

# Automatic Brake Failure Indication with Auxiliary Braking System

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## Abstract

*Accidents in vehicles often happen due to diverse factors, with brake failure being a significant contributor resulting from inadequate maintenance and product defects. To protect human lives and reduce the risk of accidents, effective monitoring of brake systems is vital in the automotive industry. Vehicle safety encompasses not only the prevention of accidents but also the mitigation of their adverse effects on human health. Today's cars come with innovative safety systems intended to ensure the protection of both those inside the vehicle and pedestrians. This work focuses on a comprehensive braking system that integrates sensors and an auxiliary braking unit, specifically engineered for automobiles. The integration of sensors in braking systems allows for real-time monitoring of critical parameters such as brake pad wear, hydraulic pressure, and temperature, enabling timely maintenance and early detection of potential failures. Brakes function as mechanical devices that slow down or inhibit motion by generating friction between surfaces, converting kinetic energy into heat. They are applied to both moving components and tires. Additionally, electric signals produced by limit switches are transmitted to the auxiliary braking unit, enhancing overall vehicle safety. The auxiliary braking unit serves as a backup mechanism, automatically engaging in emergency situations or when the primary braking system is compromised, thereby reducing the likelihood of accidents caused by brake failure. Furthermore, the use of electronic limit switches ensures precise and reliable signal transmission, contributing to the overall responsiveness of the system. The proposed approach not only improves the reliability and performance of the braking system but also aligns with the growing demand for intelligent safety solutions in modern vehicles. By combining mechanical, electronic, and sensor-based technologies, this comprehensive system aims to set a new standard in automotive safety, ultimately fostering greater confidence and peace of mind for drivers and passengers on the road. This novel method seeks to enhance braking efficiency and promote safer journeys for drivers.*

**Keywords:** Auxiliary braking, sensor integration, disc brake, vehicle safety, accident prevention

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## INTRODUCTION

A brake is a mechanical device used to reduce speed or bring movement to a halt by creating resistance. It functions by producing friction between two components, converting the moving object's kinetic energy into heat. In some instances, brake failure can occur if the brake lining is compromised.

Most braking systems in two-wheelers utilize friction between two surfaces to convert the kinetic energy of the vehicle into heat. However, there are alternative methods available, such as regenerative braking, which transforms kinetic energy into electrical energy for future use.

Other systems may convert kinetic energy into potential energy, utilizing pressurized air or oil. Eddy current brakes employ magnetic fields to create an electric current, which is subsequently turned into heat. Additionally, some systems can transfer kinetic energy to a rotating flywheel. Brakes are usually applied to the wheels but can also function on the surface of moving fluids. Two-wheelers may also incorporate a combination of braking mechanisms, such as synchronized systems that allow simultaneous application of both front and rear brakes for improved safety and control during braking.

## PRESENT THEORIES AND PRACTICES

Below is a compilation of scholars who have conducted research on automatic brake failure detection in conjunction with auxiliary braking systems.

Adhav et al. emphasized that brake failure, primarily due to hydraulic oil leaks leading to pressure loss, is a significant contributor to road accidents and fatalities. They proposed a dual-phase safety system that combines fault diagnosis with backup braking mechanisms. This system employs electronic sensors to monitor brake line integrity and detect pressure drops. When primary electromagnetic brakes fail, an electronic control unit alerts the driver and activates secondary hub motors in the rear wheels through relays managed by a microcontroller. This method ensures real-time failure detection and engages redundant braking systems, utilizing regenerative braking to convert kinetic energy into electrical energy for slowing the vehicle. By implementing these safeguards before complete brake failure, the system aims to enhance vehicle control and reduce accident risks during emergencies [1].

Kshar A focused on enhancing brake safety features. Often, when a driver suddenly notices an obstacle ahead, panic can set in, causing even experienced drivers to misuse the brakes, which can result in accidents. By considering the time it takes for a driver to react, a functional prototype for Automatic Failure Detection paired with an Auxiliary Braking System was developed. This approach aims to improve driver safety and decrease accident rates, thereby boosting overall vehicle safety. In this integrated system, if the main braking mechanism fails, the secondary braking system can be activated easily, ensuring continued braking performance with minimal effort [2].

The design of this system prioritizes human behavior, ease of operation, and optimal utilization of the braking mechanisms. It is constructed using a minimal number of components and occupies very little space. To enhance safety, a buzzer provides an audible warning to the driver, while a microcontroller automatically triggers the backup braking system, engaging the secondary brakes. This solution offers both affordability and efficiency, making it well-suited for application in the automotive sector.

Biradar et al. developed a control system featuring an electronically managed automatic brake failure indicator that utilizes an IR sensor. The automatic brake failure indicator and auxiliary braking setup include an IR sensor circuit, a control unit, and a supporting frame. The IR sensor is responsible for detecting the brake wire and sending control signals to the alarm system. The auxiliary brake, mounted on the wheel frame, can be engaged to halt the vehicle when needed. Additionally, a pressure transducer sensor continuously monitors the pressure in the brake lining. If the main hydraulic disc brake system malfunctions, the sensor identifies the pressure drop, alerts the driver, and simultaneously activates the secondary braking system, which uses hub motors installed in the rear wheels. This secondary braking system assists the driver in stopping the vehicle, thereby ensuring passenger safety [3].

Pradeep et al. emphasized the importance of monitoring brake systems to prevent accidents caused by brake failure. Their research proposed a system that continuously checks brake performance, providing real-time feedback through visual and auditory alerts. If a failure is detected, the system activates a secondary braking mechanism to ensure vehicle control and passenger safety. This approach is crucial in the automotive industry, where timely intervention can significantly reduce accident risks. Additionally, other safety systems, such as those using GPS and GSM technology, have been developed to detect accidents and alert emergency services promptly, further enhancing road safety [4].

Mohan et al. introduced a method for identifying malfunctioning brake systems and deploying a secondary auxiliary brake in the event of a failure. Their project aims to improve passenger safety by recognizing possible issues in advance, thus helping to avert accidents. The system uses an electronic control unit that activates when the primary hydraulic disc brake fails. Upon detecting pressure loss, sensors alert the driver and engage secondary hub motors in the rear wheels, allowing the driver to safely stop the vehicle. Additionally, the system can stop the vehicle by cutting off the engine's ignition supply [5].

Karthik and Santhanakrishnan, introduced a safe braking system equipped with a brake failure indicator. Brake failures typically arise from issues such as damaged liners and worn brake shoes. Their system uses two sensors: one mounted on the brake shoe and another on the brake liner. Signals from both sensors are sent to a microcontroller, which detects when the brake shoe is worn or if the brake liner is compromised. The microcontroller processes these signals and activates the appropriate indicator; a green light indicates no issues, while a red light signals a problem with either component. In the event of brake failure while the vehicle is in motion, the microcontroller automatically engages an alternate braking system. This innovative solution significantly enhances safety by helping to prevent accidents and allowing users to monitor brake status effectively, thereby reducing the likelihood of malfunctions [6].

Dhanamjayulu et al. emphasized the need for continuous monitoring of vehicle braking systems to prevent accidents and protect lives. Vehicle safety involves safeguarding both occupants and others from hazardous effects. Their approach involves using a timer to periodically inspect the condition of brake wires. The proposed circuit model checks the brake wire condition in vehicles, alerting the driver with audio or visual signals. If required, the system engages an emergency braking mechanism to help avoid accidents, thus improving overall safety [7].

Maske et al. introduced an automatic brake failure indicator and braking system designed specifically for automobiles. Brake failure, which can result from inadequate upkeep or manufacturing flaws, presents serious dangers to human safety. This system is crucial for monitoring brake conditions to prevent accidents. It features a two-way relay, buzzer, battery, motor, and wiring system. When a brake failure occurs, the buzzer alerts the driver audibly while the alternative braking system activates, applying secondary brakes through a motor attached to the chassis. This effectively reduces vehicle speed and stops it within seconds. The system's compact design and low installation cost make it an effective solution for minimizing accidents related to brake failure [8].

Joseph et al. designed and enhanced a control system that uses an IR sensor for electronically controlled automatic brake failure detection. When brakes fail, their effectiveness diminishes, increasing the likelihood of accidents, whereas a reliable braking system helps maintain vehicle stability. A proper brake system should be capable of stopping the vehicle within a safe distance, and the deceleration should correspond to the pressure applied to the pedal. The automatic brake failure indicator comprises a master cylinder, wheel cylinder, IR sensor, relay, rectifier, buzzer, and integrated circuit. The sensor is installed near the brake pedal to detect faults. If the sensor identifies a brake failure, it sends a signal to the control unit, which then activates an alarm. In cases where fluid leaks or hose damage cause a drop in master cylinder pressure, the control unit senses the reduced pedal force and triggers the alarm [9].

Nemade et al. noted that road accidents result from a combination of factors, including the extent of the road network, the number of vehicles and people, compliance with traffic safety rules, and failures of vehicle components of which some parameters are difficult to control or can be controlled by external factors such as strict traffic norms, rigorous driving tests for license, traffic separation, etc. But accidents due to failure of vehicle brake is a prime responsibility of vehicle manufacturer, the brakes must work properly without failure of any component in its assembly. Road accidents in India lead to a high number of injuries, deaths, disabilities, and hospital admissions, creating considerable socio-economic burdens across the country. Consequently, road safety has emerged as an urgent issue both in India and worldwide. The United Nations declared 2011–2020 as the Decade of Action for Road Safety to

highlight the importance of coordinated action. As a participant in the Brasilia Declaration, India pledged to cut road accidents and fatalities by half by 2020, reflecting its dedication to enhancing road safety measures [10].

Based on the findings from the literature review, it was concluded that an automatic brake failure indication system with an auxiliary braking mechanism should be developed.

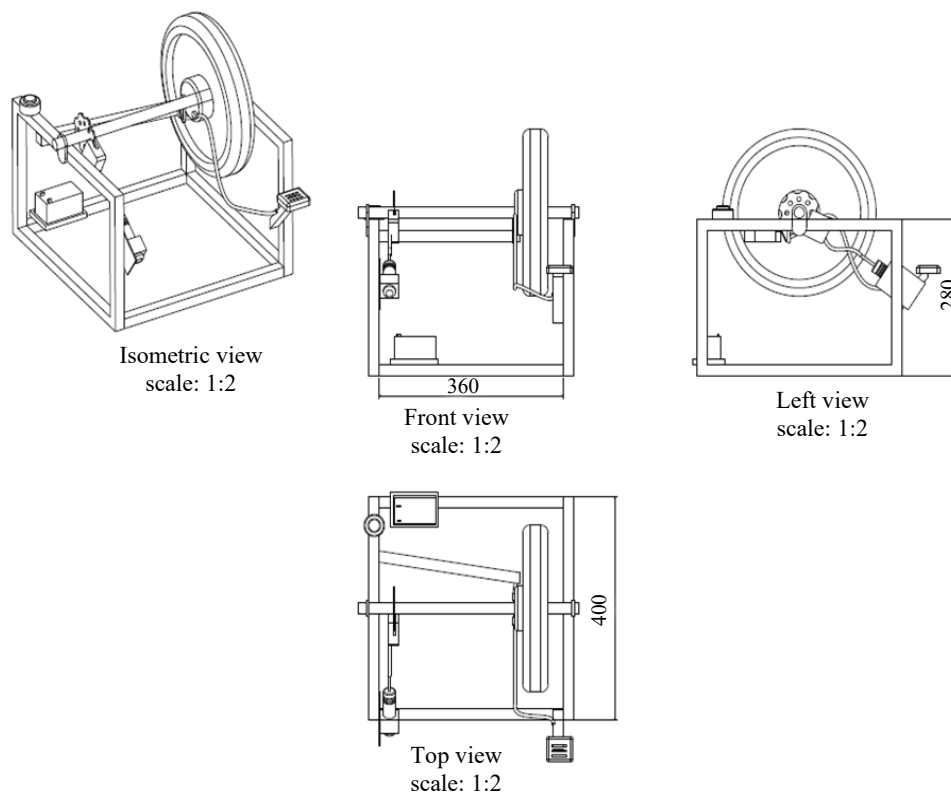
### PROBLEM STATEMENT

The absence of a brake failure indication system in two-wheelers poses a significant safety risk, necessitating the development of a solution. To address this issue, we aim to design an Automobile Brake Failure Indicator integrated with an Auxiliary Braking System specifically for drum brake systems and conduct thorough testing. Additionally, we will enhance the existing mechanisms of two-wheelers to improve safety and create a more effective braking system. Our goal is to increase overall safety during vehicle operation while also conceptualizing designs for future electric two-wheelers. This effort aims to reduce the dangers linked to brake failure and enhance overall riding safety.

### METHODOLOGY

This work focuses on implementing an automatic brake failure indication system combined with an auxiliary braking mechanism (Figure 1). The operation of this prototype is straightforward: when the brake pedal is pressed while the vehicle is in motion, the drum brakes stop the vehicle.

- *Case I:* If the drum brake fails or if the cable or linkage breaks, the drum brake lever moves backward and presses the limit switch.
- *Case II:* In this setup, when the limit switch is engaged due to brake failure, it activates the solenoid gun by connecting it to the battery terminal. Here, the limit switch functions as both a sensor and a switch, and the solenoid gun is linked to the disc brake.
- *Case III:* When the disc brake is engaged, the wheel shaft locks, causing the emergency brake to be applied. The system does not rely on complex sensors.



**Figure 1.** Automatic brake failure indication with auxiliary braking system.

The prototype operation is straight forward: when a vehicle's brake pedal is pressed, the drum brakes help stop the vehicle. However, if the drum brake fails or its connecting components break, a limit switch is triggered. This activates a solenoid connected to the disc brake, which locks the disc and applies an emergency brake to the tire shaft. The system uses mechanical elements such as levers and rods attached to the brake booster, which increases the force exerted on the brake pedal. This amplified force is then transmitted to the master cylinder, which distributes hydraulic pressure to the brakes, creating friction to slow or stop the vehicle. In case of brake failure, the auxiliary braking system engages to ensure safety.

## RESULT AND DISCUSSION

### Maximum Brake Force for Drum Brakes

The highest braking force produced by drum brakes depends on the force applied to the lever, the mechanical advantage of the connecting linkages, and the efficiency of the brake shoes. Figure 2 illustrates the drum brake arrangement used in motorcycles.

The rear drum brake system includes a pedal, a connecting rod, and a lever attached to the drum. To determine the brake force at the brake shoe, both the force applied to the pedal and the mechanical advantages of the linkages must be considered. Each linkage's mechanical advantage is evaluated separately and then combined to find the total brake force at the shoe (Figure 2).

Force applied on the pedal,  $F_{\text{pedal}} = 350 \text{ N}$

Advantage offered by the pedal,  $\text{Adv pedal} = (a/b) = 2.625$

Advantage offered by the drum lever,  $\text{Adv lever} = (d_1/c_1) = 5.278$

Force applied at the cam,  $F_{\text{cam}} = F_{\text{pedal}} \times \text{Adv pedal} \times \text{Adv lever} = 494.465 \text{ kgf}$

Coefficient of friction between brake shoe and brake drum,  $\mu = 0.4$

Maximum force applied by the brake shoes,  $F_{\text{max}} = 2 \times F_{\text{cam}} \times \mu = 395.565 \text{ kgf}$

Maximum brake torque,  $T_{\text{max}} = \text{Drum Diameter} \times F_{\text{max}} = 0.13 \times 395.565 = 51.42 \text{ kgf-m}$

The front braking system of the motorcycle is arranged as depicted in (Figure 3). Braking begins when the rider applies force to the hand lever. The mechanical advantages of both the hand lever and the drum brake lever are combined to determine the total force exerted on the cam. For calculation purposes, it is assumed that the maximum force a rider can apply to the hand lever is 20 kgf.

Force applied on the lever,  $F_{\text{lever}} = 20 \text{ kgf}$

Advantage offered by the hand lever,  $\text{Adv lever1} = (12/11) = 4$

Advantage offered by the drum lever,  $\text{Adv lever2} = (13/14) = 5.278$

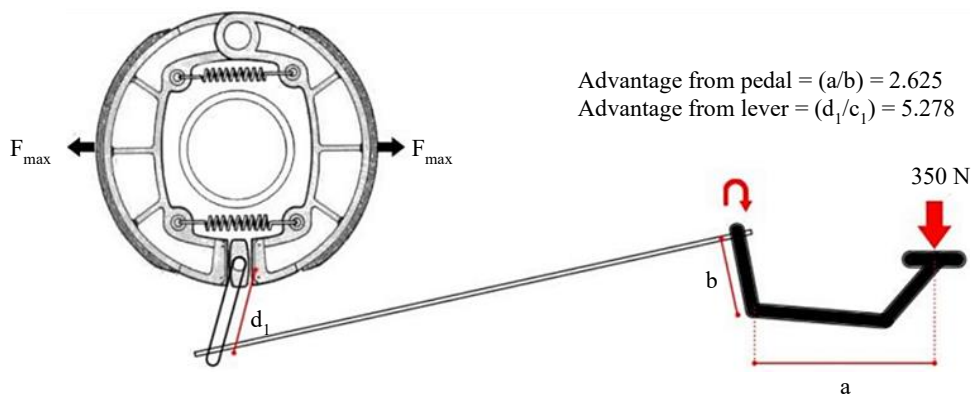
Cable efficiency,  $\eta = 0.8$

Force applied at the cam,  $F_{\text{cam}} = F_{\text{lever}} \times \text{Adv lever1} \times \text{Adv lever2} = 337.792 \text{ kgf}$

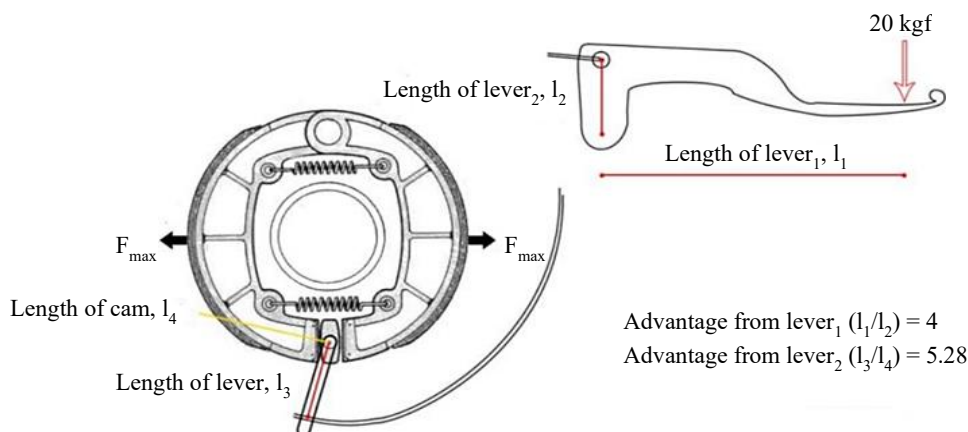
Coefficient of friction between shoe and drum,  $\mu = 0.4$

Maximum force achieved by the brake,  $F_{\text{max}} = 2 \times F_{\text{cam}} \times \mu = 270.234 \text{ kgf}$

Maximum brake torque,  $T_{\text{max}} = \text{Drum Diameter} \times F_{\text{max}} = 0.13 \times 270.234 = 35.13 \text{ kgf-m}$



**Figure 2.** Rear braking system.



**Figure 3.** Front braking system.

The experimental results reveal significant differences in braking performance between rear and front drum brakes in two-wheelers. The rear drum brake demonstrated superior braking capacity with a maximum force of 395.565 kgf and torque of 51.42 kgf-m, compared to the front drum brake's 270.234 kgf force and 35.13 kgf-m torque. This disparity aligns with the mechanical advantage of rear braking systems in typical two-wheeler designs, where rear brakes often bear a higher load during deceleration. The higher torque values in the rear brake suggest enhanced energy dissipation efficiency, critical for stabilizing the vehicle during sudden stops. These metrics validate the effectiveness of the proposed auxiliary braking system in amplifying braking force, particularly in scenarios where primary brake failure occurs. The integration of audio-visual alerts further ensures timely detection of braking anomalies, reducing reliance on manual diagnostics. While the front brake's lower values reflect its role in controlled speed modulation, the rear brake's robust performance underscores its importance in emergency braking. These findings highlight the system's potential to mitigate accidents caused by brake switch failures, particularly in electric two-wheelers, where regenerative braking systems could synergize with this design for improved safety outcomes.

## CONCLUSION

The primary objective of this work is to develop a reliable device that enhances vehicle safety by preventing accidents and damage caused by brake switch failures. By providing clear indications of the brake switch's operational status, this system aims to significantly reduce the risk of accidents in two-wheelers, including trains and boats. The experimental results indicate that the rear drum brake exhibits superior performance, with a maximum brake force of 395.565 kgf and a torque of 51.42 kgf-m, compared to the front drum brake's 270.234 kgf force and 35.13 kgf-m torque. This emphasizes the importance of the rear braking system in emergency situations, where effective braking is crucial for maintaining stability and safety.

## Declaration of Interest

All authors declare that there are no conflicts of interest regarding the publication of this paper.

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