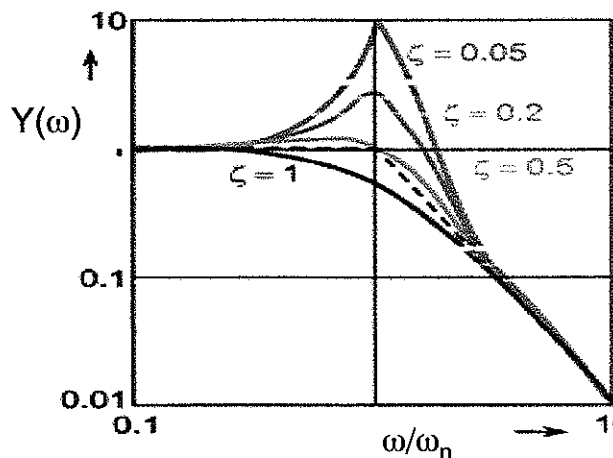


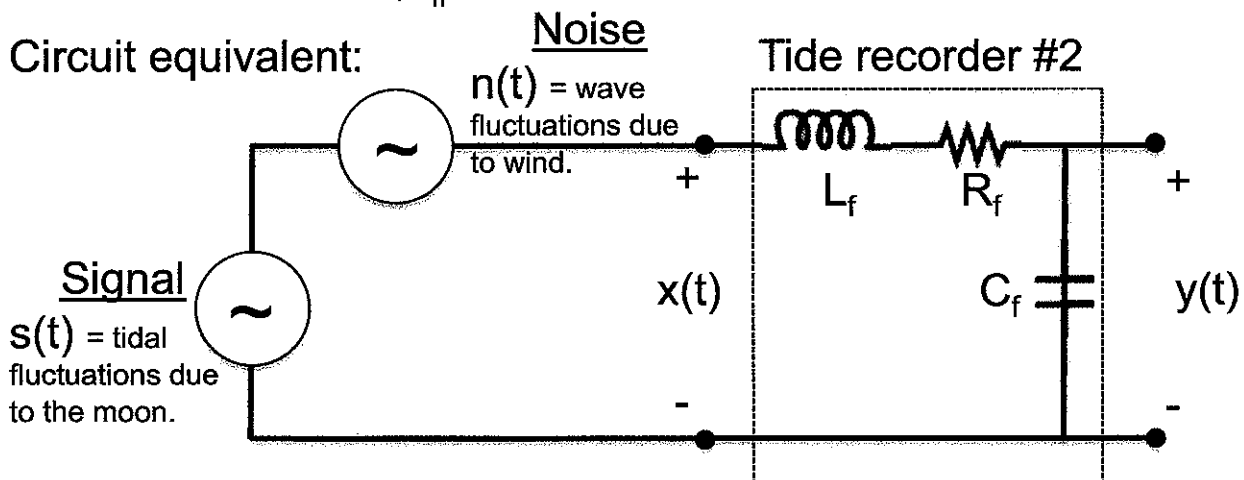
# 2010 EE PhD Quals: Solutions

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4. Device #2 is a low pass filter (equivalent to an LRC circuit). The frequency response would look something like (depending on the particular choices of A, L, and D):



In choosing A, L, and D, we want to avoid an underdamped system with a natural frequency in the range of ocean surface waves, typically on the order of 0.1 Hz ( $\omega_n = 1/\sqrt{L_f C_f}$  where  $L_f$  is the inductance [fluid analog of electrical inductance] and  $C_f$  is the fluid capacitance). The damping ratio,  $\zeta$ , equals  $(R_f/2)\sqrt{C_f/L_f}$ , where  $R_f$  is the fluid resistance. We want surface wave fluctuations  $\gg \omega_n$  and tidal variations



5a. Increasing A increases the fluid capacitance, thereby decreasing the natural frequency  $\omega_n$ .

5b. Increasing L increases the fluid inductance (thereby decreasing the natural frequency  $\omega_n$ ) and increases the fluid resistance (thereby increasing the damping  $\zeta$ ).

5c. Increasing D decreases the fluid inductance (thereby increasing the natural frequency  $\omega_n$ ) and decreases the fluid resistance (thereby decreasing the damping  $\zeta$ ).