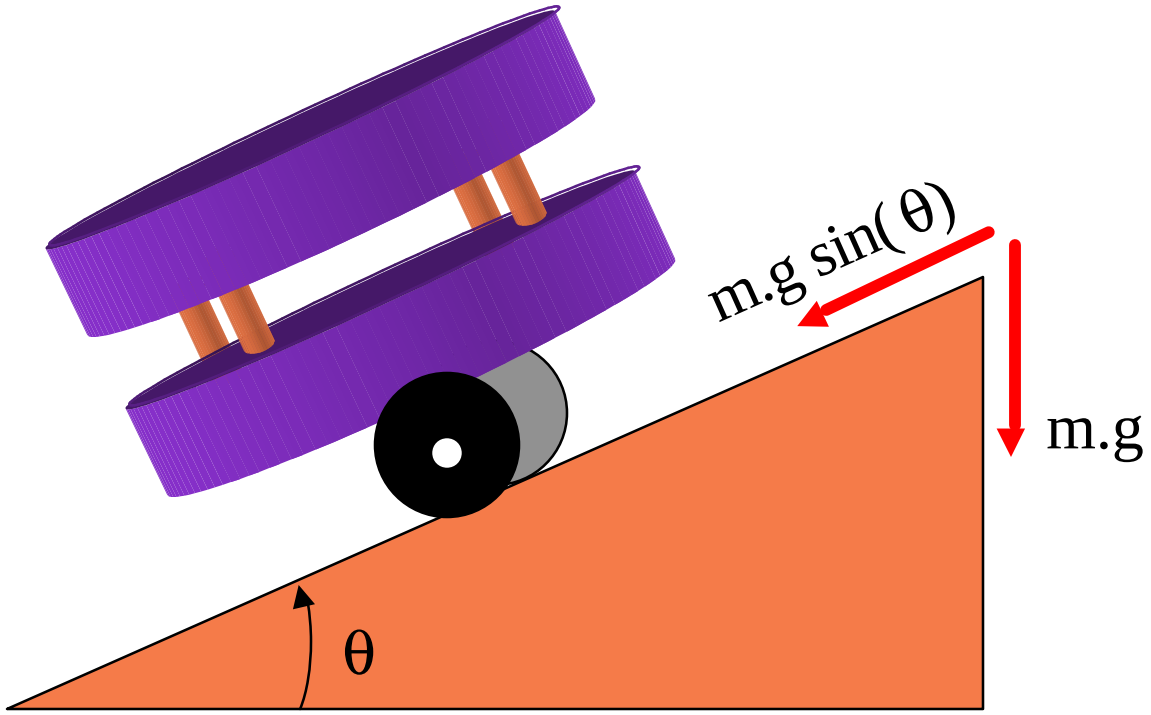
Motors

- Four basic types are commonly used
  - DC stepper motors
    - » Expensive motors; Often employed to achieve accurate linear incremental positioning (*e.g.* hard drive head motors). Their motion is not continuous but in steps!!
  - Basic reversible permanent magnet DC motors
    - » Normally referred as "DC motors". These can be "cheap" (~10¢) and small and are found in many kids toys. Typically, offer high-speed (5,000 rpm) and low torque (1-5 oz.in).
  - DC gearhead motor
    - » This variant of the simple DC motor includes an integrated gear-reduction mechanism and often a built-in optical position encoder or tachometer winding.
  - DC servo motors
    - » High quality DC motor with built-in electronics to accomplish accurate closed-loop position (or speed) control. Typically, have "stops" built in to limit angular excursion of the motor shaft.
- Conclusion: DC gearhead motors are an excellent compromise.

“Sizing” the motors

- Need to determine motor power.



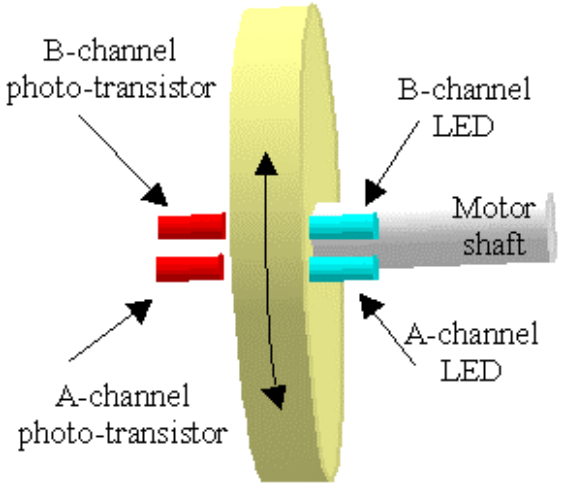
- Power = force * linear speed = torque * angular speed

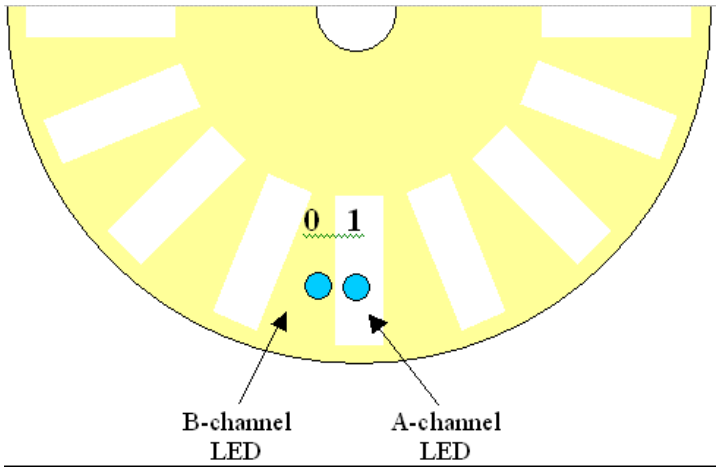
“Sizing” the motors

- Basic Specifications:
  - Maximum speed = 1 m/sec. (~3ft./sec.)
  - Wheel diameter = 0.0381 m (1.5 inches)
  - Maximum mass = 4 Kg
  - Maximum grade (slope) = 10°
- Requirements:
  - Power = Force x Speed = m g Sin(10°) x 1m/sec = 6.8Watts
  - Speed: 1 m/sec $\Leftrightarrow$ 60 / (3.14159 * 0.0381) $\cong$ 500 rpm
  - Torque = Force x distance
    = Mass x gravity x Sin(10°) x wheel radius
    = 4 x 9.81 x 0.1736 x (0.0381 ÷ 2) = 0.13 Nm (~18 oz in)
- Specs. for each motor (assuming 75% efficiency):
  - Max. Power: (6.8 ÷ 2) ÷ 0.75 = 4.5W
  - Max. Continuous Torque: (0.13 ÷ 2) ÷ 0.75 = 0.087Nm (~12oz in)
  - Speed (after gearbox): 500rpm

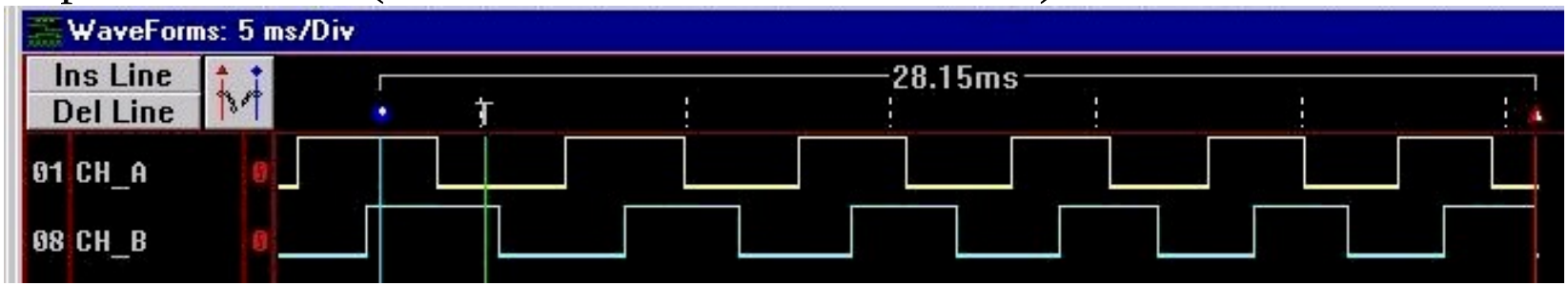
Encoders

- Optical Encoders:





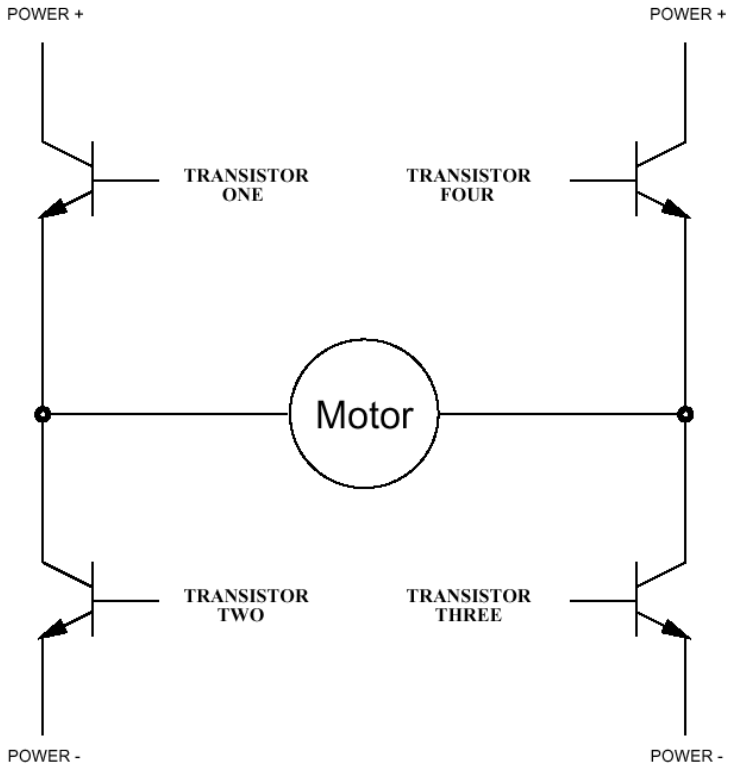
- Output Waveform (see EE231 Lab12 for more info.):



Motor Drivers

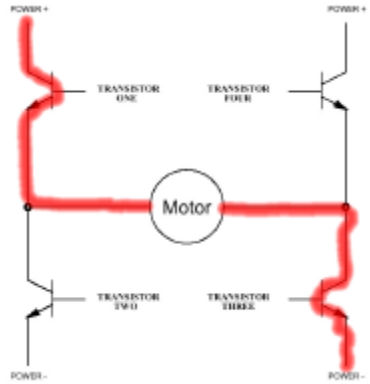
- Need for a Driver:
  - The typical digital output can supply 10-30mA while a small DC motor can draw 500-4,000 mA!! -> Need an amplifier!!

- The H-Bridge Circuit:

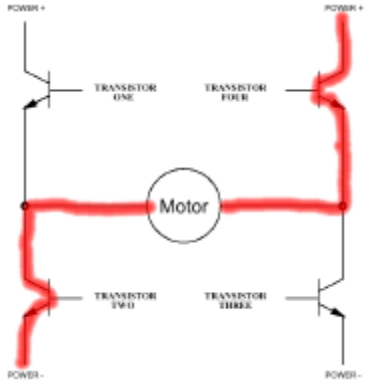


H-Bridge Modes of Operation:

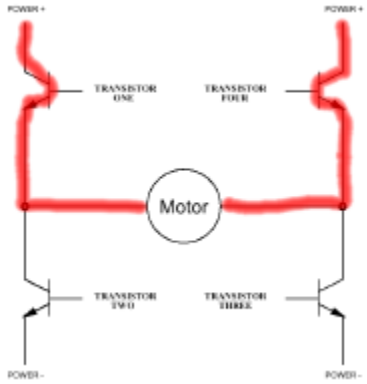
- Forward (1 & 3 ON):



Reverse (2 & 4 ON):

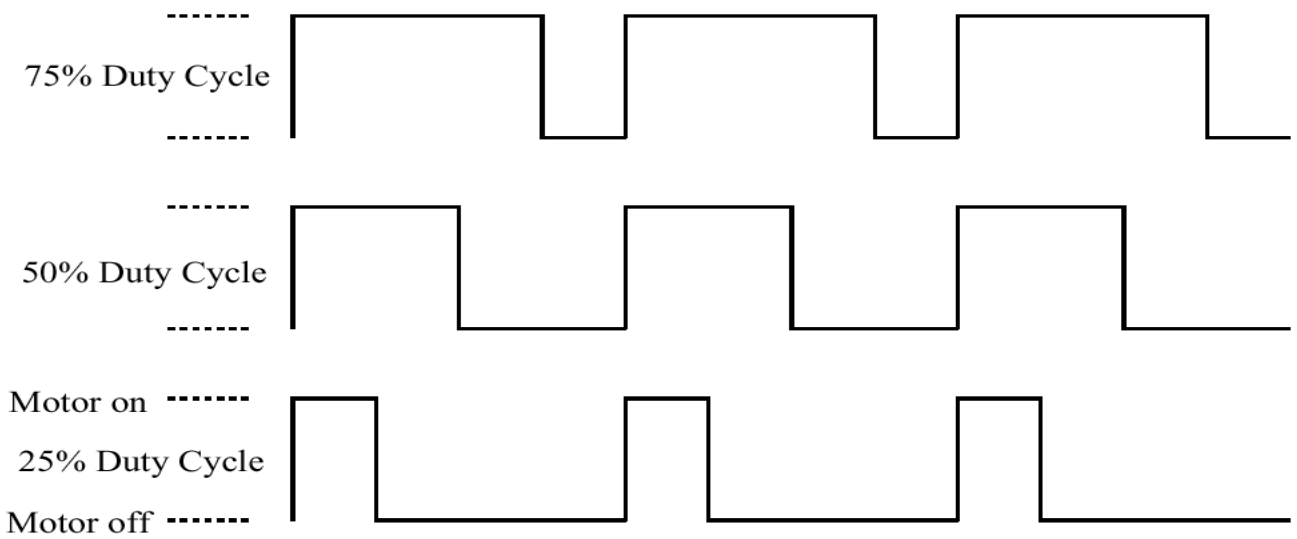


- Braking (1 & 4 ON):



Varying the Voltage Seen by the Motor

- How could we vary the voltage to the motor?
  - Vary the supply voltage ⇒ Difficult !!
  - Turn the motor on and off “very rapidly” ⇒ Pulse Width Modulation



  - Effective Voltage = Supply voltage * (time on / (time period))