# ESE 617/MEAM 613: Nonlinear Systems & Control (Fall 2019)
## Homework #8

Due on 11/11/2019, 9 a.m., in class

1. (5 points) Show that the system
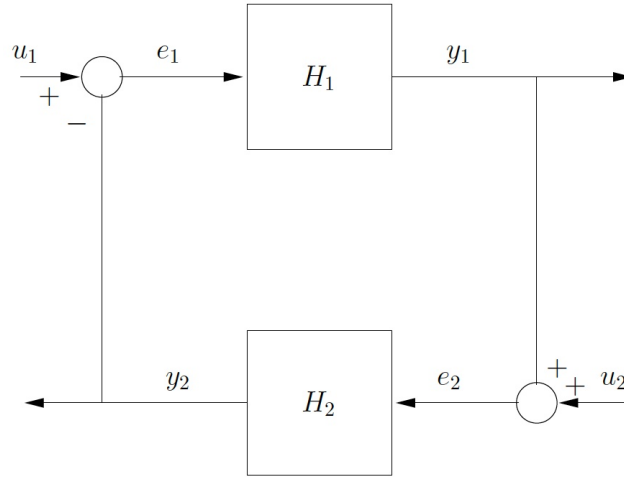
$$a\dot{x} = -x + \frac{1}{k}h(x) + u$$
$$y = h(x)$$

   is passive, where $a, k > 0$ and $h$ belongs to sector $[0, k]$.

   *Hint:* Use the storage function $V(x) = a \int_0^x h(\xi)d\xi$.

2. Consider the following feedback system:



$$H_1 : \begin{cases} \dot{x}_1 = x_2 \\ \dot{x}_2 = -x_1 - h_1(x_2) + e_1 \\ y_1 = x_2 \end{cases} \qquad H_2 : \begin{cases} \dot{x}_3 = -x_3 + e_2 \\ y_2 = h_2(x_3) \end{cases}$$

   where $h_1$ and $h_2$ are locally Lipschitz functions belonging to sector $(0, \infty]$. Further

$$|h_2(z)| \geq \frac{|z|}{1 + z^2}, \qquad \forall z \in \mathbb{R}.$$

   2.1 Show that the feedback interconnection is passive (5 points)

   2.2 Show that the unforced system has a globally asymptotically stable equilibrium at the origin (5 points).