

The Apportionment Problem

Bringing Down the House

Charles Biles, Ph.D.
Mathematics 10: Nature of Mathematics
Santa Rosa Junior College
Spring Semester 2019

website: nia977.wix.com/drbcap

“... no political problem is less susceptible of a precise solution than that which relates to the number most convenient for a representative legislature, ...”

James Madison
The Federalist 55

The Apportionment Problem

Bringing Down the House

Charles Biles, Ph.D.
Mathematics 10: Nature of Mathematics
Santa Rosa Junior College
Spring Semester 2019

website: nia977.wix.com/drbcap



“... no political problem is less susceptible of a precise solution than that which relates to the number most convenient for a representative legislature, ...”

James Madison
The Federalist 55

The Apportionment Problem

Bringing Down the House

Charles Biles, Ph.D.
Mathematics 10: Nature of Mathematics
Santa Rosa Junior College
Spring Semester 2019



website: nia977.wix.com/drbcap



“... no political problem is less susceptible of a precise solution than that which relates to the number most convenient for a representative legislature, ...”

James Madison
The Federalist 55

The Apportionment Problem

Bringing Down the House

Charles Biles, Ph.D.
Mathematics 10: Nature of Mathematics
Santa Rosa Junior College
Spring Semester 2019



website: nia977.wix.com/drbcap



“... no political problem is less susceptible of a precise solution than that which relates to the number most convenient for a representative legislature, ...”

James Madison
The Federalist 55

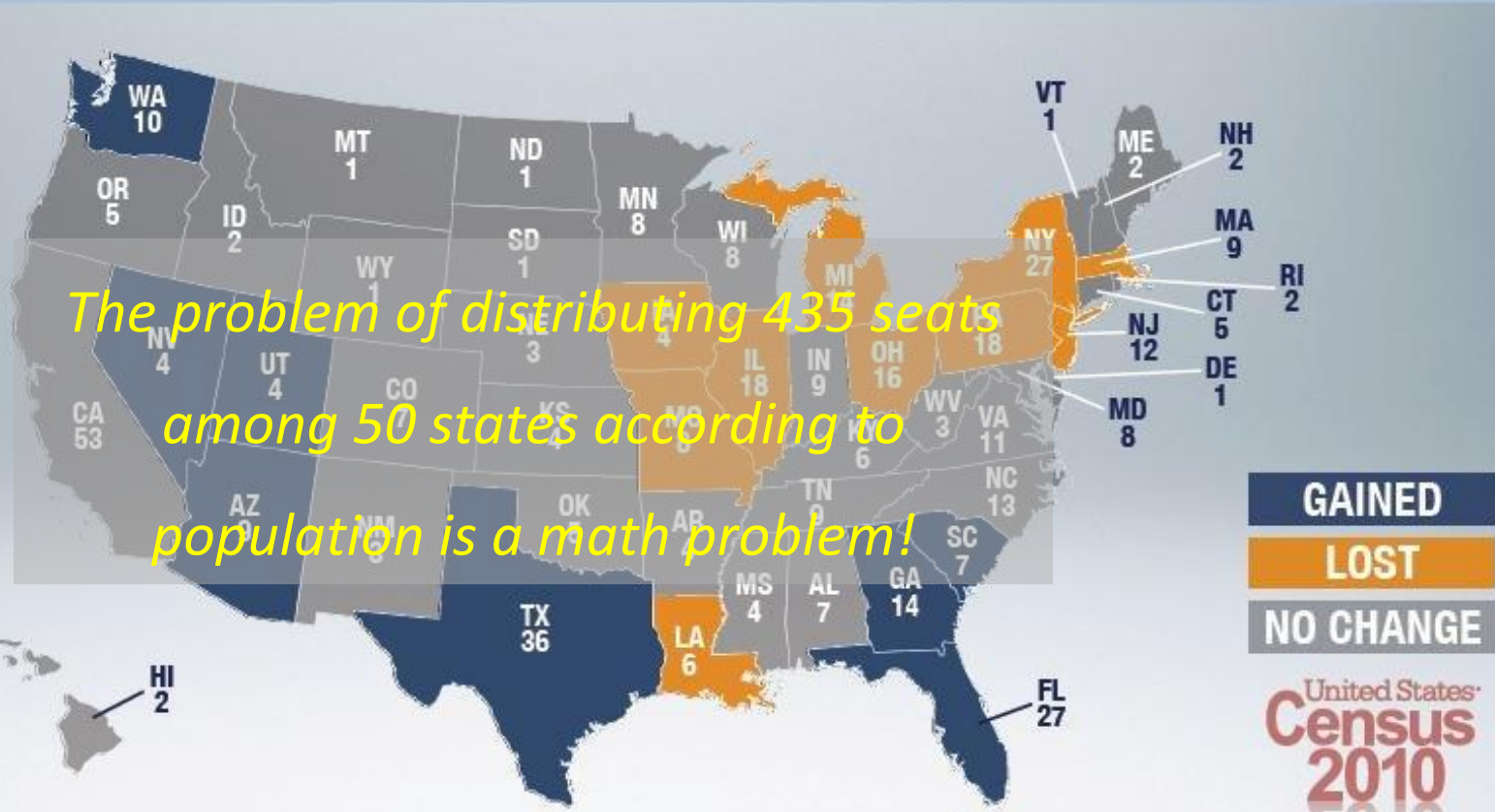


The Apportionment Problem

Determine how many seats in the U.S.
House of Representatives each state gets.

CONGRESSIONAL SEATS

2010
OFFICIAL RESULTS



(US apportionment population = 309,183,463)/**435** \approx 710,767

<http://www.census.gov/2010census/data/apportionment-data.php>

The First Census 1790

State	Population
CT 5	236841
DE 1	55540
GA 3	70835
KY 2	68705
MD 6	278514
MA 8	475327
NH 3	141822
NJ 4	179570
NY 6	331589
NC 5	353523
PA 8	432879
RI 1	68446
SC 5	206236
VT 2	85533
VA 10	630560
US 67	3615920

The first apportionment population census.

Source:
Balinski and Young,
Fair Representation,
Second Edition, 2001,
page 158.

First Apportionment Bills

Census 1790

State Population	
CT	236841
DE	55540
GA	70835
KY	68705
MD	278514
MA	475327
NH	141822
NJ	179570
NY	331589
NC	353523
PA	432879
RI	68446
SC	206236
VT	85533
VA	630560
US	3615920

First Apportionment Bills

Census 1790

State	Population
CT	236841
DE	55540
GA	70835
KY	68705
MD	278514
MA	475327
NH	141822
NJ	179570
NY	331589
NC	353523
PA	432879
RI	68446
SC	206236
VT	85533
VA	630560
US	3615920

3792621 — City of Los Angeles 2010

First Apportionment Bills

Census 1790		House Bill
State	Population	30000
CT	236841	
DE	55540	
GA	70835	
KY	68705	
MD	278514	
MA	475327	
NH	141822	
NJ	179570	
NY	331589	
NC	353523	
PA	432879	
RI	68446	
SC	206236	
VT	85533	
VA	630560	
US	3615920	

First Apportionment Bills

Census 1790		House Bill
State	Population	Divisor 30000
CT	236841	
DE	55540	
GA	70835	
KY	68705	
MD	278514	
MA	475327	
NH	141822	
NJ	179570	
NY	331589	
NC	353523	
PA	432879	
RI	68446	
SC	206236	
VT	85533	
VA	630560	
US	3615920	

First Apportionment Bills

Census 1790		House Bill
State	Population	Divisor 30000
CT	236841	7.895
DE	55540	1.851
GA	70835	2.361
KY	68705	2.290
MD	278514	9.284
MA	475327	15.844
NH	141822	4.727
NJ	179570	5.986
NY	331589	11.053
NC	353523	11.784
PA	432879	14.429
RI	68446	2.282
SC	206236	6.875
VT	85533	2.851
VA	630560	21.019
US	3615920	

First Apportionment Bills

Census 1790		House Bill	
State	Population	Divisor 30000	Seats
CT	236841	7.895	7
DE	55540	1.851	1
GA	70835	2.361	2
KY	68705	2.290	2
MD	278514	9.284	9
MA	475327	15.844	15
NH	141822	4.727	4
NJ	179570	5.986	5
NY	331589	11.053	11
NC	353523	11.784	11
PA	432879	14.429	14
RI	68446	2.282	2
SC	206236	6.875	6
VT	85533	2.851	2
VA	630560	21.019	21
US	3615920		

First Apportionment Bills

Census 1790		House Bill	
State	Population	Divisor 30000	Seats
CT	236841	7.895	7
DE	55540	1.851	1
GA	70835	2.361	2
KY	68705	2.290	2
MD	278514	9.284	9
MA	475327	15.844	15
NH	141822	4.727	4
NJ	179570	5.986	5
NY	331589	11.053	11
NC	353523	11.784	11
PA	432879	14.429	14
RI	68446	2.282	2
SC	206236	6.875	6
VT	85533	2.851	2
VA	630560	21.019	21
US	3615920		112

First Apportionment Bills

Census 1790		House Bill		Senate Bill	
State	Population	Divisor 30000	Seats	Divisor 33000	Seats
CT	236841	7.895	7	7.177	7
DE	55540	1.851	1	1.683	1
GA	70835	2.361	2	2.147	2
KY	68705	2.290	2	2.082	2
MD	278514	9.284	9	8.440	8
MA	475327	15.844	15	14.404	14
NH	141822	4.727	4	4.298	4
NJ	179570	5.986	5	5.442	5
NY	331589	11.053	11	10.048	10
NC	353523	11.784	11	10.713	10
PA	432879	14.429	14	13.118	13
RI	68446	2.282	2	2.074	2
SC	206236	6.875	6	6.250	6
VT	85533	2.851	2	2.592	2
VA	630560	21.019	21	19.108	19
US	3615920		112		

First Apportionment Bills

Census 1790		House Bill		Senate Bill	
State	Population	Divisor 30000	Seats	Divisor 33000	Seats
CT	236841	7.895	7	7.177	7
DE	55540	1.851	1	1.683	1
GA	70835	2.361	2	2.147	2
KY	68705	2.290	2	2.082	2
MD	278514	9.284	9	8.440	8
MA	475327	15.844	15	14.404	14
NH	141822	4.727	4	4.298	4
NJ	179570	5.986	5	5.442	5
NY	331589	11.053	11	10.048	10
NC	353523	11.784	11	10.713	10
PA	432879	14.429	14	13.118	13
RI	68446	2.282	2	2.074	2
SC	206236	6.875	6	6.250	6
VT	85533	2.851	2	2.592	2
VA	630560	21.019	21	19.108	19
US	3615920		112		105

Rule of Three

Federalists in Congress apply a new idea:

Multiply the House size by each state's proportion to determine each state's **quota** (fair share of the House).

Rule of Three

Federalists in Congress apply a new idea:

Multiply the House size by each state's proportion to determine each state's **quota** (fair share of the House).

$$\text{quota} = (\text{House size}) \times \frac{\text{state population}}{\text{national population}}$$

Rule of Three

Federalists in Congress apply a new idea:

Multiply the House size by each state's proportion to determine each state's **quota** (fair share of the House).

$$\text{quota} = (\text{House size}) \times \frac{\text{state population}}{\text{national population}}$$

Rule of Three

The House Bill

Census 1790

House Bill

State Population		Divisor 30000	Seats
CT	236841	7.895	7
DE	55540	1.851	1
GA	70835	2.361	2
KY	68705	2.290	2
MD	278514	9.284	9
MA	475327	15.844	15
NH	141822	4.727	4
NJ	179570	5.986	5
NY	331589	11.053	11
NC	353523	11.784	11
PA	432879	14.429	14
RI	68446	2.282	2
SC	206236	6.875	6
VT	85533	2.851	2
VA	630560	21.019	21
US	3615920		

The House Bill

Census 1790

House Bill

State Population		Divisor 30000	Seats
CT	236841	7.895	7
DE	55540	1.851	1
GA	70835	2.361	2
KY	68705	2.290	2
MD	278514	9.284	9
MA	475327	15.844	15
NH	141822	4.727	4
NJ	179570	5.986	5
NY	331589	11.053	11
NC	353523	11.784	11
PA	432879	14.429	14
RI	68446	2.282	2
SC	206236	6.875	6
VT	85533	2.851	2
VA	630560	21.019	21
US	3615920		112

The House Bill

Census 1790

House Bill

State Population		Divisor 30000	Seats	$h=112$
CT	236841	7.895	7	
DE	55540	1.851	1	
GA	70835	2.361	2	
KY	68705	2.290	2	
MD	278514	9.284	9	
MA	475327	15.844	15	
NH	141822	4.727	4	
NJ	179570	5.986	5	
NY	331589	11.053	11	
NC	353523	11.784	11	
PA	432879	14.429	14	
RI	68446	2.282	2	
SC	206236	6.875	6	
VT	85533	2.851	2	
VA	630560	21.019	21	
US	3615920		112	

The House Bill

Census 1790

House Bill

State Population		Divisor 30000	Seats	Quota $h=112$
CT	236841	7.895	7	7.336
DE	55540	1.851	1	1.720
GA	70835	2.361	2	2.194
KY	68705	2.290	2	2.128
MD	278514	9.284	9	8.627
MA	475327	15.844	15	14.723
NH	141822	4.727	4	4.393
NJ	179570	5.986	5	5.562
NY	331589	11.053	11	10.271
NC	353523	11.784	11	10.950
PA	432879	14.429	14	13.408
RI	68446	2.282	2	2.120
SC	206236	6.875	6	6.388
VT	85533	2.851	2	2.649
VA	630560	21.019	21	19.531
US	3615920		112	112

Problem

Census 1790

House Bill

State Population		Divisor 30000	Seats	Quota $h=112$
CT	236841	7.895	7	7.336
DE	55540	1.851	1	1.720
GA	70835	2.361	2	2.194
KY	68705	2.290	2	2.128
MD	278514	9.284	9	8.627
MA	475327	15.844	15	14.723
NH	141822	4.727	4	4.393
NJ	179570	5.986	5	5.562
NY	331589	11.053	11	10.271
NC	353523	11.784	11	10.950
PA	432879	14.429	14	13.408
RI	68446	2.282	2	2.120
SC	206236	6.875	6	6.388
VT	85533	2.851	2	2.649
VA	630560	21.019	21	19.531
US	3615920		112	112

The Quota Rule is violated.

The Senate Bill

Census 1790

Senate Bill

State Population		Divisor 33000 Seats		Quota $h=105$
CT	236841	7.177	7	6.877
DE	55540	1.683	1	1.613
GA	70835	2.147	2	2.057
KY	68705	2.082	2	1.995
MD	278514	8.440	8	8.088
MA	475327	14.404	14	13.803
NH	141822	4.298	4	4.118
NJ	179570	5.442	5	5.214
NY	331589	10.048	10	9.629
NC	353523	10.713	10	10.266
PA	432879	13.118	13	12.570
RI	68446	2.074	2	1.988
SC	206236	6.250	6	5.989
VT	85533	2.592	2	2.484
VA	630560	19.108	19	18.310
US	3615920		105	105



No
Quota Rule
Violation

Problem

Census 1790		Senate Bill		
State	Population	Divisor 33000	Seats	Quota $h=105$
CT	236841	7.177	7	6.877
DE	55540	1.683	1	1.613
GA	70835	2.147	2	2.057
KY	68705	2.082	2	1.995
MD	278514	8.440	8	8.088
MA	475327	14.404	14	13.803
NH	141822	4.298	4	4.118
NJ	179570	5.442	5	5.214
NY	331589	10.048	10	9.629
NC	353523	10.713	10	10.266
PA	432879	13.118	13	12.570
RI	68446	2.074	2	1.988
SC	206236	6.250	6	5.989
VT	85533	2.592	2	2.484
VA	630560	19.108	19	18.310
US	3615920		105	105

Large states are favored over small states.



Hamilton's Method

State	Population	
CT	236841	
DE	55540	
GA	70835	
KY	68705	
MD	278514	
MA	475327	
NH	141822	
NJ	179570	
NY	331589	
NC	353523	
PA	432879	
RI	68446	
SC	206236	
VT	85533	
VA	630560	
US	3615920	120.5307

$d = 30000$

Hamilton's Method

State	Population	$h = 120$
CT	236841	
DE	55540	
GA	70835	
KY	68705	
MD	278514	
MA	475327	
NH	141822	
NJ	179570	
NY	331589	
NC	353523	
PA	432879	
RI	68446	
SC	206236	
VT	85533	
VA	630560	
US	3615920	120.5307

$d = 30000$

Hamilton's Method

State	Population	$h = 120$	Quota
CT	236841		7.860
DE	55540		1.843
GA	70835		2.351
KY	68705		2.280
MD	278514		9.243
MA	475327		15.774
NH	141822		4.707
NJ	179570		5.959
NY	331589		11.004
NC	353523		11.732
PA	432879		14.366
RI	68446		2.271
SC	206236		6.844
VT	85533		2.839
VA	630560		20.926
US	3615920	120.5307	120

$$= 120 \times \frac{236841}{3615920}$$

$d = 30000$

Hamilton's Method

State	Population	$h = 120$	Quota	Lower Q
CT	236841		7.860	7
DE	55540		1.843	1
GA	70835		2.351	2
KY	68705		2.280	2
MD	278514		9.243	9
MA	475327		15.774	15
NH	141822		4.707	4
NJ	179570		5.959	5
NY	331589		11.004	11
NC	353523		11.732	11
PA	432879		14.366	14
RI	68446		2.271	2
SC	206236		6.844	6
VT	85533		2.839	2
VA	630560		20.926	20
US	3615920	120.5307	120	111

$d = 30000$

Hamilton's Method

State	Population	$h = 120$	Quota	Lower Q	Appt
CT	236841		7.860	7	8
DE	55540		1.843	1	2
GA	70835		2.351	2	2
KY	68705		2.280	2	2
MD	278514		9.243	9	9
MA	475327		15.774	15	16
NH	141822		4.707	4	5
NJ	179570		5.959	5	6
NY	331589		11.004	11	11
NC	353523		11.732	11	12
PA	432879		14.366	14	14
RI	68446		2.271	2	2
SC	206236		6.844	6	7
VT	85533		2.839	2	3
VA	630560		20.926	20	21
US	3615920	120.5307	120	111	120

$d = 30000$

Hamilton's Method

State	Population	$h = 120$	Quota	Lower Q	Appt
CT	236841		7.860	7	8
DE	55540		1.843	1	2
GA	70835		2.351	2	2
KY	68705		2.280	2	2
MD	278514		9.243	9	9
MA	475327		15.774	15	16
NH	141822		4.707	4	5
NJ	179570		5.959	5	6
NY	331589		11.004	11	11
NC	353523		11.732	11	12
PA	432879		14.366	14	14
RI	68446		2.271	2	2
SC	206236		6.844	6	7
VT	85533		2.839	2	3
VA	630560		20.926	20	21
US	3615920	120.5307	120	111	120

This became the first apportionment bill passed by Congress.

Hamilton's Method

State	Population	$h = 120$	Quota	Lower Q	Appt
CT	236841		7.860	7	8
DE	55540		1.843	1	2
GA	70835		2.351	2	2
KY	68705		2.280	2	2
MD	278514		9.243	9	9
MA	475327		15.774	15	16
NH	141822		4.707	4	5
NJ	179570		5.959	5	6
NY	331589		11.004	11	11
NC	353523		11.732	11	12
PA	432879		14.366	14	14
RI	68446		2.271	2	2
SC	206236		6.844	6	7
VT	85533		2.839	2	3
VA	630560		20.926	20	21
US	3615920	120.5307	120	111	120

This became the first apportionment bill passed by Congress.

The bill is sent to President Washington for approval.

Hamilton's Method

State	Population	$h = 120$	Quota	Lower Q	Appt
CT	236841		7.860	7	8
DE	55540		1.843	1	2
GA	70835		2.351	2	2
KY	68705		2.280	2	2
MD	278514		9.243	9	9
MA	475327		15.774	15	16
NH	141822		4.707	4	5
NJ	179570		5.959	5	6
NY	331589		11.004	11	11
NC	353523		11.732	11	12
PA	432879		14.366	14	14
RI	68446		2.271	2	2
SC	206236		6.844	6	7
VT	85533		2.839	2	3
VA	630560		20.926	20	21
US	3615920	120.5307	120	111	120

This became the first apportionment bill passed by Congress.

The bill is sent to President Washington for approval.

Washington vetoes the bill.

Hamilton's Method

State	Population	$h = 120$	Quota	Lower Q	Appt
CT	236841		7.860	7	8
DE	55540		1.843	1	2
GA	70835		2.351	2	2
KY	68705		2.280	2	2
MD	278514		9.243	9	9
MA	475327		15.774	15	16
NH	141822		4.707	4	5
NJ	179570		5.959	5	6
NY	331589		11.004	11	11
NC	353523		11.732	11	12
PA	432879		14.366	14	14
RI	68446		2.271	2	2
SC	206236		6.844	6	7
VT	85533		2.839	2	3
VA	630560		20.926	20	21
US	3615920	120.5307	120	111	120

U.S.:
 $3615920/120 = 30,132.66\dots$

Hamilton's Method

State	Population	$h = 120$	Quota	Lower Q	Appt
CT	236841		7.860	7	8
DE	55540		1.843	1	2
GA	70835		2.351	2	2
KY	68705		2.280	2	2
MD	278514		9.243	9	9
MA	475327		15.774	15	16
NH	141822		4.707	4	5
NJ	179570		5.959	5	6
NY	331589		11.004	11	11
NC	353523		11.732	11	12
PA	432879		14.366	14	14
RI	68446		2.271	2	2
SC	206236		6.844	6	7
VT	85533		2.839	2	3
VA	630560		20.926	20	21
US	3615920	120.5307	120	111	120

Connecticut:
 $236841/8 = 29605.13$

Delaware:
 $55540/2 = 27770$

U.S.:
 $3615920/120 = 30,132.66...$

Basic Jefferson Method

After Washington's veto on 5 April 1792,
Congress quickly passes the original Senate bill.
Washington signed the bill on 14 April 1792.

Two Methodologies

- Divisor Methods
- Quota Methods

Two Methodologies

- Divisor Methods
 - Basic
 - Modified
- Quota Methods

Two Methodologies

- Divisor Methods
 - Basic: *h is the result*
 - Modified
- Quota Methods

Two Methodologies

- Divisor Methods
 - Basic: h is the result
 - Modified: h is the goal
- Quota Methods

Two Methodologies

- Divisor Methods
 - Basic: h is the result
 - Modified: h is the goal
- Quota Methods
 - h is the resource

Basic Jefferson Method

Basic Jefferson Method

1. Decide on a divisor.

Basic Jefferson Method

1. Decide on a divisor.
2. Calculate each state's quotient:
$$\text{quotient} = \text{population} / \text{divisor}$$

Basic Jefferson Method

1. Decide on a divisor.
2. Calculate each state's quotient:
$$\text{quotient} = \text{population} / \text{divisor}$$
3. The state's apportionment is the quotient rounded down.

The resulting house size is the sum of the state apportionments.

First 60 years

A Basic Divisor Method would be used as the House apportionment method until 1850.

- ❖ 1790: $s = 15; d = 33000 \Rightarrow h = 105$
- ❖ 1800: $s = 16; d = 33000 \Rightarrow h = 141$
- ❖ 1810: $s = 17; d = 35000 \Rightarrow h = 181$
- ❖ 1820: $s = 24; d = 40000 \Rightarrow h = 213$
- ❖ 1830: $s = 24; d = 47700 \Rightarrow h = 240$
- ❖ 1840: $s = 26; d = 70680 \Rightarrow h = 223$

number of states

divisor (ratio of representation)

House size

Basic Jefferson Method

Problems are discovered as the method is used;
however, defects were evident from the beginning.

Basic Jefferson Method

Problems are discovered as the method is used; however, defects were evident from the beginning.

Jefferson's method systematically favors larger states; further, it can violate the Quota Rule.

1830 Census

Three new methods are proposed to deal with the decimal part of a state's quotient.

1830 Census

Three new methods are proposed to deal with the decimal part of a state's quotient.

Jefferson: round down (drop the decimal).

1830 Census

Three new methods are proposed to deal with the decimal part of a state's quotient.

Jefferson: round down (drop the decimal).

Adams: round up.

1830 Census

Three new methods are proposed to deal with the decimal part of a state's quotient.

Jefferson: round down (drop the decimal).

Adams: round up.

Dean: round down or up according to which option gives a state's constituency closest to the divisor.

1830 Census

Three new methods are proposed to deal with the decimal part of a state's quotient.

Jefferson: round down (drop the decimal).

Adams: round up.

Dean: round down or up according to which option gives a state's constituency closest to the divisor.

Webster: round normally.

James Dean

The 1830 US population was 11,931,578.
Consider: constituency = 50,000 people.

James Dean

The 1830 US population was 11,931,578.

Consider: constituency = 50,000 people.

Vermont's population: 280,657.

Vermont's quotient: $280,657/50,000 = 5.613$.

James Dean

The 1830 US population was 11,931,578.

Consider: constituency = 50,000 people.

Vermont's population: 280,657.

Vermont's quotient: $280,657 / 50,000 = 5.613$.

Jefferson: 5 seats

Adams: 6 seats

James Dean

The 1830 US population was 11,931,578.
Consider: constituency = 50,000 people.

Vermont's population: 280,657.

Vermont's quotient: $280,657/50,000 = 5.613$.

Jefferson: 5 seats; constituency is $280,657/5 = 56,131$.

Adams: 6 seats; constituency is $280,657/6 = 46,776$.

James Dean

The 1830 US population was 11,931,578.
Consider: constituency = 50,000 people.

Vermont's population: 280,657.

Vermont's quotient: $280,657/50,000 = 5.613$.

Jefferson: 5 seats; constituency is $280,657/5 = 56,131$.

Adams: 6 seats; constituency is $280,657/6 = 46,776$.

Dean: 46,776 is closer to the target of 50,000; award Vermont 6 seats.

James Dean

Step 1: Select the constituency, d .

Step 2: Calculate $q = p/d$ and $n = \text{int}(q)$.

Step 3: The apportionment is either n or $n+1$,
with $n+1$ when $p/(n+1)$ is closer to d than p/n .

James Dean

Step 1: Select the constituency, d .

Step 2: Calculate $q = p/d$ and $n = \text{int}(q)$.

Step 3: The apportionment is either n or $n+1$,
with $n+1$ when $p/(n+1)$ is closer to d than p/n .



James Dean

Step 1: Select the constituency, d .

Step 2: Calculate $q = p/d$ and $n = \text{int}(q)$.

Step 3: The apportionment is either n or $n+1$,
with $n+1$ when $p/(n+1)$ is closer to d than p/n .



This is mathematically equivalent to: let the apportionment be $n + 1$ when

James Dean

Step 1: Select the constituency, d .

Step 2: Calculate $q = p/d$ and $n = \text{int}(q)$.

Step 3: The apportionment is either n or $n+1$,
with $n+1$ when $p/(n+1)$ is closer to d than p/n .



This is mathematically equivalent to: let the apportionment be $n + 1$ when $q \geq \text{HaM}(n, n+1)$.

Daniel Webster

Step 1: Select the constituency, d .

Step 2: Calculate $q = p/d$ and $n = \text{int}(q)$.

Step 3: The apportionment is either n or $n+1$,
with $n+1$ when $q \geq n + .5$

Daniel Webster

Step 1: Select the constituency, d .

Step 2: Calculate $q = p/d$ and $n = \text{int}(q)$.

Step 3: The apportionment is either n or $n+1$,
with $n+1$ when $q \geq n + .5 = \text{ArM}(n, n+1)$.

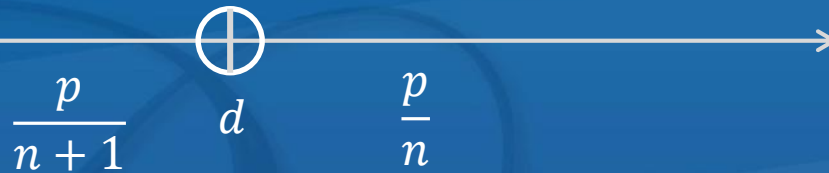
Daniel Webster

Step 1: Select the constituency, d .

Step 2: Calculate $q = p/d$ and $n = \text{int}(q)$.

Step 3: The apportionment is either n or $n+1$,
with $n+1$ when $q \geq n + .5 = \text{ArM}(n, n+1)$.

Dean:

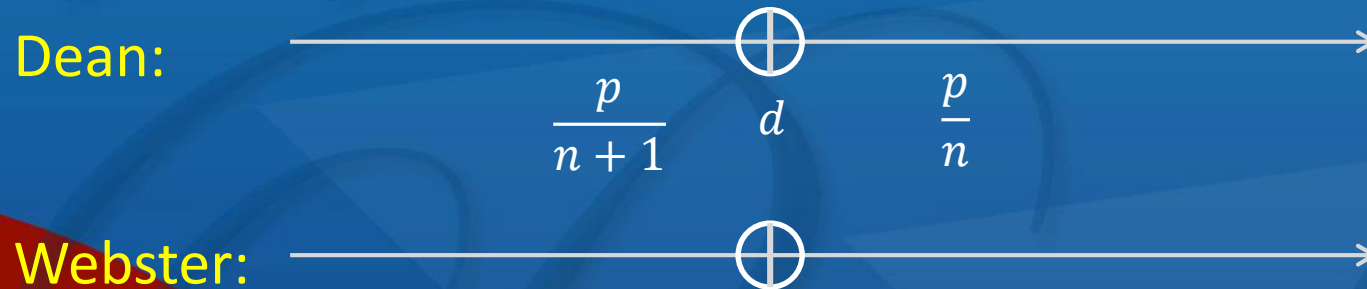


Daniel Webster

Step 1: Select the constituency, d .

Step 2: Calculate $q = p/d$ and $n = \text{int}(q)$.

Step 3: The apportionment is either n or $n+1$,
with $n+1$ when $q \geq n + .5 = \text{ArM}(n, n+1)$.



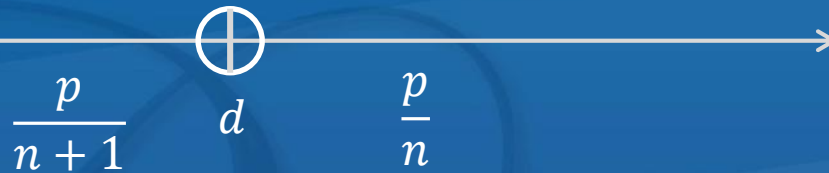
Daniel Webster

Step 1: Select the constituency, d .

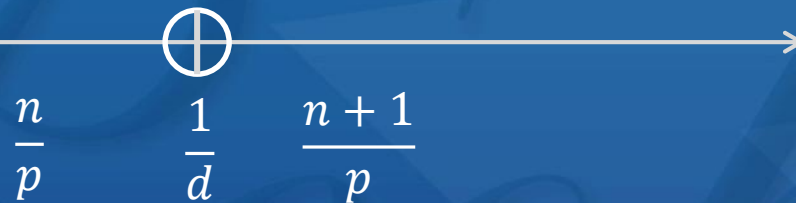
Step 2: Calculate $q = p/d$ and $n = \text{int}(q)$.

Step 3: The apportionment is either n or $n+1$,
with $n+1$ when $q \geq n + .5 = \text{ArM}(n, n+1)$.

Dean:



Webster:



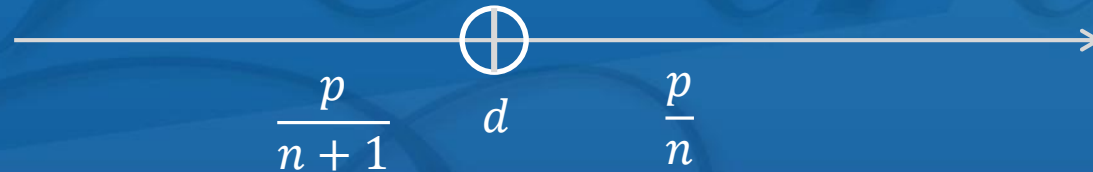
Dean and Webster

Step 1: Select the constituency, d .

Step 2: Calculate $q = p/d$ and $n = \text{int}(q)$.

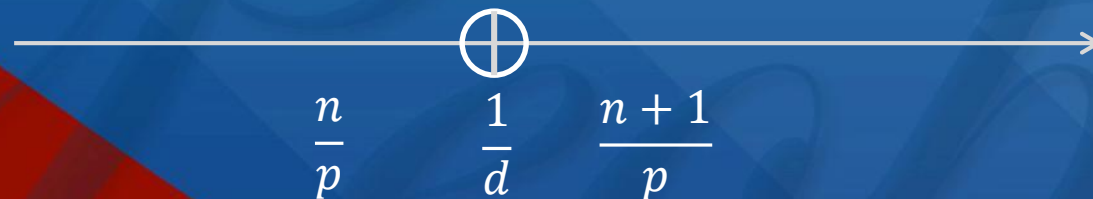
Step 3: The apportionment is either n or $n+1$,
with $n+1$ when

Dean:



Dean: $a = n+1 \iff \text{HaM}(n, n+1) \leq q.$

Webster:



Webster: $a = n+1 \iff \text{ArM}(n, n+1) \leq q.$

1830 Census

There were four different proposed apportionment methods based on a given divisor. The difference was in how the method chose to round a state's quotient (state's population divided by the chosen divisor).

1830 Census

There were four different proposed apportionment methods based on a given divisor. The difference was in how the method chose to round a state's quotient (state's population divided by the chosen divisor).

Jefferson: round down (min).

Adams: round up (max).

Dean: round by closest constituency (HaM).

Webster: round normally (ArM).

In a Round About Way

Census 1810		$d = 35000$				
State	Population	Quotient	min	ArM	HaM	max
CT	261818	7.4805	7	7	8	8
DE	71004	2.0287	2	2	2	3
GA	210346	6.0099	6	6	6	7
KY	374287	10.6939	10	11	11	11
MD	335946	9.5985	9	10	10	10
MA	700745	20.0213	20	20	20	21
NH	214460	6.1274	6	6	6	7
NJ	241222	6.8921	6	7	7	7
NY	953043	27.2298	27	27	27	28
NC	487971	13.9420	13	14	14	14
OH	230760	6.5931	6	7	7	7
PA	809773	23.1364	23	23	23	24
RI	76931	2.1980	2	2	2	3
SC	336569	9.6163	9	10	10	10
TN	243913	6.9689	6	7	7	7
VT	217895	6.2256	6	6	6	7
VA	817594	23.3598	23	23	23	24
US	6575234	188.1222	181	188	189	198

In a Round About Way

Census 1810		$d = 35000$				
State	Population	Quotient	min	ArM	HaM	max
CT	261818	7.4805	7	7	8	8
DE	71004	2.0287	2	2	2	3
GA	210346	6.0099	6	6	6	7
KY	374287	10.6939	10	11	11	11
MD	335946	9.5985	9	10	10	10
MA	700745	20.0213	20	20	20	21
NH	214460	6.1274	6	6	6	7
NJ	241222	6.8921	6	7	7	7
NY	953043	27.2298	27	27	27	28
NC	487971	13.9420	13	14	14	14
OH	230760	6.5931	6	7	7	7
PA	809773	23.1364	23	23	23	24
RI	76931	2.1980	2	2	2	3
SC	336569	9.6163	9	10	10	10
TN	243913	6.9689	6	7	7	7
VT	217895	6.2256	6	6	6	7
VA	817594	23.3598	23	23	23	24
US	6575234	188.1222	181	188	189	198

In a Round About Way

Census 1810		$d = 35000$				
State	Population	Quotient	min	ArM	HaM	max
CT	261818	7.4805	7	7	8	8
DE	71004	2.0287	2	2	2	3
GA	210346	6.0099	6	6	6	7
KY	374287	10.6939	10	11	11	11
MD	335946	9.5985	9	10	10	10
MA	700745	20.0213	20	20	20	21
NH	214460	6.1274	6	6	6	7
NJ	241222	6.8921	6	7	7	7
NY	953043	27.2298	27	27	27	28
NC	487971	13.9420	13	14	14	14
OH	230760	6.5931	6	7	7	7
PA	809773	23.1364	23	23	23	24
RI	76931	2.1980	2	2	2	3
SC	336569	9.6163	9	10	10	10
TN	243913	6.9689	6	7	7	7
VT	217895	6.2256	6	6	6	7
VA	817594	23.3598	23	23	23	24
US	6575234	188.1222	181	188	189	198

In a Round About Way

Census 1810		$d = 35000$				
State	Population	Quotient	min	ArM	HaM	max
CT	261818	7.4805	7	7	8	8
DE	71004	2.0287	2	2	2	3
GA	210346	6.0099	6	6	6	7
KY	374287	10.6939	10	11	11	11
MD	335946	9.5985	9	10	10	10
MA	700745	20.0213	20	20	20	21
NH	214460	6.1274	6	6	6	7
NJ	241222	6.8921	6	7	7	7
NY	953043	27.2298	27	27	27	28
NC	487971	13.9420	13	14	14	14
OH	230760	6.5931	6	7	7	7
PA	809773	23.1364	23	23	23	24
RI	76931	2.1980	2	2	2	3
SC	336569	9.6163	9	10	10	10
TN	243913	6.9689	6	7	7	7
VT	217895	6.2256	6	6	6	7
VA	817594	23.3598	23	23	23	24
US	6575234	188.1222	181	188	189	198

In a Round About Way

Census 1810		$d = 35000$				
State	Population	Quotient	Jefferson	ArM	HaM	max
CT	261818	7.4805	7	7	8	8
DE	71004	2.0287	2	2	2	3
GA	210346	6.0099	6	6	6	7
KY	374287	10.6939	10	11	11	11
MD	335946	9.5985	9	10	10	10
MA	700745	20.0213	20	20	20	21
NH	214460	6.1274	6	6	6	7
NJ	241222	6.8921	6	7	7	7
NY	953043	27.2298	27	27	27	28
NC	487971	13.9420	13	14	14	14
OH	230760	6.5931	6	7	7	7
PA	809773	23.1364	23	23	23	24
RI	76931	2.1980	2	2	2	3
SC	336569	9.6163	9	10	10	10
TN	243913	6.9689	6	7	7	7
VT	217895	6.2256	6	6	6	7
VA	817594	23.3598	23	23	23	24
US	6575234	188.1222	181	188	189	198

In a Round About Way

Census 1810		$d = 35000$				
State	Population	Quotient	Jefferson	ArM	HaM	Adams
CT	261818	7.4805	7	7	8	8
DE	71004	2.0287	2	2	2	3
GA	210346	6.0099	6	6	6	7
KY	374287	10.6939	10	11	11	11
MD	335946	9.5985	9	10	10	10
MA	700745	20.0213	20	20	20	21
NH	214460	6.1274	6	6	6	7
NJ	241222	6.8921	6	7	7	7
NY	953043	27.2298	27	27	27	28
NC	487971	13.9420	13	14	14	14
OH	230760	6.5931	6	7	7	7
PA	809773	23.1364	23	23	23	24
RI	76931	2.1980	2	2	2	3
SC	336569	9.6163	9	10	10	10
TN	243913	6.9689	6	7	7	7
VT	217895	6.2256	6	6	6	7
VA	817594	23.3598	23	23	23	24
US	6575234	188.1222	181	188	189	198

In a Round About Way

Census 1810		$d = 35000$				
State	Population	Quotient	Jefferson	Webster	HaM	Adams
CT	261818	7.4805	7	7	8	8
DE	71004	2.0287	2	2	2	3
GA	210346	6.0099	6	6	6	7
KY	374287	10.6939	10	11	11	11
MD	335946	9.5985	9	10	10	10
MA	700745	20.0213	20	20	20	21
NH	214460	6.1274	6	6	6	7
NJ	241222	6.8921	6	7	7	7
NY	953043	27.2298	27	27	27	28
NC	487971	13.9420	13	14	14	14
OH	230760	6.5931	6	7	7	7
PA	809773	23.1364	23	23	23	24
RI	76931	2.1980	2	2	2	3
SC	336569	9.6163	9	10	10	10
TN	243913	6.9689	6	7	7	7
VT	217895	6.2256	6	6	6	7
VA	817594	23.3598	23	23	23	24
US	6575234	188.1222	181	188	189	198

In a Round About Way

Census 1810		$d = 35000$				
State	Population	Quotient	Jefferson	Webster	Dean	Adams
CT	261818	7.4805	7	7	8	8
DE	71004	2.0287	2	2	2	3
GA	210346	6.0099	6	6	6	7
KY	374287	10.6939	10	11	11	11
MD	335946	9.5985	9	10	10	10
MA	700745	20.0213	20	20	20	21
NH	214460	6.1274	6	6	6	7
NJ	241222	6.8921	6	7	7	7
NY	953043	27.2298	27	27	27	28
NC	487971	13.9420	13	14	14	14
OH	230760	6.5931	6	7	7	7
PA	809773	23.1364	23	23	23	24
RI	76931	2.1980	2	2	2	3
SC	336569	9.6163	9	10	10	10
TN	243913	6.9689	6	7	7	7
VT	217895	6.2256	6	6	6	7
VA	817594	23.3598	23	23	23	24
US	6575234	188.1222	181	188	189	198

In a Round About Way

Census 1810		$d = 35000$				
State	Population	Quotient	Jefferson	Webster	Dean	Adams
CT	261818	7.4805	7	7	8	8
DE	71004	2.0287	2	2	2	3
GA	210346	6.0099	6	6	6	7
KY	374287	10.6939	10	11	11	11
MD	335946	9.5985	9	10	10	10
MA	700745	20.0213	20	20	20	21
NH	214460	6.1274	6	6	6	7
NJ	241222	6.8921	6	7	7	7
NY	953043	27.2298	27	27	27	28
NC	487971	13.9420	13	14	14	14
OH	230760	6.5931	6	7	7	7
PA	809773	23.1364	23	23	23	24
RI	76931	2.1980	2	2	2	3
SC	336569	9.6163	9	10	10	10
TN	243913	6.9689	6	7	7	7
VT	217895	6.2256	6	6	6	7
VA	817594	23.3598	23	23	23	24
US	6575234	188.1222	181	188	189	198

In a Round About Way

HaM(7,8)
= 7.4666...

Census 1810		$d = 35000$				
State	Population	Quotient	Jefferson	Webster	Dean	Adams
CT	261818	7.4805	7	7	8	8
DE	71004	2.0287	2	2	2	3
GA	210346	6.0099	6	6	6	7
KY	374287	10.6939	10	11	11	11
MD	335946	9.5985	9	10	10	10
MA	700745	20.0213	20	20	20	21
NH	214460	6.1274	6	6	6	7
NJ	241222	6.8921	6	7	7	7
NY	953043	27.2298	27	27	27	28
NC	487971	13.9420	13	14	14	14
OH	230760	6.5931	6	7	7	7
PA	809773	23.1364	23	23	23	24
RI	76931	2.1980	2	2	2	3
SC	336569	9.6163	9	10	10	10
TN	243913	6.9689	6	7	7	7
VT	217895	6.2256	6	6	6	7
VA	817594	23.3598	23	23	23	24
US	6575234	188.1222	181	188	189	198

1840 Census

The apportionment debate began with a political game: *Divisor!*

On one day in the 242 member House, 59 motions were made to establish a divisor. The values ranged from 30000 to 141000 with majority from 50159 to 62172.

1840 Census

The apportionment debate began with a political game: *Divisor!*

On one day in the 242 member House, 59 motions were made to establish a divisor. The values ranged from 30000 to 141000 with majority from 50159 to 62172.

The Apportionment Act of 1842 used a basic divisor method with $d = 70680$ and **Webster's method** of rounding. This yielded $h = 223$, the only time in U.S. history that h decreased as a result of a census-based re-apportionment.

The Vinton Act

The Vinton Act of 1850 (Representative Samuel Vinton, Whig-Ohio) was passed to head off politicizing the census and adopt a permanent apportionment act.



The Vinton Act

The Vinton Act **specified a House with 233** seats to be apportioned by Hamilton's method.

The Vinton Act

The Vinton Act **specified a House with 233** seats to be apportioned by Hamilton's method.

But experience exposed problems with the Vinton Act.

Lessons from History

The quota method is subject to counter-intuitive paradoxes:

- The Alabama Paradox
- The Population Growth Paradox

Alabama Paradox

The Alabama paradox may occur when applying the Hamilton quota method:

when the number of House seats is increased, a given state's apportion may decrease.

The Deal Breaker

Results from the 1890 census doomed Hamilton's Method.

A dark blue silhouette map of the state of Maine is positioned on the left side of the slide. A grey rectangular box with the word 'MAINE' in white capital letters is overlaid on the lower-left portion of the map.

MAINE

House Size	Seats
350 – 382	3
383 – 385	4
386	3
387 – 388	4
389 – 390	3
391 - 400	4

1910

Apportionment based on the 1910 census came from another mutation in apportionment methodology.

Congress abandoned the Quota Method and used a **modified divisor method**.

Modified Divisor Methods

Step 1. Select the House size, h .

Step 2. Apply a Basic Divisor Method to obtain h seats.

1910: $h = 433$ and Webster's method.

1920 Census

In the 1920 decade, the only time in U. S. History no census-based re-apportionment act was passed.

Congress could not agree on either the House size or the method of apportionment.

The politics of prohibition played a significant role: the dries would not support any proposal that gave the wets more power.

Today

The current method consists of the Census Act of 1929 (which froze $h = 435$) and a 1941 amendment that specifies the apportionment method of

Today

The current method consists of the Census Act of 1929 (which froze $h = 435$) and a 1941 amendment that specifies the apportionment method of **Huntington and Hill**.

Today

The Huntington-Hill method is a divisor method:

Let $q = p/d$ and $n = \text{int}(q)$.

Then $a = n+1$ when $q \geq$

Today

The Huntington-Hill method is a divisor method:

Let $q = p/d$ and $n = \text{int}(q)$.

Then $a = n+1$ when $q \geq \text{GeM}(n, n+1)$.

Huntington-Hill

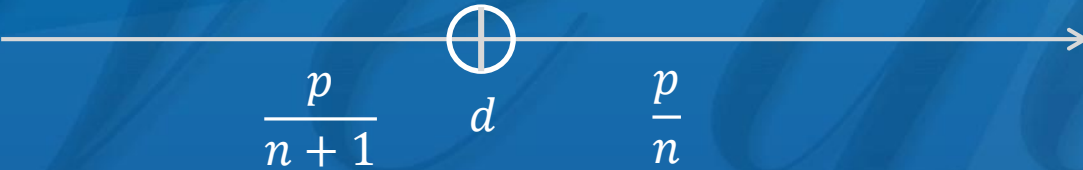
Let $q = p/d$ and $n = \text{int}(q)$.

Then $a = n+1$ when $q \geq \text{GeM}(n, n+1)$.

Huntington-Hill

Let $q = p/d$ and $n = \text{int}(q)$.

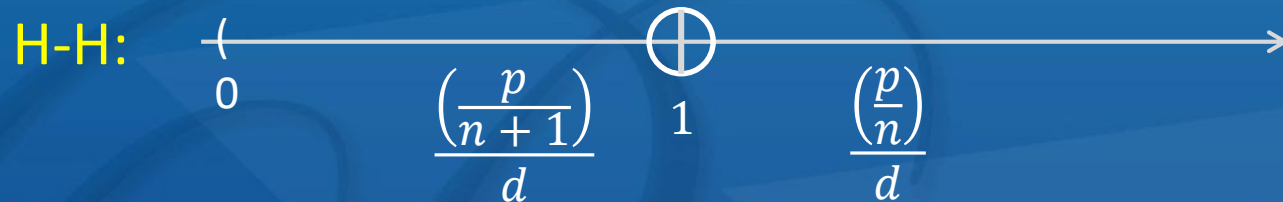
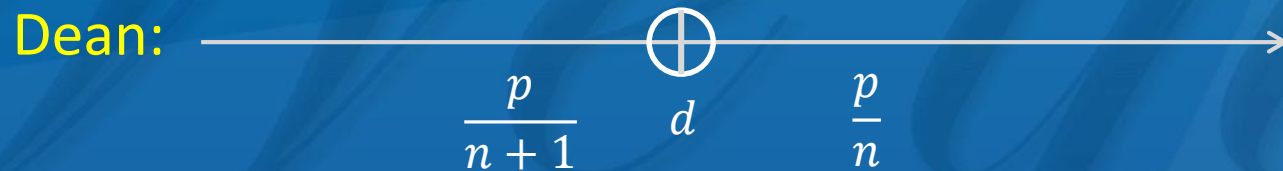
Then $a = n+1$ when $q \geq \text{GeM}(n, n+1)$.

Dean: 

Huntington-Hill

Let $q = p/d$ and $n = \text{int}(q)$.

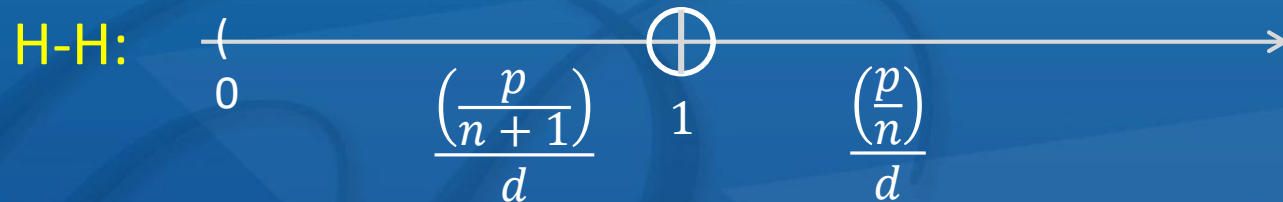
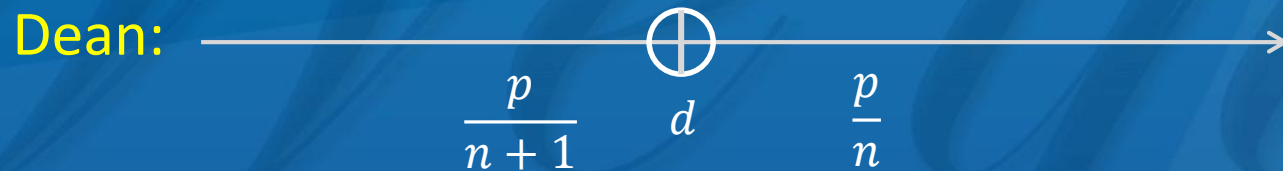
Then $a = n+1$ when $q \geq \text{GeM}(n, n+1)$.



Huntington-Hill

Let $q = p/d$ and $n = \text{int}(q)$.

Then $a = n+1$ when $q \geq \text{GeM}(n, n+1)$.

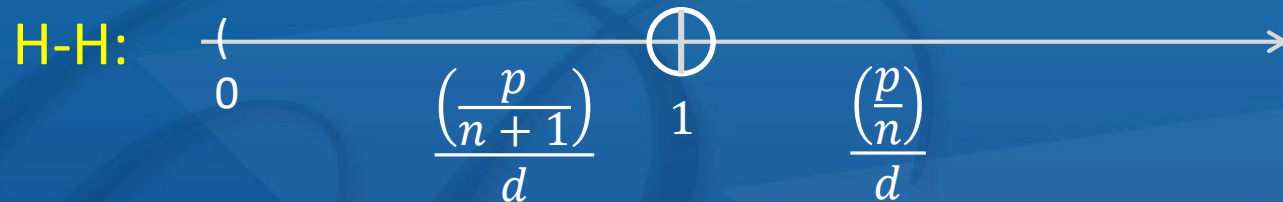
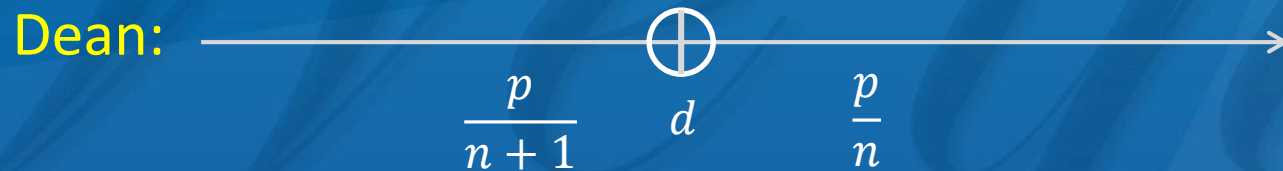


Criterion: $a = n+1$ when $\frac{d}{(\frac{p}{n+1})} \leq \frac{(\frac{p}{n})}{d}$

Huntington-Hill

Let $q = p/d$ and $n = \text{int}(q)$.

Then $a = n+1$ when $q \geq \text{GeM}(n, n+1)$.



Criterion: $a = n+1$ when $\frac{d}{\left(\frac{p}{n+1}\right)} \leq \frac{\left(\frac{p}{n}\right)}{d}$

when $\text{GeM}(n, n+1) \leq q$.

The Aftermath

Michel Balinski, Professor of Mathematics at SUNY Stony Brook and H. Peyton Young, Professor of Mathematics at Johns Hopkins, proved the following theorem in 1982:

The Aftermath

Michel Balinski, Professor of Mathematics at SUNY Stony Brook and H. Peyton Young, Professor of Mathematics at Johns Hopkins, proved the following theorem in 1982:

There are no perfect apportionment methods.

The Aftermath

Michel Balinski, Professor of Mathematics at SUNY Stony Brook and H. Peyton Young, Professor of Mathematics at Johns Hopkins, proved the following theorem in 1982:

There are no perfect apportionment methods.

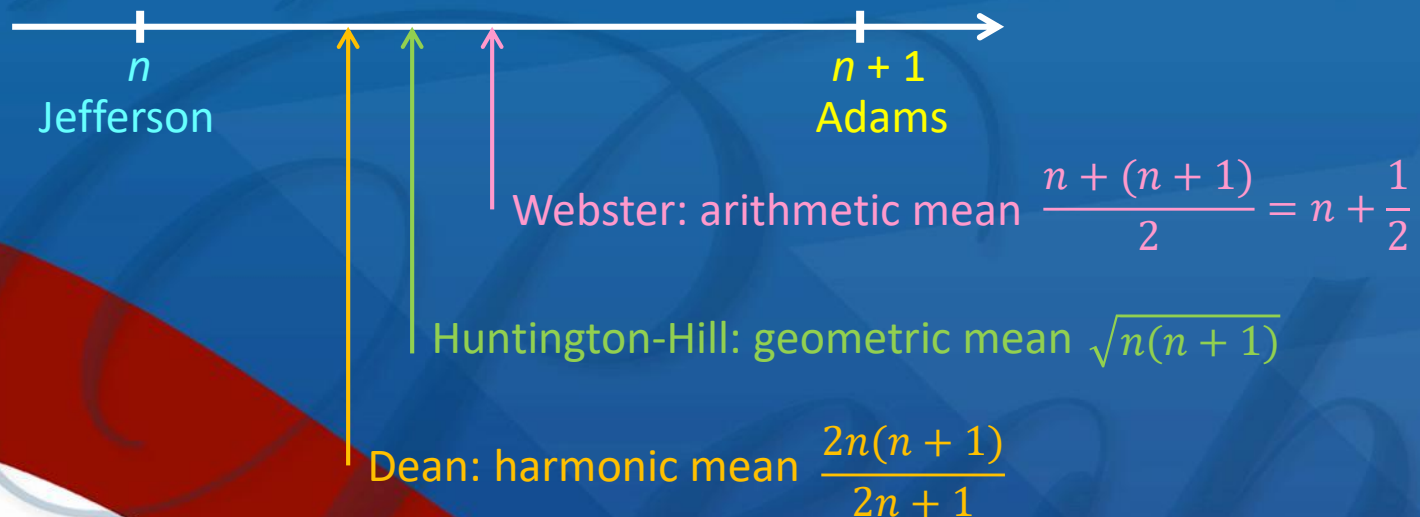
Any method that satisfies the quota rule produces paradoxes; any method that is free of the Alabama paradox may violate the quota rule.

They Mean Well

A modified ***divisor*** method first fixes the House size, then seeks a divisor that when the state's quotients are rounded appropriately and summed, the house size is achieved.

They Mean Well

A modified **divisor** method first fixes the House size, then seeks a divisor that when the state's quotients are rounded appropriately and summed, the house size is achieved.



Distributing 435 seats among 50 states
according to their respective populations
is a math problem.

Today

Today the Census Bureau obtains apportionments using a priority technique of calculation rather than an ad-hoc technique of calculation.

[Census Bureau video 2:09 minutes.](#)
[The Amazing Apportionment Machine](#)

Apportionment by Priority

- Step 1. Give one seat to each state.
- Step 2. Attach a priority number to each state.
- Step 3. Award seats one at a time by priority until the desired House size is reached.

Apportionment by Priority

- Step 1. Give one seat to each state.
- Step 2. Attach a priority number to each state.
- Step 3. Award seats one at a time by priority until the desired House size is reached.

*Priority number
for a state with
 n seats*

Apportionment by Priority

- Step 1. Give one seat to each state.
- Step 2. Attach a priority number to each state.
- Step 3. Award seats one at a time by priority until the desired House size is reached.

$$\text{Priority number for a state with } n \text{ seats} = \frac{\text{state population}}{\text{ave}(n, n+1)}$$

Five Averages

- | | ave |
|---------------------|-----|
| • Greatest Divisors | max |
| • Harmonic Means | HaM |
| • Equal Proportions | GeM |
| • Major Fractions | ArM |
| • Smallest Divisors | min |

The Last Seat

Who gets the 435th seat?

	ave	435
• Greatest Divisors	max	IL
• Harmonic Means	HaM	MN
• Equal Proportions	GeM	MN
• Major Fractions	ArM	NC
• Smallest Divisors	min	WA

The Last Seat

Who would get the 436th seat?

	ave	435	436
• Greatest Divisors	max	IL	WA
• Harmonic Means	HaM	MN	CA
• Equal Proportions	GeM	MN	NC
• Major Fractions	ArM	NC	MO
• Smallest Divisors	min	WA	PA

The Last Seat

Who would get the 436th seat?

	ave	435	436
• Greatest Divisors	max	IL	WA
• Harmonic Means	HaM	MN	CA
• Equal Proportions	GeM	MN	NC
• Major Fractions	ArM	NC	MO
• Smallest Divisors	min	WA	PA

Priority list based on the 2010 census
using the method of Equal Proportions.

Charles M. Biles, Ph.D.

Congressional Apportionment

HOME

BIO

NEWS & EVENTS

RESOURCES

CONTACT

Constitutional Congressional Apportionment Problem

How many seats in the U. S. House of Representatives does each state get?

An answer is presented as an historical narrative with relevant and timely applications in an upcoming book, *The History of Congressional Apportionment*.

Chapter 1. Congressional Apportionment Based on the Census: 1790.


Chapter 2. Congressional Apportionment Based on the Census: 1800-1840.

Chapter 3. Congressional Apportionment Based on the Census: 1850-1890.

Chapter 4. Congressional Apportionment Based on the Census: 1900-1930.

Chapter 5. Congressional Apportionment Based on the Census: 1940-2010.

Chapter 6. An Historical Overture.

NEW

UNDER CONSTRUCTION

Charles Biles

The History of Congressional Apportionment

HSU Press

Last update: 13 June 2017.

Cover Graphic courtesy of
The West Virginia Record



This site was created using WIX.com. Create your own for FREE >>

Thank You

It is time that I took my seat in this House!

<http://www.nia977.wix.com/drbcap>

Bonus Resources

Montana

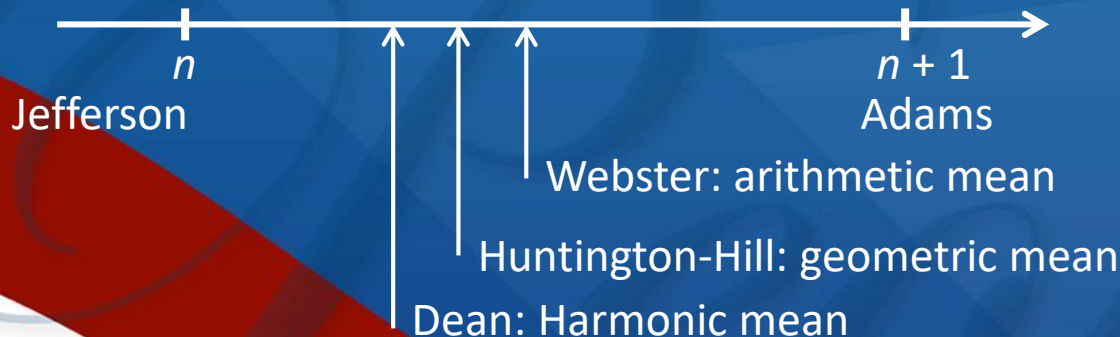
In the 1990 apportionment Montana lost one of its two seats it held for 80 years. In 1991 MT filed suit in federal district court (MT vs. US Dept Commerce).

MT argued the H-H method is unconstitutional and that either Dean's or Adams's method should be used. The federal judges voted 2-1 in favor of MT.

Montana

In the 1990 apportionment Montana lost one of its two seats it held for 80 years. In 1991 MT filed suit in federal district court (MT vs. US Dept Commerce).

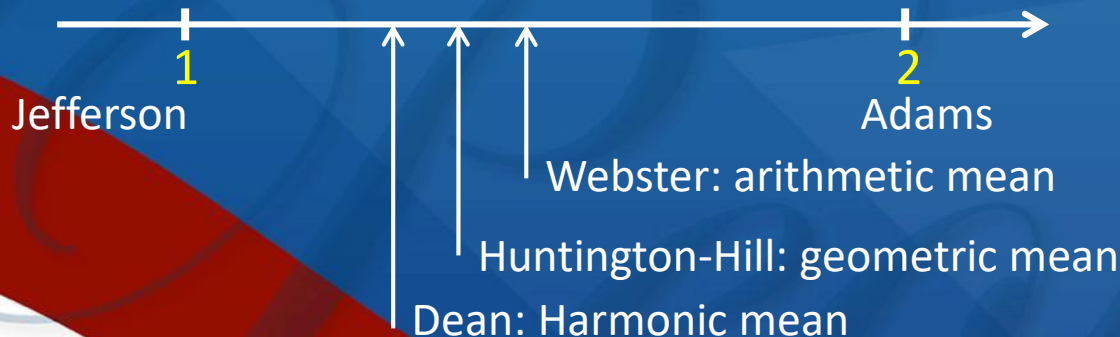
MT argued the H-H method is unconstitutional and that either Dean's or Adams's method should be used. The federal judges voted 2-1 in favor of MT.



Montana

In the 1990 apportionment Montana lost one of its two seats it held for 80 years. In 1991 MT filed suit in federal district court (MT vs. US Dept Commerce).

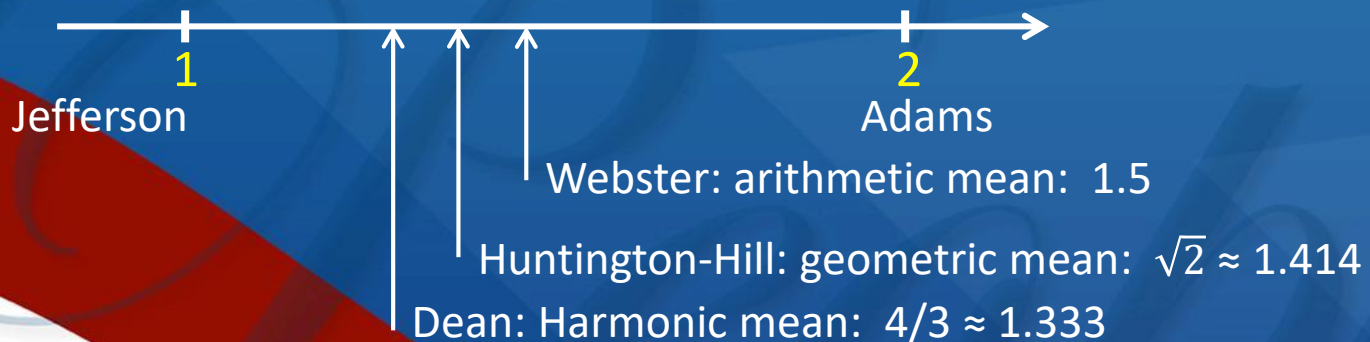
MT argued the H-H method is unconstitutional and that either Dean's or Adams's method should be used. The federal judges voted 2-1 in favor of MT.



Montana

In the 1990 apportionment Montana lost one of its two seats it held for 80 years. In 1991 MT filed suit in federal district court (MT vs. US Dept Commerce).

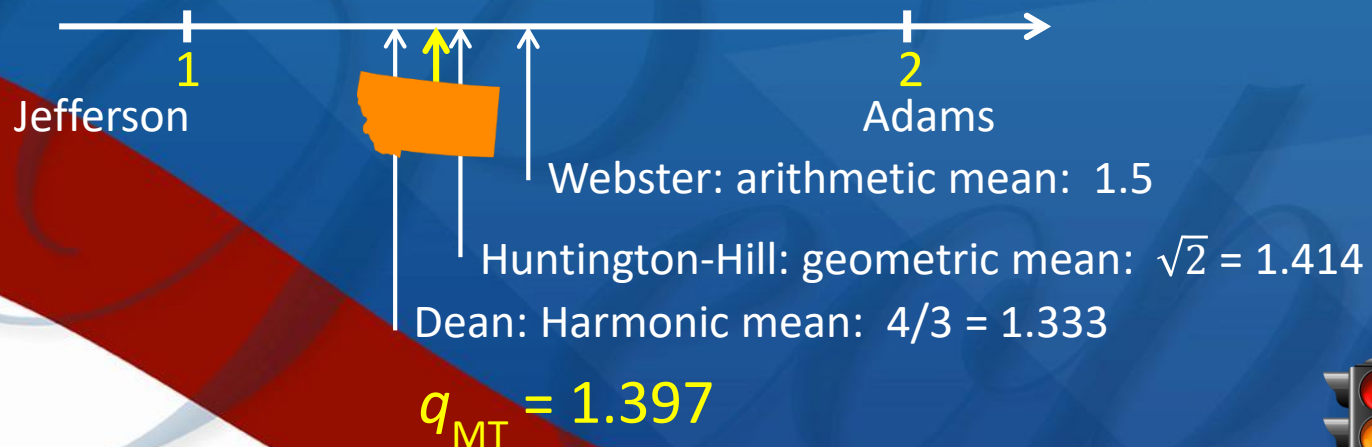
MT argued the H-H method is unconstitutional and that either Dean's or Adams's method should be used. The federal judges voted 2-1 in favor of MT.



Montana

In the 1990 apportionment Montana lost one of its two seats it held for 80 years. In 1991 MT filed suit in federal district court (MT vs. US Dept Commerce).

MT argued the H-H method is unconstitutional and that either Dean's or Adams's method should be used. The federal judges voted 2-1 in favor of MT.



Related Problems

Other problems related to apportionment include:

One Voter, One Vote: The Apportionment of Congressional Seats Reconsidered

Author(s): Howard A. Scarrow

Source: Polity, Vol. 22, No. 2 (Winter, 1989), pp. 253-268

Published by: Palgrave Macmillan Journals

Stable URL: <http://www.jstor.org/stable/3234834> .

Related Problems

Other problems related to apportionment include:

- Census: who is “enumerated.”

One Voter, One Vote: The Apportionment of Congressional Seats Reconsidered

Author(s): Howard A. Scarrow

Source: Polity, Vol. 22, No. 2 (Winter, 1989), pp. 253-268

Published by: Palgrave Macmillan Journals

Stable URL: <http://www.jstor.org/stable/3234834> .

Related Problems

Other problems related to apportionment include:

- Census: who is “enumerated.”
- State districting.

One Voter, One Vote: The Apportionment of Congressional Seats Reconsidered

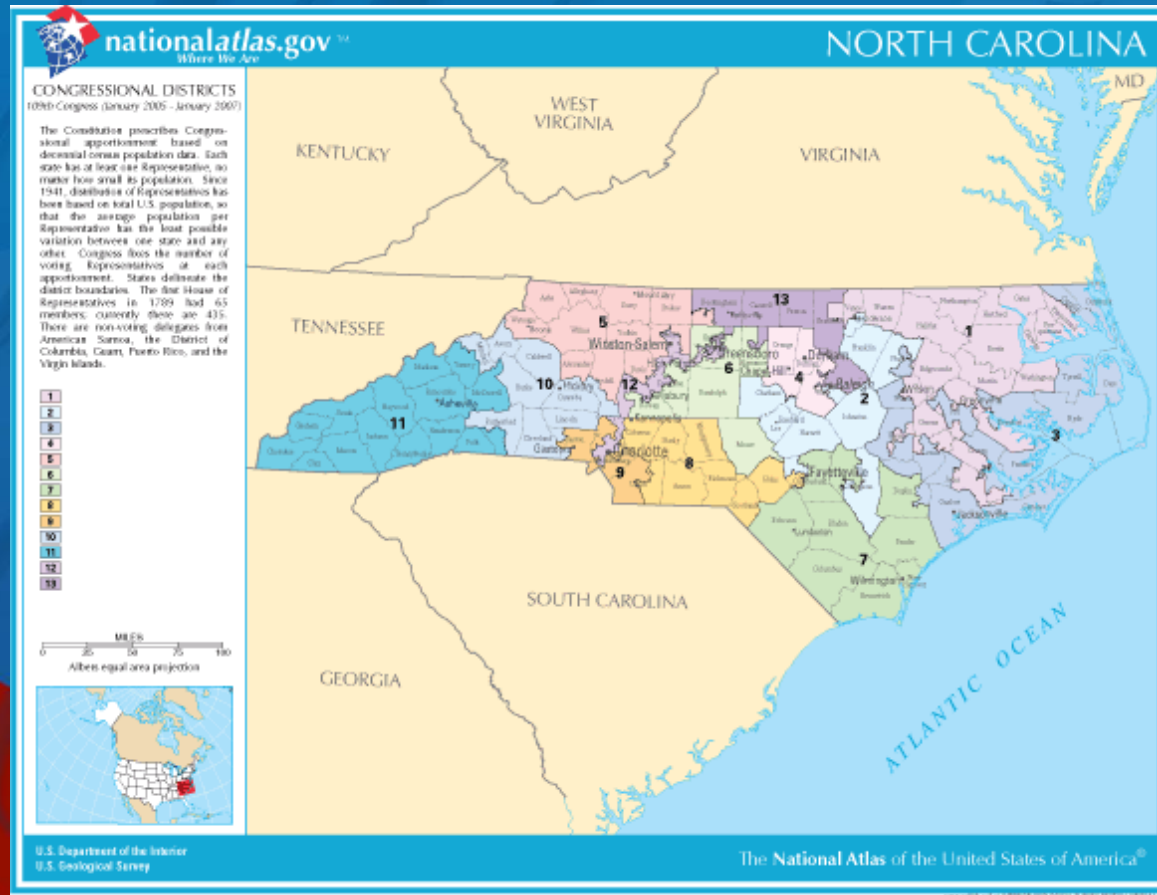
Author(s): Howard A. Scarrow

Source: Polity, Vol. 22, No. 2 (Winter, 1989), pp. 253-268

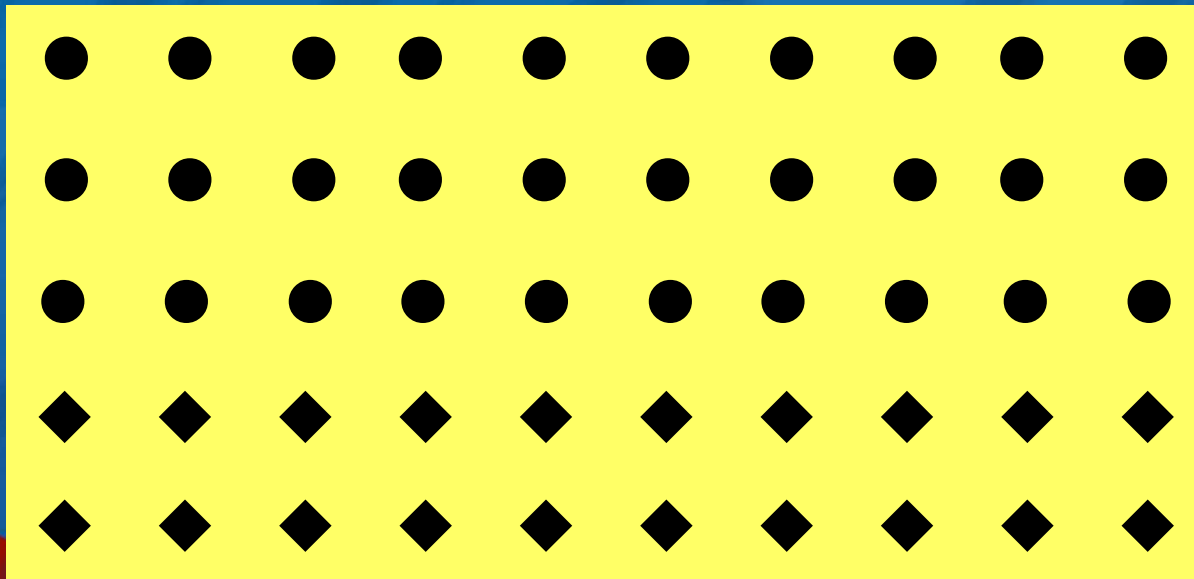
Published by: Palgrave Macmillan Journals

Stable URL: <http://www.jstor.org/stable/3234834> .

Gerrymandering

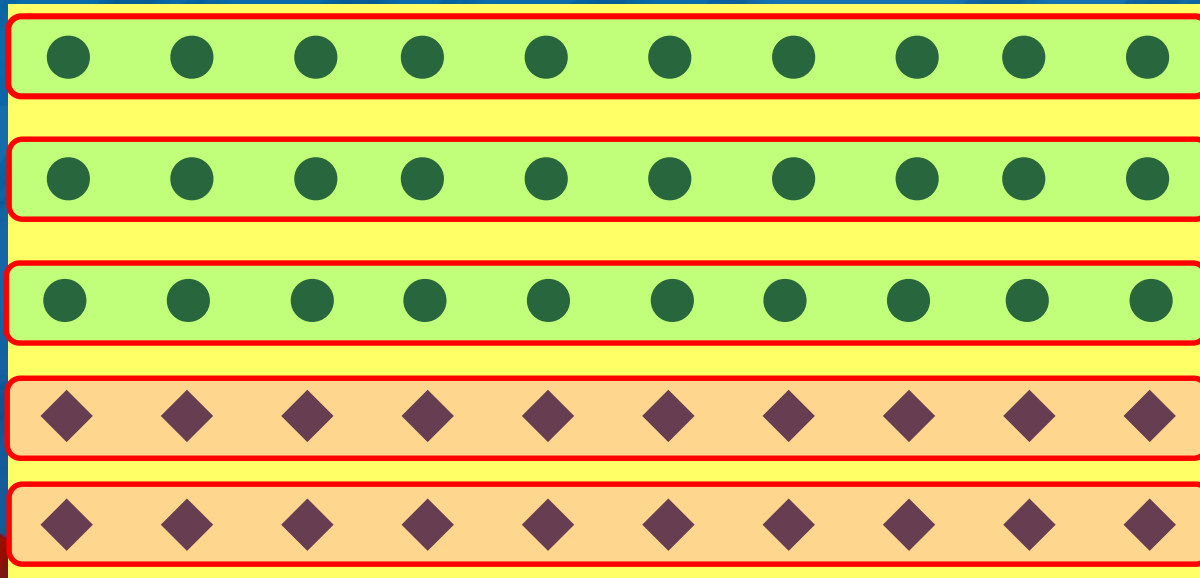


Gerrymandering

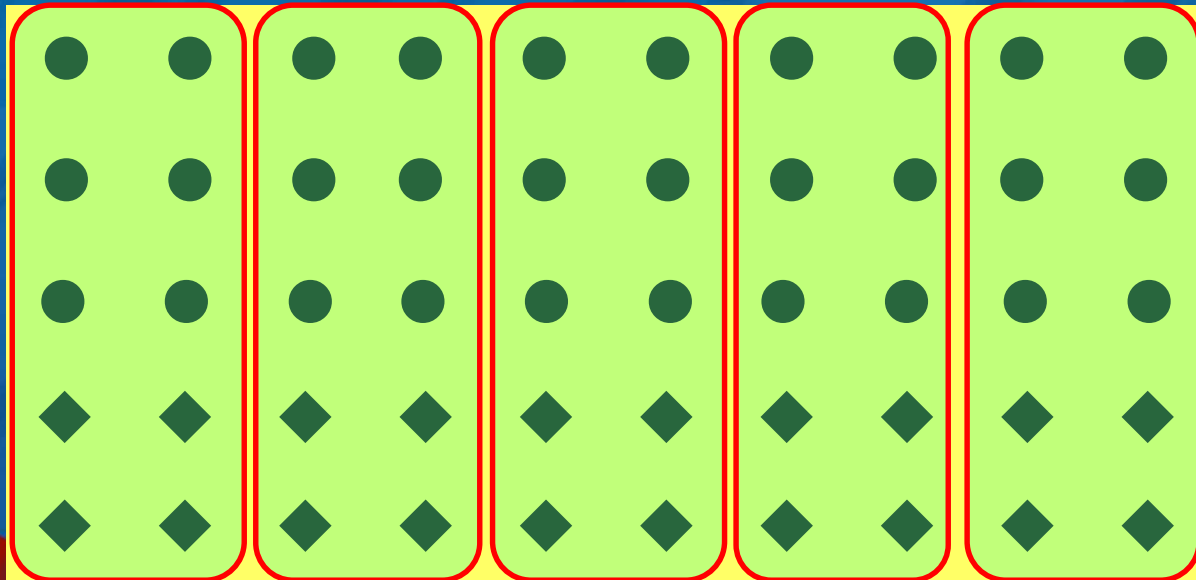


Apportion into five districts.

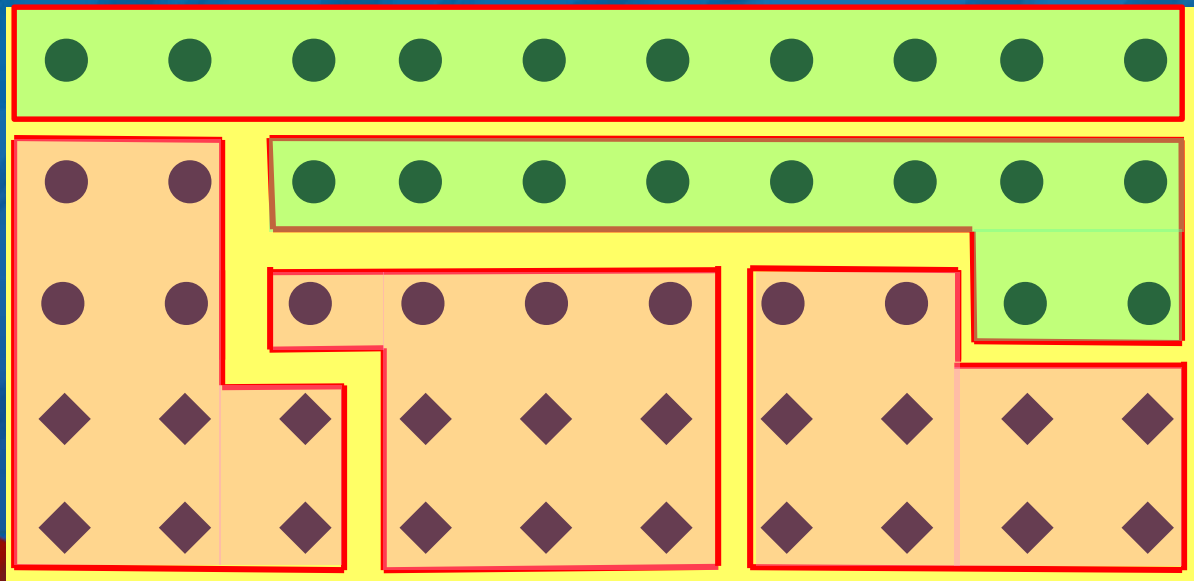
Gerrymandering



Gerrymandering



Gerrymandering



Related Problems

Other problems related to apportionment include:

- Census: who is “enumerated.”
- State districting.
- Suffrage: who is allowed to vote.

One Voter, One Vote: The Apportionment of Congressional Seats Reconsidered

Author(s): Howard A. Scarrow

Source: Polity, Vol. 22, No. 2 (Winter, 1989), pp. 253-268

Published by: Palgrave Macmillan Journals

Stable URL: <http://www.jstor.org/stable/3234834> .

Related Problems

Other problems related to apportionment include:

- Census: who is “enumerated.”
- State districting.
- Suffrage: who is allowed to vote.
- Voting: the mechanism of voting.

One Voter, One Vote: The Apportionment of Congressional Seats Reconsidered

Author(s): Howard A. Scarrow

Source: Polity, Vol. 22, No. 2 (Winter, 1989), pp. 253-268

Published by: Palgrave Macmillan Journals

Stable URL: <http://www.jstor.org/stable/3234834> .

Washington's Veto

United States [Philadelphia] April 5 1792.

Gentlemen of the House of Representatives

I have maturely considered the Act passed by the two Houses, intituled, "An Act for an apportionment of Representatives among the several States according to the first enumeration," and I return it to your House, wherein it originated, with the following objections.

First—The Constitution has prescribed that representatives shall be apportioned among the several States according to their respective numbers: and there is no one proportion or divisor which, applied to the respective numbers of the States will yield the number and allotment of representatives proposed by the Bill.

Second—The Constitution has also provided that the number of Representatives shall not exceed one for every thirty thousand; which restriction is, by the context, and by fair and obvious construction, to be applied to the seperate and respective numbers of the States: and the bill has allotted to eight of the States, more than one for thirty thousand.

George Washington.

Copy, DNA: RG 233, Second Congress, 1791–1793, Records of Legislative Proceedings, Journals; LB, DLC:GW. (from Philander Chase, et al., eds., *The Papers of George Washington, Presidential Series, Vol. 10: March–August 1792* [Charlottesville, Va., 2002], 213-14).

First Apportionment Act

CHAP. XXIII.—*An Act for apportioning Representatives among the several States, according to the first enumeration.*

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That from and after the third day of March one thousand seven hundred and ninety-three, the House of Representatives shall be composed of members elected agreeably to a ratio of one member for every thirty-three thousand persons in each state, computed according to the rule prescribed by the constitution; that is to say: Within the state of New Hampshire, four; within the state of Massachussetts, fourteen; within the state of Vermont, two; within the state of Rhode Island, two; within the state of Connecticut, seven; within the state of New York, ten; within the state of New Jersey, five; within the state of Pennsylvania, thirteen; within the state of Delaware, one; within the state of Maryland, eight; within the state of Virginia, nineteen; within the state of Kentucky, two; within the state of North Carolina, ten; within the state of South Carolina, six; and within the state of Georgia, two members.

APPROVED, April 14, 1792.

1790: Why 33000?

State	Population	$d =$	30000	31000	32000	33000	34000	35000	36000	37000	38000	39000	40000
CN	236841		0.8947	0.6400	0.4013	0.1770	0.9659	0.7669	0.5789	0.4011	0.2327	0.0728	0.9210
DE	55540		0.8513	0.7916	0.7356	0.6830	0.6335	0.5869	0.5428	0.5011	0.4616	0.4241	0.3885
GA	70835		0.3612	0.2850	0.2136	0.1465	0.0834	0.0239	0.9676	0.9145	0.8641	0.8163	0.7709
KY	68705		0.2902	0.2163	0.1470	0.0820	0.0207	0.9630	0.9085	0.8569	0.8080	0.7617	0.7176
MD	278514		0.2838	0.9843	0.7036	0.4398	0.1916	0.9575	0.7365	0.5274	0.3293	0.1414	0.9629
MA	475327		0.8442	0.3331	0.8540	0.4038	0.9802	0.5808	0.2035	0.8467	0.5086	0.1879	0.8832
NH	141822		0.7274	0.5749	0.4319	0.2976	0.1712	0.0521	0.9395	0.8330	0.7322	0.6365	0.5456
NJ	179570		0.9857	0.7926	0.6116	0.4415	0.2815	0.1306	0.9881	0.8532	0.7255	0.6044	0.4893
NY	331589		0.0530	0.6964	0.3622	0.0482	0.7526	0.4740	0.2108	0.9619	0.7260	0.5023	0.2897
NC	353523		0.7841	0.4040	0.0476	0.7128	0.3977	0.1007	0.8201	0.5547	0.3032	0.0647	0.8381
PA	432879		0.4293	0.9638	0.5275	0.1175	0.7317	0.3680	0.0244	0.6994	0.3916	0.0995	0.8220
RI	68446		0.2815	0.2079	0.1389	0.0741	0.0131	0.9556	0.9013	0.8499	0.8012	0.7550	0.7112
SC	206236		0.8745	0.6528	0.4449	0.2496	0.0658	0.8925	0.7288	0.5739	0.4273	0.2881	0.1559
VT	85533		0.8511	0.7591	0.6729	0.5919	0.5157	0.4438	0.3759	0.3117	0.2509	0.1932	0.1383
VA	630560		0.0187	0.3406	0.7050	0.1079	0.5459	0.0160	0.5156	0.0422	0.5937	0.1682	0.7640
US	3615920		8.5307	8.6426	6.9975	4.5733	6.3506	7.3120	9.4422	9.7276	8.1558	5.7159	9.3980

Unrepresented: 255920 267920 223920 150920 215920 255920 339920 359920 309920 222920 375920

Alabama Paradox

How is this possible?

State	House 299	House 300
AL	7.646	7.671
TX	9.640	9.672
IL	18.640	18.702

With the House size at 299, Alabama was the last state to be allotted an extra representative to make the House size because of its decimal. When the House size was increased to 300, all states' quotas were increased by 0.33%. And there were two states that got the extra representatives; and, this time, Texas and Illinois beat out Alabama.

US Census Bureau

The U.S. Census Bureau is housed within the Department of Commerce.

Check out the U.S. Census Bureau for what it says about apportionment.

<http://www.census.gov/>

Summary 7-page brochure:

<http://www.census.gov/prod/cen2010/briefs/c2010br-08.pdf>

History of Legislation:

[http://www.census.gov/history/www/reference/apportionment/apportionment legislation 1790 - 1830.html](http://www.census.gov/history/www/reference/apportionment/apportionment_legislation_1790_-_1830.html)

More!

For playing around, learning or teaching:

<http://www.cut-the-knot.org/ctk/Democracy.shtml>

Key Decades

The key decades in the history of the Congressional apportionment problem are 1790, 1840 and 1850, and 1920. Here are some excellent resources for each of these periods.

- Edmund J. James, *The First Apportionment of Federal Representatives in the United States*, *Annals of the American Academy of Political and Social Science*, 9 (January 1897): 1-41.
- Johanna Nicol Shields, *Whigs Reform the “Bear Garden”*: *Representation and the Apportionment Act of 1842*, *Journal of the Early Republic*, 5 (Fall 1983): 356-82.
- Charles W. Eagles, *Democracy Delayed: Congressional Reapportionment and Urban-Rural Conflict in the 1920s*, University of Georgia Press, 1990.

US History

For any serious research of U.S. history, one must know about the Journals of Congress which includes the House Journal and the Senate Journal:

<http://memory.loc.gov/ammem/amlaw/lwhj.html>

The Future: Reform?

Four Proposals:

The Future: Reform?

Four Proposals:

- Thirty-thousand.org
- Wyoming Rule
- Neubauer and Gartner
- Webster's Method.

thirty-thousand.org

Here's an example of a concerned group:

<http://www.thirty-thousand.org/>

thirty-thousand.org

Here's an example of a concerned group:

<http://www.thirty-thousand.org/>

Comment: This leads to a House with
10283 (10306) representatives.

thirty-thousand.org

Here's an example of a concerned group:

<http://www.thirty-thousand.org/>

Comment: This leads to a House with
10283 (10306) representatives.



Jefferson basic divisor method.

CA: 1244 seats!

thirty-thousand.org

Here's an example of a concerned group:

<http://www.thirty-thousand.org/>

Thirty-thousand.org advocates 50000/representative.
This creates a House with 6181 representatives using
Webster's method of rounding.
California gets 747 seats.

The Wyoming Rule

The Wyoming Rule is a basic divisor method in which the divisor is the population of the least populous state (currently WY; hence, the name).

http://en.wikipedia.org/wiki/Wyoming_Rule

<http://www.outsidethebeltway.com/representation-in-the-house-the-wyoming-rule/>

The Wyoming Rule

Results of applying the WY Rule to the 2000
and 2010 censuses.

The Wyoming Rule

Results of applying the WY Rule to the 2000 and 2010 censuses.

2000 smallest state: WY, 493782.

$h = 569$ Huntington-Hill

The Wyoming Rule

Results of applying the WY Rule to the 2000 and 2010 censuses.

2000 smallest state: WY, 493782.

$h = 569$ Huntington-Hill

2010 smallest state: WY, 563626

$h = 543$ Dean HI

$h = 542$ Huntington-Hill

$h = 540$ Webster NJ, SD

A Proposal

A Proposal for Apportioning the House

Michael G. Neubauer, CSU Northridge, Mathematics

Margo G. (Gartner) Carr, Cerro Coso Community College

...the problem of finding a “good” house size and “right” apportionment method are best considered together.

Source: PSC 44(1), January 2011: 1—3.

A Proposal

A Proposal for Apportioning the House

Michael G. Neubauer, CSU Northridge, Mathematics

Margo G. (Gartner) Carr, Cerro Coso Community College

...the problem of finding a “good” house size and “right” apportionment method are best considered together.

Definition. A House size is *agreeable* means that the apportionments by the methods of Hamilton, Dean, Huntington-Hill, and Webster all agree.

Source: PSC 44(1), January 2011: 1—3.

A Proposal

A Proposal for Apportioning the House

Michael G. Neubauer, CSU Northridge, Mathematics

Margo G. (Gartner) Carr, Cerro Coso Community College

...the problem of finding a “good” house size and “right” apportionment method are best considered together.

Definition. A House size is *agreeable* means that the apportionments by the methods of Hamilton, Dean, Huntington-Hill, and Webster all agree.

Proposal. From the 2000 census, $h = 435$ was not agreeable. The first agreeable House size greater than 435 is $h = 477$.

Source: PSC 44(1), January 2011: 1—3.

A Proposal

A Proposal for Apportioning the House

Michael G. Neubauer, CSU Northridge, Mathematics

Margo G. (Gartner) Carr, Cerro Coso Community College

...the problem of finding a “good” house size and “right” apportionment method are best considered together.

Definition. A House size is *agreeable* means that the apportionments by the methods of Hamilton, Dean, Huntington-Hill, and Webster all agree.

Proposal. From the 2000 census, $h = 435$ was not agreeable. The first agreeable House size greater than 435 is $h = 477$. From the 2010 census, $h = 435$ is still not agreeable. The first agreeable House size greater than 435 is

Source: PSC 44(1), January 2011: 1—3.

A Proposal

A Proposal for Apportioning the House

Michael G. Neubauer, CSU Northridge, Mathematics

Margo G. (Gartner) Carr, Cerro Coso Community College

...the problem of finding a “good” house size and “right” apportionment method are best considered together.

Definition. A House size is *agreeable* means that the apportionments by the methods of Hamilton, Dean, Huntington-Hill, and Webster all agree.

Proposal. From the 2000 census, $h = 435$ was not agreeable. The first agreeable House size greater than 435 is $h = 477$. From the 2010 census, $h = 435$ is still not agreeable. The first agreeable House size greater than 435 is **871**.

Source: PSC 44(1), January 2011: 1—3.

Webster's Method

The simplest reform would be to replace the geometric mean of decimal rounding in the Huntington-Hill method by the arithmetic mean of decimal rounding in Webster's method.

Webster's Method

The simplest reform would be to replace the geometric mean of decimal rounding in the Huntington-Hill method by the arithmetic mean of decimal rounding in Webster's method.

The research of Balinski and Young has produced the following two key results. Since the Alabama paradox is a deal-breaker, then congressional apportionment must be based on a divisor method. Further, Webster's is the only rounding method that is unbiased towards either larger or smaller states.

