

BALLAST

addition



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Start by projecting this puzzle to the whole class. { Trireme for Class to Sink or Save	6
Puzzles of increasing difficulty. You do not have to start all your students with the easy first ones. { Puzzle Sheets	7-22
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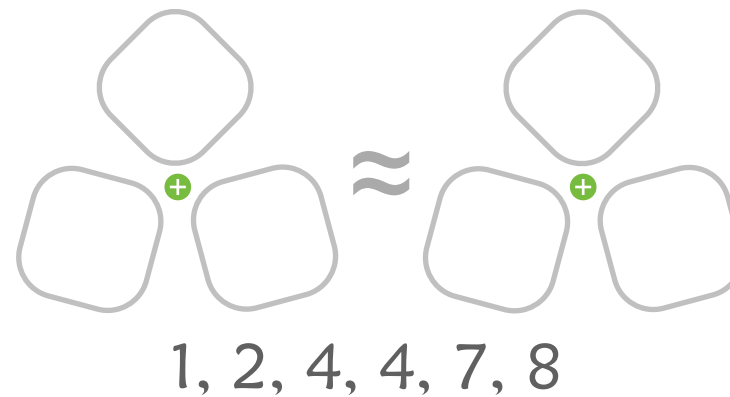


BALLAST

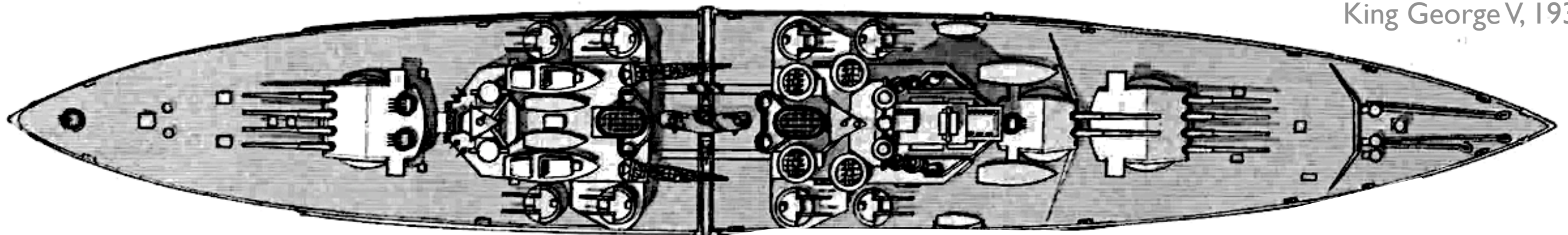
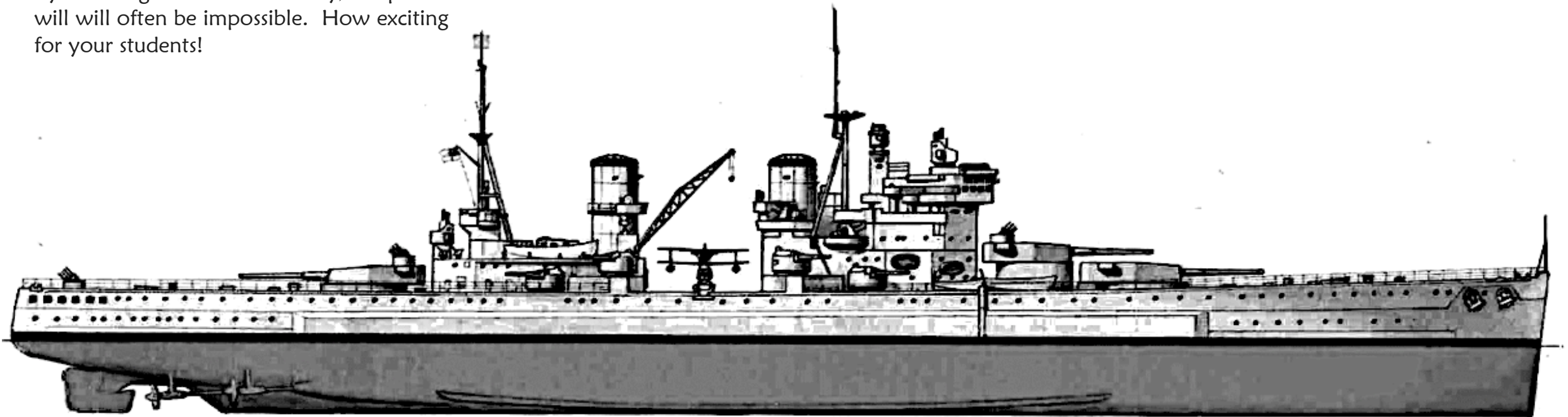
Ballast puzzles have students balancing the ballast on warships so they don't tip over. Too much weight on the starboard or port side and the warship will keel over. In the puzzle below, we are asked to add ballast weighing 1, 2, 4, 4, 7, and 8 units. One solution is to put 1, 4, and 8 on the left hand side (port) and 2, 4, and 7 on the right hand side (starboard). $1+4+8 = 2+4+7$ so this warship floats. Not all do!

Whenever I introduce this puzzle in class (page 6) - I ask six students to choose six numbers before they know the rules. Other students are then asked to put the numbers on the right or left side. They fail because they don't know the rules. I then talk about ballast and how to balance their boat. This method of introducing puzzles engages a higher fraction of students than explaining the rules at the start.

By choosing numbers randomly, the puzzle will often be impossible. How exciting for your students!



After you have introduced the puzzle (page 6) explain the ballast worksheets. They have three ship puzzles each: two warships are capable of being saved, but the third is doomed - no matter what you do, it is impossible to balance. Your student's job is to save two of the three warships and identify the one that will sink.



King George V, 1939

Standards for Mathematical Practice

All MathPickle puzzle designs, including **BALLAST**, are guaranteed to engage a wide spectrum of student abilities while targeting the following Standards for Mathematical Practice:

MP1 Toughen up!

This is problem solving where our students develop grit and resiliency in the face of nasty, thorny problems. It is the most sought after skill for our students.

MP3 Work together!

This is collaborative problem solving in which students discuss their strategies to solve a problem and identify missteps in a failed solution. MathPickle recommends pairing up students for all its puzzles.

MP6 Be precise!

This is where our students learn to communicate using precise terminology. MathPickle encourages students not only to use the precise terms of others, but to invent and rigorously define their own terms.

MP7 Be observant!

One of the things that the human brain does very well is identify pattern. We sometimes do this too well and identify patterns that don't really exist.

Common Core State Standards

BALLAST targets Common Core State Standards for students learning and practicing addition.

Grades 1-3

CCSS.MATH.CONTENT.1.NBT.C.4

Add within 100, including adding a two-digit number and a one-digit number.

CCSS.MATH.CONTENT.1.NBT.C.5

Given a two-digit number, mentally find 10 more or 10 less than the number, without having to count; explain the reasoning used.

CCSS.MATH.CONTENT.2.OA.B.2

Fluently add and subtract within 20 using mental strategies.2 By end of Grade 2, know from memory all sums of two one-digit numbers.

CCSS.MATH.CONTENT.2.NBT.A.4

Compare two three-digit numbers based on meanings of the hundreds, tens, and ones digits, using $>$, $=$, and $<$ symbols to record the results of comparisons.

CCSS.MATH.CONTENT.2.NBT.B.5

Fluently add and subtract within 100 using strategies based on place value, properties of operations, and/or the relationship between addition and subtraction.

CCSS.MATH.CONTENT.2.NBT.B.6

Add up to four two-digit numbers using strategies based on place value and properties of operations.

CCSS.MATH.CONTENT.2.NBT.B.7

Add and subtract within 1000, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction

CCSS.MATH.CONTENT.3.NBT.A.2

Fluently add and subtract within 1000 using strategies and algorithms based on place value, properties of operations, and/or the relationship between addition and subtraction.

For the Teacher...

How to introduce a new puzzle like **BALLAST**:

Instead of introducing a new puzzle by explaining rules to the class, just jump in and ask students to contribute numbers **WITHOUT KNOWING THE RULES**. Get all students to contribute - systematically going around the class. Students do not raise their hands... We want all students to contribute.

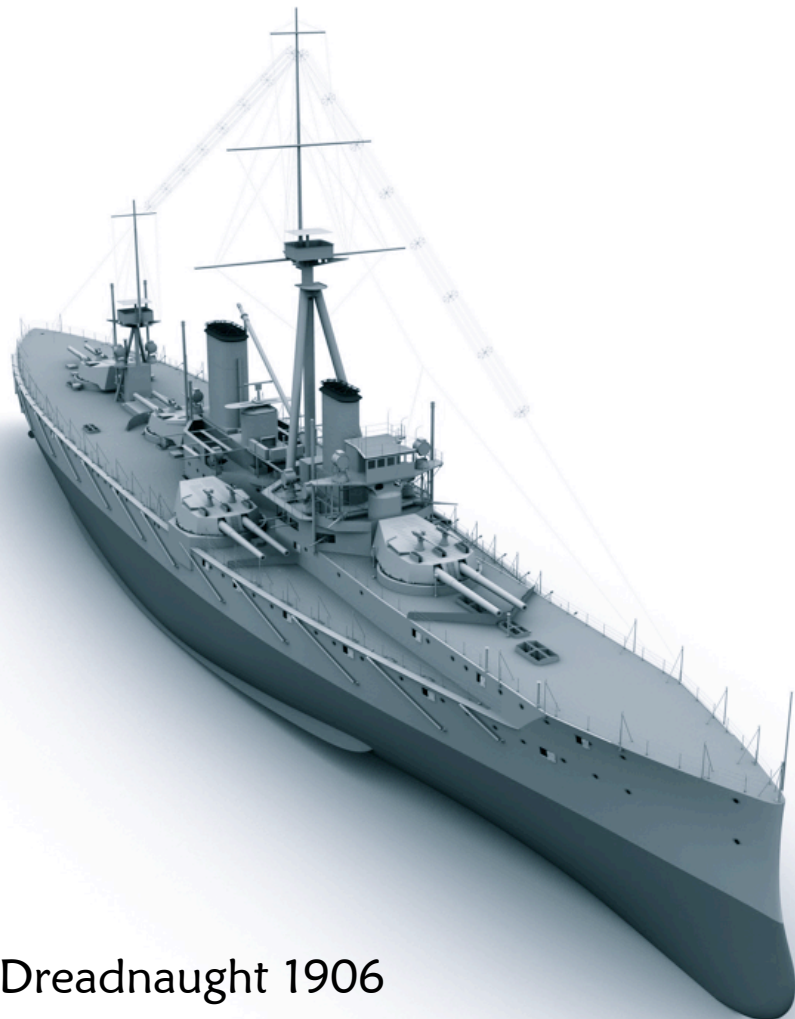
After students fail, reveal one rule. Repeat until most students understand the rules.

This strategy efficiently engages more students than going through the rules at the start. Students get engaged when they contribute. They also enjoy the tongue-in-cheek failure.

Experiment with a new way to inspire:

The worksheets for **BALLAST** are really cool for a subset of students. Do not let students see them. Keep the mystery alive.

Let's say you have a student who you want to emotionally boost or engage more effectively. Experiment by letting them be the first to have a new puzzle sheet... and tell them that they are the first to get it. Watch how they react with their peers from the corner of your eye.



Dreadnaught 1906

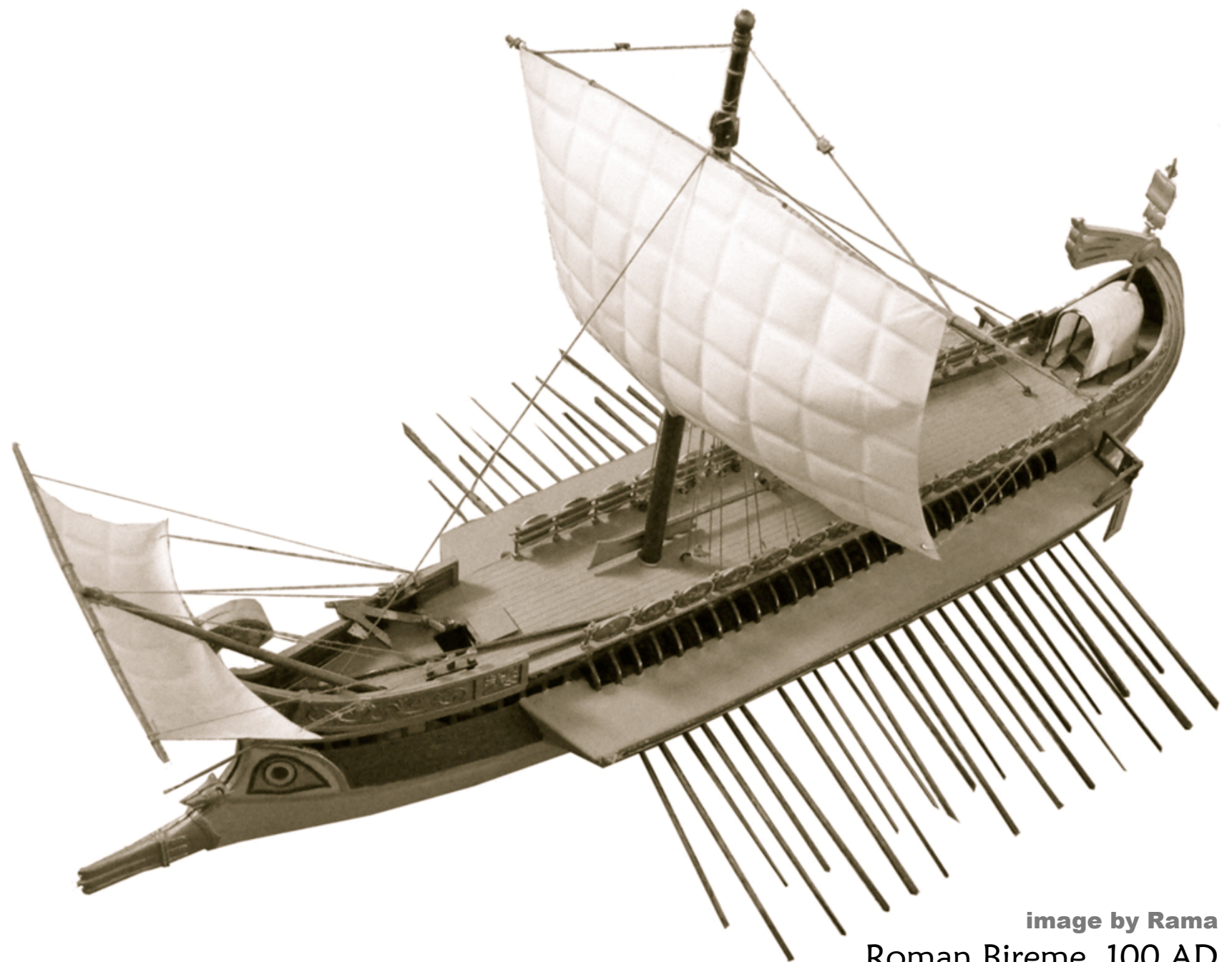
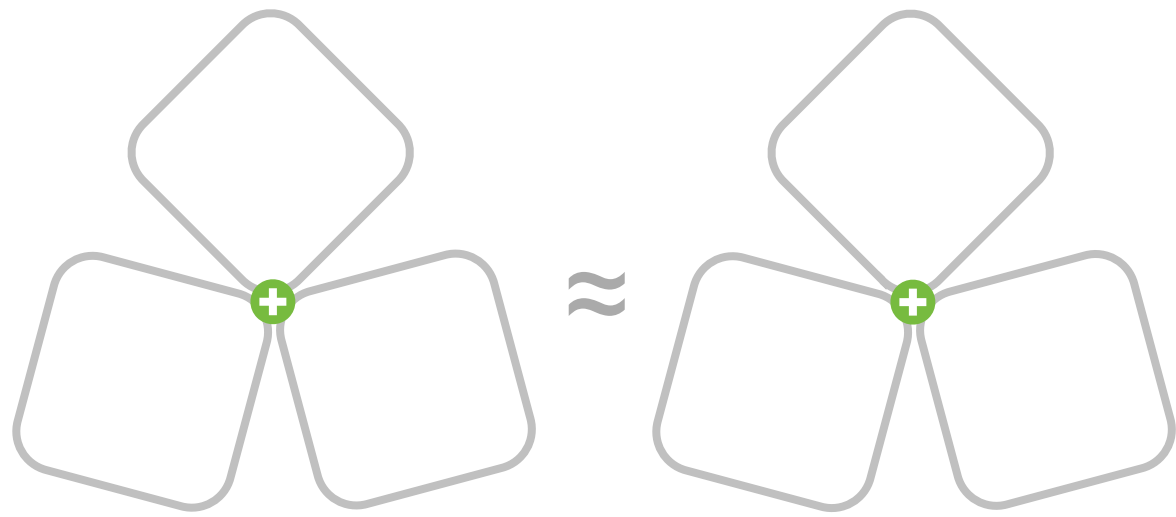
\$100 Classroom Challenge

Perhaps your students have created a warship with ballast that can only be placed in exactly one way or a student who is not usually excited about math has become engaged. Perhaps a pair of students discovered a general rule that allows warships with consecutive integers as ballast to always float... Whatever your inspirational experience with this gem of a puzzle, I'd like to know.

I'll offer \$100 for a photograph and/or story highlighting **BALLAST** in the classroom.

All students featured must have appropriate consent. All photographs and stories submitted may be used in an updated version of this pdf file and to promote this puzzle elsewhere.

Send submissions to gord@mathpickle.com. Use "\$100 Addition Ballast" as the subject of the email. The winning classroom will be announced the first March 14th that I have at least 10 submissions from different schools. I hope this will be March 14th, 2016.



see page 3 for instructions

image by Rama
Roman Bireme, 100 AD



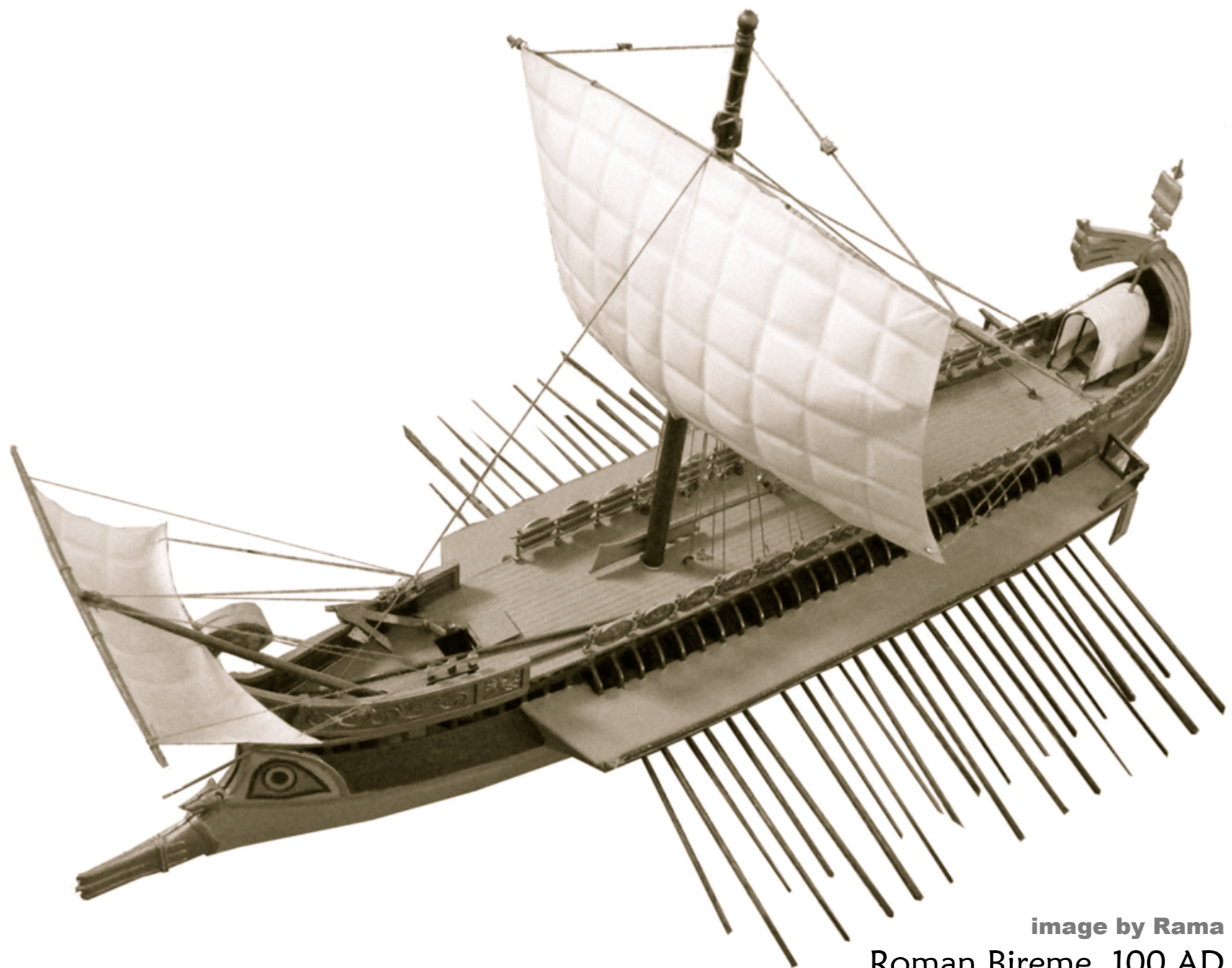
1, 2, 3, 4



1, 2, 4, 5

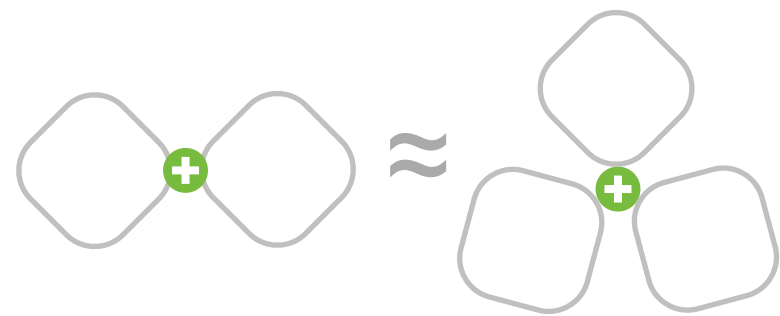


1, 3, 4, 5

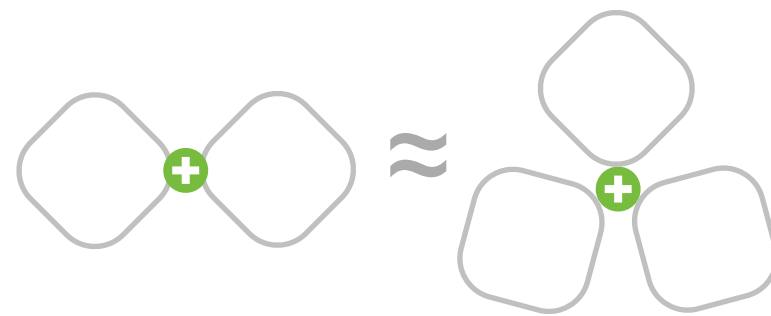


Find the warship that will sink.
Show that the other two warships can float.

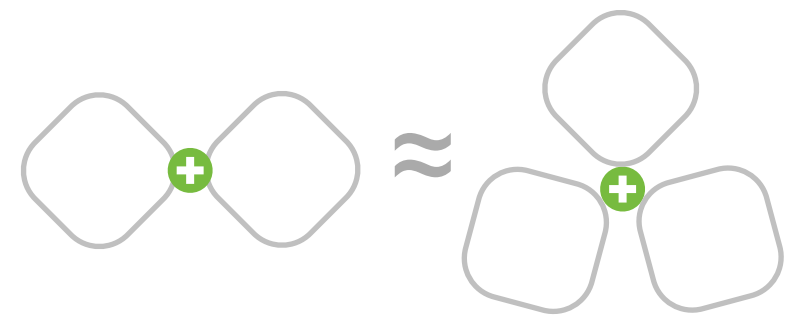
image by Rama
Roman Bireme, 100 AD



1, 2, 4, 5, 6



1, 2, 3, 5, 7

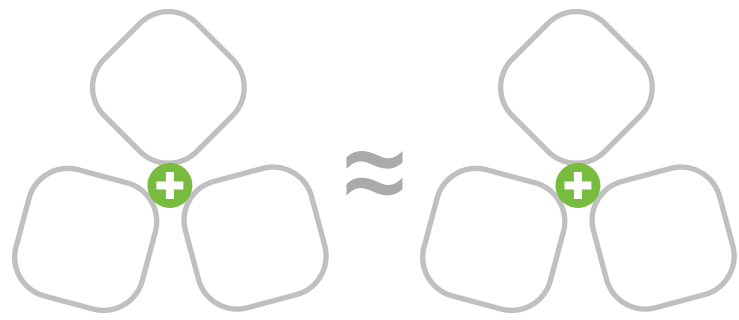


1, 2, 3, 4, 5

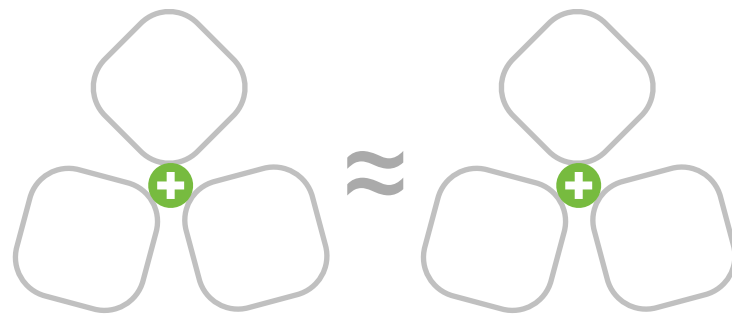


Find the warship that will sink.
Show that the other two warships can float.

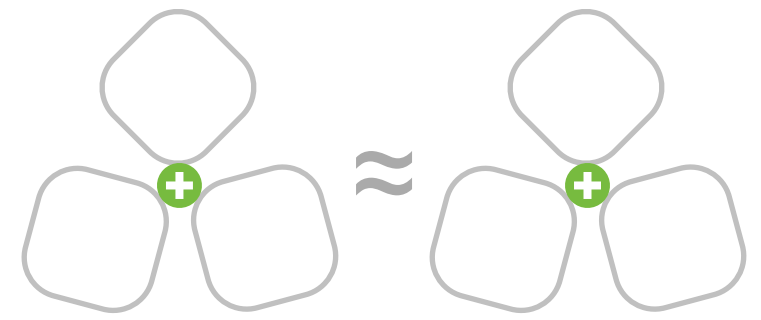
Byzantine Dromon, 700 AD



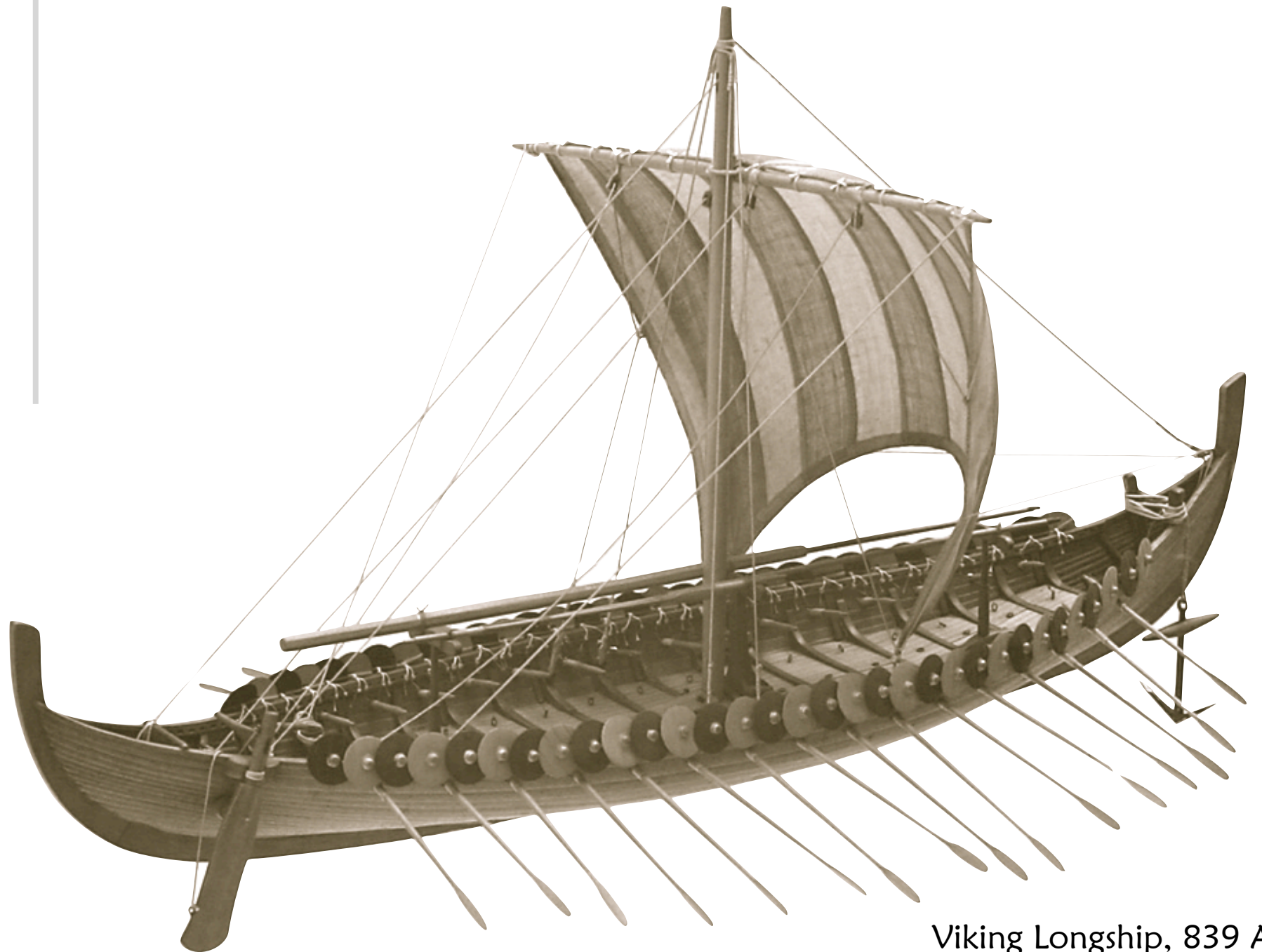
1, 2, 3, 4, 5, 5



1, 2, 3, 4, 5, 6

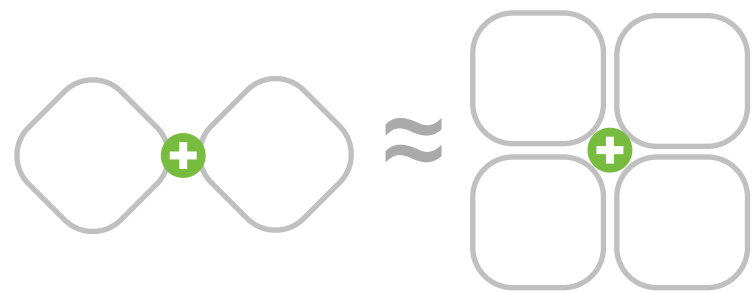


1, 2, 3, 4, 5, 7

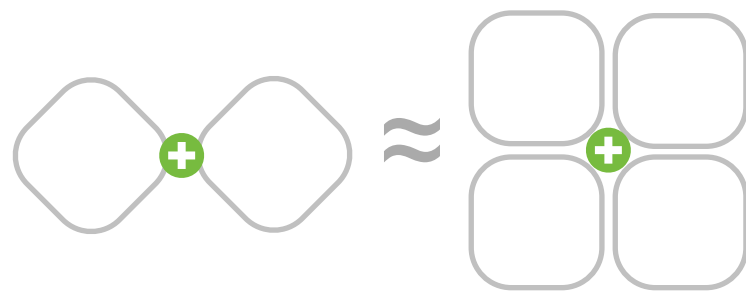


Find the warship that will sink.
Show that the other two warships can float.

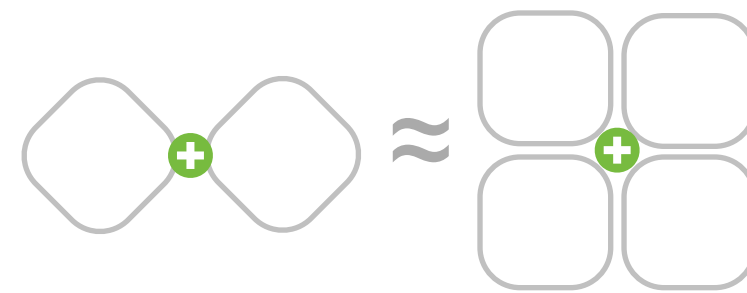
Viking Longship, 839 AD



1, 2, 3, 4, 5, 5



1, 2, 3, 4, 5, 10



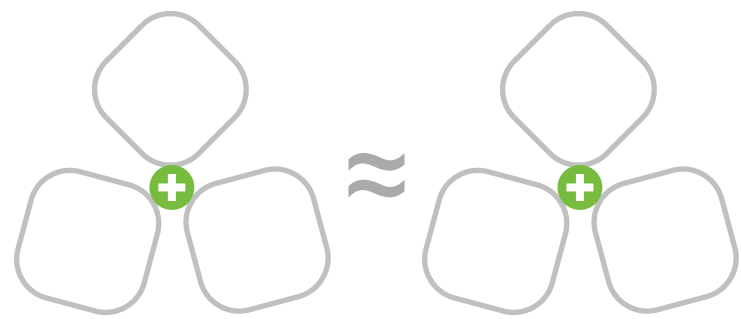
1, 2, 3, 4, 5, 11



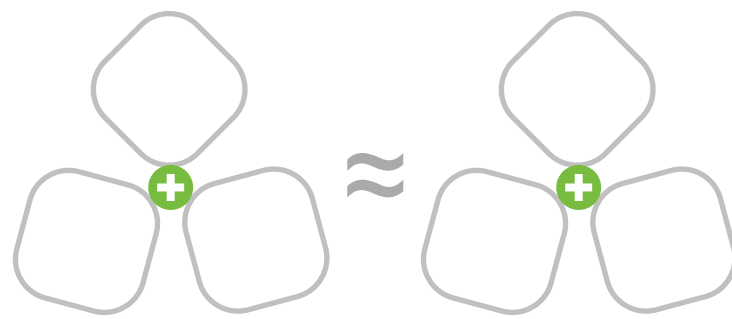
Maltese Galley, 1571

Photo by Myriam Thyges

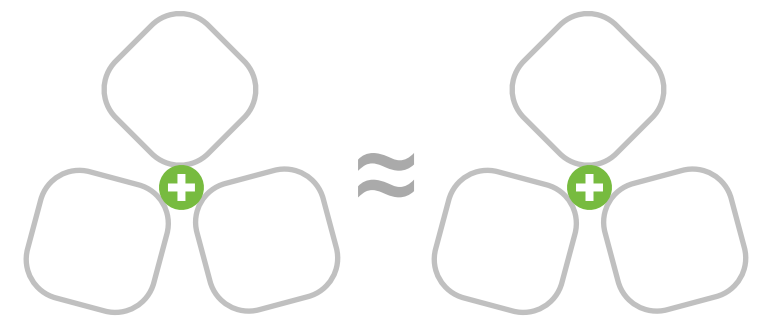
Model from the Naval History Museum in Venice



5, 10, 15, 20, 40, 50



5, 10, 20, 25, 30, 35

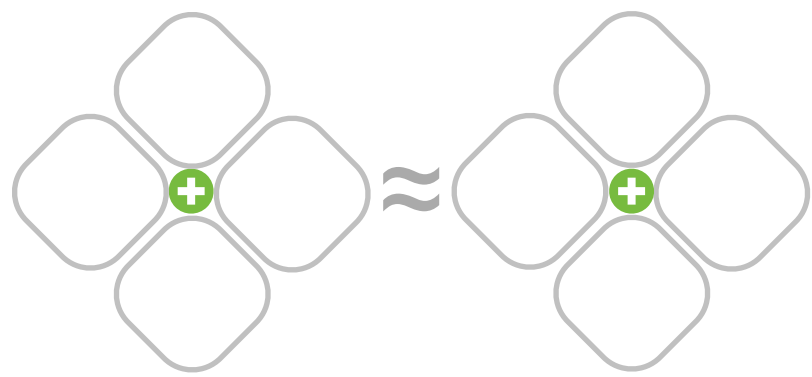


5, 10, 20, 25, 35, 45

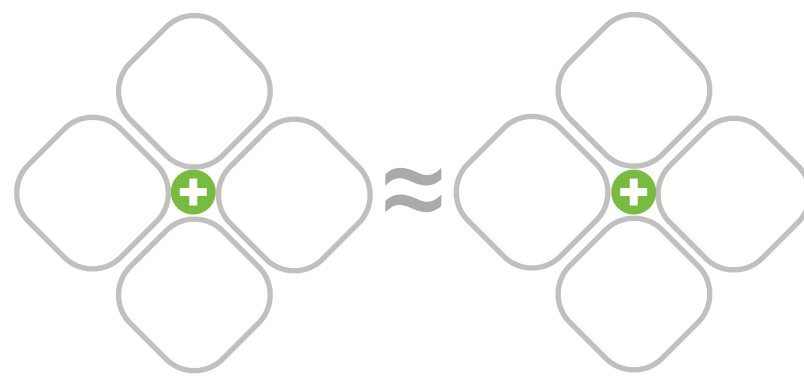


Galleass, 1690

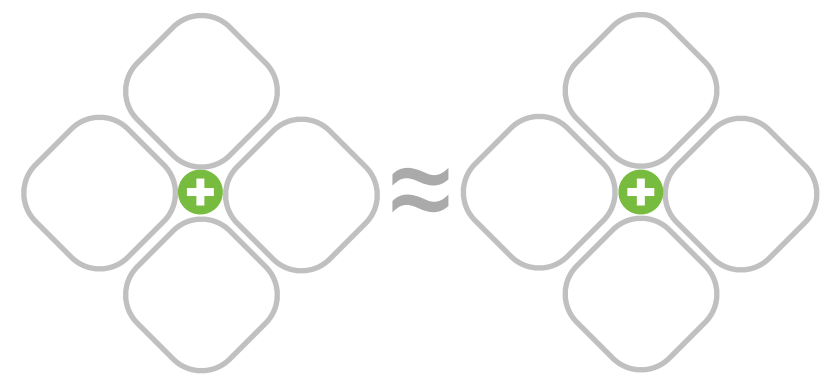
Engraving by
Henri Sbonski de Passebon



2, 2, 3, 3, 3, 7, 7, 7



2, 2, 3, 3, 3, 5, 5, 5

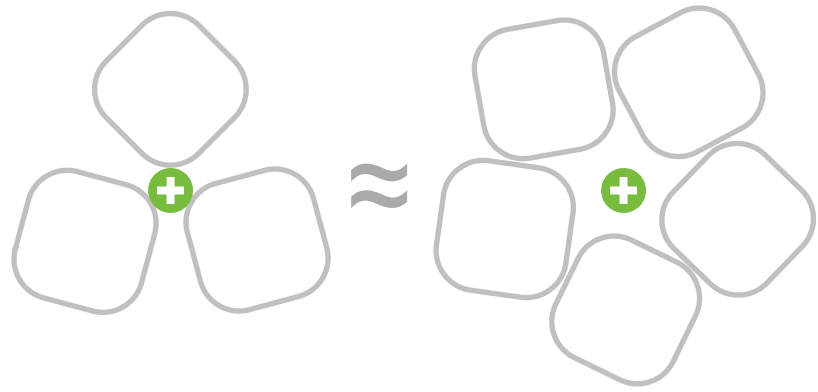


4, 4, 5, 5, 5, 7, 7, 7

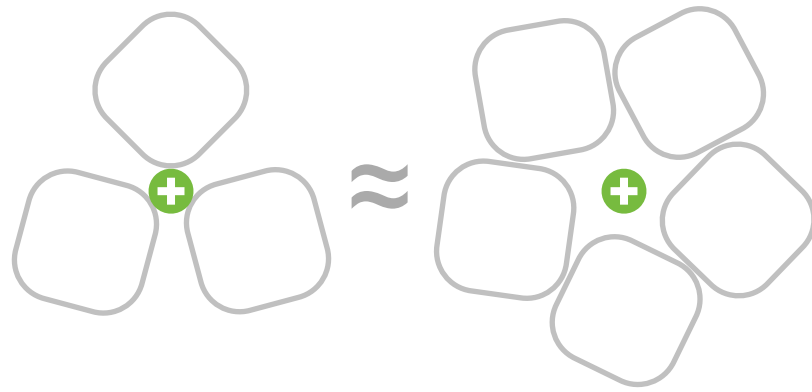


Find the warship that will sink.
Show that the other two warships can float.

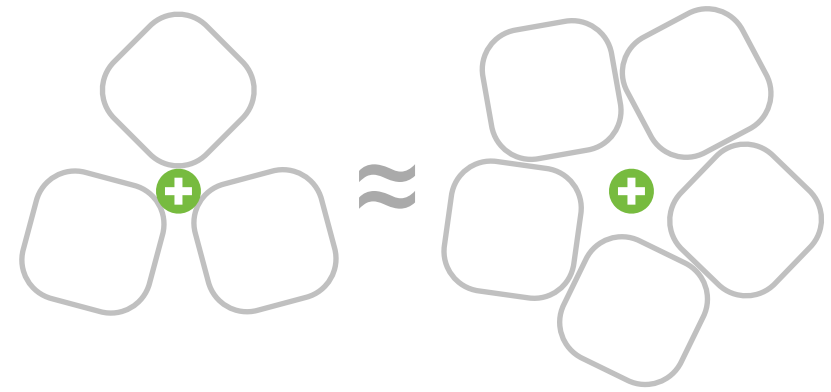
USS Constitution, 1797



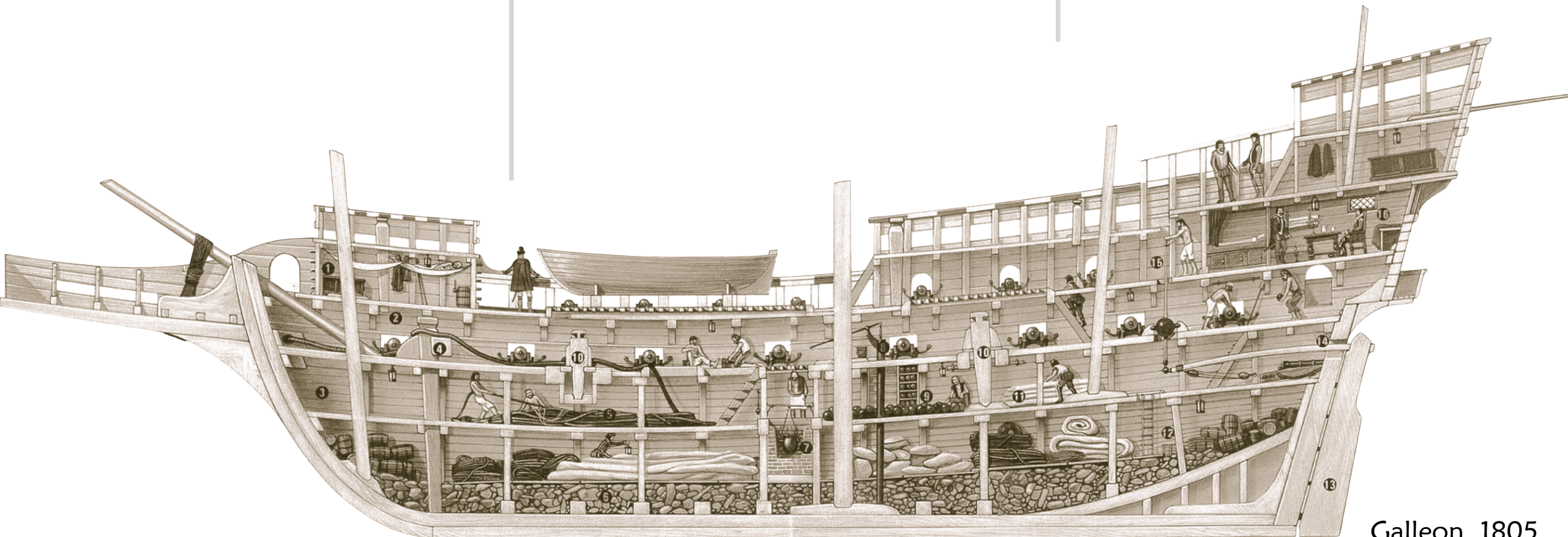
1, 2, 3, 4, 5, 5, 5, 5



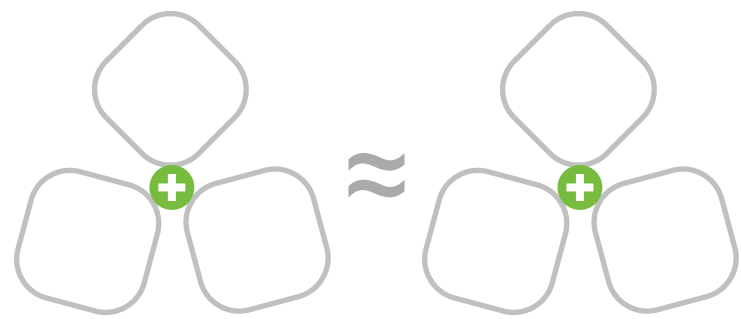
1, 1, 1, 2, 4, 4, 6, 9



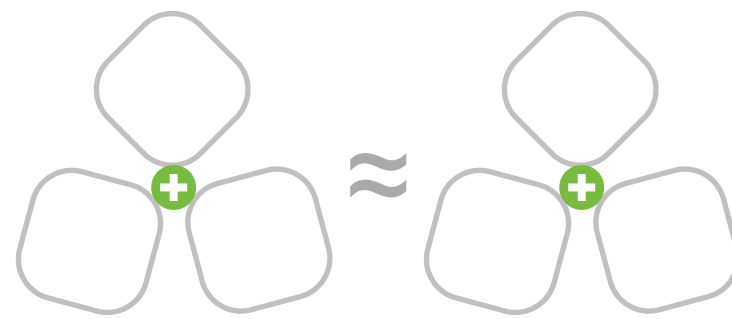
1, 2, 3, 4, 5, 6, 7, 8



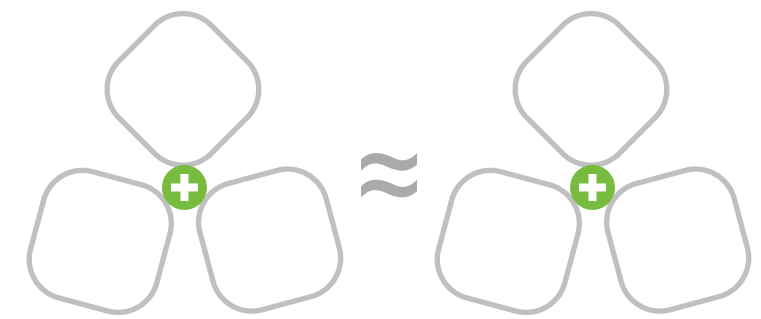
Galleon, 1805



3, 4, 12, 14, 15, 16



3, 8, 13, 14, 14, 18

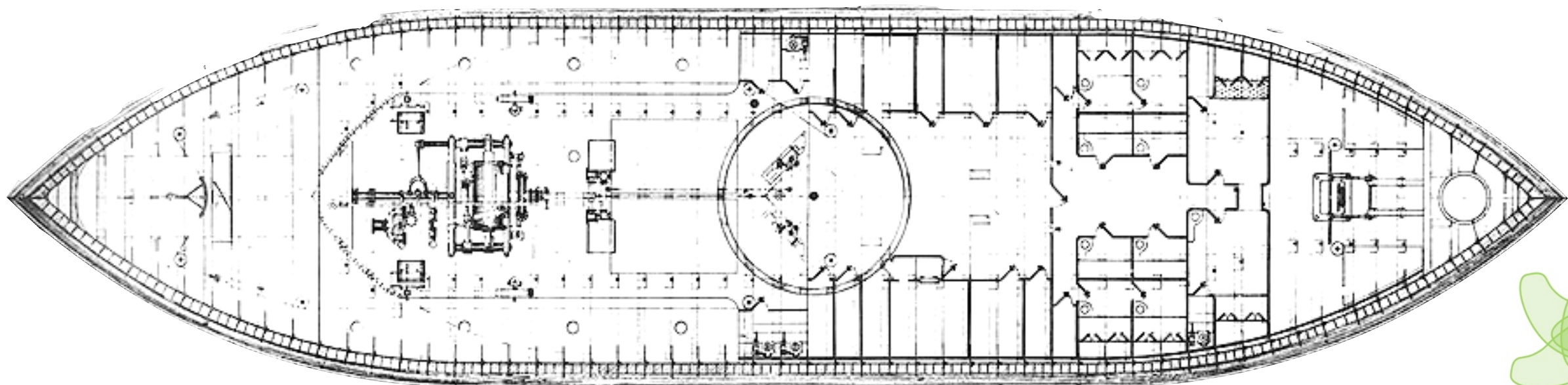
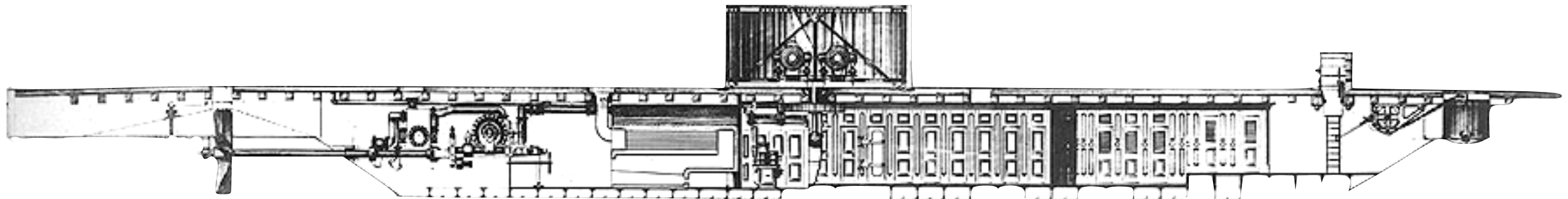


3, 4, 7, 11, 12, 14



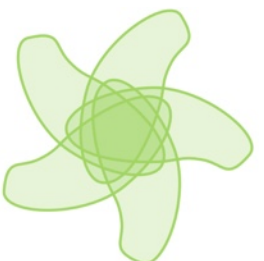
Ottoman Empire's Mahmudiye, 1829
(the largest ship in the world at the time)

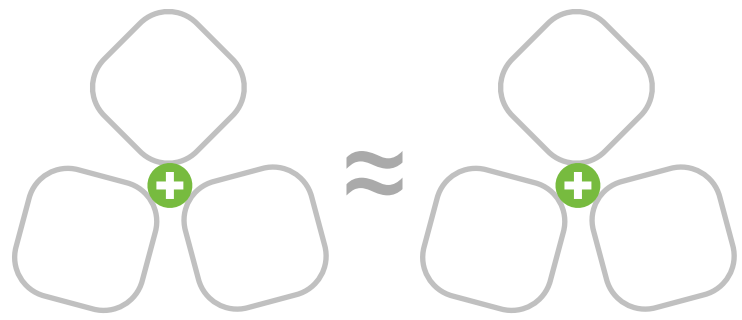




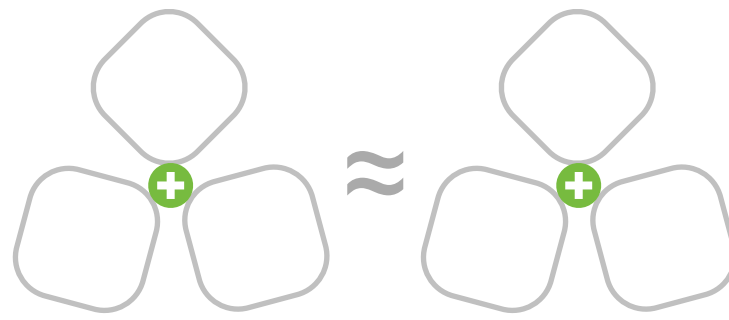
Monitor, 1862

Make a puzzle with one sinking warship. All numbers should be less than 20 and different.

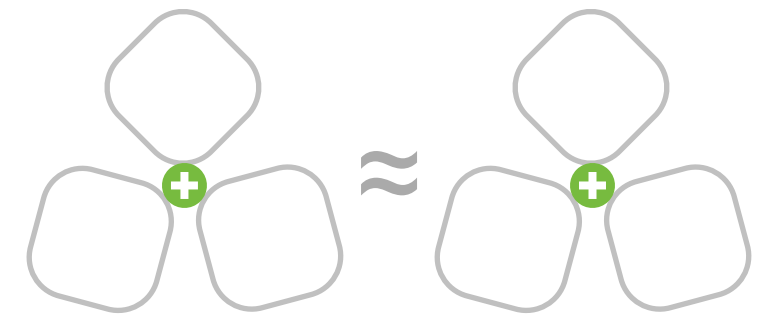




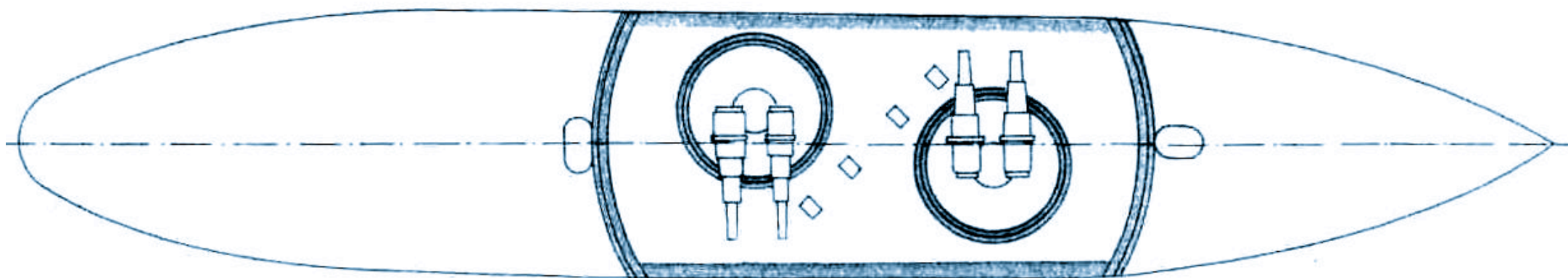
27, 29, 43, 50, 88, 93

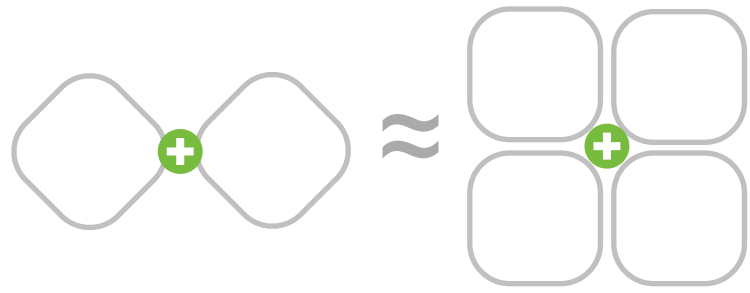


2, 16, 40, 47, 47, 90

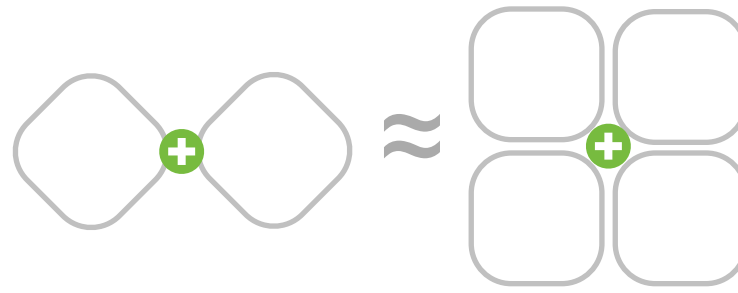


4, 9, 31, 56, 69, 89

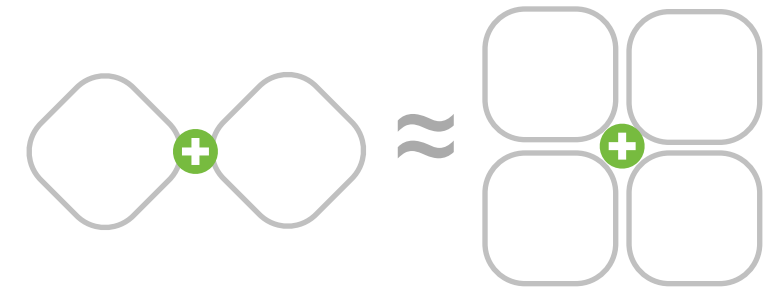




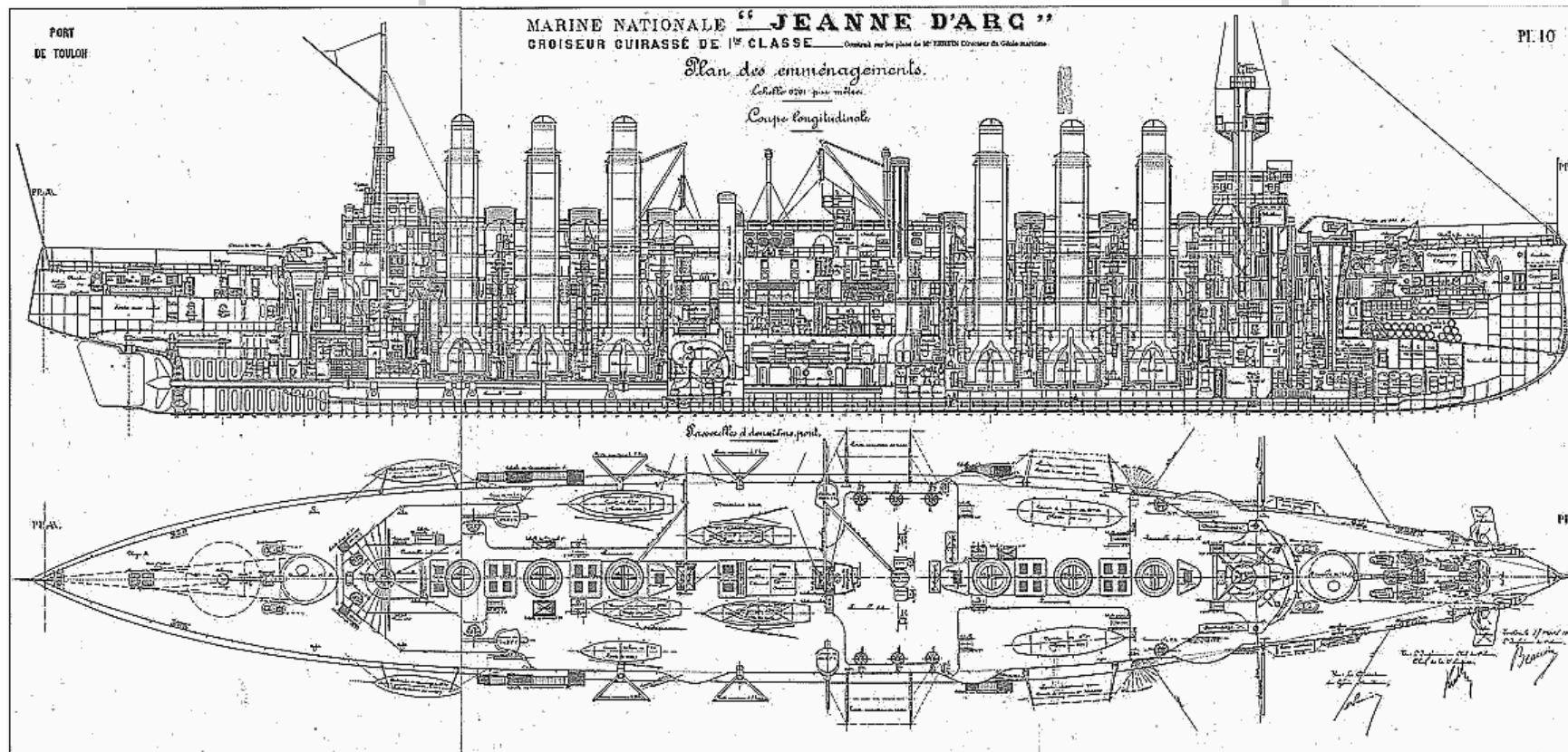
25, 29, 42, 43, 44, 99



2, 16, 40, 47, 47, 90

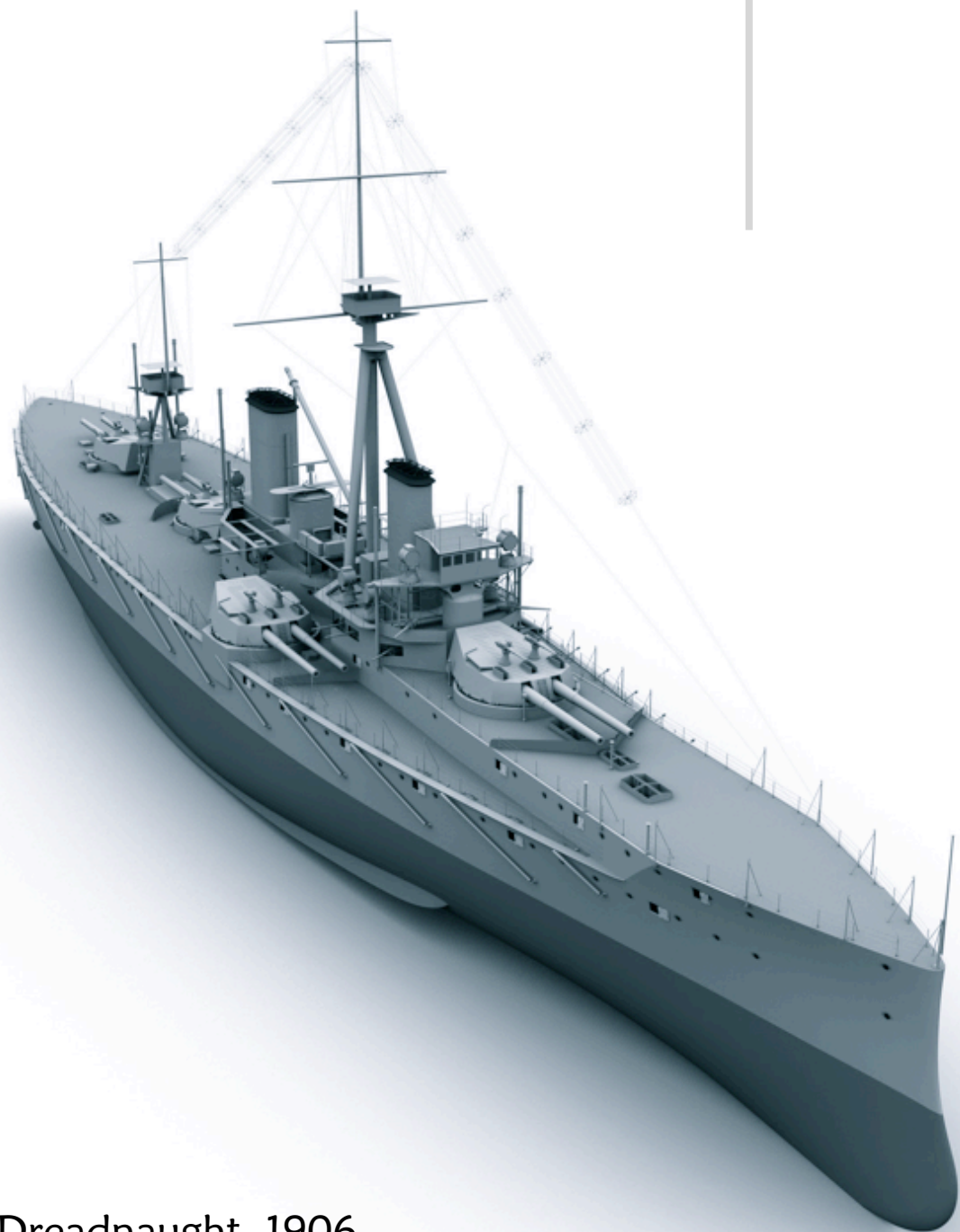
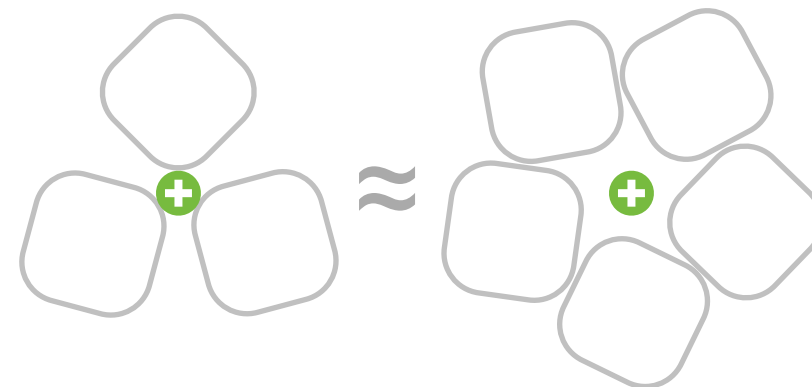
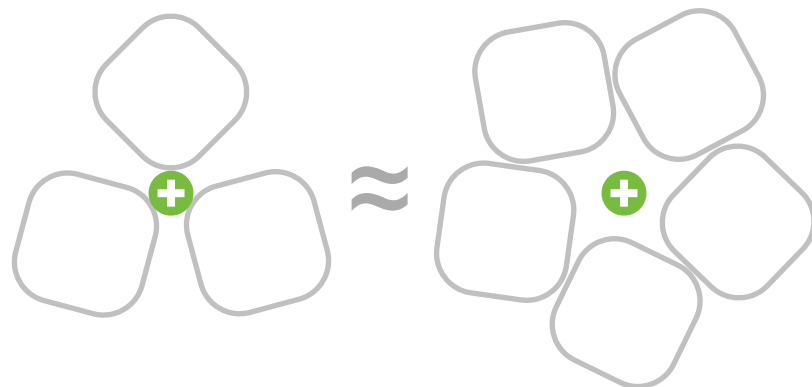
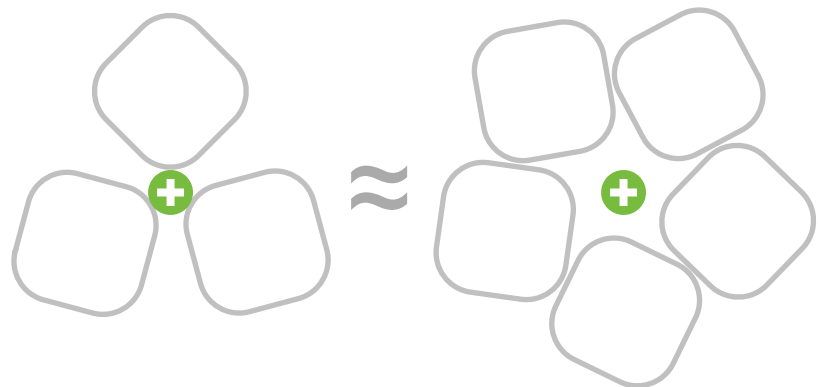


4, 5, 31, 60, 69, 89



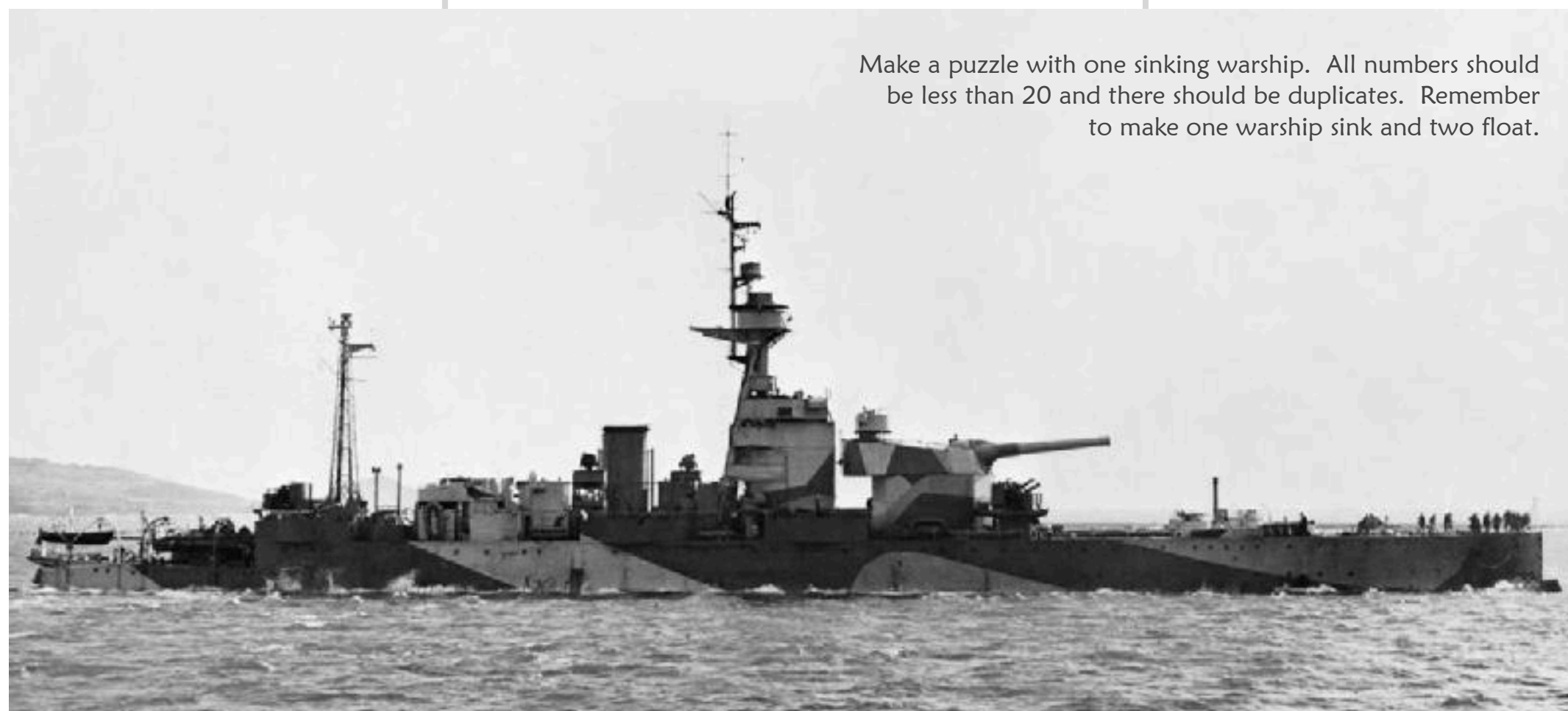
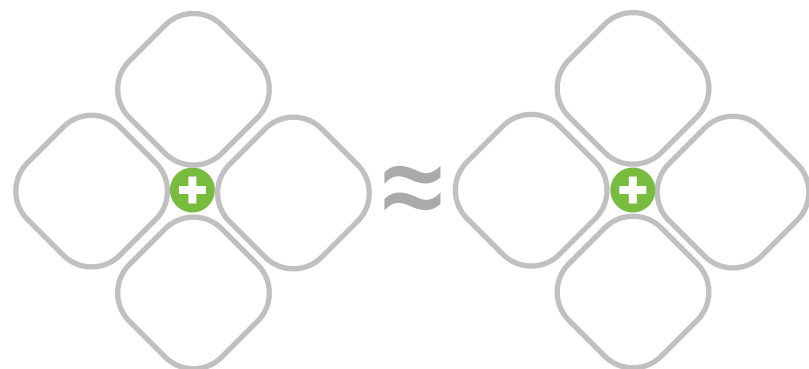
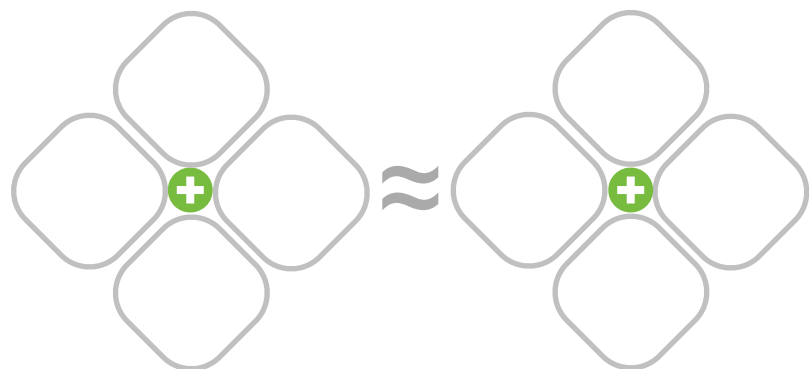
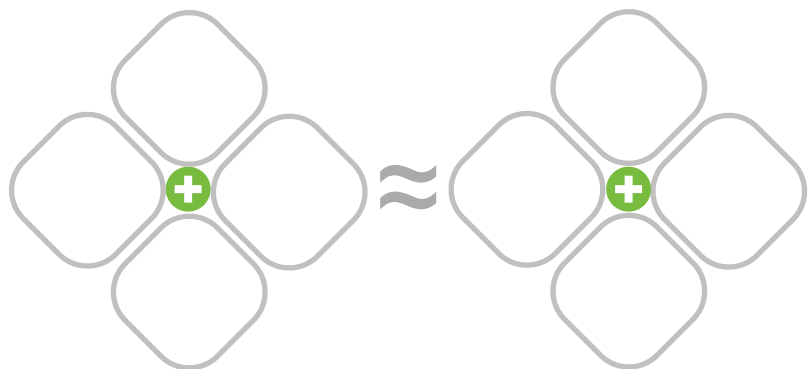
Find the warship that will sink.
Show that the other two warships can float.

Plan for French cruiser Joan of Arc, built 1899



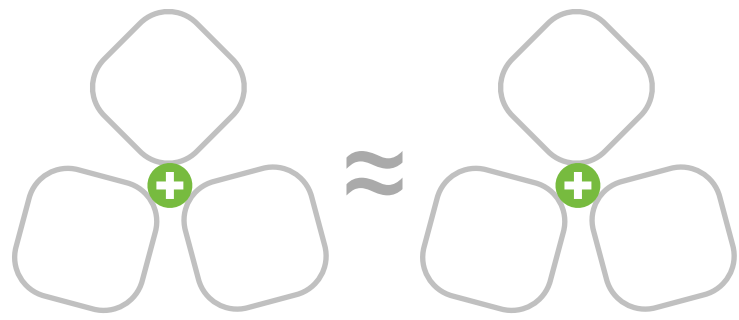
Dreadnaught, 1906

Make a puzzle with one sinking warship. All numbers should be less than 20 and there should be duplicates. Remember to make one warship sink and two float.

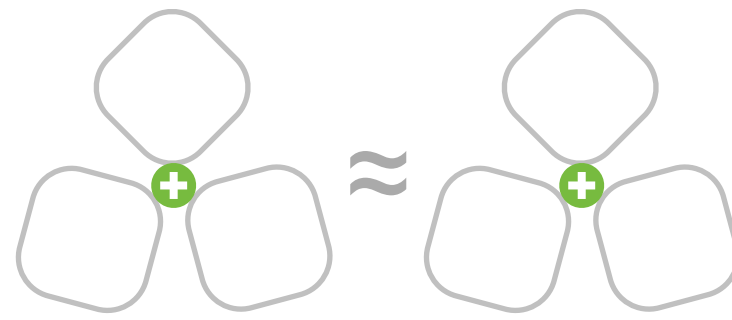


Make a puzzle with one sinking warship. All numbers should be less than 20 and there should be duplicates. Remember to make one warship sink and two float.

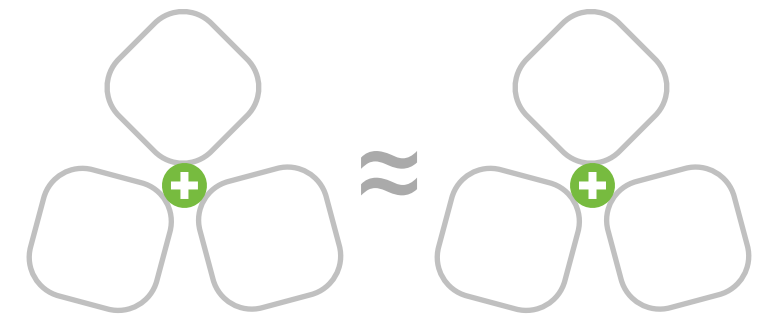
HMS Erebus - launched 1916 - photographed here in 1944



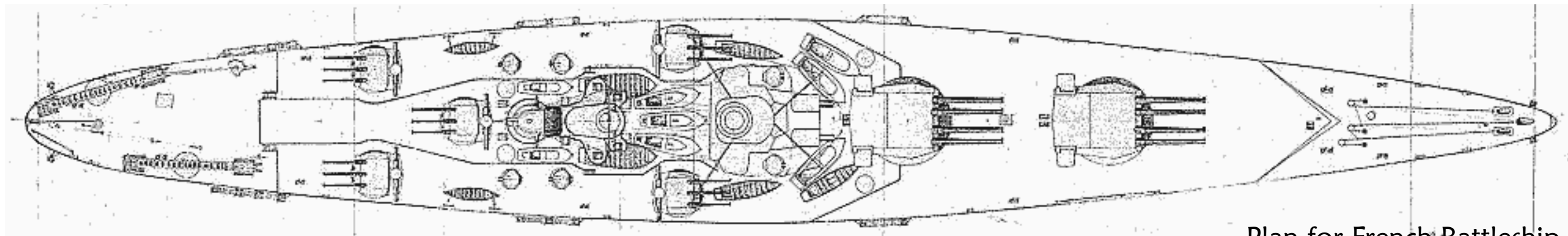
115, 120, 124, 130, 149, 150



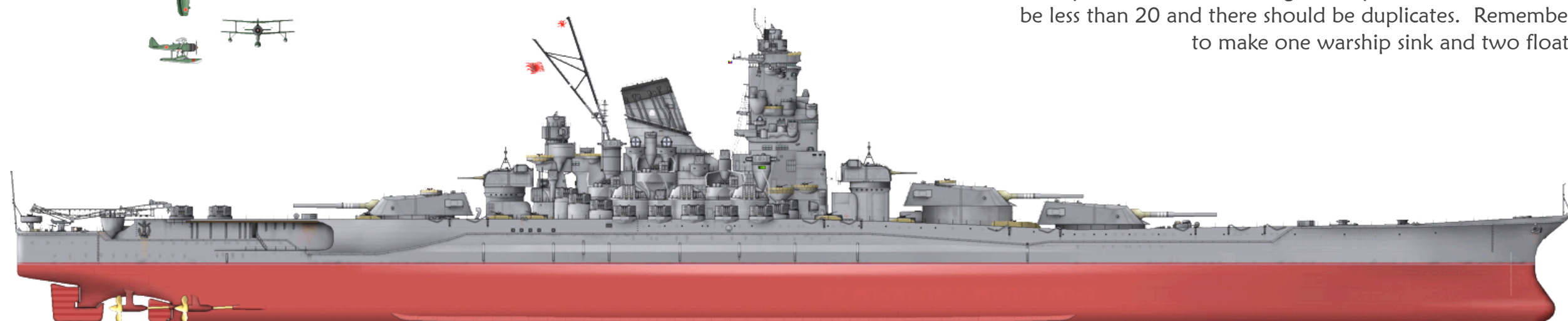
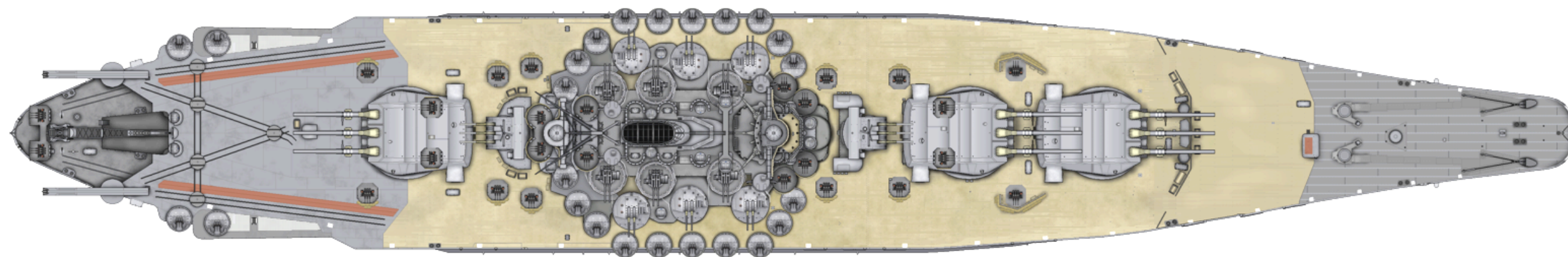
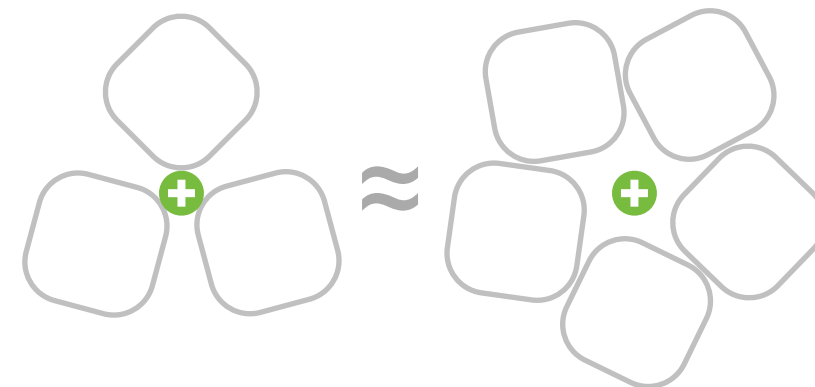
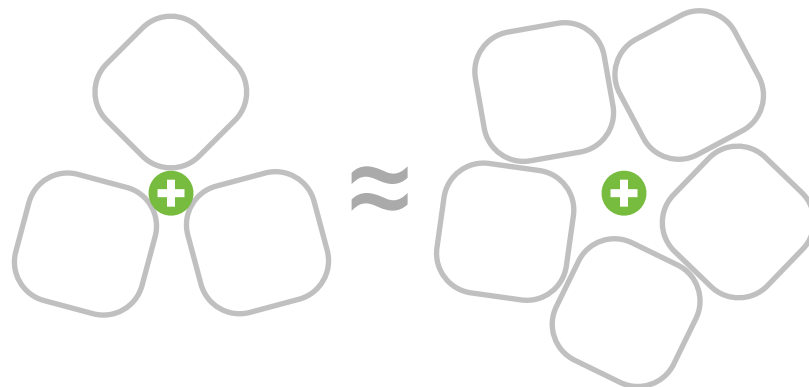
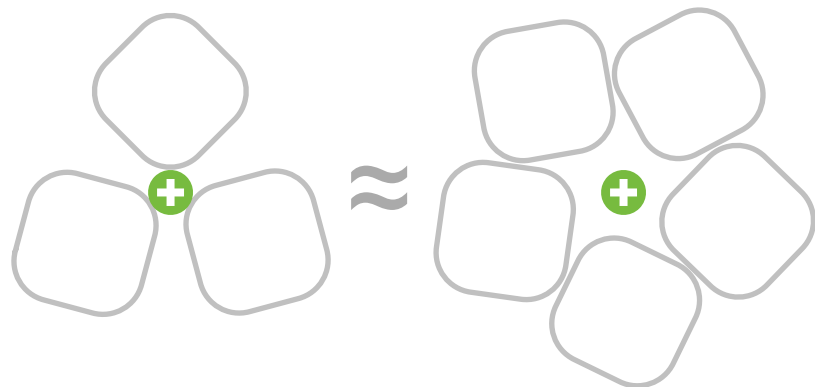
105, 120, 124, 130, 149, 150



105, 110, 124, 130, 149, 150



Plan for French Battleship
Clemenceau, 1940

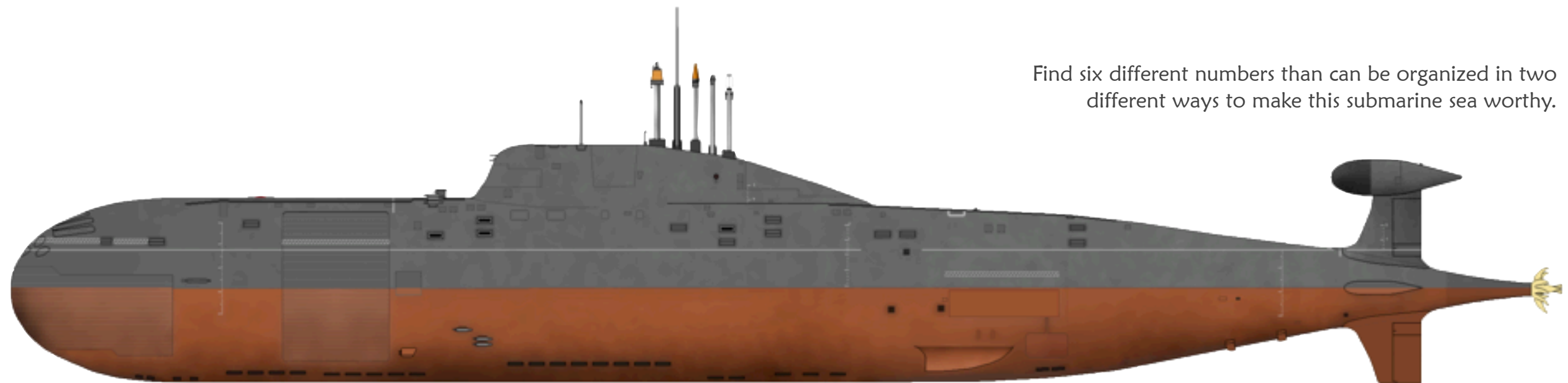
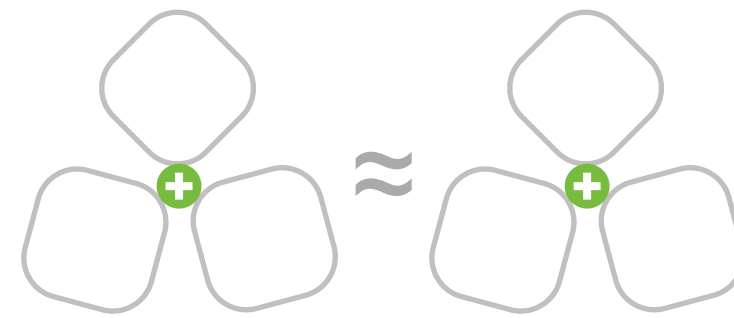
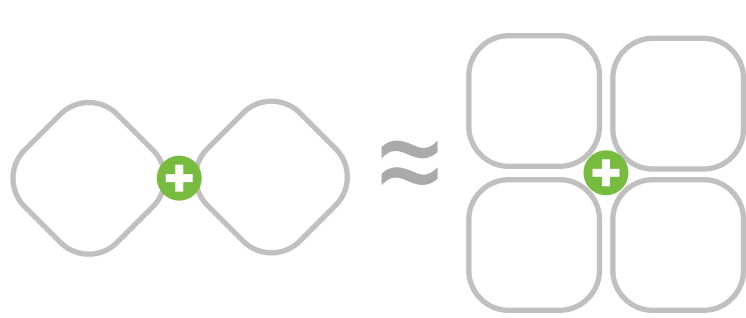


0 13 Meter
0 42,65 Feet

Make a puzzle with one sinking warship. All numbers should be less than 20 and there should be duplicates. Remember to make one warship sink and two float.

Yamato class battleships, 1945

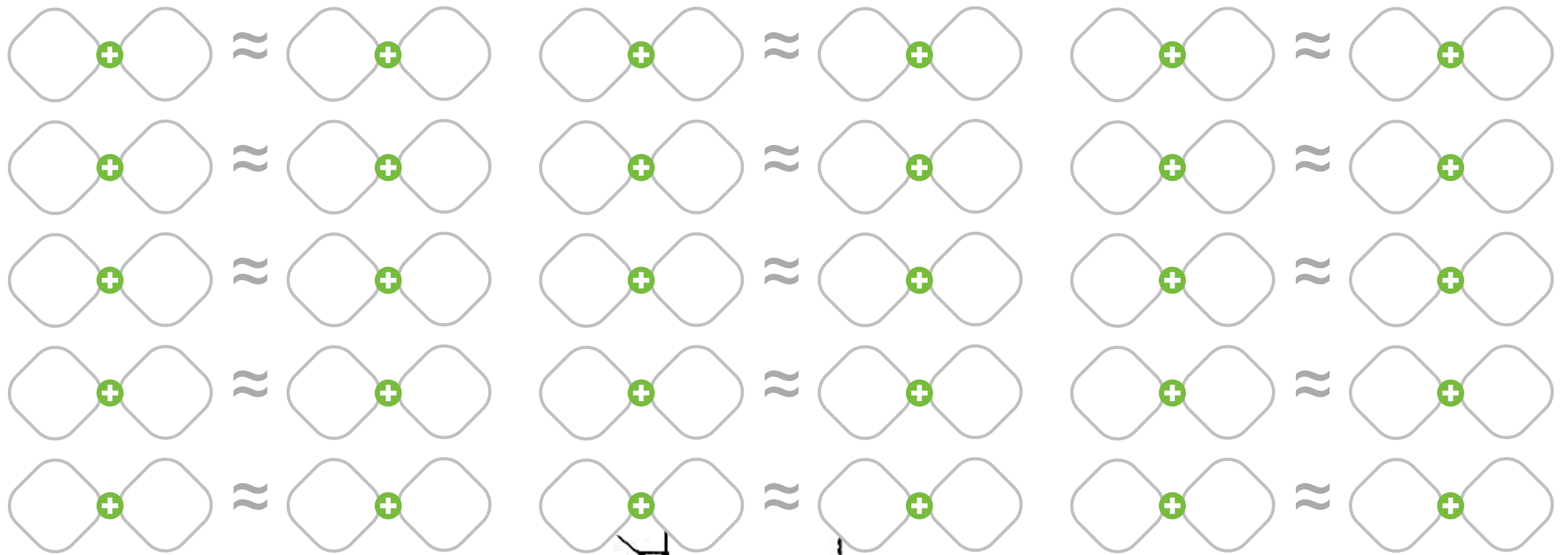
Drawing by Alexpl



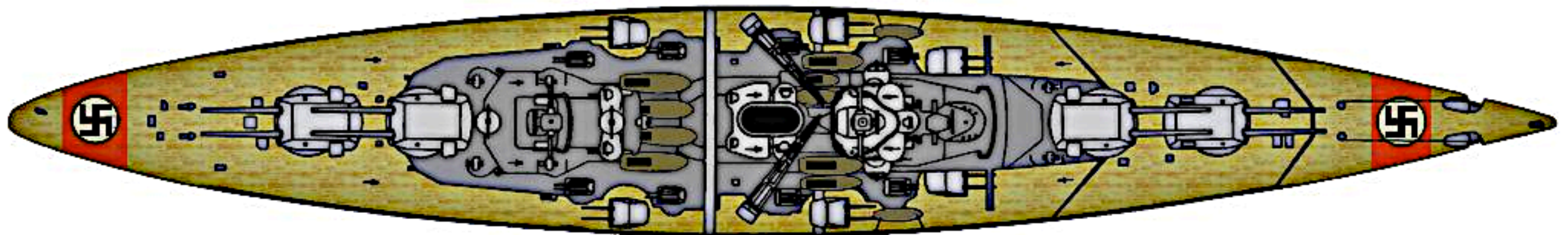
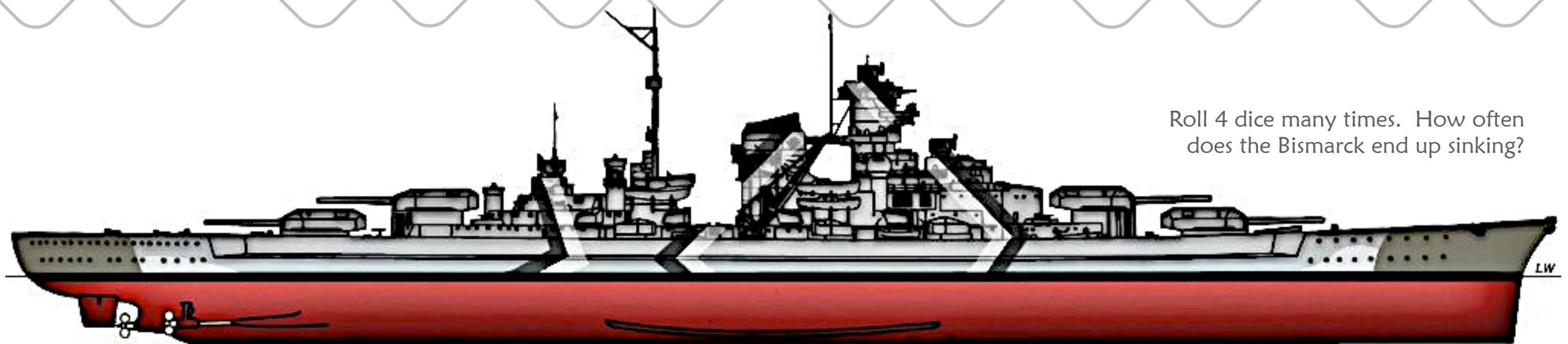
Find six different numbers than can be organized in two different ways to make this submarine sea worthy.

Russian Akula class submarines, 1990

Drawing by Alexpl

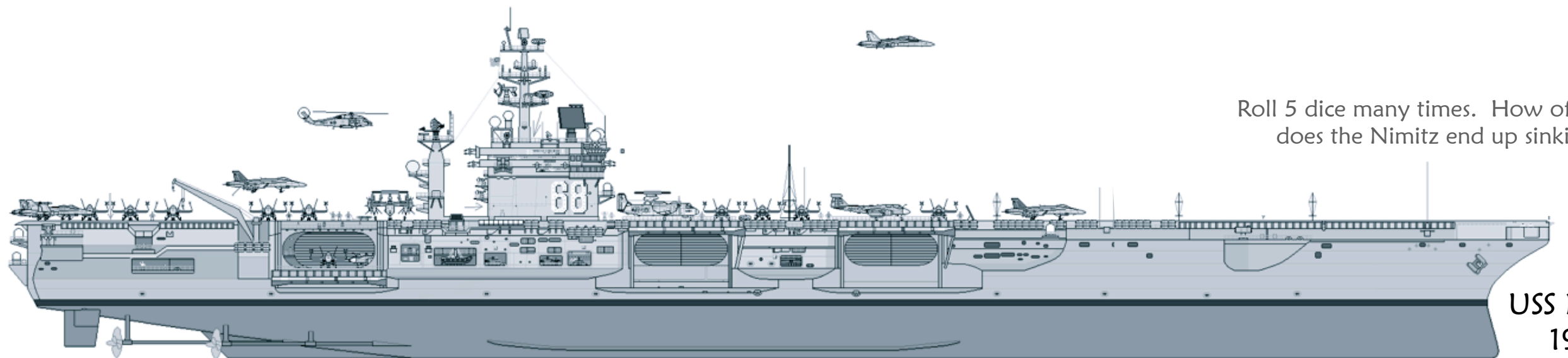
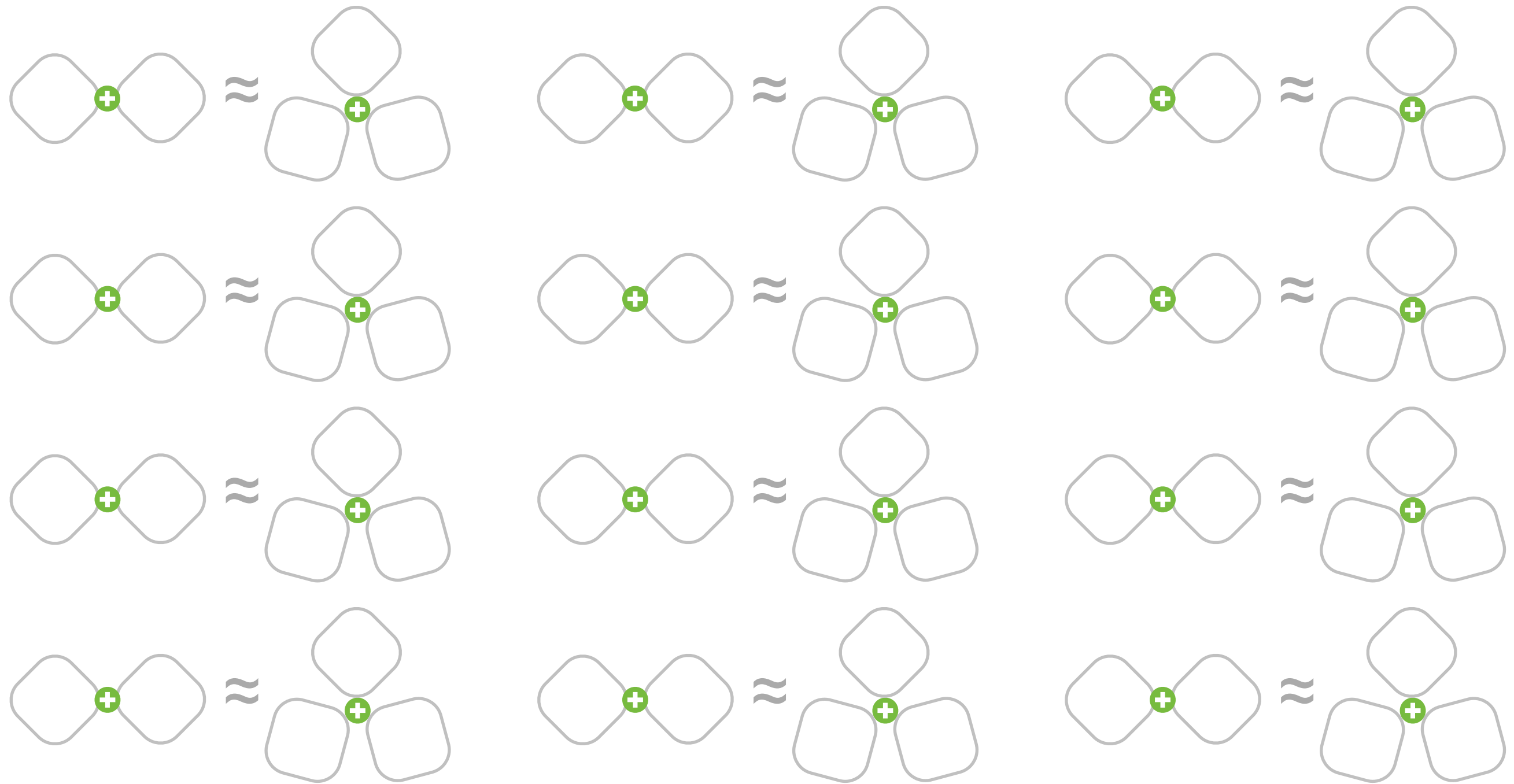


Roll 4 dice many times. How often
does the Bismarck end up sinking?



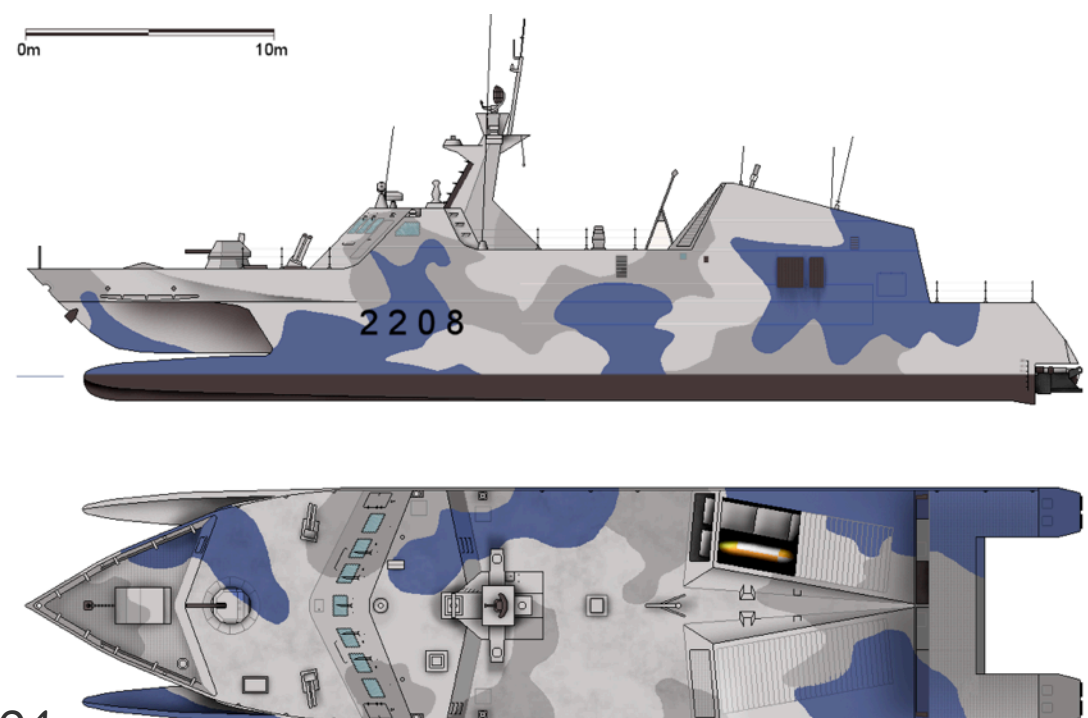
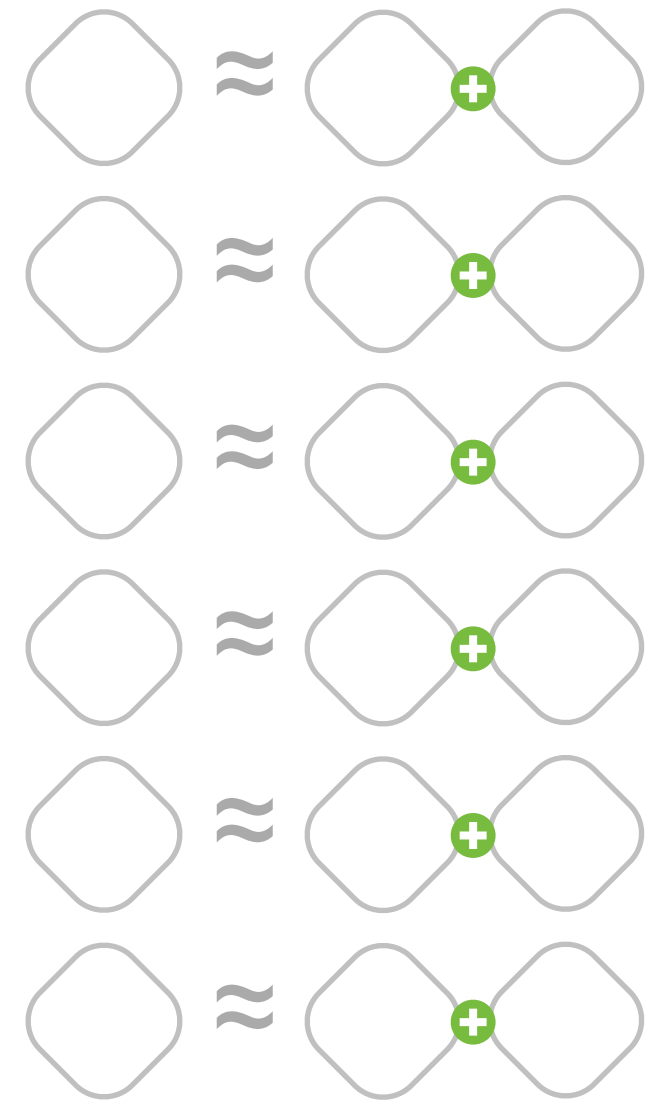
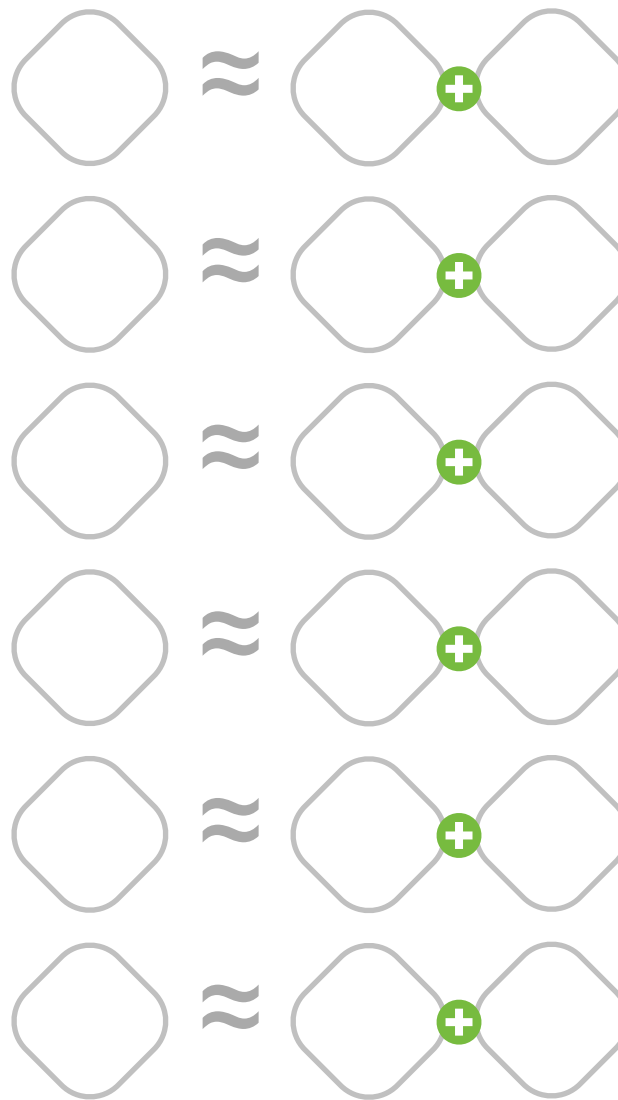
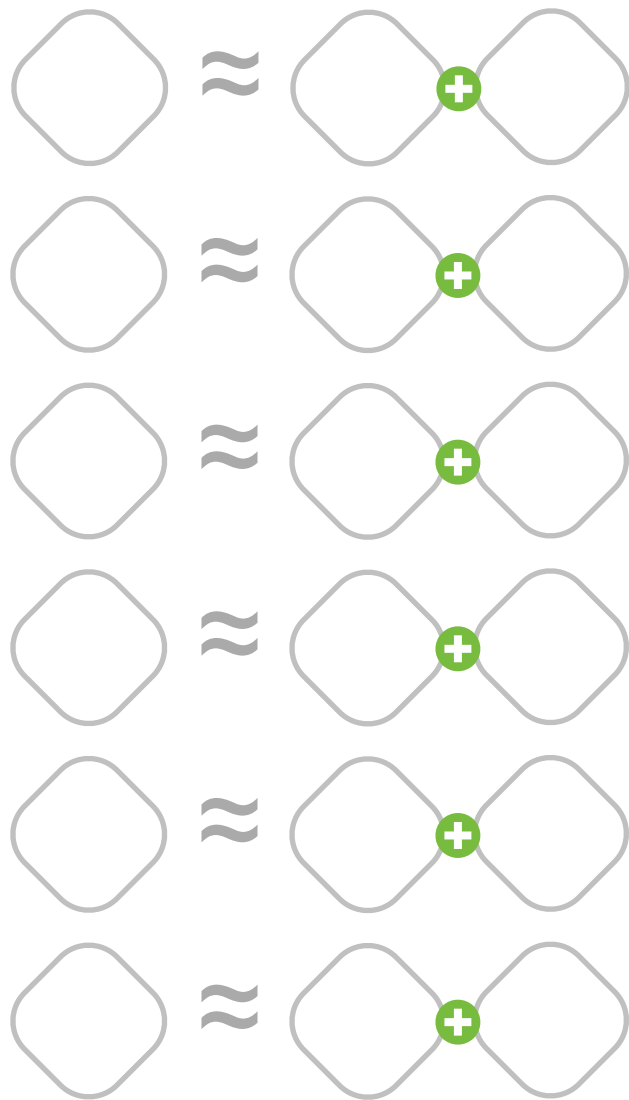
German battleship, Bismarck, 1941

Drawing by Slawomir Lipiecki



Roll 5 dice many times. How often
does the Nimitz end up sinking?

USS Nimitz
1975



Chinese Type-022 Missile boat, 2004

Roll 3 dice. Is this small missile boat better or worse than the Bismarck and Nimitz?

Drawing by Alexpl

$$\begin{array}{|c|c|} \hline 1 + 4 \approx 2 + 3 \\ \hline \end{array}$$

1, 2, 3, 4

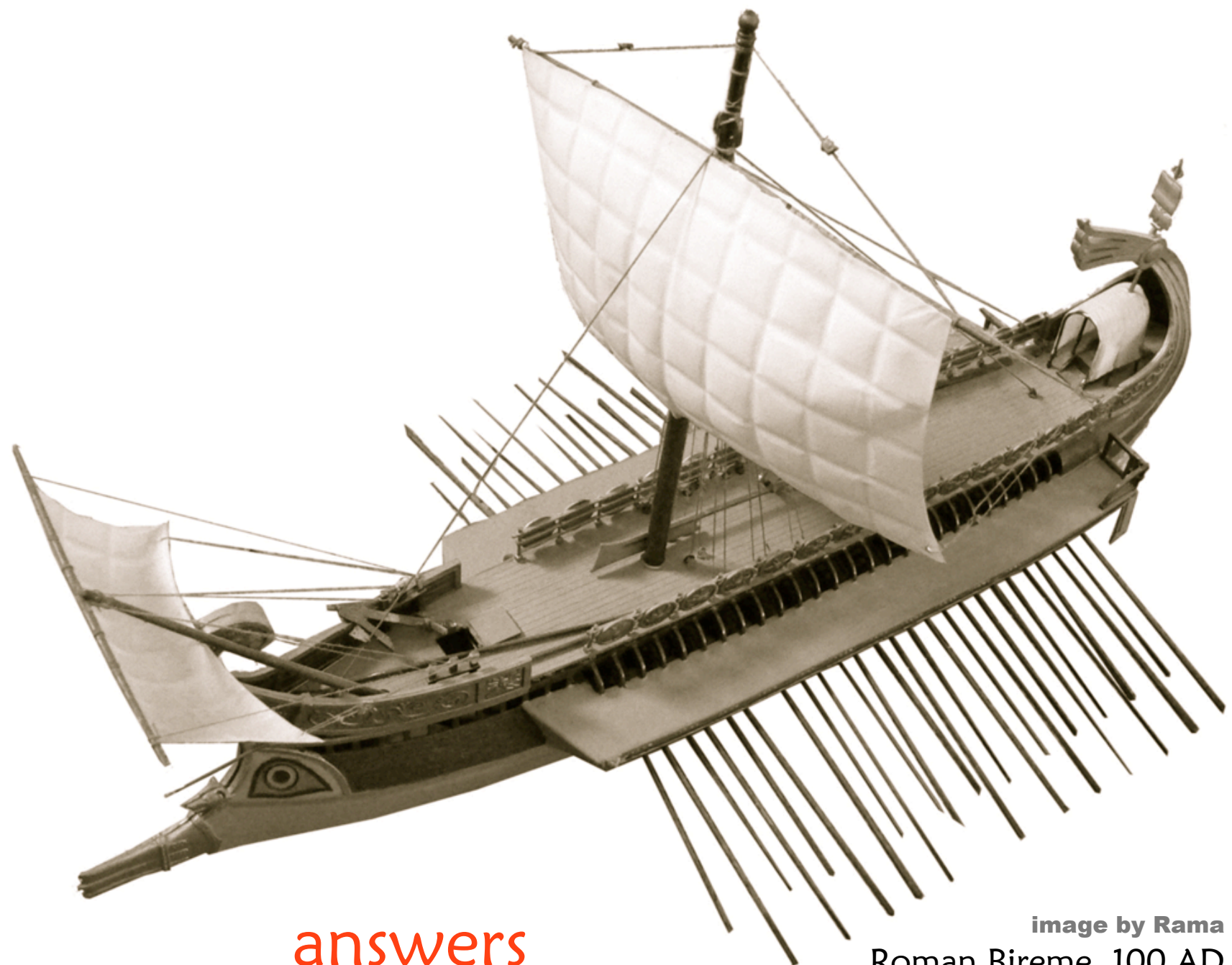
$$\begin{array}{|c|c|} \hline 1 + 5 \approx 2 + 4 \\ \hline \end{array}$$

1, 2, 4, 5

$$\begin{array}{|c|c|} \hline + \approx + \\ \hline \end{array}$$

1, 3, 4, 5

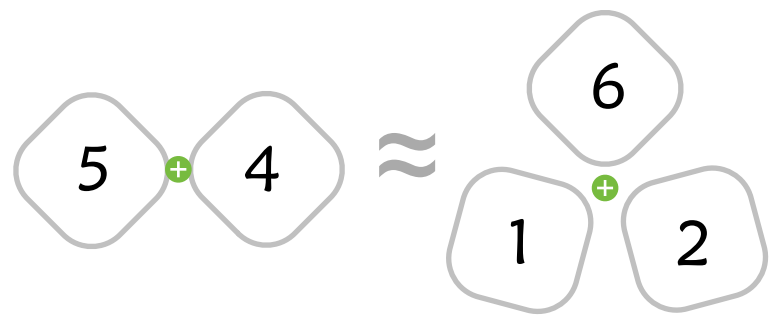
will sink



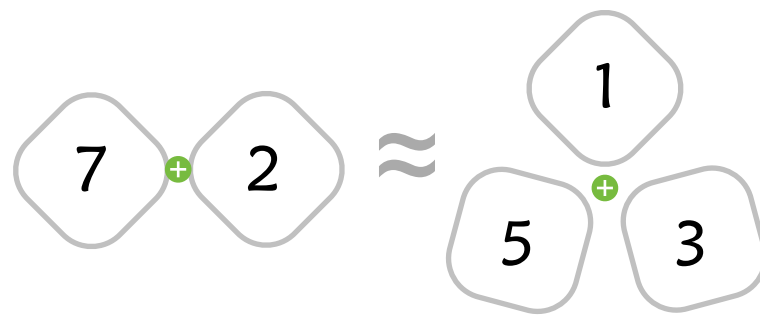
Find the warship that will sink.
Show that the other two warships can float.

answers

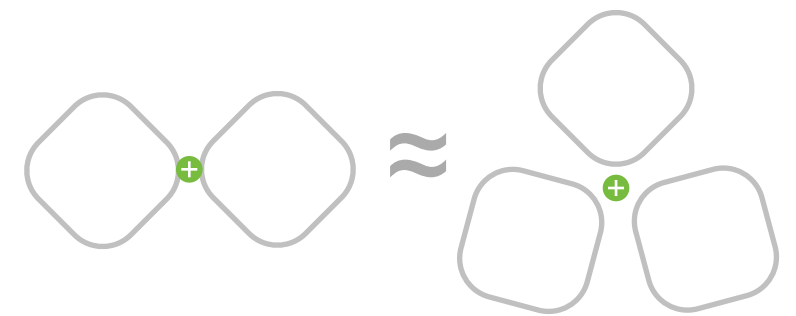
image by Rama
Roman Bireme, 100 AD



1, 2, 4, 5, 6

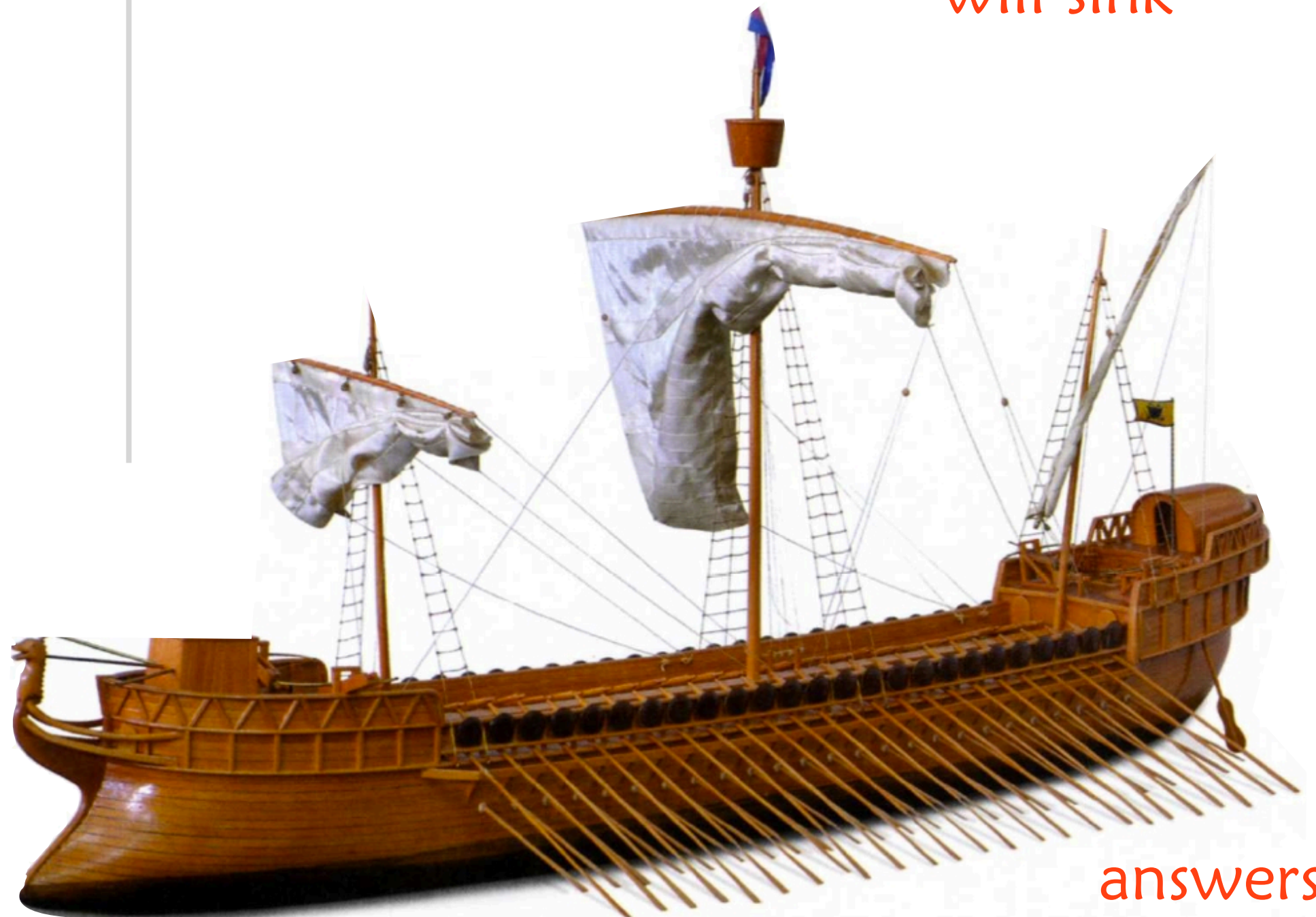


1, 2, 3, 5, 7



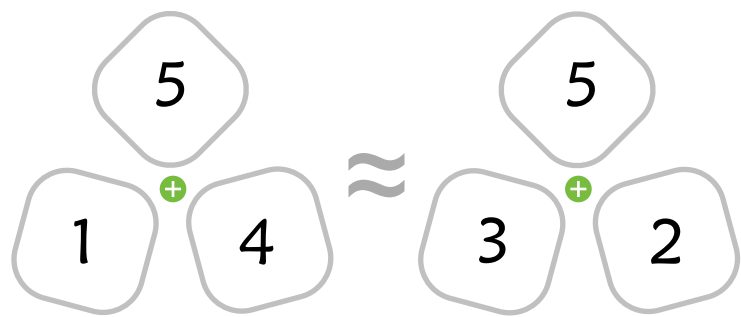
1, 2, 3, 4, 5

will sink

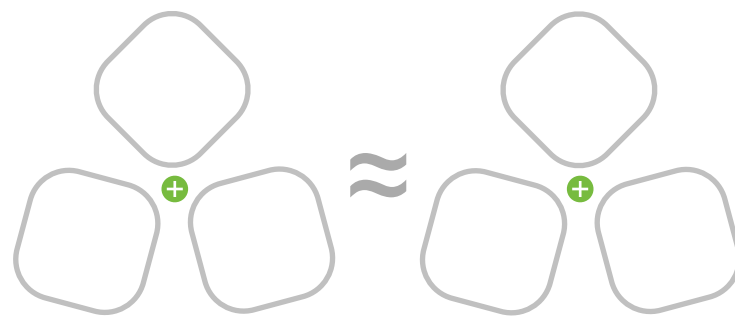


Byzantine Dromon, 700 AD

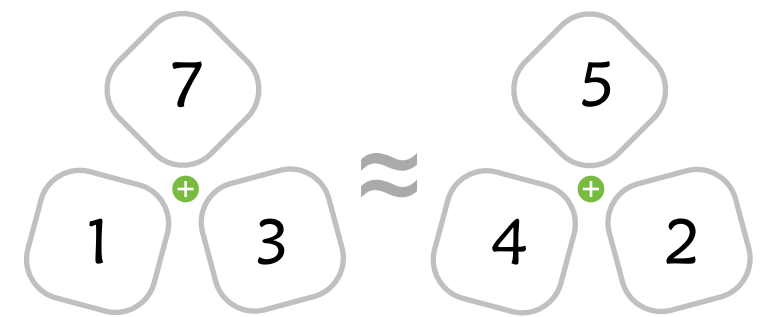
answers



1, 2, 3, 4, 5, 5



1, 2, 3, 4, 5, 6



1, 2, 3, 4, 5, 7

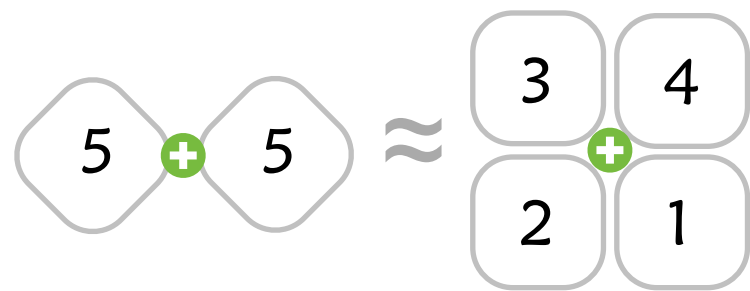
will sink



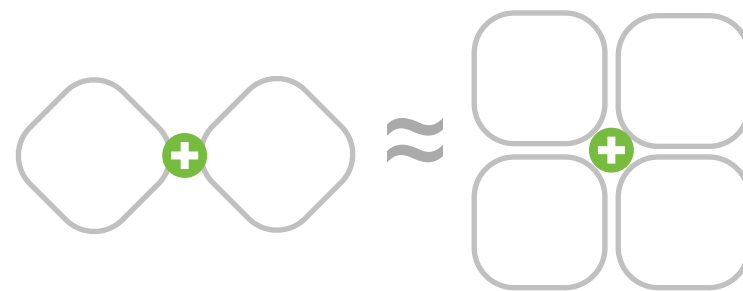
Find the warship that will sink.
Show that the other two warships can float.

answers

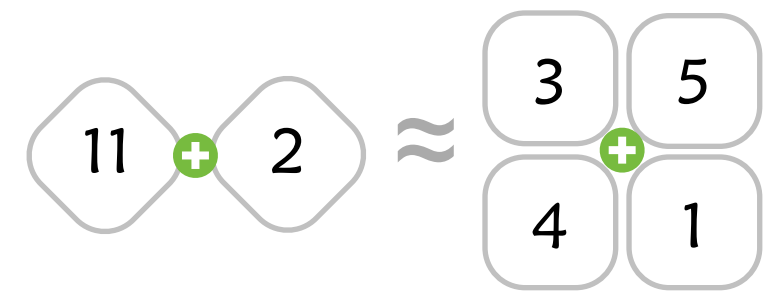
Viking Longship, 839 AD



1, 2, 3, 4, 5, 5



1, 2, 3, 4, 5, 10



1, 2, 3, 4, 5, 11

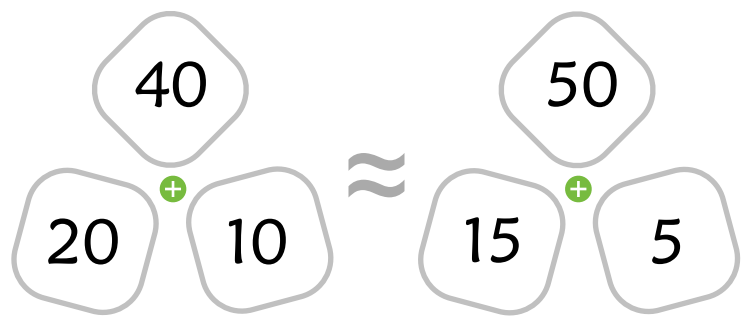
will sink



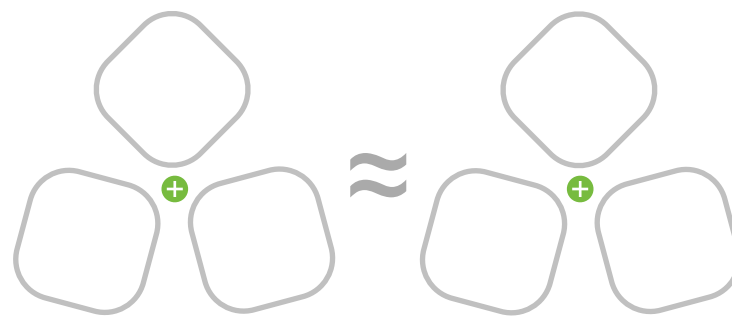
Maltese Galley, 1571

Photo by Myriam Thyges

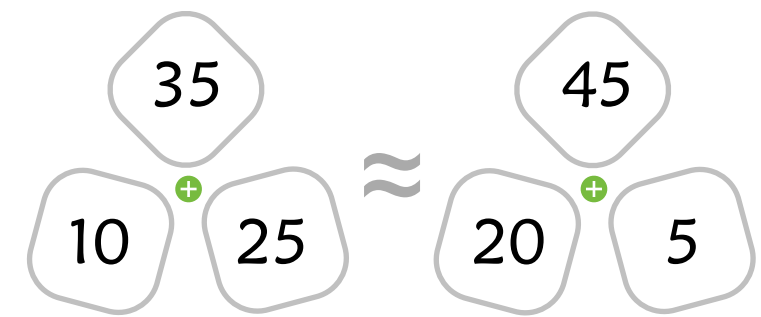
Model from the Naval History Museum in Venice



5, 10, 15, 20, 40, 50



5, 10, 20, 25, 30, 35



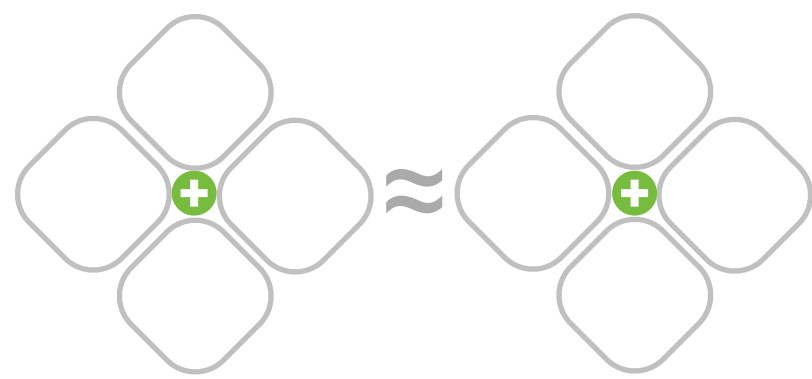
5, 10, 20, 25, 35, 45

will sink



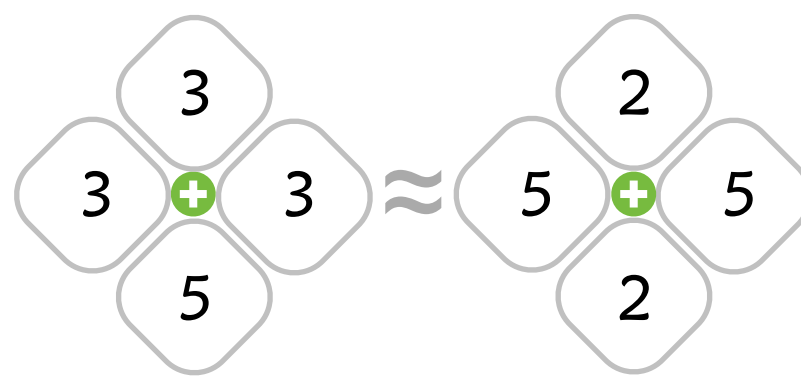
Galleass, 1690

Engraving by
Henri Sbonski de Passebon

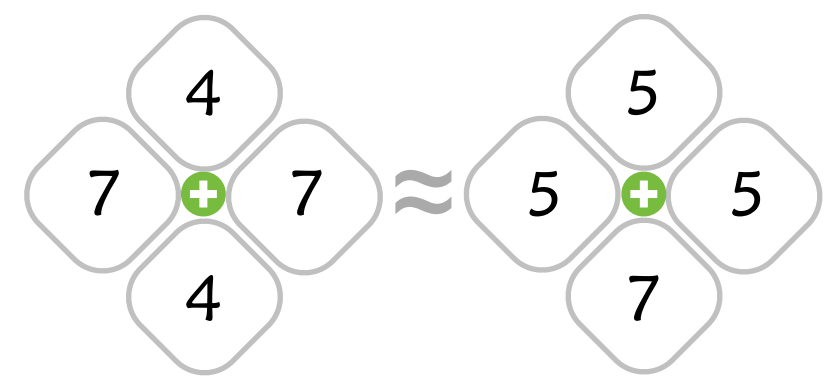


2, 2, 3, 3, 3, 7, 7, 7

will sink



2, 2, 3, 3, 3, 5, 5, 5

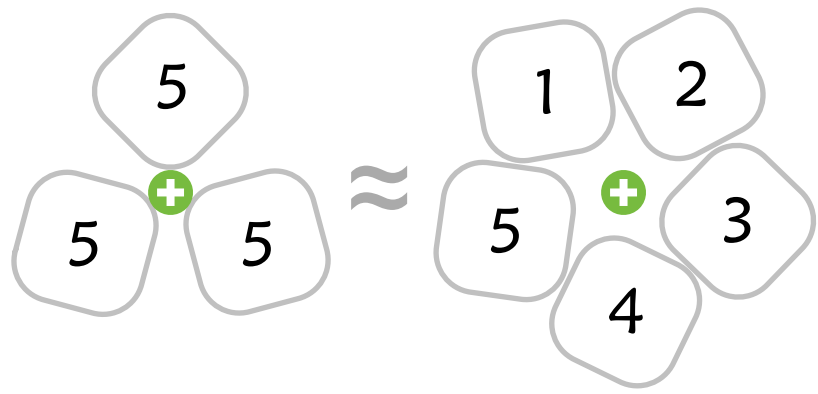


4, 4, 5, 5, 5, 7, 7, 7

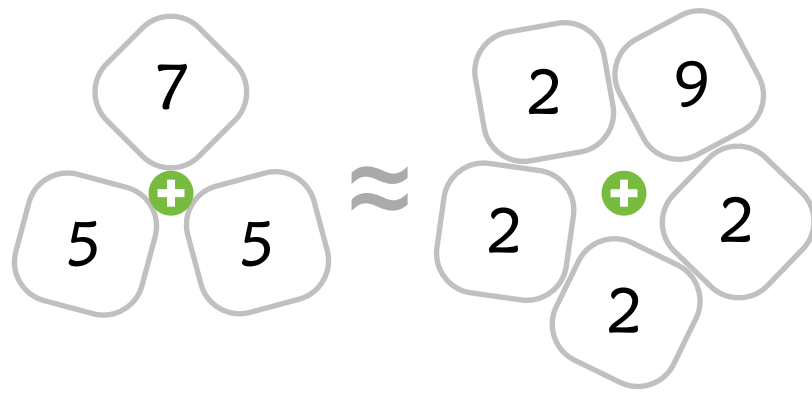


Find the warship that will sink.
Show that the other two warships can float.

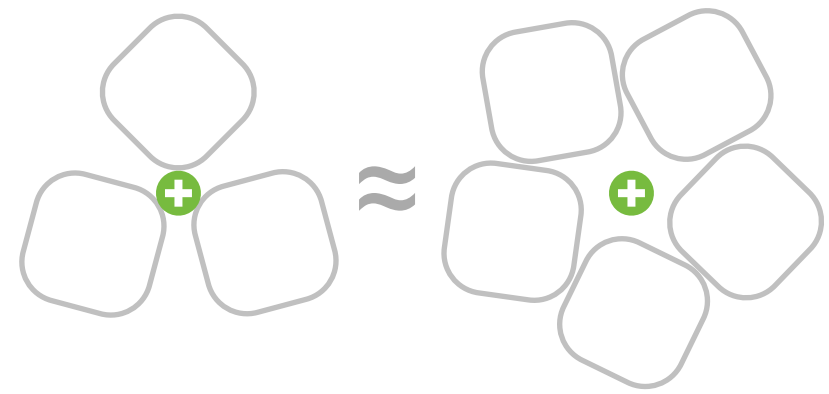
USS Constitution, 1797



1, 2, 3, 4, 5, 5, 5, 5

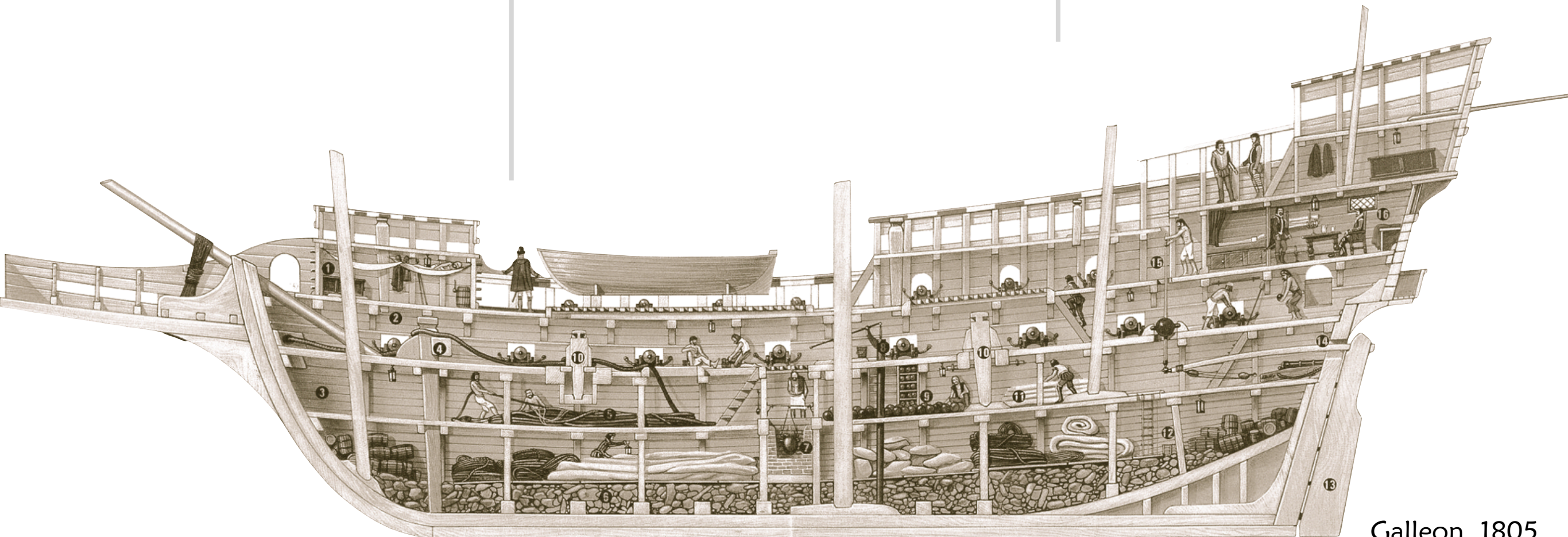


2, 2, 2, 2, 5, 5, 7, 9

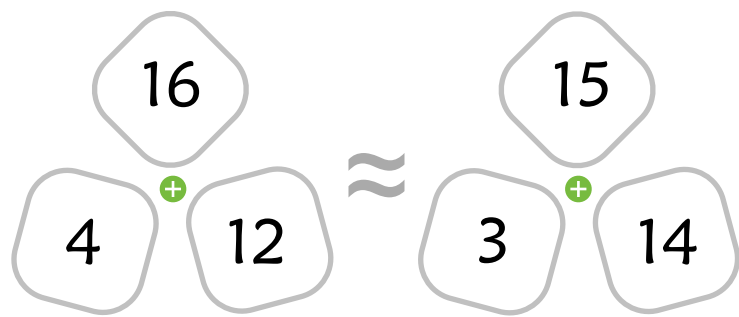


1, 2, 3, 4, 5, 6, 7, 8

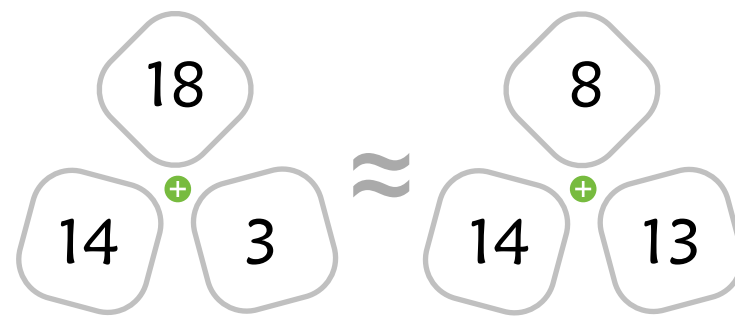
will sink



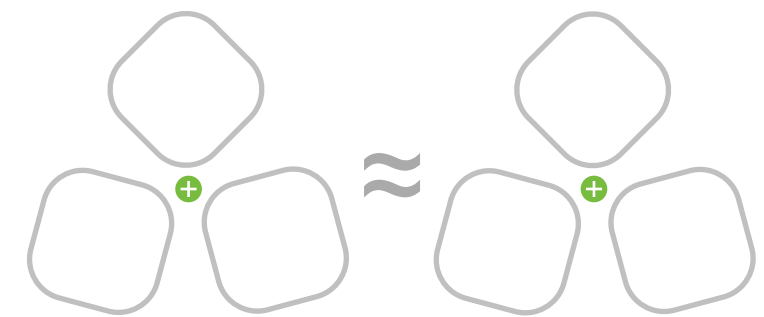
Galleon, 1805



3, 4, 12, 14, 15, 16



3, 8, 13, 14, 14, 18



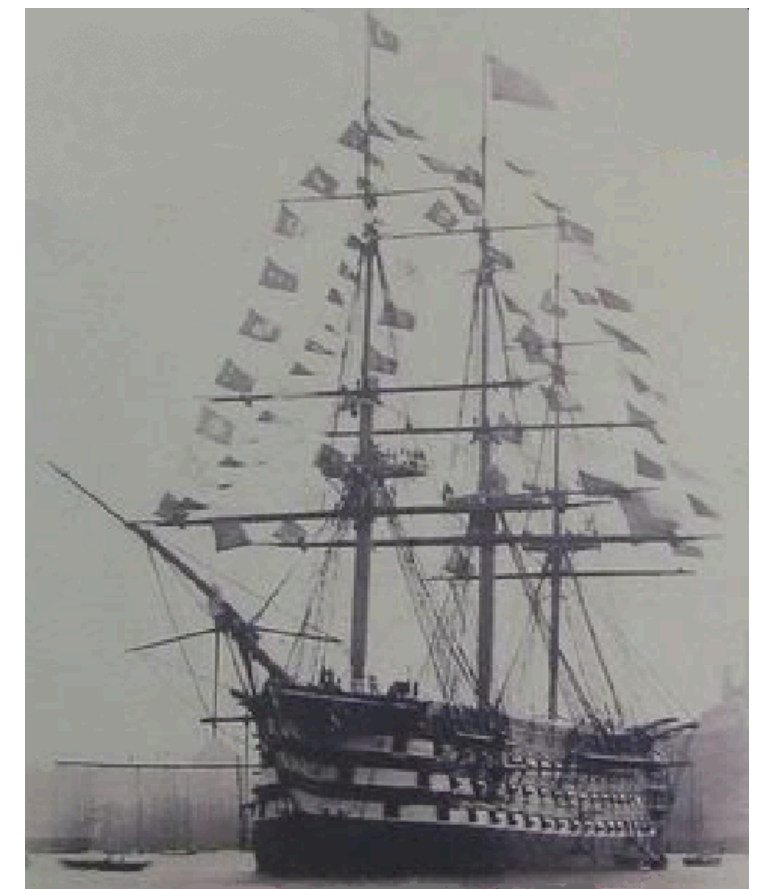
3, 4, 7, 11, 12, 14

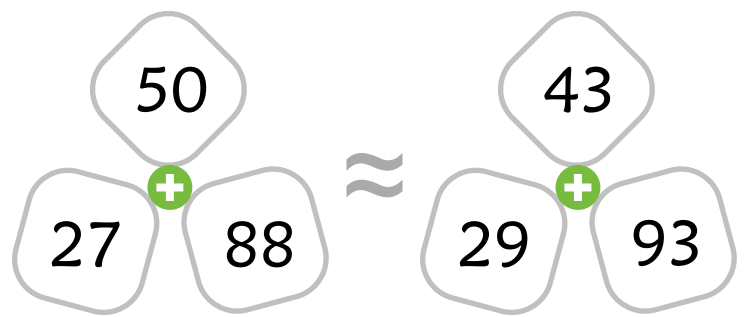
will sink



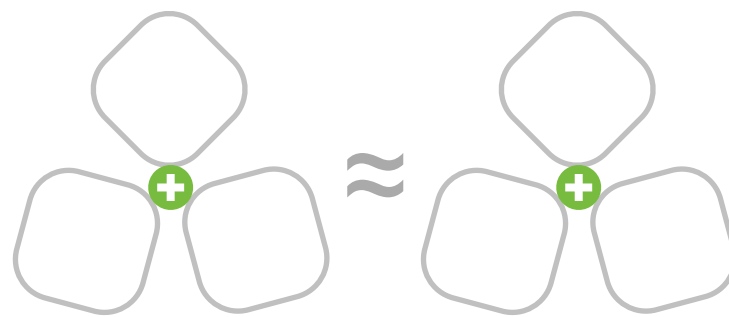
answers

Ottoman Empire's Mahmudiye, 1829
(the largest ship in the world at the time)

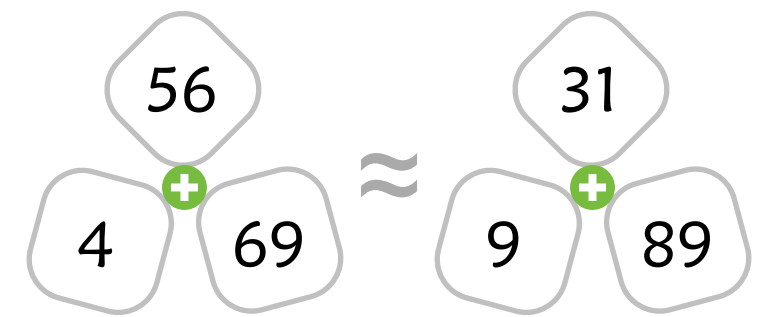




27, 29, 43, 50, 88, 93

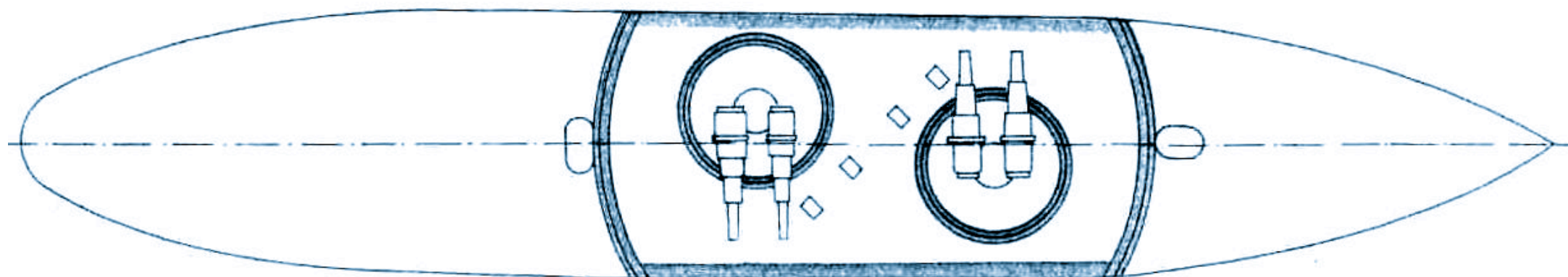


2, 16, 40, 47, 47, 90



4, 9, 31, 56, 69, 89

will sink



$$\begin{array}{|c|} \hline 99 \\ \hline \end{array} + \begin{array}{|c|} \hline 42 \\ \hline \end{array} \approx \begin{array}{|c|c|} \hline 44 & 43 \\ \hline \end{array} + \begin{array}{|c|c|} \hline 29 & 25 \\ \hline \end{array}$$

25, 29, 42, 43, 44, 99

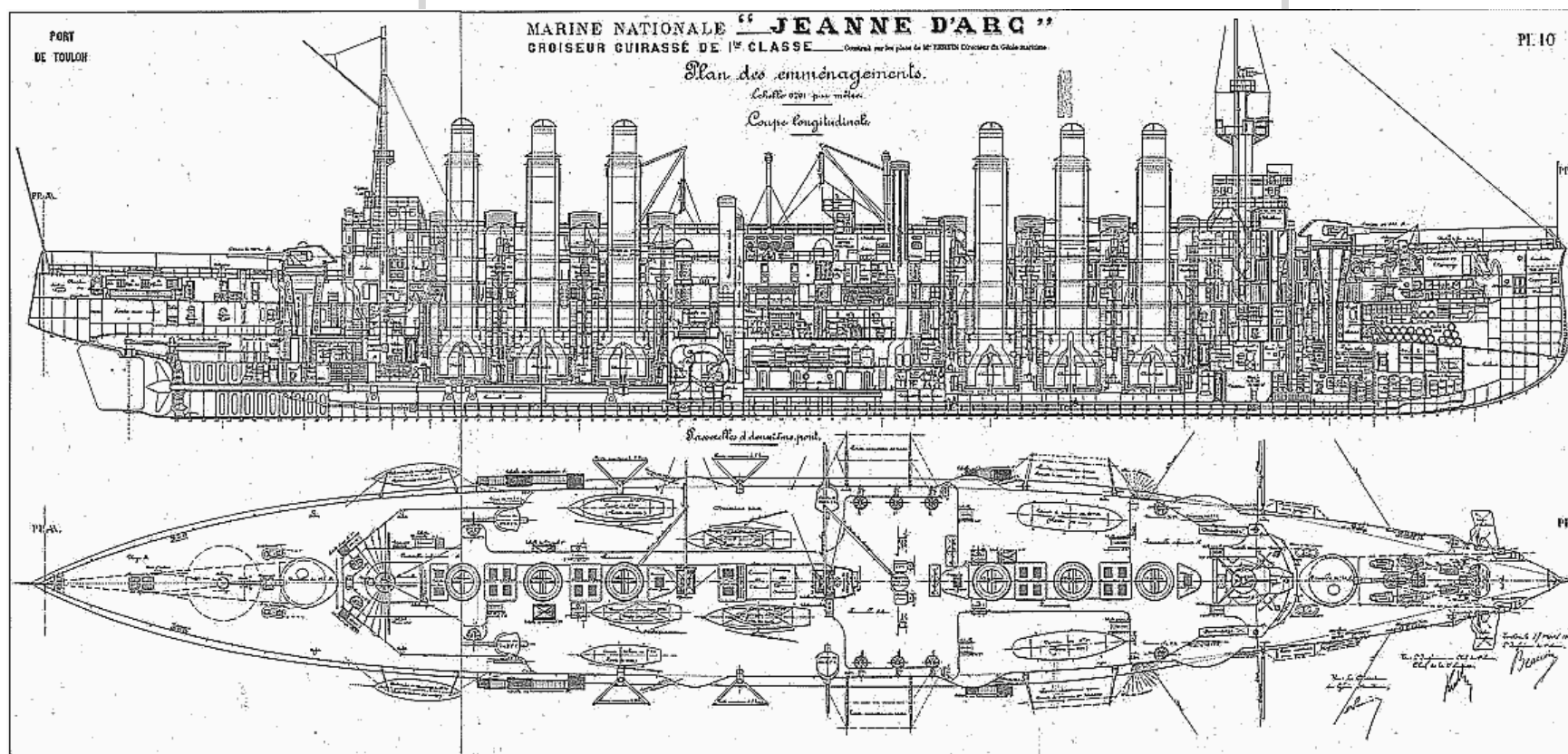
$$\begin{array}{|c|} \hline \\ \hline \end{array} + \begin{array}{|c|} \hline \\ \hline \end{array} \approx \begin{array}{|c|c|} \hline & \\ \hline \end{array} + \begin{array}{|c|c|} \hline & \\ \hline \end{array}$$

2, 16, 40, 47, 47, 100

$$\begin{array}{|c|} \hline 60 \\ \hline \end{array} + \begin{array}{|c|} \hline 69 \\ \hline \end{array} \approx \begin{array}{|c|c|} \hline 89 & 31 \\ \hline \end{array} + \begin{array}{|c|c|} \hline 5 & 4 \\ \hline \end{array}$$

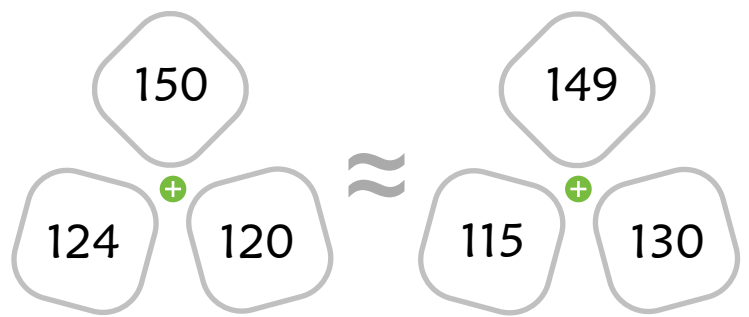
4, 5, 31, 60, 69, 89

will sink

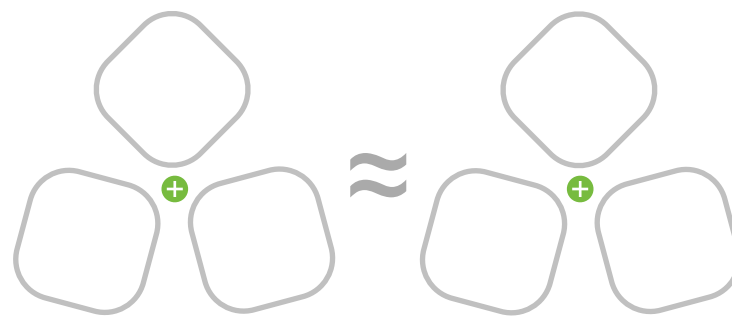


Find the warship that will sink.
Show that the other two warships
can float.

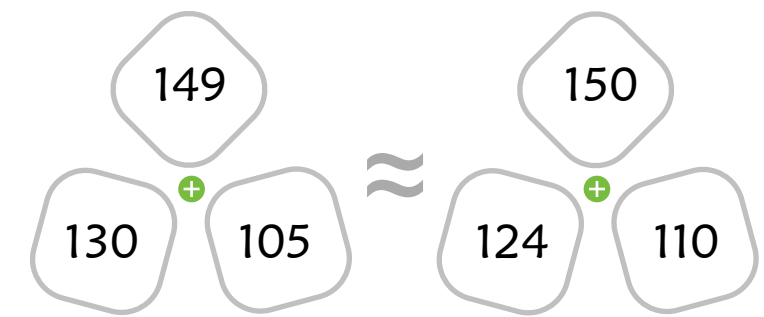
Plan for French cruiser Joan of Arc, built 1899



115, 120, 124, 130, 149, 150

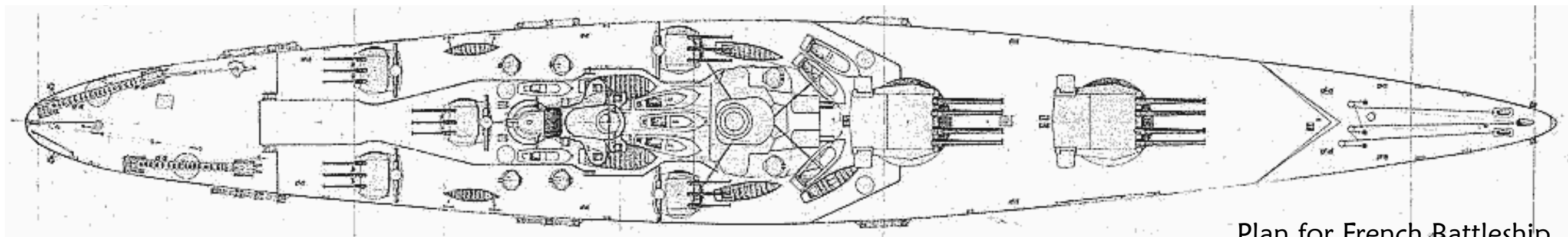


105, 120, 124, 130, 149, 150



105, 110, 124, 130, 149, 150

will sink



Find the warship that will sink.
Show that the other two warships can float.

answers

Plan for French Battleship
Clemenceau, 1940

Put Your Students in a Pickle!

I'm a father of two elementary school children, a mathematician, and designer of puzzles and board games. Students call me Dr. Pickle. There is nothing I enjoy more than stumping students and having them stump me.

I founded MathPickle.com in 2010 to inject new ideas into the classroom. MathPickle's primary objective is to get thirteen curricular unsolved problems into classrooms worldwide - one for each grade K-12. A conference in November 2013 established the thirteen unsolved problems. To aid with the dissemination of these awesome problems, MathPickle is looking at setting up a \$1,000,000 reward for each - the prize money to be split between the person who solves the problem and their most inspirational K-12 educator.

MathPickle is also developing a range of curricular puzzles like the ones you'll find at TpT. These help teachers them with their number one challenge:

“How to engage the spectrum of student ability?”

Whenever an elementary school teacher wants to teach addition, she will invariably face 20% of students who already know how to add and another 20% who are struggling with last year's curriculum. How can she engage the top students without losing the bottom students? How can she engage the bottom students without boring the top students?

One solution: Parents of top students often ask that their child be allowed to accelerate through the curriculum. This exacerbates the problem for future teachers, and sets up a failure-impooverished education experience for the bright student.

A wiser approach is to use curricular puzzles, games and mini-competitions to simultaneously teach curriculum to the students who need it, and to deflect top students into tough problem solving activities. This is never time wasted, because problem solving is the primary reason we teach mathematics.

The experience of mathematics should be profound and beautiful. Too much of the regular K-12 mathematics experience is trite and true. Children deserve tough, beautiful puzzles.

Gordon Hamilton
MMath, PhD

