Deck Gen - Dry Cargo Gear - Married Falls Calc

USCG Deck General Question 594
Two falls are supporting a 1.5 ton load. The port fall is at an angle of 40° from the vertical. The starboard fall is at an angle of 70° from the vertical. What is the stress on each fall?

In this solution vectors are used to represent the direction and magnitude of force. The length of the vector represents the weight and the direction of the vector represents the direction of the applied force. To find the stress on each fall, ●3 draw the lift as described. Label all angles to help visualize the problem. Next, ●4 use either the law of sines or the parallelogram method to compute the stress on each fall.

Note: Bowditch II, 1981 Ed., Chapter 1, Page 401 is a great review of Mathematics including key formulas for calculating Area, Volume, Angles, Basic Trigonometric Functions, Basic Geometry, and more. A digital copy is located in the Resource folder on this drive.

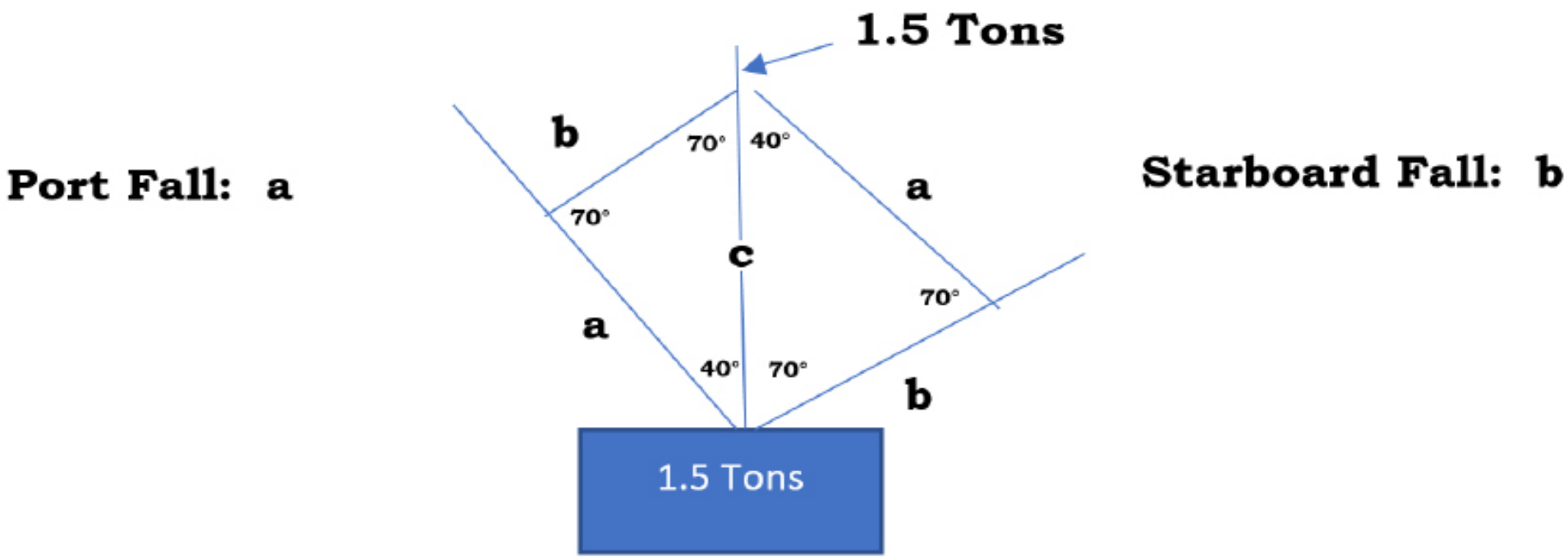
For additional dry cargo formulas and overview see the Dry Cargo Formula General explanation from the drop down menu in the upper left corner of this explanation window.

●1 Read the entire question. Clarify what is being requested.

●2 Write down all of the given items.

Married Falls: Angle of Port Fall is 40° from vertical
Angle of Starboard Fall is 70° from vertical
Weight: 1.5 Tons

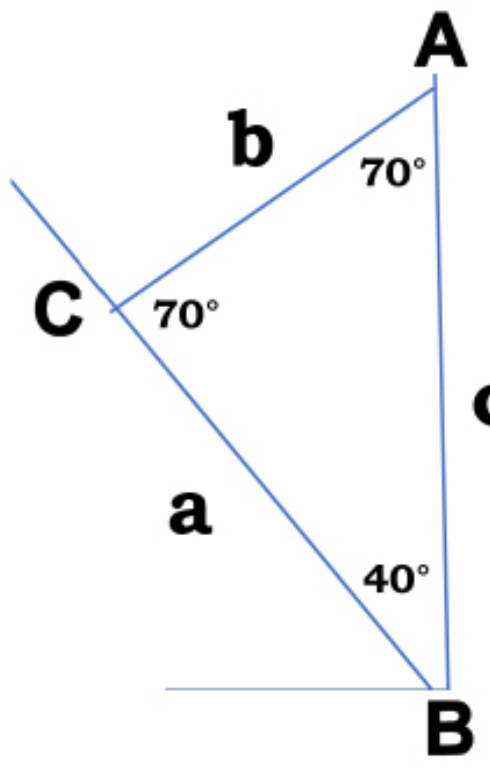
●3 Drawing the lift as described can help the student visualize how to solve the problem. Complete all respective angles. Any angle not given in the USCG question can be found as all angles in a triangle add up to 180°. The lower case letters are the length of the line segments and the upper case letters are the angles opposite of the corresponding line segments. For example angle *A* is opposite line segment *a*.



Parallelogram Constructed to Visualize Angles of *a* and *b* Falls - Not to Scale.

●4 Solve for stress on each fall. Two methods are shown in this explanation to solve step four. You may use either. There may be a slight difference in answers between the methods due to rounding or measuring scales. The first method will use the trigonometric function Sine and the second method will use direct measurement using graph paper or a maneuvering board and a protractor triangle.

First Method Step 4: Using the trigonometric function Sine and the law of Sine to solve stress on each fall.



Triangle Constructed to Visualize Law of Sines Method.

The first line of the problem shown in the math board below is the law of sine. Angles *A*, *B*, and *C* are the angles opposite the line segment with the corresponding lowercase letter. See diagram above. Solve for each line segment *a* and *b*.

Law of Sin = $\frac{a}{\text{Sin A}} = \frac{b}{\text{Sin B}} = \frac{c}{\text{Sin C}}$

$\frac{a}{\text{Sin } 70°} = \frac{b}{\text{Sin } 40°} = \frac{1.5 \text{ Tons}}{\text{Sin } 70°}$

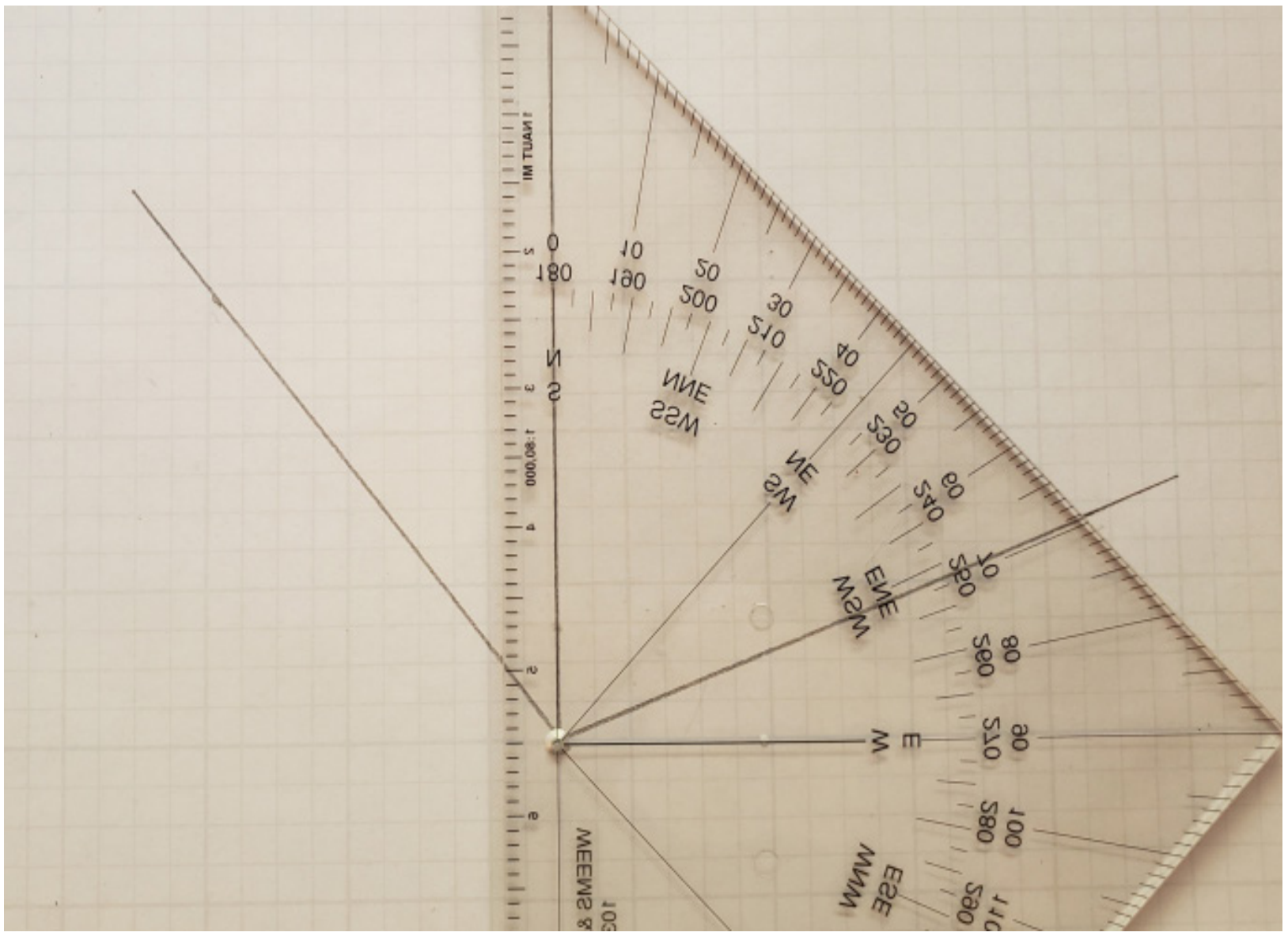
Split into two separate equations and solve for both a and b.

a = Port Fall	b = Starboard Fall
$\frac{a}{\text{Sin } 70°} = \frac{1.5 \text{ Tons}}{\text{Sin } 70°}$	$\frac{b}{\text{Sin } 40°} = \frac{1.5 \text{ Tons}}{\text{Sin } 70°}$
$a = \frac{\text{Sin } 70° \times 1.5T}{\text{Sin } 70°}$	$b = \frac{\text{Sin } 40° \times 1.5T}{\text{Sin } 70°}$
$a = \frac{.939 \times 1.5T}{.939}$	$b = \frac{.642 \times 1.5T}{.939}$
a = 1.5	b = 1.0255
Port Fall = 1.5 Tons	Stbd Fall = 1.03 Tons

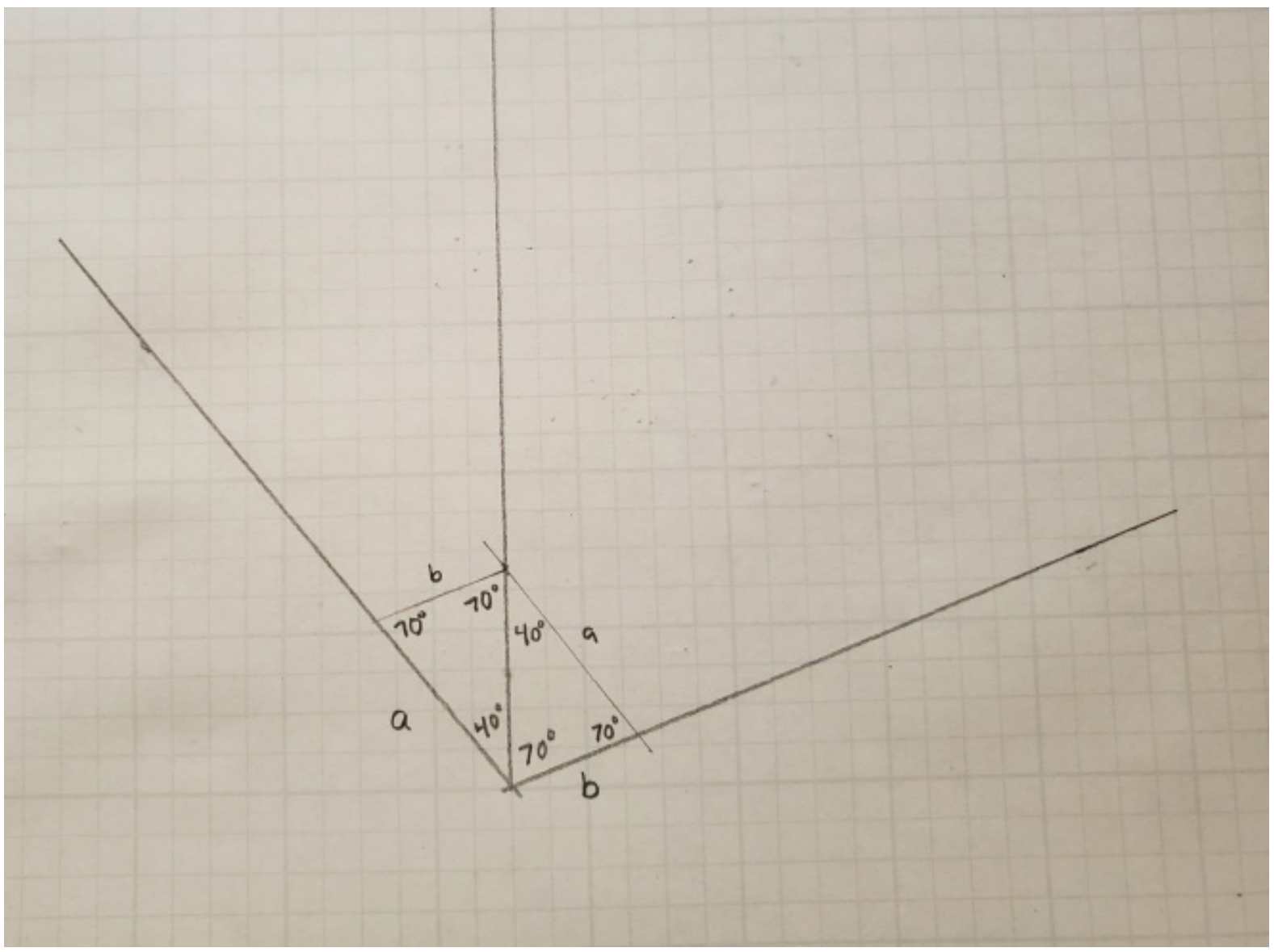
Law of Sines Solution for Both Port and Starboard Falls

Second Method Step 4: Parallelogram and direct measurement to solve stress on each fall.

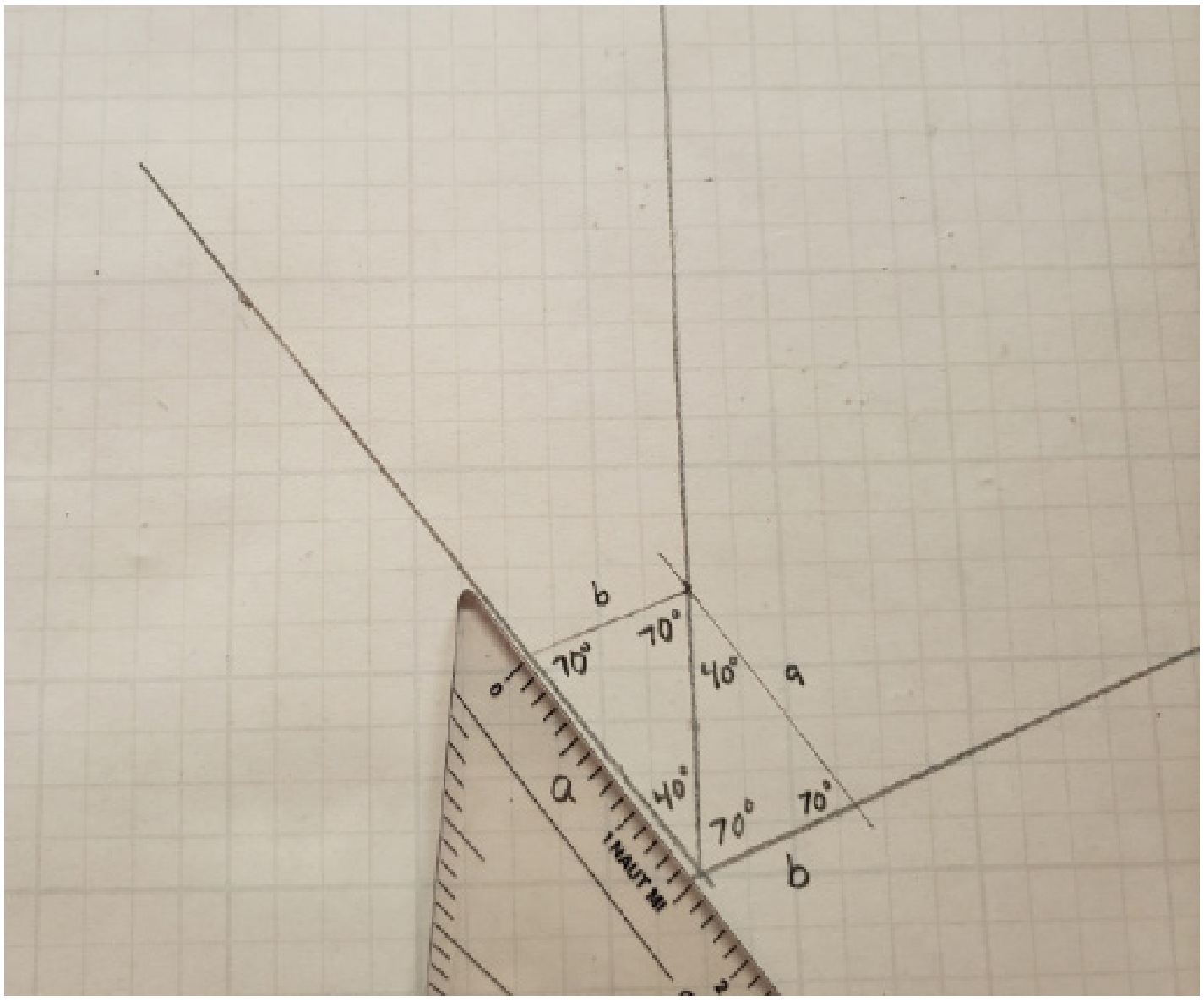
Using a Navigation Triangle measure accurate angles with appropriate Scale (either mm or inches) to represent the respective forces. This is the same rough drawn parallelogram in step 3 but measured with a protractor and drawn to scale so a direct measurement can be taken rather than use the law of sines to solve mathematically. The protractor images on the following pages show the process of drawing and measuring using this method.



Protractor Used to Draw Accurate, to Scale, Parallelogram from Step Three.



Completed and Labeled Parallelogram.



Measure the *a* and the *b* Line Segment.

Measure the *a* and the *b* line segment with the protractor. In the image above *a* is shown to measure 15 units or 1.5 tons. Segment *b* measures 10 units or 1.0 Tons.

Answer: Port 1.5 tons, starboard 1.0 tons