ECE 215 Spring 2025

Objective 1.5: Power and Efficiency

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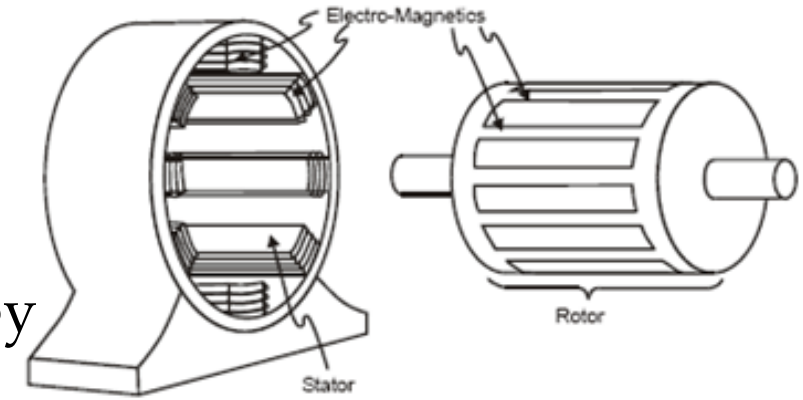
I can calculate the efficiency of a system modeled as an electrical circuit.

Motors

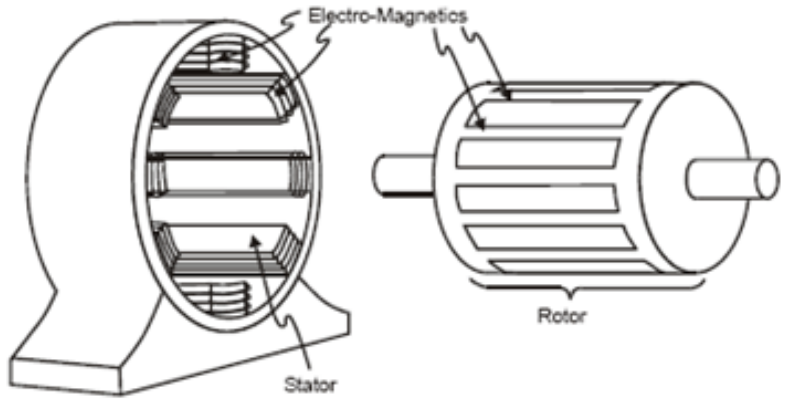
Motor: a device that converts electrical energy into mechanical energy

- Electric current induced by a voltage source (electrical energy) generates magnetic field around current
- Motors use electromagnets (created by current-carrying coils). The magnetic fields interact, causing forces to push or pull parts of the motor.
- By carefully arranging the components, these forces create a rotational force (mechanical energy) that spins the motor's rotor.



Motor Components

- **Source:** Provides the electrical energy to drive the motor.
- **Stator:** The stationary part consisting of electromagnets.
- **Rotor:** The internal spinning part that interacts with the magnetic field from the stator to generate torque and rotation
- **Shaft:** Rod that turns the electrical energy into mechanical energy by spinning the part (like a fan or driving a robot)



DC Motor Video

Motor Losses

- **Electrical:** Energy lost as heat due to the resistance in the motor's windings (rotor and stator)
- **Magnetic:** Energy lost in the motor's magnetic core materials due to the alternating magnetic field.
- **Mechanical:** Energy lost due to physical movement and friction within the motor.
- **Stray:** Miscellaneous energy losses caused by imperfections in the motor design and operation.
- *Energy lost means inefficiencies in the motor!*
- We can therefore compute the efficiency of a motor.

Efficiency

Definition

$$\eta = \frac{P}{P} * 100$$

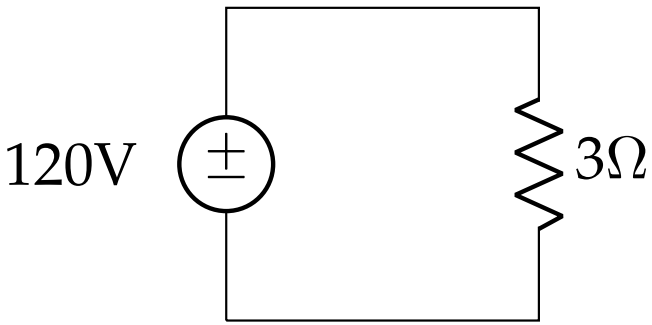
$\rightarrow$ For a motor, $P_{out} = P$ and $P_{in} = P$

Horsepower

Measure of mechanical output power where 1HP = 746W

EXAMPLE 1

You have a 5HP DC motor modeled as a 3Ω resistor connected to a $120V$ DC source. Find the efficiency of the motor.



EXAMPLE 2

Many AC electrical loads are AC motors. An AC motor may be characterized by its mechanical horsepower output, efficiency, and power factor. An induction motor rated for 5HP output and a 0.85 power factor lagging is connected to a $220V_{rms}$ bus and is delivering rated power at an efficiency of 89%. Find the current going into the motor.

Step 1: Find the mechanical power out.

Step 2: Find the real power into the motor using η.

EXAMPLE 2

Step 3: Find the motor's apparent power. Compare to real power.

Step 4: Find the motor's I_{rms}.