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SEDC 73600

Lesson Plan 3: Intro to Digital Motors

Unit: Arduino Motors Unit

Previous lesson: Analog Motors
Next lesson: DC Hobby Motors

Main objectives: Students will be able to discuss how basic commercial motors work. SWBAT identify the 3 common types of digital motors (DC hobby motors, servo motors, and stepper motors) and identify and justify which type of motor to use in different situations.

Standards: 9-12.IC.7 Career Paths: Investigate the use of computer science in multiple fields.

Timing: This is a 1-period lesson.

In-class exercises: The students will complete the worksheet, below.

Notes: This is an introductory lesson so there is a lot of information and new vocabulary. Students will use all three motor types in hands-on activities over the cou

Resources: Video on how electric motors work:
https://www.youtube.com/watch?v=CWulQ1ZSE3c&t=147s

Video on stepper motors: https://www.youtube.com/watch?v=eyqwLiowZiU

Materials: Student handouts, projector, teacher computer, Google slides presentation (the slide deck is in the lesson folder on Github)

Assignments: The class assignment for students is below, with the answer key on the following page.

Formative assessment: Student handout (see below)

Lesson:
5 min: Do Now: What is the role of a magnet in a motor?

- Possible response: the magnet causes the rotor to spin by providing a force on the current-carrying wire coil
- Share with class

2 min: Intro

- Yesterday we built our own basic motors. We're going to take a look at some commercial motors and see how those improve upon the motors that you built yesterday. Then we'll discuss the 3 types of motors that we'll be using over the next 2 weeks.

18 min: DC Motors

- Can spin CW or CCW
- Crude: either on or off
    - Speed determined by voltage
    - Direction determined by polarity of current
- Unlimited rotation in one direction
- What are some devices that could use hobby motors?
    - Cars, fans, etc
- Watch video on how electric motors work (start video at 2:27)
    - Students should answer Qs on student handout
    - The wires coming out of the motor connect to the brushes, which connect to the commutator, which connects to the coils. As electricity passes through the coils, it generates a magnetic field. The coils then are attracted to the magnet, causing them to turn. As it spins, the brushes connect to different parts of the commutator, magnetizing different coils of wire so that the rotor keeps spinning in the same direction. This coils are attached to the shaft, so this causes the shaft to spin. This is a brushed motor. Brushless motors work differently. If the polarity of the electricity is reversed, the motor will spin in the opposite direction.
- How is this design an improvement on the basic motors we built yesterday?
    - Our basic motors had no current (and thus no torque) half the time, relying on momentum to carry them through. The brushes and commutator allow the motor to always have coils that are magnetized, but simply rotate *which* coils are magnetizing, producing a more constant torque. Also the magnet surrounds the coils rather than just sitting on one side.

5 min: Servo Motors

- Precise: Can rotate to a specific angle
- Limited rotation
    - often 180^{o}
- High torque at high speeds
- Good for back and forth, open and closed, dials
- What are some devices that could use servo motors?
    - Robotic arms, windshield wipers, factory equipment, camera lenses, DVD players (to extend/retract the disk tray)
- Other advantages: More power efficient than stepper motors
  Other disadvantages: more expensive
- What's inside a servo motor?
    - Chip controls the DC motor, turning it on until the motor has rotated the correct amount and then turning it off.

5 min: Stepper Motors

- Precise: Can program to rotate to a specific angle or step

- Unlimited rotation in either direction
- High torque at low speeds
- What are some devices that could use stepper motors?
    - 3d printers, printing presses, analog clocks, feed mechanisms for ATMs and metrocard machines. Note that stepper motors have poor performance at high speeds.
- Other disadvantages is that they are often noisy and less energy efficient than servos.
- What's inside a stepper motor?
    - Stepper motor driver chip controls which of the 4 electromagnets is magnetized at any given moment. In the center is a permanent magnet which has gear teeth that align to one of the 4 electromagnets. As the electromagnets are magnetized, the rotor will spin to align its teeth with the magnet, spinning ¼ of one tooth. This allows for extremely accurate rotational angles.

10 min: Motor Applications

- Students work in pairs to complete the assignment below (also on the student handout)

With your partner, determine which type of motor you would use for each device and explain your reasoning

1. *Automatic doors*
2. *Laptop fan*
3. *Elevator*
4. *Escalator*
5. *Electric toothbrush*
6. *Grocery store conveyor belt*

Name: _____ Period: _____

Intro to Digital Motors

Do Now: What is the role of a magnet in a motor?

1. From the Motors video: what is the name for the part of the motor that the brushes touch?

2. Why do commercial motors have so many wires?

3. How is this design an improvement on the basic motors we built yesterday?

4. What are 2+ devices that could use basic DC motors?

5. What are the main advantages of servo motors?

6. What is the biggest disadvantage of servo motors?

7. What are 2+ devices that could use servo motors?

8. What are the main advantages of stepper motors?

9. What is the biggest disadvantage of stepper motors?

10. What are 2+ devices that could use stepper motors?

11. With your partner, determine which type of motor you would use for each device and explain your reasoning
    1. Automatic doors

    2. Laptop fan

    3. Elevator

    4. Escalator

    5. Electric toothbrush

    6. Grocery store conveyor belt

Name: _____KEY_____ Period: _____

Intro to Digital Motors ANSWER KEY

Do Now: What is the role of a magnet in a motor?

The magnet causes the rotor to spin by providing a force on the current-carrying wire coil

1. From the Motors video: what is the name for the part of the motor that the brushes touch?
   Commutator

2. Why do commercial motors have so many wires?

   More wires make the electromagnets stronger

3. How is this design an improvement on the basic motors we built yesterday?

In our design, the wire loop only had current (and thus only received a torque) 50% of the time, whereas this design continually has current, which switches direction at the correct time based on the commutator coming into contact with a different brush. This design has multiple coils of wire rather than just 1 so that the coil which is at the correct angle to the permanent magnets can be magnetized. This design has stronger electromagnets through the use of more wires. This design has magnets surrounding the entire apparatus rather than just on one side.

4. What are 2+ devices that could use basic DC motors?

   Fan, blender, car

5. What is are main advantages of servo motors?

   Can control the angle exactly
   High torque and high speed

6. What is the biggest disadvantage of servo motors?

   Limited to 180 degrees rotation in most cases. (Also expensive)

7. What are 2+ devices that could use servo motors?

   Robotic arm, windshield wipers

8. What are the main advantages of stepper motors?

   Precise angles, continuous rotation

9. What is the biggest disadvantage of stepper motors?

   Slow (also loud and energy inefficient)

10. What are 2+ devices that could use stepper motors?

    3d printers, printing presses, analog clocks, feed mechanisms for ATMs and metrocard machines

11. With your partner, determine which type of motor you would use for each device and explain your reasoning

    Note: Answers may vary

    1. Automatic doors

       Servo—there is a limited range of motion necessary

    2. Laptop fan

       DC motor—it's the cheapest and simplest, and the features of the other motor types aren't necessary since the angle the fan spins is unimportant

    3. Elevator

       Servo or stepper—there is a limited range of motion but precision is very important

    4. Escalator

       DC motor—must run continuously. The angle is unimportant

    5. Electric toothbrush
       DC motor—must run continuously when on. The angle is unimportant

    6. Grocery store conveyor belt

       Stepper motor—needs to be able to run continuously but also stop and start and move forward by very specific amounts