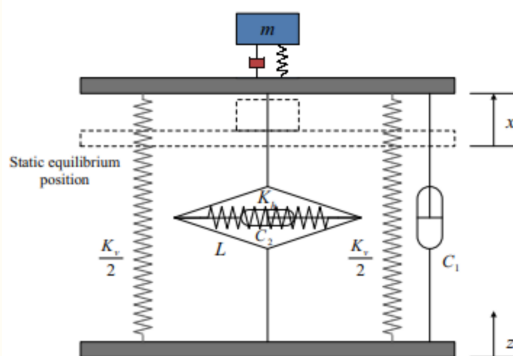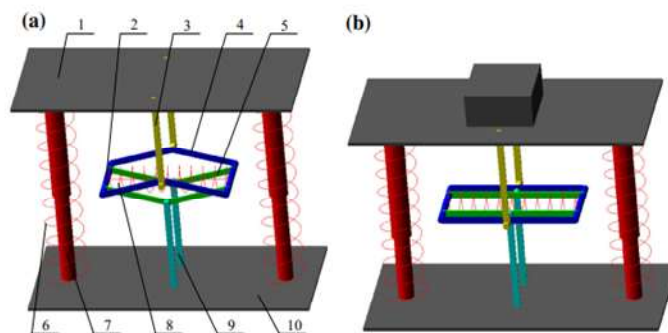# Negative-K ⇒ No Composites

NSS Transfer Functions

Really cool and interesting code

Implementation

  - The particular system implemented is a "quasi-zero stiffness" device from Ref [1]. It is roughly the same design as the device in Ref [2] (theory was too approximate {?}), and could be easily converted to that design if needed. I also added a second stage to the device.

  - Compared to the air legs & spring model, this model shows a ~1 order of magnitude decrease in (effective) resonance frequency, and a ~1 order of magnitude increase in attenuation for low frequencies. The dB/decade @ ≥10 Hz is worse for this model compared to the air legs & spring model, however putting the device in series with another spring or air legs could make the dB/decade better (possibly at the expense of some low-frequency attenuation).

  - All parameters (e.g., damping coefficients, spring constants, etc) are stable to within an order of magnitude (at least).

  - The vertical damper must be an eddy current damper, as traditional dampers provide too much damping. Links to dampers: $C_1 \rightarrow$ ([3], [4]), $C_2 \rightarrow$ [5]

Fig. 1 Physical model of the QZS vibration isolator: **a** without load; **b** with load; 1-loading support, 2-hinge axis, 3-upper bracket, 4-outer connecting rod, 5-inner connecting rod, 6-vertical spring, 7-vertical guide rod, 8-horizontal spring, 9-lower bracket, 10-base plate

Fig. 2 Flat view of the QZS system with two linear dampers

[1] https://link.springer.com/content/pdf/10.1007/s11071-016-3188-0.pdf
[2] https://www.sciencedirect.com/science/article/pii/S0020740313000726

[3] https://www.honeybeerobotics.com/wp-content/uploads/2019/10/Avior-Damper-Catalog.pdf
[4] https://www.sciencedirect.com/science/article/pii/S0022460X08001399
[5] https://www.springfixlinkages.com/en/catalog/air-cylinders/dashpots/push-pull-dampers/l4572

```
In[728]:= {NSSplt, NSSdata, params, SPRplt, CHAplt } =
       tNSS["all", cdata, Bounds → {0.1, 100}, c1 → 10, c2 → 440, kh → 500, kv → 1500, M → 10,
        L → 0.15, Hysteresis → True, PointsPerDecade → 100, kspr → 1000, cspr → 440];
    params
    Framed[Column[{Style["NSS vs Traditional Vibrational Isolation",
        Directive[ Black, Large, FontFamily → "Arial"]],
       GraphicsRow[{Show[NSSplt, plttransmult], Show[CHAplt, pltnoise2, pltnoise]},
        ImageSize → Full],
       LineLegend[{colors〚1〛, colors〚2〛, {Dashed, Gray}},
        {"NSS", "Traditional", "Initial Noise"}, LegendLayout → "Row"]
      }, Alignment → Center]]
```

Out[729]= $\{\omega_0 \to 12.2474, \delta_{qzs} \to 6., \xi_1 \to 0.0408248, \xi_2 \to 1.79629\}$

Out[730]=

NSS vs Traditional Vibrational Isolation