Doppler Effect

For all problems use the speed of sound in air.

1. A car travelling at 100 km/hrsounds its horn as it approaches a hiker standing on the highway. If the car's horn has a frequency of 440 Hz, what is the frequency the hiker hears as A) the car approaches? B)after the car passes the hiker

2. A stationary loudspeaker sends sound waves with a frequency of 400 Hz towards a wall 10 m away. An observer towards the speaker with a speed of 1 m/sec. What frequency does the observer hear?

3. A sports car sounds it horn (500 Hz) as is approaches a girl by the side of the road. She has perfect pitch and determines the sound from the horn is 520 Hz. How fast was the sports car moving?

4. A police car is chasing a speedster. The police car is moving 40 m/sec and sends out a frequency with the sound radar gun of 500 Hz. The wave is reflected back and is read to be 533 Hz. How fast is the car moving?

5. You are standing at a railway crossing. A train is approaching at 100 km/hr sounds its whistle. If the frequency of the whistle is 400 Hz, what is the frequency you hear A)as the train approaches and B)when the train has passed you by?

6. How fast must a source sound be moving if the observed frequency is 3 percent higher than the true frequency?

7. Bats navigate and search out prey by emitting, and then detecting reflections of, ultrasonic waves, which are sound waves with frequencies greater than what can be heard by the human ear. Suppose a horseshoe bat flies toward a moth at speed of 9 m/sec, while the moth flies toward the bat with a speed of 8 m/sec. From its nostrils the bat emits ultrasonic waves that reflect from the moth back to the bat. The bat continues to change the emitted frequency until the frequency that is returned (heard) to the bat is 83 kHz. What frequency is being emitted by the bat? What frequency does the moth hear? Hint: draw a picture!

8. A whistle used to call a dog has a frequency of 30 kHz. The dog however, ignores it. The dog owner wants to make sure the whistle works, wants to use the Doppler effect to make sure it works. The owner, who can not hear sounds above 20 kHz, asks a friend to drive in a car and blow the whistle while the owner remains stationary. How fast must the car go in order to hear the whistle?

9. An ambulance with a siren emitting a whine at 1600 Hz overtakes and passes a cyclist pedaling at 8 ft/sec. After being passed, the cyclist hears a frequency of 1590 Hz. How fast is the ambulance moving?

10. In 1845, Buys Ballot first tested the Doppler effect for sound. He put a trumpet player on a flatcar drawn by a locomotive and another player near the tracks. If the trumpet player emitted a frequency of 440 Hz, and the stationary player heard a frequency of 444 Hz, what was the speed of the flatcar?

11. A stationary motion detector sends sound waves of .150 MHz toward a truck approaching at a speed of 45 m/sec. What is the frequency of the waves reflected back to the detector?

12. A French submarine and US submarine move head on during maneuvers in motionless water in the North Atlantic. The French sub moves at a speed of 50 km/hr and the US sub moves at a speed of 70 km/hr. The French sub sends out a sonar signal (sound wave in water) at 1000 Hz. Sonar waves travel at 5470 km/hr. A) What is the signal's frequency as detected by the US sub?

13. In a discussion of Doppler shifts of ultrasonic waves used in medical diagnosis, the authors remark, "For every millimeter per second a structure moves, the frequency of the incident ultrasonic wave is shifted approximately 1.3 Hz per MHz." What speed of the ultrasonic waves do you deduce from this statement?

14. A submarine, near the surface, moves north at speed of 75 km/hr. The sub emits a sonar signal of frequency 1000 Hz and speed 5470 km/hr that is detected by a destroyer that is north of the sub. What is the difference between the emitted frequency and "heard" frequency if the destroyer is A) stationary and B)drifts in a current that is north at 30 km/hr?