Needed:
- Set of metric sockets, deep and normal (8/10/12/13/15 may be needed)
- Set of metric wrenches (8/10/12/13/15 may be needed)
- 1/2" drive 24mm socket
- Spark plug socket 5/8" deep socket
- Various socket 3/8” and ½” extensions, ranging from 1" to 6"
- Medium length 3/8” and ½” ratchet wrenches
- Recommended: Metric "Gear" wrenches
- Allen Wrench size 5 mm
- Torque wrench for 20lb/ft up to 240+lb/ft (or more if possible)
- Torque wrench for 0lb/ft up to 20+lb/ft
- Large 1/2" drive breaker bar
- Piece of pipe 3 foot or longer to slip over breaker bar handle
- 3 arm pulley puller
- Medium sized pliers or vise grips (for hose clamps)
- Medium sized flat head screwdriver
- 3+ gallon bucket or coolant drain pan

- JPR Cam install tool from (recommended)
    OR
    - Two 5/16” or ¼” aluminum or wooden rods approx 26”
    OR
    - 16 retractable pen magnets with pocket clip

- Valve spring compressor: There are several to choose from. Crane makes the best in my opinions but Scoggins Dickey sells a nice one, the MORE tool (sold at Thunder Racing) is also handy, or the small screw/arm style compressor from an autoparts store will work as well.
- Recommended: Air compressor and leak down spark plug hole fitting for air hose
- Optional: Flywheel locking tool (for automatic transmission cars only)

Parts/supplies you will need:
Parts:
- 1 Camshaft
- 16 valve springs
- Recommended: 2-3 spare locks (GMPN 10166345)
- Recommended: 16 hardened pushrods (7.350" or 7.400" are very common lengths)
- Recommended: 3-4 spare retainer locks in case you lose some
- Optional: New retainers (some springs will require new retainers!)
- Optional: Spring seats (some setups may need the spring seats to be changed, talk to your vendor for details)
- Optional: Valve stem seals (if you need to change the spring seat, new valve stem seals are recommended) 8x GMPN 12533586 for Int Seal(Black) GM# 12457652 Exh Seal (Brown)
- Optional: Underdrive crank pulley
- Optional: oil pump

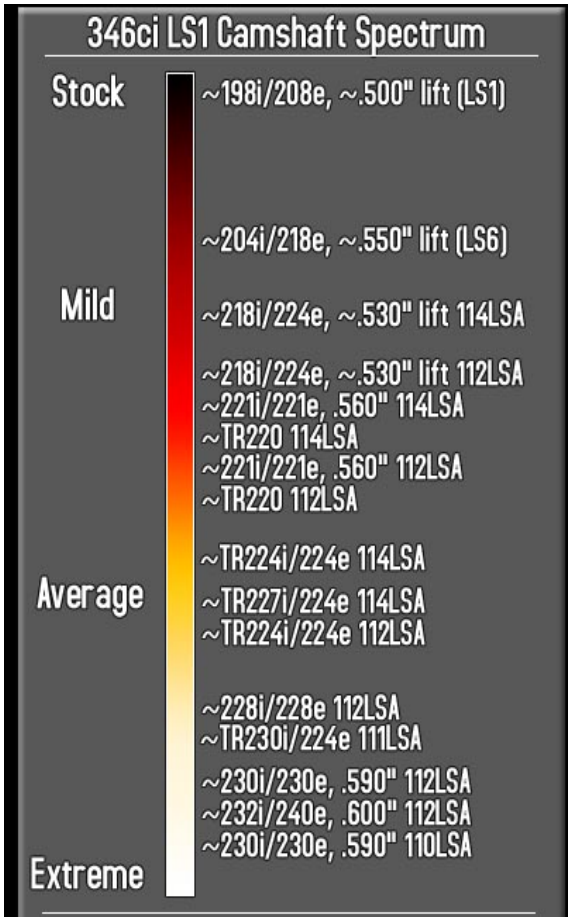
- Optional: New timing chain/gears
- Recommended: bungee cord to hold A/C condenser

Bolts/gaskets:

- 2 Water pump gaskets (optional) (2x GMPN 12559271)
- 1 front engine seal (1x GMPN 12561244)
- Highly Recommended: Longer crankshaft pulley bolt, M16 x 2.0 pitch x 120mm long
- 1 new Crank bolt (GM Part Number 12557840 or ARP 234-2503)
  Stock bolt is Torque to Yield (one time use)
- Optional but recommended: Balancer install tool like this
http://www.ls1tech.com/forums/showthread.php?t=391883&page=1

Supplies:

- 6 quarts of oil (for oil change once done)
- new oil filter
- Optional: Permatex Ultra Slick assembly lube
- Jug of Dex-cool® compatible coolant (or 2 premixed jugs)
- 1 or 2 gallons distilled water (NOT Spring water)(for coolant refill)
- RTV Hightemp silicon gasket maker
- Loctite® (red tube, medium strength)
- Anti-Seize



NOTE: This is a very rough estimation of drivability/power/idle quality. No chart this basic could possibly detail all the differences between 2 similar cams, so use it only as a rough guide

Cam Basics:

When deciding which camshaft is right for you, the best you can do is try to make an educated guess based on previous experiences or other's experiences. There are countless books about camshaft design and theory, so trying to explain what all to choose is pointless and this is why vendors are out there to see what works well in the LS1 for us. They do the research, and thus, they get our money.

When buying a cam, you'll see specs like "220/224 0.550/0.558 114lsa". The first two numbers are intake duration (in degrees) followed by exhaust duration (in degrees). The next two numbers are valve lift for the intake (in inches) and valve lift for the exhaust (in inches).Finally, the last number is the Lobe Separation Angle.

Duration:
Duration really plays a big factor in how the cam will drive and idle. The bigger the duration, the longer the valves stay open, and generally the 'lopier' and worse driving the cam will be. The numbers you'll usually see are the duration in degrees that the valve is open MORE than 0.050" of an inch. Cam cards will also list duration at 0 lift, and that will be a number like 270-290'ish. Cams that have the same duration for intake and exhaust are symmetrical, cams with more intake than exhaust are called "reverse split", and cams with more exhaust than intake are sometimes referred to as "traditional split".

LSA (Lobe Separation Angle):
Lobe Separation Angle, usually referred to as "LSA", is the angle of separation between the exhaust peak and intake peak. The lower the angle, the more the lobes will overlap, and that means more lope, gas smell, and drivability issues...however, the lower LSA can also mean more power and you get it sooner in the RPM range to boot. Duration and LSA are 2 very important items in clueing you into how a cam will idle and drive, although there is a LOT more to a cam than this.

Lift:
Cam lift, in my opinion, is less of a complicated matter on these motors. There's not much of a reason to run less than 0.550" of valve lift, so anything between 0.550 and 0.600" is probably going to be fine. If you have ported heads, it may be best to lean towards cams with 0.570" lift and up as most ported heads will just keep flowing more and more as that valve lift increases. Note that a cam card will show lobe lift, which is the actual lift of the cam lobe. Once you take lobe lift and multiply it by the ratio of the rocker arm (stock is 1.7), you get valve lift.

Lobe Profile:
The Lobe profile of a cam basically is the curve at which a valve is opened and closed. Some lobes are very EXTREME and will snap a valve open very quickly and then slam it shut, while others are "softer" and slowly open and close valves. The more extreme the lobe, the noisier your valvetrain will be and the harder it is on your valve springs...however, a more extreme lobe will generally idle better than a less extreme lobe with the same duration at 50 thousandths. If your cam has very aggressive lobes and your cam lift is up there, I'd suggest you try to lighten your valvetrain by getting titanium retainers if possible.

Choosing the cam for you:
For cars that need to stay stock sounding and driving, but still want a kick in the pants for horsepower, something between a 214 and 220'ish duration would probably be best. For the majority of the cars out there, anything in the 221-227 range is probably a better selection, and for the guys that want all they can get 228+ duration cam shafts are generally the minimum. As a novice all you can do is ask around, listen to cars, look at track/dyno results, and make your best guess. As long as you pick a cam close to what might fit you (i.e. mild, average, or extreme given the criteria above) you really can't go wrong. It's not a life or death decision here. A few degrees here and there isn't something

you should sweat about until you've gotten a few cams under your belt and know more about what you want.

Choosing the valvetrain upgrades:
Now, you can't just throw a cam in and call it a day. At the BARE minimum your valvesprings “must” be replaced with stiffer ones. Whoever sells you the cam can also recommend a spring to go along with it...this is what vendors/shops are for, so you don't need to worry about being an expert on this (although it's not very complicated if you want to learn). Some springs will require aftermarket retainers (it's kind of a hat that sits on top of the spring), some won't, but in general if you go with a very aggressive cam and plan on spinning the engine up past 6600rpms I'd recommend getting Titanium retainers to help reduce the moving mass and keep the valvetrain moving crisply.

Next there are spring seats and valve seals....some spring setups may require you change the spring seat and install new valve seals as well. If your vendor requires you install this, I will cover their install in this document as well. Hardened pushrods will also be highly recommended.

Having said all that, let's assume you've made your choices, placed your order and are now ready to install the parts!

The parts

Here are the most common parts installed. The camshaft, 16 valve springs, and 16 hardened 7.400" pushrods.

Optionally, your kit may have come with valve seals (8 black, 8 brown), 16 valve seats, and/or 16 retainers.

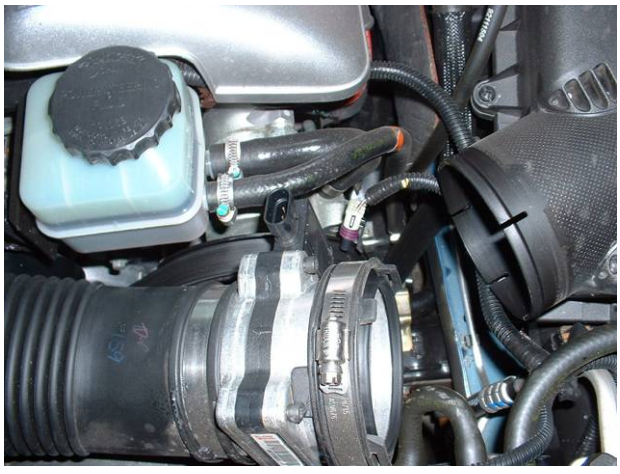
Part 1: Stripping down the engine

Disconnect the negative battery cable before you start anything (10 MM nut).
Remove the skidplate (13 MM nut), this will reduce the mess when you drain the coolant and is required to get to the two bolts on the bottom of the timing cover.
Remove the strut tower brace, it is held on by 4 nuts (13 MM), 2 on each side of the strut towers.

Remove the Radiator Shroud:

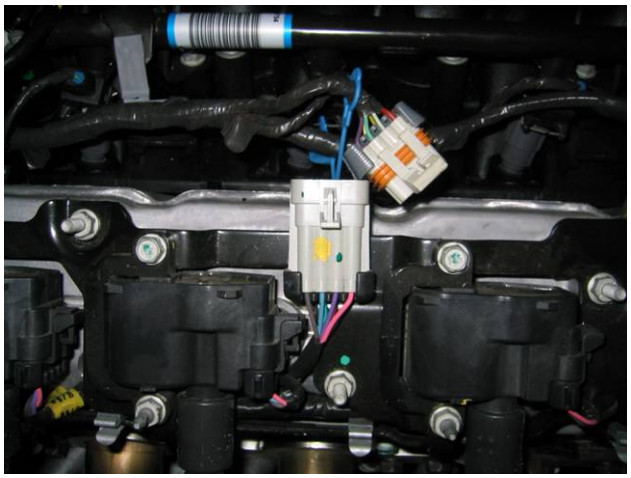
The radiator is covered by a shroud held on by 5 clips (pics to the left). Using two small flathead screwdrivers pull up on the center of the clip. Once these clips are loose, pull the shroud up and to the rear of the car.

Remove the Air box /MAF sensor/coupler assembly. Unplug the wire going to the IAT sensor on the intake tube, and then unplug the wire going to the MAF sensor. Then unscrew the band clamp where the coupler meets the throttle body and unscrew the band clamp where the coupler meets the airbox.



Remove the whole MAF/Coupler assembly as one piece and set it aside.

Removal of coil packs:



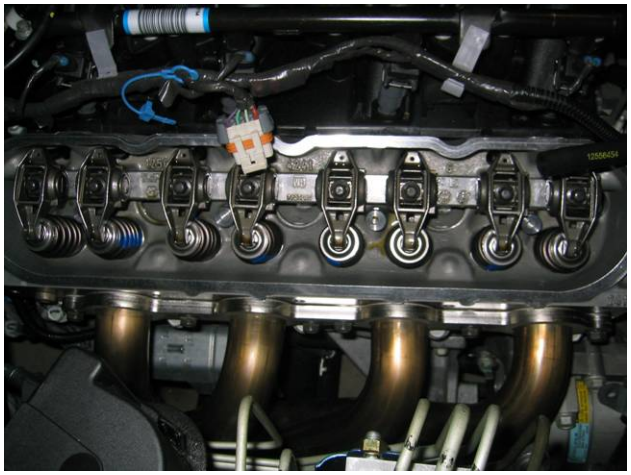
Now disconnect all 8 plugwires from the plugs. Try not to pull on the wire, but instead pull on the boot that connects to the plug. You can remove the coilpacks with the plug wires on them so don't pull the wires off the coils unless you want to. Next, disconnect the wiring harness that goes to the coilpacks. It's a large white weatherpack connector in the photo.

Next we need to remove the coil packs from each valve cover. The coil packs are on a bracket and the bracket is then mounted to the valve cover. A 10mm socket, or a 10mm gearwrench will get the job done. You can remove the coilpacks with the plug wires still attached to them. Once all the coil packs are removed you will see the bare valve covers.

Removal of valve covers and rockers:

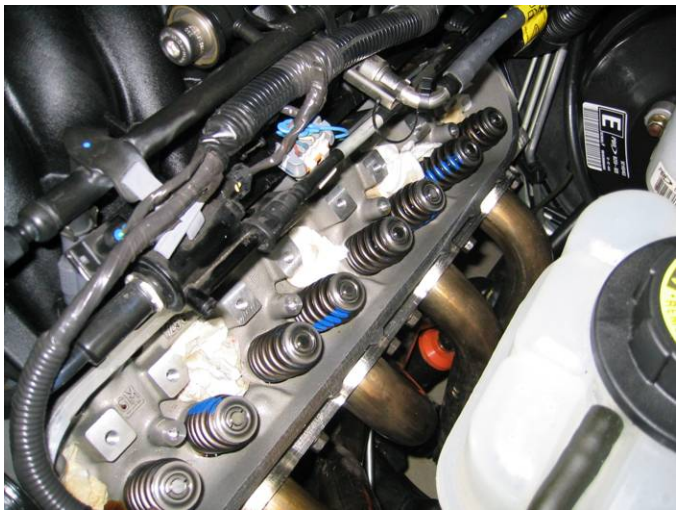
Now you can easily remove the valve covers there are 4 - 8mm center bolts going through the valve cover.

Remove both valve covers and set them aside.



Using an 8mm socket, unbolt the center bolt that goes through each rocker arm. There are 16 of them, 8 on each side of the motor. It will take a bit of force to break the bolts free at first, so be VERY careful and make sure the socket is on the bolt head tightly or you'll risk rounding it off.

Once you remove all the bolts you can pull the rocker pedestal rail assembly out with the rockers on it and set it aside. Be careful as the ROCKERS ARE NOT MOUNTED TO THE ROCKER PEDESTAL RAIL. It is recommended you keep the valvetrain in order as you remove it just in case you spot a problem later, that way you can go back and look at the specific components and see what else might be wrong with that cylinder/valve.



Take the time now to stuff the head bolt indentations with rags or paper towels. When you remove the springs and retainers later you'll thank me. We had a retainer drop down into the pushrod housing the first time and had to remove a head which will set you back several hours.

Once all the rockers are out, pull out all the pushrods, and keep them in order if you are going to reuse them.

Drain the coolant:

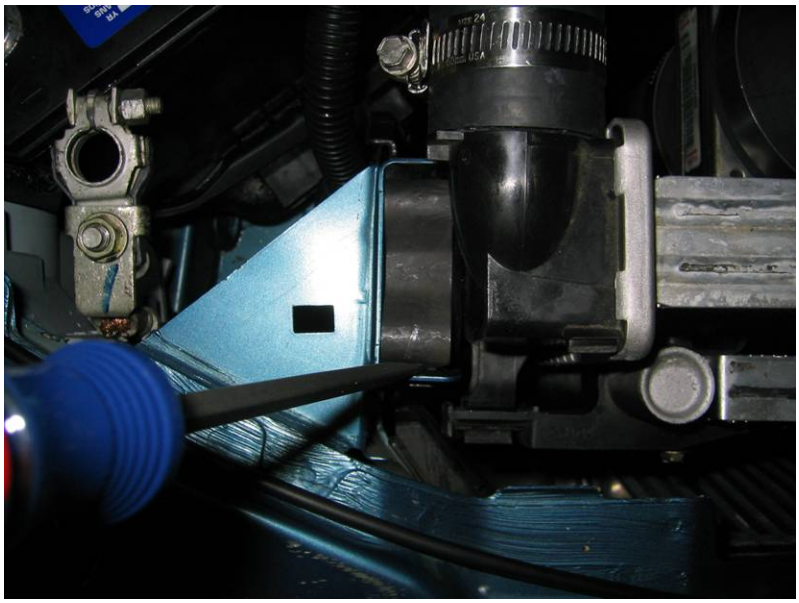
Warning: If the engine has been running a prior to this, let the coolant cool off first.

Now we need to drain the radiator. (There is no petcock valve on the radiator of the 2004 GTO)

To drain the coolant we will remove the lower radiator hose located on the driver's side of the engine compartment. Using a pair of pliers or vise grips, compress and slide the spring clamps off the lower radiator hose from the 1 ½ " metal connector located by the radiator core support and at the bottom driver's side of the radiator. Once the clamps are all slid back some, pull or pry (using a large flathead screwdriver) the hose off the radiator. There are also 2 very small hoses going to the fill neck on the radiator. Unclamp those at the radiator and leave the other end connected. Coolant will most likely start pouring out of some of these hoses. You can try to catch some of it in a bucket but I usually just let it hit the ground. Remove the hose on the top passenger side of the radiator.

Removal of Radiator:

Now we need to remove the radiator. First, unclip both fan electrical connectors. Get a friend to help with the next part. Loosen the AC drier clamps and lift the drier up a little bit out of the holder. This will make it easier to move the AC hose out of the way of the fans when we pull the radiator/fans out in the next step.

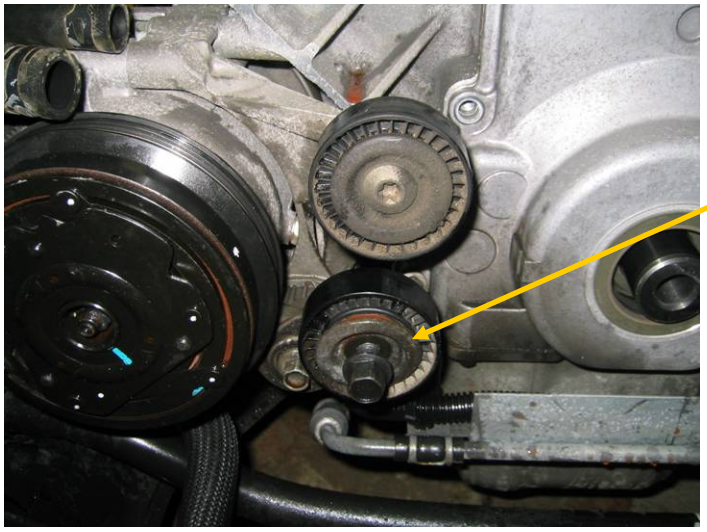


The radiator slides into place from the top, there are two clips that hold the radiator down. Using a flathead screwdriver, pry the clips off.

This a big assembly....the fan shroud is mounted on the radiator via 4 slide in tabs, and on the front of the radiator the AC condenser (looks like another radiator) is attached to the radiator with 4 tabs. (see pictures to left and bottom)

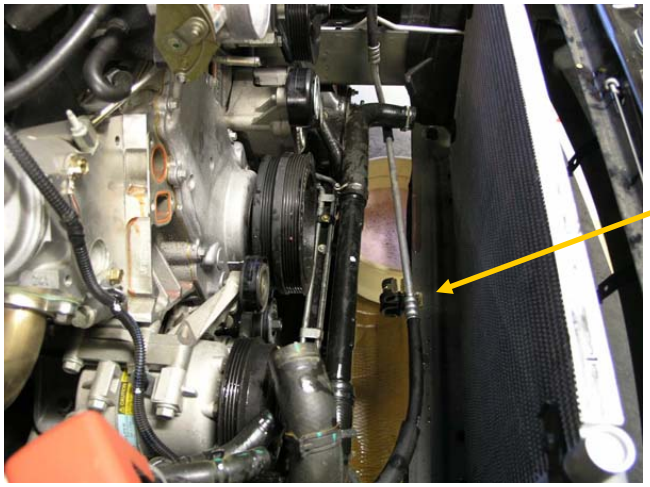
Remove the Belts

Next, grab a 15mm wrench and place it on the belt tensioner (idler arm) bolt as shown in the pic. Compress the tensioner by applying force clockwise on the wrench and slide the belt off of any pulley (the water pump is usually easy to slide the belt off of) and release the tensioner slowly. Remove the belt and set it aside.

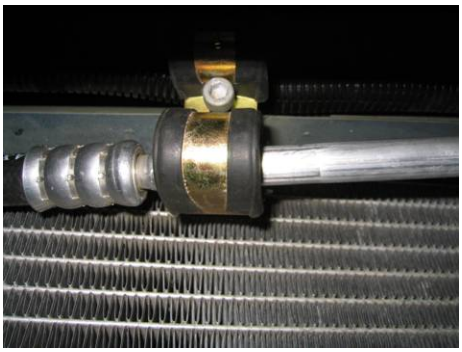


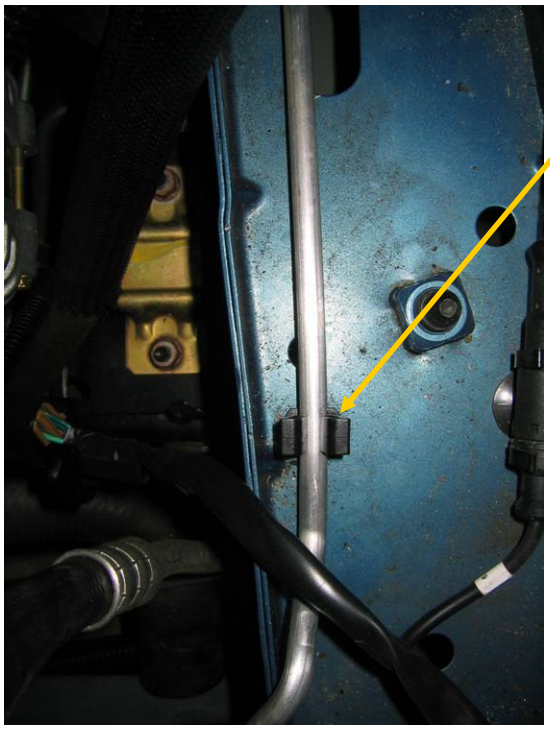
Remove the A/C belt (lower passenger side) and idler pulley (the one at the bottom) at this time

We need to create some slack for the AC lines.



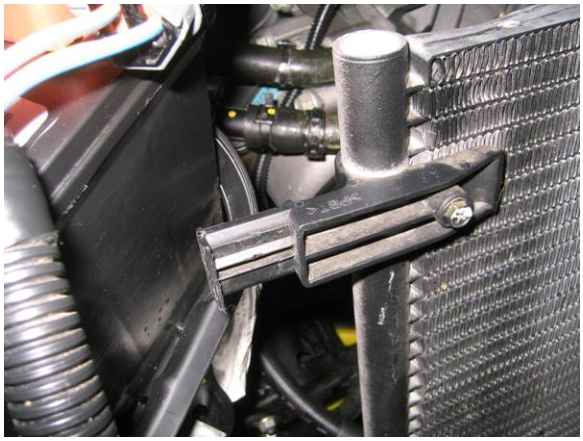
Disconnect the AC line bracket at the bottom rear of the radiator using an Allen wrench (SIZE 5 MM)



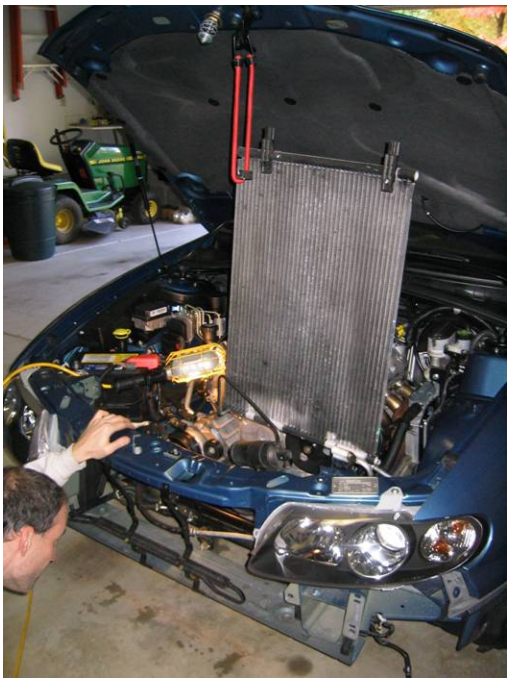


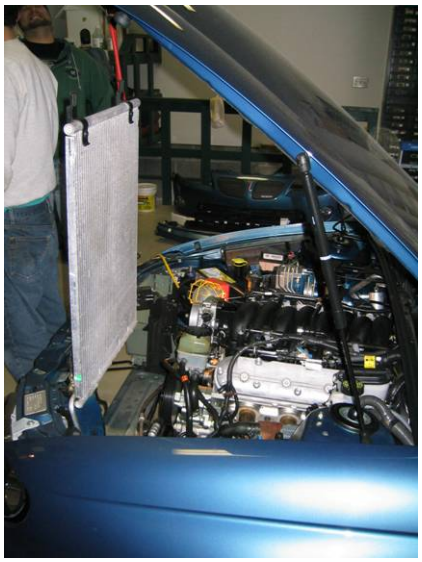
Disconnect the AC line holder on the driver's side rail behind the radiator. Careful these are aluminum lines and bend easily.

Now you need to slide the AC condenser UP about 2 inches to dislodge the tabs and get the radiator free from its grasp. This will take some cursing and a good light source so you can see the 4 slide in tabs I'm talking about. (see photo below) Once the AC condenser is loose from the radiator, both of you need to lift the radiator up and out.



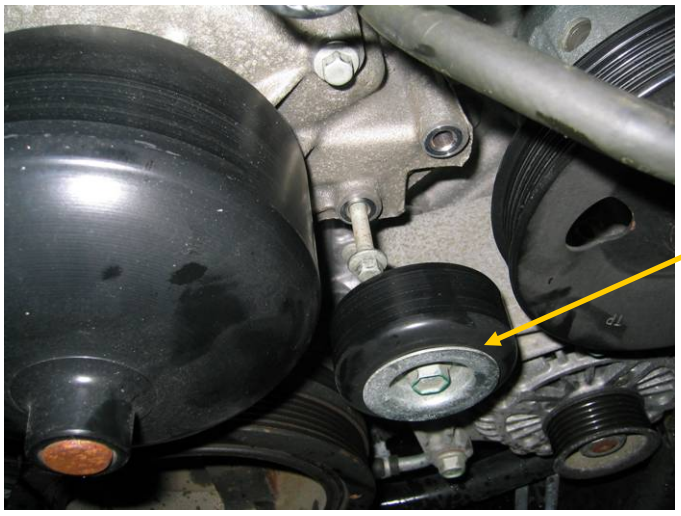
This part can sometimes be frustrating, so be patient. While trying to remove the radiator, you'll need to make sure that on the driver's side you don't catch on the AC condenser hard lines. The large coolant hose will want to snag on things. Keep wrestling with it until the radiator assembly comes out totally, and set it aside.
The AC condenser will stay in the car for the whole install but we will swing it up 90 degrees (clockwise) for parts of the install. (see photo below (you do not need to remove the front fascia we had it off for another reason)



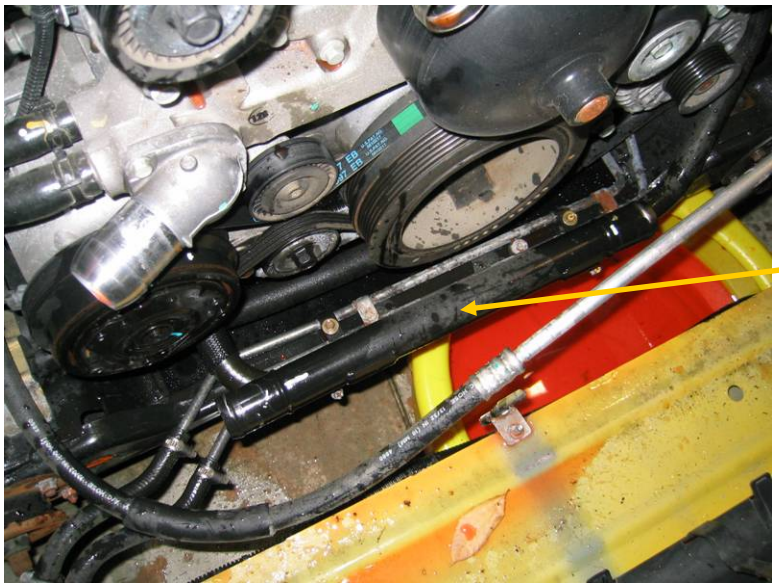


Removal of water pump:

There are 6, 10mm bolts that hold the water pump to the block, 3 on each side. See diagram of the pump on the left for their locations. Unbolt all 6 bolts and remove the water pump from the car. Coolant again will start leaking once you loosen all the bolts, it's inevitable. Don't worry about it.



You will need to remove the idler pulley by the water pump as shown in the picture. 15 MM bolt

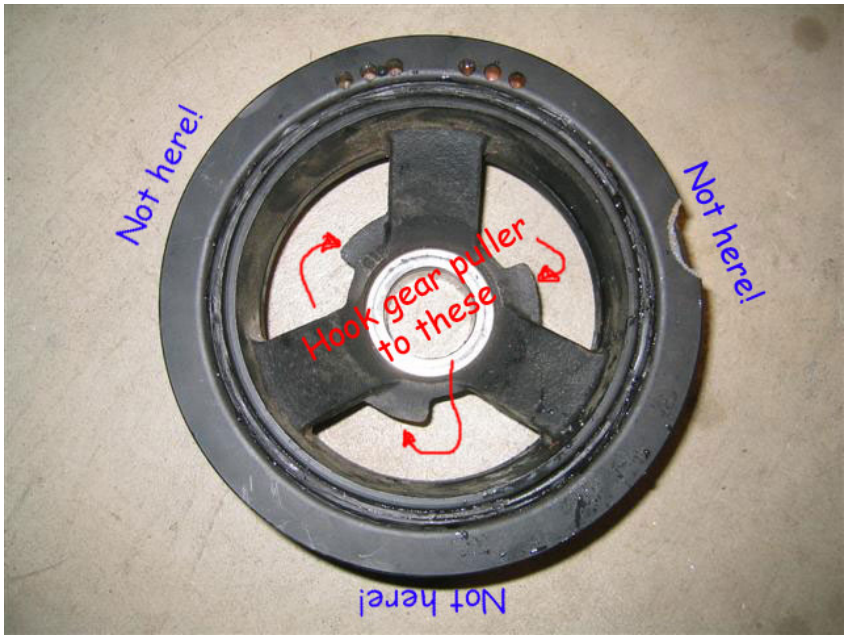


Loosen the coolant cross flow tube (in pic to left) held on by 3 10mm bolts. This will give you clearance for the crank pulley removal.

Removal of crankshaft pulley:

On a 6 speed car, put the shifter in 4th gear and make sure the parking brake is on tight. On an A4 car, you'll need to drop the starter and either install the flywheel locking tool or wedge a screwdriver in. The starter is held in by 2, 13mm bolts and is on the bottom rear passenger side of the engine. You can leave the wires attached.

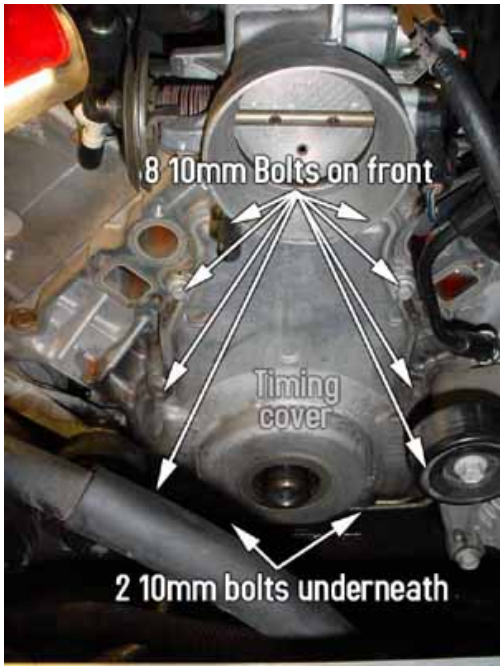
Once the engine is locked down from spinning, use your large breaker bar, a 3" extension and a 24mm socket on the crankshaft pulley bolt that goes directly into the crank through the center of the large pulley. You may need a 2-3 foot extension of pipe to slip over your wrench to break this bolt free. Once it's broken free, you should be able to unscrew it by hand. Once the bolt is out, either thread it back in 4 full turns, or if you purchased a 1" longer metric crank bolt, install it all the way at this time.



Now install your 3 arm pulley puller, mounting the hooks of the three arms on the inner part of the stock pulley. Keeping the pulley puller arms all secure and aligned, begin to tighten the bolt on the puller and crank on it until the pulley either comes loose, or hits the head of your crank bolt. If it hits the head of your crankbolt, loosen the pulley puller, unscrew the bolt 1-2 turns, and re-try it again. When you back your crank bolt out more, you are putting MORE stress on less and less of the threads...however, towards the end of pulley removal it will come off easier and easier so the stress isn't enough to damage the crankshaft threads.

If you get the pulley as far off as it'll come without totally removing the crankbolt and the pulley is still firmly on there, give it a good tug or a tap with a rubber mallet...it should be hanging on by just a hair at this point. If you have the longer crank bolt, this won't be an issue.

Removal of Timing Cover:



Next, we'll unbolt the timing cover. There are 10 bolts holding the timing cover to the engine, 8 on the front, and 2 on the bottom front of the motor. Remove all 10, 10mm bolts. Remove the timing cover once all bolts are out...it may be kind of glued at the bottom, just give it a tug.

You may need to remove the pulley to the lower right of the timing cover for clearance depending on your tools (its held on by a 15 mm head bolt)

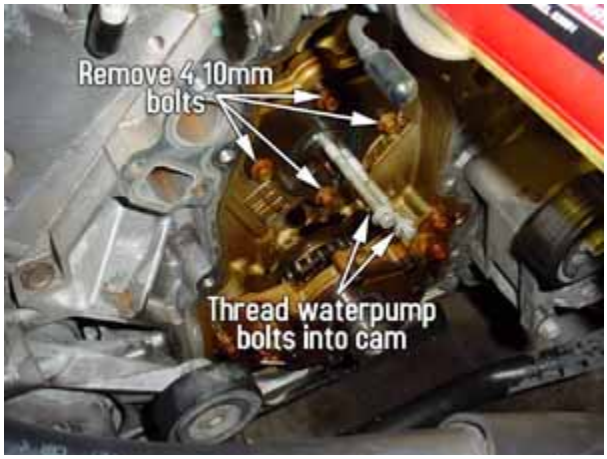
Once the timing cover is removed, you can see into the oil pan. **If you drop anything into the oil pan, you may have a nightmare situation on your hands so take the time right now and stuff a clean small towel into the front lip of the oil pan just in case you drop a bolt later**.

Part 2: Removing the cam

Now look what's in there. The big gear you see is the gear mounted to the end of the camshaft and is held on by 3, 10mm bolts. The chain is of course the timing chain, and the big metal block at the bottom is the oil pump.

Before you remove the cam gear take the time to line the timing dots up so the engine has cylinder 1 at TDC.

Unbolt the 3 cam gear bolts and remove the gear, letting the chain droop down into the oil pan for now.

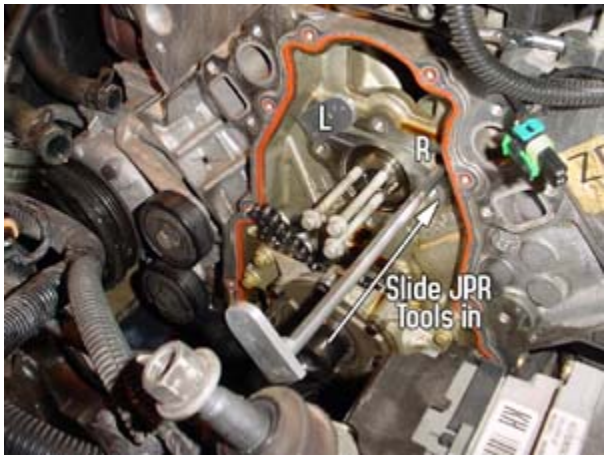


Thread 1 or 2 of the water pump bolts into the front of the cam and then spin the cam several times both directions with a quick snap of the wrist. This should push the lifters up and off the cam. Unbolt the cam retainer plate that is held on with 4, 10mm bolts and remove it.

Support the Lifters

Option 1

JPR Lifter tool method



This method is by far the easiest. You'll need to buy the JPR Cam install tool or use dowels (1/4” or 5/16” should work)

If you have these, it'll make this a no sweat operation. To install them, you simply slide them into the 2 holes in the front of the motor. The JPR tool is marked "L" goes in on the passenger’s side of the motor, and the one marked "R" goes on the driver’s side of the engine. The tool head will face up and outward as shown in the image.

If it seems the tools are tough to get in, try spinning the cam a couple more times and slowly sliding the tool in. Once both are in, the lifters are locked into place making it impossible for them to fall.

We made our own tools using aluminum rod (1/4 inch diameter and 26” long) which we oiled up with motor oil.

Option 2
Pen magnet method

If you don't have the tool in option 1, the next best thing is to go buy 16 retractable pen magnets from Walmart/AutoZone/wherever you can find them. The heads on the magnets need to be small as the opening to get to the lifter is a little less than 1/2" in diameter.

Once you have the magnets, extend the magnet about 6" and put it down the pushrod holes in the head. You should feel it 'snap' onto the lifter and at that point you should be able to push the lifter up and down. Rotate the cam some while doing this so you can understand how this works. The lifter rides on the cam, so you need to make sure (by spinning the cam) that the lifter is UP away from the cam. The magnet is there to help the lifter stay up, so you need to squish the retractable part down and bend the pocket hook on the pen magnet outwards some to grab on to the head. Hooking the pocket hook onto the bolt hole for the rocker arm bolt usually works well.

Install all 16 magnets to hold up all the lifters. Now, spin the cam and if ANY of your pen magnets move when you do this, then that lifter is hanging down too low. Use the magnet and spin the cam to hold the lifter up higher.

Pull the cam out:

Now that the lifters are up off the cam, there is nothing keeping the cam in there. Let's pull it out!

Grip the bolts on the end of the cam, and gently start pulling the cam out while trying to keep it supported and level with the bolts. The key here is to be gentle with this part. The cam will need to be slowly spun as you are removing it. You need to envision what is going on inside the motor, your cam is basically going through a few holes that suspend it. Once you pull the cam out a bit, it's going to drop down some and the lobes are going to be getting caught on the cam bearings in those holes, which is where the gentle spinning and tugging comes into play.

Whatever you do, don't force the cam if it feels like it's caught, just keep turning until it wants to naturally slide out more with gentle force. Once the camshaft if 1/4 of the way out, use 2 hands and try to leverage the end of the cam to keep the whole camshaft even, rather than dragging it out of the engine. Once you support the cam with two hands you'll see it's much easier to remove as it's not getting caught on everything inside.

Once the cam is about 70% out, Have a friend rotate the AC condenser CLOCKWISE at about 90 degrees. If you do not have a buddy handy, you can use a bungee cord to tie the condenser up and tether it to the hood latch. Move it up until you have just enough room to pull the cam out totally and set it aside. Note that the AC condenser lines are not designed to flex TOO much so only move it up out of the way as far as you need to for the cam to be removed it is important to put as little stress on the aluminum AC lines as possible.

Now, pull the last bit of the cam out and set it aside.

Optional

Now, if you are the curious type, you may want to measure the base circle of your new cam before you install it. If you have a vernier caliper, place it on one of the lobes and compress the caliper with your hand. Spin the cam slowly until you find the lowest number the caliper ever reads. This is approximately your base circle. Yours will probably be somewhere between 1.45" and 1.50". It may also be a good idea to measure the stock base circle just to compare. The new cam should have a smaller base circle.

End of optional section

Prep new camshaft:

Now we need to prep the new camshaft. I recommend using brake cleaner to clean the cam. Try to get inside the center of the camshaft (it's hollow) to get any gunk out of there. Some cams come very filthy from the vendors, some come very clean. It's always a good idea to check.

Now, grab some fresh motor oil and pour it onto the new cam. Get everything coated nicely. Some people use assembly lube (I used Permatex Ultra Slick assembly lube)

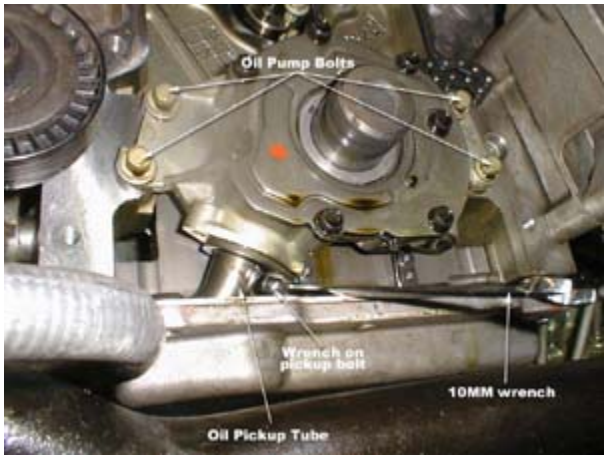
Remove the water pump bolts from your stock cam and thread them into your new cam.

Have your friend (or bungee cord) suspend the A/C condenser again and work the new cam in exactly the opposite of how you removed the stock one. SLOW and CAREFUL is the key here. You may find that the first 90% of insertion isn't too bad, but the last 10% can be kind of tricky. You have to try and support the cam and keep it level to get it up into the last hole inside the engine. Just keep turning it, lifting it, and wiggling it in and eventually it'll go right in.

If you used Option 1 (JPR Lifter tool method) to hold the lifters up make sure you remove them before putting the cam retainer plate back on.

Once in, re-install the cam retainer plate and its 4, 10mm bolts. I put some Loctite® on the 4 bolts and the GM torque spec on them is 18lb/ft.

Optional: If you purchased a new oil pump and/or a new chain, you'll need to complete this step.



First, unbolt the 4, 10mm bolts holding the oil pump to the engine block, making sure not to drop any into the oil pan.

Now we need to unbolt the oil pan to lower it some. It is held on by 8 or 10 bolts around the perimeter, some M8 and some M10 (10-12mm hex head bolts). You should be able to loosen them all enough just to get the pan to drop 1/2". It may need some prying to break it free at first.

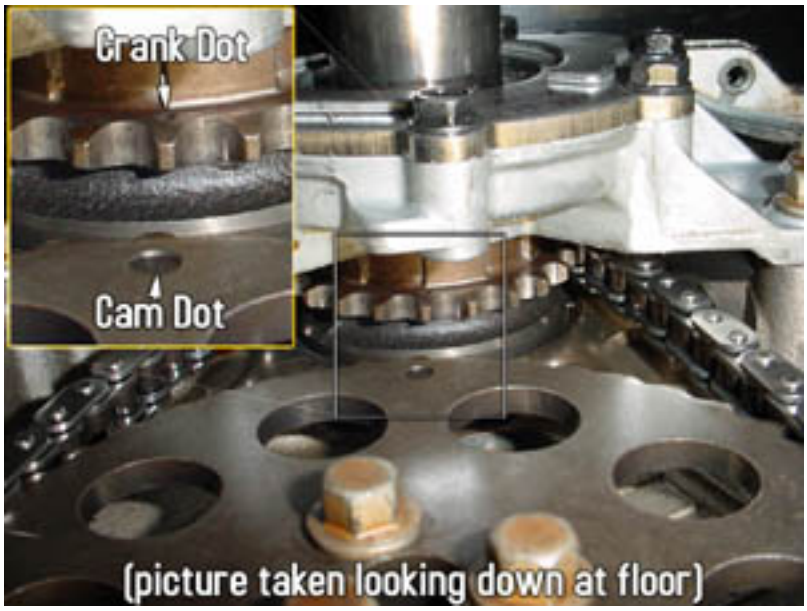
Next, grab a 10mm wrench and unbolt the pickup tube bolt...it holds the pickup tube to the oil pump. Then once it's loose, unthread it and remove it with your fingers making sure not to drop the bolt into the oil pan. Now grab the pump with one hand and with your other hand or a screwdriver, push the pickup tube downwards into the oil pump to separate it from the pump. Once it's separated, pull the pump off the front of the engine crankshaft.

You can now remove your old timing chain if you need to. Place the new chain over the crank snout and let it droop down like before. Leave the oil pump off the car for now.
End of optional section

Indexing the cam:

This step is one of the KEY parts of the install. If you mess this part up, you risk major engine damage once you try to start the car up later on. However, we'll verify everything is right before we go further, so don't worry too much. The goal here is to get the cam gear back onto the front of the cam, with the chain in place. That part is easy enough, the hard part is getting the dots lined up. There is one dot on the face of the cam gear, and one dot on the front of the crank gear (behind the oil pump)
Thread your old crankshaft bolt back into the crank and turn the crankshaft until you see the small black dot pointing straight up. See picture on the left for reference. (It is difficult to see, you may need to rotate the crank a few times to find it.)

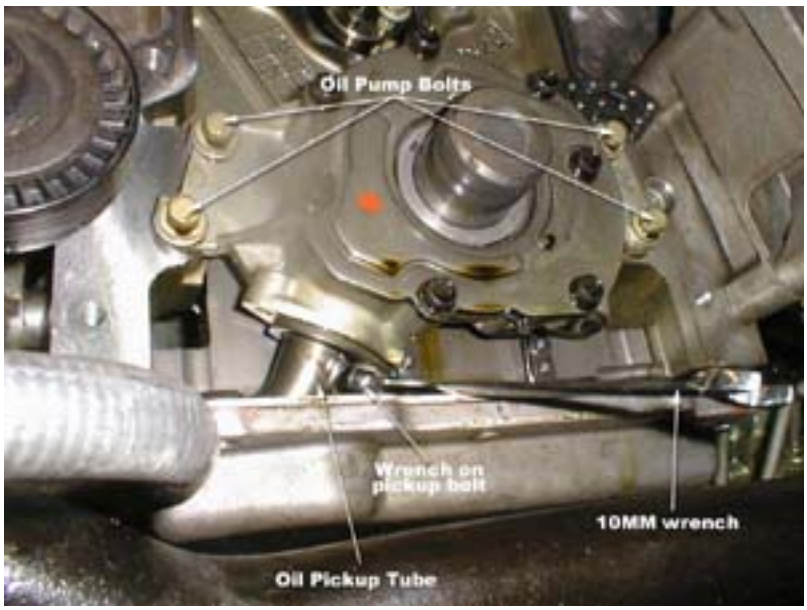
Next, in your hand, orient cam gear so dot is on bottom and hold it up to the front of the cam....see the smaller 4th hole in the cam gear? That is where the cam alignment dowel goes in. Spin camshaft by hand so dowel looks like it'll line up with cam gear properly to align the dots. Put the timing chain on the crank gear, and then put it on the cam gear, holding the cam gear up with your hand to keep tension on the chain. Carefully try to get the camgear to seat on the front of the cam. If you don't get the hole and the dowel aligned just right, you're just going to push the cam back into the block.



If you are having trouble aligning it, try threading a cam bolt through the gear into the cam to grab it and line it up like that. Most likely you are going to have to keep moving the chain on the cam gear until you get the dots lined up just perfect, and you'll have to get lucky and have the cam oriented just perfect so the gear seats on like it should. If all this sounds complicated, just look at the picture on the left and make yours look exactly like that. Don't get mad if this part takes 20-30 minutes of trying until it all looks correct. Once it's all together, make 100.000% sure the dots are lined up exactly. You can't be off by a few degrees due to the sprocket/chain setup, you can be off by one tooth at the minimum so if you are off you'll see it. If it looks off a little bit, turn the crankshaft by hand again to see if the 2 dots do indeed line up when they are straight up and down...sometimes if your crankshaft is 5 degrees too far, the cam gear will look like it's off 10 degrees or so and you'll think there's no way they'll line up exact...when in actuality you just needed to get the crankshaft straight up.

Now bolt the cam gear to the cam using the old 3 10mm bolts, again, placing Loctite® on the threads. These should be torqued to 26lb/ft. For the LS1 and 18 lb/ft for the LS2

Optional: If you removed your oil pump in the previous step, you'll need to do this to reinstall it



Find your oil pump pickup tube O-ring, it may be brown or blue in color. It will either be inside the opening of your stock oil pump, or it'll still be on the snout of the pickup tube. If it was inside the oil pump, remove it and place it on the snout of the pickup tube...just seat it on there, don't force it down any more than it wants to go naturally.

If you bought a new oil pump, get it out now and place your old pump aside. Now, push the pickup tube downwards with one hand, and with the other, try to line up the gear on the oil pump with the gear on the crankshaft and push it on. Again, this may take a few minutes to get the gears all lined up. Once the pump slides on, rotate it a little and try to line up the snout so it'll slip into the oil pump nice and centered. If you try to insert it off center, you run the risk of chewing up the o-ring which will mean you have very little oil pressure and have to tear all this apart to get back in here to replace it. You don't want that, so make sure you insert the pickup tube nice and centered. It shouldn't take much force at all to push it in. Once it's in, apply Loctite® to the old pickup tube bolt and re-install it. The torque specs are about 9 lb/ft, so just tighten it with a small wrench so it's snug but don't go crazy on it, as it's a really small bolt and the threads will strip out with too much force.

Apply Loctite® to the 4, 10mm oil pump bolts and reinstall them, torque them to 18 lb/ft.

Now, retighten up the oil pan bolts. The smaller bolts get torqued to 106 INCH lbs, or about 9 foot lbs, while the bigger bolts get torqued to 18 lb/ft. Note: You WILL break those smaller headed bolts if you go past the 9 lb/ft as specified.
End of optional section

Part 3: Changing the springs

If you used Option 2 (Pen Magnet Lifter tool method) to hold the lifters up make sure you remove them before proceeding. These pictures were taken with a variety of spring tools.

Now we start the 2nd big job of the install....changing the springs.

Before we get started, I want to show you the parts that we'll be dealing with. The most obvious part is the valve spring. Under the valve spring is a metal "spring seat". The seat sits on the head, and the spring sits on the seat. The valve stem goes straight up through the center of the spring and at the end of the valve stem is a hat. The hat is called a "retainer", and it is locked into place using 2 pieces of curved metal called "locks". The spring is basically sandwiched between the seat and the retainer, and the retainer/lock combo is what holds the valve up from falling into the engine.

If you are not replacing spring seats (most setups will not require this), then you do not need to worry about seats so you can skip those steps below.

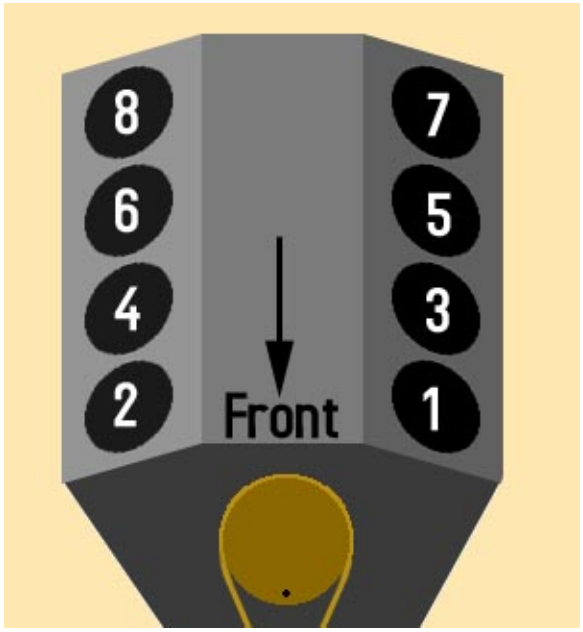
Okay, let's get to work. The first thing we need to do is remove all 8 spark plugs. You can do this with a normal 3/8" drive ratchet and a 5/8" deep socket. Sometimes a 1 inch extension is handy, but for the most part no other fancy adapters are needed.

Now that the plugs are removed, we need to figure out a way to keep our valves from falling into the cylinder, since when we remove the spring and retainer NOTHING but friction will be holding the valve up. If it falls, it could spell disaster. There are a few options for this I'll show two.

Option 1

Use an air compressor and spark plug fitting to pressurize the cylinder
This is probably the easiest method if you have an air compressor. It will require you to get a special air hose fitting that lets you screw into the spark plug hole. These come in many of the leakdown testing kits as well as a cylinder pressure testing kit. All you need to do is remove the Schrader valve in one end of the hose, screw it in, and hook the other end up to an air supply set at around 60-80psi. Once the cylinder is full of compressed air, the 2 valves for that cylinder will be locked up in place.

Option 2
Top dead center method



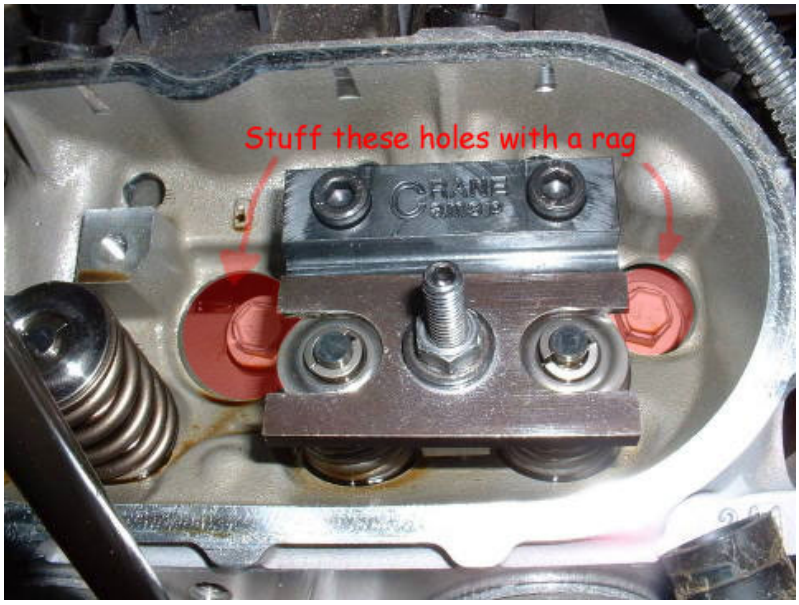
This method requires you to put the piston at the highest position in the bore, so that when you start to compress the spring, the valve can only drop until it hits the piston. When the piston is at top dead center, the valve can't move very far at all.

There are several ways to accomplish this:
A) You can place a small stick/rod/straw/something into the spark plug hole and have a buddy turn the crankshaft by putting the stock 24mm crank pulley bolt in and turning the bolt with a wrench. You should be able to feel when the piston comes up to the top.

B) This method is a bit more elegant. Rotate your motor over by hand until your cam gear and crank gear are dot to dot like you set them up as earlier. At this position, piston 1 and 6 should be at top dead center. You can change the 4 springs on these 2 cylinders now using the instructions below. After you change those 4, then, rotate the crankshaft a full 90 degrees, and the cam gear dot will turn 45 degrees, as if it is pointing to 7:30 if it were a clock. Now piston 8 and 5 are at the top and can be changed. Rotate another 90 degrees on the crank and your cam gear dot will now be at 9 o'clock. Piston 7 and 4 can now have their springs changed. And FINALLY, rotate the crank another 90 degrees and the cam gear dot will be at 10:30. You can now change your remaining four springs on piston 3 and 2.

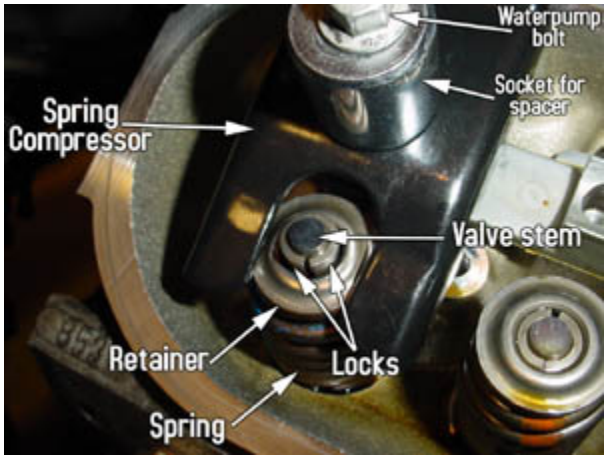
Once again, that's 1 & 6, rotate 90, 8 & 5, rotate 90, 7 & 4, rotate 90, 3 & 2.

Now that the valve won't be falling down into the cylinder, we can compress the spring. Spring compressors come in so many shapes and sizes it's impossible to list them all. The stamped steel "crowbar" shaped spring compressor available from AutoZone/Napa, and is what I show in this document, however it has a history of breaking bolts off in the head! Use this tool at your own risk! Right now I'm going to recommend the amazing valve spring compressor tool from Scoggins Dickey, and the MORE tool from thunder racing. The tool from Scoggins Dickey will not fit on the back two cylinders on the passenger's side, but the other 6 cylinders work fine. For the back two, the MORE tool does the job great. Having both of these tools will make your life VERY EASY, but you'll also end up being poor. If you can only buy one or the other, get the MORE tool since the SDPC tool wont work on all cylinders.



If you haven't done so yet, take the time now to stuff the head bolt indentations with a rag or paper towel. When you remove the springs and retainers later you'll thank me. We had a retainer drop down into the pushrod housing the first time and had to remove a head which will set you back several hours.

Install whatever spring compressor you chose, and start compressing the spring. Now, if the VALVE stem is moving down with the retainer, you may need to tap the retainer lightly with a hammer to pop the valve out of the retainer (sometimes they are sort of wedged in there). The valve stem should be sticking up ABOVE the retainer at this point!

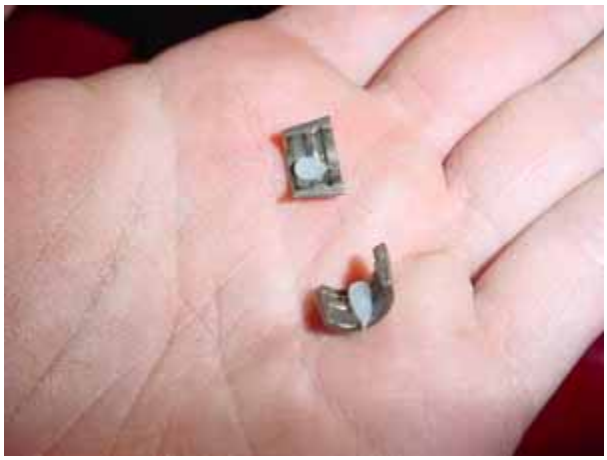


Once you've got the spring compressed enough, the 2 metal locks should be just sitting in there next to the valve stem.

Using a magnet, you should be able to easily remove these locks. If they are still stuck in there, you may need to compress the spring a little more.

The locks are removed, so literally the only thing holding the spring down now is the compressor. Unbolt the spring compressor and remove it. You can now pull off the spring and retainer!

Now, toss your new spring onto the seat and place a retainer (new if you got them, otherwise reuse the stock ones as long as the springs accept them) on top of the spring. Install the spring compressor like you did before on this new spring/retainer combo and make sure when compressing the spring that the retainer opening stays as centered as possible around the valve stem. You don't want to snag the retainer on the valve stem while you are compressing the spring.



Now put the locks in. If you are using a tool where you have to manually compress the spring by hand as you are installing the locks, it may help to put a dab of grease in the inside of each lock...this way you can "stick" them to the valve stem and that'll keep them from falling out as you mess with the spring compressor. It's a handy trick if the you are having issues getting the locks in.

Once both locks are in place, SLOWLY decompress the spring and make sure they lock into place. The locks need to lock into a groove on the end tip of the valve stem so you should be able to easily tell as you decompress it if it worked or not.

That's it! Repeat the above for all 16 springs and you're done!

From this point on, it's all reassembly! The hard parts are over.

Part 4: Reassembly and testing

Reinstall the pushrods:

Insert all 16 pushrods in order if you are reusing them, place the rocker pedestal back on the head, apply Loctite® to all the rocker bolts and reinstall all the rockers. Torque the rockers to 22lb/ft, rotate the crankshaft 180 degrees and double check the torque on all the rocker arm bolts.

Now, using your 24mm socket wrench, turn the motor over by hand (should be difficult as you are moving the valvetrain) and make sure the motor turns over by hand 3-4 turns. If you feel the crank get stuck at a certain point to where it does not want to turn anymore, you somehow messed up the degreeing of the camshaft, or your cam is WAY too big to clear stock pistons. This check is NO substitute for a real piston to valve clearance check, but it will catch any gross errors like lining up the dots VERY incorrectly. While you are tuning the engine watch the valves open and close. Make sure they are all opening and closing if not you have a problem (possibly lifter or rocker issue)

Reinstall the spark plugs:

You can start by putting the 8 spark plugs back in to the motor. Put a dab of anti-seize on the threads and HAND thread them into the hole to ensure you do not cross thread them in. It is a good time to put in brand new plugs or check the gap on your stock plugs. NGK TR-55's with a plug gap around 1.52 mm or 0.060 in, seem to be popular for engines without nitrous. (plug torque is 11 lb/ft or 15 NM)

Reinstall the valve covers:

Assuming all went well, let's move on. Place your valve covers back on the heads and bolt them down. The valve cover bolts do not need to be tight, as the valve covers use a rubber gasket to seal. "Snug" is fine, or if you are a perfectionist the torque spec on the bolts is 9 lb/ft.

Reinstall the coils:

Now reattach your coil/bracket assembly and the plug wires but DON'T plug in the big white coil pack wiring harness yet. (torque on the bolts is 106 in\lbs) If you did detach the wires from the coils, reattach them. For the coil end of the wire you'll hear it snap twice, and for the spark plug end you'll feel it snap onto the plug. I usually put a dab of dielectric grease inside both ends of the wire before I reattach it.

Reinstall the timing cover:

Now, we need to put the front cover back on; however, it's best to not reuse the front seal that is pressed into the hole in the middle of the cover. Using a big flathead screwdriver and a hammer, hammer the seal out from the back of the cover as shown in the picture. Hammer all around the seal and work it out. This may require some pretty heavy hitting with the hammer.

Once you have removed the seal, place your new seal centered on the hole. Using a block of wood or very careful hammer placement, tap the front seal into the hole. Again, this may take some trial and error as when you hammer one side in, the other will pop up. That is where the block of wood comes in handy as you can hammer the whole seal in equally using it.

Now that the new seal is in, you need to place a bead of silicon RTV gasket maker along the bottom edge of the timing cover. If there is some RTV leftover on the bottom, scrape it off before you apply the new RTV.

Remove the towel or rag you placed in the oil pan earlier then place the cover on the front of the engine (make sure you have the timing cover gasket in place, and oriented the correct way (it is NOT symmetrical!)) and hand start all 10 bolts. At this time do NOT tighten any of the bolts. Just get them started a few turns and let's move on.

Reinstall the crankshaft pulley:

If you put the pulley in your oven at 150 degrees for 15~20 minutes it may go on easier (but use gloves to avoid getting burned) Seat your pulley back onto the snout of the crankshaft as best you can by hand.

Option 1: If you purchased a longer crank bolt (or M16 x 2.0 pitch x 120mm long bolt in picture) which I highly recommend, start threading this in now and pull the pulley on about a 1/4 or 1/2 an inch and remove the longer bolt.

Option 2: If you have a balancer install tool (similar to pic below), use this to pull the pulley back on. (http://www.ls1tech.com/forums/showthread.php?t=391883&page=1)

Option 3: Use your old stock crank pulley bolt to pull the pulley onto the crankshaft until the bolt seems to get impossible to turn. Grab your biggest torque wrench and attempt to torque that bolt down to 240lb/ft. If you can't hit 240 don't worry about it. It took two people to get it to 240 lb/ft when I did it. Many people have stopped at 200lb/ft and never had a problem. Now, break the bolt free and remove it.

Warning: If you did not buy a longer crank bolt, or the balancer install tool above, and you are reinstalling the stock pulley, you run the risk of stripping out the first few threads of the crankshaft. This will NOT be fun to fix!

Take your NEW crank pulley bolt and thread it in all the way by hand. Torque this bolt to 37lb/ft. Now, we need to stretch the bolt into place. Get your breaker bar and pipe extension, and try to turn the bolt 140 degrees past where it is at now, keeping in mind the engine will be trying to turn some and those are degrees you can't count. Again, I always seem to get about 90-100 degrees worth (estimating, knowing what 90 degrees looks like) and leave it as is so don't worry about going crazy here.

Once the pulley is installed, the timing cover should be nice and centered on it, so we can now tighten all 10 of those timing cover bolts. Torque them to 18lb/ft on the bolts you can get a torque wrench on, and just make the others you can't get the wrench on about as tight as those. Reinstall the A/C belt at this time by compressing the belt tensioner (clockwise) with a 15mm wrench.

Reinstall the water pump:

Reinstall the water pump now, using new gaskets if you bought them. Hand thread in all 6 water pump bolts as far as you can, then finish the job off with a wrench. Torque the water pump bolts in a 2 pass sequence, first to 11lb/ft, then do a second pass and tighten them to 22lb/ft. Connect the 2 smaller heater hoses going to the side of the water pump now.

Reinstall the serpentine belt:

You can now reinstall the main serpentine drive belt by compressing the belt tensioner (clockwise) with a 15mm wrench.

Reinstall the coolant cross flow tube (held on by 3 10mm bolts).

Reinstall the radiator:

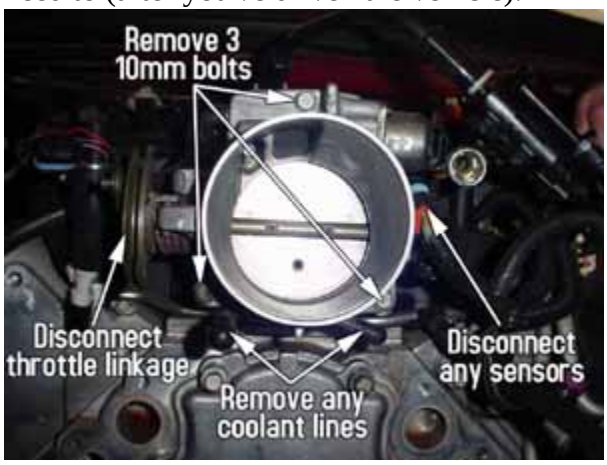
Now work the radiator back into place. This may take some effort, and you'll need to make sure the A/C condenser tabs slide back into the radiator slots so they are locked together. Once it's all back in, now reconnect the 2 big hoses going to the water pump, and reconnect your coolant vent tube that goes from the throttle body (or under the throttle body if you have a coolant bypass installed) to the radiator neck.

Reinstall the fan shroud assembly:

Re-attach the wiring harness back into place on the top rear of the fan shroud. You can now plug in both the fan electrical connectors as well.

Optional

Before you reinstall the air intake setup, you may want to drill your TB. This will be a trial and error process that will be different on each car and camshaft combination. If you purchased a very large cam and will be trying to drive it on stock tuning, go ahead and enlarge the hole a little even before we fire it up the first time. The *biggest* hole you should ever have to put in is around 1/4", so start small and work your way up later if you need to (after you've driven the vehicle).



To remove the throttle body, you'll need to unbolt the 3 10mm bolts holding it to the intake manifold, and also unclamp the 2 coolant lines running to the throttle body (unless you have a coolant bypass).

Once it is off the car you can drill it. There will already be a hole in the stock throttle body blade. Here we went a few bit sizes up from stock and enlarged the stock opening to a 3/16" hole.

Clean out any metal shavings from the throttle body after drilling, and reattach the throttle body to the intake manifold (the torque spec is 9lb/ft), and reconnect any coolant lines you may have disconnected.

End of optional section

Reinstall the MAF/pipe:

Place your Air box /MAF sensor/coupler assembly in place and slide the pipe onto the throttle body and tighten down the band clamps.

Reinstall the radiator shroud held on by 5 clips (pics to the left). Place the clips in the holes and tap them in.

Reinstall your strut tower brace (torque nuts to 22 Ft/lbs)

Reinstall your skid plate (if you aren't going to change the oil and filter now)

Now we need to do a final check on everything. Go ahead and start to fill up the radiator with coolant. You can fill it from the overflow tank. I like to mix mine before I fill the radiator but you can use this method as well. Put in one whole jug of Dex-cool® coolant. (Do NOT use green coolant, only orange Dex-cool® certified coolant.) Once you pour a jug in, fill the jug with distilled water and pour that in. Keep pouring until the radiator is full, and then keep the jug with water handy as we'll need to re-fill the radiator in a bit.

Double check your oil level, go over the engine bay and look for ANY loose connections, hoses, belts, wires, etc. If all looks good, go ahead and reconnect the battery cables and we're ready to rumble!

Make sure the radiator cap is removed and both coil pack main wiring harnesses are disconnected (one big white connector on each side). Get in the car. Insert the key, pray, and turn the motor over for 4 seconds...it won't start as long as you've disconnected the coil pack wires. If you heard a god awful noise, you screwed something up. Chances are the cam is either too big or the cam was not lined up right with the timing marks on the crank! THIS IS BAD, however, I know you followed my instructions so this didn't happen to you.

If the car turned over fine, connect the 2 coil pack harnesses. Now, PREPARE YOURSELF.

There are a few things you need to know before you turn the key:
1) The engine is going to be REALLY noisy for about 4-5 seconds. This is because the lifters need to pump up with oil. Also belts and pulley may squeak.
2) Smoke will start coming out of your engine bay like mad for the first 5 minutes. This is normal and is just coolant/oil/grease/fingerprints burning off all the stuff you touched.
3) The car may fire, and then die. You need to restart it if this happens and next time, give it 10% throttle and just try to keep it idling. Some cars take time to "learn" the cam so it may try to stall before then.

Are you ready?
Now... The car should idle really poorly (depending on how big you went with the cam), and rpms will fluctuate a lot. If it keeps trying to die, give it 5% throttle just to keep it idling and slowly back the throttle off until it knows how to stay alive on its own. If all is going well, let the car idle up to full temperature, making sure to constantly watch the radiator and refill as necessary.

Once the engine reaches full temp, reinstall the coolant fill cap and you are ready for your test drive! For the first day, cruise around in the car as long as you like and get the car nice and hot, but don't take the RPMS over 4000 until the springs have a chance to cool overnight. The next day you can take the car to redline, just remember that HIGH rpms on stiff high performance cold valve springs is bad, so from now on make sure your engine is warm before you beat on your car. OEM valve springs are MUCH more forgiving than high performance ones, so treat your motor nicely!

Final Notes:
- After you have 100 miles on it, it's probably good to go change the oil, re-check the coolant level and power steering level, and enjoy!

- Remember, with stiffer valve springs it becomes more important to make sure your car is fully warmed up before you take it to high rpms, as the springs are more brittle and prone to breaking when cold.

- If you have a check engine light, use an autotap scanner to pull the codes. A common code at this point is P0300 (Random Misfires), and may happen from time to time when idling depending on the size of your camshaft. This is nothing to worry about, and if it bugs you, tuning can get rid of it.

- Your car will try to die once you rev it up some and let off. This will make it difficult to drive at first, but after 100-200 miles of city driving it will learn itself out. If it doesn't, programming will be able to fix the issue or you can drill a bigger hole in your throttle body blade to let more air in at idle.

- More valvetrain noise is normal, depending on the ramp rates your new cam has. More aggressive cams WILL make the engine sound like a sewing machine, especially when you are inside the car driving with the windows up and radio off. This is normal.

Congrats! You have finished installing an LS1 cam and springs!
Enjoy your new power, and email me to let me know your success!

I'd like to thank:
- LS1HOWTO.com
- Joe Prince Racing for making a great tool to hold up the lifters
- Jason99TA, Patches, -Joseph-, Reckless, Country Boy, Visceral, TA GRRL, and RobertBartsch for offering some tech advice and/or proof reading feedback