PHYSICS 101: SPRING-MASS DAMPER SYSTEMS

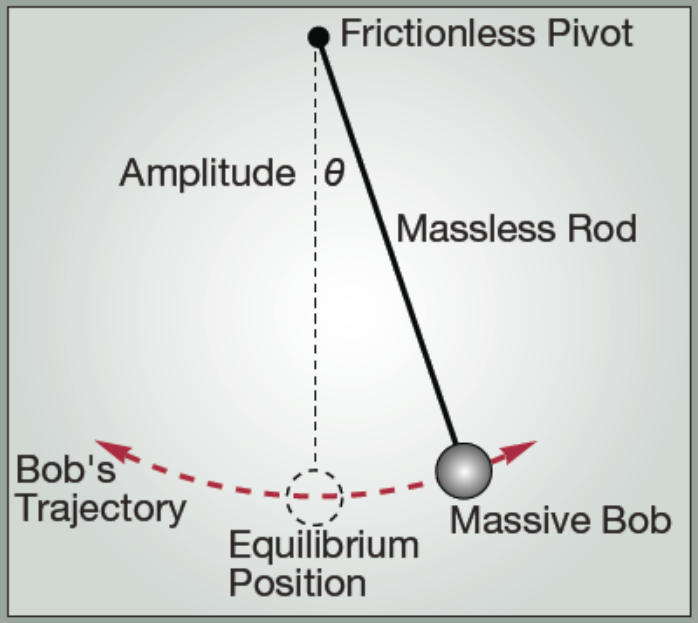
If you took physics or differential equations, you probably saw the ubiquitous spring-mass-damper system and possibly wondered what use an analysis could serve. Specifically, one imagines that a spring of a given stiffness is connected on one end to a wall. The other end is attached to a block mass sitting atop a table.

When the block is disturbed from its equilibrium position in either direction, the spring draws it back to its original resting place. The table supplies friction, or a damping force, against movement.

The disturbance is caused by an external forcing function. A mathematical analysis reveals the motions that are possible when the spring, mass, friction and forcing function act in concert after the block is set in motion by one application of the forcing function. If friction is particularly strong, then the displaced block may move directly back to its equilibrium position and the motion is overdamped. For a system with weaker friction and/or a stronger spring, the mass may overshoot the equilibrium position and continue to move back and forth (theoretically forever) before settling back to the equilibrium position.

In either case, the system is stable because eventually the mass settles back to its resting place. If one then allows the external forcing function to act in a longer-term capacity, any motion is really possible. If the mass doesn't settle back to its original position, then the system is unstable.

A beautiful facet of mathematics is that one can model phenomena that are seemingly impossible in the physical world. For instance, the model above can be used to predict the motion of the block under anti-friction; that is, a force that propels motion instead of hindering it. Surprisingly, this can apply to airplanes.



For example, based on some work done at The University of Tennessee Space Institute, it was found that the Twin Otter flown by NASA in certain icing conditions experienced a slightly unstable short-period oscillation. Such an airplane would be extremely difficult to fly. Add an external forcing function (pilot) who may not have the correct reaction and, truly, just about any motion is possible.