1. Problem 2.1 from the book (page 19).

2. Problem 2.2 from the book (page 20).

3. Consider the unforced mass-spring system

\[ m \ddot{y} + g(y) = 0 \]

with three different models for the spring force

- **hardening spring**: \( g(y) = k \left(1 + y^2\right) y \);
- **softening spring**: \( g(y) = k \left(1 - y^2\right) y \);
- **linear spring**: \( g(y) = k y \),

and \( k > 0 \).

(a) Determine a state-space representation of this system.

(b) Find equilibrium points of the above systems. Discuss your observations for three different spring force models.

(c) Is this system

- causal,
- time-varying,
- linear,
- memoryless,
- finite-dimensional?

Explain.

(d) For three different spring force models with \( m = k = 1 \), use Matlab to simulate systems’ responses from different initial conditions. Plot corresponding results in the phase plane (horizontal axis determined by position \( y(t) \), vertical axis determined by velocity \( \dot{y}(t) \)) and discuss your observations.