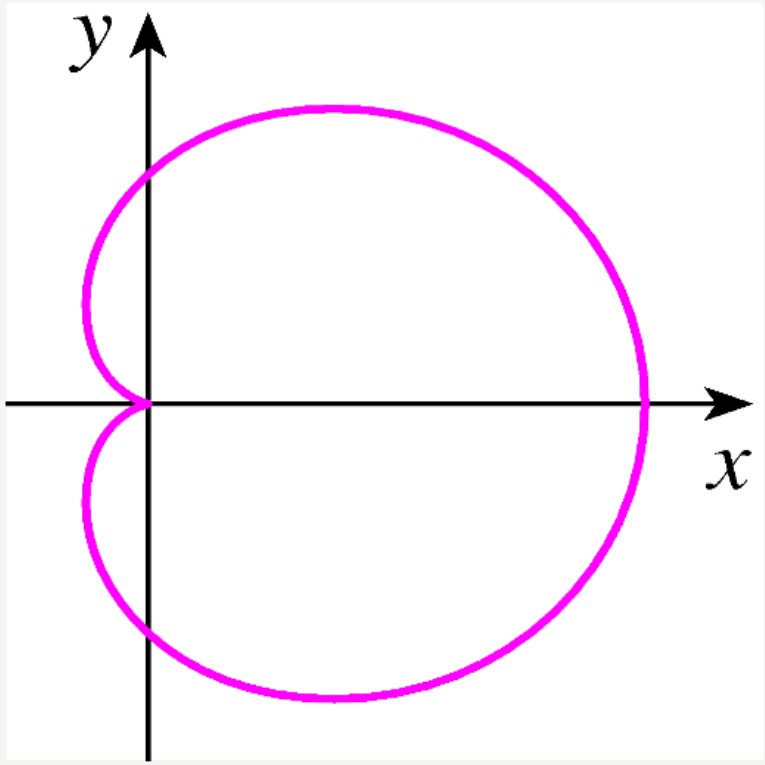
$y =$

Answer Inserted:

Use implicit differentiation to find an equation of the line that is tangent to the curve

$$x^2 + y^2 = (2x^2 + 2y^2 - x)^2$$

at the point $(0, 1/2)$.



(cardioid)

$y =$ x+1/2

Entered	Answer Preview	Result
x+(1/2)	$x + \frac{1}{2}$	correct

The answer above is correct.

- Immediate feedback
- Student may re-submit answer to correct errors (unless instructor prevents this).
- “Email my instructor” button helps students ask questions about a problem. Message includes link to student's view and student's answer to help instructor.

WeBWorK is good for ***drill***.

Formulas in problems and answers may be complicated and may use many variables.

Apply the Laplace operator to the function $h(x, y, z) = e^{3x} \sin(-8y)$.

$\nabla^2 h =$ -55e^(3x)sin(-8y) .

Entered	Answer Preview	Result
-55*[e^(3*x)]*sin(-8*y)	$-55e^{3x} \sin(-8y)$	correct

The answer above is correct.

Problem Sets

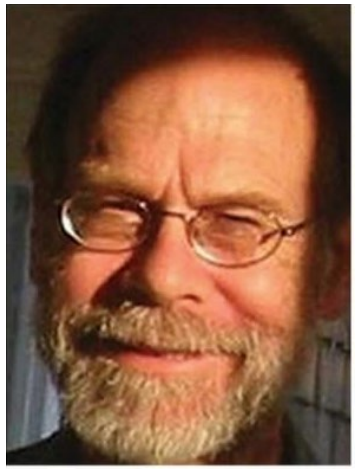
- WeBWorK has a problem library with over 30,000 homework problems in subjects covering topics from basic algebra to some upper division mathematics courses.
- Assignments can be built for no or low cost books, but WeBWorK can also be used as an alternative to fee based platforms for commercially published books.
- Most are algorithmic – different students get different versions of the problem.
- It's easy to modify existing problems, and possible (but not as easy!) to write new problems from scratch.

Benefits of WeBWorK

- Easy, intuitive interface, instructor tools.
- Records grades and keeps statistics on students' performance.
- Very reliable and stable. Has a large group of active users who support and maintain it and answer questions.

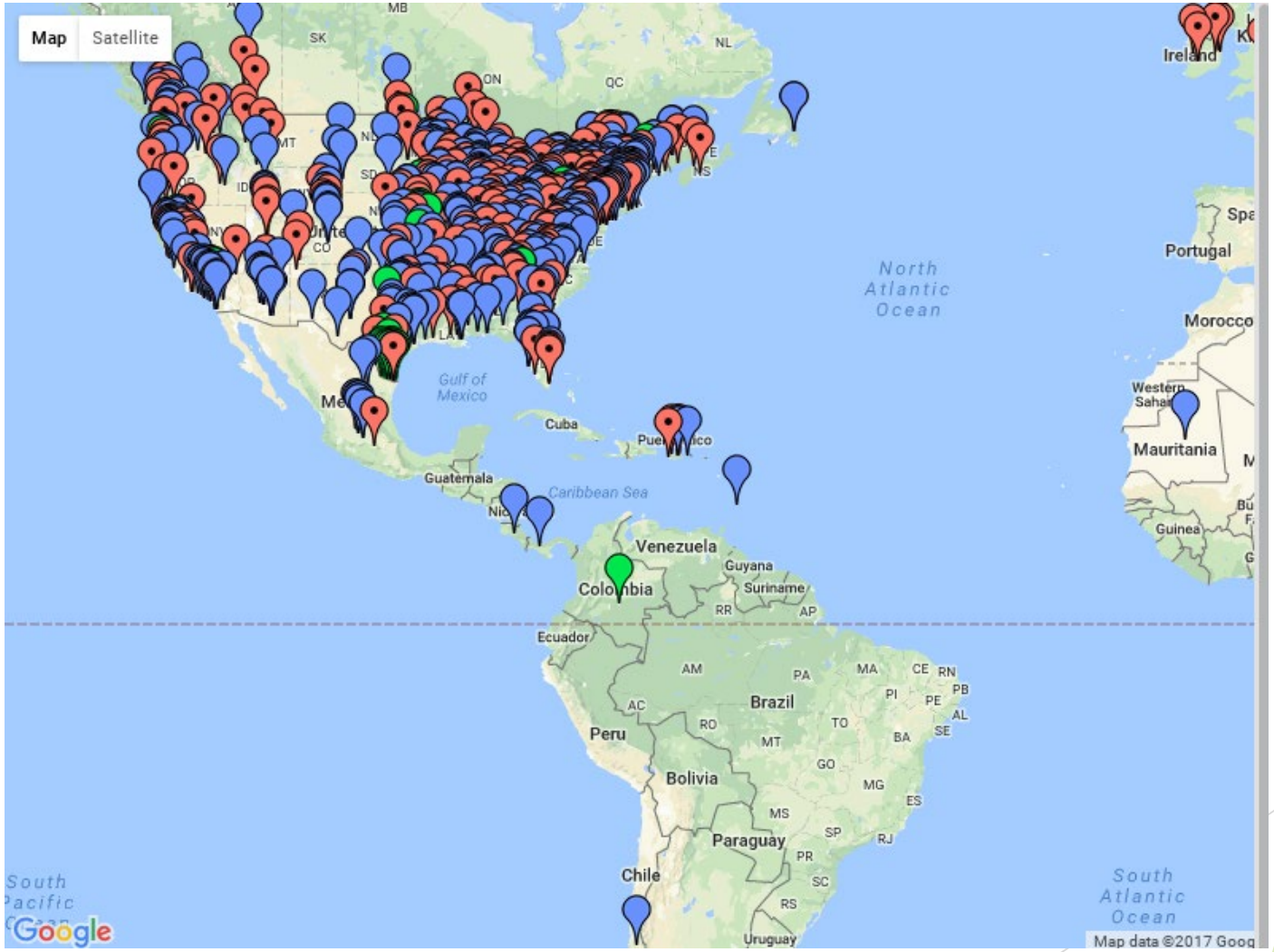
WeBWorK started in the mid 1990's at the University of Rochester.
Developed by U.R. professors

Mike Gage and Arnie Pizer



and maintained and used by a large, active group of volunteers at colleges and universities…

… across the Americas ...



… and around the world.

How We Use WeBWorK at CSUDH

- WeBWorK has been used at CSUDH to build problem sets for free and commercially published books for over 15 years.
- WeBWorK has been used to help students review essential skills for Calculus I
  - Summer Calculus Bootcamp
  - Ongoing Calculus Class Preparation Assignments

Context: About CSUDH

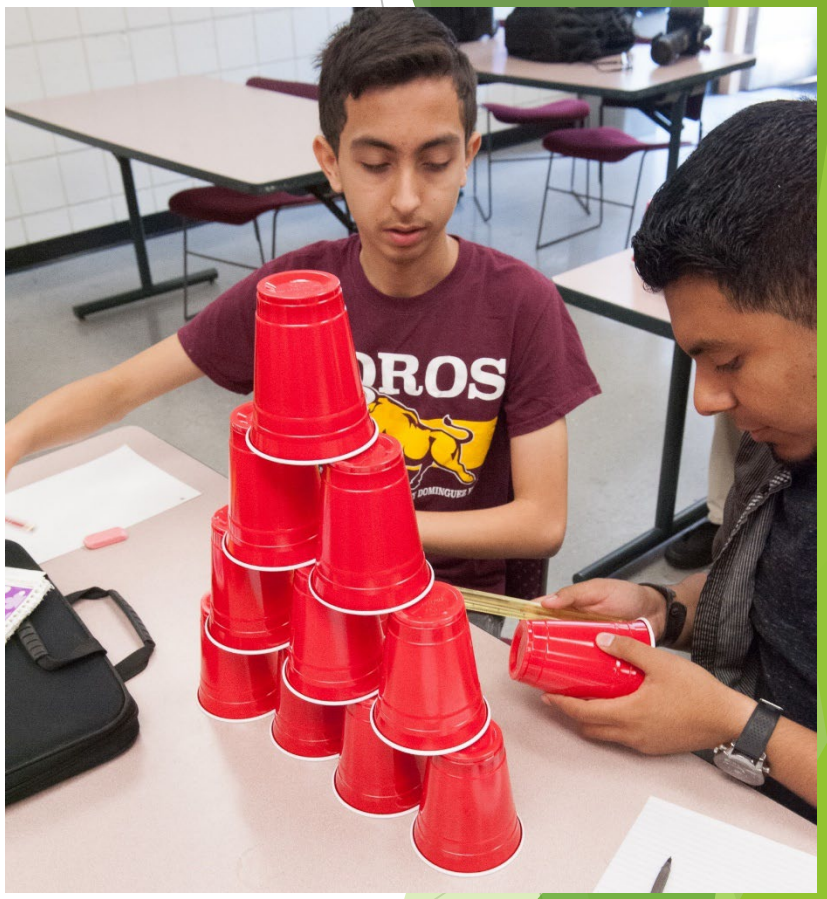
- Located in Carson, CA, south of Los Angeles
- Approximately 15,000 students, 11,000 FTE, over 89% non-white
- About 70% of incoming freshmen require remediation in Math, English or both
- Only a few STEM students enter prepared for Calculus

Using WeBWorK in Calculus Bootcamp

- Population: Incoming Freshmen STEM majors who are college ready (don't need remediation), but did not place into Calculus I based on AP Scores.
- Students can place into Calculus I by passing the Calculus Placement Test (CPT).
- Most students took Pre-Calculus, Calculus I or AP Calculus in 12^{th} grade.
- Our first year offering the CPT, only 30% of students passed and placed into Calculus I.

Calculus Bootcamp

- The second & third years, we required students to come to a two week, 2 hour per day bootcamp to be eligible to take the CPT.
- Bootcamp consisted of problem solving and skills review.
- Skills review consisted of:
  - A brief (less than 15 minutes) review of fundamental concepts or common misconceptions
  - In class lab time (all students could check out a laptop)
  - Webwork assignments with associated videos that students could work on in and outside of class.



In the two years we have been offering the Bootcamp, 43% of attending students have placed into Calculus I.

Bootcamp WeBWorK Review

- 9 WeBWorK assignments, by topic
- Students were given the assignments and a 'help' sheet with videos and 'important information'.

Quadratic Functions Webwork Assignment Help

Topic (Google this!)	Webwork Problems	Online Help
Solve quadratic equations by factoring	1, 2, 4, 5	http://patrickjmt.com/solving-quadratic-equations-by-factoring-basic-examples/
Solve quadratic equations by using the quadratic formula	3	http://patrickjmt.com/solving-quadratic-equations-using-the-quadratic-formula-ex-1/
Solve quadratic equations using the square root	6, 7	https://www.youtube.com/watch?v=RweAgQwLdMs
Complete the square to find the vertex of a parabola	8, 9, 10	https://www.brightstorm.com/math/algebra-2/quadratic-equations-and-inequalities/finding-the-vertex-of-a-parabola-by-completing-the-square-problem-1/
Find the x- and y-intercepts of a function	8	https://www.youtube.com/watch?v=BJydVDCieEc
Interpret quadratic graphs in context	11, 14	https://www.youtube.com/watch?v=1Q-trXLNENI
Solve problems involving the maximum area of rectangles	12	https://www.youtube.com/watch?v=97Y6AwmMKSs
Solve projectile motion problems	13	https://www.youtube.com/watch?v=TzRQSD3iQA4
Solve quadratic inequalities	15, 16	https://www.youtube.com/watch?v=BXWzNp-4ilA
Solve quadratic equations by completing the square	17, 18	https://www.youtube.com/watch?v=xGOQYTo9AKY https://www.youtube.com/watch?v=zKV5ZqYIAMQ

Good to know

Two forms of quadratic functions

Standard form: $f(x) = ax^2 + bx + c$
where the vertex of the parabola is at
$\left(-\frac{b}{2a}, f\left(\frac{-b}{2a}\right)\right)$

Vertex form: $f(x) = a(x-h)^2 + k$
where the vertex of the parabola is (h, k)

Quadratic formula

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

WeBWorK Assignments

Assignments were composed of a mixture of ‘standard’ computational problems

(1 point) **Library/UMN/algebraKaufmannSchwitters/ks_6_4_56.pg**
Solve the following quadratic equation, expressing your solution to the *nearest one-thousandth.*

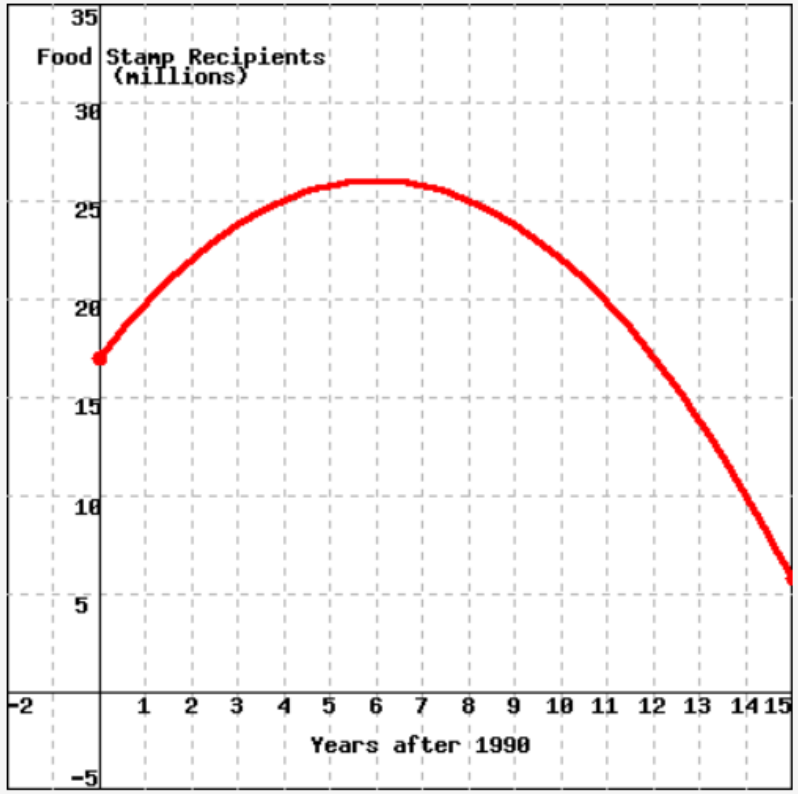
$$x^2 + 6x - 42 = 0$$

Solutions (separate by commas): $x =$

WeBWorK Assignments

Application Problems

(1 point) **Library/CollegeOfIdaho/setAlgebra_05_07_PolyEqAndApplications/57IntAlg_26_PolyEq.pg**



The Food Stamp Program is America's first line of defense against hunger for millions of families. Over half of all participants are children; one out of six is a low-income older adult. The function, $f(x)$, models the number of people, in millions, receiving food stamps x years after 1990. Use the graph of $f(x)$ given above to estimate the answers to the following questions.

a) How many million people received food stamps in the year 2002?

Answer: million

b) In which year(s) did 22 million people receive food stamps?

Note: If there are more than one year, enter the years separated with a comma.

Width:

WeBWorK Assignments

and Conceptual Problems

(1 point) **Library/PCC/BasicAlgebra/GraphingQuadratics/SketchParabola10.pg**
Answer the following questions for the parabola $y = x^2 + 3x + 2$. Then, choose the correct graph.

Use decimals when needed.

This parabola opens up or down? ?

The parabola's axis of symmetry is

The parabola's vertex is at

The parabola's y-intercept is at

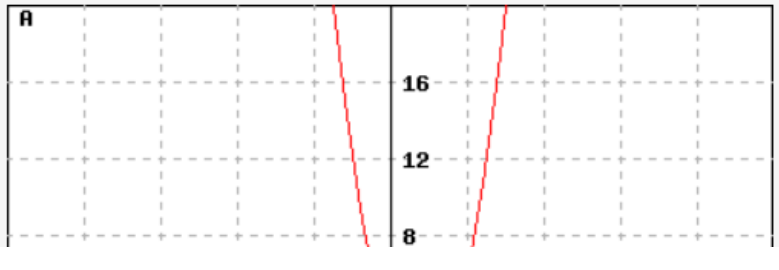
The parabola's x-intercept(s) is/are (Use a comma to separate x-intercepts if needed. If the parabola doesn't have any x-intercept, type **DNE**, meaning "does not exist.")

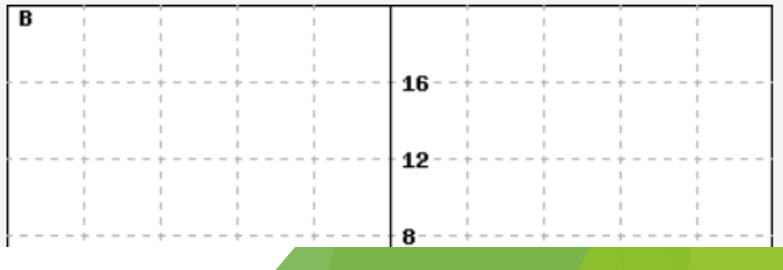
With the above information, choose the correct graph for $y = x^2 + 3x + 2$.

If you would like to enlarge the graph or make numbers and letters easier to read, you may click on it to open it in a new window. You may then enlarge that window with your mouse. To further enlarge the image, use your browser's zoom capabilities. On a PC this is usually **ctrl shift +** (and zooming out is **ctrl -**). On an Apple computer this is usually **apple shift +** (and zooming out is **apple -**).

The correct graph is graph

- A
- B
- C
- D





Results

Summer 2017 completion rates for WeBWorK assignments:

- All students: mean 51.47%, median 49.65%
- Completion by students who passed CPT: mean 67.6%, median 70.4%
- Completion by students who did not pass CPT: mean 40.9%, median 40.4%

Calculus I WeBWorK CPAs for JIT Review

- Class Preparation Assignments for Just In Time Review
- Short (~4 question) assignments that review a specific prerequisite skill that will be used in class THAT DAY
- Students are expected to do the following:
  - Login to WeBWorK and try the assignment. If they can complete it they are done.
  - If they can't complete it try watching the associated videos.
  - If the videos aren't enough help, go to tutoring, office hours, etc.
  - Complete the assignment by the beginning of class the day it's due.

Example: Logarithmic Differentiation

It would be helpful when teaching logarithmic differentiation if students remembered rules of logarithms:

$$\log_a xy = \log_a x + \log_a y$$

$$\log_a x^m = m \log_a x$$

$$\log_a \frac{x}{y} = \log_a x - \log_a y$$

$$\log_a 1 = 0$$

WeBWorK Assignment

(1 point) **Library/maCalcDB/setAlgebra29LogFunctions/srw4_3_17-20.pg**
Evaluate the following expressions.

(a) $\log_2 2^3 =$

(b) $\log_3 81 =$

(c) $\log_5 625 =$

(d) $\log_3 3^3 =$

(1 point) **Library/UCSB/Stewart5_1_6/Stewart5_1_6_40.pg**

Express the given quantity as a single logarithm.
$\ln x + 9 \ln y - 8 \ln z$

WeBWorK Assignment

(1 point) **Library/FortLewis/Algebra/11-1-Intro-to-Logarithms/MCH-11-1-56.pg**
Rewrite the logarithmic expression $\log(AB^5)$ in equivalent logarithmic form. There may be more than one correct answer.

- **A.** $\log(A)(\log(B))^5$
- **B.** $\log(A) + 5\log(B)$
- **C.** $5\log(AB)$
- **D.** $\log(A) + \log(B^5)$
- **E.** $(\log(AB))^5$
- **F.** None of the above

WeBWorK Assignment

(1 point) **Library/maCalcDB/setAlgebra29LogFunctions/srw4_3_15.pg**
Use the Laws of logarithms to rewrite the expression

$$\log\left(\frac{x^{10}y^5}{z^4}\right)$$

in a form with no logarithm of a product, quotient or power.
After rewriting we have

$$\log\left(\frac{x^{10}y^5}{z^4}\right) = A\log(x) + B\log(y) + C\log(z)$$

with

$A =$ [ ]

$B =$ [ ]

and

$C =$ [ ]

WeBWork Assignment

Students are given videos that correspond to the WeBWorK problems that they can use to help review concepts they don't remember:

CPA_Logarithm_Laws

#1: Definition of Logarithm and Evaluating Logarithmic Expressions
https://www.youtube.com/watch?v=0YH8BrlVTqk (Stop at 4:30)

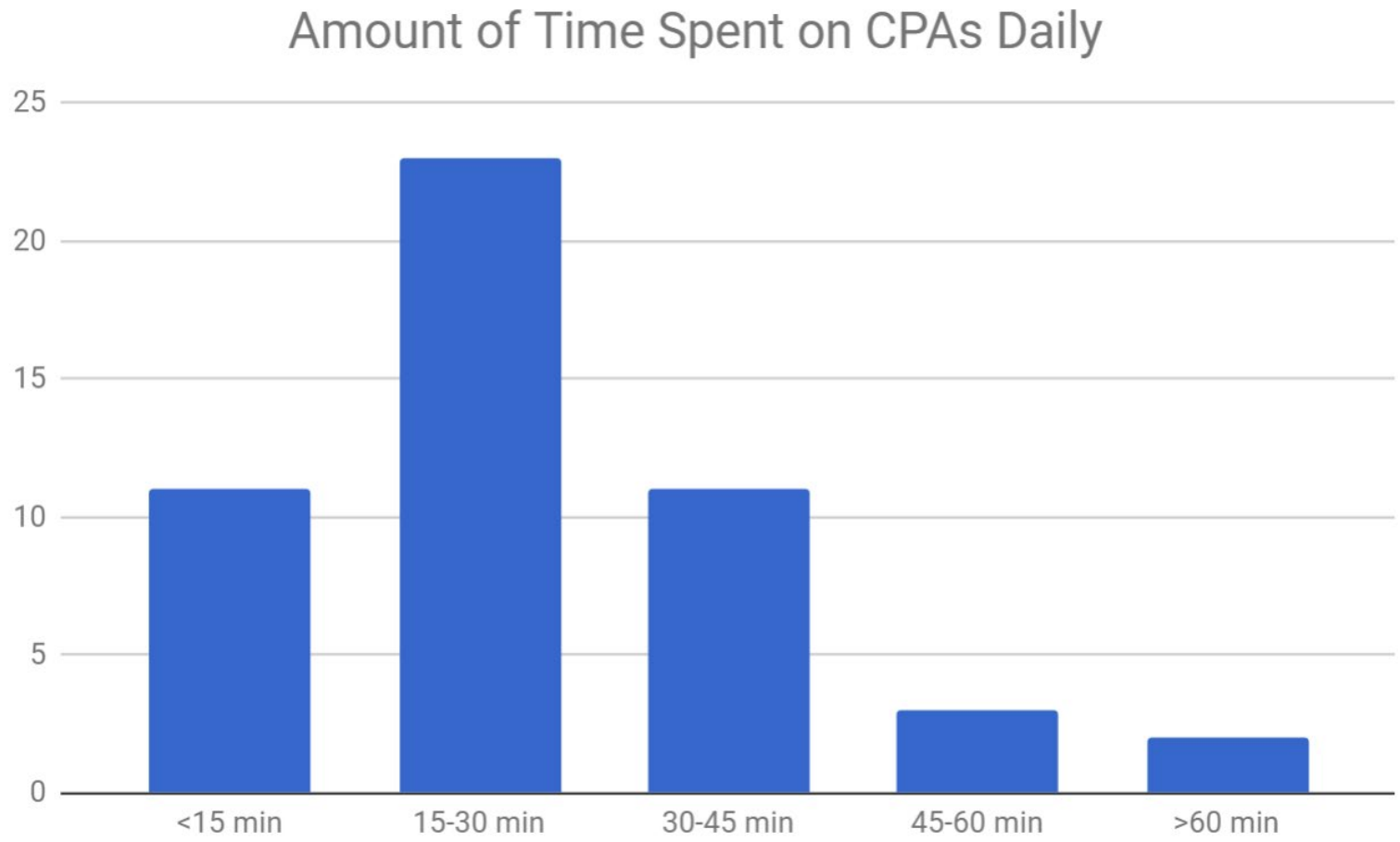
#2-4: Using Logarithm Laws
https://www.youtube.com/watch?v=pP3NunYYhzk (Start at 6:30)

Current Completion Results

Average percentage of all CPAs completed Fall 2017: 76.3%

Median percentage of all CPAs completed Fall 2017: 79.6%

Student Feedback



Student Feedback

Statement	% of Students Answering Agree/Strongly Agree (N=50)
I feel the CPAs help me review important concepts.	72%
I see the topics from CPAs show up in class.	70%
When CPA topics are used in class, I feel confident in my skills on those topics.	64%

Student Feedback

Statement	% of Students Answering Agree/Strongly Agree (N=50)
If I don't know how to do the CPAs, I watch the linked videos.	58%
If I don't know how to do the CPAs, the videos help me figure it out.	44%
If I don't know how to do the CPAs, I go to tutoring/office hours to figure it out.	14%

Where can I obtain WeBWorK?

- http://webwork.maa.org
- Look at the wiki, follow instructions for administrators.
- Or follow instructions for instructors if you just want to see how to use it.
- Fly in the ointment:
- WeBWorK needs a Linux or Unix web-server. If that's not available you can rent WeBWorK or ask someone else to share theirs.