CAMOSUN COLLEGE

Trades and Technology

ELECTRONICS & COMPUTER ENGINEERING DEPARTMENT

ELEN 148
ELECTRIC MACHINES and CONTROL SYSTEMS

Summer 2020

COURSE OUTLINE

CREDIT:	6
IN-CLASS WORKLOAD:	6 hours lecture, 2.5 hours lab
OUT-OF-CLASS WORKLOAD:	7 hours
PREREQUISITES:	ELEN 144 ELEN 142

1. INSTRUCTOR INFORMATION

(a) Instructor	Dr. Mozhgan Moazzen Zadeh-Bacon		
(b) Office hours	Email for an appointment		
(c) Location	TEC 206		
(d) Phone	250 370 4623	**Alternative:**	
(e) E-mail	BaconM@camosun.bc.ca		
(f) Website	online.camosun.bc.ca		

2. INTENDED LEARNING OUTCOMES

This course initially covers Electrical fundamentals, transformers, DC motors and generators, single and polyphase motors, alternators and systems. Part 2 of this course continues with open- and closed-loop industrial control systems. Topics include synchros and servomechanisms; semi-conductor based power control systems and process control.

3. REQUIRED MATERIALS

- Access to D2L (Course Notes, Labs, Assignments, Quizzes, Tests)
- **Electrical Machines, and Power Systems**, Theodore Wildi - Sixth Edition
- **Industrial Electronics,** Humphries & Sheets

4. COURSE CONTENT

1. Review of basic electrical concepts including DC, Single and Three-Phase AC.
   - 1.1. Electric machine applications
   - 1.2. role of electrical systems in marine and industrial technology energy systems
   - 1.3. WYE-DELTA and DELTA-WYE systems
   - 1.4. Phase sequence
   - 1.5. Electro-Magnetism Introduction
     - 1.5.1. concepts of electro-magnetism

1.5.2. Relationship between electricity and magnetism
1.5.3. Fundamental laws and equation of electromagnetic systems
1.5.4. Properties of magnetic materials
1.5.5. Range of parameters in electromagnetic systems

2. DC Generator Characteristics
   2.1. Induced voltages in series
   2.2. Commutation
   2.3. Dynamo construction
   2.4. Induced voltages, magnetization curve and the build-up process
   2.5. Shunt generator characteristics
   2.6. Compound generator characteristics
   2.7. Effects of armature reaction
   2.8. Commutation
   2.9. Shunt generators in parallel
   2.10. Compound generators in parallel
   2.11. Equalizer connections

3. Direct Current Motors
   3.1. Force on a conductor-magnitude and direction
   3.2. Generation of torque
   3.3. Counter EMF
   3.4. Power conversion
   3.5. Motor speed characteristics
   3.6. Effects of armature reaction
   3.7. Shunt motor characteristics
   3.8. Series motor characteristics
   3.9. Compound motor characteristics

4. Dynamo Efficiency
   4.1. Dynamo losses - copper, stray power and stray load
   4.2. Determining the stay-power losses
   4.3. Method of duplicating flux and speed
   4.4. Dynamo efficiency

5. Single Phase Transformers
   5.1. Transformer fundamentals
   5.2. No-load voltage relations
   5.3. Effects of frequency and flux
   5.4. No-load phasor diagram
   5.5. Current relations
   5.6. Phasor diagram with load
   5.7. Equivalent transformer circuit
   5.8. Full-load phasor diagram
   5.9. Transformer regulation
   5.10. Transformer efficiency
   5.11. Transformer ratings
   5.12. Transformer construction
   5.13. Polarity and markings
   5.14. Single phase transformer connections
   5.15. Auto transformers
   5.16. Instrument transformers

6. Polyphase Transformer Connections
   6.1. The Y-Y transformation
   6.2. The Δ-Δ transformation
   6.3. The Y-Δ transformation
   6.4. The Δ-Y transformation
   6.5. The open Δ connection
   6.6. Polyphase transformer construction

7. Polyphase Induction Motor
    - 7.1. Construction
    - 7.2. Rotating magnetic field - principles, direction and speed
    - 7.3. Torque at standstill
    - 7.4. Slip
    - 7.5. Rotor EMF, frequency and current
    - 7.6. Running torque, maximum torque
    - 7.7. Description of operation
    - 7.8. Wound rotor induction motor characteristics
    - 7.9. Current and power factor
    - 7.10. Losses and efficiency (theory)
    - 7.11. Selection and operating characteristics of polyphase induction motors

8. Alternators (Synchronous Generator)
    - 8.1. Construction
    - 8.2. Frequency of output waveform
    - 8.3. Field construction and excitation
    - 8.4. Generated EMF
    - 8.5. Alternator characteristics
    - 8.6. Armature reaction
    - 8.7. Alternator regulation
    - 8.8. Alternator efficiency
    - 8.9. Alternator ratings
    - 8.10. Voltage regulators

9. Parallel Operation of Alternators
    - 9.1. General introduction
    - 9.2. Requirements for parallel operations
    - 9.3. Synchronizing procedure
    - 9.4. Variation of field current of alternators in parallel
    - 9.5. Dividing load of parallel alternators
    - 9.6. Hunting

10. Polyphase Synchronous Motor
    - 10.1. Construction
    - 10.2. Principles of operation
    - 10.3. Methods of starting a synchronous motor
    - 10.4. Effect of load
    - 10.5. Variation of field current
    - 10.6. V curves
    - 10.7. Motor ratings and speed control
    - 10.8. Power factor correction

11. Single Phase Motors
    - 11.1. Direct current motors operated on alternating current
    - 11.2. Universal motor characteristics
    - 11.3. Single phase induction motor-cross field theory
    - 11.4. Split-phase induction motor characteristics
    - 11.5. Capacitor-start motor characteristics
    - 11.6. Permanent-split capacitor motor
    - 11.7. Two-valve capacitor motor

TOPICS PART 2:

1 Introduction to control
    - 1.1 Definition of control
    - 1.2 Control circuit development
    - 1.3 Control devices and application
    - 1.4 Plugging - zero speed controls

2 3ϕ ac motor starters and controllers
- 2.1 Across line starters
- 2.2 Resistive and reactor starters
- 2.3 Wye - delta starters
- 2.4 Auto-transformer starters
- 2.5 Closed and open transition
- 2.6 Braking
- 2.7 Starters

3 3ϕ variable speed motor drives
- 3.1 Theory of operation
- 3.2 Circuit analysis

4 Adjustable-speed D.C. drives
- 4.1 Theory of operation
- 4.2 Circuit analysis
- 4.3 Tachometer feedback
- 4.4 Regenerative braking

5 Automated control systems
- 5.1 Automatic control characteristics
  - 5.1.1 Load, lag, stability
- 5.2 Requirements
  - 5.2.1 Stability, accuracy, response
- 5.3 Types of control
  - 5.3.1 Open loop, closed loop
- 5.4 Basic control modes
  - 5.4.1 On-off, proportional, proportional plus integral, proportional plus derivative

6 Final control elements
- 6.1 Brushless DC (BLDC) Motors
- 6.2 Stepper motors
- 6.3 Switched Reluctance Motors
- 6.4 Pneumatic Control valves
- 6.5 Servo motor and amplifiers
- 6.6 Synchronous devices

LAB EXERCISES:

Various lab exercises will be performed to practice and reinforce the lecture material.

Holidays:

- Mon-May 18 - Victoria Day - College closed (Week 3)
- Wed-July 1 – Canada Day - College Closed (Week 9)
- Mon-August 3 - British Columbia Day, College closed (Week 14)

5. STUDENT ASSESSMENT (WEIGHTING)

Assignments	10%
Quizzes	10%
Mid-Term	20%
Final Exam	40%
Total theory	**80%**
Laboratory Evaluation	20%
Total	**100%**

*Students must achieve a passing grade in both the theory and lab portions of the course in order to pass the entire course. Lab attendance is compulsory and all labs must be completed satisfactorily to pass this course. 40% of the lab mark will be based on preparation, performance and successful completion of each lab.

*Students must obtain a minimum of 60% in both the theory and practical portions of the course and a minimum of 50% on the final exam.

6. Grading System

[X] Standard Grading System (GPA)

[ ] Competency Based Grading System

7. Recommended Materials or Services to Assist Students to Succeed Throughout the Course

LEARNING SUPPORT AND SERVICES FOR STUDENTS

There are a variety of services available for students to assist them throughout their learning. This information is available in the College Calendar, Student Services or the College web site at http://www.camosun.bc.ca

STUDENT CONDUCT POLICY

There is a Student Conduct Policy. It is the student's responsibility to become familiar with the content of this policy. The policy is available in each School Administration Office, Registration, and on the College web site in the Policy Section.
http://www.camosun.bc.ca/policies/policies.html

A. GRADING SYSTEMS *http://www.camosun.bc.ca/policies/policies.php*

The following two grading systems are used at Camosun College:

1. Standard Grading System (GPA)

Percentage	Grade	Description	Grade Point Equivalency
90-100	A+		9
85-89	A		8
80-84	A-		7
77-79	B+		6
73-76	B		5
70-72	B-		4
65-69	C+		3
60-64	C		2
50-59	D		1
0-49	F	Minimum level has not been achieved.	0

2. Competency Based Grading System (Non-GPA)

This grading system is based on satisfactory acquisition of defined skills or successful completion of the course learning outcomes

Grade	Description
COM	The student has met the goals, criteria, or competencies established for this course, practicum or field placement.
DST	The student has met and exceeded, above and beyond expectation, the goals, criteria, or competencies established for this course, practicum or field placement.
NC	The student has not met the goals, criteria or competencies established for this course, practicum or field placement.

B. TEMPORARY GRADES

Temporary grades are assigned for specific circumstances and will convert to a final grade according to the grading scheme being used in the course. See Grading Policy at http://www.camosun.bc.ca/policies/E-1.5.pdf for information on conversion to final grades, and for additional information on student record and transcript notations.

Temporary Grade	Description
I	*Incomplete*: A temporary grade assigned when the requirements of a course have not yet been completed due to hardship or extenuating circumstances, such as illness or death in the family.
IP	*In progress*: A temporary grade assigned for courses that are designed to have an anticipated enrollment that extends beyond one term. No more than two IP grades will be assigned for the same course.
CW	*Compulsory Withdrawal*: A temporary grade assigned by a Dean when an instructor, after documenting the prescriptive strategies applied and consulting with peers, deems that a student is unsafe to self or others and must be removed from the lab, practicum, worksite, or field placement.