Electric Motor Selection

Two basic decisions to make:

- What type of motor is needed?
  - DC motor?
  - Stepper motor?
  - AC motor?
- Once type of motor is selected, what size motor is required?

Type Selection - DC Motor

DC motors are typically used when

- low-cost, variable speed is advantageous
  - » but precise speed regulation not required
- starting torque required up to 5-10 times more than running torque
  - » brief overloads OK, since motor has time to cool
- frequent start/stop cycles, reversing, or closed-loop positioning required

See Parker-Compumotor notes for additional details

Type Selection - Stepper Motor

Stepper motors are typically used when

- low-cost, open-loop positioning required
  - » no feedback sensors required to monitor position if max torque not exceeded
  - » noncumulative nature of positioning errors gives good accuracy over long motions
- reasonably high torques at low speeds
  - » not able to handle large inertial loads due to low acceleration requirements
- energy efficiency not important

Type Selection - AC Motor

AC motors are typically used when

- low-cost, constant speed is advantageous
  - » gearing required to deliver speeds that are significantly less than 1200 RPM
- starting torque less than twice running torque
  - » brief periods of high running torque frequently handled by flywheels
- available access to AC power

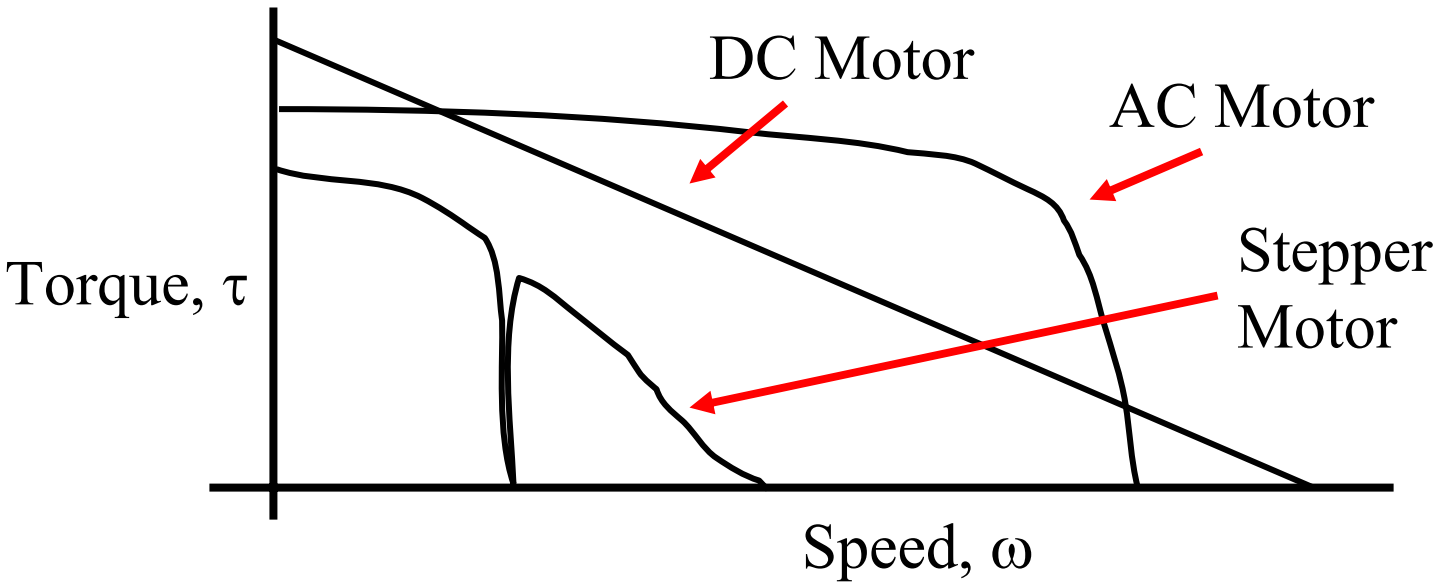
Motor Sizing #1

- The major constraint on all motor operation is thermal in nature.

- The heat a DC motor must dissipate can be calculated:

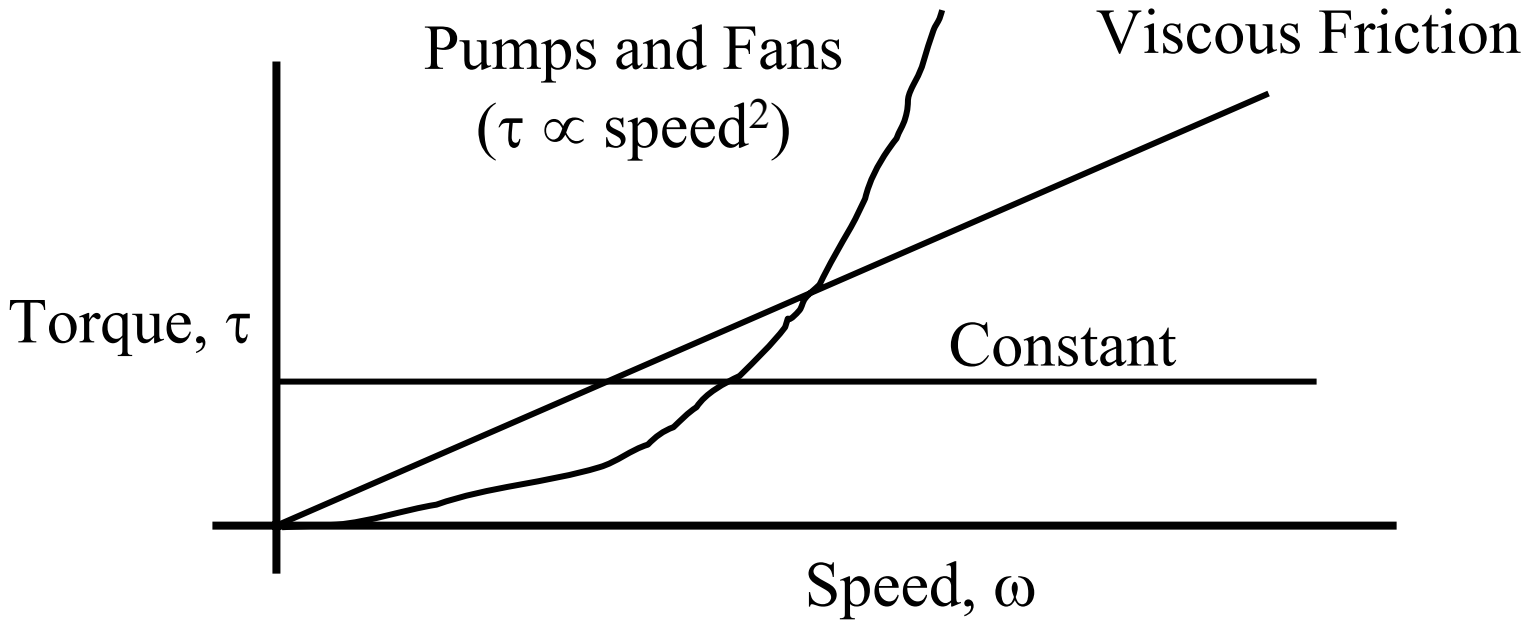
Motor Sizing #2

- Each specific electric motor will have its own characteristic torque-speed “curve”



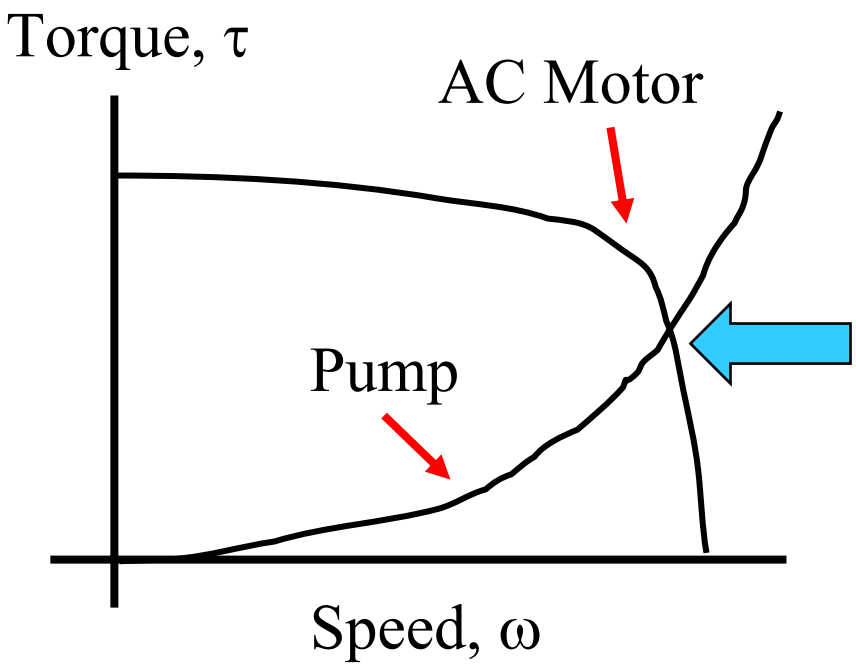
Motor Sizing #3

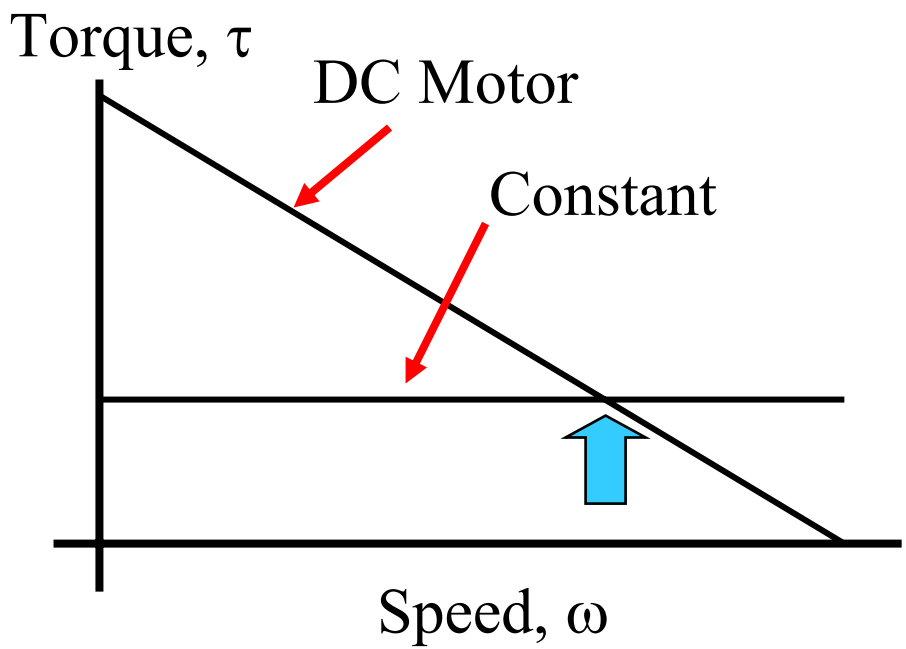
- Each type of load will have its own torque-speed requirements



Motor Sizing #4

- Operating point occurs at intersection of motor and load speed/torque “curves”



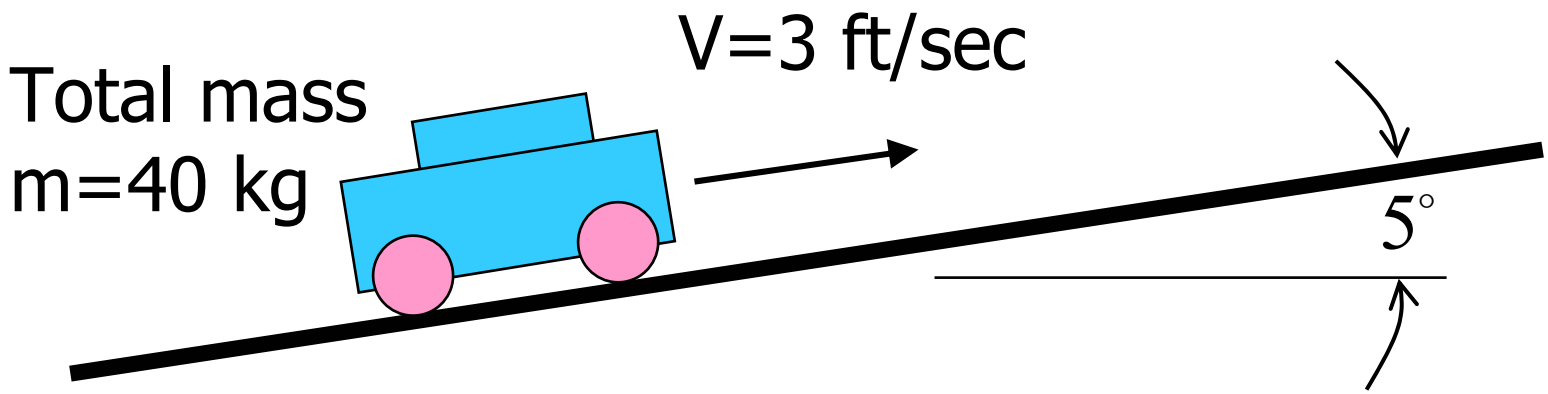


DC Motor Ratings

- DC motors are “rated” at a single speed and torque
- In most cases, the motor can operate at this point continuously
  - temperature rating will not be exceeded
  - DC motors rated with form factor of 1
- DC motors are “typically” used at
  - about 90% of rated speed
  - abour 10 to 40% of rated torque

DC Motor Selection Example

- A 12 volt battery-powered DC motor is used on a child's toy "Jeep"
- What power (in watts and hp) is required for this application? *Hint – ignore acceleration*



AC Motor Ratings

- AC motors are also “rated” at a single speed and horsepower
  - 3450, 1725, 1140, 850 RPM are common
- AC motor can operate here continuously
  - temperature rating will not be exceeded
- AC motors are “typically” used at
  - about 90% of rated torque/power
  - much lower efficiency if motor is too large (“over-rated”)

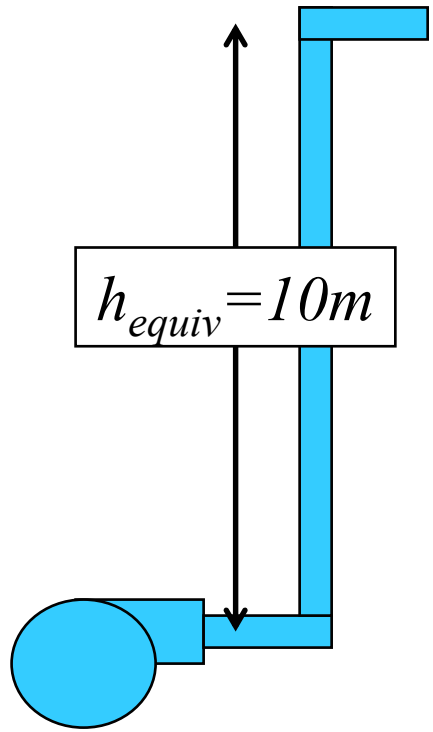
AC Motor Selection Example

- An AC motor drives a pump with an efficiency of η=0.75
- Fluid specific gravity, flow rate, and motor power are

$$\gamma = 9810\frac{N}{m^3} \quad Q = 200\frac{m^3}{hr}$$

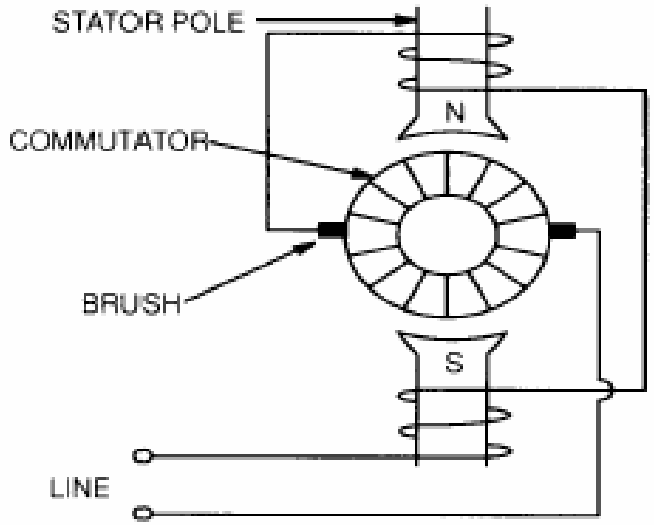
$$MotorPower = \frac{\gamma Q h_{equiv}}{\eta}$$

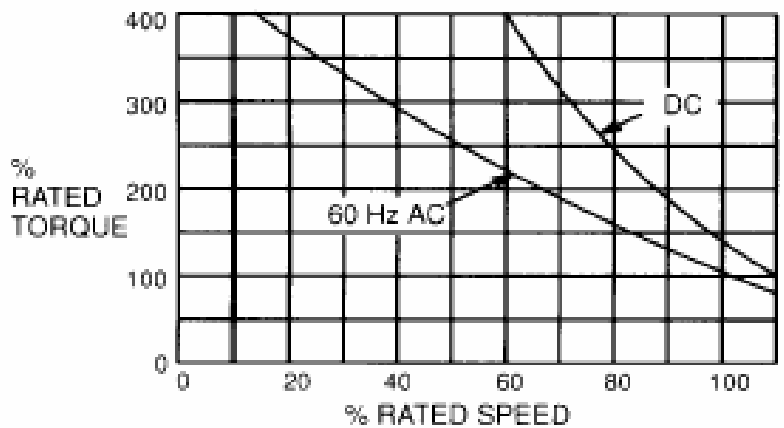
- What motor power is required (kW and hp)?
- Which motor would you select?



Universal Motor

- Very high starting torque.
- Higher torque on DC than AC (battery operated tools)
- The higher the rpm, the lower the torque.





http://baen.tamu.edu/users/stark/AGSM325_files/Lecture/6%20Motor%20Basics%20Lecture.325.pdf

Universal Motor (cont.)

- The universal motor operates with nearly equivalent performance on direct current or alternating current up to 60 Hz. It differs from a dc series motor because of winding ratios and thinner iron laminations. A dc series motor runs on ac, but with poor efficiency. A universal motor can operate on dc with essentially equivalent ac performance, but with poorer commutation and brush life than for an equivalent dc series motor.
- An important characteristic of a universal motor is that it has the highest horsepower-per-pound ratio of any ac motor because it can operate at speeds many times higher than that of any other 60-Hz motor.
- When operated without load, a universal motor tends to run away, speed being limited only by windage, friction, and commutation. Therefore, large universal motors are nearly always connected directly to a load to limit speed. On portable tools such as electric saws, the load imposed by the gears, bearings, and cooling fan is sufficient to hold the no-load speed down to a safe value.
- With a universal motor, speed control is simple, since motor speed is sensitive to both voltage and flux changes. With a rheostat or adjustable autotransformer, motor speed can be readily varied from top speed to zero.

http://www.machinedesign.com/BDE/Electrical/bdeee2/bdeee2_1.html

Brainstorming Scenario

- Your group has been hired to select motors for various applications and products
- Possibilities include:
  - DC motor (w/brushes)
  - Brushless DC motor
  - Stepper motor
  - Split phase AC motor
  - Permanent Split Capacitor (PSC) AC motor
  - Shaded pole AC motor
  - Universal motor

Question

- Match one of the 7 different types of motors to these applications & justify your selection:
  - "low cost" educational robot
  - electric knife for carving turkey
  - constant speed conveyor belt with frequent start/stops
  - power window drive in auto
  - fan in indoor HVAC unit
  - industrial robot used in painting applications