Principles of Technology I

9811/36 weeks

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Acknowledgments

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BJ Scott, Virginia TSA State Advisor, reviewed and updated the TSA correlations.
Course Description

Suggested Grade Level: 10 or 11 or 12

Students conduct experiments and tackle projects in this single-period laboratory science course to apply physics and mathematics concepts. Students study seven technical principles: force, work, rate, resistance, energy, power, and force transformers, examining how each principle plays a unifying role in the operation of mechanical, fluid, electrical, and thermal systems in technology equipment and systems. This hands-on project approach to studying technical principles provides a foundation for further education and career readiness.

Note: Students who complete Principles of Technology I and Principles of Technology II may use these courses to satisfy one (1) 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.

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Legend: ☑Essential ☐Non-essential ☐Omitted

Curriculum Framework
UNIT 1: FORCE

Task Number 39

Differentiate between scalar and vector.

**Definition**
Differentiation should include defining
- scalar as magnitude
- vector as magnitude and direction.

**Process/Skill Questions**
- How are the terms *scalar* and *vector* used?
- What are examples of scalar? What are examples of vector?
- When do you use scalar quantities and when do you use vector quantities?
- What symbol is used to denote vector?

ITEEA National Standards: 8

TSA Competitive Events: Principles of Technology (VA only event), Technology Bowl

Task Number 40

Define *force* in general and in the context of mechanical, fluid, electrical, and thermal systems.

**Definition**
Definition should include the concept that *force* is
- 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.

**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?
- What other forces exist, in addition to mechanical, fluid, electrical, and thermal?

ITEEA National Standards: 2, 3

TSA Competitive Events: Principles of Technology (VA only event), Technology Bowl

Task Number 41

Give examples of complex technological devices where force must be controlled, measured, or applied.
Definition
Giving examples may include, but are not limited to,

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

Process/Skill Questions

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

ITEEA National Standards: 3
TSA Competitive Events: Principles of Technology (VA only event)

Task Number 42

Calculate force, pressure, voltage, and temperature difference.

Definition
Calculation should include the formula and units of measurement for each and an explanation of 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?
- What are the variables?

ITEEA National Standards: 3
TSA Competitive Events: Principles of Technology (VA only event)

Task Number 43

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?

ITEEA National Standards: 2, 3
TSA Competitive Events: Principles of Technology (VA only event)

Task Number 44

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 that the measurement is correct.

Process/Skill Questions

- How are forces measured in a mechanical system? Fluid? Electrical? Thermal?
- What safety precautions are required to measure mechanical, fluid, electrical, and thermal forces?
- What are the units of measurement in each system?

ITEEA National Standards: 3, 8
TSA Competitive Events: Principles of Technology (VA only event), Technology Bowl

Task Number 45

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

Definition
Research may include, but not be limited to,

- construction workers
- electricians
- automotive technicians
- heating, ventilation, and air conditioning (HVAC) technicians
- plumbers
- engineers
- healthcare professionals.

Process/Skill Questions

- Where would a student use complex devices in their own life?
- Where would a given business or industry use complex devices?

ITEEA National Standards: 3
TSA Competitive Events: Principles of Technology (VA only event), STEM Careers
UNIT 2: WORK

Task Number 46

Define work in general and in mechanical, fluid, and electrical systems.

Definition
Definition should include

- 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?

ITEEA National Standards: 2, 3
TSA Competitive Events: Technology Bowl

Task Number 47

Compare the presence of force and movement in mechanical, fluid, and electrical systems.

Definition
Comparison 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 two types of fluid systems?
- How does a battery regain charge after being plugged into an outlet?

TSA Competitive Events: Technology Bowl

Task Number 48

Identify the International System of Units (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?
- What is equivalent to one Newton-meter?

ITEEA National Standards: 2, 3
TSA Competitive Events: Technology Bowl

Task Number 49

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

Definition
Demonstration may include, but not be limited to,

- a gear turning a shaft
- a chain hoist raising a load
- the use of a hydraulic jack to lift a car
- the charging of 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?

ITEEA National Standards: 8
TSA Competitive Events: Technology Bowl

Task Number 50

Measure work in mechanical, fluid, and electrical systems.

Definition
Measurements should include collecting variables for use in the following equations:

- Mechanical systems—work = force × distance
- Fluid systems—work = pressure × volume
- Electrical systems—work = voltage × charge

Process/Skill Questions

- How is work measured in mechanical, fluid, and electrical systems?
- Where would a given industry use work formulas?
- What safety precautions may be required for measuring work in mechanical, fluid, and electrical systems in a given industry?

ITEEA National Standards: 3, 8
TSA Competitive Events: Principles of Technology (VA only event), Technology Bowl
UNIT 3: RATE

Task Number 51

Define rate in general and in mechanical, fluid, electrical, and thermal systems.

Definition
Definition should include

- the ratio of a measured quantity to the time interval over which the measurement is made
- the difference between speed and acceleration
- the variables and 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 to operate a drill press?

ITEEA National Standards: 2, 3
TSA Competitive Events: Principles of Technology (VA only event)

Task Number 52

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?

ITEEA National Standards: 2, 3
TSA Competitive Events: Principles of Technology (VA only event), Technology Bowl

Task Number 53
Calculate rate in mechanical, fluid, electrical, and thermal systems.

Definition
Calculation should use the following equations:

- \( v = \frac{d}{t} \)
- \( \omega = \frac{\theta}{t} \)
- \( Q_v = \frac{V}{t} \)
- \( Q_m = \frac{m}{t} \)
- \( I = \frac{q}{t} \)
- \( Q_H = \frac{H}{t} \)

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?

ITEEA National Standards: 3
TSA Competitive Events: Principles of Technology (VA only event)

Task Number 54

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

Definition
Research may include, but not be limited to,

- production assembly on a conveyor belt
- gas pump at a gas station
- the amount of heat gain or loss on a residential heat pump
- household system
- manufacturing industry
- construction industry
- transportation
- medical industry.

Process/Skill Questions

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

ITEEA National Standards: 3
TSA Competitive Events: Principles of Technology (VA only event), STEM Careers
UNIT 4: RESISTANCE

Task Number 55

Define *resistance* in general and in mechanical, fluid, electrical, and thermal energy systems.

**Definition**
Definition should include

- the opposition to motion or flow
- 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?
- How does drag cause resistance in a fluid?
- How is resistance related to current and voltage?
- What causes resistance?
- What are examples of resistance?

**ITEEA National Standards:** 2, 3
**TSA Competitive Events:** Principles of Technology (VA only event), Flight Endurance, Technology Bowl

Task Number 56

Calculate resistance in each energy system relating to the unifying principle of a “force” divided by a rate.

**Definition**
Calculation should include

- the positive and negative effects of resistance for each energy system
- the formula for measuring resistance in each system, including
  - mechanical—\( F_{\text{static}} = \mu_s N \) and \( F_{\text{kinem}} = \mu_k N \)
  - mechanical—\( R_{\text{in}} = F/V \)
  - fluid—\( R_{\text{fluid}} = -\Delta P/V \)
  - electrical—\( R = \Delta V/I \)
  - thermal—\( R_{\text{thermal}} = -\Delta T/Q_H \)

**Process/Skill Questions**

- What safety precautions are required to measure resistance in a mechanical system? Fluid? Electrical? Thermal?
- What are the units of measurement in each system?
Task Number 57

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/in²/(gal/min) or N/m²/(m³/sec)
- electrical—V/I or ohms
- thermal—F/(Btu/hr) or C/(Cal/hr).

Process/Skill Questions

- What would happen if the wrong unit is 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 58

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

Definition
Comparison should include

- positive examples such as
  - brakes
  - thrust
  - heating and cooling a house
  - cooking
  - adjusting volume on an amplifier

- negative examples such as
  - drag
  - brake failure due to overheating
  - short circuits
  - processor overheating and/or failure.
Process/Skill Questions

- When is resistance a positive effect and when is it negative?
- 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?

ITEEA National Standards: 8
TSA Competitive Events: Principles of Technology (VA only event), Essays on Technology

Task Number 59

Explain workplace applications where technicians measure or control resistance.

Definition
Explanation may include, but is not limited to,

- construction industry
- medical industry
- transportation industry
- manufacturing industry.

Process/Skill Questions

- How can heat be an example of desirable and undesirable resistance?
- Where would a student measure or control resistance?
- Where would a given industry measure or control resistance?
- What machines or materials experience resistance in various industries?

ITEEA National Standards: 3
TSA Competitive Events: STEM Careers

Task Number 60

Describe how resistance is affected in thermal systems 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 an object speed up or slow down when exposed to extreme temperatures?

ITEEA National Standards: 3, 8
TSA Competitive Events: Principles of Technology (VA only event), Biotechnology Design

Task Number 61

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

- What safety precautions are required to measure mechanical, electrical, fluid, and thermal resistance?
- What are the units of measurement in each system?
- Where would a given industry use this?
- What tools and/or devices are used to measure resistance in mechanical systems? Fluid? Electrical? Thermal?

ITEEA National Standards: 3, 8
TSA Competitive Events: Biotechnology Design

Task Number 62

Construct a system that demonstrates positive vs. negative effects of resistance.

Definition
Construction may include

- simulations
- models
- prototypes.

Process/Skill Questions

- What is an example of a positive effect of resistance?
- What is an example of a negative effect of resistance?
UNIT 5: ENERGY

Task Number 63

Define energy in mechanical, fluid, electrical, and thermal systems.

Definition
Definition 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?

TSA Competitive Events: Technology Bowl

Task Number 64

Demonstrate potential energy.

Definition
Demonstration should show 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?

ITEEA National Standards: 3, 8
TSA Competitive Events: Principles of Technology (VA only event)

Task Number 65

Demonstrate kinetic energy.

Definition
Demonstration should show that kinetic energy is energy possessed by an object due to its motion.

Process/Skill Questions

- What are some examples of kinetic energy?
- When is kinetic energy maximized?
Task Number 66

Describe the relationship between the law of conservation of energy and potential energy, kinetic energy, and heat 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?
- How does one calculate potential, kinetic, and heat energy using the law of conservation of energy?

Task Number 67

Interpret types of energy conversion in mechanical, thermal, electrical, and fluid systems.

Definition
Interpretation should include

- how energy is converted from one form to another
- defining the term energy loss
- identifying causes of energy loss
- the relationship between energy conversion and efficiency.

Process/Skill Questions

- How does energy loss occur in different systems?
- What are examples of energy loss?
- What is the relationship between energy loss and negative conversion?

Task Number 68
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 the concept 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?

ITEEA National Standards: 2, 3
TSA Competitive Events: Technology Bowl

Task Number 69

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 much gravitational potential energy is stored between Earth and the moon?
- How does the gravitational potential of the moon compare with other celestial systems, such as Jupiter and the sun?
- How does the gravitational force of the moon affect Earth’s oceans?
- How does the International Space Station stay in space?

ITEEA National Standards: 3
TSA Competitive Events: Biotechnology Design, Technology Bowl

Task Number 70

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 71

Calculate energy in each energy system.

Definition
Calculation should include

- identifying the appropriate formula to use
- identifying the appropriate units
- recording data within an acceptable range of error (typically half of the smallest division on a device)
- verifying data.

Process/Skill Questions

- How is energy calculated in each system?
- What variables are measured to calculate energy in each system?

Task Number 72

Research workplaces where technicians measure or control energy.

Definition
Research may include, but may not be limited to

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

Process/Skill Questions

- What types of problems could happen in the workplace if energy is not controlled?
- What are the current efficiency standards for gas-powered and electric vehicles?

UNIT 6: POWER

Task Number 73
Define power in general and in mechanical, fluid, electrical, and thermal systems.

Definition
Definition should include

- measuring how much work is done over a given time interval (a force multiplied by a rate)
- identifying the type of work done in each system 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 is the difference between a hydraulic system and a pneumatic system?
- What units of measurement denote power?

ITEEA National Standards: 2, 3
TSA Competitive Events: Technology Bowl

Task Number 74

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?

ITEEA National Standards: 3
TSA Competitive Events: Technology Bowl

Task Number 75

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?

ITEEA National Standards: 3
TSA Competitive Events: Technology Bowl

Task Number 76

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

Definition
Analysis should include work, force, displacement, time, and velocity and how each relates to the others.

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?
• What is displacement?
• How is rate determined?

ITEEA National Standards: 3, 8
TSA Competitive Events: Principles of Technology (VA only event)

Task Number 77

Research workplace applications where technicians measure or control power.

Definition
Research 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?
• Where would a given industry use mechanical or fluid power systems?
Task Number 78

Construct a system that demonstrates the application of power.

Definition

Construction may include

- models
- simulations
- prototypes.

Process/Skill Questions

- What is the system behind the model/simulation/prototype constructed?

UNIT 7: FORCE TRANSFORMERS

Task Number 79

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

Definition

Definition should include

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

Process/Skill Questions

- What is ideal mechanical advantage?
- What is actual mechanical advantage?
- How do force transformers affect efficiency?

Task Number 80
Evaluate the efficiency of energy conversion, 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 is efficiency important?

ITEEA National Standards: 3

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**Task Number 81**

**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 principles, with an input source, coupling device, and 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 the relationship between a coupling device (transformer) and the unifying principle?
- What is the relationship between a load (output) and the unifying principle?

ITEEA National Standards: 3, 8
TSA Competitive Events: Essays on Technology

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**Task Number 82**

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

**Definition**
Research may include, but not be limited to

- mechanical (e.g., levers, pulleys, gears, belt-and-chain drives, wheels and axles)
- fluid (e.g., hydraulic jacks, pressure intensifiers)
- electrical (step-up and step-down transformers).
Process/Skill Questions

- What do we gain and what do we give up in using force transformers?

ITEEA National Standards: 3
TSA Competitive Events: Principles of Technology (VA only event)

Task Number 83

Construct a system that demonstrates the application of force transformers.

Definition
Construction may include

- models
- simulations
- prototypes.

Process/Skill Questions

- What is the system behind the model/simulation/prototype constructed?
- How is force transformed in this system?

ITEEA National Standards: 8
TSA Competitive Events: Engineering Design

SOL Correlation by Task

<table>
<thead>
<tr>
<th>Task</th>
<th>SOL Correlations</th>
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</thead>
<tbody>
<tr>
<td>39</td>
<td>Differentiate between scalar and vector.</td>
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<tr>
<td>40</td>
<td>Define force in general and in the context of mechanical, fluid, electrical, and thermal systems.</td>
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<tr>
<td>41</td>
<td>Give examples of complex technological devices where force must be controlled, measured, or applied.</td>
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<tr>
<td>42</td>
<td>Calculate force, pressure, voltage, and temperature difference.</td>
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<tr>
<td>43</td>
<td>Predict what happens to an object when forces on it are balanced and when forces on it are unbalanced.</td>
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<tr>
<td>44</td>
<td>Measure force in mechanical, fluid, electrical, and thermal systems.</td>
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<tr>
<td>Task</td>
<td>SOL Correlations</td>
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</tbody>
</table>
| 45   | **Mathematics:** AII.3  
|      | **Science:** PH.5, PH.7  
|      | English: 10.5, 10.8, 11.5, 11.8, 12.5, 12.8 |
|      | **UNIT 2: WORK** |
| 46   | Define *work* in general and in mechanical, fluid, and electrical systems.  
|      | **English:** 10.3, 11.3, 12.3  
|      | **Mathematics:** MA.7, MA.11  
|      | **Science:** PH.5 |
| 47   | Compare the presence of force and movement in mechanical, fluid, and electrical systems.  
|      | **English:** 10.5, 11.5, 12.5  
|      | **Science:** PH.5, PH.7 |
| 48   | Identify the International System of Units (SI) and English units for work in mechanical, fluid, and electrical systems.  
|      | **English:** 10.5, 11.5, 12.5  
|      | **Mathematics:** T.2  
|      | **Science:** PH.5 |
| 49   | Demonstrate the effects of work done in mechanical, fluid, and electrical systems.  
|      | **English:** 10.5, 11.5, 12.5  
|      | **Science:** PH.5, PH.7 |
| 50   | Measure work in mechanical, fluid, and electrical systems.  
|      | **English:** 10.5, 11.5, 12.5  
|      | **Mathematics:** AII.3  
|      | **Science:** PH.5, PH.7 |
|      | **UNIT 3: RATE** |
| 51   | Define *rate* in general and in mechanical, fluid, electrical, and thermal systems.  
|      | **English:** 10.3, 11.3, 12.3  
|      | **Mathematics:** AII.3, T.2  
|      | **Science:** PH.5, PH.11 |
| 52   | Identify the SI and English units for rate in all four energy systems.  
|      | **English:** 10.5, 11.5, 12.5  
|      | **Mathematics:** T.2  
|      | **Science:** PH.5, PH.10 |
| 53   | Calculate rate in mechanical, fluid, electrical, and thermal systems.  
|      | **English:** 10.5, 11.5, 12.5  
|      | **Mathematics:** AII.3  
|      | **Science:** PH.7 |
| 54   | Research workplace applications where rate is measured and/or controlled.  
|      | **English:** 10.5, 11.5, 12.5  
|      | **Science:** PH.7 |
|      | **UNIT 4: RESISTANCE** |
| 55   | Define *resistance* in general and in mechanical, fluid, electrical, and thermal energy systems.  
|      | **English:** 10.3, 11.3, 12.3  
|      | **Mathematics:** AII.3  
|      | **Science:** PH.5 |
| 56   | Calculate resistance in each energy system relating to the unifying principle of a “force” divided by a rate.  
|      | **English:** 10.5, 11.5, 12.5  
|      | **Mathematics:** AII.3  
|      | **Science:** PH.5, PH.7 |
| 57   | Identify the SI and English units for resistance in each energy system.  
<p>|      | <strong>English:</strong> 10.5, 11.5, 12.5 |</p>
<table>
<thead>
<tr>
<th>Task</th>
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<tr>
<td></td>
<td><strong>Mathematics: AII.3</strong>&lt;br&gt;<strong>Science: PH.7</strong></td>
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<tr>
<td>58</td>
<td>Compare positive and negative effects of resistance in each energy system.</td>
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<tr>
<td>59</td>
<td>Explain workplace applications where technicians measure or control resistance.</td>
</tr>
<tr>
<td>60</td>
<td>Describe how resistance is affected in thermal systems at extremely high and low temperatures in materials, including superconductors.</td>
</tr>
<tr>
<td>61</td>
<td>Measure resistance in mechanical, fluid, electrical, and thermal energy systems.</td>
</tr>
<tr>
<td>62</td>
<td>Construct a system that demonstrates positive vs. negative effects of resistance.</td>
</tr>
<tr>
<td><strong>UNIT 5: ENERGY</strong></td>
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<tr>
<td>63</td>
<td>Define energy in mechanical, fluid, electrical, and thermal systems.</td>
</tr>
<tr>
<td>64</td>
<td>Demonstrate potential energy.</td>
</tr>
<tr>
<td>65</td>
<td>Demonstrate kinetic energy.</td>
</tr>
<tr>
<td>66</td>
<td>Describe the relationship between the law of conservation of energy and potential energy, kinetic energy, and heat energy.</td>
</tr>
<tr>
<td>67</td>
<td>Interpret types of energy conversion in mechanical, thermal, electrical, and fluid systems.</td>
</tr>
<tr>
<td>68</td>
<td>Describe the relationship between work and energy.</td>
</tr>
<tr>
<td>69</td>
<td>Describe how principles of mechanics apply to celestial systems.</td>
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<tr>
<td>70</td>
<td>Identify the SI and English units for energy in each system.</td>
</tr>
<tr>
<td>71</td>
<td>Calculate energy in each energy system.</td>
</tr>
<tr>
<td>72</td>
<td>Research workplaces where technicians measure or control energy.</td>
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<tr>
<td><strong>UNIT 6: POWER</strong></td>
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<td>Task</td>
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| **73** Define *power* in general and in mechanical, fluid, electrical, and thermal systems. | English: 10.3, 11.3, 12.3  
Mathematics: AII.3  
Science: PH.5 |
| **74** Explain how thermal power and thermal rate are the same. | English: 10.5, 11.5, 12.5  
Mathematics: AII.3  
Science: PH.5, PH.7 |
| **75** 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: AII.3  
Science: PH.5 |
| **76** Analyze why power can be described in terms of a force multiplied by a rate for mechanical, fluid, and electrical systems. | English: 10.5, 11.5, 12.5  
Mathematics: AII.3, MA.7  
Science: PH.5 |
| **77** Research workplace applications where technicians measure or control power. | English: 10.8, 11.8, 12.8 |
| **78** Construct a system that demonstrates the application of power. | English: 10.5, 11.5, 12.5  
Mathematics: AII.3, COM.1 |
| **UNIT 7: FORCE TRANSFORMERS** |  |
| **79** Define force transformers in general and in mechanical, fluid, and electrical systems. | English: 10.3, 11.3, 12.3  
Science: PH.5 |
| **80** Evaluate the efficiency of energy conversion, using mathematical calculations. | English: 10.5, 11.5, 12.5  
Mathematics: AII.3 |
| **81** Explain why force transformers form a unifying principle in mechanical, fluid, and electrical systems. | English: 10.5, 11.5, 12.5 |
| **82** Research examples of force transformers in mechanical, fluid, and electrical systems. | English: 10.8, 11.8, 12.8 |
| **83** Construct a system that demonstrates the application of force transformers. | English: 10.5, 11.5, 12.5  
Mathematics: AFDA.4, AII.6, AII.7, AII.9, MA.1  
Science: PH.1, PH.5 |

### 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)

<table>
<thead>
<tr>
<th>Pathway</th>
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<td>Engineering and Technology</td>
<td>Chemical Engineer</td>
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<td>Electrical Engineer</td>
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<td>Electrical Engineering Technician</td>
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<td>Electro-Mechanical Technician</td>
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<td>Engineer</td>
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<td>Manufacturing Systems Engineer</td>
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<td>Mechanical Engineering Technician</td>
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<tr>
<td>Science and Mathematics</td>
<td>Atmospheric Scientist</td>
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<td>Hydrologist</td>
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<td>Secondary School Teacher</td>
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