



## Problem Based Learning Courses in Cate Mathematics

Problem Based Learning (PBL) in mathematics provides students with opportunities to construct mathematical understanding and skill through inquiry and exploration. Since 2016, Cate has offered a three-year sequence of honors level PBL courses that integrate algebra, geometry, trigonometry, functions, and calculus, and that emphasize problem solving. Starting in 2022-2023 all 9th grade offerings will be problem based, with two core-level PBL courses in algebra and geometry as well as an honors level course.

### What are the PBL math courses at Cate?

PBL 1 - A first year course in algebra emphasizing connections and depth of understanding, offered to 9th graders.

PBL 2 - integrating geometry, algebra, and functions, usually offered to 9th graders who have not yet taken high school geometry, and to 10th graders who have completed PBL 1.

PBL 2H - integrating advanced topics algebra and geometry and functions, usually offered to 9th graders who have had a traditional geometry course and/or an exceptionally strong algebra 1 background.

PBL 3H - integrating advanced algebra and precalculus, offered to 10th graders and 11th graders who have already completed PBL 2H or PBL 2, and occasionally to exceptionally well-prepared 9th graders.

PBL 4H - an advanced course in calculus offered to 11th or 12th graders who have completed PBL 3H.

All courses use materials developed by the Philips Exeter Academy Math Department.

### How is PBL different from the traditional courses?

Traditionally, a teacher delivers a lesson to explain concepts or demonstrate skills and then assigns problems so students can practice or apply the objectives of that lesson. In Cate's PBL math courses, students explore on their own before discussing an explanation in class the next day. The teacher facilitates group discussion by highlighting important misconceptions, important realizations, and by prompting students to generalize from their solutions. In this way students "discover" mathematical systems through problems rather than being told via lecture.

### Why does Cate teach PBL courses?

A PBL curriculum is an inquiry based curriculum that creates problem-solving scenarios that trigger natural curiosity. A PBL math book has carefully written, carefully placed problems that activate students' prior knowledge, push students to make conjectures and generalizations, to analyze different perspectives, and to synthesize information. It is always easier for students to just write down what the teacher says a rule or pattern is, but the effortful work the students do to construct their understanding leads to long-term learning.

Students learn math, but more importantly, they become adept problem solvers. Content threads are spiraled throughout the PBL text so students are continually engaging with several content areas simultaneously, rather than studying one topic then moving onto the next. Learning is not compartmentalized and therefore students need to decide on their own what tools and knowledge to try as they begin to make sense of each problem. Students develop resilience and creativity as problem solvers, and they learn to communicate their ideas clearly to each other. This focus on problem solving helps students develop the skills they'll need to be successful on standardized tests as well as in the real-world context of the 21st century.

### What will my child's classroom and homework experience be like?

Students are asked to start 8-10 problems every night, and to bring their attempts to solve the problem (complete or not, correct or not) to discuss in class the next day. In class, students share their work on the board using iPads with Apple TV, and talk through specific problem solving strategies, highlight content connections, and seek feedback on alternate methods. Class time is also spent on journaling and group problem solving.

**What will the transition to PBL be like?**

For most students, the PBL approach feels unfamiliar and requires some getting used to. Students will encounter questions they've never seen before and work to find entry points without completing the entire solution. Students will be asked to find multiple methods or explore several pathways before receiving an explanation from their teacher. This change in expectations (from problem completion to problem exploration) is a significant recasting of the math class experience. As they adjust, students will often spend too much time on homework in the early weeks, undergo real frustration, and bump up against small failures. By the end of the first trimester, students learn what they need to do to prepare for class and for assessments, and by the end of the winter trimester, students recognize how much and how deeply they're learning in terms of content, problem solving strategies, and collaboration. In her own words, one student reflected (in April), "While it was difficult with all the crazy transitions, PBL never failed to be the class I looked forward to the most. I have grown to love the creativity and I am always looking forward to showing my cool solutions to the class. [Guided] discussions and have taught me a lot about how flexible math thinking is which has translated into SO many unexpected areas of my life." Students transitioning to PBL benefit from a lot of encouragement and patience.

**What if my child struggles? Will there be support?**

Students will struggle with these problems. The questions are designed to push them to the edge of what they know and can do, and these questions were also designed to be solved in a boarding school environment so there is a lot of support available. Students are encouraged to do their homework with a peer: these problems are often best solved by talking through strategies with a partner. There are also math labs staffed by trained peer tutors three nights of the week, and students may also reach out to meet with their teacher at any time by setting up a meeting that suits both of their schedules. It may also be reassuring to know that the problem sets are written so that similar problems appear several times throughout the curriculum. These multiple exposures give students the chance to re-engage with problems over time, as their content knowledge and skills develop, so that even if they don't master something the first time around, they'll have the opportunity to try again.

**Is there another option besides PBL?**

All 9th graders' first math course at Cate will be PBL courses. After completing PBL 2 or PBL 2H, students may take courses that employ a topical approach (a year each of Algebra 2, Pre-Calculus, Calculus). These courses continue to emphasize student-centered discussion and questioning, mathematical reasoning, communication skills, and achievement toward rigorous learning goals.

**Can a student who starts their Cate math program in PBL 1 or PBL 2 gain access to the honors level courses?**

Yes, after a year in PBL 1 or PBL 2, students will understand what a PBL approach requires from them in terms of time, and energy. The load is heavier in a PBL honors course and the decision to pursue that challenge will be made by the student in consultation with their advisor and math teacher.

**Can a student who starts their Cate math program an honors level PBL course choose a grade-level topics course starting sophomore year?**

Yes, after a year in PBL 2H (or PBL 3H), students will understand what a honors level PBL approach requires from them in terms of time, and energy. A student may opt out of the honors track and will make that decision in consultation with their advisor and math teacher.

**What do students have to say about PBL?**

[PBL 2H Fall 2017 Highlight Reel](#)

[PBL/mathsonthemesa](#) (IG account)

If you have additional questions, please contact your child's teacher or Annalee Salcedo,  
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