nysical Science 9
Mr. Voight

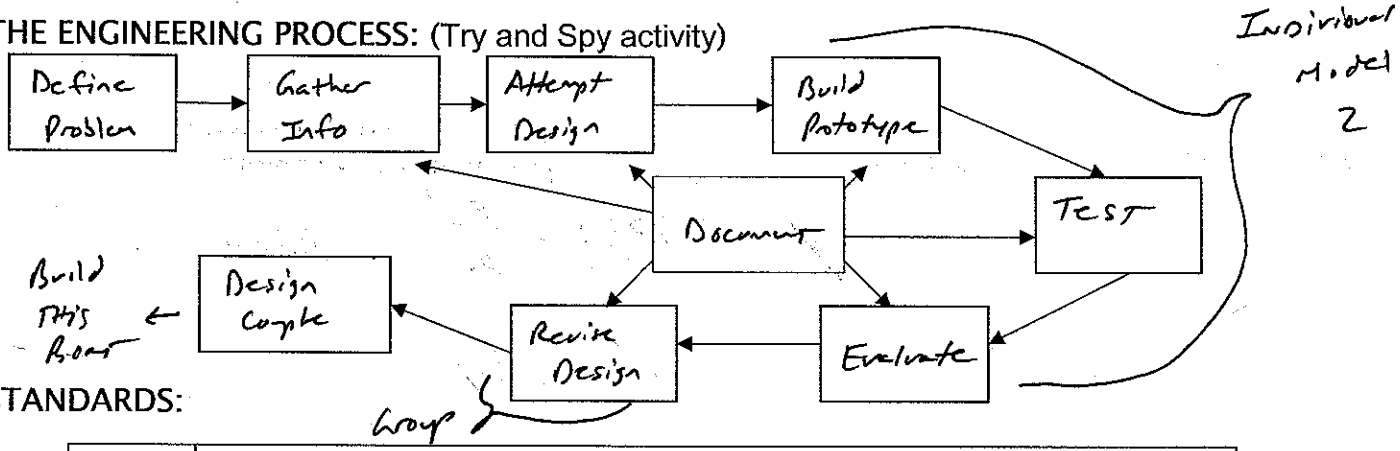
Name: NOTES
Hour 1 2 3 4 5 6

Engineering Design Packet

PROJECT DESCRIPTION

This project is the single most anticipated project for ninth graders at MGJH. Students will work in groups to design, analyze, build, and race a boat made entirely of cardboard and duct tape. This project incorporates a variety of engineering standards which will allow students to critically think about the design of their boat, how it is to be constructed efficiently, and the effectiveness of the boat as a sea-faring vessel. The key to success for this project, like many group projects, is the ability to collaborate as a group. All group members need to play instrumental roles in all aspects of the design, construction, and analysis of the boat. Do not be afraid to collaborate with your teacher and other students; engineers do not work in a box. Share your ideas with each other so that you can build the best boat in the easiest manner possible. The engineering of scale models is the first step in the boat project.

THE ENGINEERING PROCESS: (Try and Spy activity)



STANDARDS:

GRADED

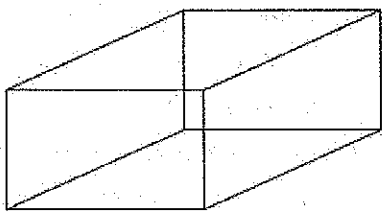
91346	Analyze the strengths and limitations of physical, conceptual, mathematical and computer models used by scientists and engineers.
91211	Understand that engineering designs and products are often continually checked and critiqued for alternatives, risks, costs and benefits, so that subsequent designs
91212	Recognize that risk analysis is used to determine the potential positive and negative consequences of using a new technology or design, including the
91213	Explain and give examples of how, in the design of a device, engineers consider how it is to be manufactured, operated, maintained, replaced and disposed of.
91221	Identify a problem and the associated constraints on possible design solutions.
91222	Develop possible solutions to an engineering problem and evaluate them using conceptual, physical and mathematical models to determine the extent to which the solutions meet the design specifications.
91341	Describe how technological problems and advances often create a demand for new scientific knowledge, improved mathematics and new technologies.

Have Fun and Learn!

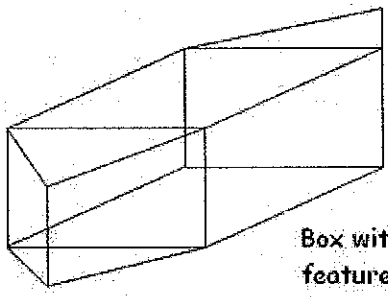
Gather Information

As you look at the schedule of events, you will notice that you have a limited time to work on your scale models, analyze your designs, and plan your theme. Much of this time is going to be self-directed. It is absolutely necessary that your group use your time wisely to prepare yourselves before it comes time to build your boat. Good planning can save a ton of mistakes and time! This is where the meat of the grade is earned!

Each boat design must contain "features." A feature is anything that deviates the exterior surface from a rectangular prism.



Simple box - no features



Box with 2 features - pointed front and back.

Scale for model boats 5 cm = 1 m

S = Scale measurement
R = real measurement

Calculating scale: $\frac{(R)\ 5cm}{1m} = \frac{S\ (R)}{R}$ $R(5cm) = S$

Scale model weight (g) = 0.125 x boat and passenger weight (kg)

Cardboard
mass = 0.915 kg/m^2
Cost = \$2.93 /m^2

Duct tape
mass = 0.0107 kg/m
Width is approximately 0.05 m
Cost = \$ 0.25/m

Density of water = 1 g/cm^3

1 m = 100 cm

each piece is ~~1.97 m x 2.28 m~~ 2.13m x 3.04m

1 kg = 2.2 lbs

Volume = length x width x height

1 kg = 1000 g

Area of rectangle = length x height

Area of triangle = ½ x base x height

Volume of a pyramid = area of base x height x 1/3

YOUR PLANNER HAS HELPFUL FORMULAS!

Attempt a Design

MODEL 1 – class example

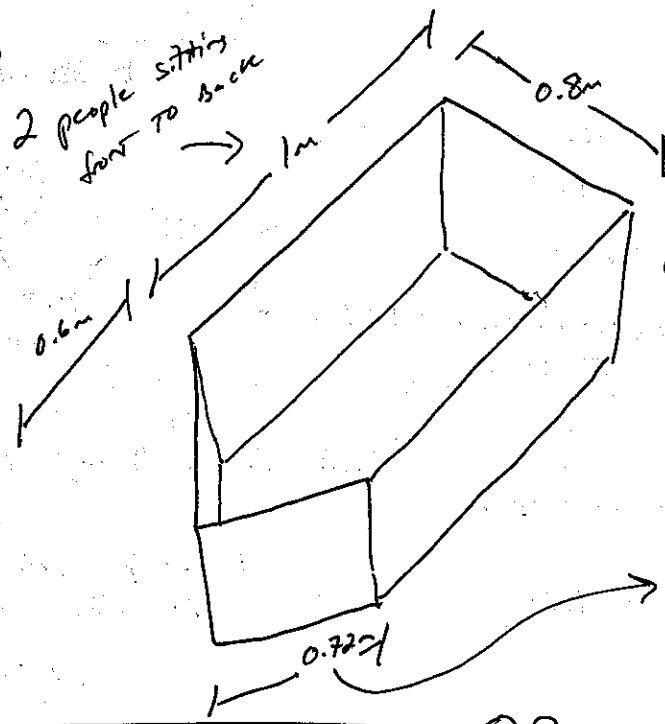
Top/back/front/side views

3D sketches DON'T require all of these views

STUDENTS SHOULD "get in" the BOX on the floor and take real measurements of their body to determine the appropriate size.

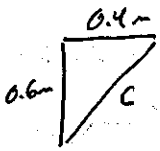
THIS is WHAT I call a "HOUSE Boat" (1 FEATURE)

3D



– sitting on knees (spread apart for stability)

= distance from floor to just below shoulder



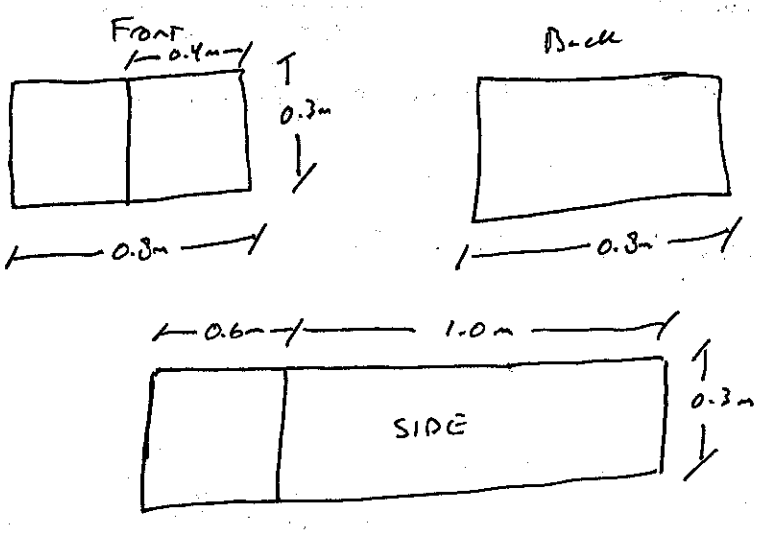
$a^2 + b^2 = c^2$

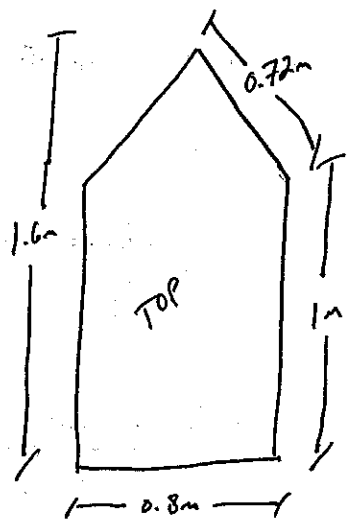
$c = \sqrt{(0.4m)^2 + (0.6m)^2}$

$c = 0.72m$

OR

2D





Briefly describe the design of your boat; focus specifically on the pros/cons of each "feature."

THIS SHOULD BE IN JP form

House Boat

Flat Bottom - more stability & less hydrodynamic

Pointed front - more hydrodynamic (cuts through water)

Straight sides/back - more space for passengers

open front - more space for passengers

etc...

Build a Prototype

What is the surface area of your boat? *(determine the area of each piece and add them together – area = l x w)*

↳ 2.13 m x 3.04 m = 6.48 m²

Front (2) x 0.72 m x 0.3 m = 0.432 m²

Back (1) x 0.3 m x 0.8 m = 0.24 m²

Sides (2) x 1.0 m x 0.3 m = 0.6 m²

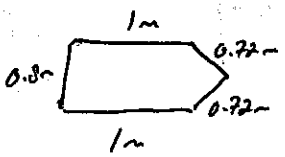
Bottom (1) x 0.8 m x 1.0 m (rectangle) + $\frac{1}{2}$ x 0.8 m x 0.6 m (triangle) = 1.04 m²

2.312 m² ← TOTAL cardboard needed

WHAT will you DO w/ extras? / TOTAL cardboard allotted

How much tape do you expect to use during construction? *(Do some math – show your work – assume you will cover the entire surface with duct tape 2-3 times – use the surface area of your boat and the width of the duct tape!))* THIS is a "Rough Estimate"

(1) Determine the perimeter of your boat



= 4.24 m

↳ Multiply this by 6 or 7 to allow for uncertainty + bottom

178.08 m of DT

(2) Determine the height = 0.3 m

(3) Determine the # of strips to cover a side → $\frac{0.3\text{m}}{0.05\text{m/strip}}$ = 6 strips

(4) Multiply step #3 by step #1 = 4.24 x 6 = 25.44 m of DT

How much do you expect this boat to weigh? *(Weight of boat = cardboard + duct tape – use the surface to calculate the weight of the cardboard)*

2312 m² of cardboard + 178 m of DT

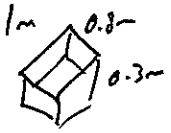
$\frac{2.312\text{m}^2\text{CB}}{1\text{ m}^2\text{CB}} \times \frac{0.915\text{ Kg}}{} = 2.12\text{ Kg CB}$

$\frac{178\text{m DT}}{1\text{ m DT}} \times \frac{0.0107\text{ Kg DT}}{} = 1.91\text{ Kg DT}$

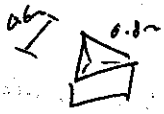
4.03 Kg

What is the total volume of water that can be displaced by the boat? *(hint – what is the volume of your boat? – "break down" your boat into simple shapes to determine the volume of each piece before adding them all together – Your planner has helpful resources!)*

Volume = area × height



$V = 1.0m \times 0.8m \times 0.3m = 0.24m^3$



$V = \left(\frac{1}{2} \times 0.8m \times 0.6m\right) \times (0.3m) = 0.072m^3$

(area) (h)

$0.312m^3$

This is how much water will be displaced

How much weight will this boat support? *(What is the mass of the volume of water above? – this is how much weight you can put in your boat before sinking)*

Convert $0.312m^3 \rightarrow$ Kg H_2O

$$\frac{0.312m^3 H_2O}{} \left| \frac{100\ cm\ H_2O}{1\ m\ H_2O} \right| \frac{100\ cm}{1m} \left| \frac{100\ cm}{1m} \right| \frac{1\ g\ H_2O}{1\ cm^3 H_2O} \left| \frac{1\ Kg\ H_2O}{1000\ g\ H_2O} \right| = 312\ Kg$$

$$\frac{312\ Kg}{1\ Kg} \left| \frac{2.2\ lbs}{} \right| = 686.4\ lbs$$

How much do the boat and passengers weight together? *(use your answer above and the weight of passengers – this should be in kilograms.)*

Boat = 4.03 kg (from previous question)

Passenger #1 = $200\ lbs \times \frac{1\ Kg}{2.2\ lbs} = 91\ Kg$

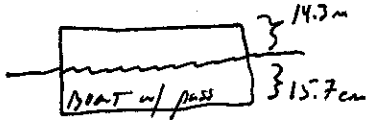
Passenger #2 = $150\ lbs \times \frac{1\ Kg}{2.2\ lbs} = 68\ Kg$

163.2 kg (Boat + passengers)

How far do you expect your boat to sink? *(set up a proportion comparing your boat's height and maximum capacity to the weight of passengers and boat.)*

$$\frac{\text{wt of Bt/pass}}{\text{Capacity}} = \%\text{ in water} \times \text{height of Boat} = \text{expected "sinking"}$$

$$\frac{163.2\ Kg}{312\ Kg} = 0.52 \times 0.3m = 0.157m$$



What is the recommended weight capacity for this boat? Why have you selected this number? *(How much of your boat should be above the water to be "safe"? How much weight does this represent?))* I want a minimum of 10 cm above H_2O → Go Backwards

$0.2m = 0.3m \times \%$

$\frac{0.2m}{0.3m} = \%$

$\% = 0.66$

$(312Kg)\ 0.66 = \frac{BC}{312\ Kg}(312Kg)$

$205.9\ Kg = BC$

$205.9\ Kg - \overset{\text{Boat}}{4\ Kg} =$

≈ 200 Kg

How much time do you expect to spend on each task while building this boat? *(Determine the total amount of time you have for building and budget the time according to your tasks.)*

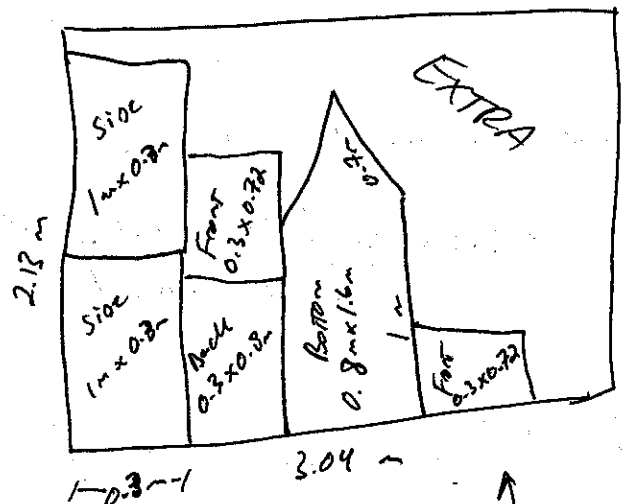
- PARTS LAYOUT (2 hours)
- CUTTING (5 hours)
- Assembly (4 hours)
- Decorating (2 hours)
- Problem solving (2 hours)

} These are roughly estimated

TOTAL TIME allotted = 5 hr/person in group

Describe how this vessel should be constructed. (Include a *cutting diagram*, *parts list*, and *specific instructions* for how to construct the boat from raw materials.) – attach additional sheets as necessary

(make this to scale)

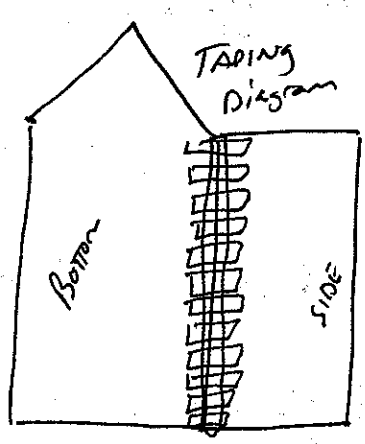


1. lay out Parts on CD
2. CUT out Parts
3. ATTACH parts

etc...

Your directions need to be ultra specific
→ provide diagrams for how you will Tape, etc...

Like a puzzle
- determine the most efficient method for laying out parts



Attempt a Design

MODEL 2 – Your design requires 3 features

Top/back/side/front views

To get a 5 your model needs 4 features!!

THE following questions are identical to model 1

Briefly describe the design of your boat; focus specifically on the pros/cons of each "feature."

Build a Prototype

Describe how this vessel should be constructed. (Include a *cutting diagram*, *parts list*, and *specific instructions* for how to construct the boat from raw materials.) – attach additional sheets as necessary

Standard 91213

1	2	3	4	5
The student is not able to provide direction on how the original paper is turned into a boat. No pictures or diagrams are presented to assist the reader.	The student is able to generically describe how the prototype should be constructed. Lots of ambiguity exists in the instructions and no diagrams are added to assist the reader.	The student is able to describe how the prototype should be constructed but lacks specific details. Some ambiguity is present in the directions and limited diagrams are added for assistance.	The student is able to describe how the prototype should be constructed in detail. No ambiguity exists in the directions. Some sketches or diagrams are presented but lack clarity or purpose.	The student is able to describe in great detail how the prototype should be constructed. No ambiguity exists in the directions. Diagrams and sketches are presented to assist the reader and are relevant and accurate.

What is the surface area of your boat?

How much tape do you expect to use during construction?

How much do you expect this boat to weigh?

What is the total volume of water that can be displaced by the boat?

How much weight will this boat support?

How much do the boat and passengers weight together?

How far do you expect your boat to sink?

What is the recommended weight capacity for this boat? Why have you selected this number?

How much time do you expect to spend on each task while building this boat?

* BUILD your scale model using Paper + Scotch Tape
Pretend as though you are trying to replicate the real thing!!

Test

Test your boat; what happened during the test that you anticipated? Did not anticipate?

was it tippy?

Did it leak?

tilt to one side?

Did the test increase or decrease your confidence in this model? Why?

Why might you question the results of the test?

- Pennies vs. People
- Paper v. Cardboard
- Scotch Tape v. Duct Tape

etc...

Standard 91222

1	2	3	4	5
A possible solution is offered but answers to the questions are incomplete and/or not supported by math.	A possible solution containing at least 2 features is offered. The student answers the above questions using math but errors exist in the math or thinking.	A possible solution containing 3 features is offered. The student accurately presents answers to the above questions using math.	A possible solution containing at least 3 features is offered. The student accurately and thoroughly presents answers to the above questions using math as evidence	A possible solution containing at least 4 features is offered. The student accurately and thoroughly presents answers to the above questions using math as evidence with great detail.

Evaluate the Design

Describe your confidence in the ability of this boat to support passengers. How many passengers can comfortably fit in the vessel and still paddle? Are there any problems with passenger configuration? How so?

What about this boat would lead you to success in the race and overall project grade?

making it all the way around the pool and staying dry!