EELE 250: Circuits, Devices, and Motors

Electric Motors

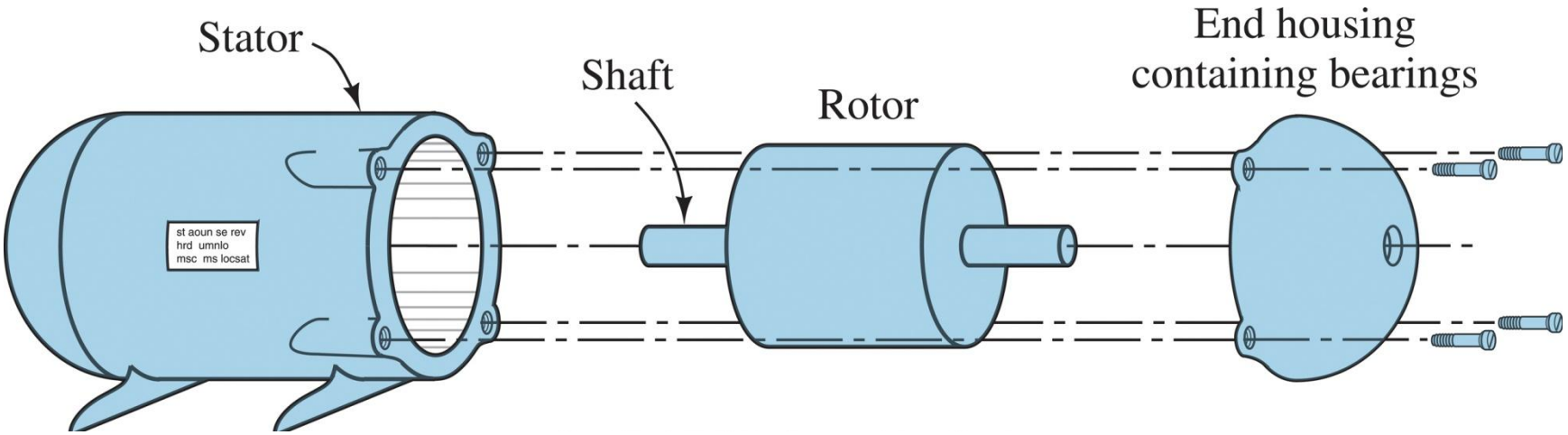
Assignment Reminder

- Read 16.1 - 16.3
- No quiz this week.
- Practice problems assigned soon.
- Work on Lab #9 this week. This is the last lab!

Motor Principles

- Electric current in a magnetic field produces a force
- Magnetic field may be from a permanent magnet or from an electromagnet
- Conductor loops are used to increase effective length of current in the magnetic field
- Motors may run on AC or DC
- Various electric motor designs are possible

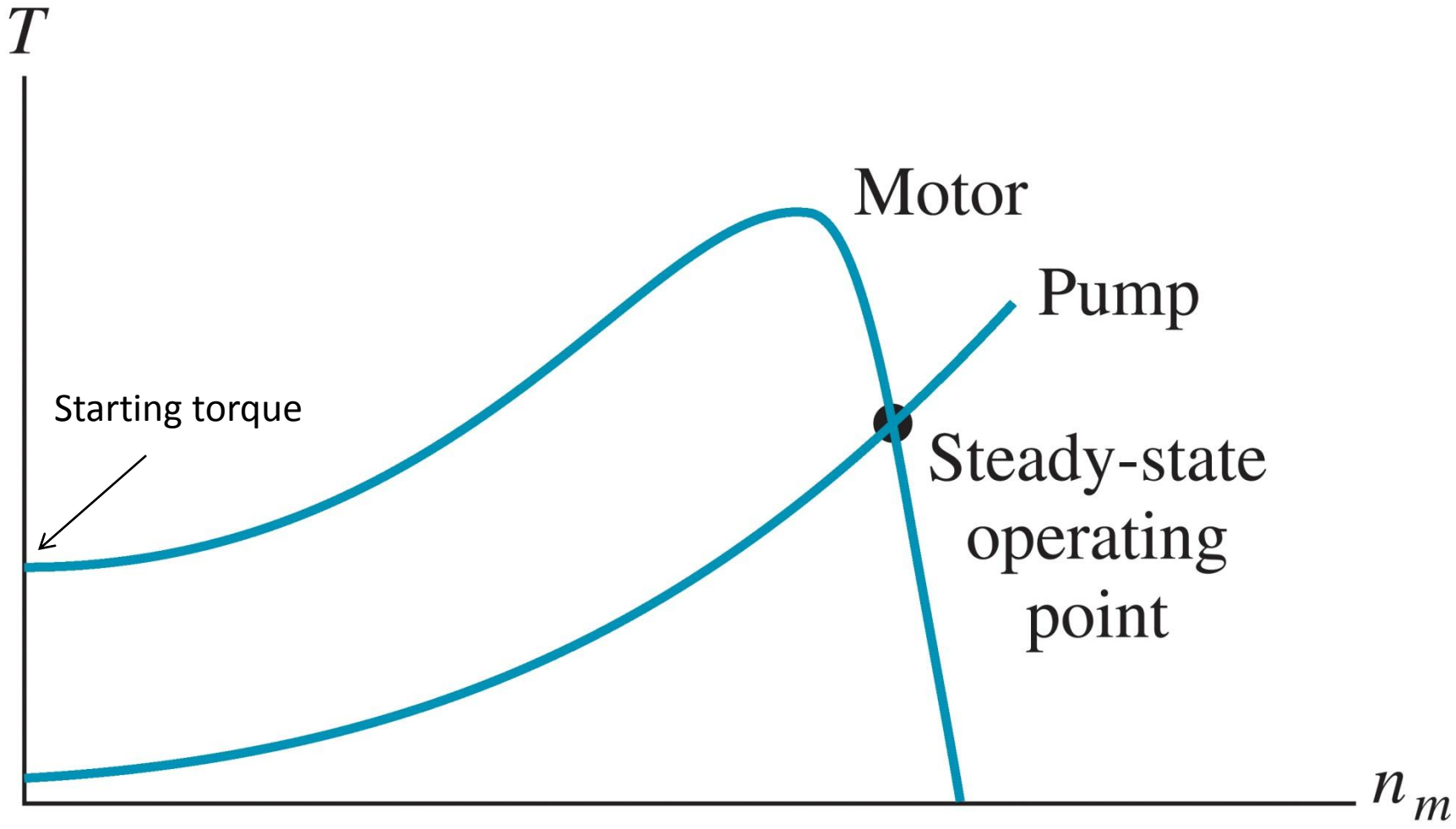
Electrical Motors



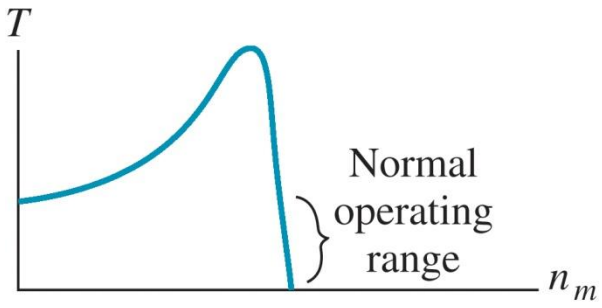
Torque

- Most useful electric motors produce rotational force: they “twist” a shaft
- Torque is the tendency of a force to rotate an object about an axis
- Newton-meter is the SI unit of torque
- For a shaft, the torque is the product of the tangential force and the radial lever arm length: $T = F \times r$

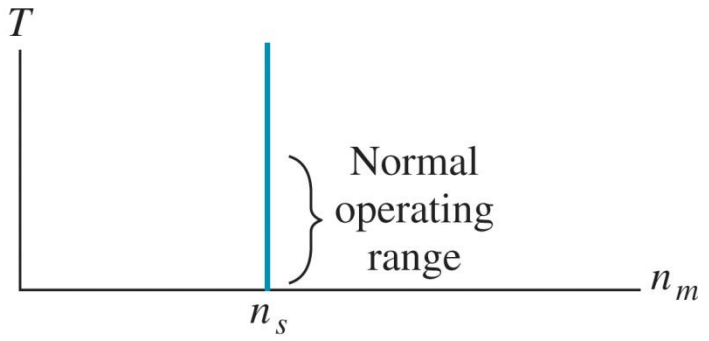
Torque typically depends upon rotation rate



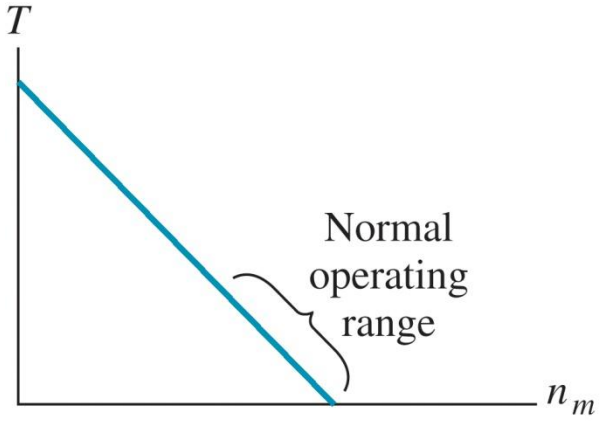
Torque vs. speed for several motor types



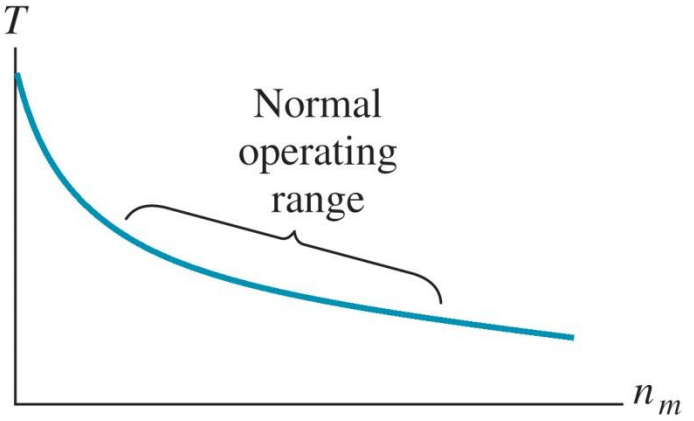
(a) Ac induction motor



(b) Synchronous motor



(c) Shunt-connected or permanent-magnet dc motor



(d) Series-connected dc motor or universal motor

Motor Properties

- Power input, 3-phase: $\sqrt{3}\ V_{rms} I_{rms} \cos(\theta)$ [watts]
- Rotation rate: ω_m [rad/sec] = $2\pi n_m/60$
- Power output: $T_{out}\ \omega_m$ [watts]
- (1 horsepower = 746 watts)
- Efficiency = (P_{out}/P_{in}) x 100%
- Speed regulation: $(n_{no\text{-}load} - n_{full\text{-}load})/n_{full\text{-}load}$

Example

- 3-phase AC induction motor rated 5-hp, attached to 440 V_{rms} line source.
- When at rated full-load condition, current is 6.8 A rms, power factor is 78% (lagging), and speed is 1150 rpm.
- With no load, current becomes 1.2 A rms, power factor 30% (lagging), and speed is 1195 rpm
- Find efficiency, power loss at full load, input power with no load, and the speed regulation

Example (cont.)

- 5-hp = 5 x 746 W = 3.73 kW
- Pin = $\sqrt{3}\, V_{rms} I_{rms} \cos(\theta) = \sqrt{3} \cdot 440 \cdot 6.8 \cdot 0.78$ = 4.042 kW
- Ploss = Pin – Pout = 4.042 kW – 3.73 kW = 312 W
- Full-load efficiency = (3.73 kW)/(4.042 kW) = 92.3 %
- Speed regulation = (1195-1150)/1150 = 3.9%