Apprenticeship Manitoba

Manitoba

Heavy Duty Equipment Technician
Level 1

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Apprenticeship Manitoba

Heavy Duty Equipment Technician

Unit: A1 Safety, WHMIS & Preventative Maintenance

Level: One

Duration: 5 hours

Theory: 5 hours

Practical: 0 hours

Overview:

This unit of instruction is designed to provide the Heavy Duty Equipment Technician apprentice with the knowledge and understanding of WHMIS and safety-related procedures. Notes: The Industry strongly recommends that apprentices acquire basic First Aid and CPR skills through the successful completion of a recognized certificate program **(employer responsibility)** prior to the commencement of Technical Training. Pre-Employment grads and those challenging Levels 1, 2 or 3 are strongly recommended to receive their WHMIS training prior to the commencement of in-school Technical Training **(employer responsibility).**

Objectives and Content:	**Percent of Unit Mark (%)**
1. Describe safety and WHMIS theory and practices.	**80%**

a. WHMIS legislation and regulations
- History of WHMIS
- WHMIS components
  -Evaluation of material
  -Determination of health risks
  -Monitoring of health hazards
  -Control measures
  -Prevention plans
  -Workplace record maintenance
- Components of the Health Hazard Regulation
  -Labeling
  -Material Safety Data Sheets
  -Worker training and instruction
- Duties and responsibilities of suppliers, employers and employees

b. WHMIS classes and symbols
- Class A
- Class B
- Class C
- Class F
- Product inventory: Manitoba WHMIS regulations

c. Appropriate work habits and related safety issues
- Safety boots
- Eye protection
- Face protection
- Hearing protection
- Head protection

- Masks
- Lifting techniques
- Location of safety equipment
- Long hair
- Jewelry
- Loose shirt and sleeves
- Oil soaked clothing
- Neck ties
- Horseplay

d. "Garage housekeeping" work habits and procedures
   - Disposal of used fluids
     -Environmental issues
     -Health issues
   - Dangers of exhaust fumes (ventilation)
   - Electrical hazards
   - Drainage and rotating devices
   - Safety shields and guards
   - Rag and waste disposal
   - Air lines and fittings
   - Interior and tender covers
   - Cluttered workplace hazards
   - Liquid spill hazards
   - In-shop driving precautions
   - Tool and equipment maintenance
   - Personal grooming

e. Safety rules for using hand drills and hand grinders
   - Goggles
   - Materials secured
   - Loose clothing, sleeves and ties, hazards
   - Water hazards
   - Condition of tool cords
   - Power tool hazards – explosive vapours
   - Unplugged when using drill chuck
   - Properly grounded power equipment
   - CSA approved

f. Safety rules for bench grinder and wire wheels
   - Use of goggles on worksite
   - Tight, clean and true abrasive stones
   - Grinder at full RPM before using
   - Tool rest close to wheel
   - Vise-grip pliers for small objects
   - Use of leather gloves for heavy grinding
   - Dangers of revolving grinding wheel
   - Importance of grinding wheel guard
   - Hazard: grinding near explosive vapors
   - New stones appropriate to grinder's RPM
   - Standing position relative to grinder

g. Fire control equipment and fire prevention procedures
   - Fire extinguisher appropriate to fire class
     -Pressurized water –Class A fires
     -Soda acid- Class A fires
     -Carbon dioxide ($CO_{2)}$ – Class B and C

-Dry chemical – Class B, C, and D
-Foam – Class A and B
- Fire blankets
- Fire classifications “A”, “B”, “C”, & “D”
- Potential fire hazards
- Location of fire fighting equipment
- Fire exits and observations
- Evacuation & fire warning procedures
- Fire suppression system hazards (on vehicles)

2. Describe cab, canopy, ROP/FLOP components; operation, inspection, repair and replacement procedures. **5%**

a. Cab, canopy, ROP/FLOP components and their operation
   - Seat assemblies
   - Operator controls
   - ROP/FLOP
   - Hand rails
   - Steps

b. Inspection, repair and replacement procedures for cab, canopy, and ROP/FLOP components. (NOTE: Requirement for Rollover Protection (ROP) certificate)
   - Visual awareness and reference to structural defects.
   - Avoidance of welding/drilling in stressed areas
   - Requirement of professional structural engineers to certify modifications
   - Cleaning of components to expose defects
   - Diagnosis of abnormal conditions
     -Misalignment
     -Bends
     -Cracks
     -Broken or cracked glass
     -Damaged interiors
     -Non-functioning accessories & controls
     -Broken parts
     -Unsafe conditions
   - Removal, repair and replacement procedures
     -Adherence to manufacturers' specifications
     -Doors & locks
     -Covers
     -Door tracks
     -Shock absorbers
     -Windows
     -Weather stripping
     -Seat systems
     -Minor sheet metal work

3. Describe the servicing of fire suppression systems. **5%**

a. Referral to manufacturers' specifications re: safety considerations
b. System safety procedures
   - Avoidance of contact with excessive heat
   - Avoidance of disconnecting / severing wires & hoses
c. Referral of all system maintenance and servicing to appropriate specialists

4. Describe forklift operation and safety (Employer responsibility) **0%**

a. Role of employer in manufacturer - specific training
b. Certification: Powered Lift Truck Training: Manitoba Labour
c. Other organizations offering forklift training

5. Describe restraint systems, their components, inspection procedures, manufacturers' tests, and repair / replacement. **10%**

a. Restraint systems and their components
   - Active restraint system components
   - Passive restraint system components

b. Restraint system inspections and manufacturers' tests
   - Seat belts servicing
   - Webbing inspection
   - Buckle inspection
   - Retractor inspection
   - Drive track assembly and anchor inspection
     -Anchors inspection
     -Upper body damage check
     -Loose bolts
     -Restoration of corrosion protection
     -Drive motor
   - Seat belt tensioner
   - Rear seat restraint system
   - Warning light and audible warning systems

c. Repair or replacement of restraint system components
   - Seat belt retractors and receivers
   - Modules
   - Sensors
   - Motors
   - Collapsible steering wheels
   - Knee bolsters
   - Solenoids
   - Actuators
   - Switches

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Apprenticeship Manitoba

Heavy Duty Equipment Technician

Unit: A2 Equipment Access / Transport and Related Procedures

Level: One

Duration: 7 hours

Theory: 7 hours

Practical: 0 hours

Overview:

This unit of instruction is designed to provide the Heavy Duty Equipment Technician apprentice with the working knowledge required to effectively and safely use proper lifting techniques and equipment as defined by broad occupational health and safety standards.

Objectives and Content: **Percent of Unit Mark (%)**

1. Describe lifting equipment. **15%**

a. Jacks and jackstands
- Mechanical & hydraulic jacks
- Jack stands

b. Hoists
- Differential chain hoist
- Screw-geared chain hoist
- Electric chain hoist
- Come-along

c. Hoist and lifting equipment raising techniques
- Capacity
- Location
- Balance
- Use of hoist pads

2. Describe safety practices and maintenance of lifting equipment. **15%**

a. Safety practices
- Equipment capacity
- Safety stands (jack stands) – proper distance and location
- Jacks
- Frame & chassis hoist
- Slings
- Capacities
- Chains (properly marked)
- Wire rope maintenance
- Overhead cranes

b. Maintenance of hoist and lifting equipment

- Hoist capacity
- Use of service manual
- Safe work practices
- Daily visual inspection
  -Damaged or loose mounts bolts
  -Worn or damaged arms
  -Hydraulic oil leakage
  -Locks for damage
  -Hydraulic controls
  -Electrical conductors, switches and controls

c. Use of overhead cranes
- Locking clip on chain hook
- Limit switches

3. Describe towing, transporting and coasting precautions. 15%

a. Care of transmission and frame
- Rotation of main shaft
- Adequate lubrication of main shaft gears
- Pulling of axle shafts
- Disconnection of driveline
- Re-tightening of axle shaft nuts to proper torque
- Proper re-installment of axle shafts
- Proper phasing of driveshafts

b. Recommended twing methods
- Preparation of vehicle for towing
- Use of a rigid tow bar with front tow hook/pin
- Alternative use of lift bar
- Lifting of front axle
- Drive wheels off-ground
- Avoidance of coasting in neutral / with clutch depressed

c. Movement of vehicles in the shop
- Caution on speed; free and clear path
- Assistance in guiding vehicle in tow setup

d. Following of manufacturers' specifications: towing distances and procedures

4. Describe manual lifting procedures using correct body mechanics. 15%

a. Consequences of improper lifting procedures
b. Approved lifting techniques
c. Lifting tolerance factors
d. Load assessment/injury avoidance

5. Describe lifting equipment construction, grading, sizing and limits. 15%

a. Overall importance
b. Slings
- Wire rope construction
- Wire rope lay & size
- Strand classification
- Breaking (nominal) strength
- Safe working load

c. Wire rope sling types
d. Synthetic web sling types
- Safe working load for synthetic web slings

e. Wire rope and sling inspection maintenance
   - Broken wires
   - Abrasion
   - Rope-diameter reduction
   - Damaged splices and end connections
   - Bird caging, kinks
   - Core protrusion
   - Heat damage and arc strikes

f. Use, handling and maintenance of wire rope slings

g. Chain
   - Construction
   - Working load limit
   - Safety factor
   - Slings & sling load leveller
   - Inspection

h. Hooks
   - Inspection & load-carrying capacity

i. Shackles
   - Rules for use

j. Swivels

k. Load binders; safety

l. Spreader bars & equalizer beams

m. Eyebolts

n. Hoists
   - Differential chain hoist
   - Screw-geared chain hoist
   - Electric chain hoist
   - Come-along

o. Lifts
   - Shop boom lift
   - Floor gantry
   - Electric overhead travelling cranes

p. Jacks and jackstands
   - Mechanical jacks
   - Hydraulic jacks
   - Jack stands
   - Air jacks

6. Select the correct equipment for rigging typical loads. 15%

a. Key factors in assessing loads

b. Lifting configurations
   - Vertical hitch
   - Bridle hitch
   - Single & double basket hitch
   - Double wrap basket hitch
   - Single choker hitch
   - Double choker hitch
   - Double wrap choker hitch

c. Safe working load for wire rope slings & chokers
   - Effect of sling angle on load
   - Recommended sling angles for lifting

- Sling shock loading

7. Describe wire rope applications. 5%

a. Overall description & general configuration
b. Installation and maintenance guidelines
   - Drum preparation
   - Unloading of rope
   - Twists
   - Attachment of rope end to drum
   - Winding of rope onto drum
   - Checking rope: twisting
   - "Breaking in" new rope
   - Maintenance procedures

8. Describe winch design, operation and troubleshooting procedures. 5%

a. Overall description & purpose configuration
b. Classifications
   - Pull-in power
   - Drive method
     -Mechanical
     -Hydraulic
     -Electric
   - Design
     -Line speed
     -Drum capacity
     -Type of application
     -Reverse powerout
     -Automatic brakes
     -Clutch type & actualtion
     -Method of power transmission
   - Track & wheel-type tractor winch
   - Single-drum tractor winch
     -Neutral operation
     -Payout & power-out operation
     -Winching-in operation
     -Troubleshooting and testing
   - Superstructure winches
     -Differences vs. track-type winches
     -Design
     -Neutral operation
     -Raising and lowering the load
     -Third drum operation
   - Two-speed hydraulic winch
     -Design
     -Neutral and hold operation
     -Raising and lowering the load
   - Hydraulic tractor winch
     -Differences vs. two-speed winch
     -Design
     -Neutral operation
     -Pull-in
     -Power-out
     -Troubleshooting

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Apprenticeship Manitoba

Heavy Duty Equipment Technician

Unit: B1 Basic Computer Skills and Information Retrieval

Level: One

Duration: 20 hours

Theory: 6 hours

Practical: 14 hours

Overview:

This unit of instruction is designed to provide the Heavy Duty Equipment Technician apprentice with basic computer / internet skills to support trade-related research and communications tasks.

Objectives and Content:	**Percent of Unit Mark (%)**

1. Describe basic computer and internet components and operations; use internet functions. — **50%**

a. Basic computer components and their functions
- Input devices
- Output devices
- CPU
- Hard drive
- RAM
- ROM
- Auxiliary drives A, B, C, etc.
- Keyboard
- Monitor
- Mouse
- Printer – types, impact and non-impact
- Parallel port
- Series port
- Care and handling of DVDs and CD-ROMs
- Aspects of Windows software
- DOS vs. Windows

b. Performance of basic computer operations
- Application programs
- Common commands
- File management tasks
- Spreadsheets
- Use of manual as reference

c. Internet system components
- The World Wide Web
- File servers
- Network addresses

- URL addresses
- Bookmarks
- Search engines

d. Performance of internet searches utilizing various search engines
   - Accessing search engines via URL addresses
   - Using key words
   - Filtering results

e. Using email for work-related communication
   - Public domain email services
   - Email addresses
   - Sending email
   - Replying to email inquiries
   - Email attachments (text, graphics)
   - Email website links

f. Use of proprietary software

2. Access and interpret service-related information from various retrieval systems. 50%

a. Interpretation of vehicle identification numbers (VINs) and manufacturers' labels
   - VIN/manufacturers label information
     -Make
     -Model
     -Year
     -Place of manufacture
     -Type of engine/fuel/emission control
   - VIN

b. Interpretation of service manuals and service bulletins (hard copy applications)
   - Sequential layout operation
   - Diagrams
   - Flow charts
   - Schematics
   - Tool specifications
   - Selecting test equipment and replacement parts

c. Accessing of service-related information from automated information retrieval systems
   - Information resources available
     -DVDs
     -Fax-back retrieval system
     -On-line system update
   - Procedure for operating microfiche
     -Procedure for operating computerized information service systems
     -Mitchell On-demand
     -On-line updates
   - Procedure for accessing on-line manufacturer assistance and on-line assistance

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Apprenticeship Manitoba

Heavy Duty Equipment Technician

Unit: C1 Welding (Oxyacetylene)

Level: One

Duration: 20 hours

Theory: 2 hours

Practical: 18 hours

Overview:

This unit of instruction is designed to provide the Heavy Duty Equipment Technician apprentice with the hands-on knowledge required to use welding equipment and perform welding techniques.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Identify the components of oxy-acetylene equipment.	**10%**
a. Tanks • Oxygen • Acetylene b. Pressure regulators • Oxygen • Acetylene c. Gauges – line pressure and tank pressure • Oxygen • Acetylene d. Manual valves e. Torch tips f. Torches – cutting and welding g. Hoses • Oxygen • Acetylene h. Fittings • Oxygen • Acetylene i. Cylinder handling – storage and transport	
2. Demonstrate procedure for setting up oxy-acetylene unit.	**10%**
a. Tanks • Oxygen • Acetylene b. Pressure regulators • Oxygen	

- Acetylene

c. Gauges – line pressure and tank pressure
   - Oxygen
   - Acetylene

d. Tips

e. Torches – cutting and welding

f. Hoses
   - Oxygen
   - Acetylene

g. Fittings
   - Oxygen
   - Acetylene
   - Construction
   - Identification

3. Describe principles for using welding and cutting equipment. 10%

a. Safety precautions
   - Eye protection
   - Boots
   - Gloves
   - Face shield
   - Fire extinguisher
   - Ventilation equipment

b. Portable units
   - Bottles
   - Safety caps
   - Valves
   - Regulators
   - Hoses
   - Torch
   - Gas flow
   - Leaks (via soapy water)

c. Lighting, adjustment, shutting down and disassembly procedures
   - Adjustment of pressures
   - Ignition procedure
   - Types of flames (oxidizing, carbonizing, and neutral)
   - Shut down procedure
   - Disassembly
   - Storage

4. Describe metallurgy. 10%

a. Identification and characteristics of metals
   - Welding of different thicknesses
   - Metal identification techniques

b. Material prep
   - Cleaning

5. Perform welding, brazing and cutting procedures. 60%

a. Material prep
   - Cleaning

b. Fusion welding

- Welding tip (identification, selection, maintenance and size)
- Fitter rod (identification, selection and size)
- Heat and cutting damage to surrounding material

c. Mild steel plate welding
   - Pressure settings and flame adjustments
   - Tip angle
   - Technique
   - Starting the weld
   - Welding results
   - Slow weld
   - Fast weld
   - Dirty tip
   - Running bead with out a filler rod
   - Running bead with a filler rod
   - Welding joints

d. Cutting torch and cutting process
   - Cutting attachments (connections, control lever)
   - Cutting tips – orifices
   - Setting pressures
   - Flame lighting and adjusting
   - Extinguishing the flame
   - Starting the cut
   - Cutting technique
   - Tip angle
   - Cutting results
   - Slow cut
   - Fast cut
   - Dirty tip
   - Safety issues with concrete floors

e. Performance of braze welding using oxy-acetylene equipment
   - Braze welding
   - Flame
   - Temperature
   - Brazing process
   - Angle
   - Technique
   - Starting the weld
   - Welding results
   - Slow weld
   - Fast weld
   - Dirty tip

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Apprenticeship Manitoba

Heavy Duty Equipment Technician

Unit: D1 Engine Systems and Repair Procedures

Level: One

Duration: 102 hours

Theory: 52 hours

Practical: 50 hours

Overview:

This unit of instruction will provide the Heavy Duty Equipment Technician apprentice an extensive knowledge of engine construction and principles of operation. It also provides hands-on knowledge of disassembly, inspection and reassembly procedures. Unit content will also provide the apprentice with the skills required to diagnose and repair engine, lubrication, cooling and intake/exhaust systems. In addition, the apprentice will learn how to effectively use tools, fasteners, gaskets and seals.

Objectives and Content: **Percent of Unit Mark (%)**

1. **Describe and use basic hand tools, measuring tools, shop equipment, and fasteners (to be taught throughout other unit objectives).** **13%**
   a. Hammers
      - Ball peen
      - Brass
      - Soft faced
      - Dead blow
      - Rubber mallet
      - Cross peen
      - Sledge

   b. Screwdrivers
      - Standard
      - Phillips
      - Reed and Prince
      - Robertson
      - Specialty (Torx, Posidrive)

   c. Socket handles
      - Ratchet handle
      - Flex handle
      - Speed handle
      - Extension

   d. Sockets
      - Deep
      - Shallow
      - 6 point
      - 12 point

- 8 point
- Impact
- Flex
- Spark plug
- Screwdriver attachments (Hex driver, Phillips drive, flat tip drive, clutch, Torx, three-wing, double square)
- Types of drives (¼", 3/8", ½", ¾")

e. Wrenches
- Open end
- Box-end
- Combination
- Adjustable
- Allen
- Off-set
- Flare nut

f. Pliers
- Combination (slip joint)
- Adjustable (channel lock)
- Needle nose
- Locking (vise grip)
- Diagonal cutting
- Snap ring

g. Punches
- Center
- Starting
- Pin punch
- Aligning
- Drift – (straight shank brass)

h. Cutting tools
- Chisel (rivet buster, diamond, round nose cape, cape, cold, flat)
- Taps (taper, plug, bottoming, machine screw)
- Dies
- Hacksaw
- Twist drills
- Files
- Reamers
- Countersinks

i. General shop tools
- Stud removers
- Tubing tools (flaring tool)
- Gear and bearing pullers
- Thread file (thread chaser)
- Impact wrenches
- Ratchet wrench
- Vice
- Battery strap
- Drill press
- Hydraulic press
- Battery service tool
- Cooling system service tools
- Grinders

- Drills
- Air chisel
- Die grinders

j. General purpose
- Non-precision measuring
- Precision measuring
- History, purpose, function, types, styles, and application
- Metric and imperial measurements and conversions
- Tool maintenance

k. Precision tool types, selection and reading
- Steel ruler
- Outside and inside micrometers
- Depth micrometer
- Vernier caliper
- Dial indicator
- Torque wrench
- Torque angle wrench
- Hole gauge
- Telescoping gauge
- Feeler gauge
- Valve seat runout gauge
- Cylinder bore dial gauge
- Pressure gauge
- Vacuum gauge
- Plastigauge

l. Primary shop tools and equipment
- Safety stands
- Drill press
- Hydraulic press
- Shop creepers
- Air compressor
- Brake pressure bleeder
- Parts washer
- Pressure washer
- Hot tank
- Air tools
- Grinders
- Sand blaster
- Engine cranes
- Engine slings

m. Safety considerations
- Equipment capacity
- Safety stands (jack stands) – proper distance and location
- Drill press
- Hydraulic press
- Shop creepers
- Air compressor
- Brake pressure bleeder
- Parts washer
- Pressure washer
- Hot tank

- Air tools
- Grinders
- Sand blaster
- Engine cranes
- Engine slings
- Creepers

n. Common fasteners and fastening devices
- Bolts & studs
- Machine screw
- Wing nut
- Prevailing torque
- Speed nut
- Self locking nuts
- Palnut
- Cap screw
- Castle nut
- Plain hex nut
- Set screw
- Sheet metal
- Pop rivet
- Cotter pin
- Key
- Roll pin
- Snap rings (internal and external)
- Locking devices
  -Split & tooth lock
  -Locking nuts (soft collar, slotted and pinched, distorted threaded palnut)
  -Lock plate
  -Safety wire

o. Principles and precautions in selecting bolts and screws

p. Bolt and screw terminology
- Pitch
- Minor diameter
- Major diameter
- Thread length
- Screw length
- Threads per inch
- Head size
- Root
- Crest
- Flank
- Size
- UNC
- UNF
- NPT
- Metric

q. Hardware descriptions
- E.g. ½ * 3 13 UNC 2A 10 32 2
- Imperial (head, grade marking, length, thread pitch, nominal diameter)
- Metric (head, property class, length, thread pitch, nominal diameter)
- UNC and UNF threads

r. Removing and installing fasteners

- Torque principles
  -Elasticity
  -Elastic limit
  -Yield
  -Torque to yield bolts
  -Hooke's Law
  -Tensile strength
  -Residual tension
  -Torque
  -Tension
  -Distortion & compression
  -High pressure lubricant
- Torque charts (imperial and metric)
  -Standard bolt and nut torque specifications
  -Metric bolt and nut torque specifications
  -Standard nut and bolt strength marking
  -Metric nut and bolt strength marking
  -Need for lubricating all head bolts
- Uses of torque wrench
  -Types
  -Choosing a torque wrench
  -Effects of adapter use
  -Torque wrench calibration
  -Recommended torque sequence
- Precautions for bolts
  -Visual inspection
  -Tighten to recommended torque
  -Head tight against surface
  -Appropriate length and size

s. Safe use, operation and maintenance of threads
- Taps and dies uses
- Broken tap removal
- External thread chasers
- Common tapping problems
- Thread repair
  -Tap to oversize
- Broken stud removal
  -Stud slotted or filed flat
  -Nut welded on
  -Punch used to unscrew broken piece
  -Screw extractor
  -Drill and use tap to remove shell

2. Describe and install sealing devices and perform seal service. 3%

a. Gasket construction, materials, and application
- Purpose
- Gasket materials
  -Steel
  -Aluminum
  -Copper
  -Asbestos
  -Cork
  -Rubber (synthetic)
  -Paper
  -Felt
  -Liquid silicone
- Gasket selection criteria
  -Temperature
  -Type of fluid to be confined

-Smoothness of the mating surfaces
-Fastener tension
-Pressure of confined fluid
-Material of mating parts
-Localized unit loading (fire-ring, coating, beads, flange, neoprene)

- Adverse forces
  -Heat and cold
  -Pressure
  -Erosion / corrosion
  -Moisture
- Gasket installation techniques
  -Avoidance of reuse
  -Checking of mating surface
  -Proper fit
  -Use of sealant (types and uses)
  -Holding of gasket during assembly
  -Straightening of stamped parts
  -Proper torque sequence
- Gasket failure
  -Checking of fastener torque
  -Visible signs (uneven pressure, burning, corrosion, cracks, voids)
  -Checking of mating surface (warpage and burrs)
- Static seals
- Dynamic seals
- Seal construction and installation
- Purpose
  -Confinement of fluids
  -Stopping of foreign materials
  -Separation of two different fluids
  -Static and dynamic seals
- Material, construction and use
  -Lip seal (three part construction, single and double lip)
  -O ring seal
  -Two piece oil seal (engine rear main bearing)
  -Graphite impregnated asbestos
  -Synthetic rubber
- Oil seal removal
  -Depth
  -Removal techniques
  -Not reusable
  -Potential damage to seal bore
- Oil seal installation
  -Proper coating
  -Suitable driver/roper depth
  -Seal sleeves and bullets
- Seal failure analysis (lip and O-ring)
  -Worn
  -Twisted
  -Flattened
  -Cut
  -Swollen
  -Dirty

b. Seal service procedures
   - Static seals
   - Dynamic seals

3. Explain engine principles. 18%

a. Engine operating theory
   - Matter

- Mass
- Energy
- Inertia
- Force
- Pressure waves
- Momentum
- Torque
- Work / horsepower
- Mechanical power
- Friction
- Combustion
- Atmospheric pressure
- Vacuum
- Laws of gases
- Boyle's Law
- Charles Law

b. Internal combustion principles
   - Internal combustion engine
     -Burning inside engine
     -Combustion requirements
   - Combustion by-products
     -Ideal (CO_2, H_2O)
     -Actual (CO, NOX, HC, smoke, $CO_{2)}$
   - Engine purpose

c. Major engine components
   - Cylinder head
   - Valves
   - Valve guide
   - Valve spring
   - Valve lifter
   - Camshaft
   - Cam lobe
   - Camshaft gear
   - Block
   - Cylinder
   - Piston pin
   - Piston
   - Connecting rod
   - Crankshaft
   - Crankshaft gear

d. Engine terminology
   - Bore and stroke
   - Square, over and under square engine
   - Calculation of engine displacement
   - Calculation of compression ratio
   - TDC; BTDC; BDC; ATDC

e. Engine classifications and their operation
   - Key classifications
     -Valve arrangement
     -Number of cylinders & arrangement
     -Cycle
     -Type of Cooling
     -Type of fuel

- Two-stroke vs. four-stroke operation intake
  -Compression
  -Power
  -Exhaust

f. Fuel types
- Gasoline & diesel
- LPG

g. Cooling systems
- Liquid
- Air

4. Explain engine performance. 18%

a. Key terms
- Work
- Power
- Torque

b. Friction force/lubrication
- Dry – metal to metal
- Greasy – cam lobe and lifter
- Viscous – engine bearing

c. Engine efficiency
- Volumetric efficiency
  -Maximum filling of cylinder
  -Cylinder intrusions
- Causes of volumetric efficiency decrease
  -Altitude
  -Dirty air filter
  -Temperature
  -RPM
  -Atmospheric pressure
  -Exhaust restriction
- Engine innovations re: volumetric efficiency
  -Less exhaust back pressure
  -Variable valve timing
  -Superchargers & turbochargers
- Thermal efficiency

5. Describe engine construction; perform removal, installation, disassembly / assembly, inspection and reconditioning procedures. 18%

a. Construction of cylinder heads, combustion chambers as well as intake and exhaust systems
- Cylinder head construction
- Finishing operation
  -Deck surface finishing operation
  -Holes drilled for oil, bolt holes, push rods etc.
  -Cooling nozzle and deflectors installed
- Integral vs. removable guides
- Induction hardening of seats
- Coolant distribution tube
- Combustion chamber shapes
- Injection sleeves

b. Construction and operation of valve train mechanism
- Valve construction and design
  -Alloy steel, case hardened
  -Head
  -Face

-Stem
-Keeper or lock groove
-Margin
-Purpose & concerns: sodium-cooled valves
-Safety issues with valve stems

- Valve spring assembly construction & design
  -Dampening out of vibration
  -Prevention of valve float
  -Installation
  -Damper spring
- Valve spring retainers
- Valve rotators
  -Positive with ball and spring
  -Release type
- Bridge & rocker arm design
  -Shaft and stud
  -Shaft and ball stud
  -Cam followers
  -Individual
- Push rod construction
  -Hollow
  -Solid
- Valve lifters
  -Roller type
  -Solid
  -Solid adjustable
- Operation of valve mechanism
  -Less weight
  -Less valve float at high speeds

c. Camshaft design & terminology
   - Base circle
   - Ramp
   - Lobe
   - Nose & heel
   - Cam lobe lift
   - Cam shape differences
     -Flat lifter
     -Roller lifter
   - Drive fuel pump
     -Injector
   - Installation
   - Damage prevention of bearings
   - Gear, chain, belt

d. Camshaft location advantages and disadvantages
   - Less weight
   - Less valve float at high speeds

e. Bearing types
   - Friction bearings
     -Split
     -Full round
   - Precision insert bearings
     -Conformability
     -Corrosion resistance
     -Embedability
     -Performance – fatigue resistance
     -Score resistance
   - Bearing construction and design
     -Steel back

-Copper alloy lining
-Barrier plate
-Tin-lead alloy over-plate
-Pure tin flash plate
-Crush & spread
-Clearance/thrust flange

f. Cylinder block construction
- Construction methods
  -Drop forging
  -Casting
- Block materials
  -High grade cast iron
  -Cast or die cast aluminum alloy
  -Nickel content
- Finishing of operations to block after casting
  -Cylinders bored and finished to size
  -Holes drilled, oil, coolant threads etc.
  -Bearing caps
  -Lining of bored caps
  -Counterbore measure, machining & shims

g. Piston and rod assembly
- Piston construction and features
  -Cam ground
  -Heat dams (location)
  -Thrust struts (diagonal, horizontal, vertical)
  -Steel struts and inserts
  -Head shapes
  -2-piece
  -Aluminum
  -Tin plated
  -Cast iron
  -Hollowed piston pin
  -Case-hardened piston pin
- Connecting rod construction
  -Alloy steel
  -Drop-forged then machined
  -I-beam construction
- Piston terminology
  -Head
  -Lands
  -Oil ring drain hole
  -Oil ring groove
  -Skirt
  -Ring grooves
  -Pin hole & pin boss
- Piston major and minor thrust side
- Attaching pistons to connecting rods
  -Fully floating
  -Piston pin locked to rod / piston

h. Piston ring construction & design
- Construction of rings
  -Cast iron with coating of chrome
  -Molybdenum, graphite and phosphate
  -Plasma coat
- Compression ring joints
  -Butt
  -Lap
  -Bevel
- Ring shapes (cross-sectional)
  -Tapered face

-Counter-bored – barrel faced
-Outer grooved-scraper type bevel
-Plain rectangular
-Inner grooved – bevel
-Center grooved

- Action of counter-bored, taper faced or grooved ring
  -Intake stroke – ring twist
  -Compression stroke – ring twist
  -Power stroke – full face contact with cylinder wall
  -Exhaust stroke – ring twist
- Oil control ring construction
  -One & three-piece oil control ring
- Expander devices
  -Location of fit: bottom of the ring groove
  -Force ring against cylinder
- Finishing operations
  -Boring bearing hole
  -Honed
  -Splitting of lower end
  -Possible drilling oil hole
  -Rifle drilling
  -Piston cooling jet Lubrication of: piston pin, cylinder and opposite cylinder

i. Crankshaft parts & arrangements
- Main journal
- Connecting rod journal
- Flywheel flange
- Web
- Fillet radius
- Crank cheek
- Balance hole
- Counterweight
- Snout
- 4, 6 & 8 cylinder
- Firing order
- Crankshaft finishing (lathe) operations
  -Drilling of oil holes
  -Filleting of radius
  -Correction of diameter
  -Grinding & polishing

j. Flywheel and harmonic balancers
- Flywheel purpose
  -Reduction of power impulses
  -Mounting for clutch
  -Gear for starter operation
- Flywheel construction
  -Machined steel
  -Bolted to crankshaft
  -Smooth surface to provide a friction surface
  -Hole in center for pilot bearing
  -Starter ring gear welded or interference fit to flywheel
  -Flex plates
- Harmonic balancer purpose
  -Absorption of torsional vibration
  -Timed to size of engine
  -Marks for timing of engine
  -Service time (life expectancy)
- Harmonic balancer construction
  -Rubber plugs

-Spring loaded friction disc
-Fluid filled
- Balance shafts & eccentrics

k. Engine mounts and bell housing
- Construction of the bell housing
-Aluminum
-Cast iron
-SAE classification
- Integral with and separated from transmission housing
- Alignment of bell housing to engine block
-Dowel pin
-Shims
- Engine mount
-Rubber pads; shock absorbers
-Three point suspension
-Location

l. Construction of the timing cover, oil pan, valve cover, seals and gasket
- Stamped steel
- Cast aluminum
- Head gasket & construction
-Localized unit loading
-Thin steel, copper and asbestos
-Fire rings
-Embossed steel (shim gasket)
-Metal clad sandwich gasket
-Soft-seal surface composition gasket – steel core, encapsulated

m. Disassembly
- Precaution and procedures
- Procedures for removal of engine components and assembly

n. Cylinder heads
- Removal procedures
- Disassembly procedures and precautions (component inspection and evaluation, wear and damage of components)
- Visual inspection; physical damage (warpage, cracks)

o. Valve train and camshafts (inspection and testing)
- Visual inspection - general
- Disassembly procedures
- Bearing wear
- Journal and thrust wear
- Valve train components: rocker arm assemblies (wear points: valve stem and pushrod; excessive clearance; loose mounting stud and bolt; plugged oil feed)
- Valve train components: pushrods (bent, grooves and tip wear, nicks and grooves at ends)
- Valve train components: spring assembly (broken or damaged parts, proper tension and free length)
- Valve train components: broken and damaged retainers and keepers
- Valve train components
-Lifters (wearing, scoring or pitting)
-Excessive loading (correct cam rotation)
-Camshaft warpage and alignment
-Plugged oil feed
-Correct cam lift (broken and damaged parts, lobe and lifter wear)

p. Timing components
- Timing gear & chain

q. Short block inspection
- Block
-Visual inspection (thread condition, cracks)

-Cranks, pistons, rods
-Oil pump (visual inspection, measurement, pickup condition)

- Block measurements
  -Deck flatness
  -Cylinder wear (walls, bore inspection, bore surface finish)
  -Block warpage
  -Crack detection and inspection
  -Bearing bore condition and alignment
  -Counter bores
- Piston and pin
  -Visual inspection (cracked skirt, ring groove wear and damage)
  -Measurement
- Rod assembly
  -Connecting rod (alignment, bore condition, size & lengths)
- Crankshaft
  -Visual inspection (includes: mounting flanges, threaded holes, crack detection)
  -Journal wear and abnormal bearing wear
  -Crankshaft warpage (alignment)
- Torque yield fasteners

r. General cleaning procedures

- Chemical solvents: equipment and procedures
  -Chemical cleaning machines
  -Soak tanks
  -Hot spray tanks
  -Citrus chemicals, salt baths
- Thermal cleaning
- Abrasive cleaning: abrasive blaster and parts tumbler
- Usage and precautions: aluminum oxide, sandpaper or cleaning discs
- Vibratory and ultrasonic cleaning

s. Service operations of key engine components

- Cylinder head
  -Warpage repair procedures (straightening, resurfacing)
  -Crack repair
  -Valve guide service procedures
  -Valve seat service procedures
  -Valve service procedures
- Cam bearings
  -Removal and replacement: procedures and equipment
  -Overhead cam bearing bore - reconditioning procedures
- Camshaft
  -Inspection and measurement
- Block
  -Short block service equipment
  -Line boring or honing
  -Deck resurfacing, cutters, grinders and sanders
  -Cylinder (integral and liner)
  -Cylinder service (ridge removal, deglazing, boring, honing)
  -Counter bore repair
- Piston, pin and ring service equipment
- Connecting rod service equipment
  -Straightening connecting rod aligner (bend, twist)
  -Resizing (grinder and precision hone)
  -Pin bushings
- Crankshaft
  -Service equipment
  -Grinding, cutting, polishing
  -Balancing

t. Assembly of short block components

- Plugs, block heaters, oil gallery plugs

- Sealing and fastening procedures and precautions
- Piston clearance
- Main bearing clearance
- Crank end play
- Ring side clearance
- Ring end gap and ring placement (staggering)
- Installation of pistons
- Connecting rod clearance & side play
- Oil pump clearance (internal)
- Camshaft installation
  -Avoidance of damaging bearings
  -Adequate clearance between camshaft gear and backing plate
  -Installation of timing chains and gears
  -Cam assembly and prelube

u. Assembly of valve train components
- Valve and valve spring: installed height
- Valve clearance adjustment (OH cam)

v. Cylinder head installation
- Preparation, procedures and cautions
- Cam and auxiliary shaft timing procedures
- Valve and bridge adjustments

w. Disassembly & reconnection: linkages, electrical systems and fuel systems

x. Disassembly & reconnection: exhaust, cooling and auxiliary devices (e.g., compressor / power steering)

y. Troubleshooting considerations
- Oiling
- Oil pressure
- Compression problems
- No-start

6. Describe and perform procedures to diagnose, service and repair engine lubrication systems. **18%**

a. Servicing procedures: purpose
- Cleaning of engine
- Reduction of friction
- Hydrodynamic suspension
- Cooling
- Absorption of shock
- Sealing between ring and block

b. Lubrication system types
- Splash
- Pressurized
- By-pass
- Full flow
- Combination

c. Engine oils
- SAE and viscosity ratings
- API service classifications
- Oil additives
- Synthetic oils
- SAE viscosity oil grades and rating systems
- Oil change intervals
  -Formation of sludge

-Formation of varnish
-Oil change intervals
- Recognition of contaminated fluid
- Oil analysis
-Contamination of sample
-Interpretation of analysis
-Identification of contaminants
-Collection of specimen

d. Components
- Oil pump
-Gears
-Rotors
- Oil pump pickup
-Pipe or cast metal
-Floating pickup type
-Filter screen
-Valve for oil bypass
- Oil filters
-Types: cartridge, spin on or throw away
-Construction of filtering media (surface & depth)
- Oil cooler
- Oil pans
- Oil filter bypass valve
- Relief valve
- Cooler bypass
- Baffles
- Oil filtering systems operation
-Full flow
-By pass
-Shunt
- Lubrication systems operation
-Crankshaft bearing: pressure
-Rocker arm: pressure and splash
-Piston: splash
-Cylinder walls: connecting rod squirthole
-Camshaft lobe: splash
-Camshaft bearing: pressure

e. Diagnosis of lubrication system problems
- Low/high oil pressure
-Installation of pressure gauges
-Importance of engine operating temperature
-Check of pressure at low and high speed
-Compliance with manufacturer's specs
- Interpretation of oil contaminants: sampling & filter contamination
- Excessive oil consumption
- Oil leakage

f. Scavenging

g. Disassembly procedures

h. Inspecting and measuring pump wear

i. Following manufacturer's specifications

j. Reassembly procedures

7. Describe the servicing of engine oil, filters and startup. 2%

a. Changing of engine oil
- Procedures for draining oil
- Precautions with hot oil

- Cleaning drain plug
- Filling procedures
- Importance of cleanliness
- Checking oil level
- Proper torque of drain plug
- Storage of used oil
- Oil change intervals
  -Formation of sludge
  -Formation of varnish
  -Oil change intervals

b. Changing of engine oil filter
- Construction of filter
- Types
- Selection of filter
- Removal
- Seals
- Cleanliness
- Consequences of not using proper procedures

c. Starting and running of engines after servicing
- Oil leak check
- Oil pressure check
- Oil level check

8. Describe cooling system types, operation and service. 4%

a. Cooling systems construction and operation
- Purposes of cooling system
  -Removal of surplus heat
  -Efficient operating temperature under all conditions
  -Efficiency in reaching operation temperature
- Cooling system types
  -Air
  -Liquid: conventional & reverse flow
- Antifreeze
  -Glycol-based type
  -Other types (long-life coolant)
  -Protection levels with water
  -Freeze protection (ethylene glycol)
  -Anti-boil protection (ethylene glycol)
  -Lubrication protection: water pump seal (ethylene glycol)
  -Anti-scale protection
  -Acidity protection
  -Anti-foam protection
  -Corrosion protection
  -Cavitation protection

b. Construction, operation & servicing of cooling systems
- Radiator cores
  -Round tube and flat fin
  -Flat fin and corrugated fin
  -Flat tube and flat fin
  -Modular core radiators
- Radiator cap pressure and vacuum valves
  -Pressure valve springs
  -Vacuum valve
  -Pressurization of system
  -relationship between pressure on a liquid and boiling point
- Construction of radiator hoses
  -Rubber –single or double ply construction

-Straight, curved or flexible
-Reinforcement in lower radiator hose
-Hose clamps types (worm drive, screw type, twin-wire, spring)

- Construction and operation of a water pump
  -Centrifugal pump
  -Circulation of water
  -Placement of impeller in closed housing
  -Minimization of pressure
  -Drive types
- Flow of coolant: cross & down-flow radiator
  -2-pass flow
- Fan shroud
  -Efficiency
  -Air flow shape
  -Problems with missing shrouds
- Radiator fans
  -Rigid vs. reversible
  -Clutch drive: viscous & air
  -Electric & air (controls)
- Shutters
  -Rigid
  -Controls
- Cooling system service
  -External leaks
  -Pressure testing method
  -Black light and dye
  -Hot or cold leak
- Internal leaks
  -Pump gauge method
  -Leaking cylinder bank
  -Chemical method
  -Other internal leak tests
- Service procedures: cooling system parts
  -Safety precautions
  -Servicing radiator leaks
  -Improper radiator cap vacuum valve operation
  -Cooling system flush methods (pressure, reverse)
  -Precautions when flushing radiators
  -Testing procedure for thermostat
  -Cooling system hose deterioration signs
  -Cooling system maintenance: (filters, conditioners, extenders)
- Belts
  -Diagnosis of belt problems
  -Belt types (V belts, serpentine)
  -Belt installation procedures

9. Describe starting aids. **2%**

a. Block heaters
   - Installation procedure
   - Frost core
   - Inline type
b. Ether kits
c. Glow plugs
d. Aftermarket cooling heaters (e.g., ProHeat or Espar)
e. Warm-up devices

10. Describe air intake and exhaust system design and operation. **4%**

a. Intake system concepts

- Principles
- Control
- Design
- Intercoolers / aftercoolers
- Volumetric efficiency
- Comparison of manifold vacuum to ported vacuum on gasoline engines

b. Intake system components
- Air filters
  -Principles
  -Types: paper and polyurethane
  -Primary & secondary
- Air cleaner assembly
- Air intake ductwork
- Naturally aspirated
- Turbo chargers (exhaust driven)
  -Service precautions
- After-coolers and inter-coolers
- Super chargers (engine driven)
  -Service precautions
- Intake manifold (in line and V-type engines)
  -Cast iron or aluminum
  -Prevention condensation
  -Assistance in vapourization
  -Efficiency in mixing of fuel
  -Air speed to reduce condensation
  -Inline engines runner configuration
  -V configurations (open and closed intakes; coolant and heat riser passage)
  -Attached sensor
  -Tuned intake system
- Intake manifolds operating principles
  -Cold air
  -Hot air
  -Control
  -Distribution
  -Tuning
  -Variable induction
  -Tuned port induction
- V-type intake manifold vs. in-line type
  -Shorter runners
  -Better fuel distribution to cylinder

c. Exhaust systems: components & servicing
- Safety precautions (carbon monoxide)
- Exhaust manifold designs & construction
- Pipes, supports, clamps
- Oxygen sensors
- Catalytic converters
- Mufflers, scrubbers & resonators
  -Reverse
  -Through flow
  -Heat riser valve and operation (butterfly valve, thermostatic spring operated, vacuum operated)
- Exhaust problems
  -Alignment
  -System checks for leaks and/or restrictions
- Exhaust system tools
  -Sealers
- Routing

- Removal and replacement procedures

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Apprenticeship Manitoba

Heavy Duty Equipment Technician

Unit: E1 Standard Transmission Systems; Drivelines, Transfer Cases and PTOs

Level: One

Duration: 63 hours

Theory: 25 hours

Practical: 38 hours

Overview:

This unit of instruction is designed to provide the Heavy Duty Equipment Technician apprentice with the working knowledge required to diagnose, service and repair problems related to clutches, standard transmissions, drive lines, transfer cases and PTOs.

Objectives and Content: **Percent of Unit Mark (%)**

1. **Describe the design, operation, maintenance and troubleshooting of flywheels, clutches and bearings.** **10%**
   a. Flywheels
      - Purpose
      - Types
      - Inspection and machining

   b. Clutch design, operation, maintenance and troubleshooting
      - Overall role of clutch
      - Basic operation concept
        -Relation of clutch to power train
      - Pilot bearings
      - Disk and plate: dry disk clutch
        -Driving and driven parts
        -Operation
        -Pressure plate assembly
        -Intermediate plate
        -Clutch disks (single & multi)
        -Clutch shaft
        -Angle spring
        -Lubrication
        -Uses
      - Disk and plate: wet disk clutch
        -Operation
        -Wet clutch disks
        -Servicing
        -Lubrication
      - Sprag clutch (wet or dry)
      - Cone
      - Expanding shoe
        -Mechanical

-Centrifugal
- Magnetic clutches
  -Direct
  -Indirect
- Pneumatic
- Slip
- Clutch brake
- Flywheel housing components
  -Shafts
  -Bushings
  -Forks
  -Alignment
- Troubleshooting
  -Chattering
  -Dragging
  -Squeaks
  -Rattles
  -Grabbing
  -Slipping
  -Vibrations
  -Failure to transmit power
  -Bearing noises

c. Clutch operating mechanisms and perform servicing
- Mechanical clutch controls
  -Standard linkage (cable & rod)
  -Over-centre linkage
  -Sprag clutch servicing
- Hydraulic
  -Master vs. slave cylinders
- Electrical
  -Direct action
  -Service
- General servicing tips
- Clutch disks
- Flywheel
- Clutch release bearing

d. Bearing design, operation, and troubleshooting
- Bearing functions
- Bearing applications
- Bearing types
  -Friction bearings
  -Anti-friction bearings (types, races, implied loads)
- Thrust loads
  -Radial loads
  -Axial loads
- Friction bearings
  -Split bearing
  -Bushing
- Roller bearings
  -Tapered
  -Plain
  -Spherical
  -Needle
- Ball bearings
  -Single & double row
  -Deep groove
  -Angular contact
- Loading bearings

- Adjustment of bearings
- Bearing lubrication
- Bearing troubleshooting & failure analysis
  -Contamination
  -Pitting
  -Etching
  -Peeling
  -Spalling
  -Brinelling
  -Arcing
  -Fatigue
- Bearing servicing

e. Bearing service (including performance)
- Removal methods
  -Cooling & heating
  -Hydraulic cylinder & puller
  -Hydraulic press
  -Bearing puller
  -Weld
- Cleaning bearings
  -Solvent baths
- Bearing installation
  -Cold mounting methods
  -Cylindrical bore bearings
  -Needle bearings
  -Tapered roller bearing assembly
  -Hot mounting methods (Preparation, Heating methods, Procedure for heating)
- Bearing adjustments
  -Internal clearance (Measuring, Radial, Axial, Residual, Running)
  -Preload & shim adjustment
  -Locking methods
- Performing bearing service
  -Packing bearings

2. Describe gear ratio theory; describe the fundamentals, components, operations, inspection / testing procedures of manual and single countershaft transmissions; perform related disassembly, reassembly, and reinstallation procedures. **70%**

a. Transmission fundamentals
- Function and purpose
- Types / speed ranges
- Applications / ratings torque
- Gear theory
  -Leverage
  -Transmission gear sets & ratios
  -Gear ratios
  -Reverse gear ratios
- Power flow variations
- Synchronizers
- Lubrication

b. Gear oil and its service requirements
- Function
- Classification & selection
- Safety precautions
  -Blocking procedures prior to removal
  -Releasing of system pressure
- Fluid and lubricant leaks: common causes
- Indicators of oil contamination

- Other indicators re: oil change
- Draining of oil
- Cleaning or replacement of filtration devices
- Refilling the system
- Type and grade
- Cleanliness
- Proper oil level
- Machinery operation re: oil
  -Flushing the system
- Consequences of mixing different types/grades of oil

c. Single countershaft transmission: components, operations, power flows, disassembly and reassembly
- General design features and speed ranges
- Collar shift
- Synchronizer types
  -Block
  -Disk-and-plate
  -Plain
  -Pin
- Shift controls & features
  -Direct & cam shifters
- Operation of transmission in downshifting mode
- General maintenance and adjustments

d. Diagnosis, inspection and testing procedures
- Fluid level checks
- Fluid changes
- In-vehicle service
  -Rear oil seal and bushing replacement
  -Backup light switch service
  -Speedometer drive gear service
  -Linkage adjustments (shift and clutch)
- Other preventative maintenance checks
- Visual inspection
- Transmission troubleshooting (component failure)
  -Primary and consequential damage
  -Noise in neutral
  -Gear noise: “Growling”, “Clicking” and “knocking”
  -Difficulty in shifting
  -Hard shifting / gear clash while shifting / smoothness of linkage
  -Sticking in gear / locked-in gear
  -Slipping out of gear
  -Oil leaks
  -Bearing noise

e. Disassembly, repair, reassembly and reinstallation
- Road testing to verify need for transmission removal
- Removal of oil to assess condition of sludge
- Positioning of vehicle to facilitate use of lifting devices
- Adherence to specific service manuals
- Removal and installation of transmission
- Dismantling and assembly of manual transmission
  -Use of appropriate tools (gear puller, hydraulic press, soft-faced hammer)
- Avoidance of excessive force with parts
- Cleaning and inspection of bearings
  -Washing and scraping of parts
- Inspection and removal: nicks and burrs
- Replacement of bent covers

- Cracks in bearings (races, bearing shields, ball separators)
  -Brinelling and fretting
- Replacement and lubrication of bearings
- Cleaning and inspection of gears:
  -Common problems (Lipping, Pitting from abrasive wear, Plastic yielding, Spalling & scoring, Fatigue Fracture, Chipped teeth edges)
  -Worn cluster gear and countershaft
  -Bore inspection: wear and damage
  -Worn idler gear, slider gear and shaft
  -Worn input shaft and gear
  -Chipped, broken, or worn main and speed gears
  -Synchronizer sleeves: free movement
  -Wear of synchronizer blocking rings
  -Damaged teeth: speedometer
  -Runout and damaged splines: output shaft
  -Worn bushings and seal: extension housing
  -Shift forks
- Verification of power: flow-through gears
- End play
- Identify component failure: primary and secondary causes
- Shift components and interlocks
- Torquing procedures for reassembly
- Alignment requirement: bell housing, chassis
- Organization and cleaning of separate parts
- Maintenance: integrity of bearings in packings
- Drilled passages free of obstructions for installation of new gears
- Referral to service manuals for varied reassembly instructions
  -Ongoing clearance steps at various reassembly steps
- Avoidance of forcing parts into position
- Adherence to timing procedure for twin/triple countershaft transmissions
- Rotation of semi-assembled components to ensure clearance
- Verification of transmission operation
  -Shifting of transmission through speed ranges
  -Checking of gear/clutch engagement
  -Rotation of clutch drive shaft
- Removal of clutch assembly and replacement or service of worn parts
- Mounting of PTO to transmission (where required)

3. Describe the design and operation of PTOs and driveline systems; perform related diagnosis, inspection, testing, disassembly and servicing/reconditioning/repair procedures; describe power transmission theory, 4WD transfer case operation, service and repair. **20%**

a. PTOs

- Types
  -Transmission-driven
  -Continuous-running
  -Independent
- PTO operation
  -At 1000 RPM vs. 540 RPM
- Relationship of drive shaft speed and balance
- Centrifugal force
- Linear and angular movement
- Slip yoke (joint)
- Propeller shafts
- Lubricating oils and additives
- Driveline operation

-Drive shafts (slip yoke, multipiece driveshafts)
- Fluctuation drive shaft speed

b. Driveshafts and universal joints
- Universal joints
  -Single vs. double-cardan
- Analysis of various noises, roughness, vibrations, play
- Runout in drive shaft
- Excess undercoating, dents, missing weights on driveshaft
- Replacement of hanger bearings

c. Driveshaft servicing/ reconditioning/repair procedures
- Drive line angle measurements
- Drive line angle alignment and adjustment
- Two-joint assembly alignment
- Measuring the offset alignment
- Balancing the propeller shaft
- Multipropeller shaft angle checks
- Trim height and frame altitude
- Drive line phasing
- Servicing the drive line
- Lubricating universal joints
- Venting service

d. 4WD transfer case operation, service and repair
- 4WD vs. AWD
- Purpose and design of transfer case
  -Differential ability
  -Ranges
  -Shifting
- Transfer case operation
  -Gears
  -Chain-type
  -Ranges
  -Shifting
  -Power flow
- Relative location and configuration
- Drive line, windup and interaxle differentials
  -Clutch pack, cone braking system vs. transfer case
- Other 4WD components
  -Locking and unlocking hubs
  -Axle disconnects
  -Centre differential
- 4WD operation
  -Servicing, inspection and testing of transfer case assemblies
  -Maintenance of fluid levels
  -Use of service manual for specific repair & overhaul procedures
  -Use of transmission jack for support
  -Disconnection of drive line and propeller shaft assemblies, linkage, wires, fasteners, electrical components
  -Marking of parts and positions
  -Measurements and adjustments
  -Identification of component failures and causes
  -Inspection of internal parts and replacement
  -Slack in chain drive
  -Shaft assembly end play
  -Factors influencing gear ratios

e. Transmission of power: gears, belts & chains
- Belt drives

- Failure analysis
- Chains
  -Lubrication
  -Alignment
- Special drives
  -Pitmans
  -Wobble boxes

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Apprenticeship Manitoba

Heavy Duty Equipment Technician

Unit: F1 Tires and Wheel Assemblies

Level: One

Duration: 18 hours

Theory: 14 hours

Practical: 4 hours

Overview:

This unit of instruction is designed to provide the Heavy Duty Equipment Technician apprentice with the working knowledge required to repair wheels, wheel ends, and tires.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Describe tire type, construction and classification.	**12%**

a. Tire construction
- Tire function
- Types of tire materials
  -Rubber
  -Fabric casting plies: rayon, nylon, polyester
  -Wire
- Parts of tire
  -Tread
  -Bead wires
  -Soft rubber liner
  -Rubbing strip
  -Width & height
  -Plies
- Construction of tire plies
  -Bias ply
  -Radial
  -Advantages of radial as compared to bias
  -Run flat
- Tire and wheel size designations
  -Matching limits: Front-to-front; side-to-side
- Tire rating systems
  -Ply rating
  -Load range
  -Tubeless tire
  -Tire grade
  -Tread wear
  -Traction
  -Temperature resistance
  -Load index and speed rating

b. Types of tires
- Tubeless
- Off-road

- Solid type

2. Describe wheel types and mounting designs. 13%

a. Types of wheels
   - Spoke wheels
   - Disc wheels
   - Stud piloted disc wheels
   - Hub piloted disc wheels
   - Drop center, steel disc
   - Drop center, cast or forged aluminum
   - Offset, width, diameter etc.
   - Directional wheels

b. Parts and purpose of wheel sections
   - Mounting holes
   - Spider (center section)
   - Drop center section
     -Bead area
     -Rim
     -Safety ridges

3. Perform hub removal, inspection, service and installation. 50%

a. Hub mounting
   - Dead axles
   - Live axles

b. Axle hub removal
   - Safety precautions (asbestos)

c. Axle hub inspection

d. Axle hub installation

e. Hub construction
   - Cast iron
   - Aluminum

f. Middle / wheel seals
   - Types
   - Construction
   - Installation
   - Troubleshooting

g. Diagnosis of wheel bearing and hub problems
   - Excessive heat
   - Abnormal noises
   - Wheel wobble
   - Uneven wheel bearing movement

h. Procedures for installing wheel studs
   - Screwed
   - Pressed
   - Left-hand threads
   - Internal/external-threaded studs

i. Anti-friction bearings
   - Ball
   - Needle
   - Roller & tapered roller
   - Bearing shoulder
   - Self-aligning

- Double-row

j. Races (friction bearings)
   - Solid races
   - Split ring

k. Loads applied on wheel bearings
   - Radial
   - Axial

l. Race construction
m. Lubrication methods
n. Removal & installation procedures
o. Cleaning & inspection
p. Packing wheel bearings
q. Adjustment procedures
r. Methods of locking adjustments
s. Cleanliness
t. Defective bearings

4. Describe safety procedures when handling wheels, tires and hubs **12%**

a. Safety precautions
b. Safety rules

5. Describe and perform tire maintenance and service. **13%**

a. Service requirements for wheels and tires
   - Radial and lateral runout
     -Use of dial indicator
     -Use of shop manual
     -Acceptable limits (runout not exceeding 1/16 inch or 1.59mm)
   - Location of tire inflation specifications (nitrogen vs. air)
   - Causes of abnormal tire wear
     -Over inflation
     -Under inflation
     -Camber wear
     -Multi problem – cupping
     -Toe wear
     -Tire rotation
   - Problems caused by mixing radial and bias tires
     -Handling problems – steering wheel pull
   - Tire matching and selection
   - Removal and installation of tires
     -Proper mounting technique
     -Installation of tube tires
     -Use of tire lubricant
     -Safety precautions
     -Reasons for torquing wheel nuts to specification
     -Wheel nut tightening sequence
   - Tire and tube repair

b. Tire care
c. Wheel balancing
   - Diagnosis
   - Safety precautions
   - Wheel weights
   - Wheel balancers
     -Dynamic balancers (on-vehicle; off-vehicle)
     -Static balancers (bubble)
     -Compare static to dynamic wheel imbalance

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Apprenticeship Manitoba

Heavy Duty Equipment Technician

Unit: H1 Brake Fundamentals and Components

Level: One

Duration: 20 hours

Theory: 15 hours

Practical: 5 hours

Overview:

This unit of instruction is designed to provide the Heavy Duty Equipment Technician apprentice with the knowledge to understand brake system components and operation. The unit will also provide the apprentice with the key skills required to diagnose and repair various braking systems.

Objectives and Content:	**Percent of Unit Mark (%)**

1. Describe the fundamentals of hydraulic brake systems. **5%**

a. Pascal's Principle/pressure volume relationship
- P=F/A
- Area of piston calculation; cylinder volume
- Calculation of piston distance movement
- Small vs. large cylinders

b. Levers
- First class
- Second class
- Third class
- Mechanical Advantage (Load or Resistance / Effort or MA=R/E)

c. Coefficient of friction
- Friction materials

d. Brake friction factors
- Component devices
- Air
- Water
- Contamination
- Oil, grease, dirt
- Temperature
- Vehicle load
- Wear
- Glazing
- Adjustment

e. Heat and heat dissipation

f. Hydraulic principles

g. Pneumatic principles

h. Servo brakes
i. Non-servo brakes

2. Describe parking brakes systems and their operation; perform adjustment/repair procedures. 5%

a. Wheel types
   - Mechanical linkage
   - Hydraulically operated
b. Driveshaft type
   - Mechanically activated
   - Internal shoe type
c. External band types
d. Electric, hydraulic & spring activated
e. Disc type
f. Spring brake chamber
   - Servicing precautions of spring brakes
g. Relationship to other brake systems

3. Describe the operation and service of master and wheel cylinders. 5%

a. Liquid under confinement
   - Transmission of pressure
   - Increase in force
   - Decrease in force
   - Transmission of motion
b. Small vs. large cylinders
   - Pressure required
   - Force required
c. Master cylinders
   - Conventional (Single piston)
   - Tandem (Dual)
d. Single piston master cylinder
   - Parts and operation
   - Residual check valve
   - Return spring
   - Piston
   - Primary cup
   - Secondary cup
   - Stop ring
   - Push rod
   - Dust boot
   - Breather port
   - Compensating port
e. Tandem (dual) master cylinder
   - Parts and operation
   - Residual check valve
   - Primary spring
   - Primary piston
   - Primary cups
   - Secondary cups
   - Stop ring
   - Push rod

- Dust boot
- Secondary piston
- Breather port
- Compensating port
- Secondary spring

f. Wheel cylinders
- Single piston
- Double pistons
- Stepped

4. Describe hydraulic brake lines, fluid and bleeding, and procedures to remove, repair and replace brake lines. **10%**

a. Brake lines
- Steel tubing
- Flexible hose

b. Steel lines and protection methods
- Double wrapped
- Brazed and tin-plated
- High pressure exceeding 1000 psi (6895 kPa)
- Straight run avoidance
- Long run support
- Detour around hot spots
- Use of rubber grommet
- Double flare and ISO
  -Proper cutting tubing
  -Removing burrs
  -Proper use of flaring tool
  -Proper flare – full contact
  -Improper flare (uneven, cocked, split, flare, shoulder, narrow contact)
  -Square with centerline
  -Correct size

c. Flexible hoses and protection methods
- Multiple-ply
- Able to exceed 8000 psi (55,160 kPa)
- Avoidance of sharp or double bends and twisting
- Allowance of slack for connections
- Flats or flange shapes on mounting brackets
- Clips to secure in place
- Sealing washers

d. Fittings
- Connectors
- Unions
- Elbows
- T-fittings
- Junction or distribution block
- ISO
- Metric

e. Valves
- Metering
- Proportioning
- Pressure differentiated

f. Brake line flares
- Double

- Flare angles

g. Brake fluids and their limitations
   - Disc brake fluid
   - Conventional (glycol-based)
   - Silicone based
   - Mineral oil-based

h. Brake fluid characteristics & precautions
   - Even viscosity throughout temperature range
   - High boiling point
   - Hydroscopic and non-hydroscopic
   - Use as lubricant
   - No corrosion of metal parts
   - No deterioration of rubber parts
   - No mixing of different brake fluids
   - Avoidance: skin contact
   - Avoidance of paint
   - Lids on containers
   - Effect of contaminated fluid

i. Flushing and changing brake fluid
   - Moisture accumulation
   - Rust and corrosion
   - Change in boiling temperature
   - Change in freezing temperature

j. ABS systems precautions

k. Procedures for removing, repairing and replacing brake lines
   - Brake lines
   - Fittings
   - Repair and replacement procedures
   - Safety considerations

5. Describe hydraulic brake valves. 5%

a. Valve types
   - Metering valve
   - Proportioning valve

b. Pressure differential

c. Brake-metering valve
   - Brake released
   - Light brake pedal application
   - Heavy brake pedal application

d. Brake-proportioning valve
   - Brake released
   - Light vs. heavy brake pedal application

e. Pressure differential switch
   - When working
   - During system failure

f. Brake light switches & warning indicators
   - Hydraulic
   - Mechanical

6. Diagnose and troubleshoot faulty brake performance. 5%

a. Brake pedal moves to floorboard (no pedal, no brakes)

b. Pulsating pedal (rapid “up and down” movement)
c. One / all-brake drag
d. Vehicle pull to one side (brake grab)
    - Brakes fade
e. Soft or spongy pedal
f. Poor braking action
    - Hard pedal (excessive foot pressure required)
g. Brakes too sensitive
h. Noisy brakes
    - Chatter
    - Squeal
    - Shoe “click”
i. Air in system
j. Brake fluid loss
k. Non-function of automatic shoe adjuster
l. Warning light on

7. Describe hydraulic drum brakes and repair procedures 10%

a. Brake drum construction
    - Brake drum functions
    - Frictional area
b. Brake drum checks
    - Over size
    - Out of round
    - Taper
    - Physical damage
    - Concave
    - Convex
    - Machining limits
c. Energy conversion process
    - Inertia
    - Kinetic energy
    - Heat transfer
d. Friction
    - Static
    - Kinetic
e. Coefficient of friction
f. Areas of friction
    - Shoes and drums
    - Tires and the road
g. Frictional influences
    - Type of materials in contact
    - Areas of material
    - Weight
    - Friction coefficient
    - Oil
    - Grease
h. Weight transfer
    - Shifting of weight to front
    - Front brakes (2/3 of braking)
    - Front/rear split

- Diagonally split

i. Brake shoe materials
   - Metallic & non-metallic
   - Synthetic substances
   - Ceramic

j. Backing plate & hardware mounting
   - Plate mounting fasteners
   - Shoe pads
   - Brake shoe hold-down pin holes
   - Use of high temperature grease
   - Brake shoe anchor

k. Shoe arrangements and frictional materials
   - Brake shoe terms
     -Web
     -Platform
     -Heel
     -Toe
     -Primary & secondary lining
   - Brake shoe action
     -Servo action
     -Self-energizing
     -Double anchor
     -Single anchor, self-centering
     -Double anchor, double cylinder
     -Single anchor, self-centering, duo-servo acting
     -Self-adjusting brakes
   - Checks to linings and shoes
     -Worn
     -Loose
     -Oil or grease soaked
     -Twisting
     -Cracked web
     -Broken weld
   - Fixed single-anchor, duo-servo, and self-adjusting rear brake design
     -Primary shoe
     -Secondary shoe
     -Anchor
     -Retraction springs
     -Hold down springs
     -Shoe pins
     -Shoe guide
     -Star wheel adjuster assembly
     -Parking brake cable
     -Emergency brake strut and spring
     -Automatic adjuster system
   - Automatic adjusting servo drum brake
     -Cable
     -Cable with over-travel spring
     -Lever with override
     -Lever and pawl

l. Drum brakes removal, repair and installation procedures

m. Measuring, machining and repairing components
   - Repair of master cylinder
     -As outlined in service manual
     -Clearance between piston and cylinder
     -Replacement of parts
     -Pitting as it affects cylinder replacement
     -Honing procedures

-Removing tube seal insert
-Bench bleeding
-Fluid level

- Final checks and adjustment to master cylinder
  -Adjustment procedures as outlined in service manual
  -Brake pedal height adjustment & free travel
  -Procedure for adjusting master cylinder push-rod for vacuum booster unit
- Disassembly, inspection and repair of the wheel cylinders
  -As outlined in service manual
  -Clearance between piston and cylinder
  -Replacement of parts
  -Pitting: need for cylinder replacement
  -Honing procedures
  -Bleeder screws for being free and open
- Machining of brake drum
  -Use of safety goggles
  -Grinding & lathing
  -Turning of drums in pairs
  -Minimal removal of metal
  -Light cut - fed slow
  -Need for damper
- Removal and reinstallation of hydraulic disc brake assemblies
  -Piston & piston seal
  -Dust boot
  -Inner pad (wear limit)
  -Outer pad (wear limit)
  -Caliper assembly
  -Bushings
- Inspection of disc brake rotor
  -Lateral run-out
  -Heavy scoring
  -Parallelism
  -Minimum thickness
- Demonstration of disc brake rotor machining
  -Machine set up
  -Speed of cut
  -Depth of cut
  -Need for damper
  -Use of safety goggles
  -Use of shop manual
- Disc brake caliper disassembly, repair and assembly
  -Removal of piston boot
  -Careful use of compressed air to remove piston
  -Honing cylinder bore
  -Installing boot on clean and lubricated piston
  -Installing piston in clean, lubricated bore
  -Use of small C-clamp
  -Use of shop manual
- Pad replacement (rear disc brakes)
  -Use of special tool to retract piston
  -Use of shop manual

8. Describe disc brake operation. 5%

a. Disc vs. drum brakes
   - Resistance to heat and fade
   - Resistance to water fade
   - More straight line stops
   - Automatically adjusts
   - No servo action

- Bigger pistons and larger reservoir

b. Rotors
   - Solid rotor
   - Ventilated rotor
   - Directional

c. Calipers
   - Fixed vs. floating
   - Sliding
   - Single & multi-piston

d. Caliper parts & operation
   - Caliper assembly
   - Piston
   - Piston seal
   - Dust boot
   - Pad
   - Inner pad
   - Outer pad
   - Wear indicator tab
   - Seal elasticity
   - Brake applied (seal stretches)
   - Brake released (seal relaxed)
   - Self adjusting feature

e. Disc brake pistons
   - Steel
   - Aluminum
   - Fiberglass reinforced Phenolic piston resin

f. Causes of pad wear & clearance
   - Excessive rotor run-out
   - Loose wheel bearings

9. Describe brake booster operation, diagnosis and repair procedures. 5%

a. Vacuum operation & installation
   - Linkage
   - Integral
   - Multiplier
   - Vacuum suspended

b. Vacuum power booster operation
   - Internal valve (vacuum and atmospheric) operation
   - Released position
   - Applied position
   - Holding position
   - Brake feel
   - Filter

c. Hydraulic operation, installation & components
   - Pump
   - Accumulator
   - Master cylinder
   - Pressure switch
   - Reservoir
   - Backup supply
     -Electric backup supply

d. Diagnosis and repair procedures
   - Vacuum power brake booster service
   - Power brake booster – vacuum suspended
     -Troubleshooting
     -Repair
   - Power brake booster – atmospheric suspended

10. Describe the operation, diagnosis and repair procedures of air over hydraulic brake booster systems. **10%**

a. Overall principles
b. Power booster – AirPak system
   - Released condition
   - Applied condition
   - Holding condition
c. Power booster – power cluster system
d. Service
e. Troubleshooting & repair

11. Describe the operation, diagnosis and repair of hydraulic over hydraulic brake booster systems. **10%**

a. Fundamentals
b. Overall principles
c. System components
d. Hydraulic booster operation
   - Released condition
   - Applied condition
   - Holding condition
e. Service
f. Troubleshooting
g. Repair

12. Describe air brake fundamentals, design, and operation; describe and perform manufacturers' maintenance procedures for air brake systems. **13%**

a. Fundamentals
   - Law of levers, mechanical advantages
   - Coefficient of friction
   - Pneumatic principles
   - Pressure volume relationship
   - Spring brake chambers
   - Brake chamber calculations
     -Potential energy & safety
     -Linear force & leverage
     -Brake torque
b. Air brake design and operation
   - Foundation assemblies
     -S-cam
     -Wedge
     -Disc
   - Actuator chambers
   - Air compressors
     -Types & classifications
   - Tanks & reservoirs
   - Hoses and hose connections
   - Control devices

-Air governors
-Pressure regulators
-Pressure protection valves
-Safety valves
-Air dryers

- Gauges and low pressure indicators
- Service emergency & relay valves
- Slack adjusters
  -Manual vs. automatic

c. Description and performance of air brake maintenance
   - Compressor buildup time
   - Governors
   - Air leakage
   - Air usage
   - Tank draining
   - Removal and installation of hoses, fittings, connectors and related components
   - Adjustment (foundation) using recommended procedures

13. Describe procedures to remove, repair and install air over hydraulic chambers. 10%

a. Air over hydraulic brakes
   - Types, designs, components
   - Principles of operation
   - Service procedures
   - Cylinder reconditioning precautions
   - Relationship to other hydraulic systems
   - Repair procedures and cautions
   - Adjustments

b. Brake accumulator
   - Purpose & types
   - Precautions

14. Describe electric brake system operation and diagnose failures 2%

a. Overall purpose
b. Components
c. Electric braking system diagnosis
   - Electric brake system faults
     -Operator abuse or misuse
     -Mechanical components
     -Electrical components
   - Service checks and adjustments
     -Synchronizing of brake sets
     -Electromagnet action
   - Voltage checks
   - Amperage checks

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Apprenticeship Manitoba

Heavy Duty Equipment Technician

Unit: I1 Electrical Fundamentals

Level: One

Duration: 25 hours

Theory: 10 hours

Practical: 15 hours

Overview:

This unit of instruction is designed to provide the Heavy Duty Equipment Technician apprentice with an understanding of electrical theory. As well, apprentices will develop a working knowledge of basic electrical components and test equipment, along with learning to diagnose problems related to related electrical wiring and components. Apprentices will also acquire a working knowledge of battery design, diagnosing battery problems and how to service batteries.

Objectives and Content:	**Percent of Unit Mark (%)**
1. Describe electrical fundamentals.	**15%**

a. Safety practices and procedures
b. Atomic theory
c. Electron theory
   - Matter
   - Element
   - Atom
   - Compound
   - Molecule
   - Proton
   - Neutron
   - Electron
   - Chemical reaction
   - Conductor
   - Insulator
   - Semi-conductor
   - Positive charge
   - Negative charge
   - Neutral charge
d. Sources of electricity and Electromotive Force (EMF)
   - Chemical
   - Magnetic
   - Heat
   - Light
   - Piezo crystals
   - Static electricity

- Vehicle EMF sources

e. Practical electrical concepts
   - Electromotive force vs. electrical pressures
   - Current or amperage flow
   - Resistance
   - Electron movement vs.current flow
   - Electron and current flow
   - Conductor failures occur
   - Insulators
   - Danger of damage from static electricity

2. Describe OHM's and related electrical laws. 10%

a. Key concepts
   - Volt
   - Ohm
   - Amp
   - Watt

b. Units and symbols, conversion between units
   - mega – M
   - kilo – k
   - milli – m
   - micro - μ

c. OHMS Law/formula (E = I * R)
d. OHMS Law calculations: voltage, amperage and resistance
e. Calculation of electrical power (W = E * I)
f. Kirchoff's Laws

3. Describe series and parallel circuits. 10%

a. Series circuit characteristics
   - Voltage
   - Current
   - Resistance

b. Total resistance (R_T) of a series circuit
c. Current flow in a series circuit
d. Voltage drop
   - Calculation in a series circuit

e. Electrical problems, terms and their effects on a series circuit
   - Open circuit
   - Short circuit
   - Ground circuit
   - Short to ground
   - I – resistance

f. Parallel circuit characteristics
   - Voltage
   - Current
   - Resistance

g. Total resistance (R_T) of a parallel circuit
h. Total current and branch current flow
   - Calculation

i. Branch voltage drops
j. Electrical problems, terms and their effects on a series/parallel circuit

- Open circuit
- Short circuit
- Ground circuit
- Short to ground
- I – resistance
- Resistance

k. Series and parallel circuit characteristics
l. Total resistance (R_T) of series and parallel circuits
m. Current flow and individual branch amperages
n. Calculation: voltage drop in series and parallel circuits

4. Describe basic electrical components and their operation. 20%

a. Resistors: purpose
   - Limit current flow
   - Protection: electrical parts & circuits

b. Resistor types
   - Fixed, ballast, tapped and variable resistors
   - Rheostat
   - Potentiometer – three wire resistor
   - Thermistor

c. Switches
   - Toggle
   - Single-pole, single-throw
   - Single-throw, double-pole
   - Double-throw, double-pole
   - Normally closed
   - Push-pull
   - Rotary
   - Thermal
   - Pressure
   - Mercury

d. Fuses
   - Purpose
   - Types (cartridge, blade, inline, fuse and fusible link)
   - Rating
   - Role of service manuals
   - Failure modes

5. Describe and use test equipment: diagnose basic electrical wiring and components. 20%

a. Meters (digital, analog)
   - Moving coil
   - Measure of current
   - Meter shunt
   - Load effects of a voltmeter
   - Ohmmeters
   - Multimeters
   - Voltmeter
   - A-Meter
   - Applications ammeters
   - Meter ranges

b. Meter hookup
c. On-board displays
d. Test lights
e. Steps in reading voltage
f. Circuit and testing problems
   - Basic checks
   - Short, open and grounds
   - High resistance
   - Diagnostic trouble-shooting procedures
   - Testing procedures and equipment
g. Installation & testing of aftermarket equipment

6. Describe the purpose and design of a battery, identify service ratings of batteries. 10%

a. Purpose
   - Starting motor, ignition and other electrical devices
   - Supplies electrical power when required
   - Use as capacitor
   - Stores energy
b. Battery design and components
   - Electrolyte
   - Cell construction
   - Battery types
     -Conventional
     -Low maintenance
     -Maintenance free
     -Hybrid batteries
     -Gel cell batteries
   - Operation and chemical reactions
c. Battery service rating
   - Battery rating
     -Reserve capacity
     -Cold cranking amps
   - Battery capacity
     -Condition of charge
     -Temperature
     -Internal structure – surface area of plates
   - Diagnosis of battery condition
     -Parasitic drains
     -Refractometer
     -Load
     -Three minute charge (sulfation testing)
     -Open-circuit voltage
     -Capacitance testing
     -Reserve capacity test
     -High-discharge test
   - Charge indicator light
     -Hydrometer test
     -Specific gravity variation

7. Explain battery charging & precautions; diagnose battery problems and service batteries. 10%

a. Charging methods
   - Slow charging
   - Fast charging
   - Trickle charging
   - Charging of low-maintenance batteries

- Filling batteries
- Battery temperature variations

b. Precautions
- Importance of ventilation
- Safety precautions: high explosive gases
  -Protective clothing
  -Avoidance of smoking
  -Avoidance of arcs
- Temperature
- Charger off, cables disconnected
- Use of manufacturer-operating instructions
- Exposure to hydrogen gas
- Removal of jewelry
- Disconnection of ground cable
- Use of well ventilated area
- Care with metal tools or other objects

c. Battery problems
- Physical condition
  -Sulfated battery
- Undercharged / overcharged
- Discharge due to parasitic draw

d. Battery removal and installation
- Cable removal
- Battery mounting
  -Types of cable terminals
  -Cable size selection
  -Methods of fastening terminals to cable (soldered/crimped)
- Cleaning and repairing terminals and cables
  -Importance of corrosion inhibitor on terminals
- Proper polarity connections and multiple battery set-up
- Voltage drop test
- Cleaning of battery

e. Special safety precautions
- Acid to water
- Wearing of safety glasses
- Medical attention after contact with electrolyte

f. Factors: service life of a battery
- Improper electrolyte level
- Poor mounting (loose battery causing vibration)
- Corroded terminals
- Cracked case
- Battery hold-down: too loose or tight
- Overcharging
- Cycling (discharging and charging)
- Undercharging (sulfation)

8. Describe battery boosting procedures. 5%

a. Importance of proper booster cables
b. Proper polarity and connections
c. Series vs. parallel connections
d. Protective glasses
e. Other safety precautions