Mechanized Systems Management 412/812
Hydraulic Power Systems
Spring 2022

COURSE OUTLINE

Description:
MSYM 412/812 Hydraulic Power Systems (3 cr)
Prerequisite: MSYM 245

This course deals with the theory and application of fluids under controlled pressure to perform work in mobile and industrial applications. Positive displacement (PD) pumps, linear and rotary hydraulic actuators (hydraulic cylinders and motors), valves, and electric over hydraulic systems will be studied in detail. Fluid power circuit development on both hydraulic benches and computer simulated environments will be performed with emphasis on circuit analysis, and system troubleshooting.

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Course level learning goals

1. Solve quantitative problems associated with the transmission of power through the medium of a confined liquid.
2. Compare the principle types of positive displacement (PD) hydraulic pumps by identifying their internal components, operational characteristics and applications.
3. Explain the working principles of hydraulic actuators (linear and rotary) operation as they convert hydraulic energy into mechanical energy and motion.
4. Compare the functions of various types of valves in the control of hydraulic systems and explain the working of electric-over hydraulic systems.
5. Interpret standard hydraulic symbols and functionally plan hydraulic circuits based on load types and their effects on circuit behavior.

Topic related learning goals:

1. Solve quantitative problems associated with the transmission of power through the medium of a confined liquid.
    - Use mathematical equations to describe the behavior and working of hydraulic components (E.g., pumps, cylinders, motors and valves)
    - Apply pascal's laws to calculate force amplification in confined liquids
    - Demonstrate the ability to determine the displacement, velocity, work, and power generated by a hydraulic actuator.
2. Compare the principal types of positive displacement (PD) hydraulic pumps by identifying their internal components, operational characteristics and applications.
    - Distinguish between the gear, vane, and axial-piston PD pumps by comparing their internal working components
    - Demonstrate the ability to determine theoretical flow rate, actual flow rate, theoretical pump power output, and actual power output of PD pumps based on the volumetric displacement and operating pressures of the pumps
    - Create PD pump efficiency (e.g., mechanical efficiency, volumetric efficiency and overall efficiency) charts based on pump input mechanical power, speed and the actual pump output power.
    - Size a PD pump for serving the requirements of a load moved by hydraulic cylinders and motors.

3. Explain the principles of hydraulic actuators (linear and rotary) operation as they convert hydraulic energy into mechanical energy and motion.
    - Demonstrate the ability to determine the load magnitude and speed of hydraulic cylinders based on pump flowrate and operation pressure of the system.
    - Distinguish the performance characteristics (e.g., speed, load, and HP) of hydraulic cylinders in extension stroke and retraction stroke of a double acting cylinder.
    - Compare and explain the functional differences between the single acting, double acting, double-rod and telescopic cylinders.
    - Distinguish between the gear, vane, and axial-piston hydraulic motors by comparing their internal working components.
    - Demonstrate the ability to determine theoretical flow rate and actual flow rate required to operate a hydraulic motor at a required speed, theoretical mechanical power output, and actual power output of based on the volumetric displacement and operating pressures of the motors.
    - Explain the working of the hydrostatic transmissions (HST) and the ability to calculate the overall efficiency of the HST system.

4. Compare the functions of the various types of valves in the control of hydraulic systems and explain the working of electric-over hydraulic systems.
    - Explain the working of pressure, flow, and directional control valves
    - Differentiate between cracking and full pump flow pressure of pressure relief valves.
    - Demonstrate the ability to identify standard hydraulic valve symbols based on the number of ports, and actuated positions of valves.
    - Explain the working of electric-over hydraulic valves and demonstrate the ability of these valves to interface with programmable logic controllers for automated applications.

5. Interpret standard hydraulic symbols and develop hydraulic circuits using circuit diagrams and simulation software (e.g., Automation Studio).
    - Identify standardized hydraulic symbols in hydraulic power circuits and explain their functionality.
    - Develop and create functional hydraulic circuits on Amatrol hydraulic benches.
    - Develop and create functional hydraulic circuits using Automation Studio simulation software.
    - Compare theoretical calculated hydraulic flow and pressure measurements in circuits to the simulated hydraulic circuit measurements.
    - Interface hydraulic circuits with programmable logic control circuits.

Methods:

The primary instructional method to be used in this course will be lecture, interspersed with student reports and small group activities and projects. A complete two hour laboratory period will be used during the semester to study components, demonstrate circuits, and troubleshoot a machine system. The remaining laboratory periods will be used to present circuit reports, solve application problems and review literature.

Students taking this course for graduate credit will be expected to demonstrate a more thorough understanding of the technical content. Additionally, they will be expected to communicate this comprehension in a more organized, systematic, and thorough manner in the form of a course project.

References:

- Esposito, A. 2009**. Fluid Power with Applications. 7th Edition,** Pearson Prentice Hall, Upper Saddle River, New Jersey 0748
- Cundiff, J.S., 2001, Fluid Power Circuits and Control, CRC Press.

Laboratory Manual:
Schinstock, J. L. 2005. *Hydraulic Power Systems Manual,* Department of Biological Systems Engineering, University of Nebraska-Lincoln, Lincoln, NE (will be provided).

Grading System:

1. Grading Outline
   a. Homework Problems (One per week) (20% of the grade)
      - Late Homework will be penalized.
   b. 2 Exams during the semester and 1 Final (55% of the grade)
   c. Laboratory Reports (15% of the grade)
   d. Class Participation (10% of the grade)

2. Letter Grade:

A+, A, A-	90%
B+, B, B-	80%
C+, C, C-	70%
D+, D, D-	60%

Attendance Policy:

Changes to the class schedule or assignments will be announced in class. Each student is responsible for everything discussed in class. Attendance will not normally be taken; however, excessive absences will adversely affect the class participation portion of your grade.

Tentative Topics (subject to change)

Topics
Introduction to Fluid Power Introduction to Fluid Power **Lab1 -** Equipment Familiarization/Diagrams
Physical Properties of Hydraulic fluids Energy and Power in Hydraulic systems **Lab2 -** Flow Generation & Aeration/Cavitation
Energy and Power in Hydraulic systems **Lab 3 -** Pressure, Force, Work and Power
Hydraulic Pumps Hydraulic Pumps **Lab 4 -** Hydraulic Pumps
Hydraulic Pumps Hydraulic Pumps **Lab 5** – Hydraulic Pumps
Exam I Hydraulic Cylinders **Lab 6 -** Hydraulic Cylinders
Hydraulic Cylinders Hydraulic Motors **Lab 7 –** Hydraulic Motors
Hydraulic Motors Hydraulic Motors **Lab 8 -** Hydraulic Motors
Hydraulic Valves – Pressure Control Hydraulic Valves – Pressure Control **Lab 9** – Pressure Control Valves
Hydraulic Valves – Flow Control Hydraulic Valves – Flow Control **Lab 10** – Types of Flow Control Valves

Hydraulic Valves Hydraulic Valves **Lab11** – Directional Control Valves
Hydraulic Valves Hydraulic Valves Hands on Activity/ Circuit Simulation
Hydraulic Circuit Design and Analysis – Automation Studio (Recorded Software Video Demo) Hydraulic Circuit Design and Analysis – Automation Studio Hands on Activity/Circuit Simulation

COVID Face Covering Policy:

- An individual in this course has a documented need for face coverings to be required in this course. Without divulging personal or identifying information, such a documented need might be that a member of their household is unable to be vaccinated or has a health condition that makes vaccines less effective for them. As a result, the College of Agricultural Sciences and Natural Resources has determined that face coverings will be required in this course. If you are unwilling to comply with this requirement, please visit with your advisor about different sections or possible alternative courses that you might take in lieu of this one.
- Students in this course must work in close physical proximity to one another for extended periods of time in order to achieve the academic goals of the course. For this reason, the Department of Biological Systems Engineering and the College of Agricultural Sciences and Natural Resources have determined that face coverings will be required in this course. If you are unwilling to comply with this requirement, please visit with your advisor about possible alternative courses that you might take in lieu of this one.

Academic Dishonesty:

Students are expected to adhere to guidelines concerning academic dishonesty outlined in Section 4.2 of the University's Student Code of Conduct (http://stuafs.unl.edu/DeanofStudents/Student%20Code%20of%20Conduct%20May%20Rev%202014%20a.pdf). The BSE Department process for grade and academic dishonesty appeals can be found at http://bse.unl.edu/academicadvising-index. Students are encouraged to contact the instructor for clarification of these guidelines if they have questions or concerns.

Mobile Devices:

Cellular phones must be silenced and not used/consulted while in the classroom/laboratory.

- **Fire Alarm (or other evacuation):** In the event of a fire alarm: Gather belongings (Purse, keys, cellphone, N-Card, etc.) and use the nearest exit to leave the building. Do not use the elevators. After exiting notify emergency personnel of the location of persons unable to exit the building. Do not return to building unless told to do so by emergency personnel.
- **Tornado Warning:** When sirens sound, move to the lowest interior area of building or designated shelter**.** Stay away from windows and stay near an inside wall when possible.
- **Active Shooter**
    - **Evacuate:** if there is a safe escape path, leave belongings behind, keep hands visible and follow police officer instructions.
    - is impossible secure yourself in your space by turning out lights, closing blinds and barricading doors if possible.
    - **Take action**: As a last resort, and only when your life is in imminent danger, attempt to disrupt and/or incapacitate the active **Hide out:** If evacuation shooter.
- **UNL Alert:** Notifications about serious incidents on campus are sent via text message, email, unl.edu website, and social media. For more information go to: http://unlalert.unl.edu.

- Additional Emergency Procedures can be found here: http://emergency.unl.edu/doc/Emergency_Procedures_Quicklist.pdf

Students with Special Needs

- Students with disabilities are encouraged to contact the instructor for a confidential discussion of their individual needs for academic accommodation. It is the policy of the University of Nebraska-Lincoln to provide flexible and individualized accommodation to students with documented disabilities that may affect their ability to fully participate in course activities or to meet course requirements. To receive accommodation services, students must be registered with the Services for Students with Disabilities (SSD) office, 132 Canfield Administration, 472-3787 voice or TTY.

Additional useful information can be found here:

http://casnr.unl.edu/pictures/PDFs/Faculty/Syllabus%20Information%202016.pdf