

**Department of Electrical and Computer Engineering
University of Waterloo**

**ECE 6618 PD – Medium and High Voltage Power Cables
Course Outline – Winter 2023**

Course Instructor: Prof. Shesha Jayaram

[REDACTED]
jayaram@uwaterloo.ca

Teaching Assistant: TBA

Course Content

Introduction: Vast urbanization and increasing pressure to meet high demand in power delivery and the use of renewable energy sources, have resulted in a significant growth in underground cable networks. In addition, underground cables being a critical asset group, any outages due to their failure will result in considerable service delivery and economic impact on the operation of power networks.

Objectives:

- Understand the basic dielectric theory, material properties and design details of underground cables and their accessories.
- Understand typical failure modes and their early detection of underground cables and their accessories.
- Understand the current carrying capacity considering the type of electrical insulation, and temperature distributions.
- Understand the steps involved in cable installations: pulling tension, bending and jamming effects, and bonding.
- Discuss in detail various laboratory and field tests (off-line and on-line) applicable to underground cables.

A detailed course outline is given in the Table below.

Course Evaluation:

- Assignments¹ — 30%
- Term Paper² — 40%
- Final Exam³ — 30%

¹ Questions including numerical examples will be assigned at the end of each major topic. In addition, you will be asked to read and evaluate a few selected research papers*.

² Each of you need to choose a topic to study about cable systems that reflects the contents of this course materials. Guidelines related to project topics, work and report will be posted at a later date.

³ It is an “open” book exam. You can have access to the Reference Materials that may be helpful for the final exam, in electronic or in printed format or in both formats.

** Most of these materials will be posted on UW LEARN*

Requisites:

A general background in power system components and distribution networks is essential. Knowledge of the course material from ECE 6608PD is an asset. But lecture 7 will cover the required topics on **conduction and breakdown mechanisms related to solid dielectrics that** is essential for understanding the aging, degradation, and failure mechanisms of power cables in service.

Course Content

Lectures	Topics	Description
1-2	Materials, Design and Manufacturing	<ul style="list-style-type: none"> • Design principles and standards • Types of cables • Paper/Oil insulated cables • Extruded polymeric cables • Conductors, • Shielding, sheaths, jackets and armors
3	Accessories	<ul style="list-style-type: none"> • Cables joints, straight joints, transition joints • Cable terminations; polymeric, ceramic • Heat shrink and cold shrink • Electric field distribution and stress grading
4	Installation	<ul style="list-style-type: none"> • Installations process • Direct buried, ducts, troughs and tunnels • Cable pulling issues • Thermo-mechanical forces • Soil thermal resistivity and temperature gradients
5-6	System Design	<ul style="list-style-type: none"> • Ampacity, electric field, eddy currents, conductor resistance. • Cable ratings and calculations • Thermal limits, standards, and practical considerations • Sheath bonding • Heat dissipation • Cable system impedance for system studies • Magnetic field considerations
7	Breakdown Mechanisms	<ul style="list-style-type: none"> • Breakdown theories; Townsend and Streamer mechanisms • Corona discharges • Breakdown in solid dielectrics • Internal and surface discharges • Failure mechanisms
8-9	Aging	<ul style="list-style-type: none"> • Defects, high fields, • Practical aging mechanisms • Partial discharges • Treeing; electrical trees, their growth • Water treeing; vented trees and bow-tie trees
10-11	Testing and Diagnostic	<ul style="list-style-type: none"> • Standards • Classical and modern diagnostic techniques • Dissipation factor, dielectric constant (permittivity), partial discharges • Laboratory and field testing • Acceptance/commissioning and maintenance testing • Low frequency testing
12	Asset Management	<ul style="list-style-type: none"> • Loading schedules, standards, and health index • Maintenance plans • Specification on cable procurement • Condition assessment/ranking

Recommended Reference Book

Electrical Power Cable Engineering, Editor: William A. Thue, ISBN: 978-0-8247-4303-1 (hardback) 978-0-203-97061-4 (electronic), June 2005. **Access to this book in electronic version is available from the University of Waterloo Library.** Link will be posted on UW-LEARN.

Other References:

During the course of presentation, several papers and sections of books/reports will be suggested as **Reference Materials**; and these materials will be posted on UW-LEARN.