UNIT 6 Review

Knowledge/Understanding

Multiple Choice

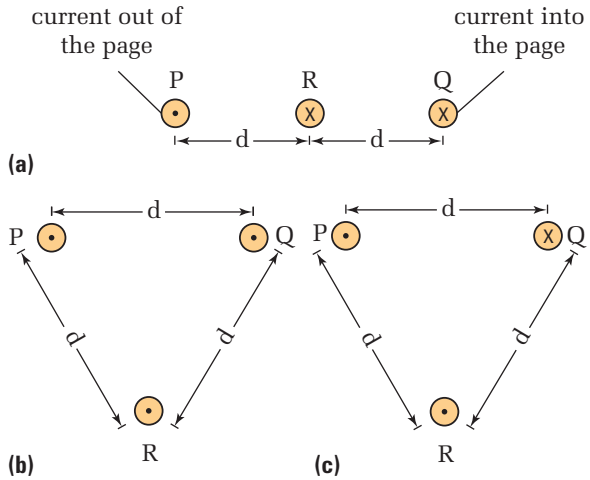
In your notebook, choose the most correct answer for each of the following questions. Outline your reasons for your choice.

1. The magnitude of the electric field at a point in space is equal to the
   - **(a)** force a charge of 1 C would experience there
   - **(b)** force a negative charge would experience there
   - **(c)** force a positive charge would experience there
   - **(d)** potential difference there
   - **(e)** electric charge there
2. Magnetic fields do not interact with
   - **(a)** stationary permanent magnets
   - **(b)** moving permanent magnets
   - **(c)** stationary electric charges
   - **(d)** moving electric charges
   - **(e)** none of the above
3. A circuit consists of two light bulbs connected in parallel with each other. Each branch of the circuit contains a switch connected to the bulb in that branch. If one of the switches is opened, then the other light bulb will:
   - **(a)** glow with the same light.
   - **(b)** glow brighter.
   - **(c)** glow less brightly.
   - **(d)** burn out.
4. Potential difference is a measure of:
   - **(a)** the energy available to a current.
   - **(b)** the energy lost when a current passes through a load.
   - **(c)** the energy per unit of time.
   - **(d)** the energy available to a unit of charge.
5. A copper ring lies in the plane of the page. A bar magnet is moving through the ring into the page, with its N-pole pointing away from the viewer. As the magnet moves through the ring, the current in the ring will be:
   - **(a)** clockwise.
   - **(b)** counter-clockwise.
   - **(c)** first clockwise, then counter-clockwise.
   - **(d)** first counter-clockwise, then clockwise.
6. A conductor carries a current eastward through a magnetic field that points directly upward. The direction of the magnetic force on the conductor is:
   - **(a)** west
   - **(b)** east
   - **(c)** north
   - **(d)** south
7. Which of the following statements is **not** true for the back *emf* in a motor:
   - **(a)** The back *emf* depends on the internal resistance of the armature coil.
   - **(b)** The back *emf* must always be less than the supplied *emf*.
   - **(c)** The back *emf* exists whenever the motor is running.
   - **(d)** The back *emf* increases with the speed of the motor.

Short Answer

8. Why do electric field lines come out of positive charges and enter negative charges?
9. What similarities and differences are there between electric potential energy and gravitational potential energy?
10. In a 10 000 V power line, how many units of energy is carried by each unit of charge making up the current?
11. Explain why there is no parallel component to the electric field on the surface of conductors.
12. The direction of a current in a conductor, the direction of the magnetic field, and the direction of the force on the conductor are mutually perpendicular. Draw a sketch of this situation and describe the right-hand rule that models the relationship among these directions.
13. Why is it more difficult to provide a simple equation for the strength of a magnetic force than it is for the strength of a gravitational force, the universal law of gravitation, or the strength of an electrostatic force, Coulomb's law?
14. Explain the similarities and differences between:
    - **(a)** current and electron flow.
    - **(b)** series and parallel circuits.
    - **(c)** Lenz's law and the generator effect.
    - **(d)** the terminal voltage and *emf* of a battery.

15. The diagram (below) shows three configurations of three parallel conductors (P, Q and R) that carry currents of equal magnitude in the indicated directions. For each of the conductors, P and Q, identify the direction of the magnetic field that their current creates at the position of conductor R. Then, find the direction of the net magnetic field at the position of conductor R, and identify the direction of the force that conductor R experiences due to the net magnetic field.



16. An electric motor is running under a heavy load. You notice that the cover of the motor is getting quite hot. Explain why the motor runs at a relatively cool temperature at high speeds, and why, when it is trying to drive a heavy load, it seems to get hot.

Inquiry

17. Devise an experiment that verifies Coulomb's law. Show that the electric force should be proportional to the product of the charges and show that the electric force should be proportional to the inverse square of the distance.

18. Two identical pith balls, mass 1.26 g, have a charge of +4.00 nC. One ball (A) is attached to the end of a light rod made of insulating material; the other (B) is suspended from a fixed point by an insulated thread 80.0 cm long. When ball A is held at various horizontal distances from B, the angle between the thread and the vertical is measured. Determine whether the results support Coulomb's law.

Horizontal distance between A and B (cm)	Angular displacement of thread
0.50	25.0°
1.00	6.65°
1.50	2.97°
1.80	2.06°
2.10	1.51°
2.50	1.07°

19. A voltmeter and ammeter are used to measure the potential difference and current for a load. The data taken from the measurements is recorded in the table below.

(a) Make a graph of the data, and use the slope of the graph to find the resistance of the load.

(b) What happens to the resistance as the current through the load rises?

Trial	Voltage (V)	Current (A)
1	0	0
2	4	0.6
3	6	0.9
4	8	1.2
5	18	1.7
6	28	1.9
7	40	2.1

20. For a given DC motor, how does the back *emf* depend on the speed (measured in revolutions per minute/RPM) at which the motor is running? First, make a hypothesis that predicts the relationship between these two variables. Then, design an investigation to measure the back *emf* of a DC motor at various speeds. You can only use equipment that would be available in your

physics laboratory. A graph of back *emf* versus motor speed should be used to test your hypothesis about the relationship between these two variables.

21. Design an investigation to show how the efficiency of a motor changes when the amount of load it carries is changed.

Communication

22. The two statements "like poles repel" and "unlike poles attract" are throwbacks to the action-at-a-distance theory, in that they imply the two poles interact with each other directly. Rewrite these two statements to reflect a field theory perspective.

23. Use the concepts of the electric field and electric field lines to convince someone that like charges should repel each other.

24. Explain how it would be possible to measure Coulomb's constant.

25. Contrast the concepts of potential difference and difference of potential energy.

26. Use Newton's law of universal gravitation to explain why Earth is round.

27. Consider a stream of protons moving parallel to a stream of electrons. Is the electric force between the streams attractive or repulsive? Is the magnetic force between the streams attractive or repulsive? What factor(s) determine which force will dominate?

28. Compare the operation of a slip-ring commutator with a split-ring commutator.

29. Explain why the induced *emf* in a coil rotating in a magnetic field alternates in direction.

30. While electric forces require the existence of electric charges, magnetic forces do not seem to require the existence of magnetic poles. Explain this apparent anomaly.

31. The torsion balance played an essential role in Coulomb's work. Research the history of the use of the torsion balance in physics. How is a torsion pendulum different?

32. Research and report on how the concept of the field has evolved. Discuss Faraday's and Maxwell's contributions.

33. The Sun's magnetic field is responsible for sunspots, small regions on the surface of the Sun that are cooler and have a much higher magnetic field concentration than their surroundings. The Sun's magnetic field is also responsible for producing solar flares and other solar activity. Prepare a report that summarizes the latest research on the Sun's magnetic field and the types of solar phenomena that are being examined. Incorporate into your report the findings provided by the orbiting solar satellite, the Solar and Heliospheric Observatory (SOHO).

34. Research and explain the part played by the electric field in
- **(a)** the xerographic process
- **(b)** laser printers
- **(c)** inkjet printers

35. "Electron guns" are used in television sets to propel electrons toward the screen. What techniques are then used to deflect the electron beam and "paint" a picture?

36. During an experiment with a bar magnet, the magnet falls on a concrete floor several times. As the experiment progresses, it is observed that the strength of the bar magnet is lower than it was at the start of the experiment. Using Domain theory, explain the probable cause of this observation.

37. Investigate the method used to record and read a signal from a magnetic medium, such as used in audio, video or computer disk-drive systems. Using Domain theory, explain how the information is stored. Using Lenz's law, explain how the patterns on the disk drive of a computer interact with the magnetic head of the disk drive when data is read from the disk.

Problems for Understanding

38. What is the magnitude of the electric force between a proton and electron in a hydrogen atom if they are 52.9 pm apart?

39. Two small ball bearings sit 0.75 m apart on a table and carry identical charges. If each ball bearing experiences a force of 3.0 N, how large is the charge on each?

40. How many electrons must be removed from an isolated conducting sphere 12 cm in diameter to produce an electric field of intensity 1.5×10^{-3} N/C just outside its surface?

41. Suppose you wanted to replace the gravitational force that holds the Moon in orbit around Earth by an equivalent electric force. Let the Moon have a net negative charge of $-q$ and Earth have a net positive charge of $+10\ q$. What value of q do you require to give the same magnitude force as gravity?

42. Earth carries a net charge of -4.3×10^5 C. When the force due to this charge acts on objects above Earth's surface, it behaves as though the charge was located at Earth's centre. How much charge would you have to place on a 1.0 g mass in order for the electric and gravitational forces on it to balance?

43. Suppose you want to bring two protons close enough together that the electric force between them will equal the weight of either at Earth's surface. How close must they be?

44. What will be the net force, considering both gravitational and electrostatic forces, between a deuterium ion and a tritium ion placed 5.0 cm apart?

45. What must be the charge on a pith ball of mass 3.2 g for it to remain suspended in space when placed in an electric field of 2.8×10^3 N/C[up]?

46. How many electrons make up a charge of 1.0 μC?

47. A 2.0 pC charge is located at point A on an imaginary spherical surface which is centred on a 4.0 μC point charge 2.8 cm away. How much work is required to move the 2.0 pC charge to the following two points?

(a) to point B, which is located on the same spherical surface an arc length 3.0 cm away

(b) to point C, which is located radially outward from A on another imaginary spherical surface of radius 4.2 cm

(c) What name could be used to describe these spherical surfaces?

48. A current of 2.0 A runs through a wire segment of 3.5 cm. If the wire is perpendicular to a uniform magnetic field and feels a magnetic force of 7.0×10^{-3} N, what is the magnitude of the magnetic field?

49. A coil, consisting of 600 turns of wire, has an edge that is 5.0 cm long that passes through a magnetic field. The field strength is 0.220 T east, and acts at right angles to the current in the coil. If the force on the coil was 8.25 N down, what was the magnitude and direction of the current in the coil?

50. The magnetic field of Earth is about 1.50×10^{-4} T due north. A transmission line carries a current of 120 A. If the distance between two of the supporting towers is 750 m, how much force does the magnetic field from the Earth exert on the current in the line segment between the towers, when the current is due (a) east? (b) south? (**Note:** Remember that force is a vector quantity.)

51. Draw a circuit section that shows how to connect five resistors, each with a resistance of 2.0 Ω, such that the equivalent resistance of the section is (a) 7.0 Ω; (b) 0.40 Ω; (c) 2.5 Ω; (d) 2.4 Ω; (e) 1.0 Ω.

52. A 15 V battery is connected to four resistors. Two resistors, 5.00 Ω and 7.50 Ω, are connected in parallel so that they are in series with resistors of 4.00 Ω and 5.00 Ω. Find the current through each resistor, and the potential drop across each resistor. What is the equivalent resistance of the circuit?

53. A battery has an *emf* of 18 V. When it is connected to an external load with a resistance of 1.5×10^2 Ω, a current of 0.115 A flows.

(a) What is the terminal voltage of the battery?

(b) What is the internal resistance of the battery?

(c) What will be the terminal voltage when the battery is connected to a 25 Ω load?