PHYS/MUS 204, Sp 08 Prelim 2 SOLUTIONS

1. (15 points)

Going up a major third multiplies the (fundamental) frequency by a factor of 5/4.
Going up a minor third multiplies the frequency by a factor of 6/5.

Overall, we have multiplied the frequency by (5/4)(6/5) = 3/2.

This frequency ratio corresponds to a perfect fifth.

***2. (15 points)**

Reason 1: violin is (usually) played with a bow, whereas guitar is plucked. Using the bow allows you to keep adding energy to a note after you have begun playing it.

Reason 2: design of the bridge is very different. When a violin is played, the bridge pivots about one foot, converting the sideways vibrations of the string into up and down motions of the top plate. This mechanism gives a very rapid and efficient transfer of energy from the string to the top plate. A guitar bridge is low and flat, so that transfer of the string vibration to the top plate is much slower. This allows the plucked guitar string to ring for much longer than a plucked violin string, but makes the guitar quieter.

NOTE: these are the most two important reasons that a violin is louder than a guitar. Some credit was given for other factors that contribute to making the violin loud.

3. (15 pts)

(a) The sound intensity is given by

$$I = \frac{W}{4\pi r^2} = \frac{7 \times 10^{-6}\ \text{Watts}}{4\pi (5\ \text{m})^2} = 2.23 \times 10^{-8}\ \text{W/m}^2$$

The sound intensity <u>level</u> is then

$$L_I = 10 \log\left(\frac{I}{I_0}\right), \quad \text{where } I_0 = 10^{-12}\ \text{W/m}^2$$

So

$$L_I = 10 \log\left(\frac{2.23 \times 10^{-8}\ \text{W/m}^2}{10^{-12}\ \text{W/m}^2}\right) = \boxed{43.5\ \text{dB}}.$$

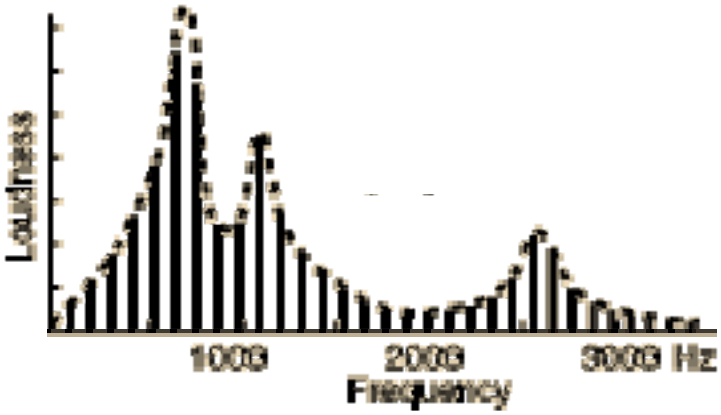
4. (15 points)

(a) FLUTE

(b) In the above spectrum, harmonics n = 1 and 2 have strong intensity, all higher harmonics are weak. A flute, whistle or recorder makes a spectrum like this. Brass instruments and reed instruments produce spectra with many more strong harmonics.

5. (20 points)

(a)



(b) The vowel sound is identified by the frequencies at which the peaks in the spectrum are most intense.

(c) The vocal folds.

(d) The singer adjusts the shape of their vocal tract using their tongue, soft palate and lips.

6. (20 points)

(a) The piano player plays $C_5^{\#}$ at four tempered half-steps above A_4 = 440 Hz:

$$f_p = (440 \text{ Hz})\,(2^{4/12}) = (440 \text{ Hz})\,(1.2599) = \boxed{554.36 \text{ Hz}}$$

(b) The violinist plays $C_5^{\#}$ at a just major third above A:

$$f_v = (440 \text{ Hz})\,(5/4) = \boxed{550.00 \text{ Hz}}$$

(c) The lowest beat frequency heard when they play $C_5^{\#}$ together is

$$f_b = |\, f_p - f_v \,| = 554.36 \text{ Hz} - 550.00 \text{ Hz} = \boxed{4.36 \text{ Hz}}\ .$$

(These are first-order beats.)

NOTE: Violin and piano duets can actually sound very beautiful, because the violin is a variable intonation instrument. A good violinist will adjust the pitch of each note she plays to sound best with whatever the piano is playing at that moment.