Mathematical Rock, Paper, Scissors
Concept Paper

Overview

Everyone knows the classic game of Rock, Paper, Scissors (RPS). It seems like it has been around since before time itself. Part of the fun of RPS is in the challenge to try and find patterns in what your opponents will throw. If they do rock three times in a row, will they throw rock a forth?

Now, the Institute of Competition Sciences (ICS) is exploring putting a new educational spin on this game. Instead of just using your logic to try to predict your opponent's next throw, you will use math. In this new "Mathematical RPS" two teams will compete against each other in a match of 200 RPS rounds. Each team will present three equations at the beginning of the match defining values for Rock, Paper, and Scissors based on the round number (1 to 200). The other team then tries to beat their opponent by determining the functions they used at the beginning of the match. The team that determines the functions earliest, and who can use them to predict what their opponent will throw in later rounds will score more points and win the match.

ICS is opening the opportunity for public comment on the rules for the Mathematical RPS tournaments until February 28th. We look forward to collaborating with our community make a great new educational opportunity to engage and excite students about math. Our goal is to launch the tournaments online with the 2019-20 school year. Please take a moment to review the draft rules noted below, and provide input through our [online Google Form](#) to help us make the best educational RPS challenge possible.

Mathematical RPS Objectives:
This program will help students:
1. Improve comprehension of mathematical formulas
2. Improve understanding of algebraic, trigonometric, and other mathematical functions
3. Improve math modeling skills
4. Improve pattern recognition skills

Definitions:
- Match = when two teams are play against each other through a group of 200 RPS rounds at the end of which teams are scored for their tournament points.
- Set = a group of 20 RPS rounds.
- Round = a pair of RPS throws, one from each team, either Rock, Paper, or Scissors that are pitched against each other to determine a winner for the round.
- Throw = what a team posts for a single match. Throws are either rock, paper, or scissors.

Level 1: Qualifying

Five Matches are posted online. In each match, students are given a series of 200 RPS throws from an opponent. The data about the throws is not release to the team all at once, but rather in sets of 20. So in the first set, the team only sees their opponent's throws for rounds 1-20. In the second set, they see the data for rounds 21-40, etc... The RPS throws of the team's opponent are based on three equations that define values for "Rock," "Paper," and "Scissors." For each round, the variable that has the highest value between these three will be the one that is thrown. The team must try to identify the equations as quickly as possible to predict the next throws. Teams are scored at the end of the match based on how many wins and ties they have against the mathematical RPS opponent (3 points for a win, 1 point for a tie). Teams must be able to beat at least 3 out of 5 of the rounds in order to qualify for a tournament.

Level 2: Tournaments

Teams
1. Teams will be 2 to 3 students.
2. Team members can be from multiple organizations, but must be able to participate in tournament play together.

Tournament Play
3. Each match is played between two teams pitted against each other through one RPS match (group of 200 rounds).
4. At the beginning of the match, each team submits three equations defining a value for each type of throw. Equations can only use the round number as a variable.
5. For each round, the highest value between each team's three equations becomes their throw (rock, paper, or scissors).
6. A preliminary set (round #s 1-20) is run to provide an initial dataset for the teams to use to try to determine the equations of their opponent.
7. Teams have 5 minutes to study their opponent's data from the preliminary 20 rounds, by the end of which they will submit 3 equations into play against their opponent's original equations. Note that the team does not play against their opponent's new equations. Through all of the match sets they are playing against their opponent's original equations.
8. After submitting their equations into play, the second set of 20 rounds is played where team 1's set equations are played against Team 2's original equations, and Team 2's set equations are played against Team 1's original equations. Scores for the set are then tabulated based on how well each team's set equations performed against their opponent's original equations.
9. Between each Set the teams have 5 minutes to analyze that set's throws from their opponent's original equations and submit updated equations for the next set.
10. At the end of each Set, scores are updated, and the data from that set's 20 rounds are provided to the teams.
11. At the end of the last Set and conclusion of the Match, the team with the highest score wins.
12. Tournament points for the league are awarded based on the difference between the points at the end of each set.

Scoring
13. Scores will be updated after each set, but tournament points are awarded at the end of the full match of 200 rounds.
14. Each win is 3 points.

15. Each tie is 1 point.
16. At the end of 10 sets the team points are tabulated and the difference is found between the two team's scores. The team with the higher score is awarded the difference as tournament points.
17. The maximum points a team can receive each round is 60 (20 wins * 3points/win).

Delay of game
18. If a team does not submit their updated equations for a round after a 5 minute analysis period, they will cause a delay of game. For each 30 second delay, they lose 10 points from that round. So if they delay for 3 minutes, they lose all possible points for the round (negative points are not possible).

Equation Requirements
19. Equations cannot use random number functions

Tournament Example

In this game, Team Abe plays Team Zara. The variable "X" is representing the match number. To start the game, Team Abe and Team Zara each submit the following equations.

Team Abe Equations	Team Zara Equations
R = COS(X) P = SIN(X) S = SIN(X)/COS(X)	R = 1+COS(X) P = 1/COS(X) S = 1/COS(X)+2*SIN(X)

Once the equations are submitted the preliminary round of matches is run (match #s 1-20). The data from this round is provided to each team for analysis. In this example, each team would receive the following table about the results of their opponent's equations.

Match	R	P	S	Throw		R	P	S	Throw
		Team Abe					Team Zara		
1	0.540	0.841	1.557	S		1.540	1.851	3.534	S
2	-0.416	0.909	-2.185	P		0.584	-2.403	-0.584	R
3	-0.990	0.141	-0.143	P		0.010	-1.010	-0.728	R
4	-0.654	-0.757	1.158	S		0.346	-1.530	-3.043	R
5	0.284	-0.959	-3.381	R		1.284	3.525	1.607	P
6	0.960	-0.279	-0.291	R		1.960	1.041	0.483	R
7	0.754	0.657	0.871	S		1.754	1.326	2.640	S
8	-0.146	0.989	-6.800	P		0.854	-6.873	-4.894	R
9	-0.911	0.412	-0.452	P		0.089	-1.098	-0.273	R
10	-0.839	-0.544	0.648	S		0.161	-1.192	-2.280	R
11	0.004	-1.000	-225.951	R		1.004	225.953	223.953	P
12	0.844	-0.537	-0.636	R		1.844	1.185	0.112	R

13	0.907	0.420	0.463	R		1.907	1.102	1.942	S
14	0.137	0.991	7.245	S		1.137	7.313	9.295	S
15	-0.760	0.650	-0.856	P		0.240	-1.316	-0.016	R
16	-0.958	-0.288	0.301	S		0.042	-1.044	-1.620	R
17	-0.275	-0.961	3.494	S		0.725	-3.634	-5.557	R
18	0.660	-0.751	-1.137	R		1.660	1.514	0.012	R
19	0.989	0.150	0.152	R		1.989	1.011	1.311	R
20	0.408	0.913	2.237	S		1.408	2.450	4.276	S

The teams then have 5 minutes to analyze this information about their opponent's equations. Before the end of the 5 minutes, each team must submit their three equations to play against their opponent's original equations for the 2nd round (matches 21-40).

Team Abe thinks they that they see Zara has a simple periodic function for Rock, but recognize that the functions are more complex for P and S. So they decide they're going to play these equations for Round 2:

R = COS(X)
P = 1/SIN(X)
S = 1/SIN(X) + 2

Team Zara reviews Abe's data and decided similarly that there are periodic functions for both Rock and Paper, but something different for Scissors. So they decide to play:

R = COS(X)
P = SIN(X)
S = 1/SIN(X)

Remember that these equations continue to be played against the other team's original equations. Not the new ones for the round. This produces the following matches for Round 2 (Matches 21-40):

Match	Team Abe (Original)					Zara's Play Against Abe			
	R	P	S	Throw		R	P	S	Throw
21	-0.548	0.837	-1.527	P		-0.548	0.837	1.195	S
22	-1.000	-0.009	0.009	S		-1.000	-0.009	-112.978	P
23	-0.533	-0.846	1.588	S		-0.533	-0.846	-1.182	R
24	0.424	-0.906	-2.135	R		0.424	-0.906	-1.104	R
25	0.991	-0.132	-0.134	R		0.991	-0.132	-7.556	R
26	0.647	0.763	1.179	S		0.647	0.763	1.311	S
27	-0.292	0.956	-3.274	P		-0.292	0.956	1.046	S
28	-0.963	0.271	-0.281	P		-0.963	0.271	3.691	S
29	-0.748	-0.664	0.887	S		-0.748	-0.664	-1.507	P
30	0.154	-0.988	-6.405	R		0.154	-0.988	-1.012	R
31	0.915	-0.404	-0.442	R		0.915	-0.404	-2.475	R
32	0.834	0.551	0.661	R		0.834	0.551	1.813	S
33	-0.013	1.000	-75.313	P		-0.013	1.000	1.000	S

34	-0.849	0.529	-0.623	P		-0.849	0.529	1.890	S
35	-0.904	-0.428	0.474	S		-0.904	-0.428	-2.335	P
36	-0.128	-0.992	7.750	S		-0.128	-0.992	-1.008	R
37	0.765	-0.644	-0.841	R		0.765	-0.644	-1.554	R
38	0.955	0.296	0.310	R		0.955	0.296	3.374	S
39	0.267	0.964	3.615	S		0.267	0.964	1.038	S
40	-0.667	0.745	-1.117	P		-0.667	0.745	1.342	S

Because this is Zara's play against Abe, we're only counting the score for Team Zara here. Zara won 8 matches and tied 7. So they got a score of 3*8 + 1*7 = 31 for that round.

Now we show how Team Abe fared against Zara's original equations:

| | Team Abe's Play against Zara | | | | | Team Zara Original | | | |
Match	R	P	S	Throw		R	P	S	Throw
21	0.408	1.095	3.095	S		0.452	-1.826	-0.152	R
22	-0.548	1.195	3.195	S		0.000	-1.000	-1.018	R
23	-1.000	-112.978	-110.978	R		0.467	-1.877	-3.569	R
24	-0.533	-1.182	0.818	S		1.424	2.357	0.546	P
25	0.424	-1.104	0.896	S		1.991	1.009	0.744	R
26	0.991	-7.556	-5.556	R		1.647	1.546	3.071	S
27	0.647	1.311	3.311	S		0.708	-3.423	-1.510	R
28	-0.292	1.046	3.046	S		0.037	-1.039	-0.497	R
29	-0.963	3.691	5.691	S		0.252	-1.337	-2.664	R
30	-0.748	-1.507	0.493	S		1.154	6.483	4.507	P
31	0.154	-1.012	0.988	S		1.915	1.093	0.285	R
32	0.915	-2.475	-0.475	R		1.834	1.199	2.302	S
33	0.834	1.813	3.813	S		0.987	-75.320	-73.320	R
34	-0.013	1.000	3.000	S		0.151	-1.178	-0.120	R
35	-0.849	1.890	3.890	S		0.096	-1.107	-1.963	R
36	-0.904	-2.335	-0.335	S		0.872	-7.815	-9.798	R
37	-0.128	-1.008	0.992	S		1.765	1.306	0.019	R
38	0.765	-1.554	0.446	R		1.955	1.047	1.640	R
39	0.955	3.374	5.374	S		1.267	3.750	5.678	S
40	0.267	1.038	3.038	S		0.333	-1.499	-0.009	R

So team Abe scored 4 wins and 3 ties for 15 points.

After Round 2 (matches 21-40) Team Zara is winning with 31 points to Abe's 15.

Now the teams have another 5 minutes to study the new data and modify the equations they play against their opponent's original set.
Tea Abe now realizes that they might be on a good track, but that they might have the equations backward a bit. They look at rounds 33-37 and see that they have all losses there. A lot of their loses came when they played S and Zara played R. So that want to switch that round. So Team Abe decides to just switch P and S.

R = COS(X)
P = 1/SIN(X) + 2
S = 1/SIN(X)

Giving the following results for Team Abe's Round 3 against Zara's original equations.

Match	Team Abe's Play against Zara					Team Zara Original			
	R	P	S	Throw		R	P	S	Throw
41	-0.667	3.342	1.342	P		0.013	-1.013	-1.330	R
42	-0.987	-4.304	-6.304	R		0.600	-2.500	-4.333	R
43	-0.400	0.909	-1.091	P		1.555	1.801	0.138	P
44	0.555	0.798	-1.202	P		2.000	1.000	1.036	R
45	1.000	58.491	56.491	P		1.525	1.904	3.605	S
46	0.525	3.175	1.175	P		0.568	-2.314	-0.510	R
47	-0.432	3.109	1.109	P		0.008	-1.008	-0.761	R
48	-0.992	10.092	8.092	P		0.360	-1.562	-3.099	R
49	-0.640	0.698	-1.302	P		1.301	3.327	1.419	P
50	0.301	0.952	-1.048	P		1.965	1.036	0.512	R
51	0.965	-1.811	-3.811	R		1.742	1.347	2.688	S
52	0.742	3.492	1.492	P		0.837	-6.135	-4.162	R
53	-0.163	3.014	1.014	P		0.082	-1.089	-0.297	R
54	-0.918	4.526	2.526	P		0.171	-1.206	-2.323	R
55	-0.829	0.210	-1.790	P		1.022	45.194	43.195	P
56	0.022	1.000	-1.000	P		1.853	1.172	0.129	R
57	0.853	0.083	-1.917	R		1.900	1.111	1.984	S
58	0.900	4.293	2.293	P		1.119	8.391	10.376	S
59	0.119	3.007	1.007	P		0.229	-1.297	-0.023	R
60	-0.771	3.571	1.571	P		0.048	-1.050	-1.660	R

So Abe scored really well on this round with 14 wins and 4 ties for 46 points!

Zara also updates their equations at this point and are pretty certain they know Abe's original equations for R and P were COS and SIN functions. But they aren't quite sure of the S function yet. They know it is related to the inverse of R, so they try:

R = SIN(X)
P = COS(X)
S = 1/COS(X)

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The play continues like this through the 10 rounds. Scores are tabulated at the end, and the high score wins.