Practice Test: Work, Energy, Gravitation, Electric Force, Electric Field, Circuits

True/False
Indicate whether the statement is true or false.

_____ 1. In materials such as metals, the outer shell electrons are loosely bound to the nuclei of their atoms and are free to move from one atom to another. These materials are good conductors.
_____ 2. The change in potential difference depends on the magnitude of the test charge.
_____ 3. Using a 1-kW heater for one hour consumes more energy than using a 100-W bulb for one day.

Multiple Choice
Identify the choice that best completes the statement or answers the question.

_____ 4. Which of the following statements is true about electric forces?
   a. Electric forces cause objects to only attract each other.
   b. Electric forces cause objects to only repel each other.
   c. Electric forces cause objects to repel or attract each other.
   d. Electric forces have no effect on each other.

_____ 5. Three rods of different materials P, Q, and R, are charged by various methods. When the rods are brought near each other, the rods P and Q repel each other, while the rods P and R attract each other.
   Which of the following could be the signs of the charges on the rods?

|	Rod P	Rod Q	Rod R
a.	–	+	–
b.	–	+	–
c.	–	–	+
d.	–	–	–

_____ 6. Which of the following materials is the best conductor of electricity?
   a. Wet skin
   b. Glass
   c. Dry air
   d. Rubber

_____ 7. When two bodies are charged, the total charge before and after charging remains the same because of:
   a. quantization of charges
   b. conservation of charges
   c. law of induction
   d. Coulomb's law

_____ 8. The distance between two charges q_a and q_b is r, and the force between them is F. What is the force between them if the distance between them is doubled?
   a. $F/4$
   b. $4F$
   c. $9F$
   d. $F/9$

_____ 9. Which of the following is true for the direction of an electric field?
   a. It is same as the direction of the force exerted on a negative test charge.
   b. It is opposite to the direction of the force exerted on a positive test charge.
   c. It is same as the direction of the force exerted on a positive test charge.
   d. It is opposite to the direction of the force exerted on a neutral test charge.

_____ 10. If the work done in moving a charge is doubled and the strength of the charge is halved, the electric potential difference:
   a. increases to four times its original value.
   b. decreases to half its original value.
   c. increases to twice its original value.
   d. decreases to one-fourth of its original value.

_____ 11. What change is observed in the strength of an electric field around a charged object if the magnitude of the test charge is doubled?
   a.   Electric field is doubled.
   b.   Electric field is halved.
   c.   Electric field remains unchanged.
   d.   Electric field reduces to one-fourth of the original value.

_____ 12. In the circuit shown below, which bulb, when burned out, will cause all other bulbs to stop glowing?
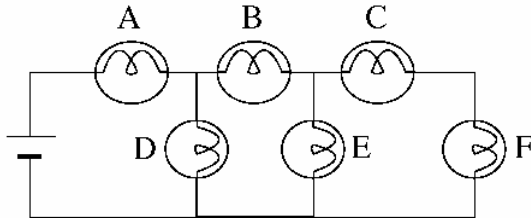
   a.   A   c.   C
   b.   B   d.   F

_____ 13. Which of the following circuits can be used to measure the resistance of the heating element, shown as a resistor in the diagrams below?
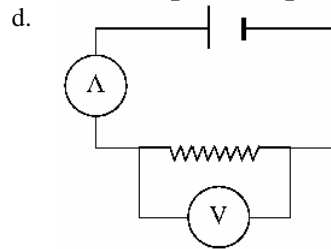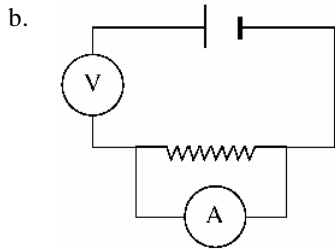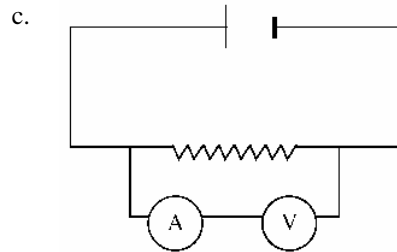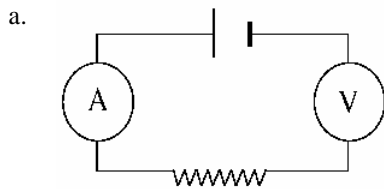
_____ 14. In a series circuit, each circuit element has the same:
   a.   current   c.   capacitance
   b.   voltage   d.   resistance

_____ 15. If a resistor is added to a parallel circuit, the equivalent resistance:
   a.   increases   c.   remains the same
   b.   decreases   d.   becomes zero

_____ 16. The number of current paths in a series circuit is:
   a.   one   c.   three
   b.   two   d.   four

____ 17. A 10.0-Ω resistor, 20.0-Ω resistor, and 25.0-Ω resistor are connected in series across a 110-V supply. Calculate the current in the circuit.
  a.   2.0 A   c.   55 A
  b.   4.5 A   d.   11 A

____ 18.
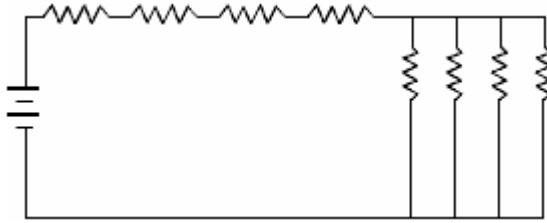
Four resistors of 10.0 Ω each are connected in parallel. A combination of four resistors of 10.0 Ω each is connected in series along with the parallel arrangement. What is the equivalent resistance of the circuit?
  a.   80.0 Ω   c.   40.0 Ω
  b.   40.4 Ω   d.   42.5 Ω

____ 19. A 20.0-Ω resistor and a 40.0-Ω resistor are connected in series across a battery. If the current is 2.00 A, what is the voltage of the battery?
  a.   30.0 V   c.   80.0 V
  b.   60.0 V   d. 1.20×10^2 V

____ 20. A 2.00-Ω resistor and a 12.0-Ω resistor are connected in parallel across a 20.0-V battery. What is the current flowing through the 2.00-Ω resistor?
  a.   1.67 A   c.   11.6 A
  b.   1.40 A   d.   10.0 A

____ 21. A 4.0-Ω resistor, an 8.0-Ω resistor, and a 10.0-Ω resistor are connected in series across an 11-V battery. The total voltage drop across the 4.0-Ω and 8.0-Ω resistors is:
  a.   2.0 V   c.   6.0 V
  b.   4.0 V   d.   11 V

____ 22. A short piece of metal that melts when a large current passes through it is a:
  a.   circuit breaker   c.   relay
  b.   surge suppressor   d.   fuse

____ 23. An automatic switch that opens when the current reaches a set value is called:
  a.   surge suppressor   c.   circuit breaker
  b.   relay   d.   fuse

____ 24. Which device measures the current in a circuit?
  a.   Ammeter   c.   Amplifier
  b.   Voltmeter   d.   Rheostat

Completion
Complete each statement.

25. When a comb is run though your hair and brought *near* a small piece of paper, the paper is attracted to the comb due to _____.

26. The charge of one electron is −1.60 × 10⁻¹⁹C. If a neutral object loses 1.4 × 10⁶ electrons, the charge on the object is _____ C.

27. The strength of an electric field around a charged object is equal to the force on a positive test charge divided by the _____ of the test charge.

28. The electric potential difference is defined as the work done to move a(n) _____ test charge between two points in an electric field divided by the _____ of the test charge.
29. The unit of electric potential difference is the _____.
30. Electric field strength is directly proportional to _____ and inversely proportional to charge.

Short Answer

31. The negative charge distribution over the surface of two isolated spheres is depicted in the diagram. One of the spheres is made of copper and the other is made of rubber. Identify the sphere that depicts the charge distribution of copper and that of rubber. Support the answer with an explanation.
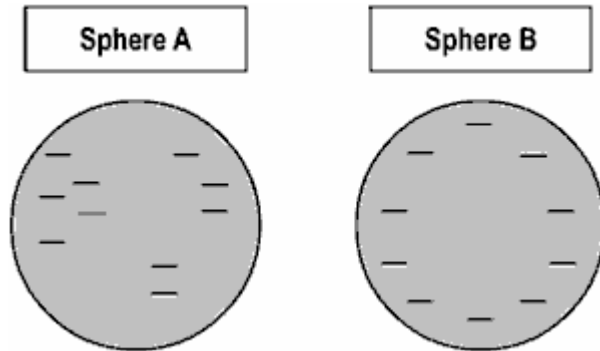

32. Electric field lines around two charges are shown in the diagram. Identify the type of charges on the objects X and Y.
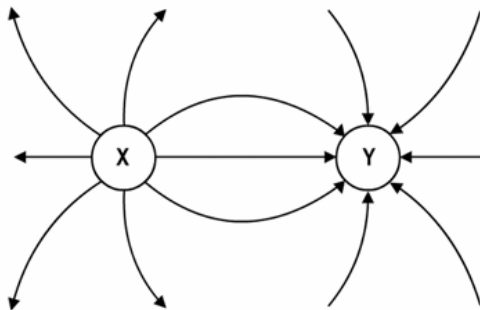
Problem

33. Andrew throws a 0.11-kg ball toward Donald, who is standing on a ledge. The ball leaves Andrew's hands at a height of 0.24 m and Donald catches it at a height of 0.82 m. Calculate the gravitational potential energy of the ball relative to the ground before being thrown.
34. A warehouse worker pushed a cart weighing 4.50 kg to the top of an inclined plane. Initially, the cart was 0.670 m above the floor. If the top of the inclined plane is 2.70 m above the floor, calculate the work done by gravity as the worker pushed the cart to the top of the plane.
35. What is the force between two small charged spheres that have charges of 2×10^{-7} C and 3×10^{-7} C and are placed 30 cm apart in air?
36. Find the magnitude of the electric field strength at a position that is 0.6 m from a point charge of 3.6×10^{-6} C.
37. Two charged plates are 1.30 cm apart and the electric field intensity between the plates is 2.60×10^{3} N/C.
    a.   What is the electric potential difference between the plates?
    b.   What work is required to move a proton from the negative plate to the positive plate?
38. What is the quantity of charge that passes through a conductor when there is a current of 0.25 A for 10 minutes?

39.
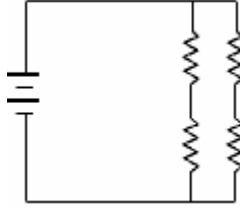
A 10.0-Ω resistor is connected in series with a 90.0-Ω resistor. This arrangement is connected in parallel with another series combination of two resistors of 10.0 Ω and 10.0 Ω each. This combination is connected across a 135-V battery. Calculate the power dissipated in the circuit.

40. Calculate the force of gravitational attraction between two spheres of mass 10.1 kg and 45.4 kg that are 38.5 m apart.

Practice Test
Answer Section

TRUE/FALSE

1. ANS: T
   Materials that allow electrons to move freely are called conductors.

   PTS: 1   KEY: Conductor   MSC: 1
   NOT: /T/ Correct! /F/ Materials that allow electrons to move freely are called conductors.
2. ANS: F
   Potential difference depends on the field around a charged object and the displacement of the test charge.

   PTS: 1   KEY: Potential difference   MSC: 1
   NOT: /F/ Correct! /T/ The change in potential difference does not depend on the magnitude of test charge. It depends only on the field around a charged object and the displacement of the test charge.
3. ANS: F
   Energy consumed in an electric circuit is equal to the product of the power of the device and the time for which it is used.
   PTS: 1   KEY: Energy   MSC: 1
   NOT: /F/ Correct! /T/ The power of a device is the rate at which it consumes energy.

MULTIPLE CHOICE
4. ANS: C
   Electric forces are repulsive between like charged objects and attractive between objects that possess opposite charges.

	Feedback
A	Objects with opposite charges attract each other and objects with like charges repel each other.
B	Objects attract or repel each other depending on the charge they possess.
C	Correct!
D	Electric forces cause objects to either repel or attract each other depending on the type of charge they possess.

   PTS: 1   KEY: Force between charged objects   MSC: 1
   NOT: /a/ Objects with opposite charges attract each other and objects with like charges repel each other. /b/ Objects attract or repel each other depending on the charge they possess. /c/ Correct! /d/ Electric forces cause objects to either repel or attract each other depending on the type of charge they possess.
5. ANS: C
   If objects are similarly charged, the force between them is repulsive. However, if the objects are oppositely charged, the force between them is attractive.

	Feedback

A	Rods P and Q cannot repel each other if they are oppositely charged.
B	Rods P and R cannot attract each other if they are similarly charged.
C	Correct!
D	There is no force of attraction between two similarly charged objects.

PTS: 1   KEY: Charge   MSC: 2
NOT: /a/ Rods P and Q cannot repel each other if they are oppositely charged. /b/ Rods P and R cannot attract each other if they are similarly charged. /c/ Correct! /d/ There is no force of attraction between two similarly charged objects.

6. ANS: A
Wet skin is the best conductor of electricity as compared to dry air, rubber, or glass.

	Feedback
A	Correct!
B	Glass is less conductive than rubber.
C	Dry air is an insulator and impedes easy flow of electrons.
D	Rubber is more conductive than glass.

PTS: 1   KEY: Conductors and insulators   MSC: 1
NOT: /a/ Correct! /b/ Glass is less conductive than rubber. /c/ Dry air is an insulator and impedes easy flow of electrons. /d/ Rubber is more conductive than glass.

7. ANS: B
When two neutral objects are charged, the total charge remains the same because charges are conserved and are not created or destroyed.

	Feedback
A	The charge on any particle is an integral multiple of the charge on an electron or proton.
B	Correct!
C	Charging is also done by bringing objects in contact.
D	Coulomb's law states that the force between two charges is inversely proportional to the distance between them.

PTS: 1   KEY: Conservation of charges MSC: 1
NOT: /a/ The charge on any particle is an integral multiple of the charge on an electron or proton. /b/ Correct! /c/ Charging is also done by bringing objects in contact. /d/ Coulomb's law states that the force between two charges is inversely proportional to the distance between them.

8. ANS: A
The magnitude of force between charges q_a and q_b, separated by a distance r, is proportional to the magnitude of charges and inversely proportional to the square of the distance between them.

	Feedback
A	Correct!
B	Force increases fourfold if distance is reduced by half.
C	Force increases ninefold if the distance is reduced by one-third.
D	Force reduces if the distance is increased threefold.

PTS: 1   KEY: Electric force   MSC: 1
NOT: /a/ Correct! /b/ Force increases fourfold if distance is reduced by half. /c/ Force increases ninefold if the distance is reduced by one-third. /d/ Force reduces if the distance is increased threefold.

9. ANS: C
The direction of an electric field is the same as the direction of force exerted on a positive text charge.

	Feedback
A	The direction of force on a positive test charge is taken as a reference.
B	The direction of electric field is the same as the direction of force exerted on the positive test charge.
C	Correct!
D	The test charge should not be neutral.

PTS: 1   KEY: Electric field   MSC: 1
NOT: /a/ The direction of force on a positive test charge is taken as a reference. /b/ The direction of electric field is the same as the direction of force exerted on the positive test charge. /c/ Correct! /d/ The test charge should not be neutral.

10. ANS: A
Electric potential difference is directly proportional to work done and inversely proportional to charge.

	Feedback
A	Correct!
B	The electric potential difference is not directly proportional to the magnitude of the charge.
C	The electric potential difference also depends on the strength of the charge.
D	Did you assume that the electric potential difference is directly proportional to the strength of charge and inversely proportional to the work done?

PTS: 1   KEY: Potential difference   MSC: 2
NOT: /a/ Correct! /b/ The electric potential difference is not directly proportional to the magnitude of the charge. /c/ The electric potential difference also depends on the strength of the charge. /d/ Did you assume that the electric potential difference is directly proportional to the strength of charge and inversely proportional to the work done?

11. ANS: C
Changing the magnitude of a test charge does not affect the electric field strength at the same location.

	Feedback
A	The electric field strength is not directly proportional to charge.
B	The change in the charge causes a change in the force.
C	Correct!
D	The electric field is independent of the size of the test charge.

PTS: 1   KEY: Electric field   MSC: 2
NOT: /a/ The electric field strength is not directly proportional to charge. /b/ The change in the charge causes a change in the force. /c/ Correct! /d/ The electric field is independent of the size of the test charge.

12. ANS: A

	Feedback
A	Correct!
B	If bulb B burns out, bulbs A and D will still glow.
C	If bulb C burns out, bulbs A, B, D, and E will still glow.
D	If bulb F burns out, bulbs A, B, D, and E will still glow.

PTS: 1   KEY: Closed circuit   MSC: 2
NOT: /a/ Correct! /b/ If bulb B burns out, bulbs A and D will still glow. /c/ If bulb C burns out, bulbs A, B, D, and E will still glow. /d/ If bulb F burns out, bulbs A, B, D, and E will still glow.

13. ANS: D

	Feedback
A	The voltmeter must be connected in parallel with the resistance to measure the potential difference.
B	The ammeter must be connected in series with the resistance and the voltmeter in parallel with it.
C	The ammeter must be connected in series to measure the current through the resistance.
D	Correct!

PTS: 1   KEY: Resistance   MSC: 2
NOT: /a/ The voltmeter must be connected in parallel with the resistance to measure the potential difference. /b/ The ammeter must be connected in series with the resistance and the voltmeter in parallel with it. /c/ The ammeter must be connected in series to measure the current through the resistance. /d/ Correct!

14. ANS: A
In a series circuit, the same current flows through each circuit element.

	Feedback
A	Correct!
B	The voltage across each circuit element differs.
C	Some circuit elements do not have any capacitance.
D	The resistance of each circuit element may differ.

PTS: 1 KEY: Current, Series circuits MSC: 1
NOT: /a/ Correct! /b/ The voltage across each circuit element differs. /c/ Some circuit elements do not have any capacitance. /d/ The resistance of each circuit element may differ.

15. ANS: B
The equivalent resistance decreases when additional devices are placed in parallel. This happens because each new resistor provides an additional path for current, increasing the total current while the potential difference remains unchanged.

	Feedback
A	The equivalent resistance of a parallel circuit increases only when one or more branches are removed.
B	Correct!
C	The new resistor provides an additional path for current.
D	The resistance would reduce to zero in case of a short circuit.

PTS: 1 KEY: Equivalent resistance, Parallel circuits
MSC: 1
NOT: /a/ The equivalent resistance of a parallel circuit increases only when one or more branches are removed. /b/ Correct! /c/ The new resistor provides an additional path for current. /d/ The resistance would reduce to zero in case of a short circuit.

16. ANS: A
Current in a series circuit flows through all the circuit elements in a single path.

	Feedback
A	Correct!
B	Only parallel circuits have multiple current paths.
C	A circuit that has more than one branch is called a parallel circuit.
D	Multiple current paths are present only in parallel circuits.

PTS: 1 KEY: Parallel circuits MSC: 1
NOT: /a/ Correct! /b/ Only parallel circuits have multiple current paths. /c/ A circuit that has more than one branch is called a parallel circuit. /d/ Multiple current paths are present only in parallel circuits.

17. ANS: A
Add the values of resistance of all the resistors to obtain the equivalent resistance. Divide the voltage by the equivalent resistance to get the current.

	Feedback
A	Correct!
B	Did you divide the voltage by the equivalent resistance to obtain the current?
C	Obtain the equivalent resistance and then divide the voltage by the resistance.
D	The current would be 11 A if the resistors of 20.0 ohms and 25.0 ohms are removed.

PTS: 1 KEY: Series circuits, Current MSC: 1
NOT: /a/ Correct! /b/ Did you divide the voltage by the equivalent resistance to obtain the current? /c/ Obtain the equivalent resistance and then divide the voltage by the resistance. /d/ The current would be 11 A if the resistors of 20.0 ohms and 25.0 ohms are removed.

18. ANS: D
Add the equivalent resistance of the resistors in series to the equivalent resistance of the resistors in parallel.

	Feedback
A	Obtain the equivalent resistance of the devices connected in parallel, and add it to the resistance

	of the resistors in series.
B	The equivalent resistance of the devices connected in parallel is the inverse of 0.4.
C	Add the equivalent resistance of the devices connected in parallel to the equivalent resistance of the series combination.
D	Correct!

PTS: 1   KEY: Equivalent resistance, Combined series-parallel circuits
MSC: 2
NOT: /a/ Obtain the equivalent resistance of the devices connected in parallel, and add it to the resistance of the resistors in series. /b/ The equivalent resistance of the devices connected in parallel is the inverse of 0.4. /c/ Add the equivalent resistance of the devices connected in parallel to the equivalent resistance of the series combination. /d/ Correct!

19. ANS: D
Add the value of resistance of the resistors to obtain the equivalent resistance. Multiply the equivalent resistance with the current to find the voltage.

	Feedback
A	To obtain the voltage, multiply the equivalent resistance with the current, and not divide.
B	Multiply the current with the equivalent resistance.
C	The voltage drop across the 40.0-ohm resistor is 80.0V.
D	Correct!

PTS: 1   KEY: Series circuits, Voltage   MSC: 2
NOT: /a/ To obtain the voltage, multiply the equivalent resistance with the current, and not divide. /b/ Multiply the current with the equivalent resistance. /c/ The voltage drop across the 40.0-ohm resistor is 80.0V. /d/ Correct!

20. ANS: D
Divide the voltage by the resistance to find the current.

	Feedback
A	The current through the 12-ohms resistor is 1.67 A.
B	The resistors are connected in parallel, and not in series.
C	The total current that the battery supplies is 11.6 A.
D	Correct!

PTS: 1   KEY: Parallel circuits, Voltage   MSC: 2
NOT: /a/ The current through the 12-ohms resistor is 1.67 A. /b/ The resistors are connected in parallel, and not in series. /c/ The total current that the battery supplies is 11.6 A. /d/ Correct!

21. ANS: C
Find the equivalent resistance of the circuit. Calculate the current in the series circuit by dividing the supplied voltage by the equivalent resistance. To find the voltage drop across a resistor, use $V = IR$. The voltage drop across two or more resistors is the sum of the individual voltage drops across each resistor.

	Feedback
A	The voltage drop across the 4.0-ohm resistor is 2.0 V.
B	The voltage drop across the 8.0-ohm resistor is 4.0 V.
C	Correct!
D	The total voltage drop across all the resistors is 11 V.

PTS: 1   KEY: Voltage drops, Series circuits   MSC: 2
NOT: /a/ The voltage drop across the 4.0-ohm resistor is 2.0 V. /b/ The voltage drop across the 8.0-ohm resistor is 4.0 V. /c/ Correct! /d/ The total voltage drop across all the resistors is 11 V.

22. ANS: D
The thickness of the fuse is determined by the amount of current allowed to pass through it. If the current exceeds a certain limit, the fuse melts.

	Feedback
A	A circuit breaker can be reused.

B	A surge suppressor prevents any dangerous voltage spikes.
C	A relay is a device that is activated by a change in conditions in an electric circuit.
D	Correct!

PTS: 1 KEY: Fuse MSC: 1
NOT: /a/ A circuit breaker can be reused. /b/ A surge suppressor prevents any dangerous voltage spikes. /c/ A relay is a device that is activated by a change in conditions in an electric circuit. /d/ Correct!

23. ANS: C
A circuit breaker opens when the current reaches or exceeds a set value. A circuit breaker is designed so that it can be reused. However, a fuse that melts cannot be reused and needs to be replaced.

	Feedback
A	A surge suppressor prevents any dangerous voltage spikes.
B	A relay is a device that is activated by a change in conditions in an electric circuit.
C	Correct!
D	A fuse melts when the circuit reaches a set value, and cannot be reused.

PTS: 1 KEY: Circuit breaker MSC: 1
NOT: /a/ A surge suppressor prevents any dangerous voltage spikes. /b/ A relay is a device that is activated by a change in conditions in an electric circuit. /c/ Correct! /d/ A fuse melts when the circuit reaches a set value, and cannot be reused.

24. ANS: A
An ammeter is a device that measures current in a circuit.

	Feedback
A	Correct!
B	A voltmeter measures voltage drop across two points.
C	An amplifier is a device that increases the strength of a signal.
D	A rheostat is a type of resistor that produces variable resistance.

PTS: 1 KEY: Ammeter MSC: 1
NOT: /a/ Correct! /b/ A voltmeter measures voltage drop across two points. /c/ An amplifier is a device that increases the strength of a signal. /d/ A rheostat is a type of resistor that produces variable resistance.

COMPLETION

25. ANS: induction
   PTS: 1 KEY: Induction MSC: 1
26. ANS: $+2.24 \times 10^{-13}$
   PTS: 1 KEY: Charge MSC: 2
27. ANS: strength
   PTS: 1 KEY: Electric field MSC: 1
28. ANS: positive, magnitude
   PTS: 1 KEY: Electric potential difference MSC: 1
29. ANS: volt
   PTS: 1 KEY: Potential difference MSC: 1
30. ANS: force
   PTS: 1 KEY: Electric field MSC: 1

SHORT ANSWER

31. ANS:
   Sphere A is made of rubber and sphere B is made of copper. The charge distribution on sphere A is non-uniform and this is characteristic of materials that are less conductive and more insulative. On the other hand, the charge distribution on sphere B is uniform and this is a characteristic of materials that are more conductive and less inductive. Therefore, the sphere A is rubber as it is less conductive than copper.
   PTS: 1 KEY: Conductors and insulators MSC: 2
32. ANS:
   The charge on X is positive and that on Y is negative.

PTS: 1   KEY: Electric field   MSC: 2

PROBLEM

33. ANS:
$PE_{ground} = 0.26\,J$

PTS: 1   KEY: Gravitational potential energy   MSC: 3
NOT: The gravitational potential energy of an object is equal to the product of its mass, the acceleration due to gravity, and its height from the reference level.

34. ANS:
−89.5 J

PTS: 1   KEY: Gravitational potential energy   MSC: 3
NOT: The work done by gravity is the weight of the cart times the vertical distance through which the cart is pushed.

35. ANS:
$6 \times 10^{-3}\,N$

PTS: 1   KEY: Electric force   MSC: 1
NOT: The force between the charges is calculated using Coulomb's law.

36. ANS:
$9 \times 10^{4}\,N/C$

PTS: 1   KEY: Electric field   MSC: 2
NOT: The electric field strength is equal to the product of the constant K and the test charge divided by the square of the distance.

37. ANS:
a.   33.8 V
b. $5.40 \times 10^{-18}\,J$

PTS: 1   KEY: Work   MSC: 2
NOT: The potential difference is the product of the electric field strength and the distance between the plates.

38. ANS:
150 C

PTS: 1   KEY: Charge   MSC: 3
NOT: The charge that flows is equal to the product of the current and the time.

39. ANS:
1094 W

PTS: 1   KEY: Combined series-parallel circuits   MSC: 3
NOT: Find the equivalent resistance of the circuit. To find the power dissipated in a circuit, divide the square of the voltage by the resistance.

40. ANS:
$2.06 \times 10^{-11}\,N$

PTS: 1   NAT: B.4   KEY: Gravitational force
MSC: 3   NOT: Use the mathematical form of Newton's law of gravitation.