Section 12.6: The Direct Current Motor

Mini Investigation: Observing a DC Motor, page 570

A. Answers may vary. Sample answer:

Parts recognized	Parts not recognized
• external magnets • split ring commutator • brushes and connectors for external circuit	• soft-iron core (because it is a different shape) • axles

B. Answers may vary. Sample answer:
Yes, the design of the hobby motor was very similar to the designs I have studied. The parts of the hobby motor were very compact and in a small space, which made them difficult to recognize at first. However, after investigating, I noticed that each part that I studied was included in the motor.
C. The split ring commutator and armature were on an axle, which is different than the motor designs I studied so far. The other difference I noticed was that the armature was not in the form of a solid cylinder, but had space in between each coil.

Research This: Brushless Motors, page 571

A. Answers may vary. Sample answer:

Brush-type motors	Brushless motors
• permanent magnets are placed on the stator • electromagnets are placed on the rotor • electromagnet is powered directly by the circuit	• permanent magnets are placed on the rotor • electromagnets are placed on the stator • electromagnet is controlled by a microprocessor

B. Answers may vary. Sample answers:
Brushless motors work by having the permanent magnets placed on the stator and the electromagnets placed on the rotor. The electromagnets are controlled by a small computer called a microprocessor. The magnetic field the electromagnets produce across the permanent magnets is varied in a precise way. The permanent magnets experience a force and continually rotate with the rotor.
C. Answers may vary. Sample answers:
Microprocessor-controlled brushless motors are quieter, more efficient, and longer lasting than brush-type motors. They can also be cooled easier and stopped in more precise positions than brush-type motors.
D. Answers may vary. Sample answers:
Brushless motors can be used in consumer electronics such as computer hard drives and DVD players. A widespread application of brushless motors is the cooling fan found in almost every computer.

Section 12.6 Questions, page 571

1. (a) A: external magnet
B: armature
C: split ring commutator
D: brush
E: coil of wire
F: battery
(b) The motor will spin clockwise. The conventional current is directed into the split ring at the brush labelled D. As a result, the charges go down the coil at the front of the coil and exit from the split ring through the opposite brush. Using the right-hand rule for a coil, my fingers go down the coil following the conventional current, and my right thumb points right, indicating that the right side of the coil is a north magnetic pole. The north pole from the external magnet and the north pole from the armature repel one another and cause a clockwise rotation. A similar thing happens with the two south magnetic poles.
(c) Reversing the current will make the left side of the coil a north magnetic pole, and the motor will spin in the opposite direction (counterclockwise).
2. (a) The loop will rotate clockwise. The conventional current is directed from the positive terminal toward the brushes, making contact with the split ring commutator on the right side of the loop. Charges flow into the right of the loop and exit from the left and flow back to the negative terminal. Using the right-hand rule for the motor principle, the force is downward at the right of the loop and upward at the left of the loop. This will start a clockwise rotation.
(b) The purpose of the split ring commutator is to interrupt the circuit when the loop is perpendicular to the magnetic field of the external magnets. This allows the current to flow in the opposite direction in the loop once the split ring comes in contact with the brushes again. This, in turn, changes the direction of the magnetic field and keeps the motor spinning continuously.

3. (a) Increasing the number of loops in the coil would increase the strength of the motor, since the magnetic field of the coil would be stronger. This causes a greater force on the armature.
(b) Using a plastic core instead of a soft-iron core would decrease the strength of the motor, since the magnetic field of the coil would be weaker. This causes a lesser force on the armature.
(c) Decreasing the current would decrease the strength of the motor, since the magnetic field of the coil would be weaker. This causes a lesser force on the armature.
(d) Reversing the polarity of the external magnets would cause the armature to rotate in the opposite direction. If the external magnetic pole nearest to the north pole of the coil were attracting the north pole of the coil, it would now be repelling it. If it were repelling the north pole of the coil, it would now be attracting it. This is similar to what would happen for the external magnetic pole nearest to the south pole of the coil, so the armature would begin to rotate in the opposite direction.
(e) Reversing the polarity of the external magnets and reversing the direction of the current would have no effect on a DC motor. The magnetic fields from the external magnet and the loop would remain the same strength but change to the opposite direction. These changes in magnetic field direction mean that if magnetic fields are aligned, they stay aligned, and if they are in opposite directions, they stay in opposite directions. So the DC motor would not be affected.