CAMOSUN COLLEGE

Electronics and Computer Engineering Department

COURSE OUTLINE

ELEN 141 Electric Circuits and Machines

This course introduces students to fundamentals of DC, AC and Machine theory. Topics include DC/AC concepts, electromagnetic induction, motors, generators and transformers.

CREDIT:	For ET4
IN-CLASS WORKLOAD:	10 hours lecture, 1 hour tutorial, 2 hours lab
OUT-OF-CLASS WORKLOAD:	10 hours
PREREQUISITES:	Reserved for DND students

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Course Objectives

On completion of this course the successful students will have demonstrated they have acquired the basic concepts of circuit analysis as applied to DC and AC circuits. Students will be able to analyse Resistor, Inductor and Capacitor, series, parallel and series-parallel circuits; use complex numbers and graphical representations to analyse series, parallel and series-parallel RC, RL circuits and series and parallel RLC circuits; understand resonant circuits; high, low pass filters; understand the operation and characteristics of 1Φ and 3Φ transformers; electro-mechanical energy conservation; Successful students will have a detailed knowledge of DC motors and generators; polyphase induction motors; alternators; polyphase synchronous motors; parallel operation of generators and a detailed understanding of single phase motors.

Week 1:

1. **Electric Principles** **6**
   - 1.1. SI Units — Ch. 1
   - 1.2. Electric Charge — Ch. 2
   - 1.3. Voltage, Current, Resistance
     - 1.3.1. Electron vs. conventional flow
   - 1.4. Symbols - schematics
   - 1.5. The battery
     - 1.5.1. Series connected cells
     - 1.5.2. Parallel connected cells
   - 1.6. Internal resistance
   - 1.7. Chemical action while discharging
   - 1.8. Bread Boards

2.	**Series Circuits**		**4**	
	2.1. The Electric Circuit	Ch. 2		
	2.2. Conductors, switches & fuses			
	2.3. Ohm's Law	Ch. 3		
	2.4. Meter Measurements			
	2.5. Energy and Power - Watts Law	Ch. 4		
	2.6. Concept of a Load			
	2.7. Series Circuit - I_T, R_T, E_T	Ch. 5		
	2.8. Kirchhoff Voltage Law (KVL)			
	2.9. Voltage Divider Rule			
	2.10. Open & short circuits			
				Week 2-3:
3.	**Parallel Circuits**	Ch. 6	**4**	
	3.1. Parallel Voltages			
	3.2. Parallel Currents			
	3.3. Kirchhoff's Current Law (KCL)			
	3.4. Parallel Resistance:			
	3.4.1. Product over sum			
	3.4.2. Conductance and RT			
	3.5. Current divider rule;			
	3.6. Open & short circuits.			
4.	**Series-Parallel Circuits**	Ch. 7	**4**	
	4.1. Equivalent series-parallel circuits			
	4.2. Current in series-parallel circuits			
	4.3. Voltage drops in series-parallel circuits			
	4.4. Voltage dividers:			
	4.4.1. Unloaded Voltage Divider			
	4.4.2. Loaded Voltage Divider			
	4.5. The Potentiometer as a Voltage divider			
	4.6. Wheatstone Bridge			
	4.7. Delta-Wye Conversion			
	4.8. Open & short circuits			
5.	**Resistive Network Analysis**	Ch. 8	**9**	
	5.1. Voltage to Current source			
	5.2. Current to Voltage source			
	5.3. Superposition Theorem			
	5.4. Thevenin's Theorem			
	5.5. Norton's Theorem (optional)			
	5.6. Maximum Power Transfer Theorem			
	5.7. Loop Analysis (Mesh Current Analysis)	Ch. 9		***Week 3-4:***
	5.8. Voltage & Current divider rule (review)			
	5.9. Kirchhoff's laws (review)			

6. **Introduction to AC** Ch. 11 **5**
   - 6.1. The Sinusoidal Wave
   - 6.2. Current Flow in AC
   - 6.3. Comparison on AC and DC Power
   - 6.4. Notational Methods used in ac ccts
     - 6.4.1. Vpeak, Vpeak-to-peak, V_{AVG}, V_{RMS}, V_{INST}
   - 6.5. Frequency, Period and Wavelength

7. Basic Magnetism Ch. 10 **3**
   - 7.1. Magnets
   - 7.2. Residual Magnetism
   - 7.3. Electromagnetism
   - 7.4. Right Hand Rule:
     - 7.4.1. Conductors
     - 7.4.2. Coils;
   - 7.5. B-H Curve

Circuits Midterm Test **2**

8. **Inductance and RL Circuits** Ch. 13 **7** ***Week 5:***
   - 8.1. Construction of an Inductor
   - 8.2. Theory of Operation
   - 8.3. Inductors in Series and Parallel
   - 8.4. Inductors in DC circuits
     - 8.4.1. L/R Time Constant
     - 8.4.2. Universal Time Constant curves
     - 8.4.3. Charging/discharging equations
   - 8.5. Inductors in AC circuits – Inductive reactance (X_L)
   - 8.6. Voltage & current phase relationship
   - 8.7. The "j"operator; CH 15
   - 8.8. Series and Parallel RL circuits

9. **Capacitance and RC Circuits** Ch. 12 **8**
   - 9.1. Construction of a Capacitor
   - 9.2. Theory of Operation
   - 9.3. Capacitors in Series and Parallel
   - 9.4. Capacitors in DC circuits
     - 9.4.1. RC Time Constant
     - 9.4.2. Universal Time Constant curves
     - 9.4.3. Charging/discharging equations
   - 9.5. Capacitors in AC circuits - Capacitive Reactance (X_C)
   - 9.6. Voltage & current phase relationship
   - 9.7. Capacitor Types
   - 9.8. Series and Parallel RC circuits. Ch. 15

10. **RLC Circuits**	Ch. 17	**5.5**	***Week 5-6:***
10.1. Series RLC Circuits			
10.2. Parallel RLC Circuits			
11. **Power in AC Circuits**	Ch. 15	**4**	
11.1. Real Power: P			
11.2. Reactive Power: Q			
11.3. Apparent Power: S			
11.4. Power Factor			
12. **Resonance**	Ch. 17	**3**	***Week 7-8:***
12.1. Series Resonance			
12.2. Parallel Resonance			
13. **Filters**	Ch. 18	**6**	
13.1. Low Pass Filters			
13.2. High Pass Filters			
13.3. Gain, Attenuation, Decibel, Decade, and Octave			
13.4. Normalized Frequency Response Curves vs. Bode-plots			
13.5. Band Pass Filters			
13.6. Band Reject Filters (or Notch Filters)			
Review for Final Electric circuit Exam		**3**	
Electric Circuit Final Exam		*3*	
14. **Electromagnetic Induction**	Ch. 10	**4**	
14.1. Similarities between Magnetism and Electricity			
14.1.1. Flux			
14.1.2. Magnetomotive Force			
14.1.3. Reluctance			
14.2. Non-linear Effects of ferromagnetic Materials			
14.2.1. Hysteresis			
14.3. Magnetic Circuits			
14.4. Voltage Induced in a conductor:			
14.4.1. Flemmings Right Hand Rule			
14.5. Voltage Induced in a Coil			
14.6. Lenz's Law			
14.7. Force Produced by a Conductor:			
14.7.1. Biot-Savart Law			
14.8. Torque Developed by a Conductor			
14.9. Torque Developed by a Coil;			
14.10. Back Electromotive Force (Back EMF)			

15. **DC Generators** **4** ***Week 8-9:***
- 15.1. Basic Theory
- 15.2. Generator Construction
- 15.3. Armature Windings
- 15.4. Armature Reaction
  - 15.4.1. Field poles, interpoles; Compensating windings
- 15.5. DC Generator characteristics
  - 15.5.1. Basic gen. Equation
  - 15.5.2. Separately excited
  - 15.5.3. Shunt
  - 15.5.4. Series
  - 15.5.5. Compound generator
- 15.6. Total Power Losses
- 15.7. Parallel operation
- 15.8. Generator Calculations

16. **DC Motor Characteristics** **10**
- 16.1. Basic Motor Equation
- 16.2. Back EMF
- 16.3. Equivalent circuit of a DC motor
- 16.4. Speed Regulation
- 16.5. Motor Efficiency
- 16.6. Shunt Motor:
  - 16.6.1. Operation
  - 16.6.2. Calculations
  - 16.6.3. Torque - Speed Characteristics
  - 16.6.4. Speed Control
- 16.7. Series Motor:
  - 16.7.1. Operation
  - 16.7.2. Calculations
  - 16.7.3. Torque – Speed characteristics
  - 16.7.4. Speed Control
- 16.8. Compound Motor:
  - 16.8.1. Operation
  - 16.8.2. Torque - Speed Characteristics
- 16.9. Starting DC motors
- 16.10. Stopping DC motors

17. **Transformers** Ch. 14 **8** ***Week 10:***
- 17.1. Review of Single-Phase AC Circuits
- 17.2. Measurement of Power
- 17.3. Basic Transformer Theory
- 17.4. Practical Single-Phase Transformer
- 17.5. Efficiency
- 17.6. Multiple-Winding Transformers
- 17.7. Autotransformer

17.8. Basic Three-Phase AC Theory Ch. 21
17.9. Power Measurement in Three-Phase Systems
17.10. Three-Phase Transformers
17.11. Three-phase Source-load Connections:
17.11.1. WYE-WYE
17.11.2. DELTA-DELTA
17.11.3. WYE-DELTA
17.11.4. DELTA-WYE

Midterm Test *2*

18. **Synchronous Alternator** **6**

Week 11-12

18.1. Basic Construction
18.2. Frequency Relationship
18.3. Generated Voltage
18.4. 3Ø Alternator
18.5. Alternator Equivalent Circuit
18.6. Power
18.7. Torque
18.8. Voltage Regulation
18.9. Efficiency
18.10. Typical Alternator Characteristics
18.11. Alternators in Parallel - Synchroscope.

19. **3-Phase Induction Motors** **7**

19.1. Basic Construction
19.1.1. Squirrel Cage
19.1.2. Wound Rotor
19.2. Principle of Operation
19.2.1. Synchronous Speed
19.2.2. Slip
19.2.3. Torques
19.3. Squirrel Cage Motor:
19.3.1. Construction
19.3.2. Operation
19.3.3. Characteristics
19.3.4. Applications
19.4. Wound Rotor Motor:
19.4.1. Construction
19.4.2. Operation
19.4.3. Characteristics
19.5. Double Squirrel Cage
19.6. Starting techniques

20. **3-Phase Synchronous Motor** **6**

Week 12-13

- 20.1. Construction
- 20.2. Theory of Operation
- 20.3. Synchronous Motor Starting Techniques
- 20.4. Single-Phase Synchronous Motor
- 20.5. Self-Synchronous Units (Selsyn)
- 20.6. Power, Efficiency, and Torque.

21. **Single-Phase Induction Motors** **5**

- 21.1. Split-Phase Motor
- 21.2. Permanent Split-Capacitor Motor
- 21.3. Capacitor-Start Capacitor-Run Motor
- 21.4. Shaded-Pole Motor
- 21.5. Series Motor (Universal Motor)

Week 14

Review for Final Exam Motors section

Assessment

Assignments	5 %
Quizzes	5 %
Midterm - Circuits section	15 %
Final - Circuits section	25 %
Midterm - Motors section	15 %
Final - Motors section	25 %
Lab exercises	10 %

Laboratory exercises

Lab 1	Voltage sources, Resistance & Measurements, Ohm's Law and Series circuits
Lab 2	Parallel and Series-Parallel Circuits
Lab 3	DC Network Theorems
Lab 4	Oscilloscope Familiarisation, measurements
Lab 5	Inductance and RL circuits
Lab 6	Capacitors in DC circuits
Lab 7	Series, parallel resonant circuits
Lab 8	Filters
Lab 9	DC Generator characteristics, DC Motor characteristics (lab volt labs 2 and 3)
Lab 10	3 Phase AC circuits (lab Volt labs 21 and 22)
Lab 11	The synchronous alternator (Lab Volt AC Labs 10 and 11
Lab 12	3-Phase induction motors (lab volt AC labs 3 and 4)
Lab 13	3-Phase synchronous motor (lab volt AC labs 7, 8 and 9)

Text Books

Principles of Electric Circuits	Floyd:	ISBN 978-0-13-507309-4
Electrical Machines	Wildi:	ISBN 0-13-177691-6
Class handouts		

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. 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.