Reverse Engineering

- General concepts
- Right and left brain thinking
- Application to product study

**Example**

A uniform beam 3 m long weighs 82 kg/m. It is pinned at one end and supported by a cable at a point 2 m along the beam. What is the tension in the cable?

**Left Brain**

\[ T = 3 \times 82 \times 9.81 \]

**Right Brain**

- Why is this beam here?
- Why is it so heavy?
- Why is it pinned at the left end?
- Do we really need a cable?
- Why is it orange?

The most creative decision making and problem solving come about when both sides of the brain bring their various skills to the table: the left brain analyzing issues, problems, and barriers; the right brain generating fresh approaches; and the left brain translating them into plans of action.”

PRODUCT STUDY
Reverse Engineering

• EXAMPLE: computer mouse
  – what is it? input device for computer
  – what does it do? translate the motions of your hand into signals the computer can use
  – how does it work? let’s have a look...

BACKGROUND

• 1946 ENIAC - first electronic computer (based on vacuum tubes)
• 1950 IBM invents dot matrix printer
• 1950 Yoshiro Nakamoto invents disc drive
• 1958 Jack Kirby invents silicon chip

BACKGROUND

• 1968 Douglas Engelbart invents the mouse as an input device for mainframe computers (the PC doesn’t exist yet). He had been a radar technician in WWII and was working at Stanford Research Institute. Nothing much happens with it.

BACKGROUND

• 1971 Intel invents the microprocessor
• 1975 Edward Roberts invents the personal computer
• 1977 Rank-Xerox invents the laser printer
• ~1979 Bill Gates established Microsoft (MS-DOS operating system; no hardware yet)

MOUSE
PRODUCT STUDY

first step - sketch of overall device, noting relevant features

• 1983 Apple Computers (Steve Jobs) attaches a mouse to the Macintosh. (Microsoft is by now building PC’s, but has to get to Windows 3.1 before they support the mouse)
**PRODUCT STUDY**

**Reverse Engineering**

what is the material? (what type of metal? what type of plastic?)

what is the function of the component? (can you tell by looking?)

what colour is the component? why? are there other sensible things about the component (sound, texture, smell, taste)

**MOUSE**
- grey-beige hard plastic casing (type?)
- foot (1.5m) flex cord with molded strain relief
- molded plastic connector (RS232 serial connector?)
- 3 button switches on top
- mystery switch on side labelled “MS/PC”

**PRODUCT STUDY**

**Reverse Engineering**

how do the individual components relate to others? (exploded diagrams work well here)

how are the components fastened to each other? (make notes)

what is the shape of the component? why is it this shape?

**Exploded View**

- 1 Phillips-head screw to undo, and comes apart
- exploded view is part observed, part visualized - arrange components so they project down and across into their actual places in the device

- may use centrelines to assist in visualizing arrangement of components
- individual components are numbered and identified

**Exploded View**

next step - begin disassembly, and make sketch(es) as you proceed

identify what you can and make notes of questions to be answered
Details

“button piece” (1) and “top cover” (2) snap together on mating plastic tabs (not shown) and are pried apart with some effort. Top cover held in place with stand-off which slot over tabs in base (10).

Details

Top cover includes a locating cage for track ball and a threaded post for screw (11). Q: why slots in button piece? Perhaps to reduce stiffness of bending section, giving more compliant “feel”?

Details

Assembly of roller (3), pin (4), lever (5), and spring (6) creates a lever arm which keep track ball (7) in contact with encoder wheel shafts in base (10). Cover plate (12) slides into hole in base (10) and confines track ball, which projects through opening.

Details

Cable (9) includes molded plastic connector with 2 knurled screws at one end (previous diagram) and strain relief at the other (shown) which slots into circuit board (8). 2 input wires (power), 2 output wires (information).

Details

Q: why is circuit board such a weird shape? A: clue to mechanical-to-electrical conversion. Wheels are mechanical elements interposed between 2 electrical elements. Switches (3 “contact”, 1 “two-position”) are mated with mechanical drive elements.

PRODUCT STUDY

mouse

Key components: (1) a ball which touches the desktop and rolls when the mouse moves.
key components:
(2) two rollers which touch the ball, at 90° to each other (X and Y motions)

(3) two shafts, one connected to (or integral with) each roller, which spin disks with holes in them (or slots or contact strips)

(4) paired photodiodes and phototransistors (optical encoders) on either side of the wheels

(5) an on-board microprocessor which turns the optical pulses into data, and passes the data to the computer

Details
CPU chip is labeled “HM8350A 9317B N34G2”
circuit board also includes resistors, capacitor(s), two zener diodes, 2 transistors, and one “5A1 5J”

Important Paradox
How much you get from a product study depends a lot on how much you already know.
Product study often leads to questions you cannot answer right away.

Be comfortable with having incomplete information.

Product study suggestions:

- use a methodical approach
- think about your drawing layout before you draw
- go beyond the first (superficial) level

Don’t be afraid of questions, and be prepared to have questions remaining.

What constitutes a good product study?

- Completeness – all parts considered
- Geometry/Materials/Interactions
- Manufacturing considered
- Identification of functions
- Leading questions provided
- Depth of analysis

And now that we've been through the loop once,