

Ballistic Pendulum Instructions (Michael Sullivan)

Introduction

3D printing dimensionally accurate components can be easily accomplished, but requires some knowledge about the process. Each .stl file requires no support and is provided in the correct print orientation. The only modification required by the user is for the mounting interface to the rotary encoder, as the provided design is specialized for the Vernier rotary motion sensor. These adaptations can be accomplished in any CAD or modern slicer available. For the inexperienced, reaching out to a student who may already be proficient in these skills is highly recommended.

Print Settings (Rod, Nut, Catcher Housing)

The rod, nut and catcher housing are very simple prints to run, low overhangs combined with a large print surface ensure high success rates. During data collection, the 3D printed apparatus printed at default slicer settings: 2 perimeters at 15% infill using PLA filament. This proved to be plenty strong for the hundreds of runs it endured, however strength and durability can be improved for longevity. Printing these components within 2-8 perimeters at 15-100% infill will produce similar results. Ideally this portion of the assembly should be as rigid as possible to translate as much momentum into angular velocity. With this in mind, it's recommended to stay on the higher side of these settings for improved rigidity.

Filament choice plays a minor role in the longevity of the assembly. Any hard plastic readily available will suffice, common filaments include: PLA, PETG, ABS, ASA, etc. The main criteria is a clean and consistent print necessary for the accuracy of the components.

Every filament has a heat threshold at which at which the plastic deforms, this temperature is rarely achieved in a climate controlled building, but may be considered elsewhere. Some filaments do need to be approached with caution, the majority of 3D printers are not suited to print every filament. Various plastics on the market release harmful fumes during the printing process and are subsequently avoided. Research is required to understand the capability of your printer.

Print Settings (Elastic Insert)

Similar to the other components of the assembly, the insert was printed at default setting: 2 perimeters at 15% infill using 95A TPU. This is one of the most common flexible filaments among 3D printing, notability for its rigidity. The Insert's primary goal is to funnel the ball bearing to the magnet on an off center strike. This requires a soft wall that will absorb most of the impact allowing the ball to roll towards the center. Printing at a high infill percentage may inhibit the success rate. Settings from 15-30% infill is recommended, along with 2-3 perimeters, These settings should vary inversely to prevent an inelastic print.

Trouble shooting

Several challenges may arise when printing with an elastic filament. Unlike the hard plastics previously mentioned, TPU is able to compress and buckle under the load of extruding.

This may lead to several issues namely stringing and inconsistent layer stacking. The easiest way to mitigate these issues is to slow down the print speed. This can be achieved in two ways: by limiting the top speed of the printer in the slicer or by changing the speed on the printer interface. This should improve both issues, but stringing may persist. In this case, the retraction distance may be too short. Increasing the distance to 3-6mm will move the filament further away from the print surface in between movements, minimizing the amount of filament dripping from the nozzle.

An undesirable characteristic of TPU is its hygroscopic tendencies, meaning the filament absorbs moisture from the air when left out. This significantly affects the performance as it causes inconsistencies when extruded. As the wet filament is extruded, the moisture turns into steam and is released in small bursts, the bursts leave gaps in the filament forming pockets in the finished print. To combat this issue, keep the filament in dry storage or dry the filament before use. Always seek the manufacturer's specific instructions for best results, but in general any appliance that can hold a temperature around 40-60°C for several hours should be sufficient.