Introduction

The braking system of a car converts kinetic energy into heat as a method to slow a car down. Over the past 100+ years automotive braking systems have evolved greatly to help slow cars quicker and safer. Within the collection at the Simeone Foundation Automotive Museum there are cars that represent many significant technological milestones in braking systems that lead to the modern systems we see in cars on the street today. Students will learn how the braking system converts energy to heat and what makes various systems such as, disk vs. drum, superior to the other.

Essential Questions

1) How does a braking system stop an automobile?
2) Why do modern braking systems preform better than older braking systems?

Objectives

1) Understand how an automotive braking system functions to stop an automobile.
2) Understand heat and the dissipation of heat through the design of braking systems.

Background

Early automotive braking systems used some type of drum arrangement to slow the vehicle. The most common design was the expanding shoe arrangement, that used half circular
shaped shoes covered in some type of friction material inside a drum or pan shaped object attached to the wheel or rotating axle of the vehicle. The braking system activated by depressing a pedal or pulling a lever causing the shoes to push or expand out contacting the inside of the brake drum slowing the vehicle.

As automobiles became faster braking systems needed to be able to absorb a greater amount of heat (energy) to slow a vehicle. Over time better friction materials were developed, along with changes from mechanical cables, pulleys, and levers to hydraulic actuation, all providing mechanical advantages. It became apparent by the 1950’s that another type of braking system would be needed to slow a vehicle from the great speeds achieved.

During the early 1950’s the disk braking system was developed that had superior heat dissipating properties when compared to its drum braking competitor. Disk braking systems also had mechanical advantages that made them superior to drum braking systems.

**Activity**

- Discuss how an automotive braking system stops an automobile.
- Discuss how force, energy, and heat, and how they relate to automobile braking systems.
- Look at different types and designs of automotive breaking systems.
- Identify how each system works.
- Discuss the positives and negatives of each type of system.
- Discuss the major benefits of the disc brake design.
- Identify how much energy a braking system needs to absorb to stop an automobile.
- Use various materials such as erasers, and surfaces like metal, to act as brake pad material and brake rotor material.
- Discuss the differences in how the materials absorb heat.

**Steps**

1) Calculate the amount of kinetic energy an automobile builds up as it travels at various speeds.
2) Convert kinetic energy in Joules to power in Watts to help better understand the amount of energy needed to stop a vehicle.
3) Compare the number in Watts of energy to other objects that use energy (Watts), such as lightbulbs, TVs, toaster ovens, and other electronic devices.
4) Discuss the amount of heat these objects give off to show a correlation to the heat dissipated in an automotive braking system.
5) Use various materials such as leather, rubber, and metal to represent the different parts of the automotive braking system.
6) Rub these objects together to create friction. i.e. rub a rubber eraser against a piece of metal to represent a brake pad friction material against a brake rotor.
7) Discuss various result students have.
8) Discuss how this experiment relates to automotive braking systems.
9) Discuss how modern disk braking systems are more able to dissipate heat when compared to older drum braking system designs.
10) Discuss how hydraulics are used to provide a mechanical advantage in force for a automobile braking system.

Reference Material

- Kinetic Energy of an Automobile (Relative, Estimate)
  \[ KE = \frac{1}{2} M V^2 \]
  
  Where:
  KE= Kinetic Energy (Joules)
  M= Total vehicle mass (kg)
  V= test speed (m/sec)

- Average Stopping Times and Distances
  60 to 0: between 100-120 feet, Time: between 2.5-3.5 seconds

- 5,280 feet in one mile

- Power: \( P = \frac{E}{t} \)
  
  Where:
  P= Average Power (Watts)
  E= Energy (Joules)
  T = Brake on Time (Seconds)