Music Listening Technology
Collingwood and Prince (2003)

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The technology of reproducing music has gone through a revolution since the early 1980's. The "old" stereo long playing record (the LP) and the "new" digital compact disc (the CD) are two methods of storing musical data for later reproduction in a home stereo system. These two technologies adopt different perspectives as to which notion of circular speed is best to work with.

Long playing stereo records are thin vinyl plastic discs of radius 6 inches onto which small spiral grooves are etched into the surface; we can approximately view this groove as a circle. The LP is placed on a flat 12 inch diameter platter which turns at a constant angular speed of 33 $^1/_3$ RPM. An arm on a pivot (called the tone arm) has a needle mounted on the end (called the cartridge), which is placed in the groove on the outside edge of the record. Because the grooves wobble microscopically from side-to-side, the needle will mimic this motion. In turn, this sets a magnet (mounted on the opposite end of the needle) into motion. This moving magnet sits inside a coil of wire, causing a small varying voltage; the electric signal is then fed to your stereo, amplified and passed onto your speakers, reproducing music!

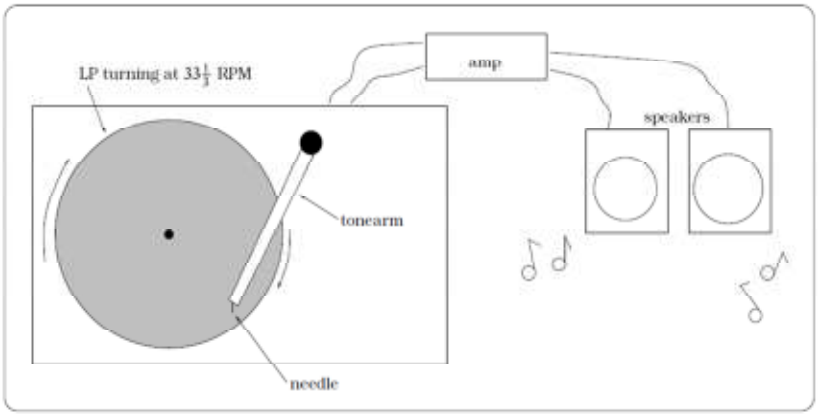

Figure 16.5: Reproducing music using analogue technology.

This is known as analogue technology and is based upon the idea of maintaining a constant angular speed of 33 $^1/_3$ RPM for the storage medium (our LP). (Older analogue technologies used 45 RPM and 78 RPM records. However, 33 $^1/_3$ RPM became the consumer standard for stereo music.) With an LP, the beginning of the record (the lead-in groove) would be on the outermost edge of the record and the end of the record (the exit groove) would be close to the center. Placing the needle in the lead-in groove, the needle gradually works its way to the exit groove. However, whereas the angular speed of the LP is a constant 33 $^1/_3$ RPM, the linear speed at the needle can vary quite a bit, depending on the needle location.

(Analogue LP's). The "lead-in groove" is 6 inches from the center of an LP, while the "exit groove" is 1 inch from the center.

Figure 16.6: Lead-in and exit grooves.

1. What is the linear speed (MPH) of the needle in the “lead-in groove”?
2. What is the linear speed (MPH) of the needle in the “exit groove”?
3. Find the location of the needle if the linear speed is 1 MPH.

In the early 1980’s, a new method of storing and reproducing music was introduced; this medium is called the digital compact disc, referred to as a CD for short. This is a thin plastic disc of diameter 4.5 inches, which appears to the naked eye to have a shiny silver coating on one side. Upon microscopic examination one would find concentric circles of pits in the silver coating. This disc is placed in a CD player, which spins the disc. A laser located above the spinning disc will project onto the spinning disc. The pits in the silver coating will cause the reflected laser light to vary in intensity. A sensor detects this variation, converting it to a digital signal (the analogue to digital or AD conversion). This is fed into a digital to analogue or DA conversion device, which sends a signal to your stereo, again producing music.

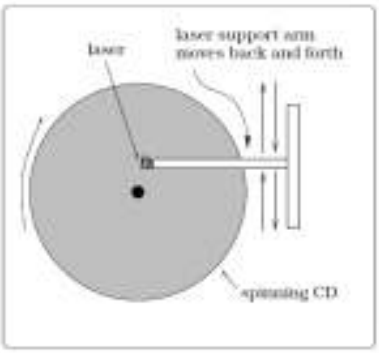

Figure 16.7: Reproducing music using digital technology.

The technology of CD’s differs from that of LPs in two crucial ways. First, the circular motion of the spinning CD is controlled so that the target on the disc below the laser is always moving at a constant linear speed of 1.2 $^{\text{meters}}/_{\text{sec}}$ = 2,835 $^{\text{inches}}/_{\text{minute}}$. Secondly, the beginning location of the laser will be on the inside portion of the disc, working its way outward to the end. In this context, it makes sense to study how the angular speed of the CD is changing, as the laser position changes.

(Digital CD’s).

4. What is the angular speed (in RPM) of a CD if the laser is at the beginning, located $^{3}/_{4}$ inches from the center of the disc?
5. What is the angular speed (in RPM) of a CD if the laser is at the end, located 2 inches from the center of the disc?
6. Find the location of the laser if the angular speed is 350 RPM.

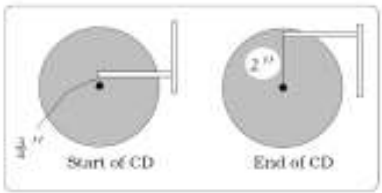

Figure 16.8: Computing the angular speed of a CD.

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