XXI. Technology/Engineering, High School

High School Technology/Engineering Test

The spring 2011 high school MCAS 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*.

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

In test item analysis reports and on the Subject Area Subscore pages of the MCAS *School Reports* and *District Reports*, Technology/Engineering test results are reported under the following four MCAS reporting categories:

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

Test Sessions

The MCAS 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 limited English proficient 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 The illustration below shows a personal digital assistant (PDA).

Which of the following is **most likely** part of the testing and evaluation stage of designing a PDA?

A. writing an advertisement for the PDA
B. defining the specifications for the PDA
C. finding the plasticity of a new alloy to be used for the PDA case
D. running the PDA over a range of voltages to determine when it will fail

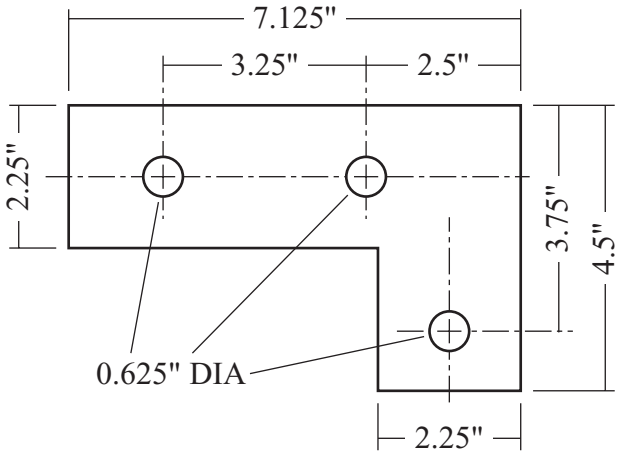
2 Which of the following tools can be used in a separating process during manufacturing?

A. kiln
B. mold
C. rivet
D. shears

3 Which of the following is the **most likely** reason for choosing a building material with a low thermal conductivity for a home?

A. reduced heating costs
B. increased heat transfer
C. reduced construction costs
D. increased structural strength

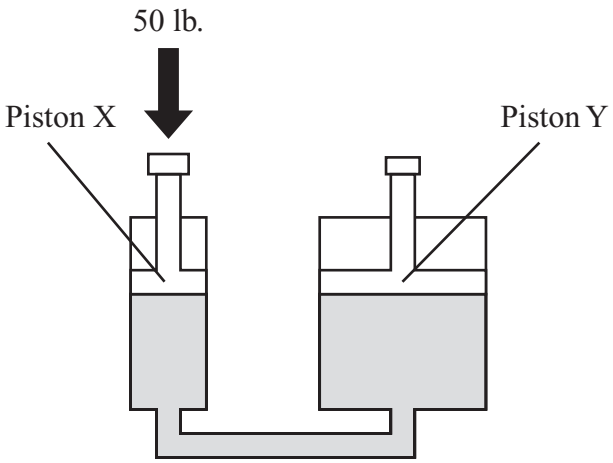
4 A mechanical drawing of a part is shown below.



Which of the following information should a machinist be able to determine by reading this drawing?

A. the density of the part
B. what size drill bit to use
C. how deep to drill the holes
D. the material to use for the part

5 In the hydraulic system shown below, the cross-sectional area of piston Y is 5 times greater than the cross-sectional area of piston X.



If a 50 lb. downward force is applied to piston X, what will be the resulting force on piston Y?

A. 50 lb. down
B. 50 lb. up
C. 250 lb. down
D. 250 lb. up

6 Which of the following is the **best** example of a transmitter functioning in a communication system?

A. A fax machine prints out an image.

B. A satellite dish on the ground receives a video signal.

C. A computer processor translates a digital signal to an analog signal.

D. A cellular telephone tower sends information to a cellular telephone.

7 A builder installs a radiant barrier on the floor of an attic to reduce summer heat gain in the house. To achieve the best result, the builder should use a material for the radiant barrier that is

A. highly porous.

B. highly reflective.

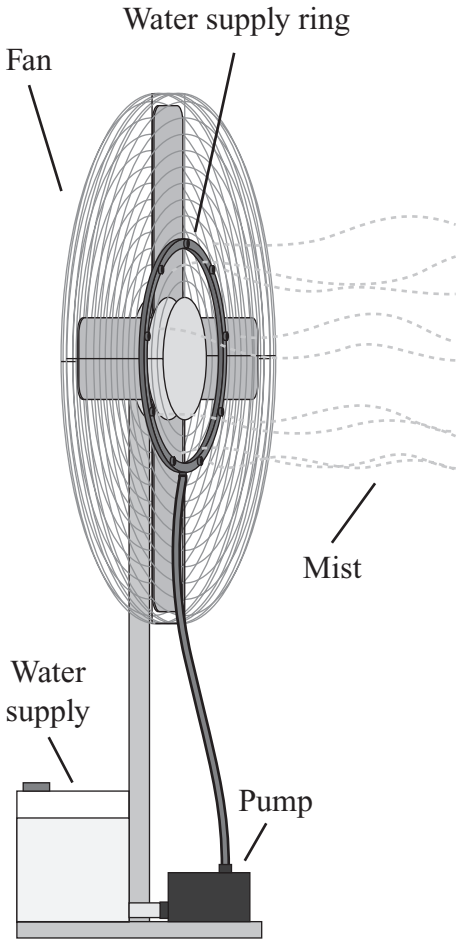
C. highly absorptive.

D. highly conductive.

8 Which of the following objects is a controller in a circuit?

A. ammeter
B. battery
C. motor
D. switch

9 The diagram below shows a cooling system that works by releasing water directly in front of a high-speed fan.



Which of the following statements explains why this cooling system is considered an open system?

A. The system causes a decrease in air temperature.
B. The water is not recirculated during operation.
C. The water is pressurized during operation.
D. The system is only used outdoors.

10 The power generated by a wind turbine can be approximated by the equation shown below.

$$\text{Power} = \frac{1}{2}(\text{air density})(\text{blade area})(\text{wind velocity})^3$$

According to this equation, which of the following modifications would cause the **greatest increase** in the power generated by a wind turbine?

A. making the area of the turbine blades $\frac{1}{2}$ as large

B. making the area of the turbine blades 3 times as large

C. moving the turbine to a location with $\frac{1}{4}$ the wind velocity

D. moving the turbine to a location with 2 times the wind velocity

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 A group of students is designing a solar cooker. As part of the design process, the students must test a prototype to see if it is able to boil water.

a. Identify one step in the engineering design process the students should do **before** testing the prototype.

b. Explain why the step you identified in part (a) is important in the engineering design process as it relates to the solar cooker.

c. Identify one step in the engineering design process the students should do **after** they test the prototype.

d. Explain why the step you identified in part (c) is important in the engineering design process as it relates to the solar cooker.

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.

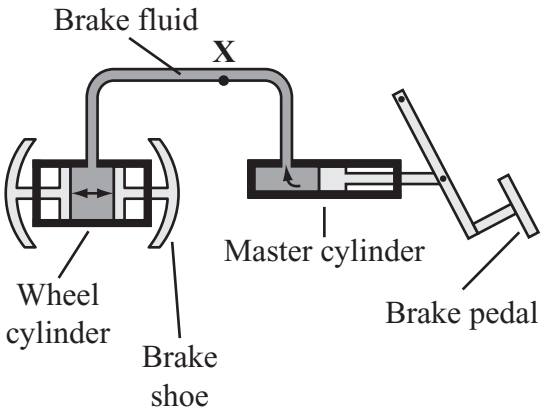
12 An automobile battery produces which type of current?

A. alternating current
B. digital current
C. direct current
D. interval current

13 Audio signals in MP3 players are stored in digital form. In order for these signals to be heard through headphones or speakers, the digitally stored data is converted by which of the following components?

A. a digital to data converter
B. a digital to video converter
C. a digital to analog converter
D. a digital to optical converter

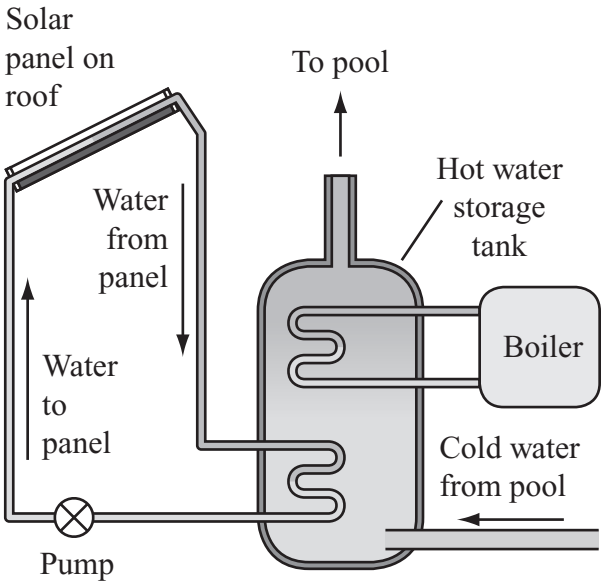
14 The hydraulic drum brake system used in cars typically contains a master cylinder and a wheel cylinder for each wheel, as shown in the cross-section below.



A small leak occurs at point **X**. Which of the following will **most likely** happen if the brake pedal is pushed shortly after the leak occurs?

A. The fluid pressure of the system will be lower than expected.
B. The fluid pressure of the system will be higher than expected.
C. The piston in the wheel cylinder will not be able to move.
D. The piston in the master cylinder will not be able to move.

15 The diagram below shows how solar energy is used to help heat water for a community swimming pool.



A city engineer wants to reduce the resistance of water flow to and from the solar panel. Which of the following suggestions would result in the **greatest** decrease in resistance in this system?

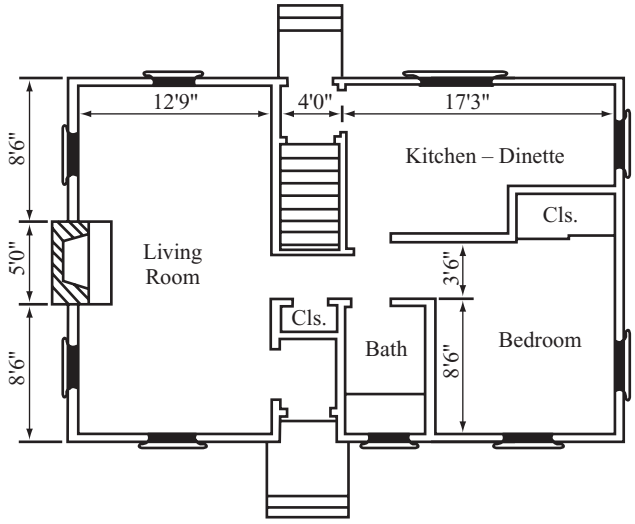
A. Add a 90° elbow in the pipe on each side of the pump.

B. Increase the length of the pipes to and from the solar panel.

C. Increase the diameter of the pipes to and from the solar panel.

D. Install a check valve in the pipe between the pump and the solar panel.

16 The floor plan of an apartment is shown below.



Based on this floor plan, approximately how many square feet is the apartment?

A. 110 sq. ft.

B. 480 sq. ft.

C. 750 sq. ft.

D. 1160 sq. ft.

17 It is not advisable to seek shelter under a highway overpass during a tornado. When air moves through this narrow area, wind speeds increase and pressure decreases. This increases the risk for injuries.

This phenomenon can be explained by which of the following?

A. Bernoulli's principle
B. gravitational force
C. R-values
D. shear

18 Which of the following diagrams **best** represents the path of a light signal inside the core of a fiberoptic cable?

A.


B.


C.


D.

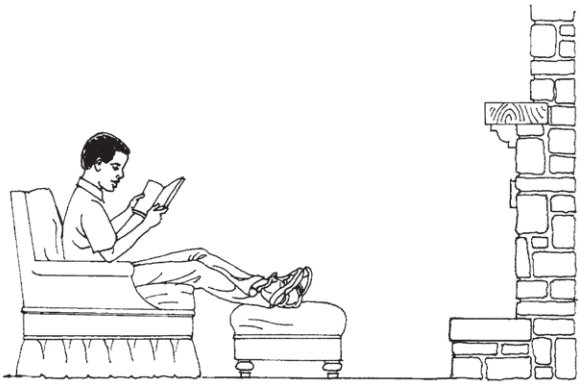

19 Which of the following statements describes the major difference between a closed fluid system and an open fluid system?

A. A closed fluid system uses a gas and an open fluid system uses a liquid.
B. A closed fluid system uses a liquid and an open fluid system uses a gas.
C. A closed fluid system does not retain all its fluids and an open fluid system does.
D. A closed fluid system retains all its fluids and an open fluid system does not.

20 Maria needs to measure the amount of current flowing through a closed circuit. Which of the following instruments should she use for this task?

A. ammeter
B. hygrometer
C. ohmmeter
D. voltmeter

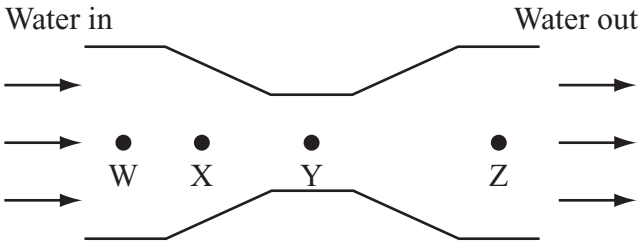
21 The drawing below shows a person sitting on a sofa in front of a fireplace.



Which of the following are the primary modes of heat transfer from the fire in the fireplace to the person?

A. radiation and convection
B. radiation and condensation
C. convection and conduction
D. conduction and condensation

22 Water is flowing through a pipe system, as shown in the cross-sectional drawing below. Four locations are labeled.



At which two locations does water move at the same speed?

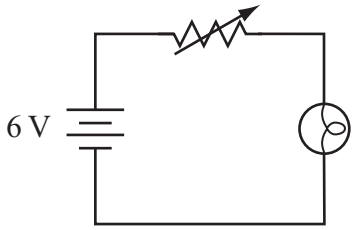
A. points W and X
B. points W and Z
C. points X and Y
D. points Y and Z

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 battery, a variable resistor, and a light bulb are shown in the circuit below.



a. Explain the function of the battery in the circuit.

b. Describe what will happen to the light bulb if the variable resistor is set at 0 Ω.

c. If the variable resistor is set at 18 Ω, calculate the current in the circuit. Assume the resistance of the light bulb is 12 Ω. Show your calculations and include units in your answer.

d. Describe what will most likely happen to the light bulb if the variable resistor's resistance is increased. Explain your answer.

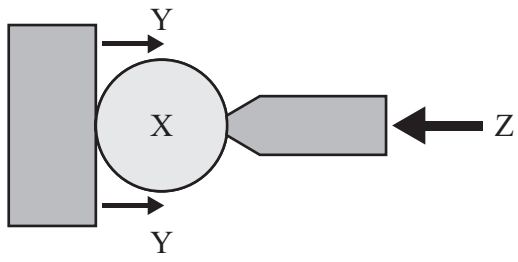
Technology/Engineering

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 The diagram below represents a round part affected by two opposite in-line horizontal forces.



Part X is required to keep its shape when forces Y and Z are applied. Part X needs to be **most** resistant to which of the following?

A. bending

B. compression

C. tension

D. torsion

25 An engineer has just finished building a prototype of a lawn tractor that is powered by a hydrogen fuel cell. Which of the following should be the **next** step in the design process?

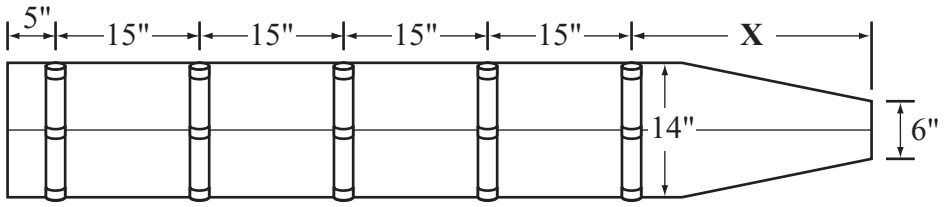
A. testing the prototype to evaluate its performance

B. asking for funding to build more copies of the prototype

C. building a second prototype that is different from the first

D. making modifications to the prototype that will increase its performance

26 The drawing below shows a design plan for a sled.



The scale of the drawing is $\frac{1}{4}" = 5"$. What is the actual length of the front section labeled **X**?

A. 20"
B. 21"
C. 25"
D. 29"

27 Which of the following acts primarily as a storage device in a communication system?

A. antenna
B. microphone
C. computer display
D. computer hard drive

28 Which of the following environmental conditions do architects **most likely** consider when they decide on the placement of windows in new houses in the northeastern United States?

A. maximum wind speeds
B. average summer temperatures
C. solar angle throughout the year
D. amount of precipitation each year

29 Building codes for single-family homes regulate the heights of chimneys.

Which of the following is the **most likely** reason for this regulation?

A. to make sure the best materials are used to build chimneys
B. to make sure chimneys can hold the maximum amount of heat
C. to make sure chimneys are strong enough to help support the house
D. to make sure dangerous gases are properly ventilated through chimneys

30 A worker is using an arc welder to join two pieces of metal. Which of the following safety precautions is **most** important for the worker to prevent infrared radiation exposure when welding?

A. Wear a helmet with a dark face plate.
B. Make sure to discharge any static electricity.
C. Have the operational manual nearby for reference.
D. Make sure the electrode material is similar to the joining metals.

31 A factory that manufactures hats uses robots for some production tasks. Which of the following tasks are the robots **most likely** doing?

A. feeding cloth into the machines
B. inspecting finished seams on the hats
C. producing sketches of new hat designs
D. performing maintenance checks on the machines

32 In a circuit, an electrician replaces a 4 ft. section of wire with a wire that has a larger diameter. This change in wire diameter will cause which of the following results?

A. The current in the new wire section will be less than in the original wire.
B. The resistance of the new wire section will be less than that of the original wire.
C. A greater power loss in the circuit will occur because of the new wire section.
D. A greater voltage drop across the circuit will occur because of the new wire section.

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 photographs below show typical houses facing south in Vermont and in Arizona.

Vermont house design

Arizona house design

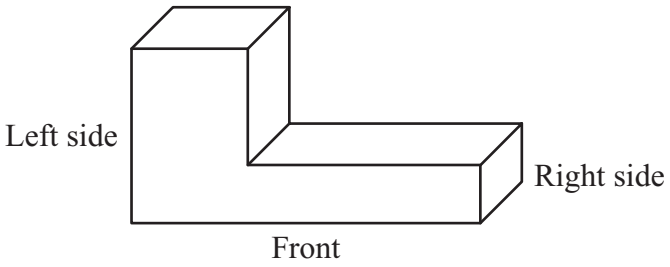
The climate in Vermont varies greatly from the climate in Arizona. Factors such as wind, solar angle, and temperature likely influenced the design of these houses.

a. Describe **two** features of the Vermont house design that make it uniquely advantageous to its geographical location. Explain your answers.

b. Describe **two** features of the Arizona house design that make it uniquely advantageous to its geographical location. Explain your answers.

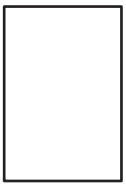
Mark your answers to multiple-choice questions 34 through 43 in the spaces provided in your Student Answer Booklet. Do not write your answers in this test booklet, but you may work out solutions to multiple-choice questions in the test booklet.

34 The diagram below represents a new mechanical part.

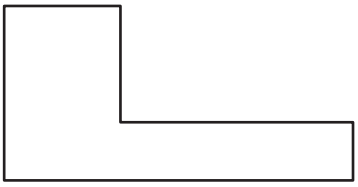


Which diagram shows what the right side view of this part would look like on an engineering drawing?

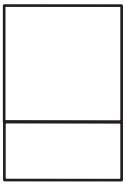
A.



B.

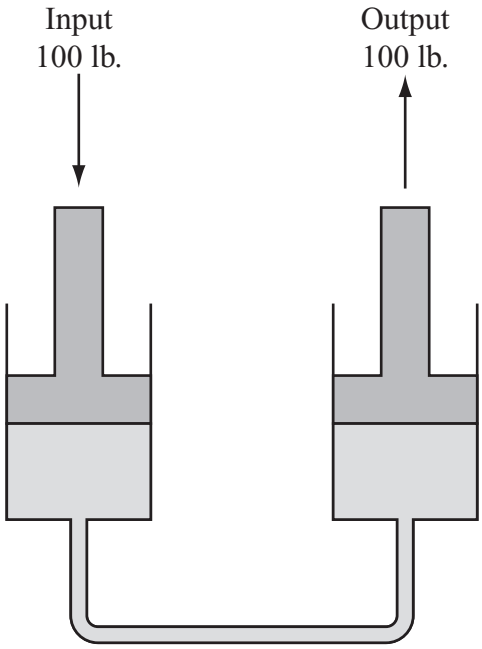


C.



D.

35 The diagram below shows a cross-section of a hydraulic system.



This hydraulic system serves as which of the following?

A. direction changer
B. distance multiplier
C. force multiplier
D. pressure changer

36 A deep space probe uses which of the following to communicate with scientists on Earth?

A. alternating current
B. radio waves
C. sound waves
D. visible light

37 Which of the following is the best example of conductive heat transfer?

A. sunlight warming sand on a beach
B. a fan blowing hot air around a room
C. warm water vapor rising from a hot tub
D. a hot water bottle resting on a person's back

38 Which of the following advances in automotive technology were developed to improve driver and passenger safety?

A. aerodynamic spoilers
B. computerized fuel injection systems
C. hybrid engines
D. shatterproof windshields

39 The drawings below show four half-filled 12-oz. plastic coffee cups, containing coffee initially at 80°C. In which cup will the coffee cool most quickly?

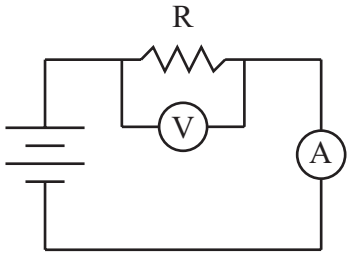
A.

B.

C.

D.

40 A simple circuit with one resistor is shown below.



The voltmeter reads 6 V and the ammeter reads 3 A. Which of the following is the resistance of R?

A. 0.5 Ω
B. 2 Ω
C. 9 Ω
D. 18 Ω

41 Which of the following statements **best** describes how mineral deposits on the interior surface of a water pipe affect the flow of water through the pipe?

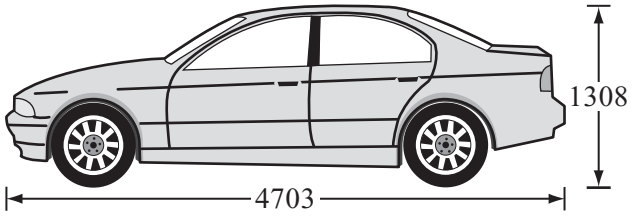
A. The deposits effectively decrease the diameter of the pipe, causing water to slowly solidify.

B. The deposits effectively increase the diameter of the pipe, causing water to slowly evaporate.

C. The deposits effectively decrease the diameter of the pipe, reducing the amount of water that can flow through the pipe per minute.

D. The deposits effectively increase the diameter of the pipe, increasing the amount of water that can flow through the pipe per minute.

42 A scale drawing of a car is shown below. The numbers indicate the measurements of the actual size of the car.



In which of the following units are the measurements **most likely** expressed?

A. centimeters

B. feet

C. inches

D. millimeters

43 An engineer is designing an injection mold that can be used to make 10,000 plastic parts per day. Which of the following materials would be **best** to use to build this mold?

A. cement

B. glass

C. plastic

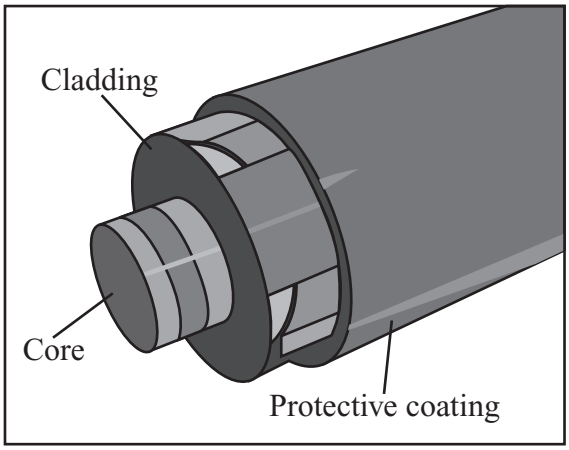
D. steel

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 illustration below shows three major components of a fiberoptic cable.



a. Describe the function of the core **and** the function of the cladding.

In recent years, fiberoptic cable has been replacing copper wire as a means of transmitting communication signals.

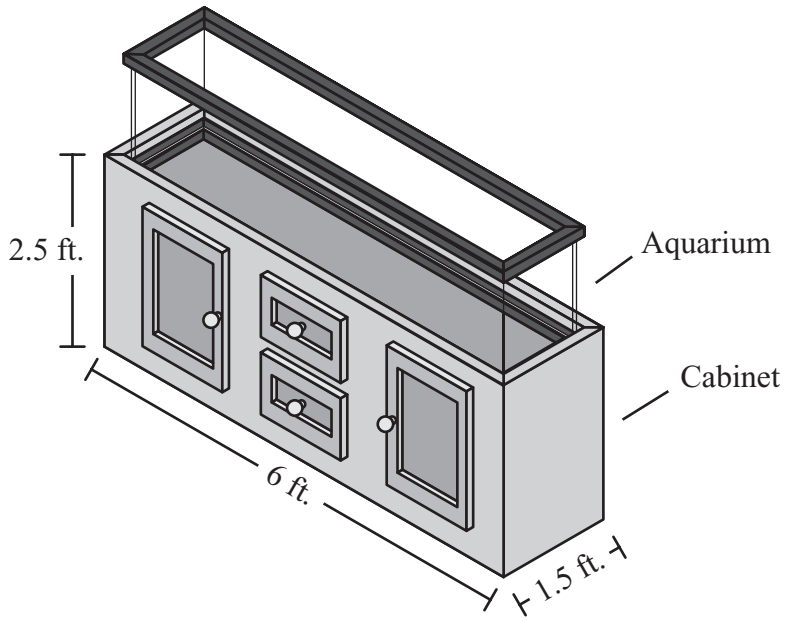
b. Describe the difference between the signals that are transmitted by fiberoptic cable and those transmitted by copper wire.

The core in a fiberoptic cable can be made of plastic or glass.

c. Identify **two** advantages of using plastic instead of glass in a fiberoptic cable.

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

45 A student wants to place a 100 gal. aquarium on a 6 ft. × 1.5 ft. × 2.5 ft. wooden cabinet, as shown below.



The floor of the student's bedroom is designed to hold 50 lb. per sq. ft. of load. The empty aquarium and cabinet weigh 30 lb. and 80 lb., respectively. One hundred gallons of water weighs 831 lb.

a. Calculate the total load exerted on the floor by the cabinet and the aquarium filled with water. Show your calculations and include units in your answer.

b. Can the floor of the student's bedroom safely support the filled aquarium? Show calculations with units to justify your answer.

c. Identify the type of load on the floor that the aquarium and cabinet represent. Explain your answer.

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 2011 Released Items:
Reporting Categories, Standards, and Correct Answers*

Item No.	Page No.	Reporting Category	Standard	Correct Answer (MC)*
1	381	*Engineering Design*	1.1	D
2	381	*Construction and Manufacturing*	7.1	D
3	381	*Construction and Manufacturing*	2.1	A
4	382	*Engineering Design*	1.5	B
5	382	*Fluid and Thermal Systems*	3.3	D
6	383	*Electrical and Communication Systems*	6.3	D
7	383	*Fluid and Thermal Systems*	4.2	B
8	384	*Electrical and Communication Systems*	5.2	D
9	384	*Fluid and Thermal Systems*	3.1	B
10	385	*Fluid and Thermal Systems*	4.4	D
11	386	*Engineering Design*	1.1	
12	387	*Electrical and Communication Systems*	5.5	C
13	387	*Electrical and Communication Systems*	6.2	C
14	387	*Fluid and Thermal Systems*	3.2	A
15	388	*Fluid and Thermal Systems*	3.5	C
16	388	*Engineering Design*	1.5	C
17	389	*Construction and Manufacturing*	2.3	A
18	389	*Electrical and Communication Systems*	6.5	C
19	389	*Fluid and Thermal Systems*	3.1	D
20	389	*Electrical and Communication Systems*	5.1	A
21	390	*Fluid and Thermal Systems*	4.1	A
22	390	*Fluid and Thermal Systems*	3.4	B
23	391	*Electrical and Communication Systems*	5.2	
24	392	*Construction and Manufacturing*	2.2	B
25	392	*Engineering Design*	1.1	A
26	393	*Engineering Design*	1.4	C
27	393	*Electrical and Communication Systems*	6.3	D
28	393	*Fluid and Thermal Systems*	4.3	C
29	394	*Construction and Manufacturing*	2.6	D
30	394	*Construction and Manufacturing*	2.5	A
31	394	*Construction and Manufacturing*	7.3	A
32	394	*Electrical and Communication Systems*	5.4	B
33	395	*Fluid and Thermal Systems*	4.3	
34	396	*Engineering Design*	1.3	C
35	396	*Fluid and Thermal Systems*	3.3	A
36	397	*Electrical and Communication Systems*	6.1	B
37	397	*Fluid and Thermal Systems*	4.1	D
38	397	*Engineering Design*	1.2	D
39	398	*Fluid and Thermal Systems*	4.2	A
40	398	*Electrical and Communication Systems*	5.3	B
41	399	*Fluid and Thermal Systems*	3.5	C

Item No.	Page No.	Reporting Category	Standard	Correct Answer (MC)*
42	399	*Engineering Design*	1.4	D
43	399	*Construction and Manufacturing*	7.2	D
44	400	*Electrical and Communication Systems*	6.4	
45	401	*Construction and Manufacturing*	2.4	

***** 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.