Hull Design
Module Description and Goals

• Hull design module gives students insight into types and various designs of hulls

• It also talks about evolution of hull

• This module uses open-ended hands-on activities to teach basic principles in hull design
Contents

- Ship: Definition and Uses 05 min.
- What is a Hull? 05 min.
- Historical Development of Hull 15 min.
- Hands-on Activity – 1: Build a Floating Container 20 min.
- Different Hull Bottoms 10 min.
- Hands-on Activity – 2: Build a Boat 45 min.
- Hull Shape 10 min.
- Hands-on Activity – 3: Test Different Hulls 30 min.
- Ship Resistance 30 min.
- Suggest a Hull Design 05 min.

Total Time 3 hours
What is a Ship? What are the Uses of a Ship?

A ship is a large vessel that floats on water.

A ship is a large, manned, self propelled vehicle that is used for transporting a payload on, over or under the ocean’s surface.

Ships can be used for merchant, military or entertainment purposes.
What is a Hull?

A Hull is the watertight body of a ship or boat.

- Hull provides buoyancy that keeps ship floating (Safety)
- Hull provides space to carry cargo (Cargo Carrying)
Historical Development of Hull
• Next few slides have different watercrafts from different time periods of history

• Please identify hull of each watercraft and discuss its characteristics related to
  1. cargo carrying capacity
  2. safety
Wood Log Raft

- Simplest form of a watercraft
- Simplest form of hull

Cargo Carrying ??

Mostly used to carry simple cargo, human beings

Safety ??
- Unsafe
- Mostly used in rivers

http://www.downtheroad.org/Asia/imagesNEW/China/DSC00041.JPG
Round Boat

- Simple floating structure
- Simple hull

Cargo Carrying ??

Mostly used to carry simple cargo, human beings

Safety ??

Unsafe, mostly used in rivers
Dug Out Canoe

- Basic hull shape
- Small size
- Dug out from wooden log

Cargo Carrying ??

Mostly used to carry simple cargo, human beings, vegetables, food

Safety ??

Safe in rivers, big ponds

Viking Ship

- Wider hull provided strength beneath the waterline
- Less likely to tip or bring in water
- Waterproofed with moss drenched in tar.

Cargo Carrying ??
Mostly used as a military and supply vessel

Safety ??
Relatively safe in seas because of wide hull

http://www.theplatelady.com/
Sail Ship

- Faster with well shaped hulls
- Roman, Spanish and French sail-ships had well designed hulls

Cargo Carrying ??

Mostly used for expeditions, could carry any type of cargo

Safety ??

Safest known design in 17th Century
Steam Ships

- Bigger, wider hull
- Steam power increased carrying capacity and thus hull size

**Cargo Carrying ??**

Could carry any cargo, proved important in military operations

**Safety ??**

Safe, controlled designs

http://upload.wikimedia.org/wikipedia
Motorized Ships

- Best design to sustain harsh conditions
- Extended life because of new materials
- Increased carrying capacity

Cargo Carrying ??
Can carry any type of cargo

Safety ??
Safest known design of modern times

http://www.maritime-connector.com/Administration

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Hands-on Activity- 1

Build a Floating Container
Hands-on Activities

You are given

Play-Doh  Craft Sticks  Pebbles

Build a container that can hold all the pebbles and is stable in unstable water

Just now you have designed crudest form of hull...

Now let us shape it
Did You Build Something Like This?

What is the use of sticks in this **structure**?

- How many sticks did you use?
- How many pebbles did your hull hold?
BREAK

5 Minutes

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Different Hull Bottoms

We will look into different types of hull bottom and bow designs

Every hull has a bottom built to one of three basic shapes or combination of them: Flat, V or Round

Flat Bottom Hull

Round Bottom Hull

“V” Shape Hull

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Different Hull Bottoms

- Simplest and least expensive to build
- Restricted to sheltered waters like lakes, ponds
- Unstable in seas, oceans therefore can be used for tugs, barges etc, but not for ocean going vessels

Flat Bottom Hull
Different Hull Bottoms

- Cuts water very fast
- Stable in rough waters
- Can be used for wide range of vessels (from speedboats to ocean going vessels)

“V” Shape Hull

Because of its suitability at high speeds, used in military ships; like destroyers
Different Hull Bottoms

- Round bottom hulls have maximum carrying space
- Stable in rough waters
- Most difficult to build using materials like steel and hence are costly

Round Bottom Hull
Hands-on Activity - 2

Build a Boat
Hands-on Activities

Build A Boat

- You are given few K’Nex parts and Aluminum foil
- Build a hull shape that can hold maximum pebbles
- Use K’Nex parts to build structure
- Use aluminum foil to make skin

Important

Implement the things you learned in Play-Doh – Stick design
Were you able to build a structure like this?

What is the role of blue members in this structure?
Observe the shape of this structure from the front side

Does it look like \( V \)

Please keep this shape in mind
Observations

• How many pebbles could your boat hold?

• Did your boat easily float?

• Did you observe any differences in your Play-Doh Stick and K’Nex Boats?
5 Minutes

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Now let us think about the shape of the hull
Hull Shape

Why did designers select this?

And not this shape?
Hands-on Activity - 3
Hands-on Activities

Test 3 Types of Bow – Hull Designs and determine which one covers the distance in minimum time?
Hands-on Activities

Instructions

STEP 1: Fill channel with water
STEP 2: Put triangular hull – ship with new set of batteries in the channel
STEP 3: Start the motor and start the stopwatch
STEP 4: Measure and record time required to cover the distance by the ship (Take three readings)
STEP 5: Repeat steps 1-4 for other two hulls with fresh batteries
Hands-on Activities

Observations

• What did you find out?

• Which hull covered the distance in minimum time?

• Why?

• Discuss the results
Hull Shape Contd.

Waterflow

Less Resistance

More Resistance
But where did the original designers get this idea from?

fish.dnr.cornell.edu

http://courses.washington.edu/

www.epa.qld.gov.au/.../grey_nurse_shark.jpg

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https://.../Great+Transformations+BJW
Resistance Encountered by Ship

- Any moving body experiences drag (resistance)
- Ships also face resistance

Identify resistances encountered by ship
Resistance Encountered by Ship
Resistance Encountered by Ship

Any ship experiences 2 types of resistances

- Water Resistance
- Air Resistance

Water resistance is much more than air resistance

Let us calculate water resistance encountered by previously tested hull designs
Resistance Encountered by Ship

Use following formula and values given in your worksheet

\[
F_d = c_d \frac{1}{2} \rho v^2 A
\]

where

- \( F_d \) = drag force (N)
- \( c_d \) = drag coefficient
- \( \rho \) = density of fluid
- \( v \) = flow velocity
- \( A \) = characteristic frontal area of the body
Resistance Encountered by a Ship

Based on the results of your calculations recommend the best shape for hull (Bow)

• Triangular
• Semi-Circular
• Rectangular
Check on Learning

• In the next few slides you will see different ships (hulls) docked in dry dock

• Try to identify the type of hull and its application for a ship.
Check on Learning

MarineTech
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Check on Learning
Suggest A Hull Design

• You will be given requirements for a ship
• Suggest a type of a ship that would be the best for this application
• Based upon knowledge you have gained so far suggest type of bow, and bottom of hull
Application 1:

Iron Ore Carrier carries ore from Brazil to Netherlands

- Bulk Carrier
- Round Bottom Hull (Max. Space)
- V or Round Bow
Application 2:
To carry iron ore / wood in the Mississippi river

- Barge
- Flat Bottom Hull
- Square Bow
Application 3: Extreme Test for a Ship

Ship travelling in icy Arctic region

- Ice Breaker
- Round Bottom
- V Bow
Review of Topics

• Definition of Ship – Uses of Ships
• Definition of Hull
• Historical Development of Hull
• Hull Bottoms – Flat, V and Round
• Hull Shapes – Testing of different Bow- Hull Designs
• Resistance Encountered by Ships
• Calculation of Resistance
• Test your knowledge – suggest a hull design
Thank You

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