Estimating Storage Capacity Worksheet Answers

1. Calculate \( d \)

\[
d = \frac{m}{\sin \theta}
\]

- \( d \) is the spacing of the structure (here: track pitch)
- \( \theta \) is the angle of the \( m^{th} \) diffracted ray
- \( m \) is the order of the diffracted ray. Here we only use the first order, i.e. \( m=+1, -1 \)

To get a better estimate for \( d \), calculate the average \( d_{\text{mean}} = \frac{d_{+1} + d_{-1}}{2} \) in the last column.

<table>
<thead>
<tr>
<th></th>
<th>Laser color</th>
<th>Wavelength (nm)</th>
<th>( \theta, m=+1 )</th>
<th>( \theta, m=-1 )</th>
<th>( d, m=+1 )</th>
<th>( d, m=-1 )</th>
<th>( d_{\text{mean}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD</td>
<td>red</td>
<td>650</td>
<td>30</td>
<td>28</td>
<td>1300 nm</td>
<td>1385 nm</td>
<td>1343 nm</td>
</tr>
<tr>
<td>DVD</td>
<td>red</td>
<td>650</td>
<td>63</td>
<td>62</td>
<td>730 nm</td>
<td>736 nm</td>
<td>733 nm</td>
</tr>
</tbody>
</table>

2. Estimate the storage

Using your measured distance \( d \) between tracks, how many tracks fit on a disc if 33 mm are writable?

Sample Calculations for a CD: \( \frac{33\text{mm}}{1343 \text{ nm}} \times \frac{1 \text{ nm}}{10^{-6} \text{mm}} = 24,572 \)

Sample Calculations for a DVD: \( \frac{33\text{mm}}{733 \text{ nm}} \times \frac{1 \text{ nm}}{10^{-6} \text{mm}} = 45,020 \)

(Answer: Typically, CD around 20,000, DVD around 45,000)

A CD track has around 270,000 pits. A DVD track fits around 500,000 pits because the pits are smaller. How many pits fit on a CD and DVD?

Sample Calculations for a CD: \( 24,572 \times 270,000 = 6,634,440,000 = 6.6 \times 10^9 \)
Estimating the Storage Capacity of a CD/DVD Worksheet

Sample Calculations for a DVD: 45,020 x 500,000 = 22,510,000,000 = 2.25x10^{10}

(Answer: Typically, CD around 5.4x10^{9}, DVD around 2.25x10^{10})

Divide the number by 8 to get an estimate of the storage in bytes. Compare with the info on the CD/DVD. Note that the DVD has two layers.

Sample Calculations for a CD: \frac{6.6x10^{9}}{8} = 825,000,000 = 825 \times 10^{6} = 825 MB

Sample Calculations for a DVD: \frac{2.25x10^{10}}{8} = 2,812,500,000 = 2.8 \times 10^{9} = 2.8 GB \times 2 \text{ layers} = 5.6 GB

(The answer should be close to 700MB for the CD and 4.7GB for the DVD. Note that 1MB=10^{6} \text{ bytes}=8x10^{6} \text{ bits} and 1GB=10^{9} \text{ bytes}=8x10^{9} \text{ bits, hence the division by 8.})

3. **Blu-ray discs** need special readers that rely on blue lasers. How can a Blu-ray disc store more information? Why is the laser blue?

   (Answer: The name blue ray comes from the blue laser. A blue ray can store more information because the distance between the pits, and the pits themselves, are smaller than what was investigated in this activity. The dimension of the pits and their separation is smaller than the wavelength of red and even green lasers. Therefore, a laser with smaller wavelength is needed.)

4. What are two advantages of using digital media to store data? What is a disadvantage?

   (Answer: Advantages may include the ability to store large amounts of information in a small space, that information can be stored reliably, and that it can be copied, transferred, and shared quickly. Disadvantages include issues with easy deletion and security/theft.)