INTRODUCTION

The goal of collision repair is to restore the vehicle to its preaccident condition. To accurately repair a wrecked car or truck, you must fully understand how the vehicle is designed and constructed. You must be capable of accurately identifying all damaged components and the repair options available. You must know the materials used in the vehicle and how these materials may affect the repair process.

To fully comprehend the challenges faced by the technician, consider the radical changes in the industry over the years (Figure 2-1). With passenger cars, minivans, and many small pickup trucks, body-over-frame construction that served the industry for over sixty years has given way to unitized construction.

The frame is usually a high strength metal structure used to support other parts of the vehicle. It holds the engine, transmission, suspension, body, and other parts in position. The frame can be separate from the body or the body can be welded together to form the frame.

The vehicle body is a steel, aluminum, fiberglass, plastic, or composite skin forming the outside of the car. The body is normally painted to give the vehicle its attractive, shiny, color appearance.

Body-over-frame vehicles have separate body and chassis parts bolted to the frame. The engine and other major assemblies are mounted on the frame. This type of frame consists of two side rails connected by a series of cross members. Body-over-frame construction is still being used on full-size pickup trucks, some small pickups, and most full-size vans. Some larger luxury cars still use traditional coil spring, body-over-frame setups.

Unibody construction uses body parts welded and bolted together to form an integral frame. No separate heavy gauge steel frame under the body is needed. Unibody construction is a totally different

OBJECTIVES

After studying this chapter, you should be able to:

✓ Name the general body shapes
✓ Describe the general evolution of vehicle body design from early body-over-frame to present-day unitized, and unitized construction.
✓ List the major design characteristics of modern body-over-frame and modern unibody construction and how they affect repair procedures.
✓ Identify the major structural components, sections, and assemblies of body-over-frame vehicles.
✓ Identify the major structural components, sections, and assemblies.
✓ Identify the important parts of motor vehicles.
✓ Read a VIN plate number.
✓ Answer vehicle construction-related ASE test questions.

KEY TERMS

anticorrosion materials
body-over-frame
center section
cowl
dash panel
deck lid
floor pan
frame rails
front section
instrument panel
pillars
quarter panels
radiator core support
rear section
shock towers
ASE TASK LIST
Job Skills covered in this chapter include:

PAINTING AND REFINISHING TEST
(B2) TASK LIST
A. Surface Preparation
7. Identify type of metal and apply suitable metal treatment or primer.

C. Paint Mixing, Matching, and Applying
9. Identify the types of rigid, semirigid, or flexible plastic parts to be refinished; determine the proper materials and refinishin procedures.

NONSTRUCTURAL ANALYSIS AND DAMAGE REPAIR TEST (B3) TASK LIST
A. Preparation
5. Remove undamaged, nonstructural body panels and components that may interfere with or be damaged during repair.

B. Outer Body Panel Repairs, Replacements, and Adjustments
3. Determine the extent of damage to aluminum body panels; repair, weld, or replace in accordance with manufacturers’ specifications.
4. Remove, replace, and align hood, hood hinges, and hood latch/lock.
5. Remove, replace, and align deck lid, lid hinges, and lid latch/lock.
6. Remove and replace doors, tailgates, hatches, lift gates, latch/lock assemblies, and hinges.
7. Remove, replace, and align bumpers, reinforcements, guards, isolators, and mounting hardware.

8. Check and adjust clearances of front fenders, header, and other panels.
9. Check door hinge condition; check door frames for proper fit; check and adjust door clearances.
17. Diagnose and repair water leaks, dust leaks, wind noise, squeaks, and rattles.

D. Moveable Glass and Hardware
5. Inspect, repair, and install convertible top and related mechanisms.

E. Welding and Cutting
1. Identify weldable and non-weldable materials used in vehicle construction.

STRUCTURAL ANALYSIS AND DAMAGE REPAIR TEST (B4) TASK LIST
A. Frame Inspection and Repair
8. Remove and replace damaged frame horns, side rails, cross members, and front or rear sections.
10. Repair or replace weakened or cracked frame members in accordance with vehicle manufacturers’/industry standards.

C. Stationary Glass
1. Remove and replace front and rear stationary glass (heated and non-heated) in accordance with manufacturers’ recommendations.

FIGURE 2-1 Great changes have occurred in automobile design since the early years of the automobile: (A) 1897 horseless carriage (Courtesy of Oldsmobile) and (B) experimental sports car. (Photograph provided courtesy of Mercedes-Benz North America, Inc.)
concept in vehicle design that requires new assembly techniques, new materials, and a completely different approach to repairs. In unibody designs, heavy gauge, cold-rolled steels have been replaced with lighter, thinner, high-strength steel alloys or aluminum alloy. This requires new handling, straightening, and welding techniques.

The ever increasing use of plastics, modular glass, and advanced paint systems is also changing the face of vehicle repair. On unibody vehicles, certain mechanical systems, such as suspension and steering, rely on the proper positioning of unibody components for alignment and smooth operation.

Space frame construction is similar to unibody construction. The main difference is that the metal structure is covered with an outer skin of plastic or fiberglass panels. These are attached with mechanical fasteners or adhesives. This type of construction requires technicians to be more careful when inspecting for collision damage because the plastic panels can hide damage to the metal structure. Greater care must also be taken with corrosion protection for this same reason.

### 2.1 Body Shapes and Parts

Various methods of classifying vehicles exist—by type of engine, fuel system, drive line, and so forth. The classifications most common to consumers are body shape, seat arrangement, number of doors, and so on. Six basic body shapes are used today:

1. **Sedan.** A vehicle with front and back seats that accommodates four to six persons is classified as either a two- or four-door sedan (Figure 2-2).

2. **Hardtop.** A vehicle with front and back seats, a hardtop is generally characterized by a lack of door or “B” pillars that extend to the roof (Figure 2-3). It can also be classified as either a two- or four-door hardtop.

3. **Convertible top.** After an absence from the domestic market for several years, the convertible top made a comeback in 1985. Today’s convertible top vehicle has a vinyl or cloth roof that can be raised or lowered (Figure 2-4). Like a hardtop, a convertible top has no door pillars and, depending on the make, can be purchased with.

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**Figure 2-2** Note typical sedan body shapes.

**Figure 2-3** These are typical hardtop body styles.

**Figure 2-4** Compare convertible body shapes.

**Figure 2-5** These are 3- and 4-door liftback bodies.
designs (Figure 2–7). They are available in two-wheel drive, four-wheel drive (4x4), or all-wheel drive. Pickup truck body designs are available with standard cab designs, with extended (larger) cab areas (some have added seats in back of the front seat), and some with open or closed pick-up spaces. While sport utilities appeal to the outdoor enthusiast who wants both road and off-road applications, van designs are considered sport vehicles, but for family use.

Although body types are sometimes classified according to these various descriptions, the body’s strength depends on the type of vehicle and its body structure. Factors, such as door size, the presence or absence of a center pillar, front body pillar, quarter panels, roof panels, and so forth, greatly affect how much or how little the impact from a collision is absorbed. For vehicles with large luggage areas, such as vans or liftbacks, the structural members and reinforcements designed into the body measurably affect overall torsional rigidity.

**MAJOR BODY SECTIONS**

For simplicity and to help communication in auto body repair, a vehicle is commonly divided into three body sections—front, center, and rear. You should understand how these sections are constructed so that you can properly repair them.

The **front section**, also called nose section, includes everything between the front bumper and the firewall. The bumper, grille, frame rails, front suspension parts, and usually the engine are a few of the items included in the front section of a vehicle.

The nickname “front clip” or “doghouse” is sometimes used to refer to the front body section. It is often purchased and cut off from a wreck in one piece from an automotive recycler or salvage yard. The empty engine compartment forms the “doghouse.”

The **center section** or midsection typically includes the body parts that form the passenger compartment. A few parts in this section include the floor pan, roof panel, cowl, doors, headlamps, glass, and related parts. A slang name for the center section is “greenhouse” because it is surrounded by glass.

The **rear section**, tail section, or rear clip commonly consists of the rear quarter panels, trunk or rear floor pan, rear frame rails, trunk or deck lid, rear bumper, and related parts. It is often sectioned or cut off of a salvaged vehicle to repair severe rear impact damage.

When discussing collision repair, body shop personnel often refer to these sections of the vehicle. It simplifies communication because everyone knows which parts are included in each section.
Panel and Assembly Nomenclature

A panel is a stamped steel or molded plastic sheet that forms a body part. Various panels are used in a vehicle. Usually, the name of the panel is self-explanatory. When panels are joined into a large part, it is called an assembly.

The vehicle left-side is the driver's or steering wheel side on vehicles and trucks built for American roads. The vehicle right-side is the passenger side or the side opposite the steering wheel. Remember that vehicles built for other countries will often have the steering wheel on the right-side because they drive on the other side of the road.

Another way to determine the right- and left-sides of a vehicle is to stand behind the vehicle. Your right hand would be on the right side and left hand would be on the left side of the vehicle. Panels and parts are often called out as left- or right-side.

Front Section Parts

The frame rails are the box frame members extending out near the bottom of the front section. They are usually the strongest part of a unibody.

The cowl is the body parts at the rear of the front section, right in front of the windshield. This includes the top cowl panel and side cowl panels.

The front fender aprons are inner panels that surround the wheels and tires to keep out road debris. They often bolt or weld to the frame rails and cowl.

The shock towers or strut towers are reinforced body areas for holding the upper parts of the suspension system. The coil springs and strut or shock absorbers fit up into the shock towers. They are normally formed as part of the inner fender aprons.

The radiator core support is the framework around the front of the body structure for holding the cooling system radiator and related parts. It often fastens to the frame rails and inner fender aprons.

The hood is a hinged panel for accessing the engine compartment (front-engine vehicle) or trunk area (rear-engine vehicle). Hood hinges, bolted to the hood and cowl panel, allow the hood to swing open. The hood is normally made of two or more panels welded or bonded together to prevent flexing and vibration. Some hoods also hinge at the radiator support.

The dash panel, sometimes termed firewall or front bulkhead, is the panel dividing the front section and the center, the passenger compartment section. It normally is welded in place.

The front fenders extend from the front doors to the front bumper. They cover the front suspension and inner aprons. They normally bolt into place around their perimeter.

The bumper assembly bolts to the front frame horns or rails to absorb minor impacts.

The grille is the center cover over the radiator support. It sometimes has an opening for airflow through the radiator.

Center Section Parts

The floor pan is the main structural section in the bottom of the passenger compartment. It is often stamped as one large piece of steel.

With front-wheel-drive vehicles, the floor pan can be relatively flat. With rear-wheel-drive vehicles, a tunnel is formed in the floor pan for the transmission and drive shaft. The drive shaft needs room to extend back to the rear axle assembly.

Pillars are vertical body members that hold the roof panel in place and protect in case of a rollover accident.

The front pillars extend up next to the edges of the windshield. They must be strong to protect the passengers. Also termed A-pillars, they are steel box members that extend down from the roof panel to the main body section.

Center pillars or B-pillars are the roof supports between the front and rear doors on four-door vehicles. They help strengthen the roof and provide a mounting point for the rear door hinges.

Rear pillars extend up from the quarter panels to hold the rear of the roof and rear window glass. Also called C-pillars, their shape can vary with body style.

Rocker panels or door sills are strong beams that fit at the bottom of the door openings. They normally are welded to the floor pan and to the pillars, kick panels, or quarter panels. The kick panels are small panels between the front pillars and rocker panels.

The rear shelf or package tray is a thin panel behind the rear seat and in front of the back glass. It often has openings for the rear stereo speakers. The rear bulkhead panel separates the passenger compartment from the rear trunk area.

The doors are complex assemblies made up of an outer skin, inner door frame, door panel, window regulator, glass, and related parts. Door hinges are bolted or welded between the pillars and door frame. The window regulator is a gear mechanism that allows you to raise and lower the door glass.

Side impact beams are metal bars or corrugated panels that bolt or weld inside the door assemblies to protect the passengers. Primarily, they prevent the door from opening upon impact. They also help keep anything from intruding into the passenger area. When made of ultra-high-strength steel, side impact beams should not be repaired.

The roof panel is a large multipiece panel that fits over the passenger compartment. It is normally welded to the pillars. Sometimes it includes a sunroof or removable top pieces, termed T-tops.

The dash assembly, sometimes termed instrument panel, is the assembly including the soft
dash pad, instrument cluster, radio, heater and air-conditioning controls, vents, and similar parts. It can be damaged in a collision by human contact.

**REAR SECTION PARTS**

The *rear frame rails* are strong boxed structures that give strength to the rear of the vehicle.

The *trunk floor panel* is a stamped steel part that forms the bottom of the rear storage compartment. Quite often the spare tire fits down into this stamped panel. It often welds to the rear rails, inner wheel houses, and lower rear panel.

The *deck lid* or *trunk lid* is a hinged panel over the rear storage compartment. A *rear hatch* is a larger panel and glass assembly hinged for more access to the rear of the vehicle.

The *quarter panels* are the large, side body sections that extend from the side doors back to the rear bumper. They are welded in place and form a vital part of the rear body structure.

The *lower rear panel* fits behind the rear bumper and between the quarter panels.

*Rear shock towers* hold the top of the rear suspension. The *inner wheelhouses* surround the rear wheels and weld to the quarter panels.

The *upper rear body panel* is the area between the back glass and trunk lid.

**ANTICORROSION AND SOUND DEADENING MATERIALS**

*Anticorrosion materials* are used to prevent rusting of metal parts. Various types of anticorrosion materials are available (weld-through primer, sealers, rubberized undercoating, etc.). When performing repairs, you must restore all corrosion protection.

*Sound deadening materials* are used to help quiet the passenger compartment. They are insulation materials that prevent engine and road noise from entering the passenger area.

**2.2 CONSTRUCTION TYPES**

Mentioned briefly, passenger cars of today use one of three types of construction:

- Conventional body-over-frame (Figure 2–8)
- Unitized or unibody (Figure 2–9)
- Spaceframe

Through the 1960s and early 1970s, American automobiles were manufactured in pretty much the same way with similar characteristics. These were

- Body/frame construction
- Rear drive
- Independent front suspension
- Symmetrical design

In 1974 a variety of events took place that rocked the foundations of the automobile industry. First of
all, the government placed very strict fuel economy and emission control laws and standards on the manufacturers. The economy standard was known as CAFE for Corporate Average Fuel Economy, and the emission control standard was set by the Environmental Protection Agency. This meant that American automotive manufacturers had to start designing more efficient methods of combustion and emission control systems for engines.

As a result of a startling revelation by the media of poor safety records and operating conditions, there came a public demand for safe as well as clean-running vehicles. As if these were not enough problems for the manufacturers to deal with, the Arab oil embargo occurred as well. The price of gasoline escalated; consumers then demanded increased fuel efficiency. Foreign car makers, who had always manufactured smaller, lighter, more fuel-efficient vehicles, captured an increasing share of the domestic new-car market. American automakers were forced to produce smaller, more efficient cars. This resulted in the development of the unibody cars on the roads today.

The five construction areas where domestic automobiles have changed since the mid-1970s are:

1. Body/frame construction  
2. Weight (average fleet)  
3. Metal composition  
4. Suspension/steering  
5. Engine location/drive

In 1977 most cars used a perimeter type frame. They averaged around 4,500 pounds (2,038 kg), used 18-gauge mild steel, and were still conventional in design. Body weight began to decrease and thinner gauge metal was used. Also, the first American-made transverse engine, front-wheel drive, strut suspension car was introduced.

By 1981 unibodies were used in almost half the American-made cars. Fleet average weight decreased 600 pounds (272 kg); 22-gauge high-strength steel was used in construction; the steering changed to rack and pinion; the suspension changed to MacPherson strut type; and the drive changed from rear- to front-wheel drive.

At the present time, most unibodies are constructed of 24-gauge high-strength steel, have a fleet average weight 900 pounds (407 kg) less than in 1980, and feature MacPherson struts, rack-and-pinion steering, and front-wheel drive. Today, 95 to 97 percent of all passenger cars on American roads are unibodies.

As construction of vehicles has changed over the years, so has the collision repair profession. In the early days of automobiles, there were no specialized shops for automobile collision repair. When a car was brought in for repair, the damaged part was usually removed and replaced with a new one that was either forged from steel or cut from wood. This method was expensive and time-consuming. Many times there was a long wait for parts. Most of the early body/frame technicians were carpenters or blacksmiths.

Because automobile bodies and frames became more complex in design, it became more practical to repair instead of replace. The early repair procedure involved placing the bent member over a massive structure and forcing it back into shape.

With more cars being manufactured, business got to such a point that repair people began to specialize as either a body or a frame technician. As repair technicians became more experienced, their techniques improved. Pushing from within the body compartment became accepted as a body alignment method. Frame technicians also used internal pushing as a means of frame alignment.

As procedures were refined, the stationary frame machine evolved. This machine was a more sophisticated version of the railroad iron and mechanical jack the blacksmith used. This stationary frame machine went through some changes to make it more efficient and easier to use. By raising the machine off the ground, it was easier to gain access to the various components. Ramps were built so cars could be pulled into place. Pits were later dug under the machine to eliminate the ramps.

In conjunction with the racks, hydraulic jacks were used to push heavy upright beams, forcing bent frame members back into place. Frame machine manufacturers had to continuously update their machines to keep their units functional. As the automobile frame design became more complex, so did the repair techniques. The job of the frame technician became a job for a highly skilled technician.

When Citroën introduced its unitized body in 1934, a whole new set of collision repair problems occurred. Since there was no frame to apply pushing pressure against, the technique of internal body and frame pushing was of little value. There was not enough material in any one place to push against.

The basic repair technique of pushing out damaged sections changed to that of pulling out damaged sections. Out of necessity, the portable body and frame puller was developed. It soon became accepted on a worldwide basis.

The manufacturers of stationary frame equipment again had to make modifications. The push technique was changed to a pull technique by adding adjustable pull towers (Figure 2-10). These units remained functional but became more massive, complicated, and expensive.

The portable body and fender puller and the updated stationary frame machine remained in use for a number of years. These machines became outdated when automobile engineers again changed the basic frame and body design. When the second generation perimeter frame and unitized bolt-on stub frame be-
came popular, a new repair system was needed. This system had to be flexible enough to repair both unitized and frame-constructed vehicles. These systems are the ones described in Chapters 9 and 10.

From the body technician's standpoint, it is important to know which type of construction is used. Repair work is different for each type of construction. For example, the mechanical components of a vehicle's steering and suspension, cooling system, drivetrain, and electrical systems are usually serviced by auto technicians. But with unibodies, because the mechanical components (Figure 2–11) are attached directly to the underbody, precision and skill are required. Since the body shop must return the vehicle to the customer completely repaired, the modern body technician requires much more knowledge than the counterpart of the era prior to the advent of the unibody.

It must provide the support and strength needed by the assemblies and parts attached to it. The frame must also be strong enough to keep the other parts of the car in alignment should a collision occur. To the body technician, the frame can be considered the most important part of the vehicle.

The conventional frame is an independent, separate component because it is not welded to any of the major units of the body shell. The body is generally bolted to the frame. Large specially designed rubber "biscuits," or mounts, are placed between the frame and body structure to reduce noise and vibration from entering the passenger compartment (Figure 2–12). Quite often, two layers of rubber are used in the mounting pads to provide a smoother ride.

Today the strong steel frame side members of the modern conventional design are normally made of U-shaped channel sections or box-shaped sections. Cross members of the same material reinforce the frame and provide support for the wheels, engine, and suspension systems. Various brackets, braces, and openings are provided to permit installation of the many parts that make up the automotive chassis. The various cross members, brackets, and braces are welded, riveted, or bolted to the frame side rails.

Most conventional frames are wide at the center and narrow at the front and rear. The narrow front
construction enables the vehicle to make a shorter turn. A wide frame at the rear provides better support of the body. Other characteristics of frame type vehicles are

- Load-induced vibrations that are transferred to the body via the frame, thus resulting in a smooth ride.
- Rubber mountings between the body and frame that insulate it from vibrations, providing a quiet interior.
- High amounts of energy are absorbed during a collision.
- Undersurfaces of the body are protected over rough roads.
- Suspension and power train parts can be quickly assembled on the basic frame.
- The heavy frame made of thick sheet metal is approximately $\frac{3}{4}$ to $\frac{1}{2}$ inch (1.2 to 3.1 mm).
- The vehicle profile is generally high off the ground.
CONVENTIONAL FRAME DESIGNS

While several conventional frame designs have been used by the auto industry, the three that the body technician may come across are the

1. Ladder frame
2. X-frame (or backbone)
3. Perimeter frame

The ladder frame consists of two side rails, not necessarily parallel, connected to each other by a series of cross members like a ladder. In fact, as shown in Figure 2-13, some of the early car frames were perfect ladder shapes. While the ladder frame design is no longer used for passenger vehicles because of the “hard” ride, it still can be found on some trucks because of its strength (Figure 2-14).

The X-frame (Figure 2-15) narrows in the center, giving the vehicle a rigid structure that is designed to withstand a high degree of twist. A heavy front cross member is used to support the upper and lower suspension control arms and coil springs. The X-frame has not been used since the late 1960s and can be considered obsolete.

A variation of the X-frame is the backbone frame, which has a single thick beam in the middle section. It can be found on some sport cars.

The perimeter frame (Figure 2-16) is similar in construction to the ladder frame. The full-length side rails support the body at its greatest width, which provides more protection to the passengers in the case of a side impact to the body. The areas behind the front wheels and in front of the rear wheels are stepped to form a torque box structure. In a head-on collision, the stepped areas absorb much of the energy. In a side impact collision, the passenger compartment is protected from collapse since the center
frame rail is near the front floor side member. In rear end collisions, the rear cross members and kick-up absorb the shock. As for twisting and bending, strategic areas are reinforced with cross members.

The perimeter frame shown in Figure 2–17 features a center rail that passes very close to the inside of the front floor side member. Because of this, the passenger compartment floor can be made lower than in cars with other types of frames.

Most of the conventional frames used today are of the perimeter design and include the following body sections.

**Conventional Front Body**
The front body section is made up of the radiator support, front fender, and front fender apron. These components (Figure 2–18) are installed with bolts and form an easily disassembled structure. The radiator support is made up of the upper support, lower support, and left- and right-side supports welded together to form a single structure. The front fender of the separate frame type vehicle differs from the front fender of the unibody. The panels in the upper inside and rear ends of the fender are spot welded. This not only increases the fender’s strength and rigidity, but also works along with the front fender apron to reduce vibration and noise and helps prevent damage to the suspension and engine from side impacts.

**Conventional Main Body**
The main body is made up of the dash panel, underbody, roof, and so on, to form the passenger and
**Figure 2-17** This perimeter frame features a center rail. Shaded portions are torque box structures. (Courtesy of Toyota Motor Corp.)

**Figure 2-18** Note front body parts of a conventional vehicle. (Courtesy of Toyota Motor Corp.)

**Figure 2-19** Carefully note the main body structural parts of this vehicle. (Courtesy of Toyota Motor Corp.)
luggage compartments and is similar in structure to that of a unibody.

The dash panel, sometimes termed firewall or front bulkhead, is the panel dividing the front section and the center, passenger compartment section. It normally welds in place.

The front of the underbody has a propeller shaft tunnel built into it, forming a channel cross section through the center of the floor pan, and cross members are welded to it where it joins the frame. Thus, the passenger compartment (Figure 2-19), roof side rail, door, and side body are protected from side impact collisions. In addition, the front, back, and left- and right-sides of the floor pan are made uneven in the stamping process, increasing the rigidity of the floor pan itself, which reduces vibration.

2.4 UNITIZED FRAME AND BODY CONSTRUCTION

Most newer models manufactured in the last few years in small to midsize classes (and even some full-size) are of the unitized or semiunitized body construction.

FIGURE 2-20 Bolt-on stub frame or carriage can be found on some vehicles and it simplifies repair since parts can easily be removed for replacement.

Semiunitized or Platform Frame Body

This frame design uses heavy gauge steel "stub" rails that are welded or bolted to the front and rear of the body or platform structure (Figure 2-20). The suspension system, engine, transmission, and, of course, rear axle assembly are either attached to the stub rails or sections of the platform-type construction. Between the front and rear stub rails is the underbody structure with no frame underneath to act as a support for the unitized body shell or platform. Many of the stub rails and their cross members are welded to both body shell and sheet metal components to form a single integral unit. Today bolt-on stub construction can be considered obsolete.

Unitized Frame and Body Assembly

As previously mentioned, the unitized frame and body assembly has no separate frame (Figure 2-21). The unibody was a design concept used for the bodies of aircraft, and the eggshell is often cited as an example of this type of structure. Even when pressing hard on an eggshell, it is difficult to crush it. All the force or strength applied is not concentrated in one place but is dispersed effectively throughout the entire shell. In mechanics, this action is called a "stressed hull structure."

In a car body, there is no complete stressed hull structure. Generally, a body with a structure that integrates the frame and body to receive and hold outside forces is called a unibody. It is made by combining pieces of thin sheet metal pressed to form panels of various shapes and joined into an integrated structure by spot welding. This lightweight structure
is highly rigid to bending or twisting and has the following characteristics:

- The bulk taken by the frame can be used to make the car more compact.
- Vibration and noise from the drivetrain and suspension enter the floor pan and are amplified by the body, which acts as an acoustic chamber. This makes it necessary to add extra components to the body to suppress vibration and noise.
- Once deformed, special procedures are needed to restore it to its original shape.
- With the thin sheet metal body close to the road surface, adequate measures must be taken to prevent the deterioration in strength from corrosion. This is particularly important when dealing with reinforcing materials that make up the underbody.

The major advantage of unibody vehicles is that they tend to be more tightly constructed because the major parts are all welded together. This design characteristic helps protect the occupants during a collision causes damage patterns that differ from those of frame-type vehicles. The stiffer sections used with unibody design tend to transmit and distribute impact energy throughout more of the vehicle, causing misalignment in areas remote from the impact point. Even sections that are buckled or torn loose might have passed along heavy force before deforming. Worse still, much of this remote damage can easily be overlooked in casual inspection but still be sufficient to cause handling or power train problems later.

Torque boxes are used in the design of some unitized frames/bodies (Figure 2–22).

The extra complexity and stiffness of the structure are especially critical in the front end, which houses not only the front suspension and steering linkage, but also the entire drivetrain—engine, transaxle, drive shafts, and constant velocity U-joints. To keep all these in proper alignment requires support, including that supplied by the front end sheet metal. Accordingly, a damaged unibody vehicle requires a more thorough damage analysis than a similar impact would require in a conventional frame/body car. If not, after a car is returned to its owner, it may later show unsafe handling qualities, water leaks, or a new family of strange noises in the power train.

The three basic unibody structures are a front-engine rear-drive (FR) vehicle, a front-engine front-drive (FF) vehicle, and a mid-engine rear-drive (MR) vehicle.

**FR Vehicle Body Structure**

The front-engine rear-drive has the engine mounted in the front and the driving wheels in the rear. The body of an FR vehicle is divided into three main sections: front body, passenger compartment (side body), and rear body. The engine, transmission, front suspension, and steering equipment are installed in the front body. The differential and the rear suspension are installed in the rear body. Since all impacts from the road surface are transmitted to the entire body through the front and rear wheels, the body must have high strength. This strength is supplied by the side and cross members welded to the floor.

FR vehicles are characterized as follows:

- Since the engine, transmission, and differential are in separate positions, weight can be distributed uniformly between the front and rear wheels, lightening the steering force.
- In an FR vehicle, the engine is placed longitudinally with respect to the vehicle. Most vehicles have a single suspension cross member placed laterally between the front side members at about the middle of the front body, which supports the engine.
- Since it is possible to remove and install the engine, propeller shaft, differential, and suspension independently, body restoration and repair workability are good.
- Since rear-wheel-drive equipment is necessary, a tunnel in the floor is necessary, which decreases interior space.
- Since the engine's output is transmitted to the rear wheels by the drive shaft and differential, the vehicle, vibration, and noise sources are widely distributed over the front and rear.

**FR Front Body**

The engine, suspension, and steering equipment are all mounted on the front fender apron and the front side member of the front body. This part is very important because it influences front-wheel alignment and the amount of vibration and noise that are transmitted into the passenger compartment. Therefore, it must be made with great accuracy and strength. With the exception of outer shell parts, such as the engine hood, front fenders, and front valance panel (installed with nuts and bolts), all other exterior parts are welded together, reducing body weight and increasing body strength (Figure 2–23).
FR Side Body

The side body (Figure 2-24) is joined to the front body and roof panel to form the passenger compartment. During travel, these panels distribute the loads from the underbody to the upper part of the vehicle and prevent bending of the left- and right-sides. The side body members also serve as door supports and maintain the integrity of the passenger compartment if the vehicle should overturn. Since the sides are weakened by large door openings, they are reinforced by joining the inner and outer panels, which forms a very strong boxed-type structure.

The basic arrangement and shapes of these members and floor pan will vary slightly depending on the size and shape of the suspension and the underbody (Figure 2-25).

- **Underbody front section** (Figure 2-26). Since the front side members and front cross members of the front underbody section directly affect front-wheel alignment, they are formed
into a boxed section. On some vehicles, they are made of high-strength steel. To prevent the collapse of the passenger compartment in a head-on collision, the front side members are made with a kick-up so that all the members will bend and absorb shock loads.

- **Underbody center section** (Figure 2-27). The center underbody section is mainly composed of the floor pan, cross member, and main floor side member. The center of the floor pan contains the propeller shaft tunnel, which prevents the floor from twisting. In addition, the main floor side member and cross members below the front seats and in front of the rear seats strengthen the left- and right-sides and prevent the floor from folding in the event of a side collision.

- **Underbody rear section** (Figure 2-28). The rear side member of the underbody extends from under the rear seat to a point near the rear axle, where it forms a large kick-up and extends to the rear floor. This kick-up, like the front side members, is designed to absorb the energy of a rear end collision.
**FR Rear Body**

The rear body sections are divided into two categories. Sedans have the luggage compartment and the passenger compartment separated (Figure 2-29). Station wagons and liftbacks have no separation between the luggage compartment and passenger compartment. The upper back panel and rear seat cushion support brace in sedans are joined at the side body and floor pan. The back panel prevents the body from twisting. In station wagons and liftbacks (Figure 2-30), body rigidity is enhanced by adding enlarged roof side inner rear panels and a back window upper frame and by extending the roof side inner panels to the quarter panels.

![Diagram showing FR Rear Body](image)

**Figure 2-28** Note the underbody rear section. [Courtesy of Toyota Motor Corp.]

![Diagram showing FR Rear Body](image)

**Figure 2-29** Study the rear body structural components of a typical FR sedan. [Courtesy of Toyota Motor Corp.]

![Diagram showing FR Rear Body](image)

**Figure 2-30** Rear body structural components are given for a typical FR station wagon. [Courtesy of Toyota Motor Corp.]
**FF Vehicle Body Structure**

In an FF passenger car (Figure 2-31), the engine is mounted in the front of the vehicle, and the engine drives the front wheels. It is also called a front-wheel-drive (FWD) vehicle. In the space ordinarily taken up by the rear axle, the passenger compartment can be enlarged and the rear suspension simplified. This results in substantial weight reduction. Since the engine, transaxle, front suspension, and steering equipment are all located in the front body section, the methods of reinforcement are much different from those used in the FR vehicles.

FF vehicles are characterized by the following:

- The transmission and differential are combined, and the propeller shaft is eliminated, providing a substantial weight reduction.
- Overall noise and vibration are reduced because they are confined to the front of the vehicle.
- Since the engine and transmission are located in the front, the load on the front suspension and tires is increased.
- The interior of the vehicle is larger because there is no need for a propeller shaft or rear-drive axle.
- Since the fuel tank can be placed under the center of the vehicle, the luggage compartment can be large and flat.
- Because of the location of the engine, there is a greater forward inertial weight in a head-on collision. Therefore, engine mounting components are reinforced accordingly.

The engine of an FR vehicle is mounted longitudinally. The engine of an FF vehicle can be mounted either longitudinally or transversely. Engine support methods differ between longitudinal mount FF vehicles and transverse mount FF vehicles.

1. **Longitudinally mounted FF engine supports.** The engine is supported by the front suspension members connected to the left and right front side members. The FF engine mounting is the same as the FR's engine mounting and is supported in the same manner (Figure 2-32).

2. **Transversely mounted FF engine supports.** The engine is supported at four points, the front and rear of the engine mounting center member, positioned longitudinally through the vehicle’s center, and the left and right front side members (Figure 2-33).
motor mounts capable of supporting the engine transaxle and suspension loads is used in the front section of the vehicle. Lightweight single structure plastic bumpers may be used on FF models.

The front suspension in FF and FR vehicles is almost identical. Both vehicles use an independent strut-type front suspension. The accuracy of the front body has a direct effect on front-wheel alignment; therefore, it is important to check the wheel alignment after performing front body repairs.

- **Longitudinal engine, front body.** The front body of a longitudinal FF (including 4WD) is nearly identical to that in an FR. The only differences are in their front fender aprons and front side members. The front fender apron is strengthened and reinforced by welding together the upper and lower front fender apron to cowl side members. The front side members of the FF are larger and heavier than their FR counterparts, since they must carry a heavier front vehicle load. A torque box is welded onto the rear end of the front side members with the suspension arms connected to it.

- **Transverse engine front body.** The lower dash panel and the front side members of FF vehicles with transversely mounted engines (Figure 2–34) are quite different from FR or FF vehicles with longitudinally mounted engines because the steering gear or rack is mounted in the lower portion of the dash panel. The steering linkage passes through a large opening in the rear portion of the front cross member, and the suspension arms are mounted to a structure that is directly below the opening.

**FF Rear Body**

The rear body section (Figure 2–35) consists of the back door panel, lower back panel, quarter panel, quarter wheelhouse outer panels, quarter wheelhouse inner panel, rear floor pan, and the rear floor side members. Since the entire power train is located in the front of FF vehicles, the fuel tank is located below the center floor, which allows the rear floor side member to be lower than in FR vehicles. The lower part of the rear floor side members is then connected to the rear suspension arm. An independent strut suspension is used to improve handling performance and driving stability. The rear suspension may also be a solid axle. Therefore, a rear end collision has a greater influence on rear-wheel alignment than it would in an FR vehicle. As a consequence, rear-wheel alignment should be checked whenever repairs are performed on a rear body section.

In the case of an FR vehicle, the front of the rear floor pan is joined to the end of the center floor pan.
FIGURE 2-34 Study the front body structural components of a typical transversely mounted engine of an FF vehicle.  
(Courtesy of Toyota Motor Corp.)

FIGURE 2-35 Note the rear body structural parts of a typical FF vehicle.  (Courtesy of Toyota Motor Corp.)

with spot welds. However, in an FF vehicle, the center and rear floor pans are joined and reinforced with an interlocking structure. The rear body of a 4WD is similar to that of an FF vehicle.

**MR VEHICLE BODY STRUCTURE**

As previously mentioned, MR is the nomenclature derived from a mid-engine rear-drive vehicle, more commonly known as a mid-engine vehicle. The term *mid-engine* refers to the central positioning of the engine and power train between the passenger compartment and the rear axle.

Due to its unique engine placement, a mid-engine vehicle (Figure 2-36) has a lower profile and hence a lower center of gravity. Since this type of vehicle has the majority of its heavy components near the center of the vehicle, the strength of the center structure is higher. A high-strength box section that runs throughout the vehicle is used in the MR vehicle, resulting in further weight reductions.
MR vehicles are characterized as follows:

- Due to the central location of the heavy components, such as the engine and transmission, the center of gravity is also concentrated toward the center of the vehicle, which gives it improved steering and handling.
- Since the engine is in the rear of the vehicle, the front hood can be sloped downward, improving aerodynamics, lowering the center of gravity, and improving the driver's field of vision.
- Engine access and cooling efficiency are reduced because the engine is located between the passenger compartment and the rear axle assembly.
- A barrier is placed between the engine and passenger compartment to reduce noise, vibration, and heat that might otherwise enter the passenger compartment.

**MR Front Body**

The front suspension, steering, radiator, and air condenser are mounted in the front body section (Figure 2-36). Since the engine and transaxle are located toward the rear body, the front body shape is low and sharp. The independent front suspension is supported by the front fender apron and front side members. Because of the engine's unique location, there is room for a front luggage compartment.

Various removable parts, such as the front fenders, hood, and front valance panel, are bolted on. The front fender apron, front cross member, and front side support are spot welded to the front side members. The upper sections of the front luggage end panel and front luggage pan are spot welded to the front cross member. The front luggage pan is spot welded to the steering gear box support member to form the front luggage compartment. The steering linkage passes through grommets in the front side members. The lower control arms are also connected to the side members. The body is reinforced by spot welding the front and rear side members together as well as joining each of the rocker panels together.

**MR Underbody**

The underbody receives the various loads from the road surface and distributes them to the side body, the various body pillars, and the roof. Many of the components (Figure 2-37) that make up the underbody are made of high-strength steel. In addition, the underbody is strengthened by raising the tunnel of the front floor pan.

**MR Rear Body**

The rear body consists of the quarter panels, luggage compartment door, engine hood, body lower back panel, rear floor pan, room partition panel, rear floor partition panel, and rear side members (Figure 2-38). The engine and rear luggage compartment are divided by the rear floor partition panel. The rear floor pan, room partition panel, and rear floor partition panel
are reinforced with a deep bead structure and, together with the rear side members, form a rigid body.

The engine is positioned transversely and supported on engine mountings located at four points, on the left and right rear side members, the room partition cross member, and the rear floor cross member. Since the engine is mounted just behind the passenger compartment, the wall between the passenger compartment and the engine compartment is a three-layered structure to keep out noise, vibration, and heat. Also, since an independent strut suspension is used for the rear suspension, the body structure is made to maintain body accuracy for components that have an influence on rear-wheel align-
FIGURE 2-39 Note the design of this rear-engine sports car. (Courtesy of American Honda Motor Co.)

Body Structure

Hood

Roof Panel

Trunk Lid

Rear Bumper

Grille

Door Skin

Front Bumper

Left Quarter Panel

Space Frame

Left Fender

Rocker Panel Skin

FIGURE 2-40 The space frame has a metal frame structure covered with plastic or fiberglass body panels. This car's door panels are flexible and will not dent easily, so no more "door dings." (Courtesy of Saturn Corp.)
FIGURE 2-41 Study the parts of a typical door assembly. (Courtesy of Chevrolet Motor Div.)
<table>
<thead>
<tr>
<th>1. HARNESS, POWER WINDOW</th>
<th>30. WASHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. REGULATOR, W/MOTOR</td>
<td>31. PLATE, LOCK STRIKER TAP</td>
</tr>
<tr>
<td>3. NUT, WINDOW GLASS W/WASHER</td>
<td>32. RETAINER, GUIDE PIN LOCATOR</td>
</tr>
<tr>
<td>4. GUIDE, STABILIZER</td>
<td>33. BOLT</td>
</tr>
<tr>
<td>5. BOLT, STABILIZER GUIDE</td>
<td>34. ROD, LOCK INSIDE HANDLE</td>
</tr>
<tr>
<td>6. HANDLE, OUTSIDE LOCK W/UNCODED KEY</td>
<td>35. GUIDES, LOCK ROD</td>
</tr>
<tr>
<td>7. BRACKET, DOOR HANDLE WIRING HARNESS</td>
<td>36. SWITCH, HATCH RELEASE</td>
</tr>
<tr>
<td>8. BOLT</td>
<td>37. KNOB, INSIDE LOCK</td>
</tr>
<tr>
<td>9. NUT</td>
<td>38. HANDLE, DOOR INSIDE</td>
</tr>
<tr>
<td>10. ROD, OUTSIDE LOCK HANDLE</td>
<td>39. CLIP, INSIDE HANDLE</td>
</tr>
<tr>
<td>11. CONNECTOR, REMOTE CONTROL ROD</td>
<td>40. PLATE, ACCESSORY MOUNTING</td>
</tr>
<tr>
<td>12. ROD, LOCK CYLINDER</td>
<td>41. SEAL, POLYURETHANE</td>
</tr>
<tr>
<td>13. RETAINER, LOCK CYLINDER ROD</td>
<td>42. INSERT, TRIM PANEL</td>
</tr>
<tr>
<td>14. PIN, GUIDE</td>
<td>43. NUT, NYLON (SEVERAL OTHER LOCATIONS)</td>
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<td>15. CLIP, OUTSIDE LOCK HANDLE ROD</td>
<td>44. HINGE, LOWER</td>
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<tr>
<td>16. CUSHION, GLASS ANTI-RATTLE</td>
<td>45. SWITCH, JAMB</td>
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<td>17. RETAINER, AJAR INDICATOR SWITCH</td>
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<td>18. STRIKER, LOCK</td>
<td>47. HINGE, UPPER</td>
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<td>19. LOCK, SIDE</td>
<td>48. BOLT, HEX W/WASHER</td>
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<td>20. SCREW, PAN HEAD TORX</td>
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<td>21. SEAL, GUIDE PIN LOCATOR</td>
<td>50. PANEL, DOOR</td>
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<td>22. LOCATOR, GUIDE PIN</td>
<td>51. NUT, WINDOW STOP</td>
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<td>23. SWITCH, AJAR INDICATOR</td>
<td>52. STUD, WINDOW GLASS</td>
</tr>
<tr>
<td>24. CLIP, SIDE LOCK REMOTE CONTROL ROD</td>
<td>53. BUSHING, WINDOW STOP</td>
</tr>
<tr>
<td>25. BRACKET, WIRING LOWER REAR</td>
<td>54. GLASS, DOOR</td>
</tr>
<tr>
<td>26. ROD, SIDE LOCK REMOTE CONTROL</td>
<td>55. STUD, WINDOW GLASS</td>
</tr>
<tr>
<td>27. ACTUATOR, ELECTRIC LOCK W/BRACKET</td>
<td>56. BRACKET, POWER MIRROR WIRING HARNESS</td>
</tr>
<tr>
<td>28. SCREW, W/WASHER</td>
<td>57. PATCH, SOUND INSULATOR</td>
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<tr>
<td>29. ROD, LOCK REMOTE CONTROL</td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE 2-41 Continued**
ment, such as the rear floor side members and quarter wheelhousing.

Figure 2–39 shows the frame structure in a modern mid-engine sport car.

**SPACE FRAME**

Similar to a unibody, a space frame has a metal body structure covered with an outer skin of plastic or fiberglass panels (Figure 2–40). It is a relatively new type of vehicle construction. A space frame design is currently used on some vans and economy vehicles. Quite often, the roof and quarter panels are not welded to the structure as they are with traditional unibodies. Exterior body panels are attached with mechanical fasteners or adhesives.

After a collision, a space frame is more likely to have hidden damage because of the ability of plastic panels to hide more severe damage. Corrosion protection is also important since the plastic body panels may look good but the hidden metal frame structure may become deteriorated.

### 2.5 BODY PARTS

The body structures or sections are divided into small units called assemblies, which in turn are divided into even smaller units, called components or parts.

For example, doors are complex assemblies made up of an outer skin, inner door frame, door trim panel, window regulator, glass, and related parts (Figure 2–41). Door hinges bolt or weld between the pillars and door frame. The window regulator is a gear mechanism that allows you to raise and lower the door glass. The door latch engages the striker and allows you to lock and unlock the door. The striker is a post mounted on the body and it engages in the latch.

The door is formed by joining a high-strength inner and outer door panel that has inner access holes. The door opens and closes on hinges and is made air- and watertight by weather-stripping. The door reinforcement guard protects the passenger compartment in collisions or if the car should accidentally overturn.

Side impact beams are metal bars or corrugated panels that bolt or weld inside the door assemblies to protect the passengers. Primarily, they prevent the door from opening upon impact. They also help keep anything from intruding into the passenger area.

The bumper assembly bolts to the front frame horns or rails to absorb minor impacts. Its parts are shown in Figure 2–42.

Stationary parts, like the floor, roof, and quarter panels, are permanently welded or adhesive bonded into place. Hinged parts, like doors, hoods, and decklids, will swing out or up.

Fastened parts are held together with various fasteners (bolts, nuts, clips, etc.). Many parts, like the fenders, hood, and grille bolt into place. These bolted-on parts also add to the strength of the vehicle.

Welded parts are permanently joined by fusing the material so that it flows together and bonds when cooled. Both metal and plastic parts can be welded.

Press-fit or snap-fit parts use clips or an interference fit to hold parts together. This assembly method is becoming more common to reduce manufacturing costs.

Adhesive bonded parts use a high-strength epoxy or special glue to hold the parts together. Both metal and plastic parts can be joined with adhesive. Structural adhesive can also be used to bond parts together.

A composite unibody is made of specially formulated plastics and other materials, like carbon fiber, to form the vehicle. These parts are adhesive bonded to each other. The frame is made totally of plastics, keeping metal parts to a minimum. This cuts weight while increasing strength, rigidity, performance, and fuel economy. Although not mass produced, several manufacturers are experimenting with composite unibody construction.

**CAUTION**

Make sure you fully understand correct repair procedures and construction technology before working on a vehicle. It can be costly, dangerous, and even deadly if you do not understand how a car or truck is made and should be repaired.
SHOP MANUALS

A vital element of technical skill that the body technician must have is a complete understanding of commonly used terms that describe and identify parts, units, components, and assemblies that make up the body structure of a modern passenger car. If the body technician does not know the correct nomenclature (technical names) of the parts to be repaired, straightened, replaced, or painted, it becomes extremely difficult to order parts and read a repair order.

All automobile companies supply shop manuals each year that describe the service and repair of the different makes and models of their vehicles. These manuals (Figure 2-43) also give important details on body styles and parts.

Before using the manufacturer's shop manual or any type of manual, it is important to accurately identify the body style, model year, engine, and other pertinent details.

Check the shop manual for the location of the vehicle identification number (VIN), vehicle certification label, or body number plate (Figure 2-44). In addition to collision repair or estimating guides, the shop manuals contain all necessary decoding information. Become familiar with each car maker's method of vehicle identification and the specific information it contains. It is wise to obtain all of the information possible on the vehicle being worked on (Figure 2-45).

The procedures in this book are general. Always refer to a factory service manual when in doubt about any operation. It will give the specific procedures needed to do competent work on the specific make and model vehicle!

NOTE: Other chapters in this text give more information on using different types of manuals. Refer to the index if needed.

CRASH TESTING

Automobile manufacturers are challenged by having to design vehicles that are light, aerodynamic (have low wind resistance), and yet strong and safe.

Computer-simulated crash testing is used before building a prototype or first real vehicle to determine how well the vehicle might survive a crash. It is critical that the passenger compartment is strong enough to help prevent injury to the driver and the passengers.

Certified crash tests are done using a real vehicle and sensor-equipped dummies that show how much impact the people would suffer during a collision. Computer readings from the sensors in the dummies give feedback about each crash test for body structure evaluation (Figure 2-46).

Crush zones are built into the frame or body to collapse and absorb some of the energy of a collision. The front and rear of the vehicle collapses while the passenger compartment tends to retain its shape. This helps reduce the amount of force transmitted to the occupants (Figure 2-47).

An insurance rating system uses a number scale to rate the vehicle’s accident survivability. It indicates how well the vehicle will survive a crash and how much it will cost to repair it. A negative five is the worst rating (most damage) and positive five is the best (least damage). A zero rating is average.
**SERVICE PARTS IDENTIFICATION LABEL**

The Service Parts Identification Label provides identification of vehicle equipment to assist in servicing and determining replacement parts. Included on this label will be regular production options (RPO's) as well as standard and mandatory options. The label will be affixed to the inside of each passenger car vehicle at the assembly plant.

For additional information on the Service Parts Identification Label, see a GM Parts Catalog.

---

### Service Parts Identification

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<td>1Y207</td>
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<td></td>
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<tr>
<td>K19 K64 LC3 MX1 M31 NA5 NB1 OMX VK3 VC2 VY1 VY4 V73 Y19 ZJ7</td>
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<tr>
<td>6BJ 62L 62U 67D 671 679 7BJ 8HJ 9HJ</td>
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**EXAMPLE**

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<tr>
<th>BSE/CLR COAT</th>
<th>WA-L8555</th>
<th>U8555</th>
<th>A4721</th>
<th>117</th>
<th>9D2</th>
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</table>

**PRINTED IN U.S.A.**

**PART NO. 14065987**

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**PAINT TECHNOLOGY**

- SOLUTION LACQUER
- DISPERSION LACQUER
- HIGH SOLIDS ENAMEL
- WATERBORNE ENAMEL
- BASECOAT/CLEARCOAT

**PAINT CODES AND LOCATIONS**

- L = LOWER BODY COLOR
- U = UPPER BODY COLOR
- A = MIDDLE BODY OR ACCENT COLOR (STRIPPING, ETC.)

**VINYL TOP COLOR**

(If applicable)

**TRIM COMBINATIONS**

---

**LABEL LOCATION**

**CORVETTE**

---

**FIGURE 2-46** Here is an explanation of one service parts label. The service manual will explain the label for different makes and models. *(Courtesy of Chevrolet Motor Div.)*
If you have ever listened to a couple of veteran body technicians talking, you may have thought they were speaking in some kind of coded jargon. The conversation might have gone, “Well Joe, it bent the frame rails and shock towers from the frontal impact. We will have to mount it on the alignment rack to pull out the damage.” If you don’t know the basic parts of a vehicle, you will not be able to understand this kind of technical language or a shop manual.
FIGURE 2-47 Crush zones help absorb the energy of a collision to protect the passengers. (A) Note how energy from front, side, and rear impacts flows through the body. (B) Study how the front and the rear of the vehicle collapse while the passenger compartment stays intact, providing a protective cage around the passengers. [Courtesy of Snell Motor Co.]

**SUMMARY**

- The goal of collision repair is to restore the vehicle to its preaccident condition.
- For simplicity and to help communication in auto body repair, a vehicle is commonly divided into three body sections—front, center, and rear.
- Anticorrosion materials are used to prevent rusting of metal parts. The five construction areas where domestic automobiles have changed since the mid-1970s are:
  1. Body/frame construction
  2. Weight (average fleet)
  3. Metal composition
  4. Suspension/steering
  5. Engine location/drive
- In the conventional body-over-frame construction, the frame is the vehicle's foundation.

  While several conventional frame designs have been used by the auto industry, the three that the body technician may come across are the
  1. Ladder frame
  2. X-frame (or backbone)
  3. Perimeter frame
- Most newer models manufactured in the last few years in small to midsize classes (and even some full-size) are of the unitized or semiunitized body construction.

  Similar to a unibody, a space frame has a metal body structure covered with an outer skin of plastic or fiberglass panels.

### ASE-STYLE REVIEW QUESTIONS

1. Which type of vehicle construction uses a frame only in areas requiring extra support and a strong attachment point?
   - A. Combination frame construction
   - B. Semiunitized stub rail construction
   - C. First generation unitized perimeter frame construction
   - D. Fully unitized construction

2. The full strength of a unitized vehicle is based on
   - A. Mass and weight of components
   - B. Rigidity and thickness of components
   - C. Shape and design of components
   - D. None of the above

3. Which of the following is not an advantage of unitized vehicle design?
   - A. Increased passenger compartment safety
   - B. Reduced vehicle weight
   - C. Higher fuel efficiency
   - D. Localized collision damage to components

4. Which of the following mechanical components are commonly found on newer unitized constructed vehicles?
   - A. MacPherson strut suspensions
   - B. Rack-and-pinion steering
   - C. Front-wheel drive with CV joints
   - D. All of the above

5. In front-engine, rear-wheel-drive unitized vehicles, the engine is mounted
   - A. Longitudinally
   - B. Transversely
   - C. Between the passenger compartment and rear axle
   - D. Either A or B

6. Which of the following is not a use or characteristic of hot-rolled steels?
   - A. Thicker components, such as frame legs and cross members
   - B. A black oxidized surface appearance
   - C. Highly accurate dimensional thickness
   - D. Poorer workability than cold-rolled steels

7. Certified crash tests are done using a real vehicle and sensor-equipped dummies that show how much impact the people would suffer during a collision.

  Technician A gives a more thorough damage analysis to a unibody vehicle than to a conventional frame vehicle. Technician B says that the modern body technician needs much more knowledge than a technician of the era prior to the advent of the unibody. Who is correct?
   - A. Technician A
   - B. Technician B
   - C. Both A and B
   - D. Neither A or B

8. Which of the following are designed to stiffen a unibody structure?
   - A. Torque boxes
   - B. Frame horns
   - C. Crush zones
   - D. Stone defectors

9. Which of the following frame designs are no longer used in automobile manufacturing?
   - A. Perimeter
   - B. Stub
   - C. Hourglass
   - D. Ladder

10. In an FF unibody structure, which panel supports the MacPherson struts?
    - A. Front cross member
    - B. Aprons
    - C. Side rails
    - D. Radiator support

11. Technician A checks the rear-wheel alignment whenever repairing a rear body section. Technician B says that a solid rear-axle equipped vehicle rarely suffers any damage in an accident. Who is correct?
    - A. Technician A
    - B. Technician B
    - C. Both A and B
    - D. Neither A or B

12. What type of body and frame is welded into one unit?
    - A. Frame body
    - B. Unibody
    - C. Stub frame
    - D. Nose frame