

S. A. WALLING  
AND J. C. HILL

# Nautical Mathematics

CAMBRIDGE

# NAUTICAL MATHEMATICS

by

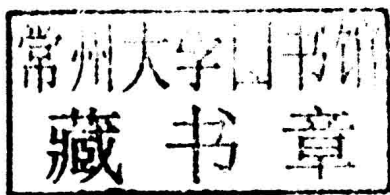
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# FOREWORD

by

REAR-ADMIRAL J. G. P. VIVIAN, C.B.

*Admiral Commanding Reserves*

A sound knowledge of mathematics is essential to the seaman; without that knowledge he is neither capable of being a competent "ship's husband" nor of navigating his ship across oceans and seas or in coastal waters.

The dry bones of mathematics have here been made alive and then clothed with a seaman's rig.

To you who have sea sense and the urge to go down to the sea in ships it is an exciting book, for it shows you how to solve many of those innumerable problems with which you will be confronted by day and by night, at sea and in harbour, in every type of ship.

Whether you be a deck hand or the captain of the ship, you will find that the knowledge which this book can impart is the basis on which the material efficiency of your ship and, that which is of equal importance, the safety, comfort and well-being of your shipmates, will largely depend.

These two things go together, the efficient ship and the happy ship's company, and both are dependent on the knowledge and skill of the leaders.

I heartily commend this book to you who aspire to be leaders in the Sea Services; if you use it with intelligence and with diligence you will be on the high road to achieve that aspiration.

A large, elegant handwritten signature in dark ink, reading "J. G. P. Vivian." The signature is written in a cursive style with a long, sweeping underline that extends across the width of the text.



## PREFACE

The call of the sea is in the blood of many of the youth of this country and the enthusiastic enrolment in such voluntary organisations as the Sea Cadet Corps is excellent evidence of this.

It is the object of those to whom the instruction of these cadets is entrusted to encourage them, by careful training and example, to fit themselves for positions of responsibility and authority in whatever branch of the Sea Services they may ultimately serve.

A most necessary preliminary to the intelligent understanding of many of the activities and duties of a sailor's life is a sound knowledge of the elementary principles of mathematics and their applications.

Much of this will have been done while at school, but for the benefit of those who have become "rusty" by lapse of time and as a stimulant to those who found difficulty or distaste in the academic study of figures, this book has been carefully designed.

Only as little as is considered essential for revision and accuracy in calculation is of a mechanical nature. The rest, without exception, has been compiled to apply these fundamental rules to the many interesting and important problems of seamanship.

It is hoped that this "flavour of the sea" may encourage the cadet and offer him a more acceptable road to proficiency.

The usefulness of this book should be, by no means, confined to members of the Sea Cadet Corps. Those already in the Royal Navy or the Merchant Service desiring to fit themselves for promotion or to specialise in some particular branch may find much here to help them.

The authors wish to express their very sincere thanks to Commander W. T. Marsh, R.N.V.R., with whose keen interest and assistance this book was originally planned; to Instructor Rear-Admiral A. E. Hall, C.B., C.B.E. and the Controller of H.M. Stationery Office for permission to include the Naval Educational Tests, and to Rear-Admiral J. G. P. Vivian, C.B. (Admiral Commanding Reserves), who has been kind enough to examine the manuscript and write the Foreword.

S. A. W.  
J. C. H.

*November 1942*

## TABLES

## Length.

12 inches (in.)	= 1 foot (ft.)
3 feet	= 1 yard (yd.)
6 feet	= 1 fathom
100 fathoms	= 1 cable = 8 shackles
10 cables	= 1 nautical mile of 2000 yd.

This measure (2000 yd.) of a nautical mile is only approximate, although frequently used at sea. A more accurate measure of a nautical mile is the length of an arc of the equator which subtends an angle of 1 minute (1') at the centre of the earth. This length is very nearly 6080 feet, which length is known as the *Mean Nautical Mile*.

1 statute mile = 5280 feet.

## Time.

60 seconds (sec.)	= 1 minute (min.)
60 minutes	= 1 hour (hr.)
24 hours	= 1 day
7 days	= 1 week
4 weeks	= 1 lunar month
365 days	= 1 year
366 days	= 1 leap year

## Measurement of Angles.

60 seconds (")	= 1 minute (')
60 minutes	= 1 degree (°)
60 degrees	= 1 sextant
90 degrees	= 1 quadrant (or right angle)
360 degrees	= 1 full circle

## Weight.

16 ounces (oz.)	= 1 pound (lb.)
14 pounds	= 1 stone (st.)
28 pounds	= 1 quarter (qr.)
112 pounds	= 1 hundredweight (cwt.)
20 hundredweights	= 1 ton

## THE FOUR RULES

**General Revision of Addition, Subtraction, Multiplication and Division of Numbers.**

Every calculation that has to be made, to obtain the answer to a problem, involves one or more of the above four rules.

It is essential, therefore, that accuracy in the use of numbers must be the first and most important consideration.

Always check an answer, and wherever possible do this by an alternative method.

For example, when working an addition sum add the numbers a second time in a different order, so that any mistake made during the first calculation is less likely to be made in the second.

When multiplying numbers, change the order of multiplication the second time for the same reason.

**Addition and Subtraction of Numbers.****EXERCISE I.**

- |                                   |                                     |                       |
|-----------------------------------|-------------------------------------|-----------------------|
| 1. $456 + 789 + 120$ .            | 2. $246 + 804 + 468$ .              |                       |
| 3. $779 + 416 + 321$ .            | 4. $1395 + 476 + 2764$ .            |                       |
| 5. $6959 + 2175 + 5432$ .         | 6. $30,142 + 2731 + 108 + 94,615$ . |                       |
| 7. $214 + 3886 + 2994 + 14,095$ . | 8. $5608 + 300 + 4215 + 71,230$ .   |                       |
| 9. $399 + 1387 + 3796 + 14,895$ . | 10. $4594 + 4378 + 374 + 2806$ .    |                       |
| 11. $273 - 241$ .                 | 12. $496 - 454$ .                   | 13. $524 - 217$ .     |
| 14. $694 - 589$ .                 | 15. $3762 - 1759$ .                 | 16. $14,360 - 9079$ . |
| 17. $10,051 - 9896$ .             | 18. $22,812 - 19,394$ .             | 19. $24,005 - 2998$ . |
| 20. $10,096 - 9997$ .             |                                     |                       |

**Multiplication and Division of Numbers.****EXERCISE II.**

- |                                   |                                  |                                  |
|-----------------------------------|----------------------------------|----------------------------------|
| 1. $896 \times 89$ .              | 2. $789 \times 96$ .             | 3. $587 \times 198$ .            |
| 4. $1756 \times 596$ .            | 5. $3417 \times 8370$ .          | 6. $514 \times 213 \times 17$ .  |
| 7. $91 \times 626 \times 727$ .   | 8. $734 \times 295 \times 317$ . | 9. $731 \times 195 \times 263$ . |
| 10. $478 \times 677 \times 954$ . | 11. $2544 \div 47$ .             | 12. $2136 \div 89$ .             |
| 13. $12,673 \div 29$ .            | 14. $95,157 \div 97$ .           | 15. $124,944 \div 456$ .         |
| 16. $1,067,520 \div 278$ .        | 17. $604,298 \div 838$ .         | 18. $115,189 \div 4266$ .        |
| 19. $395,638 \div 4986$ .         | 20. $274,321 \div 2878$ .        |                                  |

**Addition, Subtraction, Multiplication and Division of Quantities.**

A quantity describes a number of some definite thing or unit.

For instance, 17 tons, 12 seconds, 25 yards are quantities.

**Revision of Length.****EXERCISE III.**

1. Find the sum of 2 yd. 1 ft. 9 in., 5 ft. 7 in., 6 yd. 0 ft. 11 in.
2. Find the sum of 3 fathoms 3 ft. 10 in., 10 ft. 9 in.
3. Express 5 ft. + 12 ft. 5 in. - 8 ft. 9 in. in feet and inches.
4. Express 3 fathoms + 5 ft. 8 in. in inches.
5. Express 1209 in. in fathoms, feet and inches.
6. Express 3 shackles 12 yd. 1 ft. 6 in. in yards, feet and inches.
7. Express 2 cables 4 shackles in feet.
8. Express 1 cable 5 shackles in yards.
9. 4 ft. 6 in.  $\times$  8.
10. 3 ft. 2 in.  $\times$  7.
11. 1 yd. 2 ft. 3 in.  $\times$  6.
12. 2 fathoms 2 ft. 4 in.  $\times$  4.
13. 3 shackles 3 ft. 3 in.  $\times$  11.
14. 5 fathoms 4 ft. 6 in.  $\times$  19.
15. Divide 8 ft. 2 in. into 7 equal parts.
16. 7 yd. 1 ft.  $\div$  8.
17. 4 fathoms 0 ft. 6 in.  $\div$  7.
18. 2 shackles 5 ft.  $\div$  31.
19. 264 fathoms 1 ft. 6 in.  $\div$  21.
20. 11 yd. 0 ft. 7 in.  $\div$  13.

**Revision of Time.****EXERCISE IV.**

1. 2 hr. 20 min. 25 sec. + 5 hr. 15 min. 13 sec. + 3 hr. 41 min. 46 sec.
2. 3 hr. 11 min. 8 sec. - 1 hr. 38 min. 25 sec.
3. 4 hr. 19 min. 17 sec.  $\times$  8.
4. 16 hr. 8 min. 12 sec.  $\div$  12.
5. Express 2 hr. 46 min. 20 sec. in seconds.
6. Express 10,000 sec. in hours, minutes and seconds.
7. How many hours are there between 6.20 a.m. on 10 April to 4.20 a.m. on 12 April?
8. How many hours are there in a leap year?
9. How many days are there from 1 July to 31 December inclusive, in any year?
10. How many days are there from 1 January to 31 March inclusive, in a leap year?

**Revision of Weight.****EXERCISE V.**

1. 2 tons 13 cwt. 3 qr. + 7 tons 10 cwt. 2 qr. + 19 tons 17 cwt.
2. 25 tons 8 cwt. 2 qr. - 17 tons 15 cwt. 3 qr.
3. Express 3 tons 17 cwt. 2 qr. in stones.
4. Express 1589 cwt. in tons and hundredweights.
5. 5 tons 17 cwt. 3 qr.  $\times$  16.
6. 25 tons 3 cwt. 3 qr.  $\div$  13.
7. 4 tons 17 cwt. - 2 tons 19 cwt. + 6 tons 15 cwt.
8. 11 st. 13 lb. + 12 st. 10 lb. + 10 st. 12 lb.
9. Express 5 cwt. 2 st. in pounds.
10. Express 2128 lb. in hundredweights.

**Revision of Angles.****EXERCISE VI.**

1.  $24^{\circ} 16' 20'' + 32^{\circ} 58' 43'' + 19^{\circ} 32' 27''$ .
2.  $38^{\circ} 12' 21'' - 19^{\circ} 36' 46''$ .
3.  $5^{\circ} 17' 32'' \times 9$ .
4.  $110^{\circ} 42' 10'' \div 11$ .
5. Express  $3^{\circ} 28' 41''$  in seconds.
6. Express 19,680" in degrees, minutes and seconds.
7. By how much is  $79^{\circ} 59' 59''$  short of one right angle?
8. By how much is the sum of  $23^{\circ} 10'$  and  $110^{\circ} 20'$  short of two right angles?
9. Express  $7 \times 17'$  in degrees and minutes.
10. By how much is  $235^{\circ} 22' 5'' \div 5$  short of a sextant?

**Problems on the Four Rules.**

Unless otherwise stated, assume 1 nautical mile to be equal to 6080 feet. The abbreviation for nautical mile is N.M. A speed of 1 N.M. per hour is called a *knot*.

**EXERCISE VII.**

1. A ship, on five successive days, made the following runs in nautical miles: 243, 259, 282, 279 and 286. What was the total distance steamed in the five days?
2. A ship steamed 1004 N.M. in 4 days. During the first 2 days she covered 236 and 254 N.M. respectively. What was the combined run during the last two days?
3. A vessel left Plymouth bound for Alexandria, a distance of 2872 N.M. The distance from Plymouth to Lisbon was recorded as 770 N.M.; from Lisbon to Gibraltar as 302 N.M.; and from Gibraltar to Malta as 980 N.M. What is the distance from Malta to Alexandria?



4. Two ships leave Southampton for Melbourne, Australia. The first takes the Cape route and records the following distances:

Southampton to Cape Town	5947 N.M.
Cape Town to Melbourne	5814 N.M.

The second ship takes the Red Sea route, with the following log records:

Southampton to Gibraltar	1172 N.M.
Gibraltar to Suez	1920 N.M.
Suez to Aden	1310 N.M.
Aden to Colombo	2130 N.M.
Colombo to Freemantle	3120 N.M.
Freemantle to Melbourne	1553 N.M.

Which ship makes the shorter passage and by how many nautical miles?

5. Before the building of the Panama Canal all ships from Eastern American ports bound for Western American ports had to sail via South American waters and Cape Horn. What is the saving in a journey from New York to San Francisco if the distance from New York to Panama is 1985 N.M. and from Panama to San Francisco is 3260 N.M., while the distance from New York to Montevideo is 5723 N.M. and from Montevideo to San Francisco is 7536 N.M.?

6. What distance is saved between Southampton and Colombo by taking the Suez Canal route?

The distance from Southampton to Suez is 3092 N.M. and from Suez to Colombo is 3440 N.M. The distance from Southampton to Cape Town is 5947 N.M. and from Cape Town to Colombo is 4438 N.M.

7. A vessel steams a steady 18 knots for 36 hr. How far has she travelled in this time?

8. If a ship records a steady noon to noon run of 272 N.M. for 17 days, how far has she travelled?

9. From the following table of entries in a ship's speed log, find the total distance run between noon on 10 May 1942 and 8.0 a.m. on 13 May 1942:

Date	Time	Speed	N.M.
May 10	12 00	13 knots	—
10	17 00	16	65
11	8 00	15	
12	12 00	12	
13	8 00		
Total distance run			

10. Which is the greater distance, 7 statute miles or 6 nautical miles? What is the difference in feet?