Doppler Effect
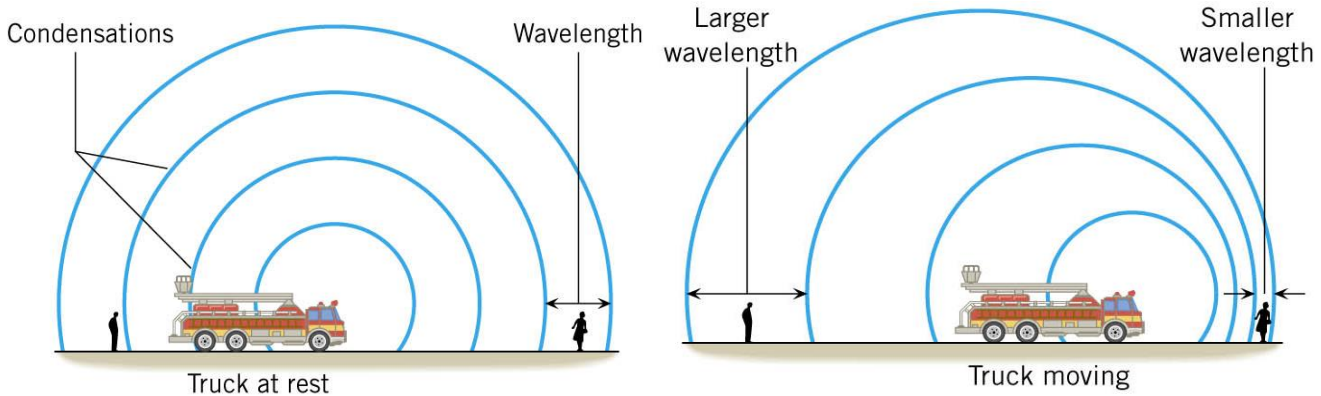
- As a source of a sound moves by a listener
- _____ pitch as they were _____, _____ pitch as they were _____.

Condensations   Wavelength   Larger wavelength   Smaller wavelength

Truck at rest   Truck moving

$$f_o = f_s \left(\frac{v_w \pm v_o}{v_w \mp v_s} \right)$$

- v_w, v_s, and v_o are _____
- Use the top signs when that object is moving _____ the other _____

You are driving down the road at 20 m/s when you approach a car going the other direction at 15 m/s with their radio playing loudly. If you hear a certain note at 600 Hz, what is the original frequency? (Assume speed of sound is 343 m/s)

A duck is flying overhead while you stand still. As it moves away, you hear its quack at 190 Hz. Because you are a brilliant naturalist, you know that this type of duck quacks at 200 Hz. How fast is the duck flying?

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1. Is the Doppler shift real or just a sensory illusion?

2. When you hear a sonic boom, you often cannot see the plane that made it. Why is that?

3. Two cars, one behind the other, are traveling in the same direction at the same speed. Does either driver hear the other's horn at a frequency that is different from that heard when both cars are at rest? Justify your answer.

4. When a car is at rest, its horn emits a frequency of 600 Hz. A person standing in the middle of the street hears the horn with a frequency of 580 Hz. Should the person jump out of the way? Account for your answer.

5. (a) What frequency is received by a person watching an oncoming ambulance moving at 110 km/h and emitting a steady 800-Hz sound from its siren? The speed of sound on this day is 345 m/s. (b) What frequency does she receive after the ambulance has passed? (OpenStax 17.30) **878 Hz, 735 Hz**

6. (a) At an air show a jet flies directly toward the stands at a speed of 1200 km/h, emitting a frequency of 3500 Hz, on a day when the speed of sound is 342 m/s. What frequency is received by the observers? (b) What frequency do they receive as the plane flies directly away from them? (OpenStax 17.31) 1.38×10^5 **Hz,** 1.77×10^3 **Hz**

7. What frequency is received by a mouse just before being dispatched by a hawk flying at it at 25.0 m/s and emitting a screech of frequency 3500 Hz? Take the speed of sound to be 331 m/s. (OpenStax 17.32) 3.79×10^3 **Hz**

8. A spectator at a parade receives an 888-Hz tone from an oncoming trumpeter who is playing an 880-Hz note. At what speed is the musician approaching if the speed of sound is 338 m/s? (OpenStax 17.33) **3.05 m/s**

9. A commuter train blows its 200-Hz horn as it approaches a crossing. The speed of sound is 335 m/s. (a) An observer waiting at the crossing receives a frequency of 208 Hz. What is the speed of the train? (b) What frequency does the observer receive as the train moves away? (OpenStax 17.34) **12.9 m/s, 193 Hz**

10. Can you perceive the shift in frequency produced when you pull a tuning fork toward you at 10.0 m/s on a day when the speed of sound is 344 m/s? To answer this question, calculate the factor by which the frequency shifts and see if it is greater than 0.300%. (OpenStax 17.35) **1.030**

11. The security alarm on a parked car goes off and produces a frequency of 960 Hz. The speed of sound is 343 m/s. As you drive toward this parked car, pass it, and drive away, you observe the frequency to change by 95 Hz. At what speed are you driving? (Cutnell 16.71) **17 m/s**

12. Suppose you are stopped at a traffic light, and an ambulance approaches you from behind with a speed of 18 m/s. the siren on the ambulance produces sound with a frequency of 955 Hz. The speed of sound I air is 343 m/s. What is the wavelength of the sound reaching your ears? (Cutnell 16.72) **0.340 m**

13. A speeder looks in his rearview mirror. He notices that a police car has pulled behind him and is matching his speed of 38 m/s. The siren on the police car has a frequency of 860 Hz when the police car and the listener are stationary. The speed of sound is 343 m/s. What frequency does the speeder hear when the siren is turned on in the moving police car? (Cutnell 16.73) **860 Hz**

14. A bird is flying directly toward a stationary bird-watcher and emits a frequency of 1250 Hz. The bird-watcher, however, hears a frequency of 1290 Hz. What is the speed of the bird, expressed as a percentage of the speed of sound? (Cutnell 16.74) **3.1%**