1. A disk drive contains n cylinders; show the expected seek distance for randomly selected seeks is proportional to $n/3$ as well as lower order terms.

   We consider a RAID Level 5 disk array of five identical drives. The disk drives each feature 10000 rpm speed; each track contains 100KB divided into 512 byte sectors. The minimum and maximum seek latencies are 0.5ms and 12ms respectively. For these exercises a small data object consists of 4KB and a large data object consists of one MB. The data is placed within the disk array so only one complete seek need be done per operation; there will be "settle" operations as the head moves from a track to an adjacent track for the large operation.

2. What is the read and write service times T_S for the two varieties of data objects on a five disk RAID Level 5?

3. Plot the read and write response times T_R for these two varieties of data objects when the array has best possible data transfer connections.

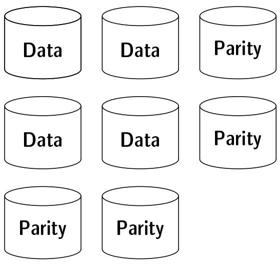
4. A disk contains c cylinders. Show for a fixed number n of seeks that move the head from one cylinder extreme to the other (inner cylinder to outer or vice versa) that if the distance traveled for each seek is the same then the seek time will be maximized.

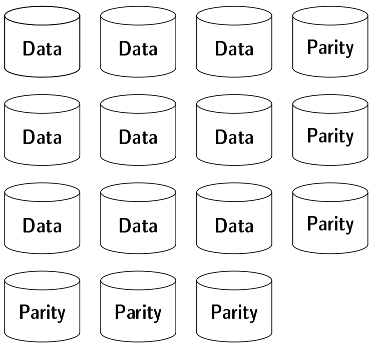
5. A disk manufacturer tells us the following regarding a disk's performance. the minimum seek time t_{min} for a cylinder to cylinder seek, the maximum seek time t_{max} for a full excursion seek, and the average seek time t_{ave}. The average seek time is determined by assuming that all pairs of cylinders are equally-likely. Calculate the coefficients $u_1, v_1, u_2,$ and v_2 for the model

$$t_{seek}(d) = \begin{cases} v_1 + u_1 d & \text{if } d \geq m \\ v_2 + u_2\sqrt{d} & \text{otherwise.} \end{cases}$$

   where m is 1200 and the number of cylinders d_{max} is 12000.

6. What is the failure Markov model for the following disk array data layouts. Both the columns and the row constitute stripes and the data is safe from multiple disk failures: all pairs of failures as well as many triples and beyond. What is the MTTDL for the layout on the left?





7. (Optional) Give general conditions on the matrix

$$\begin{pmatrix} 1 & 0 & 0 & \dots & 0 & 1 & 1 & \dots & 1 \\ 0 & 1 & 0 & \dots & 0 & \alpha_1 & \alpha_2 & \dots & \alpha_c \\ 0 & 0 & 1 & \dots & 0 & \alpha_1^2 & \alpha_2^2 & \dots & \alpha_c^2 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \dots & 1 & \alpha_1^{k-1} & \alpha_2^{k-1} & \dots & \alpha_c^{k-1} \end{pmatrix}$$

to ensure that any k columns are linearly independent.