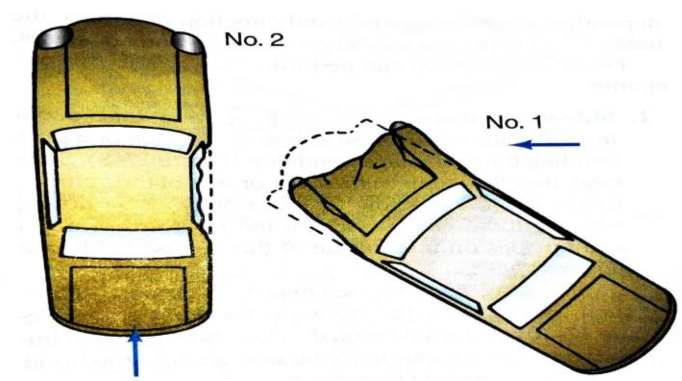
Automotive Electrical and Electronics

Level-V

Based on December 2024, Curriculum Version II



Module Title: Accident Analysis & Implement Restoring

Module Code: EIS AEE5 M02 1224

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Acronym

BOF	Body-over-Frame
PPE	Personal Protective Equipment
WHS	Workplace Health and Safety
PDR	Painless Dent Repair

Introduction to Module

In automotive mechanics field, Accident analysis and implementing restoring options are essential processes for organizations and industries to ensure safety, reduce risks, and restore normalcy after unexpected incidents. These activities involve investigating accidents, identifying their root causes, and taking corrective measures to prevent recurrence and mitigate impacts.

This module is designed to meet the industry requirement under the Automotive mechanics occupational standard, particularly for the unit of competency: Perform Accident Analysis & Implement Restoring Options.

This module covers the units:

- Fundamentals of vehicle Accident
- Vehicle Accident analysis
- Vehicle accident damage restoration

Learning Objective of the Module

- Understand the Fundamentals of vehicle Accident
- Prepare to perform analysis
- Perform complex damage restoration

Module Instruction

For effective use these modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Read the identified reference book for Examples and exercise

Unit one: Fundamentals of Vehicle Accident

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Basics of Vehicle Accident
- causes of vehicle accidents
- Types of Vehicle Accident
- Expected damages on Accidents
- Considering and responding Possible safety impacts
- OHS requirement

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Understand Basics of Vehicle Accident
- Identify causes of vehicle accidents
- Identify Types of Vehicle Accident
- Identify Expected damages on Accidents
- Observe OHS requirements and personal protection needs

1.1 Basics of Vehicle Accident

Vehicle accidents are unexpected events that result in damage to vehicles, property, or individuals. They can occur due to various factors, including human error, mechanical failures, environmental conditions, or a combination of these. Understanding vehicle accidents is critical for developing effective prevention strategies, improving safety standards, and reducing their impact on society.

1.2 The Causes of Vehicle Accident

The common causes of vehicle accidents are:

1.Human factors,

2.Mechanical failures, and

3.Environmental conditions

1. Human Factors

Human factors remain the leading cause of vehicle accidents, often due to negligence, poor judgment, or human error.

- Distracted Driving: Involves any activity that diverts attention from driving, such as texting, using a smartphone, eating, or adjusting in-car controls. Distracted driving slows reaction times, reduces situational awareness, and increases the likelihood of collisions.
  Example: A driver texting while driving may fail to notice sudden braking by the car ahead, leading to a rear-end collision.
- Speeding: Driving above the posted speed limits or too fast for road conditions. Excessive speed reduces the driver's ability to react to hazards and increases the severity of collisions due to higher impact forces.
  Example: A vehicle traveling at high speed on a wet road may lose control due to reduced traction and skid into another vehicle or obstacle.
- Fatigue: Driving while tired or drowsy, impairing cognitive functions and motor skills. Fatigue reduces alertness, delays reaction time, and can result in "microsleeps," where the driver briefly loses consciousness. For example: A fatigued truck driver may drift out of their lane, causing a head-on collision.

- Driving Under the Influence: Operating a vehicle while impaired by alcohol, drugs, or medication. Impaired drivers have reduced judgment, slower reflexes, and poor coordination, increasing the chances of accidents. For example: A driver under the influence of alcohol may misjudge a curve in the road, leading to a rollover or collision.
- Failure to Follow Traffic Rules: Disobeying traffic signals, road markings, and rules such as failing to yield, running red lights, or illegal overtaking. Ignoring traffic rules creates unpredictable driving situations, endangering the driver and others on the road, e.g. Running a red light at an intersection can result in a side-impact collision with another vehicle obeying the traffic signal.

2. Mechanical Failures

Mechanical issues can cause accidents when critical vehicle components fail to perform as intended, often due to poor maintenance or defects.

- Brake Failures: A malfunction in the braking system that prevents the vehicle from stopping or slowing down. Brake failure significantly increases stopping distances and the likelihood of collisions, especially in emergencies. e.g A vehicle descending a steep slope with faulty brakes may crash due to the inability to control speed.
- Tire Blowouts: Sudden tire deflation caused by over-inflation, under-inflation, wear, or road hazards. Tire blowouts can cause the driver to lose control, particularly at high speeds. Example: A tire blowout on a highway may cause a vehicle to swerve uncontrollably, hitting nearby vehicles.
- Engine Malfunctions: Failure of engine components, such as overheating, fuel system issues, or ignition failure, leading to sudden vehicle stoppage. Engine failures may strand vehicles in hazardous positions or lead to loss of power while driving. Example: An engine stall in the middle of an intersection can result in a collision with oncoming traffic.
- Faulty Components: Malfunctioning systems like steering, suspension, or electrical systems. Faulty components compromise vehicle handling, stability, or lighting, leading to accidents. Example: A defective steering system may cause a driver to lose control, veering off the road.

3. Environmental Factors

Environmental conditions outside the driver's control can create hazardous driving situations that contribute to accidents.

- Poor Road Conditions: Roads with potholes, cracks, uneven surfaces, or inadequate signage. Poor road surfaces reduce tire grip, cause vehicle instability, and increase the risk of losing control. For example, A vehicle hitting a pothole at high speed may lose stability, leading to a crash.
- Adverse Weather Conditions: Weather such as rain, snow, ice, fog, or strong winds that impact visibility and road traction. Wet or icy roads reduce tire traction, while fog and heavy rain decrease visibility, increasing the chances of collisions. Example: A car may skid on an icy road while braking, leading to a collision with another vehicle or guardrail.
- Inadequate Visibility: Reduced driver visibility caused by fog, darkness, heavy rain, or obstructed views (e.g., poorly placed signage or vegetation). Limited visibility makes it difficult to detect hazards, other vehicles, or road obstructions in time. For example: Driving in heavy fog can prevent drivers from seeing stopped vehicles ahead, causing multi-car pileups.

1.3 Types of Vehicle Accidents

There are five common types of car accidents: rear-end collisions, T-bone accidents, head-on collisions, side collisions, and rollovers. Each type of accident can result in different injuries

1. Rear-end collisions are the most common type of car accident. They occur when one car impacts another car from behind. These types of collisions are frequently caused by a sudden slowing down or braking, where another driver may have been following too closely or accelerated to get past the car ahead without allowing enough space to do so. A common injury for rear-end accidents is whiplash, which have symptoms such as sore neck, tense shoulders, headaches, and restriction range of motion. The fault is typically attributed to the driver of the car that had rear-ended the other, unless other influencing factors apply.

Fig 1.Rear end collision

2. T-bone accidents, also called side-impact collisions, are the second most common type of car accident. They occur when one car hits another car from the side. These accidents usually happen at intersections when one car runs a red light or stop sign and hits another car that is crossing the intersection. The most common injuries from T-bone accidents are broken bones, internal injuries, and head injuries.

Fig. Side impact collison

3. Head-on collisions are. Head-on collisions happen when the front of one car hits the front of another. These accidents usually happen on high-speed roads, such as highways. The most common injuries from head-on collisions are brain injuries, spinal cord injuries, and internal organ damage. Head-on collisions occur in many places, but because they involve cars travelling in opposite directions, the danger increases whenever cars do something that unexpectedly forces the car into the wrong lane. The usual causes are loss of control – such as speeding, failed brakes, or skidding – or driver error – such as crossing a median or passing improperly.


Fig 3. Head-on collision

4. Side-swipe collisions, also called side-swipe accidents, are the fourth most common type of car accident. They occur when two cars collide on either the driver's or passenger's side. These accidents usually happen when one car tries to pass another car and they end up colliding instead. The most common injuries from side collisions are broken bones, internal injuries, cuts and lacerations.


Fig 4. Side sway colission

A. Single-Vehicle Accidents:

Involves only one vehicle, such as a rollover or a collision with a stationary object. Rollovers are the fifth most common type of car accident. They occur when a car flips over onto its roof or side. These accidents usually happen when a car loses control on a curve or when it hydroplanes on wet roads. Accidents that involve vehicle rollovers are especially dangerous and scary to go through. Any vehicle can be part of a rollover accident, but those with a higher center of gravity are more susceptible to this type of accident, such as SUVs and other sports utility vehicles. Often caused by taking turns sharply and while speeding, rollovers can lead to a severe injury that requires medical attention immediately.

Fig.5 rollover accident

B. Multi-Vehicle Accidents:

Accidents involving multiple vehicles, often resulting in complex damage and injury patterns. Vehicle accidents with more than one other driver may be referred to as a pile-up, and usually occur on busy roadways like freeways and highways. Multiple vehicle crashes can be particularly dangerous and can lead to substantial personal injury and property damage. Depending on where the vehicles landed, some may have been hit numerous times or weren’t able to escape the oncoming danger as readily. As a motor vehicle accident lawyer from Cohen & Cohen, P.C. explains, in cases like these, you may need a lawyer to help show who was at fault.

C. Non-Collision Incidents:

Situations where no direct impact occurs but damage or injuries happen (e.g., sudden braking causing passenger injuries).

1.4 Impacts of Vehicle Accidents

1. Human Impacts: Injuries, fatalities, and psychological trauma.
2. Economic Impacts: Costs related to medical care, vehicle repair, insurance claims, and productivity loss.
3. Societal Impacts: Strain on healthcare systems and law enforcement, and disruptions to communities.

Understanding vehicle accidents and their contributing factors lays the foundation for effective analysis and the development of restoration and preventive measures. This knowledge is essential for reducing accident rates and minimizing their impact.

1.5 Classifying vehicle body damage

There are two basic types of body damage caused by a collision, direct (or primary) and indirect (or secondary);.

1.3.1. Direct damage

This results from the impact on the area in actual contact with the object causing the damage. This will result in the largest area of visible damage and is the cause of all other consequent damage. Primary damage is identified by first determining the direction of the primary impact. This knowledge will help in the search for concealed damage.

1.3.2. Indirect damage

This is usually found in the area surrounding the direct damage which causes it; although in certain cases it may be some distance from the actual point of impact. After the impact, internal damage is caused by the forced movement of objects and passengers towards the point of impact and can be seen in the form of damaged dash panels, broken seat frames and twisted steering wheels. This type of damage is more difficult to locate as it can be found anywhere on the vehicle. It occurs behind the area of impact and may even be found at the opposite side or end of the vehicle.

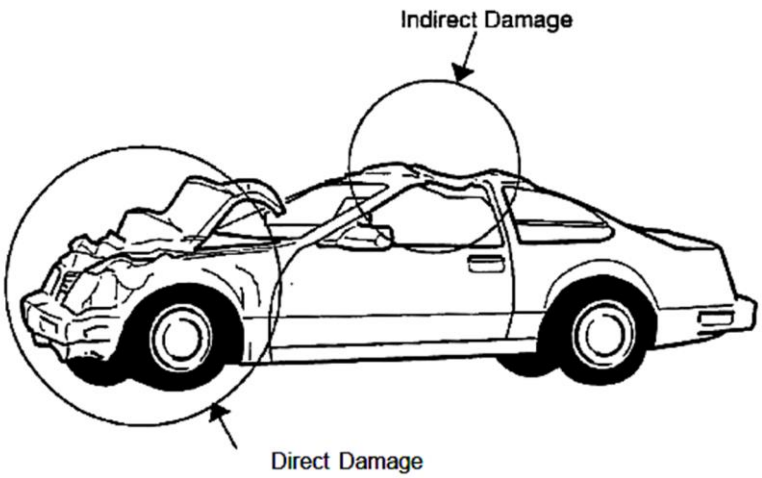


Fig.6 direct and indirect damage

Indirect damage is normally the last damage caused by the impact. This kind of damage is the result of collision shock forces traveling throughout the body and inertia forces of the weight and mass of unrestrained passengers and components. This creates the issue of concealed damage and may require damage repair supplements.

1.3.3. BOF vehicle frame damage

- Fig. illustrates a body with a perimeter frame with its built-in collapsible sections.
- The circled areas indicate the softer sections of the frame designed to absorb the major impact of a collision.
- The body is attached to the frame by rubber mounts.

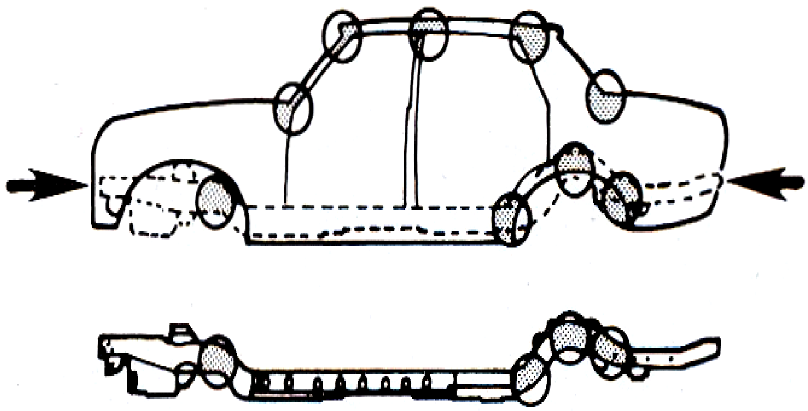


Fig. 7 :These are typical perimeter frame collapsible sections.

The rubber body mounts reduce the effects of road shocks traveling from the frame to the body. This quiets the ride in the passenger compartment. In the event of a large impact or collision, the bolts of the rubber mounts might bend, resulting in a gap between the frame and the body. Depending on the magnitude and direction of impact, the frame might experience damage while the body does not.

Frame deformation can be broken down into five categories:

1. Sideway damage

Collision impacts that occur from the side often cause a sideway damage or side bending frame damage condition (Fig. 8). Sideway usually occurs in the front or rear of the vehicle. It is possible to spot sideway by noting if there are buckles on the inside of one rail and buckles on the outside of the opposite side rail (Fig. 8).

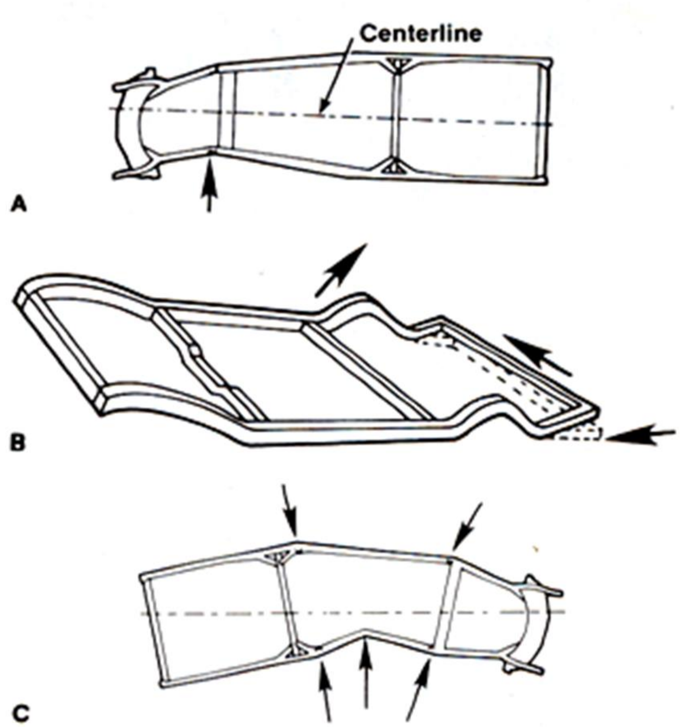


Fig. 8: Study various sidesway damages: (A) sidesway at the front of the frame caused by a front end collision: (B) rear sidesway and (C) double sidesway on the frame's outer section.

Sidesway can be recognized by abnormalities, such as a gap at the door on the long side and wrinkles on the short side. Look for impact damage obvious from the side, such as the hood and deck lid do not fit into the proper opening.

2. Sag damage

Sag damage is a condition where one area, often the cowl area, is lower than normal The structure has a sway- back appearance. Sag damage generally is caused by a direct impact from the front or from the rear.

- It can occur on one side of the vehicle or on both sides.
- Sag damage is a condition where one area, often the cowl area, is lower than normal (Fig.9).

- The structure has a sway- back appearance. Sag damage generally is caused by a direct impact from the front or from the rear (Fig.9).

- It can occur on one side of the vehicle or on both sides.

Fig. 9: (A) Note the sag condition on the left front frame section and (B) rear end sag.

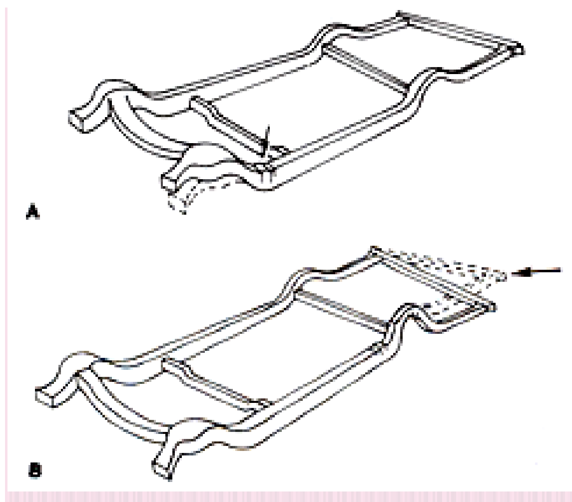
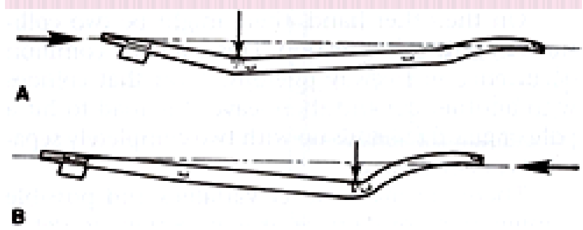


Fig. 10: (A) Side rail sag resulted from a front end collision; (B) side rail sag resulted from a rear end collision.



- Sag can usually be detected visually by a gap between the fender and the door being narrow at the top and wide at the bottom. Also look for the door appearing to hang too low at the striker.

- Sag is the most common type of damage and occurs in most vehicles that are involved in an accident.

- Enough sag can be present in the frame to prevent body panel alignment even though wrinkles or kinks are not visible in the frame itself.

3. Mash damage

Mash damage is present when any section or frame member of the car is shorter than factory specifications (Fig.11). Mash is usually limited to forward of the cowl or rearward of the rear window. Doors might fit well and appear to be undisturbed. Wrinkles and severe distortion will be found in fenders, hood, and possibly frame rails or horns. The frame will rise upward at the top of the wheel arch causing the spring housing to collapse.

With mash damage, there is very little vertical displacement of the bumper. The damage results from direct front or rear collisions

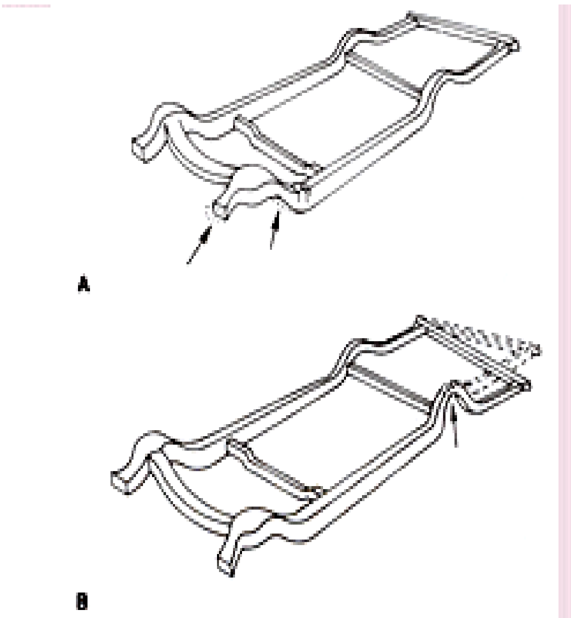


Fig.11: (A) Note the mash damage on the left front side rail; (B) mash damage on the left rear side rail.

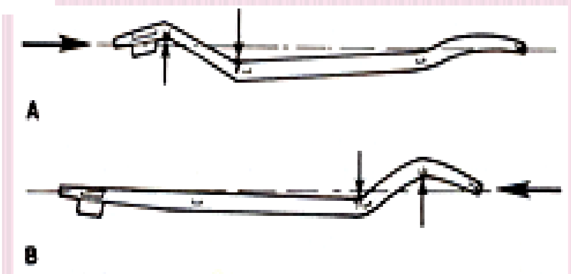


Fig. 12: (A) A frame mashed and buckled from a front end collision. (B) A frame mashed from a rear end collision.

4. Diamond damage

Diamond damage is a condition where one side of the car has been moved to the rear or front causing the frame and/or body to be out of square (Fig.). The resulting shape will be a figure similar to a parallelogram and is caused by a hard impact on a corner or off-center from the front or rear.

- Diamond damage affects the entire frame, not just the side rails. Visual indications are hood and trunk lid misalignment.
- Buckles might appear in the quarter panel near the rear wheel-housing or at the roof to quarter panel joint.
- Wrinkles and buckles probably will appear in the passenger compartment and/or trunk floor.

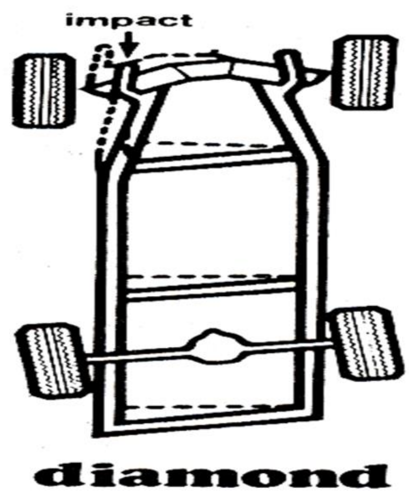


Fig. 13: A diamond condition affecting the entire frame alignment resulted from a hard impact from the front. but only on one side.

(Courtesy of Guy-Chart)

- There usually will be some mash and sag combined with the diamond.
- Diamond damage (Fig.13) usually occurs when the vehicle is struck off-center.
- However, a frame will rarely experience deformation involving the whole frame.

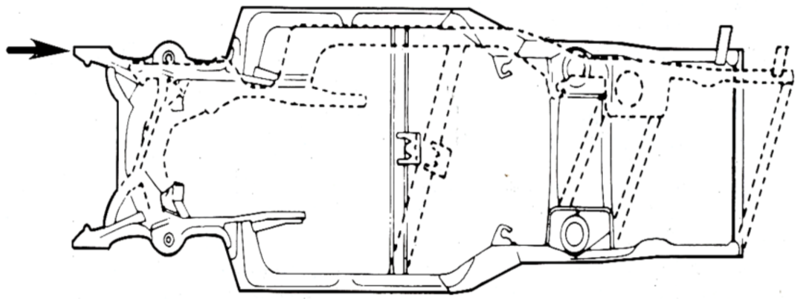


Fig.14: Study diamond conditions. Solid lines are the undamaged frame and dotted lines represent the damaged frame.

5. Twist damage

Twist damage (Fig.15) is a condition where one corner of the car is higher than normal; the opposite corner might be lower than normal. Twist can happen when a car hits a curb or median strip at high speed. It is also common in rear corner impacts and rollovers. A careful inspection reveals no apparent damage to the sheet metal. However, the real damage is hidden underneath. One corner of the car has been driven upward by the impact.

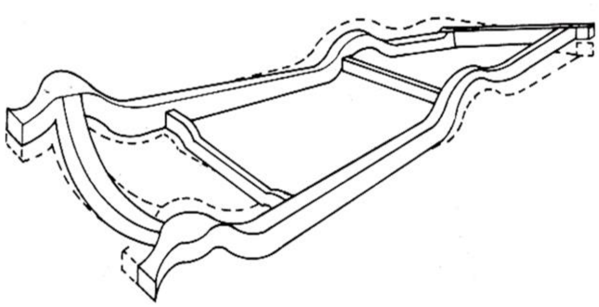


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Fig. 15: Twist conditions affect the entire frame alignment

Most likely the adjacent corner is twisted downward. If one corner of the car is sagging close to the ground as though a spring is weak, the car should be checked for twist.

- The most frequent order of occurrence of damage is:

    1. Sidesway

2. Sag
3. Mash
4. Diamond
5. Twist

1.3.4. Impact damages on unibody vehicles can be described in the following ways.

Frontal unibody damage results from a head-on collision with another object or vehicle. The impact of a collision depends upon the vehicle's weight, speed, area of impact, and the source of impact.

- In the case of a minor impact, the bumper is pushed back, bending the front side members, bumper support or bracket, front fender, radiator support, radiator upper support, and hood lock brace .
- If the impact is further increased, the front fender will contact the front door. The hood hinge will bend up to the cowl top. The front side members may also buckle into the front suspension cross member, causing it to bend.
- If the shock is great enough, the front fender apron and front body pillar (particularly the front door hinge upper area) will be bent, which will cause the front door to drop down.
- In addition, the front side members will buckle and the front suspension member will bend. The dash panel and front floor pan may also bend to absorb the shock.
- If a frontal impact is received at an angle, the attachment point of the front side member becomes a turning axis. Lateral as well as vertical bending occurs.
- Since the left and right front side members are connected together through the front cross member, the shock from the impact is sent from the point of impact to the front side member of the opposite side of the vehicle

Rear unibody damage occurs when the vehicle is moving backward and hits something or is hit by another vehicle from behind.

- When the impact is comparatively small, the rear bumper, the back panel, trunk lid, and floor pan will be deformed. The quarter panels will also bulge out.
- If the impact is severe enough, the quarter panels will collapse to the base of the roof panel. On four-door vehicles, the center body pillar might bend.
- Impact energy is absorbed by the deformation of the above parts and by the deformation of the kick-up of the rear side member

Side unibody damage will cause the door, front section, center body pillar, and even the floor to deform. When the front fender or quarter panel receives a large perpendicular impact, the shock wave extends to the opposite side of the vehicle.When the central area of the front fender receives an impact, the front wheel is pushed in. The shock wave extends from the front suspension cross member to the front side member. If the impact is severe, the suspension parts are damaged and the front wheel alignment and wheelbase may be changed. The steering gear or rack can also be damaged by side impacts.

Top impacts can result from falling objects or from a rollover of the vehicle. This type of damage not only involves the roof panel but also the roof side rail, quarter panels, and possibly the windows as well.

- When a vehicle has rolled over and the body pillars and roof panels have been bent, the opposite ends of the pillars will be damaged as well.
- Depending on the manner in which the vehicle rolled over, the front or back sections of the body will be damaged too. In such cases, the extent of the damage can be determined by the deformation around the windows and doors.

1.3.5. The typical collision damage sequence on a unibody structure

1. Bending: In the first microseconds of impact, a shock wave attempts to shorten the structure, causing a lateral or vertical bending in the central structure. Most of the forces that broadcast impact shock to remote areas occur at this instant. Since the structure is stiff and springy, it tends to snap back to its original shape-at least momentarily. Bending is usually indicated by the height measurement being out of tolerance. This damage-similar to sag in a conventional structure-can occur on one side of the car and not the other (Fig.16).

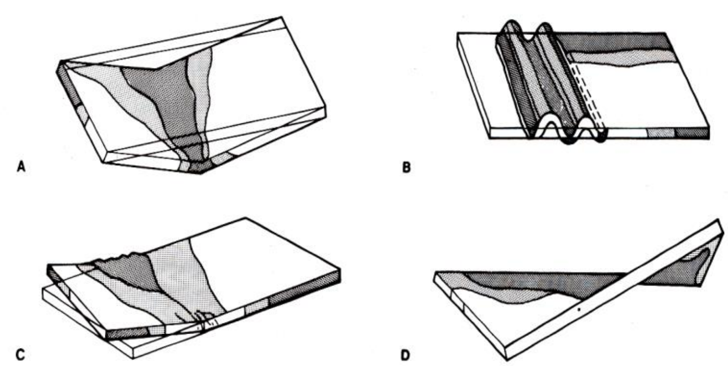


Fig.16: Study the types of unibody collision damage: (A) bending; (B) crushing or collapsing; (C) widening; and (D) twisting. [Courtesy of Blackhawk Automotive Inc.]

2. Crushing or collapsing: As the collision event continues, visible crushing occurs at the point of impact.

- Impact energy is absorbed in the deforming structure (helping protect the passenger compartment).
- Remote areas might buckle, tear, or pull loose. Crush damage, which is similar to mash on BOF (body over frame) vehicles, is indicated by the length measurement being out of tolerance.

3. Widening: In a well-designed unibody structure, impact forces reaching the passenger compartment cause the side structure to bow out away from the passengers (never in) distorting side rails and door openings. Widening is similar to sidesway damage in BOF vehicles and is indicated by the width measurement being out of tolerance.

4. Twisting: Even if the initial impact is dead center, the secondary impact can introduce torsional loads that cause a general twisting of the structure. Unibody structural twisting, like twisting of a conventional vehicle frame, is usually the last collision event. It is indicated by combinations of height and width measurements being out of tolerance.

There is a great similarity between the types of damage that can occur on body-over-frame and unibody vehicles. Unibody damage is often more complex. Note that a severe collision will not normally cause diamond damage on unitized cars. Also like conventional aligning, pulling secondary damage (last-in) so that it is corrected first, (first-out) is the best way to correct damage to a unibody car. Secondary damage is identified by accurate measurement.

Dynamics: Examines the forces and interactions influencing the motion, including friction, gravity, and collision forces.

This understanding helps in reconstructing pre- and post-collision behaviors.

1.6 Workplace Health and Safety (WHS) Requirements

Workplace Health and Safety (WHS) requirements are critical to ensure the safety of individuals involved in accident analysis and vehicle restoration processes. These requirements aim to minimize risks, prevent injuries, and create a safe working environment.

Personal Protective Equipment (PPE): Wearing appropriate PPE such as gloves, safety boots, high-visibility vests, helmets, and eye protection. Ensuring respiratory protection when dealing with fumes, dust, or hazardous materials.

Safe Work Environment: Maintaining clean, organized workspaces free of unnecessary hazards. Ensuring proper lighting and ventilation in the work area.

- Accident Scene Safety

Traffic Control Measures: Setting up barriers, cones, and warning signs to secure the accident site and prevent further collisions. Using high-visibility clothing to remain noticeable to oncoming traffic.

Emergency Preparedness: Having first aid kits and emergency contact numbers readily available. Ensuring team members are trained in basic first aid and CPR.

- Handling Hazardous Materials

Identification and Management: Identifying potentially hazardous materials such as spilled fuel, oil, broken glass, and battery acid. Safely cleaning or containing spills to avoid environmental contamination or injuries.

Waste Disposal: Following regulations for the disposal of damaged parts and hazardous materials, such as airbags, fuel, or fluids.

- Equipment and Tools Safety

Proper Tool Usage: Using tools and equipment according to the manufacturer's instructions. Inspecting tools regularly for wear or damage to prevent malfunctions.

Safe Lifting Techniques: Using mechanical aids (e.g., hoists, jacks) to lift heavy vehicle components. Training staff on proper manual lifting techniques to avoid strain injuries.

- Electrical Safety

Handling Damaged Electrical Systems: Disconnecting vehicle batteries before working on electrical components. Wearing insulated gloves and using tools designed for electrical work to prevent shocks. High-Voltage Vehicle Precautions: For hybrid or electric vehicles, ensuring de-energization of high-voltage systems before repairs.

Fire and Explosion Prevention

Flammable Material Management: Storing fuels, solvents, and other flammable materials in approved containers. Keeping fire extinguishers accessible and training workers in their use.

Avoiding Ignition Sources: Ensuring no open flames, sparks, or smoking near the work area.

- Ergonomics and Fatigue Management

Workstation Ergonomics: Designing workspaces and tools to minimize repetitive strain or awkward postures. Providing adjustable equipment like lifts and stands for comfortable work positions.

Break Schedules: Encouraging regular breaks to reduce fatigue and maintain focus, especially during long hours of analysis or repair work.

- Training and Communication

WHS Training: Providing training on safe work practices, hazard identification, and emergency response. Regularly updating employees on changes in safety standards or procedures.

Safety Meetings: Conducting toolbox talks or briefings to discuss potential hazards and safety protocols before starting work.

- Compliance with WHS Regulations

Adherence to Standards: Following national and industry-specific WHS laws and guidelines Keeping records of incidents, risk assessments, and safety training sessions.

Regular Inspections: Performing routine inspections of work areas, tools, and equipment to ensure compliance. By following these WHS requirements, workers can reduce risks, maintain safety, and ensure efficient accident analysis and vehicle restoration.

Self-check 1.1

Directions: Answer all the questions listed below.

Part I: Fill in the blank space

1. A vehicle's __________ zone is designed to absorb impact energy during a collision
2. __________ driving is one of the leading causes of vehicle accidents worldwide.
3. Airbags deploy to reduce injuries by cushioning the impact and preventing __________ with hard surfaces inside the vehicle.
4. Damage to the __________ of a vehicle can compromise its ability to protect occupants in a crash.
5. A vehicle's __________ zone is designed to absorb impact energy during a collision

Part-II: Choose the correct answer from the given alternatives

1. What is the most common cause of vehicle accidents?

   A. Faulty tires C. Engine failure

   B. Distracted driving D. Poor road conditions
2. Which type of damage occurs most often in a body-over-Frame vehicle?

   A. Side-sway B. Sag C. Mash D. Diamond
3. In a unibody structure, which of the following o0curs last in the typical collision damage sequence?

   A. Bending B. Widening C. Twisting D. Crushing

Part-III: Answer the following questions accordingly.

1. What are three common types of vehicle damage after an accident?
2. What should a driver do to ensure safety after a minor accident?
3. Write and explain some of personal protective equipment while working with batteries

Unit Two: Accident analysis

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Accident Analysis theory
- Definition and Scope of Accident Analysis
- Developing and adopting accident analysis criteria
- Functions of Accident Analysis
- Accident analysis method
- Determining extent of damage
- Accident processes reporting methods

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Understand Accident Analysis theory
- Define Accident Analysis
- Identify and Develop accident analysis criteria
- Understand the Functions of Accident Analysis
- Apply Accident analysis method
- Rate extent of damage
- Accident processes reporting methods

2.1 Accident Analysis theory

2.1.1 Introduction to Accident Dynamics

Understanding the theoretical underpinnings of accident analysis is essential to accurately reconstruct events and identify causative factors.

- Newtonian Physics and Mechanics in Crash Analysis:

  Fundamental principles such as Newton's laws of motion are applied to understand the forces, momentum, and energy transfer involved in vehicle collisions. Key considerations include impact force, deceleration rates, and trajectories.

- Understanding Vehicle Kinematics and Dynamics:

  Kinematics: Focuses on the motion of vehicles without considering the forces causing them, such as speeds, distances, and paths.

2.1.2 Principles of Crash Dynamics

Motion and force in vehicle collisions.

Motion – It is the act or process of moving, or the way in which somebody or something moves.

Dynamics – deals with the motion of bodies under the action of forces. It is composed of kinematics and kinetics.

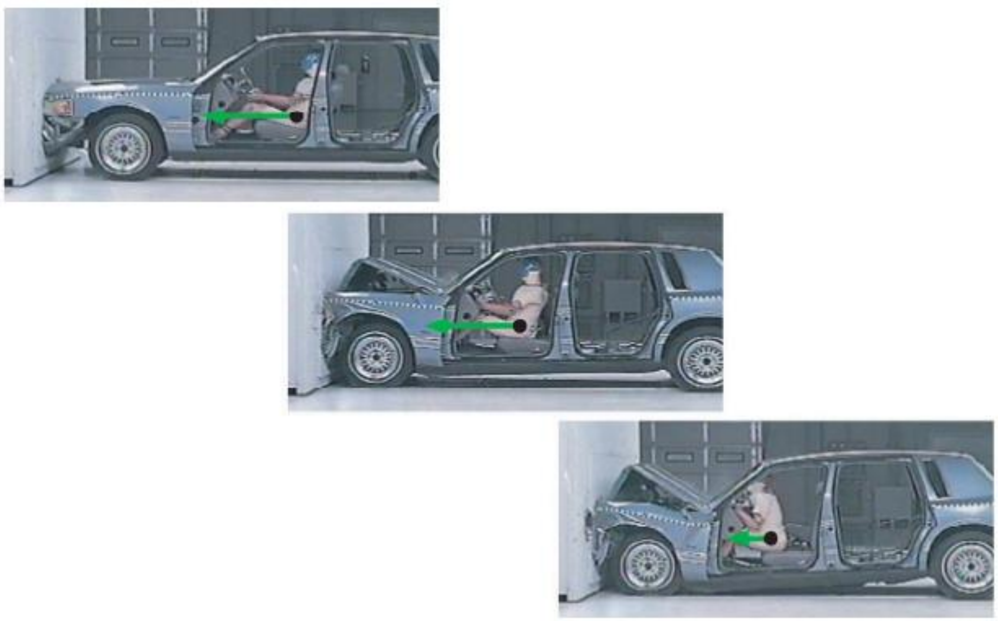
Kinematics – is the study of motion without reference to the forces which cause the motion. It deals with position, velocity, and acceleration in terms of time.

Kinetics – is the study of the relations existing between the forces acting on a body, the mass of the body, and the motion of the body. Kinetics is used to predict the motion caused by given forces or to determine the forces required to produce a given motion.

2.1.3 Newton's Laws of Motion

1. The first law

It states that everybody continues in its state of rest or of uniform motion in a straight line unless it is compelled by an external agency acting on it. A car in straight-line motion at a constant speed will keep such motion until acted on by an external force. The only reason a car in neutral will not coast (to move forward by momentum, without applying power) forever is that friction, an external force, gradually slows the car down. Friction comes from the tires on the ground and the air flowing over the car. The tendency of a car to keep **moving the way it is moving is the** inertia of the car, and this tendency is concentrated at the CG point. Friction comes from the tires on the ground and the air flowing over the car. The tendency of a car to keep moving the way it is moving is the inertia of the car, and this tendency is concentrated at the CG point.



Fig, 17 Seat Belts: An Application of Newton's First Law

2. The second law

The second law states that when an unbalanced force acts on a body, the body will accelerate in the direction of the force with a magnitude that is proportional to the force. When a force is applied to a car, the change in motion is proportional to the force divided by the mass of the car.

This law is expressed by the famous equation F = ma, where 'F' is a force, 'm' is the mass of the car, and 'a' is the acceleration, or change in motion, of the car. A larger force causes quicker changes in motion, and a heavier car reacts more slowly to forces. Newton's second law explains why quick cars are powerful and lightweight. The more 'F' and the less 'm' you have, the more 'a' you can get.. Newton's second law provides an explanation. F_{thrust} = 12 million newtons , F_{weight} = 5.8 million newton's Net force = 6.2 million newtons

3. The third law

The third law states that for every action there is an equal and opposite reaction. Every force on a car by another object, such as the g. The third law round, is matched by an equal and opposite force on the object by the car. When a brake is applied, it causes the tires to push forward against the ground, and the ground pushes back. As long as the tires stay on the car, the ground pushing on them slows the car down.

Fig. 18 application of newtons third law

2.1.4 Energy Transfer during Accident

Inertia

Inertia is the resistance to change the direction or velocity of a body in motion. Inertia moments

Examples of inertia moments

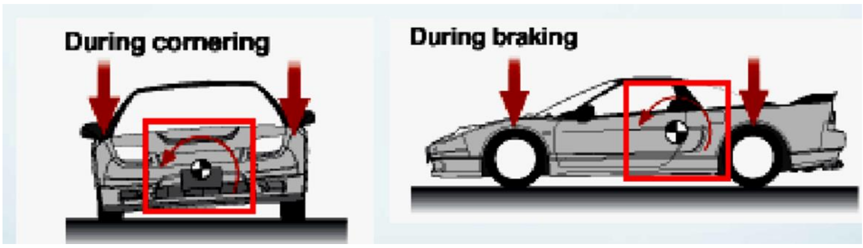


Fig 19. Effects of inertia

Centripetal Force is any motion in a curved path represents accelerated motion, and requires a force directed toward the center of curvature of the path. This force is called the centripetal force.

Centrifugal force is the apparent outward force experienced by a vehicle traveling along a curved path. It arises due to the inertia of the vehicle, which resists the change in direction. This force acts radially outward from the center of the curve and is proportional to the vehicle's mass, the square of its speed, and inversely proportional to the curve's radius.

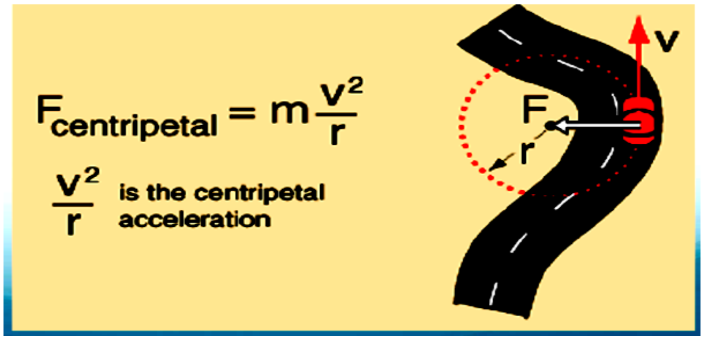
Mathematically:
$Fc=m\cdot v^{2/}r$

Where:

- Fc: Centrifugal force
- m: Mass of the vehicle
- v: Velocity of the vehicle
- r: Radius of the curve

In vehicle dynamics, excessive centrifugal force can lead to loss of traction, causing the vehicle to skid or overturn if not counteracted by friction or banking of the road.

Fig.20 Centripetal force



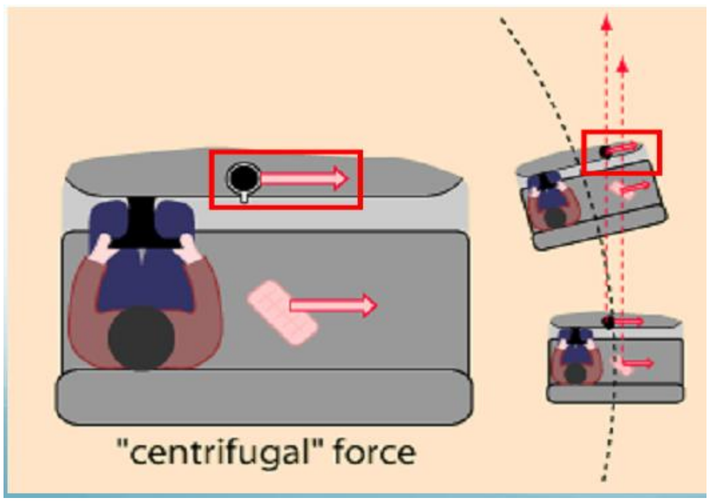


Fig.21 Centrifugal force

Traction

Traction is defined as the adhesive friction of the tire to the road surface. There are three traction forces:

1) Driving Traction – To accelerate the vehicle

2) Braking Traction – To slow or stop the vehicle

Turning forces

- Rotating bodies are influenced by turning forces. The rotation of the wheels, for example, is slowed down due to the braking torque and accelerated due to the drive torque. Turning forces act on the entire vehicle.

- If the wheels on one side of the vehicle are on a slippery surface (e.g. black ice) while the wheels on the other side are on a road surface with normal grip (e.g. asphalt), the vehicle will slew around its vertical axis when the brakes are applied (μ-split braking).

- This rotation is caused by the yaw moment, which arises due to the different forces applied to the sides of the vehicle.

Distribution of forces

In addition to the vehicle's weight (resulting from gravitational force), various different types of force act upon it regardless of its state of motion. Some of these are

- Forces which act along the longitudinal axis of the vehicle (e.g. motive force, aerodynamic drag or rolling friction); others are
- Forces which act laterally on the vehicle (e.g. steering force, centrifugal force when cornering or crosswinds).
- The tire forces which act laterally on the vehicle are also referred to as lateral forces.

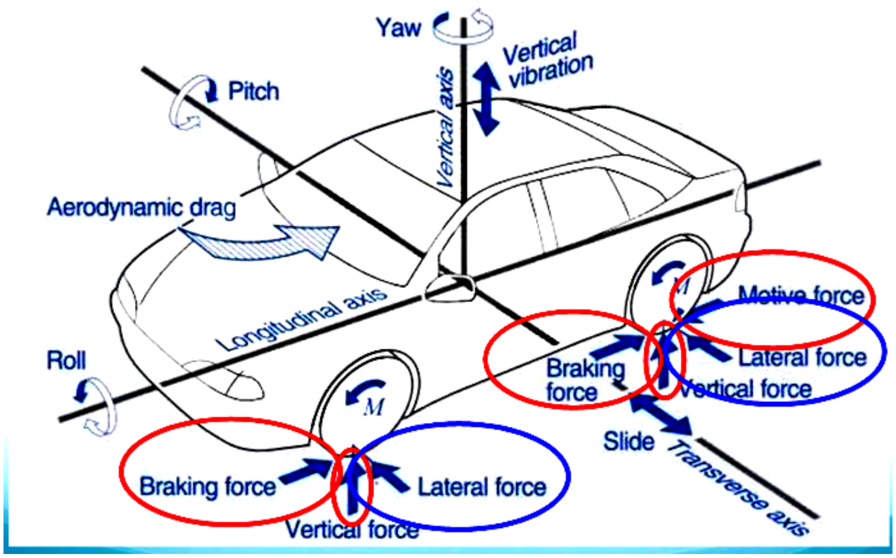


Fig 22 Effects of force that acts on longitudinal, lateral and transvers axes

2.2 Scope of Accident Analysis

Accident analysis is the systematic process of investigating, reconstructing, and understanding the factors and events that led to a vehicle collision. It encompasses collecting evidence, interpreting crash dynamics, and identifying causative elements such as human error, environmental factors, and mechanical failures. The scope includes on-site investigation, data analysis, and generating insights to improve road safety, guide restoration efforts, and inform legal or insurance processes.

2.3 Functions of Accident Analysis

Accident analysis is critical for effective vehicle restoration as it helps:

- Assess Damage: Identifies the extent and type of damage sustained by the vehicle.
- Guide Repairs: Provides insights into structural integrity and mechanical failures, ensuring repairs meet safety standards.
- Cost Estimation: Informs accurate repair and restoration cost assessments.
- Prevent Future Issues: Diagnoses underlying causes to address recurring or hidden problems.

2.4 Accident Scene Investigation Methods

Accident scene investigation involves systematically analyzing and documenting the physical evidence at the site of a vehicle collision to determine the causes and contributing factors.

2.4.1 Data Collection Methods

Effective data collection is crucial for accurate analysis and reconstruction. Key methods include:

General procedures

1. Evidence collection

A. General information

i. Police report

The police report is a summary of the police officer's investigation of the accident.

The report will often contain some or all of the following information:

- Approximate date, time, and location of the collision
- Identifying information for parties involved in the car accident, including names, addresses, phone numbers, and insurance information
- Identifying information for witnesses
- Location of damage to the vehicles involved in the accident
- Weather, roadway, and visibility conditions at the scene
- Diagram of the accident
- Statements from the parties and witnesses
- Citations and/or violations of law, and
- Opinions as to cause of the collision and/or a fault determination.

The information contained in the police report can be a fact or an opinion. For example, the date, time, and location of the collision are facts. Fault determinations (i.e. who caused the car accident) are the opinions of the police officer.

Regardless of what's included in the police report, the insurance company, through its own investigation, will come to its own conclusion (also an opinion) as to who was at fault for the accident.

ii. All participants and witness

iii. License and insurance info.

B. Specific accident evidence

- Photographic Evidence:

  High-resolution photographs capture the scene, vehicle positions, road conditions, and visible damage. Multiple angles and distances are taken to provide a comprehensive view.

- Measurement and Mapping:

  Precise measurements of skid marks, distances between vehicles, debris locations, and road features (e.g., curves, intersections) are recorded. Tools like laser scanners or total stations are often used for creating accurate maps.

- Environmental Data Collection:

  Information on weather conditions, lighting, road surface conditions, and traffic signals is documented to assess their impact on the accident.

- Witness Statements:

  Interviews with drivers, passengers, and bystanders provide context and supplement physical evidence.

- Vehicle Data Retrieval:

  Downloading data from event data recorders (EDRs) or black boxes, such as speed, braking, and steering inputs, offers objective insights into the vehicle's behavior before the collision.

2.4.2 Identifying and Documenting Evidence

Accurate documentation preserves evidence for analysis and legal purposes. Steps include:

Physical Evidence Identification:

Key elements to identify and document include:

- Tire Marks: Skid marks indicate braking, while yaw marks suggest loss of control.
- Vehicle Damage: Documenting collision points, deformations, and paint transfers.
- Debris: Location and type of debris (e.g., glass, vehicle parts) help reconstruct impact zones.

- Scene Sketching and Diagrams:
  Investigators create detailed sketches or digital diagrams to represent vehicle positions, road layout, and evidence locations.
- Labeling and Preserving Evidence:
  Collected items (e.g., broken components, samples of road materials) are labeled and stored securely to prevent contamination or loss.

Determining causation and fault in a car accident involves a careful analysis of various types of evidence, including the damage to the vehicles involved. This, along with other forensic evidence, can help reconstruct the events leading up to the collision and identify the at-fault driver and the extent of their responsibility.

The location of the damage on the vehicles can provide insight into how the accident occurred. As examples:

- If one vehicle has front-end damage while another has rear-end damage, it typically suggests that the driver of the rear vehicle was at fault for not maintaining a safe following distance.
- Side-impact damage, such as at an intersection, may indicate that one vehicle ran a red light or stop sign, striking another vehicle crossing its path.
- In the case of a left-turn accident, damage to the front corner of the turning vehicle could indicate that the driver was entering the intersection negligently. Damage to the rear

corner of the turning vehicle could mean that the oncoming vehicle's driver was speeding or was reckless.

The severity of the damage also is a factor to be analyzed. More extensive damage might imply higher speeds at the time of impact, possibly pointing to reckless or negligent behavior.

In addition to the location and severity, the pattern of damage can be revealing. For example, crumple zones and deformation patterns can suggest the direction and angle of the collision.

Beyond the damage to the vehicles, these other types of forensic evidence at the scene of the accident can help demonstrate causation and fault:

- Skid marks are vital indicators of a vehicle's behavior just before the collision. Long, straight skid marks typically indicate that a driver attempted to brake hard to avoid the collision. Curved skid marks can indicate a loss of control, possibly due to speeding or evasive maneuvers. Length and depth of skid marks can help estimate the speed of a vehicle at the time of braking.

- Debris location and distribution can provide clues about the point of impact and the movement of vehicles post-collision. If debris is scattered in a wide area, it might indicate a high-speed collision. The pattern of debris can also help determine the angles at which the vehicles collided.

- Vehicle rest positions can also offer insights. If one vehicle is found far from the point of collision, it might suggest it was moving at a high speed or was pushed by the impact forcefully. Comparing these positions with the skid marks and debris can help create a comprehensive picture of the accident.

C. Ongoing documentation-

- medical report
- Not seen and deemed before during and after collision

2.5 Determining extent of damage (Vehicle damage rating)

Vehicle Damage Rating is reported so that some correlation between direction and amount of impact force with the severity of injury and restraining device used can be established.

- Direction of force (XX)
- Damage description (ABC)
- Damage severity (Y), (0-7)

A. Direction of Force – (XX) – Describes the direction from which the vehicle damage was received in comparison to the numbers on a clock. Should be shown with a 1 or 2–digit numeric character (1–12) before the damage description and right justified.

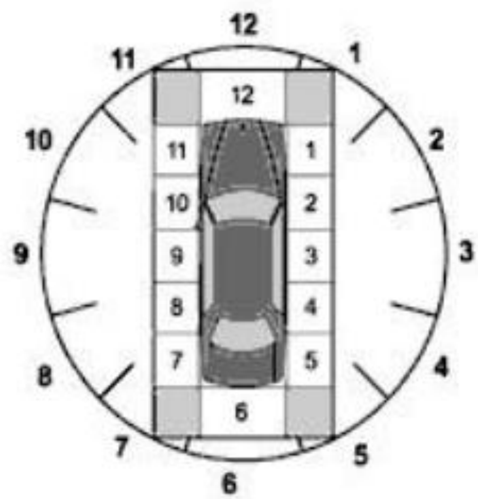


Fig. 23 Clock point Diagram for Motor Vehicle

B. Damage Description – (ABC) – Describes the area of the vehicle that received damage. Should be reported with a 2 or 3 alpha character code and right justified

For example, the Damage Description Code "FC" indicates that the vehicle received front-end damage from a concentrated impact, corresponding to the type of impact resulting from a collision with a tree, utility pole, or other narrow object.

In addition, a diagram of a car and an arrow, or series of arrows, on the left side of the page, shows the direction of the principal impact force.

C. Damage Severity – (Y) – Describes the severity of the damage received. Should be reported with a single–digit numeric character between 0–7 after the damage description.

If a vehicle sustained no discernible damage, a “0” rating should be reported. The “0” rating is generally applicable to collisions of motor vehicles with pedestrians or bicycles or to non collision crashes.

Note in cases where vehicles are damaged in more than one area, the investigator should enter the description of the two (2) most severely damaged areas, beginning with the area showing the most severe damage (Example: “FD-6, BD-3”)

During an assessment, a variety of damage types can be assessed. These damage types include:

- External Vehicle Damage: This includes dents, scratches, broken/cracked glass, and other forms of visible damage to the exterior of the vehicle.
- Mechanical Damage: The assessor will check the vehicle’s mechanical and safety systems. These include the engine, transmission, brakes, and steering.
- Interior Damage: Internal damage is caused during a collision and includes the seats, floor, windscreen and dashboard.
- Electrical Damage: They will check the vehicle’s electrical systems including lights, signals, and other electrical components to ensure they functioned properly.
- Safety Systems Damage: Modern cars have many safety systems such as airbags, seatbelts, restraint systems, and more.

A collision damage inspection can help to determine the cause of a collision by providing information about the damage caused to the vehicle as a result. The information can be used in conjunction with other types of evidence and other services to provide a detailed report. These evidence types include Witness Statements, Physical Evidence, and data from the vehicle systems. Inspecting a collision forensically provides vital information such as the location and direction of a vehicle, the damage caused through the collision, and more. This information can explain what happened at the time of a collision and the cause, whether it be a mechanical failure or road conditions.

Damage Inspection is one of the most important evidence types. It can provide a lot of information about a collision, just through the damage that has occurred.

The accuracy of an inspection does depend on the assessor and the information available. Here at TACC, we have experience in providing detailed, accurate reports from vehicle damage evidence.

Four Car Damage Categories

When the insurance company is looking into the accident, an inspector will evaluate the damage done to both vehicles. Typically, the inspector will classify the vehicle damage into one of four categories. The four different categories are:

N: The at-fault party's insurance company wants to see the vehicle labeled in the N category. This consists of minor vehicle damage, such as a broken tail light. Typically, the car does not have any substantial damage, like a ruined body or frame. The owner of the vehicle should still be able to drive the vehicle safely. However, if there are minor damages like a broken tail light, the owner should get it fixed before driving on public roads.

S: In category S, the vehicle has sustained major damage, although it can be repaired. The vehicle could have a ruined body or frame, but can be salvaged by a professional. The owner of the vehicle is not allowed to drive the vehicle until a licensed mechanic has repaired the vehicle.

B: In category B, the vehicle cannot be driven again due to the amount of damage. Now, the vehicle is only good for selling the parts. If your vehicle has been categorized in category B, your insurance company will not allow you to remove the parts, and a salvage yard will get rid of the pieces.

A: In category A, the vehicle has been completely ruined because of the wreck and no one can remove or sell any parts of the vehicle.

Self-check 2.1

Directions: Answer all the questions listed below.

Part I: Choose the appropriate answer from the given alternatives.

1. What is the primary factor in determining a vehicle's speed from skid marks?

   A. Length of the skid marks

   B. Vehicle weigh

   C. Road condition

   D. All of the above

2. What is the purpose of crush analysis in accident investigation?

   A. To estimate vehicle speed

   B. To identify the type of collision

   C. To reconstruct the accident sequence

   D. To determine driver reaction time

3. Which of the following is NOT considered physical evidence in accident analysis?

   A. Debris

   B. Eyewitness testimony

   C. Tire marks

   D. Vehicle damage

4. Which type of collision typically results in the highest energy transfer?

   E. Side-swipe collision

   F. Rear-end collision

   G. Head-on collision

   H. Single-vehicle collision

Part-II: Fill in the blank Space

1. The process of determining the events leading to a collision by analyzing physical evidence and witness statements is known as __________.
2. The term __________ refers to the point at which the first harmful event occurs in a vehicle accident.

3. Skid marks are used to estimate the __________ of a vehicle before an accident.
4. The __________ of impact is the direction a vehicle is traveling when it collides with another

Part III: Answer the following question accordingly

1. What factors influence the accuracy of speed estimation from skid marks?
2. Explain the significance of the "area of impact" in vehicle accident reconstruction.
3. How does roadway evidence, such as yaw marks, help in determining vehicle motion before a collision?
4. Describe how vehicle damage patterns can provide insight into the mechanics of a collision.

Unit Three: Vehicle accident damage restoration

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Restoration planning and implementation
- Assessing Vehicle Damage and Repair Feasibility
- Developing Restoration Plans Based on Diagnostic Findings

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Assessing Vehicle Damage and Repair Feasibility
- Developing restoring plan based on Diagnostic Findings
- Selecting Appropriate Repair Techniques and Materials
- Appling restoration

3.1 Restoration planning and implementation

Restoration planning and implementation involve evaluating vehicle damage, determining repair strategies, and ensuring the restored vehicle meets safety and performance standards. Below is a detailed explanation of the key components:

3.2 Assessing Vehicle Damage and Repair Feasibility

- Purpose: The first step in the restoration process is to assess the extent of damage and decide whether the vehicle is repairable or beyond economic repair (totaled).
- Key Steps:

1. Visual Inspection:
    - i. Examine visible damage to the exterior (body panels, lights, windows).
    - ii. Check for structural damage, especially in critical areas like the frame or crumple zones.
2. Functional Assessment:
    - i. Test the functionality of mechanical components (engine, brakes, suspension).
    - ii. Check the integrity of electrical systems (wiring, sensors, airbags).
3. Diagnostic Tools:
    - i. Use advanced tools like OBD-II scanners to identify hidden faults.
    - ii. Perform ultrasonic or X-ray imaging to detect internal cracks or stress points.
4. Repair Feasibility:
    - Compare repair costs with the vehicle's market value to determine economic feasibility.
    - Consider factors like availability of parts, labor costs, and repair complexity.

3.3 Developing Restoration Plans Based on Diagnostic Findings

- Purpose:

- A well-structured plan ensures repairs address all issues and restore the vehicle to pre-accident condition.

- Steps to Develop a Plan:

1. Damage Prioritization:

➢ Address critical safety concerns first (e.g., brakes, airbags, structural integrity).

➢ Follow with secondary repairs like cosmetic fixes or minor alignment issues.

2. Cost Estimation:

➢ Prepare a detailed breakdown of repair costs, including labor, parts, and any specialized equipment.

3. Timeline Setting:

➢ Establish a realistic timeline for repair completion, accounting for parts procurement and labor availability.

4. Compliance Considerations:

➢ Ensure the restoration plan aligns with legal safety standards and manufacturer specifications.

3.4 Selecting Appropriate Repair Techniques and Materials

- Purpose:

  ➢ Choosing the right techniques and materials is crucial for ensuring durability and reliability.

- Techniques:

- Body Repairs:
  - Use welding, panel beating, or dent removal techniques for bodywork.
  - Opt for paintless dent repair (PDR) for minor dents without affecting the paint.
- Structural Repairs:
  - For frame damage, use frame-straightening machines to restore alignment.
  - Replace irreparable sections with new components approved by the manufacturer.
- Mechanical and Electrical Repairs:
  - Replace damaged parts (e.g., engines, suspensions) with OEM (Original Equipment Manufacturer) components when possible.
  - Reprogram electronic systems to recalibrate sensors and safety features like airbags or traction control.
- Cosmetic Repairs:
  - Match paint colors using digital spectrophotometers for a seamless finish.
  - Replace cracked or scratched windows with high-quality glass.
- Materials: Use materials that meet safety and durability standards, such as:
  - High-strength steel or aluminum for structural repairs.
  - Certified adhesives and fasteners for assembly.
  - High-quality paint and coatings to protect against corrosion.

3.5 Recommended Diagnostic Procedure

Accident damage should be assessed carefully by measurements with the proper tools and equipment.

The following is a basic, recommended diagnostic procedure:

1. Know the vehicle construction type.

2. Visually locate the point of impact.

3. Visually determine the direction and force of the impact; once determined, check for possible damage.

4. Determine whether the damage is confined to the body or whether it involves functional parts (wheels Suspension, engine, and so on).

5. Systematically inspect damage to the components along the path of the impact. Find the point where there is no longer any evidence of damage. For example, pillar damage can be determined by checking the door fitting conditions

6. Measure the major components. Check body dimensions (known correct body measurements of an undamaged vehicle) by comparing the actual measurements with the values in the repair manual or body dimensions chart.

7. Check for suspension and overall body damage with the proper equipment. Vehicle damage conditions are diagnosed from the procedures

Self-check 3.1

Directions: Answer all the questions listed below.

I. Multiple Choice Questions (5)

1. What is the first step in assessing vehicle damage after an accident?
   A. Repainting the damaged areas
   B. Performing a diagnostic scan
   C. Conducting a visual inspection
   D. Replacing worn-out tires
2. What is the purpose of a diagnostic scan during restoration planning?
   A. To detect hidden electrical and mechanical issue
   B. To measure fuel efficiency
   C. To align the vehicle's suspension
   D. To clean engine components
3. When a vehicle is typically considered "beyond repair"?
   A. When it cannot be towed to a repair shop
   B. When repair costs exceed the vehicle's market value
   C. When cosmetic damages are severe
   D. When the vehicle is more than 5 years old
4. What method is most suitable for repairing minor dents without damaging paintwork?
   A. Structural welding
   B. Sandblasting
   C. Painless Dent Repair (PDR)
   D. Panel replacement
5. Which factor plays the most critical role in developing a restoration plan?
   A. Vehicle brand and model
   B. Availability of original parts
   C. Extent of damage identified through diagnostics
   D. Vehicle owner's insurance plan

Fill-in-the-Blank Questions (5)

1. A vehicle is considered a total loss when repair costs exceed the ________ of the vehicle.
2. ________ is the process of creating a structured approach to restore a vehicle after an accident.
3. A thorough ________ is required to identify visible and hidden damage to a vehicle.
4. The most common tool used for measuring structural damage is the ________ system.
5. Repair feasibility is determined by evaluating the cost of repairs against the vehicle's current ________.

Short Answer Questions (5)

1. What are the key steps involved in assessing vehicle damage after an accident?
2. How does diagnostic scanning assist in developing restoration plans?
3. What factors determine whether a vehicle is repairable or a total loss?
4. Explain the difference between structural repairs and cosmetic repairs in vehicle restoration.
5. Why is it important to create a detailed restoration plan before starting the repair process?

Reference Books

1. James E. Duffy, Auto Body Repair Technology. Authors, Jonathan Beaty Edition 7
2. Rob Thompson, Automotive Maintenance & Light Repair: Second Edition
3. Jack erjavec, Automotive technology a systems approach.5th edition
4. A.K. Babu Automotive Electrical Systems-I Theory & Practice
5. Automobile Mechanical and Electrical Systems Automotive Technology: Vehicle Maintenance and Repair

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