"I just want to say one word to you... just one word...

Plastics"

—the graduate
Form and color in Toys!
Product Form Exercise
Product Form and Color!

- 2 Year Olds: Pressure bubble mechanism
- 6 Year Olds: Introduce back pack
- 12 Year Olds: 

WATER MASTER

(No backpack)
Mockup Consulting Review

Wednesday, April 18th, during lecture

Two teams in one room (check website for assignments)

Begin lecture in your room, set up as early as 3:00pm

Reviews start promptly at 3:35pm. **Clean up** when done (put tables and chairs back to original configuration!)
Mockup Consulting Review

Discussions with review groups last 10 minutes.

You’ll meet with 3 groups

Have designated note taker(s)

Plan a 30s demo to be video recorded (will be considered for grading!)
3D Printing!

Email 200b-3dprint@mit.edu

Attach your .stl file

- Team Name
- Part Quantity
- Rough Dimension
- Type of Printer

Automatically deduct from your team budget (you still need to keep track of the cost yourself)
Mockup Communication

Understand the situation
Describe toy and its play
Specify purpose of models
Be open to interaction
Control time/guide reviewers
Take notes
Extra Lab Time this Weekend

There will be some!

Saturday 1pm-5pm

Sunday Lab Closed

Monday 11am-5pm

Tuesday 10am-8pm
Play Testing!

MITxMake, Sat. April 21st
10:30am or 1pm

At least 2 students per team

Time slot signup on the course website
Quiz!

1. What is your name?

2. Which are polymers: wood, skin (dermis), Jell-O, DNA

3. Where does almost all plastic come from?

4. Which requires more energy to produce: paper or plastic bags?
What are Polymers?

Greek for many parts

long chains of repeating molecules (monomers)

natural polymers: proteins, starch, cellulose

synthetic polymers...
What is Plastic?

synthetically polymerized material... typically from hydrocarbons from crude OIL

6-10 percent of U.S. oil consumption - approximately 2 million barrels a day *

* lawrence livermore, 2004; metabolix 2007
Thermoplastics vs. Thermosets

THERMO (heat)
PLASTIC (deform)

THERMO (heat)
SET (permanent)
Thermosets

permanent, chemical reaction

Usually two-part exothermic, or heat-cured

Used in for high temp, high tolerance, or joining

Not recyclable
# Thermoplastics

- Easy to (re)shape with different processes
- Mostly recyclable
- Most common with toys

<table>
<thead>
<tr>
<th>8 common thermoplastics</th>
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<tbody>
<tr>
<td>Acrylonitrile Butadiene Styrene (ABS)</td>
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<tr>
<td>PolyPropylene (PP)</td>
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<td>PolyEthylene (PE)</td>
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<td>PolyVinyl Chloride (PVC)</td>
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<td>PolyStyrene (PS)</td>
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<td>PolyCarbonate (PC)</td>
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<td>PolyEsters (PET, PETE)</td>
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</tbody>
</table>
Thermoplastics

common toy plastics

ABS  PP  PE  PVC

common clear plastics

PS  PMMA  PC  PET

Acrylonitrile Butadiene Styrene (ABS)
PolyPropylene (PP)
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PolyVinyl Chloride (PVC)
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PolyMethylMethAcrylate (PMMA) (Acrylic)
PolyCarbonate (PC)
PolyEsters (PET, PETE)
Thermoplastics

common toy plastics

ABS  PP  PE  PVC

common clear plastics

PS  PMMA  PC  PET

Physical Properties:
feel, look, smell
density, stiffness, opacity,
surface finish

Manufacturing Properties:
What are the processes
used with this plastic?
thickness, detail, size?

Design Considerations:
Which types of products use
this plastic? What is the cost
of these products?
ABS
Acrylonitrile Butadiene Styrene

Hard with high impact resistance

Takes color well with excellent surface finish

Can be very shiny!

Consumer product cases

Good chemical resistance
PolyVinyl Chloride (PVC)

- inexpensive, heavy, rigid, durable but brittle without plasticizers
- outdoor/water products
- characteristic smell
- environment concerns
PolyEthylene (PE)

most common plastic

HDPE, LDPE

cheap, very flexible, less dense than water

waxy feel, milky, smooth

highly resistant to food, water, salt, chemicals
PolyPropylene (PP)

VERY similar to PE but...

a bit more rigid

doesn’t fatigue: hinges, snaps

shinier surface with better color acceptance

most scratch resistant
Compare ABS, PVC, PP, PE

ABS
- Hard
- Colorful
- Strong

PVC
- Dense
- Flexible*

PP
- No Fatigue
- Tough
- Shiny Surface

PE
- Flexible
- Food/Chemical Safe
- Waxy

Stiff
- $$$$$

Nicest Finish

Flexible
- $

Worst Finish
Polystyrene (PS)
clear, hard, inexpensive, brittle, tinny sound
typically foamed into Styrofoam
good for lightweight insulation
cracks easily
Crazing

strain whitening

network of small voids or cracks
PolyMethylMethAcrylate

Acrylic, Plexiglass, Lucite
transparent like glass,
hard, brittle, but stronger
than PS
great for laser cutting
can bond using solvents
PMMA particles
suspended in water?
Polycarbonate (PC)

an “engineering” plastic

expensive, extremely tough and rigid...

and optically very clear

bullet proof
Polyesters (PET)

- inexpensive, transparent, easy to mold
- food products, barrier to moisture
- tough, able to withstand high pressures
- easy to recycle, requires less energy than glass bottles
Compare PC, PET, PMMA, PS

- **PC**: “bullet-proof” tough
- **PET**: low-permeability tough
- **Acrylic**: glass like brittle strong
- **PS**: tin sound brittle light weight

Tough $$$$$$

Brittle $

---

$
Thermo-Plastic Forming

Extrusion
Injection Molding
Thermoforming
Blow Molding
Rotational Molding
Extrusion

like a pasta extruder

constant profile extrusion
straws, etc.

high volume

dies are expensive (sort of)
Injection Molding

for thin, constant thickness parts

gate, parting lines, ejector pins

mass production, molds are expensive
Thermoforming

for thin sheets, simple one sided forms
Blow Molding

for open thin walled hollow parts

milk jugs, most bottles

pinched look on bottom
Rotational Molding

for simple closed hollow shapes

good for large, durable parts
Team Quiz

1. For each part, what is it and what is it for?

2. Identify the type of plastic it is made of.

Bonus: How do you think the part was made? What’s the evidence or reasoning?
PolyStyrene (PS)
PolyPropylene (PP)
Polypropylene (PP)
PET
PET - Plastic Bottle Preform
PolyEthylene
PolyEthylene
PolyEthylene
PVC (poly vinyl chloride)
ABS (acrylonitrile butadiene styrene)
Polyethylene (low density)
Polystyrene (two ways!)
PLA (poly-lactic acid) has a lower melting temperature than ABS.
Plastic Recycling

not everything gets recycled (even if it’s recyclable)

sorting, shredding, cleaning processing

30% of PET bottles recycled

2.5 million water bottles are discarded per hour, in the US alone!

10% of all plastics are recycled, 15% is burned

* 2010 Environment Agency report
Energy In Plastic

5 lbs of plastic ~ gallon of gasoline
Paper vs. Plastic

2 plastic bags use 13% less energy to make than one paper bag

and produce 72% less pollutants than one paper bag

but do not degrade and come from a non-renewable resource

* institute for lifecycle environmental assessment
<table>
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<tr>
<th>Sunday</th>
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<td>10-250</td>
<td>7:30pm</td>
<td>PLAYsentations!</td>
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*Mockup Consulting*

*4 weeks*
Logistics

PLAYsentations are Tuesday May 15th, 7:30pm Room 10-250

Plan, design, buy!

Make the most of lab time; **be on time**
Plastics