A1 

a) There are 6 directories which occupy 6 blocks. Then all the files in the directory occupy a total of 16,333 bytes which is 16 blocks. So, this structure occupies around 22 blocks.

b) First the file would read \( D_1 \) which is 1 block and then it will read \( F_i \) which is 3072 bytes which is 3 blocks. So, in total the system reads 4 blocks.

c) \( D_1 \rightarrow D_2 \rightarrow D_3 = 3 \) blocks. Even reading \( F_4 = 2007 \) bytes which occupies 2 blocks. 
So system reads 5 blocks.

d) First the system reads \( D_1/F_i \) which is 4 blocks. Then the system reads \( D_1/F_5 \) which is \((1+2)=3\) blocks. So it reads 7 blocks in total.

e) Only 2 \( \rightarrow D_1/D_2 \) as it will see there is no \( D_4 \) directory in \( D_2 \) & return
<table>
<thead>
<tr>
<th>File</th>
<th>Space Occupied</th>
<th>Nearest 1024 Multiple</th>
<th>Bytes washed</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>3072</td>
<td>3072</td>
<td>0</td>
</tr>
<tr>
<td>F2</td>
<td>2008</td>
<td>2048</td>
<td>40</td>
</tr>
<tr>
<td>F3</td>
<td>100</td>
<td>1024</td>
<td>0124</td>
</tr>
<tr>
<td>F4</td>
<td>2007</td>
<td>2048</td>
<td>41</td>
</tr>
<tr>
<td>F5</td>
<td>5121</td>
<td>5120</td>
<td>1023</td>
</tr>
<tr>
<td>F6</td>
<td>11</td>
<td>1024</td>
<td>1013</td>
</tr>
</tbody>
</table>

So F5 uses the most space, and F1 uses the least.

A2a) 1000 pounds = principal

\[ 5\% = 0.05 \text{ Rate of Interest} \]

\[ \text{Amount in 100 years} = \frac{1000 \times (1.05)^{100}}{\text{501.25} \times 1000} \]

\[ = \frac{131.50125}{1000} \]

\[ = 131.50125 \text{ pounds} \]

which is close to what Franklin estimated.

Also by rule of 72, the amount doubles in

\[ 72/5 = 14.4 \text{ years} \]

Approximately 7 times, so in 100 years, amount becomes

\[ 1000 \times 27 \]

\[ = 128,000 \]
b) Starting number = 1 bacterium.
Rate of growth = 3% per minute
Acc. to rule of 72, the no. of bacteria doubles in \( \frac{72}{3} = 24 \) minutes.
The closest power of 2 that results in 1,000,000 is 20. So it doubles 20 times so it takes \( 20 \times 24 = 480 \text{ mins} = 8 \text{ hours} \).

Also \( (1.03)^{20} = 1000000 \).
Taking \( \log_{10} \) both sides,
\[ 20 \log_{10}(1.03) = \log_{10}(1000000) \]
\[ 20 \times 0.0128 = 6 \]
\[ x = \frac{6}{0.0128} \]
which is approx. 8 hours.

c) To hold 2,000,000 bacterium, you just double 21 times; by rule of 72,
\[ 21 \times 24 = 504 \text{ minutes} \]
\[ = 8 \text{ hrs} 24 \text{ mins} \].

Also \( x \log_{10}(1.03) = \log_{10}(2000000) \)
\[ x = \frac{504}{0.0128} \]
which is around 8 hrs 11 mins.

d) Since 4 bytes is 32 bits and 1 bit is used for sign of the number.
=> The no. of seconds after 1970 that can be represented are \(2^{31} = 2,147,483,648\) sec.

when we divide this by \((60 \times 60 \times 24 \times 365)\)

to get no. of years:

\[
\frac{2,147,483,648}{60 \times 60 \times 24 \times 365} = 68.09 \text{ years}
\]

=> Time will overflow after 1970 + 68

= 2038.

A3 a) i) For Log:

\[\log_{10}(\text{input}) = \text{operation} - \text{own}.\]

\(10 = b^{100.1} \Rightarrow b = 1.023\)

\(\Rightarrow \log_{10}(1.023) (23) = 131.75\)

or 132 operations.

ii) For linear:

\[\text{operations} = \text{input} \times \text{input}.\]

\(100 = m \times 10 \Rightarrow m = 10\)

\(\Rightarrow 10 \times 20 = 200 \text{ operations}\)

iii) For quadratic:

\[\text{operations} = a \times \text{input}^2.\]

\(100 = a \times 100 \Rightarrow a = 1\)

\(\Rightarrow 1 \times (20)^2 = 400 \text{ operations}\)
iv) For exponential:

\[ \text{opera}tion = e^{\text{input}} \]

\[ = 100 = e^{\text{input}} \]

\[ = e = (100)^{\frac{1}{10}} \]

\[ = 1.584 \]

\[ = e^{20} = (1.584)^{20} = 16000 \text{ operation} \]

(b) 1. Number

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>2</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. 53 000 000

3. 251 107 100

4. 149,948

5. 50,650

6. 5391

7. 535

8. 192

\[ a \left(2^n\right) \]

\[ 33 \text{ (33 bits) } 5 \text{ bytes} \]

\[ 29 \text{ bits } (4 \text{ bytes}) \]

\[ 26 \text{ bits } (4 \text{ bytes}) \]

\[ 28 \text{ bits } (4 \text{ bytes}) \]

\[ 18 \text{ bits } (3 \text{ bytes}) \]

\[ 16 \text{ bits } (2 \text{ bytes}) \]

\[ 13 \text{ bits } (2 \text{ bytes}) \]

\[ 10 \text{ bits } (2 \text{ bytes}) \]

\[ 8 \text{ bits } (1 \text{ byte}) \]

\[ n \left(10^n\right) \]

\[ 10 \]

\[ 9 \]

\[ 8 \]

\[ 5 \]

\[ 6 \]

\[ 4 \]

\[ 2 \]

\[ 2 \]
A3. 9) 2 devices → Laptop 2 Phone

b) Since there are about 5,000 undergraduate students and 1,000 graduate students, so 6,000 students in total at Princeton with 2 devices each which leads to 12,000 IP addresses.

c) According to Assignment 1, we estimate there are about 30 million students in the country, each with 2 devices on average. So we need 60 million IP addresses.

d) Let's say the population of USA is 300 million each with 2 devices. This would require 600 million IP addresses.