ME242 – MECHANICAL ENGINEERING SYSTEMS

LECTURE 33:

- Over-casual and Under-casual Systems 5.1

OVER-CASUAL SYSTEMS

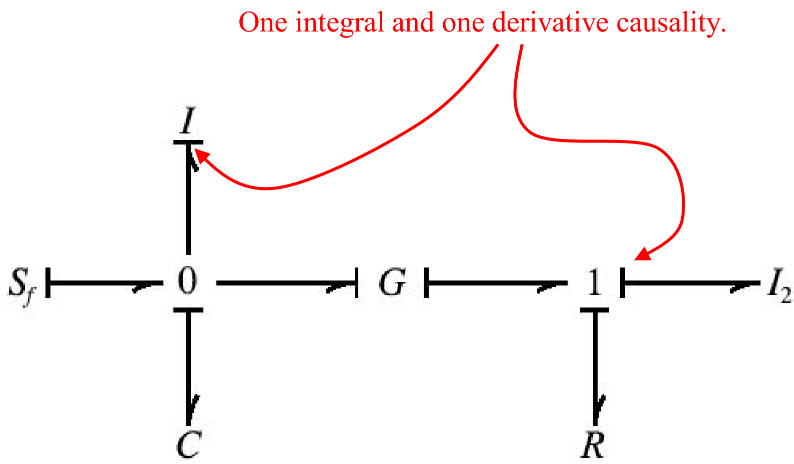
Fewer differential equations than energy storage elements.

Using bond graphs produces differential equations with derivatives on both sides of first order equations.

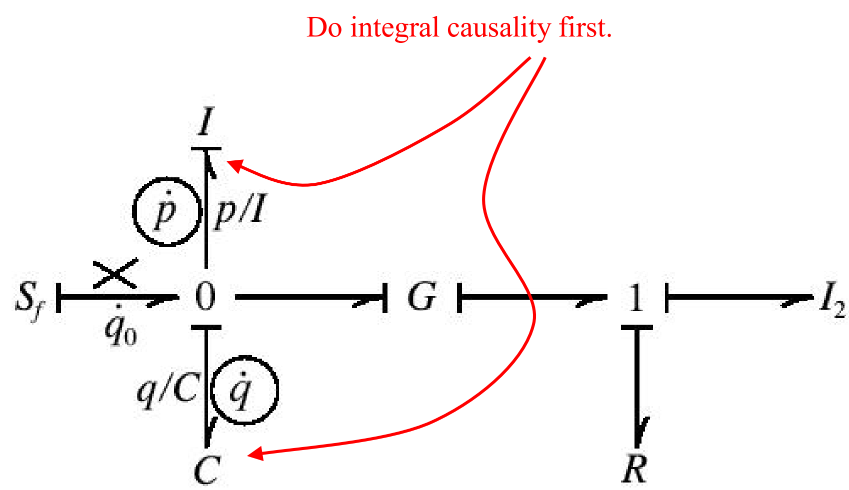
One additionial step required to get standard form.

OVER-CASUAL SYSTEMS

Case Study:



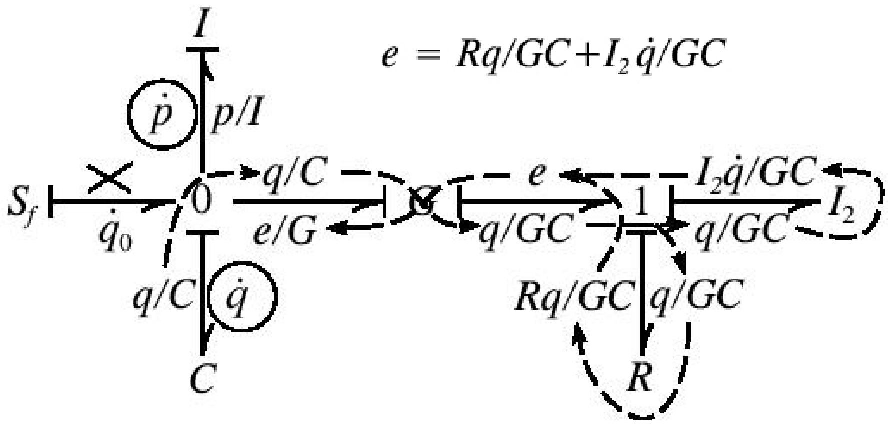
OVER-CASUAL SYSTEMS



Continue annotating like usual.

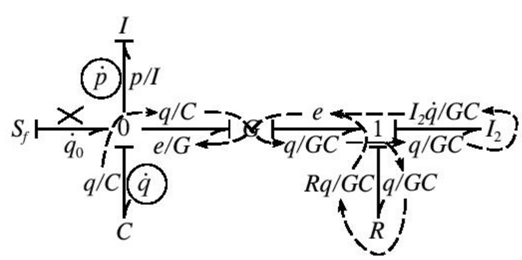
OVER-CASUAL SYSTEMS

$$e = Rq/GC + I_2 \dot{q}/GC$$



Next write state equations like usual.

OVER-CASUAL SYSTEMS



$$\frac{dp}{dt} = \frac{1}{C}q$$

$$\frac{dq}{dt} = \dot{q}_0 - \frac{1}{I}p - \frac{1}{G}e = \dot{q}_0 - \frac{1}{I}p - \frac{I_2}{G^2C}\frac{dq}{dt} - \frac{R}{G^2C}q$$

the derivative term appears on both sides of the equation

Now rewrite in standard form.

OVER-CASUAL SYSTEMS

$$\frac{dp}{dt} = \frac{1}{C}q$$
$$\frac{dq}{dt} = \dot{q}_0 - \frac{1}{I}p - \frac{1}{G}e = \dot{q}_0 - \frac{1}{I}p - \frac{I_2}{G^2C}\frac{dq}{dt} - \frac{R}{G^2C}q$$

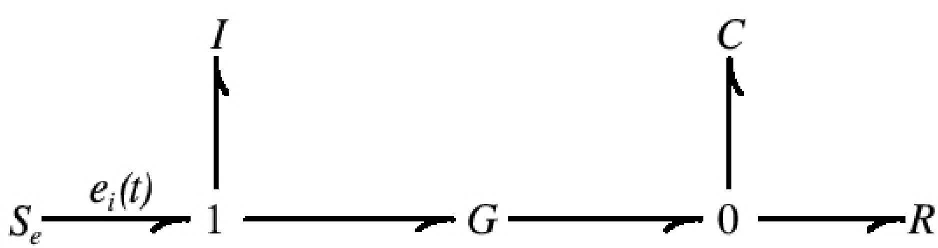
$$\Downarrow$$

$$\frac{dp}{dt} = \frac{1}{C}q$$
$$\left(1 + \frac{I_2}{G^2C}\right)\frac{dq}{dt} = \dot{q}_0 - \frac{1}{I}p - \frac{R}{G^2C}q$$

Need to divide by LHS coefficient for simulation.

OVER-CASUAL SYSTEMS

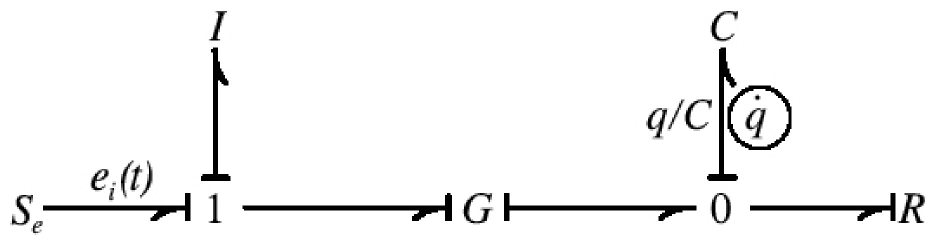
Example:



Is this over casual?

Which storage device do I set as integral causality?
(Either is o.k. --- it is your choice.)

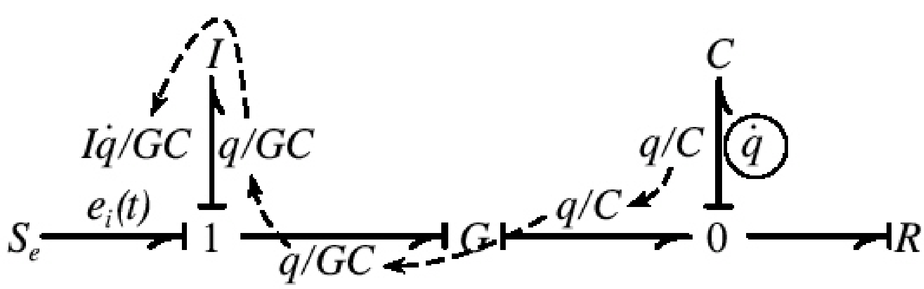
OVER-CASUAL SYSTEMS



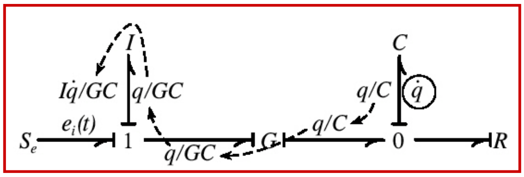
OK now what?

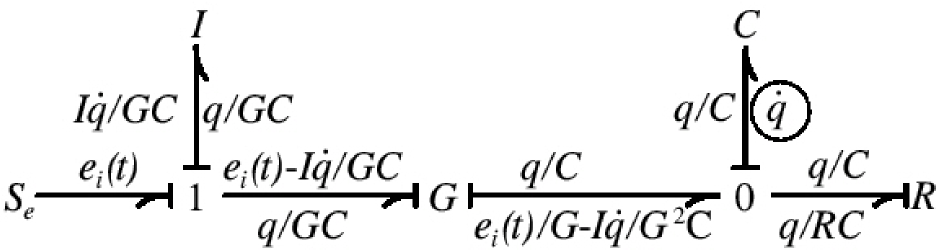
(Do the next steps then check back.)

OVER-CASUAL SYSTEMS



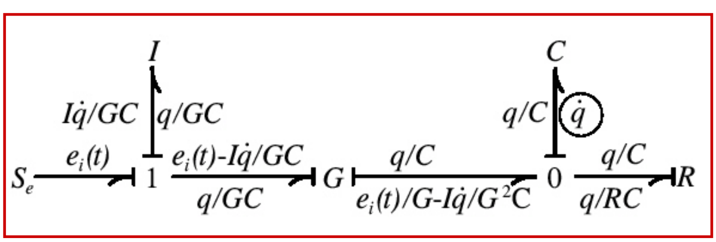
OVER-CASUAL SYSTEMS





Next write state equations like usual.

OVER-CASUAL SYSTEMS



$$\frac{dq}{dt} = \frac{1}{G}e_i(t) - \frac{I}{G^2C}\frac{dq}{dt} - \frac{1}{RC}q$$

Now rewrite in standard form.

OVER-CASUAL SYSTEMS

$$\frac{dq}{dt} = \frac{1}{G}e_i(t) - \frac{I}{G^2C}\frac{dq}{dt} - \frac{1}{RC}q$$

$$\Downarrow$$

$$\left(1 + \frac{I}{G^2C}\right)\frac{dq}{dt} = \frac{1}{g}e_i(t) - \frac{1}{RC}q$$

Need to divide by LHS coefficient for simulation.