Some Hints for Lab 1

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In Lab1, you will be dealing with some basic concepts behind the control theory: stability, feedback, steady-state response, equilibrium points, and linearization. You might have learned some of these concepts before in ME132 or EE120. But some of you might have not, or might need some recap about the concepts. So hopefully the following hints can give you some better ideas about how to do your prelab.

1. **Stability**

   A system is (strictly) stable if its initial conditions decay to zero and is unstable if they diverge. For a linear time invariant (LTI) system with transfer function $G(s)$, it is (strictly) stable if the poles of $G(s)$ all have negative real parts. Otherwise, it is called unstable. For the system to be completely oscillatory, the poles should be located at the imaginary axis in s-plane. Recall that, the poles of $G(s)$ are the roots of $G(s)$ denominator polynomial, and the zeros of $G(s)$ are the roots of $G(s)$ numerator polynomial.

   So to show the system is stable or not, you can normally check the poles of the system transfer function. Here you can find the pole locations using the quadratic equation. For higher order systems, you could check for closed loop poles in the right half plane using Routh's Stability Criterion (*FPE6e P132-134*).

   In Lab 1, the "Simple feedback system" will ask you to show whether the system is stable or not, and choose the feedback gain K such that the feedback system is stable. Example 3.31 in *FPE6e P135-136* will be a good example for you to follow (just in case if you want to use Routh's Criterion, but you don't have to).

2. **Feedback / Closed loop**

   This course is talking mainly about how to control your system (or say track your reference) by feedback method. The "**feedback**" means there are some measurements of the system states feeding back to compare with the reference. And the error between the feedback signal and the reference is used to generate the control input to the **open loop** system (the original system plant). The resulting overall feedback loop system is called **closed loop** system. The feedback method name (such as proportional feedback / PID feedback) indicates the relation between the error and the control input.

   In Lab 1, the "Simple feedback system" problem will give you some idea on how the proportional feedback controller can stabilize the open loop system.

3. **Equilibrium points / Linearization**

For a system the dynamics of which is described by $\dot{x} = f(x,t)$, the equilibrium points are defined mathematically as the state x satisfying $\dot{x} = f(x,t) = 0$. That means, the equilibrium points are the points where the state x stays there constant. Physically, for example, the equilibrium points for the following systems can be illustrated as

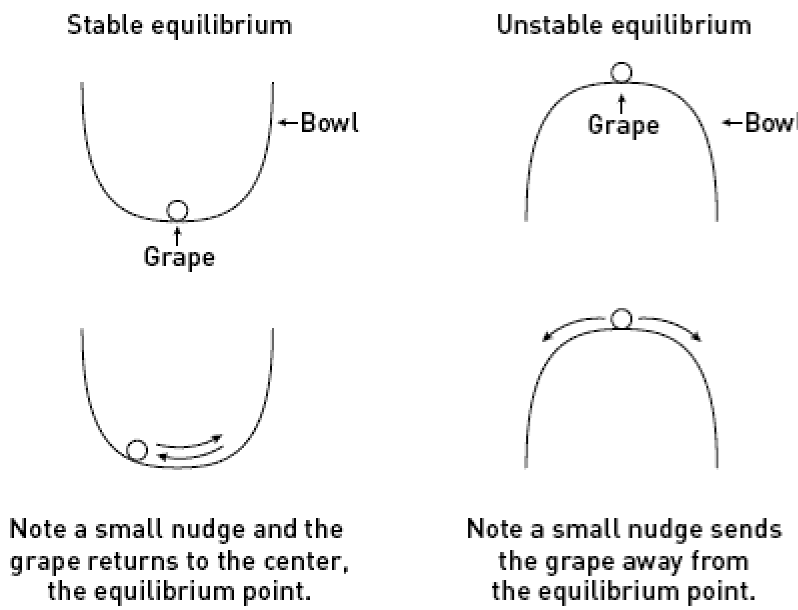

Figure 1 Equilibrium point example (www.learner.org)

In the "Nonlinear damped pendulum" problem in Lab 1, you will be investigating the effects of linearization by looking at the equilibrium points of the pendulum through simulation of how pendulum angle converges as the response of some pulses input.