

Introduction to
Hydraulics

Hydraulic Specialist
Certification Review

Control Strategies for
Dynamic Systems:
Analog

Control Strategies for
Dynamic Systems:
Digital and
Mechatronics

Introduction to
Hydraulic Systems
Modeling and
Simulation

Magnetic Actuators
and Sensors

Hydraulic Fluids and
Contamination Control

Hydraulic System
Maintenance,
Troubleshooting and
Failure Analysis



**MILWAUKEE SCHOOL OF ENGINEERING
FLUID POWER AND MOTION CONTROL
PROFESSIONAL EDUCATION SEMINARS**

2009

Register online at www.msoe.edu/seminars



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CENTER FOR COMPACT AND EFFICIENT



FLUID POWER



Visit www.ccefp.org/ for more information.

Transforming Hydraulic & Pneumatic Technology

- Reducing fuel consumption and energy use
- Reducing pollution
- Creating next generation automotive technology
- Improving mobility for the elderly and ailing
- Developing autonomous rescue robots
- Creating the next generation of service robots
- Designing high-powered portable hand tools

MSOE: A UNIVERSITY THAT WORKS

At Milwaukee School of Engineering®, theory is brought to life and reinforced for students through extensive integration of laboratory experimentation. Understanding theoretical concepts and knowing how to apply them is key to the success of MSOE graduates. Established in 1903, MSOE has enjoyed a long history of interdependence with business and industry. Industrial support in the form of scholarships, laboratories and facilities, and involvement and counsel enables MSOE to provide educational solutions and graduates to meet industry needs. MSOE has a small university atmosphere within an exciting city environment. The 15-acre, user-friendly campus is located in a historic district downtown, just blocks from beautiful Lake Michigan.

ELECTROHYDRAULIC MOTION CONTROL LABORATORY

MSOE's fluid power seminars merge classroom theory with intense, practical laboratory sessions. The state-of-the-art laboratory contains six advanced workstations, each specifically designed for the individual interested in gaining a detailed and thorough understanding of all aspects of fluid power including electrohydraulic system design. Seminar participants use servo and proportional valves in tests and systems, and make system interconnections. Computers collect data that facilitate the construction and analysis of feedback control

THE MSOE FLUID POWER INSTITUTE™

Established in 1962 and comprised of faculty, staff, students and state-of-the-art laboratories, the MSOE Fluid Power Institute™ (FPI) is an American leader in fluid power technology. Individuals from across the United States choose to participate in MSOE's fluid power seminars because the institute is instrumental in the development, advancement, promotion and application of fluid power and electrohydraulic motion control technology. Because the Fluid Power Institute performs extensive pump, valve, motor, cylinder and fluid testing, the seminar participants are exposed to highly specialized equipment, including a tribology and contamination analysis laboratory. MSOE seminars are endorsed by the National Fluid Power Association (NFPA) through sponsorship and educational partnership.

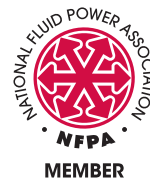


Tom Labus, professor in the Mechanical Engineering Department, works with students in the Electrohydraulic Motion Control Laboratory.



systems. This Electrohydraulic Motion Control Laboratory is not found at any other educational institution in the world. It received a patent and is supported by the National Science Foundation.

Caption 200 HP dynamometer with electrical regeneration capabilities used for testing the energy efficient fluids.



PROFESSIONAL EDUCATION

MSOE seminars offer participants the opportunity to explore technological developments and current applications and techniques. The programs are designed to keep practicing engineers abreast of new developments and applications, and also to provide a basic understanding of the technology to new entrants into the field.

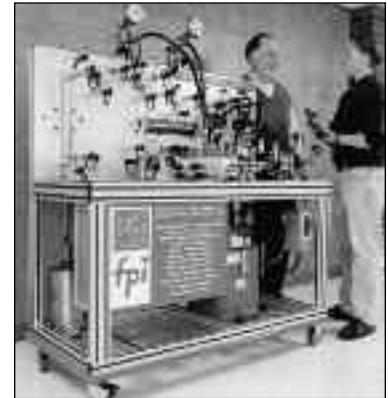
On-Site Seminars

MSOE seminars are available for an on-site presentation at your company. The curriculum may be presented in its original format or be **modified to meet your specific needs.**

Confidentiality protected! For more information, contact Dr. Medhat Khalil at (414) 277-7269 or khalil@msoe.edu.

MSOE Seminars:

- ✘ are based on applied research conducted by scholars;
- ✘ use state-of-the-art laboratories with industrial-size equipment;
- ✘ use a hands-on approach to reinforce the concepts presented in class;
- ✘ are applications-oriented and often customized to the industry or companies of the seminar participants; and
- ✘ are offered on the basis of strong long-term partnerships, with set objectives and outcomes.



Portable hydraulic trainers, designed and built at MSOE with the cooperation of industry partners, ensure hands-on learning for on-site and on-campus seminars.

For more information: www.msoe.edu/seminars

THE MSOE APPLIED TECHNOLOGY CENTER™

The Applied Technology Center™ (ATC) is the research arm of MSOE. It serves as a technology transfer catalyst among academia, business and industry and governmental agencies. The close association between MSOE and the business and industrial community has long been one of its strengths; applied research serves as a renewable resource in this linkage. In addition

to the FPI and Professional Education, the ATC is organized into several "centers of excellence:"

- ✘ Rapid Prototyping Center (RPC)
- ✘ NanoEngineering Lab
- ✘ Construction Science and Engineering Center
- ✘ Photonics and Applied Optics Center
- ✘ Center for BioMolecular Modeling

For more information: www.msoe.edu/research

INTRODUCTION TO HYDRAULICS

This 32-hour seminar is designed to acquaint individuals with the fluid power field and provide a practical working knowledge of this important and growing industry. This program features laboratory sessions where participants will gain practical experience working with actual fluid power components and systems. Specifically, laboratory sessions will treat the disassembly, inspection and assembly of individual components, as well as system design examples.

Who Should Attend?

This program is intended for individuals with limited exposure to fluid power – engineers, technical sales personnel, technicians and management personnel.



Seminar Objectives

Upon completion, participants should be able to:

- ✘ identify the distinguishing features of hydraulic and pneumatic systems.
- ✘ apply industry standards to hydraulic and schematic symbols.
- ✘ analyze hydraulic circuits from a schematic drawing.
- ✘ explain the operation and applications of valves, cylinders, pumps and motors.
- ✘ identify the chemical and physical properties of fluids as they relate to hydraulic system operation.
- ✘ utilize continuity and power balance equations.
- ✘ understand the basic configuration and operation of hydrostatic transmissions.

“This seminar will help me in the future with customers and help with troubleshooting.”

Aaron Schaefer
KTI Hydraulics Engineering

Laboratory Sessions

Component Laboratory

Participants will have an opportunity to view take-apart hydraulic system components and learn, in detail, their operation.

Hydraulic Systems Laboratory

Participants will have an opportunity to build hydraulic circuits and analyze data on state-of-the-art hydraulic trainers.

Introduction to Hydraulics

Dates

I. March 16-20, 2009

II. June 15-19, 2009

III. Oct. 5-9, 2009

Standard Fee \$1,720

Early Registration Fee \$1,580

I. By Feb. 16, 2009

II. By May 15, 2009

III. By Sept. 4, 2009

**Fee for Multiple Registrants
From the Same Company** \$1,440

CEUs 3.2

Instructors

Thomas Wanke, CFPE

Paul Michael, CES

Dr. Medhat Khalil

Program

Day 1 Session 2-6 p.m.
Reception and dinner 6 p.m.

Day 2-4 Sessions 8 a.m.-5 p.m.
Lunch on your own Noon-1 p.m.

Day 5 Session 8 a.m.-Noon
Lunch provided

Continental breakfast served on days 2-5.
Beverages/snacks provided throughout the day.

Location

MSOE

Milwaukee

INTRODUCTION TO HYDRAULIC SYSTEMS - TEXAS



For industry professionals working and living in the south.

Sponsored by:

Mechanical and Aerospace Department, College of Engineering, University of Texas at Arlington:
<http://www-mae.uta.edu/index.html>

Delivered by:

Department of Professional Education, Applied Technology Center, Milwaukee School of Engineering:
<http://www.msos.edu/seminars/>

Who Should Attend?

This program is intended for individuals with limited exposure to fluid power—engineers, technical sales technicians and management personnel.

Seminar Objectives

This four day seminar is designed to acquaint individuals with the fluid power field and to provide a practical working knowledge of this important and growing industry. This program features laboratory sessions where participants will gain practical experience working with actual fluid power components and systems. Specifically, laboratory sessions will treat the disassembly, inspection and assembly of individual components, as well as system design examples. Upon seminar completion, participants should be able to:

- ✘ identify the distinguishing features of hydraulic and pneumatic systems.
- ✘ apply industry standards to hydraulic and schematic symbols
- ✘ analyze hydraulic circuits from a schematic drawing

- ✘ explain the operation and applications of valves, cylinders, pumps and motors
- ✘ identify the chemical and physical properties of fluids related to hydraulic system operation
- ✘ utilize continuity and power balance equations
- ✘ learn about the basics of hydraulic fluids, filtration technology and contamination control
- ✘ understand the basic configuration and operation of hydrostatic transmissions

Laboratory Sessions:

- ✘ Participants will have an opportunity to view take apart hydraulic system components and learn, in detail, their operation.
- ✘ Participants will have opportunities to build hydraulic circuits and analyze data on state-of-the-art hydraulics trainers.

Lodging:

There is a motel located within walking distance of UTA:
Park Inn International
703 Bengé Street (off Cooper Street 1 block south of campus),
(817) 860-2323
There are numerous other motels located within a few miles of UTA.

For more information, please contact:

Dr. Medhat Khalil
Director of Professional Education, Milwaukee School of Engineering
(414) 277-7269.
Email: Khalil@msos.edu



Introduction to Hydraulics - Texas

Dates

Dec. 1-4, 2009

Standard Fee

\$1,720

Early Registration Fee

\$1,580

By Nov. 14, 2009

Fee for Multiple Registrants

From the Same Company \$1,440

CEUs

3.2

Instructor

Dr. Medhat Khalil

Location

University of Texas at Arlington
Nedderman Hall, Room 105
416 S. Yates Street
Arlington, TX 76019

Program

Days 1-4 Sessions 8 a.m.-5 p.m.
Lunch on your own

Beverages and snacks provided throughout the day

HYDRAULIC SPECIALIST CERTIFICATION REVIEW



Sponsored by the International Fluid Power Society, IFPS, <http://www.ifps.org/>

What is the IFPS Hydraulic Specialist Certification?

It is a certification degree granted by IFPS based on passing a three-hour written test provided and proctored by IFPS. For more information, please visit: <http://www.ifps.org/Certification/index.htm>

Hydraulic Specialist Certification Review course objectives:

It is a two and half day review session held and provided by MSOE followed by the certification exam on the fourth day. The objective of the course is to provide instructions and review basics of hydraulics to maximize the chance of passing the exam. It is a non-CEU program, meaning MSOE will not grant credit units since it is followed by an IFPS certification exam and the study material is based on the IFPS study guide.

Register for the review session at MSOE and you will be benefit from:

1. Free registration for taking the IFPS Hydraulic Specialist exam.
2. Free study manual for the exam.
3. Exam session in the same place as the training.

Who should attend?

It is required for candidates who are involved in hydraulic system sales, design, modeling and supervising system operation.

Prerequisites:

"Introduction to Hydraulics" given by MSOE OR equivalent years of experience

Topical Outlines:

- ✘ Job Responsibility 1.0: Apply hydraulic circuits to perform desired tasks
- ✘ Job Responsibility 2.0: Analyze loads and motion
- ✘ Job Responsibility 3.0: Select components for hydraulic applications

- ✘ Job Responsibility 4.0: Prepare bills of material and schematics
- ✘ Job Responsibility 5.0: Recommend fluid, fluid conductors and fluid filtration
- ✘ Job Responsibility 6.0: Analyze and troubleshoot hydraulic systems

Notes:

- ✘ Fees include: exam fees (\$385 value), study manual, catering and the instruction fees
- ✘ We can take the course to your facility for a minimum of 10 people. For terms and condition of in-house training please contact Dr. Medhat Khalil, Director of professional education at (414) 277-7269 or Khalil@msoe.edu



Hydraulic Specialist Certification Review

Dates

Feb. 9-12, 2009

Standard Fee

\$1,200

Early Registration Fee

\$1,100

By Jan. 9, 2009

Fee for Multiple Registrants

From the Same Company \$1,000

Instructors

Dr. Medhat Khalil

Program

Day 1 Session 2 p.m.-6 p.m.
Dinner Reception 6 p.m.-7 p.m.

Day 2-3 Sessions 8 a.m.-5 p.m.
Lunch on your own Noon-1 p.m.

Day 4 Session 8 a.m.-1 p.m.
(exam day)

Continental breakfast served days 2-4.
Beverages/snacks provided throughout the day.

Location

MSOE
Milwaukee

HYDRAULIC FLUIDS AND CONTAMINATION CONTROL

This is the first module of a two-part 40-hour seminar series on strategies for maximizing hydraulic system reliability. In the first 24-hour module participants will focus on fluid selection, application, analysis and contamination-control and filtration technology. Basic lubrication principles are thoroughly covered and new technologies that impact fluid selection, application and life are introduced. The participant will learn methods for evaluating fluid condition and minimizing failures in hydraulic systems related to fluid degradation. Identifying the three primary sources of contamination and diagnosing the root cause of contamination are important skills all participants will take away from part one. Also covered will be filtration technology including filter types, filter ratings (nominal, absolute and beta ratings), standardized test procedures, filter location in the hydraulic system, filter sizing and selection of filters for a given application. The seminar includes a tour of Benz Oil, a regional test lab and hydraulic fluid manufacturer.

Prerequisites

A fundamental understanding of hydraulics systems and components is necessary. MSOE's Introduction to Hydraulics seminar is an excellent preparation.

Who Should Attend?

Filtration, maintenance and design engineers; fluid power sales professionals; multi-craft maintenance personnel; millwrights; pipe fitters, plumbers; mechanics; machinery maintenance mechanics and electromechanical repair technicians. If you're responsible for the ongoing operation of a fluid-power system, or if you manage or train workers who are,

this seminar can show you what you need to know to keep the systems up and running.

Seminar Objectives

Upon completion, participants should be able to:

- ✘ identify appropriate hydraulic fluids for given applications.
- ✘ extract fluid samples from operating hydraulic systems for fluid sample analysis.
- ✘ interpret the results of a fluid sample analysis.
- ✘ explain the effects of contaminants on hydraulic systems.
- ✘ evaluate the differences of filter ratings and specifications.
- ✘ select an appropriate filter for specific applications.
- ✘ understand cost-effective filtration.

Topical Outline

Hydraulic fluids

- ✘ fluid properties and types
- ✘ selection of appropriate fluid for given application
- ✘ recommendations for preventive fluid maintenance

"I gained a better understanding of cavitation and the difference in oil and the additives."

Troy Davis
Charter Steel

Effects of contaminants on hydraulic systems

- ✘ types and sources of contaminants
- ✘ detecting contamination
- ✘ reducing contamination

Laboratory demonstration sessions - fluid sample analysis

- ✘ automated particle counting
- ✘ infrared analysis
- ✘ Karl Fisher Titration interpretation of fluid analysis results, filtration technology

Filtration technology

- ✘ filter types, ratings and selection
- ✘ filter material
- ✘ filtration mechanisms

Hydraulic system accessories

- ✘ reservoirs, accumulator, instruments, heaters and coolers

Hydraulic system safety

Hydraulic Fluids and Contamination Control*

Dates

April 20-22, 2009

Standard Fee

\$1,440

Early Registration Fee

\$1,340

By Mar. 20, 2009

Fee for Multiple Registrants

From the Same Company \$1,230

CEUs

2.4

Instructors

Thomas Wanke, CFPE
Paul Michael, CLS
Dr. Medhat Khalil

Program

Day 1 Session 8 a.m.-5 p.m.
Lunch provided Noon-1 p.m.

Day 2 Sessions 8 a.m.-5 p.m.
Lunch on your own Noon-1 p.m.

Day 3 Session 8 a.m.-5 p.m.

Continental breakfast served on all days.
Beverages/snacks provided throughout the day.

Location

MSOE
Milwaukee

*Save \$
Early Multiple
Registration*

*Can be taken with the Hydraulic System Maintenance, Troubleshooting and Failure Analysis seminar (\$1,970). Take both and save.

Save \$
Early Multiple
Registration

HYDRAULIC SYSTEM MAINTENANCE, TROUBLESHOOTING AND FAILURE ANALYSIS

This is the second module of a two-part, 40-hour seminar series for maximizing hydraulic system reliability. This second 16-hour module examines system maintenance, troubleshooting and failure analysis. This two-day session begins by looking at critical system-wide factors that impact reliability such as heat generation and vibration. Best practices for leak prevention and maintenance of seals, conductors and fittings are reviewed in a methodical manner. Informative case studies are presented in addition to systematic methods for troubleshooting and failure analysis. Troubleshooting and failure analysis are critical skills for escaping the cycle of breakdown and repair while contamination is the number one threat to hydraulic system reliability. This seminar will enhance your company's profit, quality and productivity by reducing hydraulic system down-time and repair costs.

Prerequisites

A fundamental understanding of hydraulics systems and components is necessary. MSOE's Introduction to Hydraulics seminar is an excellent preparation.

Who Should Attend?

Filtration, maintenance and design engineers; fluid power sales professionals; multi-craft maintenance personnel; millwrights; pipe fitters; plumbers; mechanics; machinery maintenance mechanics and electromechanical repair technicians. If you're responsible for the ongoing operation of a fluid-power system, or if you manage or train workers who are, this seminar can show you what you need to know to keep the systems up and running.

Seminar Objectives

Upon completion, participants should be able to:

- ✘ plan and schedule hydraulic system maintenance.
- ✘ reduce significantly the system leakage through a better handling and understanding of hydraulic systems seals and conductors.
- ✘ utilize a logical approach for hydraulic systems troubleshooting.
- ✘ identify hydraulic system failure and the approach to solve it.

Topical Outline

Hydraulic system maintenance

- ✘ maintenance safety checklist
- ✘ maintenance common mistakes
- ✘ scheduled periodic maintenance
- ✘ inspection, maintenance and adjustment instructions

Hydraulic system troubleshooting

- ✘ features of hydraulic systems failures
- ✘ troubleshooting planning
- ✘ fault detection methodology
- ✘ tabulated "symptoms-fault-remedies"

Oil conductors

- ✘ piping, tubing, hosing, fittings

Introduction to oil seals

Component failure analysis

"This seminar gave a better understanding of what to look for in most common failures."

Eric Troy
Caterpillar Inc.



Hydraulic System Maintenance, Troubleshooting and Failure Analysis*

Dates

April 23-24, 2009

Standard Fee

\$1,130

Early Registration Fee

\$1,070

By March 23, 2009

Fee for Multiple Registrants

From the Same Company \$970

CEUs

1.6

Instructors

Thomas Wanke, CFPE
Paul Michael, CLS
Dr. Medhat Khalil

Program

Both Days 8 a.m.-5 p.m.
Lunch on your own Noon-1 p.m.

Continental breakfast served on both days.
Beverages/snacks provided throughout the day.

Location

MSOE
Milwaukee

*Can be taken with the Hydraulic Fluids and Contamination Control seminar (\$1,970).
Take both and save.

INTRODUCTION TO HYDRAULIC SYSTEMS MODELING AND SIMULATION

This 24-hour seminar focuses on developing and discovering original methods to remain technologically advanced while strategically maintaining cost efficiency. MSOE maintains its leadership in the motion control global marketplace by keeping individuals in the industry constantly abreast of the latest technology in design techniques of electrohydraulic systems. One-third of this seminar will be spent in laboratory exercises using hydraulic systems simulation software.

Who Should Attend?

Hydraulic fluid power component designers, application engineers, system integrators, electrohydraulic motion control engineers, and end users of fluid power components and systems. Familiarity with Laplace transforms, block diagrams and state space is desirable for portions of the dynamic analysis.

Objectives

Upon completion, participants should be able to:

- ✘ evaluate the importance of component sizing and simulation in the design process.
- ✘ apply principles of steady state and limited dynamic characteristics in both time domain and frequency domain.



- ✘ discuss different modeling approaches and levels for hydraulic components and systems.
- ✘ discuss the differences between simulation packages available in the market.
- ✘ exercise using MATLAB®/Simulink® to build mathematical model, define the simulation parameters, run a simulation and analyze the results.

Laboratory Sessions

This seminar involves many laboratory exercises including software simulation. Some of these include effective bulk modulus and orifice flow calculations, axial pump evaluation, motor performance, compensator dynamics, ultimate cycle test and cart frequency response test. Software simulations include linear, rotary and speed control of rotary loads.

Topical Outline

Fluid properties

- ✘ viscosity, density (specific gravity), bulk modulus, specific heat and thermal conductivity

Hydraulic capacitance

- ✘ mechanical compliance and effect of entrained air

Accumulators

Motors

Pressure control valves

- ✘ relief valves (pressure-flow characteristics, time response plots), reducing valves (pressure-flow characteristics) and check valves

Directional and flow-control valves

- ✘ pressure, flow and power metering, dynamic response analysis (proportional and servo valves), step response and frequency response (bode plots, transfer functions, simulation)

Fluid flow

- ✘ laminar flow, turbulent flow, orifices and conductors

Pumps

- ✘ fixed displacement, variable displacement and pressure compensated

Cavitation

Hydrostatic transmissions

Linear servo systems (position control)

- ✘ design process, motion profiling, component sizing and simulation of a servo mechanism

“This seminar provides several different approaches to modeling hydraulic components.”

Steven Gluck
Sauer-Danfoss

Introduction to Hydraulic Systems Modeling and Simulation

Dates

July 6-9, 2009

Standard Fee

\$1,440

Early Registration Fee

\$1,340

By June 5, 2009

Fee for Multiple Registrants

From the Same Company \$1,230

CEUs

2.4

Instructors

Dr. Medhat Khalil

Program

Day 1 Session 2-6 p.m.

Reception and dinner 6 p.m.

Day 2-3 Sessions 8 a.m.-5 p.m.

Lunch on your own Noon-1 p.m.

Day 4 Session 8 a.m.-Noon

Lunch provided Noon-1 p.m.

Continental breakfast served on days 2-4.
Beverages/snacks provided throughout the day.

Location

MSOE
Milwaukee

CONTROL STRATEGIES FOR DYNAMIC SYSTEMS: ANALOG

This 16-hour, interactive seminar explores modeling, analysis, characteristics and design of analog control systems with examples for electrohydraulic applications. Electronic control systems are becoming the cornerstone of technological advancement in many industrial and mobile applications. A review of modeling and analysis methods will allow participants to move into a detailed examination of proportional-integral-derivative (PID) controllers as well as phase-lag and phase-lead controllers. Electrohydraulic valve characteristics, and position and velocity control will be examined in applying control methods to fluid power systems.

Who Should Attend?

Applications engineers, systems integrators, electrohydraulic motion control engineers, product development engineers and the end users of control systems. Basic knowledge of differential equations is recommended.



Objectives

Upon completion, participants should be able to:

- ✘ understand the basic methods of modeling including Newton's Law and block diagrams.
- ✘ understand the analysis methods involving time, Laplace transforms, frequency and state space models.
- ✘ define the characteristics of feedback control systems.
- ✘ analyze feedback system stability.
- ✘ explain the distinguishing features of PID, phase-lag and phase-lead controllers.
- ✘ apply control methods for valve characteristics, position and velocity control to fluid power systems.

Laboratory Sessions

Participants will have the opportunity to develop system models, and analyze step and frequency responses for proportional valves and cylinders utilizing Matlab to verify results. Experiments on cylinder position control and hydraulic motor speed control will allow students to observe steady-state errors, step response and ultimate cycle-tuning methods in the state-of-the-art Electrohydraulic Motion Control Laboratory.

Topical Outline

Overview of Common Controllers and Review of Basic Control Theory

- ✘ modeling methods including Newton's Law, physics, energy balance and block diagrams
- ✘ analysis methods based on time, Laplace, frequency and state space models

Exploration of Analog Linear Control Systems

- ✘ feedback system characteristics including open versus closed loop, steady-state errors, disturbance inputs and transient response characteristics
- ✘ feedback system stability including root locust and frequency response methods

Design of Common Analog Controllers

- ✘ proportional and integral-derivative
- ✘ phase-lag
- ✘ phase-lead

Analog Control Systems

- ✘ common components

Applied Control Methods

- ✘ position control
- ✘ velocity control
- ✘ command and disturbance characteristics
- ✘ valve characteristics including dead-band characteristics in proportional valves and dead-band eliminators

*Save \$
Early Multiple
Registration*

Control Strategies for Dynamic Systems: Analog*

Dates

Aug. 17-18, 2009

Standard Fee

\$1,130

Early Registration Fee

\$1,070

By July 17, 2009

Fee for Multiple Registrants

From the Same Company \$970

CEUs

1.6

Instructor

Dr. John Pakkala

Program

Day 1 session 8 a.m.-5 p.m.
Lunch provided Noon-1 p.m.

Day 2 session 8 a.m.-5 p.m.
Lunch on your own Noon-1 p.m.

Continental breakfast served on both days.
Beverages/snacks provided throughout the day.

Location:

MSOE
Milwaukee

*Can be taken with the Control Strategies for Dynamic Systems: Digital and Mechatronics seminar (\$1,970). Take both and save.

CONTROL STRATEGIES FOR DYNAMIC SYSTEMS: DIGITAL AND MECHATRONICS

This 20-hour, applications-oriented seminar explores the characteristics of analog and digital controllers, and sensors and advanced controls topics such as adaptive, nonlinear, fuzzy and multivariable controllers. Time will be spent discussing the implementation of digital controllers including computer interfacing and microprocessors. As more applications move toward autonomous systems, control of all components as well as prognostics and control integration of systems are becoming critical issues in continued technological advancement.

Who Should Attend?

Applications engineers, systems integrators, electrohydraulic motion control engineers, product development engineers and the end users of control systems. Participants are encouraged to attend the Analog Control Systems seminar prior to attending this seminar.



Objectives

Upon completion, participants should be able to:

- ✗ apply principles of digital and analog controllers in designing control systems.
- ✗ understand the hardware and software options available.
- ✗ analyze and understand the differences in sensors for controls applications.
- ✗ implement digital controllers and evaluate step responses, steady-state errors and tuning methods.
- ✗ understand multivariable, adaptive, nonlinear and fuzzy-control concepts.

Laboratory Sessions

Participants will build and operate a digital controller utilizing Matlab interfaced with various electrohydraulic components. Experiments on cylinder position control and hydraulic motor speed control will allow students to observe steady-state errors, step response, and disturbance and command input responses. Two-axes motion control, adaptable control gain and nonlinear control experiments will be conducted during the advanced topics session.

Topical Outline

Analog vs. Digital Control

- ✗ characteristics and limits
- ✗ design methods overview
 - designing from continuous system methods
 - PID controllers
 - direct digital controller design
- ✗ digital control implementation
 - computers
 - common interfaces including data acquisition boards
 - microprocessors

Sensors

- ✗ position control
- ✗ velocity
- ✗ acceleration
- ✗ force
- ✗ temperature
- ✗ special considerations

"I'm better able to connect theory with application."

Chris Benson
John Deere

Digital Controls

- ✗ introduction
- ✗ analysis methods
 - sampling characteristics and effects
 - Z transformations
 - discrete-continuous equivalents
- ✗ digital control systems
 - feedback characteristics
- ✗ design of digital controllers
 - PID controllers
 - phase-lag and phase-lead controllers
 - direct design
- ✗ implementing digital control algorithms
 - difference equations
- ✗ applied control methods
 - position control
 - velocity control

Advanced Topics

- ✗ adaptive controllers
- ✗ fuzzy control
- ✗ multivariable controllers
- ✗ nonlinear controllers
- ✗ system identification methods

Control Strategies for Dynamic Systems: Digital and Mechatronics*

Dates

Aug. 19-21, 2009

Standard Fee

\$1,440

Early Registration Fee

\$1,340

By July 17, 2009

Fee for Multiple Registrants From the Same Company

\$1,230

CEUs

2.0

Instructors

Dr. John Pakkala

Program

Day 1-2 Sessions 8 a.m.-5 p.m.
Lunch on your own Noon-1 p.m.

Day 3 Session 8 a.m.-Noon
Lunch provided Noon-1 p.m.

Continental breakfast served on all days.
Beverages/snacks provided throughout the day.

Location

MSOE
Milwaukee

Save \$
Early Multiple
Registration

*Can be taken with the Control Strategies for Dynamic Systems: Analog seminar (\$1,970). Take both and save.

MAGNETIC ACTUATORS AND SENSORS

This 16-hour seminar enables engineers to analyze magnetic actuators and sensors. Applications of these actuators and sensors are increasing rapidly due to computer control, and include electrohydraulic valves, fuel injectors, relays, contactors, position sensors and motion control. The interaction of magnetic actuators, sensors and electromechanical systems will be discussed, including use of simulation software on personal computers.

Who Should Attend?

This program is designed for individuals with limited knowledge of electromagnetics and electromagnetic devices. Electrical and mechanical engineers, sales engineers and engineering managers desiring to understand magnetic actuators and sensors will find participation valuable.

Objectives

Upon completion, participants should be able to do the following:

- ✘ identify the various types of magnetic actuators and sensors
- ✘ analyze simple actuators and sensors using the reluctance method
- ✘ analyze simple and complex actuators and sensors using

finite element analysis software on personal computers

- ✘ understand the basic principles of electromagnetics
- ✘ understand the performance parameters of various actuators and sensors
- ✘ understand how to model coupled electric/magnetic/mechanical/hydraulic systems

Laboratory Sessions

Two laboratory sessions are included. One session will provide an opportunity to take apart a typical magnetic operated solenoid electrohydraulic valve. The other session will involve the use of finite element software to compute the magnetic field in a typical actuator design.

Topical Outline

- ✘ review of electromagnetics, including Ampere's Law, Faraday's Law, potentials and Maxwell's Equations
- ✘ presentation of analytical methods, including the reluctance and finite element methods
- ✘ calculation of performance parameters such as force, input current and output voltage



- ✘ examples of actuator analysis and design, including linear and rotary actuators, stepper actuators, and excitations such as DC, AC and pulse-width modulation
- ✘ sensors analyzed will include Hall-effect and speed
- ✘ simulation of mechanical and hydraulic systems containing magnetic actuators and sensors

"This seminar improved my theoretical actuator design."

Tim Ferguson
TRW Automotive



Magnetic Actuators and Sensors

For dates please contact
Medhat Khalil at
(414) 277-7269 or
khalil@msoe.edu

Registration Fee \$1,130

**Fee for Multiple Registrants
From the Same Company** \$970

CEUs 1.6

Instructor

Dr. John Brauer, P. E.

Program

Day 1 Session 8 a.m.-5 p.m.
Lunch provided Noon-1 p.m.

Day 2 Session 8 a.m.-5 p.m.
Lunch on your own Noon-1 p.m.

Continental breakfast served on both days.
Beverages/snacks provided throughout the day.

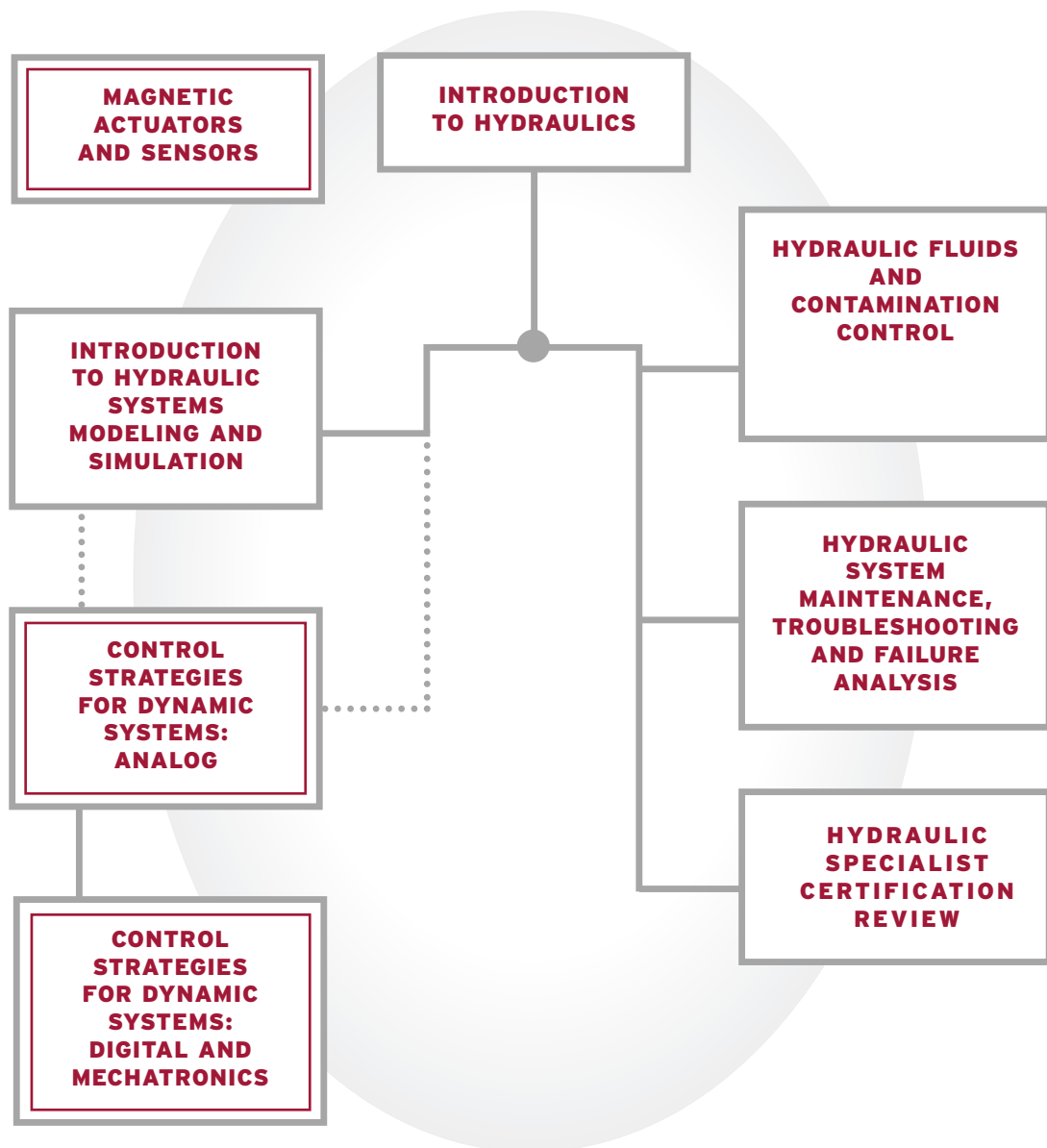
Location

MSOE
Milwaukee

SEMINAR MATRIX

The matrix shown here suggests the sequence or paths to follow to master topics in the fluid power field, depending on your background and career plans. The path following the Introduction to Hydraulics seminar to the right is recommended for people interested in operation, maintenance and troubleshooting of hydraulic systems. The left path is more advanced topics leading up to design of electrohydraulic feedback control systems that require basic hydraulics and a higher level of mathematics background.

Seminars marked with red and gray blocks are applicable to engineers interested in motion control, automation, mechatronics and smart systems within any industry.



FACULTY BIOGRAPHIES



Dr. John R. Brauer, P.E., is a retired professor from MSOE's Electrical Engineering and Computer Science Department. Before joining MSOE in 1998, Brauer was senior development engineer at Ansoft Corp. Brauer received his bachelor's degree in electrical engineering from Marquette University, and a master's degree and doctorate in electrical engineering from the University of Wisconsin-Madison. His specialty is computer modeling of coupled electromagnetic/mechanical devices.



John L. Ficken, P.E., is an associate professor in MSOE's Mechanical Engineering Department. Ficken received a B.S. in mechanical engineering from Iowa State University and an M.S. in mechanical engineering from the University of Wisconsin-Madison. He received MSOE's Outstanding Mentor Award in 2001.



Dr. Medhat K. Khalil is the director of professional education. He has a bachelor's degree in mechanical engineering and a master's degree in fluid power engineering from Military Technical College and Cairo University, respectively, of Cairo, Egypt. He earned his Ph.D. in mechanical engineering from Concordia University, Montreal, Canada. Khalil has more than 15 years of experience in fluid power control. Prior to joining MSOE, he was employed as a hydraulic system simulation software developer for CAE Inc. and an adjunct professor for Concordia University, Montreal, Canada. Khalil worked for five years as the technical officer and training manager for

Mannesmann Rexroth in Egypt. His current interest is in developing educational virtual labs for fluid power engineering.



Paul Michael, C.L.S., is a research chemist at MSOE's Fluid Power Institute™. He earned his B.S. in Chemistry at the University of Wisconsin-Milwaukee and graduated with distinction from Keller Graduate School of Management. He has 30 years of experience in the formulation and testing of hydraulic fluids and lubricants. Paul is an STLE Certified Lubrication Specialist and chairs the NFPA Fluids Committee. In addition to his research in contamination analysis, he is currently investigating energy efficient hydraulic fluids in the NSF funded multi-university Center for Compact and Efficient Fluid Power.



Dr. John Pakkala is an assistant professor of mechanical engineering at MSOE. For over twenty years, he served as principal mechanical designer and engineering manager for a variety of machine design and manufacturing projects for the automotive, defense and aerospace industries. He was awarded the General Motors Foundation Doctoral Dissertation Fellowship in electrical engineering at Michigan Technological University. Pakkala currently referees submittals for the *Journal of Measurement Science and Technology* and *Control and Intelligent Systems*. He is advisor to graduate and undergraduate students in the areas of engine controls, hydraulic valve design and machine design.



Thomas Wanke, C.F.P.E., is the director of MSOE's Fluid Power Institute™, America's leader in fluid power technology research and education. He has more than 35 years of experience in fluid power technology, 30 of which have been at MSOE. Wanke has a bachelor's degree in mechanical engineering technology and a master's degree in engineering with a fluid power specialty option, both from MSOE. He has worked on projects in the following areas: component and system design; development and evaluation; field troubleshooting and failure analysis; and fluids, filtration and contamination control. Wanke is a member of SAE and FPS. He serves on several NFPA and ISO standards committees and is chairman of the Testing Technology Committee.



To speak with a seminar instructor call (414) 277-7269.

SEMINAR INFORMATION

How to Register

MSOE offers four convenient ways to register: mail, phone, fax or Web site. To ensure maximum seminar quality, enrollment is limited. Please note the discount applicable for registering early and for multiple registrations from the same company. Advance registration is required and may be accomplished by:

Mail Registration Form and Seminar Fee to:

Applied Technology Center™
Milwaukee School of Engineering
1025 North Broadway
Milwaukee, WI 53202-3109

Phone

(414) 277-2492 or (800) 332-6763 x2492

Fax

Attn: Professional Education Office
Fax: (414) 277-7470

Web

www.msoe.edu/seminars

What the Seminar Fees Include

The seminar fees include a customized seminar manual and/or textbooks, handout materials, daily continental breakfast, break refreshments and dinner/lunch reception.

Specific Location and Parking

The Applied Technology Center - Professional Education Office is located in Room S-140 in the Allen-Bradley Hall of Science, 432 E. Kilbourn Avenue. Access the building from State Street side.

Upon receipt of your registration, you will be mailed a confirmation letter with specific location information. Parking is available on campus in the MSOE Milwaukee Street Lot A on the northwest corner of State and Milwaukee Streets (see map on last page).

Cancellation Policy

MSOE reserves the right to cancel a seminar if minimum enrollment is not met. Please be informed that payment is due two weeks before the seminar, by credit card or by check. If payment is not received by the due date, your registration is not guaranteed. Cancellations before payment due date will be fully refunded. Cancellations after payment due date will be charged a \$200 cancellation fee. Substitutions of participants may be made prior to the start of the program.

Payment

Payment may be made via check (payable to MSOE), MasterCard, VISA or by forwarding a purchase order, from which MSOE will invoice. A discount is applicable for each registrant if two or more individuals from the same company register at the same time or for early registration.

Continuing Education Unit

A certificate of participation will be awarded documenting the number of continuing education units (CEUs) earned for participating in the seminar. One CEU is awarded for 10 contact hours. The CEU is a nationally recognized standard unit of measurement awarded for participation in a continuing education experience under responsible sponsorship, capable direction and qualified instruction.

What to Wear

Dress casual and comfortable. Look up Milwaukee weather forecast to plan your trip. www.weather.com, zip code 53202.

What to Bring

Scientific Calculator

Welcome

MSOE has offered courses in fluid power and motion control to industry professionals for several decades. As you contemplate taking a short course at MSOE, talk to your senior colleagues and most likely you will find that they have taken a course or two at MSOE over the years. MSOE's academic programs and strong applied research experience provides the basis for excellence and independence. Advanced fluid power research in the United States is being conducted through the National Science Foundation (NSF) and fluid power industry-sponsored Engineering Research Center for Compact and Efficient Fluid Power, led by a consortium of universities. MSOE is a member of this consortium. Learn more about it online at www.fperc.org.

Help others learn about these unique seminars at MSOE. I look forward to having you visit the exciting, expanded MSOE campus.

Tom Bray
Dean of Applied Research



Tom Bray
Dean of Applied
Research



Medhat Khalil
Director of
Professional
Education

Questions

Phone: (414) 277-2492 • **Fax:** (414) 277-7470 • **E-mail:** learn@msoe.edu • **Web site:** www.msoe.edu/seminars

REGISTRATION FORM

Date _____

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Milwaukee School of Engineering
1025 North Broadway
Milwaukee, WI 53202-3109

Phone: (414) 277-2492
Fax: (414) 277-7470
E-mail: learn@msos.edu

Please enroll the individual(s) listed below in:

Fee:

- Introduction to Hydraulics**
 March 16-20, 2009 June 15-19, 2009 Oct. 5-9, 2009 _____
- Introduction to Hydraulic Systems - Texas**
 Dec. 1-4, 2009 _____
- Hydraulic Specialist Certification Review**
 Feb. 9-12, 2009 _____
- Hydraulic Fluids and Contamination Control**
 April 20-22, 2009 _____
- Hydraulic System Maintenance, Troubleshooting and Failure Analysis**
 April 23-24, 2009 _____
 Total for both sessions taken together _____
- Introduction to Hydraulic Systems Modeling and Simulation**
 July 6-9, 2009 _____
- Control Strategies for Dynamic Systems: Analog (if taken alone)**
 Aug. 17-18, 2009 _____
- Control Strategies for Dynamic Systems: Digital and Mechatronics (if taken alone)**
 Aug. 19-21, 2009 _____
 Total for both sessions taken together _____
- Magnetic Actuators and Sensors**
 TBD (For dates please contact Medhat Khalil at (414) 277-7269 or khalil@msos.edu) _____

1. _____
Name (Dr./Mr./Mrs./Ms.)

_____ Title _____ E-mail _____

2. _____
Name (Dr./Mr./Mrs./Ms.)

_____ Title _____ E-mail _____

_____ Company

_____ Company address

_____ City/State/Zip

(_____) _____ (_____) _____

_____ Company telephone _____ Fax _____

Seminar fee(s) of _____ are enclosed. (Make check payable to "MSOE")

Company purchase order enclosed. Please invoice accordingly. PO# _____

Charge seminar fee(s) of \$ _____ to MasterCard VISA

Account number _____ Expiration date _____

Signature

Register early or enroll multiple registrants for discounted fees. (Additional registration form on back. For more participants or future registrations, please make copies.)



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1. _____
Name (Dr./Mr./Mrs./Ms.)

_____ Title _____ E-mail

2. _____
Name (Dr./Mr./Mrs./Ms.)

_____ Title _____ E-mail

_____ Company

_____ Company address

_____ City/State/Zip

(_____) _____ (_____) _____
Company telephone Fax

Seminar fee(s) of _____ are enclosed. (Make check payable to "MSOE")

Company purchase order enclosed. Please invoice accordingly. PO# _____

Charge seminar fee(s) of \$ _____ to MasterCard VISA

Account number _____ Expiration date _____

Signature

Register early or enroll multiple registrants for discounted fees. (Additional registration form on back. For more participants or future registrations, please make copies.)



DIRECTIONS TO MSOE

Air Travel to Milwaukee

Contact your travel agent and ask about direct flights to Milwaukee on Midwest Airlines from most major cities or visit www.midwestairlines.com to book your own flight. From Mitchell International Airport (Airport Code: MKE), it is a 15-minute taxi ride to downtown Milwaukee.

Driving Directions to MSOE

From the north

Take I-43 south to downtown Milwaukee. Then take Hwy 145 east/McKinley Avenue exit (exit # 73 A). Turn left (east) on McKinley; proceed for six blocks. Turn right on Broadway to the specific building or parking lot on campus.

From the south

Take I-94 west to downtown Milwaukee. Then take Hwy 145 east/McKinley Avenue exit (exit # 73 A). Proceed on McKinley for six blocks. Turn right on Broadway to the specific building or parking lot on campus.

From the west

Take I-94 east to downtown Milwaukee; then take I-794; exit Jackson/Van Buren (exit # 1 E). Proceed north on Van Buren Street seven blocks to State Street; turn left. Follow State Street to the specific building or parking lot on campus.

Look for signs at parking lot entrances for a campus map.

Exciting Metropolitan Setting

Milwaukee is one of the largest cities in the country with a metropolitan population of approximately 1.7 million residents, yet maintains the intimacy of a smaller community. MSOE's 15-acre campus, located in historic East Town, a vibrant downtown community, is just blocks from beautiful Lake Michigan, the theater district, museums, sports and music venues, parks and shopping. The city also stages more than 50 major festivals and other public gatherings annually.

Where to Stay

We recommend the following hotels within a ten-minute walking distance to the seminar location. Mention MSOE when making reservations to receive a reduced rate. These hotels are served by airport shuttles from Milwaukee's Mitchell International Airport.

Hyatt Regency Milwaukee

(414) 276-1234
(800) 233-1234
333 W. Kilbourn Ave.
\$109 plus tax per night
www.hyatt.com/hyatt/index.jsp

Intercontinental Milwaukee

(888) 424-6835 or (414) 276-8686
139 E. Kilbourn Ave.
www.intercontinental.com

More information,
visit: www.msoe.edu/seminars



Map Key

APC-Alumni Partnership Center
CC-Student Life & Campus Center
(Cudahy Student Center)
E-Fred Look Engineering Center

G-Grohmann Museum
H-Humphrey House
K-Kern Center
KH-Krueger Hall
L-Walter Schroeder Library
MLH-Margaret Look Residence Hall

R-Rosenberg Hall
RH-Regents Residence Hall
RWJ-Roy W. Johnson Residence Hall
S-Allen-Bradley Hall of Science
W-Todd Wehr Conference Center

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