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


The *Massachusetts 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

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.

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.
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. The diagram below shows a portable circular saw.

On/off switch
Switch lock
Laser
Power cord
Base plate
Rotating blade
Retractable guard

Which of the following describes the main purpose of the retractable guard?
A. to permit proper rotation of the saw blade
B. to protect the operator's hands and fingers
C. to provide constant lubrication to the saw blade
D. to prevent sawdust from getting into the operator's eyes

2. Many new car and truck frames are made of aluminum alloys. Which of the following statements describes an advantage of using aluminum frames in vehicles instead of steel frames?
A. Aluminum frames have a higher R-value, providing greater strength to vehicles.
B. Aluminum frames have a higher density, providing greater acceleration to vehicles.
C. Aluminum frames have a lower weight, resulting in lower fuel consumption in vehicles.
D. Aluminum frames have a lower conductivity, resulting in slower corrosion rates in vehicles.
3. Under which of the following conditions would fiber optics most likely be preferred over radio waves for communication?

A. The climate of the area is hot and humid.
B. There are frequent power outages in the area.
C. The content of the communication needs to remain secure.
D. There is little money available to build the communication system.

4. What do all pneumatic tools have in common?

A. They are powered by water.
B. They are powered by compressed gas.
C. They are powered by recirculated fluid.
D. They are powered by supercooled fluid.

5. Encryption is an example of which of the following processes in a computer networking system?

A. encoding
B. receiving
C. storing
D. transmitting
6. Forced hot water is a popular type of home heating system used in the Northeast. Which of the following is the best material to use to release the thermal energy from the system?

A. ceramic  
B. fiberglass  
C. metal  
D. nylon

7. Which of the following best describes the functions of the receiver and decoder in a communication system that uses fiberoptic cables to transmit data?

A. to receive the light signal and convert it to binary data  
B. to receive the sound signal and convert it to binary data  
C. to receive the audio signal and convert it to analog data  
D. to receive the direct signal and convert it to analog data

8. The most likely reason a house is built with large south-facing windows is to reduce the need for which of the following?

A. attic insulation  
B. energy for heating  
C. energy for cooling  
D. exterior wall insulation
9. The diagram below shows an electrical circuit.

Which of the following statements describes a function of component X when the switch is closed?

A. Component X turns the circuit on and off.
B. Component X supplies energy to the circuit.
C. Component X uses a low current to control a higher-current circuit.
D. Component X allows electrical current to flow in only one direction.

10. During which of the following steps of the engineering design process would an engineer most likely use the Internet?

A. identifying the problem
B. constructing a prototype
C. researching the problem
D. selecting the best solution
A company specializes in manufacturing clothes made of delicate fabrics such as silk, lace, and nylon. The company owner is considering purchasing a robotic system that can be programmed to apply fasteners, such as buttons and snaps, to clothing items.

11 A company specializes in manufacturing clothes made of delicate fabrics such as silk, lace, and nylon. The company owner is considering purchasing a robotic system that can be programmed to apply fasteners, such as buttons and snaps, to clothing items.

a. Describe two benefits of using a robotic system to apply fasteners to clothing items manufactured by this company.

b. Identify two reasons the owner of the company may not want to purchase a robotic system for the task of applying fasteners to clothing items. 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. In an electrical circuit, which of the following has the greatest direct effect on the resistance of a metal conductor?
   A. the temperature of the conductor
   B. the malleability of the conductor
   C. the color of the conductor
   D. the age of the conductor

13. Which of the following types of power plants is better suited to the southwestern United States than to New England?
   A. solar
   B. tidal
   C. small-scale coal burning
   D. small-scale hydroelectric

14. A student has a drawing of the Federal Reserve Bank Building in Boston, Massachusetts. The building’s height in the drawing is 25 cm. The drawing has a scale of 1 cm = 7.5 m.

What is the actual height of the building?
   A. 32.5 m
   B. 187.5 m
   C. 312.5 m
   D. 375 m
The diagram below shows a water tank and hose that a person will use to water a garden. Gravity causes water to flow through the hose.

The person wants to improve the watering system by increasing the velocity with which the water leaves the hose. Which of the following would be the easiest solution to this problem?

A. increase the diameter of the water tank
B. decrease the diameter of the water tank
C. increase the diameter of the hose nozzle
D. decrease the diameter of the hose nozzle

Digital telecommunication systems allow for reliable transmission of voice, data, and video signals. Which of the following statements describes the process of data transmission in a digital communication system?

A. Sound signals use alternating frequencies to transmit continuously.
B. Sound signals use binary vibrations that are transmitted wirelessly.
C. Electrical signals are converted to x-rays and transmitted to a receiver.
D. Electrical signals are converted to binary code and transmitted to a decoder.
17. How are radio signals transmitted through the atmosphere?
   A. as direct current
   B. as mechanical waves
   C. as alternating current
   D. as electromagnetic waves

18. Which of the following is one reason that copper and aluminum are often used to make cookware?
   A. They are good radiators of heat.
   B. They are good convectors of heat.
   C. They are good conductors of heat.
   D. They are good evaporators of heat.

19. One goal of using alternative energy methods is to decrease dependency on fossil fuels. Which of the following statements best explains why dependency on fossil fuels needs to be decreased?
   A. Fossil fuels are flammable.
   B. Fossil fuels are nonrenewable.
   C. Fossil fuels cost a lot of money.
   D. Fossil fuels depend on the weather.

20. In the hydraulic system represented below, piston X has a cross-sectional area of 20 cm$^2$ and piston Y has a cross-sectional area of 10 cm$^2$.

   How far up will piston Y move if piston X is pushed down a distance of 2 cm?
   A. 1 cm
   B. 2 cm
   C. 4 cm
   D. 10 cm
A warm room is located directly below a cold room. The temperature difference and the amount of insulation between the two rooms determine the rate of heat transfer.

Which of the following statements describes the function of the insulation?

A. The insulation absorbs radiation from the warm room.
B. The insulation reflects energy back into the warm room.
C. The insulation prevents air currents from forming in the cold room.
D. The insulation reduces the conduction of energy into the cold room.

Which devices are required by the National Highway Traffic and Safety Administration to be installed in every new automobile sold in the United States to supplement the protection offered by seat belts?

A. airbags
B. antilock brakes
C. four-wheel drive systems
D. global positioning systems
A company is planning to construct a small building and needs a scale drawing of the floor plan. Information about the building is in the box below.

The building will be 42' × 60'. The 60' walls will run east to west. Inside the building there will be three areas:

- a 42' × 42' work area with four 6' wide doors, forming two 12' wide openings in the south wall
- an 18' × 21' office with a 3' wide door in the south wall
- an 18' × 21' storeroom with no exterior doors

The office will have 3' wide doors to the work area and the storeroom. The storeroom will have a 3' wide door to the work area.

a. On the grid in your Student Answer Booklet, make a scale drawing of this floor plan. Use the scale $\frac{1}{6}$" = 3'. On the grid, 6 squares = 1 inch. Disregard wall thickness. Assume that north is toward the top of the paper.

b. On your drawing, label each room and clearly show all doors.
Hydraulic pistons are commonly used to hold a load in an exact position. Why might an air-driven piston be an inappropriate tool to use for this purpose?

A. Air is invisible.
B. Air is insulating.
C. Air is weightless.
D. Air is compressible.

Which of the following most likely restricts commercial development within a residential area?

A. a zoning law
B. a building code
C. an EPA regulation
D. an OSHA regulation

Air currents under a bridge move faster than air currents above the bridge. Which of the following explains the result of Bernoulli’s principle in this situation?

A. Air currents under the bridge exert less pressure than air currents above the bridge.
B. Air currents under the bridge create more condensation than air currents above the bridge.
C. Air currents under the bridge result in a greater air volume than air currents above the bridge.
D. Air currents under the bridge cause a lower air temperature than air currents above the bridge.
28. Which of the following pipe fittings has the least resistance to fluid flow?

A. 

B. 

C. 

D. 

29. Which of the following statements accurately describes electrical circuits?

A. Only AC circuits can transmit electrical energy.
B. Only DC circuits can transmit electrical energy.
C. Current in AC circuits flows in both directions.
D. Current in DC circuits flows in both directions.

30. In manufacturing, it is important to perform routine maintenance to maintain quality and safety. Which maintenance procedure is performed for the sole purpose of ensuring that measurement instruments are measuring accurately?

A. calibration
B. lubrication
C. pressurization
D. sanitization
31 A pickup truck fully loaded with cargo weighs 5000 lb. If the cargo weighs 1000 lb., what is the dead load of the truck?

A. 1000 lb.
B. 4000 lb.
C. 5000 lb.
D. 6000 lb.

32 The owner of an office building is planning to tint all the windows. Which of the following is the most likely reason for doing this?

A. to improve the structural integrity of the building
B. to prevent the window glass from shattering
C. to improve the appearance of the building
D. to reduce the cost of air conditioning
Question 33 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 33 in the space provided in your Student Answer Booklet.

33 The diagram below shows a keyless car entry system.

![Diagram of keyless car entry system]

Many cars use a keyless entry system, which allows the doors to be locked remotely. To use this system, the driver pushes a button on a small battery-operated device. The button turns on the encoder in the device. A signal is then sent to the car’s electrical system, which activates the locking mechanism.

a. Identify the type of signal that travels from the button to the encoder in the battery-operated device.

b. Describe the function of this encoder **and** identify the type of signal sent through the air to the car.

c. Describe the function of the decoder in this keyless entry system.

d. Identify the destination in this system.
Mark your answers to multiple-choice questions 34 through 43 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.

34. Which of the following is the **best** example of a finishing process in manufacturing?
   A. filling a mold
   B. drilling a hole
   C. painting exterior surfaces
   D. assembling multiple components

35. A company is designing a new automobile brake system. After repeated testing of the brake system prototype, engineers presented a report to their company explaining that they discovered a major problem in the system. Which of the following should the engineers do next?
   A. redesign the brake system
   B. build a full-scale version of the brake system
   C. identify the reasons for building the brake system
   D. evaluate the quality of the report about the brake system

36. The diagram below shows a circuit with three different resistors, $R_1$, $R_2$, and $R_3$.

   ![Circuit Diagram]

   Which of the following equations should be used to calculate the total resistance, $R_T$, of the circuit?
   A. $R_T = R_1 \cdot R_2 \cdot R_3$
   B. $R_T = R_1 + R_2 + R_3$
   C. $R_T = \frac{1}{R_1} \cdot \frac{1}{R_2} \cdot \frac{1}{R_3}$
   D. $R_T = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
37. The drawing below shows a three-dimensional view of a simple wooden chair.

Which drawing represents the front view of the chair?

A.  

B.  

C.  

D.  

38. The voltage across a resistor in a circuit is 6 V and the current is 0.25 A. What is the resistance?

A. 0.04 Ω  
B. 1.5 Ω  
C. 9 Ω  
D. 24 Ω  

39. The drawing below shows part of a room in a house.

Which of the following describes how this room is primarily heated?

A. condensation  
B. conduction  
C. convection  
D. radiation
The diagram below shows a ship’s wheel and its parts list.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Part Name</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>handle</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>arc</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>holder</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>circle</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>front cover</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>back cover</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>rivet D 6 \times 46 mm</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>nail D 2 \times 20 mm</td>
<td>48</td>
</tr>
<tr>
<td>9</td>
<td>pin D 10 \times 80 mm</td>
<td>8</td>
</tr>
</tbody>
</table>

Which of the following parts of the ship’s wheel has a 2 mm diameter?

A. arc  
B. circle  
C. rivet  
D. nail

Highway overpasses contain concrete. Which of the following statements describes how engineers increase tensile strength when building a highway overpass?

A. They use concrete that sets more quickly.  
B. They put steel bars within the concrete.  
C. They add a layer of asphalt on top of the concrete.  
D. They reduce the amount of water in the concrete mixture.
42 Which of the following is an example of an isometric drawing?

A.  
\[ \begin{array}{c}
1.2 \text{ m} \\
0.4 \text{ m} \\
\hline
\end{array} \]

B.  
\[ \begin{array}{c}
1.2 \text{ m} \\
0.4 \text{ m} \\
\hline
\end{array} \]

C.  
\[ \begin{array}{c}
1.2 \text{ m} \\
1.2 \text{ m} \\
\hline
\end{array} \]

D.  
\[ \begin{array}{c}
1.2 \text{ m} \\
0.4 \text{ m} \\
\hline
\end{array} \]

43 A paper punch card, shown below, was an early technology developed to give commands to a computer.

Punch cards were physically inserted into a computer to deliver commands. After punch cards, the technology was improved so that commands could be delivered by keyboards, wired or wireless mice, styluses, and touch screens.

Which of the following needs was the most likely cause for these improvements in technology?

A. the need to perform experiments with computers
B. the need to use computers in fast and simple ways
C. the need to allow for computers to store information
D. the need to make computers available for medical and business applications
Questions 44 and 45 are open-response questions.

- BE SURE TO ANSWER AND LABEL ALL PARTS OF EACH 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 44 in the space provided in your Student Answer Booklet.

44 An electrical circuit can be constructed using wire, a load, and a power source.

a. Identify one object that can be used as a load in an electrical circuit.

Ammeters and voltmeters are instruments used to make measurements in electrical circuits.

b. Describe how to connect an ammeter to make a measurement.

c. Describe how to connect a voltmeter to make a measurement.

d. Suppose you have a simple electrical circuit with one load. Describe one measurable change in the circuit that would result from connecting a second, identical load in parallel with the first load.
45. The diagram below represents an evaporative cooling system for a house, which is suitable for use in hot, arid climates.

When the fans are on, hot outside air is pulled over a water reservoir. The resulting cool, moist air is then blown into the house through the duct system.

a. Identify the two fluids used in the evaporative cooling system.

b. Identify whether the evaporative cooling system is an open system or a closed system. Explain your answer.

c. Describe one change in the evaporative cooling system that would allow more cool air to be produced.

In this system, some heat is transferred by conduction between the air and the water.

d. Describe how conduction occurs between the air and the water.
Massachusetts Comprehensive Assessment System
Technology/Engineering Formula Sheet

Formulas

\[ V = I \times R \]
\[ P = I \times V \]
\[ \text{Pressure} = \frac{\text{Force}}{\text{Area}} \]
\[ \text{Area of a circle} = \pi r^2 \]

Variables

\( I = \text{current} \)
\( r = \text{radius} \)
\( P = \text{power} \)
\( R = \text{resistance} \)
\( V = \text{voltage} \)

Definitions and Abbreviations

\( \text{AC} = \text{alternating current} \)
\( \psi = \text{pounds per square inch} \)
\( \text{DC} = \text{direct current} \)
\( \pi \approx 3.14 \)
<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>358</td>
<td>Construction and Manufacturing</td>
<td>2.5</td>
<td>B</td>
</tr>
<tr>
<td>2</td>
<td>358</td>
<td>Construction and Manufacturing</td>
<td>2.1</td>
<td>C</td>
</tr>
<tr>
<td>3</td>
<td>359</td>
<td>Electrical and Communication Systems</td>
<td>6.4</td>
<td>C</td>
</tr>
<tr>
<td>4</td>
<td>359</td>
<td>Fluid and Thermal Systems</td>
<td>3.2</td>
<td>B</td>
</tr>
<tr>
<td>5</td>
<td>359</td>
<td>Electrical and Communication Systems</td>
<td>6.3</td>
<td>A</td>
</tr>
<tr>
<td>6</td>
<td>360</td>
<td>Fluid and Thermal Systems</td>
<td>4.2</td>
<td>C</td>
</tr>
<tr>
<td>7</td>
<td>360</td>
<td>Electrical and Communication Systems</td>
<td>6.3</td>
<td>A</td>
</tr>
<tr>
<td>8</td>
<td>360</td>
<td>Fluid and Thermal Systems</td>
<td>4.3</td>
<td>B</td>
</tr>
<tr>
<td>9</td>
<td>361</td>
<td>Electrical and Communication Systems</td>
<td>5.2</td>
<td>D</td>
</tr>
<tr>
<td>10</td>
<td>361</td>
<td>Engineering Design</td>
<td>1.1</td>
<td>C</td>
</tr>
<tr>
<td>11</td>
<td>362</td>
<td>Construction and Manufacturing</td>
<td>7.3</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>363</td>
<td>Electrical and Communication Systems</td>
<td>5.4</td>
<td>A</td>
</tr>
<tr>
<td>13</td>
<td>363</td>
<td>Fluid and Thermal Systems</td>
<td>4.4</td>
<td>A</td>
</tr>
<tr>
<td>14</td>
<td>363</td>
<td>Engineering Design</td>
<td>1.4</td>
<td>B</td>
</tr>
<tr>
<td>15</td>
<td>364</td>
<td>Fluid and Thermal Systems</td>
<td>3.4</td>
<td>D</td>
</tr>
<tr>
<td>16</td>
<td>364</td>
<td>Electrical and Communication Systems</td>
<td>6.2</td>
<td>D</td>
</tr>
<tr>
<td>17</td>
<td>365</td>
<td>Electrical and Communication Systems</td>
<td>6.1</td>
<td>D</td>
</tr>
<tr>
<td>18</td>
<td>365</td>
<td>Fluid and Thermal Systems</td>
<td>4.1</td>
<td>C</td>
</tr>
<tr>
<td>19</td>
<td>365</td>
<td>Fluid and Thermal Systems</td>
<td>4.4</td>
<td>B</td>
</tr>
<tr>
<td>20</td>
<td>365</td>
<td>Fluid and Thermal Systems</td>
<td>3.3</td>
<td>C</td>
</tr>
<tr>
<td>21</td>
<td>366</td>
<td>Fluid and Thermal Systems</td>
<td>4.2</td>
<td>D</td>
</tr>
<tr>
<td>22</td>
<td>366</td>
<td>Engineering Design</td>
<td>1.2</td>
<td>A</td>
</tr>
<tr>
<td>23</td>
<td>367</td>
<td>Engineering Design</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>368</td>
<td>Fluid and Thermal Systems</td>
<td>3.2</td>
<td>D</td>
</tr>
<tr>
<td>25</td>
<td>368</td>
<td>Construction and Manufacturing</td>
<td>2.6</td>
<td>A</td>
</tr>
<tr>
<td>26</td>
<td>368</td>
<td>Fluid and Thermal Systems</td>
<td>3.1</td>
<td>B</td>
</tr>
<tr>
<td>27</td>
<td>368</td>
<td>Construction and Manufacturing</td>
<td>2.3</td>
<td>A</td>
</tr>
<tr>
<td>28</td>
<td>369</td>
<td>Fluid and Thermal Systems</td>
<td>3.5</td>
<td>A</td>
</tr>
<tr>
<td>29</td>
<td>369</td>
<td>Electrical and Communication Systems</td>
<td>5.5</td>
<td>C</td>
</tr>
<tr>
<td>30</td>
<td>369</td>
<td>Construction and Manufacturing</td>
<td>7.2</td>
<td>A</td>
</tr>
<tr>
<td>31</td>
<td>370</td>
<td>Construction and Manufacturing</td>
<td>2.4</td>
<td>B</td>
</tr>
<tr>
<td>32</td>
<td>370</td>
<td>Fluid and Thermal Systems</td>
<td>4.3</td>
<td>D</td>
</tr>
<tr>
<td>33</td>
<td>371</td>
<td>Electrical and Communication Systems</td>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>372</td>
<td>Construction and Manufacturing</td>
<td>7.1</td>
<td>C</td>
</tr>
<tr>
<td>35</td>
<td>372</td>
<td>Engineering Design</td>
<td>1.1</td>
<td>A</td>
</tr>
<tr>
<td>36</td>
<td>372</td>
<td>Electrical and Communication Systems</td>
<td>5.1</td>
<td>B</td>
</tr>
<tr>
<td>37</td>
<td>373</td>
<td>Engineering Design</td>
<td>1.3</td>
<td>C</td>
</tr>
<tr>
<td>38</td>
<td>373</td>
<td>Electrical and Communication Systems</td>
<td>5.3</td>
<td>D</td>
</tr>
<tr>
<td>39</td>
<td>373</td>
<td>Fluid and Thermal Systems</td>
<td>4.1</td>
<td>C</td>
</tr>
<tr>
<td>40</td>
<td>374</td>
<td>Engineering Design</td>
<td>1.5</td>
<td>D</td>
</tr>
<tr>
<td>41</td>
<td>374</td>
<td>Construction and Manufacturing</td>
<td>2.2</td>
<td>B</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>375</td>
<td><em>Engineering Design</em></td>
<td>1.3</td>
<td>D</td>
</tr>
<tr>
<td>43</td>
<td>375</td>
<td><em>Engineering Design</em></td>
<td>1.2</td>
<td>B</td>
</tr>
<tr>
<td>44</td>
<td>376</td>
<td><em>Electrical and Communication Systems</em></td>
<td>5.1</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>377</td>
<td><em>Fluid and Thermal Systems</em></td>
<td>3.1</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 the shaded cells, will be posted to the Department’s website later this year.