High School Challenge '16

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More information on Mathematical Puzzle Programs may be found at our website `http://mappmath.org` and on our Twitter @MaPPmath. Happy mathematical puzzling!

- MaPP Directors and Volunteers

High School Challenge ’16

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Special Thanks

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High School Challenge '16

MaPP HSC16
Overview and Rules

We're challenging you with an abundance[1] of puzzles to solve today! Good luck everyone!

Schedule

Here's an overview of the schedule for the day (specific times vary by location).

- Registration: _____
- Orientation: _____
- Opening Puzzle: _____
- Main Puzzles: _____
- Solutions Due: _____
- Wrap-up, Awards, and Dismissal: _____

Opening "Puzzle"

It's not a puzzle! Or is it? We'll explain soon enough. If your school turned in a correct solution to the HSC16 teaser puzzle, then your team will have a 90 second head start on this mysterious challenge.

You'll want to find a solution to this conundrum as quickly as you can... finishing within half an hour will earn your team 100 Victory Points, and you'll immediately gain access to your Team Headquarters and five new puzzles. After thirty minutes have passed, this challenge will end and all remaining teams can move on to the rest of today's puzzles (but will not earn any Victory Points).

Main Puzzles

After finishing the opening challenge, you'll receive a packet of five Main Puzzles. Work with your teammates on each puzzle to decode a hidden message. For each correct solution you report to Game Headquarters, your team will earn 100 Victory Points.

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[1] Fun fact! An abundant number is a number whose factors (besides itself) add up to more than itself! For example, $1, 2, 3, 4, 6, 12$ are the factors of 12, and $1 + 2 + 3 + 4 + 6 = 16 > 12$. Wait, you didn't think that fact was very fun? Maybe it'll come in handy anyway...

EXTRA Puzzles

Five EXTRA Puzzles are hidden across your host campus! You'll need to use the Campus MaPP, along with the solutions to the Main Puzzles, to figure out where they are. When you think you know, check with Game HQ before heading out to collect them.

Each EXTRA Puzzle is an added challenge based on the Main Puzzle which unlocked it. Your goal is to optimize your solution as much as possible, because the team(s) which submit today's best solution for each to Game HQ before the end of the competition will earn an extra 50 Victory Points.

The Metapuzzle

What metapuzzle? :-) We will not confirm nor deny an additional hidden puzzle behind the scenes, but if it existed, it'd be worth an additional 150 Victory Points for any team which submits the correct solution to Game HQ before the end of competition.

End of the Game

All solutions to Puzzles, EXTRA Puzzles, or anything else are due at Game HQ at the time designated by the local director; players not in line at Game HQ to submit a solution will be turned away after that time.

All players and teachers/chaperones from each team must be present for the wrap-up ten minutes after the game ends to be eligible for awards.

Winning the Game

The team which has earned the most Victory Points by the end of the competition is the winner. If two teams are tied for the same number of points, then the team which solved the five Main Puzzles quickest will be ranked higher. As an example:

	Team Alpha	Team Beta	Team Gamma
Opening Puzzle	solved at 12:05	solved at 12:15	solved at 12:10
Puzzle 1	**solved at 3:00**	-	solved at 2:00
Puzzle 2	solved at 2:30	solved at 2:15	-
Puzzle 3	solved at 2:00	solved at 2:30	**solved at 2:45**
Puzzle 4	-	solved at 2:40	solved at 2:00
Puzzle 5	solved at 2:45	-	solved at 2:15
Extra Puzzle 1	best solution	-	-
Extra Puzzle 2	-	best solution	-
Extra Puzzle 3	-	best solution	-
Extra Puzzle 4	-	-	-
Extra Puzzle 5	-	-	best solution
Victory Points	450	400	450
Ranking	2nd	3rd	1st

Additional Rules

- The main rule is to be a good sport! Players should not do anything which would interfere with other teams playing the game.
- Teachers and chaperones are not allowed help players solve puzzles. However, if the teams have any questions about how to interpret a puzzle, you should relay those questions to the organizers.
- Computers, smartphones, and the internet are not allowed to be used during the competition.
- Contact the game organizers in case of emergencies or any issues with these rules.

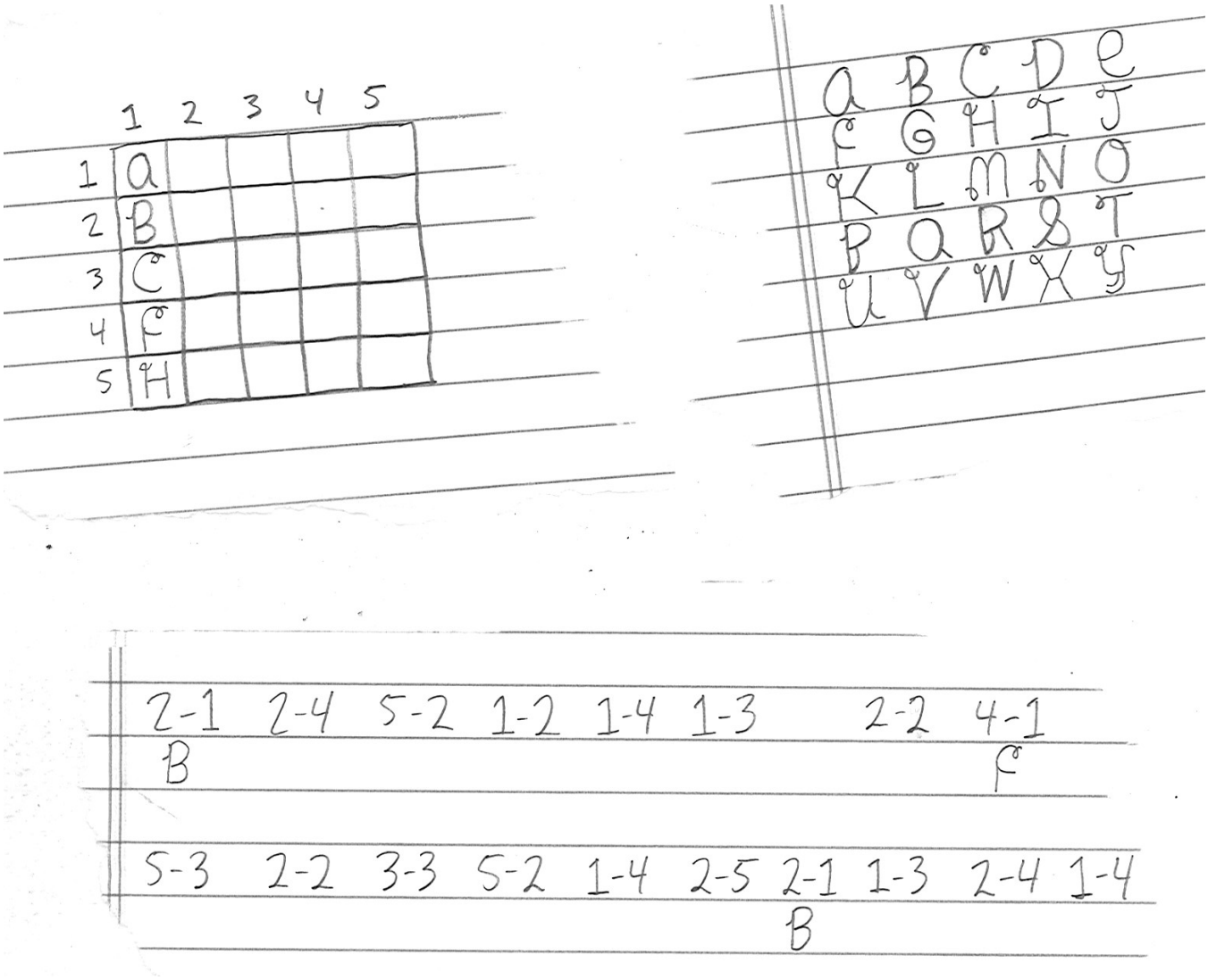
High School Challenge '16

Getting on Top of Things

HSC16 Teaser

Your friend has recently been talking about this field of math called **topology**. Something about donuts and coffee cups being the same thing? You don't know, but you tell yourself you'll look it up on Wikipedia later.

She's also into **puzzles**, so it's no surprise when she hands you three scraps of paper with a bunch of weird letters.

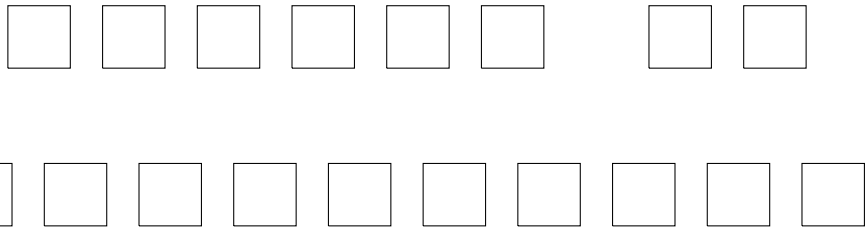


"Did you know topology can be useful in OCR -" (**optical character recognition**) "- techniques? Using this font, you can make five groups of five topologically equivalent letters. See, the A and the G are both drawn as a single loop with a curve sticking out."

"Anyway, we're looking for one more player on our school's **MaPP High School Challenge** team. I put the location of our next team meeting in that puzzle. Figure it out and I'll see you there!"

Decipher your friend's message by first filling the grid of letters so that each row has "topologically equivalent" letters and is ordered alphabetically. ***Teams that turn in a correct solution to this puzzle at MaPP HSC16 registration will get a head-start on solving the opening challenge!***

Solution:



Getting on Top of Things

HSC16 Teaser Solution

(FOR STAFF USE ONLY)

Solution:

B	R	I	D	G	E		O	F

K	O	N	I	G	S	B	E	R	G

Opening "Puzzle"
Bungled Bureaucracy
Overview

We're ready to get started solving some puzzles!... Unfortunately, there's a bit of **red tape** to clear up first.

Due to legal reasons, any puzzle-solving on these premises must be approved through the proper channels, which requires a bit of paperwork to be completed.

We'll provide each team with the required paperwork, which must be signed by the Puzzling Department. They should be located nearby, but they may not help you right away...

This is totally not a puzzle (at least, due to legal reasons we cannot claim it is), but **we'll give your team** 100 **points anyway if you can get this bureaucratic nightmare cleared up within 30 minutes**. All you have to do is get your Important Paperwork signed. Easy, right? If you don't finish within that time limit, we may be able to pull some strings and let you start puzzling anyway (no promises, though). **In either case, return to Game HQ after this challenge to get started on the main Puzzles for the day.**

Opening "Puzzle"
Bungled Bureaucracy
Important Paperwork

Due to inexplicable federal regulations surrounding puzzle-solving, prospective puzzlers must first be approved by the local Puzzling Department. Only the Puzzling Department signature is required, but maybe you'll need to collect some other signatures too...

Department Name	Signature
Puzzling Dept	
Complaints Dept	
Arguments Dept	
Insults Dept	
Dept of Silly Walks	

Opening Puzzle
Bungled Bureaucracy
Setup

FOR STAFF USE ONLY

Spread out stations for each of the Departments throughout your play area. The Puzzling Dept should be the most out-of-the-way in order to spread out teams as they search around for it during the beginning of the puzzle.

Each station should be given their appropriate instructions and briefed on their role in the puzzle before it begins.

After explaining HSC16 rules to all the teams, introduce this puzzle by going over its Overview. Clearly explain the bounds for the puzzle so teams don't wander off too far. Remind players not to interfere with other teams trying to solve the puzzle, and if playing indoors remind them not to run. When you're ready, hand out a copy of Important Paperwork to each team and start their 30 minutes.

When a team has gotten their paperwork signed by all five departments, they earn 100 points and should go to Game HQ to get their packet of the main Puzzles to take to their Team HQ.

Give warnings at 15 and 5 minutes remaining to the players. If any team doesn't finish within 30 minutes, find them and let them know time is up, and get them started on the main Puzzles (they do not earn any points for the Opening Puzzle).

Opening Puzzle
Bungled Bureaucracy
Puzzling Dept.

FOR STAFF USE ONLY

When players attempt to have their Important Paperwork approved by you, inform them that all teams must include at least one member with a Photo ID proving that their birthday is on either February 30 or September 31.

When they protest (even if they have photo ID, those dates don't exist), say that you get that a lot, but your hands are tied by the system. However, if they can get signatures from the other four departments, you can sign off on their paperwork anyway.

When they return with all four signatures, sign their Important Paperwork. Tell them they are approved to start solving puzzles and can exchange their paperwork for a packet of puzzles at Game HQ.

Opening Puzzle
Bungled Bureaucracy
Complaints Dept.

FOR STAFF USE ONLY

As part of your character, you really don't want to be at work on a Saturday. So, make sure to complain as much as possible about that, as well as anything the players want you to do (this is the Complaints Dept, after all).

If they ask you for a signature for the Puzzling Dept, tell them that you're just in too much of a bad mood to go through all that trouble. Ask them if they know of anything that will cheer you up.

If they attempt a silly walk, chuckle a bit and ask them if their silly walk is certified. If not, stop laughing and gasp - obviously silly walks require a permit. Tell them that you'll find their silly walk much funnier if they get it certified.

If they demonstrate a certified silly walk (i.e. they have the signature from the Dept of Silly Walks), you can sign their Important Paperwork.

Opening Puzzle
Bungled Bureaucracy
Arguments Dept.

FOR STAFF USE ONLY

As part of your character, you should contradict everything the players say. Tell them you will sign their Important Paperwork if they can say something you can't argue with. (You should accept anything reasonable.)

If asked about new clubs starting up, break character and say you're really excited about the new Typography Club, and hand them a flyer.

If asked about the Insults Dept., tell them they are quoting Monty Python and the Holy Grail.

Opening Puzzle
Bungled Bureaucracy
Insults Dept.

FOR STAFF USE ONLY

As part of your character, you should shout "insults" at the players. Keeping with the Monty Python theme (and keeping us out of trouble), stick to lines like these below (a French accent is optional):

- Your mother was a hamster and your father smelt of elderberries!
- I don't want to talk to you no more, you empty-headed animal food trough eaters!
- Now go away or I shall taunt you a second time!
- You don't frighten us, puzzling pig dogs.
- Go and boil your bottoms, you offspring of a silly person.
- I blow my nose in your general direction!
- You don't frighten us with your silly knees-bent running around puzzling!

You should sign their Important Paperwork if they can tell you what move you're quoting (Monty Python and the Holy Grail).

If asked about it, you should tell the players that the Dept. of Silly Walks is going to be replaced to fund a new club, but you don't know which one. Tell the players that another department official may know more.

Opening Puzzle
Bungled Bureaucracy
Dept. of Silly Walks

FOR STAFF USE ONLY

As part of your character, you should have a silly walk that you use when moving around (and you should occassionally get up and walk your silly walk).

If a player asks to certify a silly walk, say that it's not worth the trouble, since the host organization is dissolving the department tomorrow. You've heard it's going to be replaced, but you don't know by what. Tell the players you'll certify their silly walk if they bring evidence of whatever will be replacing your department's funding.

If the players bring you a flyer for the Typography Club, you should get excited because you love fonts, apparently. (If they try to give you the flyer, say that they should hold onto it.) Ask to see their silly walk, and certify their silly walk by signing their Important Paperwork (no matter what they do).

Puzzle 1
Shipped with Abandon

Independence Graphcorp is a shipping company which specializes in volatile substances. By themselves, the below materials are stable; however, they can have rather... explosive reactions when transported with certain other chemicals. Help IG find the largest collection of chemicals which can be safely stored in the same truck for each of the following shipments.

Example Shipment: Xereon, Olandrium, Karinum

- Xeroeon reacts with Olandrium, Karinum
- Olandrium reacts with Xeroeon
- Karinum reacts with Xeroeon

Example solution: Olandrium, Karinum

Shipment 1: Unobtainum, Talcium, Hydreon, Silichrome, Electrax

- Unobtainum reacts with Talcium, Hydreon
- Talcium reacts with Unobtainum, Electrax
- Hydreon reacts with Unobtainum, Electrax, Silichrome
- Silichrome reacts with Hydreon
- Electrax reacts with Talcium, Hydreon

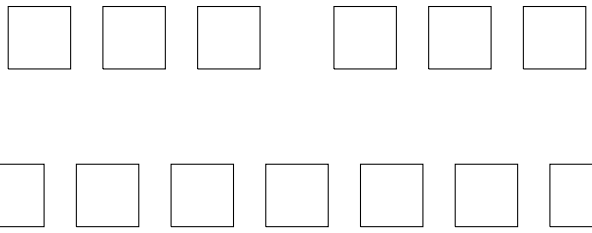
Shipment 2: Starogen, Talentium, Hardeox, Arometica, Kabbageon, Edax

- Starogen reacts with Talentium, Edax, Arometica
- Talentium reacts with Starogen, Kabbageon
- Hardeox reacts with Arometica, Kabbageon
- Arometica reacts with Starogen, Hardeox, Edax
- Kabbageon reacts with Talentium, Hardeox
- Edax reacts with Starogen, Arometica

Shipment 3: Undrax, Orangeon, Paxeox, Bargon, Grandogen, Restitin, Yandrian, Emporeon, Androxium, Nintindeon, Tarep, Segarium

- Undrax reacts with Orangeon, Yandrian
- Orangeon reacts with Yandrian, Undrax, Paxeox
- Paxeox reacts with Orangeon, Yandrian
- Bargon reacts with Grandogen
- Grandogen reacts with Bargon, Segarium
- Restitin reacts with Androxium, Tarep
- Yandrian reacts with Undrax, Orangeon, Paxeox
- Emporeon reacts with Nintindeon
- Androxium reacts with Restitin
- Nintindeon reacts with Emporeon, Segarium
- Tarep reacts with Restitin
- Segarium reacts with Grandogen, Nintindeon

The correct choices from each shipment can be used to spell out a word. **Report the completed phrase to Game HQ to receive** 100 **Victory Points.**



EXTRA Puzzle 1
Shipped with Abandon

Independence Graphcorp has one final shipment to make, it's a doozy. What is the largest collection you can find of the following 30 products (conveniently named Chemical-1 through Chemical-30) which could be safely transported in the same vehicle?

- 01 reacts with 03, 11, 18
- 02 reacts with 04, 21
- 03 reacts with 01, 30
- 04 reacts with 02, 19
- 05 reacts with 06, 07, 15
- 06 reacts with 05, 19, 30
- 07 reacts with 05, 10
- 08 reacts with 13, 25, 27
- 09 reacts with 12, 16, 23
- 10 reacts with 07, 15
- 11 reacts with 01, 17
- 12 reacts with 09
- 13 reacts with 08, 14, 26
- 14 reacts with 13
- 15 reacts with 05, 10, 28
- 16 reacts with 09
- 17 reacts with 11, 23, 30
- 18 reacts with 01, 20
- 19 reacts with 04, 06, 22
- 20 reacts with 18, 23
- 21 reacts with 02, 29
- 22 reacts with 19
- 23 reacts with 09, 17, 20
- 24 reacts with 26
- 25 reacts with 08, 29
- 26 reacts with 13, 24
- 27 reacts with 08, 28
- 28 reacts with 15, 27
- 29 reacts with 21, 25
- 30 reacts with 03, 06, 17

Submit this collection of numbers to Game HQ before the end of the game. **The team(s) submitting the largest collection of numbers without reactions will receive** 50 **Victory Points.** Teams which submit a collection of numbers with even a single reaction will be disqualified, so be careful!

01 02 03 04 05 06 07 08 09 10

11 12 13 14 15 16 17 18 19 20

21 22 23 24 25 26 27 28 29 30

Puzzle 1
Shipped with Abandon
Solutions

FOR STAFF USE ONLY

Main puzzle solution: "USE THE UPBEATS".

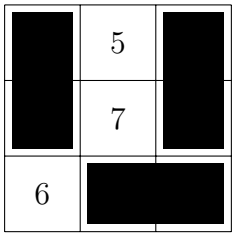
To grade the Extra, check that no two numbers cause a reaction according to the list given in EXTRA Puzzle 1. Disqualify any submissions which this checks. Otherwise, record the size of the submission; the largest submission wins.

Puzzle 2
Domineering

Vera and Horace are playing a game called **Domineering**. The game is played on a rectangular grid like a chessboard, though it usually isn't quite as big. In the game, players take turns laying down dominoes, without overlapping any previously laid dominos. Vera goes first, and she may only lay her dominoes vertically. Horace goes second, and he may only lay a domino horizontally. The players take turns until one player loses because he or she cannot make a legal move. The other player is then the winner.

In the following scenarios, write down the specified numbers going across first, then down. Then use these numbers to shift the appropriate letters.

Example Vera has won the following game because it is Horace's turn and he cannot lay a horizontal domino.



If we use the numbers not covered by a domino, we get the following:

Y	E	S
T+5=	X+7=	M+6=

1. No dominos have been played on the below board. Suppose Horace wins after making two moves. **Use the only number not covered by a domino.**

9	0	3
8	1	4
2	3	5

Z+?=

2. No dominos have been played on the below board. Suppose Vera makes her first move within the left column, and Horace wins after making his first move. **Use the two numbers Horace covered with his only domino.**

1	7	2
0	2	4
3	6	9

J+?= W+?=

3. Vera and Horace have already played one domino each on the below board. Suppose Vera is able to play three additional dominos, but ends up losing. **Use the six numbers Vera covered with her three additional dominos.**

8	2	9	5
5			
4		7	2
6	3	4	0

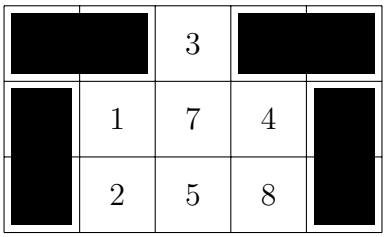
W+?= W+?= F+?= Y+?= I+?= O+?=

4. Vera and Horace have already played one domino each on the below board. Suppose Horace wins after both players play one additional domino. **Use the four numbers Vera and Horace covered with those two additional dominos.**

1	2	4	8
7			
3		5	6
3	9	5	6

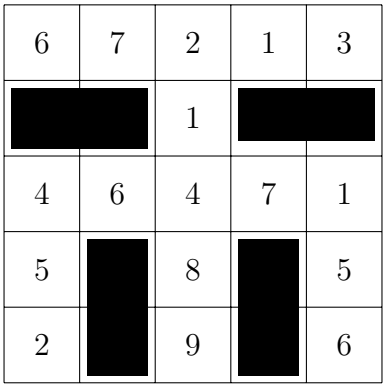
O+?= B+?= Y+?= Y+?=

5. Vera and Horace have already played two dominoes each on the below board. **Use the only number which must be covered by either Horace or Vera during any completion of this game.**



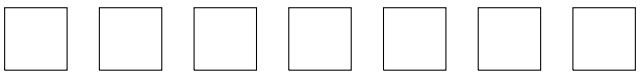
T+?=

6. Vera and Horace have already played two dominoes each on the below board. Horace can now force Vera to lose unless she makes one specific move. **Use the two numbers Vera should cover with her next move.**



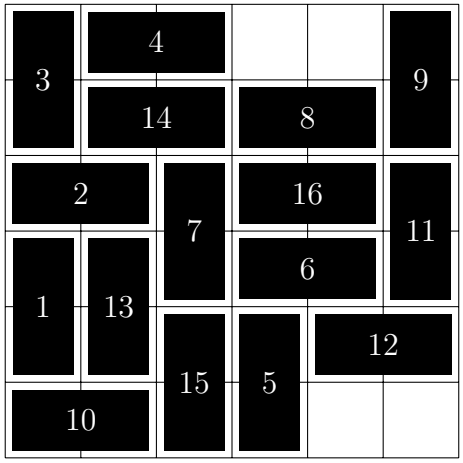
R+?= P+?=

Combine these shifted letters together to form a message. **Report the decoded message to Game HQ for** 100 **Victory Points!**

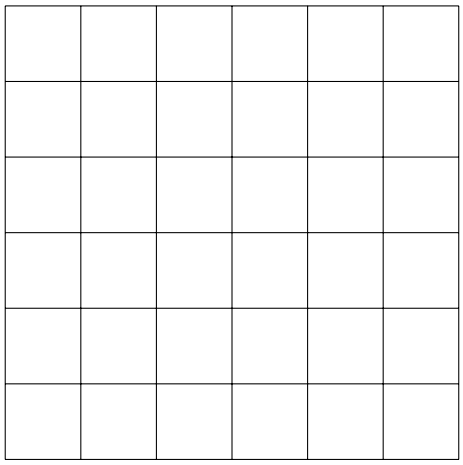


EXTRA Puzzle 2
Domineering

Vera and Horace decide to play Domineering on a 6×6 board. There are 36 squares on the board, so at most 18 dominoes can be played. Vera and Horace wonder what is the smallest number of dominoes that can be played in a completed game. For example, no matter what dominos Vera and Horace play during their first turns, Vera still has another legal move available. But it's possible to play a complete game where Horace makes the last move, and Vera cannot play any vertical dominoes, even though there is some uncovered space for a horizontal domino.



Sketch another completed board below with horizontal and vertical dominos, *numbering the order in which they are played*. Submit your completed board to Game HQ before the end of the game. Boards which are illegally constructed or incomplete will be disqualified. **The team(s) submitting a valid board using the *least* number of dominoes will earn** 50 **Victory Points.**



Puzzle 2
Domineering
Solutions

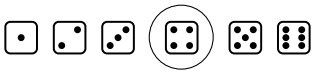
FOR STAFF USE ONLY

Main puzzle solution: ALABAMA MOVED EAST

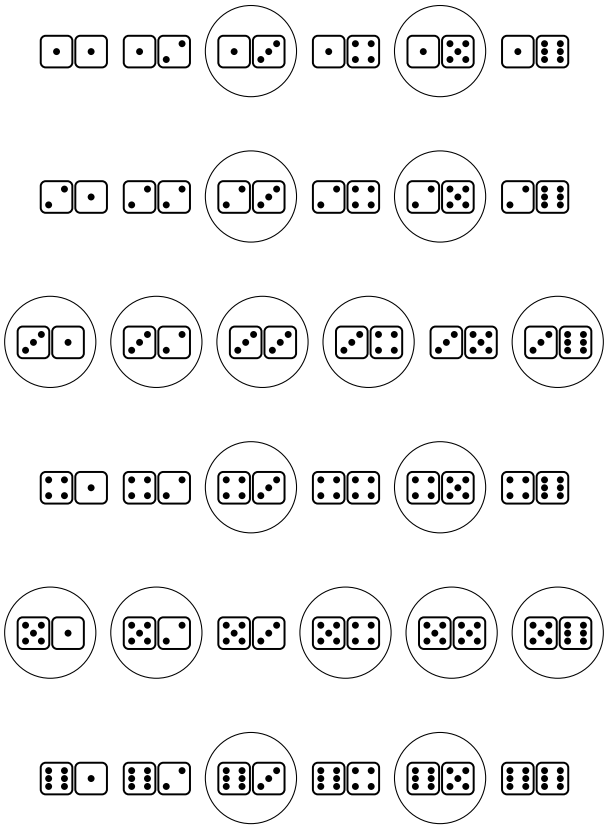
To grade the Extra, first check that the dominos are numbered legally. Then check that no further moves are possible. Disqualify any submissions which fail either check. Otherwise, record the number of dominos used; the smallest submission wins.

Puzzle 3
A Series of Improbable Events

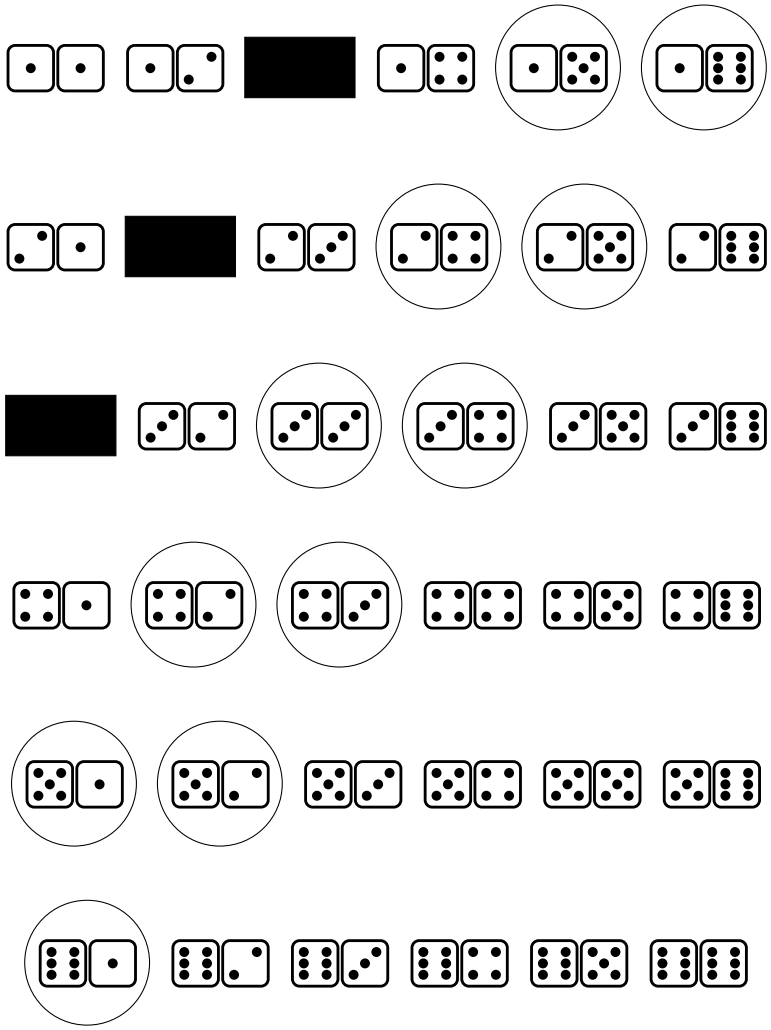
There are 6 sides on a normal die. So, as you probably know, the probability of rolling a four is 1 out of 6.



There are $6 \cdot 6 = 36$ different combinations of faces for two six-sided dice. As shown below, the probability that a roll contains either a three, or a five, but not both, is 18 out of 36. Since $\frac{18}{36} = \frac{1}{2}$, this is the same as 1 out of 2.



This can get complicated if rerolls are sometimes allowed. This can be shown by marking out the cases which would have to be rerolled. For example, what's the probability that the sum of two dice is 6 or 7, if any sums of 4 are rerolled? To solve this, we can mark out the pairs which add to 4, and circle the pairs adding to 6 or 7.

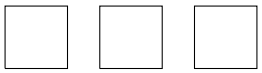


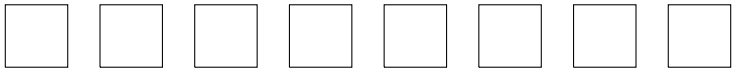
This means that the probability is 11 out of the remaining 33, so 1 out of 3.

So, can you figure out the probability of each of the following results?

Action	Outcome	Probability
Tina rolled two dice.	The sum was 5.	1 out of...
Tina rolled two dice.	The sum was a multiple of 3.	1 out of...
Tina rolled two dice, rerolling both dice if 6 appears.	The sum was 6.	1 out of...
Tina rolled two dice.	The product was odd.	1 out of...
Tina rolled two dice, rerolling snake eyes (pairs of 1s).	The product was a square number.	1 out of...
Tina rolled two dice.	The product was 4.	1 out of...
Tina rolled two dice.	The product was 12.	1 out of...
Tina rolled two dice, rerolling both dice if the product contained the letter "n" (e.g. "o**ne**", "fourtee**n**").	The sum and product were equal.	1 out of...
Tina rolled two dice, rerolling if the two faces were on opposite sides of the die.	The two faces were the same.	1 out of...
Tina rolled two dice.	The difference was ± 5.	1 out of...
Tina rolled two dice, rerolling both dice whenever the product was a multiple of 5.	The sum was 12.	1 out of...

The above results spell a message, assuming $A = 1$, $B = 2$, and so on. **Report this message to Game HQ for** 100 **Victory Points!**





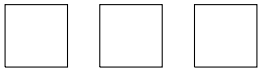
EXTRA Puzzle 3
A Series of Improbable Events

Now Tina's invited a couple friends over to play a board game, but they can't decide who gets to go first. Tina suggests that they should choose three dice from the following strange collection:

- Die A has sides labeled [1, 27, 38, 41, 43, 46]
- Die B has sides labeled [2, 10, 45, 56, 57, 59]
- Die C has sides labeled [3, 12, 24, 34, 36, 50]
- Die D has sides labeled [4, 28, 30, 44, 54, 58]
- Die E has sides labeled [5, 15, 20, 25, 33, 39]
- Die F has sides labeled [6, 18, 21, 26, 32, 55]
- Die G has sides labeled [7, 19, 31, 49, 51, 53]
- Die H has sides labeled [8, 14, 17, 22, 40, 60]
- Die I has sides labeled [9, 11, 16, 35, 42, 47]
- Die J has sides labeled [13, 23, 29, 37, 48, 52]

Each player will throw one of the three chosen dice, and the player rolling the highest goes first. For three dice, there are $6^3 = 216$ possible outcomes. If the combination is "Go-First fair", then each die wins exactly $\frac{216}{3} = 72$ of those outcomes. However, most of the above dice combinations are unfair: out of dice ABC, B wins 134 of the outcomes, A only wins 51 outcomes, and C wins just 31.

Submit a combination of the three above dice which you think is Go-First fairest. **The team(s) submitting the fairest combination of dice will receive** 50 **Victory Points.** By the way, a perfect combination of Go First Dice was first invented in 2010 by puzzle designer Eric Harshbarger and mathematician Dr. Robert Ford. Tina is certain she has that exact set lying around somewhere...



Puzzle 3
A Series of Improbable Events
Solutions

FOR STAFF USE ONLY

Main puzzle solution: ICE DELIVERY

To grade the Extra, compare the submission with the below list. We wrote a computer program to compute the "max advantage" of each combination of dice, where the advantage of each die is the number of outcomes it wins out of all 6^3 possible outcomes. Award points to the team(s) which choose a combination closest to the completely fair max advantage: $6^3/3 = 72$.

- [A, B, C] has max advantage 134
- [A, B, D] has max advantage 117
- [A, B, E] has max advantage 139
- [A, B, F] has max advantage 134
- [A, B, G] has max advantage 124
- [A, B, H] has max advantage 116
- [A, B, I] has max advantage 134
- [A, B, J] has max advantage 128
- [A, C, D] has max advantage 110
- [A, C, E] has max advantage 127
- [A, C, F] has max advantage 112
- [A, C, G] has max advantage 111
- [A, C, H] has max advantage 107
- [A, C, I] has max advantage 99
- [A, C, J] has max advantage 86
- [A, D, E] has max advantage 118
- [A, D, F] has max advantage 107
- [A, D, G] has max advantage 95
- [A, D, H] has max advantage 101
- [A, D, I] has max advantage 109
- [A, D, J] has max advantage 102
- [A, E, F] has max advantage 131
- [A, E, G] has max advantage 119
- [A, E, H] has max advantage 126
- [A, E, I] has max advantage 116
- [A, E, J] has max advantage 100
- [A, F, G] has max advantage 101
- [A, F, H] has max advantage 111
- [A, F, I] has max advantage 102
- [A, F, J] has max advantage 88
- [A, G, H] has max advantage 101
- [A, G, I] has max advantage 117
- [A, G, J] has max advantage 103
- [A, H, I] has max advantage 98
- [A, H, J] has max advantage 84
- [A, I, J] has max advantage 91
- [B, C, D] has max advantage 117
- [B, C, E] has max advantage 139
- [B, C, F] has max advantage 134
- [B, C, G] has max advantage 124
- [B, C, H] has max advantage 116
- [B, C, I] has max advantage 134

- [B, C, J] has max advantage 128
- [B, D, E] has max advantage 121
- [B, D, F] has max advantage 117
- [B, D, G] has max advantage 109
- [B, D, H] has max advantage 101
- [B, D, I] has max advantage 117
- [B, D, J] has max advantage 112
- [B, E, F] has max advantage 139
- [B, E, G] has max advantage 127
- [B, E, H] has max advantage 121
- [B, E, I] has max advantage 139
- [B, E, J] has max advantage 132
- [B, F, G] has max advantage 124
- [B, F, H] has max advantage 116
- [B, F, I] has max advantage 134
- [B, F, J] has max advantage 128
- [B, G, H] has max advantage 106
- [B, G, I] has max advantage 124
- [B, G, J] has max advantage 120
- [B, H, I] has max advantage 116
- [B, H, J] has max advantage 110
- [B, I, J] has max advantage 128
- [C, D, E] has max advantage 126
- [C, D, F] has max advantage 115
- [C, D, G] has max advantage 99
- [C, D, H] has max advantage 109
- [C, D, I] has max advantage 115
- [C, D, J] has max advantage 107
- [C, E, F] has max advantage 90
- [C, E, G] has max advantage 119
- [C, E, H] has max advantage 83
- [C, E, I] has max advantage 86
- [C, E, J] has max advantage 111
- [C, F, G] has max advantage 102
- [C, F, H] has max advantage 78
- [C, F, I] has max advantage 76
- [C, F, J] has max advantage 100
- [C, G, H] has max advantage 103
- [C, G, I] has max advantage 117
- [C, G, J] has max advantage 102
- **[C, H, I] has max advantage 72**
- [C, H, J] has max advantage 97
- [C, I, J] has max advantage 105
- [D, E, F] has max advantage 128
- [D, E, G] has max advantage 106
- [D, E, H] has max advantage 122
- [D, E, I] has max advantage 126
- [D, E, J] has max advantage 116
- [D, F, G] has max advantage 97
- [D, F, H] has max advantage 112
- [D, F, I] has max advantage 115
- [D, F, J] has max advantage 106
- [D, G, H] has max advantage 91
- [D, G, I] has max advantage 99
- [D, G, J] has max advantage 94
- [D, H, I] has max advantage 109
- [D, H, J] has max advantage 100
- [D, I, J] has max advantage 107
- [E, F, G] has max advantage 111
- [E, F, H] has max advantage 79
- [E, F, I] has max advantage 89
- [E, F, J] has max advantage 111

- [E, G, H] has max advantage 112
- [E, G, I] has max advantage 126
- [E, G, J] has max advantage 110
- [E, H, I] has max advantage 86
- [E, H, J] has max advantage 109
- [E, I, J] has max advantage 115
- [F, G, H] has max advantage 97
- [F, G, I] has max advantage 108
- [F, G, J] has max advantage 94
- [F, H, I] has max advantage 74
- [F, H, J] has max advantage 99
- [F, I, J] has max advantage 103
- [G, H, I] has max advantage 111
- [G, H, J] has max advantage 95
- [G, I, J] has max advantage 108
- [H, I, J] has max advantage 102

Puzzle 4
Simple City

Welcome to Simple City! The city planners here have designed their neighborhoods in 4×4 grids. Each row and each column is composed exactly of four towers which are 1, 2, 3, and 4 stories tall respectively. Also, the planners like to know how visible these towers can be, so they record **boundary conditions** which count the number of visible towers from each position on the outside edge of the neighborhood. For example, a 1 indicates that the tallest tower is on the edge and blocking all the other towers, and a 4 indicates that all the towers in that row or column are visible from that position.

Example Here's a completed neighborhood with its boundary conditions. For instance, the 3 in the upper left corner represents a person looking south into the 4×4 grid; she can only see the towers with heights $1, 3, 4$ since the 2 is blocked by the 3.

	$3\downarrow$	$2\downarrow$	$2\downarrow$	$1\downarrow$	
$4\rightarrow$	1	2	3	4	$\leftarrow 1$
$2\rightarrow$	3	4	2	1	$\leftarrow 3$
$2\rightarrow$	2	1	4	3	$\leftarrow 2$
$1\rightarrow$	4	3	1	2	$\leftarrow 3$
	$1\uparrow$	$2\uparrow$	$2\uparrow$	$3\uparrow$	

Your goal is to figure out the heights of the towers in each neighborhood on the following page using only the boundary conditions. Some of the towers have been marked with a symbol, and some of the boundary conditions are missing.

	3↓	2↓	2↓	1↓	
4→	⋆				←1
2→			#		←2
3→					←2
1→				=	←2
	1↑	3↑	2↑	2↑	

	2↓		2↓		
3→					←1
3→		+	∼		
1→					←3
	%				
	2↑	1↑	3↑		

		2↓	3↓		
					←3
3→				&	
			@		←3
		$			

			3↓		
	?				
3→					
2→		√		∂	←2
2→					
		1↑		3↑	

For each of the above symbols, mark the height of its tower in the chart below to reveal a message.

	⋆	?	@	$	%	#	∼	∂	&	=	+	√
4	A	A	I	M	N	K	I	G	H	T	G	R
3	F	D	M	I	H	I	E	R	U	O	N	Y
2	S	C	U	G	E	C	N	T	T	N	U	S
1	L	L	A	E	R	W	N	F	I	I	O	T

☐ ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ ☐ ☐ ☐

Report the decoded message to Game HQ for 100 **Victory Points!**

EXTRA Puzzle 4
Simple City

The citizens of Simple City have begun work on a new burough called Sudoku City. This neighborhood contains plots for up to 9×9 towers, and ordinances require that each column, row, and 3×3 square contains at most one tower with height 1 through 9, just like a Sudoku puzzle. The numbers below represent the desired boundary conditions for this neighborhood, just like in the main puzzle.

Your task is to build as many towers as possible in the 9×9 grid by labeling each plot with a height for its tower. *You do not have to fill out all the plots or fulfill all boundary conditions*, but you should *never* violate the Sudoku rules by having more than one tower with the same height in a row, column, or 3×3 square.

Submit the filled out grid to Game HQ before the end of the game. Grids violating any Sudoku rules will be disqualified. The judges will award 1 puzzle point for each of the eighty-one plots used and 100 puzzle points for each of the thirty-six boundary conditions satisfied along the border. **The team(s) earning the highest amount of puzzle points will earn** 50 **Victory Points.**

	3↓	4↓	1↓	2↓	2↓	5↓	3↓	3↓	3↓	
3→										←3
3→										←4
3→										←2
1→										←4
3→										←2
2→										←2
3→										←1
3→										←3
2→										←3
	5↑	1↑	3↑	3↑	4↑	2↑	2↑	2↑	2↑	

Puzzle 4
Simple City
Solutions

FOR STAFF USE ONLY

Main puzzle solution: LAUGH WITHOUT

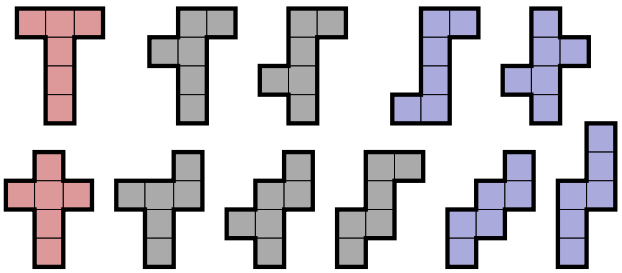
To grade the Extra, check that the submission satisfies the Sudoku conditions: each row, column, and 3×3 square contains at most one of the numbers $1, \ldots, 9$ (blanks are fine). Disqualify any submissions which fail that check. Otherwise, add 100 for each boundary condition satisfied, and 1 for each plot used; the submission with the largest sum wins.

Here's a perfect solution (from which this puzzle was generated):

	3↓	4↓	1↓	2↓	2↓	5↓	3↓	3↓	3↓	
3→	1	3	9	6	8	5	4	2	7	←3
3→	5	7	4	9	3	2	8	6	1	←4
3→	2	8	6	1	7	4	5	9	3	←2
1→	9	6	7	8	1	3	2	5	4	←4
3→	4	2	3	5	9	6	7	1	8	←2
2→	8	5	1	4	2	7	9	3	6	←2
3→	7	1	5	2	6	8	3	4	9	←1
3→	6	4	8	3	5	9	1	7	2	←3
2→	3	9	2	7	4	1	6	8	5	←3
	5↑	1↑	3↑	3↑	4↑	2↑	2↑	2↑	2↑	

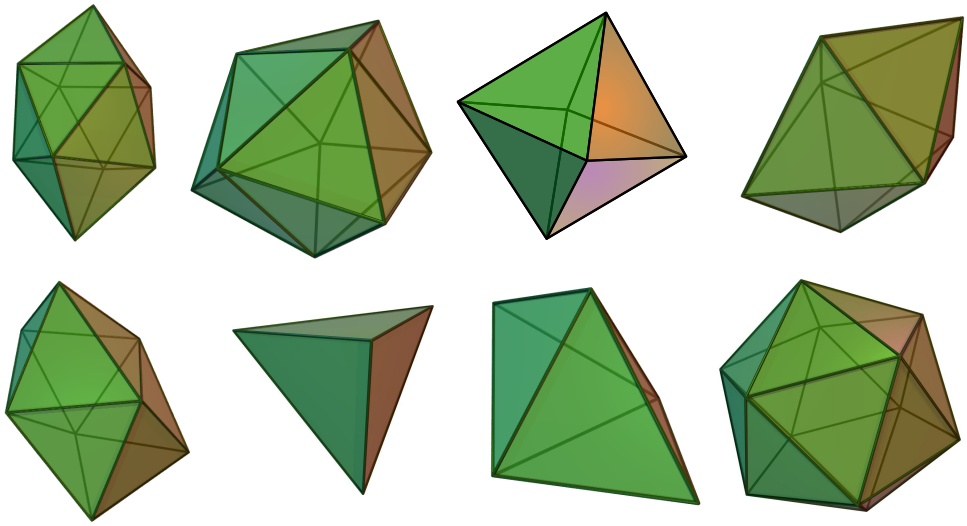
Puzzle 5
Nothin' but Nets

Have you ever folded a cube out of a sheet of paper? There's actually 11 different configurations of six squares which fold into the cube:

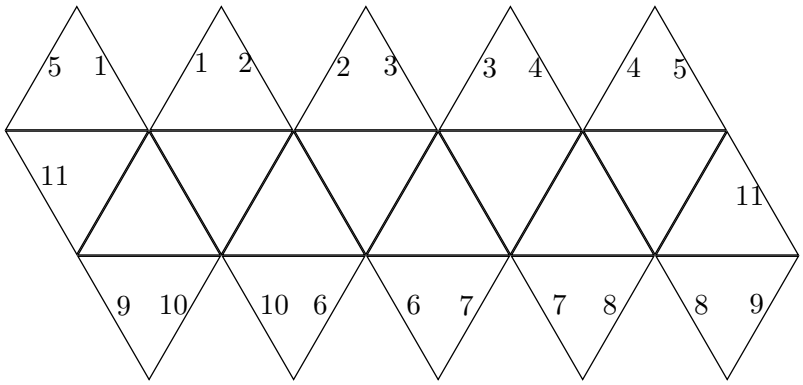


These configurations are known as **nets**, and you'll be looking at nets for special solids called **deltahedra**. A deltahedron is a solid where each face is an equilateral triangle.

Following are images of eight special deltahedra. They are called **convex** because they lack any dents; each face could be laid flat on a table.



The lower-right deltahedron on the previous page is called an **icosahedron**. It has twenty sides, and can be unfolded into the following net by taping the numbered edges together.



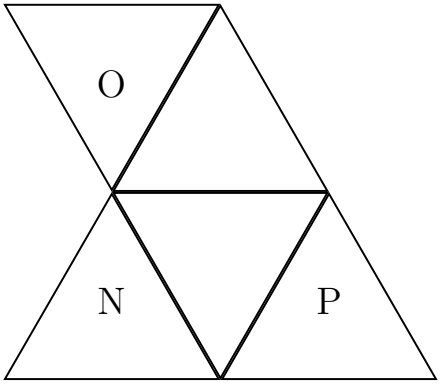
Icosahedron

On the following pages are nets for several convex deltahedra... except it looks like there's an extra triangle in each one! Let's call such a triangle **removable**.

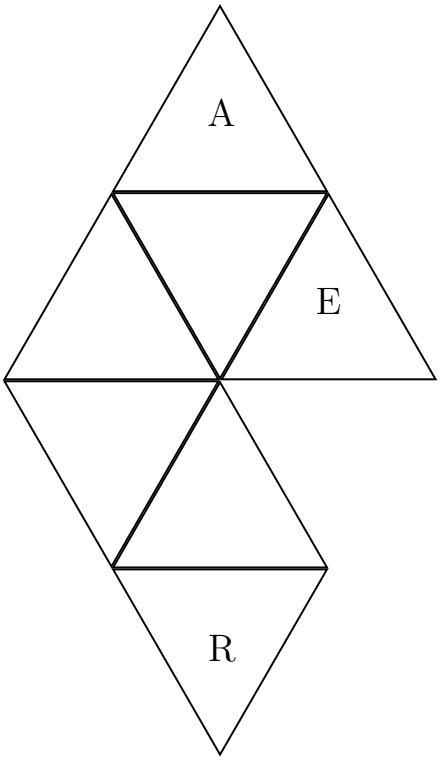
To solve this puzzle, try to fold the given nets into a convex deltahedron without using each of the lettered triangles. If it's possible, that triangle is removeable and you should write down its letter. If there are multiple removeable triangles from that net, write them down in the order they appears on the original net, going across then down. These letters will spell a message when combined below; we've filled in two letters for you. **Report the completed message to Game HQ to earn** 100 **Victory Points!**

1	1	2		3	4	4	5	5	5		
6	6	7	7	7	8		9	9	10	10	10	10
							I	M				

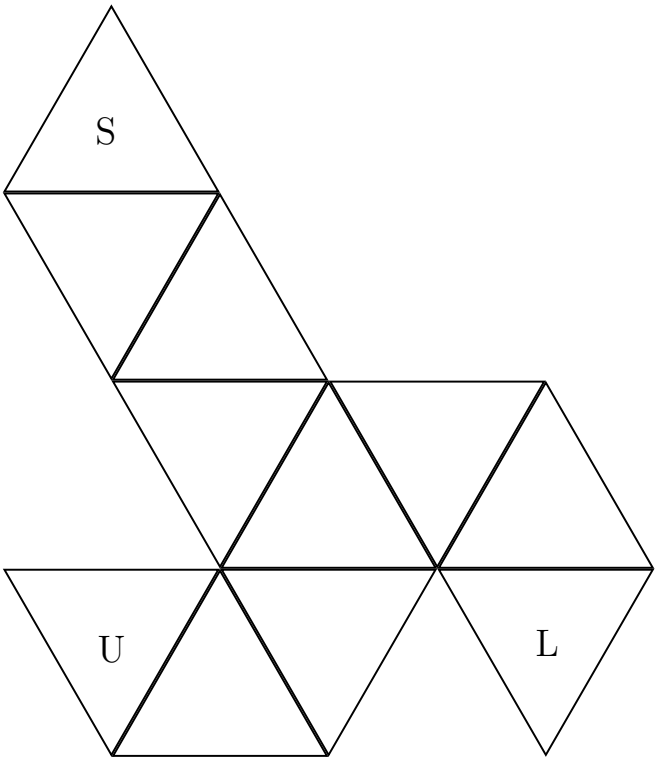
1)



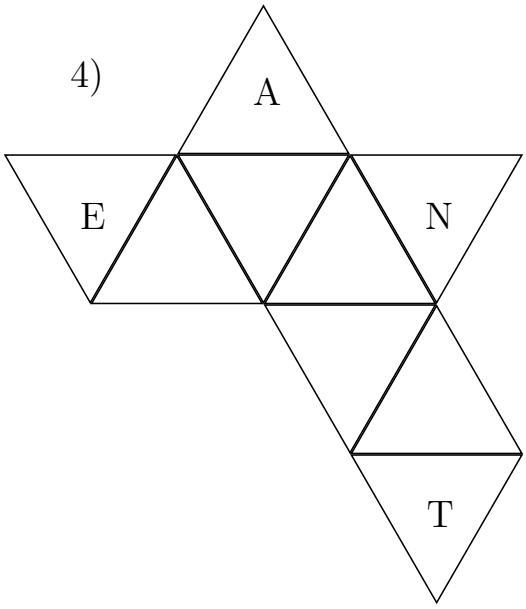
2)



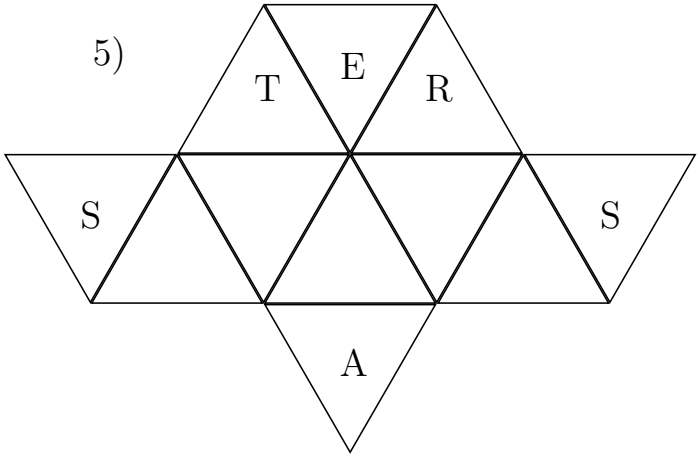
3)



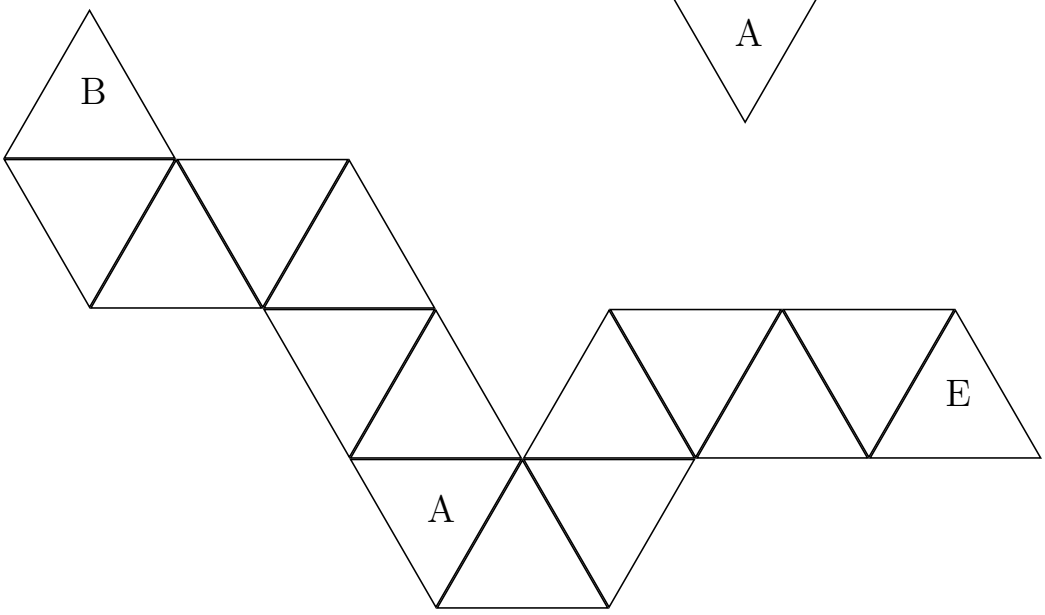
4)



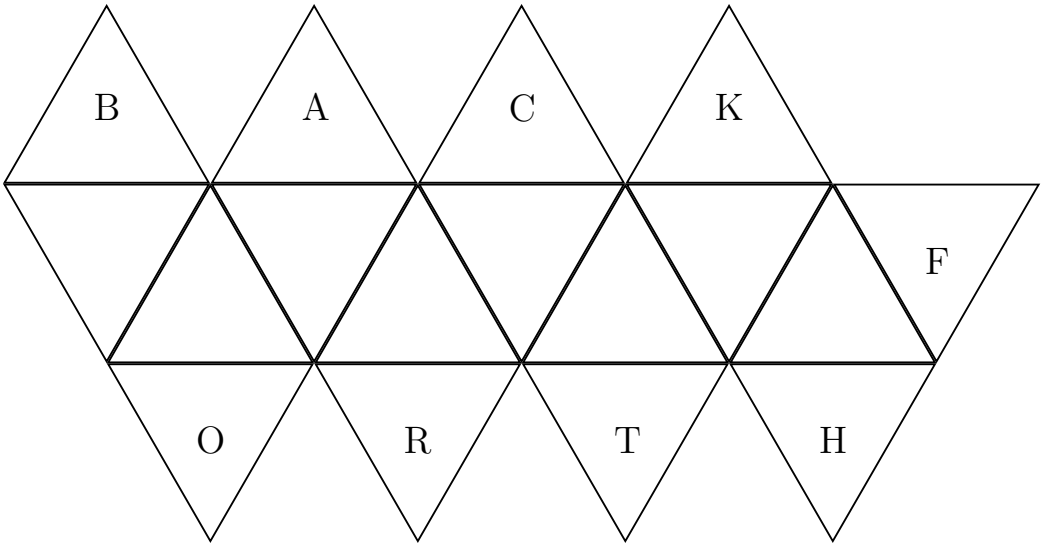
5)



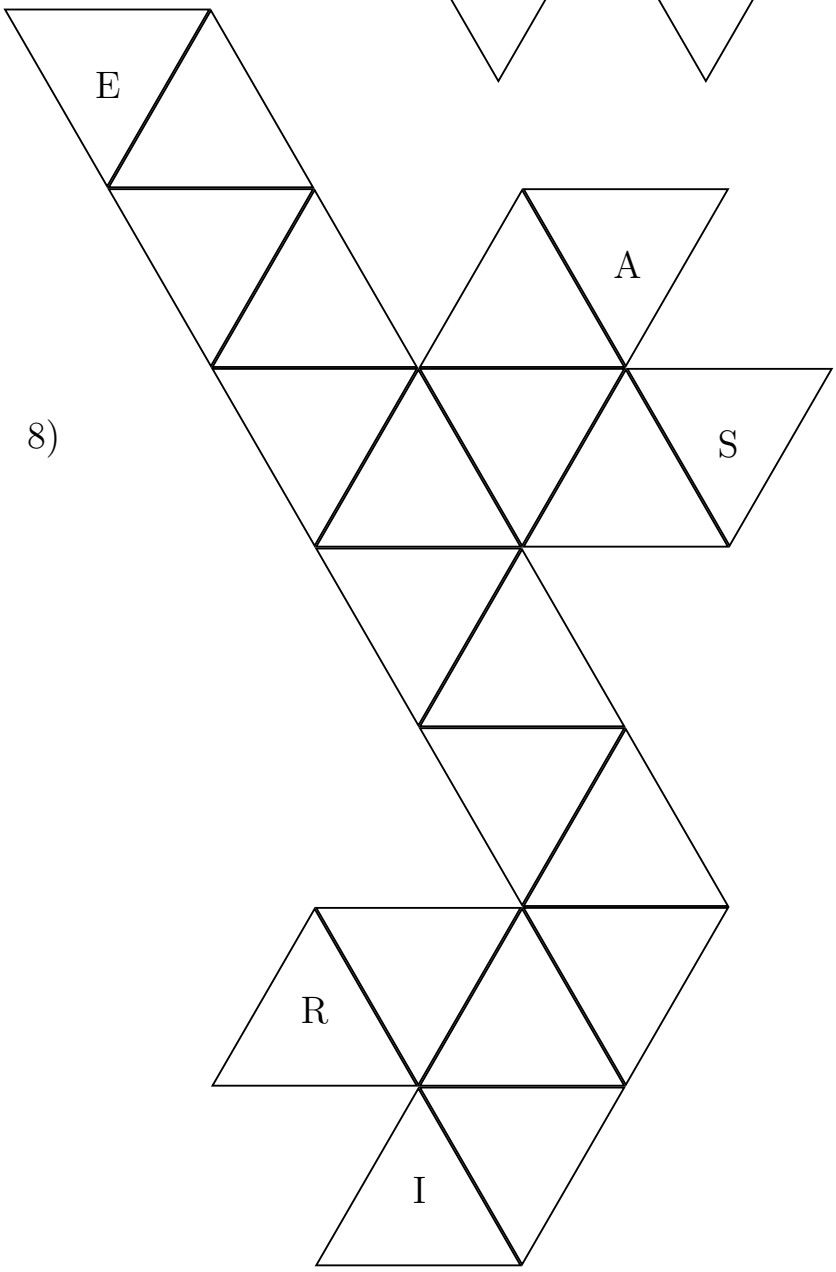
6)



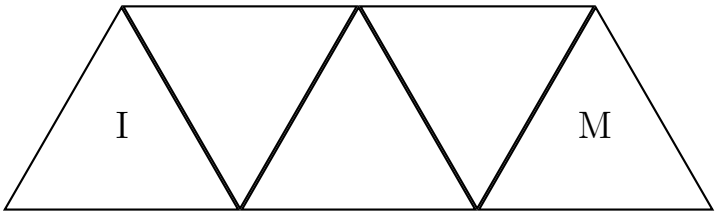
7)



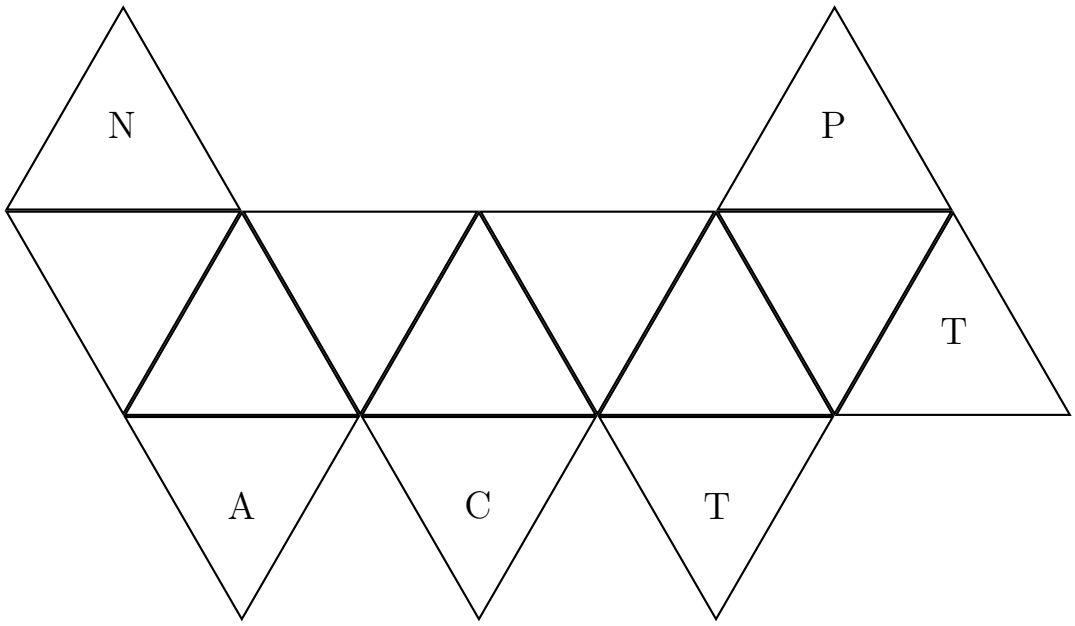
8)



9)



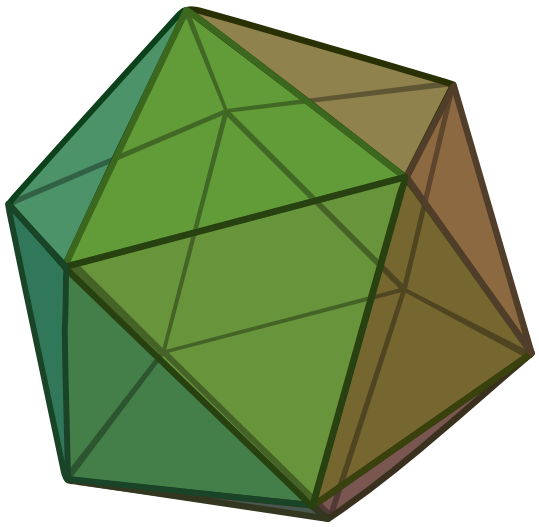
10)



High School Challenge '16

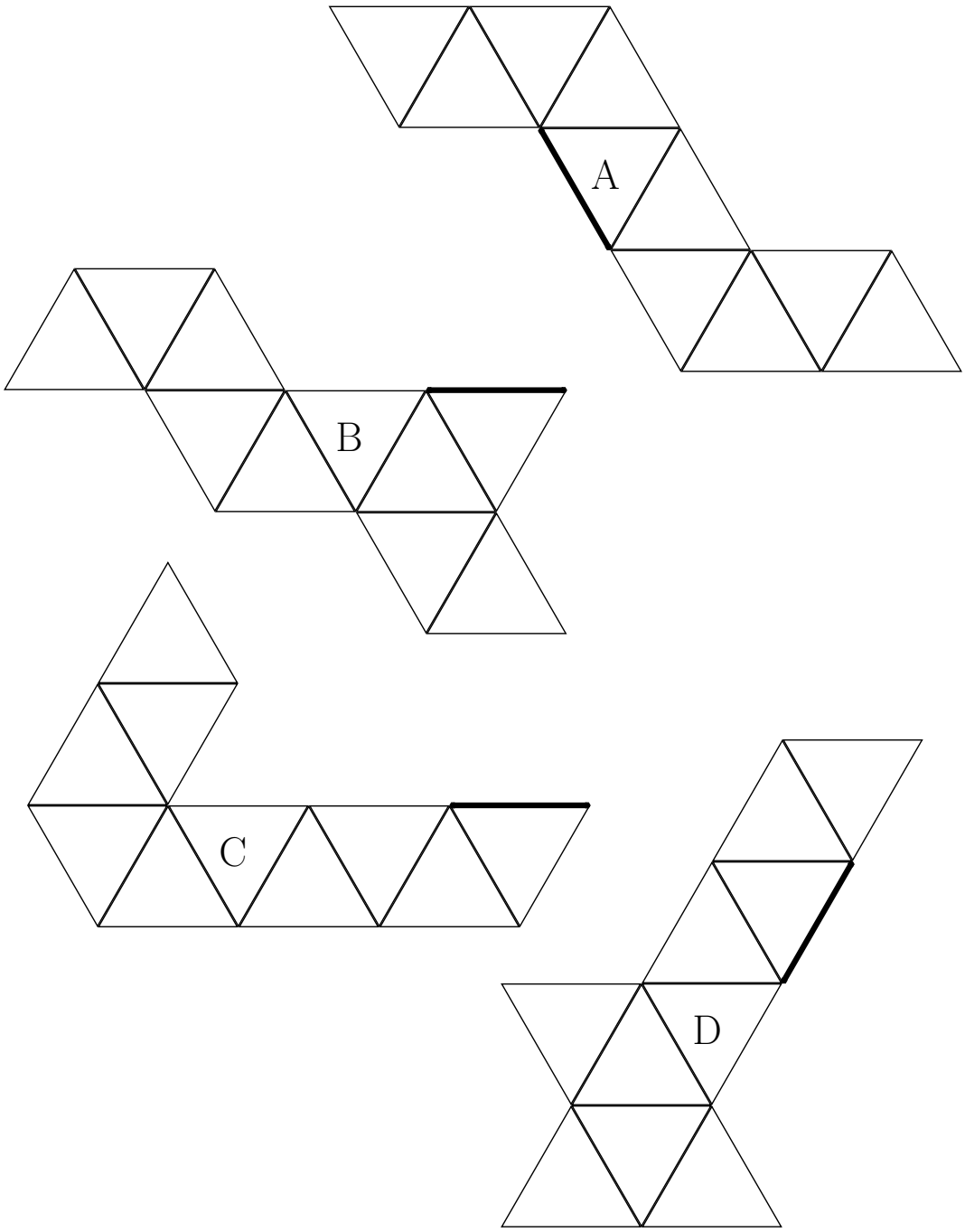
EXTRA Puzzle 5
Nothin' but Nets

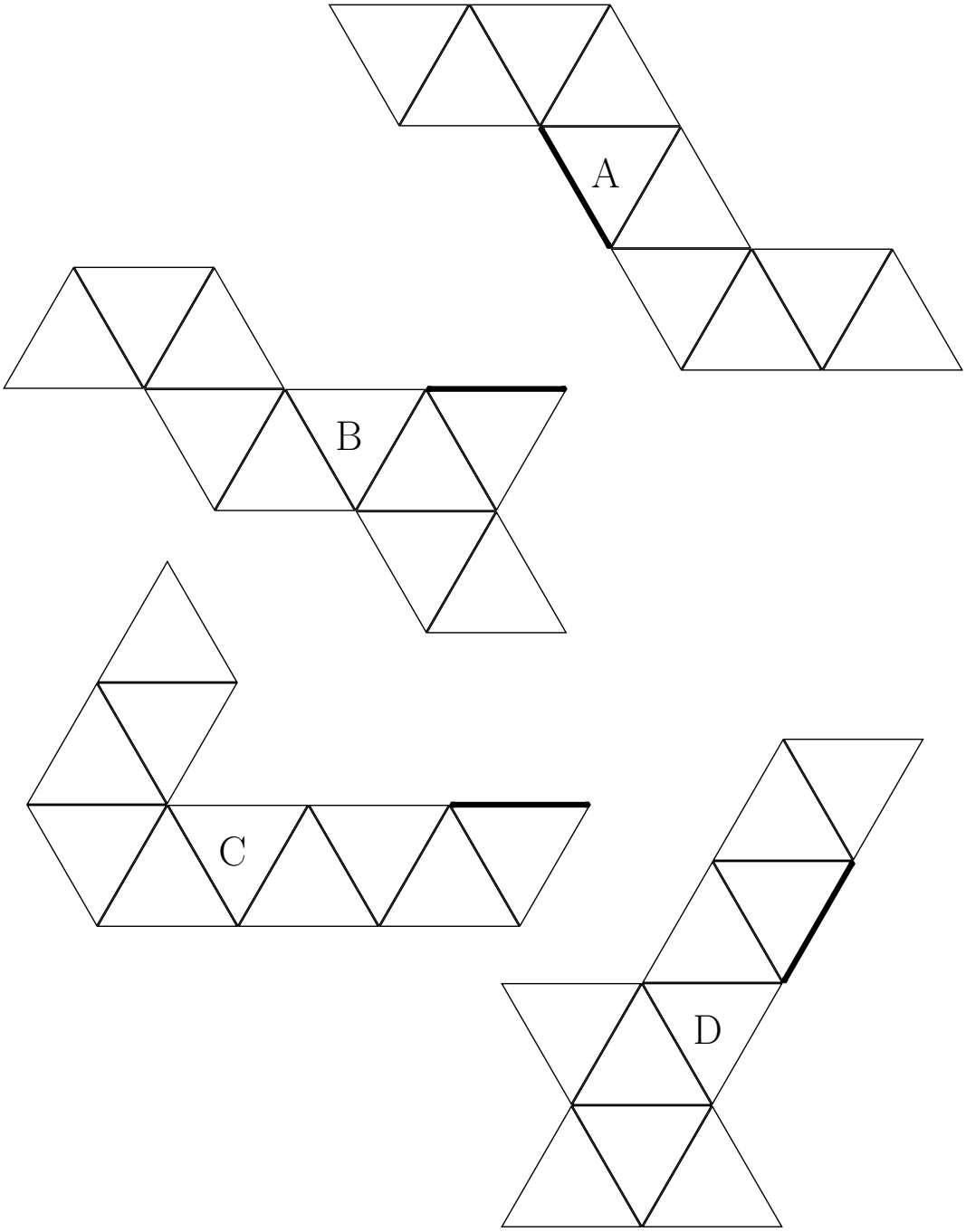
On the attached pages are eighteen **half-nets** containing 10 triangles each. They are called half-nets because each one may be joined along its bold edge with exactly one half-net (possibly a copy of itself) to create a completed net for the 20-sided icosahedron. You're allowed to rotate the configurations, but you may not flip them.

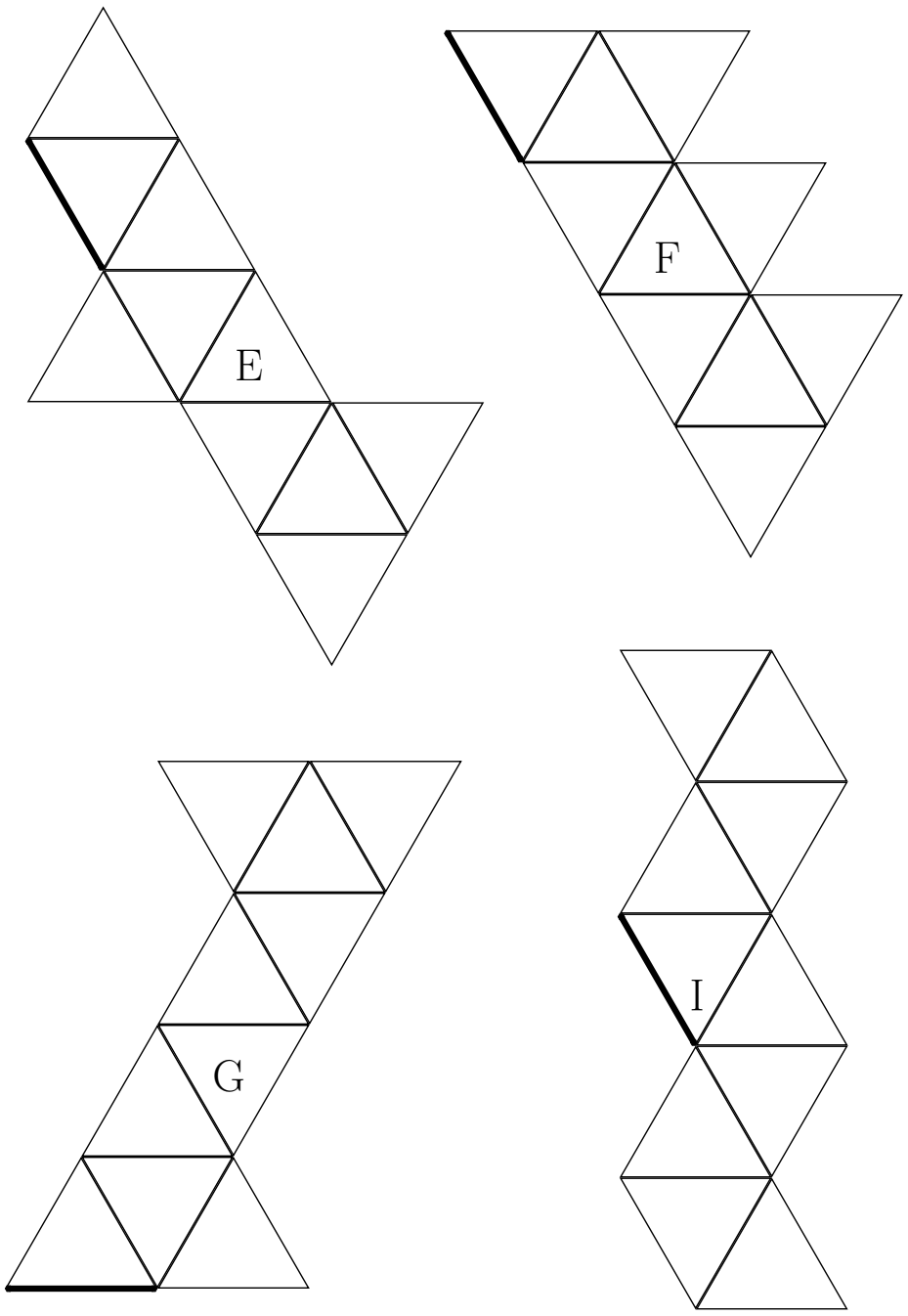


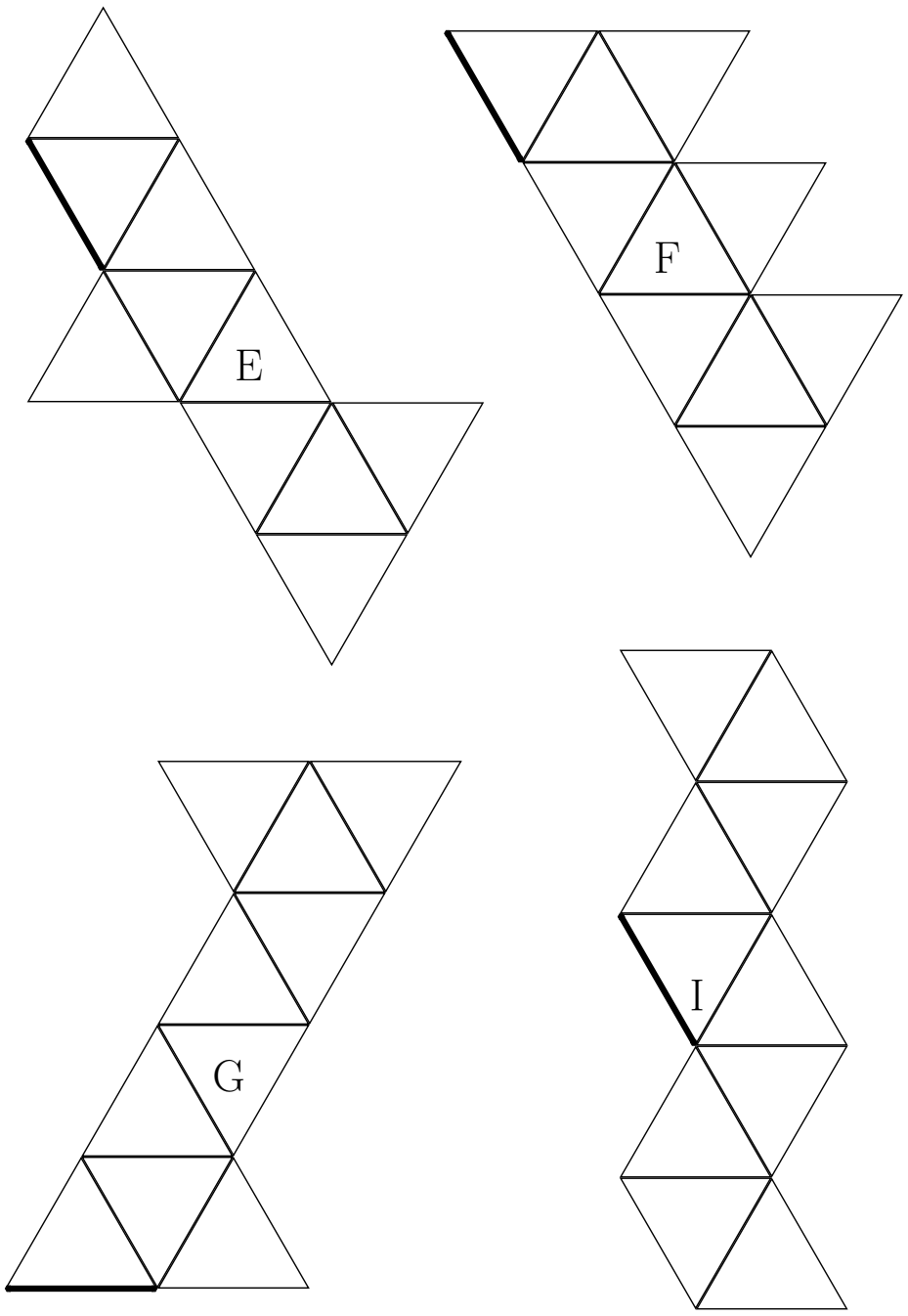
For each of the following letters, write the letter of the only half-net that joins with it to form a full icosohedron net. Turn in your list of pairs to Game HQ before the end of the game. The judges will award one puzzle point for each valid response. **The team(s) earning the greatest amount of puzzle points will earn** 50 **Victory Points!** Note that the correct responses will *not* spell out a message.

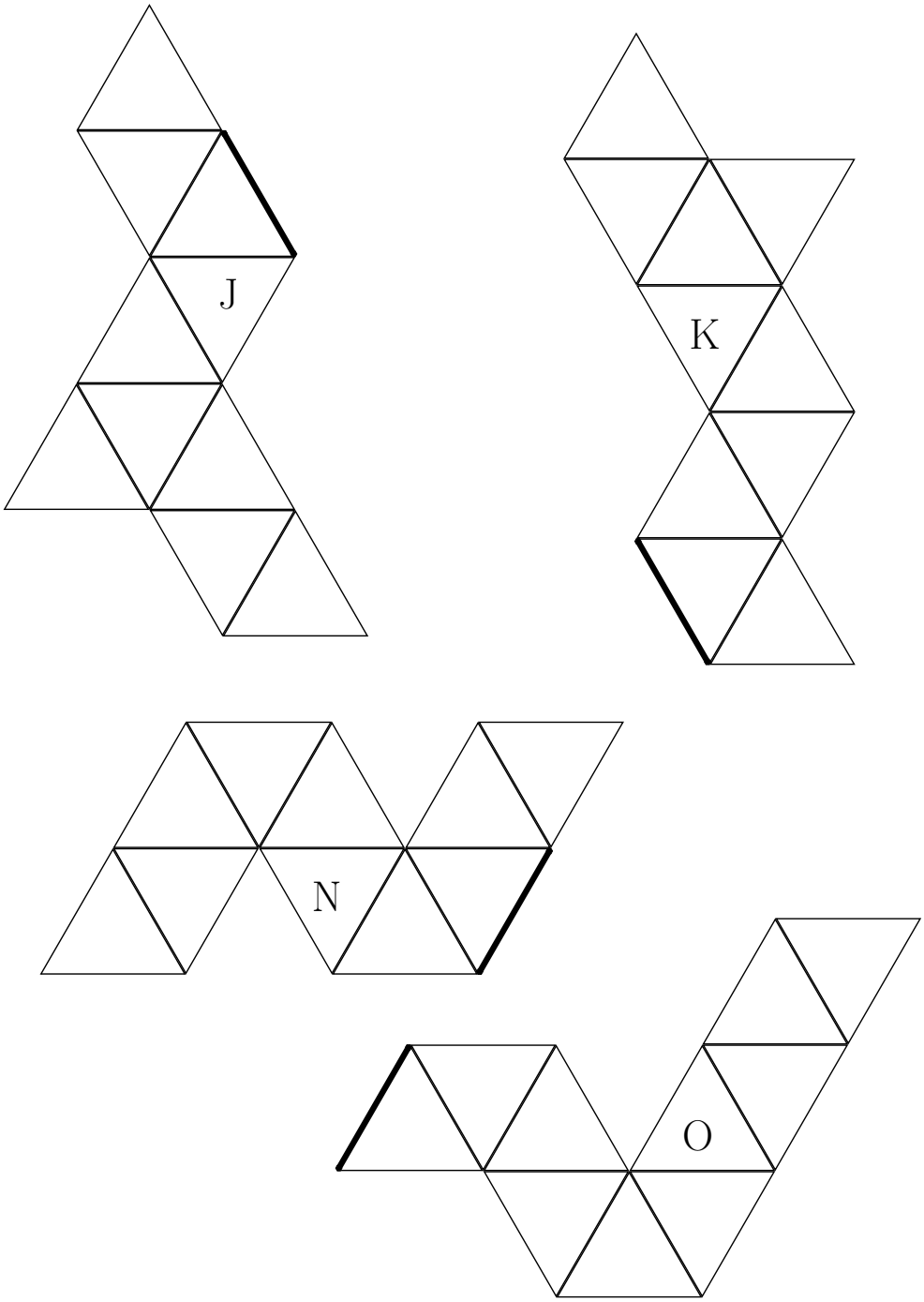
☐ Joins with A	☐ Joins with B	☐ Joins with C	☐ Joins with D	☐ Joins with E	☐ Joins with F
☐ Joins with G	☐ Joins with I	☐ Joins with J	☐ Joins with K	☐ Joins with N	☐ Joins with O
☐ Joins with Q	☐ Joins with R	☐ Joins with S	☐ Joins with W	☐ Joins with X	☐ Joins with Y

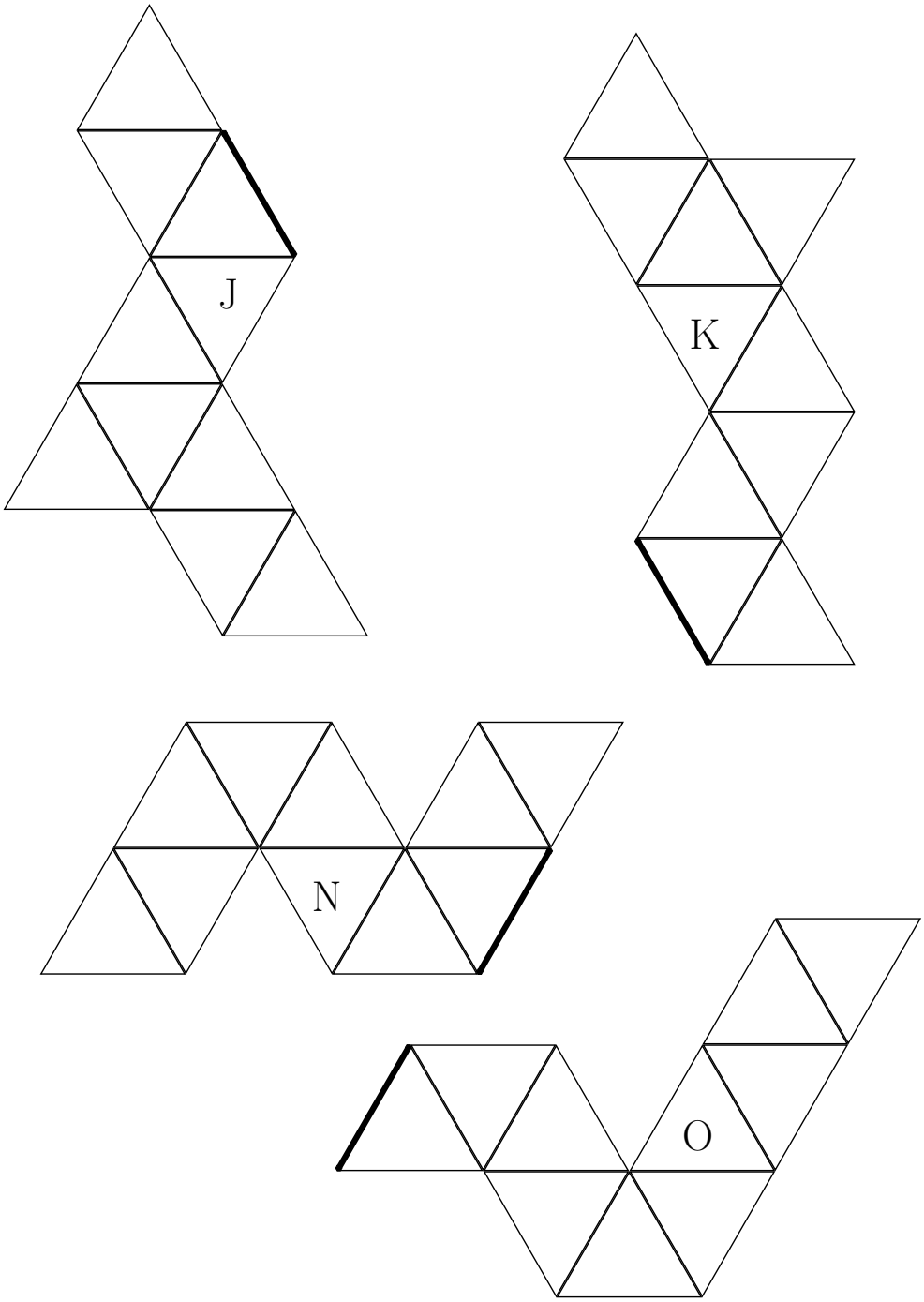

A
B
C
D

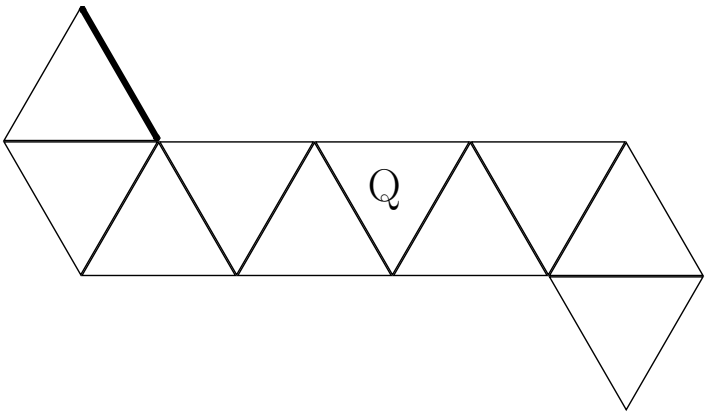

A
B
C
D

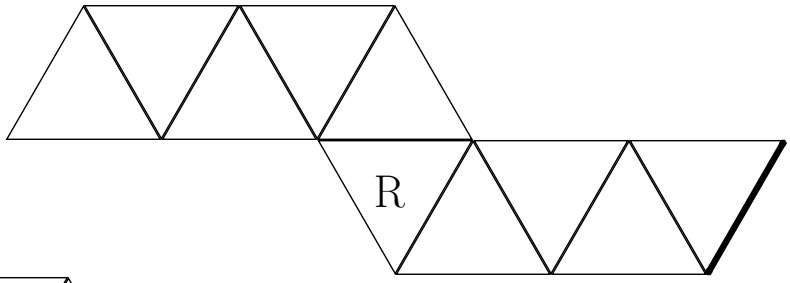

E
F
G
I

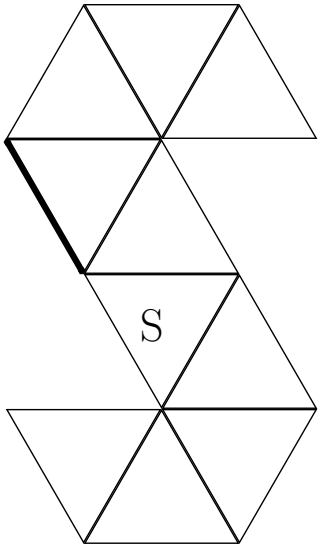

E
F
G
I

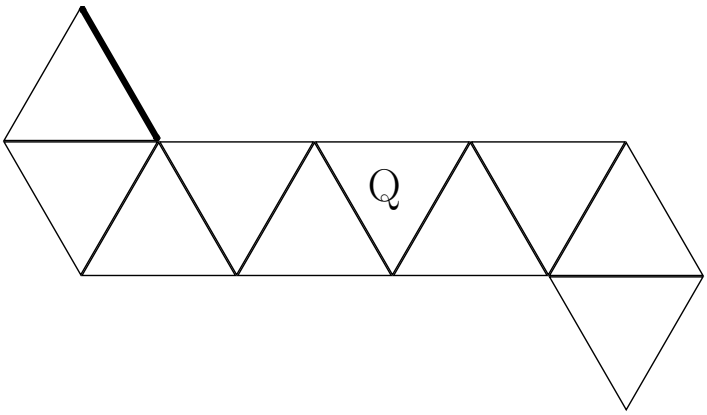

J
K
N
O

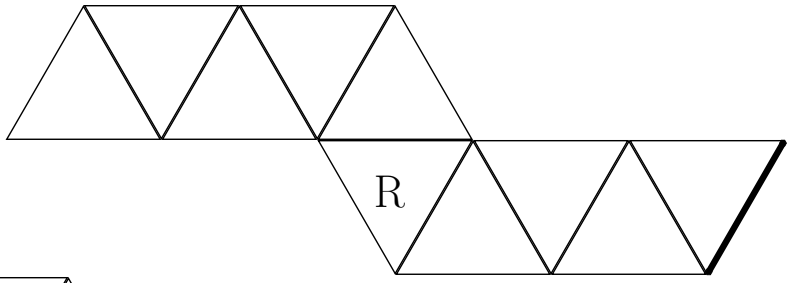

J
K
N
O


Q


R


S


Q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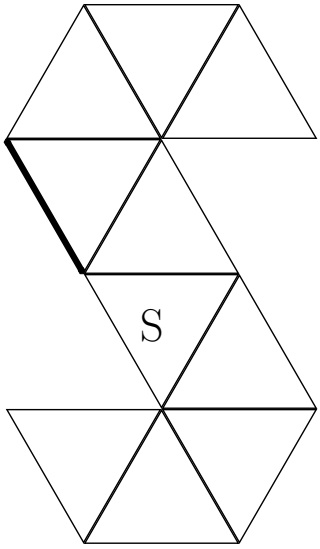
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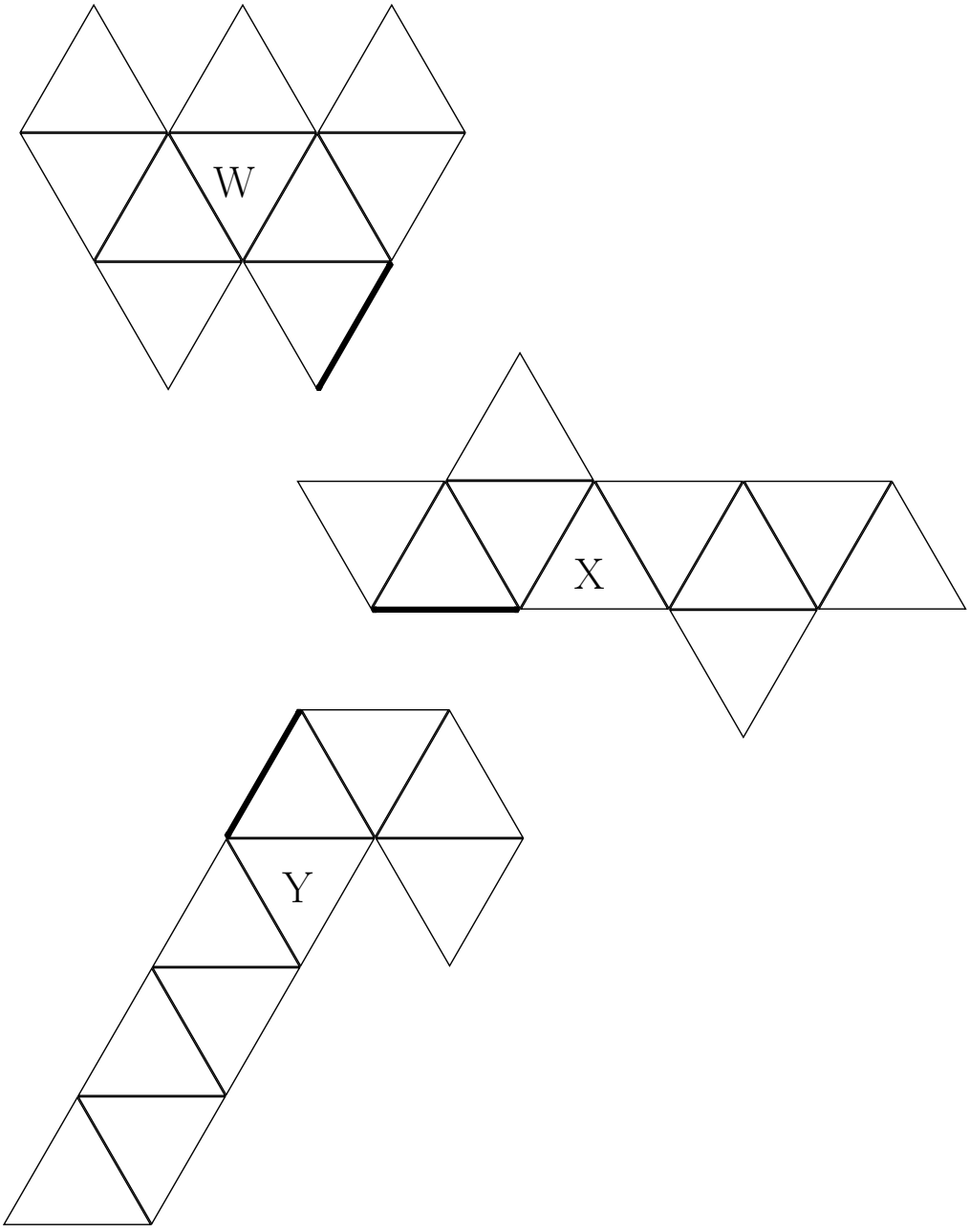
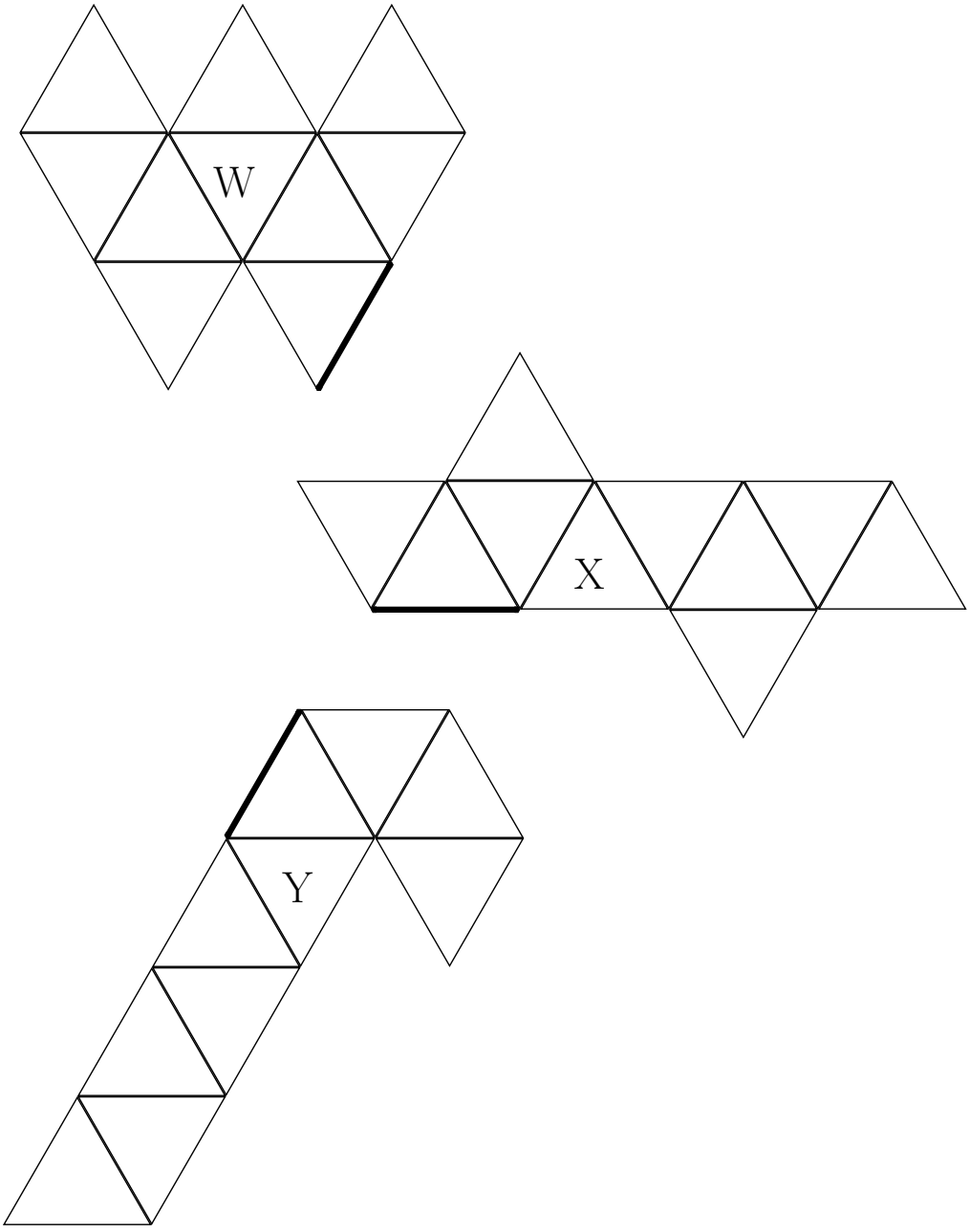

W
X
Y


W
X
Y

Puzzle 5
Nothin' but Nets
Solutions

FOR STAFF USE ONLY

Main puzzle solution: ONE LETTER BEFORE IMPACT

To grade the Extra, give one point for each of the following correct responses:

R	E	C	K	B	S
Joins with A	Joins with B	Joins with C	Joins with D	Joins with E	Joins with F
I	G	J	D	N	O
Joins with G	Joins with I	Joins with J	Joins with K	Joins with N	Joins with O
Q	A	F	W	X	Y
Joins with Q	Joins with R	Joins with S	Joins with W	Joins with X	Joins with Y

Metapuzzle
Fontastic
Solution

(FOR STAFF USE ONLY)

The favorite number is 88. It is found by interpreting the main Puzzle solutions as the following fonts and cipher rules.

- ONE LETTER BEFORE IMPACT
  - Font: Impact
  - Cipher: Rotate all letters back by 1
  - NVMUJQMFPGFMFWFO ⇒ MULTIPLEOFELEVEN
- ICE DELIVERY
  - Font: Courier
  - Cipher: Insert the missing letters I
  - DVDENNESEVENREMAN ⇒ DIVIDENINESEVENREMAIN
- ALABAMA SHIFTED EAST
  - Font: Georgia
  - Cipher: Move the letters in ALABAMA left by 1
  - UABNDNAT ⇒ ABUNDANT
- LAUGH WITHOUT
  - Font: Comic Sans
  - Cipher: Remove the letters in LAUGH
  - BLEFAOUREGOHNELFAIVUEZGERHO ⇒ BEFOREONEFIVEZERO
- USE THE UPBEATS
  - Font: Syncopate
  - Cipher: Use every other letter
  - ETEWDOIOGRITTHSR ⇒ TWOORTHREEDIGITS

88 is the only number which is a multiple of 11, has a remainder of 7 when divided by 9, is abundant (see definition in the rules), is less than 150, and has two or three digits.

What’s my favorite number?

UABNDNAT

NVMUJQMFPGFMFWFO

DVDENNESEVENREMAN

ETEWDOIOGRITTHSR

BLEFAOUREGOHNELFAIVUEZGERHO

TYPOGRAPHY CLUB!

Looking to make an "Impact"?

Does your heart have a "syncopate"-d beat?

Do you have "Georgia" on your mind?

Are you as reliable as a postal service "Courier"?

Would you say you have a "Comic Sans" personality?

THEN JOIN TYPOGRAPHY CLUB TODAY!