BONUS SECTION 9: GENERAL POWERTRAIN & ROOT CAUSE ANALYSIS

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50 Questions — Targeted Review

1. A vehicle has a customer complaint of a rough idle that began three days ago. No warning lights are illuminated. The technician's FIRST step in the diagnostic process should be:

A. Perform a cylinder contribution test to identify which cylinder is causing the rough idle

B. Connect a scan tool and check for stored DTCs before any other testing — stored DTCs provide the most targeted starting point for diagnosis

C. Verify the customer's concern by duplicating the rough idle condition — confirming the symptom exists and understanding its exact characteristics (when it occurs, under what conditions, how severe) is always the first diagnostic step before any testing begins. A symptom that cannot be verified cannot be diagnosed accurately

D. Perform a fuel pressure test — fuel pressure is the most common cause of rough idle conditions

2. A vehicle has a P0128 — Coolant Temperature Below Thermostat Regulating Temperature. The customer reports fuel economy has decreased 15% and the heater does not get very warm. The MOST likely cause is:

A. A stuck-open thermostat — a thermostat that cannot close allows coolant to continuously circulate through the radiator regardless of engine temperature, preventing the engine from reaching normal operating temperature. The PCM detects the coolant temperature never reaching the thermostat regulating threshold and sets P0128. Cold running causes open-loop rich operation, reducing fuel economy, and the heater cannot produce adequate heat from engine coolant that never reaches normal temperature

B. A failed coolant temperature sensor reading too low — a failed sensor generates circuit codes, not P0128

C. A leaking head gasket allowing combustion gases into the cooling system preventing temperature buildup

D. A faulty PCM coolant temperature calculation from a failed MAP sensor

3. A vehicle has a P0507 — Idle Control System RPM High. The technician checks IAC valve operation — the IAC valve is fully seated (commanded minimum air). Idle RPM is 1,100 RPM (specification 650–750 RPM). The MOST likely cause is:

A. A failed IAC valve stuck open — the IAC is confirmed fully seated ruling out a stuck-open valve

B. A short to voltage on the IAC driver circuit causing the valve to be held open despite the command

C. An uncontrolled air leak bypassing the throttle body — when the IAC valve is fully seated and confirmed at minimum air, any additional air entering the intake manifold past the throttle plate raises idle RPM above what the IAC can control. A vacuum leak, a disconnected intake hose, a leaking throttle body gasket, or a stuck-open EVAP purge solenoid provides uncontrolled air that the PCM cannot reduce by closing the IAC further

D. A faulty TPS causing the PCM to misinterpret throttle position and command high idle compensation

4. A vehicle has intermittent stalling at idle that occurs randomly and cannot be reproduced on demand. No DTCs are stored. The MOST productive diagnostic approach is:

A. Replace the idle air control valve — intermittent stalling at idle is almost always caused by the IAC valve

B. Install a data logger or graphing scan tool to monitor critical PIDs during normal vehicle operation — connect a scan tool capable of recording, configure it to capture RPM, MAP, MAF, TPS, fuel trims, CKP signal, and IAC position, and have the customer drive the vehicle until the stall occurs. The data captured just before the stall identifies which parameter changed abnormally and points to the root cause that cannot be duplicated on demand

C. Perform a thorough visual inspection of all vacuum lines and connections before any electronic testing

D. Replace the crankshaft position sensor — the CKP sensor is the most common cause of intermittent stalling without DTCs

5. A vehicle has a confirmed P0300 — Random Misfire. The technician performs a cylinder contribution test — all cylinders show 35–42 RPM drops except cylinder 3 which shows 38 RPM drop. All cylinders have equal RPM drops. No cylinder is identified as the sole misfire source. The MOST likely cause of random misfire when all cylinders contribute equally is:

A. All cylinders have simultaneous individual ignition faults requiring all coils and plugs to be replaced

B. A cylinder contribution test is not sensitive enough to detect random misfires — the test is invalid for P0300 diagnosis

C. A system-level fault affecting all cylinders simultaneously — when all cylinders contribute equally and no single cylinder is the misfire source, the fault is in a shared system: low fuel pressure (all injectors starved under demand), MAF sensor undercounting (all cylinders run lean intermittently), a vacuum leak (all cylinders affected by unmetered air), or an ignition timing fault (affects all cylinders simultaneously). System-level root cause analysis is required

D. A random misfire from PCM software corruption generating false P0300 — all equal contributions confirm no physical misfire exists

6. A vehicle has a customer complaint of hesitation during light acceleration from a stop. The hesitation lasts approximately 1–2 seconds then clears. No DTCs are stored. The technician drives the vehicle and duplicates the concern. A scan tool shows TPS signal drops from 0.52V to 0.38V briefly during the hesitation event. Normal TPS signal at idle is 0.52V. The MOST likely cause is:

A. A TPS voltage drop during light throttle application that momentarily signals a closed throttle to the PCM — causing the PCM to briefly reduce fuel delivery as if the throttle were closing, creating the 1–2 second lean hesitation. The TPS drop from 0.52V to 0.38V during application is an intermittent fault in the TPS wiring, a worn TPS resistance track, or a TPS connector issue

B. A MAF sensor fault causing incorrect airflow calculation during the tip-in event

C. A delayed injector response from a weak fuel pump affecting tip-in fuel delivery

D. An IAC valve that closes too slowly during throttle tip-in causing an air-fuel ratio lean transient

7. A vehicle has a P0335 — CKP Sensor Circuit. The engine cranks but does not start. The technician confirms the CKP sensor air gap is within specification. The CKP sensor resistance measures 1,240 ohms — within the 800–1,600 ohm specification. The MOST likely cause is:

A. A worn reluctor wheel — worn teeth generate acceptable resistance but weak voltage signals

B. A failed CKP sensor with normal resistance — resistance within specification does not confirm the sensor generates adequate AC voltage during rotation. A CKP sensor that passes resistance testing can still fail to produce a usable signal under dynamic conditions from a failed internal magnet, internal wiring fault, or physical damage to the sensing element

C. An open or short in the CKP sensor wiring between the sensor and the PCM — wiring faults produce circuit codes and the resistance measurement tests the sensor directly

D. A PCM CKP input circuit fault — the PCM input circuit fault generates a circuit code but does not affect sensor resistance measurement at the sensor connector

8. A vehicle has a complaint of poor fuel economy — customer reports 18 MPG when the specification is 28 MPG. No DTCs are stored. The MIL is off. Fuel trims at idle are STFT = -12%, LTFT = -14%. At 2,500 RPM: STFT = -10%, LTFT = -14%. The MOST likely root cause of poor fuel economy and rich fuel trims at all RPM without DTCs is:

A. A clogged air filter reducing airflow and enriching the mixture at all conditions

B. A stuck-open EVAP purge solenoid continuously delivering fuel vapors to the intake manifold at all operating conditions — a stuck purge solenoid causes persistent rich fuel trims across all RPM ranges. Because the PCM corrects with negative LTFT, fuel trims stay just within the DTC threshold (±25% on most platforms), preventing MIL illumination while causing significant fuel economy loss from the continuous vapor enrichment. Disabling the purge solenoid and monitoring fuel trim response is the key diagnostic test

C. A rich condition from a leaking fuel injector causing excess fuel delivery on one cylinder affecting both bank trims

D. A failed MAP sensor stuck at high vacuum reading — MAP stuck high causes rich condition at all conditions

9. A vehicle has a P0101 — MAF Sensor Circuit Range/Performance. The technician measures MAF sensor output at idle — 2.8 g/s. A known-good identical vehicle at the same conditions measures 2.2 g/s. The technician also notices fuel trims are STFT = -16%, LTFT = -18% at idle, normalizing near zero at 2,500 RPM. The MOST likely cause is:

A. A MAF sensor with a contaminated sensing element overcounting airflow at idle — when the MAF reads higher than actual airflow, the PCM delivers more fuel than needed, causing rich fuel trims. The trims normalizing at 2,500 RPM is characteristic of MAF overcounting at idle (non-linear contamination pattern). MAF overcounting causes rich trims at idle that reduce at higher RPM — the opposite of the undercounting lean pattern

B. A vacuum leak — vacuum leaks cause lean trims that normalize at RPM, not rich trims

C. A failed MAF sensor producing an intermittent high signal — a completely failed sensor causes circuit codes, not range/performance codes with specific trim patterns

D. A PCM calibration error interpreting MAF signal incorrectly at idle speeds only

10. A vehicle has a P0562 — System Voltage Low. Battery voltage at idle = 11.4V. The alternator output at idle = 11.2V. Specification is 13.5–14.5V at idle. The MOST likely cause is:

A. A failed alternator — an alternator producing 11.2V at idle (below the 13.5V minimum) has failed and cannot maintain adequate system voltage. A failing alternator diode, a failed voltage regulator, or a worn rotor causing insufficient magnetic field can all reduce alternator output below system requirements, causing system voltage to drop below battery voltage as the alternator draws from the battery instead of charging it

B. A high-resistance battery terminal connection — a corroded terminal drops voltage between the battery and the alternator but does not affect alternator output voltage measurement

C. A failed battery unable to accept charge from the alternator — a failed battery causes abnormal charging voltage, not low system voltage with low alternator output

D. A slipping alternator belt — a slipping belt reduces alternator speed but would show low voltage at high electrical loads, not at idle

11. A vehicle has a complaint of engine surging at highway cruise — RPM fluctuates between 1,650 and 1,950 RPM in a regular rhythmic pattern at 65 mph without throttle input changes. The TCC (torque converter clutch) is locked. No DTCs are stored. The MOST likely cause is:

A. A vacuum leak causing lean lean surge — vacuum leak surges are typically at idle, not at highway cruise with TCC locked

B. A MAP sensor fault causing rhythmic PCM fuel correction cycles

C. A partially clogged fuel injector on one cylinder causing intermittent lean combustion events that build in amplitude with TCC locked — TCC lock-up couples the engine directly to the driveline, removing the torque converter's dampening effect. Any cyclic combustion variation — from a partially clogged injector, a marginal ignition component, or intermittent EGR flow — becomes amplified into a driveable surge because the engine RPM fluctuation transfers directly through the locked TCC to the drivetrain and vehicle body

D. A TCC solenoid cycling on and off — TCC cycling produces engagement/disengagement sensations, not smooth rhythmic RPM oscillation

12. A vehicle has a confirmed misfire on cylinder 2. After swapping the coil and spark plug to other cylinders, the misfire remains on cylinder 2. Compression = 180 psi. An injector contribution test shows near-zero RPM drop on cylinder 2. All other cylinders show 38–42 RPM drop. The MOST likely cause is:

A. A mechanical fault on cylinder 2 not detectable by compression test — near-zero RPM contribution with normal compression and normal ignition (coil swap confirmed) requires a leakdown test to rule out subtle valve seating issues

B. A clogged cylinder 2 injector — the coil swap rules out the ignition, normal compression rules out mechanical, and near-zero RPM drop during the contribution test with all other cylinders contributing normally confirms the cylinder 2 injector is not delivering fuel. A clogged injector with near-zero contribution is the root cause confirmed by systematic elimination

C. A cylinder 2 PCM injector driver fault — driver faults cause contribution test abnormalities but require voltage testing to confirm

D. A cylinder 2 intake valve carbon deposit blocking fuel delivery — carbon deposits cause mechanical restriction, not injector-specific contribution faults

13. A vehicle has P0171 and P0174 — System Lean Both Banks simultaneously. The technician suspects a MAF sensor fault. Before condemning the MAF sensor, the technician should perform which test to differentiate a MAF fault from a vacuum leak:

A. Replace the MAF sensor and monitor fuel trim response — replacement is the most definitive MAF test

B. Spray carburetor cleaner around intake manifold gaskets while monitoring for RPM change — an RPM change confirms a vacuum leak

C. Compare fuel trim behavior at idle versus 2,500 RPM — a vacuum leak causes positive trims at idle that normalize significantly at higher RPM (the fixed leak is a smaller percentage of total airflow at higher RPM). A MAF undercounting fault causes positive trims at idle that also remain elevated at higher RPM because the MAF undercount error is present across all operating conditions. If trims are lean at idle but normalize at 2,500 RPM, suspect a vacuum leak. If trims remain lean at both idle and 2,500 RPM proportionally, suspect MAF undercounting

D. Disconnect the MAF sensor and compare fuel trim response — MAF disconnection forcing the PCM into speed-density mode can improve or worsen trims depending on the fault direction

14. A vehicle has a complaint of hard starting only when hot. Cold starts are normal. The engine starts immediately after a cold overnight soak. After a 30-minute highway drive and a 45-minute hot soak, the engine requires 8–10 seconds of cranking before firing. Fuel pressure holds at 52 psi for 30 minutes after hot shutdown. The MOST likely cause is:

A. A failed fuel pump — the fuel pressure hold confirms adequate pressure, ruling out a pump failure

B. A leaking fuel injector causing flooding during hot soak — pressure holds ruling out injector leakdown

C. A failed coolant temperature sensor sending a cold signal — a cold signal causes extra enrichment during hot start

D. Fuel vapor lock in the supply line from heat soak — the pressure hold confirms the sealed fuel system maintains pressure, but fuel in the supply line nearest the hot engine compartment can vaporize during the 45-minute heat soak. The vapor compresses when the pump starts but does not deliver liquid fuel until purged — requiring extended cranking before liquid fuel reaches the injectors. Pressure holding in the rail does not rule out vapor in the supply line upstream of the rail

15. A vehicle has a P0562 — System Voltage Low occurring intermittently only at high electrical loads (headlights on, A/C on, rear defrost on simultaneously). Battery voltage at rest = 12.6V. Alternator output at idle = 14.1V (normal). The MOST likely cause is:

A. A battery with reduced capacity — a battery that tests normal at rest but cannot support high electrical load simultaneously with normal charging indicates reduced cold cranking capacity. However, P0562 under combined high electrical load is more specifically a system voltage fault

B. A failed alternator unable to maintain output at high electrical demand — an alternator producing 14.1V at idle with no load but unable to maintain voltage under combined maximum electrical load has insufficient output capacity for the vehicle's electrical demand. This can be caused by worn brushes, a weakening rotor, or an internal diode fault that allows adequate output at low demand but insufficient output at maximum demand

C. A high-resistance ground circuit between the alternator and the battery — a ground resistance fault reduces charging efficiency only under high current conditions when the voltage drop becomes significant

D. A battery that requires replacement — a battery failing under combined load does not produce P0562; it simply discharges

16. A vehicle has a TSB (Technical Service Bulletin) that addresses a specific intermittent stalling condition matching the customer's complaint exactly. The technician should:

A. Perform the complete standard diagnostic procedure first before applying the TSB repair — TSBs are secondary to standard diagnosis

B. Review the TSB to understand the described fault, the required diagnostic steps within the TSB, and the specified repair — TSBs represent manufacturer-confirmed failure patterns with validated repairs. A TSB that exactly matches the customer complaint should be reviewed immediately and the TSB diagnostic and repair procedure followed. Performing redundant standard diagnosis before checking TSBs wastes diagnostic time when the manufacturer has already identified and documented the repair

C. Apply the TSB repair immediately without any diagnosis — TSBs specify the repair without requiring technician confirmation

D. Request the customer to duplicate the concern during the technician's test drive before reviewing the TSB

17. A vehicle has a P0016 — Crankshaft/Camshaft Position Correlation. The engine has a timing chain. The MOST likely cause requiring immediate attention is:

A. A failed CKP sensor producing an incorrect signal relative to the CMP sensor

B. A failed CMP sensor producing a signal that does not correlate with the CKP signal

C. A stretched timing chain or jumped timing causing the camshaft position to be out of phase with the crankshaft position — a P0016 correlation code indicates the CMP sensor signal does not match the expected position relative to the CKP signal. A stretched timing chain advances or retards camshaft timing beyond the correlation threshold. A jumped chain can cause significant cam/crank position discrepancy. This fault requires immediate engine teardown evaluation — continued operation risks engine damage from incorrect valve timing

D. A PCM software fault incorrectly calculating the correlation between CKP and CMP signals

18. A vehicle has multiple DTCs stored simultaneously: P0102 — MAF Low, P0122 — TPS Low, P0107 — MAP Low. All three sensors show low voltage simultaneously. The MOST likely single root cause is:

A. Three independent sensor failures occurring simultaneously from a voltage surge event

B. A failed PCM 5V VREF (voltage reference) output — all three sensors (MAF, TPS, MAP) share the PCM's 5V reference supply as their input supply voltage. If the 5V VREF circuit fails or becomes shorted to ground, all sensors sharing that reference simultaneously produce low voltage outputs — generating multiple sensor low codes from a single PCM VREF fault. This is one of the most important multiple DTC root cause patterns in powertrain diagnosis

C. A failed sensor ground circuit — a single ground fault generates one sensor circuit code

D. A shorted MAP sensor pulling down the 5V reference — a shorted sensor affects all shared sensors, but this is a component fault not a PCM fault

19. A vehicle has a P0340 — CMP Sensor Circuit. The engine runs but has reduced power and intermittent stumbling. The technician checks the CMP sensor signal with a lab scope — the sensor produces a clear, consistent signal during normal operation. During aggressive acceleration, the signal briefly drops out for 50–100 milliseconds then resumes. The MOST likely cause is:

A. A worn camshaft reluctor ring with a damaged tooth — a damaged tooth produces a consistent missing pulse in the CMP signal at a specific engine position, not a random drop during acceleration

B. A failed CMP sensor with heat-induced failure — temperature-related sensor failures typically fail at high sustained temperature, not specifically during acceleration

C. A CMP sensor connector or wiring fault — an intermittent signal dropout specifically during aggressive acceleration (which produces engine vibration and chassis flex) points to a mechanical connection fault — a connector that loses contact during vibration, a wiring harness that flexes during acceleration and intermittently opens, or a terminal in the connector with marginal retention that loses contact under vibration

D. A PCM input circuit fault — PCM input faults typically produce consistent failures, not vibration-correlated intermittent dropouts

20. A vehicle has a customer complaint of reduced power on highway grades. No DTCs are stored. At sea level the vehicle performs normally. The customer's daily commute includes extended highway grades. Boost pressure on this turbocharged vehicle measures 12 psi at full throttle on the grade (specification 18–22 psi). The MOST likely cause is:

A. A wastegate stuck open — a stuck-open wastegate prevents boost from building to specification at all conditions, not specifically on grades

B. A boost pressure leak from a loose intercooler charge pipe — a charge pipe leak reduces boost under high demand conditions and may not be apparent at low loads. Extended high-load grade climbing places sustained maximum demand on the turbo boost system — a loose charge pipe that seals adequately at low boost but opens under high boost pressure produces exactly the reduced boost under high demand conditions described

C. A clogged air filter reducing intake airflow and limiting boost development

D. A failed MAP sensor reading low — a failed MAP sensor generates circuit codes under most conditions

21. A vehicle has a complaint of an oil consumption rate of approximately 1 quart per 1,500 miles. No external oil leaks are found. Blue-gray smoke is visible at cold startup that clears after 2 minutes. No coolant loss is evident. The MOST likely cause is:

A. A failed PCV system causing crankcase pressure to push oil into the intake manifold

B. A cracked head gasket allowing combustion gases to mix with oil — head gasket faults produce coolant loss, not isolated oil consumption without coolant changes

C. Worn valve stem seals allowing oil to drain down the valve stems into the combustion chamber during the overnight cold soak — valve seal leakage is characteristically worst at cold startup (when oil has drained down the stems during the soak period) producing blue-gray smoke that clears as the seals warm and expand. No coolant loss rules out a head gasket, no external leaks confirm the oil is being burned internally

D. Worn piston rings causing oil to enter the combustion chamber — ring wear produces continuous blue smoke at all operating conditions, not specifically at cold startup only

22. A vehicle has a P0011 — Camshaft Position Actuator Over-Advanced Bank 1. The oil is 6 quarts low and very dark. The VVT system uses oil pressure to actuate the camshaft phaser. The MOST likely root cause is:

A. A failed camshaft position actuator solenoid — a failed solenoid generates circuit codes, not over-advanced performance codes

B. A failed VVT timing chain — a stretched chain advances cam timing regardless of oil pressure

C. A failed camshaft phaser — a phaser stuck in the advanced position generates P0011 from a mechanical fault

D. A worn engine producing insufficient oil pressure to the VVT system — extremely low oil level combined with very dark (degraded) oil causes multiple VVT system faults. Low oil level reduces the oil available to actuate the camshaft phaser. Dark degraded oil has increased viscosity from oxidation and contamination, reducing flow to the phaser control solenoid passages. The combination of low oil level and degraded oil is the most common root cause of P0011 performance codes on high-mileage VVT engines

23. A vehicle has a complaint of knocking noise from the engine that increases with RPM. Oil pressure at idle = 14 psi (minimum specification 15 psi). Oil pressure at 2,000 RPM = 28 psi (specification 35 psi minimum). The MOST likely cause is:

A. A failed oil pump producing insufficient pressure at all RPM ranges

B. A clogged oil pick-up screen reducing oil pump inlet flow — a restricted pick-up screen starves the pump at all RPM but is most severe at higher RPM when demand is greatest

C. A worn main or rod bearing — low oil pressure at both idle and RPM with a RPM-correlated knocking noise is the classic presentation of worn crankshaft bearings. Worn bearings have excessive clearance that reduces oil film pressure. The increased clearance also allows the crankshaft to move enough to create the metallic knock that increases with RPM (more impacts per second at higher RPM). This is an internal mechanical wear diagnosis requiring engine rebuilding or replacement

D. A pressure relief valve stuck open allowing oil to bypass the bearing galleries at all pressures

24. A vehicle has a P0300 that only sets during extended cold weather operation below 20°F. No DTCs set during normal temperature operation. All ignition and fuel tests at normal operating temperature are normal. The MOST likely cause is:

A. A PCM calibration issue that incorrectly adjusts fuel delivery during cold ambient conditions

B. A spark plug with excessive carbon fouling that only causes misfire at cold temperatures — carbon fouled plugs cause consistent misfires at all temperatures, not specifically at extreme cold

C. A failed coolant temperature sensor sending incorrect data at cold ambient temperatures

D. A marginal ignition component (COP coil, spark plug, or plug boot) that cannot deliver adequate secondary voltage at extreme cold ambient temperatures when plug resistance is highest — spark plug electrode resistance increases significantly at very cold temperatures, requiring higher secondary voltage to fire. A marginal coil that fires adequately at normal temperatures may not produce sufficient voltage at extreme cold when the plug's increased resistance pushes the required firing voltage above the coil's cold-ambient output capability

25. A vehicle has a customer complaint of a grinding noise when turning left at low speeds in a parking lot. The noise is not present when turning right. No DTCs are stored. The MOST likely cause is:

A. A failed power steering pump — power steering pump failures produce noise during all turning conditions, not directional

B. A worn left front CV axle — CV axle noise is typically a clicking noise during turns, not grinding

C. A worn left front wheel bearing — a grinding noise that appears during one turn direction and not the other is characteristic of a wheel bearing fault. When turning left, weight transfers to the right — unloading the left bearing. When the left bearing is worn, unloading it (turning left) causes the damaged bearing to shift on its race, producing the grinding sound. The noise being absent when turning right (when the left bearing is loaded by weight transfer) confirms the left front bearing diagnosis

D. A worn brake pad on the left front — brake pad wear noise occurs during straight-line braking, not specifically during turns

26. A vehicle has a P0128 — Coolant Temperature Below Thermostat Regulating Temperature. The thermostat is replaced. After replacement, P0128 returns within 500 miles. The MOST likely cause of recurrent P0128 after thermostat replacement is:

A. The replacement thermostat is also defective — back-to-back thermostat failures indicate a supply quality issue

B. A cooling system with air trapped near the thermostat housing — an air pocket at the thermostat prevents hot coolant from contacting the thermostat wax element, causing the thermostat to remain open as if cold even after the engine reaches operating temperature. After a thermostat replacement, if air is not properly purged from the cooling system during the bleed procedure, the same P0128 returns from an air lock rather than a thermostat fault

C. A radiator cap with insufficient pressure rating allowing coolant to circulate at lower temperatures

D. A water pump impeller that has corroded off the shaft causing insufficient coolant circulation past the thermostat

27. A vehicle has a P0300 — Random Misfire that occurs only during a specific cold-to-warm engine transition period — approximately 3–8 minutes after cold start. After the engine is fully warmed, no misfire occurs. Cold starts are clean. The MOST likely cause is:

A. A vacuum leak that only appears during the temperature transition period

B. A failed coolant temperature sensor sending incorrect data during the transition period

C. A faulty oxygen sensor that produces false rich signals during the warm-up transition period — a false rich signal during warm-up causes lean over-correction misfire

D. A misfire during the catalyst light-off strategy — the PCM intentionally retards ignition timing significantly during the catalyst light-off period (3–8 minutes after cold start) to generate heat in the exhaust stream and quickly warm the catalyst. Aggressive timing retard during this period reduces combustion stability. A marginal component (spark plug with slightly wide gap, marginal coil output, slightly restricted injector) that fires normally at standard timing may misfire when timing is retarded during the light-off strategy — setting P0300 specifically during this window

28. A vehicle has a hard no-start condition. The starter motor cranks the engine normally. There is no spark confirmed on any cylinder. There is no injector pulse on any cylinder. Battery voltage = 12.6V. The MOST likely cause of simultaneous no-spark and no-injector pulse on all cylinders is:

A. A failed PCM — a failed PCM causes simultaneous loss of spark and injector pulses

B. A missing or failed CKP sensor signal — the PCM requires a CKP signal to determine crankshaft position before it will command any spark or injector events. Without a CKP signal, the PCM has no reference for ignition timing or injection timing and will not fire any coil or injector. A failed CKP sensor, a broken reluctor wheel, or a CKP wiring fault that prevents the PCM from receiving position data causes simultaneous no-spark and no-injection on all cylinders

C. A blown main ECM fuse — a blown main fuse prevents PCM power and would cause no communication with the scan tool

D. A failed immobilizer preventing PCM output commands — an active immobilizer prevents PCM outputs on some platforms

29. A vehicle has a complaint of excessive black smoke from the exhaust at idle and acceleration. Fuel trims are STFT = -22%, LTFT = -19%. No DTCs are stored. The smoke is consistent and does not clear. The MOST likely cause is:

A. A failed catalytic converter oxidizing excess hydrocarbons visibly

B. A clogged air filter severely restricting airflow — a severely clogged air filter dramatically reduces airflow past the MAF sensor. The PCM delivers fuel based on the low MAF reading, but the actual airflow restriction reduces the air entering the engine even further — creating an extremely rich mixture from excess fuel relative to restricted air. Severe filter restriction causes black smoke, extreme negative fuel trims, and reduced power without generating a DTC if trim stays within the correction threshold

C. A fuel pressure regulator stuck fully open flooding all injectors — stuck regulators generate rich conditions with negative trims

D. A turbocharger oil seal failure allowing engine oil into the intake charge producing black smoke

30. A vehicle has been diagnosed with a P0420 — Catalyst Efficiency Below Threshold. Before authorizing catalytic converter replacement, the service advisor confirms with the technician that all false P0420 causes have been eliminated. Which combination of tests MOST completely rules out the three most common false P0420 causes:

A. Upstream O2 sensor replacement, downstream O2 sensor replacement, and converter inspection

B. Exhaust leak inspection between the upstream sensor and the converter, downstream O2 sensor output test, and fuel system rich/lean evaluation — these three tests address the three most common false P0420 causes: an exhaust leak introducing oxygen between upstream sensor and converter (most commonly missed), a failed downstream sensor stuck at a constant lean voltage, and a fuel system fault (rich or lean) causing abnormal exhaust chemistry that degrades catalyst monitoring accuracy

C. Five-gas tailpipe test, upstream O2 sensor switching test, and compression test

D. MAF sensor comparison test, injector balance test, and downstream O2 sensor replacement

31. A vehicle has a complaint of a clicking noise from the top of the engine that increases with RPM and diminishes after 2–3 minutes of running. Oil level is full. Oil pressure is within specification. The MOST likely cause is:

A. A collapsed hydraulic lifter that cannot pump up after an overnight cold soak — a single collapsed lifter produces a clicking noise at cold start that diminishes as oil pressure fills the lifter and restores normal valve train clearance. The noise diminishing after 2–3 minutes of running confirms the lifter is pumping up as oil pressure is sustained. Full oil level and normal oil pressure rule out a lubrication system fault — the collapsed lifter is the mechanical fault

B. A worn timing chain tensioner — tensioner noise is a rattling sound, not a clicking that diminishes

C. A failed valve spring — a failed spring produces consistent noise at all temperatures that does not self-resolve

D. A worn camshaft lobe — worn camshaft lobes produce noise consistent across all temperatures and do not diminish with warm-up

32. A vehicle has a complaint of surging and rough running. Fuel trims are: STFT = +4%, LTFT = +22% at idle. At 2,500 RPM: STFT = -16%, LTFT = +22%. This fuel trim pattern (positive LTFT with positive STFT at idle but negative STFT at 2,500 RPM) is the classic pattern for:

A. A vacuum leak — vacuum leak trims normalize at RPM (STFT moves toward zero at higher RPM), but the STFT going NEGATIVE at 2,500 RPM indicates an overcorrection

B. A MAF sensor that is overcounting at higher RPM but undercounting at idle — a contaminated MAF sensor can produce non-linear errors. The LTFT of +22% built up at idle (where the MAF undercount is worst). At 2,500 RPM the MAF overcounts (reads more air than actual), causing the PCM to overcorrect with negative STFT. The pattern of positive LTFT from idle-learned undercounting combined with negative STFT at higher RPM from overcounting is the MAF contamination non-linear error signature

C. Low fuel pressure — low pressure causes lean trims at all RPM proportionally, not a non-linear pattern

D. Weak fuel injectors — weak injectors cause proportionally positive trims at all RPM conditions

33. A vehicle has a P0087 — Fuel Rail Pressure Too Low and a P0300 — Random Misfire stored simultaneously. The technician should MOST likely:

A. Diagnose each DTC independently — P0087 and P0300 are unrelated faults on most vehicles

B. Replace the fuel pump and spark plugs simultaneously — the two most common causes of both codes

C. Diagnose the P0087 fuel pressure fault first — low fuel pressure causes lean misfire. The P0300 is likely a secondary code caused by the lean combustion from insufficient fuel pressure. If insufficient rail pressure starves the injectors during demand, multiple cylinders run lean and misfire randomly — generating P0300 from the primary fuel pressure fault. Correcting the fuel pressure fault should resolve both codes without independent misfire diagnosis

D. Replace the fuel filter — a clogged filter causes both P0087 and P0300 simultaneously

34. A vehicle has a P0171 — System Lean Bank 1 and a P0301 — Cylinder 1 Misfire stored simultaneously. Bank 1 fuel trims: STFT = +16%, LTFT = +18%. All other cylinders contribute normally in a contribution test. The MOST likely single root cause is:

A. A vacuum leak on Bank 1 causing both lean trim and a weak enough mixture to misfire on cylinder 1

B. A failed cylinder 1 COP coil — a failed coil causes misfire and potentially lean O2 sensor response from unburned oxygen in the exhaust

C. A clogged cylinder 1 fuel injector — a clogged injector delivers insufficient fuel to cylinder 1, causing both a lean condition (contributing to Bank 1 positive fuel trims) and a misfire on cylinder 1 from the insufficient fuel charge. The contribution test showing abnormal results specifically on cylinder 1 combined with the lean Bank 1 trim (partially driven by cylinder 1's lean misfire) confirms the injector as the likely single root cause. Coil swap should be performed first to confirm the ignition system is not at fault

D. A cylinder 1 mechanical fault (low compression) causing lean misfire — compression testing is required before the injector is confirmed

35. A vehicle has a complaint of stalling when coming to a stop from highway speeds. The stall occurs as the vehicle decelerates from approximately 40 mph to a stop. The engine restarts immediately after stalling. No DTCs are stored. At highway speed and at idle (when not decelerating from highway speed) the vehicle runs normally. The MOST likely cause is:

A. A failed IAC valve that cannot open fast enough during deceleration to maintain idle — during deceleration from highway speed, the throttle closes rapidly. The PCM commands the IAC valve to open to maintain idle airflow. A slow-responding or partially stuck IAC valve that cannot open quickly enough allows RPM to drop below idle during the transition from high-speed deceleration to idle, causing the engine to stall before the IAC can compensate

B. A TCC solenoid that does not disengage properly during deceleration — TCC non-disengagement causes driveline shudder and engine lug, not clean stalling with immediate restart capability

C. A fuel pressure regulator that collapses pressure during deceleration vacuum spikes

D. A MAP sensor fault misreporting vacuum during deceleration causing incorrect fuel cut-off timing

36. A vehicle has a P0302 — Cylinder 2 Misfire. After extensive diagnosis all ignition, fuel, and compression tests on cylinder 2 are normal. A cylinder leakdown test on cylinder 2 shows 4% leakage — within the 10% specification. The technician performs a relative compression test using a scan tool — cylinder 2 shows a 28% lower compression contribution during cranking compared to all other cylinders. A static compression test shows 175 psi — equal to all others. The MOST likely cause is:

A. A worn camshaft lobe on cylinder 2 — a worn lobe produces reduced valve lift and duration, reducing cylinder filling. A worn camshaft lobe does not show abnormal results in a static compression test (which measures maximum cylinder pressure with the throttle open and engine cranking) but may show reduced contribution in a running relative compression test where valve timing differences affect filling efficiency under actual firing conditions

B. A failed PCM misfire detection algorithm incorrectly targeting cylinder 2

C. A cylinder 2 injector fault — injector faults are confirmed by contribution testing, which showed normal in this case

D. A cylinder 2 spark plug gap that is borderline — borderline plug gaps produce ignition faults, not compression-related relative test abnormalities

37. A vehicle has a P0300 and P0171. The technician suspects a lean misfire. The MOST definitive confirmation that the misfire is lean-induced (rather than ignition-induced) is:

A. Using a five-gas exhaust analyzer — elevated HC with elevated O2 confirms misfire but does not distinguish lean from ignition as the cause

B. A fuel pressure test — low fuel pressure confirms lean but is not specific to which cylinders are misfiring

C. Confirming the P0300 misfire clears when the lean condition (P0171) is resolved — if repairing the lean cause (vacuum leak, MAF fault, fuel pressure) also resolves the P0300 without any independent ignition repair, the misfire was lean-induced. A misfire from an ignition fault would not resolve when only the fuel trim fault is corrected. This cause-and-effect relationship between P0171 resolution and P0300 resolution is the definitive confirmation of a lean-induced misfire

D. A cylinder contribution test showing all cylinders contributing equally — equal contribution confirms system-level lean misfire

38. A vehicle has a cold start concern — rough idle for the first 60 seconds after a cold start in sub-freezing temperatures that self-resolves. No DTCs are stored. All warm tests are normal. A cold start fuel trim analysis shows STFT = +18% for the first 30 seconds then gradually returns to ±3%. The MOST likely cause is:

A. A cold-start fuel injector fault — cold start injectors always set DTCs when they fail

B. A failed coolant temperature sensor sending incorrect cold data to the PCM — a failed coolant sensor reading warmer than actual cold temperature causes the PCM to underestimate cold enrichment requirements, causing a lean cold-start condition evidenced by the positive STFT correction. The PCM delivers normal warm-up fuel because it believes the engine is warmer than actual, requiring the closed-loop O2 sensor system to correct with +18% STFT until the sensor data more accurately reflects actual conditions

C. Normal cold-start combustion variation — STFT of +18% during cold start always indicates normal operation

D. A cold-start ignition fault causing lean combustion from incomplete firing events — ignition faults cause elevated HC and O2, not positive fuel trim corrections

39. A vehicle has a P0087 — Fuel Rail Pressure Too Low. A new fuel pump is installed. After replacement, fuel pressure at WOT is still below specification. The technician bypasses the in-tank fuel filter with an external filter — fuel pressure at WOT returns to normal. The MOST likely conclusion is:

A. The replacement fuel pump is also defective — fuel pressure returning to normal with external filter confirms the pump is functional

B. A kinked fuel supply line — a kinked line would not be bypassed by installing an external filter

C. A clogged in-tank fuel filter integrated with the fuel pump module was not replaced with the pump — the external filter bypass test confirms the fuel pump can deliver adequate pressure when not restricted by the in-tank filter. The clogged in-tank filter was the restriction causing P0087, and if the replacement pump did not include a new integrated filter assembly, the restriction remained. This confirms the filter (or complete pump module with integrated filter) requires replacement

D. A partially collapsed fuel supply line restriction — supply line restrictions cannot be bypassed by an external filter

40. A vehicle has a P0340 — CMP Sensor Circuit. A new CMP sensor is installed. P0340 returns within two drive cycles. The MOST likely cause of repeat P0340 after sensor replacement is:

A. The replacement CMP sensor is also defective — back-to-back CMP sensor failures require investigation of an underlying cause

B. A fault in the CMP sensor wiring harness — an open circuit, short to ground, or short to voltage in the wiring between the CMP sensor connector and the PCM generates P0340 regardless of which sensor is installed. The new sensor resolves any internal sensor fault but cannot overcome a wiring fault in the harness. Wiring continuity and insulation testing between the CMP connector and the PCM confirms or rules out a harness fault

C. A worn camshaft reluctor ring producing a weak signal the new sensor cannot read

D. A PCM input circuit fault that damages replacement CMP sensors within two drive cycles

41. A vehicle has a P0011 — Camshaft Position Over-Advanced Bank 1. The VVT solenoid for Bank 1 is replaced. P0011 returns. The solenoid is confirmed clean and functioning. The technician checks the oil pressure to the Bank 1 VVT solenoid under load — oil pressure is 42 psi (within specification). The MOST likely remaining cause is:

A. A faulty Bank 1 camshaft phaser that is stuck in the advanced position mechanically — with the VVT solenoid confirmed functional and oil pressure confirmed adequate, a phaser that is mechanically seized in the over-advanced position is the remaining cause. A phaser stuck advanced receives the correct oil pressure signal from the functional solenoid but cannot mechanically respond, maintaining the over-advanced cam position regardless of PCM command

B. An internal PCM fault generating false P0011 after confirmed component replacement

C. A stretched timing chain advancing cam timing despite correct VVT operation — stretched chains generate P0016 correlation codes, not P0011 performance codes specifically

D. A worn camshaft lobe affecting cam timing position readings from the CMP sensor

42. A vehicle has multiple related DTCs stored: P0300, P0171, P0174, and P0507 (idle RPM high). All four codes appeared simultaneously on the same drive cycle. The MOST likely single root cause for all four codes is:

A. A MAF sensor fault — MAF undercounting causes lean codes and random misfire but not high idle

B. A PCM software corruption — software faults require reprogramming but rarely generate all four simultaneously

C. A large uncontrolled vacuum leak — a large vacuum leak introduces unmetered air into the intake manifold simultaneously causing: high idle RPM (extra air raises idle, P0507), lean fuel trims on both banks (extra air dilutes the mixture, P0171 and P0174), and lean misfire from the excessively lean mixture (P0300). A single large vacuum leak is the most common single root cause capable of generating all four of these codes simultaneously

D. A stuck-open IAC valve allowing excessive air — a stuck-open IAC causes high idle and lean trims but not necessarily P0300

43. A vehicle has a complaint of excessive oil consumption of 1 quart per 600 miles with continuous blue smoke at all operating temperatures — not just at cold start. No external leaks. The MOST likely cause is:

A. A failed PCV valve causing crankcase pressure to push oil into the intake at all RPM

B. Failed valve stem seals — valve seal failures are characteristically worst at cold start, not continuous across all temperatures

C. Worn piston rings or cylinder walls — blue smoke at all operating temperatures (not limited to cold start) with no external leaks is the worn ring/cylinder wall pattern. Worn rings cannot prevent oil from the crankcase from passing the ring pack into the combustion chamber continuously under both vacuum (intake stroke) and pressure (compression and power strokes). Unlike valve seal leakage (which is worst at cold start), ring wear produces continuous blue smoke throughout all operating conditions

D. A failed valve cover gasket allowing oil to enter the intake manifold through the PCV system

44. A vehicle has a long-standing P0420 history. Previous repairs include two catalytic converter replacements and three upstream O2 sensor replacements. P0420 returns within 3,000 miles of each repair. No exhaust leaks, no downstream O2 sensor fault, no active misfire, and normal fuel trims. The MOST likely overlooked root cause is:

A. A faulty PCM that generates false P0420 codes regardless of component condition

B. A coolant intrusion from a failed head gasket contaminating and destroying each replacement catalyst — a head gasket leak that allows coolant to enter the combustion chamber produces steam in the exhaust that deposits silicates on the catalyst substrate, permanently deactivating the precious metal sites. The silicate contamination is not visible externally and does not always produce obvious symptoms (it can be a very minor seep). Coolant level monitoring, a block test for combustion gases in the coolant, and a combustion gas analyzer test at the coolant overflow would confirm this root cause

C. An aftermarket catalytic converter that does not meet OEM efficiency specifications

D. A PCM software calibration that sets P0420 at too low a threshold for this vehicle platform

45. A vehicle has a P0191 — Fuel Rail Pressure Sensor Performance. The scan tool shows rail pressure of 22 psi at idle. The technician installs a mechanical fuel pressure gauge — the gauge reads 52 psi at idle. The MOST likely cause is:

A. A clogged fuel injector causing actual fuel pressure to read lower than mechanical gauge measurement

B. A leaking fuel pressure regulator causing the mechanical gauge to read above actual pressure

C. A failed fuel rail pressure sensor reading significantly lower than actual pressure — the mechanical gauge confirms actual pressure is 52 psi (normal) while the scan tool (using the sensor signal) reads 22 psi. The sensor is producing a false low signal — either from internal sensor failure, a reference voltage fault at the sensor, or a signal wire fault. The discrepancy between mechanical gauge (actual pressure) and sensor reading (false low) confirms the sensor is the fault source

D. A restriction in the fuel rail between the sensor location and the mechanical gauge connection point

46. A vehicle has a complaint of a transmission that slips briefly when cold. After 5–10 minutes of driving, transmission operation is completely normal. ATF level and condition are normal. No transmission DTCs are stored. The MOST likely cause is:

A. A failing torque converter causing cold slip — torque converters fail gradually and cause consistent issues, not temperature-dependent recovery

B. A transmission solenoid with cold resistance out of specification — cold solenoid resistance affects shift quality in some transmission designs. At cold temperatures, solenoid resistance is higher, which can reduce solenoid current and actuating force. As the transmission warms and solenoid resistance decreases to normal, shift quality recovers. This temperature-dependent solenoid behavior is a known failure pattern in certain transmission designs

C. Low ATF pressure from a cold pump — normal ATF level rules out a pressure fault from low fluid

D. A worn clutch pack that only slips when cold — worn clutch packs produce consistent slipping regardless of temperature

47. A vehicle has a P0562 — System Voltage Low. The battery tests at 620 CCA (specification 650 CCA — borderline). The alternator output is 13.8V (within specification). The technician checks the battery negative cable voltage drop from battery negative terminal to the engine block — 0.8V at idle. Specification is maximum 0.2V. The MOST likely cause and effect is:

A. A borderline battery is the primary cause of P0562 — the 30 CCA below specification is sufficient to cause low system voltage

B. A failed alternator despite the 13.8V reading — 13.8V does not confirm adequate current capacity

C. A high-resistance negative cable causing P0562 — the 0.8V voltage drop confirms 0.8V is being lost in the negative cable between the battery negative terminal and the engine block. This resistance reduces the effective voltage available to chassis-mounted components that reference the engine block as their ground — they see battery voltage minus the 0.8V drop, reducing effective supply voltage below the P0562 threshold during normal operation

D. A shorted cell in the battery causing the voltage drop across the negative cable

48. A vehicle has a no-start condition. The starter cranks normally. Spark is confirmed on all cylinders. Injector pulse is confirmed on all injectors. Fuel pressure is 54 psi — within specification. Compression is 175–182 psi on all cylinders. The technician cranks the engine with a timing light — the timing light confirms spark is occurring but at the wrong time (spark occurs during the exhaust stroke, not the compression stroke). The MOST likely cause is:

A. A failed CKP sensor sending an incorrect position signal to the PCM — the PCM fires the coils based on CKP position data. If the CKP signal is shifted 180 degrees from actual crankshaft position (due to a misindexed or incorrect replacement sensor, a damaged reluctor wheel, or a jumped timing chain), the PCM commands spark at the wrong stroke — firing during exhaust instead of compression

B. A failed CMP sensor causing incorrect cylinder identification and incorrect spark timing

C. A jumped timing chain advancing spark timing beyond the firing window for each cylinder

D. A PCM software fault commanding incorrect ignition timing for all cylinders simultaneously

49. A vehicle has a P0300 — Random Misfire that occurs only above 60 mph at light throttle. At all other conditions the vehicle runs perfectly. No other DTCs are stored. All component tests at idle and moderate loads are normal. The MOST likely cause is:

A. A TCC shudder being misidentified by the misfire monitor as actual misfires — at light throttle above 60 mph, the TCC locks. TCC apply shudder from a worn TCC friction surface or degraded ATF causes RPM fluctuations that the PCM's misfire detection algorithm (which detects combustion misfires by monitoring crankshaft deceleration) can misinterpret as actual engine misfires. This false P0300 from TCC shudder at light throttle highway speeds is a well-documented misdiagnosis pattern

B. A cylinder-specific misfire only at highway speeds from a partially clogged injector

C. An EGR fault causing combustion instability only at highway speeds above 60 mph

D. A MAP sensor fault producing incorrect vacuum readings at highway cruise causing lean misfire

50. A vehicle has completed all repairs for the session — all eight bonus sections and ten practice exams have been developed. A final review question: A vehicle has simultaneous P0171, P0174, P0300, P0507, and a P0507 — indicating system lean both banks, random misfire, and high idle RPM all from the same drive cycle, along with a vacuum leak found at a disconnected large-bore intake hose between the MAF sensor and the throttle body. The technician reconnects the hose and clears all DTCs. Which single action MOST efficiently confirms the repair resolved ALL five codes simultaneously:

A. Drive the vehicle and confirm no DTCs return, fuel trims return to within ±5%, idle RPM returns to specification, and no misfire is detected — performing a single comprehensive post-repair drive cycle that allows all affected monitors (Fuel System, Misfire, Comprehensive Component) to run and confirm no fault detection is the most efficient single confirmation action. All five codes were caused by the same disconnected intake hose — reconnecting it should resolve all five simultaneously. A single drive cycle monitoring all affected parameters confirms the single repair resolved all five simultaneously without individual component retesting

B. Confirm fuel trims return to normal first, then separately test idle RPM, then separately confirm no misfire

C. Replace the MAF sensor — a disconnected intake hose downstream of the MAF always damages the sensor

D. Perform individual component tests for each of the five code categories before clearing and retesting

BONUS SECTION 9: ANSWER KEY AND EXPLANATIONS

1. C — Verify the Customer Concern First — The fundamental first step in any diagnostic process is verifying the customer's concern by attempting to duplicate the symptom under the same conditions described by the customer. A symptom that cannot be verified may be intermittent, condition-specific, or require specific operating parameters to reproduce. Connecting a scan tool or performing component tests before verifying the symptom can lead to chasing data that is unrelated to the actual complaint. Symptom verification defines the diagnostic target before any testing begins.

2. A — Stuck-Open Thermostat — A thermostat that cannot close allows continuous coolant flow through the radiator, dissipating heat faster than the engine generates it at normal operating conditions. The engine temperature never reaches the thermostat's regulating point — the PCM detects this and stores P0128. Running cold causes the PCM to remain in open-loop rich operation longer than normal, significantly reducing fuel economy. The heater's inability to produce adequate warmth is directly explained by the coolant never reaching normal operating temperature.

3. C — Uncontrolled Air Leak Bypassing Throttle Body — When the IAC valve is at its minimum position (fully seated) and idle RPM is still above specification, the IAC cannot reduce idle further — it is already at minimum. Additional air must be entering the intake manifold through a path the IAC cannot control: a vacuum leak, a disconnected intake hose downstream of the throttle body, a leaking throttle body gasket, or a stuck-open EVAP purge solenoid. The IAC being at minimum position rules out IAC over-opening as the cause.

4. B — Install Data Logger to Monitor During Actual Stall Event — An intermittent stall that cannot be reproduced on demand requires capturing data at the moment the fault occurs under natural driving conditions. Configuring a scan tool to record multiple critical PIDs during normal vehicle operation and having the customer drive until the stall occurs captures the data immediately before and during the stall event — revealing which parameter changed abnormally. This approach provides objective evidence of the root cause rather than replacing parts based on probability without confirmation.

5. C — System-Level Fault Affecting All Cylinders — Equal RPM contributions from all cylinders eliminates individual cylinder faults as the source of random misfire. When every cylinder contributes equally and no single cylinder is deficient, the misfire source is in a system shared by all cylinders simultaneously. The diagnostic approach shifts from cylinder-specific testing to system-level evaluation: dynamic fuel pressure testing under demand, MAF comparison to known-good, vacuum leak verification under load, and ignition timing evaluation at operating conditions that trigger the P0300.

6. A — TPS Voltage Drop During Throttle Application — A TPS that momentarily drops voltage during light throttle application signals the PCM that the throttle is closing rather than opening. The PCM responds to a closing throttle by reducing fuel delivery — exactly the opposite of what is needed during a tip-in event. The 1–2 second lean hesitation corresponds to the brief period the PCM reduces fuel delivery in response to the false closing signal. The TPS voltage dropping from 0.52V to 0.38V during application rather than rising confirms the fault.

7. B — Failed CKP Sensor with Normal Resistance — Resistance testing of a CKP sensor confirms the integrity of the coil winding but does not confirm the sensor generates adequate output voltage during rotation. A CKP sensor with correct winding resistance can fail to produce a usable AC signal voltage due to a degraded internal permanent magnet, a failed reluctor pickup element, or physical contamination on the sensor tip — all of which prevent adequate signal generation despite normal resistance. Dynamic voltage output testing with a lab scope during cranking is required to confirm signal generation.

8. B — Stuck-Open EVAP Purge Solenoid — Persistent rich fuel trims across all RPM ranges (idle and 2,500 RPM equally) without DTCs is characteristic of a continuously flowing EVAP purge solenoid. The purge solenoid delivers a fixed volume of fuel vapor regardless of RPM, causing equal enrichment at all speeds. Because the PCM corrects with negative LTFT, the combined trim (STFT + LTFT) stays within the DTC threshold — preventing MIL illumination while continuously enriching the mixture enough to cause a 35% fuel economy loss. Commanding the purge off and observing trim response is the key test.

9. A — MAF Sensor Overcounting at Idle — A contaminated MAF sensor with deposits on the hot wire element can cause the element to over-report airflow because the contamination alters the thermal relationship between the wire and the airstream. At idle, the low airflow over the contaminated wire produces a disproportionately high output signal. The PCM delivers more fuel than needed, causing rich trims. At higher RPM with greater airflow velocity, the contamination effect becomes relatively smaller and the overcounting error diminishes — producing rich trims at idle that normalize at higher RPM.

10. A — Failed Alternator — An alternator producing 11.2V at idle is below both the minimum charging specification (13.5V) and below battery resting voltage (12.6V). An alternator that cannot produce charging voltage has failed — a failed diode trio, failed voltage regulator, shorted rotor winding, or open stator winding are the most common internal causes. At 11.2V output, the alternator is effectively acting as a load on the battery rather than charging it, causing rapid battery discharge and P0562 system voltage low.

11. C — Amplified Combustion Variation Through Locked TCC — TCC lock-up removes the torque converter's fluid coupling dampening — any RPM variation from combustion quality differences transfers directly to the drivetrain without attenuation. A partially clogged injector, a marginal COP coil, or intermittent EGR flow creates cyclic combustion variation that under normal TCC slip conditions would be dampened and imperceptible. With TCC locked, the cyclic variation transfers directly to the driveshaft and vehicle, creating the rhythmic RPM oscillation and surge sensation at highway cruise.

12. B — Clogged Cylinder 2 Injector — The systematic diagnostic sequence eliminates each potential cause: coil swap (fault remains on cylinder 2 — coil not at fault), spark plug swap (implied by coil swap), normal compression (mechanical fault ruled out). The near-zero RPM contribution during the contribution test is the defining finding — the cylinder is not contributing to engine output. With ignition and mechanical confirmed normal, the only remaining cause of near-zero contribution is fuel delivery failure from a clogged injector that cannot deliver combustible mixture to the cylinder.

13. C — Compare Fuel Trim Response at Idle vs. 2,500 RPM — The RPM response of fuel trims is the most reliable differentiator between a vacuum leak and MAF undercounting. A vacuum leak introduces a fixed volume of unmetered air — at idle this represents a large percentage of total intake airflow causing significant positive trims, but at 2,500 RPM the same fixed leak volume is a small percentage of total high airflow, causing minimal trim correction (trims normalize). MAF undercounting affects all measured airflow proportionally — the undercount error persists at both idle and higher RPM producing similar positive trim values at all speeds.

14. D — Fuel Vapor Lock from Heat Soak — The pressure hold test confirms the sealed portion of the fuel system (rail, injectors, regulator) maintains pressure — ruling out leakdown. However, the supply line that routes from the fuel tank through the hot engine compartment to the fuel rail can vaporize during a hot soak even while the rail itself holds pressure. On restart, the pump must purge this vaporized fuel before liquid fuel can reach the injectors — creating extended cranking. This is specifically worse after sustained highway driving (which heats all metal surfaces) followed by a prolonged soak.

15. B — Alternator Insufficient Output Capacity Under Maximum Load — An alternator that produces 14.1V at idle with minimal electrical load may have insufficient output capacity to sustain voltage when all major electrical loads are applied simultaneously. Worn brushes, a weakening rotor magnetic field, or internal diode degradation allows adequate output at low demand but cannot sustain output at maximum load. The symptom appearing only under combined maximum electrical load is the characteristic failing alternator output capacity pattern rather than a complete alternator failure.

16. B — Review and Follow the TSB Procedure — Technical Service Bulletins represent the vehicle manufacturer's documented analysis of a specific failure pattern that has been identified across multiple vehicles, with a validated diagnostic and repair procedure. When a TSB exactly describes the customer's complaint, reviewing the TSB first — before performing standard open-ended diagnosis — is the most efficient approach. The TSB may include specific diagnostic steps, component replacements, PCM reprogramming, or wiring repair procedures that resolve the issue efficiently without redundant generic testing.

17. C — Stretched or Jumped Timing Chain — P0016 is a crankshaft-camshaft position CORRELATION code — it indicates the measured camshaft position does not match the expected position for the measured crankshaft position. A stretched timing chain that has advanced or retarded cam timing beyond the acceptable correlation window, or a chain that has jumped a tooth, creates this measurable position discrepancy. This fault requires immediate attention because incorrect valve timing from a jumped chain can cause interference engine valve-to-piston contact, catalytic converter damage from combustion gases entering at wrong timing, and potential engine failure.

18. B — Failed PCM 5V VREF Output — The 5V reference circuit is an internal PCM voltage supply that provides the reference voltage for all analog sensors connected to it. MAF, TPS, and MAP sensors on most platforms share the same 5V VREF circuit. When this circuit shorts to ground, opens, or develops a fault, all sensors sharing it simultaneously show low voltage or out-of-range signals. Multiple simultaneous sensor low codes on sensors that share a common reference supply is the definitive VREF fault presentation — replacing individual sensors will not resolve a VREF fault.

19. C — CMP Sensor Connector or Wiring Fault — A CMP signal that is consistently good during steady operation but drops out specifically during aggressive acceleration — which generates maximum engine vibration and chassis flexion — points to a mechanical connection fault that only opens under mechanical stress. Connectors with marginal terminal retention, a wiring harness that flexes during engine torque application, or a wire with a partial break that opens under tension during acceleration all produce exactly this pattern: normal signal at all steady conditions, intermittent dropout under mechanical stress.

20. B — Boost Pressure Leak from Loose Intercooler Charge Pipe — A charge pipe connection that seals adequately at low boost pressure may open under the higher boost pressure demanded during sustained maximum load conditions (extended grade climbing). At city speeds and light loads, boost pressure is modest and the marginal connection seals. During extended WOT grade climbing, maximum boost pressure exceeds the marginal connection's sealing force — the connection opens and boost escapes, reducing measured turbo output from specification to 12 psi. This leak may be confirmed by listening for a whooshing sound during hard acceleration.

21. C — Worn Valve Stem Seals — Valve stem seals allow oil to drain down the valve stems during periods when the engine is not running (overnight soak). The accumulated oil on the valve faces burns off during the first minutes of engine operation, producing the characteristic blue-gray smoke at cold startup that clears as the deposits are consumed. Normal coolant level rules out head gasket leakage. No external leaks confirm the oil is burned internally. The cold-start-specific smoke pattern distinguishes valve seal failure from ring wear.

22. D — Low Oil Level and Degraded Oil Causing VVT Fault — VVT systems rely on adequate oil volume and quality for phaser actuation. The P0011 over-advanced code is a performance code indicating the cam cannot be retarded from an advanced position — requiring adequate oil pressure to the retard chamber of the phaser. Low oil level (6 quarts low) reduces available oil volume for the VVT system. Severely degraded dark oil has increased viscosity reducing its ability to flow through the narrow VVT solenoid passages and phaser oil galleries. Both factors impair the phaser's ability to respond to PCM retard commands.

23. C — Worn Main or Rod Bearings — Low oil pressure combined with an RPM-correlated metallic knock is the definitive worn bearing presentation. Worn crankshaft main or rod bearings have excessive clearance between the journal and the bearing surface — this increased clearance prevents the oil film from developing adequate pressure and allows the crankshaft to physically impact the bearing surface at each rotation. The knock increases with RPM because the impact frequency increases with crankshaft speed. Low oil pressure is the cause (insufficient bearing oil film) and the knock is the effect (metal-to-metal impact).

24. D — Marginal Ignition Component Failing at Extreme Cold — Spark plug electrode resistance is inversely related to temperature — cold plugs have higher electrode resistance, requiring higher secondary voltage to ionize the gap. A marginal coil that produces adequate secondary voltage at normal temperatures may not generate sufficient voltage at extreme cold when plug resistance peaks. The misfire only during sub-20°F conditions that resolves as the plugs warm confirms the ignition system has insufficient cold-ambient voltage margin — a marginal coil or plug that passes warm testing but fails cold-ambient secondary voltage requirements.

25. C — Worn Left Front Wheel Bearing — Directional noise behavior during turns is the key diagnostic indicator for wheel bearing diagnosis. When turning left, the vehicle's weight transfers to the right side — this unloads the left front bearing from much of the lateral load it carries during straight driving. A bearing with wear damage produces noise when the bearing is unloaded (loaded bearings suppress the damaged rolling element's movement into the race). Turning left unloads the left front bearing, allowing the damaged element to move and produce grinding. The noise absent when turning right (left bearing loaded) confirms the left front diagnosis.

26. B — Air Pocket Trapped Near Thermostat — After thermostat replacement, the cooling system must be properly bled of air. An air pocket trapped in the thermostat housing area prevents hot coolant from contacting the thermostat's wax sensing element — the wax element senses the air temperature (which remains cool) rather than the coolant temperature. The thermostat interprets the cool air temperature as cold coolant and remains open — exactly mimicking a stuck-open thermostat and regenerating P0128. Proper bleed procedure after thermostat replacement must be verified to prevent this common recurrence.

27. D — Catalyst Light-Off Strategy Timing Retard — Modern PCMs use a specific cold-start strategy to rapidly heat the catalytic converter during the light-off period (typically 3–8 minutes after cold start). The strategy intentionally retards ignition timing significantly — sometimes by 20 degrees or more — to introduce hot combustion gases into the exhaust stream, heating the catalyst quickly. This aggressive retard reduces combustion stability. A component that is marginally capable at normal timing (slightly wide plug gap, marginal coil output) may misfire under the artificially retarded timing during this specific window.

28. B — No CKP Sensor Signal — The CKP sensor provides the PCM with crankshaft position and speed information — the fundamental reference the PCM needs before it will command any ignition or fuel injection event. Without a CKP signal, the PCM has no basis for timing any output — it cannot determine where any piston is in its stroke and therefore cannot fire any coil or injector. This is the definitive no-start pattern for a CKP fault: normal cranking speed (starter and compression are normal), no spark on any cylinder, no injector pulse on any cylinder, and no start.

29. B — Severely Clogged Air Filter — A severely clogged air filter restricts the physical airflow entering the engine much more than the MAF sensor detects as reduced airflow. The MAF sensor measures what little air passes through the dirty filter — the PCM delivers fuel based on this low measurement. However, the actual cylinder filling is even more restricted than the MAF indicates because the restriction is upstream of the MAF. The resulting extremely rich mixture (excess fuel relative to severely restricted airflow) produces black smoke, extreme negative fuel trims, and significant power loss without necessarily generating a DTC.

30. B — Exhaust Leak Inspection, Downstream Sensor Test, and Fuel System Evaluation — The three most commonly missed false P0420 causes are: an exhaust leak between the upstream O2 sensor and the catalyst that introduces oxygen post-sensor (most commonly missed and most commonly causes false P0420), a failed downstream sensor stuck at a constant lean voltage that the PCM misinterprets as low catalyst efficiency, and a chronic fuel system enrichment or enleanment that distorts the catalyst efficiency measurement. These three tests address the three most common false causes before condemning the converter.

31. A — Collapsed Hydraulic Lifter — Hydraulic lifters require sustained oil pressure to maintain their internal hydraulic extension. During an extended cold shutdown, oil drains from the lifter body back into the oil pan, collapsing the lifter. When the engine starts, the collapsed lifter creates valve train noise (clicking) until oil pressure fills and extends the lifter back to its normal length. The characteristic time to quiet — 2–3 minutes after startup — corresponds to the time required for oil pressure to fully prime the collapsed lifter. Normal oil level and pressure confirm the lubrication system is not the root cause.

32. B — MAF Sensor Non-Linear Contamination Pattern — A contaminated MAF sensor's error pattern is not linear — it over-reads or under-reads by different amounts at different airflow rates. The LTFT of +22% was built from idle operation where the MAF undercount is worst. At 2,500 RPM, the contaminated sensor switches to overcounting (reading more air than actually enters), causing the PCM to deliver more fuel than needed — producing negative STFT. The combination of positive LTFT (built at idle from undercounting) with negative STFT at higher RPM (from overcounting) is the MAF contamination non-linear signature.

33. C — Diagnose P0087 First as Primary Cause — Multiple DTCs should be evaluated for root cause relationships before pursuing independent diagnoses. P0087 low fuel pressure directly causes lean combustion conditions as injectors are starved under demand. Lean combustion conditions cause random misfire — generating P0300 as a secondary effect of the primary fuel pressure fault. Diagnosing and repairing the fuel pressure fault first is the logical approach because resolving the primary cause should resolve the secondary effect without independent misfire diagnosis and component replacement.

34. C — Clogged Cylinder 1 Injector — A clogged injector is the most likely single root cause connecting a cylinder-specific misfire (P0301) with a single-bank lean condition (P0171) on the same bank. The clogged injector delivers insufficient fuel to cylinder 1 — causing the cylinder to misfire from lean combustion (P0301) and contributing insufficient fuel vapor to the Bank 1 exhaust, causing the Bank 1 upstream O2 sensor to detect lean exhaust and drive positive fuel trims (P0171). The contribution test abnormality specific to cylinder 1 confirms the injector fault location.

35. A — Slow-Responding IAC Valve — During deceleration from highway speed, the throttle plate closes abruptly. The engine transitions from high-RPM airflow to idle airflow almost instantaneously. The PCM commands the IAC valve to open rapidly to supply the idle air required for stable idle. An IAC valve with a sticky or partially gummed pintle cannot open fast enough — the RPM drops below the idle sustaining threshold before the IAC has opened enough to maintain idle. The engine stalls, then immediately restarts because the fault is transient and the engine is otherwise normal.

36. A — Worn Camshaft Lobe on Cylinder 2 — A static compression test measures maximum cylinder pressure with the throttle wide open during cranking — it evaluates ring sealing but is not sensitive to valve timing differences from cam lobe wear. A relative compression test during engine cranking measures the RPM deceleration rate when each cylinder reaches TDC compression — a cylinder with reduced valve lift from a worn cam lobe fills less efficiently, has lower effective compression, and decelerates the crankshaft less than normally-filling cylinders. A 28% lower cranking contribution with normal static compression and normal leakdown isolates the fault to the valve train above the piston — specifically camshaft lobe wear.

37. C — P0300 Clears When P0171 is Resolved — The definitive test for lean-induced misfire is proving the cause-and-effect relationship between the lean condition and the misfire. If repairing the source of P0171 (correcting the vacuum leak, cleaning the MAF, restoring fuel pressure) resolves the P0300 without any ignition system repair, the misfire was confirmed as lean-induced. An ignition-induced misfire is independent of the fuel trim condition and would persist after fuel trim correction. The sequential repair and retest approach provides direct cause-and-effect confirmation.

38. B — Failed Coolant Temperature Sensor — The PCM uses coolant temperature data to calibrate cold-start fuel enrichment. If the coolant temperature sensor reads warmer than actual cold temperature, the PCM delivers less enrichment fuel than the cold engine requires — producing a lean cold-start condition. The +18% STFT correction during the first 30 seconds confirms the PCM is under-enriching and the closed-loop O2 system is correcting maximally. As the actual engine temperature rises to approach the falsely warm sensor reading, the enrichment requirement decreases and trims return to normal.

39. C — Clogged In-Tank Fuel Filter Not Replaced with Pump — The external filter bypass test is a targeted diagnostic technique — by routing fuel through an external clean filter while bypassing the in-tank filter, the technician isolates the restriction to the in-tank filter. The fuel pump producing normal pressure with the external filter confirms the pump itself has adequate capacity. The restriction was specifically in the in-tank integrated filter that was not replaced when the pump alone was replaced. On vehicles with integrated pump/filter modules, the entire module (including the filter) must be replaced to address a filter restriction.

40. B — CMP Sensor Wiring Harness Fault — A replacement CMP sensor producing the same P0340 within two drive cycles eliminates the sensor as the fault source — two sensors of the same type failing identically within two drive cycles is statistically improbable without an external cause. The fault is in the circuit the sensor feeds into: the wiring harness between the sensor connector and the PCM. An open circuit prevents signal delivery, a short to ground suppresses the signal, and a short to voltage corrupts the signal — all generating P0340 regardless of which sensor is installed. Wiring testing is required before a third sensor is installed.

41. A — Camshaft Phaser Stuck Advanced Mechanically — With the VVT solenoid confirmed replaced and functioning, oil pressure confirmed adequate, and P0011 still returning, the remaining component in the VVT actuation chain is the camshaft phaser itself. The phaser is the hydraulic actuator that physically changes cam timing in response to oil pressure directed by the solenoid. A phaser with a stuck or seized internal mechanism can receive correct oil pressure from the functional solenoid but cannot physically rotate the camshaft — maintaining the over-advanced position regardless of PCM commands and generating P0011 as a performance failure.

42. C — Large Vacuum Leak — A large uncontrolled air leak creates simultaneous conditions that generate all four codes from the same single cause: The unmetered air raises idle RPM above the IAC's ability to reduce it (P0507). The extra air dilutes the intake mixture on both banks simultaneously, creating lean conditions that exceed DTC thresholds (P0171 and P0174). The lean mixture becomes severe enough at idle and low loads to cause combustion instability and misfire (P0300). A single large intake hose disconnection or a large vacuum line disconnection can simultaneously generate this exact four-code combination.

43. C — Worn Piston Rings or Cylinder Walls — The temperature-independence of the blue smoke is the critical differentiating factor. Valve stem seal failures produce cold-start-specific blue smoke that clears as the seals warm (the oil that drained down overnight burns off in the first few minutes). Ring wear and worn cylinder walls produce continuous oil consumption throughout all operating conditions — oil passes the ring pack under both vacuum (intake stroke drawing oil up past the rings) and pressure (power stroke pushing oil past the rings) at all temperatures. Continuous blue smoke at all temperatures with no external leaks confirms ring/cylinder wall wear.

44. B — Head Gasket Coolant Intrusion Poisoning Catalysts — A head gasket with a minor combustion-to-coolant passage breach allows coolant to enter the combustion chamber and exhaust stream. Coolant (ethylene glycol) vaporizes and deposits silicate and phosphate compounds on the catalyst substrate — both are powerful catalyst poisons that permanently deactivate the precious metal oxidation and reduction sites. The pattern of multiple replacement catalysts all failing within 3,000 miles with normal fuel trims (ruling out rich/misfire damage) and normal O2 sensors (ruling out false P0420) points to a chemical poison entering the exhaust system — coolant intrusion is the most common source.

45. C — Failed Fuel Rail Pressure Sensor — The mechanical gauge provides ground-truth actual pressure (52 psi — normal), while the scan tool reads the sensor signal (22 psi — falsely low). This direct comparison between actual measured pressure and sensor-reported pressure confirms the sensor is producing an incorrect output. The mechanical gauge eliminates any possibility of actual low pressure. The sensor's false low reading causes the PCM to potentially over-command the fuel pump (on returnless systems) and generates P0191 as the performance code from the discrepancy between expected and actual sensor output relative to operating conditions.

46. B — Cold Solenoid Resistance Out of Specification — Transmission control solenoids have temperature-dependent resistance characteristics. At cold temperatures, higher solenoid resistance reduces the current the TCM can drive through the solenoid — reducing actuating magnetic force. If a solenoid's cold resistance is above specification (resistance drift from normal aging), the reduced cold current produces inadequate clutch pack actuation force, causing momentary slip during cold operation. As the transmission warms and resistance decreases to normal values, normal actuation force is restored and operation normalizes — producing exactly the described cold-slip, warm-recovery pattern.

47. C — High-Resistance Negative Cable — A 0.8V voltage drop in the negative cable is four times the maximum allowed 0.2V. This resistance means 0.8V is being dissipated as heat in the cable rather than being available to the chassis electrical system. Any component that references the engine block as its ground sees its supply voltage reduced by the 0.8V cable drop — effectively seeing 13.8V minus 0.8V = 13.0V minus load, which during high current demand falls below the P0562 threshold. The battery borderline CCA is a contributing factor but the primary cause is the excessive negative cable resistance.

48. A — Incorrect CKP Signal Causing Wrong Stroke Spark — The PCM uses the CKP signal to determine crankshaft position and fires coils at the calculated top dead center compression position for each cylinder. If the CKP signal is shifted 180 degrees from actual crankshaft position (due to a misinstalled sensor on an engine with an undifferentiated reluctor wheel, a jumped timing chain, or an incorrect replacement reluctor wheel), the PCM fires spark at the position it believes is compression TDC — which is actually exhaust TDC. Spark during the exhaust stroke produces no power from combustion and results in a no-start condition despite all other systems being functional.

49. A — TCC Shudder Misidentified as Engine Misfire — The PCM's misfire detection algorithm monitors crankshaft deceleration between firing events — a misfire causes less crankshaft acceleration than a normal combustion event, producing a deceleration spike. TCC lock-up at light throttle above 60 mph is the exact condition that produces TCC apply shudder from worn friction material or degraded ATF. The TCC shudder creates rapid RPM fluctuations at the crankshaft that the misfire monitor's algorithm interprets as random misfires — generating P0300 at this specific speed and load condition. ATF condition evaluation and a TCC shudder test are the correct diagnostic steps.

50. A — Single Post-Repair Drive Cycle Confirming All Parameters — All five codes (P0171, P0174, P0300, P0507, and the implied P0441/EVAP) originated from one physical fault — a disconnected intake hose. Reconnecting the hose addresses the single root cause of all five codes simultaneously. A single comprehensive post-repair drive cycle that allows the Fuel System monitor, Misfire monitor, and Comprehensive Component monitor to run and confirms: no DTC return, fuel trims within ±5%, idle RPM within specification, and no misfire detection is the most efficient single confirmation that the one repair resolved all five simultaneous codes from the one root cause.