Principles of Technology II

9812 36 weeks

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Course Description

Suggested Grade Level: 11 or 12
Prerequisites: 9811

Students continue to apply physics and mathematics concepts through a unified systems approach to expand their knowledge base of the principles underlying modern technical systems. This course focuses on seven technical principles: momentum, waves, energy converters, transducers, radiation, optical systems, and time constants, emphasizing how each principle plays a unifying role in the operation of mechanical, fluid, electrical, and thermal systems in high-technology equipment. This "principles and systems" approach to studying these technical principles provides a foundation for further education and career flexibility as technology and technical systems advance.

Note: Students who complete Principles of Technology I and Principles of Technology II may use these courses to satisfy one physics credit in laboratory science. A student must complete both courses in the sequence in order to receive laboratory science credit. The sequence of Principles of Technology I and Principles of Technology II will satisfy one unit of credit in laboratory science for physics and one elective credit. Students who enroll in Principles of Technology courses for a physics credit must have completed Algebra I and two other laboratory science courses as specified by the accrediting standards prior to enrolling in Principles of Technology.

Task Essentials Table

- Tasks/competencies designated by plus icons (⊕) in the left-hand column(s) are essential
- Tasks/competencies designated by empty-circle icons (○) are optional
- Tasks/competencies designated by minus icons (⊖) are omitted
- Tasks marked with an asterisk (*) are sensitive.

Task Number	9812	Tasks/Competencies	
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39	⊕	Describe linear momentum in general terms.	
40	⊕	Describe angular momentum in general terms.	
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42	⊕	Describe the relationship of impulse to change in momentum.	
43	⊕	List examples of how momentum affects mechanical and fluid systems.	
UNIT 9: WAVES and VIBRATIONS			
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45	⊕	Describe how waves transmit (move) energy.	
46	⊕	Explain the characteristics that are used to describe a wave.	
47	⊕	Demonstrate how waves transmit energy.	
48	⊕	Distinguish between longitudinal and transverse waves.	
49	⊕	Identify workplace applications where waves and vibrations are found.	
UNIT 10: ENERGY CONVERTORS			
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51	⊕	Describe what is meant by the efficiency of an energy converter.	
52	⊕	Identify converters that change mechanical energy to fluid energy or electrical energy.	

53	⊕	Identify converters that change fluid energy to mechanical energy.	
54	⊕	Identify converters that change electrical to mechanical or thermal energy.	
55	⊕	Identify converters that change thermal to mechanical, fluid, or electrical energy.	
UNIT 11: TRANSDUCERS			
56	⊕	Define the term *transducer*.	
57	⊕	Describe the action of a transducer in general terms.	
58	⊕	Distinguish between an energy converter and a transducer.	
59	⊕	Identify transducers that change mechanical signals into electrical signals.	
60	⊕	Identify transducers that change fluid signals into mechanical or electrical signals.	
61	⊕	Identify transducers that change electrical signals into mechanical or thermal information.	
62	⊕	Identify transducers that change thermal signals into mechanical, fluid, or electrical information.	
UNIT 12: RADIATION			
63	⊕	Describe what is meant by *radiant energy.*	
64	⊕	Describe what is meant by *electromagnetic radiation.*	
65	⊕	Describe what is meant by *nuclear radiation.*	
66	⊕	Explain physical relativity phenomena that occur at low speeds and as the speed of light is approached.	
67	⊕	Identify workplace applications where technicians measure or control radiation.	
68	⊕	Explain physical phenomena at the quantum mechanical level.	
UNIT 13: LIGHT and OPTICAL SYSTEMS			
69	⊕	Describe how light can be represented by light rays.	

70	⊕	Describe how light can be represented by waves.	
71	⊕	Identify the special characteristics of laser light.	
72	⊕	List several optical systems that “process” light.	
73	⊕	Identify workplace applications where technicians measure and control light.	
UNIT 14: TIME CONSTANTS			
74	⊕	Distinguish between uniform and nonuniform change.	
75	⊕	Define the term *time constant.*	
76	⊕	Identify systems where time constants are needed to describe system behavior.	
77	⊕	Define three time constants.	
78	⊕	Give examples of time constants in mechanical, fluid, electrical, and thermal energy systems.	
78	⊕	Identify workplace applications where technicians measure and control time constants.	

Legend: ⊕Essential ○Non-essential ⊖Omitted

Curriculum Framework

UNIT 8: MOMENTUM

Task Number 39

Describe linear momentum in general terms.

Definition

Description should include that momentum is the product of a moving object’s mass and its velocity ($p=m\times v$).

Process/Skill Questions

- What is the definition of linear momentum?
- What units are used to describe linear momentum in the English system? In the SI system?
- What is Newton's first law of motion?
- Upon what two things does linear momentum depend?

Task Number 40

Describe angular momentum in general terms.

Definition

Description should include the product of a rotating object's moment of inertia and its angular velocity.

Process/Skill Questions

- How is angular momentum defined?
- What units are used to describe angular momentum in the English system? In the SI system?
- Why is moment of inertia used instead of mass?

Task Number 41

Describe the law of conservation of momentum.

Definition

Description should include that in an isolated system the momentum before an interaction is equal to the momentum after the interaction.

Process/Skill Questions

- What is the law of conservation of momentum?
- What are isolated systems?
- What are two types of collisions?
- How does the law of conservation of momentum relate to angular and linear motion?

Task Number 42

Describe the relationship of impulse to change in momentum.

Definition

Description should include

- the product of a force or torque that acts on an object or fluid and the length of time that force acts
- the formula $Fx\Delta t=\Delta(mv)$
- the fact that lb•sec = slug•ft/sec and N•sec = kg•m/sec.

Process/Skill Questions

- How does the relationship between linear/angular impulse cause a change in linear/angular momentum?
- How can the relationship of linear/angular momentum and linear/angular impulse be written?

Task Number 43

List examples of how momentum affects mechanical and fluid systems.

Definition

List may include, but not be limited to

- planned or unplanned collisions
- space shuttle
- aircraft carriers
- gyroscopes
- spinning satellites
- turbines.

Process/Skill Questions

- What effect does linear momentum and impulse have on a mechanical system? A fluid system?
- What effect does angular momentum and impulse have on a mechanical system? A fluid system?
- How could linear/angular momentum be applied in everyday life?
- How could linear/angular impulse be applied in everyday life?

UNIT 9: WAVES and VIBRATIONS

Task Number 44

Describe wave motion in general.

Definition

Description should include

- stating the medium through which waves travel
- identifying the wave as a single or continuous pulse
- identifying and evaluating characteristics of wave motion.

Process/Skill Questions

- How does heat energy get transferred?
- What does the term *medium* mean?
- What is the difference between a single pulse and continuous wave?
- What is a mechanical wave?
- What is a longitudinal wave?

Task Number 45

Describe how waves transmit (move) energy.

Definition

Description should include

- defining the term *molecular movement*
- how energy moves from one molecule to the next
- how electromagnetic waves transfer energy through a vacuum.

Process/Skill Questions

- What happens if one molecule bumps into another?
- What is the difference between mechanical waves and electromagnetic waves?
- How does the term *elastic* relate to wave movement?

Task Number 46

Explain the characteristics that are used to describe a wave.

Definition

Explanation should include amplitude, phase, wavelength, frequency, period, and speed.

Process/Skill Questions

- How does the wave amplitude affect its energy?
- What is meant by the term *phase difference* when referring to a wave?
- How is a wave's period related to its frequency?

Task Number 47

Demonstrate how waves transmit energy.

Definition

Demonstration should include the use of amplitude, phase, wavelength, frequency, period, and speed.

Process/Skill Questions

- How would you calculate a wave's speed?
- How does a wave's frequency affect its energy?

Task Number 48

Distinguish between longitudinal and transverse waves.

Definition

Differences should include the direction of molecular motion in relation to the direction of the wave.

Process/Skill Questions

- What are the six characteristics of a transverse wave?
- What are the five characteristics of a longitudinal wave?
- What is meant by the term *rarefaction*?

Task Number 49

Identify workplace applications where waves and vibrations are found.

Definition

Identification may include, but not be limited to

- electrical work
- radar technology
- engineering
- architecture
- seismology
- radio/TV broadcasting
- hospital technology.

Process/Skill Questions

- Where would a student use these devices in their own life?
- Where would industry use these devices in the real world?
- What are some of the effects of wave interference?
- How does sonar use wave characteristics to determine water depth?

UNIT 10: ENERGY CONVERTORS

Task Number 50

Describe the purpose of an energy converter.

Definition

Description should include

- defining the term *energy converter* (a device that accepts one form of input energy and delivers energy in a different form of output)
- identifying types of energy converters for each energy system
- evaluating the efficiency of converting from one form to another.

Process/Skill Questions

- What is the input energy form?
- What are types of converters?
- What is the output energy form?
- How do you calculate the efficiency of a converter?

Task Number 51

Describe what is meant by the efficiency of an energy converter.

Definition

Description should include

- stating that all devices are never 100 percent efficient
- expressing the efficiency of output in the same terms as the input
- identifying the similarities in efficiency between energy converters and force transformers
- identifying the differences between energy converters and force transformers.

Process/Skill Questions

- How much waste is developed in energy converters?
- Why is it important to develop energy converters?

Task Number 52

Identify converters that change mechanical energy to fluid energy or electrical energy.

Definition

Identification may include, but not be limited to

- types of pumps (e.g., vane, centrifugal, gear, piston)
- alternators
- generators
- air compressors or fans.

Process/Skill Questions

- How does a pump convert mechanical energy to fluid energy?
- How does a fan convert mechanical energy to fluid energy?
- How does a generator or alternator convert mechanical energy to electrical energy?

Task Number 53

Identify converters that change fluid energy to mechanical energy.

Definition

Identification may include, but not be limited to

- windmills
- turbine engines
- water turbines
- hydraulic lifts and pumps
- air conditioners.

Process/Skill Questions

- How does a windmill convert fluid energy to mechanical energy?
- How does a gas turbine convert fluid energy to mechanical energy?
- How does an air conditioner compressor convert fluid energy to mechanical energy?

Task Number 54

Identify converters that change electrical to mechanical or thermal energy.

Definition

Identification may include, but not be limited to

- electric motors
- solenoids
- heating elements
- heat pumps
- computers
- appliances.

Process/Skill Questions

- How does an electric motor convert electrical energy to mechanical energy?
- How does a heat pump convert electrical energy to mechanical energy?

Task Number 55

Identify converters that change thermal to mechanical, fluid, or electrical energy.

Definition

Identification may include, but not be limited to

- thermostats
- thermocouples
- steam turbines
- engines (i.e., gasoline, diesel, gas turbine, steam turbine).

Process/Skill Questions

- What is the mechanical equivalent of heat energy?
- How does a bimetallic strip convert thermal energy to mechanical energy?
- How does a fuel mixture convert thermal energy to mechanical energy?
- How does a thermocouple convert thermal energy to electrical energy?

UNIT 11: TRANSDUCERS

Task Number 56

Define the term *transducer*.

Definition

Definition should state that a transducer (or sensor) is a device that monitors a system without diverting energy from its principal operation.

Process/Skill Questions

- What is the purpose of a transducer?

- How can transducers be classified (i.e., according to the form of energy on their input side)?
- What devices are used to measure the output of a transducer?

Task Number 57

Describe the action of a transducer in general terms.

Definition

Description should state that a transducer means to “lead across” and that it is a device that converts a signal from one energy system to another.

Process/Skill Questions

- How does a transducer lead information from one energy system to another?
- How much energy does a transducer typically consume?
- Why is a transducer typically read with a mechanical gauge or an electrical meter?

Task Number 58

Distinguish between an energy converter and a transducer.

Definition

Distinction should state that a transducer monitors an energy system without diverting energy from its principal operation, while an energy convertor takes energy from a less useful type of operation and converts it into a more useable form.

Process/Skill Questions

- What is an energy converter?
- What are the similarities and/or differences between an energy converter and a transducer?
- How does a transducer monitor a system?

Task Number 59

Identify transducers that change mechanical signals into electrical signals.

Definition

Identification should include, but not be limited to

- strain gauges
- accelerometers
- piezoelectric crystals
- microphones
- barometers
- how the mechanical signals are converted into electrical signals.

Process/Skill Questions

- How are mechanical signals converted into electrical signals?
- What are examples of transducers that convert mechanical signals into electrical signals?
- What are the applications of transducers that convert mechanical signals into electrical signals?

Task Number 60

Identify transducers that change fluid signals into mechanical or electrical signals.

Definition

Identification should include, but not be limited to

- Bourdon pressure gauges
- barometers
- flow meters
- anemometers
- rotameters
- how the motion of a fluid is converted into mechanical or electrical signals.

Process/Skill Questions

- How are mechanical signals converted into electrical signals?
- What are examples of transducers that convert mechanical signals into electrical signals?
- What are the applications of transducers that convert mechanical signals into electrical signals?

Task Number 61

Identify transducers that change electrical signals into mechanical or thermal information.

Definition

Identification should include, but not be limited to

- moving-coil meters
- electrostrictive crystals
- photoconductors and photocells
- ammeters
- voltmeters
- how electrical signals are converted into mechanical or thermal signals.

Process/Skill Questions

- How are fluids converted into mechanical or electrical signals?
- What are examples of transducers that convert fluids into mechanical or electrical signals?
- What are the applications of transducers that convert fluids into mechanical or electrical signals?

Task Number 62

Identify transducers that change thermal signals into mechanical, fluid, or electrical information.

Definition

Identification should include, but not be limited to

- bimetallic strips
- thermographs
- thermocouples
- thermistors
- how thermal energy is converted into mechanical, fluid, or electrical signals.

Process/Skill Questions

- How are electrical signals converted into mechanical or thermal information?
- What are examples of transducers that convert electrical signals into mechanical or thermal information?
- What are the applications of transducers that convert electrical signals into mechanical or thermal information?

UNIT 12: RADIATION

Task Number 63

Describe what is meant by *radiant energy.*

Definition

Description should include

- defining the term *radiation* (the process of how atoms emit energy or radiate energy)
- identifying the type of energy given off in the process.
- comparing fission and fusion in terms of end products, energy, advantages, and availability.

Process/Skill Questions

- What are the parts of an atom?
- What type of energy comes from the electrons?
- What type of energy comes from the nucleus of an atom?
- Why are only certain types of radiation harmful?
- Why is understanding radiation important?

Task Number 64

Describe what is meant by *electromagnetic radiation.*

Definition

Description should include

- defining the term *electromagnetic radiation* (transfer of energy produced by an accelerating charge)
- identifying the types of waves on the electromagnetic spectrum (i.e., radio, microwaves, light, X rays, gamma, and cosmic)
- characterizing the radiation by the wavelengths and frequency found along the electromagnetic spectrum.

Process/Skill Questions

- What is the electromagnetic spectrum?
- What are the four characteristics used to describe the electromagnetic spectrum?
- What is the relationship between photons and energy?

- Why can light push a sailboat?
- Why does an element have its own spectrum?

Task Number 65

Describe what is meant by *nuclear radiation.*

Definition

Description should include

- defining the term *nuclear radiation* (transfer of energy away from an unstable nucleus by means of alpha particles, beta particles, or gamma rays)
- understanding nuclear decay and its associated hazards
- identifying the three components of nuclear radiation, fission, and fusion
- demonstrating how to use the formula $E=mc^2$ to change mass into energy.

Process/Skill Questions

- What is nuclear decay?
- What are the three main components of nuclear radiation?
- What are the hazards associated with alpha decay? Beta decay? Gamma decay?
- What is nuclear fission?
- What is nuclear fusion?

Task Number 66

Explain physical relativity phenomena that occur at low speeds and as the speed of light is approached.

Definition

Explanation should include

- how electromagnetic energy is characterized
- how photons and electromagnetic energy are related
- how energy can be calculated by using $E=hf$, $E=hc/\lambda$, or $E=mc^2$.

Process/Skill Questions

- What is a photon?
- What is Planck's constant?
- How do you calculate the energy of a photon?

- What are we calculating when we use the formula $E=mc^2$?

Task Number 67

Identify workplace applications where technicians measure or control radiation.

Definition

Identification should include, but not be limited to

- communications
- medical applications
- power generation
- special precautions associated with working with electromagnetic and nuclear radiation.

Process/Skill Questions

- Which industries and professions use radiation?
- Where would a student encounter radiation in their own life?
- What special precautions must be in place when working with electromagnetic radiation and nuclear radiation?

Task Number 68

Explain physical phenomena at the quantum mechanical level.

Definition

Explanation should include

- quantum tunneling that occurs during radioactive decay
- Heisenberg uncertainty principle.

Process/Skill Questions

- How are atoms changing as they decay?
- What is the Heisenberg uncertainty principle?
- What are some of the barriers associated with nuclear fusion?

UNIT 13: LIGHT and OPTICAL SYSTEMS

Task Number 69

Describe how light can be represented by light rays.

Definition

Description should include

- understanding how light behaves
- the law of reflection, and how flat, concave, and convex mirrors work
- the law of refraction, and how light passes through concave and convex lenses.

Process/Skill Questions

- What is reflection?
- What is refraction?
- What is the angle of incidence?
- What is the angle of refraction?
- What is the index of refraction?
- What is a focal point and focal length?

Task Number 70

Describe how light can be represented by waves.

Definition

Description should include

- the difference between shadows caused by light rays and by light waves
- the difference between wave interference and diffraction
- the difference between constructive and destructive interference.

Process/Skill Questions

- What is meant by wave interference?
- What is the difference between constructive and destructive wave interference?
- How is an interference fringe pattern created?
- What is diffraction?
- What is collimated light?
- What is a diffraction grating?

Task Number 71

Identify the special characteristics of laser light.

Definition

Identification should include

- the main components of a laser
- the four ways to put energy into a laser
- the main types of lasers
- the differences between characteristics of laser light and other light.

Process/Skill Questions

- What are the four components of a laser?
- What are some common types of lasers?
- What is the difference between an argon laser, a carbon dioxide laser, a dye laser, and a neodymium-YAG laser?
- What makes laser light different from other types of light?
- What is radiant power and power density?

Task Number 72

List several optical systems that “process” light.

Definition

List may include, but not be limited to

- lasers
- computers
- human eyes
- fiber optic cables
- astronomical devices
- photographic equipment.

Process/Skill Questions

- How does the human eye form an image?
- What is the difference between nearsightedness and farsightedness?
- What is the “f-number” on a camera lens?
- What is a beam expander?

Task Number 73

Identify workplace applications where technicians measure and control light.

Definition

Identification should include, but not be limited to

- opticians
- health industry workers
- construction industry workers.

Process/Skill Questions

- How do opticians use the characteristics of light to improve vision?
- Where and how are lasers used in the construction industry?
- Where would a student encounter optical systems in their own life?

UNIT 14: TIME CONSTANTS

Task Number 74

Distinguish between uniform and nonuniform change.

Definition

Differentiation should state that

- a system changes in a uniform way when the rate of change is constant
- a system changes in a nonuniform way when the rate of change is not constant
- nonuniform systems operate in a transient condition.

Process/Skill Questions

- How do systems change in a uniform way? In a nonuniform way?
- Why are systems that undergo nonuniform change important?
- What are types of systems that operate in a uniform way? A nonuniform way?

Task Number 75

Define the term *time constant.*

Definition

Definition should state that a time constant is the interval required for a circuit or system to change from one state to another. A system is considered to have changed its state after five time constants have elapsed.

Process/Skill Questions

- Why is a time constant important?
- When would a system make a complete change?
- How are time constants used at work?
- Why don't time constants apply to systems that change at a constant or uniform rate?

Task Number 76

Identify systems where time constants are needed to describe system behavior.

Definition

Identification should state that time constants are needed for systems that change in nonuniform ways.

Process/Skill Questions

- Why do we need time constants?
- What types of systems do not need time constants?

Task Number 77

Define three time constants.

Definition

Definition should include

- $T_{1/2}$, which represents the time it takes for 50 percent of the total change to take place
- T_{90}, which represents the time it takes for 90 percent of the total change to take place

- τ (tau), which represents the time it takes for 63 percent of the total change to take place.

Process/Skill Questions

- Would a system ever approach its final value?
- What do the three time constants say about a system?

Task Number 78

Give examples of time constants in mechanical, fluid, electrical, and thermal energy systems.

Definition

Examples may include, but not be limited to

- mechanical—electric fan, shock absorbers
- fluid—flow rate from a tank, skydiver
- electrical—circuits with changing voltages, electronic timing devices
- thermal—insulators and refrigerators, thermocouples.

Process/Skill Questions

- Why are time constants important in thermal systems?
- What are transients in electrical systems?
- How are time constants used in fluid systems?

Task Number 79

Identify workplace applications where technicians measure and control time constants.

Definition

Identification may include, but not be limited to

- electronics
- thermodynamics and fluid mechanics
- meteorology
- thermal systems
- heating and air conditioning systems
- aeronautics
- mechanical systems

- automotive technology.

Process/Skill Questions

- Why are time constants important to a computer technician?
- Why are time constants important to an air-conditioning technician?
- Why are time constants important to a technician who works with mechanical motors?
- Why are time constants important to a technician working in the papermaking industry?

SOL Correlation by Task

39	Describe linear momentum in general terms.	English: 11.5, 12.5 Mathematics: A.4, A.8 Science: PH.6
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41	Describe the law of conservation of momentum.	English: 11.5, 12.5 Mathematics: A.4, AII.3, MA.3, MA.7 Science: PH.6
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47	Demonstrate how waves transmit energy.	Science: PH.8
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49	Identify workplace applications where waves and vibrations are found.	English: 11.5, 12.5 Science: PH.4
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51	Describe what is meant by the efficiency of an energy converter.	English: 11.5, 12.5 Mathematics: A.4, AII.3, AII.10 Science: PH.7
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65	Describe what is meant by *nuclear radiation.*	English: 11.3, 11.5, 12.3, 12.5 Mathematics: AII.3 Science: PH.7, PH.12
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68	Explain physical phenomena at the quantum mechanical level.	English: 11.5, 12.5 Science: PH.12
69	Describe how light can be represented by light rays.	English: 11.5, 12.5

		Mathematics: G.7, G.8, AII.10, MA.6 Science: PH.4
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74	Distinguish between uniform and nonuniform change.	English: 11.5, 12.5 Mathematics: AII.3, AII.4, AII.7 Science: PH.11
75	Define the term *time constant.*	English: 11.3, 12.3 Mathematics: AII.7, MA.2
76	Identify systems where time constants are needed to describe system behavior.	English: 11.5, 12.5 Mathematics: AII.7, MA.2
77	Define three time constants.	English: 11.3, 11.5, 12.3, 12.5 Mathematics: A.4, AII.3, AII.7, MA.2
78	Give examples of time constants in mechanical, fluid, electrical, and thermal energy systems.	English: 11.5, 12.5 Mathematics: A.4, AII.10, MA.2, MA.4 Science: PH.4
79	Identify workplace applications where technicians measure and control time constants.	English: 11.5, 12.5 Mathematics: A.4, AII.10, MA.2 Science: PH.4

Entrepreneurship Infusion Units

Entrepreneurship Infusion Units may be used to help students achieve additional, focused competencies and enhance the validated tasks/competencies related to identifying and starting a new business venture. Because the unit is a complement to certain designated courses and is not mandatory, all tasks/competencies are marked “optional.”

Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials: Only apply to 36-week courses

- College and Work Readiness Assessment (CWRA+)
- National Career Readiness Certificate Assessment
- Workplace Readiness Skills for the Commonwealth Examination

Concentration sequences: *A combination of this course and those below, equivalent to two 36-week courses, is a concentration sequence. Students wishing to complete a specialization may take additional courses based on their career pathways. A program completer is a student who has met the requirements for a CTE concentration sequence and all other requirements for high school graduation or an approved alternative education program.*

- Principles of Technology I (9811/36 weeks)

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
Engineering and Technology	**Chemical Engineer** **Electrical Engineer** **Electrical Engineering Technician** **Electro-Mechanical Technician** **Engineer** **Engineering Technician** **Industrial Engineer** **Industrial Engineering Technician** **Manufacturing Systems Engineer** **Mechanical Engineer** **Mechanical Engineering Technician**
Science and Mathematics	**Atmospheric Scientist** **Hydrologist** **Secondary School Teacher**