Name: Period:

Chapter 13 Packet: Sound

Part I- Fill in the blank. *Write the term that correctly completes each statement.*

Amplitude	Greater	Twice
Decibels	Interfere	$V = \lambda f$
Diffracted	Temperature	Vacuum
Distance	Longitudinal	Velocities
Echoes	Pitch	Wavelength
Frequency	Pressure	

Sound waves move in the same direction as the particles of the medium and are therefore (1)____________________ waves. The waves are caused by variations in (2)_____________________ relating to the different (3)________________ of molecules. Therefore, sound cannot travel through a(n) (4) ____________. The (5)________________ of a sound wave is the number of pressure oscillations per second. The (6)_____________________ is the distance between successive regions of high or low pressure. The speed of a sound wave in air depends on the (7)___________________ of the air. At 20 °C, sound moves through air at sea level at a speed of 342 m/s. In general, the speed of sound is (8)____________ in liquids and solids than in gases. Reflected sound waves are (9)_____________. The reflection of sound waves can be used to find the (10)________________ between a sound source and a reflecting surface. Sound waves can (11)________________ producing nodes, where little sound is heard. Sound waves can also be (12)________________; they spread outward after passing through a narrow opening. The equation that relates velocity, frequency, and wavelength is (13)_____________________.

Loudness of sound and the pitch of a sound are two unrelated measurements. The frequency of a sound wave is related to the (14)___________________ of the sound wave, which is measured in hertz (Hz). The loudness of a sound wave is measured in (15)_____________, symbolized by the letters dB. Loudness is directly proportional to the (16)________________ of the wave. The decibel level of a sound is a found using a logarithmic scale. Two sounds that have a difference of 10 dBs are roughly (17)__________________ as loud. Because the volume doubles each time the decibel level increases by 10, sounds at the threshold of pain are 4096 times as loud as sounds at the threshold of hearing.

For each term on the left, write the corresponding symbol from those on the right. Some symbols may be used more than once

18.	______Period	dB
19.	______Amplitude	Hz
20.	______Speed	m
21.	______Frequency	m/s
22.	______Loudness	s
23.	______Pitch	
24.	______Wavelength	

The Doppler Effect

State whether the process would make the apparent pitch of a sound higher, lower, or have no effect on it.

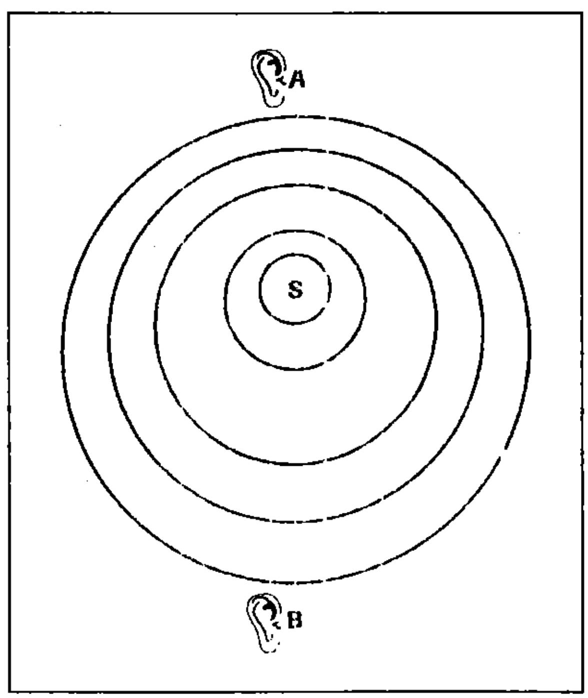
25. moving the listener away from the sound source ____________________
26. decreasing the frequency ____________________
27. increasing the # of decibels ____________________
28. decreasing the wavelength, at constant wave speed ____________________
29. increasing the wavelength, at constant wave speed ____________________
30. moving the sound source toward the listener ____________________
31. decreasing the wave amplitude ____________________
32. increasing the wavelength, at constant frequency ____________________
33. decreasing the period ____________________

The drawing below shows the crests of sound waves produced by a point source, S, that is moving. The two ears represent two listeners at different positions. Refer to the drawing to answer the following questions.

34. Which direction is the point source moving?

35. How do the apparent wavelengths at A and B compare?

36. How does the speed of the sound waves compare at A & B?



37. How does the apparent frequency at point A compare to that at point B? Give a reason for your answer, in terms of the meaning of the word *frequency* and of the equation relating frequency to speed and wavelength.

38. How loud is the sound heard at A compared that heard at B when A and B are equally far from the source?

39. Is the sound heard at A higher or lower pitch than heard at B? Give a reason for your answer.

40. If the point source began to move faster in the same direction, would the apparent sound at A and B change? If yes, how would it change?

41. If the point source stopped moving, how would the apparent sound at A and B change, if at all?

42. Suppose B started to move downward while the point source continued to move in its original direction. How would the apparent sound at B change, if at all?

43. As a dolphin swims toward a fish, it sends out sound waves to determine the direction the fish is moving. If the frequency of the reflected waves is increased, is the dolphin catching up to the fish or falling behind?

Sound Problems

Use the following formulas to answer the questions regarding sound, its speed, pitch and wavelength.

Velocity = wavelength x frequency **$v = \lambda f$**

Length of air column (both ends open) with loudest resonance = wavelength/2 **$L = \lambda/2$**

Length of air column(one closed end) with loudest resonance = wavelength/4 **$L = \lambda/4$**

Speed of sound = 330 m/s + (0.6)(Celsius Temperature) **v = 330 m/s + 0.6(Temp)**

# of beats per second (Hz) = difference of the frequencies of the 2 sounds **beat = $f_2 - f_1$**

1. Sound with a frequency of 261.6 Hz travels through water at a speed of 1435 m/s. Find the wavelength in water.

2. The human ear can detect sounds with frequencies between 20 Hz and 16 kHz (16,000 Hz). Find the largest and smallest wavelengths the ear can detect, assuming the sound travels through air with a speed of 342 m/s at 20 °C.

3. What is the frequency of sound in air at 20 °C having a wavelength equal to the diameter of a 15-inch (38-cm) "woofer" loudspeaker? Of a 3-inch (7.6-cm) diameter "tweeter"?

4. A 440 Hz tuning fork is held above a closed pipe resonator in air with a temperature of 20 °C. Find the length of pipe, L, that provides the loudest resonance.

5. The frequency of a tuning fork is unknown. A student uses an air column at 27 °C and finds that resonance occurs at a pipe length of 0.392 m. What is the frequency of the tuning fork?

6. The auditory canal, leading to the eardrum, is a closed pipe 3.0-cm long. Find the approximate value of the lowest resonant frequency at room temperature (20 °C)?

7. If the temperature of air were 33 °C, what length of pipe (closed end) would be needed to provide the loudest resonance using a tuning fork with a pitch of 536 Hz? What length pipe (open on both ends) would be needed using the same tuning fork?

8. A flute is essentially a pipe open at both ends. The length of a flute is approximately 66.0 cm. What is the fundamental frequency of a flute when all keys are closed, making the vibrating air column approximately equal to the length of the flute? The speed of sound in the flute is 340 m/s.

9. You have a tuning fork with a frequency of 518 Hz and it is held over an 18.6-cm long pipe over water to provide the loudest resonance. Knowing all of this information, calculate the temperature of the air.

10. How many beats would be heard when tuning forks of 418 Hz and 398 Hz are struck near each other at the same time?

11. A piano tuner using a 392 Hz tuning fork to tune the wire for G-natural hears 4 beats per second. What are the two possible frequencies of vibration of this piano wire?

Name: Period: Date:

Speed of Sound and Doppler Worksheet

Use the following formulas to help you answer these questions regarding sound.

$v = \lambda f$ $v = 330\text{ m/s} + 0.6(°C)$

closed pipe resonance tube (L): $L = \lambda/4$ open pipe resonance tube (L): $L = \lambda/2$

<u>Doppler Effect Calculations</u>

Calculation of Doppler Shift with a moving sound source moving towards a stationary object:

$F_o = F[V_{sound}/(V_{sound} - V_{source})]$

Calculation of Doppler Shift with a moving sound source moving away from a stationary object:

$F_o = F[V_{sound}/(V_{sound} + V_{source})]$

Calculation of Doppler Shift with an observer moving towards a stationary sound source:

$F_o = F[(V_{sound} - V_{observer})/V_{sound}]$ (Hint: consider the velocity of the object a negative #)

Calculation of Doppler Shift with an observer moving away from a stationary sound source:

$F_o = F[(V_{sound} + V_{observer})/V_{sound}]$ (Hint: consider the velocity of the object a negative #)

In each case, F = actual frequency of sound; F_o = observed frequency; v_{sound} = speed of sound; v_{source} = speed of sound source; $v_{observer}$ = speed of observer.

1. Calculate the speed of sound in air at the following temperatures. ($°C = (°F - 32)/1.8$)
   a. 18°C
   b. 37°C
   c. 75°F
   d. 62°F

2. At what temperature would sound travel through air as fast as it does through water, which is 1484 m/s?

3. Draw circles around the police car representing the sound waves coming from the siren in the following pictures.

Standing still

moving forward

4. A tuning fork of 320 Hz is held over a glass tube that is partially submerged in water. What length will the tube be if the air temperature is 25 °C to produce the loudest resonance? How long would a glass tube if the same experiment was held over a glass tube that is open to the air on both sides?

5. If the police car with a 365 Hz siren is traveling at 60 mph towards you, on a summer day of 28 °C, what frequency would you hear? (1 mile = 1609 meters; 1 hour = 3600 sec)

6. If a fire truck with a 340 Hz siren is traveling at 45 mph away from you, on a cold winter day of -10 °C, what frequency would you hear? (1 mile = 1609 meters; 1 hour = 3600 sec)

7. Driving your Ferrari through the Italian countryside at a speedy -88 m/s, you approach an opera diva singing a high C (1,046 Hz). What frequency will you actually hear as you approach? (Assume a speed of sound of 340 m/s.)

Name: Key Period:

Chapter 13 Packet: Sound

Part I- Fill in the blank. *Write the term that correctly completes each statement.*

~~Amplitude~~	~~Greater~~	~~Twice~~
~~Decibels~~	~~Interfere~~	~~$V = \lambda f$~~
~~Diffracted~~	~~Temperature~~	~~Vacuum~~
~~Distance~~	~~Longitudinal~~	~~Velocities~~
~~Echoes~~	~~Pitch~~	~~Wavelength~~
~~Frequency~~	~~Pressure~~	

Sound waves move in the same direction as the particles of the medium and are therefore (1)__longitudinal__ waves. The waves are caused by variations in (2)__pressure__ relating to the different (3)__velocities__ of molecules. Therefore, sound cannot travel through a(n) (4) __vacuum__. The (5)__frequency__ of a sound wave is the number of pressure oscillations per second. The (6)__wavelength__ is the distance between successive regions of high or low pressure. The speed of a sound wave in air depends on the (7)__temperature__ of the air. At 20 °C, sound moves through air at sea level at a speed of 342 m/s. In general, the speed of sound is (8)__greater__ in liquids and solids than in gases. Reflected sound waves are (9)__echoes__. The reflection of sound waves can be used to find the (10)__distance__ between a sound source and a reflecting surface. Sound waves can (11)__interfere__ producing nodes, where little sound is heard. Sound waves can also be (12)__diffracted__; they spread outward after passing through a narrow opening. The equation that relates velocity, frequency, and wavelength is (13)__$V = \lambda f$__.

Loudness of sound and the pitch of a sound are two unrelated measurements. The frequency of a sound wave is related to the (14)__pitch__ of the sound wave, which is measured in hertz (Hz). The loudness of a sound wave is measured in (15)__decibels__, symbolized by the letters dB. Loudness is directly proportional to the (16)__Amplitude__ of the wave. The decibel level of a sound is a found using a logarithmic scale. Two sounds that have a difference of 10 dBs are roughly (17)__Twice__ as loud. Because the volume doubles each time the decibel level increases by 10, sounds at the threshold of pain are 4096 times as loud as sounds at the threshold of hearing.

For each term on the left, write the corresponding symbol from those on the right. Some symbols may be used more than once

18.	~~Hz~~ s Period	dB
19.	dB ~~m~~ Amplitude	Hz
20.	m/s Speed	m
21.	Hz Frequency	m/s
22.	dB Loudness	s
23.	Hz Pitch	
24.	m Wavelength	

The Doppler Effect

State whether the process would make the apparent pitch of a sound higher, lower, or have no effect on it.

25. moving the listener away from the sound source lower
26. decreasing the frequency lower
27. increasing the # of decibels no effect
28. decreasing the wavelength, at constant wave speed higher
29. increasing the wavelength, at constant wave speed lower
30. moving the sound source toward the listener higher
31. decreasing the wave amplitude no effect
32. increasing the wavelength, at constant frequency no effect
33. decreasing the period higher

The drawing below shows the crests of sound waves produced by a point source, S, that is moving. The two ears represent two listeners at different positions. Refer to the drawing to answer the following questions.

34. Which direction is the point source moving?

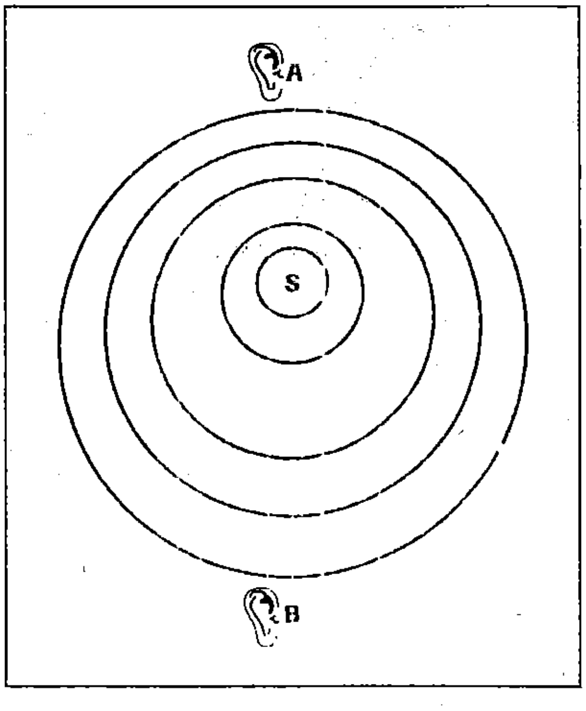
toward A

35. How do the apparent wavelengths at A and B compare?

Shorter at A

36. How does the speed of the sound waves compare at A & B?

Same speed



37. How does the apparent frequency at point A compare to that at point B? Give a reason for your answer, in terms of the meaning of the word *frequency* and of the equation relating frequency to speed and wavelength.

higher f at A because there is shorter wavelength

38. How loud is the sound heard at A compared that heard at B when A and B are equally far from the source?

Equal Loudness

39. Is the sound heard at A higher or lower pitch than heard at B? Give a reason for your answer.

higher at A

40. If the point source began to move faster in the same direction, would the apparent sound at A and B change? If yes, how would it change?

higher at A, lower at B

41. If the point source stopped moving, how would the apparent sound at A and B change, if at all?

get lower at A, higher at B until they equal

42. Suppose B started to move downward while the point source continued to move in its original direction. How would the apparent sound at B change, if at all?

it would get even lower at B.

43. As a dolphin swims toward a fish, it sends out sound waves to determine the direction the fish is moving. If the frequency of the reflected waves is increased, is the dolphin catching up to the fish or falling behind?

Catching up.

Sound Problems

Use the following formulas to answer the questions regarding sound, its speed, pitch and wavelength.

Velocity = wavelength x frequency **v = λf**

Length of air column (both ends open) with loudest resonance = wavelength/2 **L = λ/2**

Length of air column(one closed end) with loudest resonance = wavelength/4 **L = λ/4**

Speed of sound = 330 m/s + (0.6)(Celsius Temperature) **v = 330 m/s + 0.6(Temp)**

\# of beats per second (Hz) = difference of the frequencies of the 2 sounds **beat = $f_2 - f_1$**

1. Sound with a frequency of 261.6 Hz travels through water at a speed of 1435 m/s. Find the wavelength in water.

$\lambda = \frac{v}{f} = \frac{1435\ m/s}{261.6\ /s} = 5.49\ m$

2. The human ear can detect sounds with frequencies between 20 Hz and 16 kHz (16,000 Hz). Find the largest and smallest wavelengths the ear can detect, assuming the sound travels through air with a speed of 342 m/s at 20 °C.

$\lambda = \frac{v}{f} = \frac{342\ m/s}{(20\ Hz)} = 17.1\ m$ $\lambda = \frac{v}{f} = \frac{342\ m/s}{16{,}000\ Hz} = \boxed{.0214\ m}$

3. What is the frequency of sound in air at 20 °C having a wavelength equal to the diameter of a 15-inch (38-cm) "woofer" loudspeaker? Of a 3-inch (7.6-cm) diameter "tweeter"?

$f = \frac{v}{\lambda} = \frac{342\ m/s}{.38\ m} = \boxed{900\ Hz}$ $f = \frac{342\ m/s}{.076\ m} = \boxed{4500\ Hz}$

4. A 440 Hz tuning fork is held above a closed pipe resonator in air with a temperature of 20 °C. Find the length of pipe, L, that provides the loudest resonance.

$T = 20°C$ $v = 342\ m/s$

$\lambda = \frac{v}{f} = \frac{342\ m/s}{440\ Hz} = .777\ m$

$\lambda = 4L$ $L = \frac{\lambda}{4} = \frac{.777\ m}{4} = \boxed{.194\ m}$

5. The frequency of a tuning fork is unknown. A student uses an air column at 27 °C and finds that resonance occurs at a pipe length of 0.392 m. What is the frequency of the tuning fork?

$T = 27°C$ $v = 330 + .6(27°C) = 346.2\ m/s$

$L = .392\ m$

$\lambda = 4(.392) = 1.568\ m$

$f = \frac{v}{\lambda} = \frac{346.2\ m/s}{1.568\ m} = \boxed{220.8\ Hz}$

6. The auditory canal, leading to the eardrum, is a closed pipe 3.0-cm long. Find the approximate value of the lowest resonant frequency at room temperature (20 °C)?

L=.03 m   λ=.12m   v=342 m/s

$f=\frac{v}{\lambda}=\frac{342\ m/s}{.12m}=$ **2850 Hz**

7. If the temperature of air were 33 °C, what length of pipe (closed end) would be needed to provide the loudest resonance using a tuning fork with a pitch of 536 Hz? What length pipe (open on both ends) would be needed using the same tuning fork?

T=33°   330+(33).6 = 349.8 m/s

$\lambda=\frac{v}{f}=\frac{349.8\ m/s}{536\ Hz}=.653\ m$

closed: $L=\frac{\lambda}{4}=$ **.163 m**

open: $L=\frac{\lambda}{2}=$ **.326 m**

8. A flute is essentially a pipe open at both ends. The length of a flute is approximately 66.0 cm. What is the fundamental frequency of a flute when all keys are closed, making the vibrating air column approximately equal to the length of the flute? The speed of sound in the flute is 340 m/s.

v=340 m/s
L=.66 m
λ=2L=1.32m

$f=\frac{v}{\lambda}=\frac{340\ m/s}{1.32\ m}=$ ~~275.6~~ **257.6 Hz**

9. You have a tuning fork with a frequency of 518 Hz and it is held over an 18.6-cm long pipe over water to provide the loudest resonance. Knowing all of this information, calculate the temperature of the air.

L=.186 m
λ=4(.186m)=.744 m
f=518 Hz

v=λ·f=(.744 m)(518 Hz)= 385.392 m/s

V=330+(.6)(°C)

$°C=\frac{V-330}{.6}=\frac{385.392-330}{.6}=$ **92.32 °C**

10. How many beats would be heard when tuning forks of 418 Hz and 398 Hz are struck near each other at the same time?

Beat = F_2-F_1 = 418 Hz − 398 Hz = 20 Hz

20 beats/second

11. A piano tuner using a 392 Hz tuning fork to tune the wire for G-natural hears 4 beats per second. What are the two possible frequencies of vibration of this piano wire?

Beat = F_2-F_1
4 = 392 − F_1
F_1=388Hz

4 = F_2 − 392 Hz
F_2 = 396 Hz

Name: Key Period: Date:

Speed of Sound and Doppler Worksheet

Use the following formulas to help you answer these questions regarding sound.

$v = \lambda f$ $v = 330\ m/s + 0.6(^{o}C)$

closed pipe resonance tube (L): $L = \lambda/4$ open pipe resonance tube (L): $L = \lambda/2$

Doppler Effect Calculations

Calculation of Doppler Shift with a moving sound source moving towards a stationary object:

$F_o = F[V_{sound}/(V_{sound} - V_{source})]$

Calculation of Doppler Shift with a moving sound source moving away from a stationary object:

$F_o = F[V_{sound}/(V_{sound} + V_{source})]$

Calculation of Doppler Shift with an observer moving towards a stationary sound source:

$F_o = F[(V_{sound} - V_{observer})/V_{sound}]$ (Hint: consider the velocity of the object a negative #)

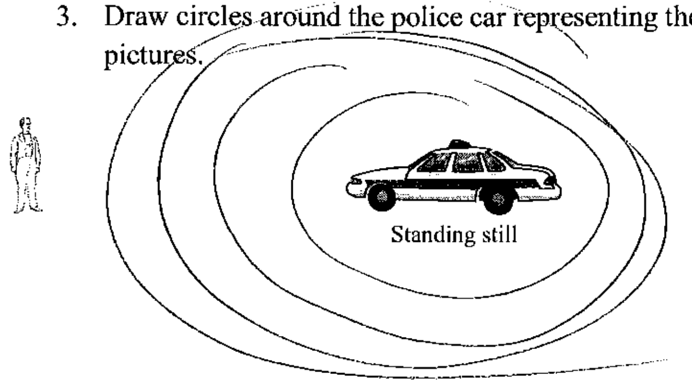
Calculation of Doppler Shift with an observer moving away from a stationary sound source:

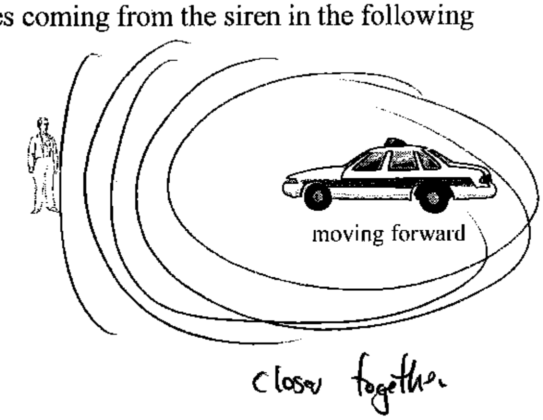
$F_o = F[(V_{sound} + V_{observer})/V_{sound}]$ (Hint: consider the velocity of the object a negative #)

In each case, F = actual frequency of sound; F_o = observed frequency; v_{sound} = speed of sound; v_{source} = speed of sound source; $v_{observer}$ = speed of observer.

1. Calculate the speed of sound in air at the following temperatures. ($^{o}C = (^{O}F - 32)/1.8$)
   a. 18°C $V = 330 + .6(18) = 340.8\ m/s$
   b. 37°C $v = 330 + .6(37) = 352.2\ m/s$
   c. 75°F $^{o}C = \frac{75-32}{1.8} = 23.9^{o}C$ $V = 330 + .6(23.9) = 344.3\ m/s$
   d. 62°F $^{o}C = \frac{62-32}{1.8} = 16.7^{o}C$ $V = 330 + .6(16.7) = 340\ m/s$
2. At what temperature would sound travel through air as fast as it does through water, which is 1484 m/s?

   $^{o}C = \frac{v - 330}{.6} = \frac{1484 - 330}{.6} = 1923\ ^{o}C$
3. Draw circles around the police car representing the sound waves coming from the siren in the following pictures.





closer together

4. A tuning fork of 320 Hz is held over a glass tube that is partially submerged in water. What length will the tube be if the air temperature is 25 °C to produce the loudest resonance? How long would a glass tube if the same experiment was held over a glass tube that is open to the air on both sides?

$V = 330 + .6(25) = 345\ m/s$

$\lambda = \frac{V}{f} = \frac{345\ m/s}{320\ Hz} = 1.08\ m$

closed pipe

$L = \frac{\lambda}{4} = \frac{1.08}{4} = .270\ m$

open pipe

$L = \frac{\lambda}{2} = \frac{1.08}{2} = .539\ m$

5. If the police car with a 365 Hz siren is traveling at 60 mph towards you, on a summer day of 28 °C, what frequency would you hear? (1 mile = 1609 meters; 1 hour = 3600 sec)

$V = 330 + .6(28) = 346.8\ m/s$

$F = 365\ Hz$

$V_{sound} = 346.8\ m/s$

$V_{source} = 60 \frac{mile}{hr} \left(\frac{1609\ m}{1\ mi}\right)\left(\frac{1\ hr}{3600\ s}\right) = 26.8\ m/s$

$F_o = F\left(\frac{V_{sound}}{V_{sound} - V_{source}}\right)$

$F_o = 365\left(\frac{346.8\ m/s}{346.8\ m/s - 26.8\ m/s}\right)$

$F_o = 395.5\ Hz$

6. If a fire truck with a 340 Hz siren is traveling at 45 mph away from you, on a cold winter day of -10 °C, what frequency would you hear? (1 mile = 1609 meters; 1 hour = 3600 sec)

$V = 330 + .6(-10) = 324\ m/s$

$F = 340\ Hz$

$V_{sound} = 324\ m/s$

$V_{source} = 45 \frac{mile}{hr} \left(\frac{1609\ m}{1\ mi}\right)\left(\frac{1\ hr}{3600\ s}\right) = 20.1\ m/s$

$F_o = F\left(\frac{V_{sound}}{V_{sound} + V_{source}}\right) = 340\left(\frac{324}{324 + 20.1}\right)$

$F_o = 320.1\ Hz$

7. Driving your Ferrari through the Italian countryside at a speedy -88 m/s, you approach an opera diva singing a high C (1,046 Hz). What frequency will you actually hear as you approach? (Assume a speed of sound of 340 m/s.)

$V_{sound} = 340\ m/s$

$V_{obs} = -88\ m/s$

$F = 1046\ Hz$

$F_o = F\left(\frac{V_{sound} - V_{obs}}{V_{sound}}\right)$

$F_o = 1046\ Hz\left(\frac{340\ m/s - (-88\ m/s)}{340\ m/s}\right)$

$F_o = 1316.7\ Hz$