

Maha Intensive Course on HYDROSTATIC PUMPS AND MOTORS

Contact Information

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How to Register

Please reach out to any of the above contact persons for the registration link and discount code if applicable.

Dates

Aug 3rd – 7th, 2026

Monday – Thursday whole days and **Friday** morning.

Target audience

This course is designed for industry professionals who have

- Engineering degrees or equivalent
- Basic understanding of the positive displacement machine principle

Course Description

This intensive five-day course is designed for Maha industrial members with an engineering background. It focuses on the design and optimization of positive displacement pumps and motors, a topic of strong interest to Maha's industrial partners. Participants will build core knowledge and practical skills in hydrostatic machines, including:

- a) The essential physics behind hydraulic machine operation and performance.
- b) The operating principles of common hydrostatic pump and motor types.
- c) A detailed study of piston and gear machines.
- d) An introduction to computer simulation for design and optimization.
- e) Hands on pump performance measurement, including efficiency and flow ripple.
- f) Hands on development of a MATLAB based lumped parameter model, including practical use of AI for model development.

The course combines lectures, in-class exercises, and hands-on laboratory sessions to provide a well-rounded learning experience. Participants will develop practical skills through numerical simulations using industry standard software such as MATLAB and Simerics MP+, along with Maha's in-house Multics platform. A distinctive feature of the course is hands on pump noise measurement. All software and lab use during the course are included at no additional cost.

Participants who complete the course will receive a Maha course completion certificate on the final day.

Learning Objectives

By the end of this course, participants will be able to:

1. **Analyze** the operating principles, strengths, and limitations of common hydrostatic pumps and motors.
2. **Explain** the kinematics and dynamics of axial piston and gear machines.
3. **Identify** major sources of power loss in hydrostatic machines and describe their analytical expressions based on appropriate assumptions.
4. **Conduct** hydrostatic pump performance measurements.
5. **Experience** advanced simulation tools for hydrostatic machines.
6. **Develop** a MATLAB based pump lumped parameter model for fluid dynamics.

Online Option

Although in-person participation at Purdue University offers the best learning experience, we introduced an online option for those with travel constraints.

The online option includes live lecture sessions from Monday through Friday mornings, and a daily assessment completed asynchronously. Online participants will not be able to attend the afternoon lab sessions.

Tentative Schedule

The table below provides the schedule for the minicourse, which will occur from Monday to Thursday and Friday morning.

Day	Topic
Monday Lecture	Refresh the working principle of the positive displacement machine <ul style="list-style-type: none"> • Displacement volume • Theoretical flow rate and torque of pumps and motors • Volumetric, hydromechanical, and total efficiency of pumps and motors • Steady-state measurement of hydrostatic pumps and motors Overview of different types of pumps and motors and their working principle (Part 1)

	<ul style="list-style-type: none"> • Overview of the characteristics and common application of different types of hydrostatic machines <ul style="list-style-type: none"> ○ Piston types – axial and radial ○ Gear types – external and internal • Working principle and application of the above-mentioned common types of positive displacement machine
<p>Monday Lab</p>	<p>Hydrostatic machine noise test</p> <ul style="list-style-type: none"> • Introduction to the hydraulic circuit and DAQ system • Conduct noise test • Interpolate the measurement results <p>Lab tour</p>
<p>Tuesday Lecture</p>	<p>Overview of different types of pumps and motors and their working principle (Part 2)</p> <ul style="list-style-type: none"> • Overview of the characteristics and common application of different types of hydrostatic machines <ul style="list-style-type: none"> ○ Gerotor ○ Vane ○ Screw • Working principle and application of the above-mentioned common types of positive displacement machine <p>Definition of common fluid properties</p> <ul style="list-style-type: none"> • Viscosity • Bulk modulus • Density <p>Laminar flow in gap analytical calculations</p> <ul style="list-style-type: none"> • Calculation of viscous friction between two parallel surfaces • Friction (viscous stress) on the surface and leakage flow • How to reduce (balance) friction and leakage in lubricating gaps <p>Compressibility of the fluid and its effects on pumps and motors' performance</p> <ul style="list-style-type: none"> • P-V diagram considering compressible fluid • Calculation of the volumetric flow rate considering compressibility • Compression loss • Common way to mitigate the challenge due to compressibility
<p>Tuesday Lab</p>	<p>Lumped parameter model:</p> <ul style="list-style-type: none"> • Introduction to lumped parameter model and ODE solver • Model architecture, assumptions, and core physics

	<ul style="list-style-type: none"> • Based coding skills in MATLAB, useful functions • Development of an axial piston pump fluid dynamics lumped parameter model
Wednesday Lecture	<p>Piston machine kinematics and dynamics</p> <ul style="list-style-type: none"> • Piston stroke and velocity • Pressure and flow in a single displacement chamber • Kinematic flow ripple • Swashplate forces and moments • Piston forces and moments (piston free body diagram) • Cylinder block forces and moments (cylinder block free body diagram) <p>Cavitation and Aeration</p> <ul style="list-style-type: none"> • Density/pressure relationship considering static cavitation • Impact of cavitation in pumps and motors
Wednesday Lab	<p>Lubricating Interface model:</p> <ul style="list-style-type: none"> • Introduction to Multics • Numerical simulation of piston/cylinder lubricating interface • Visualization of simulation results • Post-process of the power loss distribution in hydrostatic machines
Thursday Lecture	<p>Piston machine design parameters and their associated performance impact</p> <ul style="list-style-type: none"> • Piston/cylinder interface friction and leakage calculation • Cylinder block/valve plate interface friction and leakage calculation • Slipper/swashplate interface friction and leakage calculation <p>Piston machine common designs</p> <ul style="list-style-type: none"> • Common design part A: valve plate groove, filled/hollow piston, offset and gamma angle • Common design part B: male/female piston, piston groove, multi-land slipper, step slipper vs orifice, spherical cylinder block, cylinder block balance land, slipperless design <p>Gear machine kinematics and dynamics</p> <ul style="list-style-type: none"> • Involute gear profile (external and internal) • Gerotor gear profile • Definition of the displacement and the displacement volume over time (external, internal, and gerotor) • Leakage paths in gear machines (external, internal, and gerotor) • Kinematic flow ripple (external, internal, and gerotor) • Forces and moments on driving gear and driven gear (external)

	<ul style="list-style-type: none"> • Forces and moments on journal bearing bushing (external) <p>Gear machine design parameters and their associated performance impact</p> <ul style="list-style-type: none"> • Number of gears • Width of gears • Gear geometry • Meshing groove and high-speed groove <p>Gear machine common designs</p> <ul style="list-style-type: none"> • Journal bearing bushing/balance plate • Consideration of gear motors
<p>Thursday Lab</p>	<p>CFD simulation:</p> <ul style="list-style-type: none"> • Creating mesh of an existing piston pump geometry • Conduct CFD simulation and interpolate convergence criteria • Conduct CFD simulation at multiple operating points and map the performance curve <p>Visualizing simulation result (pressure distribution, flow velocity, gas fraction ...)</p>
<p>Friday Lecture</p>	<p>Swashplate control system</p> <ul style="list-style-type: none"> • Schematics of a displacement control system • Schematics of a pressure compensation system <p>Discussion of hydrodynamic effects and deformation effects on pump performance</p> <ul style="list-style-type: none"> • Definition and challenge of EHL • Pressure distribution of a sliding bearing • Pressure distribution of a journal bearing • Demonstrate a Multics simulation result of journal bearing with and without elastic deformation • Demonstrate the deformation magnitude of critical components in piston pumps and gear machines using Multics <p>Discussion of thermal effects on pump performance</p> <ul style="list-style-type: none"> • Concept of T-EHL • Demonstrate Multics simulation result with and without consideration of fluid domain heat transfer (piston pump) • Demonstrate the thermal deformation magnitude (piston pump)

Attendance

The minicourse will open to in-person participants (priority) at Purdue University and online participants. Number of participants is limited to the classroom/lab capacity.

Cost

Free registration for:

- 1 participant from Maha Fluid Power Research Center Basic Members
- 3 participants from Maha Fluid Power Research Center Executive Members

\$1,500 / additional participants from members (*)

\$3,500 / participant for non-members (*)

(*) registration priority goes to members benefitting from free registration as detailed above

Registration includes all course material (book is not included), lunches, and coffee breaks.

No dinner/hotel accommodation provided.