Mathematics & Analysis of a MEMS Semi-Absolute Pendulum Gravimeter

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This research provides an overview of the mathematics influencing the design of a pendulum-based semi-absolute MEMS (Micro-Electro-Mechanical Systems) gravimeter, currently being developed at the University of Glasgow. The device comprises two pendula actuated in anti-phase, allowing a differential measurement of local gravity that is isolated from seismic noise. The pendula are pivoted about a narrow flexure, and are therefore subject to changes in elastic stiffness with temperature. By adding mass this effect is diluted and the behaviour becomes asymptotically dominated by the gravitational restoring force, reducing temperature sensitivity.

The rationale behind the basic topology of the device will first be explained in terms of both the differential representation of the system and the corresponding vibratory profile modelled using finite-element software. This is followed by a brief discussion of the main factors influencing the measurement of gravity such as thermal and damping effects. The primary focus of the research will be how best to model the physics of pendulum motion, how to extract a value for gravity from this model, and the optimum sampling technique required in order to satisfy both device sensitivity and hardware limitations. A comparison between the simulated behaviour and preliminary experimental data will then be made from which the efficacy of the modelling solution can be inferred. Finally, the results of a lift-test, wherein the device is moved to various floors of a building and which is designed to estimate the performance of the device, will be discussed and contrasted with similar data from an existing relative MEMS gravimeter (the 'wee-g'), as well as any projected design modifications considered as a consequence of these results.