M3 Design Product Teardown
Optical Mouse

Why do the product teardowns?
Part of the product development process is to apply knowledge gained from prior experience during the concept development and design phases. Some experience comes from actively designing something in the past while other experience is gleaned from more indirect sources. It is this indirect product development experience that we gain via product teardowns.

Teardowns are different from reverse engineering
Reverse engineering is nothing more than figuring out the design and manufacturing methods of a product, typically for copying. Conversely, M3 Design views product teardowns as ways to gain insight into the design to become better product developers. We focus on "why" questions.

• Why did the designer make the choices they did?
• Why were specific construction techniques chosen?
• Why were certain features included and others left out?
• Why was the particular design approach chosen?

This serves to gain more in depth understanding into the product's design rather than a superficial once-over.

How does M3 Design approach product teardowns?
Our teardown process is a rigorous approach to carefully catalog the product's deconstruction in both pictures and written descriptions. This procedure serves two purposes:

1. It forces the deconstruction team to carefully investigate the product pieces and learn as much about the design details as possible.
2. It provides a detailed record of the process for future reference by other designers.

The end result of this meticulous process is the beneficial expansion of applicable knowledge regarding product designs. We employ the lessons and insights garnered from these teardowns during brainstorm, design, prototype development, and troubleshooting. This method of obtaining indirect product development experience is just one of many important tools that sets M3 Design apart from other product development firms.
Overview
The M3 Teardown team was tasked with getting rid of a dead rodent: the ubiquitous optical mouse. Like real, living mice, these computer accessories seem to be everywhere and tend to multiply rapidly. The teardown team seized the opportunity to split one open and examine its guts (a computer mouse, not the real thing).

External Construction
The mouse is a wired, generic, no-brand type consisting of three external plastic shells:

- Lower shell – holds optics and glides on the desk surface
- Upper shell – encloses the mouse and provides structure
- Decorative button shell cover – flexing fingers used as the left/right buttons

The decorative button shell uses snap fits plus some additional features to attach to the upper shell. Two male snaps in the upper shell limit the upward movement of the flexing fingers but allow downward movement for left and right clicks. The female catches in the decorative button shell were long enough to touch the electronic switches inside the body of the mouse.

Non-snap catches are used to connect the fronts of the upper and lower shells and a single screw at the rear secures the pair together.
Upper and lower shells with internal components shown

Decorative button shell attaching to upper shell
Systems

The systems in a mouse are fairly simple: user input detection circuitry and the optics. All of the circuit board electronics were through-hole type, which indicates that this is likely an older optical mouse.

User Input Detection Circuitry

The user inputs are typical: left/right buttons and a scroll wheel with an incorporated center button. Each of the buttons presses on a standard, normally-open (NO) switch. The scroll wheel switch has a spacer underneath it to raise it 4mm higher than the other two. The team guessed that the leads on these switches are long enough to allow such mounting versatility.

The scroll wheel utilizes a single IR emitter/detector pair, which was confusing at first. How does the mouse know which way the wheel is turning? Upon closer inspection we noticed that the center leg of the detector and one of the emitter legs are tied together, possibly to V+. The other two pins of the detector connect to two pins on the main microcontroller. Thus, by monitoring the two output pins the microcontroller can determine which direction the scroll wheel is turning.

The scroll wheel also provides tactile feedback to the user during scrolling. The inner surface of the rotating wheel has 12 flats rather than a continuous smooth surface. A fixed plastic flexure in contact with these flats flexes then returns to its normal shape as each flat rotates by it. This mechanism generates gentle “snaps” as the scroll wheel is rotated. Polypropylene is a commonly used material for long life flexures and is likely the material used here.
Button switches, and IR emitter/detector pair

Scroll wheel (background) with plastic flexure (foreground)
Optics
Since this is an optical mouse, there are no moving parts to detect the position of the mouse as it moves on a surface. The detection system consisted of a red LED, a periscope/focusing lens, and a detection chip. The solder mount holes and length of the LED anode and cathode do not provide precise enough positioning, so a molded plastic shell fits over the LED to hold it in a specific place relative to the lens.

The optical surfaces on the plastic periscope/focusing lens are highly polished. It is unknown how forgiving the detection chip is of imperfections in the lens but it seems logical that the lenses have a large impact on how well the mouse functions.
Summary & Conclusions

Like a CD player, optical mouse technology is largely taken for granted. The large R&D investment in developing these products is invisible to most consumers. Optics play a large role in both CD players and optical mice and the end results are elegant designs.

It's unknown how old this mouse is, but the through-hole mounted electronics indicate that it is relatively outdated. Modern mice likely use surface-mount components to reduce cost and to allow smaller packaging. Given that many mice now use wireless technology, space needs to be made inside the housing for those electronics as well.