

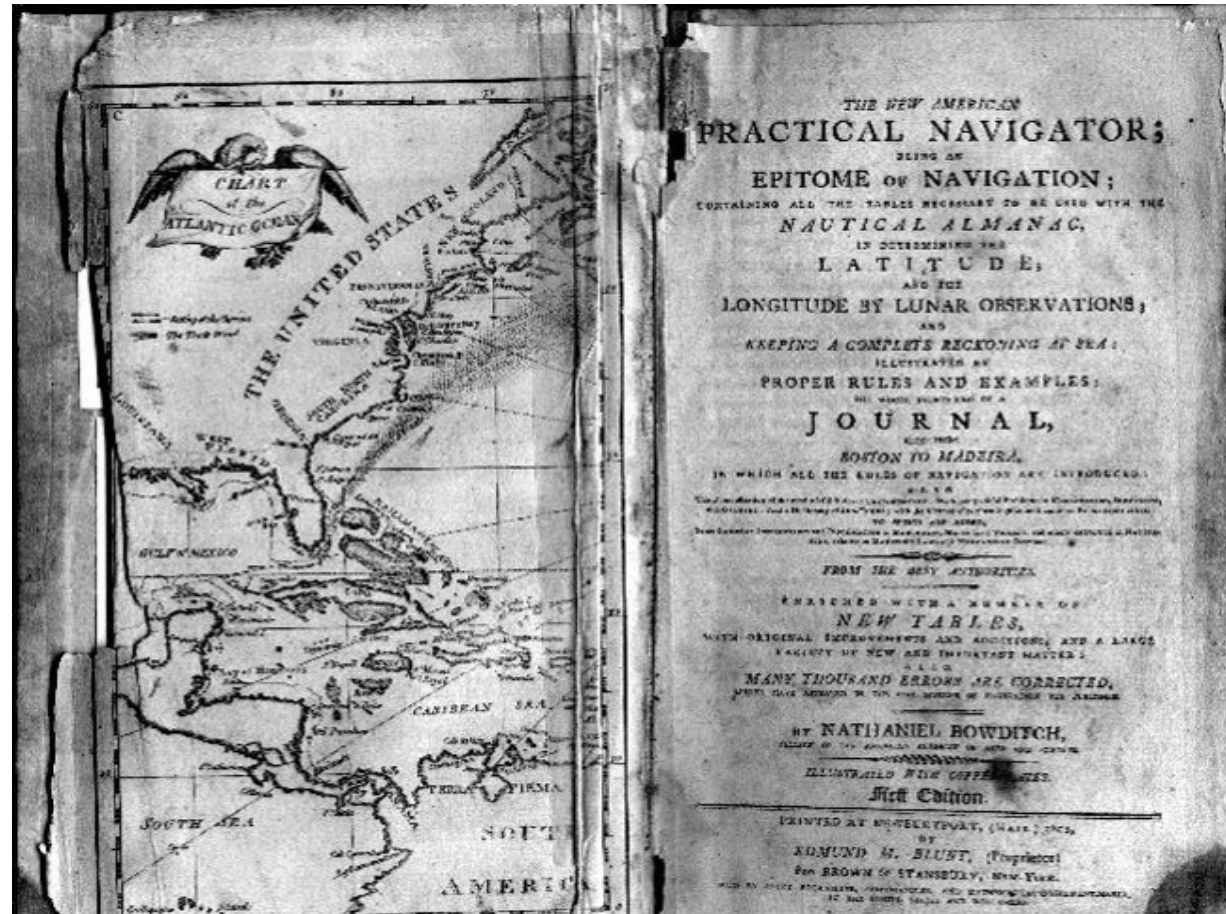
# Nathaniel Bowditch

Three Myths

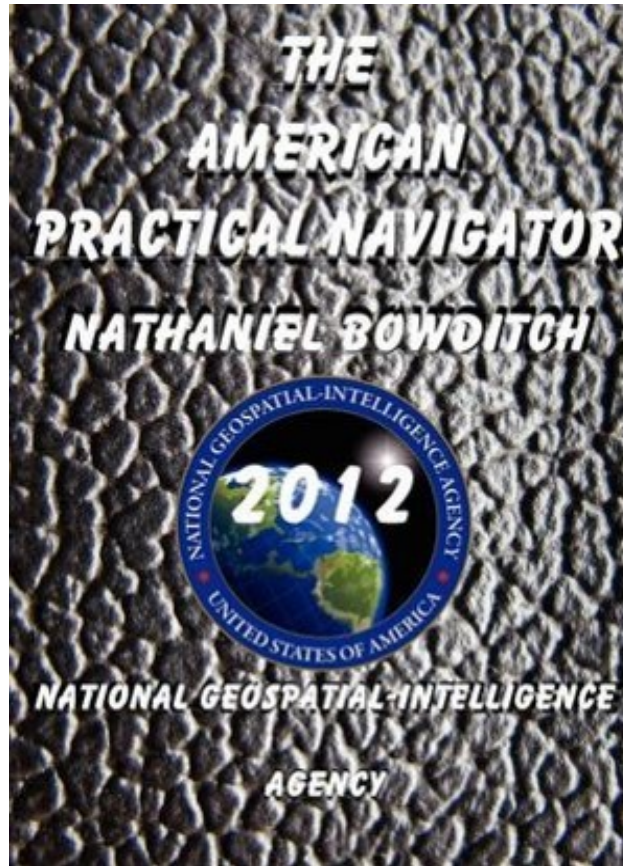
and

Three (Even More Interesting) Realities

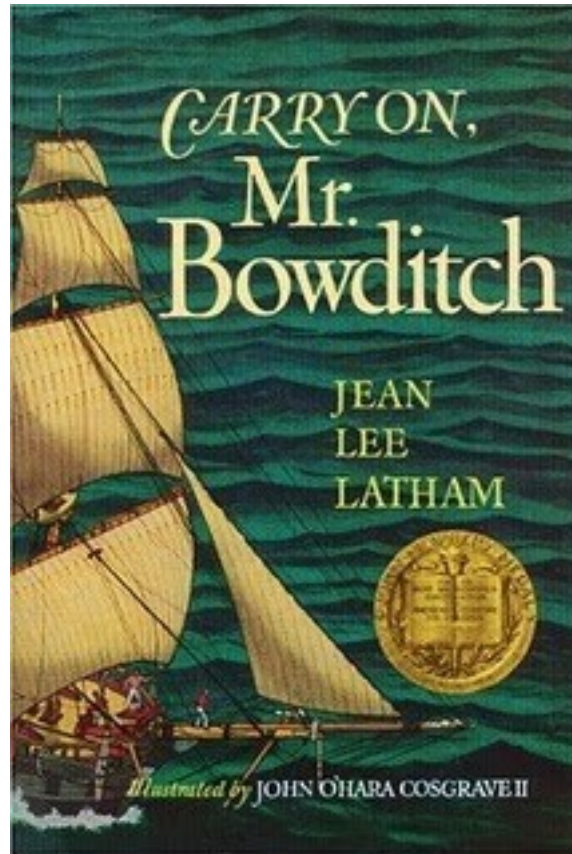
# Bowditch's *New American Practical Navigator* (Newburyport, 1802)



When Bowditch first went to sea, “a system of determining longitude by ‘lunar distance,’ a method which did not require an accurate timepiece, was known, but this product of the minds of mathematicians and astronomers was so involved as to be beyond the capabilities of the uneducated seamen of that day.”



The plot: Bowditch's modern science vs. sailors' hidebound practices





“An American original means something better . . . Nathaniel Bowditch gave the world something better in the science of navigation” (Seagram’s advertisement, 1948)



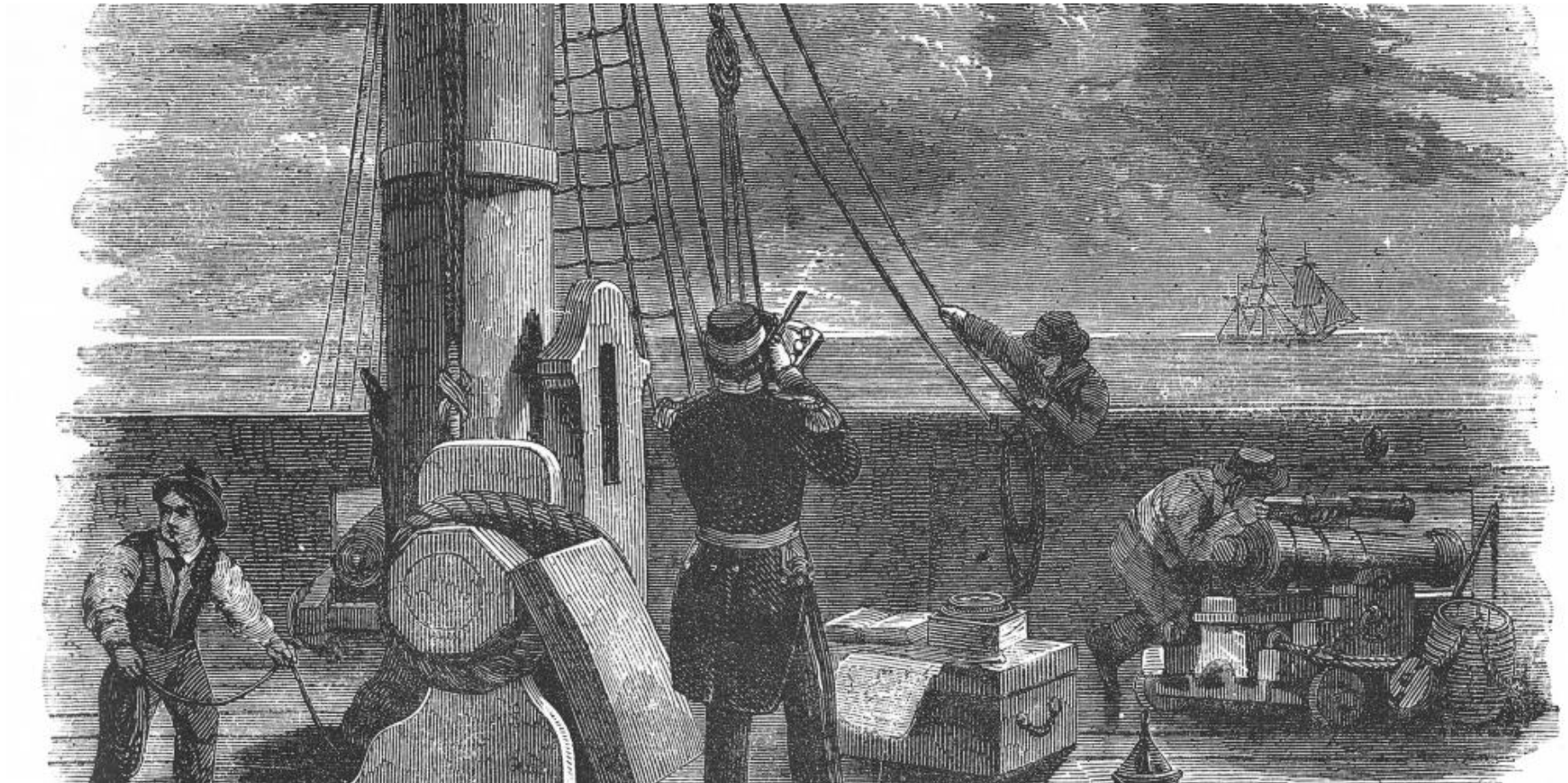
# Myth #1

**Bowditch invented the lunar method of  
establishing longitude at sea**

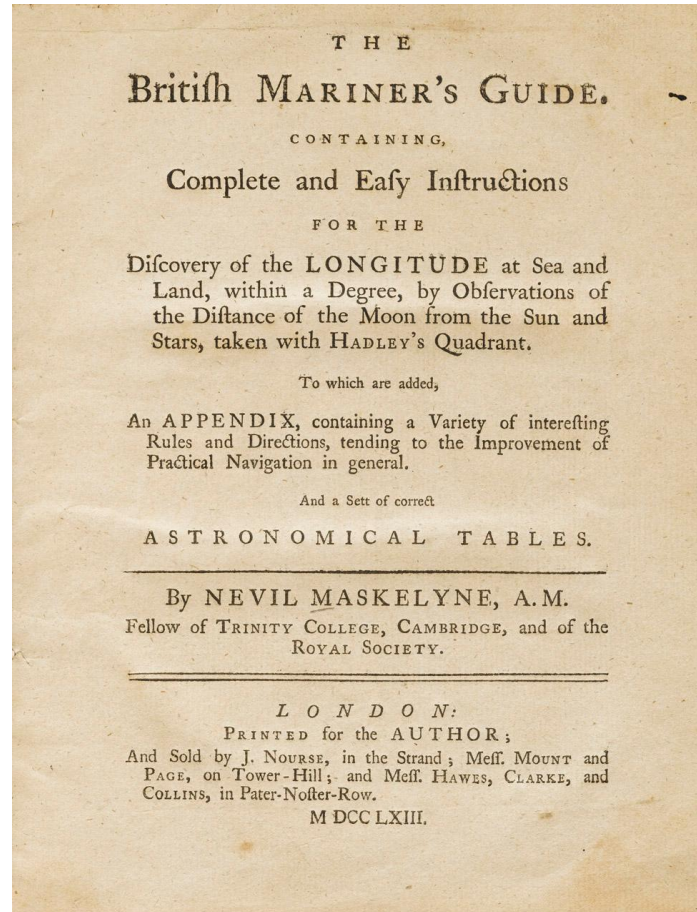
# John Harrison's H4



# “Taking a Lunar Distance,” from Edward Dunkin’s Midnight Sky (1869)



“Complete and Easy Instructions for the Discovery of the LONGITUDE at Sea and Land, within a Degree, by Observations of the Distance of the Moon from the Sun and Stars, taken with Hadley’s Quadrant” (1763)





Teaching the “method of finding the longitude at sea by lunar observations,” Boston, 1788

*Osgood Carleton*  
**R**ESPECTFULLY informs his friends  
and others, that his EVENING-SCHOOL  
is opened at Mrs. PULLING's near Oliver's Dock,  
where he teaches (both days and evenings) Navi-  
gation, with the method of finding the longitude  
at sea by lunar observations. *Also*, Writing,  
Arithmetick, Book-Keeping, Surveying, Gaug-  
ing, Gunnery, Mensuration, Algebra, Geogra-  
phy, Astronomy, Dialing, Use of the Globes, &c.  
on the most moderate terms.  
Gentlemen who study the Lunar Observations,  
will have a separate room.  
He attends on pupils any hours which are most  
convenient for them, either days or evenings.  
He has had several years experience in the  
practice of navigation at sea, surveying land, &c.  
the latter of which he now practices occasionally.  
*Boston, Sept. 27. 1788. (f.)*



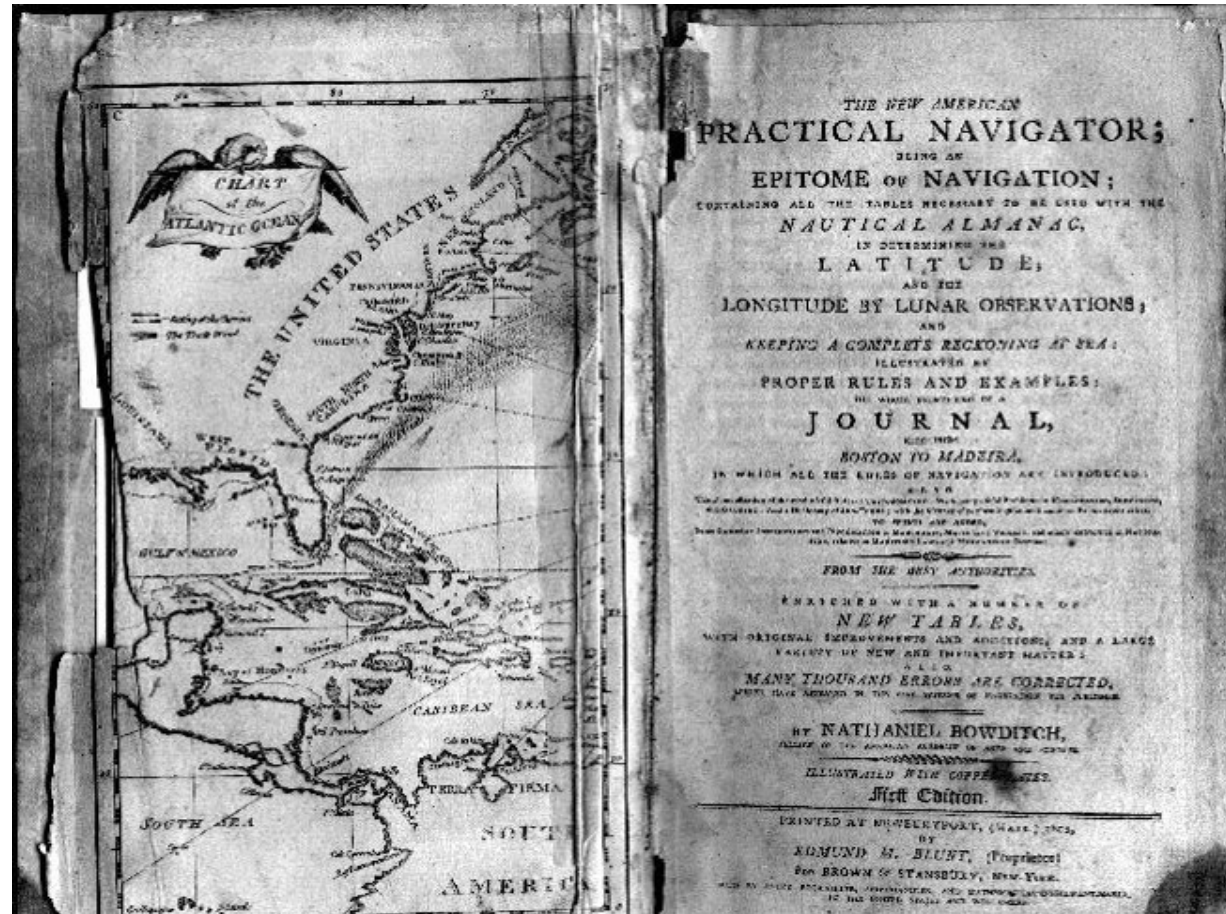
Josef de Mendoza y Rios. The Royal Society of London published his method of working lunars in 1797.



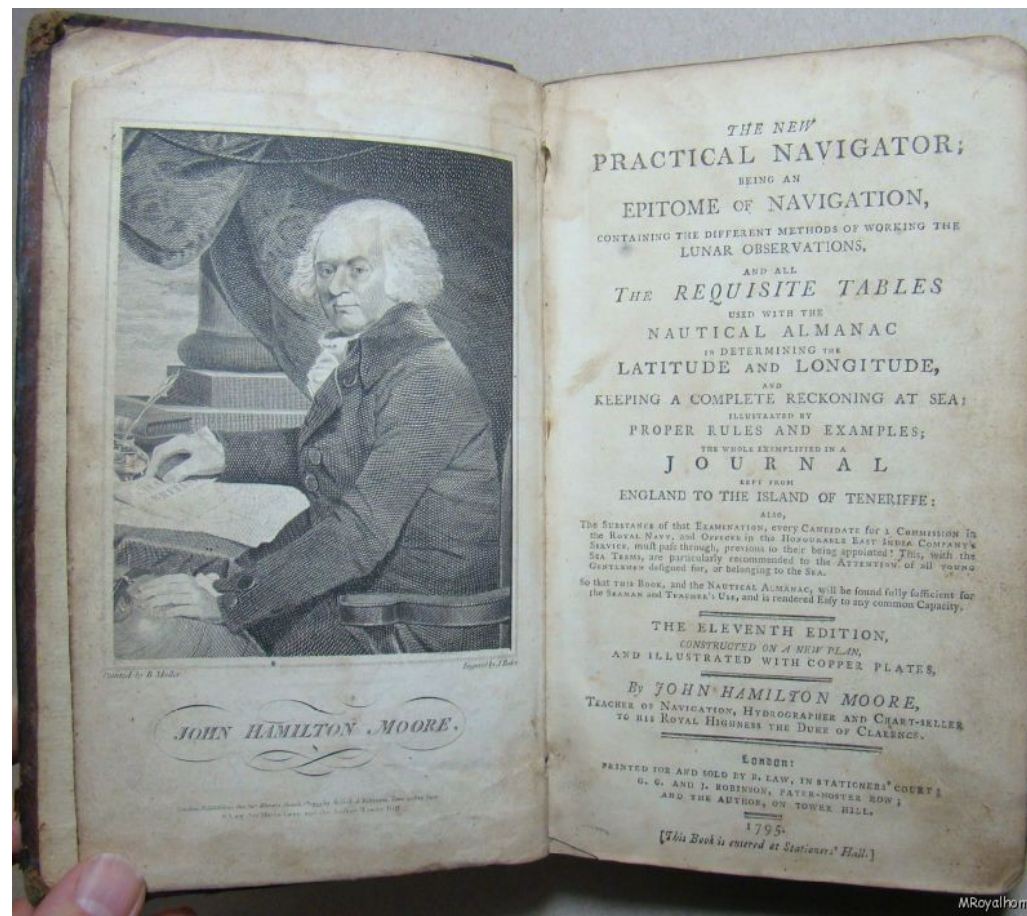
## Myth #2

**Bowditch's *New American Practical Navigator* (1802) was the first practical navigation manual**

Bowditch's *New American Practical Navigator* (Newburyport, 1802)



John Hamilton Moore's *New Practical Navigator* First edition, London, 1772. (Below, 11<sup>th</sup> ed., 1795).



Moore's *Navigator*, in a catalog of books for sale, Boston, 1773.

( 27 )

Moore's practical Navigator, 8vo. (new)  
Marshall's Travels through Holland, Flanders, Germany, Sweden, Lapland, Russia, the Ukraine and Poland, in 1768, 1769, and 1770. 3 vols. 8vo.

# Moore's *Navigator*, in a catalog of books for sale, Philadelphia, 1789

( 9. )  
Montesquieu's Spirit of Laws  
Mair's Introduction to making Latin  
—— Salust  
Melmoth's Translation of Cicero's Letters to his  
Friends  
Moore's Navigator's Assistant  
Milton's Paradise Lost  
Millar's Gardener's Dictionary



# Moore's *Navigator*, in a catalog of books for sale, Salem, 1791

M.	
Millot's Elements of Ancient and Modern History.	5
Ditto's Elements of England.	4
Minot's History of Insurrection in Massachusetts.	1
Minute Philosopher.	2
Melmoth's Universal Story Teller, or a Modern Picture of Human Life—consisting of a great variety of valuable matter.	1
M'Fingal, an epic poem, by Trumbull.	1
Man of Feeling.	1
Moore's Practical Navigator.	1

## Myth #3

**Bowditch was a self-taught mathematical  
genius**

Vermonter Zerah Colburn, age 8, "Remarkable for solving arithmetical questions"(1813)



# Colburn's mental math problems (e.g., How many seconds in eleven years?)

## A LIST OF QUESTIONS ANSWERED BY THE AUTHOR WHEN A CHILD.

In order to furnish those who never saw the writer while exhibited with a further opportunity to understand the nature of his gift, the following questions, answered by him, are inserted. They are not all, nor perhaps the most extraordinary ones that he has solved; but they are such as he can say were proposed to him. They are given as specimens of the character of the questions proposed to him, and the time employed in answering them. Other questions will be found interspersed through the Memoir, particularly on pp. 37, 38, 39, from the London Prospectus.

*In Boston, on his first visit, in the fall of 1810.*

The number of seconds in 2000 years was required.

730,000 days.

17,520,000 hours.

1,051,200,000 minutes.

63,072,000,000 seconds—Answer.

Allowing that a clock strikes 156 times in 1 day, how many times will it strike in 2000 years? 113,880,000 times.

What is the product of 12,225 multiplied by 1,223? 14,951,175.

What is the square of 1,449? 2,099,601.

Supposing I have a corn field, in which are 7 acres, having 17 rows to each acre; 64 hills to each row; 8 ears on a hill, and 150 kernels on an ear; how many kernels on the corn field? 9,139,200.

*In Portsmouth, New-Hampshire, June, 1811.*

Admitting the distance between Concord and Boston to be 65 miles, how many steps must I take in going this distance, allowing that I go three feet

at a step? The answer, 114,400, was given in ten seconds.

How many days and hours since the Christian Era commenced, 1811 years? Answered in twenty seconds.

661,015 days.

15,864,360 hours.

How many seconds in eleven years? Answer in four seconds; 346,896,000.

What sum multiplied by itself will produce 998,001? In less than four seconds, 999.

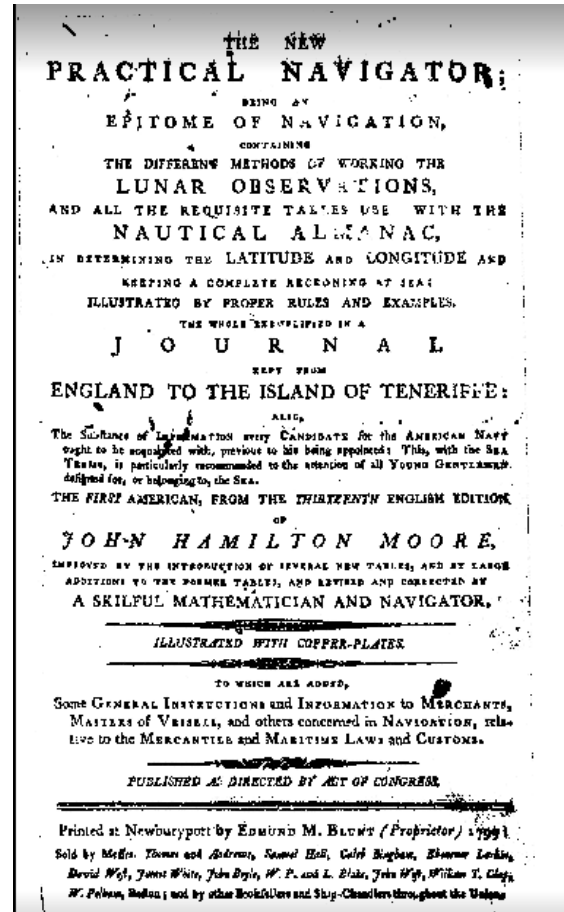
How many hours in 38 years, 2 months, and 7 days? In six seconds; 334,488.

At one time in London he was requested to square 888,888. He gave it correctly, 790,121,876,544; and afterwards multiplied this product by 49, making 38,715,971,950,656, being the square of 6,222,216.

# True Story #1

Bowditch's book was a nautical best-seller,  
the "seaman's Bible"

1799, 1st American (from the 13<sup>th</sup> English) edition of Moore, “Revised and Corrected by a Skilful Mathematician and Navigator”





Rival *Navigators* at William Sawyer's bookstore, Newburyport, 1807

CHARTS and PILOTS of all parts of  
world : Navigators by Bowditch and Mackay :  
Quadrants : Glaſſes : Scales and Dividers :  
cases of Instruments : Writing Deſks : Slates  
and Pencils : Blank Books of all kinds : Writing  
Books : Wafers and Wafer Seals, and Sealing  
Wax : gentlemen's and ladies' Pocket Books  
Purſes and Thread Cases, &c. &c. and a general  
aſſortment of Fancy Articles.

Four rival *Navigators* at T. & J. Swords  
Nautical Bookstore, New York, 1808

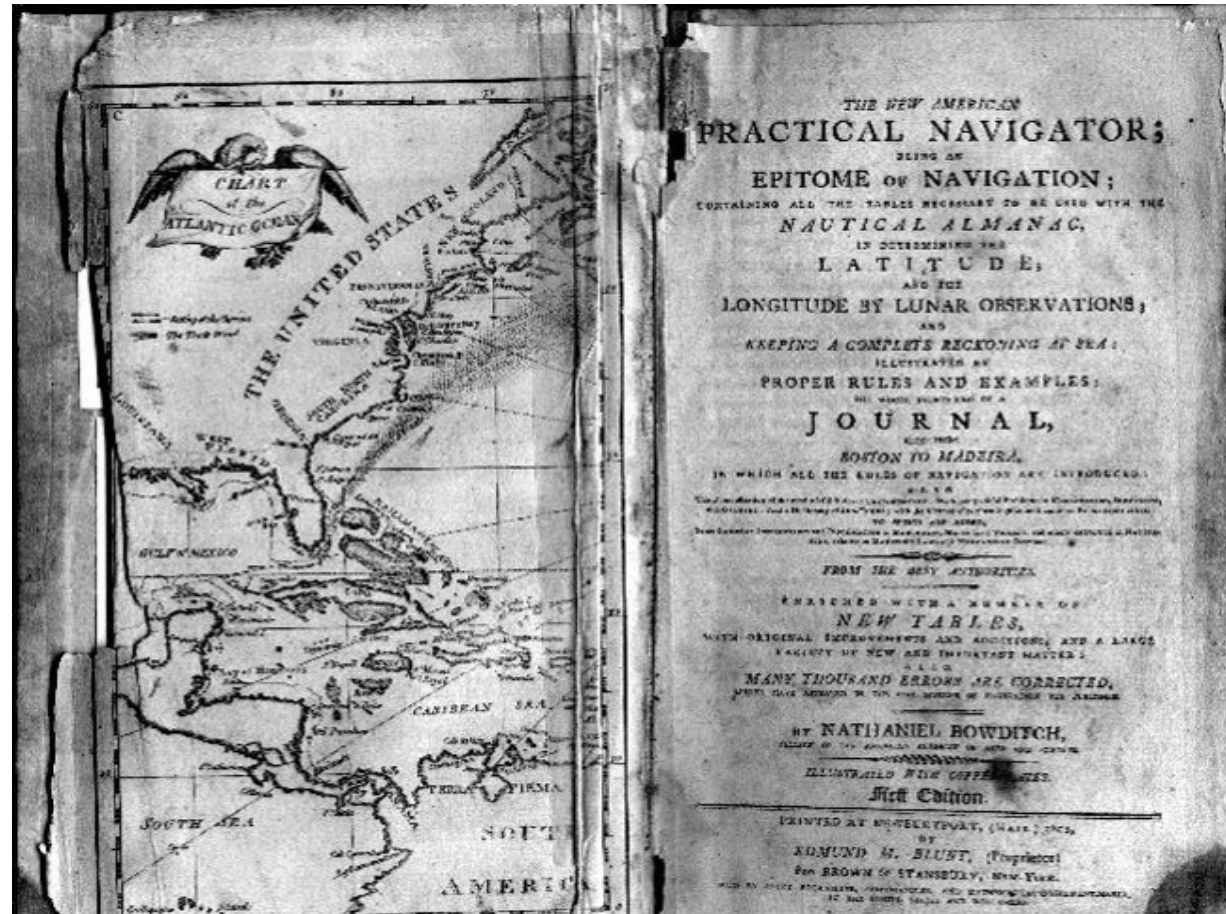
**Mackay's complete navigator.**  
**Bowditch's new American practical navigator.**  
**Moore's practical navigator.**  
**Norie's complete epitome of practical navigation.**  
**Norie's complete set of nautical tables.**  
**Requisite tables for finding the latitude and longitude at sea.**



Bowditch wins the day: Baltimore, 1815

**NAUTICAL BOOKS, &c.**  
Blunt's American Coast Pilot,  
Bowditch's Navigator,  
Seamanship in Theory and Practice,  
Nautical Almanacs for 1815,  
Charts of various coasts, &c. &c.  
May be had on application at  
**WILLIAM WARNER'S,**  
**BOOK & STATIONARY STORE,**  
No. 37, corner of south Gay and Market-st.

Bowditch's *New American Practical Navigator* (Newburyport, 1802) with map of American coast opposite title page



# Bowditch's recalculated *Navigator* tables

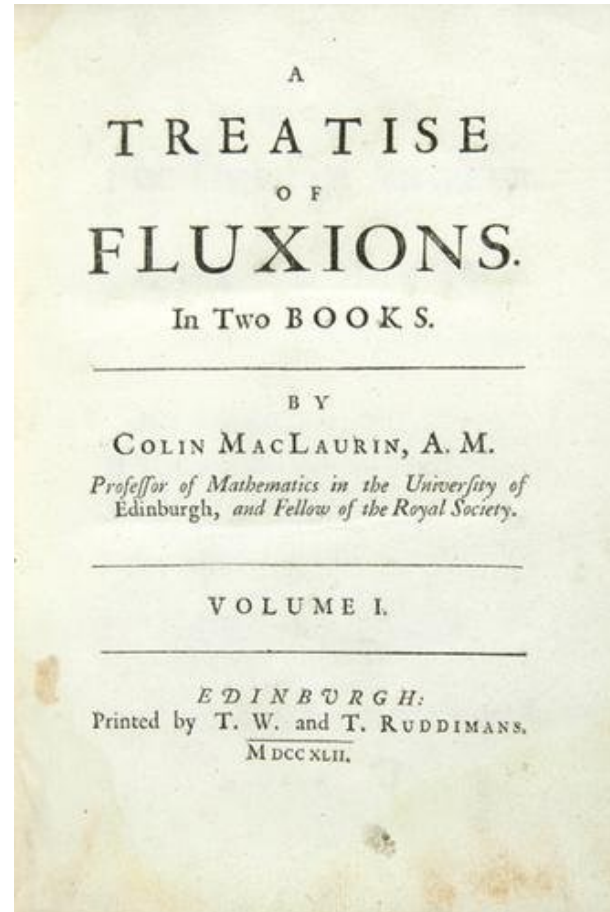
TABLE XXI. For finding the Latitude by two Altitudes of the Sun.														
H O U R.														
M.	S.	Log Sin	Log Cos	Log Tan	M.	S.	Log Sin	Log Cos	Log Tan	M.	S.			
0	0	0.58700	4.71403	3.53443	10	0	0.52186	4.77917	3.66542	10	0	0.52186	4.77917	3.66542
10	0	0.58583	4.71520	3.53482	10	10	0.52086	4.78017	3.66547	10	10	0.52086	4.78017	3.66547
20	0	0.58465	4.71638	3.53521	20	0	0.51986	4.78117	3.66552	20	0	0.51986	4.78117	3.66552
30	0	0.58348	4.71755	3.53559	30	0	0.51886	4.78217	3.66557	30	0	0.51886	4.78217	3.66557
40	0	0.58231	4.71871	3.53597	40	0	0.51786	4.78317	3.66562	40	0	0.51786	4.78317	3.66562
50	0	0.58114	4.71988	3.53634	50	0	0.51686	4.78417	3.66567	50	0	0.51686	4.78417	3.66567
1	0	0.57997	4.72104	3.53670	11	0	0.51586	4.78517	3.66572	11	0	0.51586	4.78517	3.66572
10	0	0.57880	4.72221	3.53705	10	10	0.51486	4.78617	3.66577	10	10	0.51486	4.78617	3.66577
20	0	0.57763	4.72338	3.53740	20	0	0.51386	4.78717	3.66582	20	0	0.51386	4.78717	3.66582
30	0	0.57646	4.72455	3.53775	30	0	0.51286	4.78817	3.66587	30	0	0.51286	4.78817	3.66587
40	0	0.57529	4.72571	3.53810	40	0	0.51186	4.78917	3.66592	40	0	0.51186	4.78917	3.66592
50	0	0.57412	4.72688	3.53845	50	0	0.51086	4.79017	3.66597	50	0	0.51086	4.79017	3.66597
2	0	0.57295	4.72804	3.53880	12	0	0.50986	4.79117	3.66602	12	0	0.50986	4.79117	3.66602
10	0	0.57178	4.72921	3.53915	10	10	0.50886	4.79217	3.66607	10	10	0.50886	4.79217	3.66607
20	0	0.57061	4.73038	3.53950	20	0	0.50786	4.79317	3.66612	20	0	0.50786	4.79317	3.66612
30	0	0.56944	4.73155	3.53985	30	0	0.50686	4.79417	3.66617	30	0	0.50686	4.79417	3.66617
40	0	0.56827	4.73271	3.54020	40	0	0.50586	4.79517	3.66622	40	0	0.50586	4.79517	3.66622
50	0	0.56710	4.73388	3.54055	50	0	0.50486	4.79617	3.66627	50	0	0.50486	4.79617	3.66627
3	0	0.56593	4.73504	3.54090	13	0	0.50386	4.79717	3.66632	13	0	0.50386	4.79717	3.66632
10	0	0.56476	4.73621	3.54125	10	10	0.50286	4.79817	3.66637	10	10	0.50286	4.79817	3.66637
20	0	0.56359	4.73738	3.54160	20	0	0.50186	4.79917	3.66642	20	0	0.50186	4.79917	3.66642
30	0	0.56242	4.73855	3.54195	30	0	0.50086	4.80017	3.66647	30	0	0.50086	4.80017	3.66647
40	0	0.56125	4.73971	3.54230	40	0	0.49986	4.80117	3.66652	40	0	0.49986	4.80117	3.66652
50	0	0.56008	4.74088	3.54265	50	0	0.49886	4.80217	3.66657	50	0	0.49886	4.80217	3.66657
4	0	0.55891	4.74204	3.54300	14	0	0.49786	4.80317	3.66662	14	0	0.49786	4.80317	3.66662
10	0	0.55774	4.74321	3.54335	10	10	0.49686	4.80417	3.66667	10	10	0.49686	4.80417	3.66667
20	0	0.55657	4.74438	3.54370	20	0	0.49586	4.80517	3.66672	20	0	0.49586	4.80517	3.66672
30	0	0.55540	4.74555	3.54405	30	0	0.49486	4.80617	3.66677	30	0	0.49486	4.80617	3.66677
40	0	0.55423	4.74671	3.54440	40	0	0.49386	4.80717	3.66682	40	0	0.49386	4.80717	3.66682
50	0	0.55306	4.74788	3.54475	50	0	0.49286	4.80817	3.66687	50	0	0.49286	4.80817	3.66687
5	0	0.55189	4.74904	3.54510	15	0	0.49186	4.80917	3.66692	15	0	0.49186	4.80917	3.66692
10	0	0.55072	4.75021	3.54545	10	10	0.49086	4.81017	3.66697	10	10	0.49086	4.81017	3.66697
20	0	0.54955	4.75138	3.54580	20	0	0.48986	4.81117	3.66702	20	0	0.48986	4.81117	3.66702
30	0	0.54838	4.75255	3.54615	30	0	0.48886	4.81217	3.66707	30	0	0.48886	4.81217	3.66707
40	0	0.54721	4.75371	3.54650	40	0	0.48786	4.81317	3.66712	40	0	0.48786	4.81317	3.66712
50	0	0.54604	4.75488	3.54685	50	0	0.48686	4.81417	3.66717	50	0	0.48686	4.81417	3.66717
6	0	0.54487	4.75604	3.54720	16	0	0.48586	4.81517	3.66722	16	0	0.48586	4.81517	3.66722
10	0	0.54370	4.75721	3.54755	10	10	0.48486	4.81617	3.66727	10	10	0.48486	4.81617	3.66727
20	0	0.54253	4.75838	3.54790	20	0	0.48386	4.81717	3.66732	20	0	0.48386	4.81717	3.66732
30	0	0.54136	4.75955	3.54825	30	0	0.48286	4.81817	3.66737	30	0	0.48286	4.81817	3.66737
40	0	0.54019	4.76071	3.54860	40	0	0.48186	4.81917	3.66742	40	0	0.48186	4.81917	3.66742
50	0	0.53902	4.76188	3.54895	50	0	0.48086	4.82017	3.66747	50	0	0.48086	4.82017	3.66747
7	0	0.53785	4.76304	3.54930	17	0	0.47986	4.82117	3.66752	17	0	0.47986	4.82117	3.66752
10	0	0.53668	4.76421	3.54965	10	10	0.47886	4.82217	3.66757	10	10	0.47886	4.82217	3.66757
20	0	0.53551	4.76538	3.54999	20	0	0.47786	4.82317	3.66762	20	0	0.47786	4.82317	3.66762
30	0	0.53434	4.76655	3.55034	30	0	0.47686	4.82417	3.66767	30	0	0.47686	4.82417	3.66767
40	0	0.53317	4.76771	3.55069	40	0	0.47586	4.82517	3.66772	40	0	0.47586	4.82517	3.66772
50	0	0.53200	4.76888	3.55104	50	0	0.47486	4.82617	3.66777	50	0	0.47486	4.82617	3.66777
8	0	0.53083	4.77004	3.55139	18	0	0.47386	4.82717	3.66782	18	0	0.47386	4.82717	3.66782
10	0	0.52966	4.77121	3.55174	10	10	0.47286	4.82817	3.66787	10	10	0.47286	4.82817	3.66787
20	0	0.52849	4.77238	3.55209	20	0	0.47186	4.82917	3.66792	20	0	0.47186	4.82917	3.66792
30	0	0.52732	4.77355	3.55244	30	0	0.47086	4.83017	3.66797	30	0	0.47086	4.83017	3.66797
40	0	0.52615	4.77471	3.55279	40	0	0.46986	4.83117	3.66802	40	0	0.46986	4.83117	3.66802
50	0	0.52498	4.77588	3.55314	50	0	0.46886	4.83217	3.66807	50	0	0.46886	4.83217	3.66807
9	0	0.52381	4.77704	3.55349	19	0	0.46786	4.83317	3.66812	19	0	0.46786	4.83317	3.66812
10	0	0.52264	4.77821	3.55384	10	10	0.46686	4.83417	3.66817	10	10	0.46686	4.83417	3.66817
20	0	0.52147	4.77938	3.55419	20	0	0.46586	4.83517	3.66822	20	0	0.46586	4.83517	3.66822
30	0	0.52030	4.78055	3.55454	30	0	0.46486	4.83617	3.66827	30	0	0.46486	4.83617	3.66827
40	0	0.51913	4.78171	3.55489	40	0	0.46386	4.83717	3.66832	40	0	0.46386	4.83717	3.66832
50	0	0.51796	4.78288	3.55524	50	0	0.46286	4.83817	3.66837	50	0	0.46286	4.83817	3.66837

## True Story #2

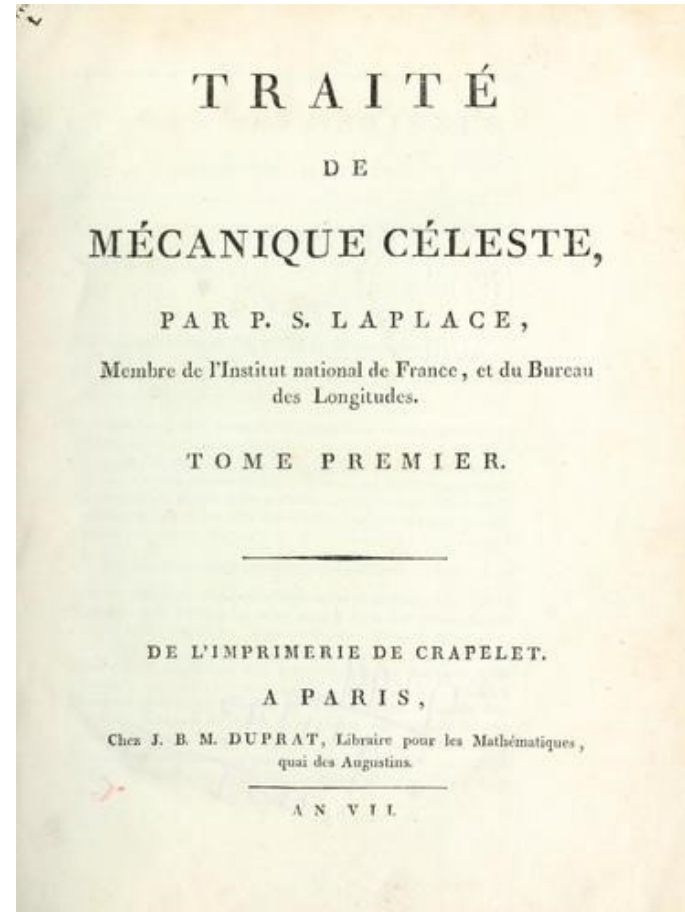
**Bowditch taught himself the math that put him on the cutting-edge of mathematical knowledge in the English-speaking world**



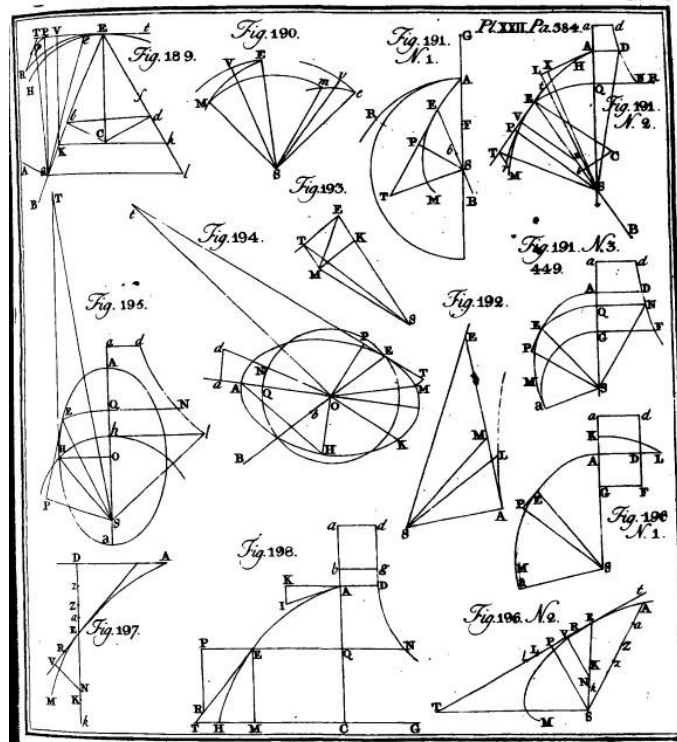
Newtonian calculus, in the collections of the Salem Philosophical Library



# The master work of Enlightenment science: Laplace



# Newton's fluxions: geometrical figures



# Laplace's differential calculus: numbers and symbols

$$\begin{aligned}
 &0 = x \cdot \left( \frac{dU'}{dx'} \right) + y \cdot \left( \frac{dU'}{dy'} \right) + z \cdot \left( \frac{dU'}{dz'} \right); \\
 &x' \cdot \left( \frac{dU}{dx} \right) + y' \cdot \left( \frac{dU}{dy} \right) + z' \cdot \left( \frac{dU}{dz} \right) = \frac{\mu}{r^3} \cdot \left\{ x \cdot \left( \frac{dU''}{dx'} \right) + y \cdot \left( \frac{dU''}{dy'} \right) + z \cdot \left( \frac{dU''}{dz'} \right) \right\} \\
 &x' \cdot \left( \frac{dU'}{dx} \right) + y' \cdot \left( \frac{dU'}{dy} \right) + z' \cdot \left( \frac{dU'}{dz} \right) = \frac{\mu}{r^3} \cdot \left\{ x \cdot \left( \frac{dU'''}{dx} \right) + y \cdot \left( \frac{dU'''}{dy'} \right) + z \cdot \left( \frac{dU'''}{dz'} \right) \right\} \\
 &x' \cdot \left( \frac{dU''}{dx} \right) + y' \cdot \left( \frac{dU''}{dy} \right) + z' \cdot \left( \frac{dU''}{dz} \right) = \frac{\mu}{r^3} \cdot \left\{ x \cdot \left( \frac{dU^{iv}}{dx'} \right) + y \cdot \left( \frac{dU^{iv}}{dy'} \right) + z \cdot \left( \frac{dU^{iv}}{dz'} \right) \right\} \\
 &\&c.
 \end{aligned}
 \left. \vphantom{\begin{aligned} &0 = x \cdot \left( \frac{dU'}{dx'} \right) + y \cdot \left( \frac{dU'}{dy'} \right) + z \cdot \left( \frac{dU'}{dz'} \right); \\ &x' \cdot \left( \frac{dU}{dx} \right) + y' \cdot \left( \frac{dU}{dy} \right) + z' \cdot \left( \frac{dU}{dz} \right) = \frac{\mu}{r^3} \cdot \left\{ x \cdot \left( \frac{dU''}{dx'} \right) + y \cdot \left( \frac{dU''}{dy'} \right) + z \cdot \left( \frac{dU''}{dz'} \right) \right\} \\ &x' \cdot \left( \frac{dU'}{dx} \right) + y' \cdot \left( \frac{dU'}{dy} \right) + z' \cdot \left( \frac{dU'}{dz} \right) = \frac{\mu}{r^3} \cdot \left\{ x \cdot \left( \frac{dU'''}{dx} \right) + y \cdot \left( \frac{dU'''}{dy'} \right) + z \cdot \left( \frac{dU'''}{dz'} \right) \right\} \\ &x' \cdot \left( \frac{dU''}{dx} \right) + y' \cdot \left( \frac{dU''}{dy} \right) + z' \cdot \left( \frac{dU''}{dz} \right) = \frac{\mu}{r^3} \cdot \left\{ x \cdot \left( \frac{dU^{iv}}{dx'} \right) + y \cdot \left( \frac{dU^{iv}}{dy'} \right) + z \cdot \left( \frac{dU^{iv}}{dz'} \right) \right\} } \right\}; (I')
 \end{aligned}$$

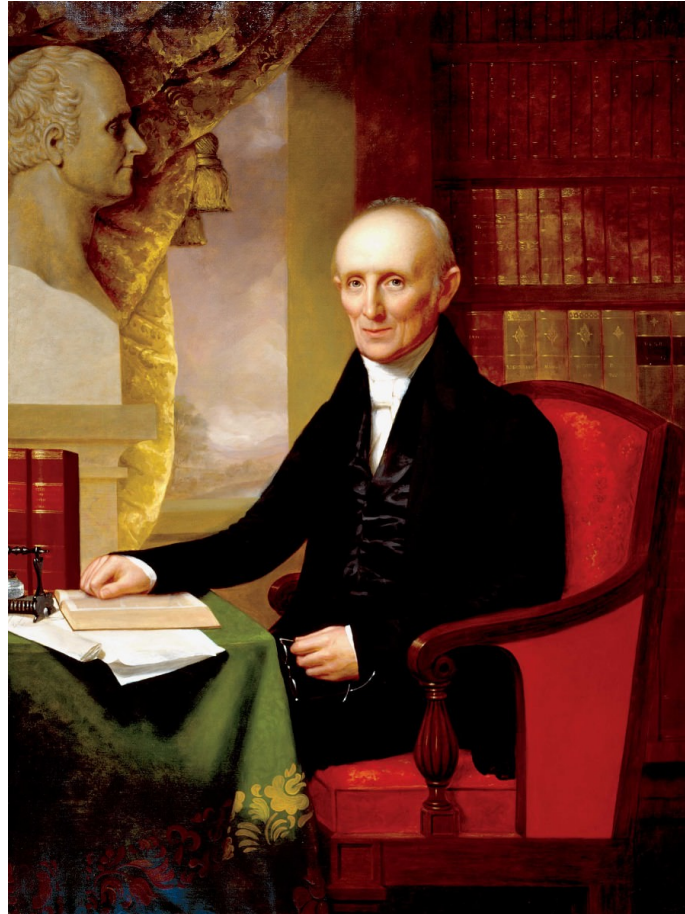
MÉCAN. CÉL. *Tome I.* X





DR. BOWDITCH'S STUDY IN EARLY LIFE.

Bowditch in his library, 1835. Bust of Laplace, upper left.



# True Story #3

**Bowditch's perspective as a navigator and mathematician had a transformative impact on American business and practical affairs**



# State Street, Boston, circa 1837

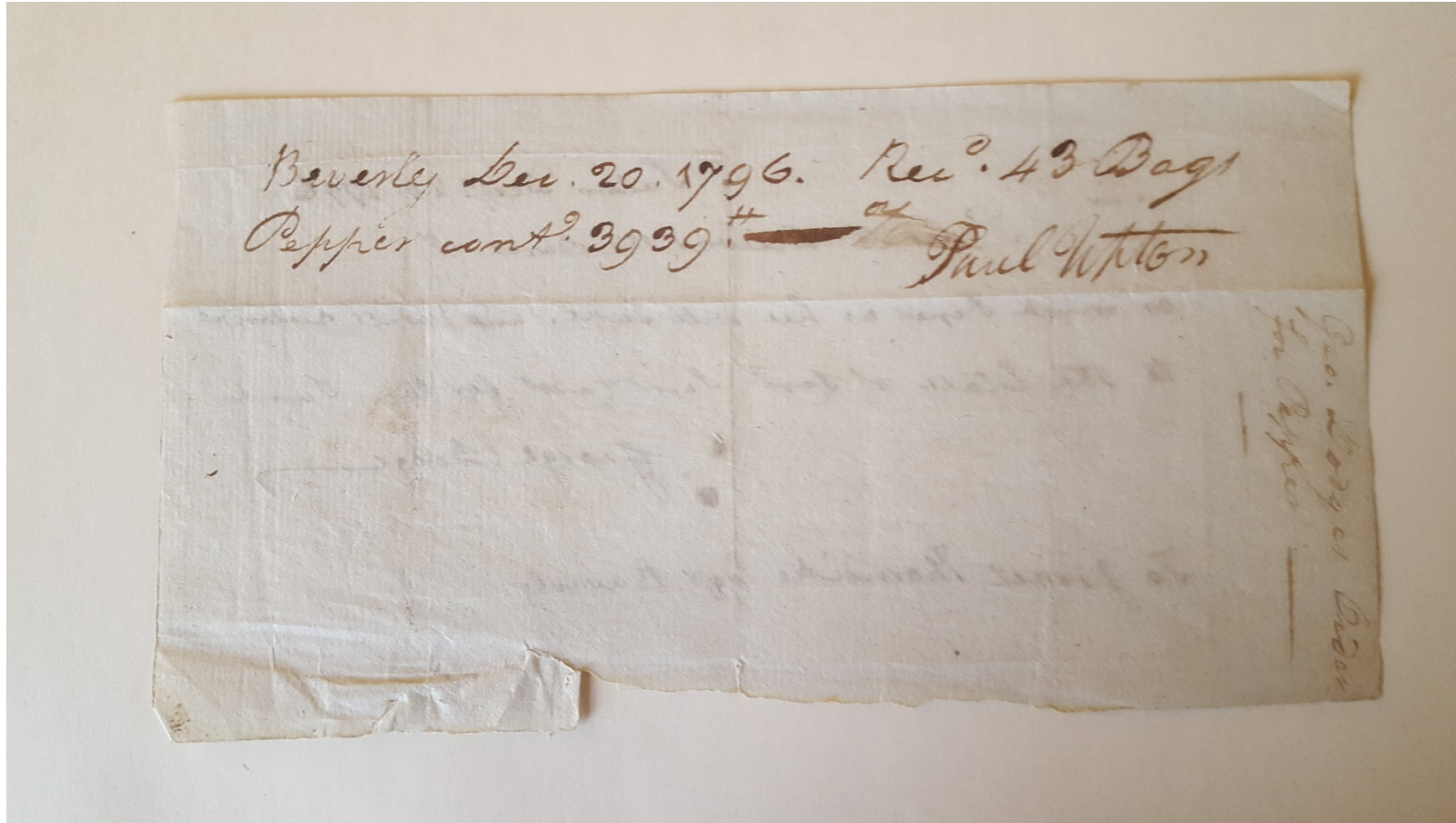




# Merchant's order for pepper, Salem, 1796

Salem Decr 20. 1796  
Sir  
Please to Deliver the Baver n<sup>o</sup>  
as much Pepper as he will Take, and I will amount  
to the Estate of Capt. Sam<sup>l</sup> Cabot for the Same  
George Dodge  
To Israel Thordike Esq. Baverly

On reverse: receipt for pepper





# Receipt, Boston, 1821

Kingston January 16 1822 This Day Received of  
Mr Thomas C Holmes in full of amount & pay for  
John C Work Done in 1821 John Prince 1822

# An 18<sup>th</sup>-century merchant's counting house (Hogarth "Industrious Apprentice," 1747)





Merchant's desk, Boston, 1780-90: office organization, 18<sup>th</sup>-c. style



# Bowditch's printed blank forms: predictable, standardized, systematic

44 APPLICATION FOR AN ENDOWMENT.

day of annually ;  
the first payment to be made on the day of  
The said having been  
born at on the day of  
in the year one thousand  
hundred and

THIS DECLARATION to be the basis of the agreement ; and  
if any thing false or fraudulent is contained therein, all monies  
paid, or which shall be paid to the Company in consequence  
thereof, shall be forfeited.

Dated 18

---

No. 3.

APPLICATION FOR A DEFERRED ANNUITY.

of in the State of  
on behalf of of in the State  
of desires to purchase an Annuity of  
dollars, for the life of of  
to commence at attaining the age of  
years, to be paid on the day of  
annually ; the first payment to be made on the day  
of in the year one thousand eight hundred and  
The said having been born  
at on the day of in the  
year one thousand hundred and

THIS DECLARATION to be the basis of the agreement : and if  
any thing false or fraudulent is contained therein, all monies paid,  
or which shall be paid to the Company in consequence thereof,  
shall be forfeited.

Dated at 18

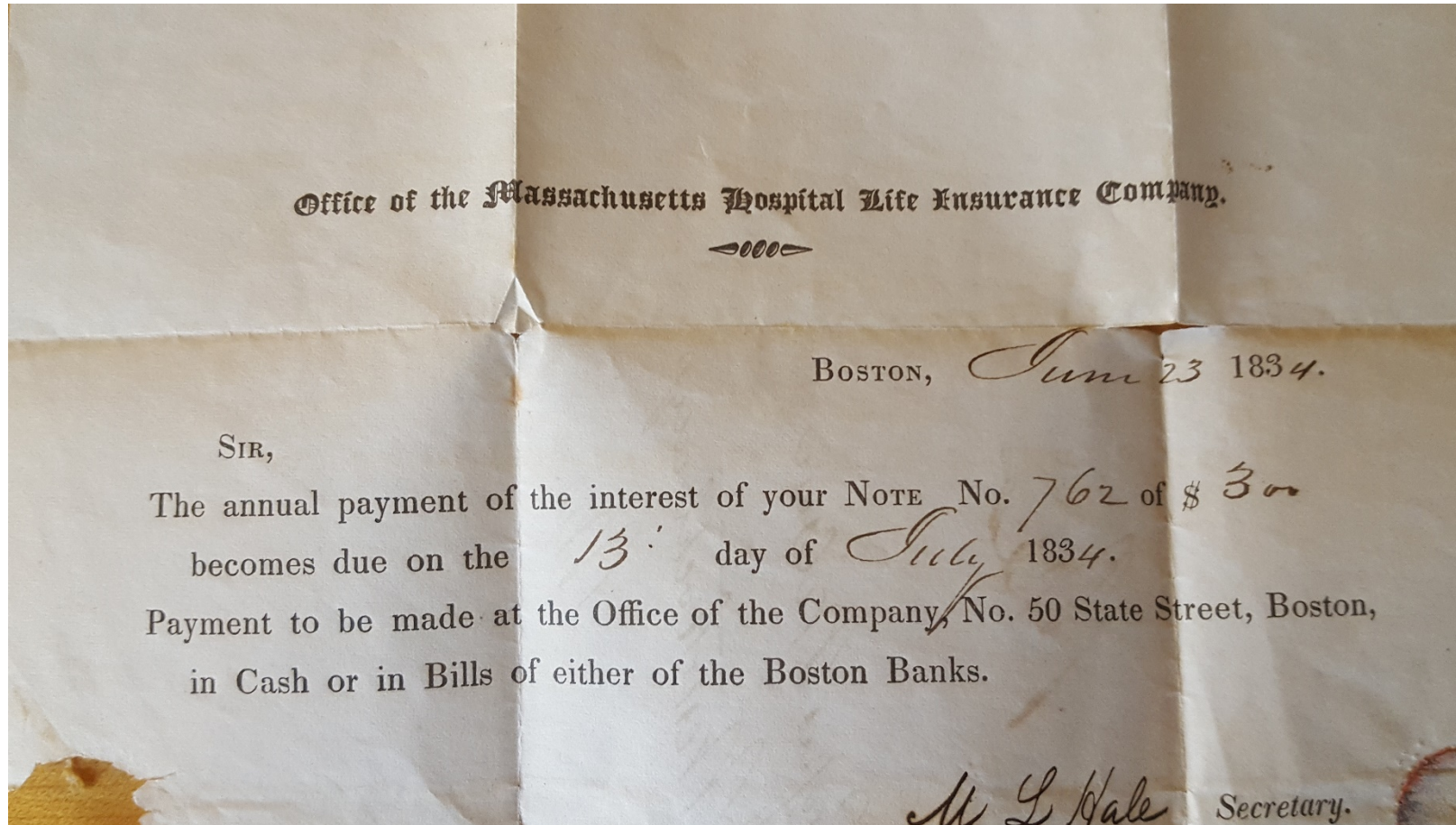
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No. 4.

APPLICATION FOR AN ENDOWMENT.

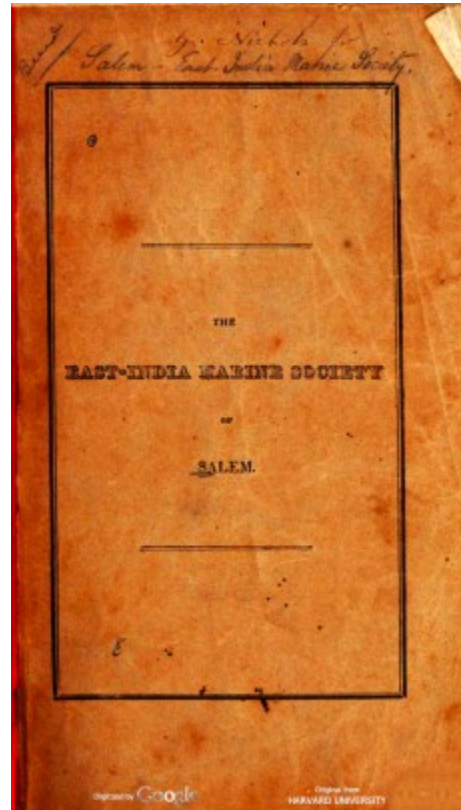
of in the State of  
on behalf of of

Bowditch's office procedures: Printed blank forms. Numbered loans.  
Firm due dates. Rule-bound regularity.





# Bowditch's 1821 East India Marine Society collections catalog: numbered objects



51	
Catalogue of the Museum.	
694,	An Iron Arrow-head, and case of Wood.
696,	A Stone Chisel, from the Marquesas, Wm. P. Richardson.
697,	Stone Chisel, found in Salem, Rev. Dr. Wm. Bentley.
698,	A Spear-head, of Stone, made by N. A. Indians, John Rust.
699, 709,	A Stone Chisel, and Arrow-head, found in Danvers, do. Nathan Reed.
700,	A Stone Chisel, from New Zealand, Wm. P. Richardson.
701, 704,	Stone Gouges, made by the Indians in New England.
702, 707, 708,	Stone Arrow-heads, do. Miss King.
703,	Stone Axe, found in New England, do.
705,	A Grey Gull, ( <i>Larus Naevius</i> ) Dr. Bass.
710, 711,	Heads for Arrows, made of Stone.
712, 713,	The two Valves of a <i>Chama Gigas</i> , from Sumatra, (the largest species of bivalve shells,) Jonathan Carney.
714, 717,	<i>Chama Hippopus</i> .
715, 716,	<i>Chama Gigas</i> , (small size.)
718,	A Chinese Angling Rod, C. Cronmishield & M. Folger.
719,	A Specimen of Rhode Island Coal.
720, 721,	Do. Carbonate of Lime, or Marble.
722,	Do. Mica, with Feldspar.
723,	Do. Free, or Sand-stone, from the Bay of Chaleur, R. Foster.
724, 725,	Do. Carbonate of Lime.
726, 728, 729,	Petrifications from Ohio, E. Hathorne.
727,	A Specimen of Basalt, from Owyhee, Wm. Fairfield.
731,	Do. Greenstone, ( <i>Grauwacke</i> , G.) with petrified Scallops embedded in it, from Montville, Maine. Nathan Reed.
732,	Specimen of a variety of Pitch-stone, from Louisiana.
733,	Do. Lava, from Owyhee.
734, 736, 737,	Petrifications, and Petrified Wood, from Ohio, E. Hathorne.
735,	A fragment of Silex, broken from one of the Pyramids in Egypt.
738, 739,	Specimen of the Norfolk Island Pine, John F. Jeffrie, by Capt. Holmes.

# Navigator table: the power of numbers

TABLE XXI. For finding the Latitude by two Altitudes of the Sun.

H O U R.											
M.	S.	Log. Sin.	Log. Cos.	Log. Tan.	Log. Sec.	M.	S.	Log. Sin.	Log. Cos.	Log. Tan.	Log. Sec.
0	0	0.58700	4.71403	3.53443		10	0	0.52186	4.77917	3.66542	
	10	0.58583	4.71520	3.53482			10	0.52086	4.78017	3.66547	
	20	0.58464	4.71638	3.53521			20	0.51986	4.78117	3.66552	
	30	0.58344	4.71755	3.53559			30	0.51886	4.78217	3.66556	
	40	0.58224	4.71871	3.53597			40	0.51786	4.78316	3.66559	
	50	0.58104	4.71988	3.53634			50	0.51686	4.78415	3.66562	
1	0	0.57999	4.72104	3.53670		11	0	0.51586	4.78514	3.66565	
	10	0.57884	4.72219	3.53705			10	0.51486	4.78612	3.66567	
	20	0.57768	4.72335	3.53740			20	0.51386	4.78710	3.66568	
	30	0.57652	4.72450	3.53773			30	0.51286	4.78809	3.66569	
	40	0.57536	4.72564	3.53806			40	0.51186	4.78906	3.66570	
	50	0.57420	4.72679	3.53841			50	0.51086	4.79004	3.66570	
2	0	0.57310	4.72793	3.53874		12	0	0.51000	4.79101	3.66569	
	10	0.57196	4.72907	3.53905			10	0.50900	4.79198	3.66569	
	20	0.57083	4.73020	3.53937			20	0.50800	4.79295	3.66567	
	30	0.56970	4.73133	3.53967			30	0.50700	4.79392	3.66566	
	40	0.56857	4.73246	3.53997			40	0.50600	4.79488	3.66563	
	50	0.56745	4.73359	3.54026			50	0.50500	4.79584	3.66561	
3	0	0.56633	4.73470	3.54055		13	0	0.50414	4.79680	3.66558	
	10	0.56521	4.73582	3.54083			10	0.50314	4.79776	3.66554	
	20	0.56409	4.73694	3.54110			20	0.50214	4.79871	3.66550	
	30	0.56298	4.73805	3.54137			30	0.50114	4.79966	3.66545	
	40	0.56187	4.73916	3.54163			40	0.50014	4.80061	3.66540	
	50	0.56076	4.74027	3.54189			50	0.49914	4.80156	3.66535	
4	0	0.55966	4.74137	3.54214		14	0	0.49814	4.80251	3.66530	
	10	0.55856	4.74247	3.54238			10	0.49714	4.80345	3.66523	
	20	0.55747	4.74356	3.54262			20	0.49614	4.80439	3.66516	
	30	0.55637	4.74466	3.54286			30	0.49514	4.80533	3.66509	
	40	0.55528	4.74575	3.54309			40	0.49414	4.80626	3.66501	
	50	0.55419	4.74684	3.54332			50	0.49314	4.80720	3.66493	
5	0	0.55311	4.74793	3.54354		15	0	0.49214	4.80811	3.66485	
	10	0.55203	4.74900	3.54377			10	0.49114	4.80906	3.66476	
	20	0.55095	4.75008	3.54399			20	0.49014	4.80999	3.66467	
	30	0.54987	4.75116	3.54421			30	0.48914	4.81091	3.66457	
	40	0.54880	4.75223	3.54443			40	0.48814	4.81183	3.66447	
	50	0.54773	4.75330	3.54465			50	0.48714	4.81275	3.66436	
6	0	0.54666	4.75437	3.54486		16	0	0.48614	4.81367	3.66425	
	10	0.54559	4.75544	3.54508			10	0.48514	4.81459	3.66413	
	20	0.54453	4.75650	3.54529			20	0.48414	4.81551	3.66401	
	30	0.54347	4.75756	3.54549			30	0.48314	4.81641	3.66389	
	40	0.54241	4.75861	3.54568			40	0.48214	4.81732	3.66376	
	50	0.54136	4.75967	3.54585			50	0.48114	4.81823	3.66363	
7	0	0.54031	4.76072	3.54600		17	0	0.48014	4.81914	3.66350	
	10	0.53926	4.76177	3.54618			10	0.47914	4.82004	3.66336	
	20	0.53821	4.76281	3.54634			20	0.47814	4.82094	3.66321	
	30	0.53718	4.76385	3.54649			30	0.47714	4.82182	3.66307	
	40	0.53614	4.76489	3.54662			40	0.47614	4.82274	3.66291	
	50	0.53510	4.76593	3.54674			50	0.47514	4.82363	3.66276	
8	0	0.53406	4.76697	3.54684		18	0	0.47414	4.82451	3.66260	
	10	0.53302	4.76800	3.54694			10	0.47314	4.82541	3.66243	
	20	0.53200	4.76903	3.54703			20	0.47214	4.82630	3.66227	
	30	0.53098	4.77005	3.54711			30	0.47114	4.82716	3.66209	
	40	0.52996	4.77108	3.54718			40	0.47014	4.82805	3.66192	
	50	0.52895	4.77210	3.54724			50	0.46914	4.82893	3.66174	
9	0	0.52793	4.77311	3.54729		19	0	0.46814	4.82984	3.66155	
	10	0.52692	4.77413	3.54733			10	0.46714	4.83072	3.66137	
	20	0.52591	4.77514	3.54737			20	0.46614	4.83159	3.66118	
	30	0.52489	4.77616	3.54741			30	0.46514	4.83244	3.66098	
	40	0.52388	4.77718	3.54744			40	0.46414	4.83328	3.66078	
	50	0.52286	4.77819	3.54747			50	0.46314	4.83411	3.66058	

18<sup>th</sup>-century orrery: the clockwork solar system, and the inspiration for Bowditch's clockwork institutions





Bowditch's grave: the navigator in 18<sup>th</sup>-century breeches

