Test 2A, Math of Democracy

Dr. Adam Graham-Squire, Fall 2019

Name: _____

I pledge that I have neither given nor received any unauthorized assistance on this exam.

_____

(*signature*)

DIRECTIONS

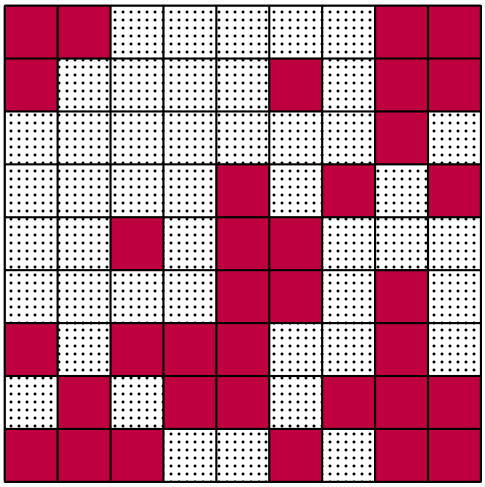
1. Don't panic.
2. **Show/explain all of your work**. A correct answer with insufficient work will lose points.
3. Read each question carefully, and make sure you answer the the question that is asked. If the question asks for an explanation, make sure you give one.
4. Clearly indicate your answer.
5. Calculators are allowed on this test, but any other technology (cell phones, computers, etc) is NOT allowed without prior authorization.
6. Make sure you sign the pledge above.
7. Not a direction, but funny nonetheless: "Did you know that butter tastes really good with nothing on it?" (Ronan, age 3).
8. Number of questions = 4. Total Points = 20.

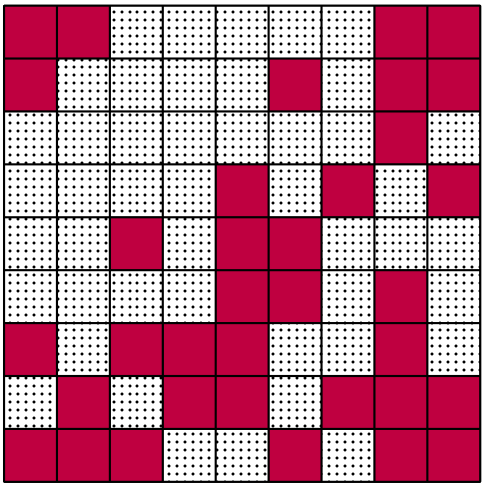
1. (6 points) In the 9 by 9 Squaretopia below, there are 35 Filled squares and 46 Dotted squares. The Squaretopia must be divided into 9 districts of 9 squares each. Both maps below are identical, I just gave you multiple copies in case you want to do scratch work. Do the following:

   (a) Calculate what would be a proportional distribution of districts to each party.

   (b) What is the theoretical maximum number of districts that the (i) Filled and (ii) Dotted party can each win?

   (c) Draw districts that are as favorable as possible for the Filled party. Are your districts as good as you could practically do? Why?

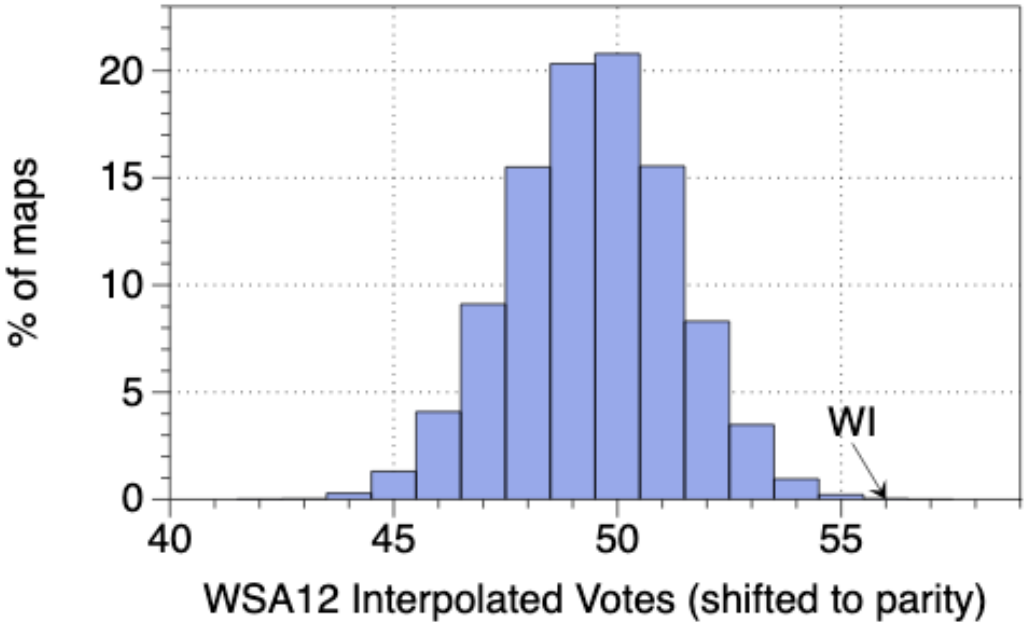


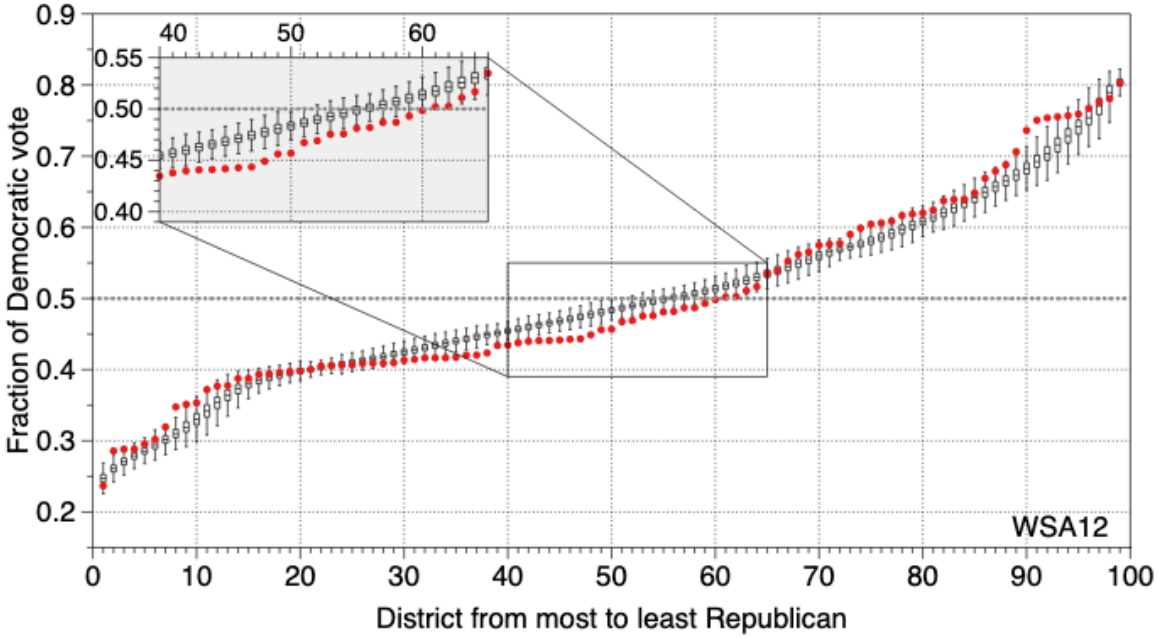


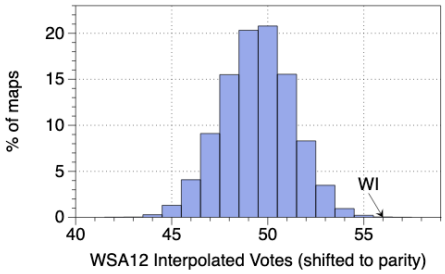
2. (4 points) Calculate the efficiency gap for one of the gerrymandered maps you made in question 1, part (c) or (d). Explain how the efficiency gap score does or does not demonstrate gerrymandering.

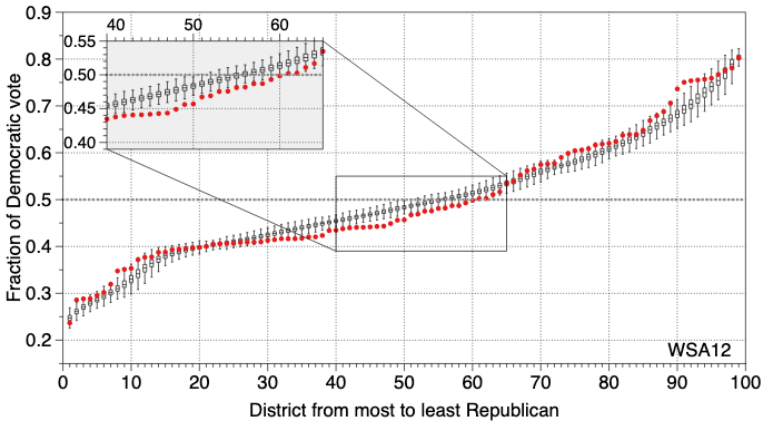
3. (5 points) Below are diagrams that represent an outlier analysis done for the State Assembly of Wisconsin in 2012. There are 99 districts in their State Assembly. In the bar graph (the top diagram), the blue bars represent the frequency that *Republicans* win a certain number of seats, and the "WI" is what the Wisconsin legislature's districting gave. In the bottom graph, there are box and whisker plots, and the red dots are the actual numbers for the Wisconsin legislature's districting. Note that a part of the diagram is enlarged to help you see what is happening more easily.

   Here is the question: What does outlier analysis say about gerrymandering in Wisconsin, in terms of proportionality, packing and cracking, and/or partisan symmetry? Support your claims (as specifically as possible) with information from the diagrams. You can also use the next page for your answer.



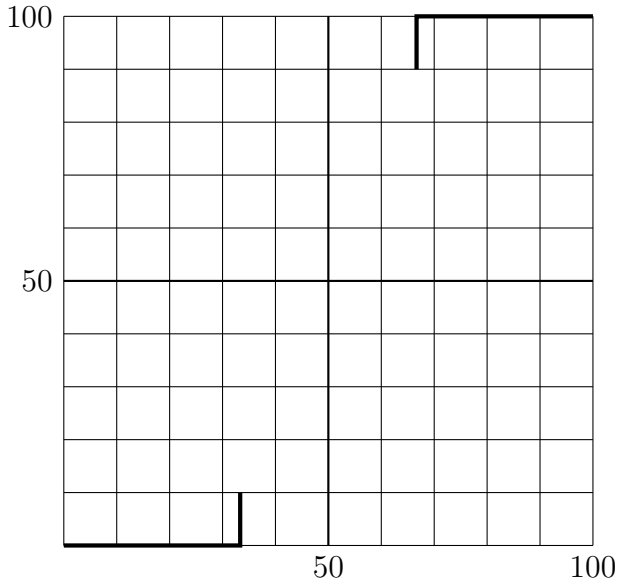



% of maps
20
15
10
5
0
40
45
50
55
WI
WSA12 Interpolated Votes (shifted to parity)

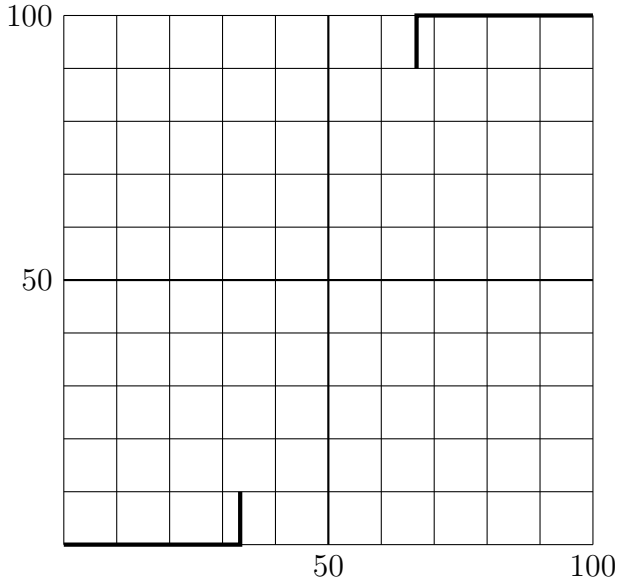

Fraction of Democratic vote
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
40
50
60
0.55
0.50
0.45
0.40
0
10
20
30
40
50
60
70
80
90
100
WSA12
District from most to least Republican

4. (5 points) Suppose a state has 10 districts, and when each party has 67% of the vote, they will win all of the districts (the graphs below show what that part of the symmetry graph would look like). Does that mean that the districting is fair and free of gerrymandering? Complete the symmetry graphs below to make examples that fit with the description above, *one* of which would indicate gerrymandering and the *other* that does not. Explain in words how the gerrymandered graph shows packing and/or cracking, *and* why the not gerrymandered graph demonstrates fairness.

IS gerrymandered:



Is NOT gerrymandered:



Extra Credit (1 point) Suppose a friend tells you the following: "My state is really unfairly gerrymandered! The redistricting made by the state legislature has low compactness scores. Like, the average Polsby-Popper score for the districts is a 0.27!"

What would you say to your friend about whether or not their state has been unfairly gerrymandered, based on what they have told you?

Formulas:

1 Compactness measures in Squaretopia

- **Skew measure:** W/L
- **Isoperimetric (Square Polsby-Popper) measure:** $16A/P^2$
- **Square Reock measure:** A/S

2 Real-world Compactness Measures

- **Harris:** W/L
- **Polsby-Popper:** $4\pi A/P^2$
- **Reock:** A/C

3 Efficiency Gap Formulas

- $EG = \dfrac{W_A - W_B}{\text{total votes}}$
- $EG = 2V - S - \dfrac{1}{2}$