

# Feedback control of manipulators

## Equations of motion

Euler-Lagrange

$$\frac{d}{dt} \left( \frac{\partial \mathcal{L}}{\partial \dot{q}_j} \right) - \frac{\partial \mathcal{L}}{\partial q_j} = Q_j$$

Manipulator

$$\underline{M(q) \ddot{q} + C(q, \dot{q}) \dot{q} + G(q) = \tau}$$

$M(q)$  - mass matrix

$C(q, \dot{q}) \dot{q}$  - Coriolis acceleration

$G(q)$  - gravitational acceleration

$\tau$  - external torque

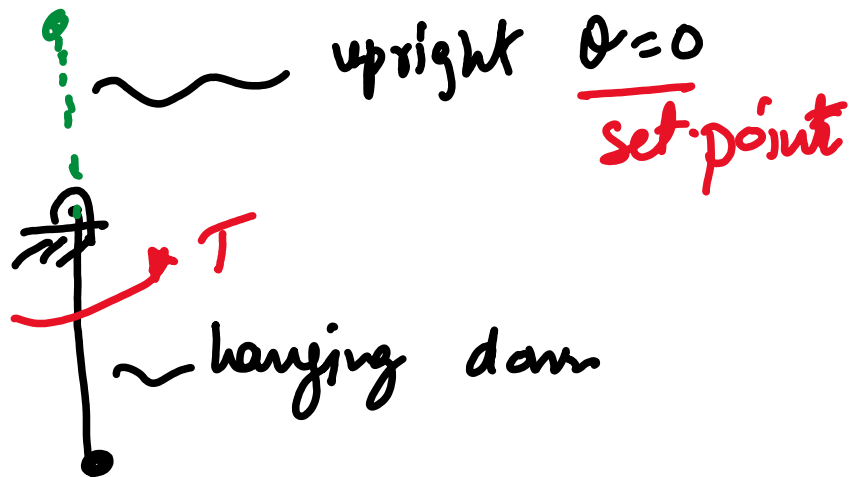
$$* \quad A \ddot{q} = b$$

$$M(q) \ddot{q} = (\tau - C(q, \dot{q}) \dot{q} - G(q))$$

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# Two objectives of control

## ① Set-point control



## ② Trajectory tracking control

