Course Number & Name: MET 210 – Kinematics

Credit Hours: 3.0  Contact Hours: 4.5  Lecture: 3.0  Lab: 1.5  Other: N/A

Prerequisites: Grade of “C” or better in ENR 110

Co-requisites: MTH 114  Concurrent Courses: None

Course Outline Revision Date: Fall 2010

Course Description: Students learn about moving elements used in the design and analysis of basic mechanisms in machines. Topics covered in the course include velocity and acceleration analysis on a plane, design and analysis of four-bar linkages, and cams, gears, and other mechanisms using graphical and analytical methods. Laboratory work is included.

Course Goals: Upon successful completion of this course, students should be able to do the following:

1. describe elements of various linkages and mechanisms associated with the design of machines;
2. build computer models of mechanisms using AutoCAD and Working Model software;
3. perform vector analysis;
4. perform position, displacement, velocity, and acceleration analysis;
5. demonstrate knowledge and apply concepts of mechanism design;
6. perform design and kinematic analysis of cams; and
7. demonstrate knowledge and apply concepts of kinematic analysis and selection of gears.

Measurable Course Performance Objectives (MPOs): Upon successful completion of this course, students should specifically be able to do the following:

1. Describe elements of various linkages and mechanisms associated with the design of machines:
   1.1 explain and use kinematic and mechanism terminology;
   1.2 draw kinematic diagrams and explain kinematic inversions;
   1.3 compute mobility of mechanisms using Gruebler’s equation;
   1.4 identify commonly used links and joints;
   1.5 classify and analyze four-bar mechanisms using Grashof’s criterion; and
   1.6 explain the various techniques of mechanism analysis
Measurable Course Performance Objectives (MPOs) (continued):

2. Build and analyze computer models of mechanisms using AutoCAD and Working Model software:
   
   2.1 use AutoCAD software to design linkages of a complex mechanism;
   2.2 use Working Model software to build kinematic models of mechanisms;
   2.3 use Working Model software to animate the motion of a mechanism; and
   2.4 use Working Model software to determine the kinematic values of a mechanism

3. Perform vector analysis:

   3.1 differentiate between a scalar quantity and a vector;
   3.2 apply appropriate trigonometry principles to a right triangle;
   3.3 apply appropriate trigonometry principles to a general triangle;
   3.4 resolve vector quantities into components in the horizontal and vertical directions;
   3.5 determine the resultant of two vectors by using both graphical and analytical methods;
   3.6 subtract two vectors by using both graphical and analytical methods;
   3.7 manipulate vector equations; and
   3.8 determine the magnitude of vectors

4. Perform position, displacement, velocity, and acceleration analysis:

   4.1 define position and displacement of a point;
   4.2 graphically and analytically determine the position of all links in a mechanism as the driver links are displaced;
   4.3 graphically and analytically determine the limiting positions of a mechanism;
   4.4 graphically and analytically determine the position of all links for an entire cycle of a mechanism motion;
   4.5 plot a displacement diagram for various points on a mechanism as a function of the motion of other points on the mechanism;
   4.6 define linear, rotational, and relative velocities;
   4.7 convert between linear and angular velocities;
   4.8 using the relative velocity method, graphically and/or analytically solve for the velocity of a point on a link when the velocity of another point on that link is known;
   4.9 using the relative velocity method, graphically and analytically determine the velocity of a point on a floating link;
   4.10 construct a velocity curve to locate extreme velocity values;
   4.11 define linear, rotational, normal, tangential, and relative accelerations;
   4.12 using the relative acceleration method, graphically and/or analytically solve for the acceleration of a point on a link when the acceleration of another point on that link is known;
   4.13 using the relative acceleration method, graphically and/or analytically determine the acceleration of a point of interest on a floating link; and
   4.14 construct an acceleration curve to locate extreme acceleration values

5. Demonstrate knowledge and apply concepts of mechanism design:

   5.1 design an in-line slider-crank mechanism;
   5.2 compute the desired mechanism time ratio and determine an appropriate imbalance angle;
   5.3 using graphical methods, design offset slider-crank and crank-rocker mechanisms;
Measurable Course Performance Objectives (MPOs) (continued):

5.4 using graphical methods, design a single-pivoted link to move between two prescribed positions;
5.5 using graphical methods, design a four-bar mechanism in which the coupler link moves between two prescribed positions;
5.6 describe and implement the strategy for using a general spreadsheet for mechanism analysis; and
5.7 create computer routines for determining kinematic properties of either four-bar or slider-crank mechanisms.

6. Perform design and kinematic analysis of cams:

6.1 identify the different types of cams and followers;
6.2 create a follower displacement diagram from prescribed follower motion criteria;
6.3 compare and contrast the benefits of different follower motion schemes;
6.4 use equations to construct cam follower displacement diagrams;
6.5 geometrically construct cam follower displacement diagrams;
6.6 graphically and analytically construct disk cam profiles with several types of followers; and
6.7 graphically and analytically construct cylindrical cam profiles

7. Demonstrate knowledge and apply concepts of kinematic analysis and selection of gears:

7.1 identify the different types of gears;
7.2 identify and use standard gear geometry features;
7.3 calculate center distance, contact ratio, interference limitations, and backlash variations;
7.4 calculate and use the velocity ratio to determine the kinematic properties mating gears; and
7.5 determine the kinematic properties of gear and planetary gear trains

Methods of Instruction: Instruction will consist of lectures, problem solving, and laboratory exercises.

Outcomes Assessment: Selected homework, quiz, test, and exam questions are blueprinted to course objectives. A checklist rubric is used to evaluate lab reports and the term project reports for the presence of course objectives. Data is collected and analyzed to determine the level of student performance on these assessment instruments in regards to meeting course objectives. The results of this data analysis are used to guide necessary pedagogical and/or curricular revisions.

Course Requirements: All students are required to:

1. Maintain regular attendance and participate in classroom discussions.
2. Complete homework assignments and lab reports on time.
3. Sit for all quizzes, tests and exams that are scheduled.
4. Participate in all lab exercises.
5. Read all assigned textbook pages.
### Methods of Evaluation

Final course grades will be computed as follows:

<table>
<thead>
<tr>
<th>Grading Components</th>
<th>% of final course grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>• <strong>Quizzes and class participation</strong></td>
<td>5 – 10%</td>
</tr>
<tr>
<td>A perusal of quizzes and analysis of class discussion will indicate the extent to which students master course objectives.</td>
<td></td>
</tr>
<tr>
<td>• <strong>Homework</strong></td>
<td>10 – 15%</td>
</tr>
<tr>
<td>A perusal of homework problems will indicate the extent to which students master course objectives.</td>
<td></td>
</tr>
<tr>
<td>• <strong>3 or more Tests</strong> (dates specified by the instructor)**</td>
<td>30 – 40%</td>
</tr>
<tr>
<td>Tests will show evidence of the extent to which students meet course objectives, including but not limited to identifying and applying concepts, analyzing and solving problems, estimating and interpreting results and stating appropriate conclusions using correct terminology.</td>
<td></td>
</tr>
<tr>
<td>• <strong>2 or more Lab Reports</strong></td>
<td>15 – 25%</td>
</tr>
<tr>
<td>Lab reports will show evidence of the extent to which students can apply course concepts to physical problems, analyze errors, and compose a technical report. Labs are designed to reinforce student mastery of course objectives.</td>
<td></td>
</tr>
<tr>
<td>• <strong>Term Project</strong></td>
<td>10 – 20%</td>
</tr>
<tr>
<td>The term project will show evidence of the extent to which students can apply course concepts to real world problems, design a solution, and compose a technical report.</td>
<td></td>
</tr>
<tr>
<td>• <strong>Team work</strong></td>
<td>5 – 10%</td>
</tr>
<tr>
<td>Collaboration between colleagues, an essential component of engineering practice in industry, will be practiced as students complete their lab and term projects.</td>
<td></td>
</tr>
<tr>
<td>• <strong>Final Exam</strong> (comprehensive)**</td>
<td>25 – 35%</td>
</tr>
<tr>
<td>The same objectives apply as with tests, but it is anticipated that students will provide increased evidence of synthesizing a combination of concepts.</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** The instructor will provide specific weights, which lie in the above-given ranges, for each of the grading components at the beginning of the semester.
**Academic Integrity:** Dishonesty disrupts the search for truth that is inherent in the learning process and so devalues the purpose and the mission of the College. Academic dishonesty includes, but is not limited to, the following:

- plagiarism – the failure to acknowledge another writer’s words or ideas or to give proper credit to sources of information;
- cheating – knowingly obtaining or giving unauthorized information on any test/exam or any other academic assignment;
- interference – any interruption of the academic process that prevents others from the proper engagement in learning or teaching; and
- fraud – any act or instance of willful deceit or trickery.

Violations of academic integrity will be dealt with by imposing appropriate sanctions. Sanctions for acts of academic dishonesty could include the resubmission of an assignment, failure of the test/exam, failure in the course, probation, suspension from the College, and even expulsion from the College.

**Student Code of Conduct:** All students are expected to conduct themselves as responsible and considerate adults who respect the rights of others. Disruptive behavior will not be tolerated. All students are also expected to attend and be on time for all class meetings. No cell phones or similar electronic devices are permitted in class. Please refer to the Essex County College student handbook, *Lifeline*, for more specific information about the College’s Code of Conduct and attendance requirements.
**Course Content Outline:** based on the text *Machines and Mechanisms*, 3rd edition, by David H Myszka; published by Pearson Education, 2005.

<table>
<thead>
<tr>
<th>Week (2 meetings @135 minutes)</th>
<th>Topic/Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 2</td>
<td><strong>BASIC CONCEPTS:</strong> System of units, terminology and definitions, degrees of freedom, Gruebler’s equation, classification of linkages, Grashof’s criterion</td>
</tr>
<tr>
<td>3</td>
<td><strong>WORKING MODEL MECHANISM DESIGN AND ANALYSIS:</strong> Design of linkages using Working Model and AutoCAD software, building and simulating mechanisms using Working Model software</td>
</tr>
<tr>
<td>4</td>
<td>Lab 1: Crank-Rocker and Crank-Slider design, <strong>Test 1</strong></td>
</tr>
<tr>
<td>5</td>
<td><strong>Lab 1 Report due</strong>; <strong>MOTION IN MACHINERY:</strong> Motion, vectors, displacement analysis of planar linkages, limiting positions, analytical vector and graphical methods</td>
</tr>
<tr>
<td>6</td>
<td>Term Project assigned; <strong>VELOCITY ANALYSIS OF MECHANISMS:</strong> Basic concepts, moving coordinate systems, relative velocity, application of analytical vector methods to linkages, graphical analysis of linkage motion utilizing relative velocity, the velocity polygon, graphical analysis of basic linkages</td>
</tr>
<tr>
<td>7</td>
<td><strong>ACCELERATION ANALYSIS OF MECHANISMS:</strong> Basic concepts, analysis of 4-bar linkages using analytical vector methods, the acceleration polygon, equivalent linkages, graphical analysis of sliding contact linkages, cams and cam followers, analyzing combinations of basic linkages, limiting positions</td>
</tr>
<tr>
<td>8</td>
<td>Mechanism Design: Time ration, imbalance angle, limiting positions, quick-return mechanisms, linkage interference, mechanisms for specific applications</td>
</tr>
<tr>
<td>9</td>
<td>Lab 2: Airplane landing gear design, <strong>Test 2</strong></td>
</tr>
<tr>
<td>10</td>
<td><strong>Lab 2 Report due</strong>; <strong>CAMS – DESIGN AND ANALYSIS:</strong> Introduction, graphical cam design, analysis of cam follower motion, analytical cam design, positive-motion cams, cylindrical cams, practical consideration in cam design</td>
</tr>
<tr>
<td>11</td>
<td><strong>GEARS – DESIGN AND ANALYSIS:</strong> Basic considerations, gear types, spur gear terminology, fundamental law of gearing, internal gears, standard gears, gear manufacture, sliding action of gear teeth, interference, gear tooth forces, helical gears on parallel shafts, crossed helical gears, worm gears, bevel gears</td>
</tr>
<tr>
<td>12</td>
<td>Review, <strong>Test 3</strong></td>
</tr>
<tr>
<td>Week</td>
<td>Topic/Content</td>
</tr>
<tr>
<td>------</td>
<td>---------------</td>
</tr>
<tr>
<td>13</td>
<td>DRIVE TRAINS – DESIGN AND ANALYSIS: Introduction, velocity ratios for spur and helical gear trains, speed ratio change, planetary gear trains, other drive train elements, velocity and acceleration in a planetary train, forces, torques, transmitted power in gear trains</td>
</tr>
<tr>
<td>14</td>
<td>Oral presentations, Term Project due</td>
</tr>
<tr>
<td>15</td>
<td>Comprehensive Final Exam</td>
</tr>
</tbody>
</table>