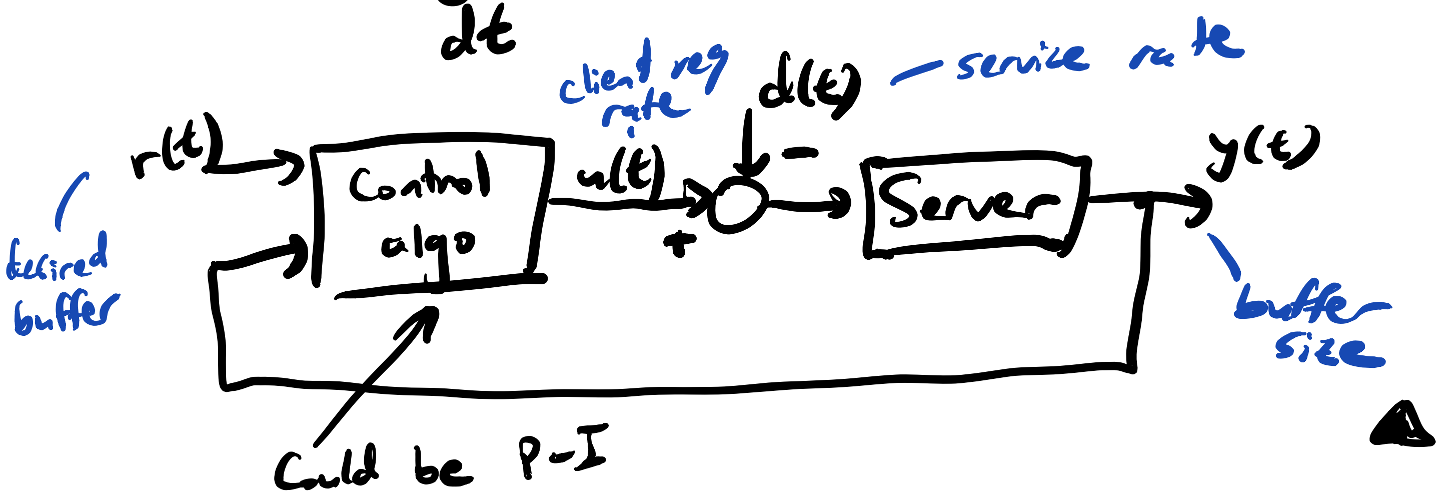
e.g. 1.4.1 cont'd

buf size $y(t)$

difficulty is that the server's service rate is unknown. Depends on many things, e.g. # of clients connecting. — we'll model it as an unknown disturbance $d(t)$.

- the control objective is to manage the client request rate $u(t)$ given $r(t)$ and $y(t)$.

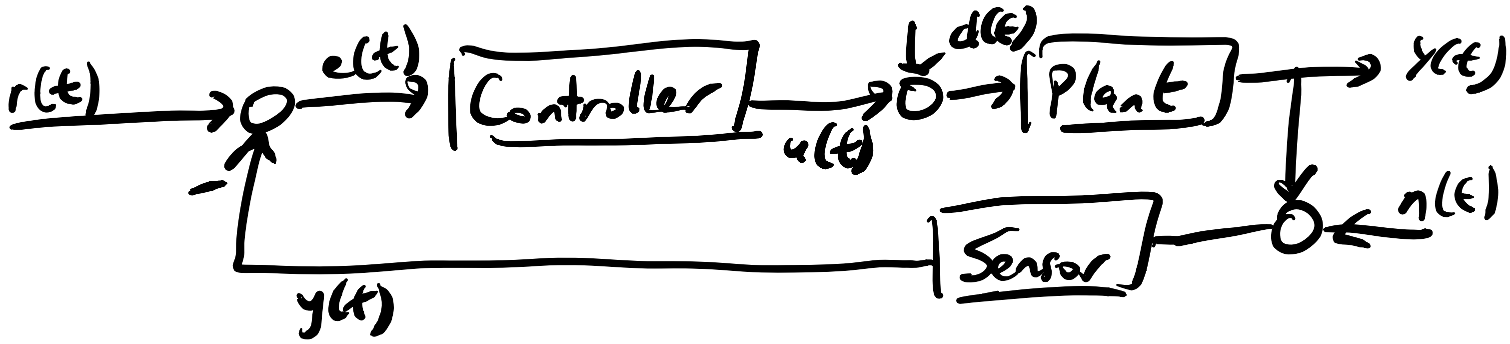
$$\frac{dy(t)}{dt} = u(t) - d(t)$$



Control engineering attempts to change the behaviour of a system (<u>plant</u>) in a useful way despite the presence of external influences (<u>disturbances</u>) and despite <u>model uncertainty</u>.

This is typically done by interconnecting the plant with another system (<u>controller</u>). Feedback is the most powerful interconnection architecture.

<u>Essential picture:</u> (Figure 1.9)



<u>Signals</u>

r(t) - reference command
y(t) - plant output
u(t) - controller output
d(t) - disturbance
n(t) - sensor noise

<u>Systems</u>

Plant, Controller, Sensor

<u>Control Cycle</u>

1. <u>Sense</u> operation of system
2. Compare against desired behaviour
3. <u>Compute</u> corrective actions informed by a model of the system's response to external stimuli
4. <u>Actuate</u> the system to effect the desired change

sense → compute → actuate
↑__________________________|

1.3. Design Cycle

1. Study the system to be controlled, decide on sensors and actuators. e.g. camera vs. LIDAR
2. Model the resulting system.
   - by model, we mean a mathematical model.
   - often one or more DEs e.g. follower

$$\frac{dx_f}{dt} = u$$

- obtained through analysis and/or experiments

3. Simplify model if necessary
   - classical control (most prevalent; this course)
   - require that we have linear, time-invariant plant → has a transfer function

   e.g. follower

$$s X_f(s) - \cancel{x_f(0)}^{0} = U(s)$$

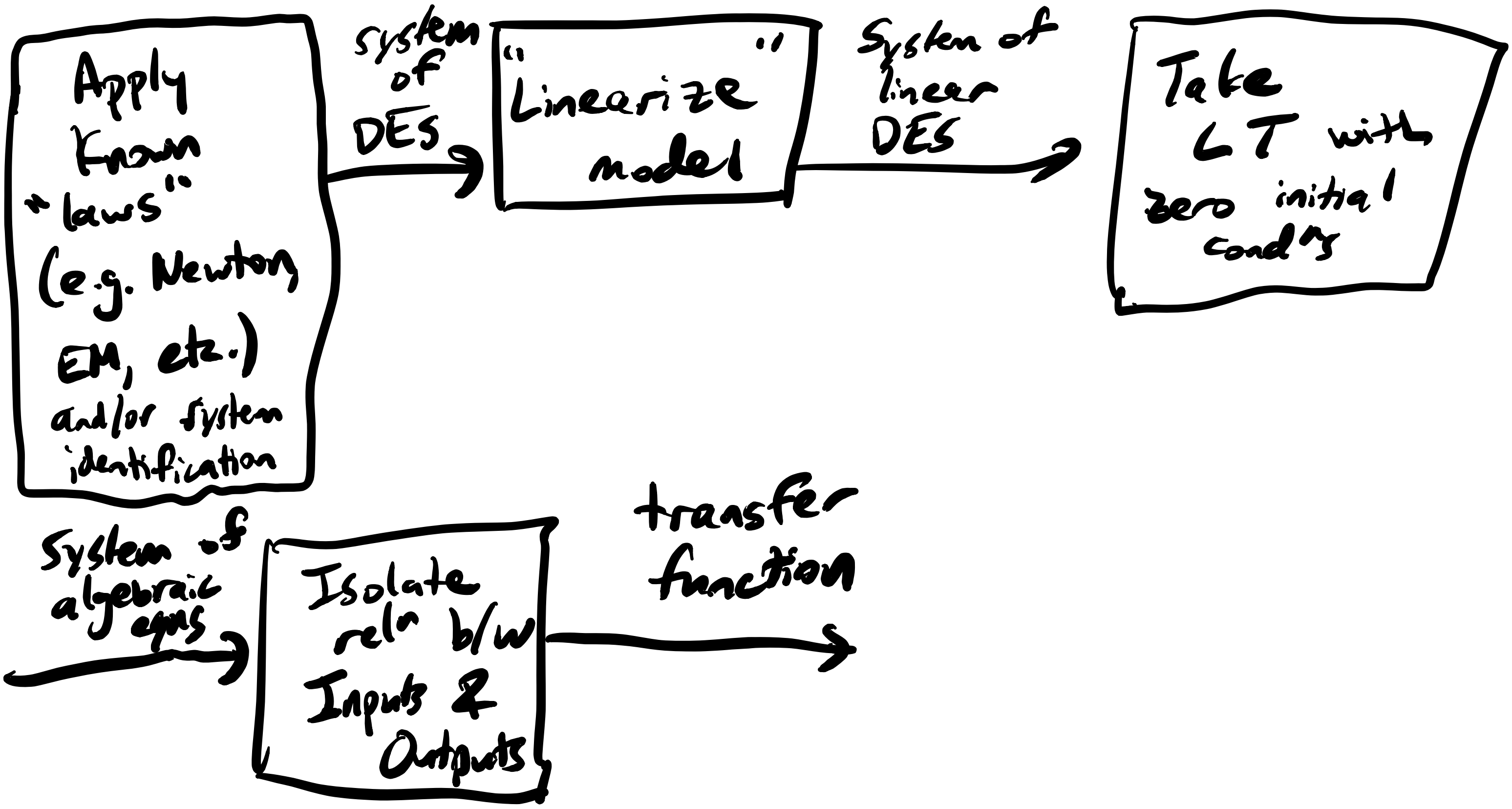
$$\frac{X_f(s)}{U(s)} = \frac{1}{s} \text{ is the TF}$$

4. Analyze resulting model
5. Determine design specifications
   - stability!
   - good steady-state behaviour
   - robustness to model uncertainty
   - good transient behaviour
6. Decide on the type of controller
   - in this course, the controller itself is a transfer function
7. Design the controller
8. Simulate the closed-loop system
   - usually MATLAB, also Octave, Scilab
9. Return to Step 1 if necessary.

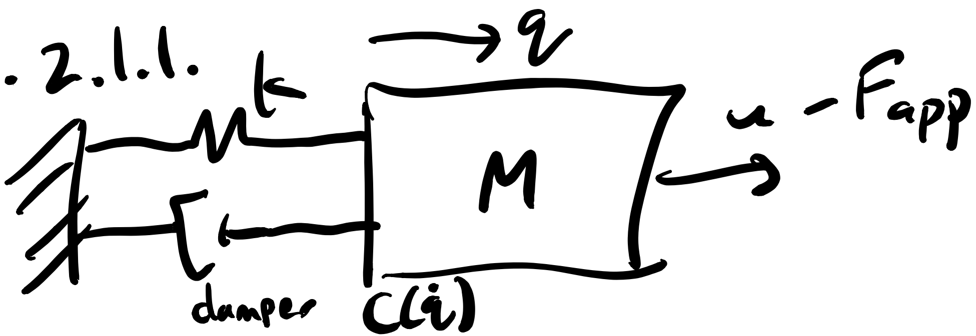
10. Implement on actual system

Ch 2: Mathematical Models of Systems

- For control design we need a "good" math. model of the plant
- good = simple but accurate
- no model is perfect
- complexity tradeoff (design → simple model vs. simulation → more complex)



e.g. 2.1.1.



$q \in \mathbb{R}$ is the position of mass

$\dot{q} = \frac{dq}{dt}$ $\ddot{q} = \frac{d^2q}{dt^2}$

Assume $q = 0$ when spring unstretched