# SPH3U UNIVERSITY PHYSICS

WAVES & SOUND

- Beats (P.427-429)

## Beats

*We have been examining the interference of waves with identical frequencies and wavelengths. Now we will consider the interference of sound waves with slightly different frequencies and wavelengths. Consider two identical tuning forks – except that one fork has a tine "loaded" with plasticine or it has an elastic band wrapped around it.*

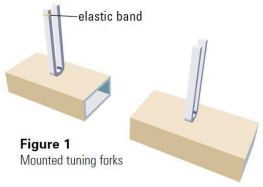



**Figure 1**
Mounted tuning forks



## Activity: Beats

**INSTRUCTIONS**

A. Place two mounted tuning forks close to and facing each other. Wrap an elastic band tightly around a prong on one of the tuning forks.
B. Sound the forks together and describe the resulting sound.
C. Repeat the procedure using two elastic bands on the same prong.
D. Remove the elastic bands and repeat the process a third time.

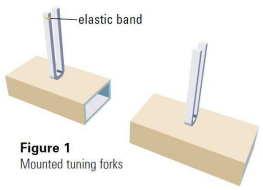



**Figure 1**
Mounted tuning forks

## Activity: Beats

**QUESTIONS**

1. Did the frequency of a tuning fork increase or decrease when elastic bands were added to a prong? Explain your answer.
2. The observed sound alternated between loud and soft. Explain this observation.

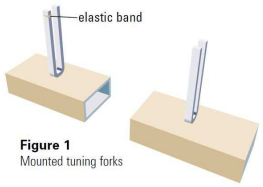
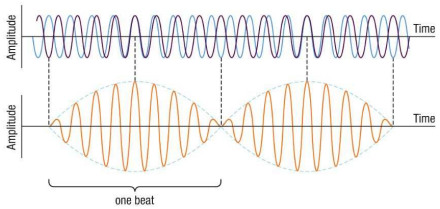



**Figure 1**
Mounted tuning forks



## Beats & Beat Frequency

*If a "loaded" fork is struck at the same time as an "unloaded" identical tuning fork, the observed sound will alternate between loud and soft, indicating alternating constructive and destructive interference. Such periodic changes in sound intensity are called* ***beats****.*

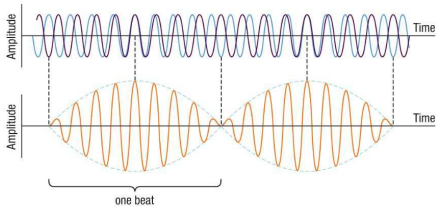





## Beats & Beat Frequency

***NOTE!***

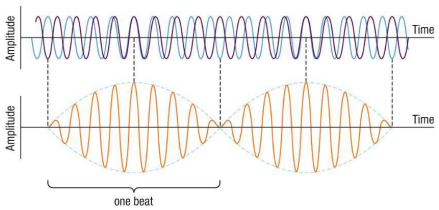
*Beats are formed by the superposition of two waves with slightly different frequencies.*



## Beats & Beat Frequency

**BEATS**

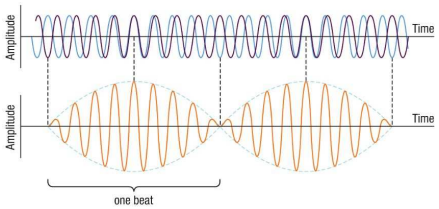
- periodic change in sound intensity
- formed by the superposition of two waves with slightly different frequencies






## Beats & Beat Frequency

*At times, the waves are in phase and constructive interference occurs. At other times, the waves move out of phase with each other and destructive interference occurs. As time passes, the waves move into phase, then out phase, and so on. The number of beats that occur per second is called the* ***beat frequency****.*






## Beats & Beat Frequency

***NOTE!***

*Beats can be used to assess very small differences in frequency between two waves, because you can hear the change in loudness. Violinists and other musicians can use beats to tune their instruments. By checking the frequency of the beats with a standard note, perhaps from a piano or an oboe, musicians can adjust their instrument until beats are no longer heard. The beat frequency is equal to the difference in frequencies of the two interfering waves.*

$$\text{beat frequency} = | f_1 - f_2 |$$

## Beats & Beat Frequency

**BEAT FREQUENCY**

- number of beats heard per second

$$f_{beat} = |f_1 - f_2|$$

where $f_{beat}$ is the beat frequency (Hz)
$f_{1\ \&\ 2}$ are the two frequencies (Hz)

***RECALL!***

*The bars (||) in the equation above represent "absolute value". This means that, mathematically, if a = 3 and b = -3 then |a| = |b| = 3.*



## Beats & Beat Frequency

**PRACTICE**

1. A tuning fork with a frequency of 256 Hz is sounded together with a note played on a piano. 9 beats are heard in 3.0 s. What is the frequency of the piano note?

   253 Hz or 259 Hz
   notice that there are two possible answers – without more information, there is no way of knowing which is correct



## Beats & Beat Frequency

**PRACTICE**

2. (a) A tuning fork with a frequency of 400 Hz is struck with a second fork, and 20 beats are counted in 5.0 s. What are the possible frequencies of the second fork?
   (b) A third fork with a frequency of 410 Hz is struck with the second fork above, and 18 beats are counted in 3.0 s. What is the frequency of the second fork?

   (a) 396 Hz or 404 Hz
   (b) 404 Hz since the possible frequencies are 404 Hz or 416 Hz

## Beats & Beat Frequency

**PRACTICE**

3. A 440 Hz tuning fork is sounded together with a guitar string, and a beat frequency of 3.0 Hz is heard. When an elastic band is wrapped tightly around one prong of the tuning fork, a new beat frequency of 2.0 Hz is heard. Determine the frequency of the guitar string.

   437 Hz since the addition of a "load" lowers the frequency of an object



## Beats & Beat Frequency

**PRACTICE**

4. How would a piano tuner use a tuning fork or pitch pipe to tune a piano by adjusting the tension of the strings?

   sound the tuning fork and piano string together and then increase/decrease the tension until fewer beats are heard



## ✔ Check Your Learning

**TEXTBOOK**

P.429 Q.2,3