

# Mathematical Dominoes

Rules from [<http://www.pfmathcircle.org/gamesDominoes.html>]

The game of Mathematical Dominoes is the most recent addition to the Prime Factor games collection. It quickly became the favorite with our students. <sup>[1]</sup>

- Its rules and format are as interesting and exciting for a 3rd-grader as for a 9th-grader
- It engages each and every student in active problem solving
- It can be played for as long as it is needed and can be stopped at any moment
- It requires very few helpers
- It allows all students to work at their pace and their level

## ***Mathematical Dominoes Rules***

Math Dominoes is a team (or individual) contest in problem-solving. The game is played by several teams of 2 players each. Each team work on problems at its own pace, selecting problem one-by-one from the pool of available problems.

Math Dominoes problems are written on back sides of two-sided cards. The front side of each problem card looks like a domino tile: it has a pair of numbers (domino value) on it. At the start of a game, the circle leader arranges all the cards with problems on the judge's table. The cards are placed dominoes-side up; therefore, the actual problems are hidden from students. Teams start working on the problems at their own pace, selecting problem one-by-one from the pool of available problems. The numbers on the dominoes side of a problem card serve as a predictor of the difficulty level of the problem on this card.

A team earns (or loses) points depending on whether it was able to solve the selected problem. The scoring system works as follows:

- If a team presents the correct solution on the first try, this team is awarded a full score for the problem. The full score is equal to the sum of the two numbers on the domino side of the problem card. For example, if the card shows [5:3] then the team gets  $5+3=8$  points for

the successful first try.

- If a team solves the problem on the second try, this team is awarded a partial score, which is equal to the larger of the two numbers on the domino side of the problem card. For example, if the card shows [5:3] then the team gets 5 points for the problem solved on the second try.
- If the answer presented on the second try was incorrect, the team loses points. The penalty is equal to the smaller of the two numbers on the domino side of the card. For example, a team loses 3 points if it failed to solve a [5:3] problem.
- A [0:0] card is special. A team can present the problem on this card just once. The correct solution brings in 10 points, an incorrect answer is not penalized.

After the team is finished with a problem (either by solving it or by failing to solve it on the second try), it returns the problem card to the pool, and chooses a new problem to work on.

The game stops at some prearranged time. The team that collects the most points wins the game. The length of a game can vary from thirty minutes to an hour and a half depending on time available, age of students, and size of the problem pool.

### ***What makes Math Dominoes so interesting for children?***

One of the most important factors is the presence of an unknown element and, at the same time, of the ability to plan the strategy. How does it work? The problems and their domino values are matched in such a way that the domino side of a card carries a lot of information about expected difficulty of a problem.

Let us compare, for example, the cards with [2:1] and [6:4] domino values. While the maximum reward for the problem on the first card is 3 point, for the second card it is equal to 10 points. Therefore, the problem on the first card should be much easier than on the second card. This example illustrates that the sum of two domino values serves as a good predictor of the difficulty level of a problem.

What about two cards with the same total? Should the difficulty level be the same? Let us look at the [7:1] and [4:4] cards. Each of these

problems, if solved on the first try, would bring 8 points. However, if solved on the second try, the first problem is worth 7 points, and the second one - just 4. Moreover, the penalty is much higher for the second card -- 4 points versus 1 point. If the maximum profit is the same, and the punishment is much higher, what would be the motivation to select the second card? The reason is that the [7:1] problem should be more difficult and risky than [4:4] problem. This example shows how the balance of the two domino values on a card can be used for guessing risk and difficulty level of a problem.

Therefore, it is possible for a team to choose its strategy according to the team's standing and the level of players. There are a lot of ways to accumulate points: it is possible to concentrate on difficult high-risk problems, or to bet on solving a lot of easy ones. It is also possible to adjust of difficulty level based on teams' past performance.

Another very important factor is that Dominoes problems, as all other math circle problems, are interesting, challenging and intriguing.

### ***What makes Math Dominoes so so attractive for teachers?***

First, all children in the classroom are engaged in active problem-solving from the start of the contest till its end. Why is it so? The very important factor is that children work in in small groups. (The best team size is 2.) Moreover, a team should be composed from students of similar strength. This way everyone is an important member of his/her team, nobody stays idle, communication with a peer help a child to stay focused and motivated, and children learn from each other.

Another attractive point of the game is that it can be played in the classroom with students of diverse math abilities. Since a Math Dominoes set contains problems of different levels of difficulty, students can choose the difficulty level that they are comfortable with.

Next, a game can last for as long (or as short) as it is needed, and can be stopped at any moment. The same set of problems would work both for a 30-minutes game, and for an hour and a half game.

Finally, the game is easy to proctor. Extra judges will definitely be needed to help checking student's answers. However, these helpers do

not have to be experienced circle leaders since they will be judging off the list of correct answers.

## ***Detailed Rules***

### **Before the Game**

At the start of the game, all problem cards are arranged domino-side up (and problem side down) at the judges table. The judges are seated around the table; each judge has a list of Dominoes problems with answers. Whenever a team will have an answer ready, it will be able to present it to any of the judges.

The teacher explains the rules of the game and how to use the Score Cards. Score cards, which are described in more details below, are used for keeping track of teams' progress. It is a good idea to remind the students that they should not write or make any marks on the problem cards. (All answers should be entered into the team's score table. If an answer to a problem is a drawing which is too big for the card, the team presents it on a separate piece of paper.)

The teacher splits students into teams and hands out score cards. Each team chooses a name, enters it into the score card, and the game begins.

### **During the Game**

A team chooses a problem card from the pool of the cards on the judges table. It marks problem's number in the Score Card table, and starts working on the problem. When the problem is solved, the team writes the answer in the "First Try" column and presents it to a judge. If the answer is correct, the team earns full score for the problem. Otherwise, the team heads back and keeps working on the problem. When the "second attempt" answer is ready, the team enters it to the "Second Try" column, and presents it to a judge. Depending on whether this answer is correct, the judge either awards the team with partial score, or gives the team a penalty - a negative score. The judge enters points earned (or lost) by the team into the "Problem Score" column of the Score Card table.

One problem can be chosen by several teams one after another. After a

domino card is played by a team, it goes back to the pool of problems. However, while a team works on the problem, no one else has access to this card.

Note that depending on the goal of a specific game (a strict competition or an educational tournament) the teacher may choose to provide limited help to students who are stuck on more difficult problems. The length of a math domino tournament is defined by a teacher. The same set of domino cards can be used for a longer and a shorter game) Five minutes before the end of the game, the judges should invite teams to turn in their last-moment answers. At the same time, the problem cards are removed from the table. Next, the score cards are collected, and the total number of points earned by each team is calculated. The team with the most points wins the game.

### ***Score Cards and Answer Tables***

At the start of the game each team receive a blank Score Card to be used for tracking teams' progress. The Score card has an entry for the team name, and a blank table with four columns:

- Problem Number
- Answer, First Try
- Answer, Second Try
- Points Earned

The first three are to be filled by children, the last one - by a judge. Each judge should have an Answer Table (the list of answers to all the problems). A judge uses an Answer Table to verify correctness of solutions.

### ***Organizational details***

- Enough judges should be available during the game. The good news is that it is easy to recruit judges for a math domino game. Since the judges use an answer table to verify answers, some of the judges can be “unqualified” -- they don't have to know solutions.
- How many judges are needed for a smooth game? In our classes, two or three judges would comfortably handle 8 teams of students.
- Out of all judges, at least one should be “qualified.” He or she should be

able to answer student's questions and to give occasional problem hints to struggling teams.

- It is a good practice for judges to be spread around the room. If all judges are seated at one table, this table will become overcrowded with students willing to present the answers.
- One of the judges should have an extra duty of supervising the problem cards table. If cards are left unsupervised, curious children may start peeking at the problems.
- A team should be composed of students of a similar level. (In an unbalanced team, only the faster kid will be problem-solving.)
- The Math Dominoes game can be played as a team game or an individual game. We recommend playing it with 2-student teams. (It is fine to have an occasional team of 3 or of 1.)

### ***How to make two-sided domino problem cards***

We arrange problems in a table, one row per problem. The table has three columns: the first one for problem number, the second one - for text, and the third one - for problem domino values. Each of the "problem text" and "domino values" columns should be approximately half-page wide.

We print the table, and cut out the strips with problems (together with their numbers and their domino value) along the dividing lines. Afterwards, we fold each problem strip along the line that separates the problem text and its domino value. The result is a two-sided card with the problem number and text on one side, and domino value on another.