Chapter 10 Summary
Actuators

Lorentz's Force Law:
$$\vec{F} = \vec{I} \times \vec{B}$$

dc motor electrical equations:

back emf:
$$V_{\text{emf}} = k_e\omega$$

input voltage:
$$V_{\text{in}} = L\frac{dI_{\text{in}}}{dt} + RI_{\text{in}} + k_e\omega$$

permanent magnet motor dynamic equations:

torque:
$$T = k_t I_{\text{in}} = (J_a + J_L)\frac{d\omega}{dt} + T_f + T_L$$

input voltage:
$$V_{\text{in}} = RI_{\text{in}} + k_e\omega = \left(\frac{R}{k_t}\right)T + k_e\omega$$

$$T = \left(\frac{k_t}{R}\right)V_{\text{in}} - \left(\frac{k_e k_t}{R}\right)\omega$$

$$T(\omega) = T_s\left(1 - \frac{\omega}{\omega_{\max}}\right)$$

stall torque:
$$T_s = \left(\frac{k_t}{R}\right)V_{\text{in}}$$

no-load speed:
$$\omega_{\max} = \frac{T_s R}{k_e k_t}$$

power:
$$P(\omega) = T\omega = \omega T_s\left(1 - \frac{\omega}{\omega_{\max}}\right)$$

speed for maximum power:
$$\omega^* = \frac{1}{2}\omega_{\max}$$

stall current:
$$I_s = \frac{V_{\text{in}}}{R}$$

pulse width modulation (PWM):

period:
$$T = \frac{1}{f}$$

$$\text{duty cycle} = \frac{t}{T}100\%$$

unipolar step phase sequence

	Step	ϕ_1	ϕ_2	ϕ_3	ϕ_4
CW ↓	1	ON	OFF	ON	OFF
	1.5	ON	OFF	OFF	OFF
	2	ON	OFF	OFF	ON
	2.5	OFF	OFF	OFF	ON
CCW ↑	3	OFF	ON	OFF	ON
	3.5	OFF	ON	OFF	OFF
	4	OFF	ON	ON	OFF
	4.5	OFF	OFF	ON	OFF

<u>motor selection considerations:</u>

- Will the motor start and will it accelerate fast enough?

$$\alpha = (T_{\text{motor}} - T_{\text{load}})/J$$

- What is the maximum speed the motor can produce?
- What is the operating duty cycle?
- How much power does the load require?
- What is the load inertia?
- Is the load to be driven at constant speed?
- Is accurate position or speed control required?
- Is a transmission or gearbox required?

$$J_{\text{eff}} = J_{\text{load}}\left(\frac{\omega_{\text{load}}}{\omega_{\text{motor}}}\right)^2$$

- Is the motor torque-speed curve well matched to the load?
- For a given motor torque-speed curve and load line, what will the operating speed be?
- Is it necessary to reverse the motor?
- Are there any size and weight restrictions?