Laboratory One

CD/DVD Drives

Basic Concepts

Your lab instructor will discuss the following concepts:

1. Safety in the ECE 2500 lab. (Touching live electronics, viewing laser light, finding the fire extinguisher, etc.)
2. The procedure and format of the lab notebook.
3. Turn-in procedure when a prelab is due
4. Lab points, prelab points and total score.
5. ASCII code is a 8-bit binary representation of 256 common alphanumeric and special characters.
6. Binary is stored on CDs as patterns of 'pits' and 'lands' recorded on a long spiral-shaped track.
7. A blank CD/DVD track is one big continuous 'land'.
8. ASCII is recorded on a CD by using the EFM code
9. Data is read from a CD/DVD by reading the reflection of laser light off the pit and land pattern in the CD/DVD.

There is no prelab exercise associated with this lab. However, You must bring an approved lab notebook with you to the laboratory. See the course syllabus.

Task One: Number Conversion Practice

[Discussion] The lab instructor will assign everyone 3 number conversions to do by hand in their lab notebooks. The lab instructor will discuss solutions on the board so all will understand.

1. Make the conversion between octal and decimal for one of the three cases shown at right.

   $(455)_8 = (?)_{10}$
   $(455)_{10} = (?)_8$, Other cases: 342, 677

2. Make the conversion between hexadecimal and 8-bit binary for one of the numbers shown at right.

   $(1000\ 1100)_2 = (??)_{16}$
   Others: $(0111\ 1010)_2$, $(0100\ 1101)_2$

3. Make the conversion between "characters" and ASCII for one of the three cases shown. Use this ASCII table.

   "3" $= (??)_{16} = (????\ ????)_2$
   Other characters: "&", "H"

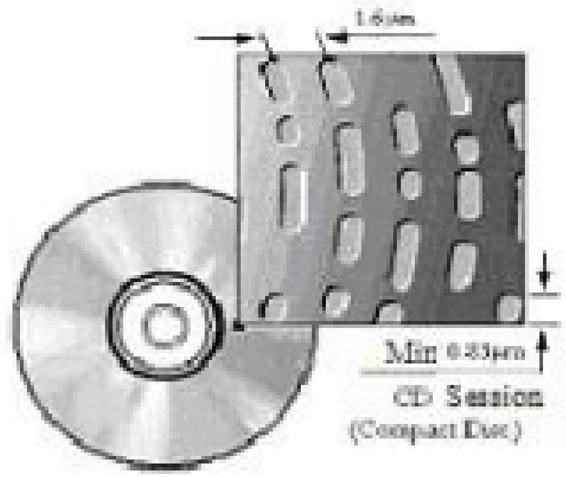
Task Two: Track Speed Measurement

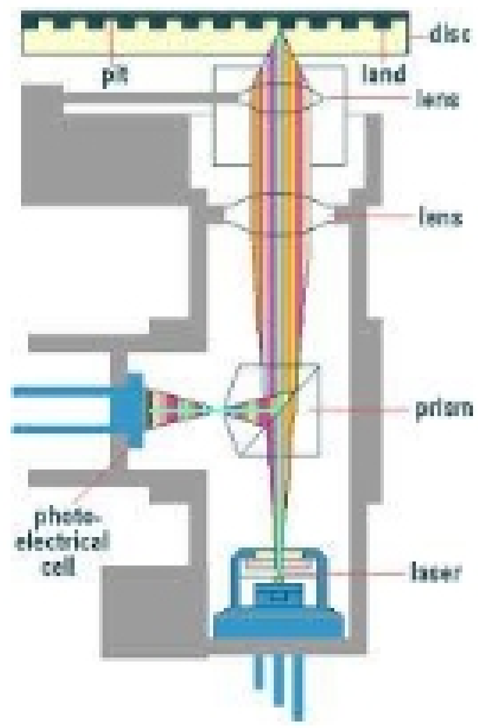
If one holds up an unmarked CD-R disc to the light, there doesn't seem to be much to see. But a whole world of pits and lands, invisible to the eye, awaits you. See this also.

1. Examine the large CD-R disc and notice that it is semi-transparent. The CDs in the lab are specially unmarked and have no logo so you can see through it. Look closely and see if you can find some markings that identify which side is the top surface of the CD.
2. Place the large CD in the modified 1x CD player with the door removed. Play the first track of the CD (hold the door latch button down with a stick) and verify that the CD player plays the music track properly.
3. Remove the CD and press 'Play' to rotate the spindle with no CD. You should be able to see some residual red light from the laser lens on top of the head. Most of the power of the laser is in the infrared at a wavelength of .78 µm. Now watch the head. Write down what do you think the lens is trying to do after pressing 'Play'.
4. We are going to use the Neiko Laser Photo Tacometer to measure the rotation speed of the CD disc, in rotations per minute (RPM), the surface of which is marked with special reflective tape marking.
   a) Place the CD player flat on the table, play track 1.
   b) Hold the tachometer so the laser points at the reflective marker on the CD. A 45-degree angle works well. (Make sure the laser from the CD is pointed away from everyone's eyes.)
   c) Press and hold the Test button and read the RPM from the screen of the tachometer. Record your rotation speed in your lab notebook and call it RPM_1.
5. Go to the last track on the CD. (We will call this track n) Notice that the disc is rotating more slowly. Use the tachometer and measure the rotation speed RPM_n.
6. Measure the radii of tracks 1 and n, using the metric rulers, and record these values as r_1 and r_n.
7. CD players operating less than 12x speed, like this one, run at CLV (constant linear velocity). Using the formula for linear track speed

   $$s_i = 2\pi r_i RPM_i$$

   calculate the track speeds s_1 and s_n that the head sees the disc spinning above it for the first and last track. Record your values in units of cm/minute and m/minute. How close (percentage-wise) is s_n from s_1?





CD vs DVD vs Blue-Ray:

1. Spiral pit size:
   0.8 vs 0.4 vs 0.15 µm
2. Spiral track separation:
   1.6 vs 0.7 vs 0.3 µm
3. Laser λ:
   .78 vs .65 vs .40 µm
4. Capacity:
   800 MB vs
   4700 MB (4.7 GB) vs
   25 GB for Blue-Ray

Task Three: ASCII & Music Encoding

1. Record the hex ASCII code for each of the initials of your first and last name (see example shown at right) in your lab notebook. Use this ASCII table again.
2. Next, make a 16-bit binary and 28-bit CD modulation code for your two initials (used together) using an EFM conversion table, which spreads the binary pattern out to make it more reliable to read.
3. Finally draw a pit and land pattern for your initials using the following rules: **1**s cause a change from a land to a pit or a pit to a land; **0**s cause no change.
4. Your lab instructor will now help you observe the raw pit and land data coming from your CD, using the **Diligent Analog Discovery** USB scope. First bring up the USB scope app and activate the C1 analog channel and one digital channel (DIO). Next, connect the all black USB scope ground wire to the white CD wire and the USB scope C1 and DIO wire to the blue CD wire.
5. With a CD playing, put the C1 analog channel data and DIO digital data on top of each other.
6. Pause the USB scope and see if you can find any A/D errors (where the digital data does not follow the analog data).
7. Find an errorless frame of USB scope data and record the waveforms in your notebook.

Initial	ASCII Hex	ASCII Binary	EFM Binary
A	41	01000001	10000100100100

Draw P&L: 

Task Four: Spiral Density Calculation

1. Place the small CD-R disc in the CD player with the top up. Play the first track of the CD and verify that the CD player plays the music track properly.
2. Restart track 1 and keep time to the end of the song. Also, measure the location of the head using the red marker under the small disc and call it h_1.
3. When the song is complete, record your track time as T_1 (make it in units of minutes) and measure the location of the head at the beginning of track 2 and call it h_2.
4. Calculate the number of rotations needed to play track 1 from the formula:
   $$N_1 = RPM_1 * T_1$$
5. Calculate the spiral density D of the CD, which is the number of revolutions of the CD per unit mm, as
   $$D = \frac{N_1}{\Delta h} = \frac{N_1}{h_2 - h_1}$$
6. Calculate the length of track 1 (in units of cm and km):
   $$l_1 = N_1 * 2\pi r_1$$
   Where r_1 is the radius of track 1.
   Convert your song track length to units of miles.