Mechatronics/Industrial Automation

Submitter's Information

| | |
|---|---|
| **Name** | Margee Loya |
| **Title** | Curriculum Analyst |
| **Email** | margee.loya@cloviscollege.edu (mailto:margee.loya@cloviscollege.edu) |
| **Phone** | (559) 325-5223 |
| **Extension** | n/a |
| **Region** | Central/Mother Lode |
| **College** | Clovis Community College |
| **CTE Dean** | Robbie Kunkel |
| **CTE Dean Email** | robbie.kunkel@cloviscollege.edu (mailto:robbie.kunkel@cloviscollege.edu) |

Program Information

| | |
|---|---|
| **Program Name** | Mechatronics/Industrial Automation |
| **Projected Start Date** | 08/13/2018 |
| **Program Type(s)** | Certificate of Achievement 18+ Semester (27+ Quarter) Units |
| **Certificate Required Units** | 26 |
| **Units of Major Degree** | n/a |
| **Total Units for Degree** | n/a |
| **TOPs Code** | Manufacturing and Industrial Technology (095600) |
| **Program Goals** | Program Goals:<br>1. Prepare students to obtain an entry-level positions as industrial automation technicians in various local and regional industries.<br>2. Provide foundational training and mentorship that enables students to transfer to related four-year baccalaureate programs.<br>Program Learning Outcomes:<br>Upon completion of this program students will be able to:<br>1. Safety: Identify the hazards associated with automated machinery and determine appropriate safety methods for working in an industrial environment.<br>2. Troubleshooting: Utilize electrical/mechanical troubleshooting and communication skills to diagnose, repair, test, and return to service failed components.<br>3. Identify and Solve Problems: Identify, analyze, and solve narrowly defined technical problems |

determining root cause with a general understanding of industry practices.
4. System Design and Programming: Use basic understanding of programming and industrial system design to enhance systems via incremental changes in software and/or in hardware modifications.
5. Communication: Apply written, oral and graphical communication skill in both technical and non-technical environments, and identify and use appropriate technical literature.
6. Teamwork, Professionalism and Quality: Function effectively as a team member, both individually and as group, demonstrating a commitment to quality, timeliness, and continuous improvement in a professional manner.

**Program Description**

The certificate in Mechatronics/Industrial Automation is designed to prepare students for employment as entry-level industrial automation technicians. The program prepares students for careers in the design, operation, and maintenance of industrial automation systems focusing on the local industries that utilize these technologies, such as food production, petroleum production, fabrication, and logistics. This program focuses on the application of electronics and computer technology to industrial automation systems, including instrumentation and control, industrial robotics, and process control systems. Significant emphasis is placed on project-based learning facilitated by significant laboratory work.

**Program Requirements**

MECH-2, Mechanical Systems; 3 units; Year 1, Fall
MECH-3, Electricity and Electronics (AC & DC); 4 units; Year 1, Fall
MECH-4, Electric Motors - Controls; 4 units; Year 1, Fall
MECH-5, Programmable Logic Controllers (PLCs); 3 units; Year 1, Fall
MECH-19V, Work Experience, Mechatronics/Industrial Automation; 3 units; Year 1, Spring
MECH-23, Instrumentation and Process Control; 3 units; Year 1, Spring
MECH-35, Industrial Communications Networks; 3 units; Year 1, Spring
MECH-45, Industrial Automation Systems; 3 units; Year 1, Spring

**Program Projections**

2018: 5
2019: 10

**Labor Market Information**

Download Mechatronics LMI documentation.pdf (/storage/lmi/95-123-Mechatronics LMI documentation.pdf)

**Created At**

12/06/17 - 01:12 PM

**Status**

**Submitted**

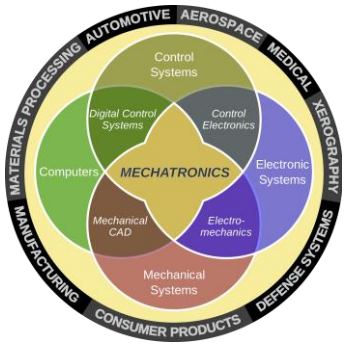
Central/Mother Lode Region Specific Questions

**Advisory Minutes**

Download 9-14-17 Advisory Minutes to accept Mechatronics Industrial Automation program.pdf (/storage/Central/Mother Lode/95-123-282-9-14-17 Advisory Minutes to accept Mechatronics Industrial Automation program.pdf)

# MECHATRONICS CAREERS in the CENTRAL VALLEY/MOTHER LODE REGION & SOUTH CENTRAL VALLEY SUB-REGION

A labor market profile of Mechatronics in Community College Programs

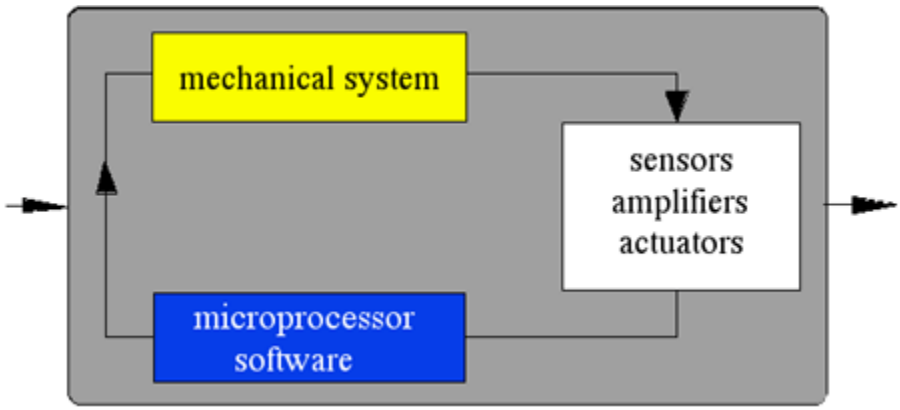



## What is Mechatronics?

Mechatronics is an interdisciplinary area of engineering that combines mechanical and electrical engineering and computer science. A typical mechatronic system picks up signals from the environment, processes them to generate output signals, and then transforms them into forces, motions and actions (Exhibit 1).

Examples of mechatronic systems are robots, digitally controlled combustion engines, machine tools with self-adaptive tools, contact-free magnetic bearings and automated guided vehicles. The design of these products and devices typically requires extensive knowledge of systems and software. With advances in technology, software has become integral to the function and operation of products and devices. Consequently, software has become an actual "machine element."

**Exhibit 1 – Relationship among mechatronics disciplines**




The following labor market information provides context for the purpose of supporting mechatronics program conversations at Clovis College. It is recommended that the college work with department advisory boards and local industry partners to reach consensus.

## Occupational Overview

Mechatronics professionals are the technicians and engineers who research, design, develop or test automation systems, smart devices or industrial systems control. They also maintain automated equipment. Technicians and engineers conduct their work in laboratories, offices or on-site manufacturing plants. These professionals work toward the same goal of producing and/or maintaining safe and efficient automated equipment. While technicians usually maintain machinery, engineers are more concerned with the design and development of components and products.

There are a few mechatronics postsecondary programs in California and a couple within the California community college system; however, the latter are housed under more generalized TOP codes and titles. The TOP code and title options in Exhibit 2 are based on the occupational titles provided for this profile.

**Exhibit 2 – Mechatronics-related TOP codes**

| TOP Code | Program | SOC Code | Occupation |
|---|---|---|---|
| 070600 | Computer Science (transfer) | 15-1131 | Computer Programmers |
| 070700 | Computer Software Development | 15-1131 | Computer Programmers |
| 070710 | Computer Programming | 15-1131 | Computer Programmers |
| 092400 | Engineering Technology, General | 17-3023 | Electrical and Electronics Engineering Technicians |
| | | 17-3026 | Industrial Engineering Technicians |
| | | 17-3027 | Mechanical Engineering Technicians |
| | | 51-2022 | Electrical and Electronic Equipment Assemblers |
| 093400 | Electronics and Electric Technology | 17-3023 | Electrical and Electronics Engineering Technicians |
| | | 51-2022 | Electrical and Electronic Equipment Assemblers |
| | | 49-2093 | Electrical and Electronics Installers and Repairers, Transportation Equipment |
| | | 49-2094 | Electrical and Electronics Repairers, Commercial and Industrial Equipment |
| | | 49-2095 | Electrical and Electronics Repairers, Powerhouse, Substation, and Relay |
| 093410 | Computer Electronics | 17-3023 | Electrical and Electronics Engineering Technicians |
| | | 49-2094 | Electrical and Electronics Repairers, Commercial and Industrial Equipment |
| 093420 | Industrial Electronics | 17-3026 | Industrial Engineering Technicians |
| | | 49-2094 | Electrical and Electronics Repairers, Commercial and Industrial Equipment |
| | | 51-2022 | Electrical and Electronic Equipment Assemblers |
| 093430 | Telecommunications Technology | 17-3023 | Electrical and Electronics Engineering Technicians |
| 093440 | Electrical Systems and Power Transmission | 17-3023 | Electrical and Electronics Engineering Technicians |
| | | 49-2095 | Electrical and Electronics Repairers, Powerhouse, Substation, and Relay |
| 093500 | Electro-Mechanical Technology | 17-3024 | Electro-Mechanical Technicians |
| 094300 | Instrumentation Technology | 17-3025 | Electro-Mechanical Technicians |
| 094500 | Industrial Systems Technology and Maintenance | 17-3027 | Mechanical Engineering Technicians |
| 094830 | Motorcycle, Outboard and Small Engine Repair | 49-2093 | Electrical and Electronics Installers and Repairers, Transportation Equipment |
| 095220 | Electrical | 17-3023 | Electrical and Electronics Engineering Technicians |
| 095600 | Manufacturing and Industrial Technology | 17-3026 | Industrial Engineering Technicians |
| | **No TOP Code Match** | 49-9041 | Industrial Machinery Mechanics |
| | | 51-2023 | Electro-Mechanical Equipment Assemblers |
| | | 17-2199.05 | Mechatronics Engineers |

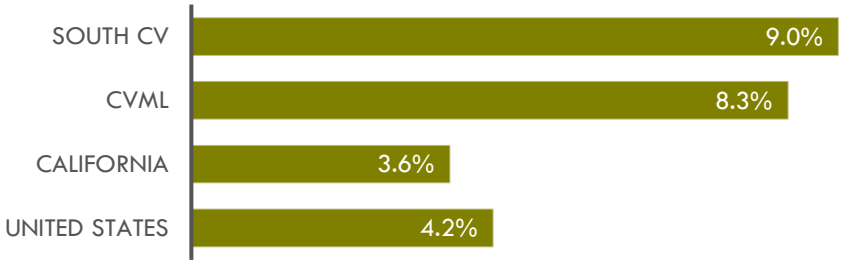
## Projected Employment Growth

O*NET online projects a 2-4% national employment increase in mechatronics jobs between 2014 and 2024 with 33,000 projected openings. The top two industries with the most mechatronics positions are government and manufacturing.

Overall, mechatronics occupations identified by the study are projected to add jobs over the next five years with the greatest gains at the subregional level (South Central Valley), followed by the entire region (Central Valley/Mother Lode).

The South Central Valley is projected to grow at a speed more than double state and national rates (Exhibit 3). The Central Valley/Mother Lode region also far out-paces both the state and nation in terms of job growth, but not quite at the level of the South Central Valley.

**Exhibit 3 – Projected mechatronics job growth**




The study also analyzed projected growth by occupation for the Central Valley/Mother Lode region and South Central Valley subregion. Twelve occupations were identified, employing a total of 10,802 workers in the region.

Industrial Machinery Mechanics is the largest occupation at both the regional and subregional level, with 4,514 and 2,833 jobs respectively. Within the mechatronics cluster, this occupation also has the greatest projected growth at 13% and 15%, adding more than 5,000 jobs in the region over the next five years.

The largest occupation requiring an associate degree is Electrical and Electronics Engineering Technicians. This occupation has a more modest projected growth rate of 4% (regional) and 5% (subregional).

The smallest occupation is Electro-Mechanical Technicians which is projected to only add two jobs annually over the next five years.

Exhibit 4 shows the employment outlook for each mechatronics occupation in the Central Valley/Mother lode region. The data are sorted in descending order by current number of jobs and projected annual openings.

**Exhibit 4 – Projected occupational growth for the Central Valley/Mother Lode region**

| SOC Code | Occupation | 2016 Jobs | 2021 Jobs | % Growth* | Annual Openings** |
|---|---|---|---|---|---|
| 49-9041 | Industrial Machinery Mechanics | 4,514 | 5,111 | 13% | 263 |
| 49-9051 | Electrical Power-Line Installers and Repairers | 1,177 | 1,228 | 4% | 61 |
| 17-3023 | Electrical and Electronics Engineering Technicians | 1,175 | 1,223 | 4% | 35 |
| 15-1131 | Computer Programmers | 1,104 | 1,152 | 4% | 41 |
| 17-2199 | Engineers, All Other | 937 | 975 | 4% | 26 |
| 49-2094 | Electrical and Electronics Repairers, Commercial and Industrial Equipment | 618 | 646 | 5% | 19 |
| 51-2022 | Electrical and Electronic Equipment Assemblers | 546 | 583 | 7% | 15 |
| 51-2023 | Electromechanical Equipment Assemblers | 221 | 227 | 3% | 5 |
| 17-3027 | Mechanical Engineering Technicians | 207 | 229 | 11% | 9 |
| 17-3026 | Industrial Engineering Technicians | 143 | 157 | 10% | 6 |
| 49-2093 | Electrical and Electronics Installers and Repairers, Transportation Equipment | 118 | 124 | 5% | 4 |
| 17-3024 | Electro-Mechanical Technicians | 42 | 47 | 12% | 2 |

*Growth refers to net change over the period, i.e. new job creation or job decline, and does not factor in replacement jobs.
**Annual openings represents the annual average number of new jobs plus replacement jobs projected for the five-year period.

## Hourly Wages

The living wage for one adult in the Central Valley/Mother lode region ranges from $9.99/hour in Merced County to $12.62/hour in Mono County. The region's overall average is $10.53/hour. In the South Central Valley subregion, the living wage ranges from $10.21/hour in Kings County to $10.70/hour in Fresno County, with an overall average of $10.43/hour.

Wages were analyzed by occupation and compared with regional and subregional living wages.

Entry-level hourly wages range from $10.02 regional/$9.83 subregional for Electromechanical Equipment Assemblers to $24.96 regional/$25.43 subregional for Electrical Power-Line Installers and Repairers. Only the Electromechanical Equipment Assemblers occupation falls below the average living wage for a single adult.

The average hourly entry-level wage within the mechatronics occupational cluster is $18.05 for the region and $18.07 for the South Central Valley subregion. These averages are far above the average hourly living wage for one adult at the regional ($10.53) and subregional ($10.43) levels.

**Exhibit 5 – Entry-level and median hourly wages**

| SOC Code | Occupation | Entry-level Hourly Wage* | Median Hourly Wage |
|---|---|---|---|
| 49-9041 | Industrial Machinery Mechanics | $14.86 | $24.14 |
| 49-9051 | Electrical Power-Line Installers and Repairers | $24.96 | $44.43 |
| 17-3023 | Electrical and Electronics Engineering Technicians | $23.60 | $34.51 |
| 15-1131 | Computer Programmers | $21.63 | $34.66 |
| 17-2199 | Engineers, All Other | $18.31 | $47.65 |
| 49-2094 | Electrical and Electronics Repairers, Commercial and Industrial Equipment | $18.41 | $25.35 |
| 51-2022 | Electrical and Electronic Equipment Assemblers | $10.63 | $14.93 |
| 51-2023 | Electromechanical Equipment Assemblers | $10.02 | $13.78 |
| 17-3027 | Mechanical Engineering Technicians | $17.38 | $25.82 |
| 17-3026 | Industrial Engineering Technicians | $19.78 | $27.35 |
| 49-2093 | Electrical and Electronics Installers and Repairers, Transportation Equipment | $20.21 | $27.62 |
| 17-3024 | Electro-Mechanical Technicians | $19.54 | $27.81 |

*Entry-level hourly wage is represented by the 10th percentile wage – 10% of workers in the occupation make less, while 90% of the workers in the job make more than this amount.

## Typical Education Level

Education and training requirements for entry-level work will vary by occupation and employer preference. Exhibit 6 shows the typical required entry-level education as identified by the Bureau of Labor Statistics as well as employer educational preferences collected by O*NET.

Based on Bureau of Labor Statistics, two mechatronics occupations require at least a bachelor's degree: computer programmers and engineers, all other/mechatronics engineers.

In addition, there are four occupations that require at least an associate degree and two that require at least a postsecondary non-degree award. Technicians comprise the occupations requiring an associate degree, while installers and repairers are occupations that require a postsecondary non-degree award.

**Exhibit 6 – Mechatronics educational requirements**

| Occupation | Typical Entry-level Education | O*NET Job Zone: Education |
|---|---|---|
| **Computer Programmers** | Bachelor's degree | Most require a bachelor's degree, but some do not. |
| **Engineers, All Other**/Mechatronics Engineers | Bachelor's degree | Most require a bachelor's degree, but some do not. |
| **Electrical and Electronics Engineering Technicians** | Associate degree | Most require vocational training or an associate degree. |
| **Electro-Mechanical Technicians** | Associate degree | Most require vocational training or an associate degree. |
| **Industrial Engineering Technicians** | Associate degree | Most require vocational training or an associate degree. |
| **Mechanical Engineering Technicians** | Associate degree | Most require vocational training or an associate degree. |
| **Electrical and Electronics Installers and Repairers, Transportation Equipment** | Postsecondary non-degree award | Most require vocational training or an associate degree. |
| **Electrical and Electronics Repairers, Commercial and Industrial Equipment** | Postsecondary non-degree award | Most require vocational training or an associate degree. |
| **Industrial Machinery Mechanics** | High school diploma/equivalent | Most require vocational training or an associate degree. |
| **Electrical Power-Line Installers and Repairers** | High school diploma/equivalent | Most require vocational training or an associate degree. |
| **Electrical and Electronic Equipment Assemblers** | High school diploma/equivalent | Most require a high school diploma. |
| **Electromechanical Equipment Assemblers** | High school diploma/equivalent | Most require a high school diploma. |

## Occupational Trends

Mechatronics is vital to modern engineering systems and requires multidisciplinary expertise across a range of disciplines, such as mechanical engineering, electronics, information technology and control systems science.

- Safety-enabled productivity is one trend as manufacturers look to broaden their horizons beyond protecting operators and equipment to encompass protecting performance.

- Some organizations are using safe speed and speed to make a variety of operations more productive and continuous by reducing frequent delays.

Trends that manufacturers should be taking a close look at in 2016 include big data, predictive maintenance, the Industrial Internet of Things (IIoT), and smart energy monitoring for transparent factory operations.

- The combination of sensors, the broad connectivity of the Internet of Things (IoT) and big data functionality will increasingly enable organizations to mine their data for actionable insights. This level of transparency into operations will allow an entire organization, from machine operators to upper management, to make decisions that streamline performance and enhance profitability.

- Depending on the implementation, information can be available in minutes or even in real time. Management can review information such as operational equipment effectiveness, throughput and changeover time. Maintenance and system integrators alike can have parameters like current draw and load curve delivered to their mobile phones.

## Regional Programs

Nine of the 14 community colleges in the region have one or more programs within the 15 mechatronics-related TOP codes. When program award data for the Central Valley/Mother Lode region was reviewed, it was determined that a total of 302 awards were earned in the 2013-2014 academic year, and 393 were awarded in 2014-2015. Awards represented a combination of certificates and associate degrees.

**Exhibit 7 – Mechatronics-related postsecondary awards**

| College | Awards 2013-2014 | Awards 2014-2015 |
|---|---|---|
| Bakersfield | 71 | 71 |
| Cerro Coso | 4 | |
| Fresno City | 58 | 133 |
| Merced | 56 | 53 |
| Modesto | 31 | 50 |
| Porterville | | 25 |
| Reedley | 4 | 7 |
| San Joaquin Delta | 29 | 14 |
| Sequoias | 49 | 40 |

A review of educational institutions in the region revealed that that three California State Universities, one private university and two private technical schools offer mechatronics-related programs. In 2013-2014, these institutions reported conferring 113 awards or degrees.

## Conclusion & Recommendations

Based on this study's occupational and program findings, it is suggested that colleges in the region and subregion consider taking the following steps:

- Review the TOP codes and occupational titles included in this assessment to ensure that only those occupations with the most direct employment relevance to the curricula have been included.
- As curriculum is review and updated or as new curriculum is developed, consider incorporating some of the industry trends identified by the study such as safety-enabled productivity, predictive maintenance, and smart energy monitoring.
- Based on the review of employer educational preferences and employment projections, mechatronics associate degree programs should focus on the following occupations: Electro-Mechanical Technicians, Industrial Engineering Technicians and Mechanical Engineering Technicians.
- Only two occupations in the mechatronics cluster require a postsecondary non-award degree. However, these occupations are projected to experience little growth (only 4-5%) in coming years. Colleges may want to take this into consideration when updating existing programs or developing new programs.
- Encourage employers on the advisory board to participate in the Center of Excellence Central Valley/Mother Lode regional study of manufacturing production line occupations scheduled to begin in June 2016. The study will be used to identify or validate in-demand coursework as well as certificates and degrees preferred by employers for new hires.

For more information on this report, please contact:


Nora Seronello
Director, Central Region
Center of Excellence (CoE) for Labor Market Research
seronellon@mjc.edu / 209.575.6894

***Important Disclaimer***

All representations included in this report have been produced from primary research and/or secondary review of publicly and/or privately available data and/or research reports. Efforts have been made to qualify and validate the accuracy of the data and the reported findings; however, neither the Centers of Excellence, COE host District, nor California Community Colleges Chancellor's Office are responsible for applications or decisions made by recipient community colleges or their representatives based upon components or recommendations contained in this study.

Sources: Economic Modeling Specialists Intl. (EMSI), Bureau of Labor Statistics (BLS), and Mechatronics Consulting (http://www.mcgs.ch/index.html)

# Sign-in Sheet

**Event Name:** Mechatronics / Industrial Automation – Industry Forum
**Event Date:** September 14th, 2017
**Location:** Room 310, Herndon Center, Clovis Community College 390 W Fir Avenue, Clovis, CA 93611
**Time:** 5 pm – 7 pm

| | Name (Please Print) | Organization | Signature |
|---|---|---|---|
| 1 | Matthew Graff | Clovis Community College | |
| 2 | GURMINDER SANGHA | COS/CCCCO | |
| 3 | Glenn Pangh | Lyon Managers | |
| 4 | Dale Putman | Allied Electric | |
| 5 | Colleen Brannon | CCC | |
| 6 | David Pruitt | Producers Dairy | |
| 7 | William Dean | Producers Dairy | |
| 8 | Ed Schmalzel | Clovis Adult School | |
| 9 | Alain Spaland | Allied Electric | |
| 10 | MIKE VASILESCU | READY ROAST | |
| 11 | BRIAN EMERSON | CTEC High School | |
| 12 | JOHN MARR | BETTS COMPANY | |
| 13 | DORAN ALFORD | PRODUCERS | |
| 14 | A Alexander | Fresno State | |

# Sign-in Sheet

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| | Name (Please Print) | Organization | Email | Phone Number | Signature |
|---|---|---|---|---|---|
| 29 | Chris K Cruz | Mi Rancho | C.K.Cruz@favorite4orthtec. | (559)994-2160 | |
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**Mechatronics / Industrial Automation – 1st Advisory Board Meeting**

HC308

September 14th, 2017

**Present:**

Industry:

- Criss K Cruz (Mi Rancho)
- John Marr (Betts Company)
- Joel Ratto (ICAD/Lighthouse Elec)
- Anthony Olivo (ICAD- Industrial Control and Design)
- William "Bill" Dean (Producers Dairy)
- Frank Corgiat (Producers Dairy)
- David Pruitt (Producers Dairy)
- Hyung Yam (Producers Dairy)
- Doran Alford (Producers Dairy)
- Dale Putman (Allied Electric)
- Alain Spalard (Allied Electric)
- Travis Asher (Allied Electric)
- Mike Vasilescu (Ready Roast)
- Glenn Peugh (Lyons Magnus)

Other:

- Brissa Quiroz (Fresno State)
- Walter Mizuno (Fresno State)
- Athanasios Alexandrou (Fresno State)
- Gurminder Sangha (COS/Deputy Sector Navigator)
- Ed Schmalzel (Clovis Adult School)
- Brian Emerson (CTEC High School)
- Matthew Graff (Clovis Community College)
- Colleen Brannon (Clovis Community College)
- Robbie Kunkel (Clovis Community College)

I. Dinner served 7:00 pm

II. Meeting called to order 7:15 pm

III. Powerpoint Overview of Program- Matthew Graff

IV. Program Outcomes

A. Large Group discussion

B. The follow items were recommended to be considered in the Program Outcomes

1. Job placement
2. Independence added into point #6
3. General industry knowledge

C. Advisory board agreed to Program Outcomes

V. Program Courses

A. The following courses were shared with Advisory Board
   1. Mechanical Systems
   2. Electricity and Electronics (AC & DC)
   3. Electric Motors - Controls
   4. Programmable Logic Controllers (PLCs)
   5. Industrial Automation Systems
   6. Instrumentation and Process Control
   7. Industrial Communications Networks
   8. Work Experience/Internship

B. Advisory board went into small groups and looked at course outlines

C. In large group discussion the following changes were discussed/recommended:
   1. MECH 2- Mechanical Systems
      a) Prerequisites
      b) Remove some topics from Mechanical Drives to give more time for Pneumatics and Hydraulics
   2. MECH 3- Electricity and Electronics (AC & DC)
      a) Prerequisites
      b) Using basic algebra and physics… perform related student learning outcomes.
   3. MECH 4- Electric Motors Control
      a) Add to Student Learning Outcome #3 to emphasis on motor torque and horsepower formules
      b) Miscellaneous other changes to equipment, course objectives, outline and textbook.
   4. MECH 5- Programmable Logic Controllers
      a) Prerequisites
      b) Equipment recommendations
   5. MECH 15- Industrial Automation Systems (Distributed Manufacturing)
      a) Various recommendations on Outcomes, Objectives and updating outline in areas where obsolete equipment is mentioned.
   6. MECH 23- Instrumentation/Process Control
      a) Prerequisites: add MECH 5
      b) Other small changes
   7. MECH 35- Industrial Communications Networks
      a) Various small changes including Fieldbus, HART, ect

VI. Advisory Board agreed that classes and program fill a need in industry and look forward to Clovis Community College moving forward with program

VII. Meeting adjourned at 9:00 pm

Clovis Community College

# Proposed Mechatronics Program and Courses 9/12/17 Draft

**Mechatronics / Industrial Automation- Program Outcomes**

*Upon completion of this program students will be able to:*

1. **Safety-** Describe the hazards associated with automated machinery and determine appropriate safety methods for working in an industrial environment.
2. **Troubleshooting-** Utilize electrical/mechanical troubleshooting and communication skills to diagnose, repair, test, and return to service failed components.
3. **Identify and Solve Problems-** Identify, analyze, and solve narrowly defined technical problems.
4. **System Design and Programing-** Use basic understanding of programing and industrial system design to enhance systems via incremental changes software and/or hardware modifications.
5. **Communication-** Apply written, oral and graphical communication skill in both technical and non-technical environments; identify and use appropriate tech literature.
6. **Teamwork, Professionalism and Quality-** Function effectively as a team member demonstrating a commitment to quality, timeliness, and continuous improvement in a professional manner.

**Courses:**

| Course | Title | Prerequisites |
|---|---|---|
| MECH 2 | Mechanical Systems | |
| MECH 3 | Electricity and Electronics (AC & DC) | |
| MECH 4 | Electric Motors - Controls | |
| MECH 5 | Programmable Logic Controllers (PLCs) | |
| MECH 15 | Industrial Automation Systems | MECH 5 |
| MECH 23 | Instrumentation and Process Control | MECH 3 |
| MECH 35 | Industrial Communications Networks | MECH 5 |
| MECH ?? | **Independent Study?** | |
| MECH 19V | **Work Experience/Internship** | ??? |

**Number:** MECH 2
**Title:** Mechanical Systems
**Units:** 4 units (3 hours lecture, 3 hours lab)
**Equipment needed:**

- **Hand tools**
  - Common hand tools (screw drivers, pliers, etc.)
  - Drilling devices, twist drills, punch presses
  - Abrasives
  - Saws and shears
  - Arbors and hydraulic presses
  - Screw threads, thread forms, and threaded fasteners
  - Pop rivets and other mechanical fasteners
  - Sheet metal shear, brake
- **Power tools**
  - Drill press
  - Hand drill
  - Pneumatic tools
  - Hand grinders and bench grinders
- **Measuring Tools**
  - Measurement Systems, Decimal Measurement, Fractional Measurement
  - Tools for dimensional measurement: rule, caliper, micrometer, depth gage
- Mini Lathe and CNC Mill
- Mechanical drive training system (gears, belts and pulleys, clutches)
- Pneumatic training system
- Hydraulic training system

**Prerequisite:** None
**Advisory:** ???

**Catalog Description:**
Introduction to machinery and machining processes, essential elements of mechanical systems, mechanical drives (gears, belts and pulleys, clutches), mechanical hardware, bushings, bearings, lubrication systems, basic properties of materials, hydraulics and pneumatics, preventive maintenance, basic hand and power tools, and basic precision dimensional measurement.

**Course Outcomes (SLOs):**
*Upon completion of this course students will be able to:*

1. Describe the hazards associated with automated machines and determine appropriate safety methods for working around machinery.
2. Perform leveling and alignment for electric motors.

        - Assembly Concepts
        - Bolt: types, sizes, grades
        - Washers
    - Wrenches: Fixed, Adjustable, Allen Ratchet
    - Pneumatic system fabrication
        - Fluid circuit components
        - Pipe thread components
        - Pneumatic fittings & tubings
    - Screwdrivers: Screws,nut drivers, flat & Phillips head screwdriver
    - Pliers and locking devices
        - Clamps & Vises
        - Pliers
        - Locking Nut Devices
        - Rings
    - Mallets and non-threaded fasteners
        - Mallets and Hammers
        - Key Fasteners
        - Press fit assembly
        - Pins
    - Torque wrench: Concepts and Applications
    - Portable Power Tools: Safety, operation

III. Mechanical Drives 1 (2 Weeks)
    - Introduction to Mechanical Drive Systems
        - Mechanical Power Transmission Safety
        - Machine Installation
        - Motor mounting
        - Shaft speed measurement
    - Key fasteners: key & seat
    - Torque and power measurement
    - Mechanical efficiency
    - Power transmission systems: shafts, bearings, couplings, alignment
    - V-belt drives: concepts, operation, tensioning
    - Chain drives: concepts, operation, tensioning, fixed center chain installation
    - Spur gear drives: concepts, designs, operation, installation, analysis
    - Multiple shaft drives: analysis, installation, sleeve couplings

IV. Mechanical Drives 2 (2.5 Weeks)
    - Heavy duty V-belt drives
    - V-belt selection and maintenance: specification, identification and troubleshooting
    - Synchronous belt drives: timing, torque, selection
    - Lubrication concepts: oils, greases, management

**Number:** MECH 3
**Title:** Electricity and Electronics (AC & DC)
**Units:** 4 units (3 hours lecture, 3 hours lab)
**Equipment:**

- Function Generator
- Power Supply
- Electronic test boards

**Prerequisite:** None

**Catalog Description:**
Introduction to electricity and electronics including basic components, electronic circuit calculations, basic electronic test equipment use, electrical measurement, relays and ladder diagrams, alternating current (AC) circuits, and electronic schematic diagrams.

**Course Outcomes (SLOs):**
*Upon completion of this course, students will be able to:*

1. Identify the production, characteristics, applications, and voltage change methods of Direct Current and Alternating Current.
2. Apply circuit analysis methods for DC and AC circuits containing resistive devices, capacitors, and inductors using Ohm's Law, Watt's Law, and Kirchoff's Laws.
3. Choose and perform measurements using multimeters, oscilloscopes, and signal generators, perform circuit fabrication using electronic schematic diagrams, and perform simple problem-isolation techniques on laboratory circuits.
4. Identify common component symbols, and explain the functions of common electronic components.
5. List the career opportunities in electronics technology, the methods for receiving training in those areas, and essential workplace skills that are needed for career success in a technical field.

**Course Objectives:**
*In the process of completing this course, students will:*

1. Solder wire and various electrical junctions
2. Use schematic to build and troubleshoot a circuit.
3. Calculate voltage, current, resistance and power in a circuit.
4. Use electrical measurement tools (i.e. multi-meter, oscilloscope)

**Course Outline:**

Lecture:
Introduction to Electricity and Electronics
Basic Electricity and Electrical Quantities (charge-voltage-current-power-energy)

Matt, Stephen R. *Electricity and Basic Electronics*. Tinley Park, Ill: Goodheart-Willcox Co, 2013. Print.

14. Demonstrate methods for reversing AC and DC motors.
15. Explain the methods for accelerating and braking motors.
16. Demonstrate ability to read and interpret technical documents.
17. Demonstrate ability to use various types of software applicable to course.

**Course Outline:**

I. Safety: lockout/tagout system, importance of equipment ground
II. Basic Electrical Motors
    - Motor specification: size, application, type
    - DC Series motor, reversing DC series motor
    - DC Shunt and compound motors
    - Motor speed and torque: calculations and measurement
    - Motor performance: power, efficiency and analysis
    - Split-phase AC motors
    - Capacitor-start AC motors
    - Permanent-capacitor and two capacitor motors
    - Three-phase AC induction motors: operation, characteristics, configurations, reversing
    - Servo motors
III. Electric Motor Control
    - Intro to motor control: Three-phase power, disconnects and protective devices
    - Manual motor control: starter operation, overload protection
    - Control transformers: operation and applications
    - Electrical control ladder logic: ladder diagram and logic elements (AND, OR, etc)
    - Control relays and motor starters: two-wire control and three-wire start/stop
    - System troubleshooting: control component, motor starter, power component
    - Reversing motor control: manual, magnetic, interlocking, hands-off-automatic
    - Automatic input devices: float & pressure switches, sequence control
    - Basic timer control: on-delay and off-delay timers
IV. VFD Wiring and PLC Wiring | Electrical Wiring Training
    - Wiring emergency stop
    - Low voltage AC drives (i.e. Powerflex drives)
V. Troubleshooting techniques and theory
    - Diagnosis of motor failure
    - Troubleshooting safety relays
    - Troubleshoot motors with a insulation tester (i.e. Megger)
    - Basic troubleshooting and programming of the VFD

**Number:** MECH 5
**Title:** Programmable Logic Controllers
**Units:** 4 units (3 hours lecture, 3 hours lab)
**Prerequisite:**
**Equipment:**
Allen Bradley Compactlogix PLC trainer
Electric Relay Control Trainer

**Catalog Description:**
The function and application of programmable logic controllers. Students will become familiar with the programming of Programmable Logic Controllers. Topics covered include bit-level input and output instructions, timers, counters, latches, documentation, and troubleshooting.

**Course Outcomes (SLOs):**
*Upon completion of this course, students will be able to:*

1. Establish communications with PLC and perform documentation control.
2. Develop ladder logic diagrams for a PLC application and program the PLC.
3. Accurately explain PLC addressing and successfully create input/output configurations.
4. Implement program timer-on/timer-off and up-counter/down counter instructions.
5. Utilize math instructions, logic comparisons, bit shift instructions and sequencer instructions in PLC programming.
6. Control PLC programs using master control reset instructions and subroutines.

**Course Objectives:**
*In the process of completing this course, students will:*
See Outline

**Course Outline:**
Lecture:

I. Programmable Logic Controller (PLC) Overview (1 week)
   - History and development
   - PLC block diagram
   - Discrete input and output modules
   - Analog input and output modules

II. PLC and Control System Components (1 week)
   - PLC Communication Systems
   - PLC Memory Maps
   - PLC Terminology

- Equal To(EQU)
- Not Equal To (NEQ)
- Less Than (LES)
- Greater Than (GRT)
- Less Than or Equal To (LEQ)
- Greater Than or Equal To (GEQ)
- Limits Test (LIM)

X. Program Control Instructions (1 week)
- Master Control Reset (MCR)
- Jump (JMP) and Label (LBL) Instructions
- Jump to Subroutine (JSR)
- Label Subroutines (SBR)
- Return from Subroutine (RET)
- Subroutine Applications

XI. Sequencer Functions (1 weeks)
- Sequencer Concepts
- Sequencer Output Function (SQO)
- Sequencer Compare Function (SQC)
- Sequencer Load Function (SQL)
- Cascading Sequencers
- Paralleling Sequencers

Lab Content:

1. View a directory of processor files using PLC software
2. Restore a PLC processor file using PLC programming software
3. Monitor a PLC processor file using PLC programming software
4. Run a PLC processor file using PLC programming software
5. Stop a PLC processor file using PLC programming software
6. Convert between Decimal and Binary
7. View the status of the PLC Input and Output Data tables
8. Create a PLC project using PLC software
9. Configure the I/O for a PLC project using PLC software
10. Enter a basic PLC program using PLC software
11. Save a PLC program to disk using PLC software
12. Edit a PLC program using PLC software
13. Generate and print out a ladder logic report using PLC software
14. View project documentation and use it to operate a PLC program
15. Document a PLC program file
16. Troubleshoot a PLC program with manual and automatic modes
17. Design a motor control program which uses both manual and automatic modes
18. Design a PLC program which has both a Halt and Cycle-Stop functions
19. Troubleshoot a PLC program which has both Halt and Cycle-Stop functions

**Number:** MECH 15
**Title:** Industrial Automation Systems (Distributed Manufacturing)
**Units:** 4 units (3 lecture, 1 lab)
**Prerequisite:** MECH 5 PLC
**Equipment:**
Capstone Mechatronics System

**Catalog Description:**
Introduction to industrial automation technologies and the procedures utilized when troubleshooting automated control systems. Topics include programmable logic controllers (PLC), machine control, industrial robots, barcode readers, material handling systems, and Ethernet communications.

**Course Outcomes (SLOs):**
*Upon completion of this course, students will be able to:*

1. Safety- Know eight mechatronics operator safety rules.
2. Design a PLC program that provides manual/auto/reset functions for a servo robotic assembly station.
3. Design a PLC program that sequences a powered parts feeder.
4. Configure and operate an automatic storage and retrieval system (ASRS).

**Course Objectives:**
*In the process of completing this course, students will:*

1. Define a pick and place automation system and give an application.
2. Define a flexible manufacturing system and give an application.
3. Describe how to manually override an electro-pneumatic valve.
4. Describe how to adjust pneumatic actuator stroke position and/or speed.
5. Describe how to manually override a magnetic motor starter.
6. Describe the operation of a digital I/O interface module.
7. Describe how to adjust a limit switch.
8. Describe how to adjust a proximity sensor.
9. Describe three types of material feeding systems: ASRS, servo robot, and non-servo pick and place.
10. Describe how to adjust a vacuum gripper.
11. Describe how to adjust a shock absorber.
12. Describe a sequence of operation of a powered parts feeder.
13. Design a PLC program that sequences a 2-axis pick and place pneumatic manipulator
14. Operate an automated gauging station
15. Describe how to adjust non-servo electric traverse axis travel
16. Adjust a synchronous belt drive
17. Design a PLC project that sequences a non-servo electric traverse axis

- Function, Operation, and Configuration of the 1747-KE Interface Module

VI. PLC Serial Communications (2 weeks)
- Communication Channels of the Allen Bradley SLC-500 PLC
- RS-232 Interface of the SLC-500
- ASCII Instructions of the SLC-500

VII. Barcode Pallet Tracking (1 week)
- Barcode System Concepts
- Barcode Readers
- Function and Operation of an Barcode Reader Network
- Operation of PLC's with Barcode Readers

VIII. Enterprise Resource Planning (1 week)
- Definitions of Computer Integrated Manufacturing
- Introduction to Enterprise Resource Planning (ERP) Software
- Manufacturing Resource Planning (MRP)
- Capacity Requirements Planning (CRP)
- Bills of Material (BOM's)
- Manufacturing Execution Systems (3 weeks)

IX. Definition of Manufacturing Execution Systems (MES)
- Introduction to MES software
- Process Planning
- Work Centers and Product Cost
- Product Routing using ERP Software

X. Manufacturing Management and Simulation (1 weeks)
- Definition of Manufacturing Order Management
- Applications of Production Planning
- Master Production Schedules
- Human Machine Interfaces (HMI)

XI. Ethernet Operation (1 weeks)
- Local Area Networks and LAN topologies
- Components of Ethernet
- Function and Operation of TCP/IP communications
- IP Addresses

XII. Ethernet Applications (1 weeks)
- File Transfer via Ethernet Communications
- Robot and PLC Programming via Ethernet

**Number:** MECH 23
**Title:** Instrumentation/Process Control
**Units:** 3 (2 lecture, 1 lab)
**Prerequisite:** MECH 3 Basic Electronics (AC & DC)
**Advisory (prerequisites):** MECH 5 PLCs, MECH 4 Motor Controls
**Equipment:**
Level/Flow Process Control Trainer
Temperature Process Control Trainer
Pressure Process Control Trainer

**Transfer:**

**Catalog Description:**
Basic principles of process instrumentation and control. Topics include: level, pressure, flow, and level measurement, final control elements, piping and instrument diagrams and tags, PID controller programming, and basic control algorithms.

**Course Outcomes (SLOs):**
*Upon completion of this course, students will be able to:*

1. Explain the operation, programming, and calibration of closed loop process controllers and control systems, including liquid level, flow, pressure, and temperature.
2. Define closed-loop tuning and give an application.
3. Create and interpret instrument tags and line symbols used in piping and instrument (P&ID) diagrams.
4. Describe the operation of current and pressure methods of transmitting instrument valves, and the applications of current-to-pressure converters.
5. Describe the operation of PID control and give an application.

**Course Objectives:**
*In the process of completing this course, students will:*

**Course Outline:**
Lecture:

- Basic Electronics Applied to Instrumentation
- Introduction to Instrumentation and Basic Industrial Measurement
- Instrumentation Symbols and Diagrams
- Process Variables
- Control Loops and Loop Controllers
- Final Control Elements
- Level Measurement and Control

**Number:** MECH 35
**Title:** Industrial Communications Networks
**Units:** 3 (2 lecture, 1 lab)
**Equipment:**
Capstone Mechatronics System

**Prerequisite:**

**Transfer:**

**Catalog Description:**
Fundamentals of Industrial communication networks including: EtherNet/IP & TCP/IP operations, setting IP addresses, remote I/O network operation/configuration/tags, and troubleshooting.

**Course Outcomes (SLOs):**

**Course Objectives:**
1. Troubleshoot control and data networks.
2. Know difference between hub and a switch
3. Learn about gateways
4. Understand different types of networks, Profibus, devicenet
5. Troubleshoot/maintain switch.
6. Use network analyzer, test cable
7. Troubleshoot HMI issues
8. Understand the difference between cat5, and cat6
9. Terminate the communication wiring and know how to run cables
10. Know how ping the node
11. Looking at packet servers, when a node is talking
12. What an IP address is what standards look like IEEE standpoint
13. How to troubleshoot fiber network
14. Understand differences between fiber vs cable

**Course Outline:**
I. Industrial Communications Networks: network operation, installation, configuration
II. Remote I/O: operation, configuration, tags
III. Produced/Consumed data and messages: transfer between controllers, message instruction
IV. Troubleshooting Ethernet/IP: viewing Ethernet/IP network counters, troubleshooting MSG instruction
V. Troubleshooting Ethernet/IP: viewing Ethernet/IP network counters, troubleshooting MSG instruction

**Number:** MECH 19V
**Title:** Work Experience/Internship
**Units:** Students may enroll for a maximum of 6 units per semester. Students earn units using the following formula: for paid work, 75 hours = 1 unit; for volunteer work, 60 hours = 1 unit.

**Prerequisite:**

**Transfer:**

**Catalog Description:**
Supervised employment, directly related to the student's major.

**Course Outcomes (SLOs):**
*Upon completion of this course, students will be able to:*
1. compare and analyze work environments related to career goal decisions.
2. evaluate work experience, in regards to human relations and skill attainment needed for gainful employment.
3. explain positive work ethics for the workplace experience
4. describe how the work experience has influenced career decisions and goals.
5. identify how classroom knowledge integrates into the workplace

**Course Objectives:**
*In the process of completing this course, students will:*
1. prepare a detailed time log and work experience record
2. assess the work environment and the skills needed to perform in the workplace
3. evaluate the work experience as it relates to career decisions
4. research and evaluate work ethics
5. prepare a work performance self-analysis
6. prepare a self-improvement plan
7. identify the future skills needed for jobs in the selected career

**Course Outline:**

**Readings:**