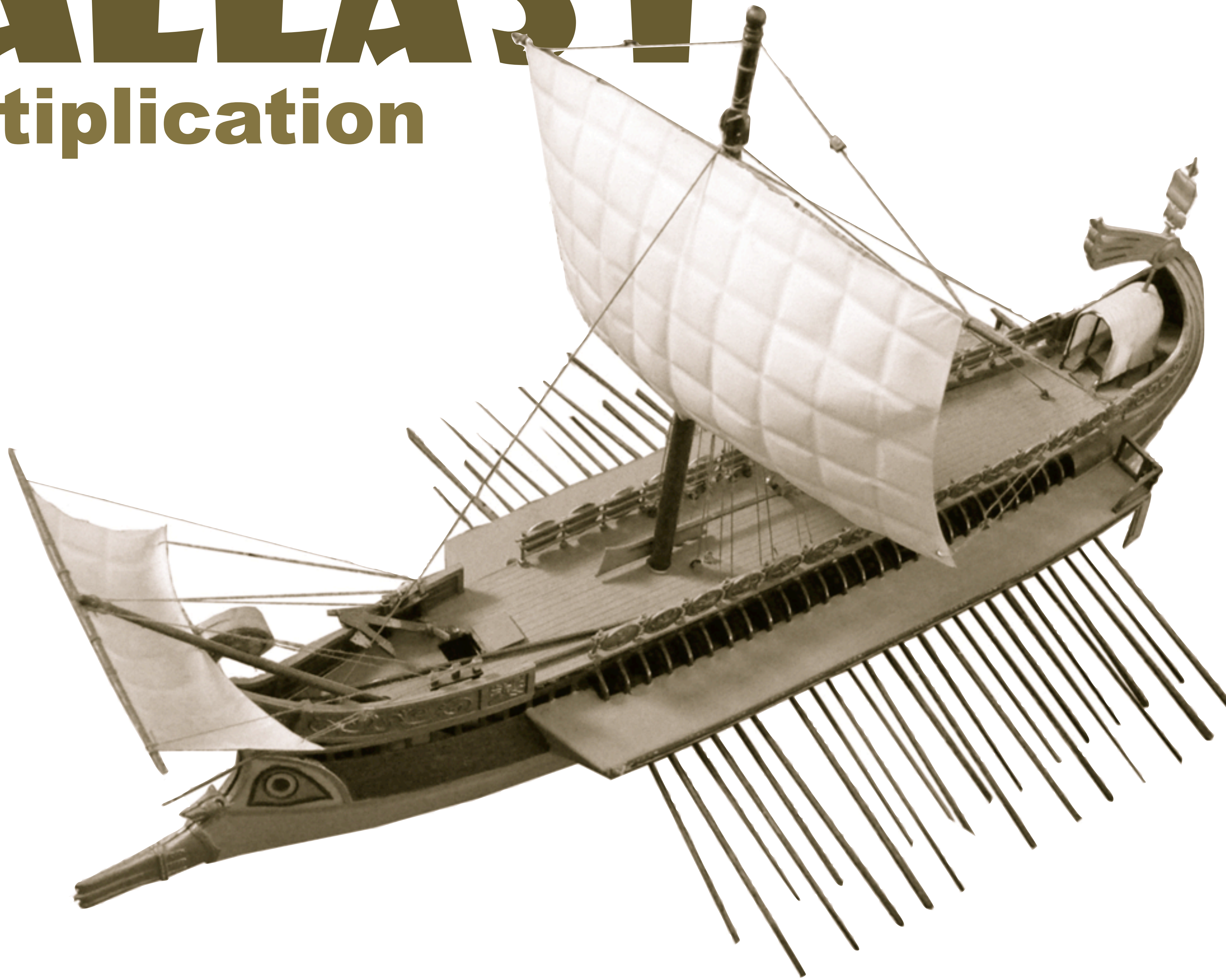
BALLAST

multiplication

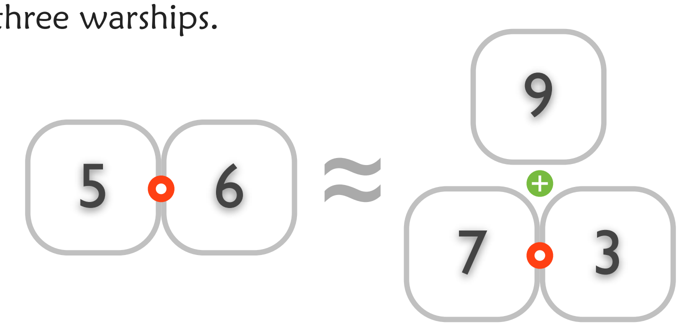


Contents

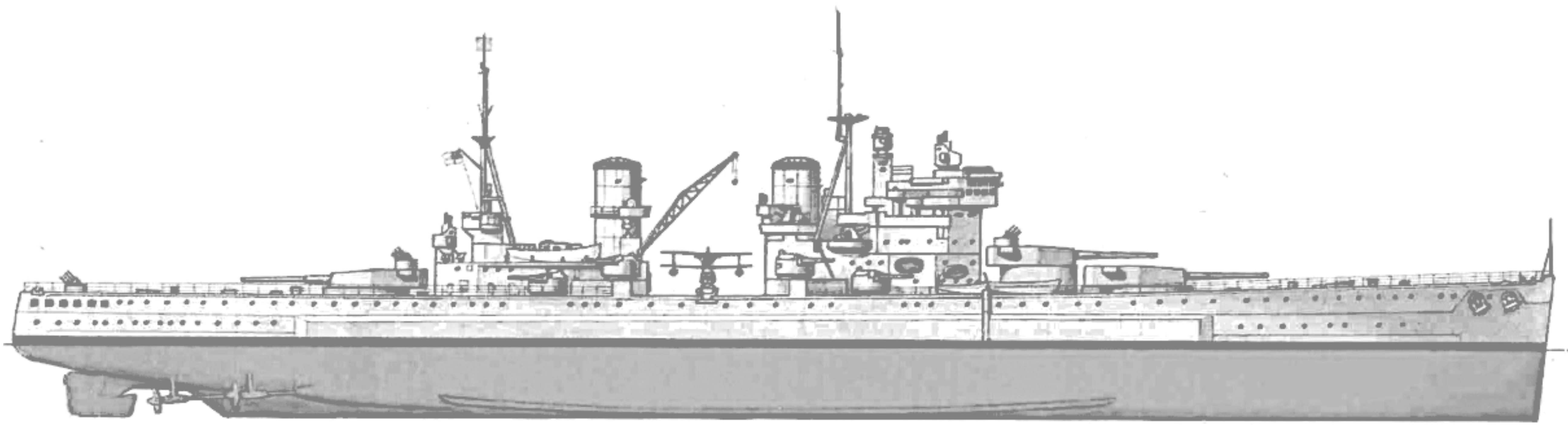
MathPickle

BALLAST

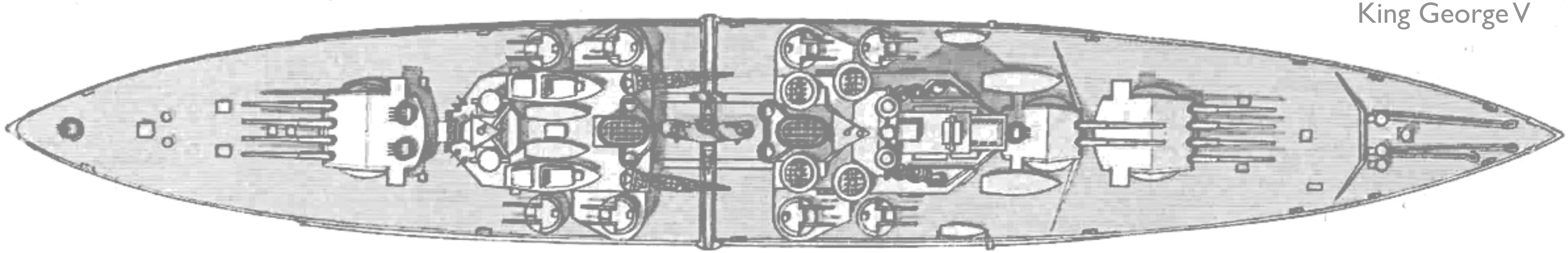
Ballast is a puzzle where you win by balancing warships so they don't tip over. To achieve this, you must make the left hand side equal to the right hand side. Allocate the given numbers into the portholes. Dots mean multiplication. Plusses mean addition. Here we have 5x6 = 3x7 + 9 which is balanced, so this warship floats. Ballast puzzles appear in triples. In each triple, two warships are capable of being saved, but the third is doomed - no matter what you do, it is impossible to balance. Your job is to save two of the three warships.



3, 5, 6, 7, 9



King George V



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 multiplication.

Grades 3-5

CCSS.MATH.CONTENT.3.OA.C.7
Fluently multiply and divide within 100, using strategies such as the relationship between multiplication and division (e.g., knowing that 8 × 5 = 40, one knows 40 ÷ 5 = 8) or properties of operations. By the end of Grade 3, know from memory all products of two one-digit numbers.

CCSS.MATH.CONTENT.3.NBT.A.3
Multiply one-digit whole numbers by multiples of 10 in the range 10-90 (e.g., 9 × 80, 5 × 60) using strategies based on place value and properties of operations.

CCSS.MATH.CONTENT.4.NBT.B.5
Multiply a whole number of up to four digits by a one-digit whole number, and multiply two two-digit numbers, using strategies based on place value and the properties of operations. Illustrate and explain the calculation by using equations, rectangular arrays, and/or area models.

CCSS.MATH.CONTENT.5.NBT.B.5
Fluently multiply multi-digit whole numbers using the standard algorithm.

http://www.corestandards.org/Math/Practice/

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

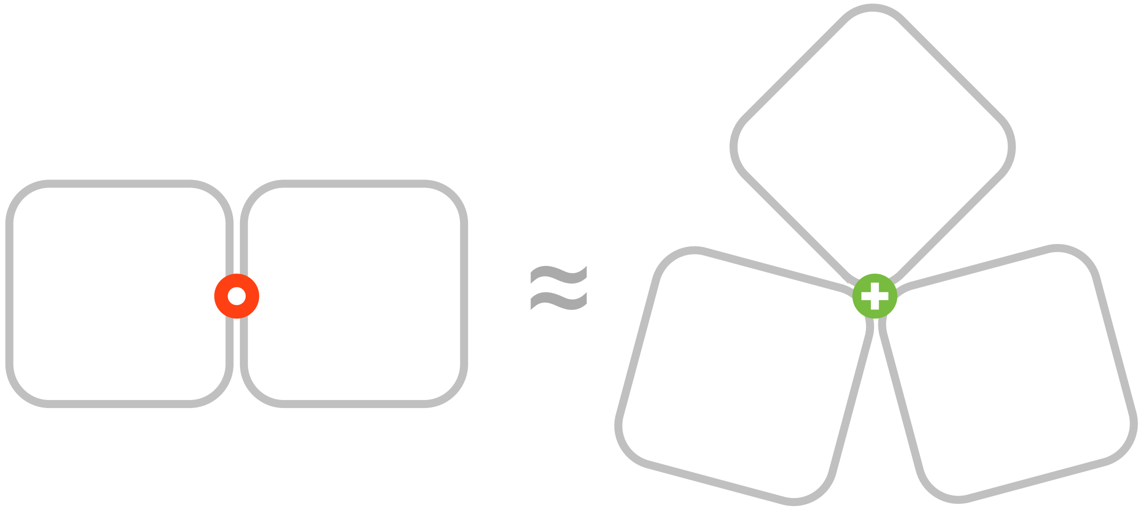
$100 Classroom Challenge

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 Multiplication 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.



The problem on the next page is for the whole class to solve. Project it, or draw it on the blackboard... The 5 students in the back row should each think of a number between 1 and 10. These should be written down. Other students try to save the trireme by making it float using those 5 numbers. That means they must place two of the numbers on the left so their product equals the sum of the other three numbers on the right. This may be impossible in which case the trireme would sink.

If it looks impossible, you might want to let a student change one number. Experiment by going sequentially through all students without having arms raised.

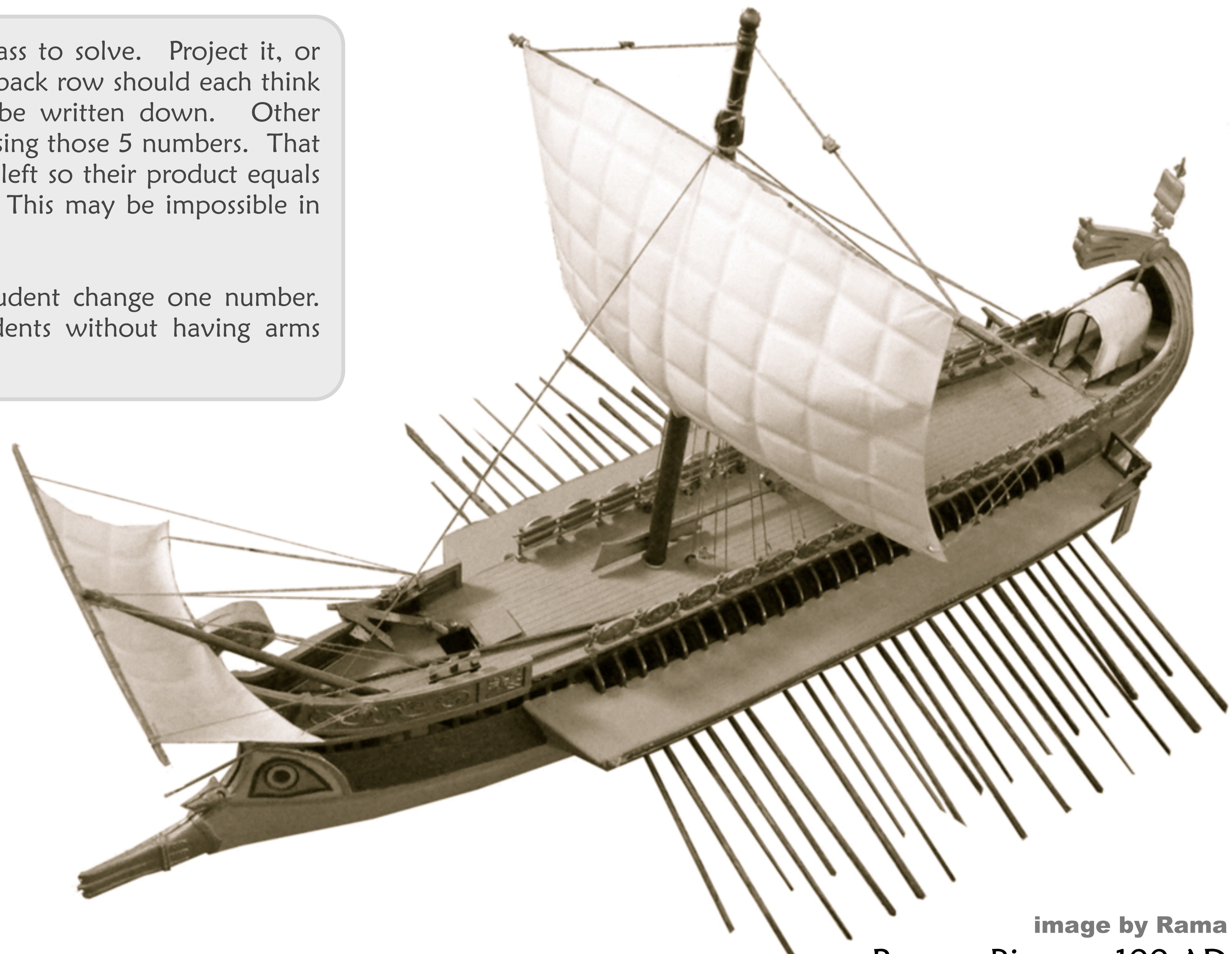
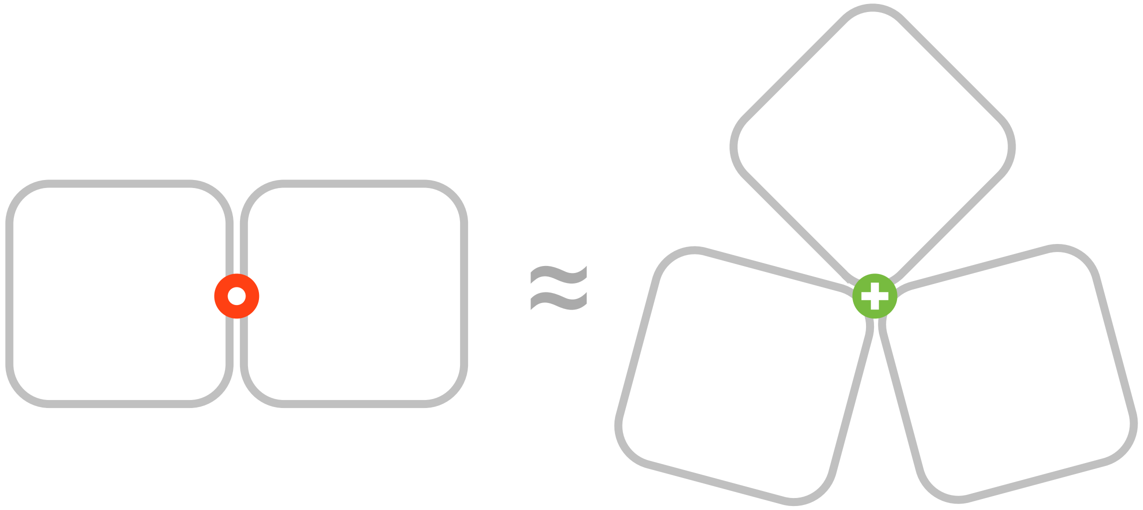


image by Rama

Roman Bireme, 100 AD



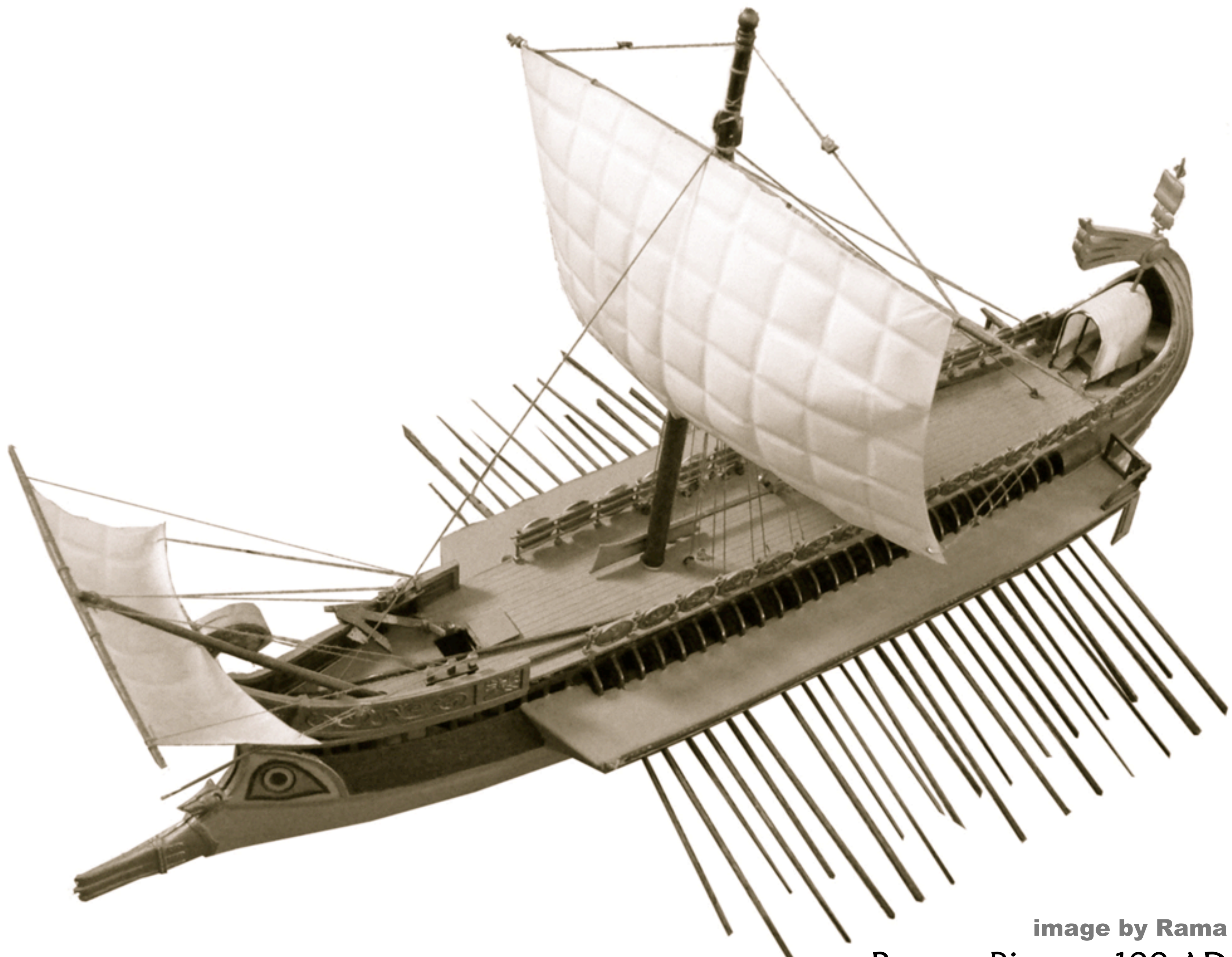


image by Rama

Roman Bireme, 100 AD

1, 2, 3, 4, 5

2, 3, 4, 5, 6

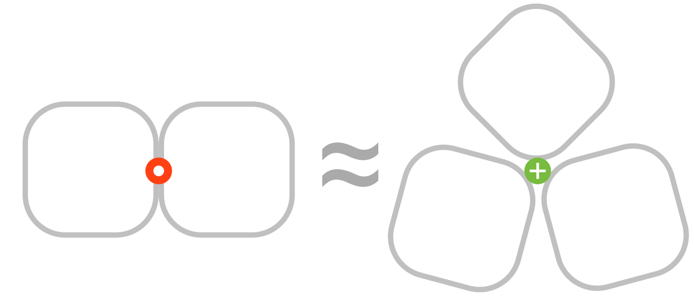
3, 4, 5, 6, 9

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

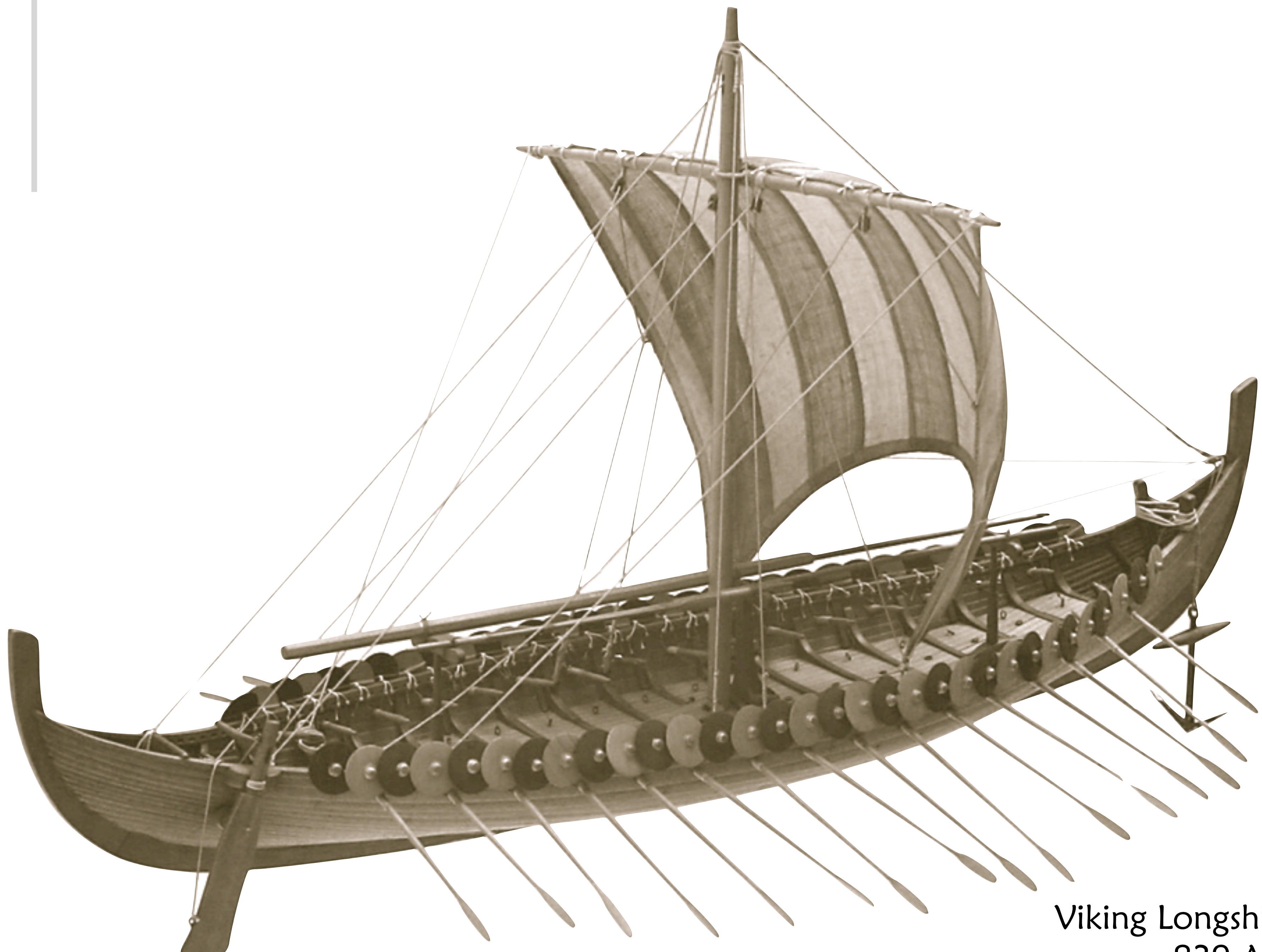
Byzantine Dromon, 700 AD

3, 5, 7, 9, 11

2, 6, 9, 11, 13

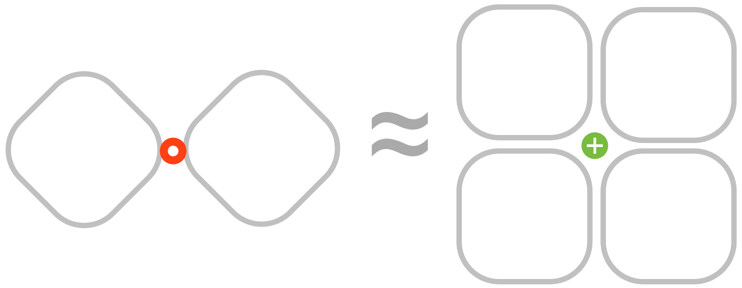


3, 5, 7, 8, 8

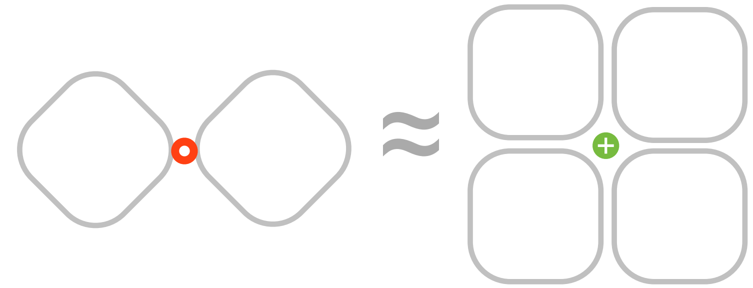


Viking Longship
839 AD

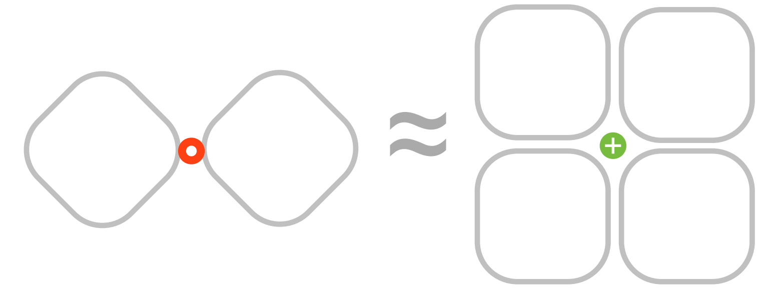
Find the warship that will sink.
Show that the other two warships can float.



1, 2, 3, 4, 5, 5



1, 2, 3, 4, 4, 5



2, 3, 4, 4, 5, 6

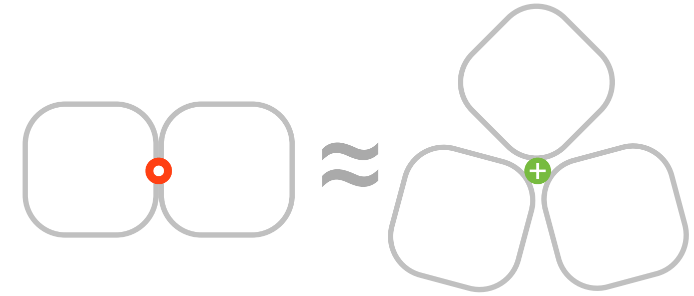
Maltese Galley, 1571

Photo by Myriam Thyes

Model from the Naval History Museum in Venice

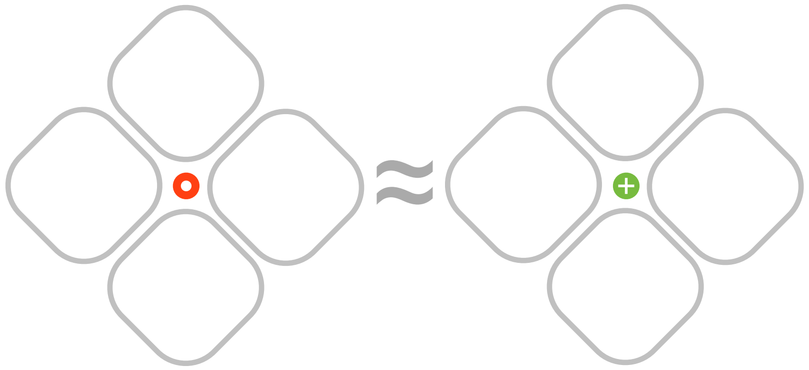
2, 10, 30, 40, 50

5, 10, 20, 40, 50

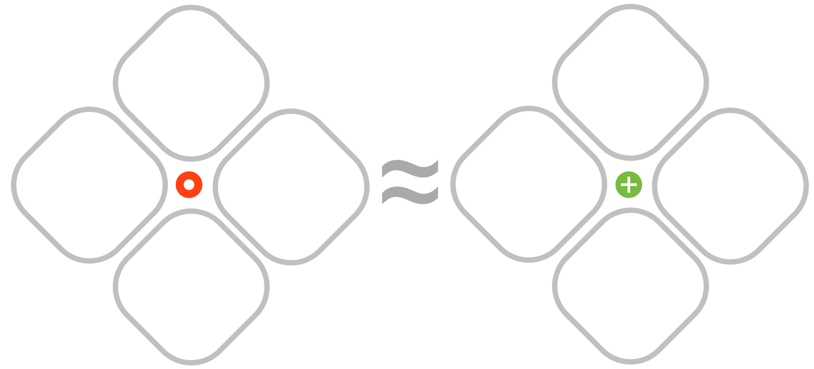


0, 1, 10, 20, 30

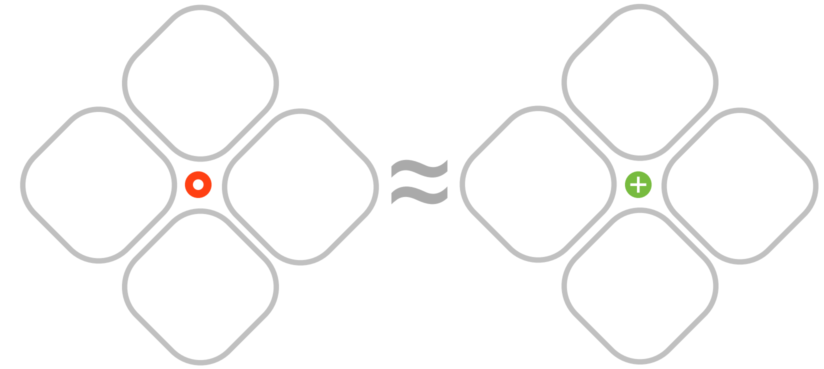
Galleon
1805



1, 3, 3, 3, 7, 7, 7, 7



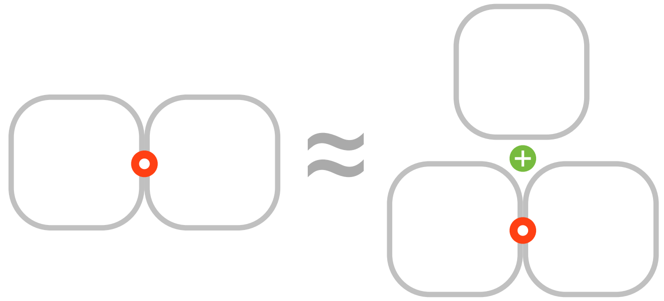
1, 1, 1, 2, 3, 3, 7, 7



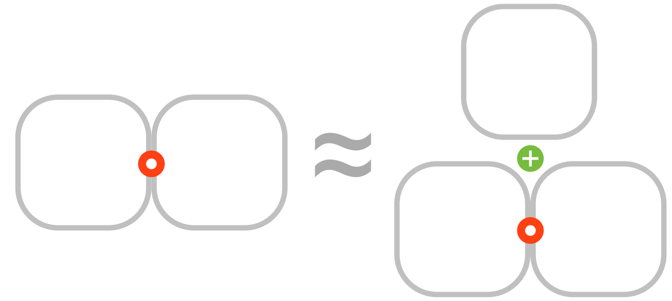
1, 1, 2, 3, 3, 7, 7, 7

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

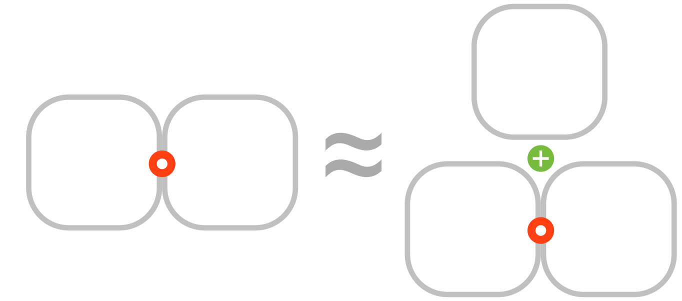
USS Constitution, 1797



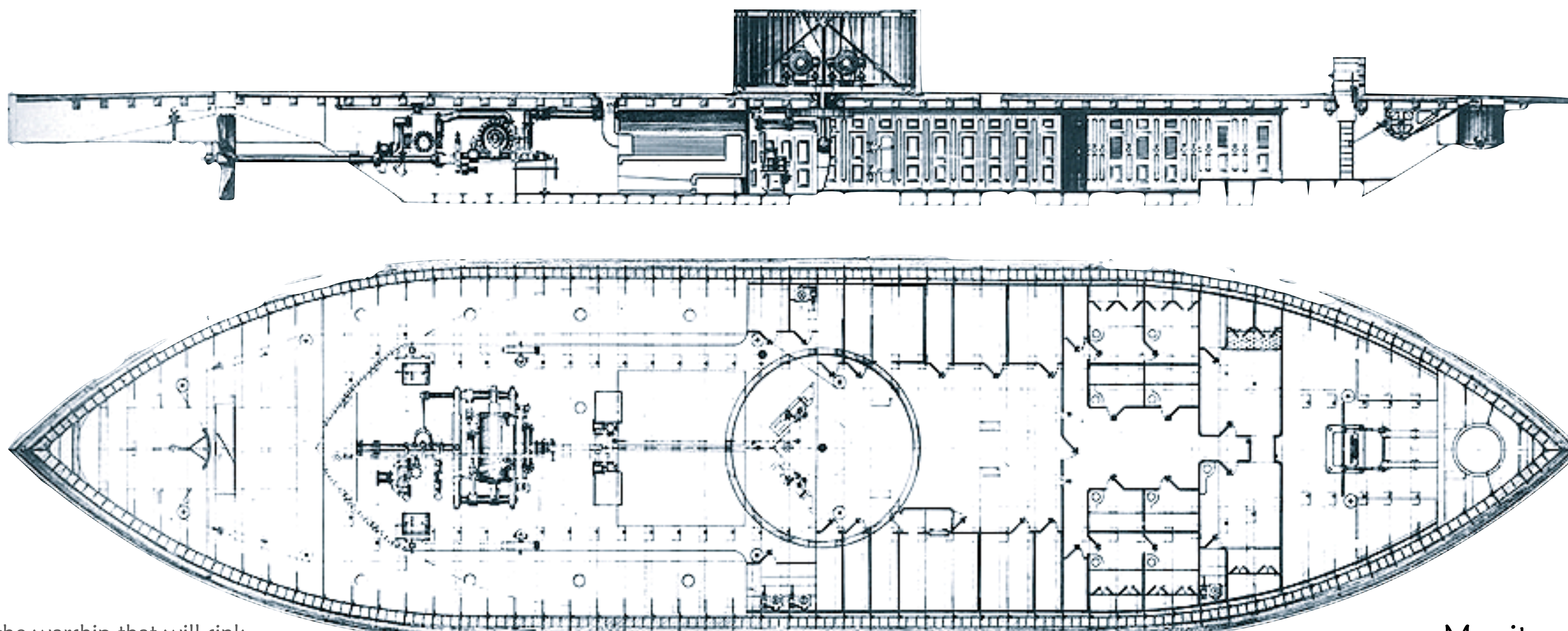
1, 2, 3, 4, 10



2, 3, 4, 5, 10

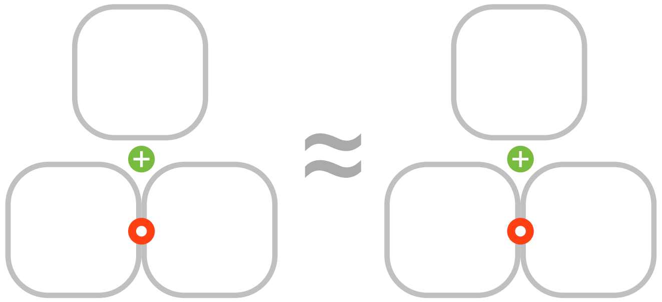


2, 3, 4, 5, 6

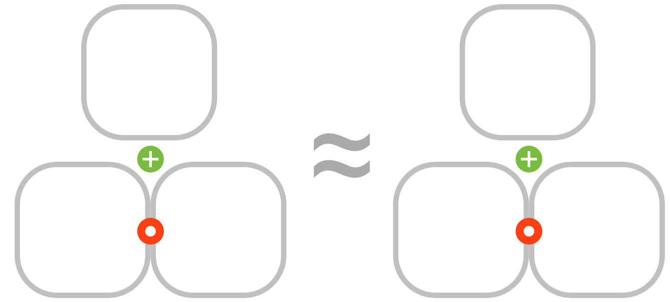


Monitor 1862

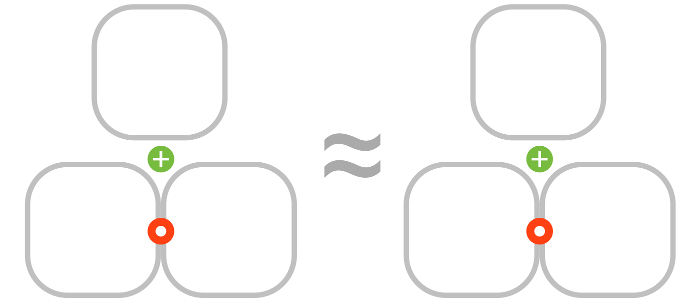
Find the warship that will sink.
Show that the other two warships can float.



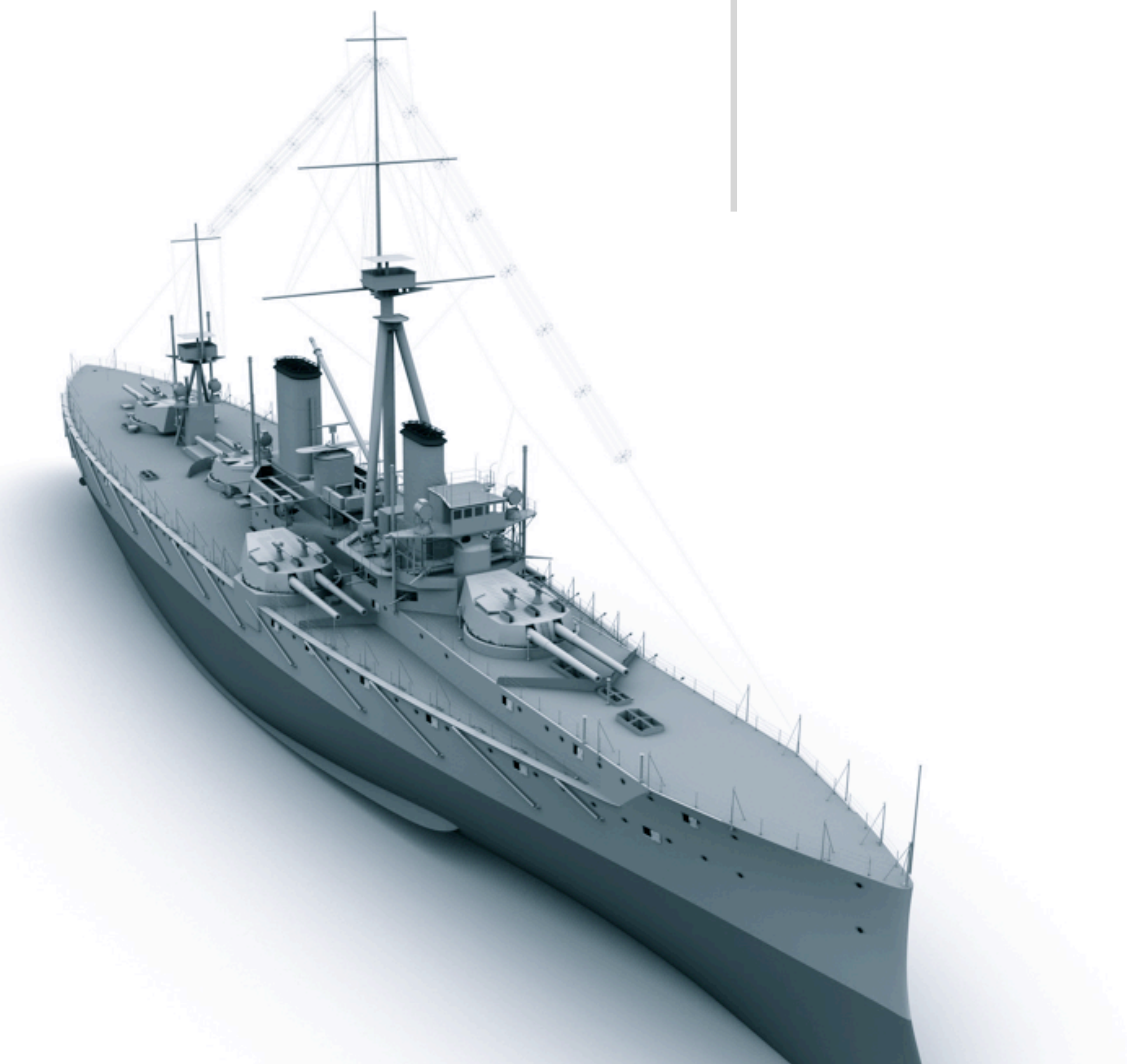
2, 3, 4, 5, 6, 7



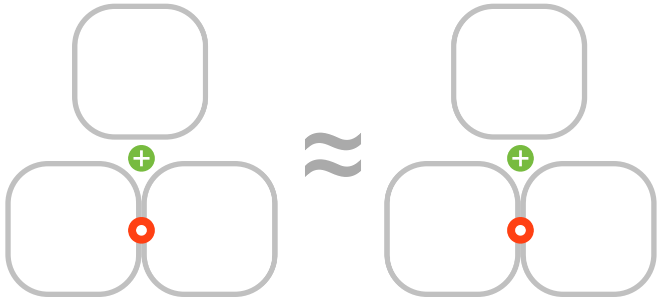
2, 3, 4, 5, 6, 10



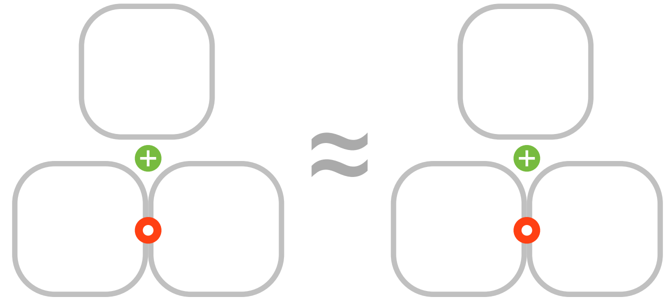
3, 4, 5, 6, 7, 8



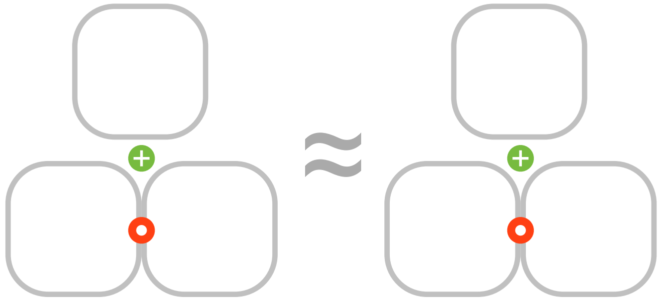
Dreadnaught, 1906



4, 4, 5, 5, 5, 6

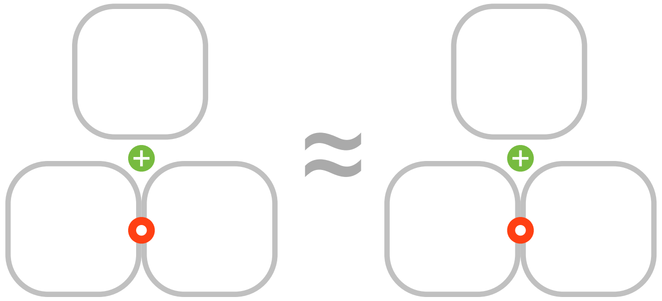


4, 5, 5, 5, 6, 6

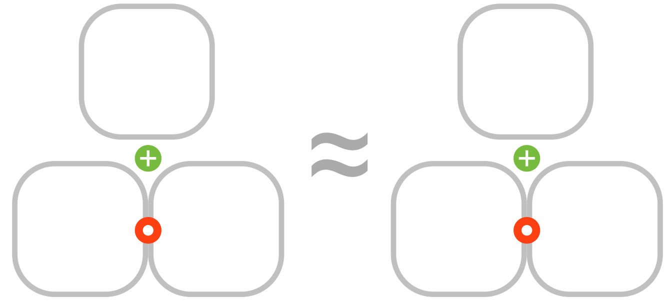


4, 4, 4, 5, 6, 6

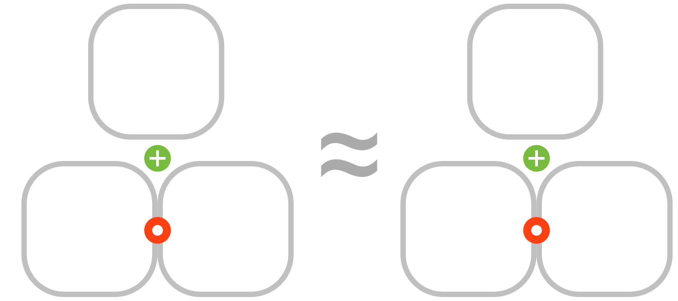
HMS Erebus - launched 1916 - photographed here in 1944



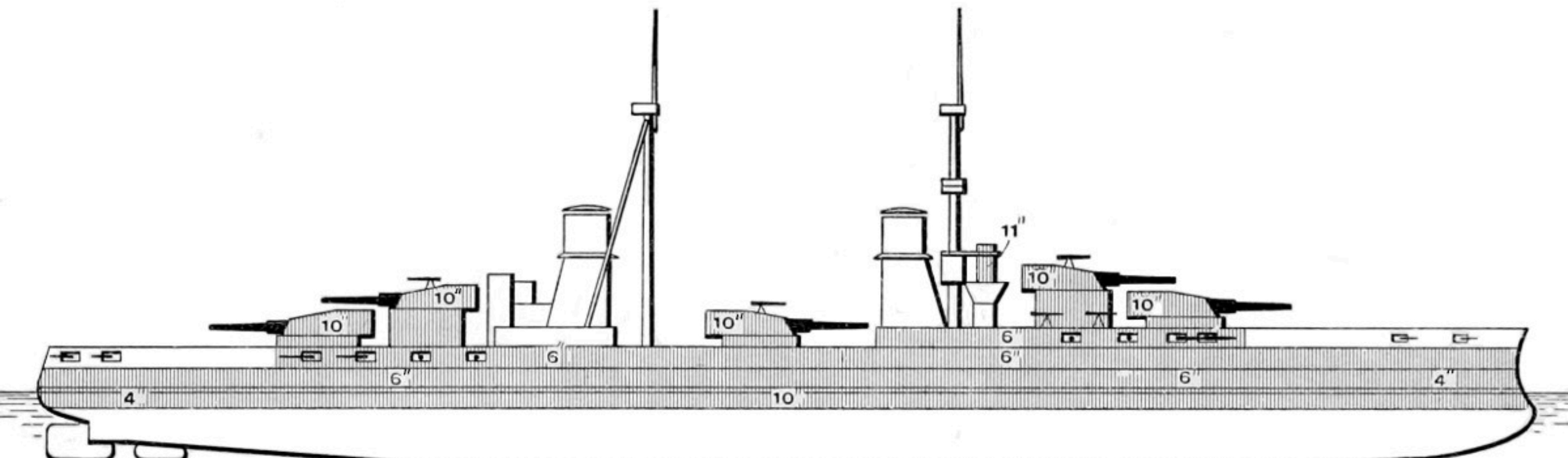
2, 3, 6, 7, 10, 10



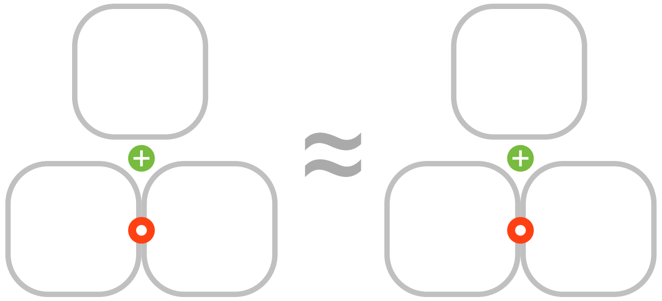
2, 3, 6, 8, 10, 10



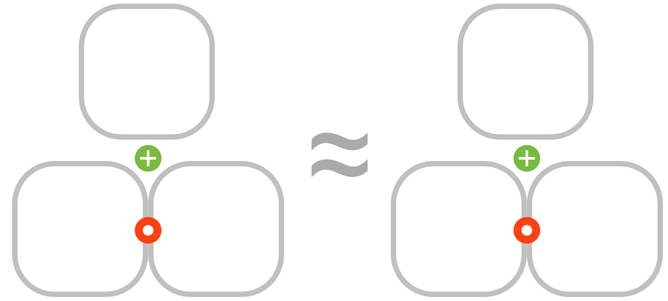
2, 3, 6, 9, 10, 10



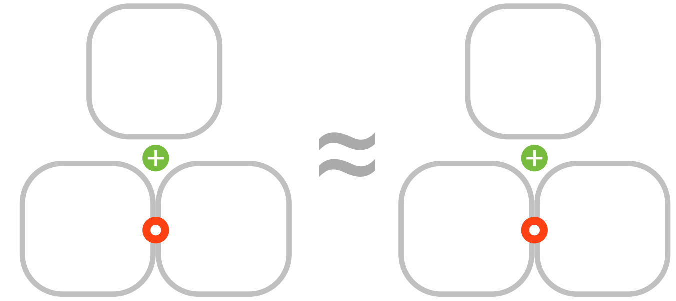
Andrea Doria-class battleship of Italy - launched during WWI



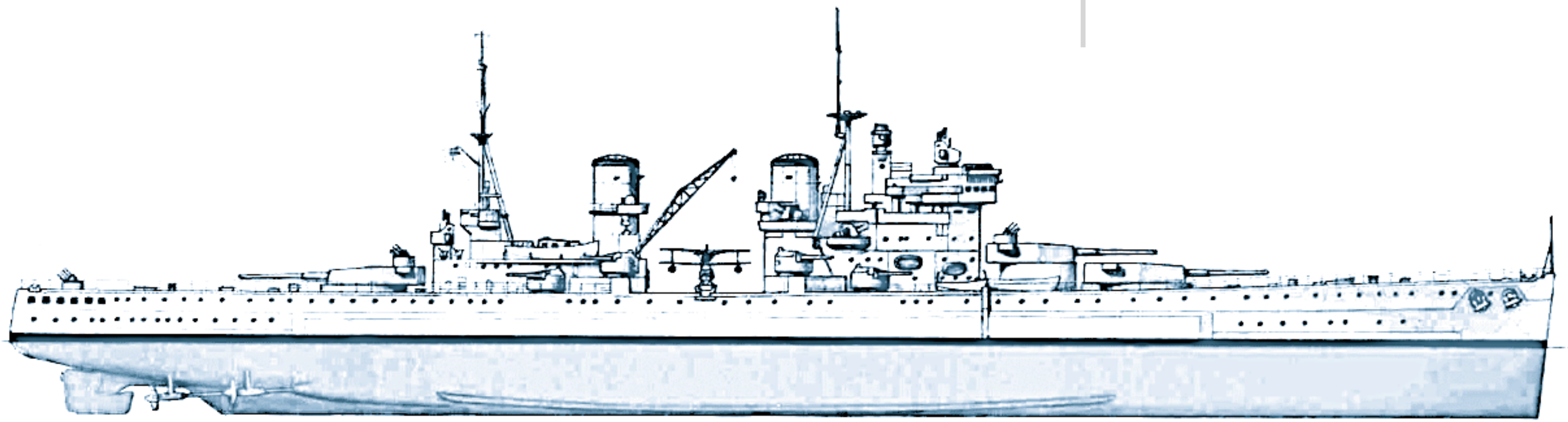
3, 5, 7, 11, 13, 17



4, 5, 7, 10, 13, 17

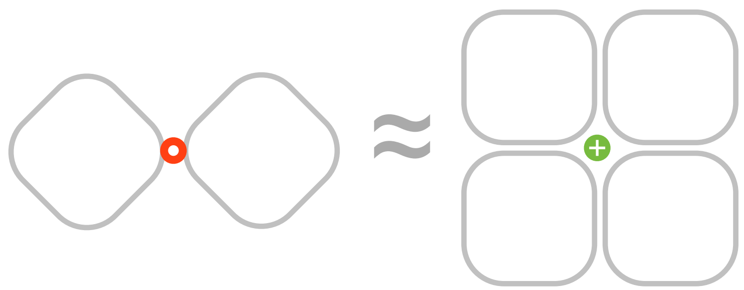


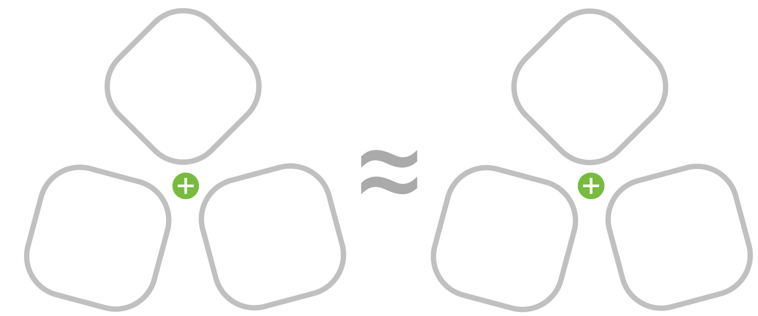
3, 5, 10, 13, 17, 18

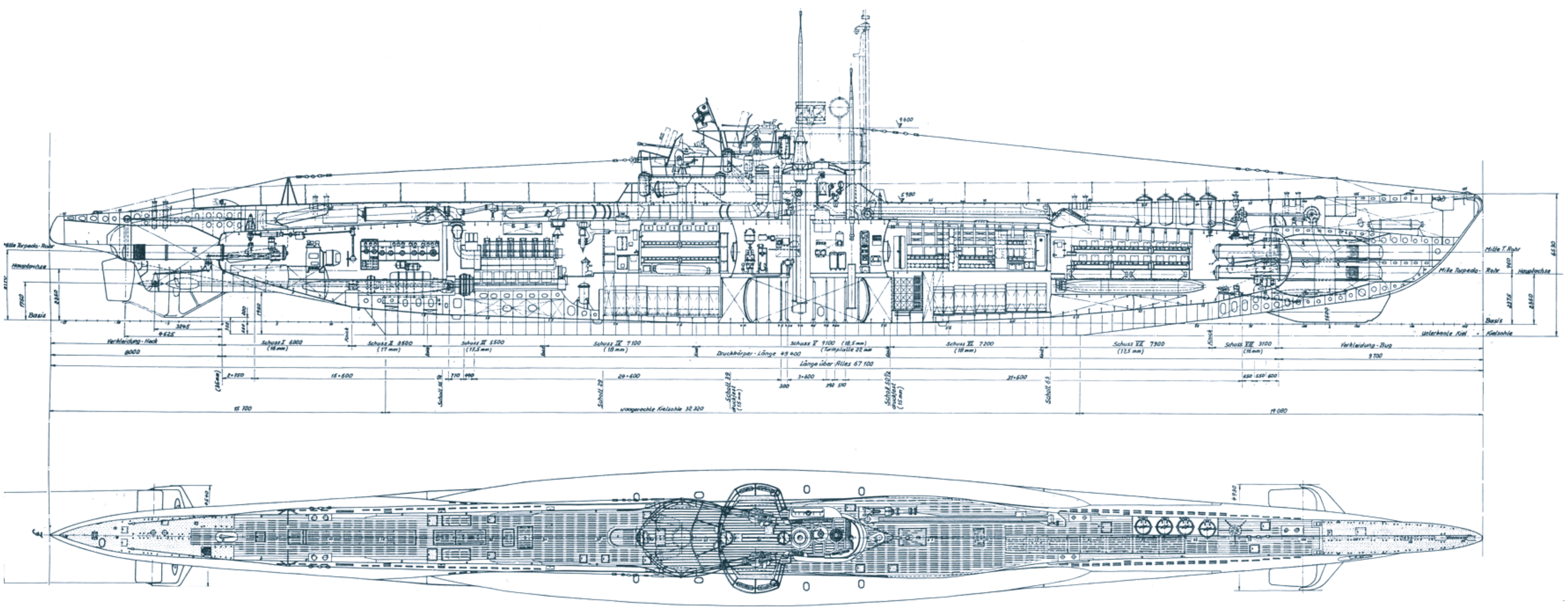


Find the warship that will sink.
Show that the other two warships can float.

King George V 1939

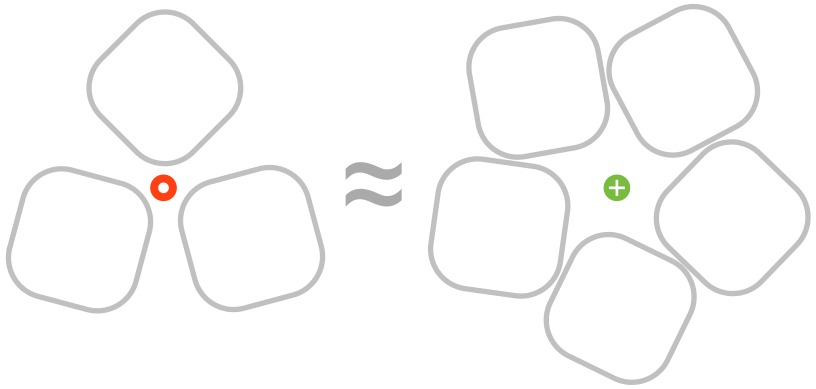




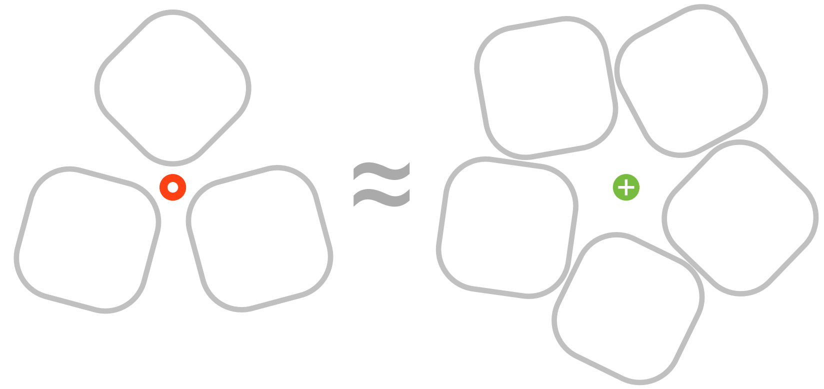


Find six numbers than can be organized in two different ways to make this submarine sea worthy.

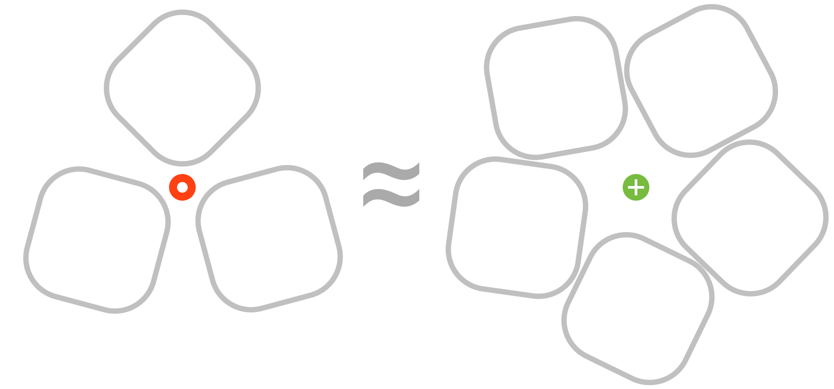
German U-boat
1944



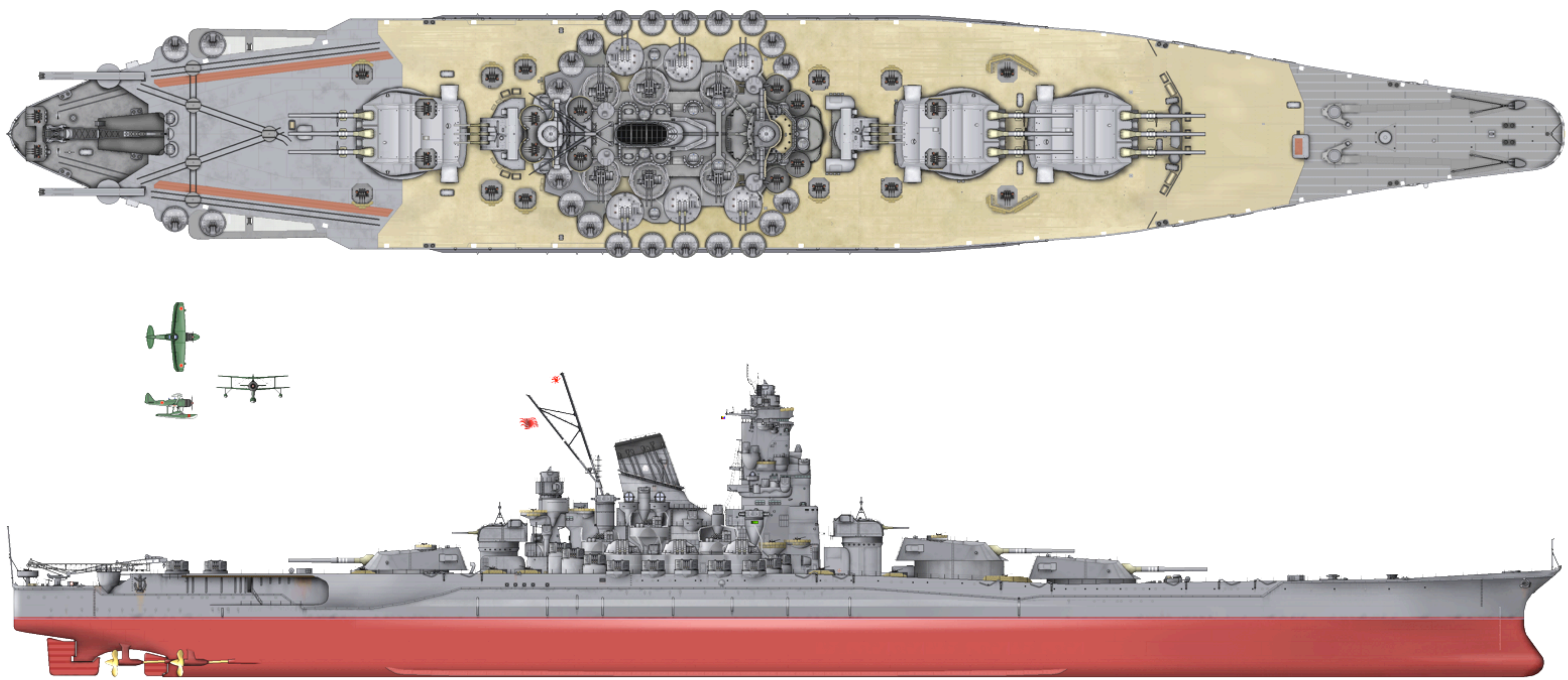
1, 2, 3, 4, 5, 6, 7, 8



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

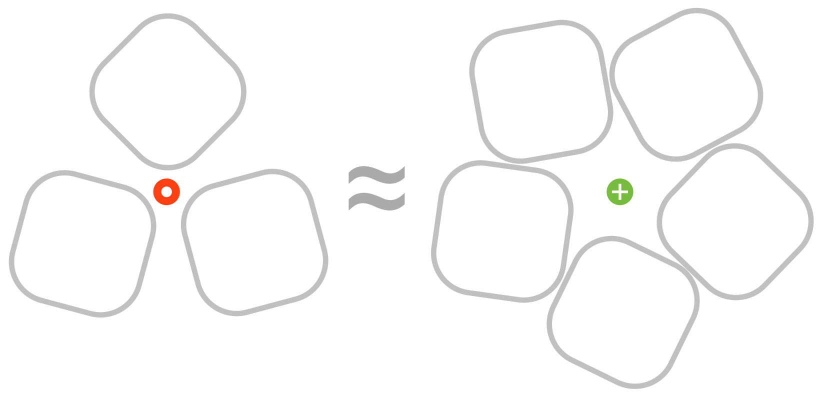


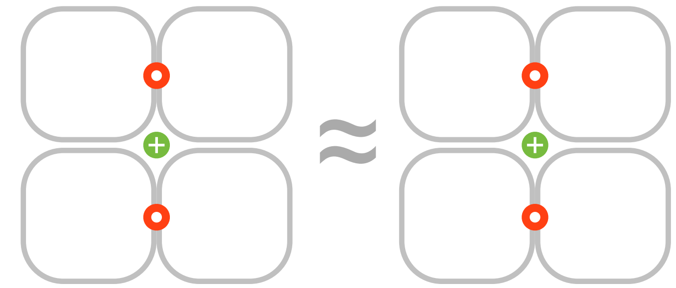
2, 3, 4, 5, 6, 9, 9, 9



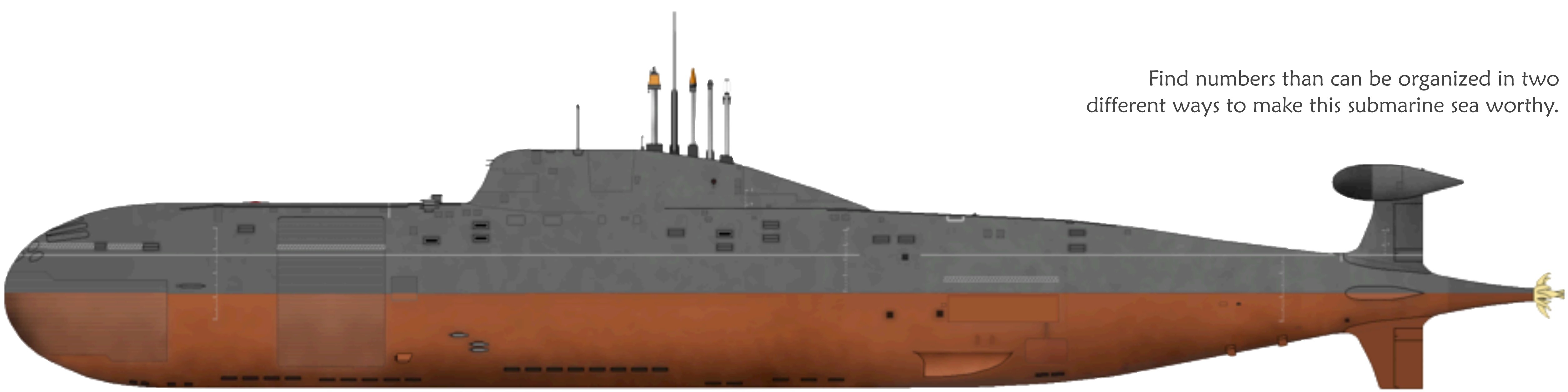
Yamato class battleships, 1945

Drawing by Alexpl



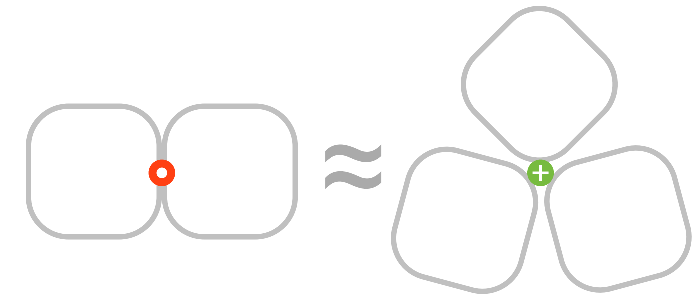


Find numbers than can be organized in two different ways to make this submarine sea worthy.



Russian Akula class submarines, 1990

Drawing by Alexpl



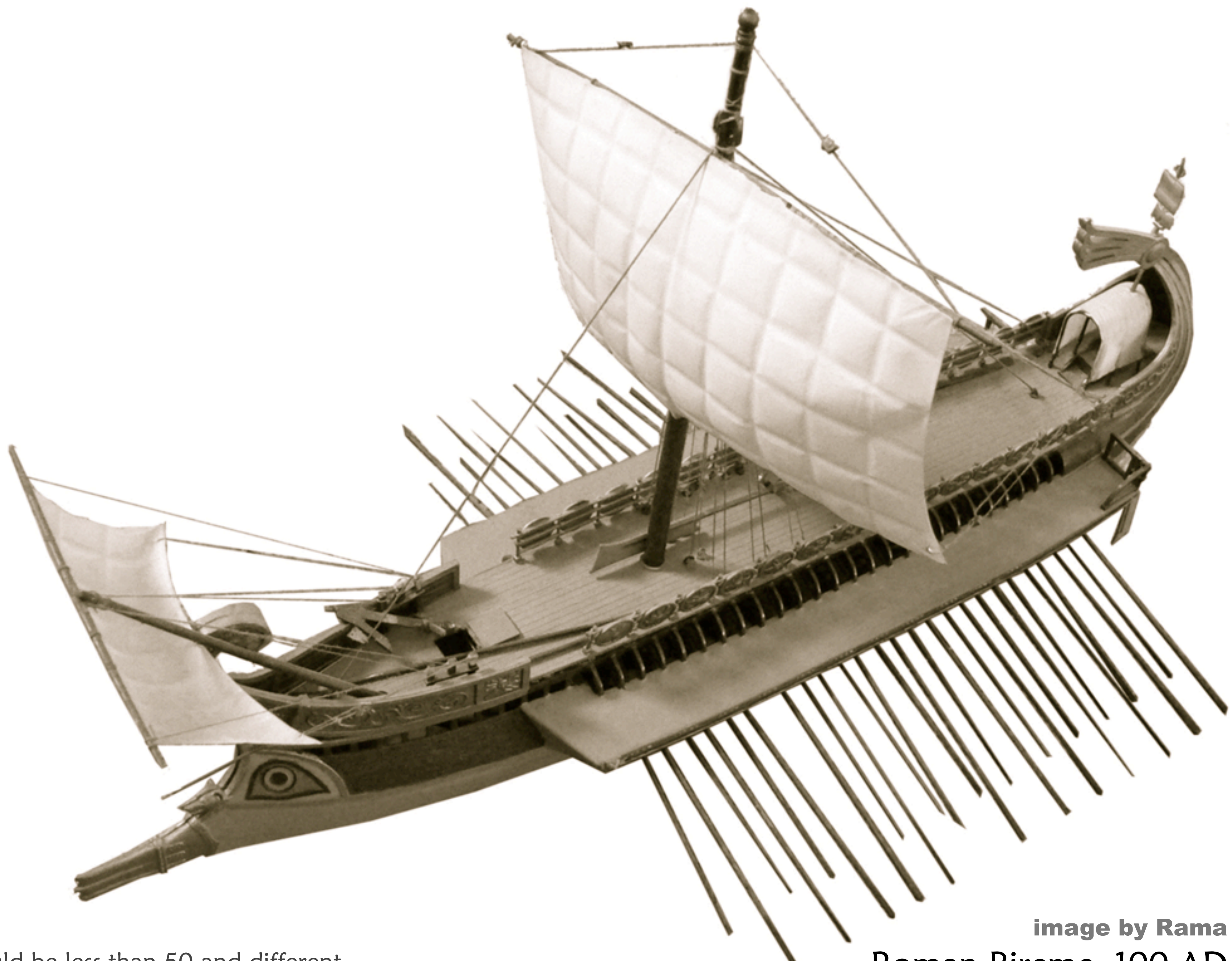
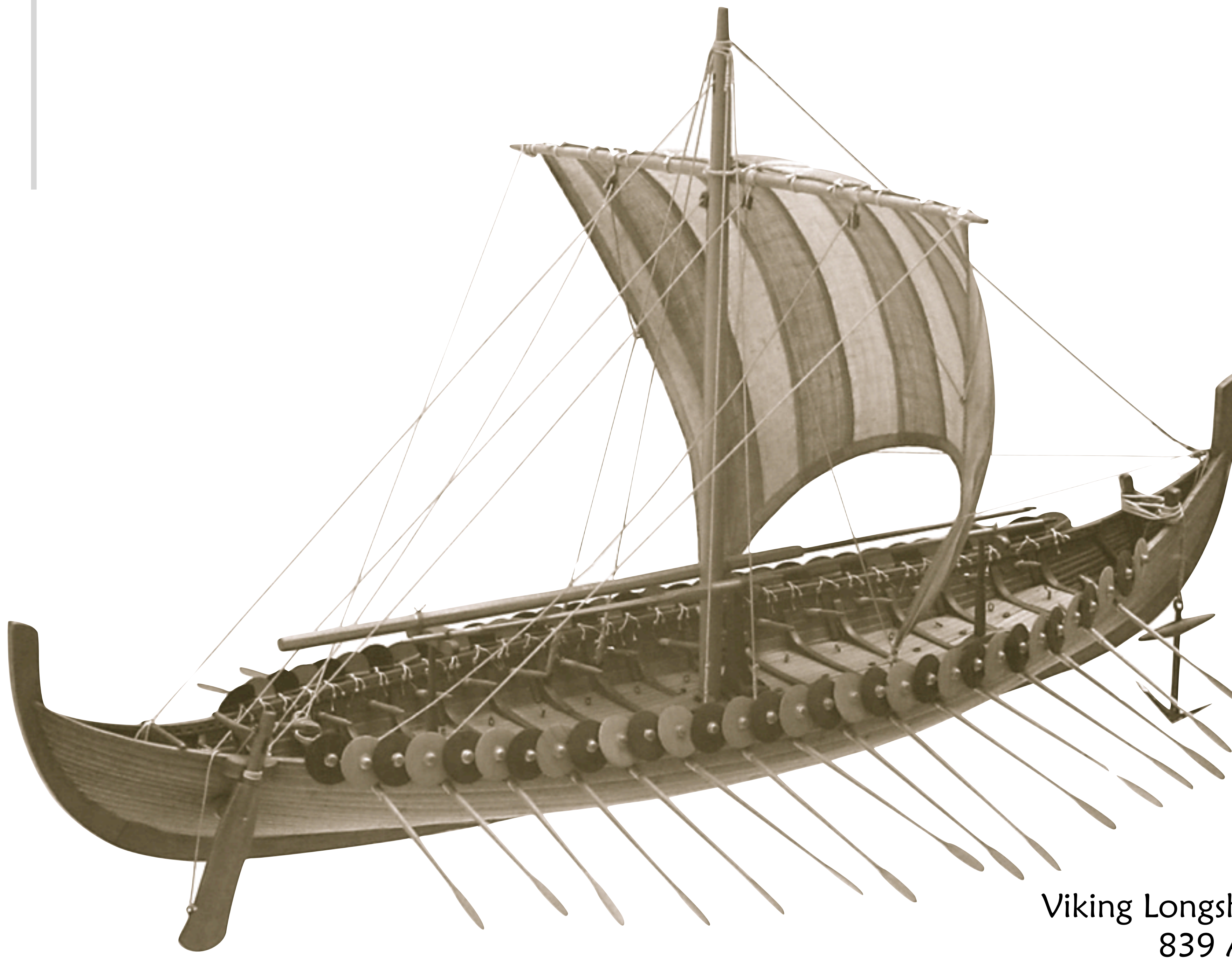


image by Rama

Roman Bireme, 100 AD

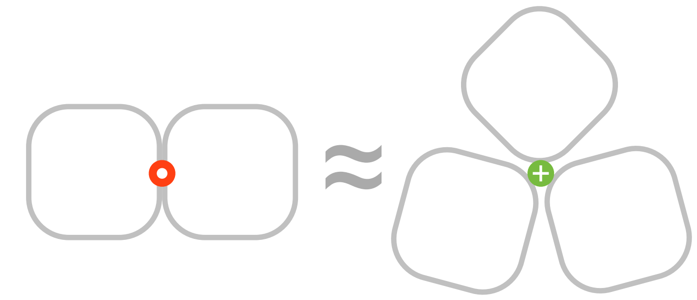
Make a puzzle with one sinking warship. All numbers should be less than 50 and different.

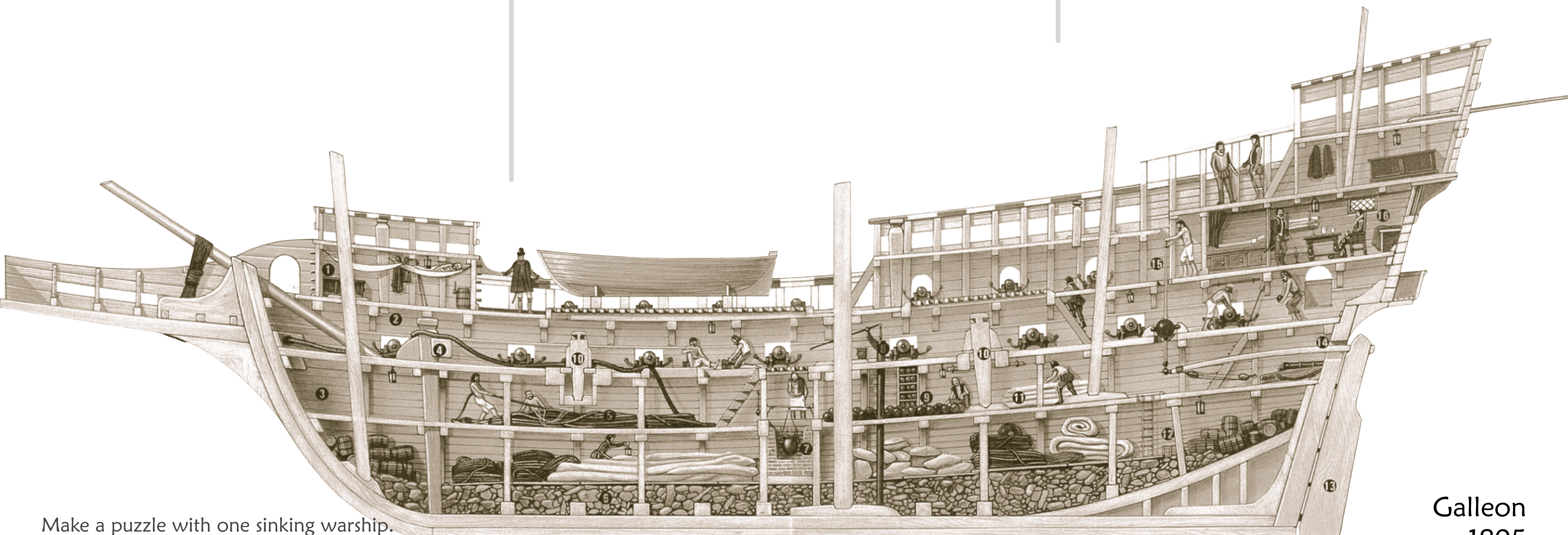


Make a puzzle with one sinking warship.

Viking Longship
839 AD

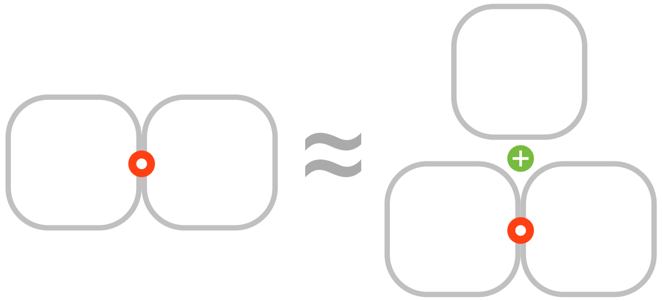


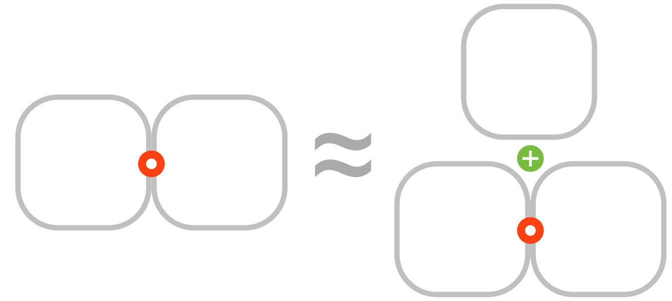


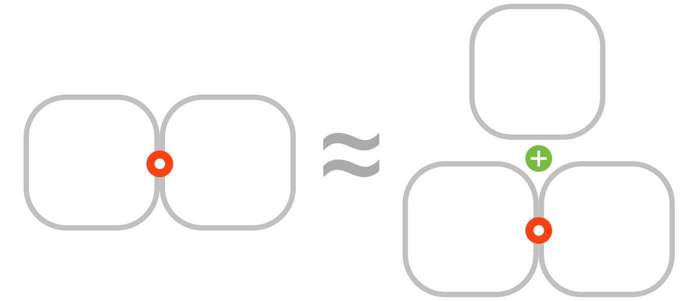


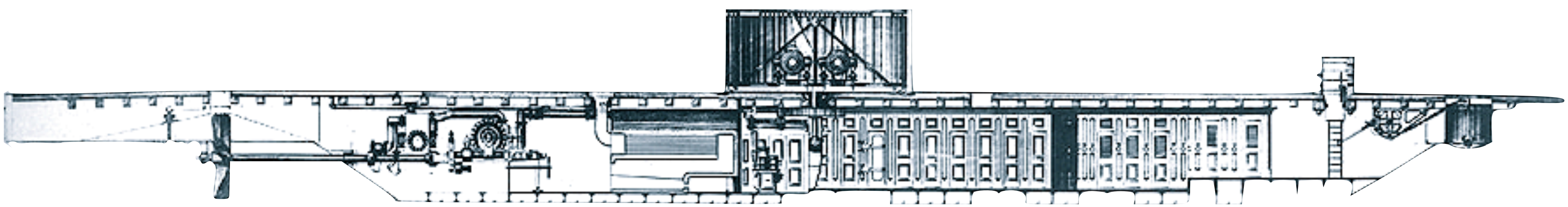
Make a puzzle with one sinking warship.

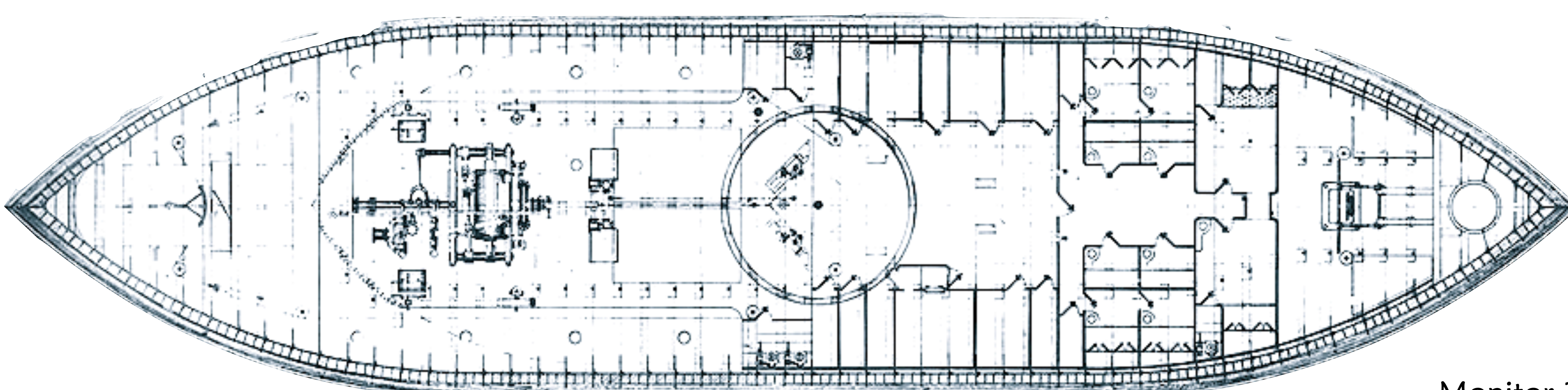
Galleon
1805





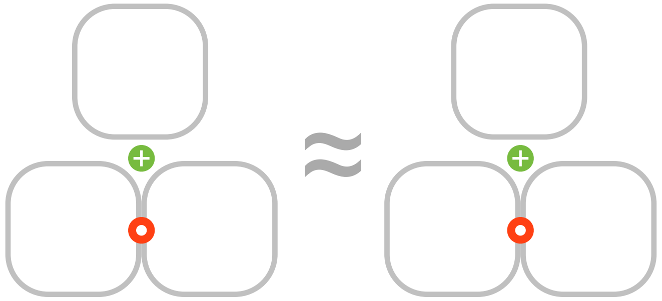


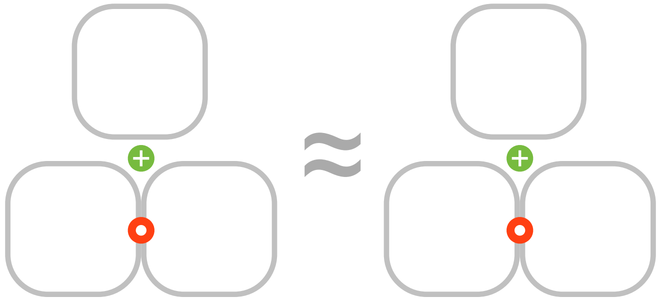


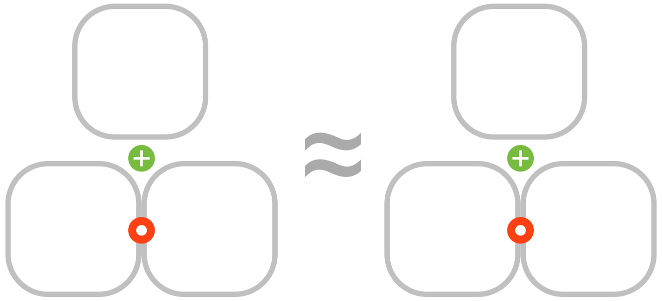


Monitor 1862

Make a puzzle with one sinking warship.

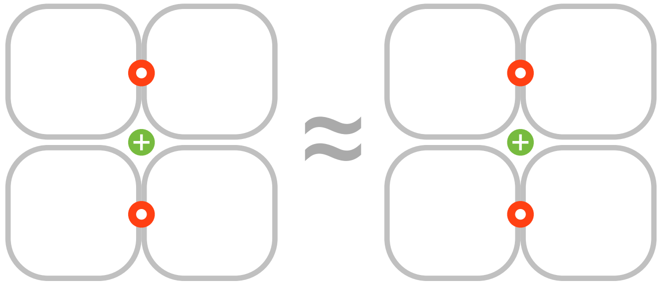


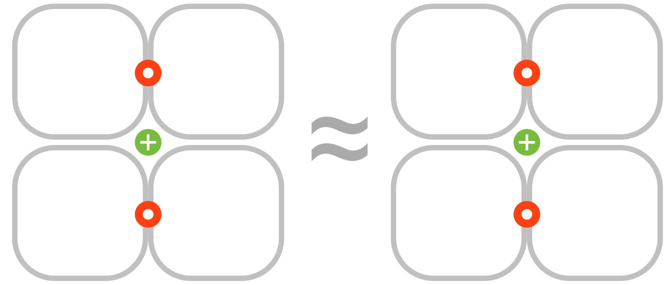


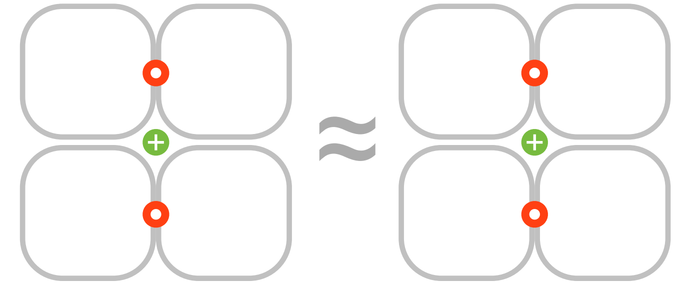


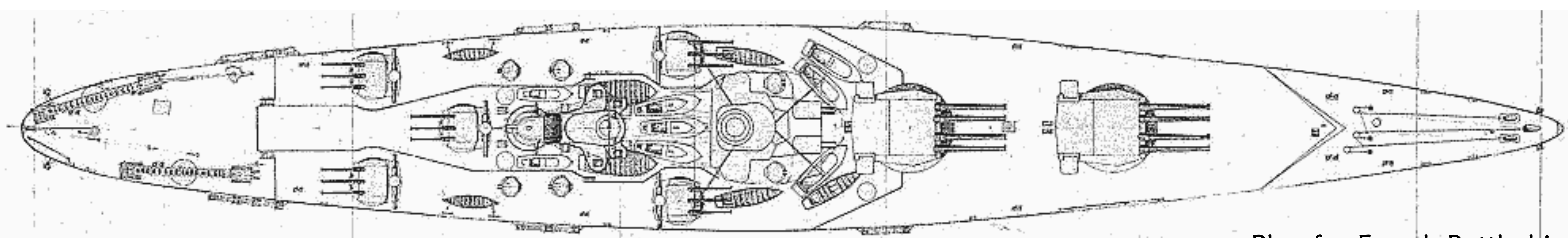
Dreadnaught, 1906

Make a puzzle with one sinking warship.



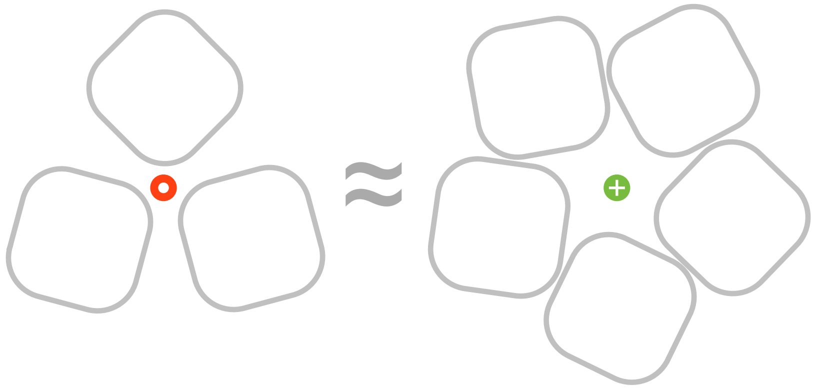


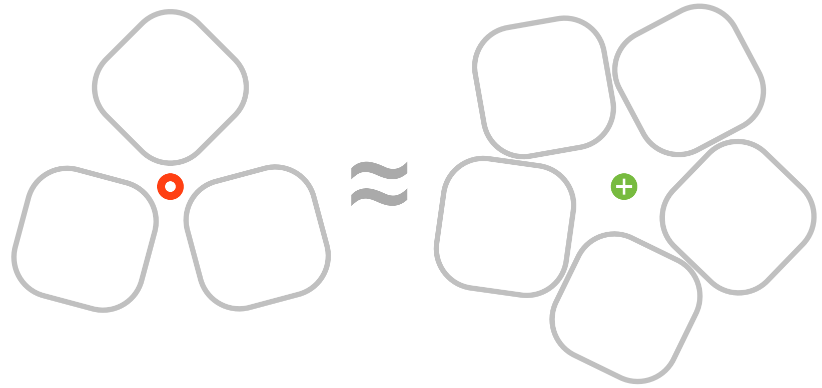


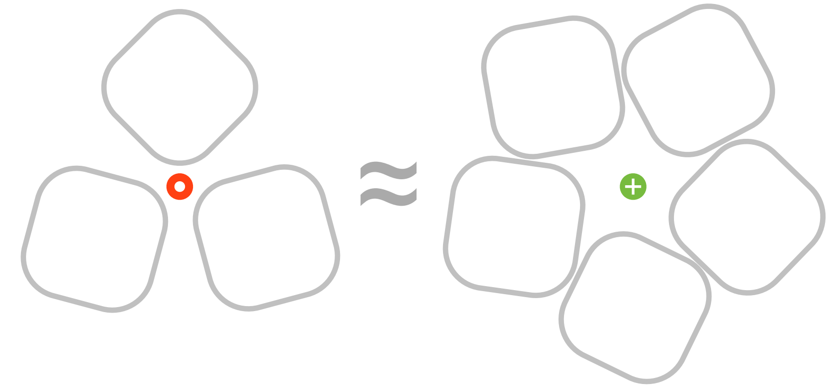


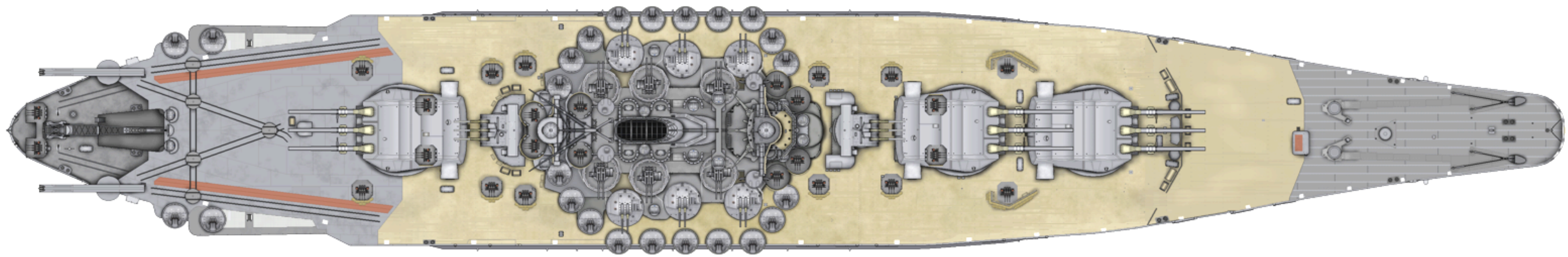
Plan for French Battleship
Clemenceau, 1940

Make a puzzle with one sinking warship.

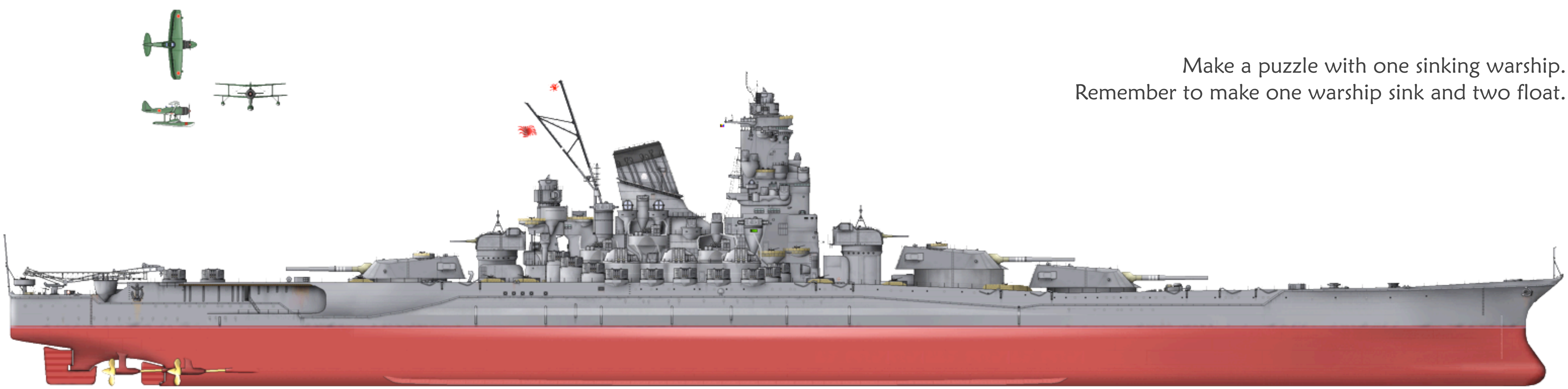






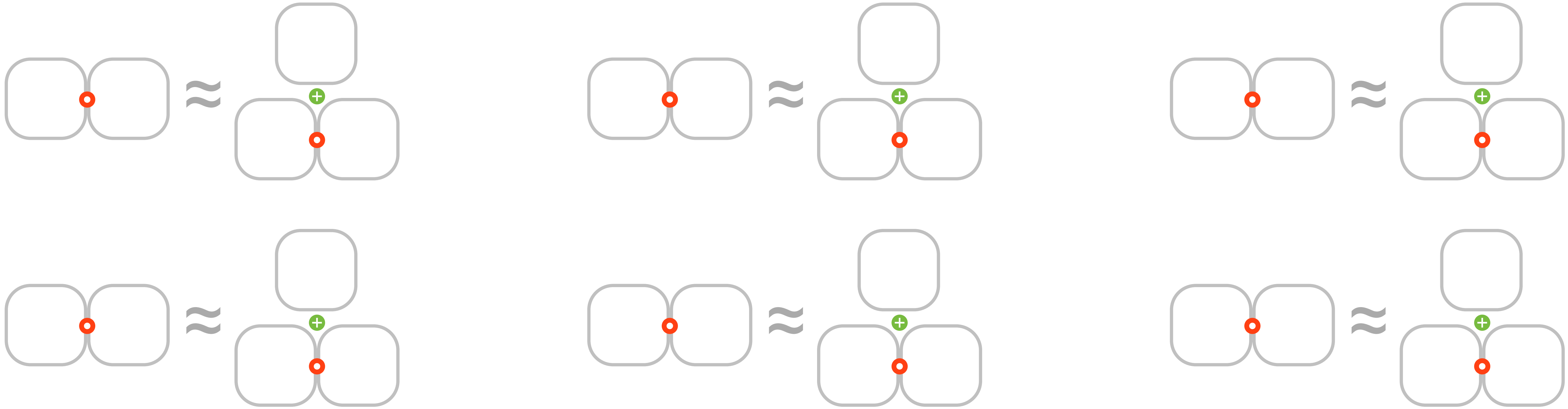


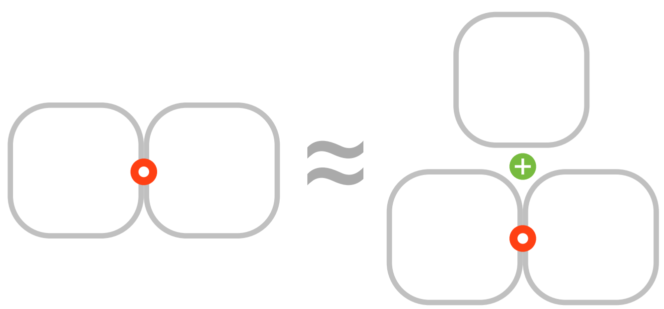
Make a puzzle with one sinking warship.
Remember to make one warship sink and two float.



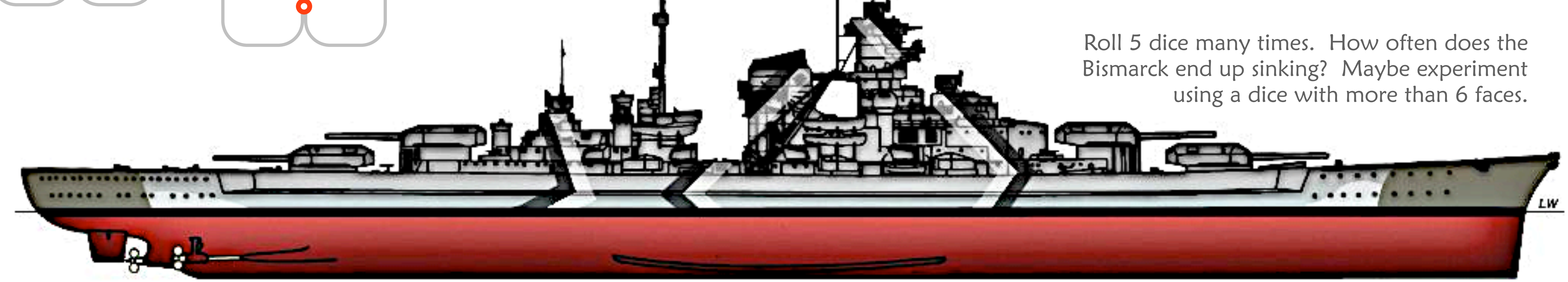
Yamato class battleships, 1945

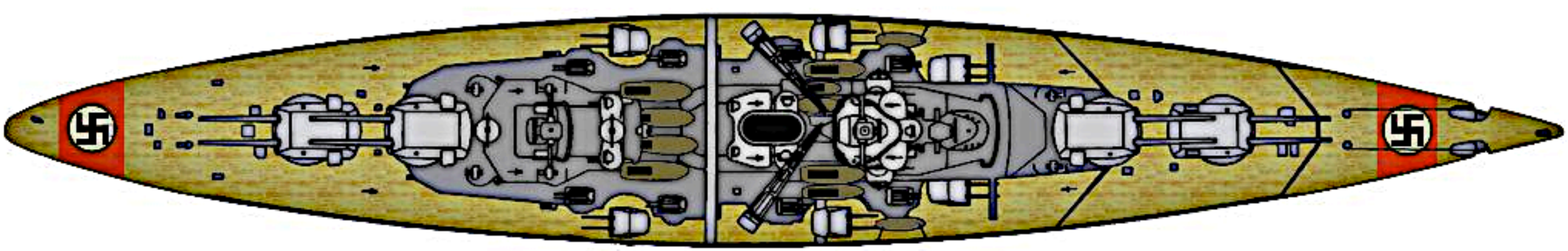
Drawing by Alexpl





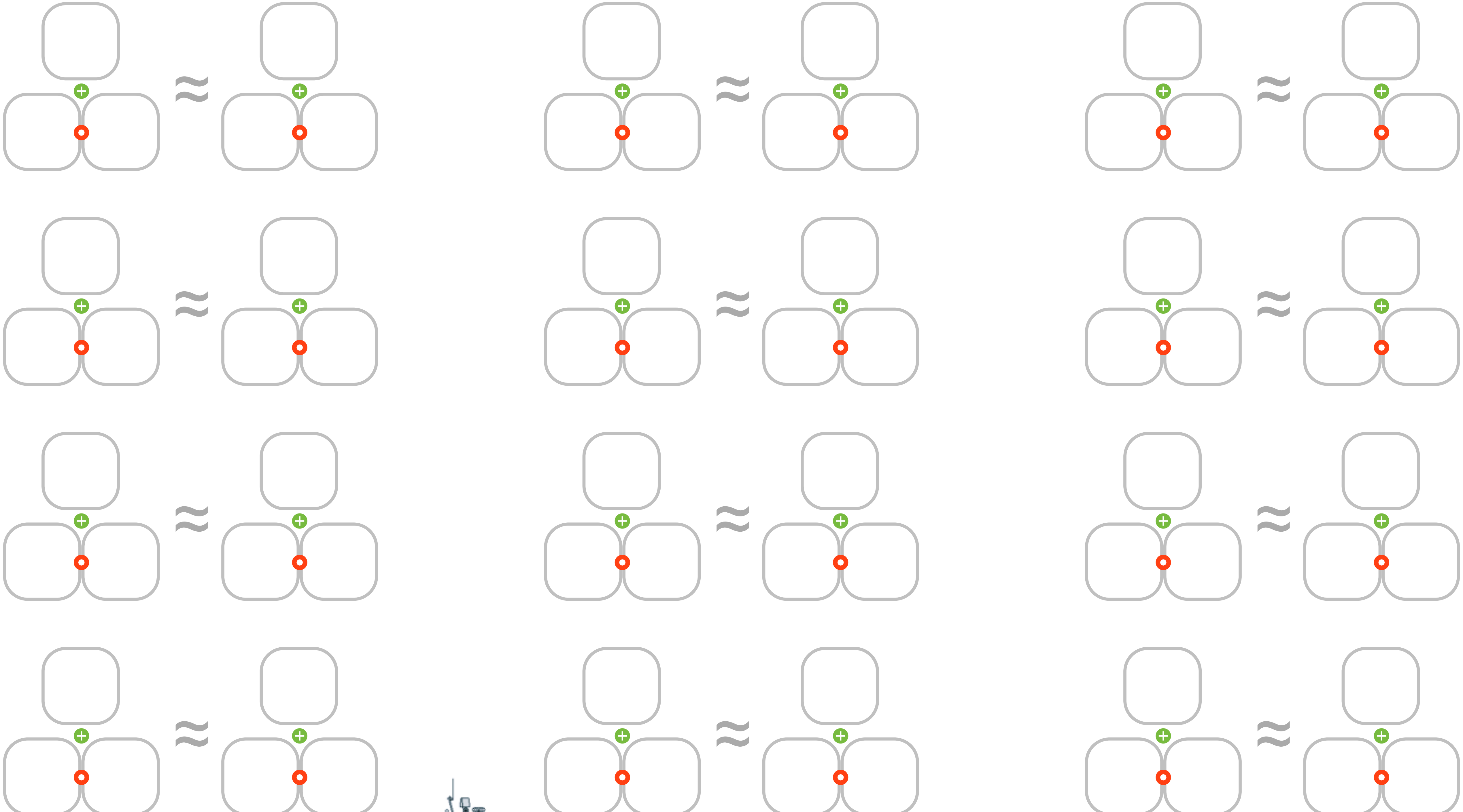
Roll 5 dice many times. How often does the Bismarck end up sinking? Maybe experiment using a dice with more than 6 faces.

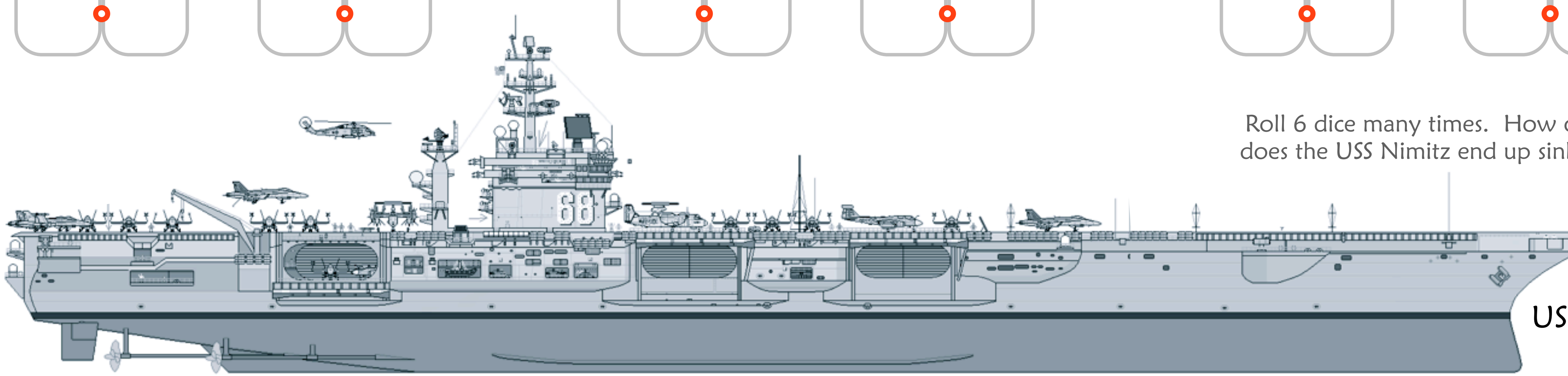




German battleship, Bismarck, 1941

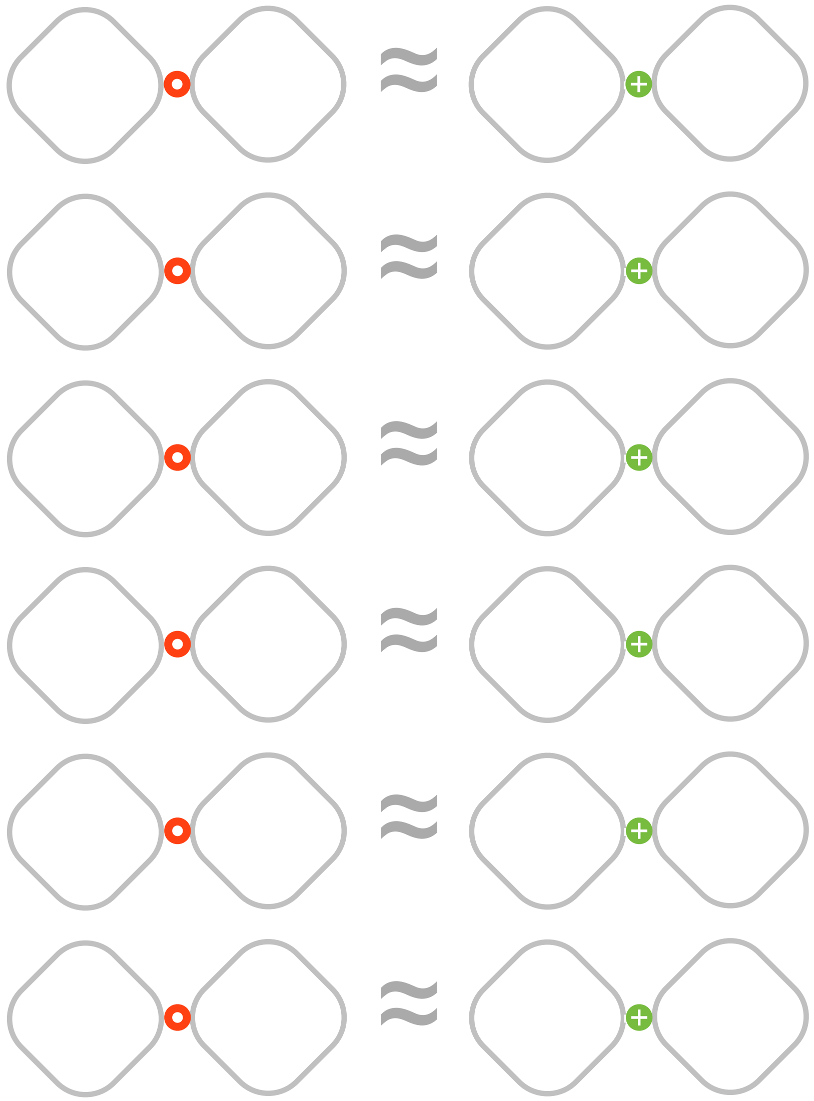
Drawing by Slawomir Lipiecki

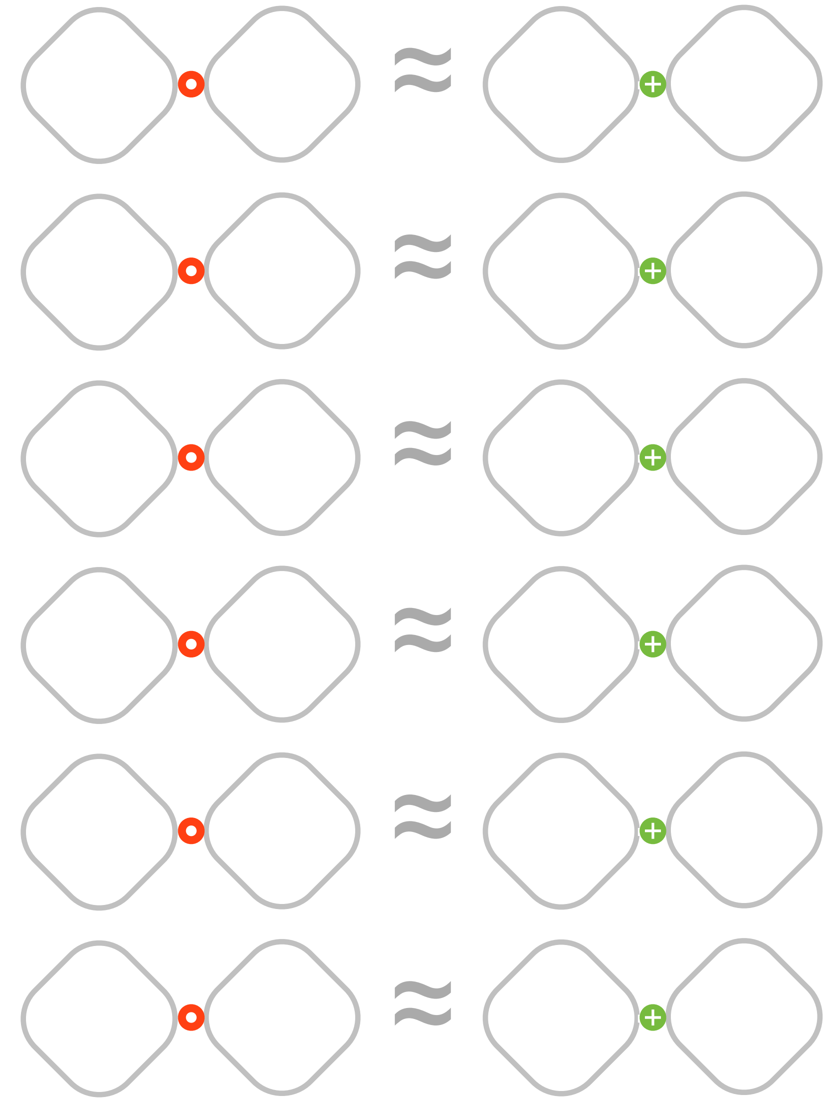


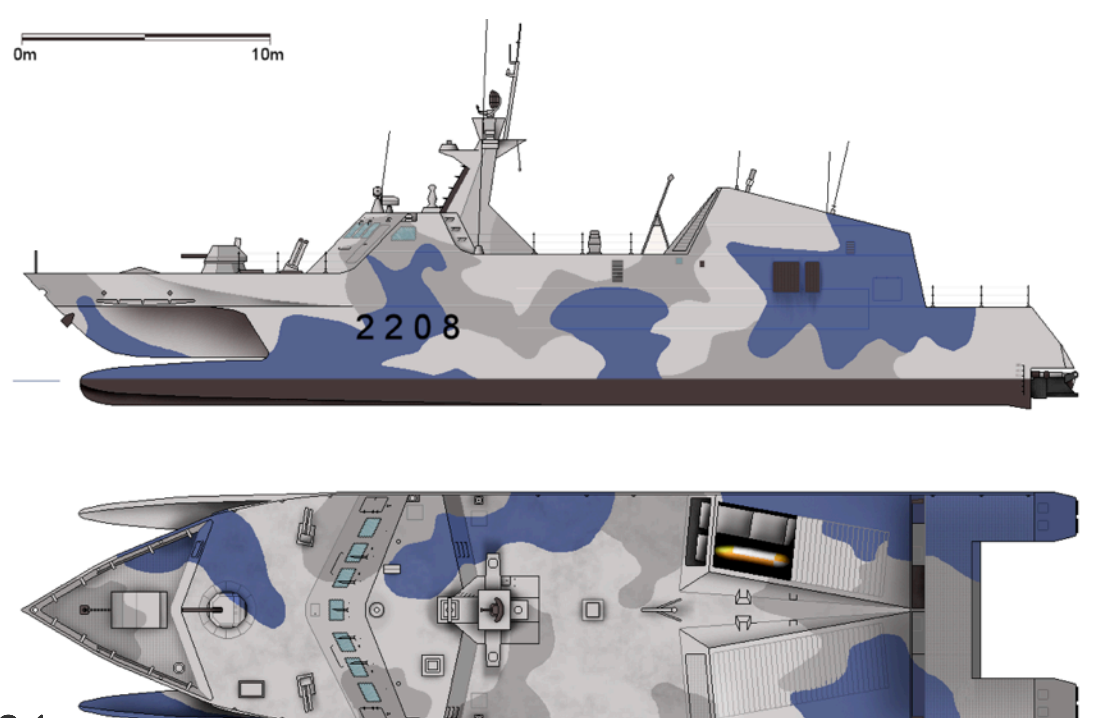


Roll 6 dice many times. How often does the USS Nimitz end up sinking?

USS Nimitz
1975





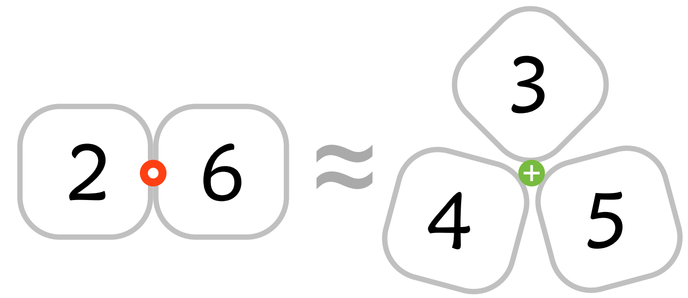


Roll 4 dice. Is this small missile boat better or worse than the Bismarck and Nimitz?

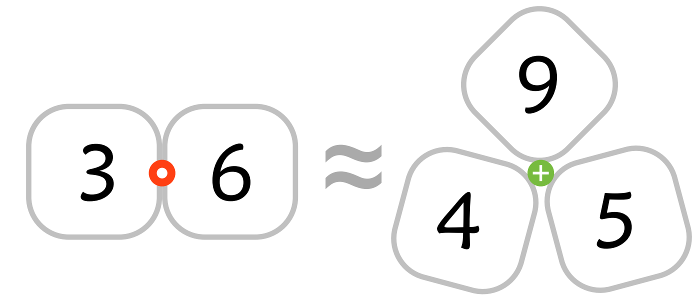
Chinese Type-022 Missile boat, 2004

Drawing by Alexpl

1, 2, 3, 4, 5



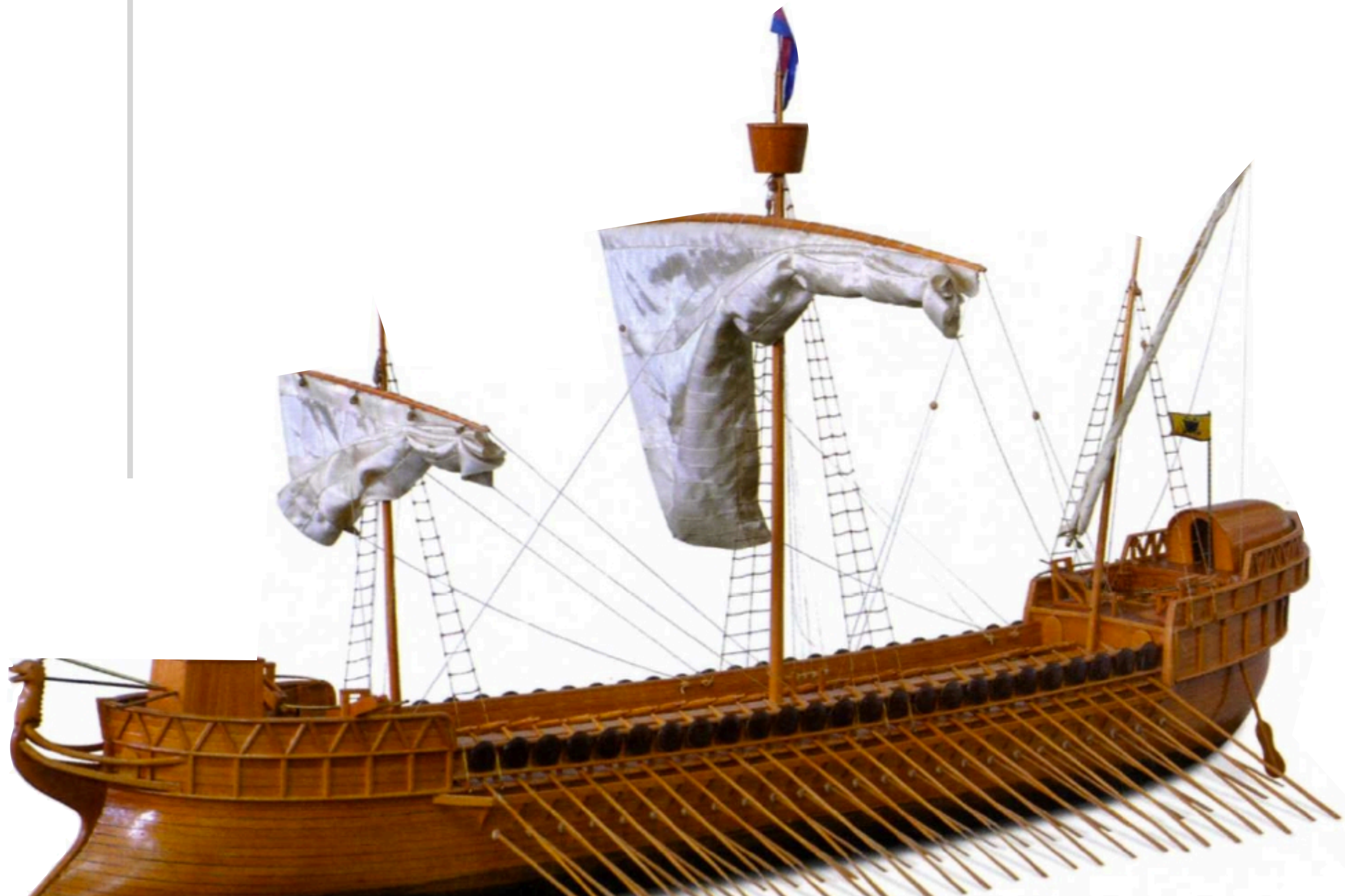
2, 3, 4, 5, 6



3, 4, 5, 6, 9

will sink

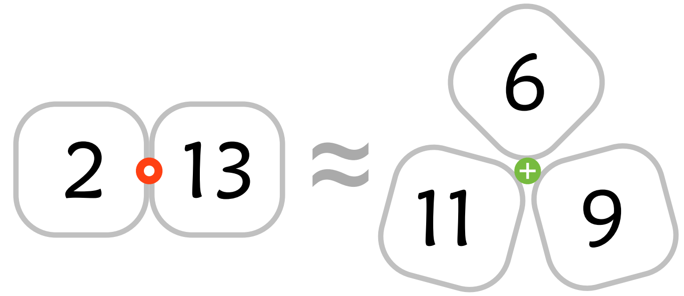
answers



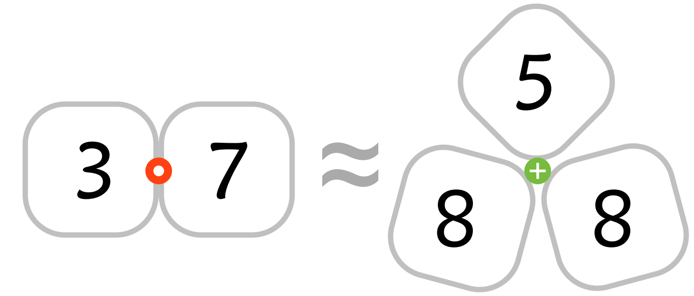
Find the warship that will sink.
Show that the other two warships can float.

Byzantine Dromon, 700 AD

3, 5, 7, 9, 11



2, 6, 9, 11, 13

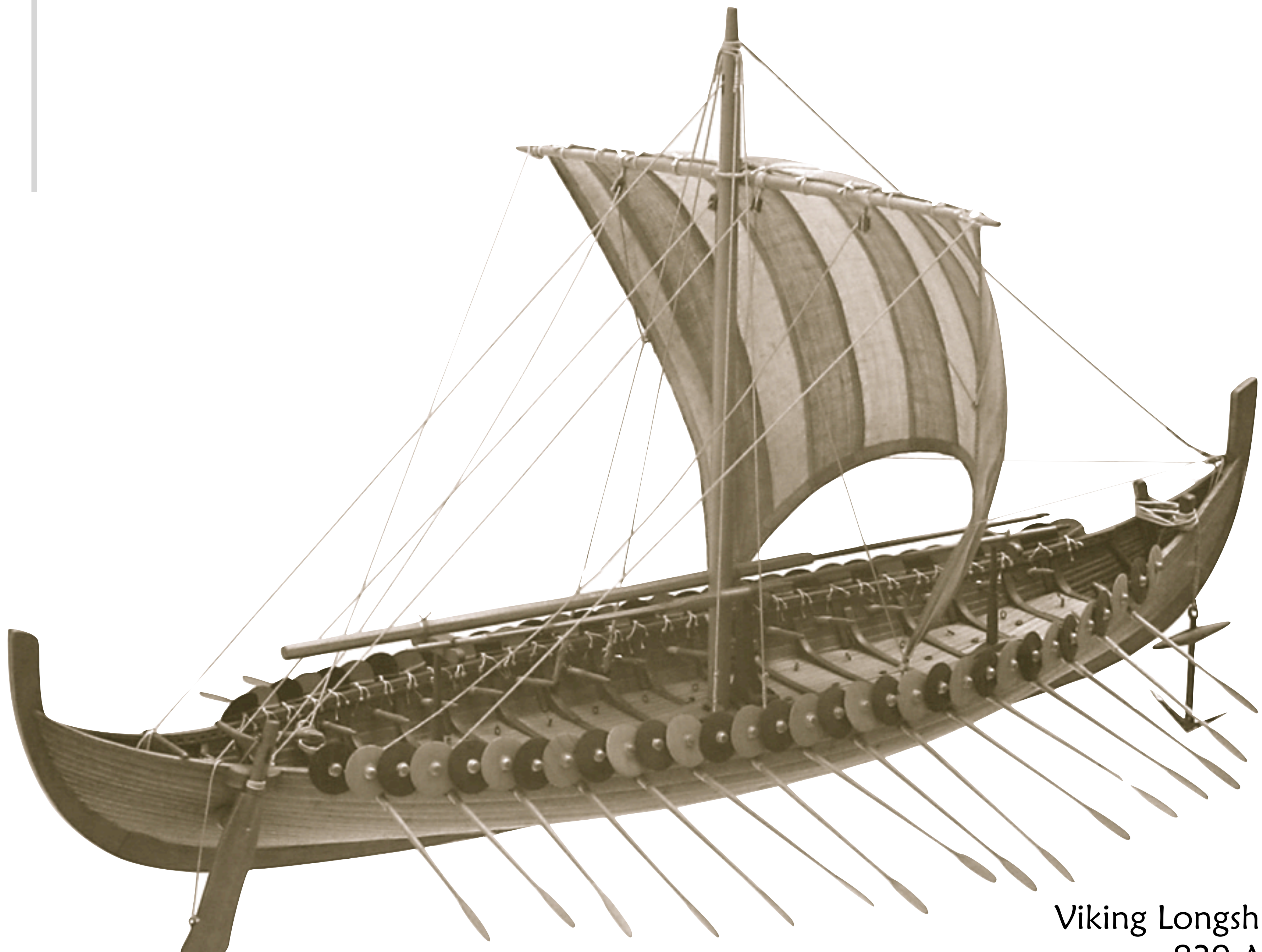


3, 5, 7, 8, 8

will sink

answers

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



Viking Longship
839 AD

$\square \circ \square \approx \begin{matrix} \square & \square \\ \square & \square \end{matrix}$

1, 2, 3, 4, 5, 5

$3 \circ 4 \approx \begin{matrix} 2 & 4 \\ 1 & 5 \end{matrix}$

1, 2, 3, 4, 4, 5

$4 \circ 4 \approx \begin{matrix} 2 & 3 \\ 6 & 5 \end{matrix}$

2, 3, 4, 4, 5, 6

will sink

answers

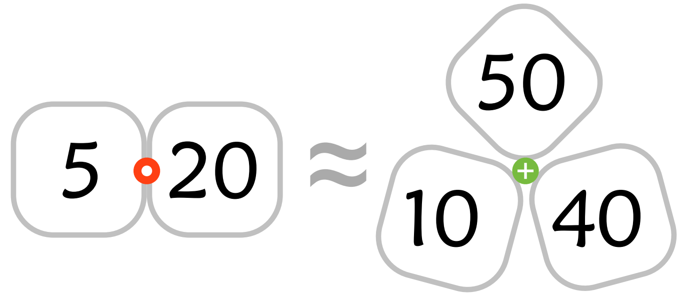
Maltese Galley, 1571

Photo by Myriam Thyes

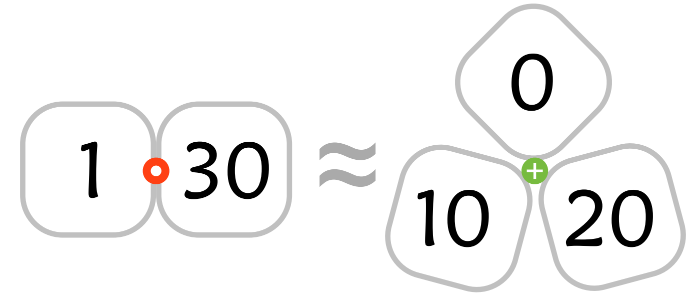
Model from the Naval History Museum in Venice

2, 10, 30, 40, 50

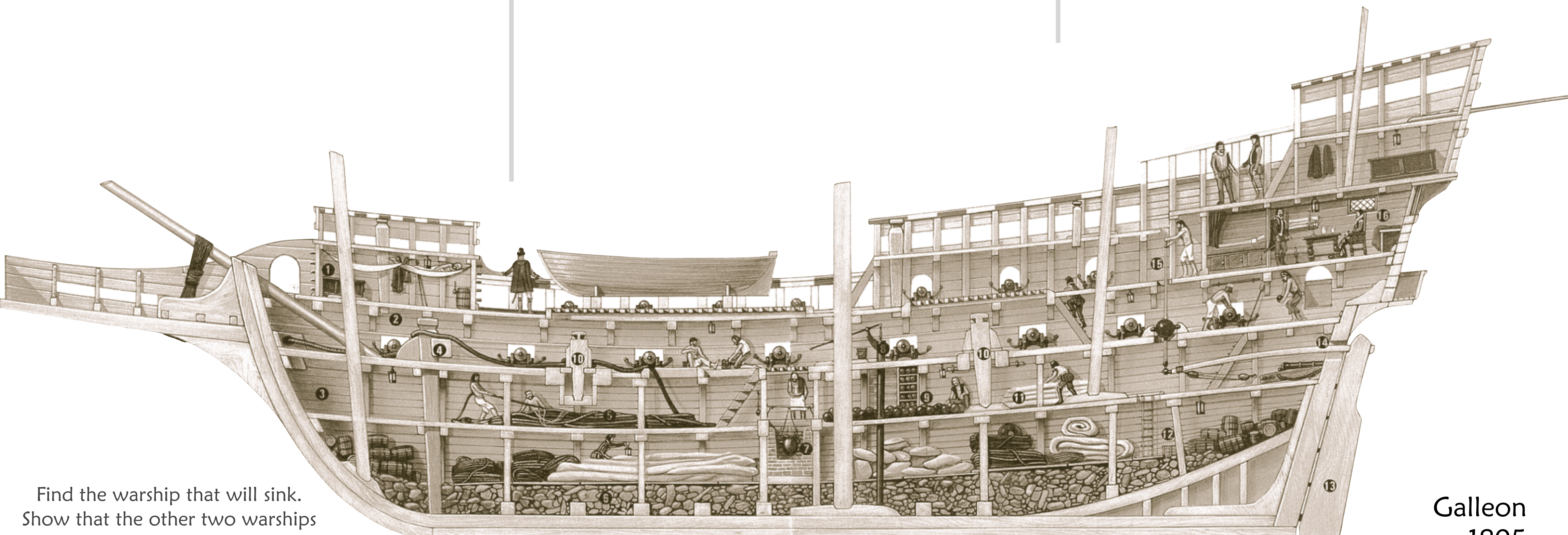
will sink



5, 10, 20, 40, 50

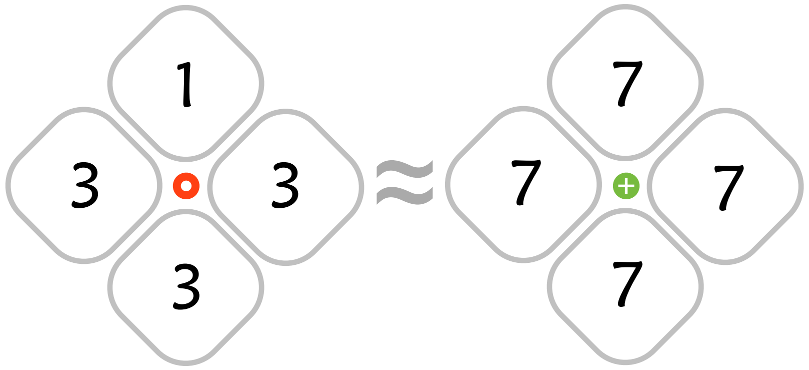


0, 1, 10, 20, 30

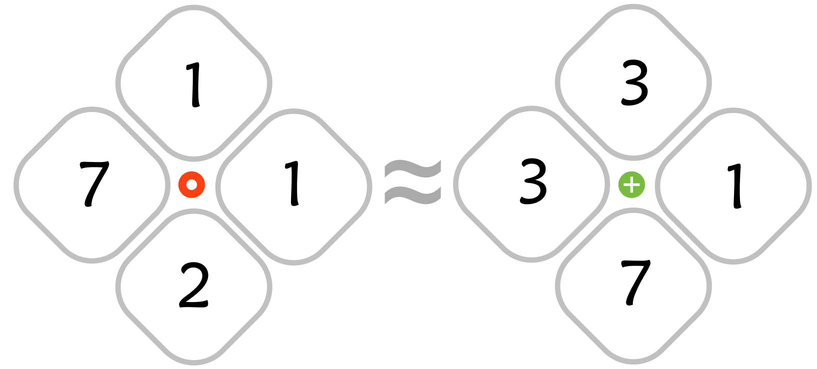


Find the warship that will sink.
Show that the other two warships can float.

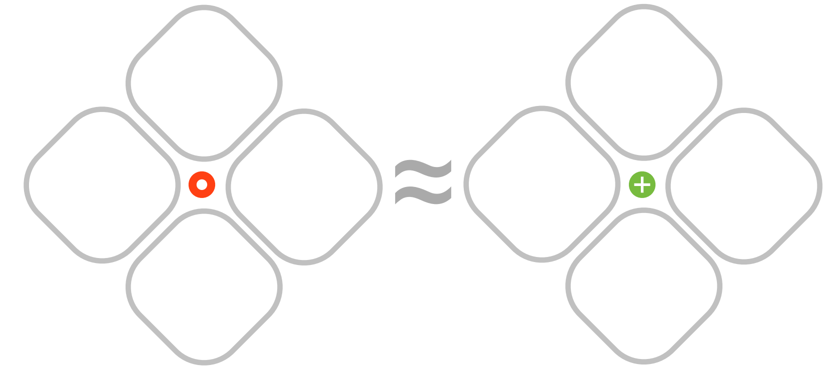
Galleon
1805



1, 3, 3, 3, 7, 7, 7, 7



1, 1, 1, 2, 3, 3, 7, 7



1, 1, 2, 3, 3, 7, 7, 7

will sink

USS Constitution, 1797

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

3 4 ≈ 10
1 2

1, 2, 3, 4, 10

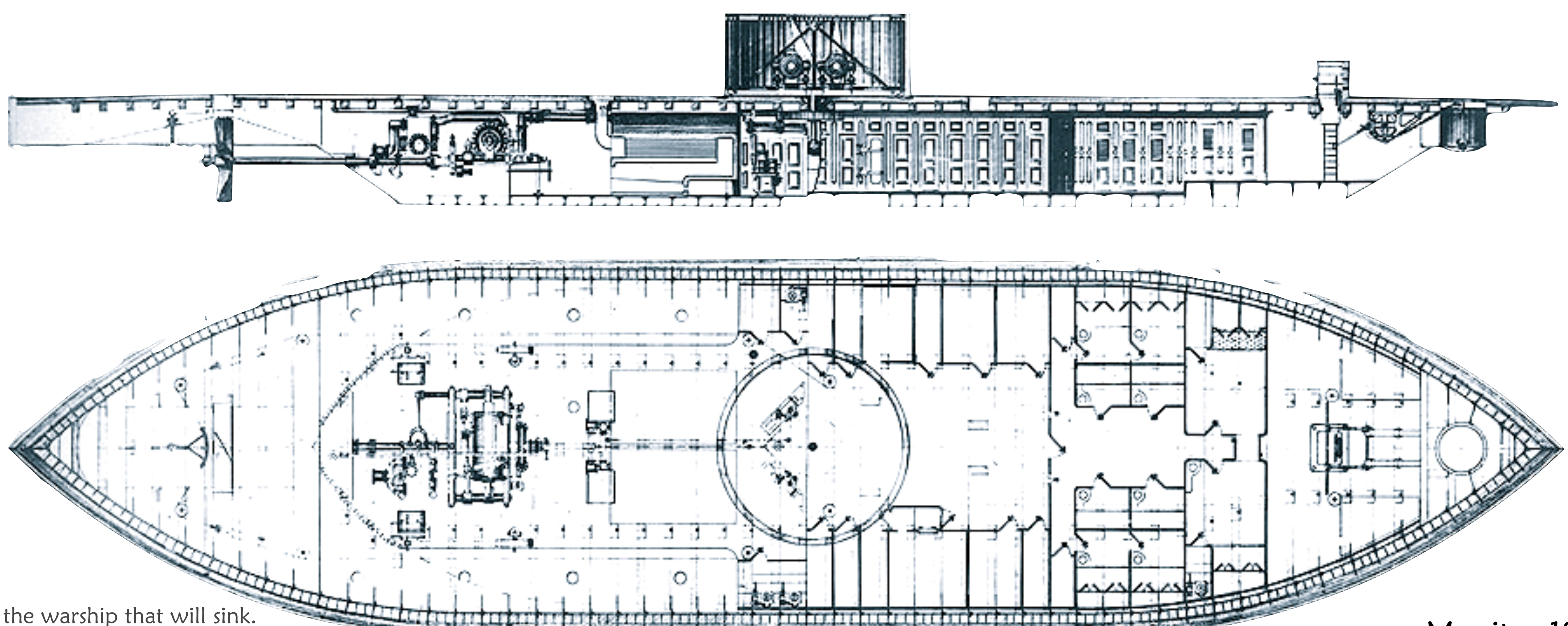
≈

2, 3, 4, 5, 10

will sink

4 5 ≈ 2
3 6

2, 3, 4, 5, 6



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

Monitor 1862

5 ≈ 2

3 7 ≈ 4 6

2, 3, 4, 5, 6, 7

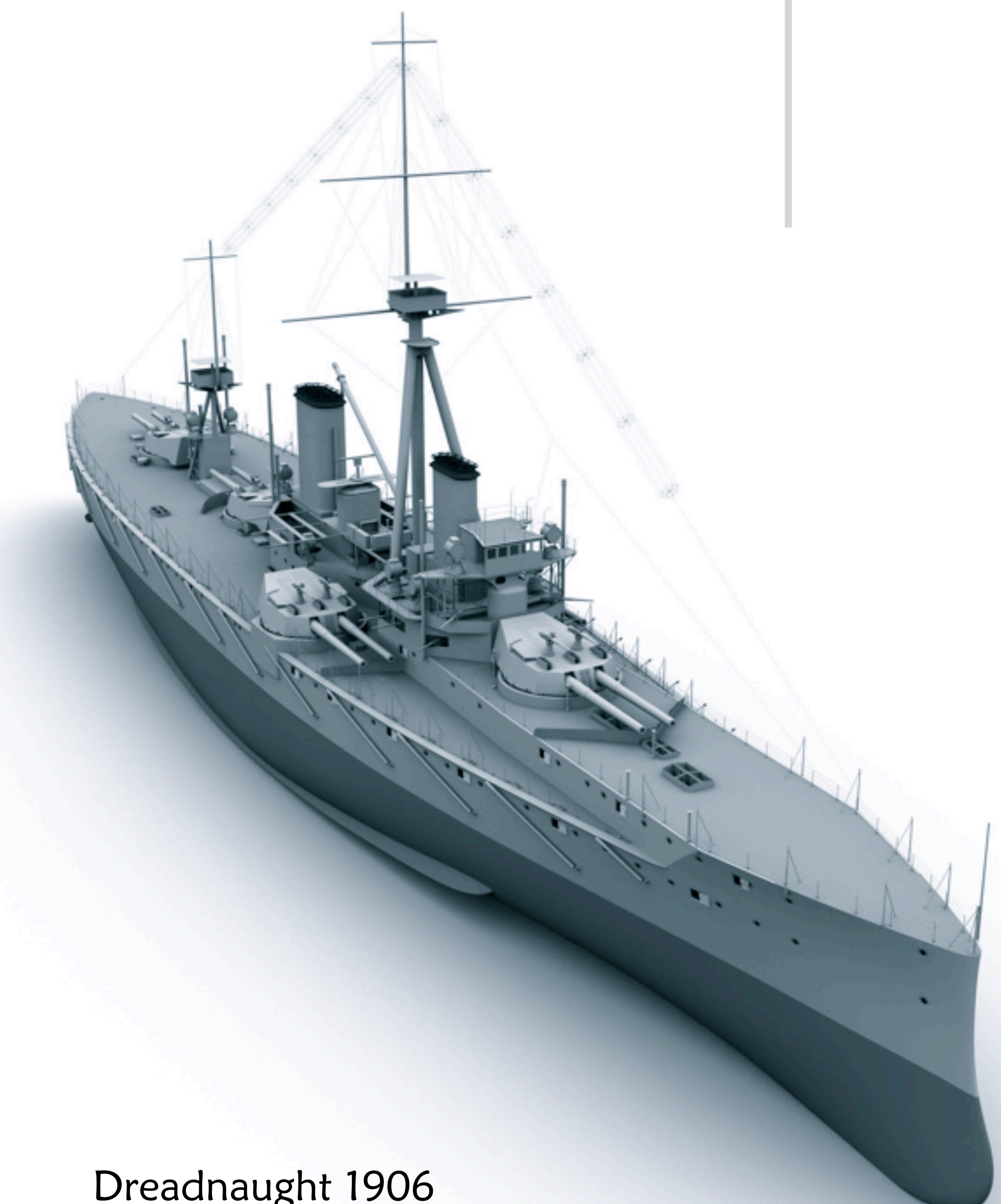
2, 3, 4, 5, 6, 10

will sink

6 ≈ 3

4 8 ≈ 5 7

3, 4, 5, 6, 7, 8



Dreadnaught 1906

answers

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

4
5 5 ≈ 5
4 6

4, 4, 5, 5, 5, 6

5
5 5 ≈ 6
4 6

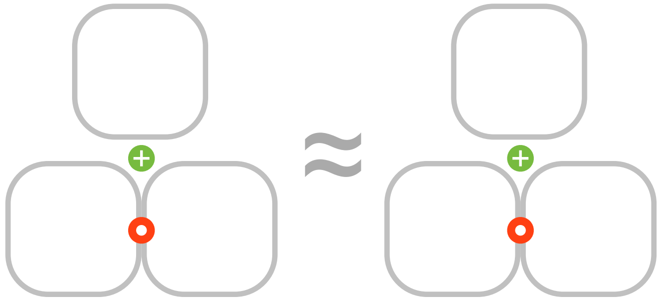
4, 5, 5, 5, 6, 6

≈

4, 4, 4, 5, 6, 6

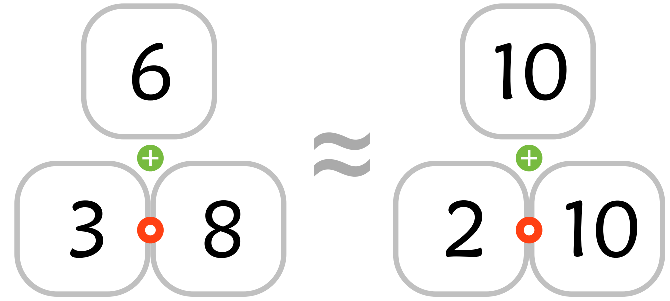
will sink

HMS Erebus - launched 1916 - photographed here in 1944

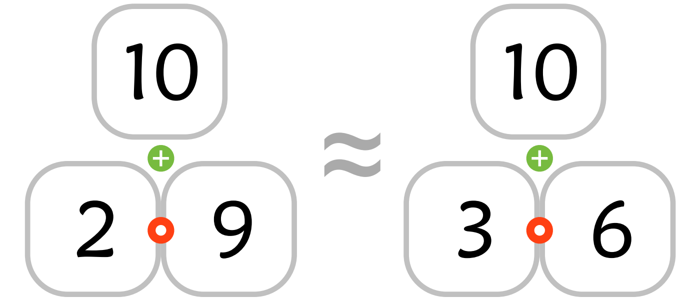


2, 3, 6, 7, 10, 10

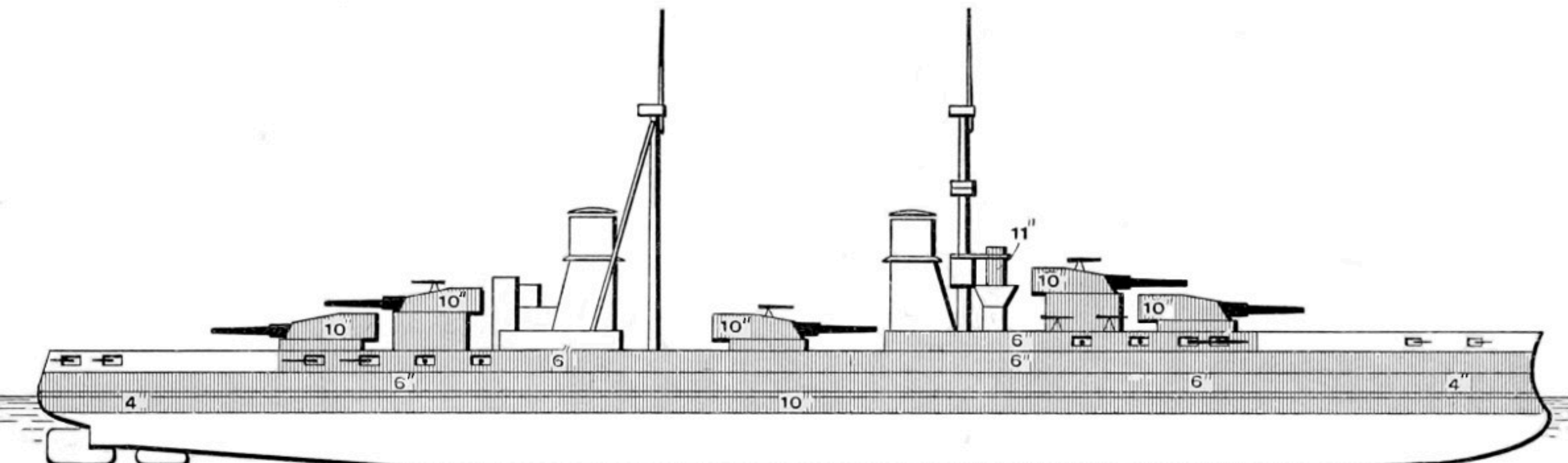
will sink



2, 3, 6, 8, 10, 10



2, 3, 6, 9, 10, 10



Andrea Doria-class battleship of Italy - launched during WWI

≈

3, 5, 7, 11, 13, 17

will sink

7 ≈ 10

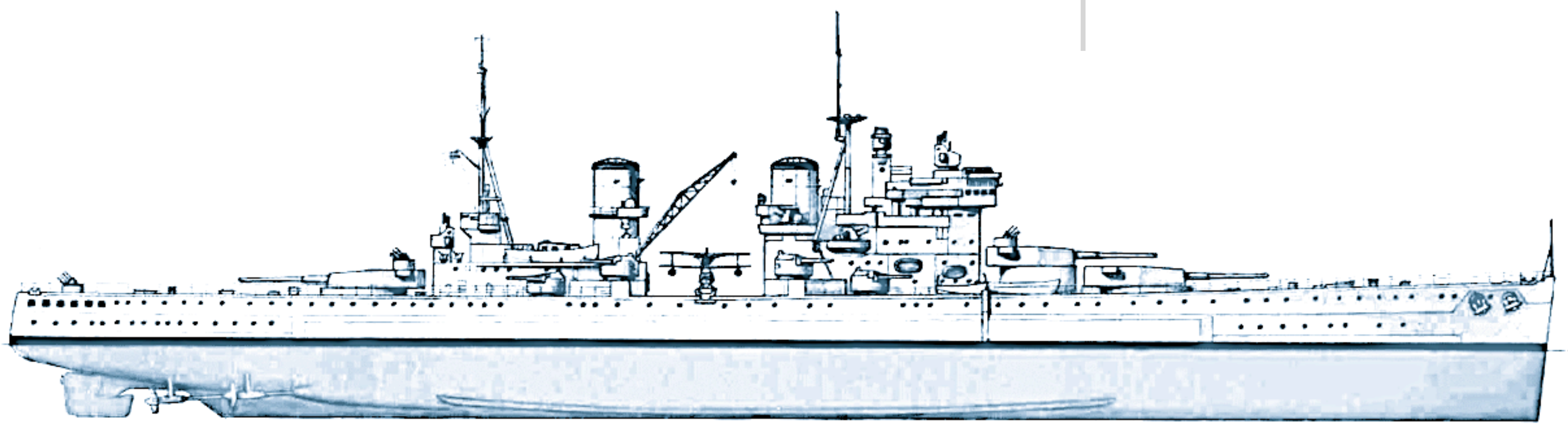
4 17 5 13

4, 5, 7, 10, 13, 17

13 ≈ 17

3 18 5 10

3, 5, 10, 13, 17, 18



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

answers

King George V 1939

2 ∘ 2 ≈ 1 1 ⊕ 1 1

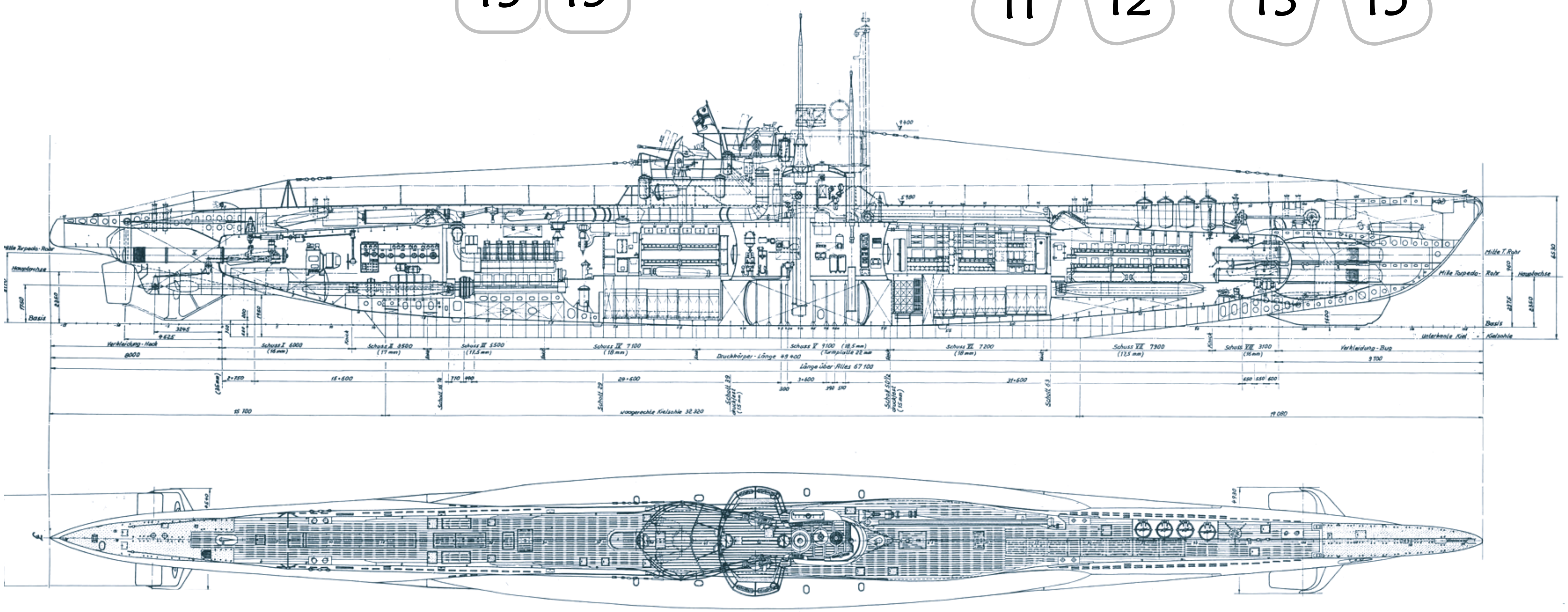
1 ⊕ 2 1 ≈ 1 ⊕ 2 1

two possible answers

(there are infinitely many, but that doesn't mean they are easy to find.)

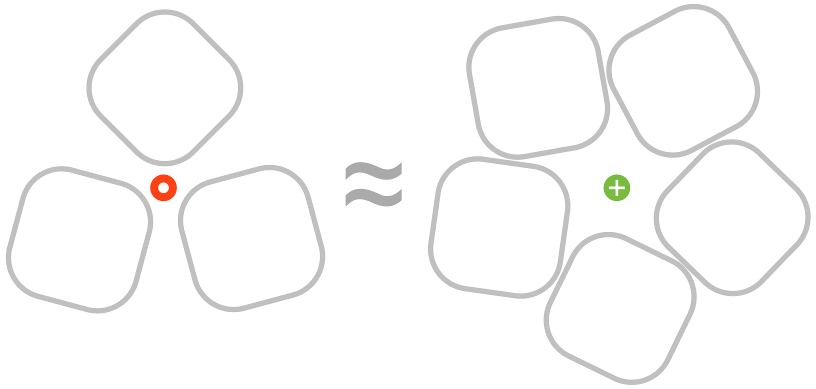
12 ∘ 4 ≈ 9 11 ⊕ 13 15

9 ⊕ 11 12 ≈ 4 ⊕ 13 15



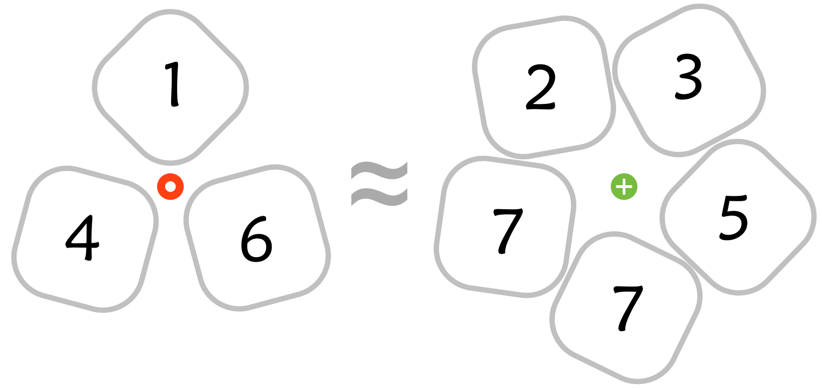
Find six numbers than can be organized in two different ways to make this submarine sea worthy.

German U-boat
1944

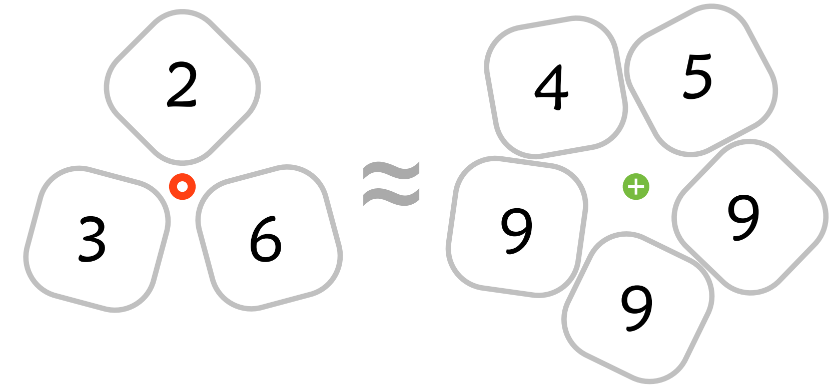


1, 2, 3, 4, 5, 6, 7, 8

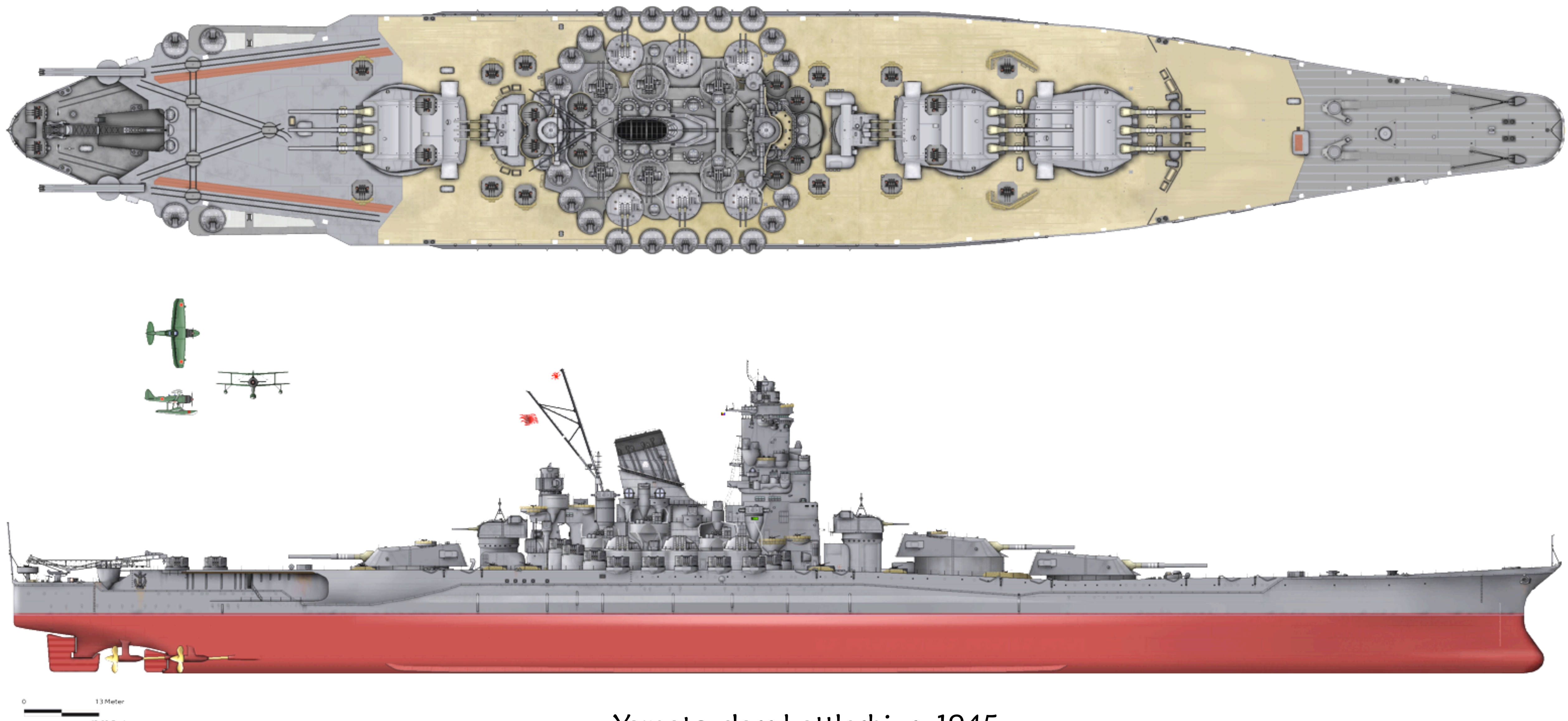
will sink



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

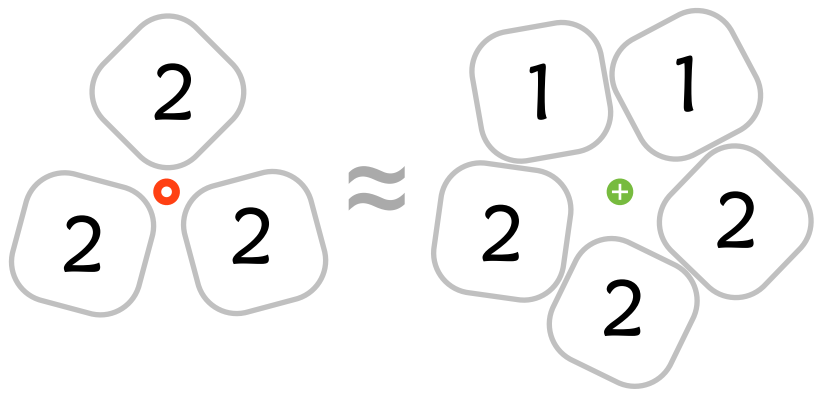


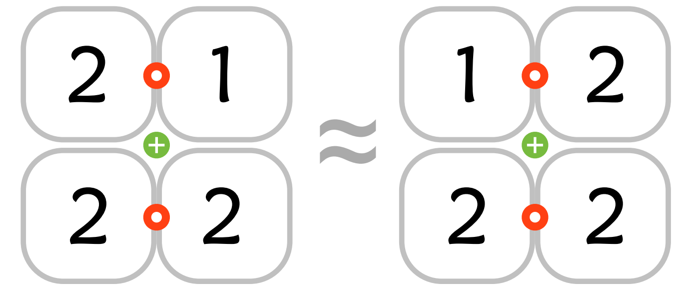
2, 3, 4, 5, 6, 9, 9, 9



Yamato class battleships, 1945

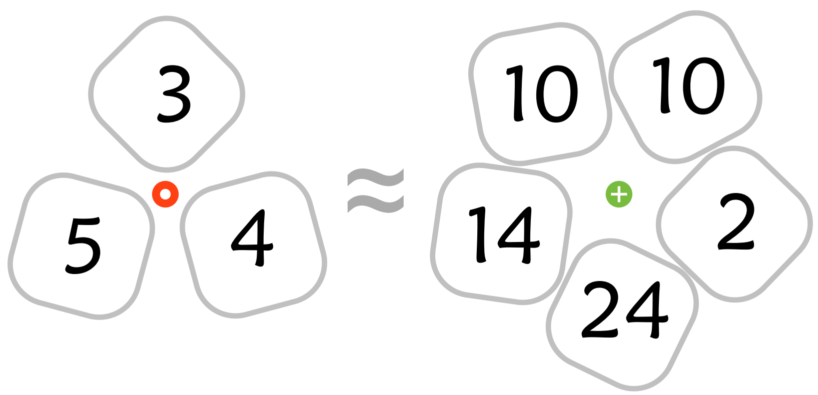
Drawing by Alexpl

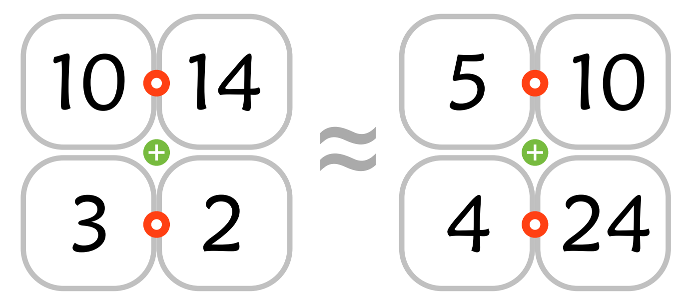




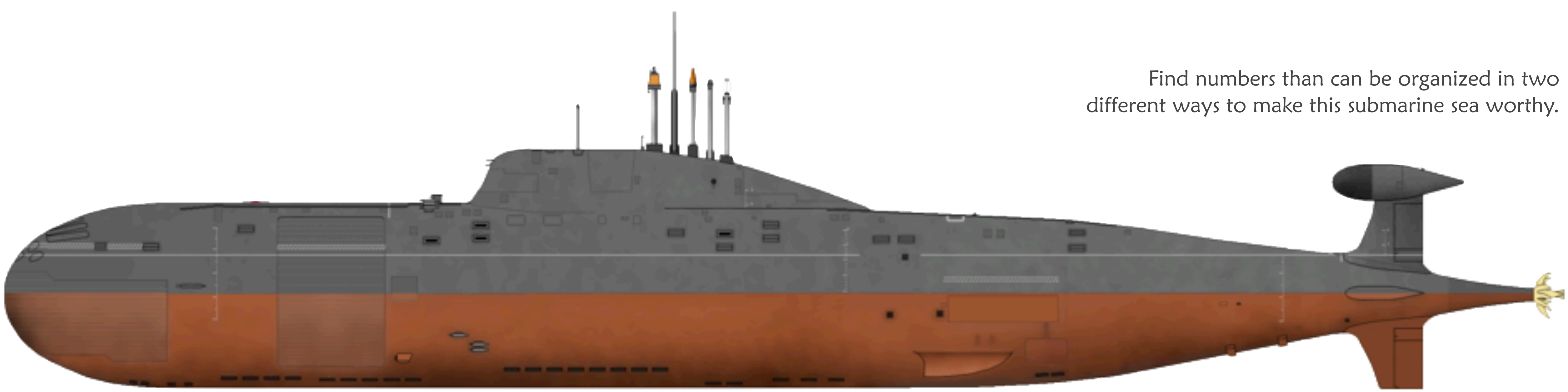
two possible answers

(there are infinitely many, but that doesn't mean they are easy to find.)





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



Russian Akula class submarines, 1990

Drawing by Alexpl

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-impoverished 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