Your Name: $\qquad$

Names of people you worked with: $\qquad$

Instructions: Work on this problem in class with your group (if you are attending class synchronously) or out of class (hopefully with a person or two! if you are attending class asynchronously). The problem should be done on a piece of paper with a pencil or on some kind of tablet. The problem should not by typed up or done in LaTeX.

Work for a maximum of 15 minutes on the problem (regardless of what time you are working). Do not come back to the problem to "fix it up" or "finish it." Be sure to write down the names of the people you worked with during class (or outside of class).

Take a picture of your work and use a scanning app to create a pdf (or create a pdf directly from your tablet). Upload your work to Gradescope (via Sakai) within 24 hours of class.

Task: How can a random sample of integers between 1 and $N$ (with $N$ unknown to the researcher) be used to estimate $N$ ? This problem is known as the German tank problem and is derived directly from a situation where the Allies used maximum likelihood to determine how many tanks the Axes had produced. See https://en.wikipedia.org/wiki/German_tank_problem.

1. The tanks are numbered from 1 to $N$. Working with your group, randomly select five tanks, without replacement, from the bowl. The tanks are numbered:
2. Think about how you would use your data to estimate $N$. (Come up with at least 3 estimators.) Come to a consensus within the group as to how this should be done. One person from your group will report out after the warm-up is over. Ideally, the person to report out will be someone who has not yet spoken in class this semester. Step-up if you haven't yet spoken. Step back if you speak regularly. Our estimates of $N$ are:

Our rules or formulas for the estimators of $N$ based on a sample of n (in your case 5) integers are:

Assuming the random variables are distributed according to a discrete uniform. (Tbh, this model is with replacement, but the answers you get aren't much different than without replacement if $n \ll N$.)

$$
X_{i} \sim P(X=x \mid N)=\frac{1}{N} \quad x=1,2, \ldots, N \quad i=1,2, \ldots, n
$$

3. What is the method of moments estimator of N ?
4. What is the maximum likelihood estimator of N ?
