SAULT COLLEGE

COURSE OUTLINE

Course Title: Heavy Equipment II Theorv

Code No.: HED ill

Program: Heavy Equipment 5080

Semester: Winter

Date: September *1,* 1993

Author: Jack Bowes

New: Revision:

< f

Approved: Date:

IW 0 3 to

***9mM* CoOaae of Amiled Arts**

HEAVY EQUIPMENT II THEORY HED 111

TOTAL CREDIT HOURS 160 hrs. approx.

PREREQUISITE(S): HED100, HED101

I. PHIIOSOPHY/GGAIS: TO better prepare the graduate for the heavy equipment repair industry, this course encompasses electrical principles, test meters, batteries, engine combustion requirements, governors, fuel systems and overall engine performance.

II. STUDENT PERFORMANCE OBJECTIVES:

Upon successful completion of this course the student will:

Be able to use analog and digital test meters on conventional cranking and wiring circuits, analyze lead acid battery condition and potential. Engine performance and fuel injection systems are covered in such a manner as to enable the student to analyze, field test and diagnose related problems with a minimum of test equipment, and a sound knowledge of injection and engine basics to serve the broad industry spectrum.

III. TOPICS TO BE COVERED:

1) Electricity
2) Test Equipment
3) Voltage Drop Testing
4) Lead Acid Batteries
5) Combustion
6) Air Induction System
7) Air Filters
8) Compression
9) Governors
10) Engine Performance
11) Diesel Fuel
12) Pressure Time Fuel System
13) Single and Multiple Plunger Fuel Injection Pumps
14) Hydraulic Fuel Injectors
15) Unit Injector Fuel Systems
16) Rotary Distributor Fuel Injection Pumps
17) Diesel Smoke

HEAVY EQUIPMENT II THEORY	HH5 111
IV. LEARNING ACTIVITIES	REQUIRED RESOURCES
1.0 Electricity	HED2EL1T16
1.1 Listen to teacher presentation on: . atomic structure . electron movement . conductors . producing electricity . electron theory of electricity . convention theory of electricity . volts . amperes . ohms . watts . Ohms's Law . electrical schematic symbols	Diesel Fundamentals Thiessen/Dales p. 589-604
1.2 Calculate amperage, ohm's resistance, and volts of: . simple circuits . series circuits . parallel circuits . series parallel circuits	
2.0 Electrical Test Equipment	
2.1 Listen to teacher presentation on construction, operation and proper test procedures for electrical test equipment.	Class Demo
3.0 Voltage Drop Testing	HED2EI2T6
3.1 Listen to teacher presentation on troubleshooting faulty electrical systems using voltage drops as an indicator.	Class Demo
4.0 Lead Acid Batteries	HED2EL3T29
4.1 Listen to teacher presentation on purpose, construction, operation and maintenance of lead acid batteries for the heavy equipment trade. Included in this topic are: . ratings . charging . state of charge testing . high rate discharge testing . charge testing . boosting	Diesel Fundamentals p. 575-587 Class Demo
5.0 Combustion	HED2EN4T2
5.1 Discuss the requirements for proper combustion in all internal combustion engines.	Diesel Fundamentals p. 63

LEARNING ACTIVITIES cont.-..	REQUIRED RESOURCES
6.0 Air Induction Systems	HED2EN5T18
6.1 Follow teacher presentation on: . atmospheric pressure and naturally aspirated engines . volumetric efficiency	Diesel Fundamentals p. 76, 82
6.2 Observe presentation and demonstration on supercharging diesel engines including: . blowers . turbochargers . aftercooling - (i) jacket water (ii) air to air . series turbocharging . turbocharging troubleshooting installation and maintenance	Class Demo CAT 3406 Diesel Fundamentals p. 265-278
7.0 Air Filters	HED2EN6T14
7.1 Discuss engine air filtering through recent history including oil wick, oil bath, and dry element types.	Diesel Fundamentals p. 259-263 p. 284-295 1/2" VHS Video "That Engines May Live" (Clean Air)
7.2 Trace air flow through various air filtration systems including: . single stage filters . two stage filters . three stage filters	Lab Engine Tour
7.3 Follow discussion and demonstration of measuring air flow restriction in naturally aspirated and turbo-charged diesel engines.	Diesel Fundamentals p. 279-282 Cat 3406 Manometer Demo
8.0 Compression	HED2EN7T5
8.1 Listen to teacher presentation on the importance of adequate compression and what influences compression pressure, and what engine performance is affected by compression variables.	Diesel Fundamentals p. 571 HED Compression Test Kit
8.2 Discuss compression test procedures following manufacturers pressure and rpm specifications, cylinder balance limits and also safety considerations to technician and engine.	
9.0 Governors	HED2EN8T8
9.1 Follow teacher presentation on the need, purpose, construction and operation of a mechanical governor.	Diesel Fundamentals p. 335-377 Library FS/CASS TJ012B "Diesel Injection &

VI. REQUIRED STUDENT RESOURCES:

Textbooks:
Diesel Fundamentals (Second Edition) - Thiessen/Dales
Diesel Equipment I - Schulz

VII. ADDITIONAL RESOURCE MATERIALS AVAILABLE IN THE COLLEGE LIBRARY:

See Attached List

Periodical Section

Suggested list of periodicals in the Library which are of interest to Heavy Duty Equipment Students:

Heavy Construction News
Engineering & Contract Record
Northern Logger
Construction Methods & Equipment
Diesel Equipment Superintendent
Hydraulics and Pneumatics
Power
Bus and Truck Transport
Motor
E.M. (Heavy Duty "Equipment Maintenance'')
Motor Truck
Diesel and Gas Turbine Progress

Audiovisual Section (Library Film Strip/Cassette Modules)

TJ 02a The crawler Tractor Operator Familiarization
TJ 02b Working The Crawler
TJ 03 Cummins Aneroids
TJ 04 Cummins Dial Indicator Tune-up
TJ 05 Cummins Piston Rings
TJ 06 Cummins PTD Fuel Injection
TJ 07 PTG AFC Theory and Operation
TJ 08 Diesel Truck History
TJ 09 Cummins Professional Driver Techniques
TJ 010 Drive Line Alignment
TJ 011 Driving With "Skid-Trol"
TJ 012 Introduction To Diesel
TJ 013 High Energy Ignition
TJ 014 Stopmaster Brake Troubleshooting
TJ 015 Oils For The 70's
TJ 016 Theory and Operation of Fluid Drive
TJ 017 VE Pump Operation

VII, SPECIAL NOTES:

High Top Safety Boots (CSA Approved)
Safety Glasses (CSA Approved), Impact on Prescription Lenses
Coloured Pencils (red, blue, green, yellow)

Students with special needs (eg. physical limitations, visual impairments, hearing impairments, learning disabilities) are encouraged to discuss required accommodations confidentially with the instructor.

Your instructor reserves the right to modify the course as he/she deems necessary to meet the need of the students.

C

HEAVY EQUIPMENT LIBRARY BOOKS

Title	Author(s)	Publisher
Hydraulics For Off The Road Equipment	Harry L. Stewart	Theodore Audel & Co.
Fluid Power - 1st Ed.	Harry L. Stewart John M. Storer	Howard W. Sams & Co.
Diesel Engines Principles & Practice	C. C. Pounder	George Newnes Ltd.
Moving The Earth - 2nd Ed.	Herbert L. Nichols	North Castle Books
Diesel - Heavy Duty Truck Application & Performance Factors	Joseph Nunes	Prentice Hall Inc.
Basic Mathematics for Electricity & Electronics - 2nd Ed.	Bertrans B. Singer	McGraw-Hill Book Co.
Operating Techniques for the Tractor - Loader Backhoe	Gary J. Ober	Ober Publishing
Modern Diesel Cars	Jan P. Nor bye	Tab Books
Diesel Engine Manual - 4th Ed.	E. Molloy	George Newnes Ltd.
Standard Practices for Stationary Diesel & Gas Engines - 6th Ed.		Diesel Engine Manuf.
Maintenance of High Speed Diesel Engines - 4th Ed.	Authur W. Judge	Chapman & Hall Ltd.
How To Prepare Diesel Engines	Paul Dempsey	Tab Books
Industrial Hydraulic Manual		Sperry & Vickers
Diesel Fundamentals Principles & Service	Frank Thiessen Davis Dales	Reston Publishing Co.
Heavy Vehicle Technology	D.J. Leeming R. Hartley	Hutchinson & Co.
Diesel Engine Operation & Maintenance	V.L. Maleev	McGraw-Hill Books Co.
Agricultural & Automotive Diesel Mechanics	Gene L. Davis	Prentice-Hall Inc.
Diesel Equipment I	Erich J. Schulz	McGraw-Hill Book Co.
Diesel Equipment II	Erich J. Schulz	McGraw-Hill Book Co.
Diesel Engine Manual	Perry 0. Black	Theodore Audel & Co.

Questions & Answers On Ihe Marine Diesel Engine	John Lamb	Charles Griffin & Co,
Questions & Answers Diesel Eng.	J.N. Seale	George Newnes Ltd.
Fuel Injection Systems - 3rd. Ed	Brian P. Emerson	Diesel Publications
Study Guide For Diesel & High Compression Gas Eng. - Fundamentals	W.H. Doll	American Technical Society
How To Convert Your Car, Van or Pickup To Diesel	Paul Dempsy	Tab Books
Engine Service	W. Garry Lewis	Prentice-Hall Inc.
FOS Fundamnetals & Service - Hydraulics	Louis R. Hathaway	Johne Deere Service Publications
Diesel & Mobile Plant Service Technology	Clifford M. Tempest	McGraw-Hill Book Co.
Diesel Mechanics	Erich J. Schulz	McGraw-Hill Book Co.
Diesel Engineering Handbook - 12th Edition	Karl Stinson	Business Journal Inc.
Controlling Power Transmission Systems	Ralph L. Jaeschke	Penton/IPC Inc.
Fastener Standards - 5th Ed.		Industrial Fasteners Institute
Automatic Transmissions	Frank Thiessen Davis Dales	Reston Publishing
Fuel Injection Systems: Gas & Diesel	Robert N. Brady	Prentice-Hall Inc.
Fluid Power 1		Parker Hannifin Corp.
Fluid Power 2		Parker Hannifin Corp.
Industrial Hydraulic Technology		Parker Hannifin Corp.
Power Mechanic	Ewart J. Davis Pat H. Atteberry	General Publishing Company
Automotive Cooling System Training & Reference Manual	Richard F. Armento	Reston Publishing
Marine Diesel	M. David Barghardt George D. Kingsley	Prentice-Hall Inc.
Solid State Ignition System	R.F. Graf G.J. Whalen	Howard W. Sams & Co. Inc.
Automotive Fundamentals- 3rd Ed.	Ernest A. Venk Halter E. Billiet	American Technical Society

Tractors & Crawlers	Irving Frazee Philip V. Eshelman	American Technical Society
Diesel Engine Reference Book	L.R.C. Lilly	Butterworths & Co.
Moving The Earth - 3rd Ed,	Herbert L. Nichols	North Castle Books
General Power Mechanics - 2nd Ed.	Chris H. Groneman	McGraw-Hill Book Co.
Heavy Equipment Repair - 2nd Ed.	H. L. Nichols	North Castle Books
Automotive Fundamentals - 2nd Ed*	Frederick C. Nash	McGraw-Hill Book Co.
Hie Auto Book	William H. Crouse	McGraw-Hill Book Co.
Fluid Power - 2nd Ed.	Harry L. Stewart John M. Storer	Howard H. Sam & Co.
Practical Guide To Fluid Power	Harry L. Stewart	Theodore Audel & Co.
Mobile Hydraulics Manual - 1st Ed.		Sperry & Vickers
Mobile Hydraulics Manual - 2nd Ed.		Sperry & Vickers
Mobile Hydraulic Testing	Ronald E. Glenn James E. Blenn	American Technical Society
Fluid Power Components		Parker Hannifin Corp.
Fluid Power Instructor Manual	Harry L. Stewart John M. Storer	Howard W. Sams & Co.
Analyzing Hydraulic Systems		Parker Hannifin Corp.
Industrial Fluid Power Text - Volume 1	Charles S. Hegges	Womack Machine Supply Company
Industrial Fluid Power Text - Volume 2	Charles S. Hegges	Womack Machine Supply Company
1986-87 Fluid Power Handbook & Directory		Hydraulics & Pneumatics
Operation & Care of Hydraulic Machinery		McColl - Frontenac Oil Company Ltd.
Industrial Hydraulics Catalogue		Sperry & Vickers
Pumps	Perry 0. Black	Theodore Audel & Co.
Atlas Copco Manual - 3rd Ed.		Atlas Copco
Simplified Hydraulics	L.S. McNickle Jr.	McGraw Hill Book Co.
Dictionary of Technical Terms 10th Edition	Frederic S. Crispen	The Bruce Publishing Company
National Fluid Power Association Directory & Product Guide - 25th Anniversary	James I. Morgan	National Fluid Power

Diesel Fundamentals Principles & Service	Frank Thiessen Davis Dales	Prentice-Ball Inc.
Elementary Technical Mathematics	Frank L. Juszli Charles A. Rodgers	Prentice Hall Inc.
Mathematics for Technicians	Edward M. Tronaas	Prentice Hall Inc.
Practical Problems in Mathematics	Boyce H. Dwiggins	Delmar Publishers
Basic Mathematics Simplified	C. TSiomas Olivo Thomas P. Olivo	Van Nostrand Reinhold Ltd.
The Starrett Book for Student Machinists		L. S. Starrett Co.
The Tractor Electrical System		American Assoc, for Vocational Instruct. Materials
Tractor Maintenance Principles & Procedures		American Assoc, for Vocational Instruct. Materials
Instrumentation Training Coarse - Pneumatic Instruments - Vol, 1	Howard W. Sams	Howard W. Sams & Co.
Basic Earthmoving for Machine Users		Caterpillar Tractor
British Engines - 9th Ed.	G.G. MacLennan D.S.D. Williams	British Interal Combustion Eng. Manu,
How Components Fail	Donald J. Wulpi	American Society for Metals
Marine Machinery Lubrication - 2nd Edition		McColl-Frontenac Oil Company Limited
British Engines	G.R. Hutchinson D.S.D. Williams	British Internal Combustion Eng. Manu.
Shall Engines Vol. 1 - 3rd. Ed	J. Howard Turner	American Assoc, for Vocational Instruct. Materials
Staall Engines Vol. 2 - 3rd. Ed	J. Howard Turner	American Assoc, for Vocational Instruct. Materials
Bearings & Their Lubrication		British American Oil Company Limited
Brakes - Cars, Truck, Buses		Canadian Raybestos Company Limited
Disc & Drum Brake Service	Walter Alley **Walter E.** Billiet	American Technical Society

	LEARNING ACTIVITIES cont____	REQUIRED RESOURCES
	Governors continued.	
9.1		Governing" also Lab Tour
9.2	Discuss the terns and their definitions concerning engine governing, including: . speed droop (percent regulation) . isochronous . sensitivity . stability . promptness . work capacity . governor hunting	
9.3	Compare the various types of governors used and their applications and operating principles including: . mechanical governors . hydraulic governors . pneumatic governors . velocity governors . electronic governors	
10.0	Engine Performance	HED2EN9T4
10.1	Follow teacher presentation on engine performance terminology and fill in definitions for: . work . torque . power - (i) horsepower (ii) watts	Diesel Fundamentals p. 78-82 16mm Film "Motors" (Cummins) "Understanding and Measuring Power" (Tool Crib)
10.2	Discuss with teacher proper definitions for all the power ratings that may or may not include accessories. Calculate torque, horsepower or R.P.M. unknowns according to the given H.P. formula. Discuss how the engine H.P. formula is derived from force, distance and time factors and define: . maximum horsepower . intermittent horsepower . continuous horsepower	HED2EN10T13
10.3	Listen to teacher presentation on Brake Specific Fuel Consumption and calculate fuel used at various loads and r.p.m. at full throttle.	
10.4	Discuss construction and operating principles of: . prony brake dynamometer . hydraulic water brake . electric dynamometer	Diesel Fundamentals p. 84 Lab "Dyno Tour"

LEARNING ACTIVITIES cont. . . .	REQUIRED RESOURCES
11.0 Diesel Fuel	HED2FU11T12
Discuss with teacher, the five minimum requirements that any diesel fuel injection system must provide to the engine.	Diesel Fundamentals p. 301-308
11.1 Listen to teacher presentation on diesel fuel characteristics and qualities, including: . grades . cetane number and rating . viscosity . sulphur content . cloud point . crystallization point . pour point . caloric value . flash point	Class Demo
11.2 Follow the handout and instructors presentation on the need for fuel conditioning to safeguard the precision delivery system. Discuss contaminants such as: . water . abrasive . bacteria	
11.3 Trace the flow of diesel fuel through a well designed fuel delivery system. Discuss and define: . strainers . water traps . vents . primary fuel filters . transfer pumps . secondary fuel filters . watchdog filters . water separators . fuel heaters . diesel drain oil blending	HED2FU11T12 Diesel Fundamentals p. 309-315 Fuel System Components Demo 1/2" VHS "Arctic Fox Fuel Heaters"
12.0 Pressure Time Fuel Systems	HED2FU12T16
12.1 Listen to teacher presentation on physical characteristics of a typical Cummins engine using a PT fuel system including: . comb, chamber . mechanical injector . roller lever cam followers . unique cam profile . PT fuel pump . low pressure fuel lines	Diesel Fundamentals p. 453-475

LEARNING ACTIVITIES cont.	REQUIRED RESOURCES
Pressure Time Fuel Systems continued.	
12.2 Follow the overall fuel paths for the PT fuel system and their maintenance points.	
12.3 Follow teacher overview of PTG pump internal operation and the mechanical injector operation and their combined relationship to the pressure-time fuel metering theory. Discuss it's capability to vary (meter) fuel according to engine load and speed.	
12.4 Listen to teacher presentation and discuss the torque method tune-up for some Cummins engines. Describe: . cold set . hot set . injector hold down torque . crossheads & adjustment procedure . injector plunger adjustment procedure . valve clearance adjustment procedure and sequence necessity after injector adjustment . engine rotations following tune-up	HED2FU12T16 Class Demo
12.5 Discuss the effects of improper adjustment on timing and metering of fuel to the combustion chamber as well as neglected top end tune up for extended periods of time.	
12.6 Discuss precautions of removing mechanical injectors from engine, and removing plungers from injector bodies in engine.	
13.0 Single And Multiple Plunger Fuel Injection Pumps	HED2FU13T14
13.1 Listen to teacher presentation on the manufacturers, benefits and overall characteristics of multi-plunger pumps and service procedure during normal engine oil change.	Diesel Fundamentals p. 379-414 Class Demo
13.2 Trace diesel fuel flow through a typical multi-plunger pump fuel circuit. Include: . tank . filters . transfer pump . constant air bleed lines . overflow valve . return lines	Components
13.3 Follow teacher presentation on transfer pumps, including: . gear	

LEARNING ACTIVITIES cont.	REQUIRED RESOURCES
Single And Multiple Plunger Fuel Injection Pumps continued.	
13.3 . vane . diaphragm . piston . electric	
13.4 Follow the teachers presentation on the operating principles of a helix plunger and barrel. Define: . constant plunger stroke . effective stroke . upper helix . lower helix . rack . delivery valve . variable beginning of injection . constant beginning of injection . timing advance unit . aneroid or air/fuel ratio control . phasing . calibration	HED2FU13T14 Diesel Fundamentals p. 379-414 Lab Fuel Bench Demo
13.5 Follow teacher presentation and discuss field testing and trouble-shooting multi-plunger pumps and hydraulic injectors on engine. Differentiate between engine mechanical health and fuel injection system faults.	HED2FU13T14
14.0 Hydraulic Fuel Injectors	HED2FU14T8
14.1 Listen to teacher presentation on fuel injectors. Note the difference of mechanical types versus hydraulic types. Define: . closed nozzles . open nozzles . pintle type . hole type	Diesel Fundamentals p. 321-333 Fuel Lab Demo
14.2 Follow the teachers presentation and demonstration on testing hydraulic injector nozzles for: . tip leakage . opening pressure . atomization . distribution . chatter . back leakage	

LEARNING ACTIVITIES cont____	REQUIRED RESOURCES
15.0 Unit Injector Fuel System	HED2FU15T12
15.1 Listen to teacher presentation on the history of the Detroit Diesel unit injection system and it's adaptation to some Cat and Waukeshau engines. Also it's flexibility from mechanical governance to electronic microchip control.	Diesel Fundamentals p. 415-452 Classroom Component Demo
15.2 Follow and discuss coverage of overall fuel circuit including: . primary and secondary filters and their maintenance and priming procedures . transfer pump construction and its reg. valve importance . return line restriction fitting importance	
15.3 Follow teachers disassembly of a unit injector and trace fuel flow through the injector, noting two possible helixes and ports, and their effect on metering and timing fuel to the combustion chamber.	
15.4 Watch instructor demonstration of tuning up a Detroit Diesel two stroke engine including: . bridge adjustment . valve lash adjustment . injector timing adjustment . rack bounce Discuss neglect or improper tune-up adjustment on engine smoothness and startability.	HED2FU15T12 Lab Demo
15.5 Follow demonstration on isolating unit injectors on a running engine to diagnose smoke engine miss, or overfueling of unbalanced cylinders.	
16.0 Rotary Distributor Fuel Injection Pump	HED2FU16T12
16.1 Follow teacher presentation on the history, necessity and physical construction of a typical stanadyne rotary distributor pump, including: . overall external fuel circuit . transfer pump and pressure regulator . rotor and hydraulic head . rollers, plungers and cam ring . governor and metering valve . speed or load sensitive advance units	Diesel Fundamentals p. 543-563 Classroom Components "Roosa DM Pump" 16mm Film "Roosa Master Pump"

I£AKNING ACTIVITIES cont. . . . REQUIRED RESOURCES

Rotary Distributor Fuel Injection Pump continued....

16.2 Follow and discuss the timing procedures for pump installation, checking proper advance operation and troubleshooting faulty engine/inj. pump/injector possibilities. Also follow discussion of precautions required for prevention of hand injury when timing these pumps, and precautions needed to ensure long pump life.

17.0 Combustion And Diesel Smoke HED2FU17T8

17.1 Follow teacher presentation on combustion quality and acceptable emissions.

17.2 Discuss the contents and possible causes of:

. white diesel smoke
. black diesel smoke
. blue diesel smoke

V. EVALUATION METHODS: HED 111 assessment is based on regularly tests and assignments. Attendance and homework checks are recorded and used as an aid for counselling.

The following grades will be assigned.

A+	(>90%) (Numerical Equivalent 4.0)	- Consistently Outstanding
A	(85-90%) (Numerical Equivalent 3.75)	- Outstanding Achievement
B	(75-84%) {Numerical Equivalent 3.00)	- Consistently Above Average Achievement
C	(65-74%) (Numerical Equivalent 2.00)	- Satisfactory or Acceptable Achievement
R	(<65%) (Numerical Equivalent 0.00)	- Repeat - Objectives of course not achieved and course must be repeated

CR - Credit exemption

X - A temporary grade, limited to situation with extenuating circumstances, giving a student additional time to complete course requirements.

Your Semester Theory Letter Grade will be comprised of:

- 80% of Semester Theory Exam Average
- 20% of Semester Theory Assignment Average

A 65% Average of the total semester exam and assignment must be achieved to receive a passing grade in Heavy Equipment Diesel Theory.

A student can not rewrite a test to improve his mark.

If a test is missed by a student, without a good reason, an "Incomplete" grade is allotted.