

**focus on quizzes (nomenclature) and written homeworks (technical)**

**Actuators** : Chapter 2

1. muscle - actin/myosin interaction (Huxley model)
2. DC motors - Lorentz force, Faraday's law (back emf), DC motor curves
3. gearheads

Exercises:

- muscle capacity
- DC motor torque/speed - curves (2 questions)
- gearhead

**Control Theory** : Chapter 3 and Appendix

1. spinal processing,  $\alpha$ - $\gamma$  motor neurons, motor units, the stretch reflex, negative feedback
2. Spring-Mass-Damper, harmonic oscillators
3. Stability - energy-based method
  - (a) Lyapunov's Direct Method

$$V(0, t) = 0, V(x, t) > 0, \partial V / \partial t \leq 0$$

- (b) stable and asymptotically stable
4. Frequency domain analysis - Laplace transform, characteristic equation, solving for time-domain response,
  5. Stability - complex frequency domain
    - (a) root locus,
    - (b) stable and asymptotically stable
  6. PD control - 2<sup>nd</sup> order dynamic response, roots of the characteristic equations, over-, under-, and critically-damped response, phase/amplitude response, bandwidth

Exercises:

- SMD - characteristic equation, natural frequency, damping ratio, boundary conditions & time domain response
- tuning K, B for natural frequency
- analyzing the characteristic equation - natural frequency, damping ratio, bandwidth
- CLTF - stability
- stability - time- and complex frequency domain analysis
- (non-linear) pendulum - Lyapunov, phase portrait

## Kinematics : Chapter 4 and Appendix

1. Terminology - links, joints, kinematic chain, mechanism, closed- and open-chain, degrees of freedom, configuration space, revolute, prismatic
2. spatial tasks, coordinate frames, holonomic and nonholonomic
3. homogeneous transforms (deriving, interpreting, composing, inverting)
4. forward kinematics  $\theta \xrightarrow{FK} \mathbf{x}$ ,
5. inverse kinematics  $\mathbf{x} \xrightarrow{IK} \theta$ , workspace constraints, dextrous workspace, reachability
6. imaging kinematics - pinhole camera model, perspective distortion,
7. stereo kinematics - disparity, spatial reconstruction
8. hand-eye coordination
9. Jacobian (velocity and force relations),
10. kinematic conditioning - manipulator velocity ellipsoid, stereo localizability ellipsoid

### Exercises:

- inverting homogeneous transforms
- structure in the HT
- spatial algebra and the HT (2 problems)
- planar 2P Mechanism - FK, workspace (reachable, dexterous), Jacobian
- planar 2R Mechanism - FK (HT), Jacobian,  $\dot{\theta} = J^{-1} \dot{\mathbf{x}}$ ,  $\boldsymbol{\tau} = J^T \mathbf{f}$ , velocity ellipsoid
- pinhole camera projective geometry