Submarine Force Museum Lesson Plan

Developed by 2015 Submarine Force Library and Museum STEM –H Teacher Fellow
Caitlin Kennedy, Math Teacher, Fitch High School, Groton, CT

Lesson Name: Torpedo Dimension Investigation **Number of minutes in the Lesson** 60 – 90 min.

Intended Audience Middle/High School Geometry Student

Content Standards: Identify state **CCSS content and literacy standards** (when applicable) **and** national curricular standards this lesson is designed to help students attain. Also include **state and district standards** as well as the **Technology Standards** and **CCSS Math Standards** when applicable.

CCSS.MATH.CONTENT.HSG.GMD.A.1 Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone.

CCSS.MATH.CONTENT.8.G.C.9 Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real-world and mathematical problems

CCSS.MATH.CONTENT.HSG.MG.A.1 Use geometric shapes, their measures, and their properties to describe objects.

CCSS.MATH.CONTENT.8.G.B.7 Apply the Pythagorean theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions.

CCSS.MATH.CONTENT.HSN.Q.A.1
Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

CCSS.MATH.CONTENT.HSS.ID.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).

CCSS.ELA-LITERACY.L.9-10.6
Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

CCSS.ELA-Literacy.L.9-10.4 Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grades 9–10 reading and content, choosing flexibly from a range of strategies.

Pre-Visit Materials/Activities: Describe the students' prior knowledge or skill related to the learning objective(s) and the content of this lesson, using data from pre-assessment as appropriate. What background knowledge or skills do you want students' to come to the museum prepared with, and what materials will you provide to groups ahead of time so they are prepared for this lesson?
Students should have prior knowledge on the following concepts:

- Circles: radius, diameter and circumference
- Triangles: Pythagorean theorem for slant height
- Cylinders: volume and surface area
- Cones: volume and surface area
- Unit analysis
- Graphing from a set of data points

However, at the museum the students will utilize these separate mathematical skills and apply them to a real-world multistep problem.

Set up Before the Lesson Begins: Describe any preparation that is necessary before the lesson.
There isn't a lot of preparation required before the lesson other than gathering all materials listed below.

SOLUTIONS TO ALL PARTS OF THE ACTIVITY ARE ON PAGES 20-24 Measurements/Calcs & 25-34 for Graphs

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Content Objective(s): Identify specific and measurable learning objectives for this lesson. Remember only one for a 45 minute class, two for a 90-minute class.

Students will understand circles and Pythagorean theorem and be able to calculate the radius, diameter, circumference and slant height of various torpedoes in order to find the volume and surface area.

Students will understand volume and surface area of cylinders and cones and be able to use them to solve real-world and mathematical problems involving torpedoes.

Students will understand unit analysis and be able to make unit conversions for a torpedo's measurements in order to graph.

Students will understand graphing and be able to construct graphical representation of the data collected on torpedo in order to analyze, compare and contrast similarities and difference.

Language Objective(s): Distinguish between receptive skills (**listening and reading**) and productive skills (**speaking and writing**). Please **include how you would use them all where appropriate**: Listening, reading, speaking and writing.

Students will be required to listen and read the information presented in the PowerPoint presentation while writing the important information. Throughout the entire measurement activity, calculations and graphing students will be writing the required data. Lastly the compare and contrast activity will require student to think critically about math, draw conclusions and explain their reasoning through class discussion and presentation.

Differentiation: Think about:

Students with special needs How will you differentiate this lesson for special education students?
Regular education students: Think about how you would differentiate the lesson for all students on all levels:

Differentiation is simple for this particular lesson because there a four different types of torpedoes displayed at the Submarine Force Museum; Whitehead Mark 3, Mark 14, Mark 37 and Mark 48. Each torpedo has a different number of sections (i.e. the Whitehead Mark 3 has three separate section where the Mark 48 has six separate sections). Gifted or students with higher cognitive levels would be assigned the more complex torpedo with more mathematics required. These students will receive the least amount of guidance when problem solving. They will simply be given the problem and expected to come up with a solution. Lower level students would be assigned a more manageable torpedo. Throughout lesson, my focus will be on these groups. I will try to focus my attention on lower level students as they are struggling with the concepts most. I may give them guiding questions so that they do not become too frustrated during the assignments. Both higher level and lower level students are required to apply the same mathematical skills within the lesson. Challenging each student to apply his or her level of understanding to a real-world problem.

Sheltered Instruction Observation Protocol (SIOP) Strategies for ELL and regular Ed Students:

Identify the S.I.O.P features that support English Learners and all learners including thorough and accurate explanations on how they will assist English Learners. Identify Sheltered Instruction strategies throughout the lesson.

- Preparation
- Building Background
- Comprehensible Input
- Strategies
- Interaction
- Practice/Application
- Lesson Delivery
- Review/Assessment

Initiation: Briefly describe how you will initiate the lesson. (Set expectations for learning; articulate to learners what they will be doing and learning in this lesson, how they will demonstrate learning, and why this is important)

Students will tour the Submarine Force Museum and Nautilus, including the several torpedo displays. This will gain students interests as a hook. Once in the classroom, the instructor should have a brief outline displayed on the board of all activities.

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Lesson Development: (Add a Time for Each Segment of the Lesson)

Performance Tasks: Describe in outline how you will develop the lesson and what learning activities students will be engaged in order to gain the key knowledge and skills identified in the student learning objective(s).

Teaching and Learning Strategy: Strategies that you used during the lesson, including **modeling, guided practice and independent practice** where applicable.

PowerPoint (10-15 min): As a whole group guided by the instructor, the students will view a PowerPoint about the different torpedoes. During the demonstration the students will record important and required information about their assigned torpedo (brief description, year developed, years in service, speed, range and energy source). The PowerPoint info is provided on pages 11-18. Copies of the PowerPoint can be obtained from the Submarine Force Museum Education Specialist.

Measurement Activity (10-20 min): Within groups, students will venture into the museum to measure their assigned torpedo to collect data. (total length, length of each section, diameter and weight), using data sheets on pages 5 – 8.

Calculations (10-15 min): Once the data is collect, students will need to make all required calculations. (unit conversions, radius, circumference, slant height, volume and surface area), using the information provided on the data sheets pages 5 – 8.

Re-group compare/contrast (5-10 min): Students will regroup with students who collect data for the other three torpedoes. They will compare and contrast the similarities and differences between the torpedoes through discussion. (i.e. Which torpedo had the bigger war head and why? Which torpedo had the biggest space for fuel and why? What torpedo traveled the farthest/fastest and why? The torpedoes have the same diameter, why?)

Graphing Activity (20-30 min): Within the re-group, student will also create a graphical representation of the differences as a way to understand the collected data. Groups will also present their graph to the whole class describing different trends and patterns displayed numerically and graphically. Use the graph on page 9 and the data table on page 10 to gather your team's data for: year vs length, weight, volume, surface area, range and speed. Complete the graphs and compare with other teams.

Monitoring and Adjusting: How do you know the students have learned what you taught them and that they have achieved the objective?

Answer keys will be provided to the instructor for continual checking of students' progress towards the objective.
Please see attached documents below.

Assessment: How will you ask students to demonstrate mastery of the student learning objectives? Attach a copy of any assessment materials you will use, along with assessment criteria.

Student handouts and class discussion will be used to demonstrate mastery of the student-learning objectives.
Please see attached documents below.

Post-Visit Materials/Activities: Provide additional materials if they would reinforce a good learning experience after leaving the museum.

Student will complete the graphing activity. Please see attached documents below.
Optional: students to conduct research and collect data on a torpedo not modeled at the museum.

Technology: Please explain the technology used: why you will use it, how you will use it and how you will assess the results of using this technology.

- PowerPoint presentation including projecting capabilities
- Calculators
- Student computers optional (for individual research on torpedoes and graphs generated in excel)

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Key Vocabulary: Words students need to know in order to reach the objectives.

- Mathematical vocabulary: length, circle, diameter radius, circumference, triangle, Pythagorean theorem, slant height, cylinder, cone, volume, surface area, and unit analysis
- Torpedo vocabulary: speed, range, energy source, warhead, air flask, engine room, afterbody, tail, nose, fuel tank, extender, sonar, control, and propulsion.
-

Extension: What do you have in place in case during the lesson you finish early, run out of time or need to accommodate students who complete the class work before other students, or your technology fails?

Finish Early: Students can roam the museum
Run out of time: Complete calculations, compare/contrast and graph activity post museum visit
Want More Work: Complete torpedo energy activity, building on work completed, on page 19.
Technology Fails: Students can view PowerPoint post museum visit

Materials: List the materials you will use in each learning activity.

- PowerPoint presentation including projecting capabilities
- Copies of student handouts
- Measuring tape
- Calculators
- Student computers optional (for individual research on torpedoes and graphs generated in excel)

Resources: Include any resources you may use such as textbooks and any technological resources.

Dence, David. *The Mk 14 Submarine-launched Torpedo: Four Decades of Service*. Newport, RI: Naval Undersea Warfare Center Division, 1994. Print.

Jolie, E. W. *A Brief History of U.S. Navy Torpedo Development*. Newport, RI: U.S. Naval Underwater Systems Center, 1978. Print.

"Mark 37C Torpedo System Technical Description." *Mark 37C Torpedo System Technical Description*. Web. 17 July 2015. http://www.maritime.org/doc/torpedomk37/index.htm

McCandless, Bruce, Admiral. "The Howell Automobile Torpedo." *U.S. Naval Institute Proceedings* Oct. 1966: 174-76. Print.

PBS. PBS. Web. 17 July 2015. http://www.pbs.org/wgbh/nova/subsecrets/nauttorhi.html

"Submarine Force Museum Home of Historic Ship Nautilus." *Historic Ship NAUTILUS Virtual Tour*. Web. 17 July 2015. http://www.ussnautilus.org/virtualTour/torpedo.shtml

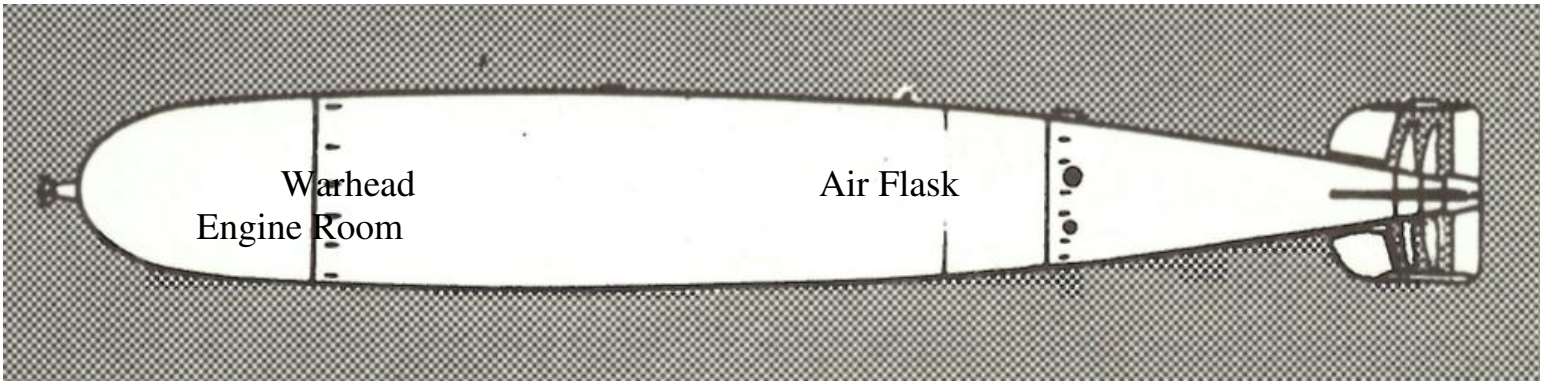
Submarine Force Library and Archives. Archives/Vertical Files/Torpedoes. Library. Groton, CT

The Whitehead Torpedo: U.S.N. 45c/m. X 3.55m. Mark I, Mark II, Mark III, and 45c/m. X 5m. Mark I. General Description. Newport, RI: Naval Torpedo Station, 1898. Print.

Wikipedia. Wikimedia Foundation. Web. 17 July 2015.
https://en.wikipedia.org/wiki/Howell_torpedo
https://en.wikipedia.org/wiki/Whitehead_torpedo
https://en.wikipedia.org/wiki/Mark_14_torpedo
https://en.wikipedia.org/wiki/Mark_37_torpedo
https://en.wikipedia.org/wiki/Mark_48_torpedo
https://en.wikipedia.org/wiki/Axial_engine
https://en.wikipedia.org/wiki/File:Howell_torpedo_fly_wheel.jpg

Submarine Force Museum Lesson Plan

Whitehead MK3



Section	Length (units)	Volume (units^3)	Surface Area (units^2)
Warhead		Volume Cylinder: $v = \pi r^2 h$	Surface Area: $T = 2\pi rh + 2\pi r^2$
Air Flask			
Engine Room Pythagorean Theorem (slant height): $r^2 + h^2 = s^2$		Volume Cone: $v = \frac{1}{3}\pi r^2 h$	Surface Area: $T = \pi rs + \pi r^2$
Total			

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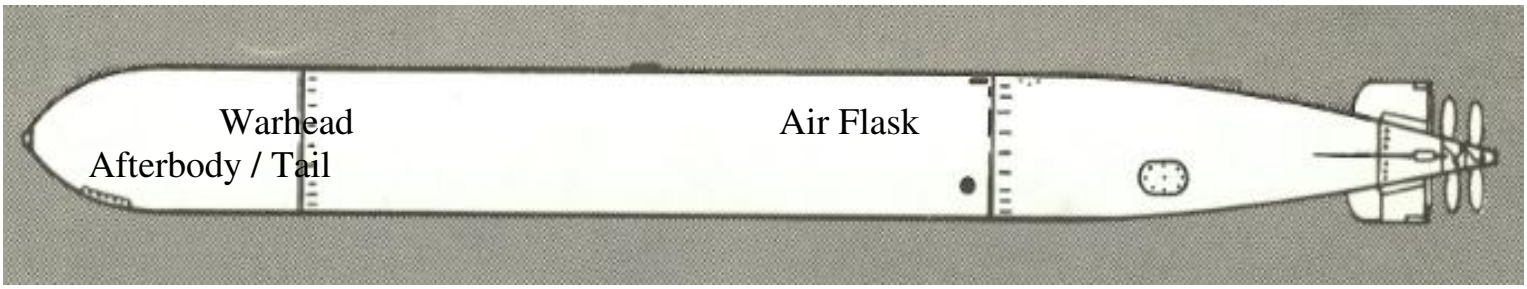
MK 14



Section	Length (units)	Volume (units^3)	Surface Area (units^2)
Warhead Volume Cylinder: $v = \pi r^2 h$ Surface Area: $T = 2\pi rh + 2\pi r^2$		Volume Cylinder: $v = \pi r^2 h$	Surface Area: $T = 2\pi rh + 2\pi r^2$
Air Flask			
Afterbody / Tail Pythagorean Theorem (slant height): $r^2 + h^2 = s^2$		Volume Cone: $v = \frac{1}{3}\pi r^2 h$	Surface Area: $T = \pi rs + \pi r^2$
Total			

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MK 37

Section	Length (units)	Volume (units^3)	Surface Area (units^2)
Nose		Volume Cylinder: $v = \pi r^2 h$	Surface Area: $T = 2\pi rh + 2\pi r^2$
Fuel Tank			
Afterbody			
Extender			
Tail Pythagorean Theorem (slant height): $r^2 + h^2 = s^2$		Volume Cone: $v = \frac{1}{3}\pi r^2 h$	Surface Area: $T = \pi rs + \pi r^2$
Total			

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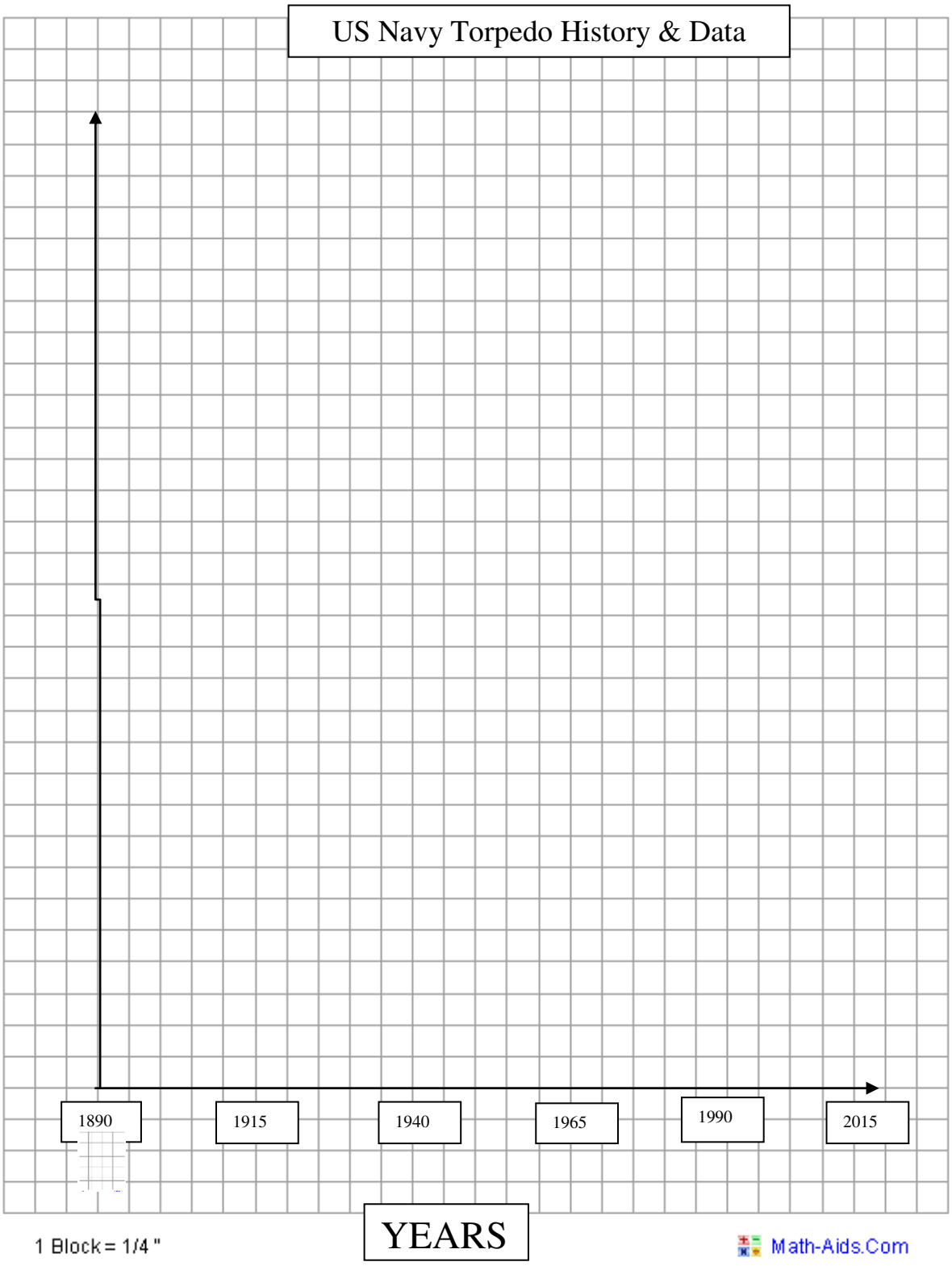
MK 48 / ADCAP

Section	Length (units)	Volume (units^3)	Surface Area (units^2)
ADCAP Sonar Guidance Control		Volume Cylinder: $v = \pi r^2 h$	Surface Area: $T = 2\pi rh + 2\pi r^2$
Warhead or Exercise System			
Control Section			
Fuel Tank			
Propulsion			
Tail Pythagorean Theorem (slant height): $r^2 + h^2 = s^2$		Volume Cone: $v = \frac{1}{3}\pi r^2 h$	Surface Area: $T = \pi rs + \pi r^2$
Total			


US Navy Torpedo History & Data
1890
1915
1940
1965
1990
2015
YEARS
1 Block = 1/4 "
Math-Aids.Com

Submarine Force Museum Lesson Plan

Torpedo Dimension Investigation Graphing

Complete the table and graph comparing the different torpedoes
Year vs. _____ Circle one: Length, weight, volume, speed, or range

Type	Howell	Mark 3 (WH)	Mark 14	Mark 37	Mark 48	ADCAP
Years						

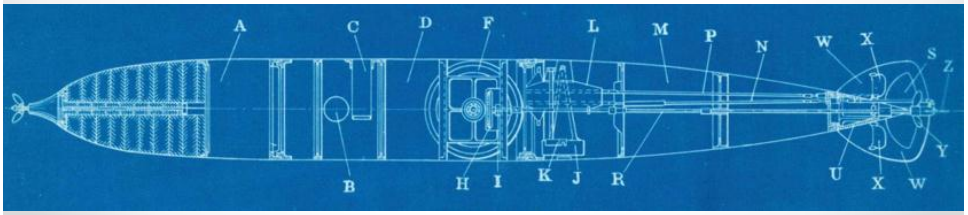
TORPEDOS

Howell - Whitehead - MK 3 - MK 14 - MK 37 - MK 48/ADCAP

The decommissioned Australian navy warship Torrens is blown up by a Mark 48 homing torpedo fired by one of the navy's new Collins class submarines HMAS Farncomb, off the coast of Western Australia 15 June 1999.

Howell Torpedo

The Howell MarK 1 was the first self-propelled torpedo produced in quantity by the United States Navy. It was conceived by Lieutenant Commander John A. Howell, United States Navy in 1870 and served from 1890 – 1899. With a length of 132 inches, diameter of 14.2 inches, and weighting 580 pound and containing 20,000 cubic inches it could travel 400 yards at 25 knots.



Howell Torpedo

The Howell Torpedo used a 60 kg (130 lb) flywheel spun at very high speed (10000 to 12000 rpm) to store energy and drive propellers. The energy to spin the flywheel came from a small external steam driven turbine to spin-up the flywheel.

Flywheel: Naval Undersea Museum, Keyport, WA

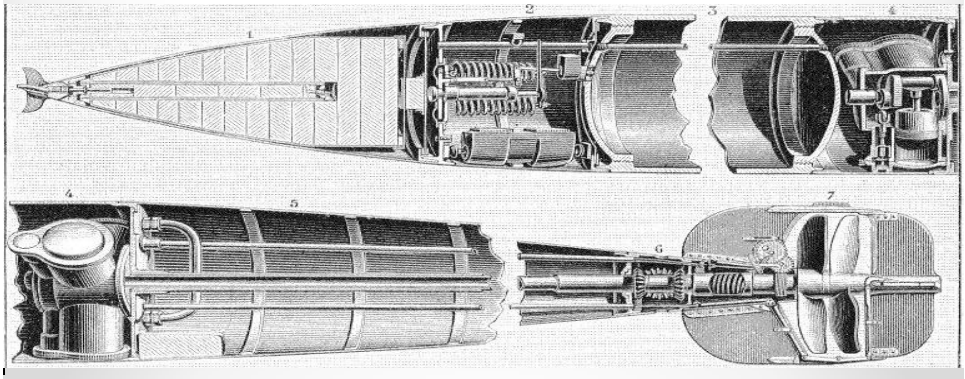
Whitehead MK 3

Robert Whitehead was an Englishman who developed a practical torpedo in 1869. Used through the first World War (1916-1918), the Whitehead was one of the earliest to use gyroscope to control the aim of the 845 pound torpedo. Serviced from 1894 to 1922.

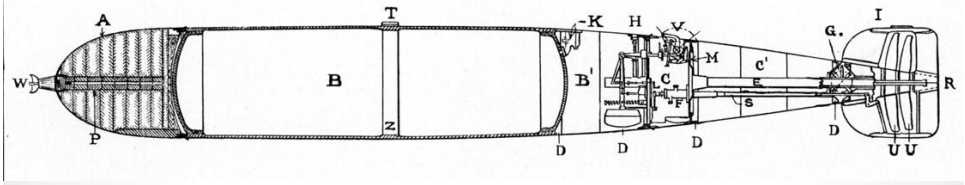
Robert Whitehead with a battered test torpedo
Rijeka (Croatia), c.1875

Whitehead MK 3

The war head contained 200 pounds of explosive which detonated upon impact with the target. The center portion of the torpedo help compressed air at 1300 per square inch (90 atmosphere). This air operated three piston engine which turned the counter–rotating propellers. The torpedo can obtain speeds up to 26.5 knots with a range of 800 yds.



Whitehead MK 3



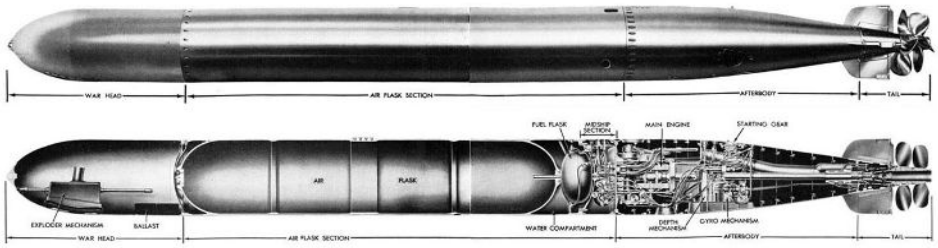
A: Warhead **B: Air Flask** **C: Engine Room**

B': immersion chamber
C': after body
D: drain holes
E: shaft tube
F: steering engine
G: bevel gear box
H: depth index
I: tail
K: charging and stop valves
L: locking gear

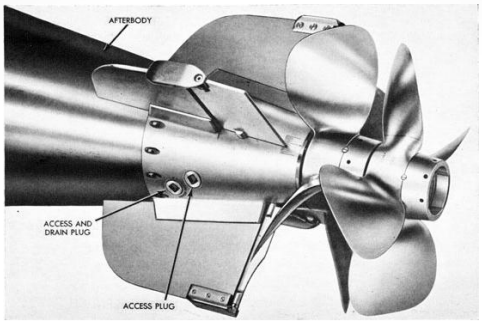
M: engine bed plate
P: primer case
R: rudder
S: steering rod tube
T: guide stud
U: propellers
V: valve group
W: war nose
Z: strengthening band

MK 14

The Mark 14 torpedo, developed in the 1930s, is a steam-driven torpedo weighing 3209 pounds. It is 20.5 feet long and 21 inches in diameter. It had a maximum range of 4.5 miles (9,000 yards) but was usually used for much shorted engagements (4,500 yards). Its maximum speed was 46 knots and a minimum speed was 31 knots. U.S. submarines used this torpedo throughout World War Two and into the 1970s. Serviced from 1931 – 1980.

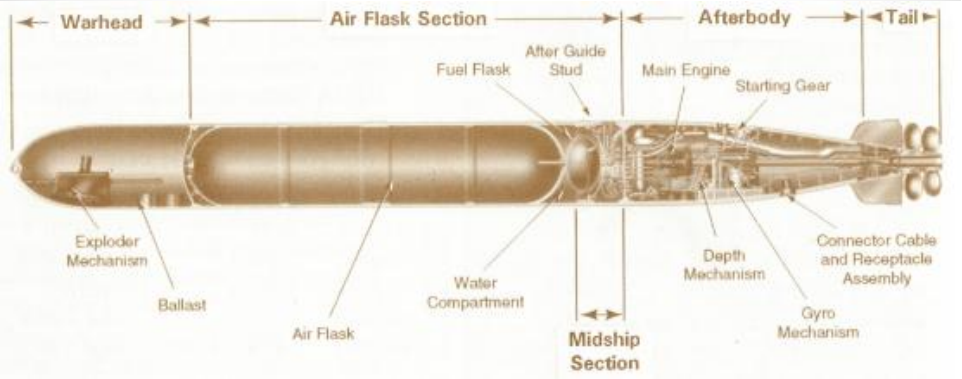


MK 14



The energy source was methanol, which combined with compressed air to burn in a Wet-heater combustion / steam turbine which rotated the propellers. The wet-heater used water to cool the combustion chamber of the methanol-air burning in the torpedo. This not only solved heating problems so more fuel could be burnt but also allowed additional power to be generated by feeding the resulting steam into the steam turbine together with the combustion products.

MK 14



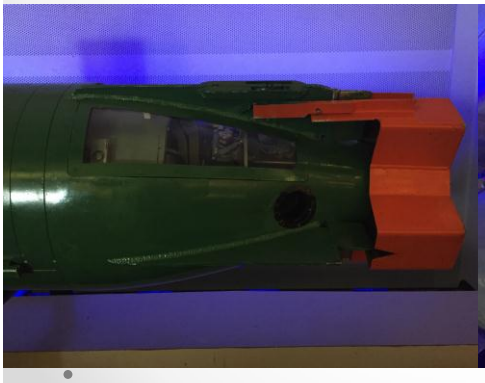
MK 37

Developed in 1946 and served from 1956 to 1972, the Mark 37 torpedo was an anti-submarine torpedo launched from U.S. submarines. It was a free running torpedo which employed active or passive homing. It is 11.5 feet long and weighs 1,690 pounds. The U.S. Submarine Force no longer uses this class of torpedo.

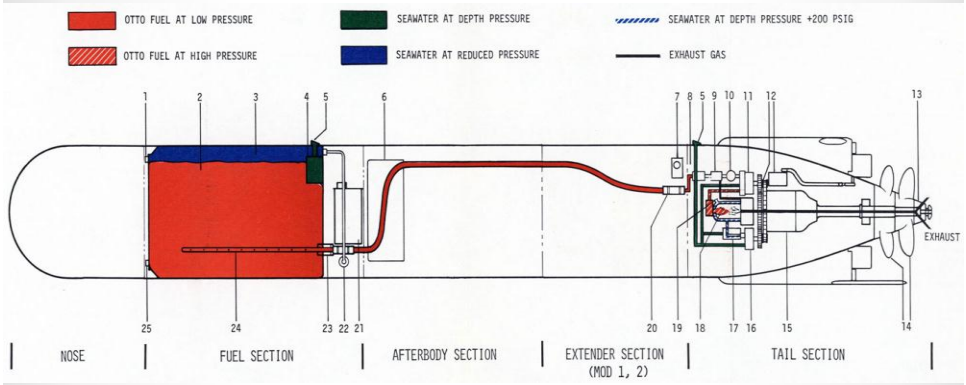
Mark 37 torpedo at the German Marine Museum Wilhelmshaven

MK 37

The energy source was stored chemical energy of a silver-zinc battery, used to make electrical power to operate a two speed electric DC motor, which turned the propellers. Giving it a maximum range of 23,000 yards at 17 knots and a minimum range of 10,000 yards at 26 knots.



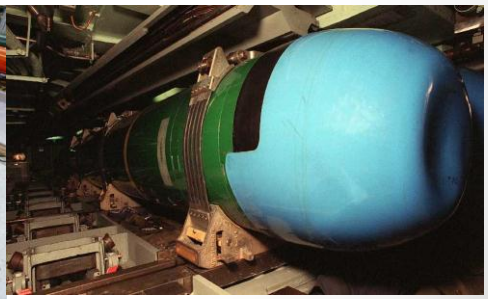
MK 37



Source: http://www.maritime.org/doc/torpedomk37/index.htm

MK 48 / ADCAP

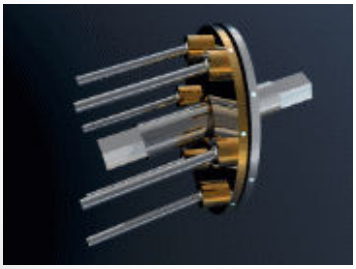
The Mark 48 torpedo is the Navy's primary submarine torpedo developed in 1965 and served from1971 to 1988. Submarines employ it against other submarines and surface ships. It is a long range, deep-diving weapon which uses wire guidance and acoustic homing. The Mark 48 is 19 feet long, 21 inches in diameter and weighs 3,480 pounds.



- Keyport Technicians working on a Mark 48 in early 1982
- Mark 48 ADCAP torpedo aboard USS Asheville (SSN-758)

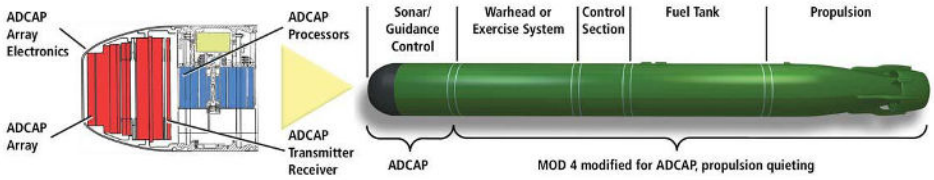
MK 48 / ADCAP

Both the Mark 48 and ADCAP use a swash-plate piston engine fueled by Otto fuel II, a monopropellant that decomposes into hot gas when ignited, which drives the piston engine to rotate the shaft. The thrust is generated in the rotating propulsor assembly at the tail of the torpedo. Giving them a maximum range of 80,000 yards at 55 knots and a minimum range of 46,000 yards at 55 knots.



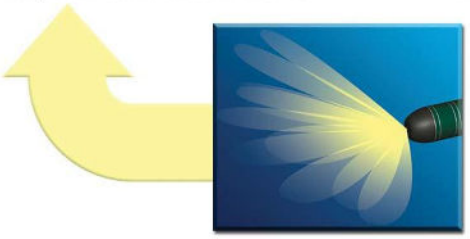
MK 48 / ADCAP

The ADCAP (Advance Capabilities) is the improved Mark 48 used today, starting in 1989. The 3,700 pound torpedo was designed to sink deep-diving nuclear-powered submariners and high-performance surface ships using sonar guidance and control.



Modern, Proven Sonar/Guidance and Control

MK 48 ADCAP Mod 6 AT Configuration



- Digital beam forming (transmit and receive)
- Mutiple steerable beams
- Multiple waveforms
- Very low self-noise (enhanced passive detection)

Resources

Dence, David. *The Mk 14 Submarine-launched Torpedo: Four Decades of Service*. Newport, RI: Naval Undersea Warfare Center Division, 1994. Print.

Jolie, E. W. *A Brief History of U.S. Navy Torpedo Development*. Newport, RI: U.S. Naval Underwater Systems Center, 1978. Print.

"Mark 37C Torpedo System Technical Description." *Mark 37C Torpedo System Technical Description*. Web. 17 July 2015.
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McCandless, Bruce, Admiral. "The Howell Automobile Torpedo." *U.S. Naval Institute Proceedings* Oct. 1966: 174-76. Print.

PBS. PBS. Web. 17 July 2015.
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"Submarine Force Museum Home of Historic Ship Nautilus." *Historic Ship NAUTILUS Virtual Tour*. Web. 17 July 2015.
http://www.ussnautilus.org/virtualTour/torpedo.shtml

Submarine Force Library and Archives. Archives/Vertical Files/Torpedoes. Library. Groton, CT

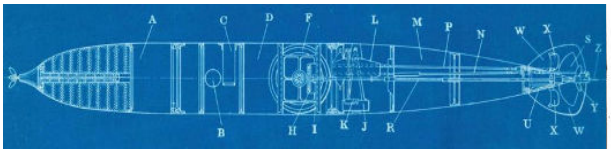
The Whitehead Torpedo: U.S.N. 45c/m. X 3.55m. Mark I, Mark II, Mark III, and 45c/m. X 5m. Mark I. General Description. Newport, RI: Naval Torpedo Station, 1898. Print.

Wikipedia. Wikimedia Foundation. Web. 17 July 2015.
https://en.wikipedia.org/wiki/Howell_torpedo
https://en.wikipedia.org/wiki/Whitehead_torpedo
https://en.wikipedia.org/wiki/Mark_14_torpedo
https://en.wikipedia.org/wiki/Mark_37_torpedo
https://en.wikipedia.org/wiki/Mark_48_torpedo
https://en.wikipedia.org/wiki/Axial_engine
https://en.wikipedia.org/wiki/File:Howell_torpedo_fly_wheel.jpg

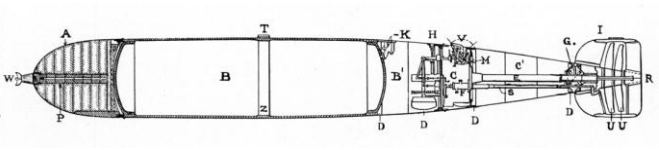
Activity: Energy Sources for Torpedo Propulsion

Using the information from the presentation used in the "Torpedo Dimension Investigation" classify the U.S Navy Torpedoes pictured below, by the type of energy used to turn the propellers to develop thrust. Write the torpedo names next to correct type of energy source.

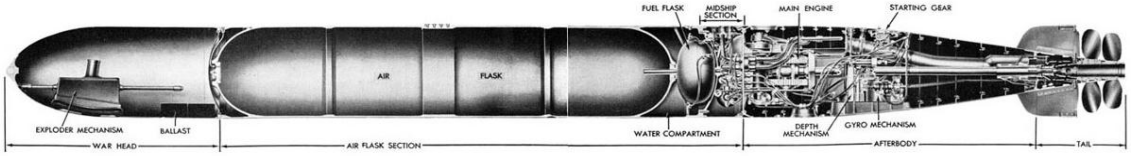
Howell:



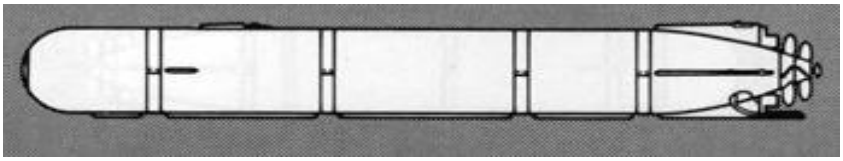
Whitehead:



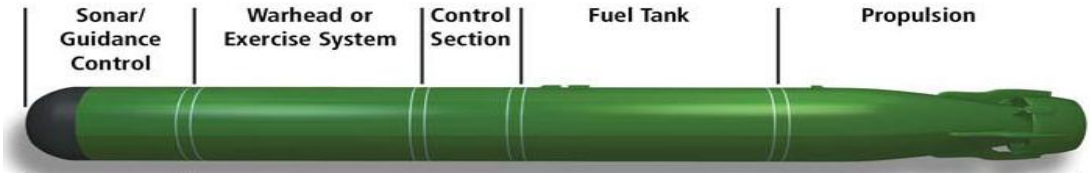
Mark 14:



Mark 37:



Mark 48/ADCAP:



General Types of Energy:

Mechanical Energy:

Electrical Energy:

Chemical Energy & Heat:

Compare the Speed and Range of the Torpedoes, relative to the type of energy used.

Which torpedo(s) source is like that of a: balloon, gyroscope, ChevyVolt, turbo-prop plane?

Submarine Force Museum Lesson Plan

Torpedo Dimension Investigation (ANSWERS)

Torpedo: Howell Torpedo

Year Developed: 1870 Years in service: 1890 - 1899

Brief Description of Torpedo:

_____
_____
_____
_____
_____

Complete the following chart: Round to the nearest hundredths

	Feet	Inches
Length	11 ft	132 in
Diameter	1.18 ft	14.20 in
Radius: $r = \frac{d}{2}$	0.59 ft	7.10 in
Circumference: $c = 2\pi r$	3.71 ft	44.61 in

Weight (pounds)	580 pounds (Volume 20,000 cubic inches)
Speed (knots)	25 Knots
Range (yards)	400 Yards
Energy source	Small external steam driven turbine spun a flywheel to store energy

Submarine Force Museum Lesson Plan

Torpedo Dimension Investigation (ANSWERS)

Torpedo: Whitehead MK3

Year Developed: 1869 Years in service: 1894 - 1922

Brief Description of Torpedo:

_____
_____
_____
_____
_____

Complete the following chart: Round to the nearest hundredths

	Feet	Inches
Length	11.67 ft	140 in
Diameter	1.48 ft	17.70 in
Radius: $r = \frac{d}{2}$	0.74 ft	8.85 in
Circumference: $c = 2\pi r$	4.65 ft	55.61 in

Weight (pounds)	845 lb
Speed (knots)	26.50 knots
Range (yards)	800 yards
Energy source	3-cylinder reciprocating: compressed air to operate 3 piston engines

Submarine Force Museum Lesson Plan

Torpedo Dimension Investigation (ANSWERS)

Torpedo: MK 14

Year Developed: 1930's Years in service: 1931-1980

Brief Description of Torpedo:

_____
_____
_____
_____
_____

Complete the following chart: Round to the nearest hundredths

	Feet	Inches
Length	20.50 ft	246 in
Diameter	1.75 ft	21 in
Radius: $r = \frac{d}{2}$	0.88 ft	10.5 in
Circumference: $c = 2\pi r$	5.53 ft	65.97 in

Weight (pounds)	3209 lb
Speed (knots)	31 knots or 46 knots
Range (yards)	9000 yards or 4500 yards
Energy source	Turbine: Methanol combined with compressed air burned in a wet heater – steam turbine

Submarine Force Museum Lesson Plan

Torpedo Dimension Investigation (ANSWERS)

Torpedo: MK 37

Year Developed: 1946 Years in service: 1956 - 1972

Brief Description of Torpedo:

_____
_____
_____
_____
_____

Complete the following chart: Round to the nearest hundredths

	Feet	Inches
Length	13.42 ft	161 in
Diameter	1.75 ft	21 in
Radius: $r = \frac{d}{2}$	0.88 ft	10.5 in
Circumference: $c = 2\pi r$	5.53 ft	65.97 in

Weight (pounds)	1690 lb
Speed (knots)	17 knots or 26 knots
Range (yards)	23000 yards or 10000 yards
Energy source	Electric motor: Silver-Zinc battery used to make electrical power

Submarine Force Museum Lesson Plan

Torpedo Dimension Investigation (ANSWERS)

Torpedo: MK 48 / ADCAP

Year Developed: MK 48 : 1965
ADCAP : 1970

Years in service: MK 48 : 1971 - 1988
ADCAP : 1989 - present

Brief Description of Torpedo:

_____
_____
_____
_____
_____

Complete the following chart: Round to the nearest hundredths

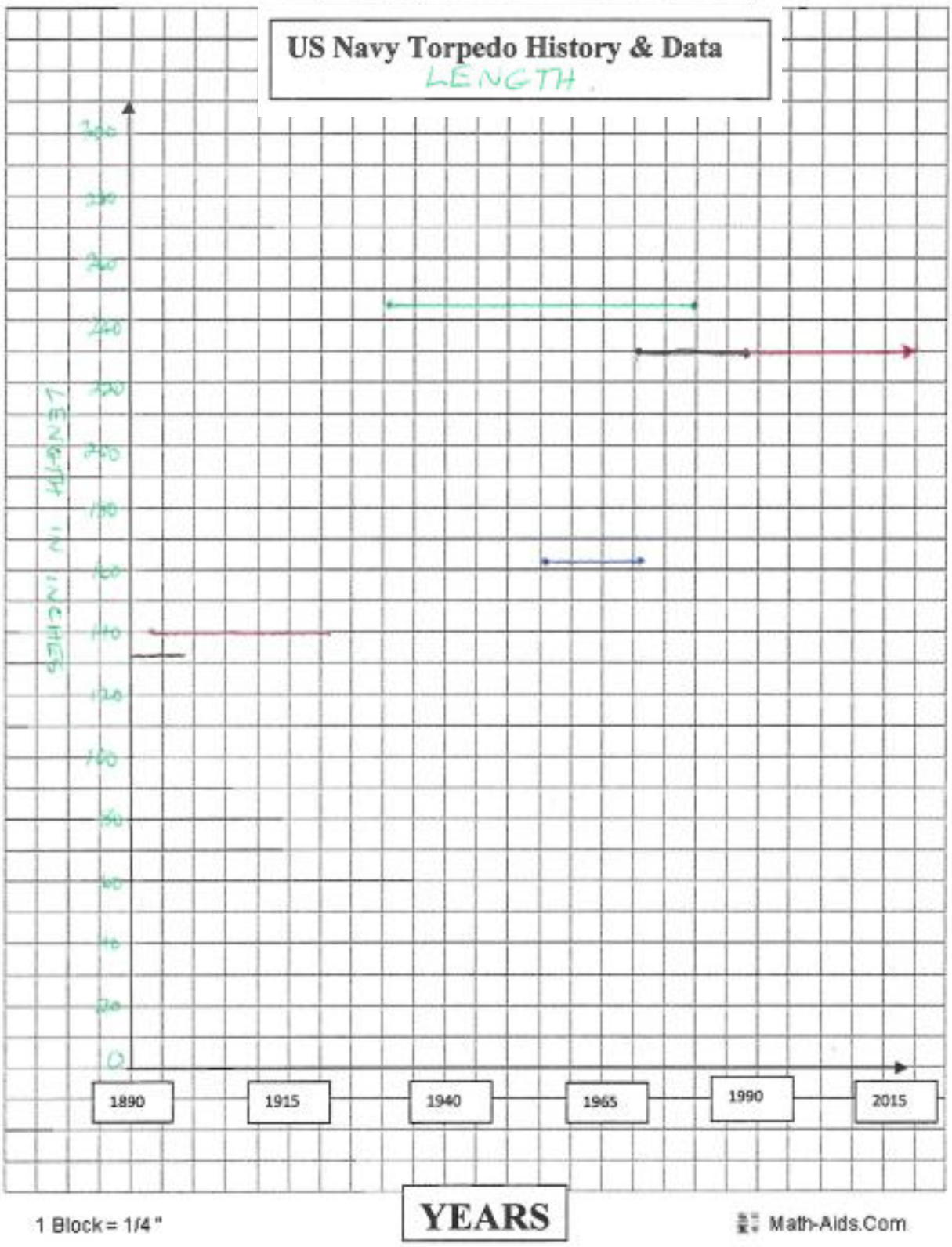
	Feet	Inches
Length	19.17 ft	230 in
Diameter	1.75 ft	21 in
Radius: $r = \frac{d}{2}$	0.88 ft	10.5 in
Circumference: $c = 2\pi r$	5.53 ft	65.97 in

Weight (pounds)	MK 48 : 3480 lb ADCAP : 3700 lb
Speed (knots)	55 knots or 40 knots
Range (yards)	46000 yards or 80000 yards
Energy source	Positive displacement piston-type acoustic: Swash-plate piston engines fueled by Otto Fuel II

Torpedo Dimension Investigation Graphing (ANSWERS)

Complete the table and graph comparing the different torpedo
Year vs. _____ Circle one: Length, weight, volume, speed, or range

Type	Howell	Mark 3 (WH)	Mark 14	Mark 37	Mark 48	ADCAP
Years	1890 – 1899	1894 – 1922	1931 – 1980	1956 – 1972	1971 – 1988	1989 – 2015
Length(inches)	132	140	246	161	230	230

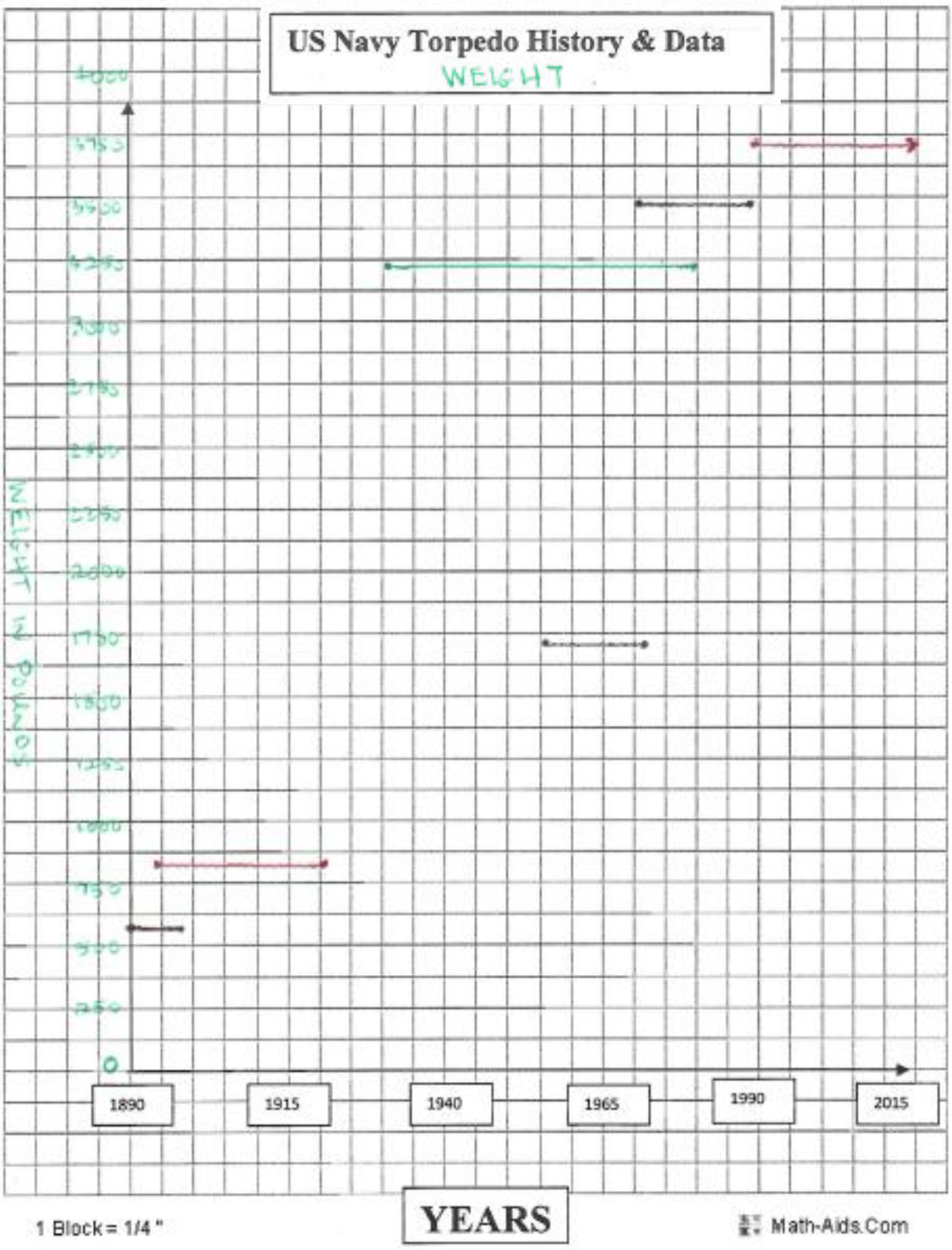

US Navy Torpedo History & Data
LENGTH
LENGTH IN INCHES
1890
1915
1940
1965
1990
2015
YEARS
1 Block = 1/4 "
Math-Aids.Com

Submarine Force Museum Lesson Plan

Torpedo Dimension Investigation Graphing (ANSWERS)

Complete the table and graph comparing the different torpedo
Year vs. _____ Circle one: Length, weight, volume, speed, or range

Type	Howell	Mark 3 (WH)	Mark 14	Mark 37	Mark 48	ADCAP
Years	1890 – 1899	1894 – 1922	1931 – 1980	1956 – 1972	1971 – 1988	1989 – 2015
Weight(pounds)	580	845	3209	1690	3480	3700

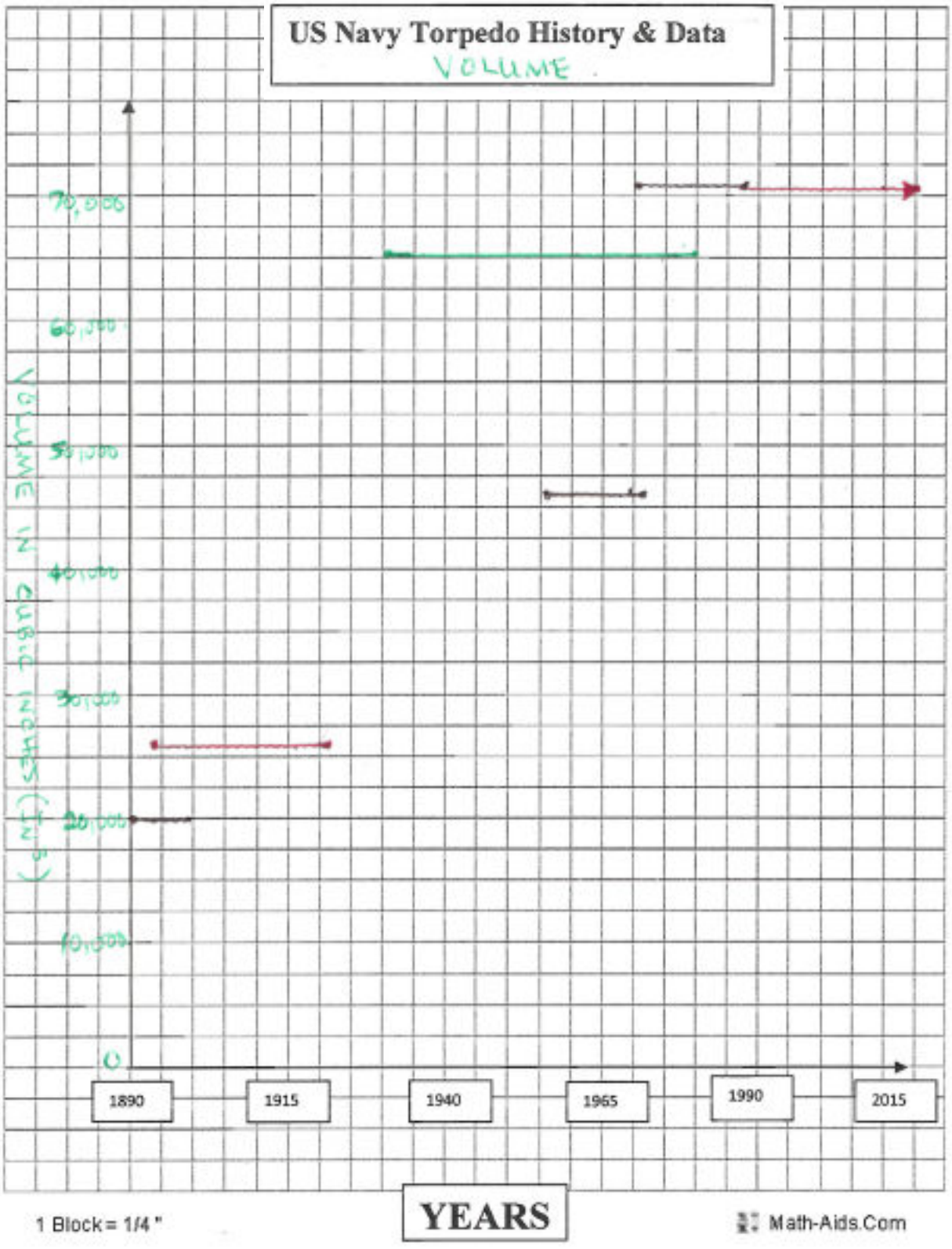

US Navy Torpedo History & Data
WEIGHT
WEIGHT IN POUNDS
0
1890
1915
1940
1965
1990
2015
YEARS
1 Block = 1/4 "
Math-Aids.Com

Submarine Force Museum Lesson Plan

Torpedo Dimension Investigation Graphing (ANSWERS)

Complete the table and graph comparing the different torpedo
Year vs. _____ Circle one: Length, weight, volume, speed, or range

Type	Howell	Mark 3 (WH)	Mark 14	Mark 37	Mark 48	ADCAP
Years	1890 – 1899	1894 – 1922	1931 – 1980	1956 – 1972	1971 – 1988	1989 – 2015
Volume (in^3)	20,000	26,902	65,808	47,451	70,658	70,658

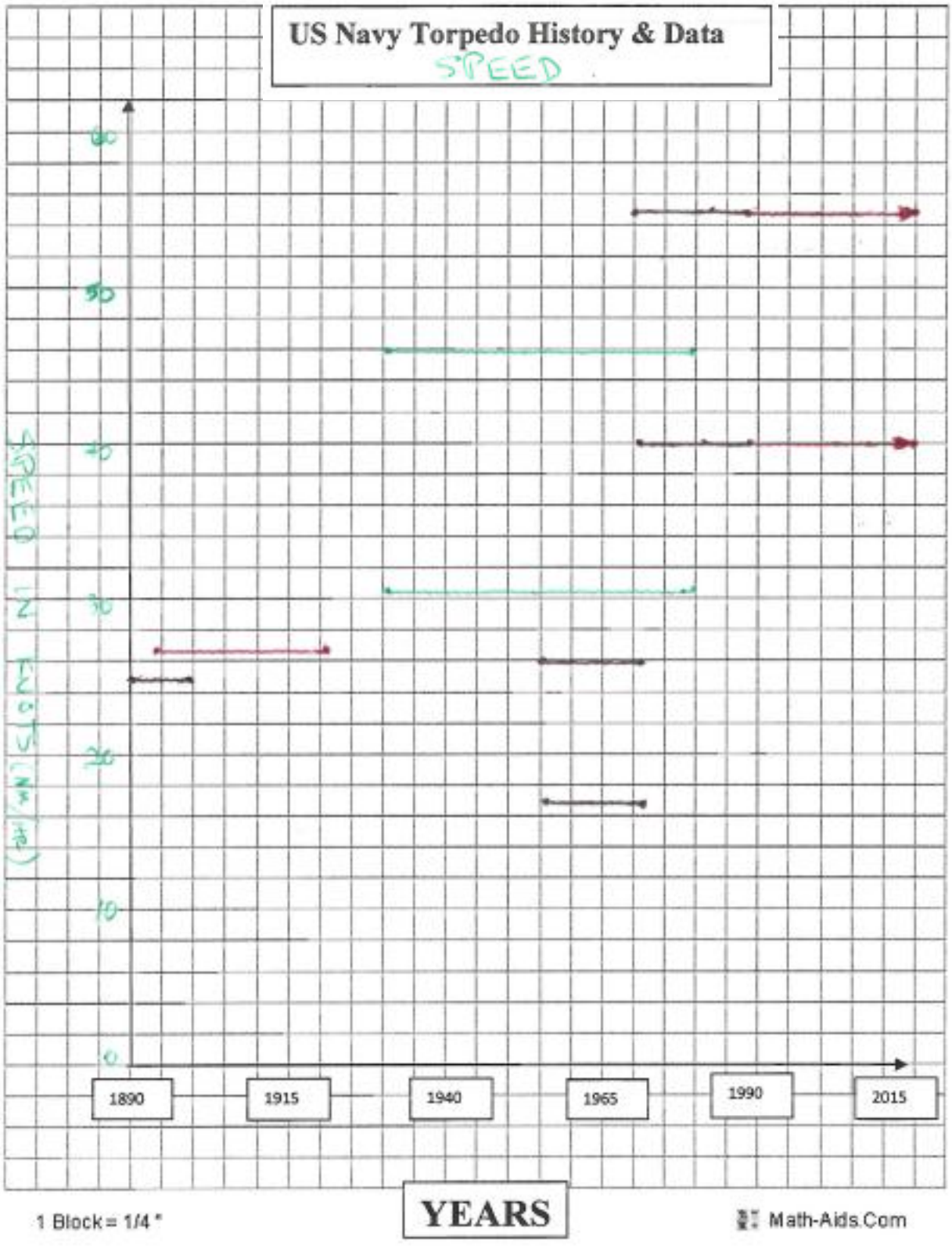

US Navy Torpedo History & Data
VOLUME
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
VOLUME IN CUBIC INCHES (IN³)
1890
1915
1940
1965
1990
2015
YEARS
1 Block = 1/4 "
Math-Aids.Com

Submarine Force Museum Lesson Plan

Torpedo Dimension Investigation Graphing (ANSWERS)

Complete the table and graph comparing the different torpedo
Year vs. _____ Circle one: Length, weight, volume, speed, or range

Type	Howell	Mark 3 (WH)	Mark 14	Mark 37	Mark 48	ADCAP
Years	1890 – 1899	1894 – 1922	1931 – 1980	1956 – 1972	1971 – 1988	1989 – 2015
Speed (knots)	25	26.5	31 / 46	17 / 26	40 / 55	40 / 55

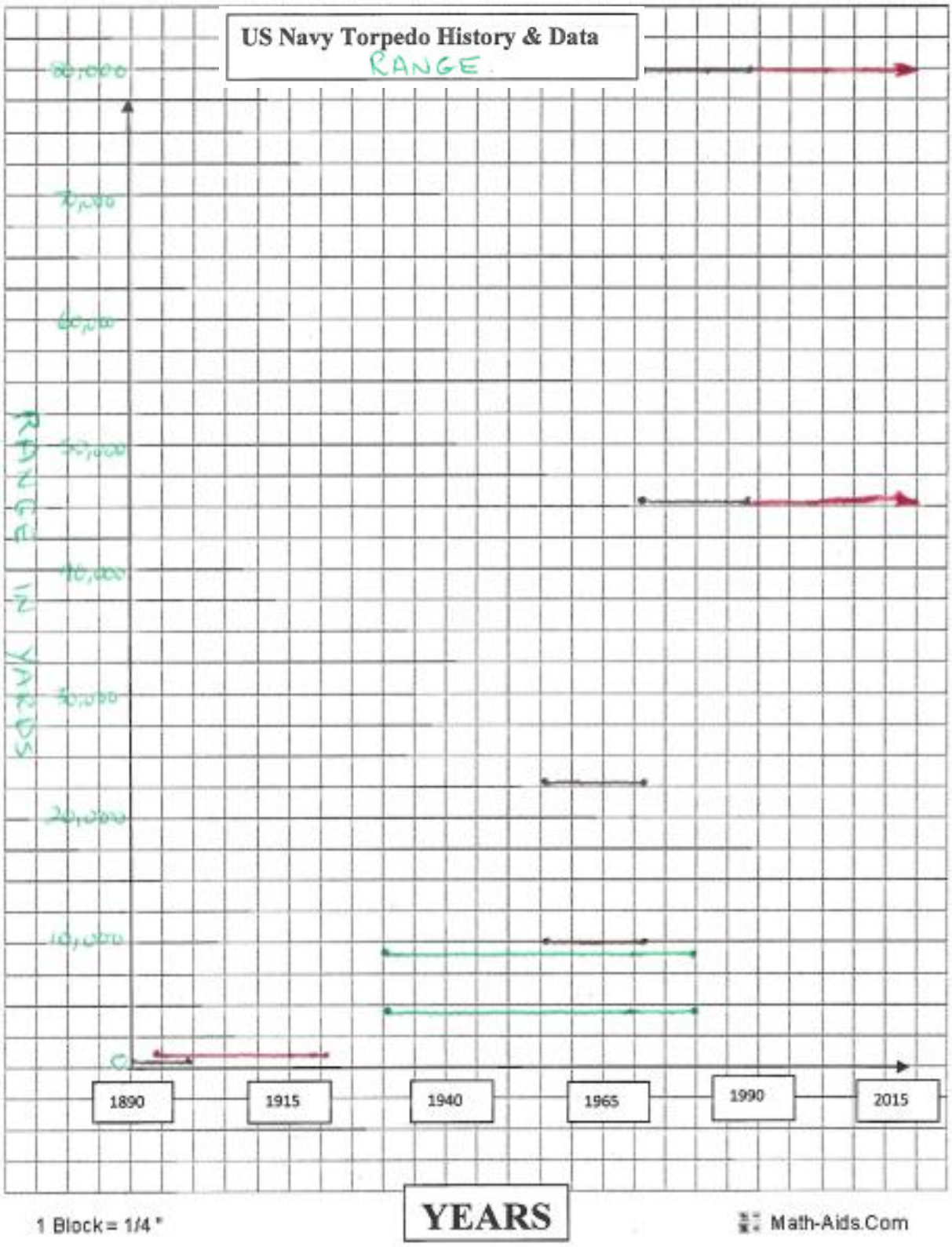

US Navy Torpedo History & Data
SPEED
SPEED IN KNOTS (MPH)
60
50
40
30
20
10
0
1890
1915
1940
1965
1990
2015
YEARS
1 Block = 1/4 "
Math-Aids.Com

Submarine Force Museum Lesson Plan

Torpedo Dimension Investigation Graphing (ANSWERS)

Complete a the table and graph comparing the different torpedo
Year vs. _____ Circle one: Length, weight, volume, speed, or range

Type	Howell	Mark3(WH)	Mark 14	Mark 37	Mark 48	ADCAP
Years	1890 – 1899	1894 – 1922	1931 – 1980	1956 – 1972	1971 – 1988	1989 – 2015
Range(yd)	400	800	9,000 / 4,500	23,000 / 10,000	80,000 / 46,000	80,000 / 46,000


US Navy Torpedo History & Data
RANGE
RANGE IN YARDS
1890
1915
1940
1965
1990
2015
YEARS
1 Block = 1/4 "
Math-Aids.Com