# Foundations of CPS
# Tutorial - Hybrid Automata

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1. Hot-Air Balloons: Some interesting facts...

Modern hot air balloons, with an onboard heat source, were developed by Ed Yost. Hot air balloons are able to fly to extremely high altitudes. The burner unit gasifies liquid propane, mixes it with air, ignites the mixture, and directs the flame and exhaust into the mouth of the envelope.

Draw a Hybrid Automata model for the Hot-air balloon described below.

The Hot-air balloon has a gas tank that when full, has a volume of 10 units. When the burner is burning the gas, the hot air balloon rises at a rate of $\frac{t^2}{2}$, where $t$ is the amount of time for which the burner has been continuously on. When the burner is off, the hot-air balloon rises at a rate of $-t^2$, $t$ being the amount of time for which the burner has been off.

When the hot-air-balloon runs out of fuel, the fuel tank may be re-placed. Re-placing the fuel tank takes 3 units of time. During this time the balloon will be falling. The hot-air balloon drains at a rate of 1 unit per unit time.

You need to design a strategy that ensures that the Hot-air balloon stays between heights of 100 and 120 units; after having first crossed 100 units of height.

2. There are three taps in the system, namely Tap-1 having a flow rate of $u = 5$, Tap-2 having a flow capacity of $v = 2$, and Tap-3 having a flow capacity of $w = 4$. Tap-2 and Tap-3 are always on. Tap-1 is switched on when $x_1 + x_2$ falls below 10 and is switched off when $x_1$ exceeds 80. Initially, we have $x_1 = 50$ and $x_2 = 50$. Draw a hybrid automaton for the system. Explain the dynamics of the system.