2.009

PRODUCT ENGINEERING PROCESSES

Rough

Tough &

Messy
Everything You Always Wanted To Know About Product Cost but Were Afraid to Ask

Apple 6s
Price $529.99

What does it cost to make?
Everything You Always Wanted To Know About Product Cost but Were Afraid to Ask

Apple 6s

Price  $529.99

Cost    $187.91*

Mark up 2.82

* ihs/iSupply costed teardown

David Meeker  Meeker@MIT.edu
Everything You Always Wanted To Know About Product Cost but Were Afraid to Ask ............

David Meeker  Meeker@MIT.edu
Surprise quiz

How many parts are in each of these products?

747-400

Toyota Camry

Milwaukee oscillating Multi tool 18 volt
Surprise quiz

How many parts are in each of these products?  

<table>
<thead>
<tr>
<th>PARTS</th>
<th>DRIVE</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>747-400</td>
<td>6 million</td>
<td>--- ½ are fasteners</td>
</tr>
<tr>
<td>Toyota Camry</td>
<td>30,000</td>
<td></td>
</tr>
<tr>
<td>Milwaukee oscillating Multi tool 18 volt</td>
<td>59</td>
<td></td>
</tr>
</tbody>
</table>
**Product Cost**

Product Cost Equals =

**Material Cost + Assembly Labor + Profit**

Material cost = parts, scrap, maybe amortized tooling to make parts.

Assembly labor = All labor to get it out the door to the customer manufacturing, assembly, testing, packaging,

Profit = $$$ left over after you pay all the bills
Product Cost the Other Stuff

All the Bills include:

• Salary for your team about $100,000/ engineer including benefits
• Rental Space for offices, lab areas
• Manufacturing areas, tools assembly fixtures ........
• Equipment office, computers, Xerox machines .......
• Heat, lights ..... If not included in rent
• Inventory of raw and finished materials
• Phones, internet,
• Marketing
• Product Liability insurance

But to name a few ........................................
Cost estimating is an art as well as a science
Cost Estimating requires the skills of:

- Librarian
- Detective
- Design Engineer
- Manufacturer
Typical Product Cost Breakdown

- Part Costs: 72%
- Overhead: 24%
- Labor: 4%

Source: The True Cost of Oversea Manufacturing June 2004 N. Dewhurst & D. Meeker
Cost and Expenses

IBIS World’s Industry Research Reports

What Are they?

IBISWorld's Industry Research Reports are powerful business tools that provide strategic insight and analysis on over 700 U.S. industries. Extensive, content on U.S. industries

http://www.ibisworld.com/industry/home.aspx?partnerid=googlead&gclid=Cj0KEQjwqfvABRC6gJ3T_4mwspoBEiQAyoQPkZpFlVbE4Ovo5zC29LLQX2yIWZfGTJAcKyq88txkvhQaAnN28P8HAQ

http://libraries.mit.edu/get/ibisworld
Cost and Expenses

IBIS World’s Industry Research Reports

The reports IBIS Research Reports are structure around NAICS codes

The North American Industry Classification System (NAICS) classifies business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. economy. The NAICS industry codes define establishments based on the activities in which they are primarily engaged.

You can look up industry codes at https://www.naics.com/
Cost and Expenses

IBIS World’s Industry Research Reports

IBISWorld Industry Report OD4378
Hiking & Outdoor Equipment Stores in the US

http://libguides.mit.edu/bizcat/industries
Lots of other Business Data bases of industries
Product Cost Equals =

Material Cost + Assembly Labor + Profit

References to find material and labor cost
Useful Sources for all kinds of information

• **Metals** LME  [http://www.lme.com/](http://www.lme.com/)

• **Kitco Metals**  [http://www.kitcometals.com/](http://www.kitcometals.com/)

• **Energy**  [http://www.eia.doe.gov/](http://www.eia.doe.gov/) (U.S. Energy Information Administration)

• **Labor rates**  [http://www.bls.gov/FLS/](http://www.bls.gov/FLS/)

• **Dollar price parity**  [http://www.economist.com/content/big-mac-index](http://www.economist.com/content/big-mac-index)

• **Wide Range of commodities**  [http://www.indexmundi.com/commodities/](http://www.indexmundi.com/commodities/)

• **Plastics**  [http://www.ptonline.com/articles/commodity-resin-prices-drop](http://www.ptonline.com/articles/commodity-resin-prices-drop)
Useful Sources for all kinds of information

- **Ceramics** [http://www.standardceramic.com/Materials.html](http://www.standardceramic.com/Materials.html)
- **General list** [http://www.supplymanagement.com/commodity-prices](http://www.supplymanagement.com/commodity-prices)

**PLASTICS**

- [http://www.plasticnews.com/resin](http://www.plasticnews.com/resin)
- [http://www.plastictoday.com/topics/resin-pricing](http://www.plastictoday.com/topics/resin-pricing)
- [http://plasticker.de/preise/index_en.php](http://plasticker.de/preise/index_en.php)
The Big Mac Index

http://www.economist.com/content/big-mac-index
Manufacturing Labor Cost

Manufacturing labour costs in select provinces and countries, 2014

<table>
<thead>
<tr>
<th>Country</th>
<th>Labourforce (m)</th>
<th>Labourforce (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>50.1</td>
<td>44.3</td>
</tr>
<tr>
<td>US</td>
<td>37.2</td>
<td>155.7</td>
</tr>
<tr>
<td>Japan</td>
<td>27.6</td>
<td>65.9</td>
</tr>
<tr>
<td>South Korea</td>
<td>26.4</td>
<td>110.9</td>
</tr>
<tr>
<td>Portugal</td>
<td>5.3</td>
<td>11.5</td>
</tr>
<tr>
<td>Brazil</td>
<td>5.3</td>
<td>18.3</td>
</tr>
<tr>
<td>Taiwan</td>
<td>5.3</td>
<td>52.9</td>
</tr>
<tr>
<td>Poland</td>
<td>20.2</td>
<td>20.2</td>
</tr>
<tr>
<td>Mexico</td>
<td>27.6</td>
<td>75.3</td>
</tr>
<tr>
<td>South Africa</td>
<td>75.3</td>
<td>12.0</td>
</tr>
<tr>
<td>Turkey</td>
<td>75.3</td>
<td>48.1</td>
</tr>
<tr>
<td>Russia</td>
<td>75.3</td>
<td>64.2</td>
</tr>
<tr>
<td>Guangdong</td>
<td>75.3</td>
<td>38.2</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>75.3</td>
<td>9.1</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>75.3</td>
<td>14.0</td>
</tr>
<tr>
<td>Malaysia</td>
<td>75.3</td>
<td>48.3</td>
</tr>
<tr>
<td>Sichuan</td>
<td>75.3</td>
<td>24.9</td>
</tr>
<tr>
<td>Liaoning</td>
<td>75.3</td>
<td>39.3</td>
</tr>
<tr>
<td>Thailand</td>
<td>75.3</td>
<td>41.9</td>
</tr>
<tr>
<td>Anhui</td>
<td>75.3</td>
<td>37.4</td>
</tr>
<tr>
<td>Hubei</td>
<td>75.3</td>
<td>41.4</td>
</tr>
<tr>
<td>Philippines</td>
<td>75.3</td>
<td>41.1</td>
</tr>
<tr>
<td>Hunan</td>
<td>75.3</td>
<td>66.6</td>
</tr>
<tr>
<td>Shandong</td>
<td>75.3</td>
<td>29.9</td>
</tr>
<tr>
<td>Yunnan</td>
<td>75.3</td>
<td>64.0</td>
</tr>
<tr>
<td>Henan</td>
<td>75.3</td>
<td>41.4</td>
</tr>
<tr>
<td>Hebei</td>
<td>75.3</td>
<td>27.0</td>
</tr>
<tr>
<td>Jiangxi</td>
<td>75.3</td>
<td>54.1</td>
</tr>
<tr>
<td>Vietnam</td>
<td>75.3</td>
<td>502.2</td>
</tr>
<tr>
<td>India</td>
<td>75.3</td>
<td>54.9</td>
</tr>
<tr>
<td>Nigeria</td>
<td>75.3</td>
<td>124.3</td>
</tr>
<tr>
<td>Indonesia</td>
<td>75.3</td>
<td></td>
</tr>
</tbody>
</table>

Source: The Economist Intelligence Unit.
International Comparisons of Hourly Compensation Costs in Manufacturing, 2012


Commodity prices

Copper High Grade Front Month Futures US@HG.1:CMX

PRICE (USD)       TODAY'S CHANGE     SHARES Traded     1 YEAR CHANGE     52 WEEK RANGE
2.20              ↑ 0.0015 / 0.07%  60.00              ↓ -4.74%            1.94 - 2.34

Data delayed at least 15 minutes, as of Nov 01 2016 13:34 BST.

http://markets.ft.com/data/commodities/tearsheet/summary?c=Copper
Commodity Prices

NYMEX Crude Oil Front Month CL1:NYM

Price (USD) | Today's Change | Shares Traded | 1 Year Change | 52 Week Range
---|---|---|---|---
46.98 | ↑0.12 / 0.26% | 214.03k | ↑1.27% | 26.05 - 51.93

Data delayed at least 15 minutes, as of Nov 01 2016 12:29 BST.

http://markets.ft.com/data/commodities/tearsheet/summary?c=WTI+Crude+Oil
Commodity Prices

Data from 2017 Metal miner Annual metals Outlook 10142016 report
Commodity Prices

http://www.indexmundi.com/commodities/
Define Levels of Cost Analysis

**Level 1** - A first impression by knowledgeable engineers of what a part, assembly or system would cost based on prior experience. (analogy)

**Level 2** - An estimation based on prior experience with similar products, budgetary estimates, vendor quotes and expert opinion and experience. (parametric)

**Level 3** - Detailed costing of every part accomplished by using material cost estimation data bases, and time/motion studies. A high degree of accuracy is achieved by comparisons to industry standards and vendor quotes. (analytical)
Product Cost

*Level 1* - A first impression by knowledgeable engineers of what a part, assembly or system would cost based on prior experience. (parametric)

<table>
<thead>
<tr>
<th></th>
<th>Pro-Lite Spine Board</th>
<th>Aquaboard</th>
<th>SKED Rapid Deployment</th>
<th>Flotation Assist Device</th>
<th>Our Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$250</td>
<td>$600</td>
<td>$1,164</td>
<td>$300 (add-on)</td>
<td>Goal: $600</td>
</tr>
</tbody>
</table>

Quick and dirty way to look at cost is try to figure out markup for the industry or the company. Take Pro-lite board

<table>
<thead>
<tr>
<th>Markup</th>
<th>$208.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>$125.</td>
</tr>
<tr>
<td>3.0</td>
<td>$83.</td>
</tr>
<tr>
<td>4.0</td>
<td>$62.5</td>
</tr>
<tr>
<td>5.0</td>
<td>$ 50.</td>
</tr>
</tbody>
</table>
Product Cost

Shop on Google

- Rapid Deployment Products: PRO...
  - $184.39
  - theEMSstore

- Rapid Deployment Products: PRO...
  - $196.39
  - TheFireStore

- Pro-Lite Spineboard with...
  - $240.31
  - SwimOutlet.com

- Pro-Lite Spineboard...
  - $349.95
  - AmericanLifeguard.com

- Pro-Lite 18" XT Spineboard -...
  - $220.60
  - SwimOutlet.com

- Pro Lite Spineboard...
  - $194.15
  - Common Cents E

Features
- Seamless design prevents fluids from entering and eliminates cross-contamination.
- The unique design allows 2 boards to be stored together in less than 4" of space.
- Ideal for water rescue, the spineboard will float with up to 250 lbs on it.
- Foot section is angled slightly downward to assist rescuer in auto extrication.
- Only board that provides natural curvature of the lower extremities.
- Offers better patient centering and requires much less padding.
- Compatible with all head immobilization devices.
- 1000 lb. single patient weight capacity.
- Minimal deflection under maximum load.
- 16 – 2" x 5.25" hand holes.
- Tapers from 16" to 14" at foot end.
- Speed clip pins.
- 100% guarantee for the life of the spineboard under normal conditions.
- Guaranteed not to warp for the life of the spineboard.
- **Weight:** 14 lbs.
- **Size:** 72" x 16" x 2.25".

Polyethylene / polypropylene
Approximately 0.82 cents /lb
Collect Competitive specification data

<table>
<thead>
<tr>
<th>Product</th>
<th>CMC Equipment</th>
<th>RQ3 Superlite - Titanium Stokes Litter</th>
<th>Sked Stretcher</th>
<th>Junkin Backboard - Plastic Stretcher</th>
<th>Flitter - the Foldable Litter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Image</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Width(cm)</strong></td>
<td>58</td>
<td>60.96</td>
<td>91.44</td>
<td>60.96</td>
<td>60.96</td>
</tr>
<tr>
<td><strong>Length(cm)</strong></td>
<td>211</td>
<td>210.82</td>
<td>243.84</td>
<td>214.63</td>
<td>243.84</td>
</tr>
<tr>
<td><strong>Depth(cm)</strong></td>
<td>18</td>
<td>20.32</td>
<td>19.05</td>
<td>17.78</td>
<td></td>
</tr>
<tr>
<td><strong>Load(kN)</strong></td>
<td>11.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weight(kg)</strong></td>
<td>16.3</td>
<td>5.44</td>
<td>6.35</td>
<td>14.30</td>
<td>21.41</td>
</tr>
<tr>
<td><strong>Price (USD)</strong></td>
<td>875</td>
<td>1499</td>
<td>591</td>
<td>778</td>
<td>600</td>
</tr>
<tr>
<td><strong>Spill(cm)</strong></td>
<td>115.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Straps</strong></td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
## Competition

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>Automatic Golf Tee</th>
<th>RA-200 Golf Teeing Machine</th>
<th>TC 200</th>
<th>QuickTee Golf Ball Dispenser</th>
<th>Golf Teer 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portable</td>
<td>★</td>
<td>★</td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Powered</td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Capacity</td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Reliability</td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Weight</td>
<td>★</td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Price</td>
<td>$2,900</td>
<td>$1,199</td>
<td>$250</td>
<td>$99</td>
<td>$350</td>
</tr>
</tbody>
</table>
Product Cost

**Level 2** - An estimation based on prior experience with similar products, budgetary estimates, vendor quotes and expert opinion and experience. (analogy)

Might look at the major subassemblies, what they are made of, look at a trend line or a benchmark rule of thumb.

General rules of thumb:

- Printed circuit Boards 4 cents per square inch per layer
- Power supplies PC 10 cents per watt
- Large enclosures (servers) 1 cent per cubic inch
- Heatsinks Alum. Extrusions 50 -100 K volume no finish 3.0 times cost per pound *(LME London Metals Exchange www.lme.co.uk/)*
Trend Line Analysis

Tractor example

$/HP 42 & 48 inch cut lawn tractors

\[ y = 2.4787x + 43.107 \]  
\[ R^2 = 0.9997 \]

\[ y = 2.78x + 29.84 \]  
\[ R^2 = 0.9876 \]
Product Cost

**Level 3** - Detailed costing of every part accomplished by using material cost estimation databases, and time/motion studies. A high degree of accuracy is achieved by comparisons to industry standards and vendor quotes. (analytical)
Creating A Product Cost

When you are off buying material for you product. Remember to get quotes for larger quantities than you are buying.

Ideally several quantities which include you highest volume.

40mm x 20mm 12 volt 10.8 cfm fan

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Price $</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>$9.98</td>
</tr>
<tr>
<td>1K</td>
<td>$5.08</td>
</tr>
<tr>
<td>20K</td>
<td>$3.66</td>
</tr>
<tr>
<td>50K</td>
<td>$3.25</td>
</tr>
<tr>
<td>100K</td>
<td>$3.09</td>
</tr>
</tbody>
</table>
Creating A Product Cost

First
You need a bill of material BOM
This is a listing of all the materials, and parts it takes to making your product. The BOM should have a part name, description, quantity used in the product, dimensions and weights, and the material it is made of.

Ideally the BOM should be indented starting with the finished product.
Next all the subassemblies should be under it, and the parts and subassemblies that go into those listed under them respectively.

Second
You need to know the Volume of units you plan to produce. You want to cost your product at the max volume you plan to make for the year. Volumes can increase over time if you believe your sales of units will increase.
Bill of Material BOM
Quick way to create a BOM is to use your product’s Assembly View as a starting point
Creating A Product Cost

Labor Cost:

Can be calculated by using Boothroyd and Dewhurst Design for Manufacturing and Assembly.

The Software estimates time to assemble various parts and subassemblies into a product.
Creating A Product Cost

Software That Helps You Estimate part cost

Boothroyd and Dewhurst DFM Concurrent Costing Version 2.4 Can estimate cost on the following processes and materials.
Costing Case Study

Aluminum Tubing

There are several ways to make Aluminum tubing. The most common way is by extrusion.
Extrusions

Most of you have some experience in extrusions from your childhood.

Traditional Play Dough

1 cup flour
1 cup warm water
2 teaspoons cream of tartar
1 teaspoon oil
1/4 cup salt
food coloring

Mix all ingredients, adding food coloring last. Stir over medium heat until smooth. Remove from pan and knead until blended smooth. Place in plastic bag or airtight container when cooled. Will last for a long time.
Flitter / Fortrus
McMaster-Carr does not offer Volume discounts on Alum. tubing. Their price on a per inch basis is pretty linear.

Most of you bought your tubing from McMaster-Carr

- Tube Type: Round
- Finish/Coating: Unpolished (Mill)
- Round Tube Type: Single-Wall
- Tolerance: Standard
- Wall Thickness: 0.065" in
- Inside Diameter: 0.870" in
- Outside Diameter: 1" in
- System of Measurement: Inch
- Test Report: Without Test Report
- Hardness: 93 Brinell
- Application: Structural Tubes
- Specifications Met: American Society for Testing and Materials (ASTM)
- ASTM Specification: ASTM B241

Length

- 12' | 36' | 6'

These 3 products match your selections

<table>
<thead>
<tr>
<th>Length</th>
<th>Each</th>
</tr>
</thead>
<tbody>
<tr>
<td>12'</td>
<td>8056K753 $9.10</td>
</tr>
<tr>
<td>36'</td>
<td>8056K752 21.48</td>
</tr>
<tr>
<td>6'</td>
<td>8056K751 36.41</td>
</tr>
</tbody>
</table>
2.009 Product Engineering Processes

Quote from and Extrusion Company SAPA AL-6061-T6 1'' OD 0.065'' Wall

5k, 10k (feet)
$0.4136/FT

50k, 100k (feet)
$0.3929/FT

Links to design guide and power point on extrusions

Typically the Tooling cost which are dies are relatively inexpensive ie; a few thousand dollars. In this case it is a standard die size no cost.
Extrusions comparison McMaster vs. SAPA

McMaster Carr

6 foot piece $36.41

SAPA

$0.3929/foot 6 foot $2.36

McMaster Carr

Approximately 15 times more expensive for convenience
Recap

- No one cares what your prototype cost

- Product Cost = Material Cost + Assembly labor cost + profit

To Get Started

- Bill of Material (BOM)
- Product volume first year and subsequent years of business plan
Product costing

DFMA Online Tutorials

These tutorials are designed to help new DFMA users to quickly grasp basic DFMA concepts and tools, using real examples. More advanced topics are also included for the more experienced user.

These are youtube videos so you will need the Adobe Flash Player plugin. You can watch them directly on youtube as well.

DFMA Product Simplification

Learn the basics of the DFA software
Open a DFA 9 file in DFA 10
Learn how to use the DFA structure chart
Learn how to use the DFA questions
Learn how to use the DFA worksheets
Import a bill of material (BOM) into DFA
Learn how to use the DFA items library
Learn how to use the DFA function groups
Import a CAD model into DFA
Learn how to use the DFA reports
Learn how to batch print DFA reports
Learn how to create a DFA custom tabular report
Learn how to use DFA to redesign my product

DFM Concurrent Costing

Learn the basics of the DFM software
Import a CAD model into DFM Concurrent Costing
Share the results of my DFMA analyses with others
Analyze an injection molded part
Analyze a sheet metal part
Analyze a machined part
Analyze a machined part using the quick estimator
Add a machine to the machine library in DFM
Add a material to the material library in DFM

http://www.dfma.com/support/tutorials.htm
Cost Tutorial

VERY IMPORTANT

Where possible and as you are buying things now ask for quotes in quantities you need to build at least your first year volume.
I Keep Six Honest Serving Men

I KEEP six honest serving-men
(They taught me all I knew);
Their names are What and Why and When
And How and Where and Who.
I send them over land and sea,
    I send them east and west;
But after they have worked for me,
    I give them all a rest.

I let them rest from nine till five,
    For I am busy then,
As well as breakfast, lunch, and tea,
    For they are hungry men.
But different folk have different views;
    I know a person small—
She keeps ten million serving-men,
    Who get no rest at all!
She sends'em abroad on her own affairs,
    From the second she opens her eyes—
One million Hows, two million Wheres,
and seven million Whys!

Rudyard Kipling

Questions

http://www.youtube.com/watch?v=WIn5CQ_XH1Q