FIGURE 64.1 Spur gears have straight-cut teeth.

FIGURE 64.2 The teeth of helical gears are cut at an angle to the gear axis.
A spur gear has straight teeth. This design is very strong and is used where strength is important. Spur gears are noisy during operation. Helical-cut gears, on the other hand, operate quietly but create a force in line with the axis of the gears due to the angle of the gear teeth.

A pinion gear meshed with an internal ring gear rotates in the same direction around a parallel axis of rotation.

When two external gears mesh, they rotate in opposite directions.
Bevel gears are often used to change the direction of rotation.

A rear-wheel-drive axle differential uses a hypoid gear set to provide a change in the direction of torque and for gear reduction (torque increased) to the drive wheels.

Gear ratio is determined by dividing the number of teeth on the driven (output) gear (24 teeth) by the number of teeth on the driving (input) gear (12 teeth). The ratio illustrated is 2:1.
FIGURE 64.9 This gear combination provides a gear reduction of \( \frac{3}{1} \).

FIGURE 64.10 This gear combination provides an overdrive ratio of \( \frac{0.33}{1} \).

FIGURE 64.11 Idler gears affect the direction of rotation in a gear train, but not the final drive ratio.
FIGURE 64.12 Gears apply torque in the same way a wrench applies torque—the force applied multiplied by the distance from the center of the gear equals the torque.

FIGURE 64.13 A lever can be used to multiply torque, but it does so at the expense of distance or speed.

FIGURE 64.14 Cross section of a five-speed manual transmission showing the main parts.
FIGURE 64.15 Cutaway of a six-speed manual transmission showing all its internal parts.

FIGURE 64.16 Notice that the countershaft and the main shaft both use gears of increasing size that mesh together.

FIGURE 64.17 A typical shift mechanism is designed to not only give the driver a solid feel when shifting but also prevent shifting into reverse except from the neutral position.
FIGURE 64.18 The shifter fork fits into the groove of the synchronizer sleeve. When a shift is made, the sleeve is moved toward the speed gear. This moves the stop ring (synchronizer ring) against the cone area of the speed gear. The friction between the stop ring and the speed gear causes the speeds of the two to become equal, permitting the sleeve to engage the gear clutch teeth of the speed gear. When the engagement occurs, the shift is complete.

FIGURE 64.19 Typical synchronizer assembly.

FIGURE 64.20 Synchronizer keys are attached to the clutch hub and push against the synchronizer ring when the sleeve is being moved during a shift. Notice the grooves on the synchronizer ring. These grooves prevent lubricating oil from becoming trapped between the ring and the cone surface of the speed gear. The grooves also help the ring release from the cone surface when a shift is made out of it is gear.
A shift sequence starts when the shift fork is moved by the driver, (1) applying a force on the sleeve that moves it toward the speed gear. (2) The sleeve and the inserts contact the stop ring (blocking ring). (3) The synchronizer ring (stop ring) engages the cone on the speed gear, causing both assemblies to reach the same speed. (4) The shift is completed when the internal teeth of the sleeve mesh with the gear clutch teeth of the speed gear.

Before reassembling the transmission/transaxle, carefully inspect the splines on the synchronizer sleeves for wear. The shape of the splines helps prevent the transmission/transaxle from jumping out of gear during acceleration and deceleration.

A three-piece synchronizer assembly. This type of synchronizer uses two cones, which helps reduce a reverse shift with no shift effort. Many newer transmissions/transaxles use a paper lining to that of the clutch in an automatic transmission. The transmissions/transaxles that have these paper linings must use automatic transmission fluid (ATF) for proper operation and long life.
FIGURE 64.24 In neutral, the input shaft and the countershaft are rotating if the clutch is engaged (clutch pedal up), but no torque is being transmitted through the transmission.

FIGURE 64.25 In first gear, the 1–2 synchronizer sleeve is moved rearward, locking the first speed gear to the output shaft. Torque is transmitted from the input shaft to the countershaft and then to the output shaft.

FIGURE 64.26 In second gear, the 1–2 synchronizer sleeve is moved forward, which locks the reverse speed gear to the output shaft.
To achieve third gear, the shaft linkage first centers the 1–2 synchronizer sleeve and then moves the 3–4 synchronizer sleeve rearward, locking third speed gear to the output shaft.

In fourth gear, the 3–4 synchronizer sleeve is moved forward, which locks the fourth speed gear to the output shaft.

To achieve fifth gear, the shift linkage first centers the 3–4 synchronizer sleeve and then moves the fifth synchronizer sleeve toward the fifth speed gear, locking it to the output shaft.
Torque flows through the transmission in reverse gear. Note that the idler gear drives the 1–2 synchronizer sleeve gear, which is splined to the output shaft.

Cutaway of a T56 six-speed transmission showing all its internal parts.

Notice that this five-speed transaxle from a Dodge/Plymouth Neon uses synchronizers on both the input and output shafts.
FIGURE 64.33 Cutaway of a typical manual transaxle showing all of its internal parts including the final drive assembly.

FIGURE 64.34 Some manual transmissions/transaxles require synchromesh transmission fluid.