Problem Set 1 Written Answers

Modeling The Living Cell - Spring 2021

Benjamin Fry - bfry2

Problem 1:

`randn` is a function in MATLAB that generates pseudorandom numbers sampled from the normal distribution. It can take in 1 integer as in `randn(N)` as its input in which case it will output an $N \times N$ matrix of these numbers. If passed two integers as inputs as in `randn(A, B)` it will output an $A \times B$ matrix of these random numbers where A is the number of rows and B is the number of columns of the output matrix.

Problem 2:

The size of the `data_prob2` matrix is 50×2.

Therefore, there are 50 rows and 2 columns.

Problem 3:

The dimensions of the `magic(5)` output is a 5×5 matrix.

Each row sums to 65.

Problem 4:

The function takes in two general numeric inputs corresponding to the frequency and damping constant for a damped oscillator. The third input is a positive integer corresponding to the figure number for the generated plot.

When we try to run the script without fixing anything, the error message tells us that matrix `f1` and matrix `f2` are the wrong shape for matrix multiplication.

Because the two matrices are the same shape and we want to multiply them, we can do this by using the elementwise multiplication operator `.*` rather than the normal multiplication operator.

Problem 5:

Completed in MATLAB script.

Problem 6:

Completed in MATLAB script.

Problem 7:

The matrix contained in `datapts3.dat` is 1000×1 (1000 rows by 1 column).

The mean of the data is 0.1911

The standard deviation of the data is 5.7164

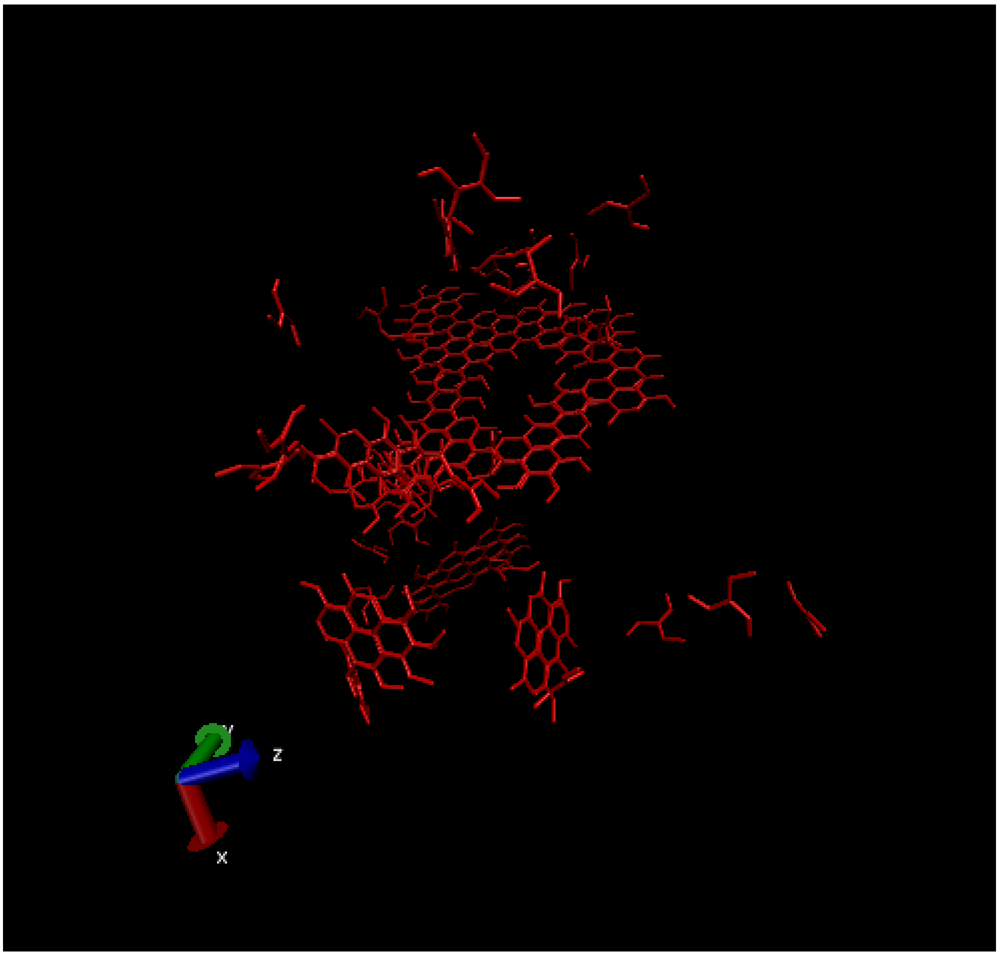
The Standard Error of the Mean (SEM) for the first 10 data points is 1.7001

The mean of the first 10 data points is -1.5777

The rest of the SEMs and Means are in the vectors in the MATLAB script as instructed which are then visualized in the plot.

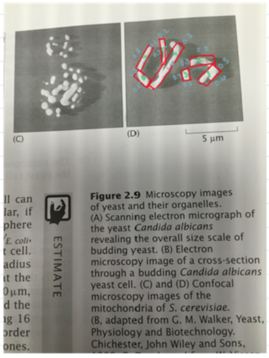
Problem 8:

Here is the image I took after loading the VMD script:



Problem 9:

a)



Measure w/ ruler and approx as 7 cylinders w/ smaller $\frac{\text{width}}{2}$ as radius

$\frac{5\ \mu m}{1.6\ in}$

	h (in)	d (in)	r (in)	$V = \pi r^2 h$ (in³)	$SA = 2\pi r^2 + 2\pi r h \approx 6r^2 + 6rh$ (in²)
1 :	0.6	0.3	~0.1	3(0.01) 0.6 = .018	0.42
2 :	0.8	0.3	0.1	.024	0.54
3 :	0.4	0.3	0.1	.012	0.30
4 :	1.6	0.3	0.1	.048	1.02
5 :	0.7	0.2	0.1	.021	0.48
6 :	0.5	0.3	0.1	.015	0.36
7 :	0.8	0.2	0.1	.024	0.18

* total

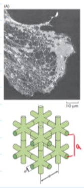
* Total SA = 3.3 in²

Tot: $\approx 0.162\ in^3 \times \left(\frac{5\ \mu m}{1.6\ in}\right)^3 \approx 4.9\ \mu m^3 \times \left(\frac{1\ m}{10^6\ \mu m}\right)^3 \times \frac{10^3\ L}{1\ m^3} =$

Volume: $40\ \cancel{\mu m^3} \times \frac{1\ \cancel{m^3}}{10^{18}\ \cancel{\mu m^3}} \times \frac{10^3\ L}{\cancel{m^3}} = \frac{4 \times 10^4}{10^{18}} L = \boxed{4.9 \times 10^{-15}\ L \text{ or } \sim 5 \text{ Femtoliters}}$

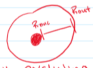
SA: $3.3\ in^2 \times \left(\frac{5\ \mu m}{1.6\ in}\right)^2 \approx \boxed{32\ \mu m^2}$

b)



given $a \approx 60\ nm$
$d \approx 10\ nm$

Approx cell as a sphere



on pg 62 R_{nuc} given as 5 μm and 10 μm as R_{out}

The volume of cell excluding nucleus is $V = \frac{4}{3}\pi(R^3 - r^3) \approx \frac{4}{\cancel{3}}\cancel{3}\left[(10\ \mu m)^3 - (5\ \mu m)^3\right] \approx 4 \times (10^3 - 5^3) \approx 3.5 \times 10^3\ \mu m^3/\text{cell}$

A "unit cell of reticulum" is $\approx a^3 \approx (60\ nm)^3 = 2.16 \times 10^5\ nm^3/\text{unit cell}$ in volume

unit cells / cell : $\frac{V/\text{cell}}{V/\text{unit cell}} = \frac{3.5 \times 10^3\ \mu m^3}{2.16 \times 10^5\ nm^3} = \frac{3.5 \times 10^3\ \mu m^3}{2.16 \times 10^5\ \cancel{nm^3} \times \frac{1\ \mu m^3}{10^9\ \cancel{nm^3}}} = \frac{3.5 \times 10^3\ \mu m^3}{2.16 \times 10^{-4}\ \mu m^3} = 1.62 \times 10^7$ unit cells/cell

S. Area of one unit cell
(Assume just 12 equal cylinders of $SA = 2\pi r^2 + 2\pi r h$): $SA = 12(6r^2 + 6rh) = 72\left(\frac{d}{2}\right)^2 + 36da$

$= 72\left(\frac{10\ nm}{2}\right)^2 + 36(10\ nm)(60\ nm) = 2.34 \times 10^4\ nm^2$ SA/UC

Total SA of ER: $2.34 \times 10^4\ \frac{nm^2\ ER}{\cancel{UC}} \times 1.62 \times 10^7\ \cancel{UC}/\text{cell} = \boxed{3.79 \times 10^{11}\ \frac{nm^2\ ER}{\text{cell}} \text{ or } 37.9 \times 10^4\ \mu m^2\ \frac{ER}{\text{cell}}}$

SA of one unit cell of ER

$\frac{\#\ \text{unit cells}}{1\ \text{cell}}$

very close to concent. circ. approx in book!