XXI. Technology/Engineering, High School
High School Technology/Engineering Test


The Science and Technology/Engineering Curriculum Framework is available on the Department website at www.doe.mass.edu/frameworks/current.html.

Technology/Engineering test results are reported under the following four MCAS reporting categories:

- Engineering Design
- Construction and Manufacturing
- Fluid and Thermal Systems
- Electrical and Communication Systems

Test Sessions

The high school Technology/Engineering test included two separate test sessions, which were administered on consecutive days. Each session included multiple-choice and open-response questions.

Reference Materials and Tools

Each student taking the high school Technology/Engineering test was provided with a plastic ruler and a Technology/Engineering Formula Sheet. A copy of this formula sheet follows the final question in this chapter. An image of the ruler is not reproduced in this publication.

Each student also had sole access to a calculator with at least four functions and a square-root key.

The use of bilingual word-to-word dictionaries was allowed for current and former English language learner students only, during both Technology/Engineering test sessions. No other reference tools or materials were allowed.

Cross-Reference Information

The table at the conclusion of this chapter indicates each item’s reporting category and the framework learning standard it assesses. The correct answers for multiple-choice questions are also displayed in the table.
Technology/Engineering
SESSION 1

DIRECTIONS
This session contains twenty-one multiple-choice questions and two open-response questions. Mark your answers to these questions in the spaces provided in your Student Answer Booklet. You may work out solutions to multiple-choice questions in the test booklet.

1. In the 1800s, inventors built a device that could be used to send and receive encoded messages through electrical wires. Later inventors modified this technology to create voice-transmitting devices such as the telephone.

Which of the following is the original device upon which voice-transmitting devices were based?

A. the radio
B. the tape recorder
C. the telegraph
D. the television

2. A section of a piping system is shown below.

Which of the following locations identifies where the resistance to water flow is the greatest?

A. at point W
B. at point Y
C. between point X and point Y
D. between point W and point X
3. A certain component in a communications system receives a signal and converts it into a digital data stream. This component is an example of which of the following?

A. encoder
B. source
C. storage
D. transmitter

4. Lupe built the simple circuit shown below.

Lupe modifies this circuit by decreasing the voltage of the battery by one-half. In order to keep the amount of current flowing through the circuit the same as it was before, which other change must Lupe make to the circuit?

A. She must add a switch.
B. She must increase the resistance.
C. She must decrease the resistance.
D. She must remove a section of wire.

5. Which of the following statements describes an advantage of AC electricity over DC electricity?

A. AC is found in most low voltage operations.
B. AC is provided as strong, short bursts of electricity.
C. AC transforms easily to higher or lower voltage levels.
D. AC travels in one direction, avoiding power supply interruptions.
6. The diagram below shows a circuit with three resistors.

At which of the following points should the two leads of a voltmeter be placed to measure the voltage across \( R_1 \)?

A. at points U and W
B. at points S and X
C. at points S and T
D. at points T and U

7. The diagram below shows a section of a water pipe. The diameter of the pipe changes along the length of this section.

At which two points in the pipe does water travel at approximately the same speed?

A. points W and Y
B. points W and Z
C. points X and Y
D. points X and Z

8. The diagram below shows a typical household electrical light circuit.

What is the most likely function of the component marked X in this circuit?

A. to open and close the circuit
B. to produce voltage for the circuit
C. to protect the circuit from excess current
D. to ensure that current flows in only one direction
The diagrams below show how polyethylene bottles are made through a process called blow molding. In this process, compressed air is blown into a warm tube of polyethylene in order to expand the polyethylene in the mold.

Warm polyethylene tube is inserted.

Compressed air is injected.

Polyethylene expands.

Polyethylene bottle is cooled and removed.

Which type of manufacturing process is blow molding?

A. assembling
B. conditioning
C. finishing
D. forming

Some small MP3 music players use solid-state memory chips to store music. In which of the following formats is music stored in these MP3 players?

A. digital codes
B. magnetic codes
C. photovoltaic cells
D. laser-etched patterns
The diagram below shows four common tools.

Wrench  Pliers  Rubber mallet  Steel hammer

“Use the right tool for the right task” is an important safety rule in any situation.

a. Describe a task for which the right tool to use is a wrench but not pliers. Explain your answer.

b. Describe a task for which the right tool to use is pliers but not a wrench. Explain your answer.

c. Describe a task for which a rubber mallet is better suited than a steel hammer. Explain your reasoning.
Mark your answers to multiple-choice questions 12 through 22 in the spaces provided in your Student Answer Booklet. Do not write your answers in this test booklet, but you may work out solutions to multiple-choice questions in the test booklet.

12 The amount of commercial development that the local government allows in a certain part of a city is limited by which of the following?

A. zoning laws  
B. building codes  
C. OSHA regulations  
D. board of health requirements

13 A remotely controlled robotic arm is used in the cleanup of contaminated areas. Which of the following best describes why robotics rather than humans are used for this task?

A. to prevent site investigation by OSHA  
B. to minimize expense of safety equipment  
C. to avoid human exposure to hazardous waste  
D. to limit human exposure to poor weather conditions

14 The drawing below shows the dimensions of the interior walls of a room.

What is the scale on this drawing?

A. \[ \frac{1}{8} " = 1' \]  
B. \[ \frac{1}{4} " = 1' \]  
C. \[ \frac{1}{2} " = 1' \]  
D. 1" = 1'
A green roof is a vegetation system installed on the rooftop of a building. A cross-sectional diagram of a green roof is shown below.

Which of the following statements is supported by the diagram?

A. The green roof has more cubic feet of soil than gravel.
B. The green roof adds no more than 6 in. of height to a structure.
C. The green roof adds no more than 6 cu. in. of mass to a structure.
D. The green roof has a drainage mat and a waterproof covering made out of the same material.

A homeowner uses an extension cord to provide power to exterior holiday lights. A strand of holiday lights consists of 100 light bulbs wired in parallel.

Which of the following actions will have the greatest effect on the resistance of the extension cord?

A. connecting several strands of lights to the extension cord
B. plugging the extension cord into a ground-fault circuit interrupter outlet
C. operating an indoor appliance while providing power to the extension cord
D. leaving several burned-out bulbs in a strand of the lights connected to the extension cord
17. Which of the following devices uses laser technology to function?
   A. bluetooth headset
   B. computer monitor
   C. DVD player
   D. USB drive

18. The illustration below shows a dump truck with its truck bed raised in order to empty the contents.

   [Image of a dump truck]

Which of the following statements best explains why a hydraulic system is better than a pneumatic system for lifting the bed of a dump truck?
   A. Hydraulic systems are less prone to leakage than pneumatic systems.
   B. Hydraulic systems are more energy efficient than pneumatic systems.
   C. Hydraulic systems can provide changes in motion faster than pneumatic systems.
   D. Hydraulic systems can handle heavy, sustained loads better than pneumatic systems.

19. An engineer wants to be certain that a product he is designing will return to its original shape after being subjected to torsional force. Which of the following should the engineer consider when selecting a material for this product?
   A. The material should be rigid.
   B. The material should be elastic.
   C. The material should be expandable.
   D. The material should be compressible.

20. Which of the following would increase the amount of information that can be transmitted by a fiberoptic cable?
   A. increasing the length of the cable
   B. increasing the number of fibers in the cable
   C. using fewer optical amplifiers along the cable
   D. using plastic instead of glass in the cable
21. Which of the following fluids cannot be used in any hydraulic system?
   A. oil
   B. nitrogen gas
   C. a flammable liquid
   D. a water-based substance

22. A company is thinking of developing a hydrogen-powered motorcycle. Based on the engineering design process, which of the following tasks should the company complete next?
   A. Build a working prototype of the motorcycle.
   B. Produce engineering designs for the proposed motorcycle.
   C. Evaluate the efficiency of the proposed motorcycle’s engine.
   D. Conduct market research to find out if there is a need for the motorcycle.
Question 23 is an open-response question.

- BE SURE TO ANSWER AND LABEL ALL PARTS OF THE QUESTION.
- Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.
- If you do the work in your head, explain in writing how you did the work.

Write your answer to question 23 in the space provided in your Student Answer Booklet.

The illustration below shows the Amundsen-Scott South Pole Research Station.

The research station is located in an area where more than eight inches of snow accumulates each year without ever melting. Architects utilized Bernoulli’s principle when designing the exterior of the building. The station has an adjustable elevation and is built facing the prevailing wind direction. The front of the building slopes downward and inward.

a. Explain why the research station has an adjustable elevation.

b. Describe in detail, using Bernoulli’s principle, how the inwardly sloping design of the building has an impact on snow management.

c. Describe one other possible design feature that would make a building suitable for this environment. Explain your answer.
Technology/Engineering

SESSION 2

DIRECTIONS
This session contains nineteen multiple-choice questions and three open-response questions. Mark your answers to these questions in the spaces provided in your Student Answer Booklet. You may work out solutions to multiple-choice questions in the test booklet.

24 Which of the following uses only renewable energy?
   A. a battery-powered radio
   B. a gasoline-engine car
   C. a natural-gas stove
   D. a solar-heated shower

25 Which of the following fluid systems is characterized by the release of fluids?
   A. closed
   B. indoor
   C. open
   D. outdoor

26 Several college students want to design and build a solar-powered car. They have chosen a design.
   Which of the following should they do next to follow an engineering design process?
   A. Build a prototype of the car.
   B. Sell the design to a car company.
   C. Research the demand for solar-powered cars.
   D. Use the design to mass-produce solar-powered cars.

27 A car audio system processes information in both digital form and analog form to create an output to the speakers. Which of the following components of the car’s audio system processes information that is always stored in a digital form?
   A. FM radio
   B. AM radio
   C. CD player
   D. cassette player
The illustration below shows two heat lamps being used to keep food warm.

In which way does most of the heat from the lamps reach the food?

A. by conduction  
B. by evaporation  
C. by radiation  
D. by resistance

A drawing is scaled so that 1" = 16'. A wall section in the scaled drawing measures $3\frac{3}{4}$". What is the actual dimension of the wall?

A. 30'  
B. 48'  
C. 54'  
D. 60'

When winds blow around a skyscraper at high speeds, the air pressure outside some parts of the building becomes lower than the air pressure inside the building. If Bernoulli’s principle was not considered when designing this building, which of the following problems might occur?

A. The roof might cave in.  
B. Some windows might pop out.  
C. The building might catch on fire.  
D. Some elevator shafts might collapse.

Which of the following technologies has increased the efficiency of telecommunications systems such as television, telephone, and high-speed Internet?

A. DVD burners  
B. MP3 players  
C. electrical wires  
D. fiber optics

Which of the following qualities of a material is most important to consider before the material is sheared?

A. absorbency  
B. conductivity  
C. luster  
D. thickness
33 A hydraulic system is represented below.

A force of 200 lb. is applied to piston X and a load is placed on piston Y.

a. Calculate the pressure exerted by piston X on the hydraulic fluid. Show your calculations and include units in your answer.

b. What is the pressure that the hydraulic fluid exerts on piston Y? Explain your answer.

c. What force is exerted on piston Y to support the load? Show your calculations and include units in your answer.

d. If piston X moves down 3 in., what distance does piston Y move up? Include units in your answer.
A homeowner’s new garden hose has a larger diameter than his old garden hose. Both hoses are the same length. Which of the following changes should the homeowner expect when using the new garden hose?

A. a decrease in the density of the water  
B. a decrease in the velocity of the water  
C. a decrease in the viscosity of the water  
D. a decrease in the temperature of the water

The diagram below shows 500 kg of water in a plastic tank on a steel structure.

What is the live load of this structure?

A. 305 kg  
B. 500 kg  
C. 700 kg  
D. 805 kg
Many home entertainment devices such as televisions, stereos, and DVD players can be operated wirelessly utilizing infrared remote controls. Which of the following is a limitation of this type of communication technology?

A. The remote control cannot use rechargeable batteries.
B. The remote control can operate only one component of a system.
C. The infrared signal cannot be activated in a brightly lit environment.
D. The infrared signal must have an unobstructed path to the receiving component.

A steel cable helps move an elevator from one floor to another, as shown in the diagram below.

What is the primary type of stress on the cable above the elevator?

A. compression
B. tension
C. torsion
D. vibration
A working drawing of a mechanical puller is shown below.

**Parts List**

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screw and yoke</td>
<td>1</td>
</tr>
<tr>
<td>D hook</td>
<td>2</td>
</tr>
<tr>
<td>Hex bolt and nut, $\frac{5}{16}$ in $\times 1\frac{1}{4}$ in</td>
<td>2</td>
</tr>
</tbody>
</table>

What do the circled numbers on the drawing represent?

A. the size of the parts  
B. the quantity of the parts  
C. the order in which to assemble the parts  
D. the order of importance of detailed parts
39. The development of computer simulations to model and test bridge designs has improved the safety of new bridges. Which of the following statements best explains why computer simulation has improved the safety of new bridges?

A. Materials can be tested for defects before being purchased.
B. Design flaws can be identified and corrected before construction.
C. Plans can be sent electronically to other engineers for their review.
D. Multiple types of building materials can be incorporated in one design.

40. The two most common media through which voice and data transmissions are carried are copper cable and fiberoptic cable. Which of the following statements describes the type of signals carried by each cable?

A. Copper cable carries electrical signals; fiberoptic cable carries light signals.
B. Copper cable carries electrical signals; fiberoptic cable carries sound signals.
C. Copper cable carries transport signals; fiberoptic cable carries electrical signals.
D. Copper cable carries modulation signals; fiberoptic cable carries electrical signals.
41 Which of the following statements explains why buildings in the northern United States usually have steeper roofs than buildings in the southern United States?

A. Steeper roofs have tighter rafter joints, which leak less during the cold winter season.
B. Steeper roofs have more surface area, which allows less heat to escape during the cold winter season.
C. Heavy snow loads in the North easily slide off steeper roofs, reducing the risk of roofs collapsing.
D. Minimal wind loads in the North allow for steeper roofs, reducing the number of shingles needed on roofs.

42 During the construction of a house, which of the following actions would most likely minimize heat loss due to conduction?

A. installing a forced hot air heating system
B. increasing the number of south-facing windows
C. making sure all exterior doors are properly sealed
D. insulating exterior walls to attain the highest R-value

43 A student removes a 4-gigabyte flash drive from the USB port of her computer. Which of the following is the primary function of the flash drive in the computer system?

A. encoder
B. processor
C. storage
D. transmitter
Some basic electrical components found on motherboards and video cards of personal computers are listed below.

- diode
- battery
- resistor
- fuse

a. Select three of the electrical components in the list. Describe the basic function of each component in an electrical circuit of a personal computer.

Some circuit components found in personal computers are also used to build simple circuits in a classroom.

b. In your Student Answer Booklet, draw a circuit diagram that uses a battery, a switch, and two resistors. Make sure that in your diagram current always passes through one resistor, but only passes through both resistors when the switch is closed. Be sure to label each component.
An isometric drawing of a metal block is shown below. All the holes pass completely through the block.

45. An isometric drawing of a metal block is shown below. All the holes pass completely through the block.

a. In your Student Answer Booklet, draw and label the front, top, and right side views of the block. Include all hidden lines. Make your drawing in proper proportion.

b. Which of these two types of drawings, the isometric drawing shown or your drawing from part (a), would an engineer give to a machinist to make a prototype of the block? Explain your answer.
Formulas

\[ V = I \times R \quad \text{Pressure} = \frac{\text{Force}}{\text{Area}} \]

\[ P = I \times V \quad \text{Area of a circle} = \pi r^2 \]

Variables

\[ I = \text{current} \quad r = \text{radius} \]

\[ P = \text{power} \]

\[ R = \text{resistance} \]

\[ V = \text{voltage} \]

Definitions and Abbreviations

\[ AC = \text{alternating current} \quad \text{psi} = \text{pounds per square inch} \]

\[ DC = \text{direct current} \quad \pi \approx 3.14 \]
<table>
<thead>
<tr>
<th>Item No.</th>
<th>Page No.</th>
<th>Reporting Category</th>
<th>Standard</th>
<th>Correct Answer (MC)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>396</td>
<td>Engineering Design</td>
<td>1.2</td>
<td>C</td>
</tr>
<tr>
<td>2</td>
<td>396</td>
<td>Fluid and Thermal Systems</td>
<td>3.5</td>
<td>C</td>
</tr>
<tr>
<td>3</td>
<td>397</td>
<td>Electrical and Communication Systems</td>
<td>6.3</td>
<td>A</td>
</tr>
<tr>
<td>4</td>
<td>397</td>
<td>Electrical and Communication Systems</td>
<td>5.3</td>
<td>C</td>
</tr>
<tr>
<td>5</td>
<td>397</td>
<td>Electrical and Communication Systems</td>
<td>5.5</td>
<td>C</td>
</tr>
<tr>
<td>6</td>
<td>398</td>
<td>Electrical and Communication Systems</td>
<td>5.1</td>
<td>D</td>
</tr>
<tr>
<td>7</td>
<td>398</td>
<td>Fluid and Thermal Systems</td>
<td>3.4</td>
<td>D</td>
</tr>
<tr>
<td>8</td>
<td>398</td>
<td>Electrical and Communication Systems</td>
<td>5.2</td>
<td>A</td>
</tr>
<tr>
<td>9</td>
<td>399</td>
<td>Construction and Manufacturing</td>
<td>7.1</td>
<td>D</td>
</tr>
<tr>
<td>10</td>
<td>399</td>
<td>Electrical and Communication Systems</td>
<td>6.2</td>
<td>A</td>
</tr>
<tr>
<td>11</td>
<td>400</td>
<td>Construction and Manufacturing</td>
<td>2.5</td>
<td>A</td>
</tr>
<tr>
<td>12</td>
<td>401</td>
<td>Construction and Manufacturing</td>
<td>2.6</td>
<td>A</td>
</tr>
<tr>
<td>13</td>
<td>401</td>
<td>Construction and Manufacturing</td>
<td>7.3</td>
<td>C</td>
</tr>
<tr>
<td>14</td>
<td>401</td>
<td>Engineering Design</td>
<td>1.4</td>
<td>B</td>
</tr>
<tr>
<td>15</td>
<td>402</td>
<td>Engineering Design</td>
<td>1.5</td>
<td>A</td>
</tr>
<tr>
<td>16</td>
<td>402</td>
<td>Electrical and Communication Systems</td>
<td>5.4</td>
<td>A</td>
</tr>
<tr>
<td>17</td>
<td>403</td>
<td>Electrical and Communication Systems</td>
<td>6.4</td>
<td>C</td>
</tr>
<tr>
<td>18</td>
<td>403</td>
<td>Fluid and Thermal Systems</td>
<td>3.2</td>
<td>D</td>
</tr>
<tr>
<td>19</td>
<td>403</td>
<td>Construction and Manufacturing</td>
<td>2.1</td>
<td>B</td>
</tr>
<tr>
<td>20</td>
<td>403</td>
<td>Electrical and Communication Systems</td>
<td>6.5</td>
<td>B</td>
</tr>
<tr>
<td>21</td>
<td>404</td>
<td>Fluid and Thermal Systems</td>
<td>3.2</td>
<td>B</td>
</tr>
<tr>
<td>22</td>
<td>404</td>
<td>Engineering Design</td>
<td>1.1</td>
<td>D</td>
</tr>
<tr>
<td>23</td>
<td>405</td>
<td>Fluid and Thermal Systems</td>
<td>4.3</td>
<td>D</td>
</tr>
<tr>
<td>24</td>
<td>406</td>
<td>Fluid and Thermal Systems</td>
<td>4.4</td>
<td>D</td>
</tr>
<tr>
<td>25</td>
<td>406</td>
<td>Fluid and Thermal Systems</td>
<td>3.1</td>
<td>C</td>
</tr>
<tr>
<td>26</td>
<td>406</td>
<td>Engineering Design</td>
<td>1.1</td>
<td>A</td>
</tr>
<tr>
<td>27</td>
<td>406</td>
<td>Electrical and Communication Systems</td>
<td>6.2</td>
<td>C</td>
</tr>
<tr>
<td>28</td>
<td>407</td>
<td>Fluid and Thermal Systems</td>
<td>4.1</td>
<td>C</td>
</tr>
<tr>
<td>29</td>
<td>407</td>
<td>Engineering Design</td>
<td>1.4</td>
<td>D</td>
</tr>
<tr>
<td>30</td>
<td>407</td>
<td>Construction and Manufacturing</td>
<td>2.3</td>
<td>B</td>
</tr>
<tr>
<td>31</td>
<td>407</td>
<td>Electrical and Communication Systems</td>
<td>6.4</td>
<td>D</td>
</tr>
<tr>
<td>32</td>
<td>407</td>
<td>Construction and Manufacturing</td>
<td>7.2</td>
<td>D</td>
</tr>
<tr>
<td>33</td>
<td>408</td>
<td>Fluid and Thermal Systems</td>
<td>3.5</td>
<td>D</td>
</tr>
<tr>
<td>34</td>
<td>409</td>
<td>Fluid and Thermal Systems</td>
<td>3.4</td>
<td>B</td>
</tr>
<tr>
<td>35</td>
<td>409</td>
<td>Construction and Manufacturing</td>
<td>2.4</td>
<td>B</td>
</tr>
<tr>
<td>36</td>
<td>410</td>
<td>Electrical and Communication Systems</td>
<td>6.1</td>
<td>D</td>
</tr>
<tr>
<td>37</td>
<td>410</td>
<td>Construction and Manufacturing</td>
<td>2.2</td>
<td>B</td>
</tr>
<tr>
<td>38</td>
<td>411</td>
<td>Engineering Design</td>
<td>1.5</td>
<td>C</td>
</tr>
<tr>
<td>39</td>
<td>412</td>
<td>Engineering Design</td>
<td>1.2</td>
<td>B</td>
</tr>
<tr>
<td>40</td>
<td>412</td>
<td>Electrical and Communication Systems</td>
<td>6.1</td>
<td>A</td>
</tr>
<tr>
<td>41</td>
<td>413</td>
<td>Fluid and Thermal Systems</td>
<td>4.3</td>
<td>C</td>
</tr>
<tr>
<td>Item No.</td>
<td>Page No.</td>
<td>Reporting Category</td>
<td>Standard</td>
<td>Correct Answer (MC)*</td>
</tr>
<tr>
<td>---------</td>
<td>----------</td>
<td>-----------------------------------------------</td>
<td>----------</td>
<td>----------------------</td>
</tr>
<tr>
<td>42</td>
<td>413</td>
<td>Fluid and Thermal Systems</td>
<td>4.2</td>
<td>D</td>
</tr>
<tr>
<td>43</td>
<td>413</td>
<td>Electrical and Communication Systems</td>
<td>6.3</td>
<td>C</td>
</tr>
<tr>
<td>44</td>
<td>414</td>
<td>Electrical and Communication Systems</td>
<td>5.2</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>415</td>
<td>Engineering Design</td>
<td>1.3</td>
<td></td>
</tr>
</tbody>
</table>

* Answers are provided here for multiple-choice items only. Sample responses and scoring guidelines for open-response items, which are indicated by shaded cells, will be posted to the Department’s website later this year.