1. **Course number and name -**
   CHBE 3130 – Chemical Engineering Thermodynamics II *(required)*

2. **Credits and contact hours** - 3 credit hours, 3 lecture hours (3-0-0-3)

3. **Instructor's or course coordinator's name -** Dr. Corey Wilson

4. **Textbook, title, author, and year**
   Introduction to Chemical Engineering Thermodynamics; Smith, Van Ness, Abott, and Swihart, 8^{th} Edition, , McGraw-Hill, 2017 (6^{th} and 7^{th} edition also suitable)

5. **Specific course information**
   a. **Catalog Description -** Phase and chemical reaction equilibria. Vapor-liquid, liquid-liquid, and solid-vapor phase equilibrium. Fugacity and activity coefficients. Multi-reaction equilibrium. Credit not allowed for both CHBE 3130 and CHBE 3110.
   b. **Prerequisites or co-requisites** - MATH 2551 Multivariable Calculus (grade "C" or better); MATH 2552 Differential Equations (grade "C" or better); CHBE 2130 Chemical Engineering Thermodynamic I (grade "C" or better); CHBE 2120 Numerical Methods in Chemical Engineering (grade "C" or better).
   c. **Required, elective, or selected elective course** (as per Table 5-1) – Required

6. **Specific goals for the course**
   a. **Specific outcomes of instruction**:
   By the end of this course, a student should be able to:
      1) Understand the origin of chemical potential and fugacity
      2) Understand the molecular basis for ideal mixtures and calculate equilibrium phase compositions by relating chemical potential of fugacity to composition. Also apply in calculating boiling point elevation, osmotic pressure and other colligative properties.
      3) Determine the fugacity of a pure component non-ideal gas and of pure liquids and solids under high pressure.
      4) Understand partial molar properties of components in a particular phase and apply to calculations of the heat of mixing, volume, and entropy changes on processing of idea and real mixtures.
      5) Calculate phase compositions for real mixtures at equilibrium based on EOS for gas phases, and activity coefficient models for non-ideal liquid or solid behavior. Understand the molecular interaction theory behind common models.
      6) Apply the above tools to equilibrium separations including flash distillation and batch distillation.
      7) Understand when phase equilibrium calculations require use of an EOS applicable to all phases, and perform such calculations using computer software.

8) Determine the equilibrium composition of single and multi-phase reaction mixtures. Determine activity of a component in the reaction mixture and know how to determine it in solid, gas, and liquid phases.
9) Determine the effects on reaction equilibrium composition of temperature, pressure, diluents, mole ration of reactants, and other variables, and determine the heat requirements to reach equilibrium.
10) Calculate the activity of electrolytes in solution. Apply Debye-Huckel theory to calculate mean ionic activity coefficients.
11) Understand the effect of surface energy on vapor-liquid equilibrium.

b. **Connection with Student Outcomes**

CHBE 3130							
	Student Outcomes						
Course Outcomes	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Course Outcome 1	**X**						
Course Outcome 2	**X**					**X**	
Course Outcome 3	**X**						
Course Outcome 4	**X**						
Course Outcome 5	**X**					**X**	
Course Outcome 6	**X**	**X**					
Course Outcome 7	**X**	**X**				**X**	
Course Outcome 8	**X**	**X**					
Course Outcome 9	**X**	**X**				**X**	
Course Outcome 10	**X**						
Course Outcome 11	**X**						

Student Outcomes

(1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

(2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

(3) an ability to communicate effectively with a range of audiences

(4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

(5) an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

(6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

(7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

7. **Brief list of topics to be covered**

a. Pure-component multi-phase systems
   1) VLE and saturation pressure
   2) chemical potential, fugacity and fugacity coefficient

b. Ideal multi-component systems
   1) chemical potential, fugacity and fugacity coefficient
   2) Ideal solutions and gas mixtures, VLE
   3) Raoult's law, phase-diagrams
   4) Flash drum calculations

c. Non-ideal multi-component systems

1) EOS calculations of fugacity and chemical potential
2) VLE calculations form EOS
3) Activity models for non-ideal liquid mixtures, modified Raoult's law
4) Excess Gibbs free energy: relating models to experimental data e. LLE, SLE, and VLLE calculations

d. Molecular thermodynamics
   1) Association and solvation
   2) Equilibrium criteria on molecular level
   3) Ideal chemical theory
e. Reacting systems
   1) Reaction coordinates and equilibrium for ideal solutions
   2) Pressure and temperature effects
   3) Electrolyte thermodynamics
f. Special topics
   1) Electrochemistry
   2) Thermodynamics of biomacromolecules or polymers
   3) Surface thermodynamics