Principles of Technology I

9811 36 weeks

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Course Description

Suggested Grade Level: 10 or 11 or 12

Students in this single-period laboratory science course apply physics and mathematics concepts through a unified systems approach to develop a broad knowledge base of the principles underlying modern technical systems. Students study seven technical principles: force, work, rate, resistance, energy, power, and force transformers, 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 List

- 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	9811	Tasks/Competencies
UNIT 1: FORCE		
39	⊕	Describe what is meant by *force* in general and in mechanical, fluid, electrical, and thermal systems.
40	⊕	Give examples of complex technological devices where force must be controlled, measured, or applied.
41	⊕	Describe what force, pressure, voltage, and temperature difference have in common.
42	⊕	Predict what happens to an object when forces on it are balanced and when forces on it are unbalanced.
43	⊕	Measure force in mechanical, fluid, electrical, and thermal systems.
44	⊕	List occupations that require technicians to measure, control, or otherwise deal with force in complex devices.
UNIT 2: WORK		
45	⊕	Describe what is meant by *work* in general and in mechanical, fluid, and electrical systems.
46	⊕	Describe how work in mechanical, fluid, and electrical systems involves the presence of force and movement.
47	⊕	Identify the SI and English units for work in mechanical, fluid, and electrical systems.
48	⊕	Identify the effects of work done in mechanical, fluid, and electrical systems.
49	⊕	Measure work in mechanical, fluid, and electrical systems.
UNIT 3: RATE		

50	⊕	Describe what is meant by *rate* in general and in mechanical, fluid, electrical, and thermal systems.	
51	⊕	Identify the SI and English units for rate in all four energy systems.	
52	⊕	Measure rate in mechanical, fluid, electrical, and thermal systems.	
53	⊕	Identify workplace applications where rate is measured and/or controlled.	
UNIT 4: RESISTANCE			
54	⊕	Describe what is meant by *resistance* in general and in mechanical, fluid, electrical, and thermal energy systems.	
55	⊕	Explain how resistance in each energy system relates to the unifying principle of a "force" divided by a rate.	
56	⊕	Identify the SI and English units for resistance in each energy system.	
57	⊕	Identify positive and negative effects of resistance in each energy system.	
58	⊕	Identify workplace applications where technicians measure or control resistance.	
59	⊕	Describe how resistance is affected at extremely high and low temperatures in materials, including superconductors.	
60	⊕	Measure resistance in mechanical, fluid, electrical, and thermal energy systems.	
UNIT 5: ENERGY			
61	⊕	Describe the nature of energy in mechanical, fluid, electrical, and thermal systems.	
62	⊕	Describe what is meant by *potential energy.*	
63	⊕	Describe what is meant by *kinetic energy.*	
64	⊕	Describe the relationship of potential energy, kinetic energy, and heat energy to the law of conservation of energy.	
65	⊕	Describe the relationship between work and energy.	
66	⊕	Describe how principles of mechanics apply to celestial systems.	

67	⊕	Identify the SI and English units for energy in each system.	
68	⊕	Measure energy in each energy system.	
69	⊕	Identify workplaces where technicians measure or control energy.	
UNIT 6: POWER			
70	⊕	Describe what is meant by *power* in general and in mechanical, fluid, electrical, and thermal systems.	
71	⊕	Explain how thermal power and thermal rate are the same.	
72	⊕	Explain how power in each energy system relates to the unifying principle of work divided by time.	
73	⊕	Analyze why power can be described in terms of a "force times a rate" for mechanical, fluid, and electrical systems.	
74	⊕	Identify workplace applications where technicians measure or control power.	
UNIT 7: FORCE TRANSFORMERS			
75	⊕	Describe force transformers in general and in mechanical, fluid, and electrical systems.	
76	⊕	Evaluate the efficiency of converting energy from one form to another, using mathematical calculations.	
77	⊕	Explain why force transformers form a unifying principle in mechanical, fluid, and electrical systems.	
78	⊕	List examples of force transformers in mechanical, fluid, and electrical systems.	

Legend: ⊕Essential ○Non-essential ⊖Omitted

Curriculum Framework

UNIT 1: FORCE

Task Number 39

Describe what is meant by *force* in general and in mechanical, fluid, electrical, and thermal systems.

Definition

Description should include

- the amount of push or pull needed to put an object in motion
- the amount of push or pull needed to change an object's shape
- the amount of push or pull needed to change an object's direction
- defining *scalar*
- defining *vector*.

Process/Skill Questions

- What is a contact force?
- What is a distance force?
- What is the difference between weight and mass?
- What is the prime mover in each system?

Task Number 40

Give examples of complex technological devices where force must be controlled, measured, or applied.

Definition

Examples should include

- thermometers
- voltmeters
- spring scales
- hydraulic jacks
- manometers.

Process/Skill Questions

- Which device would be used to measure force in each energy system (mechanical, fluid, thermal, electrical)?
- How is force measured in each of the devices described?
- What would be an appropriate situation to use each device?

Task Number 41

Describe what force, pressure, voltage, and temperature difference have in common.

Definition

Description should include the formula for each and how they

- are prime movers
- cause something to move
- can be measured.

Process/Skill Questions

- What is the relationship between voltage and electron flow?
- What is the unifying principle among all four energy systems?
- What is causing the object to move in each system?

Task Number 42

Predict what happens to an object when forces on it are balanced and when forces on it are unbalanced.

Definition

Prediction should include

- whether the object moves
- in what direction the object moves
- whether the object changes shape.

Process/Skill Questions

- What are examples of balanced forces? Of unbalanced forces?
- When are forces balanced and unbalanced as a parachutist descends?
- What would be an example of an object changing direction?

Task Number 43

Measure force in mechanical, fluid, electrical, and thermal systems.

Definition

Measurement for each system should include the units of measurement, the device used, demonstration of the use of the device, and calculation to verify the measurement is correct.

Process/Skill Questions

- How do you measure forces in a mechanical system? Fluid? Electrical? Thermal?
- What safety precautions are required to measure mechanical/fluid/electrical/thermal forces?
- What are the units of measurement in each system?
- Where would a student use this in their own life?
- Where would industry use this in the real world?

Task Number 44

List occupations that require technicians to measure, control, or otherwise deal with force in complex devices.

Definition

List may include, but not be limited to

- construction workers
- electricians
- automotive technicians
- HVAC technicians
- plumbers
- engineers.

Process/Skill Questions

- Where would a student use complex devices in their own life?
- Where would industry use complex devices in the real world?

UNIT 2: WORK

Task Number 45

Describe what is meant by *work* in general and in mechanical, fluid, and electrical systems.

Definition

Description should include

- a definition of the term *work* (the amount of energy gained or lost by an object when a force moves the object through a distance)
- use of the unifying equation for work.

Process/Skill Questions

- What must take place for work to be done?
- Why is work not being done when you hold a book above your head?

Task Number 46

Describe how work in mechanical, fluid, and electrical systems involves the presence of force and movement.

Definition

Description should include

- how forces and torques move or rotate objects
- how pressure moves fluids
- how voltage moves a charge through a circuit.

Process/Skill Questions

- What are the effects of mechanical work?
- What are the two types of fluid systems?
- How does a battery regain charge after being plugged into an outlet?

Task Number 47

Identify the SI and English units for work in mechanical, fluid, and electrical systems.

Definition

Identification should include foot-pound, newton-meter, and coulomb volt (or joule).

Process/Skill Questions

- What is equivalent to one coulomb volt in joules?
- What is one radian equal to in degrees?

Task Number 48

Identify the effects of work done in mechanical, fluid, and electrical systems.

Definition

Identification should include, but not be limited to

- when a gear turns a shaft
- when a chain hoist raises a load
- the use of a hydraulic jack to lift a car
- charging a cell phone battery.

Process/Skill Questions

- What is the force being acted upon when a crane lifts a beam?
- What is the force being acted upon when using a fire hose to put out a fire?
- What is the force being acted upon when a motor turns a conveyor belt in a supermarket checkout?

Task Number 49

Measure work in mechanical, fluid, and electrical systems.

Definition

Measurements should use the following equations:

- for mechanical systems: work = force × distance
- for fluid systems: work = pressure × volume
- for electrical systems: work = voltage × charge

Process/Skill Questions

- How do you measure work in mechanical, fluid, and electrical systems?
- Where would industry use work formulas in the real world?
- What safety precautions are required for measuring work in mechanical, fluid, and electrical systems?

UNIT 3: RATE

Task Number 50

Describe what is meant by *rate* in general and in mechanical, fluid, electrical, and thermal systems.

Definition

Description should include

- definition of the term *rate* (the ratio of a measured quantity to the time interval over which the measurement is made)
- the difference between speed and acceleration
- the unifying equation for rate.

Process/Skill Questions

- What is the relationship between voltage and current?
- What role does time play in the unifying equation of rate?
- Why must a machinist understand rate in order to operate a drill press?

Task Number 51

Identify the SI and English units for rate in all four energy systems.

Definition

Identification should include

- feet per second (ft/sec)
- meters per second (m/sec)
- gallons per minute (gal/min)

- coulombs per second (coulomb/sec)
- British thermal unit per second (Btu/sec)
- calories per second (cal/sec).

Process/Skill Questions

- What do ft/sec^2 and m/sec^2 represent?
- In the fields of technology and engineering, in what units are angles measured?
- How many degrees are in one radian?

Task Number 52

Measure rate in mechanical, fluid, electrical, and thermal systems.

Definition

Measurement of rate should use the following equations:

- $v=d/t$
- $\omega=\theta/t$
- $Q_v=V/t$
- $Q_m=m/t$
- $I=q/t$
- $Q_H= H/t$

Process/Skill Questions

- How do you measure rate in mechanical, fluid, electrical and thermal systems?
- How do police officers use rate to catch drivers who are speeding?
- What are some examples of rate in fluid systems?

Task Number 53

Identify workplace applications where rate is measured and/or controlled.

Definition

Identification may include, but may not be limited to

- production assembly on a conveyor belt
- gas pump at a local gas station

- the amount of heat gain or loss on a residential heat pump.

Process/Skill Questions

- Where would a student use complex devices that involve rate in their own life?
- Where would industry use complex devices that involve rate on the job?
- How is rate used in the drive-through service at a fast food restaurant?

UNIT 4: RESISTANCE

Task Number 54

Describe what is meant by *resistance* in general and in mechanical, fluid, electrical, and thermal energy systems.

Definition

Description should include

- defining the term *resistance* (the opposition to motion or flow)
- stating the cause of opposition to movement in each system (e.g., friction, drag, electrical resistance, thermal resistance).

Process/Skill Questions

- Why is heat a byproduct of resistance?
- Why is drag a fluid resistance?
- What is the relationship of resistance to current and voltage?

Task Number 55

Explain how resistance in each energy system relates to the unifying principle of a “force” divided by a rate.

Definition

Explanation should include

- the positive and negative effects for each energy system

- the formula for measuring resistance in each system, including
    - mechanical: $F_{static}=\mu_s N$ and $F_{kinetic}=\mu_k N$
    - mechanical: $R_D=F/v$
    - fluid: $R_{fluid}=-\Delta P/V$
    - electrical: $R=\Delta V/I$
    - thermal: $R_{thermal}=-\Delta T/Q_H$.

Process/Skill Questions

- How do you measure resistance in a mechanical system? Fluid? Electrical? Thermal?
- What tools and/or devices are used to measure resistance in mechanical systems? Fluid? Electrical? Thermal?
- What safety precautions are required to measure resistance in a mechanical system? Fluid? Electrical? Thermal?
- What are the units of measurement in each system?
- Where would a student use this in their own life?
- Where would industry use this in the real world?

Task Number 56

Identify the SI and English units for resistance in each energy system.

Definition

Identification should include a measurement of a force divided by rate using units appropriate to the energy system.

Examples of appropriate units should include

- mechanical: lb/(ft/sec) or N/(m/sec)
- fluid: lb/in^2 /(gal/min) or $N/m^2/(m^3/sec)$
- electrical: V/I or ohms
- thermal: F/(Btu/hr) or C/(Cal/hr).

Process/Skill Questions

- What would happen if the wrong unit were to be used?
- What is the SI or English unit for mechanical resistance?
- What is the SI or English unit for fluid resistance?
- What is the SI or English unit for electrical resistance?
- What is the SI or English unit for thermal resistance?

Task Number 57

Identify positive and negative effects of resistance in each energy system.

Definition

Resistance has positive and negative effects in every energy system. Identification may include both positive and negative effects:

- Positive examples may include, but may not be limited to
  - brakes
  - thrust
  - heating and cooling a house
  - cooking
  - adjusting volume on an amplifier.

- Negative examples may include, but may not be limited to
  - drag
  - brake failure due to overheating
  - short circuits
  - processor overheating and/or failure.

Process/Skill Questions

- What are the positive effects of resistance in a mechanical system? Fluid? Electrical? Thermal?
- What are the negative effects of resistance in a mechanical system? Fluid? Electrical? Thermal?

Task Number 58

Identify workplace applications where technicians measure or control resistance.

Definition

Identification may include, but is not limited to

- construction industry
- electrician
- automotive technician
- HVAC technician
- plumber
- engineer.

Process/Skill Questions

- How can heat be an example of desirable and undesirable resistance?
- Where would a student measure or control resistance in their own life?
- Where would industry measure or control resistance in the real world?

Task Number 59

Describe how resistance is affected at extremely high and low temperatures in materials, including superconductors.

Definition

Description should state that

- thermal resistance depends upon the material's composition and conductivity
- thermal resistance is the ratio of temperature drop to heat flow rate
- materials with high thermal resistance are used to insulate an object
- heat flows from an area of high temperature to an area of low temperature
- resistance increases at extremely high temperatures because of expansion and an increase in surface area
- resistance decreases at extremely low temperatures because of contraction and a slowing of molecular motion.

Process/Skill Questions

- What is considered an extremely high temperature in Fahrenheit? An extremely low temperature?
- What is considered an extremely high temperature in Celsius? An extremely low temperature?
- Why does the object speed up or slow down when exposed to extreme temperatures?

Task Number 60

Measure resistance in mechanical, fluid, electrical, and thermal energy systems.

Definition

Measurement should include the units of measurement used in each energy system, the device used for measurement, demonstration of the use of the device, and verification of the results using the appropriate formula.

Process/Skill Questions

- How do you measure resistance in a mechanical system? Fluid? Electrical? Thermal?
- What safety precautions are required to measure mechanical/electrical/fluid/thermal resistance?
- What are the units of measurement in each system?
- Where would a student use this in their own life?
- Where would industry use this in the real world?

UNIT 5: ENERGY

Task Number 61

Describe the nature of energy in mechanical, fluid, electrical, and thermal systems.

Definition

Description should state that energy is the ability to do work (e.g., a moving volleyball, hot exhaust gas on a jet engine, the springs on a car, capacitors, inductors).

Process/Skill Questions

- How is energy represented in mechanical, fluid, electrical and thermal systems?
- What are some types of energy systems?
- How is energy used in each system?

Task Number 62

Describe what is meant by *potential energy.*

Definition

Description should state that potential energy is energy stored by an object.

Process/Skill Questions

- What are some examples of potential energy?
- When is it necessary for objects to store energy?

Task Number 63

Describe what is meant by *kinetic energy.*

Definition

Description should state that kinetic energy is energy possessed by an object due to the motion of the object.

Process/Skill Questions

- What are some examples of kinetic energy?
- When is kinetic energy maximized?

Task Number 64

Describe the relationship of potential energy, kinetic energy, and heat energy to the law of conservation of energy.

Definition

Description should include

- stating the law of conservation of energy (the sum of all energy present in a system)
- stating the specific types of energy to consider (i.e., kinetic and potential)
- defining heat energy as energy lost in the system.

Process/Skill Questions

- In what systems is energy conservation most challenging?
- How can energy conservation be maximized in each system?
- What is the law of conservation of energy?

Task Number 65

Describe the relationship between work and energy.

Definition

Description should include the work-energy theorem (a measure of the energy that is transmitted by a force) and that work is a specific type of energy.

Process/Skill Questions

- In what situation or situations is work actually done?
- What is the difference between the units for work and the units for energy?

Task Number 66

Describe how principles of mechanics apply to celestial systems.

Definition

Description should include how gravitational potential energy can be determined between celestial systems.

Process/Skill Questions

- How are forces between Earth and the moon calculated?
- How much gravitational potential energy is stored between Earth and the moon?
- How does the gravitational potential of the moon compare to other celestial systems, such as Jupiter and the sun?

Task Number 67

Identify the SI and English units for energy in each system.

Definition

Identification should include

- joules
- Newton-meters
- foot-pounds
- calories
- British thermal units (Btu).

Process/Skill Questions

- Why are SI units important?
- What is the definition of a Btu?
- What is the definition of a calorie?

Task Number 68

Measure energy in each energy system.

Definition

Measurement should include how to record data within an acceptable range of error, typically half of the smallest division on a device, and verification of data using calculations.

Process/Skill Questions

- How is energy measured in each system?
- What devices are used to measure energy in each system?

Task Number 69

Identify workplaces where technicians measure or control energy.

Definition

Identification may include, but may not be limited to

- transportation workplaces (land, air, and sea)
- hospitals
- farms and dairies
- supermarkets
- factories
- machine shops.

Process/Skill Questions

- What types of problems could happen in the workplaces above if energy is not controlled?
- If the efficient use of energy keeps nations productive, why do we produce things like automobiles that are only 16 percent efficient?

UNIT 6: POWER

Task Number 70

Describe what is meant by *power* in general and in mechanical, fluid, electrical, and thermal systems.

Definition

Description should include

- defining the term *power* (a measure of how much work is done over a given time interval, or as a "force times a rate")
- identifying the type of work done in each system in order to produce power.

Process/Skill Questions

- What are the mathematical formulas used to determine mechanical, fluid, electrical, and thermal power?
- What is real power as opposed to apparent power?
- What is horsepower?
- What is an accumulator?
- What is an actuator?
- What are the two forms in which electric power is generated?
- What is the difference between a hydraulic and pneumatic system?
- What is wattage?
- What is photovoltaic?

Task Number 71

Explain how thermal power and thermal rate are the same.

Definition

Explanation should include how thermal power and thermal rate are defined by the same equation.

Process/Skill Questions

- What is the formula for thermal power?
- What is the formula for thermal rate?
- What is heat transfer?
- How is thermal power created?
- How is thermal power measured?

Task Number 72

Explain how power in each energy system relates to the unifying principle of work divided by time.

Definition

Explanation should state

- the relationship of work relative to time in each system
- the relationship of energy usage per unit of time
- the type of energy used in each energy system
- the rate or distance in which an object moves using various times.

Process/Skill Questions

- What is the unifying principle between each system?
- What is an example of mechanical power? Fluid? Electrical? Thermal?
- How do you calculate or measure the amount of power in each system?
- What are the units of measurement for power in each system?

Task Number 73

Analyze why power can be described in terms of a “force times a rate” for mechanical, fluid, and electrical systems.

Definition

Analysis should include the relationship of work, force, displacement, time, and velocity.

Process/Skill Questions

- How is work related to force and displacement?
- How is velocity related to displacement and time?
- What is the formula for power in respect to “force times a rate”?
- What is displacement?
- How is rate determined?

Task Number 74

Identify workplace applications where technicians measure or control power.

Definition

Identification may include, but not be limited to

- power generation
- automotive engine repair
- electrical work
- construction
- machining
- mechanical systems.

Process/Skill Questions

- Where would a student use complex devices in their own life?
- Where would industry use mechanical or fluid power systems in the real world?

UNIT 7: FORCE TRANSFORMERS

Task Number 75

Describe force transformers in general and in mechanical, fluid, and electrical systems.

Definition

Description should include

- defining the term *force transformer* (machines or devices that change force, movement, or rate)
- identifying what is being transformed in each system (i.e., force, torque, speed, pressure, voltage, current)
- identifying how the object is being transformed in each system
- identifying what is being sacrificed to make the change in each system.

Process/Skill Questions

- What is ideal mechanical advantage?
- What is actual mechanical advantage?
- How is efficiency affected by force transformers?

Task Number 76

Evaluate the efficiency of converting energy from one form to another, using mathematical calculations.

Definition

Evaluation should include the formulas for each conversion.

Process/Skill Questions

Why are machines not 100 percent efficient at converting energy into another form?
Why do we need to know about efficiency?

Task Number 77

Explain why force transformers form a unifying principle in mechanical, fluid, and electrical systems.

Definition

Explanation should include

- defining the term *unifying principle* (each energy system uses force transformers that work on the same physical principle; input source, coupling device, output load)
- applying the unifying principle to
    - levers
    - pulleys
    - gears
    - pressure systems
    - transformers.

Process/Skill Questions

- What is a source (input) to the unifying principle?
- What is a coupling device (transformer) to the unifying principle?
- What is a load (output) to the unifying principle?

Task Number 78

List examples of force transformers in mechanical, fluid, and electrical systems.

Definition

List should include, but not be limited to

- levers, pulleys, gears, belt and chain drives, wheels and axles in mechanical systems
- hydraulic jacks, pressure intensifiers in hydraulic systems
- step-up and step-down transformers in electrical systems.

Process/Skill Questions

- What do we gain and what do we give up in using force transformers?
- What are the advantages?
- What are the losses?

SOL Correlation by Task

39	Describe what is meant by *force* in general and in mechanical, fluid, electrical, and thermal systems.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5 Science: PH.5
40	Give examples of complex technological devices where force must be controlled, measured, or applied.	English: 10.5, 11.5, 12.5 Science: PH.1
41	Describe what force, pressure, voltage, and temperature difference have in common.	English: 10.5, 11.5, 12.5 Mathematics: A.4, A.8, AII.3, AII.10 Science: PH.10, PH.11
42	Predict what happens to an object when forces on it are balanced and when forces on it are unbalanced.	English: 10.5, 11.5, 12.5 Science: PH.1, PH.5
43	Measure force in mechanical, fluid, electrical, and thermal systems.	Science: PH.1, PH.2, PH.4, PH.5, PH.10, PH.11
44	List occupations that require technicians to measure, control, or otherwise deal with force in complex devices.	English: 10.5, 10.6, 10.7, 11.5, 11.6, 11.7, 12.5, 12.6, 12.7 History and Social Science: GOVT.9, GOVT.15, VUS.8, VUS.10, VUS.13, VUS.14 Science: PH.4
45	Describe what is meant by *work* in general and in mechanical, fluid, and electrical systems.	English: 10.3, 10.5, 11.3, 11.5 Mathematics: A.4, A.8, T.9, AII.3, MA.7

		Science: PH.1, PH.2, PH.3, PH.4, PH.5, PH.7
46	Describe how work in mechanical, fluid, and electrical systems involves the presence of force and movement.	English: 10.5, 11.5 Mathematics: A.4, T.9, AII.3, MA.7 Science: PH.5, PH.11
47	Identify the SI and English units for work in mechanical, fluid, and electrical systems.	Science: PH.1
48	Identify the effects of work done in mechanical, fluid, and electrical systems.	English: 10.5, 11.5 Science: PH.1, PH.5, PH.7
49	Measure work in mechanical, fluid, and electrical systems.	Mathematics: A.4, AII.9 Science: PH.1, PH.2, PH.5
50	Describe what is meant by *rate* in general and in mechanical, fluid, electrical, and thermal systems.	English: 10.3, 11.3 Mathematics: A.4, AII.3 Science: PH.1, PH.2, PH.5
51	Identify the SI and English units for rate in all four energy systems.	Science: PH.1, PH.11
52	Measure rate in mechanical, fluid, electrical, and thermal systems.	Mathematics: A.4, A.8, T.9, AII.3 Science: PH.1, PH.2, PH.7, PH.11
53	Identify workplace applications where rate is measured and/or controlled.	English: 10.5, 11.5 Science: PH.4
54	Describe what is meant by *resistance* in general and in mechanical, fluid, electrical, and thermal energy systems.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5 Science: PH.5, PH.6, PH.7, PH.11
55	Explain how resistance in each energy system relates to the unifying principle of a “force” divided by a rate.	Mathematics: A.4, A.8, AII.3, AII.10 Science: PH.1, PH.2, PH.3, PH.5, PH.11
56	Identify the SI and English units for resistance in each energy system.	Science: PH.1, PH.3, PH.5
57	Identify positive and negative effects of resistance in each energy system.	English: 10.5, 11.5, 12.5 Science: PH.4, PH.5
58	Identify workplace applications where technicians measure or control resistance.	English: 10.5, 11.5, 12.5 Science: PH.4

59	Describe how resistance is affected at extremely high and low temperatures in materials, including superconductors.	English: 10.5, 11.5, 12.5 Mathematics: A.4, A.8 Science: PH.1, PH.12
60	Measure resistance in mechanical, fluid, electrical, and thermal energy systems.	Science: PH.1
61	Describe the nature of energy in mechanical, fluid, electrical, and thermal systems.	English: 10.5, 11.5, 12.5 Mathematics: A.8 Science: PH.4
62	Describe what is meant by *potential energy.*	English: 10.5, 11.5, 12.5 Science: PH.6
63	Describe what is meant by *kinetic energy.*	English: 10.5, 11.5, 12.5 Science: PH.6
64	Describe the relationship of potential energy, kinetic energy, and heat energy to the law of conservation of energy.	English: 10.5, 11.5, 12.5 History and Social Science: WG.2 Science: PH.3, PH.6
65	Describe the relationship between work and energy.	English: 10.5, 11.5, 12.5 Science: PH.5
66	Describe how principles of mechanics apply to celestial systems.	English: 10.5, 11.5, 12.5 Mathematics: A.4, T.9, AII.3, AII.9, MA.6 Science: ES.13, PH.12
67	Identify the SI and English units for energy in each system.	Science: PH.1
68	Measure energy in each energy system.	Science: PH.1, PH.4, PH.7
69	Identify workplaces where technicians measure or control energy.	English: 10.5, 11.5, 12.5 Science: PH.4
70	Describe what is meant by *power* in general and in mechanical, fluid, electrical, and thermal systems.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5 Mathematics: A.4, AII.3 Science: PH.5
71	Explain how thermal power and thermal rate are the same.	English: 10.5, 11.5, 12.5

		Mathematics: A.8, AII.3 Science: PH.3, PH.5
72	Explain how power in each energy system relates to the unifying principle of work divided by time.	English: 10.5, 11.5, 12.5 Mathematics: A.4, A.7, AII.3, AII.7 Science: PH.5
73	Analyze why power can be described in terms of a "force times a rate" for mechanical, fluid, and electrical systems.	English: 10.5, 11.5, 12.5 Mathematics: A.4, AII.3, MA.7 Science: PH.2, PH.5, PH.7, PH.10
74	Identify workplace applications where technicians measure or control power.	English: 10.5, 11.5, 12.5 Science: PH.4
75	Describe force transformers in general and in mechanical, fluid, and electrical systems.	English: 10.3, 10.5, 11.3, 12.3, 12.5 Mathematics: A.4, A.8, T.9, AII.3, AII.10, MA.7 Science: PH.4
76	Evaluate the efficiency of converting energy from one form to another, using mathematical calculations.	Mathematics: A.4, AII.3
77	Explain why force transformers form a unifying principle in mechanical, fluid, and electrical systems.	English: 10.3, 10.5, 11.3, 11.5, 12.3, 12.5 Mathematics: T.9, AII.3, MA.3, MA.7 Science: PH.5
78	List examples of force transformers in mechanical, fluid, and electrical systems.	English: 10.5, 10.6, 11.5, 11.6, 12.5, 12.6 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 II (9812/36 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**