XXI. Technology/Engineering, High School

High School Technology/Engineering Test

The spring 2015 high school Technology/Engineering test was based on learning standards in the Technology/Engineering content strand of the *Massachusetts Science and Technology/Engineering Curriculum Framework* (2006). These learning standards appear on pages 92–95 of the *Framework,* which 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.

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

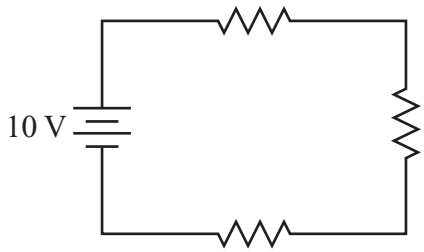
Technology/Engineering

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 A series circuit is shown in the diagram below.



What is the total resistance of the circuit if the current is 2 A?

A. 5.0 Ω

B. 6.6 Ω

C. 15 Ω

D. 60 Ω

2 One type of thermostat has a metal base plate that is attached to the surface being heated. As a result, electrical contacts in the thermostat are opened and closed by expansion and contraction.

The proper operation of the thermostat depends on heat transfer by which of the following processes?

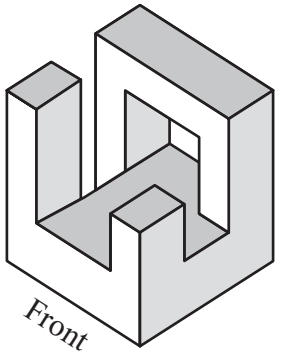
A. conduction

B. convection

C. radiation

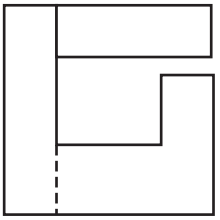
D. sublimation

3 A drawing of a spacer block is shown below.

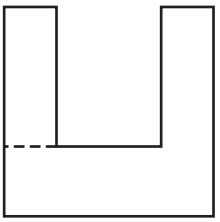


Which of the following represents the front view of the spacer block?

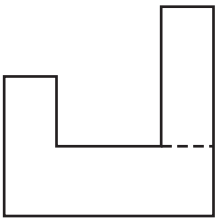
A.



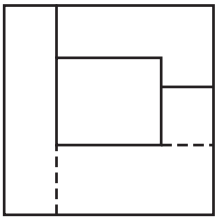
B.



C.



D.



4 A building contractor is reviewing architectural plans for a new deck. The scale of the plan is $\frac{1}{2}$" = 1'. The width of the deck on the scaled drawing measures $5\frac{1}{2}$".

What length of decking material should be used to span the width of the deck with a single board while minimizing waste?

A. 6'

B. 10'

C. 12'

D. 16'

5 Which of the following devices is most likely to use a laser?

A. computer speaker

B. DVD player

C. microwave oven

D. space heater

6 Many types of models are used throughout the design process to help engineers create, develop, test, evaluate, and explain solutions.

An automobile company is ready to test a new, full-size, fully operational model. This type of model is called a

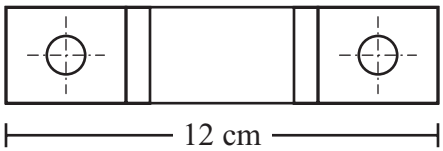
A. mockup.

B. prototype.

C. scaled system.

D. control system.

7 The front view of a piece of equipment is shown in the diagram below.



Which of the following conclusions about the piece of equipment can be made from this diagram?

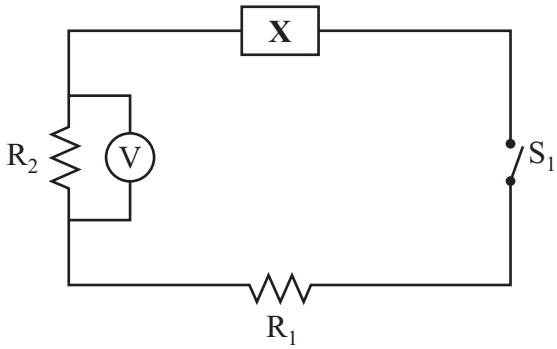
A. It has two holes.

B. It has two types of material.

C. It has the same length and width.

D. It has strength in compression and tension.

8 The drawing below shows a series circuit.



This series circuit operates when the switch is closed. Which of the following is **most likely** represented by X?

A. source

B. ground

C. transistor

D. ohmmeter

9 The table below shows the thermal conductivities of several different materials.

Material	Thermal Conductivity (W/cm • K)
copper	401
aluminum	237
iron	80
tin	66.6
wood	0.16
rubber	0.05

Based on the thermal conductivity data, which pair of materials would be **best** to use for the body and the handle of a cooking pot?

A. iron for the body and copper for the handle

B. tin for the body and aluminum for the handle

C. copper for the body and rubber for the handle

D. aluminum for the body and wood for the handle

10 Which of the following statements **best** explains why fiberoptic cable is preferred over copper wire in telephone and Internet applications?

A. Fiberoptic cable can be used both indoors and outdoors.

B. Fiberoptic cable is more flexible and needs no power source.

C. Fiberoptic cable is easier to manufacture and install into office buildings.

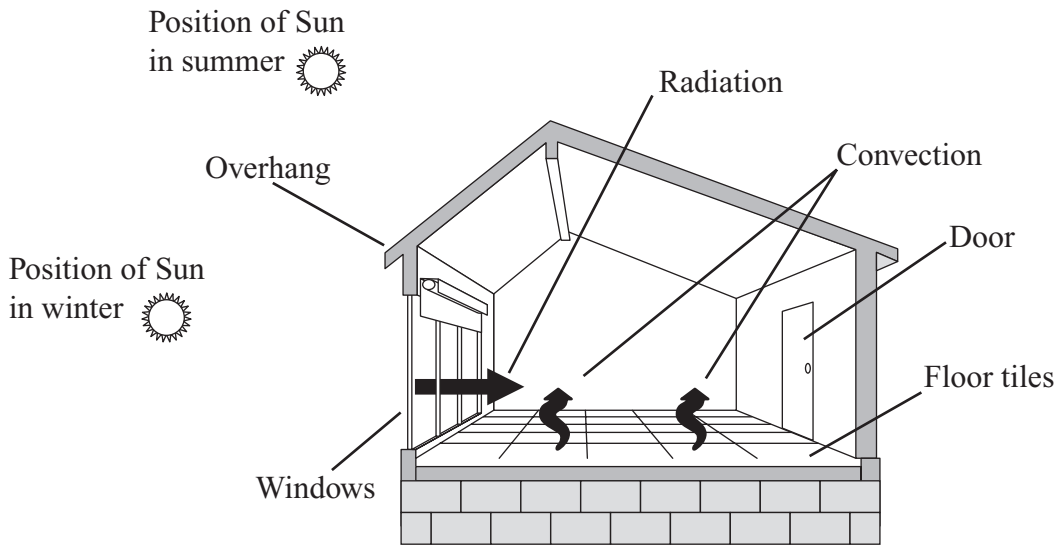
D. Fiberoptic cable is less sensitive to temperature and electromagnetic interference.

Question 11 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 11 in the space provided in your Student Answer Booklet.

11 The drawing below shows a passive solar design for a house in Massachusetts.



a. Explain why a properly sized overhang is important for this design in terms of energy efficiency in the summer.

b. Explain why a properly sized overhang is important for this design in terms of energy efficiency in the winter.

c. Which direction should the windows of the house be facing in order to increase energy efficiency during the winter? Explain your answer.

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 Which of the following would be the **most likely** result if human workers were replaced by robots in a manufacturing assembly line?

A. an increase in labor costs

B. a decrease in productivity

C. a decrease in initial investment

D. an increase in product reliability

13 Some banks use tubes to transport cylindrical canisters between the bank teller and the customer in the drive-through lane. Pressurized air propels the canister from the bank teller to the customer and back.

Which of the following best describes this system?

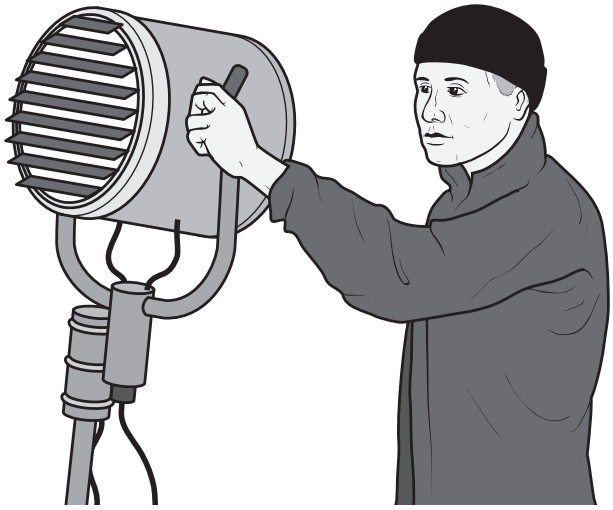
A. a hydraulic system using liquids that can be compressed

B. a hydraulic system using liquids that cannot be compressed

C. a pneumatic system using gases that can be compressed

D. a pneumatic system using gases that cannot be compressed

14 The illustration below shows a person operating a light signal.



Light signals were once commonly used by ships for communication. By rapidly opening and closing the horizontal shutters in front of the light source, a person could send a coded message. This form of communication uses discrete signals.

Which of the following modern technologies also uses discrete signals?

A. fiber optics
B. film cameras
C. record players
D. sound speakers

15 Many mechanical systems are modeled after natural processes. Which human body function is most like a closed system?

A. excreting sweat
B. circulating blood
C. breathing in oxygen
D. secreting tears from ducts

16 Geothermal systems produce electricity from what energy source?

A. heat from the Sun
B. heat from Earth's interior
C. mechanical energy from wind
D. mechanical energy from waves

17 During which stage of manufacturing a wooden rocking chair are the pieces of the chair fastened together?

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

18 Concrete is an excellent material for foundations because it has which of the following properties?

A. high elasticity
B. high permeability
C. high tensile strength
D. high compression strength

19 Which of the following devices **most likely** operates on alternating current?

A. a cell phone
B. a flashlight
C. a laptop computer
D. a microwave oven

20 An engineer uses the chart below when finalizing the design of a metal part that will undergo a machining process.

Tolerances of Some Machining Processes (in inches)

Range of Part Sizes		Tolerances						
From	Through							
0.000	0.599	0.00015	0.0002	0.0003	0.0005	0.0008	0.0012	0.002
0.600	0.999	0.00015	0.00025	0.0004	0.0006	0.001	0.0015	0.0025
1.000	1.499	0.0002	0.0003	0.0005	0.0008	0.0012	0.002	0.003
1.500	2.799	0.00025	0.0004	0.0006	0.001	0.0015	0.0025	0.004
2.800	4.499	0.0003	0.0005	0.0008	0.0012	0.002	0.003	0.005
4.500	7.799	0.0004	0.0006	0.001	0.0015	0.0025	0.004	0.006
Lapping and honing		■	■	■				
Diamond turning and grinding		■	■	■	■			
Broaching			■	■	■	■		
Reaming				■	■	■	■	■
Turning, boring, slotting, planing, and shaping						■	■	■
Milling							■	■
Drilling								■

What is the **most likely** reason that the engineer uses the chart?

A. to improve the ability of the machining process to make the part to exact dimensions

B. to adjust the machining process's minimum tolerance to match the part's requirements

C. to determine which machining process can make the part within the required tolerance range

D. to make sure the part is larger than the maximum dimension for the machining process that will be used

21 Wireless signals can be used in long-distance data communication systems. Which two components of these communication systems interact with the wireless signals that travel a long distance?

A. source and encoder
B. receiver and decoder
C. destination and storage
D. transmitter and receiver

22 A forced hot air system minimizes cold spots within the interior rooms of a house. Which of the following is primarily responsible for the efficient heating by a forced hot air system?

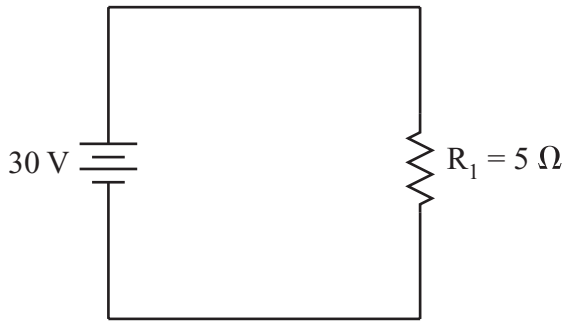
A. convective heating
B. geothermal heating
C. infrared absorption
D. radiant reflection

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.

23 A simple circuit is shown below.



a. Calculate the current in the circuit. Show your calculations and include units in your answer.

A second resistor, R_2, with a resistance of 10 Ω, is added to the circuit and placed in series with R_1.

b. Calculate the total resistance in this circuit. Show your calculations and include units in your answer.

c. Calculate the current in this circuit. Show your calculations and include units in your answer.

d. Describe how adding this second resistor, R_2, in series affects the power output of the battery. 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 Homeowners adding a new bathroom to their house are required by law to get a building permit before work is started. Which statement **best** describes the purpose of building permits for construction in existing homes?

A. Building permits provide homeowners with assistance in planning construction.

B. Building permits ensure that all construction work meets building codes for safety.

C. Building permits provide construction services to homeowners who are doing their own construction work.

D. Building permits ensure that the construction project will make the home more appealing to future homeowners.

25 Many communication systems use fiberoptic technology instead of copper wire. Which of the following statements describes an advantage of using fiber optics instead of copper wire for communications applications?

A. Fiber optics have a lower initial cost.

B. Fiber optics have a higher power rating.

C. Fiber optics do not require expensive electric conductors to complete a communication system.

D. Fiber optics provide greater bandwidth and can transmit more information along a similar-sized cable.

26 Which of the following would be **most** affected if the temperature of a 20 ft. piece of 14-gauge copper wire were increased by 30°C?

A. the melting point of the wire

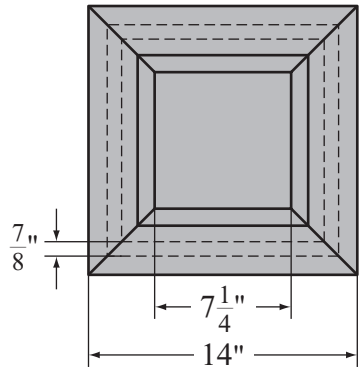
B. the electrical resistance of the wire

C. the signal processing speed of the wire

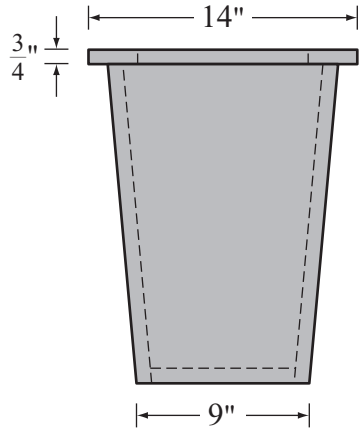
D. the direction of current flow within the wire

27 The diagram below shows two views of a plant container.

Top View



Front View



What is the thickness of the plant container wall?

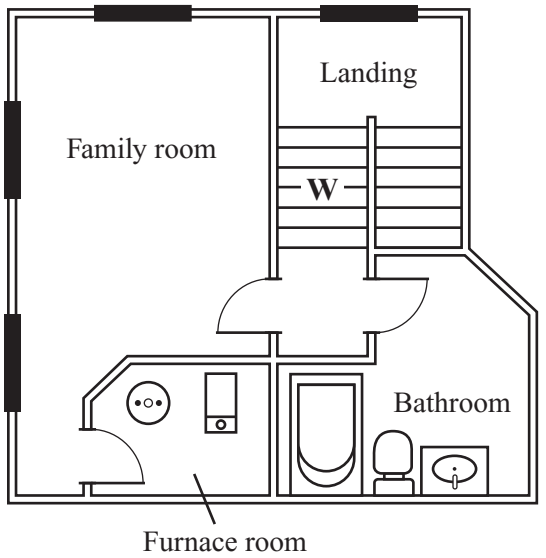
A. $\frac{3}{4}$"

B. $\frac{7}{8}$"

C. $7\frac{1}{4}$"

D. $14\frac{3}{4}$"

28 The drawing below represents a finished basement floor plan.



What does **W** represent in the drawing?

A. pipelines
B. a staircase
C. ceiling tiles
D. a ventilation duct

29 Which of the following practices is unsafe when using a drill press to make a hole through a piece of wood?

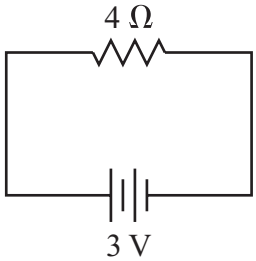
A. sharpening the bit before drilling
B. running the drill at a constant speed while drilling
C. removing the wood chips with a brush after drilling
D. holding the wood in place with one hand while drilling

30 In many microwave ovens, a turntable slowly rotates food while the oven is in operation. The turntable, however, was not part of the original microwave oven design.

Which of the following statements is the **most likely** reason the turntable was added to the microwave oven?

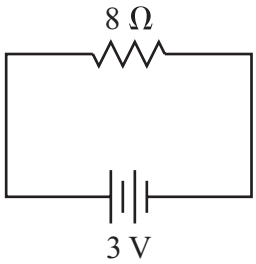
A. Food did not cook evenly.
B. The oven used too much power.
C. Food did not receive enough energy.
D. The oven became too hot during operation.

31 The diagram below shows a simple circuit.

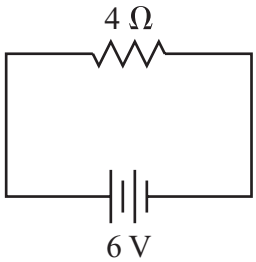


Which of the following circuits has the same current as the circuit in the diagram?

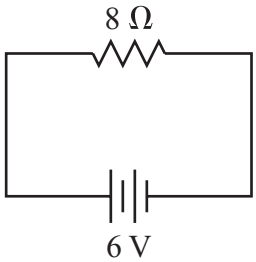
A.



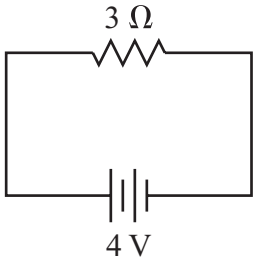
B.



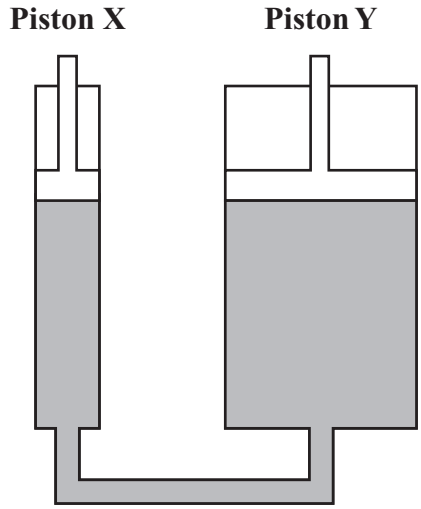
C.



D.



32 The diagram below shows a system of hydraulic pistons. The surface area of piston **Y** is nine times greater than the surface area of piston **X**.



If a downward force of 10 N is applied to piston **X**, what upward force will piston **Y** exert?

A. 3 N

B. 10 N

C. 30 N

D. 90 N

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.

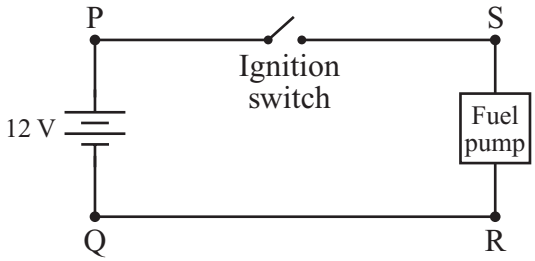
33 Engineering students must use the engineering design process for a class project. The problem for this class project has been identified.

a. List **four** other steps of the engineering design process that the students should do. Be sure to put the steps in the order in which they should be done.

b. Describe one purpose for **each** step you identified in part (a).

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 The diagram below represents a circuit to a fuel pump in a car. The ignition switch is turned off.



This fuel pump may have an internal short circuit. At which two points should an ohmmeter be connected to measure the resistance of the fuel pump?

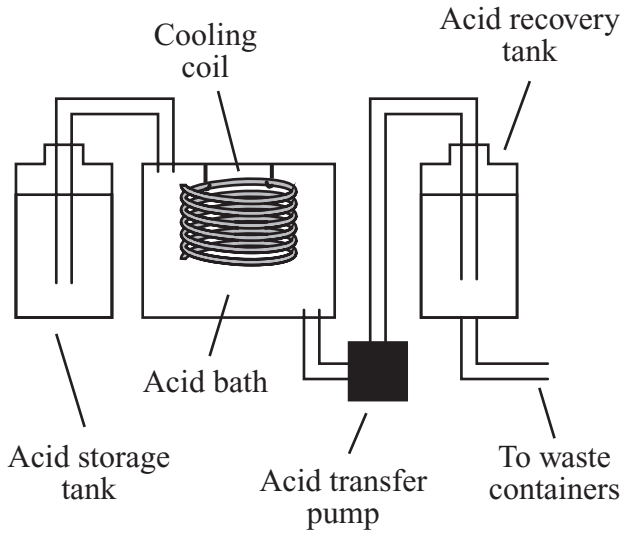
A. P and S

B. Q and P

C. R and Q

D. S and R

35 An air compressor contains cooling coils that circulate water. Over time, these coils corrode and need to be cleaned in an acid bath to restore the efficiency of the system. A simplified diagram of this coil cleaning process is shown below.



Which of the following would convert the cleaning process from an open fluid system to a primarily closed fluid system?

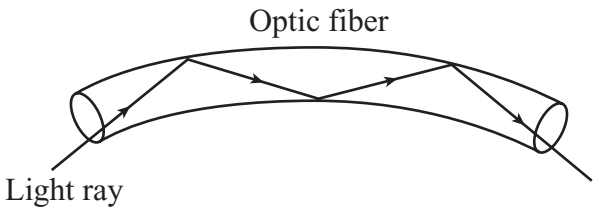
A. combining the fumes from the acid bath and the acid recovery tank

B. transferring the acid from the acid bath directly to the waste containers

C. moving the acid from the acid bath to the acid recovery tank at a slower rate

D. pumping the acid from the acid recovery tank back into the acid storage tank

36 The diagram below represents a section of fiberoptic cable used in a communication network.



Which of the following allows fiberoptic cables to transmit data?

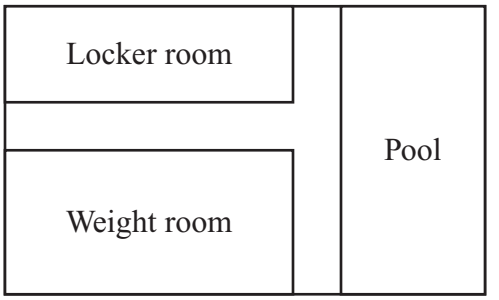
A. total bending of light

B. total dispersion of light

C. total internal reflection

D. total internal refraction

37 A scale drawing of a proposed hotel fitness center is shown below.



Scale
$\frac{1}{4}$ inch = 20 feet

What is the total combined area of the pool **and** the locker room?

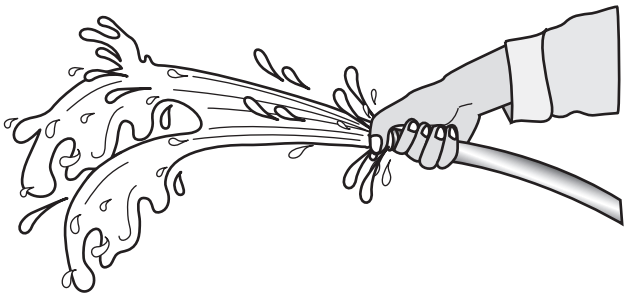
A. 4,800 sq. ft.

B. 7,200 sq. ft.

C. 12,000 sq. ft.

D. 24,000 sq. ft.

38 A person is using a garden hose to water the plants in his yard. The hose does not have a nozzle. To make the water spray, the person covers part of the hose opening with his thumb, as shown below.



The water will have the **greatest** velocity if the person leaves which percentage of the hose opening uncovered?

A. 10%

B. 25%

C. 50%

D. 80%

39 A certain technology transmits information between nearby devices, such as cell phones, digital cameras, and headsets. Which of the following are mainly used by this technology to transmit information?

A. ethernet cables

B. gamma rays

C. optical fibers

D. radio waves

40 An architect is designing a special fountain for an art museum. A system of copper pipes will be used to supply water to different parts of the fountain.

Which of the following will occur if the architect uses a 45° elbow instead of a 90° elbow in one section of the piping system?

A. The water will stop flowing through the pipe, causing it to overflow.

B. The water will flow with less resistance, allowing it to spray farther.

C. The water will be blocked by air bubbles in the pipe, causing it to build up.

D. The water will have more turbulent flow, decreasing the flow rate in the elbow.

41 A music producer can use digital recording technology to create a signal that closely resembles a song performed in the recording studio. The recording of the song can then be replayed an indefinite number of times without worry that the signal will become distorted or worn out.

Which of the following statements describes how digital recording technology achieves this?

A. The technology records and stores the signals as binary values and then converts the binary values back to an analog wave form during replay.

B. The technology records the signals as alphanumeric values and then converts the alphanumeric values back to direct current during replay.

C. The technology records the signals as a variable wave form and then converts the variable wave form back to alternating current during replay.

D. The technology records the signals as a constant wave form and then converts the constant wave form back to a digitized code during replay.

42 Which of the following statements describes an advantage of using ceramic roof tiles instead of asphalt shingles in tropical climates?

A. Ceramic tiles are less brittle.

B. Ceramic tiles absorb more water.

C. Ceramic tiles are more lightweight.

D. Ceramic tiles absorb less heat energy.

43 The total load on a building floor is 60 lb. per sq. ft. The dead load is 40 lb. per sq. ft.

What is the live load on the floor?

A. 20 lb. per sq. ft.

B. 40 lb. per sq. ft.

C. 60 lb. per sq. ft.

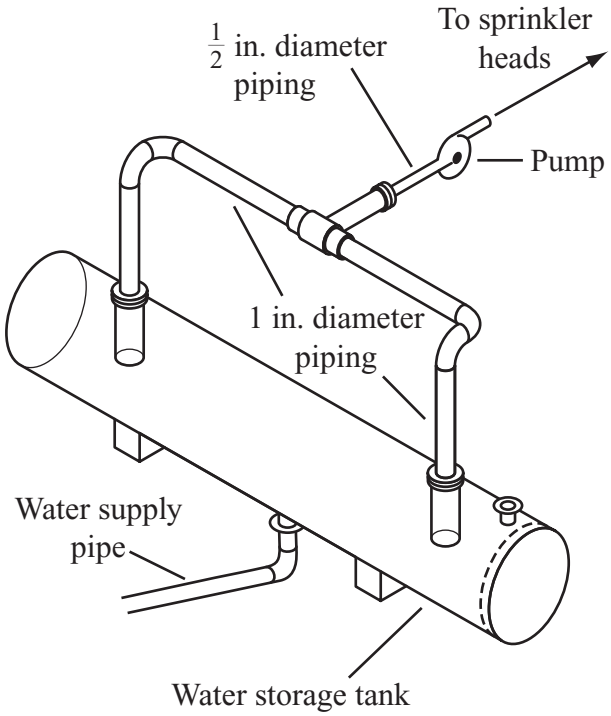
D. 100 lb. per sq. ft.

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 The diagram below shows a storage tank, piping, and a pump for a building's sprinkler system. The sprinkler system is located in the ceiling.



When the sprinkler system is on, water is pumped from the storage tank through the building's ceiling piping to the sprinkler heads.

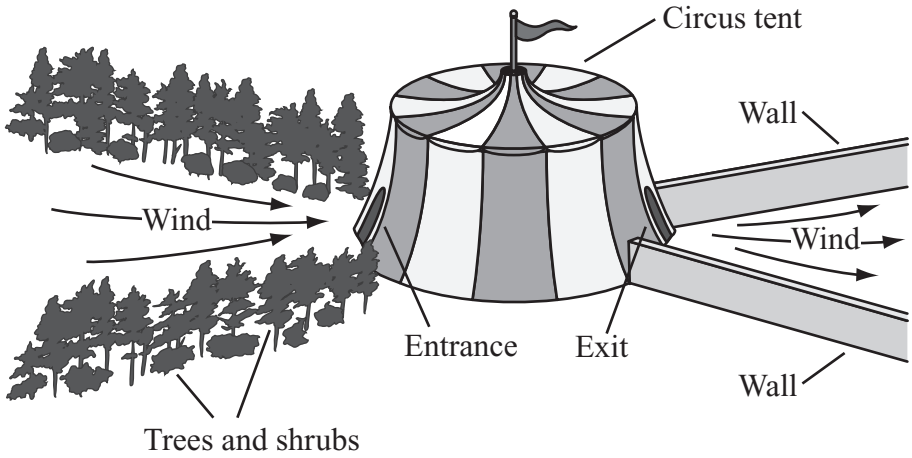
a. Identify the sprinkler system as an open system or a closed system. Explain your answer.

b. Describe how the decrease in pipe diameter, from 1 in. to $\frac{1}{2}$ in., affects the resistance to water flow as water moves through the pipes.

c. Describe one advantage **and** one disadvantage of using copper piping instead of PVC piping for the sprinkler system.

Write your answer to question 45 in the space provided in your Student Answer Booklet.

45 The diagram below shows a circus tent in a permanent location. The tent is cooled using a passive ventilation system.



There is an entrance on the west side of the tent and an exit on the east side. During the months when the circus tent is used, the prevailing wind blows from west to east.

a. Describe **two** benefits of using a passive ventilation system rather than a traditional air-conditioning system to cool the tent.

b. Describe one function of the trees and shrubs on the west side of the tent in the passive system.

c. Based on Bernoulli's principle, describe what happens to the velocity **and** the pressure of the air at the entrance of the tent.

MASSACHUSETTS DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION

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 = current

P = power

R = resistance

V = voltage

r = radius

Definitions and Abbreviations

AC = alternating current

DC = direct current

psi = pounds per square inch

$\pi \approx 3.14$

High School Technology/Engineering
Spring 2015 Released Items:
Reporting Categories, Standards, and Correct Answers*

Item No.	Page No.	Reporting Category	Standard	Correct Answer (MC)*
1	356	*Electrical and Communication Systems*	5.1	A
2	356	*Fluid and Thermal Systems*	4.1	A
3	357	*Engineering Design*	1.3	D
4	357	*Engineering Design*	1.4	C
5	357	*Electrical and Communication Systems*	6.4	B
6	358	*Engineering Design*	1.1	B
7	358	*Engineering Design*	1.5	A
8	358	*Electrical and Communication Systems*	5.2	A
9	359	*Construction and Manufacturing*	2.1	C
10	359	*Electrical and Communication Systems*	6.5	D
11	360	*Fluid and Thermal Systems*	4.3	
12	361	*Construction and Manufacturing*	7.3	D
13	361	*Fluid and Thermal Systems*	3.2	C
14	362	*Electrical and Communication Systems*	6.1	A
15	362	*Fluid and Thermal Systems*	3.1	B
16	362	*Fluid and Thermal Systems*	4.4	B
17	363	*Construction and Manufacturing*	7.1	A
18	363	*Construction and Manufacturing*	2.2	D
19	363	*Electrical and Communication Systems*	5.5	D
20	364	*Construction and Manufacturing*	7.2	C
21	365	*Electrical and Communication Systems*	6.3	D
22	365	*Fluid and Thermal Systems*	4.2	A
23	366	*Electrical and Communication Systems*	5.3	
24	367	*Construction and Manufacturing*	2.6	B
25	367	*Electrical and Communication Systems*	6.4	D
26	368	*Electrical and Communication Systems*	5.4	B
27	368	*Engineering Design*	1.3	B
28	369	*Engineering Design*	1.5	B
29	369	*Construction and Manufacturing*	2.5	D
30	369	*Engineering Design*	1.2	A
31	370	*Electrical and Communication Systems*	5.3	C
32	370	*Fluid and Thermal Systems*	3.3	D
33	371	*Engineering Design*	1.1	
34	372	*Electrical and Communication Systems*	5.1	D
35	372	*Fluid and Thermal Systems*	3.1	D
36	373	*Electrical and Communication Systems*	6.5	C
37	373	*Engineering Design*	1.4	C
38	374	*Fluid and Thermal Systems*	3.4	A
39	374	*Electrical and Communication Systems*	6.1	D

Item No.	Page No.	Reporting Category	Standard	Correct Answer (MC)*
40	374	*Fluid and Thermal Systems*	3.5	B
41	375	*Electrical and Communication Systems*	6.2	A
42	375	*Fluid and Thermal Systems*	4.3	D
43	375	*Construction and Manufacturing*	2.4	A
44	376	*Fluid and Thermal Systems*	3.5	
45	377	*Construction and Manufacturing*	2.3	

* 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.