(b) Let us now consider the effect of friction in the rotation point. This can be modelled as a rotation damping, causing a torque equals:

$$T_D = -c_D \cdot \dot{\theta}(t)$$

Determine the new differential equation and draw the corresponding block diagram:

$\sum T = T_g + T_D = I \cdot \ddot{\theta}(t)$ / $ml^2\ddot{\theta}(t) = -c_D \cdot \dot{\theta}(t) - mgl\,\theta(t)$

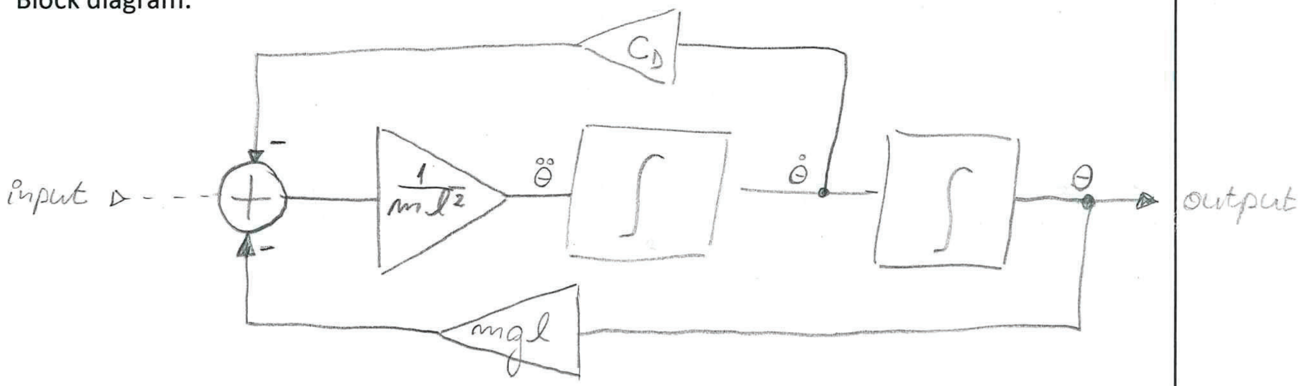
Differential equation:

$$ml^2\ddot{\theta}(t) + c_D \cdot \dot{\theta}(t) + mgl\,\theta(t) = 0$$

Isolate highest derivate:

$$\ddot{\theta}(t) = \frac{1}{ml^2} \cdot \left[-c_D \cdot \dot{\theta}(t) - mgl \cdot \theta(t)\right]$$

Block diagram:



(c) Let us now build and simulate this block diagram in Matlab using Simulink. Open the script ***runSimulink _single_pendulum.m*** which initialize parameters and open the Simulink model ***single_pendulum.slx*** , and work through the following steps:

- Complete the Simulink model according to the equation calculated above (with attenuation). Use the parameters defined in the Matlab file to describe the gain values;
- Insert the initial condition ***thetaA_0*** in the corresponding integrator box;
- Check the logging parameters of the scope block (to import data in Matlab workspace);
- Check the set up in menu >Simulation >Model Configuration Parameters;
- Then carry on the simulation and visualize the results.