ME 327: Design and Control of Haptic Systems
Spring 2020

Interactive Session 9:
Kinesthetic haptic devices: Dynamics and Control

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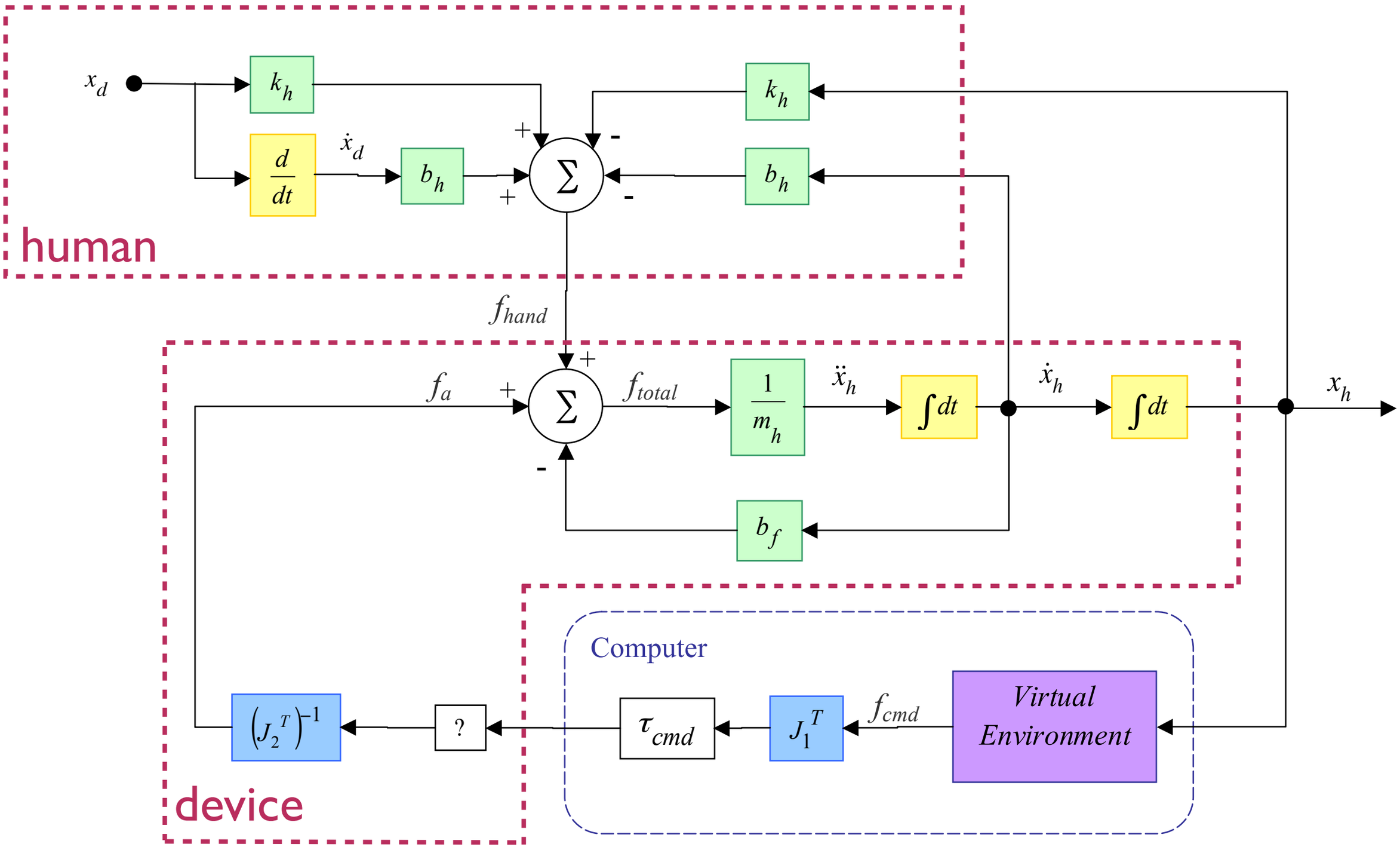
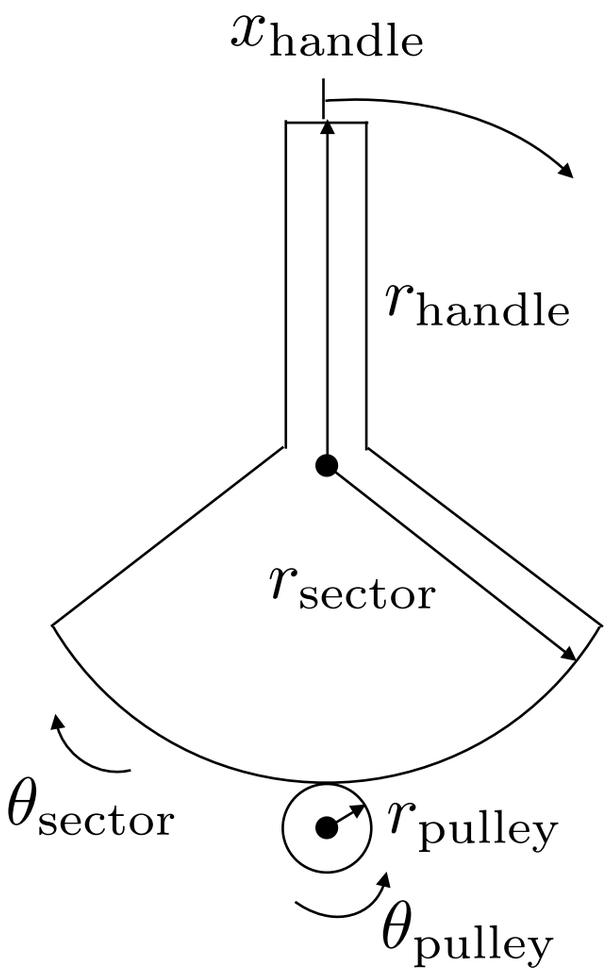
Questions from prerecorded video?

system block diagram



Hapkit Kinematics: Motions



$$r_{\text{pulley}}\theta_{\text{pulley}} = r_{\text{sector}}\theta_{\text{sector}}$$

$$x_{\text{handle}} = r_{\text{handle}}\theta_{\text{sector}}$$

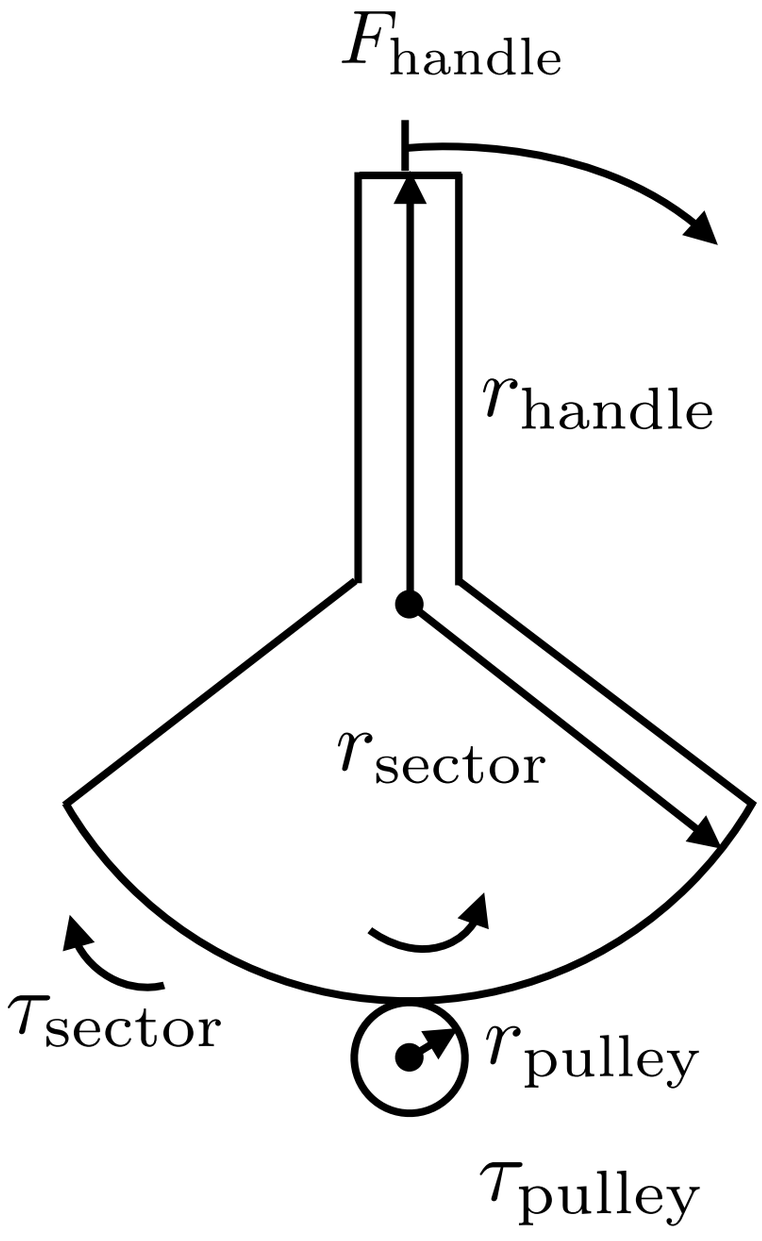
$$x_{\text{handle}} = \frac{r_{\text{handle}}r_{\text{pulley}}}{r_{\text{sector}}}\theta_{\text{pulley}}$$

$$\dot{x}_{\text{handle}} = \frac{r_{\text{handle}}r_{\text{pulley}}}{r_{\text{sector}}}\dot{\theta}_{\text{pulley}}$$

differential kinematics

$$\dot{x}_{\text{handle}} = J\dot{\theta}_{\text{pulley}} \qquad J = \frac{r_{\text{handle}}r_{\text{pulley}}}{r_{\text{sector}}}$$

Hapkit force/torque relationships



$$\frac{\tau_{\text{pulley}}}{r_{\text{pulley}}} = \frac{\tau_{\text{sector}}}{r_{\text{sector}}}$$

$$F_{\text{handle}} = \frac{\tau_{\text{sector}}}{r_{\text{handle}}}$$

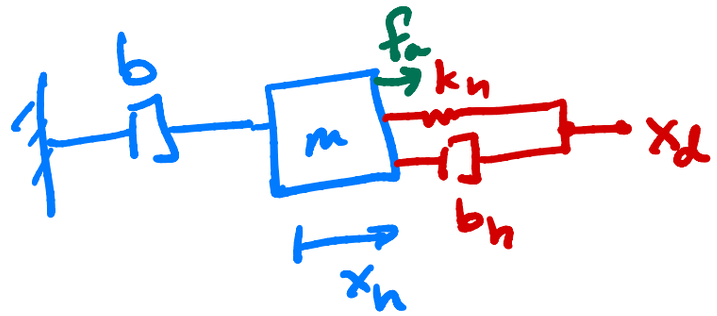
$$F_{\text{handle}} = \frac{r_{\text{sector}}}{r_{\text{handle}} r_{\text{pulley}}} \tau_{\text{pulley}}$$

$$F_{\text{handle}} = J^{-T} \tau_{\text{pulley}}$$

$$\tau_{\text{pulley}} = J^{T} F_{\text{handle}}$$

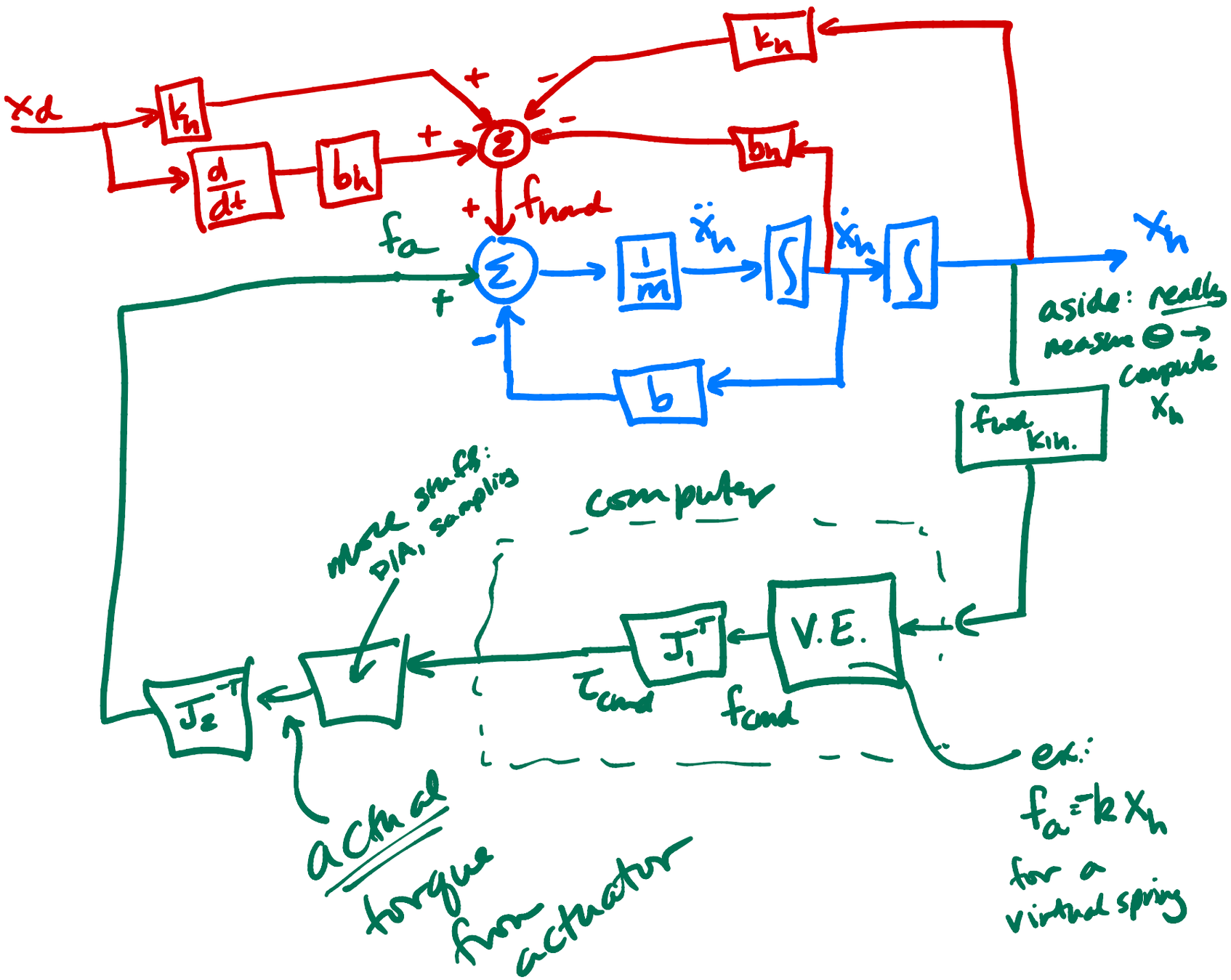
$$J = \frac{r_{\text{handle}} r_{\text{pulley}}}{r_{\text{sector}}}$$

transpose is irrelevant for a 1-dof system



(ex. $f_a = -k x_h$ from the actuator)

$$m\ddot{x}_h = -b\dot{x}_h + k_h(x_d - x_h) + b_h(\dot{x}_d - \dot{x}_h) + f_a$$



Reminders:

Assignment 4 due Thursday

Quiz will be discussed later — there are still a couple students who need to take it

Office Hours/Q&A with Allison until 10 am.
Question queue (see tab with today's date):
https://tinyurl.com/HapticsAllison

