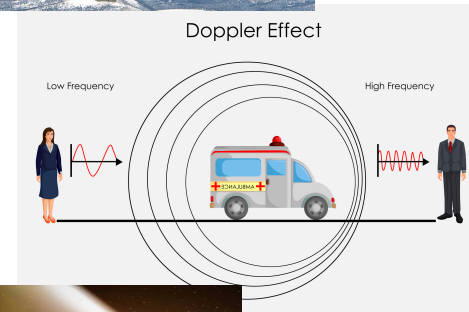
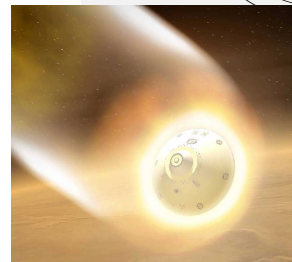


Supersonic Travel and the Doppler Effect

- The Doppler Effect and Shift
- Calculating Observed Frequency
- Applications
- Supersonic Travel
- Mach Speed
- Supersonic Flight
- Sound Barrier
- Supersonic Travel and Sonic Booms
- Vapor Cone



$$f_2 = f_1 \left(\frac{v}{v \pm v_s} \right)$$



Preview File

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- Student versions have portions of the text removed which is given in the teacher version and appear as _____ which the students are to fill in
- Other slides may have on them, this represents writing that has been removed on this sample

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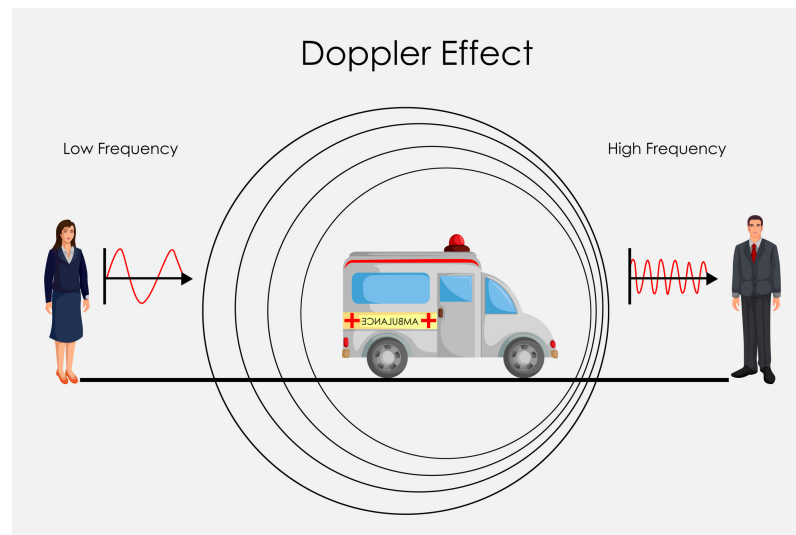
The Doppler Effect

- _____
- Examples:
 - moving cars and trains
 - rotating whistle
 - light waves



The Doppler Effect

- As the waves approach the observer, they become compressed (shorter wavelength)
- _____
- As the waves move away from the observer, they move apart resulting in a lower frequency sound
- This also occurs if the source is stationary and the observer is moving



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Calculating Observed Frequency

- Observed frequency can be determined using the following formula:

$$f_2 = f_1 \left(\frac{v}{v \pm v_s} \right)$$

- f_2 = the observed frequency
- f_1 = the produced frequency
- v = the speed of sound in the medium
- v_s = the speed of the source through the medium
- $v + v_s$ is used when the source is moving away from the observer
- $v - v_s$ is used when the source is moving towards the observer

Check Your Understanding

A truck travelling at 100.0 km/h sounds its horn as it approaches a pedestrian standing on the highway. If the car's horn has a frequency of 440 Hz and the temperature of the air is 0°C, what is the frequency of the sound waves reaching the hiker

- a) as the truck approaches?
- b) after it has passed the pedestrian?

$$f_2 = f_1 \left(\frac{v}{v \pm v_s} \right)$$

$$v = 332 \text{ m/s} + \left(0.59 \frac{\text{m/s}}{^\circ\text{C}} \right) t$$

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Application – The Doppler Shift

- The Doppler Effect can be used for any wave (sound, light, etc.)
- _____
- Radar guns use the Doppler Shift to determine the speed of an oncoming car or the speed of a pitch in baseball



Supersonic Travel

- _____
- Objects travelling at speeds equal to the speed of sound are moving at Mach 1
- Objects travelling at speeds greater than the speed of sound are moving at supersonic speeds
 - Speeds of



Hot air balloons move at subsonic speeds

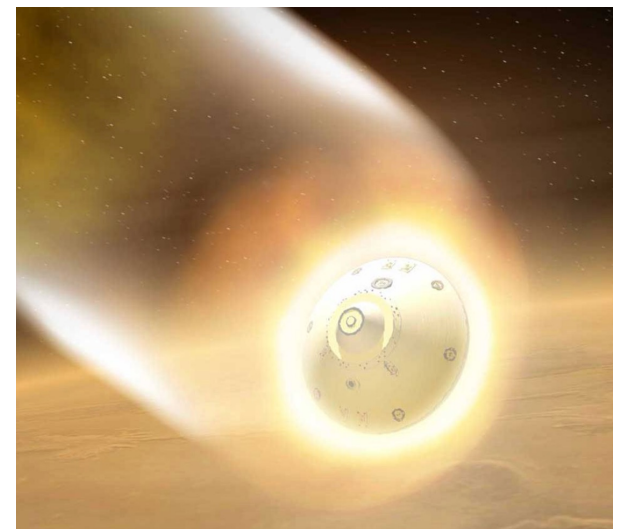


Some military aircraft can move at supersonic speeds

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Supersonic Flight

- The F-22 Raptor can reach speeds of Mach 2.2 (2,410 km/h, 1,500 mph)
- Upon reentry, some space vehicles can exceed Mach 25 and as a result, create a fireball



Check Your Understanding

At an altitude of 10 km, the speed of sound is approximately 1060 km/h. What is the Mach number of an aircraft flying at an altitude of 10 km with a speed of 1800 km/h?

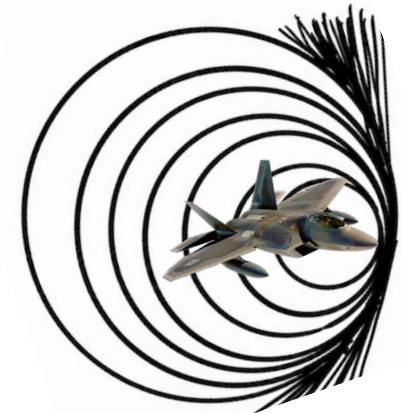
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Supersonic Travel

- **THINK:** Regarding the sound waves, what happens when the speed of the aircraft reaches the speed of the sound waves it produces?
- What happens when the aircraft's speed exceeds the speed of sound it produces?
 - For example, what happens if an airplane travels at approximately 332 m/s? What if it travels at 400 m/s?

Supersonic Travel

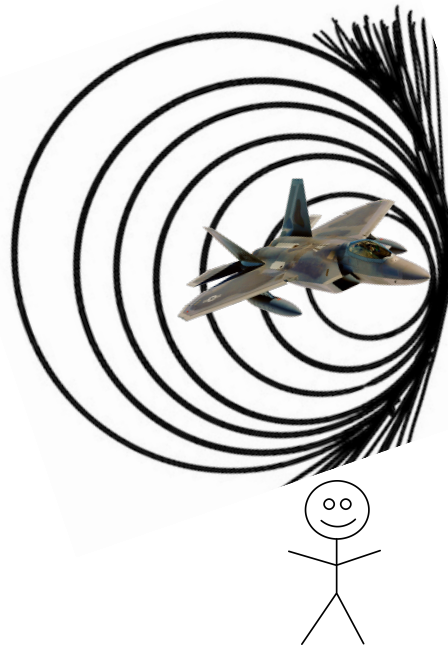
- Aircrafts emit sound in all directions
- Sound waves are compressed in front and spread out behind
- At speeds equal to the speed of sound, the sound waves pile on top of each other and constructively interfere
 - the plane and sound are moving at the same speed



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Supersonic Travel and Sonic Booms

Note: A sonic boom isn't created as the aircraft surpasses the sound barrier as many people believe. _____



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Vapor Cone

- A vapor cone can suddenly appear as the aircraft approaches the speed of sound
- _____
- The cloud appears due to a sudden decrease in temperature around the wings caused by a rapid drop in pressure associated with very high speeds

