

# Heavy Duty Equipment Technician Level 2

## Heavy Duty Equipment Technician

**Unit:** B2 Customer / Interpersonal Relations & Communications

**Level:** Two

**Duration:** 20 hours

Theory: 20 hours

Practical: 0 hours

**Overview:**

This unit of instruction is designed to help the Heavy Duty Equipment Technician apprentice develop interpersonal skills that facilitate effective and positive interaction with customers and industry peers.

<b>Objectives and Content:</b>	<b><u>Percent of Unit Mark (%)</u></b>
<b>1. Describe government policies, procedures, guidelines and standards.</b>	<b>40%</b>
a. Work-related accident reporting procedure of the Workers Compensation Board (WCB)	
• The Workers Compensation Act	
• WCB claim procedures	
• Written report: supervisor	
• Examples: accident report forms	
b. Legislation and regulations that govern workplace safety and health	
• Workplace Safety and Health Act	
• Garagekeepers Act	
• Information access regarding potential hazards in the workplace	
• Worker participation: workplace safety conditions	
• Right of refusal in dangerous working conditions	
• Key definitions: safety and health laws	
-“Shall”	
-“May”	
-“Duty”	
-“Power”	
-“Act”	
-“Regulation”	
-“Code”	
-“Health”	
-“Safety”	
-“Welfare”	
-“Discriminatory Action”	
c. Material Safety Data Sheets (MSDS)	
• MSDS	
-Definition	
-Location	
-Purpose	
• Interpret information provided	

- Storage of chemicals
- Proper labeling of containers, new and used
- Duties of suppliers, employers, employees

**2. Describe aspects of public relations and customer service. 30%**

- a. Today's heavy duty technician
- b. Effective public relations
- c. Professionalism
- d. Creating trust
- e. Listening skills
- f. Telephone etiquette
- g. Customer appreciation
- h. Use of appropriate language
- i. Positive attitude
- j. Role of the professional

**3. Describe basic communications principles and practices. 20%**

- a. Types of communications
  - Verbal
  - Non-verbal communications
  - Awareness of non-verbal codes
  - Your own non-verbal vocabulary
- b. Factors influencing interpersonal communication
  - Self-awareness
  - Self-concept
  - Self-esteem
- c. Interpersonal skills
  - Assertiveness
  - Supportiveness
  - feedback
- d. Small group interaction
  - Small group characteristics
  - Small group types
  - Panels
  - Discussion groups
  - Committees
  - Group roles
  - Task roles
  - Maintenance roles
  - Negative individual roles
- e. Small group interaction
  - Conformity
  - Cohesiveness
  - Consensus
  - Conflict and conflict resolution

**4. Describe and perform key on-the-job written communications duties. 10%**

- a. Work orders
- b. Work procedures documentation
- c. Purchase orders
- d. Parts requisition

- e. Time sheets
- f. Warranty documentation
- g. Log books
- h. Working drawings

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## Heavy Duty Equipment Technician

**Unit:** C2 Welding (Electric/Arc/MIG)

**Level:** Two

**Duration:** 40 hours

Theory: 8 hours

Practical: 32 hours

### Overview:

This unit of instruction is designed to provide the Heavy Duty Equipment Technician apprentice with the working knowledge required to use equipment and perform tasks related to electric, arc, and MIG welding.

### Objectives and Content:

**Percent of  
Unit Mark (%)**

- |  |                  |
|--|------------------|
| <p><b>1. Describe prerequisite knowledge of the electric arc welding process.</b></p> <p>a. Applied safety precautions</p> <ul style="list-style-type: none"><li>• Eye, face, hand, foot and clothing protection</li><li>• Cut and burn treatments</li><li>• Fire extinguisher availability</li><li>• Setup and shutdown sequence</li><li>• Ventilation equipment</li><li>• Safety shielding</li><li>• Cylinder and shutdown sequence</li><li>• Cylinder handling</li><li>• Electrical shock protection</li><li>• Vehicle electronic systems protection</li></ul> <p>b. Applied tools and equipment</p> <ul style="list-style-type: none"><li>• Compressed gas cylinders</li><li>• Pressure regulators</li><li>• Hoses</li><li>• Approved welding work place</li><li>• Ventilation equipment</li></ul> <p>c. Applied communications</p> <ul style="list-style-type: none"><li>• Interpretation of manufacturers' service and operating procedures</li><li>• Practical report</li><li>• Information accessing</li></ul> | <p><b>5%</b></p> |
| <p><b>2. Describe the fundamentals of the electric arc welding process.</b></p> <p>a. Metallurgy</p> <p>b. Arc emissions</p> <p>c. Electrical fundamentals &amp; polarity</p>  | <p><b>5%</b></p> |

- 3. Describe the components and applications of electric arc welding equipment and consumables. 5%**
- a. Transformers
  - b. Rectifiers
  - c. Controls
  - d. Electrode holders
  - e. Electrode specifications
    - Codes
    - Current type and polarity
    - Position
    - Penetration
    - Base metal material
    - Material condition
- 4. Describe the operation of shielded electric arc welding equipment. 5%**
- a. Equipment settings
  - b. Transformers
  - c. Rectifiers
  - d. Stationary and portable units
  - e. Open circuit voltage
  - f. Closed circuit voltage
- 5. Perform electric welding procedures with A/C, D/C and MIG welding equipment. 75%**
- a. Machine adjustments and welds
  - b. Single and multi pass butt and fillet welds in flat position
  - c. Examples of defective welds
  - d. Trial beads
- 6. Describe manufacturers' maintenance procedures for shielded metal arc welding equipment. 5%**
- a. Welding cables
  - b. Holding devices
  - c. Power sources
  - d. Protective equipment

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## Heavy Duty Equipment Technician

**Unit:** E2 Hydraulic Transmissions, Retarders and Torque Converters

**Level:** Two

**Duration:** 34 hours

Theory: 14 hours

Practical: 20 hours

### Overview:

This unit of instruction provides the Heavy Duty Equipment Technician apprentice with the working knowledge required to diagnose, service and repair problems related to hydraulic transmissions, torque converters and hydraulic retarders.

<b>Objectives and Content:</b>	<b>Percent of Unit Mark (%)</b>
<b>1. Describe torque converter fundamentals; perform diagnosis, disassembly and reassembly.</b>	<b>15%</b>
a. Overall purpose	
• Torque converters vs. fluid couplings	
b. Conventional torque converter	
• Components	
-Impeller	
-Turbine	
-Stator	
-Ground sleeve	
-Turbine and impeller vane angles	
-Half-guide rings	
-Lockup clutches	
• Design	
• Operation	
• Torque converter variation/efficiency increases	
c. Twin-turbine torque converter	
• Design	
• Operation	
d. Variable pitch, twin stators torque converter	
• Design	
• Operation	
e. Torque divider	
• Design	
• Operation	

- 2. Describe planetary gear sets and drive combinations. 15%**
- a. Overall purpose
  - b. Basic components
  - c. Planetary gear operation
  - d. Drive combinations
- 3. Describe hydraulic transmission fundamentals; perform diagnosis, disassembly and reassembly. 50%**
- a. Hydraulic principles
  - b. Gear train hydraulic control
  - c. Transmission fluid
    - Purpose
    - Requirements
    - Cooling
    - Types, designations
    - Viscosity
    - Friction
    - Service intervals
  - d. Planetary powershift transmissions
    - Design & operation
    - Hydraulic system
    - Inching control
    - Clutch cutoff
    - Power flows
  - e. Automatic planetary transmissions
    - Design
    - Hydraulic system
      - Rear governor
      - Modulator pressure regulator
      - Trimmer regulator valve and trimmer valve
      - Hold regulator valve
      - Priority valve
      - Front governor (lockup circuit)
      - Relay valves
      - Selector valves
    - Neutral operation
    - First-to-fifth & reverse-gear operation
    - Power flows
- 4. Describe the diagnosis and maintenance of hydraulic/powershift transmissions. 15%**
- a. Basic troubleshooting
    - Mechanical failure
      - Noises from worn bearings, shafts or splines (planetary gears)
    - Hydraulic system failure
      - Use of flow meters and test gauges
  - b. Maintenance procedures
  - c. Pressure testing
  - d. Torque converter stall test
  - e. Operator complaints
    - High temperature
    - Rough shifting
    - No transmission lockup



**5. Describe the fundamentals, operation and diagnosis of hydraulic retarders.**

**5%**

- a. Overall purpose
- b. Design
  - Stationary converter housing
  - Stationary brake housing
  - Rotor
  - Vanes
  - Pockets
  - Turbine shaft
  - Configuration of components
- c. Hydraulic piping
  - Components
    - Pump
    - Pressure control valve
    - Spool valve
    - Oil cooler
  - Operation

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## Heavy Duty Equipment Technician

**Unit:** E3 Differentials, Drive Axles, Final Drives and Clutch Steering Systems

**Level:** Two

**Duration:** 34 hours

Theory: 14 hours

Practical: 20 hours

### Overview:

This unit of instruction provides the Heavy Duty Equipment Technician apprentice with the working knowledge required to service and repair differentials, drive axles, final drives and clutch steering systems.

### Objectives and Content:

**Percent of  
Unit Mark (%)**

1. **Describe the design, components and operation of differentials.**
  - a. Role and purpose of differentials.
  - b. Differential assembly components
    - Drive pinion and ring gears
    - Differential pinions, side gears and pinion shaft
      - Limited slip differentials (clutch packs and brake cones)
  - c. Differential operation
  - d. Differential locks
    - Mechanical locks
    - Hydraulic & air
    - Automatic “no spin”
  - e. Differential troubleshooting/diagnosis
    - Noise
      - Damaged differential gears and pinion shaft
      - Excessive clearance between pinion and ring gear
      - Excessive wear or loose and broken parts
      - Loose parts striking together
      - Vibrations or “chattering” around corner: clutch packs or cones
    - Differential lock not holding
  - f. Adjustment of differentials
  - g. Housing types
    - Integral
  - h. Final drive
    - Spur bevel
    - Spiral bevel
    - Helical
    - Hypoid
  - i. Gear set identification & timing

**10%**

- Hunting & non-hunting
  - Partial hunting
  - j. Drive pinion mounting
    - Straddle & overhung
  - k. Drive axles and retention
  - l. Axle shafts
    - Live vs. dead axles
    - Full floating vs. semi-floating
    - Independently suspended axles
    - Axle shaft bearings (radial vs. thrust loading) & adjustments
  - m. Final drive assemblies
- 2. Perform diagnosis, inspection, testing and disassembly procedures on RWD drive assemblies. 50%**
- a. Separation of shims, cups and caps
  - b. Uniform torque and alignment while installing ring gear
  - c. Adjustment of pinion gear depth (shims), bearing preload
  - d. Gear patterns and backlash
  - e. Bearing damage
  - f. Ring and pinion gears: excessive runout and side play
  - g. Shim wear and damage
  - h. Differential case bearing preload
- 3. Service and recondition/repair differential components. 10%**
- a. Limited slip differential assembly (loading, unloading and locking type)
  - b. Interaxle differential
- 4. Describe the operation, components and maintenance procedures of final drives. 15%**
- a. Role and purpose of final drives.
  - b. Types of final drives.
    - Straight axle drive
      - Rigid axle shaft: Full-floating & semi-floating axles
    - Pinion & spur gear final drives
    - Planetary drives
      - Operation
      - Parts construction
      - Mounting next to differential
      - Mounting at outer ends of final drives
    - Chain final drives
  - c. Final drive lubrication
  - d. Diagnosis of final drives
    - Excessive drive shaft endplay
    - Overheating & lack of lubrication
  - e. Adjustment of final drives
    - Adjusting axle bearings
      - Preloading bearings
      - Adjusting for end play
- 5. Describe the components and operation for clutch steering systems. 15%**
- a. Shoe and band (clutches / brake)
  - b. Hydraulically & mechanically activated shoe & band clutches (brake)
    - Operation
    - adjustment

c. Internal and multiple disc clutches

- Operation
- Disadvantages

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## Heavy Duty Equipment Technician

**Unit:** F2 Tracks, Frames and Undercarriages; Ground Engaging Tools, Booms and Attachments

**Level:** Two

**Duration:** 17 hours

Theory: 17 hours

Practical: 0 hours

### Overview:

This unit of instruction provides the Heavy Duty Equipment Technician apprentice with the working knowledge required to diagnose problems with tracks, frames, undercarriages, ground engaging tools, booms and attachments. The unit also provides the knowledge and skills for apprentices to perform related service and repairs.

<b>Objectives and Content:</b>	<b>Percent of Unit Mark (%)</b>
<p><b>1. Describe off-highway frames.</b></p> <ul style="list-style-type: none"> <li>a. Design &amp; configuration</li> <li>b. Materials and fabrication</li> </ul>	<b>10%</b>
<p><b>2. Describe undercarriage components, problems, maintenance and service.</b></p> <ul style="list-style-type: none"> <li>a. Overall purpose &amp; configuration               <ul style="list-style-type: none"> <li>• Conventional</li> <li>• High drive</li> <li>• Bogie systems</li> </ul> </li> <li>b. Tractor undercarriages</li> <li>c. Track roller frames</li> <li>d. Front idler and yoke</li> <li>e. Drive sprockets</li> <li>f. Track adjusting and recoil mechanisms               <ul style="list-style-type: none"> <li>• Coil spring recoil mechanism &amp; mechanical track adjustment -Operation and adjustment</li> <li>• Cone spring plates &amp; hydraulic adjuster</li> <li>• Nitrogen gas recoil mechanism &amp; adjuster</li> </ul> </li> <li>g. Track rollers</li> <li>h. Track carrier rollers</li> <li>i. Track chains               <ul style="list-style-type: none"> <li>• Flush type</li> <li>• Interlocking type</li> <li>• Tri/quad-track</li> </ul> </li> <li>j. Track shoes</li> <li>k. Track roller, idler and sprocket guards</li> </ul>	<b>40%</b>

- I. Crawler carrier undercarriages
  - Side frames
  - Track belt and shoes
- m. Track chain and belt action
- n. Undercarriage problems
  - Undercarriage components and wear
    - Components unsuitable to operating condition
  - Wear due to operating conditions
    - Excessive water or wet terrain
    - Exclusive use for push-loading or ripping
    - Work on side slopes
    - Continuous use for loading operations
    - Reverse wear
  - Wear due to poor maintenance and misalignment
    - Maintenance of clean undercarriage
    - Maintenance of correct track chain tension
    - Regular lubrication of track rollers, idlers & final drives
    - Visual checks: loose or missing parts & misalignment
    - Minor repairs & replacement: Track rollers, track shoes, turning pins, bushings
  - Improper track tension
  - Checking of components: wear, loose or missing
  - Track chain & link wear
  - Sprocket wear
  - Grouser wear
  - Front idler wear
    - Adjustment to compensate
  - Track and carrier roller wear
  - Checking of track frame alignment
- o. Undercarriage service
  - Replacement of track rollers
  - Replacement of carrier rollers
  - Replacement of carrier belt rollers
  - Inspection of crawler belt rollers
  - Track carrier roller service
    - Disassembly
    - Inspection
    - Reassembly
  - Track roller service
    - Disassembly
    - Inspection
  - Bearing replacement
    - Reassembly
    - Lubrication
  - Front idler and yold service
    - Ring seal installation
  - Servicing of track recoil and track-adjusting mechanisms
    - Removal & replacement of a recoil mechanism
    - Service
    - Safety
  - Track chain servicing
    - Track shoe replacement
    - Removal of track chain
    - Installation of track chain
    - Replacement of tracks on large tractors
    - Adjustment of track tension
  - Track link replacement
  - Crawler belt service

- Replacement of crawler shoe
- Replacement of crawler belt
- Checking of crawler belt tension
- Drive sprocket service
  - Replacement of sprocket segments
  - Replacement of one-piece / ring drive sprocket
- Checking of crawler belt tension
- Track roller frame service
  - Pivot-attached vs. fixed frame

**3. Describe the removal, repair and installation of blades, cutting and corner edges. 15%**

- a. Types and construction of blades
  - Straight blades
  - Angle blades
  - U-blade
  - Special application blades
- b. Blade components
  - Push arm
  - Tilt arm
  - Pins
  - Cutting edge
  - Corner edge
- c. Types and application of cutting edge
- d. Moldboard construction
- e. Blade removal procedures
  - Blade inspection
  - Bushing and pin replacement
- f. Cutting and corner edges
  - Safety procedures
  - Procedures for removal
  - Reversing principles of cutting edge
  - Installation procedures
  - Cleanliness
  - Correct torquing of all attaching bolts

**4. Describe the removal, repair and installation of buckets and teeth. 15%**

- a. Safety procedures
- b. Types and construction of buckets
  - Multipurpose
  - Rock
  - Snow
  - Four-in-one
  - Side-dump
  - Backhoe
  - Excavator
- c. Components
  - Cutting edge
  - Teeth
  - Shank
  - Bushings
  - Pins
  - Arms

- d. Removal procedures
- e. Inspections
- f. Replacement of shank
- g. Replacement of cutting edge
- h. Replacement of pins and bushings
- i. Installation procedures
- j. Removal of teeth
- k. Attachment of teeth to shank
- l. Importance of using proper teeth
- m. Teeth reversible principles
- n. Tooth installation
- o. Checking and servicing of quick-coupling attachments
  - Types of quick-coupling systems
    - Hydraulic
    - Air
  - Advantages
  - Service procedures

**5. Describe the inspection, repair and servicing of aprons, bowls and tailgates. 10%**

- a. Principles of scraper operation
- b. Scraper types
  - Two-axle
  - Three-axle
  - Push-loading
  - Push-pull
  - Elevating
  - Two-engine
  - Chain-rail
  - Auger
- c. Components
  - Bowl
  - Apron
  - Tailgate ejector
  - Gooseneck
  - Cutting edge
- d. Repair procedures
- e. Checking for cracks
- f. Checking of worn pins, bushings, rollers and rails
- g. Safety precautions

**6. Describe the servicing of booms, sticks and attachments. 10%**

- a. Safety procedures
- b. Boom types and their construction
  - Main boom
  - Secondary (“stick”) booms
  - Telescoping booms
  - Stabilizer or outrigger
- c. Removal procedures
- d. Inspections
- e. Following of manufacturers’ specifications
- f. Installation procedures
- g. Removal of pins and bushings



- Types and designs
  - Removal & installation procedures
  - Inspections
  - Lubrication procedures
- h. Servicing
- Following manufacturers' specifications
  - Inspection procedures for cracks
  - Inspection of pin and bushing wear
  - Lubrication procedures

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## Heavy Duty Equipment Technician

**Unit:** H2 Manual / Hydraulic Steering Systems, Linkage and Geometry

**Level:** Two

**Duration:** 25 hours

Theory: 14 hours

Practical: 11 hours

### Overview:

This unit of instruction provides the Heavy Duty Equipment Technician apprentice with the working knowledge required to diagnose problems related to manual and power steering systems, steering linkage and geometry - along with performing the necessary repairs.

<b>Objectives and Content:</b>	<b><u>Percent of Unit Mark (%)</u></b>
<b>1. Describe steering system components.</b>	<b>5%</b>
a. Overall purpose	
b. Steering wheel	
c. Steering column	
d. Steering gear	
e. Pitman arm	
f. Drag link	
g. Steering arm	
h. Tie-rod assembly	
<b>2. Describe the design, operation, diagnosis and servicing of manual steering gears.</b>	<b>5%</b>
a. Overall purpose	
b. Worm and roller gears	
c. Re-circulating ball	
d. Rack and pinion	
e. Twin cam and lever	
f. Diagnosis and servicing	
• Mesh and backlash	
• Preloads	
• Measurement and adjustment of preloads	
• Worm bearing preload check	
• Roller shaft total mesh preload check & adjustment	
• Steering system centering	
• Dismantling, inspection, reassembly and adjustment of manual steering gears	
• Lubrication	
<b>3. Describe the design and operation of power steering systems.</b>	<b>10%</b>

- a. Hydraulic principles (re: power steering)
- b. Hydraulic fluids
- c. Power steering pumps
  - Gear
  - Vane
  - Roller & slipper
- d. Power steering lines, hoses and coolers
- e. Control valves
  - Pressure relief
  - Flow control
  - Rotary spool directional control valve
  - Axial spool directional control valve
- f. Power steering gearbox
- g. Integral piston system
- h. Power-assisted rack and pinion system
  - Hydraulic operation
- i. Full hydraulic steering control
- j. Articulated steering

**4. Perform troubleshooting, diagnosis and repair of power steering system. 30%**

- a. Pumps
- b. Reservoirs
- c. Lines and hoses
- d. Control valves
- e. Checking and adjustment of drive belt tension
- f. Hydraulic tests
- g. Dismantling, inspection, reassembly and adjustment of system assembly
- h. Adjustment of steering gear assemblies, linkages, steering stops and column phasing

**5. Describe steering geometry and wheel alignment theory. 20%**

- a. Ackerman's Principle
- b. Parallelogram
- c. Steering geometry: terms & definitions
  - Caster, toe and camber
  - Steering axis inclination
  - Included angle
  - Turning radius
  - Ride height
  - Thrust line
  - Centre line
  - Setback
  - Track
  - Tire pressures
- d. Centre of gravity
- e. Centrifugal force
- f. Levers, mechanical advantage
- g. Lubricants
- h. Linear & angular measurement
- i. Column phasing
- j. Vehicle alignment angles and measurements

- 6. Describe the operation and service of steering linkage. 5%**
- a. Parallelogram steering linkage
    - Linkage placed behind vs. front-of-wheel suspension
    - Pitman arm (wear vs. nonwear)
    - Idler arm
    - Steering links
    - Knuckles
  - b. Rack and pinion steering linkage
    - Design and construction of rack vs. pitman arm / idler arm / centre link
- 7. Describe inspection and testing procedures on steering axle/linkage components. 10%**
- a. Visual inspection
  - b. Wheel alignment
  - c. Steering axle stops
  - d. Knuckle vertical play inspection
  - e. King pin fit inspection: upper & lower bushings
  - f. Upper/lower bushing torque deflection test
  - g. Steering component integrity
    - Excessive steering wheel play
    - Tie rod wear
    - Idler arm wear
    - Pitman
    - Pully and drifting
    - Shimmy
  - h. Wheel bearings
  - i. Adjustment of knuckle vertical play
- 8. Describe steering axle component removal and replacement. 5%**
- a. Overall preliminary steps
  - b. Steering knuckle disassembly
  - c. Knuckle pin removal
  - d. Cleaning
  - e. Knuckle pin grease seal replacement
  - f. Pitman arm
  - g. Idler arm
  - h. Tie rods (inner, outer and sleeves)
  - i. Knuckle pin bushing replacement
  - j. Knuckle assembly
  - k. Steering linkages
  - l. Steering dampers
- 9. Describe vehicle suspension types and axle alignment. 10%**
- a. Vehicle suspension alignment
    - Two-wheel geometric centre line alignment
  - b. Axle alignment
    - Overall purpose/concept
    - Measurement
    - Axle offset

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## Heavy Duty Equipment Technician

**Unit:** I2 Electronic Components, Body Electrical, and Warning Safety Systems

**Level:** Two

**Duration:** 34 hours

Theory: 20 hours

Practical: 14 hours

### Overview:

This unit of instruction provides the Heavy Duty Equipment Technician apprentice with the working knowledge required to repair and replace basic electronic components. The unit also provides the advanced working knowledge required to diagnose, service and repair body-related electrical systems.

<b>Objectives and Content:</b>	<b><u>Percent of Unit Mark (%)</u></b>
<b>1. Describe electrical components and their operation.</b>	<b>10%</b>
a. Types and uses of capacitors	
• Purpose (construction, charge, discharge cycle)	
• Uses (noise suppressor, counter voltage spikes)	
• Types (fixed, variable); identification (size, farads)	
b. Reluctors	
c. Operation of electrical components	
• Circuit breakers vs. fuse	
• Flashers	
• Light bulbs	
• Coils	
• Transformers	
• Relays	
• Buzzers	
• Solenoids	
• Motors	
d. Electrical components in service manual	
• Circuit breakers – state advantage over a fuse	
• Flashers & light bulbs	
• Coils	
• Transformers	
• Relays	
• Buzzers	
• Solenoids	
• Motors	

- 2. Describe semiconductor and transistor design. 15%**
- a. Semiconductor material
    - Crystal material
    - Sand – silica or silicon
    - Doping of silicon (adding phosphorus, boron, etc.)
  - b. N-type semiconductor
  - c. P-type semiconductor
  - d. Diode construction
    - Joining of P and N material
    - Blocking and passing of current
    - Design of electrical check valve
    - Forward and reverse bias
  - e. Diode types and applications
    - Conventional diode
    - Rectifying
    - Light emitting
    - Zener diode
  - f. Common semiconductor types
    - Thermistors
    - Piezo crystals
    - Photonic semiconductors
      - Light emitting diodes
      - Photoresistors
      - Solar cells
      - Phototransistors
  - g. Purpose and design
    - Use in solid circuitry
    - Change from a resistor to conductor
    - Construction: joining of three semiconductor chips
    - NPN & PNP
    - Bonding of chips
    - Small wire attached to each type material
  - h. Transistor connections
    - Emitter
    - Collector
    - Base
  - i. Transistor operation
  - j. Common types of transistors
    - Signal transistor
    - Power transistor
    - PNP and NPN
- 3. Describe the inspection and testing of electronic components. 10%**
- a. Diodes
  - b. Transistors
  - c. Switching circuits
  - d. Reluctor
  - e. Piezo crystals
- 4. Describe lighting systems and schematic diagrams. 5%**
- a. Exterior lighting
    - Bulb identification

- Sealed housing headlamp
- Sealed halogen headlamp
- Halogen insert bulb
- Single contact bulb
- Double contact bulb
- Headlights and circuits
- Park lights
- Brake lights
- Signal lights
- Emergency flashers
- b. Interior lighting
  - Dome lights
  - Dash lights
  - Courtesy lights

**5. Describe and apply wiring diagrams for troubleshooting. 20%**

- a. Repair manuals and troubleshooting charts
  - Common abbreviations
  - Service manual illustrations section
  - Reference section
  - Diagnosis charts
- b. Role of wiring diagrams
  - Wire connections
  - Component locations
- c. Wire terminals
- d. Wire repair
  - Solid and stranded
  - Number vs. size
  - American Wire Gauge System
  - Number = conductor diameter
  - Metric size = cross-sectional area = (mm<sup>2</sup>)
  - Solid colour
  - Stripe
  - Spiral stripe
  - Hashmark
  - Marker band

**6. Diagnose and repair/replace malfunctions in wiring harnesses and related components. 20%**

- a. Wiring harness
  - Schematics
  - Connectors
  - Routing
  - Circuit protection
  - Fault tracing
- b. Diagnosis of electrical system problems
  - Wiring diagrams
- c. Weather and vapour proof connectors
- d. Wire repair
  - Wire protection devices
  - Tubing

- Retainer
- Tie strap
- Sleeve
- Clip
- Boot
- Vinyl plastic electrical tape
- Wiring harness
- Soldering of wires and terminals
- Use of rosin core
- Tinning
- Connector types (eye, tab, spade, hook, butt, mid-line splice, spade, secondary)
- Crimp type connector and tool
- Proper wire repair
- Proper installation of terminal ends from connectors

**7. Describe the fundamentals of monitoring and safety devices. 5%**

- a. Instrument gauges
  - Instrument voltage regulators
  - Magnetic gauges
  - Thermal and bimetallic gauges
- b. Indicators
  - Oil, temperature and fuel gauges
  - Indicator lights
  - Pressure gauges
- c. Safety devices
  - Park brake warning
  - Travel alarms
- d. Horns
  - Horn
  - Controls
  - Relays
- e. Windshield wiper and washers

**8. Describe diagnostic procedures; perform the repair of body electrical systems and related electronic components. 15%**

- a. Procedures for diagnosing faults
  - Shorts
  - Opens
  - Grounds
  - Resistance
- b. Intermittent faults
  - Possible causes: wire chafing, poor connections, connector damage, corroded terminals
  - Visual inspection
  - Damage to sensors and actuators
  - Connections to sensors, actuators, control modules, ground points
  - Damage to wiring
- c. Sequential troubleshooting techniques
  - High impedance digital multimeter
  - Circuit damage precautions
  - Electrostatic discharge
- d. Wiper and warning system component tests



- e. Circuit analysis following manufacturers' troubleshooting charts
- f. Removal and replacement procedures for instrument gauges and display systems
- g. Safety precautions: electronic devices
- h. Proper circuit wiring routing (reduction of magnetic field interference)
- i. Radio interference factors

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## Heavy Duty Equipment Technician

**Unit:** I3 Starting and Charging Systems

**Level:** Two

**Duration:** 56 hours

Theory: 28 hours

Practical: 28 hours

**Overview:**

This unit of instruction provides the Heavy Duty Equipment Technician apprentice with the working knowledge required to diagnose as well as repair starting and charging systems.

<b>Objectives and Content:</b>	<b><u>Percent of Unit Mark (%)</u></b>
<b>1. Describe magnetism and inductance.</b>	<b>5%</b>
a. Inductance	
b. Magnetic field	
c. Insulators	
d. Holes	
e. Permeability	
f. Retentivity	
g. Natural magnet	
h. Electromagnet construction	
i. Electron flow and magnetism	
j. Use of electromagnets on vehicles	
k. Conversion of energy by magnetism	
• Electrical energy into mechanical energy	
• Mechanical energy into electrical energy	
• Electrical energy into other forms	
l. Self-induction	
m. Mutual induction	
n. Examples of induction, self-induction and mutual induction	
• Ignition coil	
• Alternator	
• Starter	
<b>2. Define the purpose and fundamentals of starting systems.</b>	<b>5%</b>
a. Electromagnetic principles	
• Permanent magnet and electromagnetism	
• Ohm's Law	
• Torque and wattage	
• Counter-electromotive force	

- Centrifugal force
- Voltage drop of high current circuits
- Batteries
- b. Cranking motors
  - Series
  - Series-shunt
  - Series-parallel
  - Counter-electromotive force effect on current flow
  - Temperature effect on load and torque output
- c. Control systems
- d. Prelube circuits

**3. Describe the design and operation of starter motor circuits and drives.**

**5%**

- a. Starter circuit
  - Battery and cables
  - Relay controlled cranking circuits
  - Solenoid controlled cranking circuits
  - Combination relay and solenoid-controlled cranking circuits
  - Control circuits (starting safety switch)
  - Thermal protection circuit
- b. Starting motors
  - Motor components
    - Armature & windings
    - Commutator
    - Brushes
    - Springs
  - Gear reduction
  - Permanent magnet type
  - Positive engagement moveable pole shoe drive
  - Series & parallel-wound
  - Compound-wound
- c. Starting motor drives
  - Over-running clutch
  - Bendix/inertia
  - Dyer
  - Follow through
  - Sprag
  - Positork
  - Friction-clutch
- d. Types of starters
  - Electric
  - Air
  - Hydraulic
- e. Starter switches
  - Magnetic
  - Solenoid
  - Series-parallel
  - Manual

**4. Describe the factors affecting starting system operation.**

**30%**

- a. Temperature
- b. Battery conditions and ratings

- c. Engine loads
- d. Oxidation and corrosion of connections
- e. Cable sizes and condition
- f. Excessive starting time and overheating

**5. Perform the inspection, testing and maintenance of starting motors, circuits and control devices. 5%**

- a. Starting system visual inspection
- b. Starting system problems
  - Engine not cranking
  - Engine cranking slowly
  - Starter not disengaging
  - Starter turns but not engaging
  - Noise and vibration
  - Cable protection
- c. Review of battery load test
- d. Available voltage check
- e. Control circuit test
- f. Cranking circuit voltage drop tests
- g. Starting system current draw test
- h. Relay and solenoid tests
  - Winding resistance
  - Current draw
- i. Procedures for removing and replacing a cranking motor
- j. Disassembly, reassembly & cleaning procedures
- k. Major component test and inspection of cranking motors
  - Armature for shorts, opens, ground, alignment
  - Field coils for shorts, opens, ground
  - Pole shoes
  - Bushings and bearings; brushes and springs
  - Solenoids
- l. Cranking motor no-load tests (comparison of results to specifications)
- m. Importance of pinion to ring gear clearances for proper gear tooth contact
- n. Ring gear tooth inspection
- o. Starter and circuit performance tests
  - Engine cranking speed
  - No-load
  - Amperage draw
  - Voltage drop
- p. Component failure analysis
- q. Removal and replacement procedures for relays and solenoids
- r. Resurfacing commutator

**6. Describe procedures to service and repair air starting systems. 5%**

- a. Circuitry
  - Valve
  - Supply systems
- b. Operating principles
- c. Applications (RPM)
- d. Motor types
- e. Drive mechanisms

- f. Maintenance procedures
  - g. Operational hazards and precautions
  - h. Lubrication provisions
- 7. Describe and perform procedures to service and repair starting aid components and functions. 5%**
- a. Glow plugs
  - b. Intake manifold heater
  - c. Fluid starting aids
  - d. Battery warmer
- 8. Describe the fundamentals of charging systems and control circuits. 5%**
- a. Overall principles
  - b. Coil and flux density
  - c. Induced density
  - d. Alternators (AC generators)
  - e. Voltage regulation
  - f. Factors affecting voltage and amperage output
    - Battery condition and temperature
    - Circuit condition
    - Engine speeds
    - Hysteresis
    - Copper loss (resistance)
    - Charging circuit resistance
- 9. Describe the design and function of alternators, voltage regulators and charging systems. 5%**
- a. Charging systems by field control
    - A-type vs. B-type
  - b. AC generator (alternator) types
    - Brushless
    - 12 & 24-volt
    - Oil-cooled
  - c. AC generator (alternator) construction
    - Rectifier
    - Diodes
    - Stator
      - Delta
      - Wye
    - Rotor
      - Field winding
      - Poles
    - Brush assemblies
    - Bearings
    - Pulleys
    - End frame assemblies
    - Cooling fans
    - Brushless alternators
  - d. Voltage regulators
    - External electronic
    - Internal electronic
    - Transistorized
  - e. Charge indicators

- Lights & gauges
  - Volts
  - Amps
- Monitoring systems

**10. Describe and perform diagnostic procedures on charging systems.**

**30%**

- a. Visual inspection
  - Belt tension and alignment
  - Connections and wiring
  - Battery and alternator capacity
- b. Charging system testing
  - Battery condition
  - Charging system current and voltage output test
  - Diode tests
  - Circuit and ground resistance
- c. Analysis of test results
- d. Removal and replacement procedures - precautions
- e. Disassembly procedures and testing of components
  - Internal circuitry
  - Stator test
  - Rotor field tests
  - Rectifier diodes test
  - Regulator test
  - Bearing condition check
  - Slip ring condition check
  - Cleaning procedures
  - Reassembly procedures
- f. Alternator bench testing: output current
  - Voltage
  - Amperage
  - Appropriate testing equipment
- g. Diagnosis of charging system problems
  - No alternator output
  - Low alternator output
  - High alternator output
  - Noisy alternator
  - Overcharging

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## Heavy Duty Equipment Technician

**Unit:** J1 Standard and Electronic Ignition Tune-up

**Level:** Two

**Duration:** 20 hours

Theory: 10 hours

Practical: 10 hours

**Overview:**

This unit of instruction provides the Heavy Duty Equipment Technician apprentice with the working knowledge required to perform standard and electronic ignition tune-ups.

<b>Objectives and Content:</b>	<b><u>Percent of Unit Mark (%)</u></b>
<b>1. Define the fundamentals and purpose of ignition systems and controls.</b>	<b>15%</b>
a. Combustion burn time	
b. Engine load and spark timing	
c. Factors that affect ignition timing	
• Engine speed, load, and temperature	
• Air and fuel ratio (AFR)	
d. System types	
• Standard	
• Electronic	
• Distributorless	
<b>2. Describe the various types of ignition components.</b>	<b>10%</b>
a. Coils	
• Conventional	
• Primary and secondary wiring	
b. Rotors	
c. Triggering devices	
• Hall Effect device	
• Pulse generator	
d. Spark timing advance mechanisms	
• Mechanical	
• Vacuum	
e. Secondary voltage circuit	
• High tension spark plug wires	
-Spark plugs (construction)	
f. Control unit	
<b>3. Inspect and test ignition components.</b>	<b>15%</b>
a. Pick-up coil	

- b. Control unit
  - c. Ignition coil
  - d. Distribution cap
  - e. Rotor
  - f. Primary wiring
  - g. Secondary wiring
- 4. Describe procedures to remove, service and install spark plugs. 10%**
- a. Spark plug construction and types
  - b. Heat range
  - c. Removal procedures
  - d. Inspections
  - e. Gapping
  - f. Installation procedures
- 5. Describe procedures to perform tune-ups on gasoline engines. 35%**
- a. Testing procedures
  - b. Tune-up procedures
  - c. Tune-up intervals
  - d. Visual inspection of engine
  - e. Check of air intake system
  - f. Check of engine compression
  - g. Adjustment of ignition timing
- 6. Describe ignition system problems. 15%**
- a. No spark at plugs
  - b. Weak or intermittent spark at plugs
  - c. Missing at idle or low speed
  - d. Missing during acceleration
  - e. Circuit analysis following manufacturers' troubleshooting charts
  - f. Coil failure
  - g. Shortened spark plug life
  - h. Pre-ignition
  - i. Detonation
  - j. Backfire in intake manifold
  - k. Backfire in exhaust manifold

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