

Statewide Framework Document for: 470604

Automotive Technology 2

Standards may be added to this document prior to submission but may not be removed from the framework to meet state credit equivalency requirements. Performance assessments may be developed at the local level. In order to earn state approval, performance assessments must be submitted within this framework. **This course is eligible for 1 credit of science.** The Washington State Science Standards performance expectations for high school blend core ideas (Disciplinary Core Ideas, or DCIs) with scientific and engineering practices (SEPs) and crosscutting concepts (CCCs) to support students in developing usable knowledge that can be applied across the science disciplines. These courses are to be taught in a [three-dimensional manner](#). The details about each performance expectation can be found at [Next Generation Science Standards](#).

School District Name	
Course Title: Automotive Technology 2	Total Framework Hours: 540
CIP Code: 470604 <input type="checkbox"/> Exploratory <input checked="" type="checkbox"/> Preparatory	Date Last Modified: December 30, 2020
Career Cluster: Transpiration, Distribution and Logistics	Cluster Pathway: Transportation Operations
Course Summary: A STEM Enriched Course Scope and Sequence that prepares individuals to engage in the specialized servicing and maintenance of all types of automobiles. This course includes instruction in the diagnosis of malfunctions in, the adjustment or repair of, and/or properly replacing of parts in, 4 of the 8 Nationally recognized NATEF/ASE units: Automatic Transmission and Trans Axle, Suspension and Steering, Heating and Air Conditioning, and engine Performance/Drivability. "Soft/Life skills" (Leadership, Interpersonal, NATEF supplemental tasks, and 21 st Century Skills) are embedded throughout this course along with a substantial correlation to Science, Physics and Chemistry as cross-referenced to the Next Generation Science Standards and NATEF publication, "Being Relevant Matters" cross referencing English, science, and math. Foundational courses to support student success in this course include Physical Science, Chemistry, Life Science, Earth Science, Engineering Technology, etc. These are the NATEF units taught in this framework: A-2 Automatic Transmission and Trans Axle (90hrs. minor). A-4 Suspension and Steering (180hrs. major). A-7 Heating and Air Conditioning (90hrs. minor). A-8 Engine Performance/Drivability (180hrs. major). *Appendix A , Engine Performance/Drivability, at end of this Framework, though not formatted according to state frameworks, shows every "Industry Standard Competency" individually aligned to science standards. All four sections and competencies are aligned and are available for determination.	
Eligible for Equivalent Credit in: Science	Total Number of Units: 4

Unit Summary:

- A. General: Transmission and Transaxle Diagnosis
- B. In-Vehicle Transmission/Transaxle Maintenance and Repair
- C. Off-Vehicle Transmission and Transaxle Repair

Performance Assessments: (Districts to complete for each unit)

Example assessments for this unit include:

- Students plan and conduct an investigation using quantitative methods to model, design, evaluate and refine a solution to complex problems using the following vehicle diagnostic and repair process for automatic transmissions and transaxles.

Vehicle Repair Procedures • Concern – Cause – Correction	21st Century / Leadership correlations	NGSS Science Correlations
Verify / Confirm - Condition / Problem	Reason Effectively, Think Creatively,	Plan and conduct an investigation to gather evidence to compare the structure... Evaluate the validity and reliability of multiple claims... verifying the data when possible. Scientific inquiry... include logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.
Analyze Data: Diagnose problem Data Notation: DTC's, Freeze Frame, Fuel Trim's, MAF's, measurements, mechanical and electronic testing.	Make Judgments and Decisions, Access and evaluate information, Apply technology effectively, Be self-directed learners, Be flexible,	Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence... Use quantitative methods to compare the potential of different solutions. Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability... to scientific and engineering questions and problems, using digital tools when feasible. Analyze data using computational models in order to make valid and reliable scientific claims.
Research Information: How does system work? Technical Service Bulletins Flow Charts / Diagnostic procedures	Use systems thinking, Analyze media, Apply technology effectively, Be responsible to others,	Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Wiring Diagram's Discuss in Group Use of multiple "sites" for common diagnostic procedures.	Work effectively in diverse teams, Adapt to change,	Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources. Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.
Student Service Manager or Asst. discussion.	Collaborate with others, Guide and lead others, Manage projects (and groups)	Design, evaluate, and/or Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. Ask questions that arise from examining models or a theory to clarify relationships. Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors
P&A Parts / look up Labor/ Print Estimate	Create media products, Communicate with adults...	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
Notation of performed / Estimate work order	Interact effectively with others,	Develop a model based on evidence to illustrate the relationships between systems or between components of a system. Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Construct an oral and written argument or counter-arguments based on data and evidence.
Schedule (time/repair) with Svc. Mngr.	Work creatively with others, Manage goals and time,	Communicate scientific and technical information in multiple formats... Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
Instructor Approval (Discuss in Group)	Communicate clearly,	Constructing explanations, arguments from evidence Create a computational model or simulation of a phenomenon, designed device, process, or system.

		Make and defend a claim based on evidence... Communicate technical information or ideas
Call Customer / sell job / Estimate Time	Use and manage information, Communicate with adults...	Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.
Fix: Follow Technical Instructions / Perform Service	Solve Problems, Implement innovations, Apply technology effectively, Produce results,	Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. Use a model to provide mechanistic accounts of phenomena.

Leadership Alignment: (Districts to complete for each unit)

Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.

Example:

- Students complete personality, career interest, and aptitude assessments, and in small groups discuss, and analyze the results.
- Individually student summarize the career opportunities in the clusters of their personal interest through a presentation before their group.

21st Century Skills:

- Access and /Evaluate Information
- Interact Effectively with Others
- Collaborate with Others.

Industry Standards and/or Competencies:

The following technical competencies are produced and endorsed by the **National Automobile Technical Education Foundation (NATEF) for Automatic Transmission and Transaxle. Automotive Service Excellence (ASE) area A2.**

A: General: Transmission and Transaxle Diagnosis

1. Identify and interpret transmission/transaxle concern, differentiate between engine performance and transmission/transaxle concerns; determine necessary action.
2. Research applicable vehicle and service information fluid type, vehicle service history, service precautions, and technical service bulletins.
3. Diagnose fluid loss and condition concerns; determine necessary action.
4. Check fluid level in a transmission or a transaxle equipped with a dip- stick.
5. Check fluid level in a transmission or a transaxle not equipped with a dip-stick.
6. Perform pressure tests (including transmissions/transaxles equipped with electronic pressure control); determine necessary action.
7. Diagnose noise and vibration concerns; determine necessary action.
8. Perform stall test; determine necessary action.
9. Perform lock-up converter system tests; determine necessary action.
10. Diagnose transmission/transaxle gear reduction/multiplication concerns using driving, driven, and held member (power flow) principles.
11. Diagnose electronic transmission/transaxle control systems using appropriate test equipment and service information.
12. Diagnose pressure concerns in a transmission using hydraulic principles (Pascal's Law).

B: In-Vehicle Transmission/Transaxle Maintenance and Repair

1. Inspect, adjust, and replace external manual valve shift linkage, transmission range sensor/switch, and park/neutral position switch.
2. Inspect for leakage; replace external seals, gaskets, and bushings.
3. Inspect, test, adjust, repair, or replace electrical/electronic components and circuits including computers, solenoids, sensors, relays, terminals, connectors, switches, and harnesses.
4. Drain and replace fluid and filter(s).
5. Inspect, replace and align powertrain mounts.
- D. Off-Vehicle Transmission and Transaxle Repair
 1. Remove and reinstall transmission/transaxle and torque converter; inspect engine core plugs, rear crankshaft seal, dowel pins, dowel pin holes, and mating surfaces. P-1
 2. Inspect, leak test, and flush or replace transmission/transaxle oil cooler, lines, and fittings.
 3. Inspect converter flex (drive) plate, converter attaching bolts, converter pilot, converter pump drive surfaces, converter end play, and crankshaft pilot bore.
 4. Describe the operational characteristics of a continuously variable transmission (CVT).
 5. Describe the operational characteristics of a hybrid vehicle drive train.
 6. Disassemble, clean, and inspect transmission/transaxle.
 7. Inspect, measure, clean, and replace valve body (includes surfaces, bores, springs, valves, sleeves, retainers, brackets, checkvalves/balls, screens, spacers, and gaskets).
 8. Inspect servo and accumulator bores, pistons, seals, pins, springs, and retainers; determine necessary action.
 9. Assemble transmission/transaxle.
 10. Inspect, measure, and reseal oil pump assembly and components.
 11. Measure transmission/transaxle end play or preload; determine necessary action.
 12. Inspect, measure, and replace thrust washers and bearings.
 13. Inspect oil delivery circuits, including seal rings, ring grooves, and sealing surface areas, feed pipes, orifices, and check valves/balls.
 14. Inspect bushings; determine necessary action.
 15. Inspect and measure planetary gear assembly components; determine necessary action.
 16. Inspect case bores, passages, bushings, vents, and mating surfaces; determine necessary action.
 17. Diagnose and inspect transaxle drive, link chains, sprockets, gears, bearings, and bushings; perform necessary action.
 18. Inspect, measure, repair, adjust or replace transaxle final drive components.
 19. Inspect clutch drum, piston, check-balls, springs, retainers, seals, and friction and pressure plates, bands and drums; determine necessary action.
 20. Measure clutch pack clearance; determine necessary action.
 21. Air test operation of clutch and servo assemblies.
 22. Inspect roller and sprag clutch, races, rollers, sprags, springs, cages, retainers; determine necessary action.

Aligned Washington State Academic Standards

Science

Below are the aligned standards addressed in this section: Integrated Science Lesson Objectives are from the 2014 NATEF/ASE publication "Being Relevant Matters"
<https://www.asealliance.org/wp-content/uploads/2016/05/Being-Relevant-Matters.pdf> . NGSS and ELA

Standards are correlated from a collaboration of Automotive, Science, ELA, OSPI teachers, and advisory group representative members.

Integrated Science Lesson Objectives

Automatic Transmission: Pressure vs. volume, Thermal effect on fluids, Balancing & phasing of the drive line, Fluid dynamics, Pascal's Law, Chemistry of sealants, Basic principles of electrical circuitry, Ergonomics (science of lifting properly), Rotational inertia, Power conversions, Chemical reaction with metals, Types of gasket materials, Hydraulics & pneumatics, Sequential torquing, Torque effect on fasteners

Washington Science Standards (Next Generation Science Standards):

HS-PS1-3 Matter and its Interactions: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles

HS-PS1-4 Matter and its Interactions: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy

HS-PS1-5 Matter and its Interactions: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS1-6 Matter and its Interactions: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS2-1 Motion and Stability: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS2-3 Motion and Stability: Apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*

HS-PS2-5 Motion and Stability: Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

HS-PS2-6 Motion and Stability: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*

HS-PS3-1 Energy: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2 Energy: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects)

	<p>HS-PS3-3 Energy: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*</p> <p>HS-PS3-4 Energy: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).</p> <p>HS-PS3-5 Energy: Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.</p> <p>HS-PS4-2 Waves and their Applications in Technologies: Evaluate questions about the advantages of using digital transmission and storage of information</p> <p>HS-PS4-5 Waves and their Applications in Technologies: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*</p> <p>HS-LS2-7 Ecosystems; Interactions, Energy, and Dynamics: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*</p> <p>HS-ESS3-1 Earth and Human Activity: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.</p> <p>HS-ESS3-2 Earth and Human Activity: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*</p> <p>HS-ESS3-4 Earth and Human Activity: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*</p> <p>HS-ETS1-3 Engineering Design: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.</p> <p>HS-ETS1-4 Engineering Design: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.</p>	
Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept

Unit 2: Suspension and Steering (ASE/NATEF: A-4)	Total Learning Hours for Unit: 180
Unit Summary: <ul style="list-style-type: none"> A. General: Suspension and Steering Systems B. Steering System Diagnosis and Repair C. Suspension System Diagnosis and Repair D. Related Suspension and Steering Service E. Wheel Alignment Diagnosis, Adjustment, and Repair 	

F. Wheels and Tires, Diagnosis and Repair

Performance Assessments: (Districts to complete for each unit)

Example assessments for this unit include:

- Students plan and conduct an investigation using quantitative methods to model, design, evaluate and refine a solution to complex problems using the following vehicle diagnostic and repair process for suspension and steering systems.

Vehicle Repair Procedures <ul style="list-style-type: none"> Concern – Cause – Correction 	21st Century / Leadership correlations	NGSS Science Correlations
Verify / Confirm – Condition / Problem	Reason Effectively, Think Creatively,	Plan and conduct an investigation to gather evidence to compare the structure... Evaluate the validity and reliability of multiple claims... verifying the data when possible. Scientific inquiry... include logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.
Analyze Data: Diagnose problem Data Notation: DTC's, Freeze Frame, Fuel Trim's, Maf's, measurements, mechanical and electronic testing.	Make Judgments and Decisions, Access and evaluate information, Apply technology effectively, Be self-directed learners, Be flexible,	Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence... Use quantitative methods to compare the potential of different solutions. Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability... to scientific and engineering questions and problems, using digital tools when feasible. Analyze data using computational models in order to make valid and reliable scientific claims.
Research Information: How does system work? Technical Service Bulletins Flow Charts / Diagnostic procedures Wiring Diagram's Discuss in Group Use of multiple "sites" for common diagnostic procedures.	Use systems thinking, Analyze media, Apply technology effectively, Be responsible to others, Work effectively in diverse teams, Adapt to change,	Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources. Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.

		Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.
Student Service Manager or Asst. discussion.	Collaborate with others, Guide and lead others, Manage projects (and groups)	Design, evaluate, and/or Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. Ask questions that arise from examining models or a theory to clarify relationships. Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors
P&A Parts / look up Labor/ Print Estimate	Create media products, Communicate with adults...	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
Notation of performed / Estimate work order	Interact effectively with others,	Develop a model based on evidence to illustrate the relationships between systems or between components of a system. Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Construct an oral and written argument or counter-arguments based on data and evidence.
Schedule (time/repair) with Svc. Mngr.	Work creatively with others, Manage goals and time,	Communicate scientific and technical information in multiple formats... Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
Instructor Approval (Discuss in Group)	Communicate clearly,	Constructing explanations, arguments from evidence Create a computational model or simulation of a phenomenon, designed device, process, or system. Make and defend a claim based on evidence... Communicate technical information or ideas
Call Customer / sell job / Estimate Time	Use and manage information, Communicate with adults...	Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.

Fix: Follow Technical Instructions / Perform Service	Solve Problems, Implement innovations, Apply technology effectively, Produce results,	Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. Use a model to provide mechanistic accounts of phenomena.
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Leadership Alignment: (Districts to complete for each unit)

Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.

Example:

- Students prepare a program of study for one career of interest using knowledge gained from individual assessment and set goals for a career plan. Students provide written documentation to instructor.

21st Century Skills:

- Make Judgments and Decisions
- Work Independently
- Produce Results

Industry Standards and/or Competencies:

The following technical competencies are produced and endorsed by the **National Automobile Technical Education Foundation (NATEF) for Steering and Suspension. Automotive Service Excellence (ASE) area A4.**

A. General: Suspension and Steering Systems

1. Research applicable vehicle and service information, vehicle service history, service precautions, and technical service bulletins.
2. Identify and interpret suspension and steering system concerns; determine necessary action.

B. Steering Systems Diagnosis and Repair

1. Disable and enable supplemental restraint system (SRS).
2. Remove and replace steering wheel; center/time supplemental restraint system (SRS) coil (clock spring).
3. Diagnose steering column noises, looseness, and binding concerns (including tilt mechanisms); determine necessary action.
4. Diagnose power steering gear (non-rack and pinion) binding, uneven turning effort, looseness, hard steering, and noise concerns; determine necessary action.
5. Diagnose power steering gear (rack and pinion) binding, uneven turning effort, looseness, hard steering, and noise concerns; determine necessary action.
6. Inspect steering shaft universal-joint(s), flexible coupling(s), collapsible column, lock cylinder mechanism, and steering wheel; perform necessary action.
7. Remove and replace rack and pinion steering gear; inspect mounting bushings and brackets.
8. Inspect rack and pinion steering gear inner tie rod ends (sockets) and bellows boots; replace as needed.
9. Determine proper power steering fluid type; inspect fluid level and condition.
10. Flush, fill, and bleed power steering system.
11. Inspect for power steering fluid leakage; determine necessary action.
12. Remove, inspect, replace, and adjust power steering pump drive belt.
13. Remove and reinstall power steering pump.

14. Remove and reinstall press fit power steering pump pulley; check pulley and belt alignment.
15. Inspect and replace power steering hoses and fittings.
16. Inspect and replace pitman arm, relay (center-link/intermediate) rod, idler arm and mountings, and steering linkage damper.
17. Inspect, replace, and adjust tie rod ends (sockets), tie rod sleeves, and clamps.
18. Test and diagnose components of electronically-controlled steering systems using a scan tool; determine necessary action.
19. Identify hybrid vehicle power steering system electrical circuits and safety precautions.
20. Inspect electric power-assisted steering.

C. Suspension Systems Diagnosis and Repair

1. Diagnose short and long arm suspension system noises, body sway, and uneven ride height concerns; determine necessary action.
 3. Diagnose strut suspension system noises, body sway, and uneven ride height concerns; determine necessary action.
 4. Inspect, remove and install upper and lower control arms, bushings, shafts, and rebound bumpers.
 5. Inspect, remove and install strut rods and bushings.
 6. Inspect, remove and install upper and/or lower ball joints (with or without wear indicators).
 7. Inspect, remove and install steering knuckle assemblies.
 8. Inspect, remove and install short and long arm suspension system coil springs and spring insulators.
 9. Inspect, remove and install torsion bars and mounts.
 10. Inspect, remove and install front stabilizer bar (sway bar) bushings, brackets, and links.
 11. Inspect, remove and install strut cartridge or assembly, strut coil spring, insulators (silencers), and upper strut bearing mount.
 12. Inspect, remove and install track bar, strut rods/radius arms, and related mounts and bushings.
 13. Inspect rear suspension system leaf spring(s), bushings, center pins/bolts, and mounts.

D. Related Suspension and Steering Service

1. Inspect, remove, and replace shock absorbers; inspect mounts and bushings.
2. Remove, inspect, and service or replace front and rear wheel bearings.
3. Describe the function of the power steering pressure switch.

E. Wheel Alignment Diagnosis, Adjustment, and Repair

1. Diagnose vehicle wander, drift, pull, hard steering, bump steer, memory steer, torque steer, and steering return concerns; determine necessary action.
2. Perform pre-alignment inspection and measure vehicle ride height; perform necessary action.
3. Prepare vehicle for wheel alignment on alignment machine; perform four-wheel alignment by checking and adjusting front and rear wheel caster, camber and toe as required; center steering wheel.
4. Check toe-out-on-turns (turning radius); determine necessary action.
5. Check SAI (steering axis inclination) and included angle; determine necessary action.
6. Check rear wheel thrust angle; determine necessary action.
7. Check for front wheel setback; determine necessary action.
8. Check front and/or rear cradle (sub-frame) alignment; determine necessary action.
9. Reset steering angle sensor

F. Wheels and Tires Diagnosis and Repair

1. Inspect tire condition; identify tire wear patterns; check for correct tire size and application (load and speed ratings) and adjust air pressure; determine necessary action.
2. Diagnose wheel/tire vibration, shimmy, and noise; determine necessary action.
3. Rotate tires according to manufacturer's recommendations.
4. Measure wheel, tire, axle flange, and hub runout; determine necessary action.
5. Diagnose tire pull problems; determine necessary action.
6. Dismount, inspect, and remount tire on wheel; balance wheel and tire assembly (static and dynamic).
7. Dismount, inspect, and remount tire on wheel equipped with tire pressure monitoring system sensor.
8. Inspect tire and wheel assembly for air loss; perform necessary action.
9. Repair tire using internal patch.
10. Identify and test tire pressure monitoring system (indirect and direct) for operation; calibrate system; verify operation of instrument panel lamps.
11. Demonstrate knowledge of steps required to remove and replace sensors in a tire pressure monitoring system.

Aligned Washington State Academic Standards

Science

Below are the aligned standards addressed in this section: Integrated Science Lesson Objectives are from the 2014 NATEF/ASE publication "Being Relevant Matters" <https://www.asealliance.org/wp-content/uploads/2016/05/Being-Relevant-Matters.pdf>. NGSS and ELA Standards are correlated from a collaboration of Automotive, Science, ELA, OSPI teachers, and advisory group representative members.

Integrated Science Lesson Objectives

Suspension & Steering: Chemical reactions, Basic electricity, Levers, Properties of materials, Chemistry of fluids, Hydraulics, Aerodynamics, Pneumatics, Bearing types, Balancing of forces, Material science, Rubber & rubber compounds, Wheel rims & corrosion issues, Vulcanization, Electronics diagnosis

Washington Science Standards (Next Generation Science Standards):

HS-PS1-2 Matter and its Interactions: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3 Matter and its Interactions: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles

HS-PS1-4 Matter and its Interactions: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy

HS-PS1-5 Matter and its Interactions: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS1-6 Matter and its Interactions: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS2-1 Motion and Stability: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS2-3 Motion and Stability: Apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*

HS-PS2-5 Motion and Stability: Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

HS-PS2-6 Motion and Stability: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*

HS-PS3-1 Energy: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2 Energy: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects)

HS-PS3-3 Energy: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*

HS-PS3-4 Energy: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

HS-PS3-5 Energy: Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

HS-PS4-2 Waves and their Applications in Technologies: Evaluate questions about the advantages of using digital transmission and storage of information

HS-PS4-5 Waves and their Applications in Technologies: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*

HS-LS2-7 Ecosystems; Interactions, Energy, and Dynamics: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*

HS-ESS3-1 Earth and Human Activity: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

HS-ESS3-2 Earth and Human Activity: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*

	<p>HS-ESS3-4 Earth and Human Activity: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*</p> <p>HS-ETS1-3 Engineering Design: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.</p> <p>HS-ETS1-4 Engineering Design: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.</p>	
Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept

Unit 3: Heating and Air Conditioning (ASE/NATEF: A-7)		Total Learning Hours for Unit: 90
<p>Unit Summary:</p> <ul style="list-style-type: none"> A. General A/C System Diagnosis and Repair B. Refrigeration System Component Diagnosis and Repair C. Heating, Ventilation, and Engine Cooling System Diagnosis and Repair D. Operating Systems and Related Controls Diagnosis and Repair E. Refrigerant Recovery, Recycling, and Handling 		
<p>Performance Assessments: (Districts to complete for each unit)</p> <p><i>Example assessments for this unit include:</i></p> <ul style="list-style-type: none"> • Students plan and conduct an investigation using quantitative methods to model, design, evaluate and refine a solution to complex problems using the following vehicle diagnostic and repair process for heating and air conditioning systems. 		
<p>Vehicle Repair Procedures</p> <ul style="list-style-type: none"> • Concern – Cause – Correction 	<p>21st Century / Leadership correlations</p>	<p>NGSS Science Correlations</p>
Verify / Confirm - Condition / Problem	Reason Effectively, Think Creatively,	<p>Plan and conduct an investigation to gather evidence to compare the structure...</p> <p>Evaluate the validity and reliability of multiple claims... verifying the data when possible.</p> <p>Scientific inquiry... include logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.</p>
Analyze Data: Diagnose problem	Make Judgments and Decisions,	Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence...

Data Notation: DTC's, Freeze Frame, Fuel Trim's, MAF's, measurements, mechanical and electronic testing.	Access and evaluate information, Apply technology effectively, Be self-directed learners, Be flexible,	Use quantitative methods to compare the potential of different solutions. Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability... to scientific and engineering questions and problems, using digital tools when feasible. Analyze data using computational models in order to make valid and reliable scientific claims.
Research Information: How does system work? Technical Service Bulletins Flow Charts / Diagnostic procedures Wiring Diagram's Discuss in Group Use of multiple "sites" for common diagnostic procedures.	Use systems thinking, Analyze media, Apply technology effectively, Be responsible to others, Work effectively in diverse teams, Adapt to change,	Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources. Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.
Student Service Manager or Asst. discussion.	Collaborate with others, Guide and lead others, Manage projects (and groups)	Design, evaluate, and/or Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. Ask questions that arise from examining models or a theory to clarify relationships. Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors
P&A Parts / look up Labor/ Print Estimate	Create media products, Communicate with adults...	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
Notation of performed / Estimate work order	Interact effectively with others,	Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

		<p>Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.</p> <p>Construct an oral and written argument or counter-arguments based on data and evidence.</p>
Schedule (time/repair) with Svc. Mngr.	Work creatively with others, Manage goals and time,	<p>Communicate scientific and technical information in multiple formats...</p> <p>Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.</p>
Instructor Approval (Discuss in Group)	Communicate clearly,	<p>Constructing explanations, arguments from evidence</p> <p>Create a computational model or simulation of a phenomenon, designed device, process, or system.</p> <p>Make and defend a claim based on evidence...</p> <p>Communicate technical information or ideas</p>
Call Customer / sell job / Estimate Time	Use and manage information, Communicate with adults...	Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.
Fix: Follow Technical Instructions / Perform Service	Solve Problems, Implement innovations, Apply technology effectively, Produce results,	<p>Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.</p> <p>Use a model to provide mechanistic accounts of phenomena.</p>

Leadership Alignment: (Districts to complete for each unit)

Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.

Example:

- Students create a personal career portfolio including academic, certification and technical-skill requirement, career opportunities, expected wages, skills and aptitude necessary and the impact of technology on careers of personal interest.
- Students present to class the academic/training or certification requirements to transition to employment or academic training needed for their High School and Beyond plan.

21st Century Skills:

- Reason Effectively
- Use and Manage Information
- Create Media Products.

Industry Standards and/or Competencies:

The following technical competencies are produced and endorsed by the **National Automobile Technical Education Foundation (NATEF) for Heating and Air Conditioning. Automotive Service Excellence (ASE) area A7.**

A. General: A/C System Diagnosis and Repair

1. Identify and interpret heating and air conditioning problems; determine necessary action.
2. Research applicable vehicle and service information, vehicle service history, service precautions, and technical service bulletins.
3. Performance test A/C system; identify problems.
4. Identify abnormal operating noises in the A/C system; determine necessary action.
5. Identify refrigerant type; select and connect proper gauge set; record temperature and pressure readings.
6. Leak test A/C system; determine necessary action.
7. Inspect condition of refrigerant oil removed from A/C system; determine necessary action.
8. Determine recommended oil and oil capacity for system application.
9. Using a scan tool, observe and record related HVAC data and trouble codes.

B. Refrigeration System Component Diagnosis and Repair

1. Inspect and replace A/C compressor drive belts, pulleys, and tensioners; determine necessary action.
2. Inspect, test, service or replace A/C compressor clutch components and/or assembly; check compressor clutch air gap; adjust as needed.
3. Remove, inspect, and reinstall A/C compressor and mountings; determine recommended oil quantity.
4. Identify hybrid vehicle A/C system electrical circuits and service/safety precautions.
5. Determine need for an additional A/C system filter; perform necessary action.
6. Remove and inspect A/C system mufflers, hoses, lines, fittings, O-rings, seals, and service valves; perform necessary action.
7. Inspect A/C condenser for airflow restrictions; perform necessary action.
8. Remove, inspect, and reinstall receiver/drier or accumulator/drier; determine recommended oil quantity.
9. Remove, inspect, and install expansion valve or orifice (expansion) tube.
10. Inspect evaporator housing water drain; perform necessary action.
11. Diagnose A/C system conditions that cause the protection devices (pressure, thermal, and PCM) to interrupt system operation; determine necessary action.
12. Determine procedure to remove and reinstall evaporator; determine required oil quantity.
13. Remove, inspect, and reinstall condenser; determine required oil quantity.

C. Heating, Ventilation, and Engine Cooling Systems Diagnosis and Repair

1. Inspect engine cooling and heater systems hoses; perform necessary action.
2. Inspect and test heater control valve(s); perform necessary action.
3. Diagnose temperature control problems in the heater/ventilation system; determine PCM) to interrupt system operation; determine necessary action.
4. Determine procedure to remove, inspect, and reinstall heater core.

D. Operating Systems and Related Controls Diagnosis and Repair

1. Inspect and test A/C-heater blower motors, resistors, switches, relays, wiring, and protection devices; perform necessary action.
2. Diagnose A/C compressor clutch control systems; determine necessary action.

3. Diagnose malfunctions in the vacuum, mechanical, and electrical components and controls of the heating, ventilation, and A/C (HVAC) system; determine necessary action.
4. Inspect and test A/C-heater control panel assembly; determine necessary action.
5. Inspect and test A/C-heater control cables, motors, and linkages; perform necessary action.
6. Inspect A/C-heater ducts, doors, hoses, cabin filters, and outlets; perform necessary action.
7. Identify the source of A/C system odors.
8. Check operation of automatic or semi-automatic heating, ventilation, and air-conditioning (HVAC) control systems; determine necessary action.

E. Refrigerant Recovery, Recycling, and Handling

1. Perform correct use and maintenance of refrigerant handling equipment according to equipment manufacturer's standards.
2. Identify and recover A/C system refrigerant.
3. Recycle, label, and store refrigerant.
4. Evacuate and charge A/C system; add refrigerant oil as required.

Aligned Washington State Academic Standards

Science

Below are the aligned standards addressed in this section: Integrated Science Lesson Objectives are from the 2014 NATEF/ASE publication "Being Relevant Matters" <https://www.asealliance.org/wp-content/uploads/2016/05/Being-Relevant-Matters.pdf>. NGSS and ELA Standards are correlated from a collaboration of Automotive, Science, ELA, OSPI teachers, and advisory group representative members.

Integrated Science Lesson Objectives

Heating & A/C: Refrigerant handling & EPA concerns (environmental science), Electrical Fundamentals (Ohm's Law), Thermoelectric theory, The Peltier effect, Thermodynamics, Airflow Dynamics

Washington Science Standards (Next Generation Science Standards):

HS-PS1-2 Matter and its Interactions: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3 Matter and its Interactions: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles

HS-PS1-4 Matter and its Interactions: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy

HS-PS1-5 Matter and its Interactions: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS1-6 Matter and its Interactions: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS2-1 Motion and Stability: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS2-3 Motion and Stability: Apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*

HS-PS2-5 Motion and Stability: Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

HS-PS2-6 Motion and Stability: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*

HS-PS3-1 Energy: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2 Energy: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects)

HS-PS3-3 Energy: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*

HS-PS3-4 Energy: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

HS-PS3-5 Energy: Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

HS-PS4-2 Waves and their Applications in Technologies: Evaluate questions about the advantages of using digital transmission and storage of information

HS-PS4-5 Waves and their Applications in Technologies: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*

HS-LS2-7 Ecosystems; Interactions, Energy, and Dynamics: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*

HS-ESS3-1 Earth and Human Activity: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

HS-ESS3-2 Earth and Human Activity: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*

HS-ESS3-4 Earth and Human Activity: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*

	<p>HS-ETS1-3 Engineering Design: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.</p> <p>HS-ETS1-4 Engineering Design: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.</p>	
Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept

Unit 4: Engine Performance (ASE/NATEF: A-8)		Total Learning Hours for Unit: 180
<p>Unit Summary:</p> <p>A: General Engine Diagnosis</p> <p>B: Computerized Controls Diagnosis and Repair</p> <p>C: Ignition System Diagnosis and Repair</p> <p>D: Fuel, Air Induction, Exhaust Systems Diagnosis and Repair</p> <p>E: Emission Control Systems Diagnosis and Repair</p>		
<p>Performance Assessments: (Districts to complete for each unit)</p> <p><i>Example assessments for this unit include:</i></p> <ul style="list-style-type: none"> Students plan and conduct an investigation using quantitative methods to model, design, evaluate and refine a solution to complex problems using the following vehicle diagnostic and repair process for engine performance systems. 		
<p>Vehicle Repair Procedures</p> <ul style="list-style-type: none"> Concern – Cause – Correction 	<p>21st Century / Leadership correlations</p>	<p>NGSS Science Correlations</p>
Verify / Confirm - Condition / Problem	Reason Effectively, Think Creatively,	<p>Plan and conduct an investigation to gather evidence to compare the structure...</p> <p>Evaluate the validity and reliability of multiple claims... verifying the data when possible.</p> <p>Scientific inquiry... include logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.</p>
Analyze Data: Diagnose problem Data Notation: DTC's, Freeze Frame, Fuel Trim's, MAF's, measurements, mechanical and electronic testing.	Make Judgments and Decisions, Access and evaluate information,	<p>Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence...</p> <p>Use quantitative methods to compare the potential of different solutions.</p>

	<p>Apply technology effectively, Be self-directed learners, Be flexible,</p>	<p>Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability... to scientific and engineering questions and problems, using digital tools when feasible. Analyze data using computational models in order to make valid and reliable scientific claims.</p>
<p>Research Information: How does system work? Technical Service Bulletins Flow Charts / Diagnostic procedures Wiring Diagram's Discuss in Group Use of multiple "sites" for common diagnostic procedures.</p>	<p>Use systems thinking, Analyze media, Apply technology effectively, Be responsible to others, Work effectively in diverse teams, Adapt to change,</p>	<p>Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources. Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.</p>
<p>Student Service Manager or Asst. discussion.</p>	<p>Collaborate with others, Guide and lead others, Manage projects (and groups)</p>	<p>Design, evaluate, and/or Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. Ask questions that arise from examining models or a theory to clarify relationships. Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors</p>
<p>P&A Parts / look up Labor/ Print Estimate</p>	<p>Create media products, Communicate with adults...</p>	<p>Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.</p>
<p>Notation of performed / Estimate work order</p>	<p>Interact effectively with others,</p>	<p>Develop a model based on evidence to illustrate the relationships between systems or between components of a system. Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.</p>

		Construct an oral and written argument or counter-arguments based on data and evidence.
Schedule (time/repair) with Svc. Mngr.	Work creatively with others, Manage goals and time,	Communicate scientific and technical information in multiple formats... Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
Instructor Approval (Discuss in Group)	Communicate clearly,	Constructing explanations, arguments from evidence Create a computational model or simulation of a phenomenon, designed device, process, or system. Make and defend a claim based on evidence... Communicate technical information or ideas
Call Customer / sell job / Estimate Time	Use and manage information, Communicate with adults...	Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.
Fix: Follow Technical Instructions / Perform Service	Solve Problems, Implement innovations, Apply technology effectively, Produce results,	Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. Use a model to provide mechanistic accounts of phenomena.

Leadership Alignment: (Districts to complete for each unit)

Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.

Example:

- Students develop and analyze tables, charts, and graphs related to career interests and make oral presentation regarding the career pathway of their choice.
- Students create a career planning presentation (written, verbal or technical) on financial aid, scholarship, and other sources of income to support postsecondary education/training.

21st Century Skills:

- Analyze Media
- Use and Manage Information
- Produce Results

Industry Standards and/or Competencies:

The following technical competencies are produced and endorsed by the **National Automobile Technical Education Foundation (NATEF) for Engine Repair. Automotive Service Excellence (ASE) area A8.**

A. General: Engine Diagnosis

1. Identify and interpret engine performance concerns; determine necessary action.

2. Research applicable vehicle and service information, vehicle service history, service precautions, and technical service bulletins.
3. Diagnose abnormal engine noises or vibration concerns; determine necessary action.
4. Diagnose the cause of excessive oil consumption, coolant consumption, unusual exhaust color, odor, and sound; determine necessary action.
5. Perform engine absolute (vacuum/boost) manifold pressure tests; determine necessary action.
6. Perform cylinder power balance test; determine necessary action.
7. Perform cylinder cranking and running compression tests; determine necessary action.
8. Perform cylinder leakage test; determine necessary action.
9. Diagnose engine mechanical, electrical, electronic, fuel, and ignition concerns; determine necessary action.
10. Verify engine operating temperature; determine necessary action.
11. Verify correct camshaft timing.

B. Computerized Controls Diagnosis and Repair

1. Retrieve and record diagnostic trouble codes, OBD monitor status, and freeze frame data; clear codes when applicable.
2. Access and use service information to perform step-by-step (troubleshooting) diagnosis.
3. Perform active tests of actuators using a scan tool; determine necessary action.
4. Describe the importance of running all OBDII monitors for repair verification.
5. Diagnose the causes of emissions or driveability concerns with stored or active diagnostic trouble codes; obtain, graph, and interpret scan tool data.
6. Diagnose emissions or driveability concerns without stored diagnostic trouble codes; determine necessary action.
7. Inspect and test computerized engine control system sensors, powertrain/engine control module (PCM/ECM), actuators, and circuits using a graphing multimeter (GMM)/digital storage oscilloscope (DSO); perform necessary action.
8. Diagnose driveability and emissions problems resulting from malfunctions of interrelated systems (cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems); determine necessary action.

C. Ignition System Diagnosis and Repair

1. Diagnose (troubleshoot) ignition system related problems such as no-starting, hard starting, engine misfire, poor driveability, spark knock, power loss, poor mileage, and emissions concerns; determine necessary action.
2. Inspect and test crankshaft and camshaft position sensor(s); perform necessary action.
3. Inspect, test, and/or replace ignition control module, powertrain/engine control module; reprogram as necessary.
4. Remove and replace spark plugs; inspect secondary ignition components for wear and damage.

D. Fuel, Air Induction, and Exhaust Systems Diagnosis and Repair

1. Diagnose (troubleshoot) hot or cold no-starting, hard starting, poor driveability, incorrect idle speed, poor idle, flooding, hesitation, surging, engine misfire, power loss, stalling, poor mileage, dieseling, and emissions problems; determine necessary action.
2. Check fuel for contaminants; determine necessary action.
3. Inspect and test fuel pumps and pump control systems for pressure, regulation, and volume; perform necessary action.
4. Replace fuel filter(s).
5. Inspect, service, or replace air filters, filter housings, and intake duct work.
6. Inspect throttle body, air induction system, intake manifold and gaskets for vacuum leaks and/or unmetered air.

7. Inspect and test fuel injectors.
8. Verify idle control operation.
9. Inspect integrity of the exhaust manifold, exhaust pipes, muffler(s), catalytic converter(s), resonator(s), tail pipe(s), and heat shields; perform necessary action.
10. Inspect condition of exhaust system hangers, brackets, clamps, and heat shields; repair or replace as needed.
11. Perform exhaust system back-pressure test; determine necessary action.
12. Check and refill diesel exhaust fluid (DEF).
13. Test the operation of turbocharger/supercharger systems; determine necessary action.

E. Emissions Control Systems Diagnosis and Repair

1. Diagnose oil leaks, emissions, and driveability concerns caused by the positive crankcase ventilation (PCV) system; determine necessary action.
2. Inspect, test, and service positive crankcase ventilation (PCV) filter/breather cap, valve, tubes, orifices, and hoses; perform necessary action.
3. Diagnose emissions and driveability concerns caused by the exhaust gas recirculation (EGR) system; determine necessary action.
4. Diagnose emissions and driveability concerns caused by the secondary air injection and catalytic converter systems; determine necessary action.
5. Diagnose emissions and driveability concerns caused by the evaporative emissions control system; determine necessary action.
6. Inspect and test electrical/electronic sensors, controls, and wiring of exhaust gas recirculation (EGR) systems; perform necessary action.
7. Inspect, test, service, and replace components of the EGR system including tubing, exhaust passages, vacuum/pressure controls, filters, and hoses; perform necessary action.
8. Inspect and test electrical/electronically-operated components and circuits of air injection systems; perform necessary action.
9. Inspect and test catalytic converter efficiency.
10. Inspect and test components and hoses of the evaporative emissions control system; perform necessary action.
11. Interpret diagnostic trouble codes (DTCs) and scan tool data related to the emissions control systems; determine necessary action.

Aligned Washington State Academic Standards

Science

Below are the aligned standards addressed in this section: Integrated Science Lesson Objectives are from the 2014 NATEF/ASE publication "Being Relevant Matters" <https://www.asealliance.org/wp-content/uploads/2016/05/Being-Relevant-Matters.pdf> . NGSS and ELA Standards are correlated from a collaboration of Automotive, Science, ELA, OSPI teachers, and advisory group representative members.

Integrated Science Lesson Objectives

Engine Performance: Electrical Fundamentals (Ohm's Law), Environmental Science, Electronics Diagnostics, Chemistry of Batteries (Electrolysis), Physical Science, Personal Protection, Computer Science, Electromagnetic induction (Faraday's Law), Basic Engine Theory, Principles of Corrosion, Electrical Safety, Piezoelectric effect, Chemical reactions & accelerants, Electromechanical Theory, Electro Mechanic Wave Theory, Dynamic Flow effects, James Watt's Law of Horsepower, Thermal Efficiencies

Washington Science Standards (Next Generation Science Standards):

HS-PS1-2 Matter and its Interactions: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3 Matter and its Interactions: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles

HS-PS1-4 Matter and its Interactions: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy

HS-PS1-5 Matter and its Interactions: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS1-6 Matter and its Interactions: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

HS-PS2-1 Motion and Stability: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS2-3 Motion and Stability: Apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*

HS-PS2-5 Motion and Stability: Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

HS-PS2-6 Motion and Stability: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*

HS-PS3-1 Energy: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2 Energy: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects)

HS-PS3-3 Energy: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*

HS-PS3-4 Energy: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

HS-PS3-5 Energy: Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

	<p>HS-PS4-2 Waves and their Applications in Technologies: Evaluate questions about the advantages of using digital transmission and storage of information</p> <p>HS-PS4-5 Waves and their Applications in Technologies: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*</p> <p>HS-LS2-7 Ecosystems; Interactions, Energy, and Dynamics: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*</p> <p>HS-ESS3-1 Earth and Human Activity: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.</p> <p>HS-ESS3-2 Earth and Human Activity: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*</p> <p>HS-ESS3-4 Earth and Human Activity: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*</p> <p>HS-ETS1-3 Engineering Design: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.</p> <p>HS-ETS1-4 Engineering Design: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.</p>	
Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept

*Appendix A

Leadership Alignment

15 hours embedded into each section

Leadership activities include NATEF/ASE Supplemental tasks and 21st Century Skills. These Soft/Life skills, embedded into the curriculum and instruction for each unit of instruction and are being taught and assessed within the curriculum for all students.

NATEF/ASE soft/life skills and 21st Century Skills are clearly articulated during every **Vehicle Repair Procedures**, Concern – Cause – Correction. Students will demonstrate the ability to communicate clearly through their group project presentations.

Industry Standards and Competencies

This section should include appropriate industry standards and competencies aligned to the course, as is a required section:
Shop and Personal Safety

1. Identify general shop safety rules and procedures.

2. Utilize safe procedures for handling of tools and equipment.
3. Identify and use proper placement of floor jacks and jack stands.
4. Identify and use proper procedures for safe lift operation.
5. Utilize proper ventilation procedures for working within the lab/shop area.
6. Identify marked safety areas.
7. Identify the location and the types of fire extinguishers and other fire safety equipment; demonstrate knowledge of the procedures for using fire extinguishers and other fire safety equipment.
8. Identify the location and use of eye wash stations.
9. Identify the location of the posted evacuation routes.
10. Comply with the required use of safety glasses, ear protection, gloves, and shoes during lab/shop activities.
11. Identify and wear appropriate clothing for lab/shop activities.
12. Secure hair and jewelry for lab/shop activities.
13. Demonstrate awareness of the safety aspects of supplemental restraint systems (SRS), electronic brake control systems, and hybrid vehicle high voltage circuits.
14. Demonstrate awareness of the safety aspects of high voltage circuits (such as high intensity discharge (HID) lamps, ignition systems, injection systems, etc).
15. Locate and demonstrate knowledge of material safety data sheets (MSDS).

Tools and Equipment

1. Identify tools and their usage in automotive applications.
2. Identify standard and metric designation.
3. Demonstrate safe handling and use of appropriate tools.
4. Demonstrate proper cleaning, storage, and maintenance of tools and equipment.
5. Demonstrate proper use of precision measuring tools (i.e. micrometer, dial-indicator, dial-caliper).

Preparing Vehicle for Service

1. Identify information needed and the service requested on a repair order.
2. Identify purpose and demonstrate proper use of fender covers, mats.
3. Demonstrate use of the three C's (concern, cause, and correction).
4. Review vehicle service history.
5. Complete work order to include customer information, vehicle identifying information, customer concern, related service history, cause, and correction.

Preparing Vehicle for Customer

1. Ensure vehicle is prepared to return to customer per school/company policy (floor mats, steering wheel cover).

Career Planning

- Complete, discuss, and analyze the results of personality, career interest, and aptitude assessments;
- Explore the career clusters as defined by the U.S. Department of Education and summarize the career opportunities in a cluster of personal interest;
- Create a personal career portfolio including academic, certification and technical-skill requirement, career opportunities, expected wages, skills and aptitude necessary and the impact of technology on careers of personal interest.
- Determine academic/training or certification requirements for transition from one learning level to the next and explore opportunities for earning credit/certifications in high school such as advanced placement, tech prep, International Baccalaureate, college in the high school, military and apprenticeship opportunities.
- Develop and analyze tables, charts, and graphs related to career interests and make oral presentation regarding the career pathway of your choice.
- Develop an awareness of financial aid, scholarships, and other sources of income to support postsecondary education/training and discuss the impact of effective college and career planning.
- Identify how performance on assessments such as the SAT®, ACT®, ASVAB®, COMPASS® and ACCUPLACER® impact personal academic and career goals.
- Prepare a personal budget reflecting desired lifestyle and compare and contrast at least three careers of interest in regards to salary expectations and education/training costs.
- Prepare a program of study for at least one career of interest
- Apply knowledge gained from individual assessment to a set of goals and a career plan
- Develop strategies to make an effective transition from school to career
- Identify industry certification opportunities

Personal Success

- Reports to work daily on time; able to take directions and motivated to accomplish the task at hand.
- Dresses appropriately and uses language and manners suitable for the workplace.
- Maintains appropriate personal hygiene
- Meets and maintains employment eligibility criteria, such as drug/alcohol-free status, clean driving record, etc.
- Demonstrates honesty, integrity and reliability
- Implement effective study skills for academic success;
- Develop personal goals using SMART (Specific Measurable Attainable Realistic Timely), objectives and strategies.
- Use interpersonal skills to facilitate effective teamwork;
- Use a problem-solving model and critical-thinking skills to make informed decisions;
- Use effective time-management and goal-setting strategies;
- Effectively use information and communication technology tools; and
- Identify skills that can be transferable among a variety of careers.
- Create and complete appropriate documents such as electronic portfolio, personal resume, employment application, letter of intent, letters of recommendation and thank you letters.

- Complete job search documents, including job applications and W-4 forms;
- Demonstrate proper interview techniques in various situations Employability and Entrepreneurship
- Complies with workplace policies/laws
- Contributes to the success of the team, assists others and requests help when needed.
- Works well with all customers and coworkers.
- Negotiates solutions to interpersonal and workplace conflicts.
- Contributes ideas and initiative
- Follows directions
- Communicates (written and verbal) effectively with customers and coworkers.
- Reads and interprets workplace documents; writes clearly and concisely.
- Analyzes and resolves problems that arise in completing assigned tasks
- Organizes and implements a productive plan of work.
- Uses scientific, technical, engineering and mathematics principles and reasoning to accomplish assigned task
- Identifies and addresses the needs of all customers, providing helpful, courteous and knowledgeable service and advice as needed.
- Demonstrate effective verbal, nonverbal, written, and electronic communication skills;
- Evaluate the impact of positive and negative personal choices, including use of electronic communications such as social networking sites;
- Model characteristics of effective leadership, teamwork, and conflict management;
- Recognize the importance of a healthy lifestyle, including the ability to manage stress;
- Explore and model characteristics necessary for professional success such as work ethics, integrity, dedication, perseverance, and the ability to interact with a diverse population; and
- Complete activities using project- and time-management techniques.
- Identify and model appropriate grooming and appearance for the workplace;
- Demonstrate dependability, punctuality, and initiative;
- Research positive interpersonal skills, including respect for diversity;
- Model appropriate business and personal etiquette in the workplace;
- Exhibit productive work habits, ethical practices, and a positive attitude;
- Demonstrate the ability to work with the other employees to support the organization and complete assigned tasks;
- Demonstrate willingness to learn and further develop skills
- Describe the importance of having a positive attitude and techniques that boost morale
- Show initiative by coming up with unique solutions and taking on extra responsibilities
- Explain the importance of setting goals and demonstrate the ability to set, reach, and evaluate goals
- Explain the importance of taking pride in work accomplished and extrinsic and intrinsic motivators that can be used to increase pride
- Identify how to prioritize work to fulfill responsibilities and meet deadlines;
- Research and compare published workplace policies and procedures;
- Summarize provisions of the Fair Labor Standards Act;
- Describe the consequences of breach of confidentiality;

Aligned Washington State Standards

***Appendix A:** Not formatted appropriately, this Engine Performance/Drivability, standard/units example, shows number of comps and hours. The five columns are explained below.

1. Competency from the NATEF/ASE National Task List (A-E).
2. Priority: NATEF/ASE priority (1,2,or3), certification requires the ability to teach 90% of P-1, 80% of P-2, and 70% of P-3
3. AST Task: AST (Automotive Service Technology) is our current certification (because of hours), though we teach to the MAST (Maser Auto Service Tech) level.
4. Science Principle/Concepts (Black) are from Being Relevant Matters. Science Application (Red) are "Science verbs" and descriptions of accompanying required technology.

Standards and Competencies	
Standard/Unit: A-8 ENGINE PERFORMANCE (major)	
Competencies 47 Total, 34 AST	Unit Learning Hours: 165 hours + 15 hrs. soft/life skills = 180

A. General: Engine Diagnosis	priority	AST TAS K	Science Principle/Concept Being Relevant Matters Scientific Application	NGSS Aligned Standards
1. Identify and interpret engine performance concerns; determine necessary action.	P-1		Basic Engine Theory computer service information, Diagnostic flow charts, choosing solutions, ability to solve, design criteria, constraint solutions, Complex systems, Question, Investigate, Explain, Communicate Clearly, ENVIRO.	HS-PS1-3 HS-PS2-3 HS-PS2-6 HS-PS3-1 HS-PS3-4 HS-PS3-5
2. Research applicable vehicle and service information, vehicle service history, service precautions, and technical service bulletins.	P-1	X	wiring diagrams, TSB's, computerized service information, DVOM usage, Scan tool data	HS-PS2-6 HS-ETS1-2 HS-ETS1-4
3. Diagnose abnormal engine noises or vibration concerns; determine necessary action.	P-3	X	Basic Engine Theory, Personal Protection Piezoelectric sensor, mechanical and electronic stethoscope,	HS-PS1-4 HS-PS1-5 HS-PS1-6 HS-PS3-1
4. Diagnose the cause of excessive oil consumption, coolant consumption, unusual exhaust color, odor, and sound; determine necessary action.	P-2	X	Basic Engine Theory, Personal Protection, Antifreeze chemistry, heat transfer, pressure vs. boiling point, EPA concerns (environmental science) Identify Blow-by and PCV principles	HS-PS2-6 _HS-PS3-3

5. Perform engine absolute (vacuum/boost) manifold pressure tests; determine necessary action.	P-1	X	Basic Engine Theory Diagnose un-metered air, Data acquisition using mechanical and electronic gauges	HS-PS1-3 HS-PS2-3 HS-PS2-6 HS-PS3-1 HS-PS3-4 HS-PS3-5
6. Perform cylinder power balance test; determine necessary action.	P-2	X	Basic Engine Theory, Electrical Fundamentals (Ohm's Law), Electronics Diagnostics Data acquisition using mechanical and electronic gauges	HS-PS2-6
7. Perform cylinder cranking and running compression tests; determine necessary action.	P-1	X	Basic Engine Theory Data acquisition using mechanical and electronic gauges	HS-PS2-6
8. Perform cylinder leakage test; determine necessary action.	P-1	X	Basic Engine Theory Data acquisition using mechanical and electronic gauges	HS-PS2-6 _HS-PS3-3
9. Diagnose engine mechanical, electrical, electronic, fuel, and ignition concerns; determine necessary action.		X	Basic Engine Theory, Electrical Fundamentals (Ohm's Law), Electronics Diagnostics Electronic Testing using wiring diagrams & DVOM	HS-PS1-3 HS-PS2-3 HS-PS2-6 HS-PS3-1 HS-PS3-4 HS-PS3-5
10. Verify engine operating temperature; determine necessary action.	P-1	X	Basic Engine Theory, Thermal Efficiencies Computerized service information, procedural steps Data acquisition using mechanical and electronic gauges	HS-PS3-4
11. Verify correct camshaft timing.	P-2	X	Basic Engine Theory Computerized service information, procedural steps	HS-PS2-6

B. Computerized Controls Diagnosis and Repair	priority	AST TASK	Science Principle/Concept Being Relevant Matters Scientific Application	NGSS Aligned Standards		
1. Retrieve and record diagnostic trouble codes, OBD monitor status, and freeze frame data; clear codes when applicable.	P-1	X	Computer Science, Electronics Diagnostics Diagnosis & data acquisition using Scan tool	HS-PS1-3 HS-PS3-1 HS-PS4-1	HS-PS2-3 HS-PS3-4 HS-PS4-2	HS-PS2-6 HS-PS3-5
2. Access and use service information to perform step-by-step (troubleshooting) diagnosis.	P-1	X	Computerized service information, procedural steps	HS-PS1-3 HS-PS3-1 HS-PS4-1	HS-PS2-3 HS-PS3-4 HS-PS4-2	HS-PS2-6 HS-PS3-5
3. Perform active tests of actuators using a scan tool; determine necessary action.	P-2	X	Computer Science, Electrical Fundamentals (Ohm's Law), Electronics Diagnostics Distinguish sensor vs. actuator, Scan tool usage,	HS-PS1-3 HS-PS3-1 HS-PS4-1	HS-PS2-3 HS-PS3-4 HS-PS4-2	HS-PS2-6 HS-PS3-5
4. Describe the importance of running all OBDII monitors for repair verification.	P-1		Computer Science Verify electronically the self-test / electronic algorithm in complex computer system after repair	HS-PS1-4 HS-PS3-1	HS-PS1-5	HS-PS1-6
5. Diagnose the causes of emissions or driveability concerns with stored or active diagnostic trouble codes; obtain, graph, and interpret scan tool data.	P-1		Electrical Fundamentals (Ohm's Law), Electronics Diagnostics, EPA concerns (environmental science) Diagnosis & data acquisition using Scan tool, freeze frame & PID data, Computerized service information, flow charts, TSB's, & procedural steps, DSO usage	HS-PS1-3 HS-PS3-1 HS-PS4-1	HS-PS2-3 HS-PS3-4 HS-PS4-2	HS-PS2-6 HS-PS3-5 HS-PS3-3

6. Diagnose emissions or driveability concerns without stored diagnostic trouble codes; determine necessary action.	P-1		Electrical Fundamentals (Ohm's Law), Electronics Diagnostics, EPA concerns (environmental science) Diagnose live data, compare & contrast to electronic specs.	HS-PS1-3 HS-PS1-4 HS-PS1-5 HS-PS1-6 HS-PS2-3
7. Inspect and test computerized engine control system sensors, powertrain/engine control module (PCM/ECM), actuators, and circuits using a graphing multimeter (GMM)/digital storage oscilloscope (DSO); perform necessary action.	P-2		Computer Science, Electrical Fundamentals (Ohm's Law), Electronics Diagnostics Diagnose using GMM & DSO	HS-PS3-5 HS-PS1-3
8. Diagnose driveability and emissions problems resulting from malfunctions of interrelated systems (cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM installed accessories, or similar systems); determine necessary action.	P-3		Computer Science, Electrical Fundamentals (Ohm's Law), Electronics Diagnostics, EPA concerns (environmental science) Data acquisition using wiring diagrams, computerized service information, DVOM usage, Scan tool	HS-PS3-5 HS-ESS3-4 HS-ETS1-2 HS-ETS1-4

C. Ignition System Diagnosis and Repair	priority	AST TASK	Science Principle/Concept Being Relevant Matters Scientific Application	NGSS Aligned Standards
1. Diagnose (troubleshoot) ignition system related problems such as no-starting, hard starting, engine misfire, poor driveability, spark knock, power loss, poor mileage, and emissions concerns; determine necessary action.	P-2	X	Basic Engine Theory, Electrical Fundamentals (Ohm's Law), Electronics Diagnostics, EPA concerns (environmental science) computer service information, Diagnostic flow charts, choosing solutions, ability to solve, design criteria, constraint solutions, Complex systems, Question, Investigate, Explain, Communicate Clearly, ENVIRO.	HS-PS3-5 HS-PS3-1

2. Inspect and test crankshaft and camshaft position sensor(s); perform necessary action.	P-1	X	Computer Science, Electromagnetic induction (Faraday's Law), Basic Engine Theory, Electro-Mechanic Wave Theory Waves and their Applications in Technologies, objects interacting through electric or magnetic field electromagnetic force, Question, Investigate, Explain, Communicate Clearly	HS-PS3-5 HS-PS4-1 HS-PS4-5
3. Inspect, test, and/or replace ignition control module, powertrain/engine control module; reprogram as necessary.	P-3	X	Computer Science, Electrical Fundamentals (Ohm's Law), Electronics Diagnostics wiring diagrams, computerized service information, DVOM usage, Scan tool data, pin-point testing, flow chart/tree, ability to solve, procedural steps from electronic media,	HS-PS3-5
4. Remove and replace spark plugs; inspect secondary ignition components for wear and damage.	P-1	X	Electromagnetic induction (Faraday's Law), Principles of Corrosion Ohms Law Disassembly, Cleaning, Sealing, Assembling, High voltage leakage to path of least resistance, DVOM, DSO, procedural steps from electronic media	HS-PS1-4 HS-PS1-5 HS-PS1-6 HS-PS3-1

D. Fuel, Air Induction, and Exhaust Systems Diagnosis and Repair	priority	AST TASK	Science Principle/Concept Being Relevant Matters	NGSS Aligned Standards
1. Diagnose (troubleshoot) hot or cold no-starting, hard starting, poor driveability, incorrect idle speed, poor idle, flooding, hesitation, surging, engine misfire, power loss, stalling, poor mileage, dieseling, and emissions problems; determine necessary action.	P-2		Basic Engine Theory, Electrical Fundamentals (Ohm's Law), Electronics Diagnostics wiring diagrams, computerized service information, DVOM usage, Scan tool data, pin-point testing, flow chart/tree, ability to solve	HS-PS2-6

2. Check fuel for contaminants; determine necessary action.	P-2	X	Chemical reactions & accelerants, Personal Protection, EPA concerns (environmental science) Water/alcohol/fuel separation,	HS-PS1-6 HS-LS2-7
3. Inspect and test fuel pumps and pump control systems for pressure, regulation, and volume; perform necessary action.	P-1	X	Basic Engine Theory, Electrical Fundamentals (Ohm's Law), Electronics Diagnostics Data acquisition using mechanical and electronic gauges	
4. Replace fuel filter(s).	P-1	X	EPA concerns (environmental science) Disassembly, Cleaning, Sealing, Assembling	
5. Inspect, service, or replace air filters, filter housings, and intake duct work.	P-1	X	Airflow Dynamics Unmetered/unfiltered intake air vs. MAF/MAP	
6. Inspect throttle body, air induction system, intake manifold and gaskets for vacuum leaks and/or unmetered air.	P-2	X	Basic Engine Theory, Electronics Diagnostics, Dynamic Flow effects Unmetered/unfiltered intake air vs. MAF/MAP	HS-PS1-3 HS-PS2-3 HS-PS2-6 HS-PS3-1 HS-PS3-4 HS-PS3-5 HS-PS4-1 HS-PS4-2
7. Inspect and test fuel injectors.	P-2	X	Computer Science, Electromagnetic induction (Faraday's Law), Basic Engine Theory, Electronics Diagnostics Pulse Width Modulation PWM, Waves and their Applications, relationships among the frequency, wavelength, and speed	HS-PS1-3 HS-PS2-3 HS-PS2-6 HS-PS3-1 HS-PS3-4 HS-PS3-5 HS-PS4-1 HS-PS4-2
8. Verify idle control operation.	P-1	X	Electronics Diagnostics, Piezoelectric effect	HS-PS1-3 HS-PS2-3 HS-PS2-6 HS-PS3-1 HS-PS3-4 HS-PS3-5 HS-PS4-1 HS-PS4-2
9. Inspect integrity of the exhaust manifold, exhaust pipes, muffler(s), catalytic converter(s),	P-1	X	Basic Engine Theory, Dynamic Flow effects, X Chemical Reaction (Catalyst)	HS-PS1-3 HS-PS2-3 HS-PS2-6 HS-PS3-1 HS-PS3-4 HS-PS3-5 HS-PS4-1 HS-PS4-2

resonator(s), tail pipe(s), and heat shields; perform necessary action.				
10. Inspect condition of exhaust system hangers, brackets, clamps, and heat shields; repair or replace as needed.	P-1	X	Catalyst Chemical Reaction	HS-PS2-6
11. Perform exhaust system back-pressure test; determine necessary action.	P-2	X	Basic Engine Theory, Dynamic Flow effects Vacuum/pressure relations, intrusive and non- intrusive pressure testing,	HS-PS2-6
12. Check and refill diesel exhaust fluid (DEF).	P-3	X	Basic Engine Theory, Dynamic Flow effects, Chemical Reaction (Catalyst & Urea), EPA concerns (environmental science)	HS-ESS3-4 HS-LS2-7
13. Test the operation of turbocharger/supercharger systems; determine necessary action.	P-3		James Watt's Law of Horsepower, Physical Science, Thermal Efficiencies	HS-PS3-1

E. Emissions Control Systems Diagnosis and Repair	priority	AST TASK	Science Principle/Concept Being Relevant Matters Scientific Application	NGSS Aligned Standards		
1. Diagnose oil leaks, emissions, and driveability concerns caused by the positive crankcase ventilation (PCV) system; determine necessary action.	P-3	X	Basic Engine Theory, Chemical Reaction (Catalyst), EPA concerns (environmental science) Constructing explanations, arguments from evidence, computer service information, Diagnostic flow charts, choosing solutions, ability to solve, design criteria, constraint solutions, Complex systems, Question, Investigate, Explain, Communicate Clearly, ENVIRO.	HS-PS1-3 HS-PS3-1 HS-PS4-1	HS-PS2-3 HS-PS3-4 HS-PS4-2	HS-PS2-6 HS-PS3-5 HS-LS2-7

2. Inspect, test, and service positive crankcase ventilation (PCV) filter/breather cap, valve, tubes, orifices, and hoses; perform necessary action.	P-2	X	Basic Engine Theory, Chemical Reaction, EPA concerns (environmental science) Constructing explanations, arguments from evidence	HS-PS1-3 HS-PS3-1 HS-PS4-1	HS-PS2-3 HS-PS3-4 HS-PS4-2	HS-PS2-6 HS-PS3-5
3. Diagnose emissions and driveability concerns caused by the exhaust gas recirculation (EGR) system; determine necessary action.	P-3	X	Basic Engine Theory, Dynamic Flow effects, Chemical Reaction, EPA concerns (environmental science) Use quantitative methods to compare the potential of different solutions	HS-PS2-6	HS-PS3-4	HS-LS2-7
4. Diagnose emissions and driveability concerns caused by the secondary air injection and catalytic converter systems; determine necessary action.	P-2		Computer Science, Chemical Reaction, EPA concerns (environmental science), Basic Engine Theory, Electronics Diagnostics Use quantitative methods to compare the potential of different solutions	HS-PS2-6	HS-LS2-7	
5. Diagnose emissions and driveability concerns caused by the evaporative emissions control system; determine necessary action.	P-2		Computer Science, Chemical Reaction, EPA concerns (environmental science), Basic Engine Theory, Electronics Diagnostics	HS-PS1-3 HS-PS3-1 HS-PS4-1	HS-PS2-3 HS-PS3-4 HS-PS4-2	HS-PS2-6 HS-PS3-5
6. Inspect and test electrical/electronic sensors, controls, and wiring of exhaust gas recirculation (EGR) systems; perform necessary action.	P-2		Computer Science, Chemical Reaction, EPA concerns (environmental science), Basic Engine Theory, Electronics Diagnostics, Piezoelectric effect Constructing explanations, arguments from evidence	HS-PS2-6	HS-PS3-4	HS-PS3-5
7. Inspect, test, service, and replace components of the EGR system including tubing, exhaust passages, vacuum/pressure controls, filters, and hoses; perform necessary action.	P-2		Basic Engine Theory, Chemical Reaction, EPA concerns (environmental science) Constructing explanations, arguments from evidence Use quantitative methods to compare the potential of different solutions	HS-PS1-3 HS-PS3-1 HS-PS4-1	HS-PS2-3 HS-PS3-4 HS-PS4-2	HS-PS2-6 HS-PS3-5

8. Inspect and test electrical/electronically-operated components and circuits of air injection systems; perform necessary action.	P-3	X	Computer Science, Chemical Reaction, EPA concerns (environmental science), Basic Engine Theory, Electronics Diagnostics, Piezoelectric effect Constructing explanations, arguments from evidence	HS-PS1-4 HS-PS3-1	HS-PS1-5 HS-PS3-4	HS-PS1-6
9. Inspect and test catalytic converter efficiency.	P-2	X	Basic Engine Theory, Chemical Reaction (Catalyst), EPA concerns (environmental science) Scan tool PID Data, Element conversion through oxidation and reduction catalyst, Rules that govern the behavior of tiny things like molecules, atoms, and subatomic particles, electron mass, Molecular compounds, Atoms, Ions	HS-PS1-4	HS-PS1-6	HS-PS3-4
10. Inspect and test components and hoses of the evaporative emissions control system; perform necessary action.	P-1	X	Basic Engine Theory, Chemical Reaction, EPA concerns (environmental science) Constructing explanations, arguments from evidence, generate inert smoke for testing leaks, PWM	HS-PS1-3 HS-PS3-1 HS-PS4-1	HS-PS2-3 HS-PS3-4 HS-PS4-2	HS-PS2-6 HS-PS3-5
11. Interpret diagnostic trouble codes (DTCs) and scan tool data related to the emissions control systems; determine necessary action.	P-3	X	Computer Science, Electronics Diagnostics, EPA concerns (environmental science) Use quantitative methods to compare the potential of different solutions	HS-PS1-3 HS-PS3-1 HS-PS4-1	HS-PS2-3 HS-PS3-4 HS-PS4-2	HS-PS2-6 HS-PS3-5