

TABLE 3-10 Average formant frequencies for common vowels in American English (after Peterson and Barney, 1952). The vowels are shown in order of increasing formant frequency F_2 .

Symbol	Typical Word	F_1	F_2	F_3
/ow/	bought	570	840	2410
/oo/	boot	300	870	2240
/u/	foot	440	1020	2240
/a/	hot	730	1090	2440
/uh/	but	520	1190	2390
/er/	bird	490	1350	1690
/ae/	bat	660	1720	2410
/e/	bet	530	1840	2480
/i/	bit	390	1990	2550
/iy/	beet	270	2290	3010

quality to virtually any harmonic-rich waveform simply by properly emphasizing the frequencies shown in Table 3-10.

For example, the following cmusic score produces a fairly realistic male voice singing /a/. The sing instrument has five basic parts:

- A pitch control section
- A simple vibrato section
- An amplitude envelope control section
- A source sound section
- A formant-filtering section

In this instrument, the main amplitude is given by p5, and p6 sets the number of components used in the band-limited pulse excitation waveform. p7 through p15 specify a three-part pitch inflection via the trans unit generator. Note that the vibrato depth and rate as well as the formant frequencies are fixed, though the instrument could easily be modified to allow these parameters to be controlled on a dynamic or note-by-note basis. A diagram of this instrument is shown in Figure 3-41.

```
#include <carl/cmusic.h>
```

```
ins 0 sing ;
{pitch inflection}
  trans b8 d d d 0,p7 p8 p9,p10 p11 p12,p13 p14 1,p15 ;
{vibrato}
  mult b10 b8 .015 ;           {+-1.5% depth}
  osc b9 b10 5Hz f1 d ;        {5 Hz rate}
  adn b7 b8 b9 ;
```