Physics of Music  
**Homework 7**  
Winter 2008  
**Solutions**

1. For a wave on a string, we examined the relation

\[ v = \sqrt{\frac{F}{\mu}} \]

where \( F \) is the tension in N and \( \mu \) is the mass per unit length, in kg/m. Show explicitly that the expression on the right above reduces to units of m/s. (You need to know the definition of a newton: \( N = \text{kg m/s}^2 \).)

We use the fact that one newton is one kg-m/s\(^2\). Then the units for \( \sqrt{\frac{F}{\mu}} \) are

\[
\sqrt{\frac{\text{kg-m/s}^2}{\text{kg/m}}} = \sqrt{\frac{\text{kg-m}^2}{\text{kg-s}^2}}
\]

\[
= \sqrt{\frac{\text{m}^2}{\text{s}^2}}
\]

\[
= \text{m/s}
\]

Q.E.D.
2. In class we showed a woodcut from *Theorica Musicae* by Gafurius (1451-1522). It shows a figure which is supposed to be Pythagoras playing a stringed instrument. The tension in each string is produced by a weight, and the weights are labeled “4, 6, 8, 9, 12, 16.” The implication is that the frequency is proportional to the weight.

(A) Which pairs of strings are (allegedly) an octave apart?

4 and 8; 8 and 16; 6 and 12

(B) Which pairs of strings are (allegedly) a perfect fifth apart?

We find a 3/2 ratio (a fifth) for 6/4, 9/6, and 12/8.

(C) The 12:9 pair and the 16:12 pair would each represent what musical interval?

12:9 and 16:12 both reduce to 4/3, a fourth.

(D) Galileo helped his father, Vincenzio Galilei, in experiments which disproved the idea that the frequency is proportional to the tension. What is the correct relation between frequency and tension? You don’t have to give the exact equation: just complete the following sentence:

“__________ is proportional to __________.”

“Frequency is proportional to the square root of the tension.”