Wisconsin Youth Apprenticeship

Science, Technology, Engineering, & Math (STEM)

PROGRAM GUIDE

Investing in Wisconsin's Future

Department of Workforce Development

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For more information contact:

Department of Workforce Development
P.O. Box 7972
Madison, WI 53707-7972

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Science, Technology, Engineering, & Math (STEM)
YOUTH APPRENTICESHIP
PROGRAM GUIDE

Description

The Science, Technology, Engineering, & Math (STEM) cluster provides thousands of career opportunities for learners with an interest in math, science, and problem-solving. Students who pursue one of these careers will be involved in planning, managing, and providing valuable scientific research and technical services. Job possibilities abound, even in economic downturns, as more scientists and engineers are called upon to create solutions for problems ranging from the environmental to the economic, the aeronautical to the zoological[1].

Employment of scientists is projected to grow about as fast as the average for all occupations. Opportunities will differ by specialty; however, biologic scientists are expected to increase faster than the average. Growing numbers of agricultural and medicinal products from biotechnology research will drive this demand. Employment will be best for those workers well trained on equipment used in laboratories or production facilities[2].

The outlook in engineering is the same with opportunities varying by specialty. Biomedical engineers should experience the fastest growth, while civil engineers should see the largest employment increase spurred by population growth and related infrastructure demands[2].

This Youth Apprenticeship occupational area focuses on both pathways within the Science, Technology, Engineering, & Math (STEM) industry: Engineering & Technology and Science & Math. In the Engineering and Technology pathway, students study and apply principles of science and math to solve problems in engineering projects involving design, development or production in various technologies. Careers in the Science and Math pathway apply essential math and science content in a real-world application to increase knowledge in physical, environmental and human endeavors[1].

The Youth Apprenticeship Program was approved by the Wisconsin State legislature in 1991 to provide a direct link between business, schools, and youth to meet the demands of technology, teamwork, communication, and leadership.

[1] STEM Career Cluster Brochure, www.careercluster.org, October 2008.
[2] Department of Labor, Occupational Outlook Handbook, 2010-11.

Wisconsin Youth Apprenticeship (YA) is a rigorous program that combines academic and related technical classroom instruction with mentored on the job learning for high school students. By training youth apprentices, employers play an active role in shaping the quality of their future workforce, improving the skill level of potential workers, and enhancing their competitive positioning in the marketplace. Employers, school districts, local consortiums, parents, and potential YA students are referred to the Youth Apprenticeship Program Operations Manual for general YA Program requirements.

Objective

The Wisconsin Science, Technology, Engineering, & Math (STEM) YA Program is designed to provide students with a working understanding of occupational and technical skills in both pathways within the Science, Technology, Engineering, & Math (STEM) industry. This program provides the framework for educators and industry to work together to produce work-ready, entry-level employees that will compete favorably in a global market, as well as, provide for post-secondary educational advancement while integrating work-based learning in the school and worksite.

The following features distinguish a YA Program from other similar youth school to work programs.

- Level Two Youth Apprenticeship is a two-year program for high school juniors and seniors with an interest in a particular field; i.e., mechanical or electrical engineering. One-year Youth Apprenticeship Programs are also available to pursue.
- Youth apprentices, parents, employers, YA program coordinators, and school districts enter into a written agreement approved by the Department of Workforce Development.
- Statewide skills are established by the industry, making the youth apprentice skill set more relevant to the state's employers.
- Youth apprentices are trained at the worksite by skilled mentors and are paid minimum wage or better for their work. Students average 10-15 hours/week.
- Youth apprentices receive a high school diploma and a Certificate of Occupational Proficiency from the Wisconsin Department of Workforce Development (DWD) at graduation.
- Youth apprentices may receive advanced standing credit and/or transcripted credit for the YA Program at a Wisconsin Technical College and/or at some four year colleges. See **Appendix F** for current details.
- Statewide skill standards focus on skills and knowledge needed by employers for entry level employment in the Science, Technology, Engineering, & Math (STEM) industry.

Students apply and are interviewed by Science, Technology, Engineering, & Math (STEM) employers for positions in the Science, Technology, Engineering, & Math

(STEM) YA Program. The state approved skill standards and program guide for the Science, Technology, Engineering, & Math (STEM) YA Program are used in both the classroom instruction and worksite learning. If the local school district is unable to provide the related technical classroom instruction courses, they may contract with their local technical college or employer practitioners to do so.

The skill standards are competency based. Competencies are performance-based outcome statements of occupational related skills defined by representatives of Science, Technology, Engineering, & Math (STEM) worksites throughout Wisconsin and aligned with national skill standards. The competencies in this program are aligned with curriculum objectives from the Project Lead the Way (http://www.pltw.org/) and STEM Academy (http://www.stem101.org/index.asp) high school engineering and biotechnology programs, as well as, the National States' Career Cluster Skill Standards in Science, Technology, Engineering, & Math (STEM), http://www.careerclusters.org/ for both of the Science, Technology, Engineering, & Math (STEM) Career Cluster pathways: Engineering & Technology and Science & Math.

The competencies will be taught at the worksite in combination with supportive, related technical classroom instruction. While the skill competencies are established statewide, program implementation and oversight occurs through local consortium committees to assure local needs are met.

Target Population

This Youth Apprenticeship occupational area focuses on having Science, Technology, Engineering, & Math (STEM) **Engineering & Technology** pathway YA students acquire basic skills pertinent to understanding and working with drafting and engineering technical documents in the first year along with the core employability and safety skills. Students will acquire basic concepts needed to read, edit, and create basic engineering technical drawings. The second year allows these students to develop further skills in a specific specialization depending on their worksite placement or area of interest. Choices of specialization include Mechanical/Electrical Engineering or Civil Engineering.

Science, Technology, Engineering, & Math (STEM) **Science & Math** pathway YA students will work in bioscience/biotechnology settings. There they will acquire basic skills pertinent to lab work and techniques in the first year along with the core employability and safety skills. In the second year, students will further develop testing skills and become proficient in a variety of bioscience tests and applications dependent on their worksite setting.

All students successfully meeting current high school graduation requirements and with a good attendance record for that year are encouraged to apply for the Science, Technology, Engineering, & Math (STEM) Youth Apprenticeship (YA) Program. The student must apply to the program in the year previous to program entry and be on

track toward fulfilling high school graduation requirements in their school district. SEE **Appendix G** for students entering or continuing the Science, Technology, Engineering, & Math (STEM) YA Program in 2011.

All Youth Apprentices must complete the industry-wide foundational skill competencies consisting of competencies in core employability skills and safety. The Required Skill competencies may be completed concurrently with the specific technical skills.

Potential youth apprentices will be required to complete a minimum of 450 work hours with 180 hours (2 semesters) of related technical classroom instruction for a Level One (1-year) Science, Technology, Engineering, & Math (STEM) YA Program or a minimum of 900 work hours with 360 hours (4 semesters) of related technical classroom instruction for a Level Two (2-year) Science, Technology, Engineering, & Math (STEM) YA program.

Science, Technology, Engineering, & Math (STEM) YA students are required to perform all of the Core and Safety skills. **Level One (one year)** YA students also are required to complete the one year Basics Unit. **Level Two (two year)** YA students are to complete an additional second one year unit in addition to the Level One requirements.

Science, Technology, Engineering, & Math (STEM) Units

Engineering & Technology Pathway-

- Engineering Drafting Unit- REQUIRED FIRST
- Mechanical/Electrical Engineering Unit
- Civil Engineering Unit

Science & Math Pathway-

- Bioscience Lab Foundations Unit- REQUIRED FIRST
- Bioscience Applications Unit

Science, Technology, Engineering, & Math (STEM) Program Responsibilities

The following responsibilities are outlined for individuals involved in the Science, Technology, Engineering, & Math (STEM) YA Program.

Students –

1. Maintain academic skills and attendance at the high school to remain on track for high school graduation.
2. Participate in progress reviews as scheduled.
3. Exhibit maturity and responsibility to meet requirements of employment as designated by the employer.

Parents or Guardians-

4. Ensure that adequate transportation is available to and from the worksite.
5. Participate in student progress reviews as scheduled.

School District-

6. Recruit students and coordinate student enrollment in the program with the consortiums and/or employers.
7. Integrate the YA Program related technical classroom instruction and worksite training into the student's overall education program with high school graduation credit issued for each semester successfully completed.
8. Participate in student progress reviews as scheduled.

YA Program Coordinators-

9. Apply and maintain approval from the DWD to operate a YA Program.
10. Ensure a minimum of 450 hours of worksite instruction/experience plus a minimum of 180 hours of related technical classroom instruction for each one year YA program.
11. Establish and meet regularly with an advisory committee that will identify when and where tasks will be taught during the Science, Technology, Engineering, & Math (STEM) YA Program.
12. Develop and maintain a yearly commitment with participating high schools, technical colleges, and local businesses to accommodate the number of students involved in the Science, Technology, Engineering, & Math (STEM) YA Program.
13. Establish and maintain a YA student grievance procedure.
14. Provide employer mentor training.

Related Technical Classroom Instruction Faculty-

15. Qualify in the specialty areas being taught in the YA Program.

Employers and Worksite Mentors-

16. SEE **Appendix B –** Science, Technology, Engineering, & Math (STEM) YA Implementation Guide for Employers.
17. Participate in a mentor training session and provide on the job training of the Youth Apprentices.

Department of Workforce Development-

18. Monitor national and state regulatory agencies, such as OSHA, for changes and impact on the Science, Technology, Engineering, & Math (STEM) Youth Apprenticeship Program.

Program Guide Organization

The competencies in this program are aligned with curriculum objectives from the Project Lead the Way (http://www.pltw.org/) and STEM Academy (http://www.stem101.org/index.asp) high school engineering and biotechnology programs, as well as, the National States' Career Cluster Skill Standards in Science, Technology, Engineering, & Math (STEM), http://www.careerclusters.org/ for both pathways: Engineering & Technology and Science & Math.

The Science, Technology, Engineering, & Math (STEM) YA Program also requires that Related Technical Classroom Instruction is provided to support attainment of the knowledge necessary to master the competencies. While recommendations for specific Related Technical Classroom Instruction are detailed separately in **Appendix C**, instructional requirements will vary depending on local consortium and advisory group decisions. It is strongly advised that local consortiums work with their advisory groups to determine appropriate Related Technical Classroom Instruction based on their local needs and resources.

The Youth Apprenticeship Program curriculum is written and organized according to the Worldwide Instructional Design System (WIDS) format and includes the Science, Technology, Engineering, & Math (STEM) YA Skill Standards Checklist and Course Outcome Summary (COS) for the program. Overall progress is documented on the Skill Standards Checklist which lists skill level achievement for each competency achieved. The COS outlines each skill competency with its corresponding performance standards and learning objectives. The Performance Standards describe the tasks and behaviors, as applicable, that employers should look for in order to evaluate the competency. The Learning Objectives outline the recommended content to be covered in the related technical classroom instruction. SEE **Appendix D** - Wisconsin Instructional Design System (WIDS) Format and Youth Apprenticeship Program Guide Terms and **Appendix E** - Use and Distribution of the Curriculum for further details.

Evaluation

The student must successfully complete the related technical classroom instruction and demonstrate the minimum skill level required on the Science, Technology, Engineering, & Math (STEM) YA Skill Standards Checklist for each competency according to the applicable curriculum. Worksite mentors and/or instructors use this checklist to evaluate the learner on each of the required skills. It is the responsibility of the mentor(s) to rate the students skill level on all tasks performed at the worksite.

Science, Technology, Engineering, & Math (STEM) YA Program Completion

Upon successful completion of high school and the Level Two (2 year) Science, Technology, Engineering, & Math (STEM) YA Program requirements, the youth apprentice will receive a high school diploma and the applicable Certification of Occupational Proficiency from the Department of Workforce Development indicating "Science, Technology, Engineering, & Math (STEM) Youth Apprenticeship." Youth Apprentices who successfully complete a Level One (1 year) Science, Technology, Engineering, & Math (STEM) YA Program and who are on track for graduation will be eligible for a Level One Certificate from the Department of Workforce Development. Furthermore, the YA students may;

1. Continue to work in the Science, Technology, Engineering, & Math (STEM) industry.
2. Apply to a registered apprenticeship.
3. Pursue a degree or diploma from a Wisconsin Technical College with advanced standing and/or transcripted credit.
4. Apply for admission to a four-year University of Wisconsin school with high school academic elective credit for admission.
5. Go into military service.

SEE **Appendix F** for current agreements for post-secondary credit at Wisconsin Technical Colleges and University of Wisconsin colleges.

This curriculum was developed through a Grant from the Wisconsin Department of Workforce Development to the University of Wisconsin-Oshkosh's Center for Career Development and Employability Training (CCDET)

Appendices

Appendix A - Work Contracts, Child Labor Laws, Liability & Insurance

Appendix B - Science, Technology, Engineering, & Math (STEM) YA Implementation Guide for Employers

- Benefits to the Employer
- Role of the Employer
- Role of the Mentor
- Checklist for Program Participation
- Checklist for Program Operation
- Frequently Asked Questions
- Work Contracts, Child Labor Laws, Liability & Insurance (insert Appendix A)

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Appendix D - Wisconsin Instructional Design System (WIDS) Format and Youth Apprenticeship Program Guide Terms

Appendix E - Use and Distribution of the Curriculum

Appendix F - Post Secondary Credits

Appendix G - Grandfather Clause – Program Transition Guidelines

Appendix H - Science, Technology, Engineering, & Math (STEM) Skill Standards Checklist

Appendix I - Science, Technology, Engineering, & Math (STEM) YA Course Outcome Summary: Overview and Table of Contents (COS)

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Appendix K- Engineering Drafting Unit (Unit 3)

Appendix L- Mechanical/Electrical Engineering Unit (Unit 4)

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Appendix N- Bioscience Lab Foundations Unit (Unit 6)

Appendix O- Bioscience Applications Unit (Unit 7)

Appendix A

WORK CONTRACTS, CHILD LABOR LAWS, LIABILITY & INSURANCE

WORK CONTRACTS

Education Training Agreement -

Students and employers participating in an approved youth apprenticeship program must have a signed Education/Training Agreement (ETA) on file with both the school AND the employer. Employers without a valid ETA may be assessed (a) double compensation in the event of injury on the job, and/or (b) fines ranging from $25 to $1,000 for every day without a permit for a first offense to $250 to $5,000 for every day without a permit for a second offense within a five year period. The Local Youth Apprenticeship Coordinator will provide the employer with a copy of the ETA. This form is also available from the Department of Workforce Development at http://dwd.wisconsin.gov/youthapprenticeship/forms_pubs.htm

Work Permits -

Students and employers participating in an approved youth apprenticeship program do not need to obtain a separate work permit for the work to be performed as a part of the youth apprenticeship program, **although it is highly recommended**. If employers hire the youth apprentices to perform other work duties outside of their youth apprenticeship duties, a work permit will be required. Employers without a valid work permit (if applicable) may be assessed (a) double compensation in the event of injury on the job, and/or (b) fines ranging from $25 to $1,000 for every day without a permit for a first offense to $250 to $5,000 for every day without a permit for a second offense within a five year period.

CHILD LABOR LAWS

Youth apprentices enrolled in approved youth apprenticeship programs and their employers are subject to all state and federal child labor laws regarding the employment of minors. The Department of Workforce Development (DWD) will review all statewide youth apprenticeship curriculum for compliance with the child labor laws and will clarify the laws whenever necessary to allow for program implementation. Youth apprentices are allowed to work in some prohibited occupations because they meet the criteria of "student learner" AND the work performed is incidental to their training and is for intermittent and for short periods of time (DWD 270.14(3)(c)1). However, they are not exempt from the child labor laws by virtue of being enrolled in a youth apprenticeship program. Students and employers must comply with child labor laws with regard to daily/weekly hours, time of day, employment, etc.

While DWD can interpret the law, DWD cannot exonerate employers from liability should an accident occur on the job which results in injury to an employee and a subsequent lawsuit. Determining liability for an accident can only be settled in a court of law. DWD can assure employers that they will not be cited (by DWD) for illegally employing a minor in a prohibited occupation as long as the students are enrolled in a DWD approved youth apprenticeship program and a signed Education/Training Agreement is on file with both the student's high school and the employer. This means that employers will not be assessed treble fines should an injury occur which results in the employer being cited.

Readers should refer to DWD 270.12 and 270.14 Child Labor Laws for descriptions and definitions of the occupations or activities which are normally prohibited to minors.

Science, Technology, Engineering, & Math (STEM)-

Youth apprentice students who are 16-17 years old can perform the following tasks, *only after appropriate operation/safety training* AND *only as indicated below*. The ***student learner exception*** limits the minor to using ***hazardous*** equipment on an incidental basis [less than 5% of their work time] and only occasionally [can't be a regular part of their job]. For example, the student learner exception works better in a job like carpentry where most of the work is acceptable but once in a while you might need the minor to use a portable saw to cut a piece to fit. Further interpretation or clarification of Child Labor Laws should be directed to the Department of Workforce Development (DWD) Labor Standards Bureau Director.

- Woodworking Power-drive Machine Use (270.12(27))-
  - Minors may operate power-driven woodworking machines **only if** placing of material on a moving chain or in a hopper or slide for automatic feeding. *All other types are considered hazardous.*
  - "*Power-driven woodworking machines*" means all fixed or portable machines or tools driven by power and used or designed for cutting, shaping, forming, surfacing, nailing, stapling, wire stitching, fastening, or otherwise assembling, pressing, or printing wood or veneer.

- Saws and guillotine shears (270.12(25))-
  - Students may operate or assist on these types of machines **only if** they are equipped with automatic feed and ejection. *All other types are considered hazardous.*

- Metal forming, punching and shearing power-driven machines (270.12(19))-
  - Students may operate or assist on pressing or punching machines such as punch presses machines **only if** they are equipped with automatic feed and ejection, as well as, a fixed barrier guard to prevent the hands or fingers of the operator from entering the area between the dies; power presses; and plate punches. *All other types are considered hazardous.*

- Infectious Agents (270.12(13))-

- Students may work with bacterial, mycoplasma, fungal, parasitic or viral agents **only if** they do not cause illness in humans or human fetuses or both.

- Radioactive Substances and Ionizing Radiations (270.12(23))-
  - Students are **not allowed** in any workroom where any mixture of phosphorescent material and radium, mesothorium, or other radioactive material is stored, used, or made OR incandescent mantles made from fabric and thorium salt solutions are processed and packaged.
  - Students may work in workrooms with *other* radioactive substances **only if** the radioactive substances present in the air are average concentrations less than 10% of maximum permissible concentrations recommended for occupational exposure.
  - Students may work in workrooms with ionizing radiation **only if** exposure to ionizing radiations is less than 0.5 rem per year.

- Motor Vehicle Driver and Outside Helper (270.12(21))-
  A minor, **age 17**, may operate a motor vehicle as a part of employment **only if**:
  - the vehicle does not exceed 6,000 pounds gross weight;
  - driving is done during daylight hours only;
  - the driving amounts to no more than 20% of the work week or 1/3 of the work day;
  - the student has attended drivers' education training and holds a valid driver's license;
  - the driving takes place within a 30-mile radius of the minor's place of employment;
  - the minor has no record of any moving violations at the time of hire; and
  - the driving does not involve: towing of vehicles, route deliveries or sales, transportation for hire, urgent time-sensitive deliveries, transporting more than 3 passengers who are employees of employer at one time.

Student Learner Criteria -

In order to be considered a student learner, youth apprentices must meet the following criteria:

1. They are enrolled in a youth apprenticeship program approved by DWD;
2. They are enrolled in school and receiving school credit for program participation;
3. They receive appropriate safety instruction at the school and at the workplace;
4. The work performed is under direct and close supervision of a qualified and experienced person;
5. The ***work performed in any occupation declared hazardous*** is incidental to their training and is for intermittent and short periods of time (refer to DWD 270.14(3)(c)1; and
6. There is a schedule of organized and progressive work processes to be performed on the job (i.e. the worksite is following the state curriculum);

Hours of Work -

The hours an apprentice spends working in the program *during* the hours school is in session during the day DO NOT COUNT towards the limitation on total hours a minor may work. See the DWD Child Labor web site for applicable hours and times of the day that minors may work in Wisconsin.

LIABILITY AND INSURANCE

As employees of the company, youth apprentices are covered by worker's compensation in the event of injury on the job. Employers should review their specific liability coverage to ensure there are no restrictions on employing minors and/or on coverage of minors operating particular machinery. Schools are not allowed to cover youth apprentices through their own workers' compensation policy while the youth apprentice is an employee of the local business.

As stated previously, DWD and/or local schools cannot exonerate employers from liability if a youth apprentice is injured on the job and a subsequent lawsuit is filed against the employer. Determining liability for an accident can only be settled in a court of law and will be based on the specific circumstances for each case. It is important that a signed ETA be on kept on file by both the school and the employer to ensure that employers will not be cited for illegally employing a minor in a prohibited occupation.

General Liability –

An employer is liable for the service provided at their facility. In general an employer has adequate general liability and workers compensation coverage, no additional liability is required as a result of the Youth Apprenticeship program. However, before participating in the program, an employer may wish to consult with their insurance carrier.

Transportation –

In general, the party responsible for transportation is liable in case of an accident. Youth apprentices responsible for their own transportation to and from the worksite are responsible for their own insurance. In instances where the school provides transportation for the youth apprentices, the school is responsible for insurance coverage. Only if the facility provides transportation to and from work for the youth apprentice is the facility responsible for this insurance coverage.

Workers Compensation –

Once a youth apprentice becomes a paid employee they must be covered by the employer's workers compensation coverage.

Unemployment Compensation –

If a youth apprentice is enrolled full-time in a public educational institution and receives school credit for their participation in the YA program, then they are NOT eligible to file for unemployment compensation from the employer. Youth apprentices who do NOT meet this criteria may be eligible for unemployment compensation benefits.

Worker Displacement –

No employer may hire a youth apprentice who will displace any currently employed worker, including a partial displacement, such as reduction in the hours of non-overtime work, wages, or employment benefits.

Layoffs/Strikes –

A youth apprentice cannot be hired when any other individual is on temporary layoff, with the clear possibility of recall, from the same or equivalent job OR if the employer has terminated the employment of any regular employee, or otherwise reduced the workforce, with the intention of filling the vacancy created with a youth apprentice. Local bargaining units should determine the status of youth apprentices already working in the facility in the event of a layoff. Youth apprentices may be laid off or transferred to work areas to take the place of laid off workers. Child labor laws prohibit youth apprentices from working in a company where a strike or lockout is in active progress.

Collective Bargaining Agreements –

The youth apprenticeship program should not impair existing contracts for services or collective bargaining agreements. Any youth apprenticeship program that would be inconsistent with the terms of a collective bargaining agreement shall be approved only with the written concurrence of the labor organization and employer involved.

Appendix B

Wisconsin Science, Technology, Engineering, & Math (STEM) Youth Apprenticeship
Implementation Guide for Employers

BENEFITS TO THE EMPLOYER

The Science, Technology, Engineering, & Math (STEM) cluster provides thousands of career opportunities for learners with an interest in math, science, and problem-solving. Students who pursue one of these careers will be involved in planning, managing, and providing valuable scientific research and technical services. Job possibilities abound even in economic downturns as more scientists and engineers are called upon to control and solve problems ranging from the environmental to the economic, the aeronautical to the zoological[1].

Employment of scientists is projected to grow about as fast as the average for all occupations. Opportunities will differ by specialty; however, biologic scientists are expected to increase faster than the average. Growing numbers of agricultural and medicinal products from biotechnology research will drive this demand. Employment will be best for those workers well trained on equipment used in laboratories or production facilities[2].

The outlook in engineering is the same with opportunities varying by specialty. Biomedical engineers should experience the fastest growth, while civil engineers should see the largest employment increase spurred by population growth and related infrastructure demands[2].

By working with the STEM Youth Apprenticeship Program you make an investment in the young people in your community. You will have access to a dependable recruitment pipeline of entry level workers that can be used to increase workforce diversity and provide supervisory opportunity for staff. You will be directly involved in the economic development efforts of your community as well as become a part of the creation of highly skilled workers, an excellent point in any public relations marketing.

A unique opportunity and added incentive for participation in the STEM Youth Apprenticeship Program for both the employer and the student is that the competencies are aligned with the curriculum objectives of the Project Lead the Way and STEM Academy high school engineering and biomedical programs, the national occupational skill standards recognized by the National States' Career Cluster Skill Standards in STEM, http://www.careerclusters.org/, and the Secretary's Commission on Achieving Necessary Skills (SCANS).

[1] STEM Career Cluster Brochure, www.careercluster.org, October 2008.
[2] Department of Labor, Occupational Outlook Handbook, 2010-11.

Employers also play an active role in improving the quality of the future workforce by helping develop skill standards geared to employer needs, reducing employee turnover by hiring program graduates, supporting program graduates as they continue their education in post-secondary settings, raising the interest of other employees in education and training, and increasing the potential for teamwork and flexibility in work sharing. One employer noted, "This program is the single most effective use of taxpayer dollars to link our business community to the workforce and training needs of the community. We must expand, celebrate, promote and encourage participation in this endeavor. I have personally gained staff, changed some lives, and enjoyed the successes of the participants. It has enriched our staff in learning to operate as mentors, and enhanced our perception in the community as involved participants.[3]"

ROLE OF THE EMPLOYER

The work-based learning component of the Youth Apprenticeship Program is the **primary** method for teaching the required competencies. The local business becomes an extension of the classroom for the youth apprentice. The related classroom instruction is intended to *support* the work-based learning experience by providing theoretical knowledge and, when needed, providing appropriate skill development. The work-based learning component is designed to provide an on-the-job learning environment for students by being "apprenticed" to an experienced mentor.

As an employer of a youth apprentice, you will be responsible for the following:

Student Selection

Review employment applications, interview candidates, and select the student(s) they want to hire. New Employee Orientation is provided by you according to your facility's Human Resources policies.

Wages

Youth apprentices must receive minimum wage or higher. A pay schedule is agreed upon with the employer, local YA coordinator and the student. Most employers grant periodic raises dependent upon performance or length of employment.

Workers Compensation

Once a youth apprentice becomes a paid employee they must be covered by the employer's workers compensation coverage. Other benefits may be provided at the discretion of the employer.

Education/Training Agreement (ETA)

Employers must sign and comply with the requirements in the ETA, and have a copy on file. See *Appendix A* "*Work Contracts, Child Labor Laws, Liability & Insurance"* for more detail.

[3] Kent Olson, YA Employer, Wausau, WI

Work Permits
See *Appendix A* "*Work Contracts, Child Labor Laws, Liability & Insurance"* for more detail.

Child Labor Laws
Employers must ensure that the work of any student at their worksite is allowed by Child Labor Laws and is under the direct and close supervision of a qualified and experienced person. Students must be provided with adequate safety training both in the school and at the worksite. All STEM Youth Apprenticeship skill standards competencies have been reviewed by the Wisconsin Department of Workforce Developments Labor Standards Bureau and are in compliance with the child labor rules.
See *Appendix A* "*Work Contracts, Child Labor Laws, Liability & Insurance"* for more detail.

Unemployment Compensation
YA students are typically not eligible for unemployment compensation from the employer.
See *Appendix A* "*Work Contracts, Child Labor Laws, Liability & Insurance"* for more detail.

Job Performance
Employers review, evaluate, and report on the youth apprentice's job performance approximately every nine weeks to ensure they are learning the required competencies. Mentors are expected to participate in progress reviews with the apprentice, school staff and/or Youth Apprenticeship instructors, and parent(s)/guardian(s).

Worksite Hours
Employers must provide for the youth apprentice to meet the following work requirements:

- Youth Apprentices in a Level Two (2-year) program must complete a *minimum* of 900 hours of work-based learning while they are enrolled in the program. At least 500 hours of the required minimum work-based learning hours must take place when related classes are being held, so that classroom instruction can be integrated with worksite learning.

- Youth apprentices in a Level One (1 year) program must complete a *minimum* of 450 hours of work based learning while they are enrolled in the program. At least 250 hours of the required minimum work-based learning hours must take place when related classes are being held, so that classroom instruction can be integrated with worksite learning.

- Youth apprentices may work *more* than the required minimum hours throughout the program as long as they do not exceed the daily or weekly hours allowable under the child labor laws.

Training to Competencies
The employer is responsible for providing the worksite training required to meet the skills standard competencies specified in the applicable STEM area. This requirement means that while the youth apprentice may be hired under one particular job function, he/she must be allowed to rotate and perform other functions in other departments to meet competencies if some of them are not normally a part of that job function.

Mentors
Employers assign worksite mentors to supervise and train youth apprentices. They also allow the mentors to attend special training classes provided by the local YA consortium to become successful mentors of high school apprentices.
See "Role of Mentors" below for more detail.

Organized Labor
Usually the STEM Youth Apprenticeship is considered an educational activity rather than a job classification/position status. However, the youth apprenticeship program should not impair existing contracts for services or collective bargaining agreements. Any youth apprenticeship program that would be inconsistent with the terms of a collective bargaining agreement shall be approved only with the written concurrence of the labor organization and employer involved. If youth apprentices will be working in areas covered by labor agreements, organized labor must be involved to approve the program at the worksite.
See *Appendix A* "*Work Contracts, Child Labor Laws, Liability & Insurance"* for more detail.

ROLE OF THE MENTOR

Workplace mentors are one of the most critical elements which often determine the success of a youth apprenticeship. One mentor may work with more than one youth apprentice at a worksite, and the mentor may assign multiple "trainers" to instruct the youth apprentice while they rotate among various departments.

Effective Mentor Qualifications.

- Experience working with adolescents either on the job, through family, or through outside activities
- Effective teaching/training skills with adults and/or youth
- Highly skilled in the area in which the youth apprentices will be trained
- Good communication skills in the workplace
- Knowledge of and commitment to the STEM Youth Apprenticeship program

Mentor Responsibilities.

- Develop a cooperative training schedule for the youth apprentice to ensure performance of the required work-based skills
- Work with instructors to coordinate the application of classroom learning objectives to the worksite
- Communicate regularly with the school, YA coordinator, and the instructor to ensure work-based learning objectives are being met
- Demonstrate tasks to youth apprentices and explain their importance
- Identify other trainers appropriate to train youth in the required competencies
- Evaluate the youth apprentice's progress on a regular basis and document achievements and skills
- Meet with the student, the student's parent(s)/guardian(s), and school staff and/or YA instructor at least once each grading period to review and update them on the student's progress
- Provide encouragement, support, and direction about the work site culture and skills
- Help the youth apprentice build self-confidence and self-esteem
- Be alert to personal problems that may affect the apprentice's work performance and guide them to seek help from appropriate sources
- Attend mentor training workshops and mentor meetings

Obtain additional resources for mentoring guidance from your YA coordinator.

CHECKLIST FOR PROGRAM PARTICIPATION

The following checklist will help you to participate in an STEM Youth Apprenticeship (YA) Program. Youth Apprenticeship coordinators are available to meet at your location to facilitate any phase of the YA program.

- Discuss the STEM YA program with the local partnership that offers Youth Apprenticeship Programs.
- Consult with the management team of your organization and union officials, if applicable.
- Obtain approval from appropriate organization officials to hire youth apprentices.
- Identify mentors and arrange for mentor training through your local YA Coordinator.
- Interview STEM YA candidates for the program.
- Select youth apprentice(s).
- Sign Education/Training Agreement (ETA).
- Secure a Work Permit form.
- Orient your new youth apprentice to the workplace according to your organization's Human Resources policies.

CHECKLIST FOR PROGRAM OPERATION

The following checklist will help ensure continued operation of the STEM Youth Apprenticeship (YA) Program.

- Provide worksite training according to the STEM Youth Apprenticeship Area curriculum.
- Participate in progress reviews with youth apprentices, school staff and/or YA instructors, and parents/guardians.
- Meet regularly with the youth apprentices to discuss their performance and any other issues.
- Employ youth apprentices during school breaks, either part-time or full-time.
- Participate in recognition events organized by the school for youth apprenticeship graduates.

FREQUENTLY ASKED QUESTIONS

For questions not addressed here, do not hesitate to call your local youth apprenticeship coordinator or visit the Department of Workforce Development Youth Apprenticeship website.

How does this program differ from other work-based programs like coop education?
Skilled Certified Coop Education and Youth Apprenticeship are similar in that they are both components of Wisconsin's overall school to work transition programs. An important difference, however, is that Youth Apprenticeship students are exposed to an occupational cluster versus a specific job. Additionally, the skills the student learns are developed in association with Wisconsin STEM personnel, Wisconsin technical college faculty, YA consortium coordinators, and school district coordinators/instructors. The curriculum is standardized throughout the state.

Will the mentor have to spend his/her entire time at work teaching the student?
No. Apprentices need to be supervised, but you are not required to "shadow" them at all times. However, someone should be available for guidance as necessary. One mentor may work with more than one youth apprentice at a worksite, and the mentor may assign multiple "trainers" to instruct the youth apprentice while they rotate among various departments.

Will the student do productive work?
Yes. After appropriate training, youth apprentices can become productive employees of the facility. However, since they are often rotated through different departments they will require more training time than employees who stay in the same department. It is important to remember that this is a training program. Upon completion of the probationary period, students are expected to meet the requirements of the position.

Will there be a lot of paperwork for me to complete?
Prior to the program, employers are required to sign the Education Training Agreement and maintain it. During the program, employers are expected to verify the youth apprentice's skills on the job and provide input during grading periods. Mentors must

complete/maintain a simple “Skill Standards Checklist” as the student completes their competencies.

What happens if I cannot provide all of the required competencies at my facility?
In order to successfully complete the program and receive a Certificate of Occupational Proficiency, the youth apprentice must demonstrate proficiency in all areas required on the Skill Standards Checklist. If your facility does not provide the full range of services needed for competency mastery, the local youth apprenticeship coordinator may be able to arrange for the missing skills to be provided by another company. This arrangement should be discussed with the coordinator before you hire the youth apprentice.

What costs will my business incur and will I be reimbursed?
Primary costs to the employers are the wages paid to the youth apprentice and mentor during the training period.

Will I have to treat the youth apprentice differently than my other employees?
It is important to remember youth apprentices are placed in your facility to learn. Patience and guidance are required while they learn responsible work habits as well as the required skills. However, they are expected to follow your facility’s work rules, e.g., dress code, behavior, discipline, etc., and to become a productive member of the STEM team.

What is the typical time frame for activities over the course of a youth apprentice’s stay with a facility?
Most program activities follow a one-year or two-year cycle depending on the offerings within your company. There may be variance in the timing of learning activities to accommodate local and seasonal needs including trainer availability.

Appendix C

RECOMMENDATIONS FOR RELATED TECHNICAL CLASSROOM INSTRUCTION FOR SCIENCE, TECHNOLOGY, ENGINEERING, & MATH (STEM) YA

These recommendations are intended to be used by the Local YA Consortium when determining appropriate related technical instruction for Science, Technology, Engineering, & Math (STEM) YA. It is not all inclusive but should be used to assist the partnership with identification and/or development of course work that supports the work-based competencies as identified in the Skill Standards Checklist. As with all YA programs the consortium must ensure that the related instruction meets with the approval of their administration and school board.

OPERATIONAL NOTES

- Related Technical Classroom Instruction maybe offered by the employer, within the school district, at another school district, at a Wisconsin Technical College, and/or at a Community College or University by instructors qualified according to the Youth Apprenticeship Program Operations Manual.

- Learning Objectives are the foundation of related technical classroom instruction. Consortiums may teach using locally developed coursework, however, it is recommended that agreements with the local technical college be pursued to obtain post-secondary credit for YA worksite and classroom experiences.

- A minimum of 180 hours (2 semesters) of related technical instruction is required for each one year YA program with 250 of the **work** hours coinciding with the instruction. The student must also receive high school credit towards graduation for this instruction, no matter the provider.

- It is suggested that the following courses or learning experiences be provided as a pre-requisite OR concurrently for students interested in this youth apprenticeship:
    - Introduction to STEM Careers
    - Engineering Pathway-
        - Basic Drafting with CAD software
        - Introductory overview of production/fabrication OR construction processes depending on specific area of interest
        - Strong math skills
    - Science Pathway-
        - Basic lab safety & techniques
        - Advanced science classes such as Molecular or Micro-Biology
        - Strong math skills
    - Additionally, students should complete a job shadow prior to enrollment in the STEM YA program.

- Commercial programs or Employer provided classroom certification programs are also appropriate provided that the student receives high school credit towards graduation for the class work. A variety of commercial courses are available. Programs that support Engineering or Biotechnology learning based on the Project Lead the Way curriculum units (http://www.pltw.org/) or STEM Academy curriculum units (http://www.stem101.com/index.asp) are appropriate for this YA program.

- Courses chosen should coincide as much as possible to occupational program requirements if the student intends to continue in the Wisconsin Technical College System or University of Wisconsin system.

- Recommendations for this Appendix were obtained from Employers, Wisconsin Technical College Faculty, Wisconsin secondary Career and Technical Education teachers, and YA Consortium/School District Coordinators during the STEM YA Survey, August 2010, and through the States' Career Clusters recommendations at http://www.careerclusters.org/- Funded in part by the U.S. Department of Education.

Science, Technology, Engineering, & Math Youth Apprenticeship (YA) Plan of Study

NAME: _____ **DATE:** _____

The STEM Youth Apprenticeship Pathway Units and Related Technical Instruction course selection and delivery are entirely within local consortium control. The recommendations listed below are only a suggested path of YA STEM career planning and should be individualized to meet each learner's educational and career goals. All plans should meet high school graduation requirements, as well as, college entrance requirements if applicable.

HIGHLY Recommended for **STEM** YA students

Educational Level	Grade	**English/ Language Arts** 4 required	**Social Studies Social Sciences** 3 Required	**Math** 2 Required	**Science** 2 Required	**Career Pathway Courses** **(Electives)**	**Recommended Enhancement Electives or Activities**
Secondary	**9**	Oral Communications (Speech) Business Communications		Algebra	Biology	• IT Applications • Engineering Pathway- ○ Computer Aided Drafting (CAD) ○ Basic Fabrication or Building Processes ○ Project Lead the Way, STEM Academy or similar • Bioscience Pathway- ○ Project Lead the Way, STEM Academy or similar	• Skills USA • 4H STEM • Battle Bots IQ • Lego Robotics • Science Olympiad
	10			Geometry	Chemistry		
	11			Algebra II	Physics	**STEM Youth Apprenticeship - Level One or Two** • Employability Skills • Customer Service • Bioscience Pathway- Lab Safety & Techniques	
	12			Trigonometry Calculus	Advanced Science in Pathway		

Post-Secondary Occupational Opportunities

The chart below shows examples of career ladders organized by pathway.
For additional career cluster information, visit www.careerclusters.org
For additional career information on a specific occupation, visit http://wiscareers.wisc.edu/ or http://worknet.wisconsin.gov/worknet/default.aspx

Science, Technology, Engineering, & Math (STEM) Pathways		High School Diploma, On-the-Job Training	Certificate, Licensing, and/or Associate's Degree (1-2 years college)	Bachelor's/Master's Degree (4 year college)
	Engineering & Technology	Drafter Helper Electrician Power Plant Operator	Agricultural Technician Applied Engineering Technician CAD Technician Civil Drafter Electronics Technician Electrical Drafter Industrial Engineering Technician Mechanical Drafter Nuclear Technologist Sound Technician Survey Technician	Aerospace Engineer Architectural Engineer Biomedical Engineer Chemical Engineer Commercial product designer Electrical Engineer Geothermal Engineer Industrial Engineer Mechanical Engineer Metallurgist Nuclear Engineer Systems Engineer Technical Writer Transportation Engineer
	Science & Math	Lab Aide	Animal Breeder Biomedical Technician Chemical Technician Food Quality Assurance Lab Technician Forest & Conservation Technician Geological Technician Medical Lab Technician	Analytical Chemist Archeologist Biologist Ecologist Environmental Scientist Food Scientists Forester Hydrologist Geologist Marine Scientist Materials Scientist Meteorologist Nanobiologist Science Teacher Soil & Plant Scientist Zoologist

SOURCES: The States' Career Clusters Initiative, 2010, www.careerclusters.org; Worknet, 2010, http://worknet.wisconsin.gov/worknet/default.aspx, Waukesha County Technical College (WCTC), Susan Maresh, Waukesha County School-to-Work, 2007.

Appendix D

WISCONSIN INSTRUCTIONAL DESIGN SYSTEM (WIDS)
FORMAT AND YOUTH APPRENTICESHIP PROGRAM GUIDE TERMS

WIDS/YA Program DOCUMENTS:

Course Outcome Summary (COS)
The list of *competencies* and corresponding *performance standard criteria, conditions, and Learning Objectives* required for competency mastery

Science, Technology, Engineering, & Math (STEM) YA Program Guide
Description of the Science, Technology, Engineering, & Math (STEM) YA Program. In WIDS, this information is located in the Program Outcome Summary (POS)

Skill Standards Checklist
Listing of ALL the competencies in ALL of the industry-wide and industry-specific skill areas. The checklist provides the overall documentation for DWD of the skill achievement levels for the competencies in the Specialty Areas

WIDS TERMS:

Competency
The major skill or outcome stated in observable, measurable terms telling learners what they must be able to do AFTER a learning experience.

Performance Standards
Specifications by which performance of a competency will be evaluated (criteria) and the circumstances/situation (condition) in which the competency will be evaluated.

Core Skills
Competencies that address the abilities, values, and attitudes required for productive and successful employment.

Learning Objective
The background knowledge that is needed in order to master the competency; the related technical classroom instruction information needed by the learner to master the competency.

Appendix E

USE AND DISTRIBUTION OF THE CURRICULUM

New and current employers should be given at least one set of the complete curriculum package. The curriculum package includes a copy of the **Program Guide**, **Skill Standards Checklist** (https://dwd.wisconsin.gov/dwd/forms/dws/detw-17020-e.htm), and the **Course Outcome Summary (COS)**. In particular, the performance standards on the COS should be highlighted with the employer mentor(s) so that they know HOW to assess the learner for competency evaluation.

All related technical classroom instructors will need to be provided with the **Course Outcome Summary (COS**) in order to see the Learning Objectives for the related technical classroom instruction. The local Science, Technology, Engineering, & Math (STEM) Youth Apprenticeship advisory group should determine the requirements and delivery of the required related technical classroom instruction ***prior to*** offering this YA program in the local consortium area. The advisory group should ensure that each learning objective is being taught either at the employer facility, school, and/or technical college.

At the beginning of the Science, Technology, Engineering, & Math (STEM) YA program, student learners should receive a copy of the **Skill Standards Checklist** (https://dwd.wisconsin.gov/dwd/forms/dws/detw-17020-e.htm) and the applicable pages from the **Course Outcome Summary (COS)** to review with their instructor(s) and worksite mentor(s). This is the opportunity for instructors and mentors to highlight the worksite experiences, related technical classroom instruction, and assessments that will occur. In a performance-based curriculum successful learning is enhanced when the learners have the opportunity to review what will be expected of them in advance of the lessons.

It is recommended that a portfolio be prepared for EACH learner. The learner should be given the responsibility for maintaining this documentation and making it available to the instructor and/or worksite mentor for recording performance assessments.

When the performance criteria are completed successfully, the learner achievement level information must be recorded on the **Skill Standards Checklist** (https://dwd.wisconsin.gov/dwd/forms/dws/detw-17020-e.htm). The completed Skill Standards Checklist is the piece of documentation required by DWD in order to issue the Certification of Occupational Proficiency.

Appendix F

POST SECONDARY CREDITS

Wisconsin Technical College System

Graduates of one-year or two-year Science, Technology, Engineering, & Math (STEM) Youth Apprenticeship programs may be awarded credits in Wisconsin Technical College programs. Each Technical College may grant credit through specific local articulation agreements. Contact the local technical college to determine the number and type of articulated credits available for Science, Technology, Engineering, & Math (STEM) YA. The credits may be taken as technical college courses within Youth Apprenticeship programs or may be granted through advanced standing agreements when students enroll in the technical college.

In addition, YA students should request a credit evaluation of their YA classroom and work experiences upon admission to the local technical college under the Wisconsin Technical College System "Credit for Prior Learning Policy" #323 and through the WTCS-YA Credit Articulation Guidance Document http://dwd.wisconsin.gov/youthapprenticeship/pdf/wtcs_ya_articulation_guidance_10_2010.pdf.

UW Institutions Credits for *Admission* –

Admission Credits for the *revised* Science, Technology, Engineering, & Math (STEM) Youth Apprenticeship Program are yet TO BE DETERMINED.

The following website lists the current agreement for the acceptance of high school credit for UW four year university admission in Drafting & Design- Engineering YA and Biotechnology YA: UW System Acceptance of YA Program Credit (http://uwhelp.wisconsin.edu/preparing/youth.aspx#biotech)

Appendix G

GRANDFATHER CLAUSE – PROGRAM TRANSITION GUIDELINES

For NEW and CONTINUING Science, Technology, Engineering, & Math (STEM) YA Students

- If the student begins Science, Technology, Engineering, & Math (STEM) YA using the OLD checklist in Drafting & Design- Engineering, Drafting & Design- Mechanical Design, or Biotechnology YA, then the student must complete the YA program using the OLD checklist. The appropriate Level One or Level Two Certificate of Occupational Proficiency from the Wisconsin Department of Workforce Development (DWD) will be awarded.

- Senior graduating in 2012 **Level One** YA: The youth apprentice may complete either an OLD checklist in Drafting & Design- Engineering, Drafting & Design- Mechanical Design, or Biotechnology YA OR use the revised Science, Technology, Engineering, & Math (STEM) YA checklists. The appropriate Level One Certificate of Occupational Proficiency from the Wisconsin Department of Workforce Development (DWD) will be awarded.

- Senior graduating in 2012 **Level Two** YA: The youth apprentice completes the OLD checklist for the year 2 curriculum for Drafting & Design- Engineering, Drafting & Design- Mechanical Design, or Biotechnology YA. An appropriate Level Two Certificate of Occupational Proficiency from the Wisconsin Department of Workforce Development (DWD) will be awarded.

- Junior in 2011-2012, **Level One** YA: The youth apprentice may complete either an OLD checklist in Drafting & Design- Engineering, Drafting & Design- Mechanical Design, or Biotechnology YA or use the revised Science, Technology, Engineering, & Math (STEM) YA checklists. The appropriate Level One Certificate of Occupational Proficiency from the Wisconsin Department of Workforce Development (DWD) will be awarded for the Junior year participation in the YA program.

- Junior in 2011-2012, **Level Two** YA: The youth apprentice starts either the OLD checklist in Drafting & Design- Engineering, Drafting & Design- Mechanical Design, or Biotechnology YA or uses the revised Science, Technology, Engineering, & Math (STEM) checklists, however, the youth apprentice must complete the YA program using the same checklist the 2nd year, their Senior year. The appropriate Level Two Certificate of Occupational Proficiency from the Wisconsin Department of Workforce Development (DWD) will be awarded.

- Sophomores applying for the Science, Technology, Engineering, & Math (STEM) YA Program for 2012-2013: New youth apprentices must use the revised Science, Technology, Engineering, & Math (STEM) YA checklists **by the 2012-13** school year. A Certificate of Occupational Proficiency will not be issued to students who submit the old checklist.

NOTE: Additionally, Youth Apprenticeship students must maintain good academic standing and be on track for graduation to be eligible for a Certificate of Occupational Proficiency from the Department of Workforce Development.

Appendix H

SCIENCE, TECHNOLOGY, ENGINEERING, & MATH (STEM) YOUTH APPRENTICESHIP

SKILL STANDARDS CHECKLIST

http://www.dwd.state.wi.us/dwd/forms/dws/ydetw_17020_e.htm

(DOWNLOAD MOST CURRENT)

dwd.wisconsin.gov/youthapprenticeship/skills_checklists.htm

Appendix I

SCIENCE, TECHNOLOGY, ENGINEERING, & MATH (STEM)
YOUTH APPRENTICESHIP

COURSE OUTCOME SUMMARY:
OVERVIEW AND TABLE OF CONTENTS

Science, Technology, Engineering, & Math (STEM) Youth Apprenticeship
Course Outcome Summary

Course Information

Organization	Center for Career Development & Employability Training (CCDET)- University of Wisconsin- Oshkosh
Developers	Robin Kroyer-Kubicek
Development Date	July 2011

Description
This curriculum describes the performance-based worksite Competencies, Performance Standards, and Learning Objectives for the Wisconsin Youth Apprenticeship (YA) Program in Science, Technology, Engineering, and Math (STEM). The Wisconsin Science, Technology, Engineering, and Math (STEM) YA Program is designed to provide students with a working understanding of core industry skills and occupationally specific technical skills that serve as the standard for occupations in the Science, Technology, Engineering, and Math (STEM) industry. This program provides the framework for educators and industry to work together to produce work-ready, entry-level employees that will compete favorably in a global market, as well as, provide for post-secondary educational advancement while integrating work-based learning in the school and worksite.

The Science, Technology, Engineering, and Math (STEM) YA program competencies are aligned with the national States' Career Cluster Skill Standards maintained by the States' Career Clusters project (http://www.careerclusters.org/), as well as applicable skills in the Project Lead the Way (http://www.pltw.org/) Curriculum and STEM Academy (http://www.stem101.org/index.asp) Curriculum. Science, Technology, Engineering, and Math (STEM) YA students are required to perform all of the Core and Safety skills for the pathway they enroll in. **Level One (one year)** YA students are to choose additional competencies from the REQUIRED Science, Technology, Engineering, and Math (STEM) Unit in the specific pathway. **Level Two (two year)** YA students are to complete all of the Level One requirements plus an additional unit within their chosen pathway.

Pathway choices:

- Engineering & Technology
- Science & Math

EACH competency (work site skill) is listed with its corresponding Performance Standards and Learning Objectives. The Performance Standards describe the behaviors, ***as applicable***, that employers should look for in order to evaluate the competency. The Learning Objectives describe the classroom learning content for the required related technical instruction.

This curriculum was developed through a Grant from the Wisconsin Department of Workforce Development to the University of Wisconsin-Oshkosh's Center for Career Development and Employability Training (CCDET).

Curriculum Sources

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- Wisconsin Department of Workforce Development, Principles of Engineering DACUM dated October, 1994, and Mechanical Design DACUM dated November, 1994.
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Science, Technology, Engineering, & Math (STEM) Youth Apprenticeship

Table of Contents

REQUIRED SKILLS

APPENDIX J:

Unit 1: Core Skills

1. Apply academic knowledge
2. Apply career knowledge
3. Communicate effectively
4. Act professionally
5. Demonstrate customer service skills
6. Cooperate with others in a team setting
7. Think critically
8. Exhibit legal and ethical responsibilities
9. Use basic technology
10. Use resource wisely

Unit 2: Safety

1. Follow personal safety requirements
2. Maintain a safe work environment
3. Demonstrate professional role to be used in an emergency

APPENDIX K:

Unit 3: Engineering & Technology Pathway: Engineering Drafting

1. Apply engineering principles
2. Interpret technical drawings
3. Use measuring devices accurately
4. Organize databases, files, & drawings
5. Reproduce documents & plans
6. Use engineering drafting software
7. Develop one-view drawings
8. Develop 2D (orthographic) view drawings
9. Develop 3D view models
10. Prepare auxiliary views
11. Prepare section views
12. Dimension drawings
13. Apply lettering & basic annotation to drawings
14. Check, revise, & record drawings
15. Participate on an engineering project

APPENDIX L:

Unit 4: Engineering & Technology Pathway: Mechanical/Electrical Engineering

1. Apply manufacturing & mechanical/electrical systems principles
2. Interpret mechanical/electrical technical drawings
3. Develop the engineering problem & plan with team
4. Research physical limitations
5. Research required materials properties
6. Research manufacturing/assembly process & limitations
7. Design prototype with team
8. Prepare prototype technical drawings
9. Assist to build prototype
10. Assist to test & revise prototype
11. Assist to calculate & analyze prototype test results
12. Finalize part/process technical drawings
13. Apply quality concepts to project

APPENDIX M:

Unit 5: Engineering & Technology Pathway: Civil Engineering

1. Apply structural & building principles
2. Interpret civil engineering technical drawings
3. Research codes & site requirements
4. Conduct site analyses with team
5. Assist to compile & analyze site measurements & other data
6. Research structural requirements
7. Assist to create materials specifications
8. Design site structure(s)
9. Draw a working site plan
10. Construct a Bill of Materials
11. Assist to create a project plan
12. Assist to coordinate project activities
13. Apply quality concepts to project

APPENDIX N:

Unit 6: Science & Math Pathway: Bioscience Lab Foundations

1. Apply Bioscience Lab knowledge
2. Use aseptic technique
3. Clean & prepare glassware & instruments
4. Prepare reagents, solutions, and/or buffers
5. Perform calculations and conversions
6. Weigh and measure accurately
7. Operate lab equipment properly
8. Conduct testing according to protocol
9. Record results of testing accurately
10. Maintain accurate records
11. Monitor & maintain lab &/or personal inventory

APPENDIX O:

Unit 7: Science & Math Pathway: Bioscience Applications

Required Competencies

1. Assist to organize & analyze data
2. Prepare a Bioscience presentation (W/S)

Choose a MINIMUM of 6 additional competencies

1. Grow &/or care for plants &/or lab animals
2. Collect plant or animal tissues from source
3. Isolate &/or purify cells, microbes, nucleic acids, &/or proteins
4. Quantify &/or identify cells, microbes, nucleic acids, &/or proteins
5. Culture cells &/or microbes
6. Harvest cells &/or microbes
7. Perform spectroscopy (light, uv, IR, mass, fluorescence)
8. Perform chromatography (gas, TLC, HPLC)
9. Perform flow cytometry
10. Perform microscopy
11. Perform restriction digests
12. Hybridize nucleic acids
13. Perform gel electrophoresis
14. Perform amplification (PCR, RT-PCR)
15. Perform blot assays (Southern, Western, Northern)
16. Perform nucleic acid sequencing
17. Perform cellular assays
18. Perform immunoassays (ELISA)
19. Perform protein assays (Bradford, Lowry)
20. Perform transfection/transformation
21. Perform basic cloning
22. Run expression cloning tests

Appendix J

SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH (STEM)
YOUTH APPRENTICESHIP

REQUIRED SKILLS CURRICULUM
UNITS 1-2

Unit 1: Required Skills
Core Skills

Competency

1. Apply academic knowledge

Performance Standard Condition

Competence will be demonstrated

- at the worksite and classroom

Performance Standard Criteria

Performance will be successful when the learner:

- Reads and comprehends work related materials
- Applies mathematical operations involving whole numbers, fractions, decimals, percentages, formulas and methods of measurement accurately when necessary
- Interprets charts, tables, and graphs

Learning Objectives

MATH

- Add, subtract, multiply, and divide whole numbers, fractions, decimals and percents
- Calculate averages, ratios, proportions, and rates
- Convert decimals to fractions, fractions to percents and vice versa
- Measure and accurately report measurements of time, temperature, length, width, height, width, perimeter, area, volume, and weight
- Use appropriate formulas
- Convert measurements correctly (e.g., English (standard) to metric)
- Interpret meaning from data
- Correspond the correct number of significant figures in given values to the measuring device

ENGLISH

- Use standard English to compile information and prepare written reports
- Apply English language correctly (spelling, grammar, structure)
- Derive meaning from text through summarizing
- Discern meaning from written word
- Use acceptable language
- Write legibly

SCIENCE

- Explain the key elements of the scientific process
- Define the differences in qualitative and quantitative measurements
- Compare and contrast subjective and objective information
- Discriminate between fact and opinion

Comments:

Unit 1: Required Skills
Core Skills

Competency
2. Apply career knowledge

Performance Standard Condition

Competence will be demonstrated

- at the worksite and classroom

Performance Standard Criteria

Performance will be successful when the learner:

- Demonstrates understanding of career development in the STEM industry
- Obtains necessary skills and knowledge to meet position requirements

Learning Objectives

- Explain the process for seeking employment
- Describe the major functions and duties of the career pathways within the STEM career cluster
- Discuss educational, training, and credentialing requirements for a selected job
- Research job requirements and characteristics of a selected job
- Contrast "positive" and “less positive” aspects of a selected job
- Describe opportunities for advanced training in STEM careers

Comments:

Unit 1: Required Skills
Core Skills

Competency
3. Communicate effectively

Performance Standard Condition

Competence will be demonstrated

- at the worksite and classroom

Performance Standard Criteria

Performance will be successful when the learner:

- Delivers coherent verbal messages in words that can be understood
- Uses appropriate and bias-free language
- Uses appropriate body language
- Listens actively to others
- Demonstrates courtesy with self-introduction
- Responds to inquiries or statements within the scope of current responsibilities and understanding
- Does not provide confidential information without appropriate authorization
- Does not overreact in response to anger
- Records information in a timely manner
- Records written information legibly and accurately
- Organizes and compiles messages, technical information, and summaries accurately
- Uses email, the Internet, printer, copier, scanner, and fax machine equipment appropriately as applicable
- Is sensitive to special, multicultural, and/or multilingual needs

Learning Objectives

GENERAL

- Compare verbal and nonverbal behaviors
- Explain how empathy and bias can be communicated verbally & non-verbally

LISTEN

- Discuss effective and active listening skills
- Differentiate between hearing and listening

WRITTEN

- Discern meaning from written instructions
- Write clearly to communicate written ideas
- Discuss common recording errors and how to avoid them

CUSTOMER

- Identify internal and external customers at your facility
- Discuss steps to assess customer understanding
- Describe the steps to follow when dealing with complaints

PHONE

- Describe the proper telephone answering procedure
- Emphasize the importance of accuracy in taking telephone messages
- Describe the use of telephone documentation/logs required by some departments/facilities

TOOLS

- Describe technology used in communicating such as, telephone, texting, instant messaging (IM), computers, fax, intercom, beepers, tube systems, etc.
- Explain the proper use and etiquette required for these forms of communication technology
- Review the policies and procedures for using written communication tools in your company such as email, Internet, printer, copier, scanner, and/or fax

Comments:

Unit 1: Required Skills
Core Skills

Competency
4. Act professionally

Performance Standard Condition

Competence will be demonstrated

- at the worksite and classroom

Performance Standard Criteria

Performance will be successful when the learner:

- Follows oral and written instructions
- Is pleasant, courteous, and professional with coworkers and internal and external customers
- Appearance and dress are appropriate according to the requirements of the employer
- Takes personal responsibility for attendance
- Is punctual
- Begins work promptly
- Organizes and prioritizes tasks efficiently
- Exhibits positive attitude and commitment to task at hand
- Completes assigned tasks accurately and in a timely manner
- Takes responsibility for actions and decisions
- Recognizes lack of knowledge and seeks help from information sources
- Evaluates work goals periodically with worksite professional
- Accepts constructive criticism and applies suggestions
- Communicates safety, training, and job-specific needs
- Adheres to safety rules and regulations

Learning Objectives

- Locate and explain written organizational policies, rules and procedures to help employees perform their jobs
- Locate and explain your company's employee manual for policies on Appearance, Breaks, Time Off, Cell Phone Use, Weather, Personal Issues, etc.
- List qualities of successful STEM employees
- Describe how you can demonstrate enthusiasm and commitment at the worksite
- Define initiative
- Explain ways that you can show initiative at a worksite
- Explain methods to evaluate work assignments and prioritize them
- Describe how to effectively receive feedback

Comments:

Unit 1: Required Skills
Core Skills

Competency

5. Demonstrate customer service skills

Performance Standard Condition

Competence will be demonstrated

- at the worksite and classroom

Performance Standard Criteria

Performance will be successful when the learner:

- Is knowledgeable about products and services
- Addresses the customer, either in person, by telephone, e-mail or other means
- Gathers information about customer's needs, and customer's knowledge of products or services
- Responds to customer's comments and questions
- Solicits supervisor or co-worker support and advice when necessary to meet customer needs
- Coordinates as needed with other services to expedite delivery of service or product
- Handles complaints tactfully without insult or conflict

Learning Objectives

- Define customer service
- Identify internal and external customers at your facility
- Describe how customer service affects a company's "bottom line"
- Describe standards of service
- Evaluate customer service scenarios
- Determine appropriate customer service solutions
- List strategies for maximizing customer satisfaction
- Describe the functions of other departments or units to serve the customer
- Describe the steps to follow when dealing with complaints
- Identify customer service methods to use when encountering an angry customer
- Review material pertaining to products and services produced by your department or company

Comments:

Unit 1: Required Skills
Core Skills

Competency

6. Cooperate with others in a team setting

Performance Standard Condition

Competence will be demonstrated

- at the worksite and classroom

Performance Standard Criteria

Performance will be successful when the learner:

- Demonstrates respect relating to people
- Contributes to a group with ideas, suggestions, and effort
- Listens and responds appropriately to team member contributions
- Works collaboratively with people from other backgrounds/cultures
- Resolves differences for the benefit of the team
- Completes their share of tasks necessary to complete a project

Learning Objectives

- Explain the functions of each department or unit within the larger organization
- Identify roles found in teams such as leader, facilitator, recorder, etc.
- List effective meeting management skills
- Demonstrate techniques which show respect for others
- Describe how to effectively give and receive feedback
- Discuss effective and active listening skills
- Describe conflict resolution methods
- Discuss ways to participate within a team setting
- Explain how to interact appropriately with diverse ethnic, age, cultural, religious, and economic groups in different situations
- Describe how work teams coordinate work flow and help manage resources

Comments:

Unit 1: Required Skills
Core Skills

Competency
7. Think critically

Performance Standard Condition

Competence will be demonstrated

- at the worksite and classroom

Performance Standard Criteria

Performance will be successful when the learner:

- Recognizes the existence of a problem
- Applies problem-solving steps
- Differentiates between fact and opinion
- Considers other viewpoints and perspectives
- Applies the principles and strategies of organized thinking
- Evaluates information, ideas, and problems
- Collects information through probing questions and research
- Defines the problem
- Uses techniques such as brainstorming to acquire alternative solutions
- Demonstrates comparison skills
- Makes decisions based on analysis
- Presents ideas for critical evaluation
- Supports viewpoints with evidence

Learning Objectives

- Describe how to break a problem down in order to brainstorm, evaluate, and analyze possible solutions
- Discuss the difference between fact and opinion
- Discuss data collection techniques for the problem solving process
- Describe how to present a solution with evidence
- Explain ways to reach a decision by consensus
- Discuss methods to evaluate a solution that has been implemented

Comments:

Unit 1: Required Skills
Core Skills

Competency

8. Exhibit regulatory and ethical responsibilities

Performance Standard Condition

Competence will be demonstrated

- at the worksite and classroom

Performance Standard Criteria

Performance will be successful when the learner:

- Follows all safety and worksite standards and regulations including those required by the Occupational Safety & Health Administration (OSHA) and the Environmental Protection Agency (EPA)
- Performs legally and ethically by all local, state, and national standards
- Uses email, the Internet, printer, copier, scanner, and fax machine equipment appropriately and correctly as applicable
- Operates within scope of authority adhering to company rules, regulations, and policies as established in employee handbook/procedures
- Complies with legal requirements for documentation
- Documents work processes as required
- Records and files appropriate documents in timely manner
- Maintains confidentiality of company, customer, and co-worker information
- Documents reportable incidents to worksite professional immediately, if applicable
- Receives, handles, packages, and ships materials and product according to shipping laws and regulations if applicable

Learning Objectives

GENERAL

- Explain the role of the government in regulating and managing the Engineering **or** Bioscience Lab industry
- Compare national, state and local regulators that oversee the Engineering **or** Bioscience Lab industry such as: Occupational Safety and Health Administration (OSHA), Environmental Protection Agency (EPA), Food and Drug Administration (FDA), Nuclear Regulatory Commission (NRC), U.S. Department of Agriculture (USDA), National Institutes of Health (NIH), National Research Council (NRC), Department of Transportation (DOT), Center for Disease Control and Prevention (CDC), Clinical Laboratory Improvement Amendments (CLIA), etc. **as applicable**
- Identify the management structure and employees' roles within your organization
- Describe common legal requirements that must be met in Engineering **or** Bioscience Lab facilities
- Describe your legal responsibilities, limitations, and implications for action in your job role
- Identify the rules and regulations of the company as they relate to the employee
- Identify penalties for regulation non-compliance
- Compare and contrast behaviors and practices that could result in liability or negligence
- Explain legal issues faced by Engineering **or** Bioscience Lab professionals
- Summarize the rights and responsibilities **of** Engineering or Bioscience Lab workers

- Explain what situations are reportable in Engineering **or** Bioscience Lab facilities
- Explain the importance of Good Manufacturing Processes (GMPs) or Good Laboratory Practices in Engineering **or** Bioscience Lab facilities

ETHICAL

- Explain the difference between an ethical practice and a legal responsibility
- Identify current ethical issues common to the Engineering **or** Bioscience Lab field
- Describe ethical work values such as confidentiality, productivity during the day, following safety standards
- Define and discuss the concept of intellectual property
- Explain fundamentals of patents, trademarks, copyrights, and proprietary information

SAFETY

- Define legal and ethical responsibilities for safety procedures
- Describe the certification/license requirements to operate specific equipment or perform specific functions

RECORDS

- Identify the main functions of documents and documentation
- Identify the guidelines for retaining common documents
- Describe the patent process and its importance in Engineering or Bioscience Lab work

Comments:

Unit 1: Required Skills
Core Skills

Competency
9. Use basic technology

Performance Standard Condition

Competence will be demonstrated

- at the worksite and classroom

Performance Standard Criteria

Performance will be successful when the learner:

- Uses communication technology (such as pagers, radios, phone, fax, email, Internet) to access and distribute data and other information within the scope of the job
- Follows rules for proper computer and communication technology usage
- Uses calculating tools such as a computer, calculator, and adding machine correctly
- Enters, edits, and stores data on computerized equipment according to worksite guidelines
- Verifies data entry prior to data storage or equipment operation
- Use computer applications to solve problems

Learning Objectives

- Identify the parts and functions of a computer system using correct terminology including the keyboard, monitor, mouse, printer
- Point out the storage device locations on the computer such as the Hard drive, Floppy drive, CD-ROM drive, and Portable File Storage drive, etc
- Show the appropriate connections and positioning of peripheral devices such as a mouse, keyboard, monitor, and printer
- Discuss the importance of backing up computerized files
- Compare different forms of communications technology including email, texting, word processing, spreadsheets, database, presentation software, and use of the internet to communicate, search and display information
- Describe how to evaluate internet web sites and information for validity and reliability
- Explain appropriate and inappropriate uses of email and internet while at work
- Describe how to develop effective presentations using appropriate technologies (e.g., tables, charts, and visual graphics)
- Explain the use of writing/publishing/presentation applications
- Describe how database and spreadsheet technology is used at your worksite to manage worksite operations

Comments:

Unit 1: Required Skills
Core Skills

Competency
10. Use resources wisely

Performance Standard Condition

Competence will be demonstrated

- at the worksite and classroom

Performance Standard Criteria

Performance will be successful when the learner:

- Follows the facility pollution/waste prevention plan
- Recycles whenever possible
- Disposes of materials appropriately
- Disposes of hazards legally and with regard to environmental impact

Learning Objectives

- Identify current environmental issues affecting the Engineering or Bioscience Lab industry
- Determine effects of environmental issues on the Engineering or Bioscience Lab industry
- Define what is meant by making “green” choices
- Compare renewable and nonrenewable natural resources
- Explain the meaning of sustainable resources use
- Identify practices that contribute to sustainability
- Describe why wise use of resources at the worksite is important
- Give examples of wasteful uses of resources (unnecessary waste and duplication) at the worksite
- Explain how your choices of resources impact your department, your facility, and the environment
- List materials that can be recycled
- Describe materials that require special disposal
- Explain purpose of pollution control systems
- Relate power generation to energy sources
- Compare environmental impact of energy sources (e.g., fuel cells, chemical, wind, hydro, nuclear, electric, mechanical, solar, biological)

Comments:

Unit 2: Required Skills
Safety

Competency
1. Follow personal safety requirements

Performance Standard Condition

Competence will be demonstrated

- at the worksite and classroom

Performance Standard Criteria

Performance will be successful when the learner:

- Participates in all required safety training
- Follows all worksite guidelines for personal safety
- Applies principles of proper body mechanics when necessary
- Reports any exposures, injuries, or accidents, personal or to others, immediately, if applicable
- Locates and can find key information on Material Safety Data Sheets (MSDS)
- Handles and disposes of any hazardous materials appropriately, if applicable
- Operates only equipment that he/she is trained on
- Adheres to equipment safety standards
- Visually inspects equipment to ensure safety compliance and function before operation
- Wears the required Personal Protective Equipment (PPE) at all times as required by the worksite for specific tasks

Learning Objectives

- Discuss the regulatory purpose and responsibility of the Occupational Safety and Health Administration (OSHA)
- List your rights as a worker according to OSHA
- Explain the procedure to follow in case of an exposure, injury, or accident to self or to another
- Explain ways your company prevents accidents
- List engineering controls that are taken to protect workers from accidents
- Describe safe and unsafe work habits and their implications
- List safety hazards common in your facility
- Explain potential hazards associated with blood borne pathogens
- Explain the ergonomic impact of work techniques
- Describe proper techniques for lifting loads
- Describe the Material Safety Data Sheet (MSDS) and its purpose
- Discuss the procedures of handling & disposing of hazardous material
- List mechanical, chemical, electrical, compressed air, and equipment safety hazards at your facility
- Explain how Lock Out/Tag Out procedures prevent accidents
- Define the Personal Protective Equipment (PPE) required for specific tasks in your facility
- Explain the safe use of ladders
- Describe ways to prevent burns
  Demonstrate safe use of equipment you will commonly use

Comments:

Unit 2: Required Skills
Safety

Competency
2. Maintain a safe work environment

Performance Standard Condition

Competence will be demonstrated

- at the worksite and classroom

Performance Standard Criteria

Performance will be successful when the learner:

- Complies with posted safety warnings and symbols
- Identifies unsafe conditions and/or work habits and reports them to the worksite professional immediately, if applicable
- Helps maintain a clean and safe working environment free of debris and obstacles
- Cleans, organizes, puts away items in the work area
- Safely identifies, handles, stores, and uses hazardous materials according to company procedure, if applicable
- Reports any indications of insects or pests

Learning Objectives

- List the major components of a facility safety program
- List the different state and federal agencies that provide regulatory oversight at your facility for personal safety, environmental safety, and equipment safety
- List accident and fire prevention techniques
- Describe posted safety warnings and symbols and what they mean
- Describe safe and unsafe work habits and their implications
- Discuss the importance of keeping the work area and tools/equipment clean
- List mechanical, electrical, and equipment safety hazards at your facility
- Discuss how to identify and report unsafe conditions in your facility
- Discuss safety procedures to prevent accidents
- Describe the requirements at your facility for safety training and auditing
- Assess need for good housekeeping practices
- List accident and fire prevention techniques
- List hazards that contribute to injury due to slips, trips, or falls
- Outline compliance requirements of sanitation and health inspections

Comments:

Unit 2: Required Skills
Safety

Competency

3. Demonstrate professional role to be used in an emergency

Performance Standard Condition

Competence will be demonstrated

- at the worksite and classroom

Performance Standard Criteria

Performance will be successful when the learner:

- Participates in emergency safety simulations and drills
- Outlines the company's policy and procedure for worksite incidents, accidents, electrical, fire, tornado, bomb threats, robbery, hostage situations, and other emergency situations
- Identifies the closest fire alarms and emergency exits in the assigned worksite area
- Identifies the fire extinguishers in the assigned worksite area
- Identifies appropriate alarms and procedures for using alarms
- Contacts emergency personnel according to company requirements in the event of an emergency
- Documents any emergency incidents according to company requirements

Learning Objectives

- Describe the procedures in your company to report an emergency
- Review your company procedures for responding to exposures, injuries, accidents, spills, fire, tornado, bomb threat, robbery, hostage situations, etc.
- Demonstrate how to use the fire blanket and/or fire extinguisher
- Explain the evacuation plan for the worksite
- Indicate the demeanor necessary during an emergency
- Identify methods to cope with emergency situations
- Name the resources for assistance in crimes or accidents
- Locate and explain use of first aid emergency care kits
- Detail steps to use in medical emergencies requiring First Aid, CPR, and/or Heimlich maneuver
- Locate and explain use of spill kits, if applicable to worksite
- Explain who in your facility can give first aid care in the event of an emergency
- Explain the local protocols in place with local law enforcement
- Explain the role of the Hazardous Materials (HAZMAT) team
- Detail how to access help in a robbery or terrorist situation
  Explain the use of safety equipment such as eyeball washers and chemical safety showers and when you would use them

Comments:

Appendix K

SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH (STEM) YOUTH APPRENTICESHIP

ENGINEERING & TECHNOLOGY PATHWAY ENGINEERING DRAFTING (UNIT 3)

Unit 3: Engineering & Technology Pathway
Engineering Drafting

Competency
1. Apply engineering principles

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Demonstrate Engineering principles understanding based on ***current training and knowledge***
- Comply with specifications, regulations, and codes during the design process

Learning Objectives

SYSTEMS, PRINCIPLES, CONCEPTS

- Explain physical principles such as forces, friction, and energy
- Apply fundamental laws and principles such as the laws of conservation of energy and momentum relevant to engineering and technology
- Use the relationships between force, motion, energy, work, power to solve a variety of engineering problems
- Apply scalar and vector quantities as applied to physical systems, such as the relationship between position, velocity, and acceleration
- Calculate the mean, mode, median, and range of a data set

DESIGN PROCESS

- Describe what pressures are prevalent in engineering design
- Discuss product specifications and their role in engineering
- Contrast quality and efficiency as significant factors in engineering
- Identify and quantify the impact of potential failures

Comments:

Unit 3: Engineering & Technology Pathway
Engineering Drafting

Competency

2. Interpret technical drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Interpret technical drawings accurately as needed for job task
- Use appropriate terminology
- Identify basic elements of technical drawings
- Identify lines, views, symbols, and representations on the drawings as applicable
- Interpret dimensions and scale on the drawings as applicable
- Utilize a metric scale to properly read a drawing

Learning Objectives

- Discuss different types of technical drawings
- Define the basic types of lines
- Define and explain the use of lines, views, symbols, dimensions, and scale on engineering technical drawings
- Interpret auxiliary drawing information
- Identify different lines by name, type, order of usage, & application such as object, hidden, center, section, dimension, extension, cutting plane, short break, long break, phantom
- Demonstrate standard view placement practices
- Compare orthographic projections, pictorial/3D (isometric, diametric, trimetric) view, sectional views, auxiliary (oblique, inclined) views, and dimensional views
- Discuss the ANSI and the National CAD standards for engineering document lines
- Define tolerances
- Identify tolerancing symbols in a technical drawing

Comments:

Unit 3: Engineering & Technology Pathway
Engineering Drafting

Competency

3. Use measuring devices accurately

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Choose appropriate instrument or aid for measuring task
- Verify instrument is accurate for calibration if applicable
- Use and/or measure as required
- Read measuring instrument accurately
- Scale proportions accurately
- Apply appropriate formula and units for measurements
- Record measurements using proper symbols
- Clean and maintain instrument(s) as required
- Store instrument(s) properly

Learning Objectives

- List drafting aids and measuring devices commonly used by engineers
- List common measurements used by engineers
- Add and subtract measurements
- Discuss how to convert standard English measures to metric and vice versa
- Explain engineering scale
- Explain the impact of error in measurement
- Predict the effect of error propagation in calculations
- Explain the link between measurement, calculation and data with the correct number of significant digits

Comments:

Unit 3: Engineering & Technology Pathway
Engineering Drafting

Competency

4. Organize databases, files, & drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Select appropriate documents
- Code documents as required
- Save and store drawings and files to appropriate database
- Sort and retrieve drawings and data from databases
- Enter data and edit fields and documents
- Query to extract information from files and documents
- Create reports from queries
- Use appropriate computer codes, formatting, macros, charts, spreadsheets, etc.
- Verify data prior to entry/storage

Learning Objectives

- Define basic database terms such as database, field, record, query, table, etc.
- Identify the various types of data and documents stored in your companies database management system
- Discuss the access and responsibilities you will have for managing engineering records and documents

Comments:

Unit 3: Engineering & Technology Pathway
Engineering Drafting

Competency

5. Reproduce documents & plans

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain documents or plans
- Remove any staples if hard copy
- Save copies to computer storage devices
- Operate copy machines
- Operate printers, plotters, and scanners
- Number copies as required
- Document copies made

Learning Objectives

- Explain the purpose of copy control and document numbering systems in engineering
- Explain the size of drawings to standards
- Compare ISO to U.S. customary drawing sizes
- Define aspect ratio and how it applies to drawing sizes and copying
- Describe how to operate the computer database storage system, copy machine, printer, scanner, etc. at your facility

Comments:

Unit 3: Engineering & Technology Pathway
Engineering Drafting

Competency

6. Use engineering drafting software

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- Access & use appropriate file management to search, create, copy, edit, and save drawing files
- Execute application software
- Demonstrate view use in CAD
- Retrieve or create drawings
  - Access predefined drawing setup
  - Import/export drawings from/to various graphic formats
  - Convert an existing hard copy drawing to an electronic format
- Draw or modify drawings
  - Utilize drawing management standards
  - Set up plot parameter
  - Select appropriate scale
  - Utilize various coordinate systems
  - Apply appropriate naming conventions, line types, and symbol/object management to drawing
  - Apply appropriate notes and/or leaders to drawing
  - Apply appropriate lettering, fonts, line thickness and type
- ***Check drawing***
- Maintain drawings in the file management system

Learning Objectives

- Explain the purpose, principle, and advantages of Computer-Aided Drawing (CAD)
- Compare cost, advantages, and disadvantages of CAD versus Manual drawing
- Compare types of CAD
- Identify drafting references, handbooks, vendor's product catalog, and other related appropriate standards and how they are used in engineering drafting
- List appropriate engineering design standards used by your facility
- Identify the hardware and software used at the CAD workstations in your facility
- Discuss common CAD system variables used in engineering
- Describe the feature manager design tree schematic for the CAD software used in your facility
- Compare symbols, text based information, and libraries in the CAD software used in your facility
- Discuss CAD plotting guidelines

Comments:

Unit 3: Engineering & Technology Pathway
Engineering Drafting

Competency
7. Develop one-view drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- ***Use engineering drafting software*** OR draw manually
- Select proper view
- Draw geometric shapes such as circles, polygons, ellipses, parabola, triangles of various angles, tangent lines, and arcs as needed
- Identify types of lines to be used
- Determine and utilize line precedence
- Construct a one-view drawing
- Show hidden features and centerlines as required
- Complete title block by selecting lettering style and size
- Apply proper thickness to all lines
- ***Check drawing***
- Label and save to appropriate project family

Learning Objectives

- Determine the front view for a given object
- Explain how an oblique view of simple geometric solids differs from an isometric view
- Identify common geometric shapes and forms by name
- List formulas used in geometric constructions
- Calculate the area of simple geometric shapes
- Explain how to draw one-views and geometric constructions

Comments:

Unit 3: Engineering & Technology Pathway
Engineering Drafting

Competency

8. Develop 2D (orthographic) view drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- ***Use engineering drafting software*** OR draw manually
- Select proper views
- Identify types of lines to be used
- Determine and utilize line precedence
- Construct an orthographic drawing
- Show hidden features and centerlines as required
- Complete title block by selecting lettering style and size
- Apply proper thickness to all lines
- ***Check drawing***
- Label and save to appropriate project family

Learning Objectives

- Explain the alphabet of lines for drawing
- Explain the three dimensions and how they are represented for width, depth, and height
- Describe projection rules to create 2D sketches of 3D objects
- Define orthographic view and its purpose
- Compare types of orthographic views
- Discuss the line types used in orthographic views
- Explain how orthographic projections are used in engineering drawings
- Explain how to draw orthographic views
- Explain how an oblique view of simple geometric solids differs from an isometric view

Comments:

Unit 3: Engineering & Technology Pathway
Engineering Drafting

Competency

9. Develop 3D view models

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- ***Use engineering drafting software*** OR draw manually
- Select proper view
- Lay out view corner
- Identify lines to be used
- Determine and utilize line precedence
- Draw 3D view models
- Show hidden features and centerlines as required
- Complete title block by selecting lettering style and size
- Apply proper thickness to lines
- ***Check drawing***
- Label and save to appropriate project family

Learning Objectives

- Compare orthographic to pictorial (3D) views
- Describe the types of pictorial (3D) views
- Explain how the viewing direction for a pictorial drawing is chosen
- Explain how to draw pictorial (3D) views
- Compare solid modeling to surface modeling
- Understand and compare 3D features that add and remove geometry including extrude, fillet, shell, revolve, sweep, loft, pattern features

Comments:

Unit 3: Engineering & Technology Pathway
Engineering Drafting

Competency

10. Prepare auxiliary views

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- ***Use engineering drafting software*** OR draw manually
- Select proper auxiliary plane
  - Inclined
  - Oblique
- Prepare auxiliary drawing
- Complete title block by selecting lettering style and size
- Apply proper thickness to lines
- ***Check drawing***
- Label and save to appropriate project family

Learning Objectives

- Define the purpose of auxiliary views
- Compare auxiliary views to one-view, section, orthographic, and pictorial (3D) views
- Explain why auxiliary views are considered special orthographic views
- Compare types of auxiliary views
- Describe how auxiliary views are used in engineering design drawings
- Explain how to draw auxiliary views

Comments:

Unit 3: Engineering & Technology Pathway
Engineering Drafting

Competency

11. Prepare section views

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- ***Use engineering drafting software*** OR draw manually
- Select proper section view
- Prepare section drawing
- Complete title block by selecting lettering style and size
- Apply proper thickness to lines
- ***Check drawing***
- Label and save to appropriate project family

Learning Objectives

- Define the purpose of section views
- Compare section views to orthographic and pictorial views
- Compare types of section views
- Define the "cut line"
- Describe how section views are used in engineering design drawings
- Explain how to draw section views

Comments:

Unit 3: Engineering & Technology Pathway
Engineering Drafting

Competency
12. Dimension drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- ***Use engineering drafting software*** OR draw manually
- Select views to be dimensioned
- Dimension views to standard
  - Draw dimension lines
  - Dimension views using appropriate style of dimensioning (coordinated, linear)
- Continue until all features have been dimensioned
- Dimension complex shapes when appropriate (e.g., spheres, cylinders, tapers, pyramids)
- Apply appropriate line thickness and type to dimension, extension, and center lines
- ***Check drawing***

Learning Objectives

- Define proportion
- Explain engineering scale
- Describe how scales are indicated on technical drawings
- Define dimensioning in engineering
- Discuss the common rules for engineering dimensioning
- Explain the relationship between design intent and dimensioning
- Define driven and driving dimensions
- Define ordinate dimension
- List common standards for dimensioning at your worksite
- Discuss the basic parts of a dimension
- List common symbols used in dimensioning
- Identify and dimension fillets, rounds, diameters, chamfers, holes, slots, and screw threads in orthographic projection drawings
- Explain the rules that are associated with the application of dimensions to multiview drawings
- Identify and explain the difference between general tolerances, limit dimensions, unilateral, and bilateral tolerances
- Differentiate between clearance and interference fits

Comments:

Unit 3: Engineering & Technology Pathway
Engineering Drafting

Competency

13. Apply lettering & basic annotation to drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain & use appropriate reference materials
- ***Use engineering drafting software*** OR draw manually
- Add lettering
- ***Draw dimension*** and extension lines
- Apply adequate drawing notations
- Use appropriate abbreviations
- Apply finish marks
- ***Check drawing***

Learning Objectives

- Explain the importance of standardized lettering on engineering design documents
- Discuss common standards to use in lettering
- Discuss when to use dashed lines
- Describe general rules of the use of line weights
- Define annotation
- Explain the purpose of engineering annotations on technical drawings
- List common abbreviations used in annotations in engineering

Comments:

Unit 3: Engineering & Technology Pathway
Engineering Drafting

Competency

14. Check, revise, & record drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

CHECK

- Obtain all material (catalogs, calculations, references) pertaining to drawn item
- Check dimensioning, tolerances and references to other drawings
- Check for complete calculations and dimensioning on all required documents
- Check material specifications are given in detail
- Check that all necessary drawing views are included
- Check clearances and interference between moving and adjacent parts
- Check the parts list on assembly drawings for sizes, catalog information, material, etc.
- Check appropriate unit of scale is indicated

REVISIONS

- Review drawing revision (change) procedures
- Identify drawing to be modified
- ***Use engineering drafting software*** OR draw manually
- Make modifications to drawing
- Construct a revision table on drawing
- Record changes properly on revision table
- Apply appropriate line thickness and type
- Check revised drawing
- Label and save to appropriate project family

RECORD

- Number all view drawings and supporting documents as required
- Document all checks and revisions as required by facility

Learning Objectives

- List criteria and conditions to evaluate when reviewing technical drawings at your facility
- Compare how drawing changes are made and tracked on CAD and/or manual drawings
- Explain how drawing revisions are tracked to other connected technical documents and materials specifications documents
- Discuss the impact on resources of revisions to completed plans

Comments:

Unit 3: Engineering & Technology Pathway
Engineering Drafting

Competency

15. Participate on an engineering project

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the scope and phases of the design project with worksite professional
- Participate in the following project team activities to develop and implement the engineering project plan as able
  - Identify customer requirements
  - Identify design specifications
  - Research design constraints and criteria
  - Identify possible design solutions with team
  - Finalize design criteria and parameters
  - Plan development process
  - Evaluate project requirements
  - Estimate required resources and budget
  - Estimate time requirements
  - Identify interdependencies
  - Identify critical milestones
  - Create model/prototype
  - Test prototype
  - Refine prototype
  - Coordinate project steps with other project/departments
  - Track critical milestones
  - Track changes to engineering plans and costs
  - Track progress of project
- Periodically review plan activities completed and their results

Learning Objectives

- Define the term engineering design
- Explain the elements and steps of the engineering design process
- Describe design constraints, criteria, and trade-offs in regard to variety of conditions (e.g. technology, cost, safety, society, the environment, time, human resources, manufacturability)
- Identify the steps of a product's lifecycle
- Explain why teams of people are used to develop solutions to design problems
- Describe the use of Gantt and flow charts to manage the various phases of a design project
- Discuss product specifications and their role in engineering
- Contrast quality and efficiency as significant factors in engineering
- Identify and describe estimation techniques
- Classify costs (e.g., direct and indirect, fixed and variable, methods and standards)

Comments:

Appendix L

SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH (STEM) YOUTH APPRENTICESHIP

ENGINEERING & TECHNOLOGY PATHWAY MECHANICAL/ELECTRICAL ENGINEERING (UNIT 4)

Unit 4: Engineering & Technology Pathway
Mechanical/Electrical Engineering

Competency

1. Apply manufacturing & mechanical/electrical systems principles

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Demonstrate Manufacturing and Mechanical and/or Electrical Engineering principles understanding based on ***current knowledge and training***
- Comply with specifications, regulations, and codes during the design process

Learning Objectives

MANUFACTURING

- Recognize how manufacturing skills can aid those in an engineering role
- Define common processes used in the following manufacturing processes:
  - Machining
  - Cutting, drilling, and bonding
  - Joining & Welding
  - Finishing & Assembly
- Explain the function of the following manufacturing equipment:
  - CNC
  - Lathe
  - Milling Center
  - Machine Center
  - Router
  - Grinder
  - Welding equipment
  - Jigs and fixtures

MECHANICAL SYSTEMS

- Describe the simple machines
- Identify the characteristics of simple machines
- Explain the function of pulleys, gears, and belts
- Explain fluid power
- Illustrate how pressure distributes itself in a closed system

ELECTRICAL SYSTEMS

- Determine the basic requirements for an electrical circuit to function
- Determine the basic requirements of a series circuit
- Examine the differences and similarities of series and parallel circuits
- Analyze and describe the relationship between voltage, current and resistance
- Explore the relationship between electricity and magnetism
- Identify common components used in electronics

Comments:

Unit 4: Engineering & Technology Pathway
Mechanical/Electrical Engineering

Competency

2. Interpret mechanical/electrical technical drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Interpret mechanical and/or electrical technical drawings accurately as needed for job task
- Use appropriate terminology
- Identify basic elements of mechanical and/or electrical technical drawings
- Identify lines, views, symbols, and representations on the drawings as applicable
- Interpret dimensions and scale on the drawings as applicable
- Interpret product specifications
- Interpret (geometric) dimensioning and tolerancing symbols
- Analyze part prints

Learning Objectives

- Describe the relationship between Parts, Assemblies and Drawings
- List types and purposes of engineering technical drawings
- Describe the common conventions of engineering technical drawings for such things as layout, terminology, interpretation, appearance, size, etc.
- Compare standard views required for engineering technical drawings such as multiview, section, auxiliary, pattern, exploded
- Compare working drawings to assembly drawings
- Identify threads and thread terms
- Identify fasteners
- Identify gears and gearing terms
- Identify cams and cam terms
- Identify welding joints and welding terms & symbols
- Identify tolerancing fit symbols and feature control
- Identify surface finish symbols
- Identify electronic/electrical symbols and how to arrange the components

Comments:

Unit 4: Engineering & Technology Pathway
Mechanical/Electrical Engineering

Competency

3. Develop the engineering problem & plan with team

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the engineering problem, project instructions, and/or specifications requirements with worksite professional
- Brainstorm possible solutions to meet project specifications with engineering team
- Identify engineering work piece/part/process to be designed
- Write a problem statement based on team input
- Create a decision matrix based on the problem statement
- Identify & plan requirements for research and drawing
  - Identify research needed prior to drawing
  - Identify critical features on the part/process
  - Identify the key control characteristics
  - Research previous FMEA for similar work pieces/parts/processes
  - Assess the seriousness of the failure effect on the next component or the user
  - Determine design methods or product features that help diagnose failure
- Review conclusions with worksite professional
- Document problem statement, planning and identification process as required

Learning Objectives

- Discuss the purpose and use of the problem statement
- List common research strategies used by engineers approaching a problem statement
- Define PFMEA (process failure mode and effects analysis) and FMEA (failure mode and effects analysis)
- Identify typical failure modes
- Discuss potential causes of typical failure modes
- Explain action to reduce or eliminate typical failure modes

Comments:

Unit 4: Engineering & Technology Pathway
Mechanical/Electrical Engineering

Competency

4. Research physical limitations

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Refer to research strategies identified in the problem statement to direct research of physical limitations and constraints
- Obtain/contact appropriate resources for researching physical limitations of work piece/part/process
- Research physical constraints of limitations such as
  - Forces, shear, and moments acting on part/process
  - Statics
  - Equilibrium
  - Energy and energy requirements
  - Kinematics & mechanics
  - Electrical/electronics
- Use graphical and mathematical analysis to identify physical limitations
- Review research and conclusions with worksite professional
- Document physical research process as required

Learning Objectives

Force & Statics

- Define force, shear, and moments
- Define statics
- Identify forces acting on the object in a diagram
- Explain transmissibility of forces
- Analyze forces applied to structures and mechanical devices
- Identify the basic stress and vibration equations
- Determine shear and moment forces in a diagram
- Analyze loads applied to structures and mechanical devices
- Calculate moment of inertia of structural members
- Review the concepts of tension and compression and how they relate to statics

Equilibrium

- Define equilibrium
- Calculate the location of the center of gravity for a rigid body
- Solve equilibrium problems involving friction

Energy

- Define types of energy
- Define the possible types of power conversion
- Calculate work and power in mechanical systems

Kinematics

- Define kinematics
- Determine efficiency in a mechanical system
- Describe the motion of machine components including linkages, cams, gears, & belt drives

Electrical/Electronics

- Compare analog and digital electronics
- Compare combinational and sequential logic fundamentals
- Explain how design specifications are translated into logic circuits
- Determine efficiency in an electrical system

Math Analysis

- Describe common units of measure used in engineering
- Explain number rounding rules
- Review the laws of sine, cosine and tangent

Comments:

Unit 4: Engineering & Technology Pathway
Mechanical/Electrical Engineering

Competency

5. Research required material properties

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Refer to research strategies identified in the problem statement to direct research of material properties and requirements
- Obtain/contact appropriate resources for researching material properties to meet requirements of part/process
- Research material properties such as applicable
  - Physical (such as density, strength, stress/strain, continuity, hardness, flexure)
  - Thermal factors (such as melting point, boiling point, conductivity, expansion, specific heat capacity)
  - Chemical (such as reactivity, flammability, enthalpy, oxidation, stability, toxicity)
  - Size needed
  - Costs
  - Recycling/sustainability
- Select a material and standard structural shape to fit design specifications
- Review research, testing, and conclusions with worksite professional
- Document material properties research as required

Learning Objectives

- Classify and describe the typical physical and chemical characteristics of metals, alloys, ceramics, glass, polymers and composites
- Compare non-destructive and destructive material property tests
- Explain how to conduct typical materials tests for strength, stress/strain relationships, hardness, flexure, etc.
- Explain typical physical properties considered for materials used in mechanical and/or electrical engineering
- Stress & Shear
  - Define stress, sheer stress, bending stress, combined stress
  - Identify principle stresses on an object
  - Define torsion
  - Examine the distribution of stress in an object subjected to bending moments
- Strain
  - Define strain
  - Explain relationship between stress and strain
  - Distinguish between ductile and brittle
- Inertia
  - Define moments of inertia
  - Explain the use of standard structural shape tables
  - Define the purpose and use of the section modulus

- Thermal Factors
  - Describe how heat treating affects a material's strength
  - Describe stresses due to thermal contraction and expansion
  - Describe deflection due to heating and cooling
  - Explain factors related to electrical conductivity

Comments:

Unit 4: Engineering & Technology Pathway
Mechanical/Electrical Engineering

Competency

6. Research manufacturing/assembly process & limitations

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Refer to research strategies identified in the problem statement to direct research of manufacturing processes & limitations
- Obtain/contact appropriate resources for researching manufacturing processes & limitations of work piece/part/process
- Research manufacturing processes & limitations such as
  - Manufacturing processes to be used to fabricate and assemble part
  - Handling during manufacturing
  - Features to be added to ensure proper assembly orientation
- Research currently available parts and assemblies already in manufacture
  - Identify sources of part information (catalogs, Internet, design conventions, etc.)
  - Research available components & parts
  - Obtain specific component dimensions
- Review research and conclusions with worksite professional
- Document manufacturing process research as required

Learning Objectives

- Compare manufacturing processes and equipment used in molding/casting, heat treating, cutting, joining/welding, machining, and forming (shearing, bending, drawing, etc.)
- Discuss the importance of quality principles in the manufacturing of products
- Identify plastic processing
- Identify types of welds
- Identify machining equipment and processes
- Identify mechanical fasteners
- Discuss proper selection of fasteners
- Identify surface coatings
- Relate properties of materials to various manufacturing processes
- Identify the product assembly process
- Explain manufacturing fixturing
- Examine concerns related to fixturing during part assembly
- Describe the process of building electrical circuits for assemblies

Comments:

Unit 4: Engineering & Technology Pathway
Mechanical/Electrical Engineering

Competency

7. Design prototype with team

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the problem statement identified
- Define the work piece/part/process engineering specifications based on preliminary research and testing
- Select mechanical and/or electrical elements by type and size
- Select materials to be used for prototype
- Determine form, fit, function, and relationship of components and assembly
- Integrate design for manufacturing and assembly
- Complete OR review completed engineering calculations for prototype
- Set initial tolerances based on preliminary research factors
- Estimate cost factors including labor, materials for fabrication, costs for assembly, testing, and/or installing
- ***Prepare prototype technical drawings*** to solve the engineering problem identified based on based on preliminary research and testing

Learning Objectives

- Define the purpose of mechanical and/or electrical product specifications
- Explain methods for selecting designs based of product specifications
- Describe how characteristics of function, stress analysis, and economics impact materials selection and design
- Discuss the impact of failure and effects analysis (FMEA) on design
- Explain design for manufacturing and assembly concepts
- Explain how to determine hole depth and proper thread
- Define tolerance
- List considerations for setting tolerances
- Compare dimensional tolerance to fit in mechanical engineering
- Explain how to perform common engineering calculations for such characteristics as
  - Bend allowances
  - Critical load
  - Angle of twist
  - Stress/strain
  - Moment of inertia
  - Energy conversion efficiency
  - Circuit resistance, current and voltage

Comments:

Unit 4: Engineering & Technology Pathway
Mechanical/Electrical Engineering

Competency

8. Prepare prototype technical drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Create technical draft(s) drawings for prototype fabrication based on engineering specifications and research
- Prepare working, assembly, and development drawings as required
  - Draw appropriate views of standard components
  - Position the components in relationship to other components
  - Select references
  - Dimension and fully constrain the drawing
  - Create pattern drawings for parts
  - Transfer parts into an assembly
- Simulate fit or motion to analyze problems, issues or processes
  - Edit features such as depth, direction, planes, attributes
  - Resolve failed features (redefine, reroute, reorder, delete)
  - Create and edit assemblies (insert, align, mate)
  - Create features in assemblies using mate features
- Review fastener selection based on strength, cost, material, appearance and ease of assembly during installation
- Detail drawing to request parts fabrication by machine, metal sheet or wood shops/departments
- Evaluate drawing by measuring dimensions and comparing with original specifications for form and function designated in engineering problem statement
- ***Check, revise, & record drawing***

Learning Objectives

- Describe the following elements used in design drafts- base, extrusions, sweeps, blends, fillets, rounds, chamfers, patterns (arrays), revolve, holes, datum, rib, relation, cut, shell
- Define commonly used terms in mechanical tolerance
- Explain the use of International Tolerance grades, limits and fits
- Describe special features, symbols and annotations for the following mechanical/electrical assembly drawings
  - Sheet metal
  - Surfacing
  - Welding
  - Casting
  - Forging
  - Jig and fixture
  - Tool and die
  - Cam

- Spring
- Mechanical power transmission (belts, chains, and gears)
- Electrical power transmission (transformers, relays, circuits, resistors, breakers)
- Fasteners
- Revolution
- Electrical circuits

Comments:

Unit 4: Engineering & Technology Pathway
Mechanical/Electrical Engineering

Competency

9. Assist to build prototype

Performance Standard Condition

Competence will be demonstrated

- at the worksite
- while assisting a worksite professional

Performance Standard Criteria

Performance will be successful when learners:

- ***Prepare prototype technical drawing***
- Request parts fabrication by machine, sheet metal or wood shops
- Order commercial materials and/or parts needed for prototype
- Build models/prototypes
  - Operate drill press, grinders, engine lathe, soldering irons, or other machines to modify parts or to fabricate experimental parts for testing ***only if properly trained***
  - Assemble part(s) and components as specified in prototype drawing
- Verify assembly as indicated in prototype drawings
- Verify assembly of prototype with worksite professional

Learning Objectives

- Discuss reasons for building a prototype
- Define rapid prototyping
- Discuss how prototypes differ from final products
- Explain characteristics and limitations of prototypes

Comments:

Unit 4: Engineering & Technology Pathway
Mechanical/Electrical Engineering

Competency

10. Assist to test & revise prototype

Performance Standard Condition

Competence will be demonstrated

- at the worksite
- while assisting a worksite professional

Performance Standard Criteria

Performance will be successful when learners:

- Determine testing required based on engineering problem statement
- Create documents of testing procedures and scenarios
- ***Assist to build prototype*** of part or process
- Set up prototype and test apparatus
- Operate test controlling equipment to observe and record prototype test results
- Set up and conduct tests of complete units and components
- Test prototype
  - Test fit or motion
  - Test different scenarios to multiple variables
  - Test the feasibility of product/design
  - Test operational conditions
  - Test extreme conditions
- Record test procedures and testing information
- Record test results data
- Organize all testing data

Learning Objectives

- Explain the purpose of prototype testing
- Compare non-destructive and destructive tests
- Identify the basic functional requirements of a prototype in response to external force
- Discuss reasons for structural failure
- Identify common tests used to test structure and functionality of prototypes
- Describe typical extreme conditions tests
- Define PFMEA (process failure mode and effects analysis) and FMEA (failure mode and effects analysis)
- Identify typical failure modes
- Discuss potential causes of typical failure modes
- Explain action to reduce or eliminate typical failure modes

Comments:

Unit 4: Engineering & Technology Pathway
Mechanical/Electrical Engineering

Competency

11. Assist to calculate & analyze prototype test results

Performance Standard Condition

Competence will be demonstrated

- at the worksite
- while assisting a worksite professional

Performance Standard Criteria

Performance will be successful when learners:

- Obtain prototype testing data
- Calculate required capacities for work piece/part/process to obtain specified performance
- Select and use statistical tools to analyze and synthesize data and study performance
- Apply statistical tools to verify reliability and/or validity of the data
  - Verify accuracy and legibility of data recordings
  - Use IT tools to manipulate data into tables, graphs, spreadsheets as needed to evaluate prototype
  - Organize data into written and visual formats
- Analyze test results with engineering team in relation to design or rated specifications and test objectives
- Discuss changes in design, method of manufacture and assembly, and drafting techniques and procedures with team
- Make recommendations for changes in product or test methods
- Modify or adjust work piece/part/process/equipment to meet specifications
- Document all calculations, statistics, evaluations and modifications to prototype or process

Learning Objectives

- List common features considered when modifying or adjusting work pieces/parts/process(es) in prototype testing
- Define reliability and validity
- Describe how statistical tools are used to verify reliability and validity
- Statistics
  - Create a histogram of recorded measurements showing data elements or class intervals, and frequency
  - Calculate the mean, mode, median, and range of a data set
  - Describe the meaning of probability and how it applies to a set of data
  - Calculate the theoretical probability that an event will occur
- Explain how product liability is impacted by testing

Comments:

Unit 4: Engineering & Technology Pathway
Mechanical/Electrical Engineering

Competency

12. Finalize part/process technical drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain and collate ALL data collected during prototype testing
- ***Assist to calculate & analyze prototype test results***
- Evaluate and discuss ALL prototype testing with engineering team
- Refer back to engineering problem statement
- Present final project recommendations to team, management, client, etc.
- Document project recommendations
- Revise engineering plan or drawings, rebuild, and retest new prototype OR
- Finalize work piece/part/process engineering plan and documents from prototype testing results
- Define the technical requirements for use

Learning Objectives

- Explain the process for re-engineering or reverse engineering failed prototype designs
- Identify different types of product support documentation (brochures, warranties, warning labels, user's manuals, etc.)
- Identify types of manufacturing related registers
- Explain the patent process
- Describe features involved in marketing a newly engineered product or process
- Explain how to develop a Plan for Procedure for manufacturing a product

Comments:

Unit 4: Engineering & Technology Pathway
Mechanical/Electrical Engineering

Competency

13. Apply quality concepts to project

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Apply quality concepts/standards at all stages of engineering design
- Monitor and refer to customer requirements and specifications documents throughout process
- Follow written standards and procedures for all protocols and troubleshooting
- Communicate progress at each step of process
- Ensure decisions are justified with data
- Perform quality inspection of prototype and manufactured work pieces/parts/processes
- Document failures and errors
- Evaluate failures and errors for corrective actions taken
- Complete and monitor basic statistical process control charts
- Document all research, design, testing, and production activities
- Follow the process for change control of design, process and final product

Learning Objectives

- Discuss the concept of quality assurance
- Explain key features of a quality assurance system
- Compare quality assurance to quality control
- Define ISO 9000
- Explain the importance of documentation
- Define systems integration
- Discuss the importance of change control pre- and post- design
- Define risk analysis
- Discuss factors considered in risk/benefit analysis
- Define PFMEA (process failure mode and effects analysis) and FMEA (failure mode and effects analysis)
- Describe the use of statistics and control charts in the work place
- Discuss the basics of Lean Manufacturing
- Explain CQI (Continuous Quality Improvement) and ongoing evaluation of produced work pieces/parts/processes (run charts, statistical analysis, cp/cpk number, capability, cost, etc.)

Comments:

Appendix M

SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH (STEM) YOUTH APPRENTICESHIP

ENGINEERING & TECHNOLOGY PATHWAY CIVIL ENGINEERING (UNIT 5)

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency
1. Apply structural & building principles

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Demonstrate Structural and Building Construction principles understanding based on ***current knowledge and training***
- Comply with specifications, regulations, and codes during the design process

Learning Objectives

STRUCTURAL

- Define a structure
- Explain multidirectional forces applied to structures
- Identify categories of loads acting on structures
- Explain how load-bearing factors are considered in structural design
- Describe the physics of structures to bear loads via walls, columns, and beams
- Explain the characteristics of structural beams, cables, trusses, and other structural forms

BUILDING & CONSTRUCTION

- Recognize how construction skills can aid those in a civil engineering role
- Describe the common processes used in the following construction processes:
  - Steel welding
  - Carpentry
  - Plumbing
  - Roofing
  - Walls & insulation
  - Power generation
  - Highway & road construction
  - Skyscraper construction

Comments:

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency

2. Interpret civil engineering technical drawings

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Interpret civil engineering technical drawings accurately as needed for job task
- Use appropriate terminology
- Identify basic elements of civil engineering technical drawings
- Identify lines, views, symbols, and representations on the drawings as applicable
- Interpret dimensions and scale on the drawings as applicable
- Utilize a metric scale to properly read a drawing

Learning Objectives

- List types and purposes of engineering technical drawings
- Describe the common conventions of civil engineering technical drawings for such things as layout, terminology, interpretation, appearance, size, etc.
- Compare standard views required for civil engineering technical drawings such as multiview, section, detail schedules, etc.
- Identify structural symbols
- Identify site water supply and drainage symbols
- Identify electrical systems connection symbols
- Identify land contour and use symbols
- Explain how site and system design changes are indicated and tracked on civil engineering project plans
- Identify welding joints and welding terms & symbols

Comments:

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency
3. Research code & site requirements

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the civil engineering plan with the worksite professional
- Identify site location, building systems, and structures designated in the plan
- Consult with customers, architects, construction professionals, landscape architects, environmental scientists and/or government officials
- Determine categories of applicable codes required by site, systems, and structures
- Locate resources to conduct code and site research
- Look up codes, zoning ordinances and regulations to determine the applicable requirements for a project
- Review research with worksite professional

Learning Objectives

- Describe the resources and process to be followed to research required codes and site restrictions at your facility
- List sustainable building principles and how to apply them to civil engineering projects
- Site
  - Explain general environmental codes and requirements for a civic project
  - Discuss the need to prevent/control wind, water erosion and/or flood plain analysis in land development and construction
  - Interpret and explain code requirements and constraints as they pertain to the installation of services and utilities
- Structures
  - Explain the purpose of building codes
  - Identify the national codes typically used in the United States and know who is responsible for determining which code is applied to the process
  - Recognize the potential dangers of built structures, particularly structures that do not follow code
  - Define easement, buffer area and setback as they relate to local codes and construction sites
  - Classify a building according to its use, occupancy, and construction type using International Building Codes
  - Discuss the Wisconsin energy code and code requirements
  - List common building codes that apply to areas such as soil, footing, windows, foundation, ventilation, roofing, masonry, drainage, fire prevention, etc.
  - Discuss the difference between habitable and non-habitable spaces
  - Analyze risks associated with natural disasters including wind, earthquake, fire and floods, and design

Comments:

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency
4. Conduct site analysis with team

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Identify the boundaries of a property based on its legal description
- Visit site to gather information pertinent to the viability of a project on the site
- Participate in surveying to lay out installations and establish reference points, grades, and elevations to guide construction
  - Take measurements of structures, distances, length, width, height, perimeter, and area
  - Determine elevations and contour lines
  - Establish a point of known elevation for a project
  - Read gauges and measurement instruments accurately
  - Document measurements accurately
- Schedule or conduct land surveys
  - Arrange for evaluation of basic service & utility systems needs including service capacity, service entrance, meter base, and distribution panel locations
  - Arrange for geological and geophysical investigations
  - Obtain soil samples & send for analysis
  - Arrange studies of water & utility needs
  - Arrange studies of air, water and solid waste pollution assessment
  - Conduct studies of traffic patterns or environmental conditions to identify engineering problems and assess the potential impact of projects
  - Arrange topographical surveys

Learning Objectives

- Describe criteria for building site selection
- Discuss the impact of zoning in site selection
- Explain how to identify the boundaries of a property based on legal description
- Explain how maps and aerial photos are used in site determination and measurement
- Explain how property lines, utilities, building line, setback, building corners, and elevation are indicated in land maps
- Explain general survey methods used to obtain site measurements
- Explain how to locate and identify an elevation level
- Describe how elevation reference points and footing grades are established
- Discuss how GIS (Geographic Information Systems), GPS (Global Positioning Systems), and lasers are used to measure sites
- Identify site factors which affect the layout of a site and design of a structure
- Identify climatic and geographic criteria that impact the civil engineering project
- Explain the importance of the location and accessibility of the structure to the property

Comments:

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency

5. Assist to compile & analyze site measurements & other data

Performance Standard Condition

Competence will be demonstrated

- at the worksite
- while assisting a worksite professional

Performance Standard Criteria

Performance will be successful when learners:

- Obtain survey information on a site from documented resources and/or survey measurements
- Obtain site analysis information from documented resources and/or site testing
- Identify measurements and elevations from site
- Collect data from all surveys, testing and analyses completed
- Analyze measurement, service, utility, zoning & coding, and ecosystem data
- Evaluate site feasibility with civil engineering project team
- Document site analysis and feasibility decision

Learning Objectives

- Determine environmental impacts of civil engineering project sites
- Describe how to determine the most suitable foundation for a proposed structure based on the site constraints
- Discuss service and utility requirements
- Discuss criteria and constraints to layout energy and utility systems for a civil engineering project
- Explain how the United Soil Classification System designation determines soil characteristics important to the design and construction of a building on the site
- Describe the impact of passive energy, sustainability and landscaping on site selection
- Discuss common methods for site preparation
- Explain the process for demolition of old structures prior to repair or new construction

Comments:

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency
6. Research structural requirements

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Obtain/contact appropriate resources for researching structural requirements and efficiency
- Analyze what structural load the site can bear
- Research structural constraints such as
  - Forces, stress, shear, inertia, and moments acting on a structure
  - Statics
  - Equilibrium
- Use graphical and mathematical analysis to identify structural requirements
- Review research and conclusions with worksite professional
- Document structural requirements as required

Learning Objectives

- Force & Statics
  - Define force, shear, statics, and moments
  - Identify forces acting on the object in a diagram
  - Explain transmissibility of forces
- Analyze forces applied to structures
- Determine the forces in each member of a truss
- Determine the forces in each member of a frame
  - Review the concepts of tension and compression and how they relate to statics
- Stress & Shear
  - Define stress, sheer stress, bending stress, combined stress
  - Identify principle stresses on an object
  - Identify the basic stress and vibration equations
  - Determine shear and moment forces in a diagram
  - Define torsion
  - Examine the distribution of stress in an object subjected to bending moments
- Strain
  - Define strain
  - Explain relationship between stress and strain
- Inertia
  - Define moments of inertia
  - Explain the use of standard structural shape tables
  - Define the purpose and use of the section modulus
- Equilibrium
  - Define equilibrium
  - Use equations of equilibrium to calculate unknown forces

- Math Analysis
  - Describe common units of measure used in engineering
  - Explain number rounding rules
  - Review the laws of sine, cosine and tangent

Comments:

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency

7. Assist to create materials specifications

Performance Standard Condition

Competence will be demonstrated

- at the worksite
- while assisting a worksite professional

Performance Standard Criteria

Performance will be successful when learners:

- ***Research structural requirements***
- Utilize appropriate reference handbooks
- Test selected materials if needed
- Compile materials testing results if applicable
  - Identify strength
  - Identify stress/strain relationships
  - Identify continuity, ferrous metal, hardness, and flexure
- Compute materials stress factors
- Select structural and construction materials and assemblies that meet project specifications
- Use appropriate combinations of building materials and components that satisfy the requirements of the civil engineering project
- Review research, testing, and conclusions with worksite professional
- Select materials to fit design specifications with worksite professional
- Document material specification research as required
- Prepare materials specifications documents

Learning Objectives

- Classify and describe the typical physical and chemical characteristics of metals, alloys, ceramics, glass, polymers and composites
- Explain typical physical & chemical properties considered for materials used in civil engineering
- Explain how to conduct typical materials tests for strength, stress/strain relationships, hardness, flexure, etc.
- List common calculations completed to determine materials stress factors
- Identify the four most common materials used in the construction of structures: wood, steel, masonry, and concrete
- Explain criteria used for building materials selection
- Describe applications and restrictions pertaining to the use of construction materials
- Discuss the use of sustainable construction materials and products
- Compare wood and steel frame construction requirements
- Compare typical foundation materials and when each is preferred
- Compare common framing materials and when each is preferred
- Cite typical floor materials
- Distinguish between control, construction, and isolation joints

Comments:

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency
8. Design site structure(s)

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review site analysis and structural requirements with worksite professional
- Calculate the structural efficiency of a structure
  - Compute load requirements
  - Determine loads using load tables and appropriate mathematics
  - Trace a gravity load imposed on a structure to the ground through all structural elements that contribute to supporting the load
  - Analyze simply supported beams to determine maximum shear and bending moment
  - Calculate moment of inertia of structural members
  - Calculate the location of the center of gravity for a rigid body
- Complete other engineering calculations
  - Compute grade requirements
  - Estimate the amount of cut and/or fill necessary to build a structure
  - Compute impact of site development on water drainage
  - Compute water pressure and water flow rates
  - Evaluate whether structures will be able to withstand earthquakes, wind, gravity, snow and other natural forces
- Design structural elements *as applicable* to the civil engineering project
  - Design the foundation, framing, supports, floor, walls, roof as applicable to required structures
  - Design a spread footing for a given loading condition

Learning Objectives

- Discuss reasons for structural failure
- Explain how load-bearing factors are considered in structural design
- Describe the physics of structures to bear loads via walls, columns, and beams
- Explain how to perform common engineering calculations for such characteristics as
  - Fill needed
  - Drainage
  - Water Pressure and head loss
  - Structural efficiency
  - Bend allowances
  - Loads
  - Critical load on a column
  - Stress/strain
  - Statics
  - Thermal Dynamics such as contraction, expansion, deflection
- Foundation

- List common foundation types and describe their use
- Define cantilever

- Framing & Walls
  - Identify common components of a framing system
  - Distinguish among fixed, free, and pinned columns
  - Examine beam design
  - Understand what factors provide strength in a beam
  - Identify the forces that bend a beam
  - Compare common wall systems
  - Distinguish between bearing and non-bearing walls
- Roof
  - Compare common roof systems
  - Define truss
  - Identify basic truss types
  - Identify and explain framing terms common to both conventional and trussed roofs

Comments:

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency
9. Draw a working site plan

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- ***Compile site measurements & other analysis data***
- Review site analyses data and dimensions of site layout
- Select size and scale for plan
- ***Use engineering drafting software*** OR draw manually
- Identify parcel features
  - Indicate existing ground features on drawing (e.g., utilities, contours, landscape features, etc.)
  - Indicate boundaries, easement, buffer areas, and established setbacks of site
  - Draw existing structures
  - Locate and identify bench mark and elevation level
- Indicate modifications of any existing site elements
  - Draw proposed contour lines and indicate any new grade elevations
- ***Design site structure(s)***
- Place proposed structure(s) on site with favorable orientation considering site-specific information
  - Draw utility lines and connections
  - Incorporate required site elements such as power systems, water supply & drainage, sewage systems for roads, airports, dams, bridges and other structures
  - Draw additional construction extending beyond structure(s) (e.g., driveways, sidewalks, roadways, proposed utilities, etc.)
  - Draw landscaping elements
- Estimate the amount of cut and/or fill necessary to build structure(s)
- Estimate the increase in storm water runoff from a site
  - Apply Low Impact Development techniques to reduce the impact of development on the storm water runoff quantity and quality
- Indicate scale of drawing and view title
- Indicate north arrow
- Check drawing

Learning Objectives

- Interpret factors that influence site plan
- Describe the process to draw a site plan
- List and identify site plan abbreviations
- Explain the purpose of contour lines
- Describe how choice of structure placement on site relates to energy, utility, sanitation, and drainage requirements

- Classify a roadway, bridge, dam, airport according to its level of use
- Explain the information and calculations needed to plan for a roadway, bridge, dam, airport design
- Discuss how to design appropriate pedestrian access, vehicular access, and parking for a commercial site
- Explain how common site and system designs incorporate energy conservation techniques
- Compare water waste management types
- Discuss issues of storm water run-off
- Estimate the increase in storm water runoff from a site
- Explain Low Impact Development techniques to reduce the impact of development on the storm water runoff quantity and quality

Comments:

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency

10. Construct a Bill of Materials

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the working site plan with worksite professional
- Utilize appropriate reference handbooks
- Convert civil engineering drawing scale to full dimensions for the project
- Calculate the required materials needed
- Select materials and assemblies that meet project specifications
- Use appropriate combinations of materials and components that satisfy the requirements of the construction process

Learning Objectives

- Explain how to assign numbers to materials required for construction
- Describe the calculations used to calculate the amount of materials needed
- Explain criteria used for construction materials selection
- Discuss the use of sustainable materials and processes

Comments:

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency

11. Assist to create a project plan

Performance Standard Condition

Competence will be demonstrated

- at the worksite
- while assisting a worksite professional

Performance Standard Criteria

Performance will be successful when learners:

- Review the civil engineering project, project instructions, and specifications requirements with worksite professional
  - Identify the engineering structure/process to be designed
- ***Research codes & site requirements*** to determine the applicable requirements
- Identify the criteria and constraints of the project to be designed
- Brainstorm possible solutions to meet project specifications with engineering team
- Identify & plan project requirements with the civil engineering team
  - Identify critical features on the project
  - Identify the critical milestones
  - Develop detailed programs for the construction process
  - Develop detailed programs for the coordination of site activities
- Analyze and interpret reports on loading, labor, and materials
- ***Research structural requirements*** and ***create materials specifications*** documents
- ***Draw working site plan***
- ***Design site structures(s)***
- ***Construct a Bill of Materials***
- Prepare cost estimates
- Verify site plan with worksite professional
- Obtain bids and prepare contract documents
- Obtain approvals and permits from relevant authorities
- Assist to conduct public surveys and hold public forums
- Document project plan as required
- Modify technical drawings and plans as required
  - Review drawing revision (change) procedures
  - Construct a revision table on drawing
  - Record changes properly

Learning Objectives

- Compare civil engineering to other types of engineering and architects
- Compare types of civil engineering specialties
- Discuss the role of the civil engineer in project design and construction
- List common research strategies used by civil engineers approaching a project
- Explain criteria and considerations when reviewing loading, labor, and materials reports
- List common documents associated with civil engineering projects
- Explain how to generate a cost estimate for a civil engineering project

- Explain how drawing revisions are tracked to other connected technical documents and materials specifications documents
- Discuss the impact on resources of revisions to completed plans
- Explain the purpose of contracts
- List common contractors employed on civil engineering projects
- Describe the engineering bid process
- Discuss how deeds, environmental impact statements, right of way descriptions, and permits impact project design and implementation

Comments:

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency

12. Assist to coordinate project activities

Performance Standard Condition

Competence will be demonstrated

- at the worksite
- while assisting a worksite professional

Performance Standard Criteria

Performance will be successful when learners:

- Review project plans with civil engineering team periodically
- Assist to monitor activities associated with the project plan and critical milestones
- Communicate regularly with project managers and construction crew
- Organize the delivery of materials and equipment needed
- Review and record information for reports on productivity, quality, and performance

Learning Objectives

- Discuss common critical milestones in typical civil engineering projects
- Explain how civil engineers monitor site activities
- Discuss criteria and considerations when organizing construction building, materials and equipment
- Describe typical reports and measures taken to indicate productivity and performance at a civil engineering project site

Comments:

Unit 5: Engineering & Technology Pathway
Civil Engineering

Competency

13. Apply quality concepts to project

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Apply quality concepts/standards at all stages of civil engineering design and project
- Follow written standards and procedures for all protocols and troubleshooting
- Communicate progress at each step of process
- Ensure decisions are justified with data
- ***Coordinate and monitor project activities***
- Periodically inspect civil engineering projects
- Document errors
- Evaluate errors for corrective actions taken
- Document all research, design, testing, and project activities
- Follow the process for change control of design, process and final product
- Verify project is within specifications, contract terms and regulations

Learning Objectives

- Discuss the concept of quality assurance
- Explain key features of a quality assurance system
- Compare quality assurance to quality control
- Define ISO 9000
- Explain the importance of documentation
- Discuss the importance of change control
- Identify types of changes that are typically made in a civil engineering project
- Define risk analysis
- Discuss factors considered in risk/benefit analysis

Comments:

Appendix N

SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH (STEM) YOUTH APPRENTICESHIP

SCIENCE & MATH PATHWAY
BIOSCIENCE LAB FOUNDATIONS (UNIT 6)

Unit 6: Science & Math Pathway
Bioscience Lab Foundations

Competency
1. Apply Bioscience Lab knowledge

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Demonstrate Bioscience Lab systems understanding based on ***current training and knowledge***
- Read Bioscience Lab materials discerning the information and concepts
- Locate and read reference materials and scientific publications

Learning Objectives

SCIENCE CONCEPTS

- Explain the importance of the scientific method to research
- Explain the steps in conducting research
- Explain the importance of controlled research
- Identify the major parts of a research report
- Define biotechnology/bioscience

BIOLOGY PRINCIPLES

- Compare types, chemical make-up, and function of bio-molecules
- Describe the basic components and functions of the cell
- Explain the structures of DNA and RNA
- Explain the process of replication, transcription and translation in a cell
- Explain the molecular basis for heredity and how genotype influences phenotype
- Discuss the genetic code and expression of a gene
- Analyze factors that influence gene expression
- Describe how biological life forms are structured from cells to organisms
- Discuss the inheritability of traits and evolution of new traits through genetic bio-molecules

CHEMISTRY PRINCIPLES

- Differentiate between physical and chemical properties of matter
- Describe the structure of the atom and its effect on molecular formulas
- Identify different chemical reactions
- Identify between ionic and molecular compounds

HISTORY, TRENDS, & IMPACT

- Explain how protein biochemistry, molecular biology, microbiology and genetics are interrelated
- Identify the major innovations in the development of biotechnology/bioscience
- Describe current applications of bioscience
- Research emerging and future applications of bioscience
- Describe the emergence, evolution, and implications of bioethics
- Identify the steps in bringing a new bioscience product to market
- Describe the testing procedures to determine the safety of a new product

- Describe the processes used in the production of molecules/organisms for use in industrial applications

Comments:

Unit 6: Science & Math Pathway
Bioscience Lab Foundations

Competency

2. Use aseptic technique

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Wear the appropriate Personal Protective Equipment (PPE) as required
- Disinfect surfaces before and after use as required
- Gather all materials prior to beginning procedure
- Prevent unwanted air current flow from doors and windows
- Sterilize or use sterilized equipment, reagents and/or supplies
- Hold caps or tops when removing them
- Hold open plates, tubes, lids, etc. at an angle in a manner to prevent unwanted exposure to uncontrolled environment
- Keep lids on as much as possible
- Avoid talking, sneezing, coughing when working with exposed analytes
- Discard contaminated materials properly

Learning Objectives

- Define asepsis
- Compare sterilization to disinfecting
- Compare different sterilization procedures for equipment, reagents and supplies
- Compare disinfecting products
- Compare equipment or lab lay-out, such as laminar flow hoods and clean rooms, used in maintaining asepsis
- Describe basic aseptic techniques in the bioscience laboratory
- Explain the purpose of reducing air currents and holding open items at an angle
- Demonstrate proper removal and holding of lids when removed

Comments:

Unit 6: Science & Math Pathway
Bioscience Lab Foundations

Competency
3. Clean & prepare glassware & instruments

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Rinse items thoroughly, as required, with the appropriate solvent
- Soak glassware & other items in warm aqueous solution of detergent
- Clean items to remove all residual matter
  - Consults worksite professional for more aggressive cleaning protocols if required
- After cleaning, rinse thoroughly with water
- Dry items in required manner
- Place cleaned & dried items in sterilization pouches or wraps if required
  - Perform following steps as applicable to lab setting
  - Label and seals items properly
  - Place items in sterilization equipment
  - Ensure items remain apart during the sterilization cycle
  - Place empty canisters upside-down in order to prevent accumulation of water
  - Does not overload sterilizer trays
  - Allow a distance between trays to permit steam circulation
- Document cleaning procedure if required
- Return clean glassware & instruments to their proper storage locations

Learning Objectives

- Identify common glassware, instruments, and reusable testing supplies used in the laboratory
- Describe the use of common lab glassware and instruments
- Explain the sensitivity and care of glassware
- Describe proper dish washing technique for chemical glassware
- Describe other aggressive cleaning procedures to be used with residual materials
- Describe clean-up procedures used for flammable, corrosive and organic materials
- List the glassware and items requiring sterilization in your lab
- Describe the sterilization procedures required for glassware, instruments, or testing supplies in your lab

Comments:

Unit 6: Science & Math Pathway
Bioscience Lab Foundations

Competency

4. Prepare reagents, solutions, and/or buffers

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the appropriate protocol for safely preparing the item required including safety precautions
- Determine the concentration and amount required
- ***Calculate the amount*** of solute and solvent needed to prepare the desired amount
- Verify calculations with worksite professional
- ***Weigh or measure the solute***
- Add solute to mixing flask
- Measure the solvent if needed
- Fill flask with about 2/3 solvent
- Stopper and mix flask by inverting OR as required by protocol
- Complete filling of remaining required solvent to mixing flask
- Mix as required
- Test and adjust pH if required by protocol
- Return solute and solvent to proper storage area
- Label and store prepared item as required per protocol
- Clean up

Learning Objectives

- Describe the proper storage and handling of various chemicals: Inorganic, Organic, acids, chlorinated chemicals, flammable, corrosive
- Define the common uses of reagents, solutions, and buffers in bioscience testing labs
- Explain how to avoid contaminating reagents during preparation
- Compare and contrast the properties of reagents, solutions, and buffers used in your lab
- Describe hazards associated with the reagents, solutions and/or buffers used in your lab
- Define the uses of biological media
- Define the pH scale

Comments:

Unit 6: Science & Math Pathway
Bioscience Lab Foundations

Competency
5. Perform calculations and conversions

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the appropriate chart or reference materials to make calculations or conversions
- Identify given values
- Identify unknown values
- Determine the calculations or conversions and formulas that need to be performed
- Perform calculations or conversions as required
  EXAMPLES
  - Perform calculations on parts per million and similar concentrations
  - Calculate the concentration of solutions in percent composition by mass
  - Calculate the concentration of solutions in percent composition by volume
  - Calculate to prepare molar solutions
  - Calculate to prepare dilutions from stock solutions using the law of conservation of mass
- Verify calculations or conversions with worksite professional
- Record calculations or conversions as required

Learning Objectives

- Explain how to convert between U.S. standard measurements and metric measurements
- Explain the link between significant figures in calculations and the measuring devices used
- Describe the units involved in concentrations of mass, volume, molarity, molality, normality, ppm and ppb
- Use the mole concept to convert between moles and grams
- Explain how to calculate Percent by mass, Percent by volume, Molarity, Molality, Normality, parts per million (ppm) and parts per billion (ppb)

Comments:

Unit 6: Science & Math Pathway
Bioscience Lab Foundations

Competency
6. Weigh and measure accurately

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the protocol for accurately using the measuring equipment including safety precautions
- Ensure equipment is usable and current for calibration

MASS

- SOLIDS
  - Add pan or weighing paper
  - Tare scale
  - Add solid to be weighed
  - Note reading
- LIQUIDS
  - Add container to scale
  - Tare scale
  - Add liquid to be weighed
  - Note reading

VOLUME

- LIQUIDS- Cylinder
  - Choose smallest container available to hold desired volume
  - Position at eye level to the device markings
  - Pour liquid into measuring device until it reaches the mark or measurement you need
  - Add liquid drop by drop until bottom of curved surface matches desired line
- LIQUIDS- Pipets
  - Choose appropriate sized pipet for sample required
  - Attach pump to pipet if needed
  - Set pipet volume OR pull up required amount of liquid
  - Drain/dispense liquid to desired amount in container

TEMPERATURE

  - Verify thermometer probe is operational OR that thermometer has no gaps in the liquid
  - Place thermometer or probe in middle area of material or space
  - Allow thermometer or probe time to reach equilibrium
  - Note reading
- Record measurements in appropriate units and amount of significant figures as required
- Clean up equipment

Learning Objectives

- Explain how to properly carry and pour solid and liquid chemicals
- List common units used in Bioscience labs for mass, volume, & temperature

- Explain how to zero and use scales
- Identify the proper glassware to deliver and contain specific volumes
- Demonstrate reading volume in glassware
- Explain how to pipette and micropipette different volumes of liquid correctly
- Convert measurements from U.S. Standard to metric and vice versa
- Correspond the correct number of significant figures in given values to the measuring device

Comments:

Unit 6: Science & Math Pathway
Bioscience Lab Foundations

Competency
7. Operate lab equipment properly

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the protocol for the procedure or lab equipment to be used including safety precautions
- Operate only equipment that he/she is trained on
- Choose correct equipment for the task
- Follow and completes any equipment check list prior to use
- Verify equipment is available for use and in working order
- Verify equipment is current for preventative maintenance and/or calibration
- Verify safety requirements and any Personal Protective Equipment (PPE) needed for equipment use
- Inspect equipment and work area for safety considerations
- Set up and prepare equipment for safe operation
  - Check settings
  - Check power
  - Check lubrication and fluid levels
- Monitor equipment for safe operation while operating
- Follow protocol for clean up and shut down after use
- Properly shut down and label any equipment that is not operating as expected, if applicable
  - Follow Lock Out/Tag Out procedures as applicable
  - Promptly report abnormal equipment conditions to worksite professional
- Document use as required

Learning Objectives

- Explain the function of common bioscience laboratory tools and equipment
- Explain the safety precautions and routine care of common bioscience laboratory tools and equipment
- List mechanical, chemical, electrical, compressed air, and other equipment safety hazards at your facility
- Describe the basic procedure to be followed when a piece of equipment is not functioning properly in your lab
- Discuss the need for quality control (QC) samples and/or equipment controls in some bioscience lab equipment
- Explain how Lock Out/Tag Out procedures prevent accidents
- Explain standard use of common heating equipment
- Explain standard use of electrical current/power supply equipment
- Explain proper use of magnetic stirrers and hot plates

- Describe the safety and procedures involved in the use of flame
- Explain how to use a pipet and micropipetter
- Describe use of simple centrifugation
- Describe use of simple filtration
- Explain standard use of a microscope

Comments:

Unit 6: Science & Math Pathway
Bioscience Lab Foundations

Competency
8. Conduct testing according to protocol

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the testing protocol including safety precautions
- Select and set-up the correct equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
- Prepare any controls required
- Locate and identify the sample(s) to be tested
- Prepare samples for testing according to protocol
- Test the sample(s) according to protocol ***Using Aseptic Lab Technique*** and Standard/Universal Precautions
  - Include Quality Control (QC) samples, if applicable
  - ***Operate lab equipment properly***
- ***Records results***
- ***Clean glassware and instruments***
- Segregate, Recycle or Dispose of chemical, biohazardous, or infectious waste according to facility guidelines using Standard/Universal Precautions

Learning Objectives

- Discuss the need for quality control (QC) samples and/or equipment controls in bioscience testing
- Define positive and negative control
- Explain the procedures for safe Handling and Disposal of Chemical, Biological, and Radioactive Materials
- Define the purpose of Standard/Universal Precautions
- Explain the procedure for Standard/Universal Precautions in your lab
- Discuss the purpose of fume hoods and biological safety cabinets/hoods
- Explain how to handle and dispose of laboratory wastes safely

Comments:

Unit 6: Science & Math Pathway
Bioscience Lab Foundations

Competency
9. Record results of testing accurately

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Select appropriate forms/records
- Use appropriate note-taking methods
- Record results, readings, measurements, calculations, times, etc. with appropriate scientific units carefully without transcription
- Record your identification
- Report any discrepancies or unexpected results to worksite professional
- Add data in electronic files if applicable

Learning Objectives

- Explain the importance of keeping laboratory records
- Explain the purpose and structure of a laboratory data book
- Describe the procedures followed in maintaining a laboratory notebook

Comments:

Unit 6: Science & Math Pathway
Bioscience Lab Foundations

Competency
10. Maintain accurate records

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Select appropriate forms/records
- Label and/or code documents as required
- File forms/records in appropriate location
- Use appropriate computer codes, formatting, macros, charts, spreadsheets, etc.
- Verify data prior to entry/storage
- Maintain files as required
- Add Edit, Verify and Query data in electronic files if applicable

Learning Objectives

- Explain the purpose of Standard Operating Procedures (SOPs)
- Define terms used in bioscience lab records
- Demonstrate how electronic data is manipulated such as in a spreadsheet system
- Explain how data & files are stored and "backed up"
- Describe the purpose of security and ID information within record keeping systems

Comments:

Unit 6: Science & Math Pathway
Bioscience Lab Foundations

Competency

11. Monitor & maintain lab &/or personal inventory

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Check incoming containers for damage or contamination of items
- Verify that items ordered match the purchase order and description
- Identify any defective items
- Notify worksite professional and take appropriate corrective action when defective or missing items are identified
- Assist worksite professional to perform inventory checks
- Check that proper storage levels are maintained
- Rotate items to minimize old and outdated inventory
- Care for plants and animals as required by protocol
- Monitor temperature and atmospheric controlled spaces

Learning Objectives

- Explain the importance of maintaining an accurate inventory of biological and chemical materials
- Discuss the Chemical Hygiene Plan at your lab
- Identify the main types of inventory in bioscience labs
- Identify the costs of maintaining inventory
- Describe techniques used to order, stock, and maintain biological, chemical, and radioactive items
- Identify and describe hazards associated with biological, chemical, and radioactive items
- Explain how common safety, chemical, radioactive, and biological hazards are indicated on shipping labels
- Describe the proper storage, handling and disposal of various chemicals: Inorganic, Organic, acids, chlorinated chemicals, flammable, corrosive, radioactive
- Describe the proper storage, handling and disposal of biologic items

Comments:

Appendix O

SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH (STEM) YOUTH APPRENTICESHIP

SCIENCE & MATH PATHWAY BIOSCIENCE APPLICATIONS (UNIT 7)

Unit 7: Science & Math Pathway
Bioscience Applications- Required Competencies

Competency

1. Assist to organize & analyze data

Performance Standard Condition

Competence will be demonstrated

- at the worksite
- while assisting a worksite professional

Performance Standard Criteria

Performance will be successful when learners:

- Collect data and results from testing
- Select and use statistical tools to analyze and synthesize data
- Create tables and graphs to organize data
- Query and extract information from data
- Interpret graphs and the trends in data
- Use IT tools to manipulate data creating models, reports, plans, processes, or projects from data provided
  - Access the appropriate database or search engine desired
  - Navigate to the specific source of information needed
  - Discuss information search with worksite professional
  - Perform identification and/or design sequencing from research databases & software
- Document analysis process and tools used
- Draw conclusions based on analysis with worksite professional

Learning Objectives

- Express numbers in scientific notation
- Manipulate numbers expressed in scientific notation back to simple numbers
- Describe standard statistical calculations performed on sets of data
- Explain the difference between data analysis and drawing conclusions
- Explain how statistical tools are used to verify the reliability or validity of the data
- Discuss how error is calculated
- Discuss methods for organizing and representing data
- Discuss how standard curves are developed and evaluated using an equation for a line
- Explain how a standard curve and the equation for a line can be used to predict unknown values or outcomes
- Define bioinformatics
- List common activities or uses of bioinformatics
- Compare basic bioinformatics web services
- Define computational biology

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Required Competencies

Competency

2. Prepare a Bioscience presentation

Performance Standard Condition

Competence will be demonstrated

- at the worksite OR in the classroom in a simulated setting
- NOTE: A simulated setting should ONLY be used IF there is not possibility of skill performance at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Choose a topic based on current research or a project at the worksite
- Outline information to be presented on the topic
- Collect information and data needed for the topic presentation
- Identify and prepare support materials to enhance presentation
- Prepare the presentation in oral, written, and/or visual formats
- Report information with the intent of being informational & instructive
- Explain technical concepts to non-technical audiences
- Use professional terminology
- Identify, select, use appropriate multimedia resources
- Deliver presentation with supporting materials

Learning Objectives

- Explain the various methods for presenting information
- Compare oral, written, visual, and multimedia presentation modes to present scientific, technological, engineering, or mathematical reports
- Discuss how to adjust presentations depending on the intended audience
- List common support materials used to enhance presentations

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency

1. Grow &/or care for plants &/or lab animals

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review protocols for growth and care of plants &/or animal including safety precautions
- Obtain equipment and supplies needed

PLANTS

- Prepare planting spaces
- Prepare soils/media
- Plant seeds, seedlings, or cuttings
- Monitor plants for light, moisture, and temperature requirements
- Mix and apply fertilizers and additives
- Measure growth or other characteristics
- Document planting and feeding

ANIMALS

- Clean and maintain animal quarters
- Safely handle animals
- Mix feed, additives, and/or medicines
- Measure growth or other physical characteristics
- Manage animal waste
- Document care and feeding

Learning Objectives

PLANTS

- Describe the components of a plant and explain their functions
- Explain how soil/media structure, texture, pH, temperatures and salinity affect plant growth
- Explain the growth processes of photosynthesis, respiration & transpiration
- Discuss essential nutrients in plant growth

ANIMALS

- Discuss the Animal Welfare Act
- List proper housing requirements for your lab animals
- Explain how to properly handle your lab animal if required
- List the common nutrients required to maintain animal health
- Define basic terms common in animal anatomy and physiology

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency
2. Collect plant or animal tissues from source

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review protocol for collection of tissue from source including safety precautions
- Obtain equipment and supplies needed to collect tissue
- ***Prepare reagents, solutions, and/or buffers***
- Obtain sample from analyte source
- BLOOD
  - Layer on density gradient
  - Centrifuge
  - Select cells of correct density
- PLANT OR ANIMAL TISSUE
  - Chop up tissue with scissors and/or scalpel
  - Add enzymes
  - Centrifuge on slow speed to separate cells from debris
  - Layer cells on density gradient
  - Centrifuge
  - Select cells of correct density
- Store collected sample as required for further testing
- Document collection as required
- Clean up and shut down equipment

Learning Objectives

- Compare types of tissues and animal products collected for animal examination and testing
- Identify animal tissues that pose health risks
- Compare types of plant tissues
- Explain methods for collecting plant or animal tissues

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency

3. Isolate &/or purify cells, microbes, nucleic acids &/or proteins

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review protocol for isolation &/or purification of desired analyte including safety precautions
- Obtain equipment and supplies needed to isolate &/or purify analyte
- ***Prepare reagents, solutions, and/or buffers***
- Obtain sample from analyte source

CELLS- LABEL BINDING

- Label sample cells with antibodies, fluorescence, etc.
- Separate desired cell set with cell sorter, antibody columns, magnetic beads, chromatography, etc.

CELLS- CENTRIFUGATION

- Layer on density gradient
- Centrifuge at correct speed
- Select cells of correct density

CELL LINES

- ***Culture cells*** from cell lines

MICROBES

- Isolate the microbe in question
  - Streak plate to isolate individual colonies
  - Grow with selective agar media
- ***Culture microbe***

NUCLEIC ACIDS

- Lyse the cell using detergents, enzymatic digestion, or physical methods
- Remove contaminating material from the nucleic acids
- Purify and concentrate the nucleic acids required

PROTEINS

- Prepare cell or tissue sample as required to extract cellular protein from biological sample
- Separate protein from other components
- Isolate specific protein subset

ALL

- Evaluate isolation and/or purification with blotting, ELISA, flow cytometry, spectroscopy, etc.
- Complete any further purification procedures as required by protocol
- Store isolated & purified analyte subset as required for further testing
- Document isolation and/or purification procedures as required
- Clean up and shut down equipment

Learning Objectives

CELLS

- Define eukaryotic
- Compare animal to plant cells
- Discuss common methods to separate and isolate the desired set of cells
- Describe advantages and disadvantages of using cells from blood, tissue or other “live” cultures
- Explain the function of cell surface markers and how they are used in isolating cells
- Describe how antibodies are used to isolate specific cells

NUCLEIC ACIDS

- Compare cell lysis methods and how they work using detergents, enzymes, and physical disruption
- Describe scientific basis behind methods for purifying and concentrating DNA from RNA
- Compare purification using methods such as precipitation, centrifugation, and dialysis membranes

PROTEINS

- Define what is meant by the primary, secondary and tertiary structure of proteins
- Describe categories of characteristics unique to individual proteins such as amino acid sequence, size, shape, solubility, binding, etc.
- Compare methods for separating proteins such as precipitation, chromatography, centrifugation
- Compare advantages and disadvantages of purification procedures

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency

4. Quantify &/or identify cells, microbes, nucleic acids &/or proteins

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review protocol for quantification and/or identification of analyte including safety precautions
- Set up equipment and supplies needed
- ***Prepare reagents, solutions, and/or buffers***
- Sample and transfer the purified analyte in question
- Dilute sample as required

QUANTIFICATION

- Create serial dilutions if required
- Stain and/or label analyte in sample to be counted as required by protocol for microscopy, cytometry, spectrophotometry, etc.
- Obtain readings and/or calculate number of analyte taking into account any dilution factor
- Document counts and calculations as required
- MICROBE CULTURES
  - Culture samples on plates in order to count visible levels of growth
  - Isolate the microbe in question
  - Dilute the sample
  - Streak plate to isolate individual colonies
  - Grow with selective agar media
  - Serially dilute the sample as many times as required
  - Incubate under appropriate conditions
  - Count the CFUs
- NUCLEIC ACIDS
  - Quantify nucleic acid sample by:
  - Abundance in weight: spectroscopy
  - Absolute abundance in number: Q-PCR
  - high-throughput relative abundance: DNA-microarray
  - high-throughput absolute abundance: Serial Analysis of gene expression (SAGE)
  - Size: Gel Electrophoresis
  - Document quantification procedure, calculations and counts as required
  - Clean up equipment and supplies used

IDENTIFICATION

- Follow protocols to perform identification tests such as the following:
- Visually inspect colony morphology
- Obtain images using microscopy
- Stain the sample (Gram stain, Acid Fast, fluorescence, etc.)
- Test agglutination to a specific antibody (Phage Testing)

    - Perform fermentation, hydrolysis, and enzyme tests
    - Complete electrophoresis of the nucleic acids and/or proteins
    - Perform PCR to amplify specific nucleic acid sequences
    - Determine ratio of nucleic acid base pairs to a known
    - Complete nucleic acid sequencing
- Document identification procedure as required
- Clean up and shut down equipment

Learning Objectives

- Describe how to set up serial dilutions and calculate accordingly
- Explain how fluorescent stains, antibodies, & proteins interact in quantification methods
- Compare methods for quantifying analytes such as microscopic counting, colorimetry, flow cytometry, spectrophotometry, etc.

MICROBES

- Define Colony Forming Unit (CFU)
- Explain how phage quantification of plaque forming units (PFU) is performed
- Describe direct and indirect methods for counting viruses
- Compare microscopic, stain, plate, and DNA methods for microbe identification
- Discuss difference in identification techniques for the different types of microbes

NUCLEIC ACIDS

- Compare methods of nucleic acid quantification and when each is indicated
- Describe how to obtain quantification measures and calculate nucleic acid amounts from spectroscopy, electrophoresis and PCR

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency
5. Culture cells &/or microbes

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review protocol for analyte to be prepared including safety precautions
- ***Isolate and/or purify analyte*** to be cultured
- Prepare culture growth media with appropriate growth factors, pH, etc.
- Calculate the concentration required of cells to media
- ***Use aseptic technique*** to sample and transfer analyte to suspension media or to adherent surface media components
  - Remove a sample of suspension OR
  - Dislodge cells from adherent surfaces
- Store culture in area of appropriate temperature, humidity, light, and gas mixture as required by protocol
- Visually inspect culture frequently as required for color, pH, cloudiness, etc.
- Examine analyte cells as required for viability, morphology, density, etc.
- Feed culture as required by protocol
  - Dilute suspensions with fresh media
  - Divide and ***harvest*** adherent cultures or replace old medium with fresh medium
- Document culture and feeding as required
- Clean up and shut down equipment

Learning Objectives

- Define prokaryote and eukaryote
- Explain the cell process of division- mitosis
- Compare bacteria, virus, fungi, and protist structure
- Compare how bacteria, virus, fungi, and protists replicate
- Define bacteriophage
- Compare common sources of cells for cell culture
- List common ingredients in culture media
- Compare suspension (broth or phage) and adherent culture methods
- Explain how to maintain a cell culture in suspension cultures
- Explain how to maintain a cell culture in adherent cultures
- Describe common culture storage conditions
- Explain the issues that arise as cells grow in culture
- Explain special considerations for virus cultures
- Compare characteristics of mortal versus immortalized cell lines

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency
6. Harvest cells &/or microbes

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review protocol for harvesting analyte from culture including safety precautions
- ***Prepare reagents, solutions, and/or buffers***
- Remove analyte cells from suspension culture as required for further processing
- Remove analyte cells from adherent cultures mechanically, chemically and/or with enzymes as required
- Wash cells or colony as required
- Transfer harvested cells to fresh medium
- Examine harvest for viability, if required
- ***Quantify*** analyte cells
- Document harvesting as required
- Clean up and shut down equipment

Learning Objectives

- Describe the typical growth pattern of cells in organisms (in vivo)
- Describe the growth patterns of cells in culture (in vitro)
- Explain how to harvest cells mechanically, chemically and with enzymes that reduce loss of viability
- Discuss the advantages and disadvantages of cell harvesting techniques
- Explain how analyte viability is determined after harvesting

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency
7. Perform spectroscopy

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review protocol for spectroscopic testing including safety precautions
- Set up equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
- Prepare sample as required for spectroscopic analysis
- Blank, Zero or run control on the spectrophotometer
- Run sample as required
- Note the reading(s)
- Calculate and analyze the results
- Document testing as required
- Clean up and shut down equipment

Learning Objectives

- Explain the purpose of spectroscopy
- Discuss the fundamental science behind spectroscopy
- Distinguish between the common types of spectroscopy and their uses
- Describe common complications and troubleshooting in spectroscopy

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency

8. Perform chromatography (gas, TLC, HPLC)

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review protocol for chromatography including safety precautions
- Set up equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
- Prepare sample as required for chromatographic analysis
- Run control(s) along with sample as required
- Note the reading(s)
- Calculate and analyze the results
- Document testing as required
- Clean up and shut down equipment

Learning Objectives

- Explain the purpose of chromatography
- Discuss the fundamental science behind chromatography
- Distinguish between the common types of chromatography and their uses
- Describe common complications and troubleshooting in chromatography

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency
9. Perform flow cytometry

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review protocol for flow cytometry including safety precautions
- Set up equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
- Prepare sample as required for flow cytometry analysis
  - Stain or label the marker in question with tagged conjugates
- Run control(s) along with sample as required
- Visualize sample in flow cytometer
- Note the reading(s)
- Calculate and analyze the results
- Document testing as required
- Clean up and shut down equipment

Learning Objectives

- Explain the purpose of flow cytometry
- Discuss the fundamental science behind flow cytometry
- Discuss how flow cytometry selects for cells desired
- Describe common complications and troubleshooting in flow cytometry

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency

10. Perform microscopy

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review protocol for the microscopy required including safety precautions
- Power on the microscope
- Set control and magnification settings to scan first
- Adjust light aperture, power, stage, etc. according to protocol
- For Scanning Electron Microscopes (SEMs) or Transmission Electron Microscopes (TEMs)- Use the computer to set & adjust appropriate mode, vacuum settings, & image resolution

BASIC

- Place slide/sample on stage
- Find item in scan setting
- Switch to low power and use course knob to refocus
- Switch to high power and use fine adjustment to refocus only if slide has cover slip or is thin enough
- For Scanning Electron Microscopes (SEMs) or Transmission Electron Microscopes (TEMs)- set sample height, evacuate chamber, obtain, capture & store images as required

MOUNT

- Place drop of sample on slide
- Cover sample with cover slip by placing slip at liquid edge at an angle and lower over drop
- For Scanning Electron Microscopes (SEMs) or Transmission Electron Microscopes (TEMs)- prepare samples as required per protocol

STAIN

- Stain samples according to protocol prior to slide mount or on slide as required
- Place one drop of stain at edge of cover slip
- Draw to stain other side

CLEAN UP

- Remove slide from stage
- Return all settings to lowest magnification
- Power off microscope
- Wipe excess material as required
- Cover and store microscope as required
- Wash and dry slides as required
- Discard covers lips as required
- Document testing as required

Learning Objectives

- Compare types of microscopes and how they function to magnify samples
- List basic components of a microscope and their functions
- Demonstrate proper use and care of a microscope

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency
11. Perform restriction digests

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review protocol for restriction digests including safety precautions
- Set up equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
- Prepare sample as required for restriction digestion
- Combine buffer(s), nucleic acid sample and restriction enzymes
- Digest control(s) along with sample as required
- Centrifuge, incubate, and wash/cut/dye as required
- Document digestion procedure as required
- Clean up and shut down equipment

Learning Objectives

- Explain the common purposes of nucleic acid restriction digestion
- Define restriction enzyme & restriction site
- Explain the source of restriction enzymes
- Describe the action of restriction enzymes
- Compare restriction enzyme types
- Describe common complications and troubleshooting in the restriction digestion procedure
- Discuss the importance of proper reaction and storage conditions for enzymes

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency

12. Hybridize nucleic acids

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the protocol for hybridization including safety precautions
- Set up equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
- ***Isolate*** the nucleic acids
- Heat the nucleic acids to melting temperature
- Label strands of one type of nucleic acid
- Mix the labeled strands with unlabeled strands from another source of nucleic acid
- Incubate
- Asses the hybridized nucleic acid binding visually
- Analyze the results
- Document hybridization procedure as required
- Clean up and shut down equipment

Learning Objectives

- Explain the purpose of hybridization
- Discuss common applications of hybridization
- Describe the scientific principle behind hybridization
- Explain how hybridization is analyzed

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency
13. Perform gel electrophoresis

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the protocol for electrophoresis including safety precautions
- Set up equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
  - Prepare the gel for the size of the bio-molecule to be assessed
- Prepare the sample as required
- Pour the gel
- Set up the gel rack and cool
- Submerge rack into buffer
- Inject stained markers, control(s) and sample into gel wells
- Apply current as required
- Stop current when control marker approaches end of gel
- Remove gel
- Stain gel as required
- Visualize gel as required
- Note the reading(s)
- Calculate and analyze the results
  - Calculate molecular weight based in standards and distance traveled
- Document testing as required
- Clean up and shut down equipment

Learning Objectives

- Explain the purpose of gel electrophoresis
- Discuss the fundamental science behind gel electrophoresis
- Compare types of electrophoresis and their uses
- Explain how to interpret electrophoresis fragmentation patterns
- Explain the purpose of the gel
- Discuss factors that affect the migration of bio-molecules
- Explain how to calculate molecular weight
- Describe common complications and troubleshooting in the electrophoresis procedure
- Compare methods for staining and visualizing electrophoresis results

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency

14. Perform amplification

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the protocol for nucleic acid amplification including safety precautions
- Set up equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
- Prepare the nucleic acid sample as required
- Pipet amplification reagents into centrifuge tubes
- Pipet nucleic acid samples into tubes and mix
- Amplify the control(s) and nucleic acid through the required thermocycle steps
- Note the reading(s)
- Calculate and analyze the results during or after amplification
  - Calculate the amplification of sample during PCR or RT-PCR
  - Analyze amplification products with gel electrophoresis
- Document amplification as required
- Clean up and shut down equipment

Learning Objectives

- Explain the purpose of nucleic acid amplification
- Define PCR and RT-PCR
- Discuss the fundamental science behind amplification
- Distinguish between PCR & RT-PCR and their uses
- Describe common complications and troubleshooting in amplification
- Define primer and its purpose in PCR
- Define polymerase and its purpose in PCR
- Compare stains used in PCR & RT-PCR
- Describe quantification calculations completed in nucleic acid amplification

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency

15. Perform blot assays (Southern, Western, Northern)

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the protocol for blotting including safety precautions
- Set up equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
- Prepare the sample as required
- ***Perform restriction digests***
- ***Perform gel electrophoresis*** to separate and isolate desired bio-molecule
- Transfer separate bio-molecule to membrane
- Hybridize with labeled target probe
- Wash any unbound tags
- Detect and visualize the pattern
- Calculate and analyze the results
- Document testing as required
- Clean up and shut down equipment

Learning Objectives

- Explain the purpose of the blot assay
- Discuss the fundamental science behind blotting
- Distinguish between the types of blots and their uses
- Describe common complications and troubleshooting in blotting
- Compare blot detection methods

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency

16. Perform nucleic acid sequencing

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the protocol for nucleic acid sequencing including safety precautions
- Set up equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
- Prepare nucleic acid to be sequenced as a single strand
- Anneal primer
- Supply nucleic acid with a labeled mix of the four nucleotides
- Incubate
- Separate fragments by length
- Visualize fragments
- MICROARRAYS
  - Prepare nucleic acid to arrayed
  - Spot sample cDNA or cRNA onto chip plate of probe DNA
  - Visualize probes
- Calculate and analyze the results
- Document sequencing as required
- Clean up and shut down equipment

Learning Objectives

- Explain the purpose of nucleic acid sequencing
- Discuss the fundamental science behind nucleic acid sequencing
- Distinguish between the types of sequencing techniques and when each is preferred
- Describe common complications and troubleshooting in nucleic acid sequencing
- Define high-throughput sequencing
- Compare standard dye-terminator sequencing to high-throughput sequencing
- Describe DNA microarrays
- Explain how DNA microarrays are used
- Explain how to calculate and analyze sequencing results

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency

17. Perform cellular assays

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review protocol for manipulating cells including safety precautions
- Set up equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
- ***Harvest cells*** to be manipulated
- ***Conduct the testing according to protocol***
  - Conduct assays to measure for cell proliferation, cell death, cell metabolism, cell protein turnover, receptor binding, receptor activation, cell signaling, reporter gene activity, high throughput screening, etc.
  - Use technologies such as electrophoresis, ELISA, flow cytometry, fluorescence microscopy, phase microscopy, spectroscopy, etc.
- Calculate and analyze the results
- Document assay procedure as required
- Clean up and shut down equipment

Learning Objectives

- List common reasons for testing cells
- Compare common types of cellular assays and when each is used

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency

18. Perform immunoassays (ELISA)

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review protocol for immunoassay including safety precautions
- Set up equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
- Prepare the sample as required
- Prepare test plate with capture antigen or antibody
- Add sample to each test well
- Wash test plate
- Add labeled antibody-enzyme conjugates
- Wash test plate
- Visualize wells
- Calculate and analyze the results
- Document assay procedure as required
- Clean up and shut down equipment

Learning Objectives

- Define antigens and their function
- Describe how antibodies are formed
- Explain how antibodies can be used to detect and quantify antigens
- Explain how the principle of antigen-antibody binding is used in bioscience lab testing
- Define monoclonal and polyclonal antibodies
- Explain the purpose of the Enzyme-Linked Immunoabsorbent Assay (ELISA)
- Discuss the fundamental science behind the ELISA
- Describe common complications and troubleshooting in ELISA testing

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency

19. Perform protein assays (Bradford, Lowry)

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review protocol for performing assay including safety precautions
- Set up equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
- ***Separate and isolate protein*** to be tested
- ***Conduct the testing according to protocol***
  - Use technologies such as electrophoresis, ELISA, flow cytometry, spectroscopy, etc.
- Calculate and analyze the results
- Document assay procedure as required
- Clean up and shut down equipment

Learning Objectives

- List common reasons for testing proteins
- Compare common types of protein assays and when each is used
- Discuss common techniques for protein interaction and function testing
- Explain immunostaining for proteins
- Compare types of immunostaining for proteins
- Indicate how enzyme activity assays are used to detect proteins

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency
20. Perform transfection/transformation

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the protocol for transfection/transformation including safety precautions
- Set up equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
- ***Isolate & purify the nucleic acid*** material to be transfected
- Incubate the vector DNA, insert DNA, DNA Ligase, and buffers
- Prepare the vector with promoter elements and/or resistance markers
- Isolate competent host cells
- Transfect the host according to protocol
  - Use methods such as calcium phosphate, liposomes, cationic polymers, electroporation, viruses, magnetic nanoparticles, etc.
- Wash, store and/or culture cells as required
- Document procedure as required
- Clean up and shut down equipment

Learning Objectives

- Explain the DNA transformation, translation and replication process in cells
- Define transfection, transformation, and transduction
- Define plasmid and vector
- Explain the common conformations of plasmid DNA
- Discuss common applications of plasmids
- Explain the purpose of transfection/transformation
- Discuss the fundamental science behind transfection/transformation
- Compare transfection/transformation techniques and when each is preferred
- Describe common complications and troubleshooting in transfection/transformation

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency
21. Perform basic cloning

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Review the protocol for cloning including safety precautions
- Set up equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
- ***Isolate & purify the nucleic acid*** material to be cloned
- Prepare the vector
- Isolate competent host cells
- ***Transfect/transform*** the cells
- Wash and plate cells
- Incubate
- ***Harvest cells***
- Check/select cloned cells with gel electrophoresis
- Document procedure as required
- Clean up and shut down equipment

Learning Objectives

- Explain the DNA transformation, translation and replication process
- Define cloning and sub-cloning
- Explain the purpose of cloning
- Discuss the fundamental science behind cloning
- Describe common complications and troubleshooting in cloning
- Compare molecular cloning to artificial embryo twinning
- Discuss legislation restricting the uses of cloning and recombinant technology
- Define genomics

Comments:

Unit 7: Science & Math Pathway
Bioscience Applications- Competency Choices

Competency

22. Run expression cloning tests

Performance Standard Condition

Competence will be demonstrated

- at the worksite

Performance Standard Criteria

Performance will be successful when learners:

- Choose the appropriate test for cloning genetic analysis
- Review the protocol for expression tests including safety precautions
- Set up equipment and supplies
- ***Prepare reagents, solutions, and/or buffers***
- ***Perform basic cloning***
- Analyze genes and gene expression using technologies such as PCR, RT-PCR, DNA sequencing, Microarrays, hybridization and karyotyping
- Evaluate results according to procedure used
- Document analysis procedure as required
- Clean up and shut down equipment

Learning Objectives

- Explain the importance of genetics
- Explain how to estimate the heritability of certain traits
- Describe a karyotype
- Describe sex determination, linkage, crossover, and mutation
- Explain the reasons for the genetic modification of organisms
- Describe the processes and techniques used to produce transgenic organisms
- Describe how biotechnology can be used to evaluate existing transgenic organisms
- Explain the purpose of the expression testing
- Discuss the fundamental science behind expression testing
- Distinguish between the types of expression testing and when each is preferred
- Describe common complications and troubleshooting in expression testing
- Define single nucleotide polymorphisms (SNPSs)
- Describe how SNPs are identified
- Explain problems associated with expression cloning testing

Comments: