How Clutches Work

Source: http://clutchwizard.com/basics.htm (viewed 2008-04-04)

The clutch allows engine power to be applied gradually when a vehicle is starting out, interrupts power to the transmission to avoid gear clashing when shifting and prevents engine stalling when bringing the vehicle to a stop. Engaging the clutch (clutch pedal fully raised) allows power to transfer from the engine to the transmission and drive wheels. Disengaging the clutch (clutch pedal fully depressed) stops the power transfer and allows the engine to continue turning without force to the drive wheels.

Common clutch-related components are:

- **Flywheel** – mounts to the engine crankshaft
- **Clutch Disk** – the friction material assembly that provides easy engagement and firm torque transference
- **Pressure Plate** – also known as “Clutch Cover” – this is the spring-loaded surface that locks the clutch
- **Throw-out Bearing** – also known as “Release Bearing”
- **Pilot bearing** – centers and supports the transmission input shaft (many cars do not have this bearing)
- **Clutch Cable** – mechanical release mechanism for some vehicles
- **Clutch Master Cylinder** – force-multiplying cylinder for vehicles with hydraulic release mechanisms
- **Clutch Slave Cylinder** – used along with a Master Cylinder for hydraulic release mechanisms
- **Misc. hoses, lines, brackets, linkages, etc.** – varies from vehicle to vehicle

The flywheel is a large steel or aluminum disc. It acts as a balance weight for the engine, dampening engine vibrations caused by the firing of each cylinder and provides a surface that the clutch can contact. The flywheel also has teeth around its circumference for the starter motor to engage and crank the engine.

The clutch disc is a steel plate, covered with a frictional material that is sandwiched between the flywheel and the pressure plate. The center of the disc is the hub, which fits the spines of the transmission input shaft. When the clutch is engaged, the disc is "squeezed" between the flywheel and pressure plate, and power from the engine is transmitted by the disc's hub to the input shaft of the transmission.

A pressure plate is a metal spring-loaded friction surface that is bolted to the flywheel. It has a metal cover, heavy release springs, a metal pressure surface, and a thrust ring or fingers for the release bearing. The thrust ring or fingers release the clamping force of the springs when the clutch is disengaged.

When the clutch pedal is depressed, the "Throw-out bearing" pushes the pressure plate's release fingers. The pressure plate pulls away from the clutch disc, disengaging the clutch, thus interrupting...
power flow. When the clutch pedal is released and the clutch is fully engaged, the release bearing is normally stationary and does not rotate with the pressure plate.

Clutch operation is accomplished either mechanically or with a hydraulic pressure system.

If a vehicle has a mechanically operated linkage, it will incorporate either a shaft-and-lever linkage arrangement or a cable.

Systems that are made up of linkages, levers and pivot points are found primarily on older vehicles. These systems require regular lubrication and can only be designed to fit a limited range of configurations.

A cable operated clutch mechanism is relatively simple. A cable connects the clutch pedal directly to the clutch release fork. This simple design is flexible and compact. There is however, a tendency for cables to gradually stretch and eventually break due to age and wear.

On a hydraulically operated clutch, a master cylinder is usually directly operated by the clutch pedal assembly. A slave cylinder at the transmission is connected to the master cylinder by high-pressure tubing. The slave cylinder pushes either an operating lever or directly on the release bearing. Hydraulic systems require less pedal pressure and provide a smooth "liquid" feel to clutch engagement. Design configuration is very flexible and can very easily be adapted to most any required configuration.

The Clutch

There are many different vehicle clutch designs but most are based on one or more friction discs, pressed tightly together or against a flywheel using springs. The friction material is very similar to the material used in brake shoes and pads and contained asbestos in the past. Also, clutches found in heavy duty applications such as trucks and competition cars use ceramic clutches that have a greatly increased friction coefficient, however these have a "grabby" action and are unsuitable for road cars. The spring pressure is released when the clutch pedal is depressed thus either pushing or pulling the diaphragm of the pressure plate, depending on type, and the friction plate is released and allowed to rotate freely.

While engaging the clutch, the engine speed may need to be increased from idle, using the manual throttle, so that the engine does not stall (although in most cars, especially diesels, there is enough power at idling speed that the car can move although fine movements with the clutch are needed). However, raising the engine speed too high will cause excessive clutch plate wear and cause a harsh, jerky start. This kind of start is desired in drag racing and other competitions, however.

Wet and dry clutches

A 'wet clutch' is immersed in a cooling lubricating fluid, which also keeps the surfaces clean and gives smoother performance and longer life. A 'dry clutch', as the name implies, is not bathed in fluid that robs it of some energy. Since the surfaces of a wet clutch can be slippery (as with a motorcycle clutch bathed in engine oil), stacking multiple clutch disks can compensate for slippage. Most Moto Guzzi and BMW motorcycles use a triple plate clutch like a car.
Clutch operation in automobiles

In a car it is operated by the left-most pedal using hydraulics or a cable connection from the pedal to the clutch mechanism. Even though the clutch may physically be located very close to the pedal, such remote means of actuation are necessary to eliminate the effect of slight engine movement, engine mountings being flexible by design. With a rigid mechanical linkage, smooth engagement would be near-impossible, because engine movement inevitably occurs as the drive is "taken up". No pressure on the pedal means that the clutch plates are engaged (driving), while depressing the pedal will disengage the clutch plates, allowing the driver to shift gears.

A manual transmission contains cogs for selecting gears. These cogs have matching teeth, called dog teeth, which means that the rotation speeds of the two parts have to match for engagement. This speed matching is achieved by a secondary clutch called a synchronizer, a device that uses frictional contact to bring the two parts to the same speed, and a locking mechanism called a blocker ring to prevent engagement of the teeth (full movement of the shift lever into gear) until the speeds are synchronized.

Non-powertrain clutches in automobiles

There are other clutches found in a car. For example, the radiator fan may have a clutch that is heat-activated. The driving and driven elements are separated by a silicone-based fluid. When the temperature is low, the fluid is thin and so the clutch slips. When the temperature is high, the fluid thickens, causing the fan to spin.

How Clutches Work
Source: http://auto.howstuffworks.com/clutch.htm (viewed 2008-04-04)

If you drive a manual transmission car, you may be surprised to find out that your car has more than one clutch in it. And it turns out that folks with automatic transmission cars have clutches, too. In fact, there are clutches in many things you probably see or use everyday: Many cordless drills have a clutch, chainsaws have a centrifugal clutch and even some yo-yos have a clutch.

In this article, we will learn why you need a clutch, understand how the clutch in your car works, and talk about some interesting and perhaps surprising places where clutches can be found.
Clutches are useful in devices that have two rotating shafts. In these devices, one of the shafts is typically driven by a motor or pulley, and the other shaft drives another device. In a drill, for instance, one shaft is driven by a motor and the other drives a drill chuck. The clutch connects the two shafts so that they can either be locked together and spin at the same speed, or be decoupled and spin at different speeds.

In a car, you need a clutch because the engine spins all the time, but the car wheels don't. In order for a car to stop without killing the engine, the wheels need to be disconnected from the engine somehow. The clutch allows us to smoothly engage a spinning engine to a non-spinning transmission by controlling the slippage between them.

To understand how a clutch works, it helps to know a little bit about friction, which is a measure of how hard it is to slide one object over another. Friction is caused by the peaks and valleys that are part of every surface -- even very smooth surfaces still have microscopic peaks and valleys. The larger these peaks and valleys are, the harder it is to slide the object.

A clutch works because of friction between a clutch plate and a flywheel. We'll look at how these parts work together in the next section.

Fly Wheels, Clutch Plates and Friction

In a car's clutch, a flywheel connects to the engine, and a clutch plate connects to the transmission. You can see what this looks like in the figure below.

When your foot is off the pedal, the springs push the pressure plate against the clutch disc, which in turn presses against the flywheel. This locks the engine to the transmission input shaft, causing them to spin at the same speed.
the pressure plate away from the clutch disc (see below). This releases the clutch from the spinning engine.

Clutch plate

Note the springs in the clutch plate. These springs help to isolate the transmission from the shock of the clutch engaging.

This design usually works pretty well, but it does have a few drawbacks.

Common Problems and Other Types of Clutches

The most common problem with clutches is that the friction material on the disc wears out. The friction material on a clutch disc is very similar to the friction material on the pads of a disc brake, or the shoes of a drum brake -- after a while, it wears away. When most or all of the friction material is gone, the clutch will start to slip, and eventually it won't transmit any power from the engine to the wheels.

The clutch only wears while the clutch disc and the flywheel are spinning at different speeds. When they are locked together, the friction material is held tightly against the flywheel, and they spin in sync. It is only when the clutch disc is slipping against the flywheel that wearing occurs. So if you are the type of driver who slips the clutch a lot, you will wear out your clutch a lot faster.

Another problem sometimes associated with clutches is a worn throwout bearing. This problem is often characterized by a rumbling noise whenever the clutch engages.

There are many other types of clutches in your car or in your garage:

An automatic transmission contains several clutches. These are used to engage and disengage various sets of planetary gears.

An air conditioning compressor in a car has a magnetic clutch. This allows the compressor to shut off even while the engine is running. When current flows through a magnetic coil in the clutch, the clutch engages. As soon as the current stops, such as when you turn off your air conditioning, the clutch disengages.

Most cars that have an engine-driven cooling fan have a thermostatically controlled viscous clutch. This clutch is positioned at the hub of the fan, in the airflow coming through the radiator. This type of clutch is a special viscous clutch, much like the viscous coupling sometimes found in all-wheel drive
cars. The fluid in the clutch gets thicker as it heats up, causing the fan to spin faster to catch up with the engine rotation. When the car is cold, the fluid in the clutch remains cold and the fan spins slowly, allowing the engine to quickly warm up to its proper operating temperature.

Many cars have limited slip differentials or viscous couplings, both of which use clutches to help increase traction. You can learn more about differentials and viscous couplings in How Differentials Work.

A gas-powered chain saw and weedwacker have centrifugal clutches, so that the chains or strings can stop spinning without you having to turn off the engine.

When Fact Meets Friction: The Basics of Clutch Operation

Flywheel  Pilot Bearing  Clutch Disc  Clutch Cover  Clutch Release Bearing
Clutch Release Fork  Clutch Cover  Boot

If you've ever driven a vehicle with a manual transmission, you know how to depress the clutch, select a gear, and release the clutch while applying power to get the car to move. But what really happens when you depress and release the clutch? Let's get to the bottom of that question.

In its simplest form, the clutch allows engine power to be applied gradually when a vehicle is starting out and interrupts power to avoid gear crunching when shifting. Engaging the clutch allows power to transfer from the engine to the transmission and drive wheels. Disengaging the clutch stops the power transfer and allows the engine to continue turning without force to the drive wheels. To understand how a clutch works, we first need to understand who the players are and how the whole shebang works. So let's look at the basic components: the flywheel, clutch disk, pressure plate, throw-out bearing and linkage.

A large steel or aluminum "disc," the flywheel is bolted to the crankshaft of the engine. The flywheel does many things - acts as balancer for the engine, dampens engine vibrations caused by the firing of each cylinder, and provides a smooth-machined "friction" surface that the clutch can contact. But its main function is to transfer engine torque from the engine to the transmission. The flywheel also has teeth along the circumference, allowing the starter motor to contact when turning the engine over.

The clutch disc is basically a steel plate, covered with a frictional material that goes between the flywheel and the pressure plate. In the center of the disc is the hub, which is designed to fit over the spines of the input shaft of the transmission. When the clutch is engaged, the disc is "squeezed" between the flywheel and pressure plate, and power from the engine is transmitted by the disc's hub to the input shaft of the transmission.

In layman's terms, a pressure plate is a spring-loaded "clamp," which is bolted to the flywheel. It
includes a sheetmetal cover, heavy release springs, a metal pressure ring that provides a friction surface for the clutch disc, a thrust ring or fingers for the release bearing, and release levers. The release levers lighten the holding force of the springs when the clutch is disengaged. The springs used in most pressure plates are of a diaphragm-type, however a few use multiple coil springs. Some high-performance pressure plates are "semi-centrifugal," meaning they use small weights on the tips of the diaphragm springs to increase the clamping force as engine revolutions increase.

The "throw-out bearing" is the heart of clutch operation. When the clutch pedal is depressed, the throw-out bearing moves toward the flywheel, pushing in the pressure plate's release fingers and moving the pressure plate fingers or levers against pressure plate spring force. This action moves the pressure plate away from the clutch disc, thus interrupting power flow.

Mounted on an iron casting called a hub, the throw-out bearing slides on a hollow shaft at the front of the transmission housing. The clutch fork and connecting linkage convert the movement of the clutch pedal to the back and forth movement of the clutch throw-out bearing. To disengage the clutch, the release bearing is moved toward the flywheel by the clutch fork. As the bearing contacts the pressure plate's release fingers, it begins to rotate with the pressure plate assembly. The release bearing continues to move forward and pressure on the release levers or fingers causes the force of the pressure plate's spring to move away from the clutch disc. To engage the clutch, the clutch pedal is released and the release bearing moves away from the pressure plate. This action allows the pressure plate's springs to force against the clutch disc, engaging the clutch to the flywheel. Once the clutch is fully engaged, the release bearing is normally stationary and does not rotate with the pressure plate.

Now that we have the parts, how do they all work together? Thankfully, it's not rocket science.

A mechanical or hydraulic linkage usually operates the clutch in a manual transmission. If your vehicle has a mechanical linkage, it is usually either a cable or shaft and lever style. The shaft and lever linkage has many parts and various pivot points, including a release lever and rod, an equalizer or cross shaft, a pedal to equalizer rod, an "over-center" spring (to return the clutch pedal to the rest position), and the pedal assembly that transfers the movement of the clutch pedal to the throw-out bearing. In older vehicles, these pivot points need to be lubricated properly on a regular basis to keep the movement buttery smooth and prevent wear.

If you have a newer vehicle, you're lucky, as pivot points are now fitted with low-friction plastic grommets or bushings. As the older "lube-it-yourself" pivot points wear, the extra play in the linkage makes clutch pedal "free-play" adjustments difficult. When the pedal is released, the assist spring returns the linkage to its normal "up" position and removes the pressure on the release rod. This action causes the release bearing to move away from the pressure plate.

A cable-type clutch linkage is simple, lightweight and is the most common linkage on newer cars today. Normally, a cable connects the pivot of the clutch pedal directly to the release fork. This simple design is flexible, compact, and eliminates nearly all of the wearing pivot points found in a shaft and lever linkage. There is one downside to this type of setup: cables will gradually stretch and can break due to excessive wear and electrolysis.
On a typical installation, one end of the cable is connected to the clutch pedal and a spring is attached to the pedal assembly to keep the pedal in the "up" position. The other end of the cable is connected to the clutch release fork with a fitting that allows for free-play adjustments. When the clutch pedal is depressed, the cable pulls the clutch fork, causing the release bearing to move forward against the pressure plate.

Commonly found in mid- and rear-engine vehicles, a hydraulic clutch linkage is basically a mini hydraulic brake system. A master cylinder is attached to the clutch pedal by an actuator rod, and the slave cylinder is connected to the master cylinder by high-pressure tubing. The slave cylinder is normally attached to a bracket next to the bell housing, so that it can move the clutch release fork directly.

Just like depressing the brake pedal on your car, depressing the clutch pedal pushes a plunger into the bore of the master cylinder. A valve at the end of the master cylinder bore closes the port to the fluid reservoir, and the movement of the plunger forces fluid from the master cylinder through the tubing to the slave cylinder. Since the fluid is under pressure, it causes the piston of the slave cylinder to move its pushrod against the release fork and bearing, thus disengaging the clutch. When the clutch pedal is released, the springs of the pressure plate push the slave cylinder's pushrod back, which forces the hydraulic fluid back into the master cylinder. The biggest plus to a hydraulic linkage is the physics: a small amount of pedal force can be used to manipulate what would normally be a heavy clutch with a shaft and lever linkage.

Now that you know what happens when you depress the clutch pedal, what are the warning signs that a clutch needs adjustment or replacement? While most new car clutch linkages are self-adjusting, there are some telltale signs that will tell you if adjustment is needed. For instance, if the clutch engages and disengages close to the floorboard or the transmission "grinds" when shifting, your clutch may need attention. Does the clutch pedal move easily, but the transmission will not go into gear? More than likely, the clutch linkage has become disconnected or a clutch cable has snapped. If the clutch slips (doesn't fully engage), the linkage could be grossly out of adjustment, or the clutch disk could be worn to the point of replacement. Clutch "chatter" is often caused by an overheated clutch (normally from "slipping" the clutch when starting on an incline) or from oil on the clutch disk. In either case, the clutch must be replaced. No matter what symptoms your vehicle may have, always consult with a certified ASE mechanic to diagnose the problem properly.

Although it may seem like there's not much to getting your car in and out of gear, a lot is going on behind the scenes each time you depress the clutch pedal. Now you have something to think about each time you're faced with rush-hour traffic.