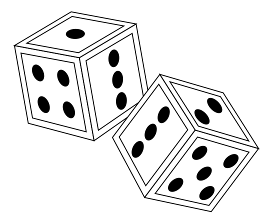
Design

and



ENGINEERING

Thomas Jefferson National Accelerator Facility - Office of Science Education
http://education.jlab.org/

Design and Engineering

HOW MANY DICE CAN YOUR ALUMINUM FOIL BOAT FLOAT?

1. Your team's job is to design and build four boats from four squares of aluminum foil. Only one square of aluminum foil can be used per boat. No other materials, such as tape, paper or staples, can be added to the foil.
2. Talk with you teammates about how different boats look. What kinds of boats can your team make from the foil? How might they look? Draw some plans for your boats before you start to build them.
3. **As a team**, build **one** boat at a time.
4. When one boat is complete, test it by first floating it in the water, then carefully load the boat with dice until it sinks. Count the number of dice the boat **successfully** floated and record that number on the data sheet.
5. Remove the boat from the water, label it and put it in a safe place. **DO NOT PLAY WITH IT!!** Your team may need it later!
6. Use what you learned from the last boat to make a new, better boat. Use a new square of foil for each new boat.
7. After your team has built and tested all four boats, decide on a price for the best one.
8. Write your team's name and the price for your team's best boat on the bid slip.
9. The best boats will be demonstrated in front of the class, so make sure you **keep your boats safe!**

WHAT COULD OUR BOAT LOOK LIKE?

(Draw some sketches here)

Team Name: ______________________________

Team Members: ___________________________

____

____

____

Price for our best boat: **$**

Prototype	Number of Dice Held

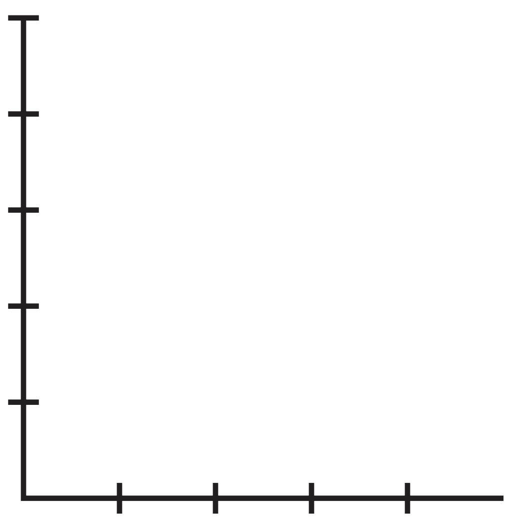
TAKE A CLOSER LOOK!

Directions: Calculate the **mean**, **median** and **mode** of your data.

Mean	Median	Mode

LET'S MAKE A GRAPH!

Directions: Make a **bar graph** showing how many dice each of your boats held. Don't forget to label and title your graph! **Extra:** Why didn't we make a line graph?



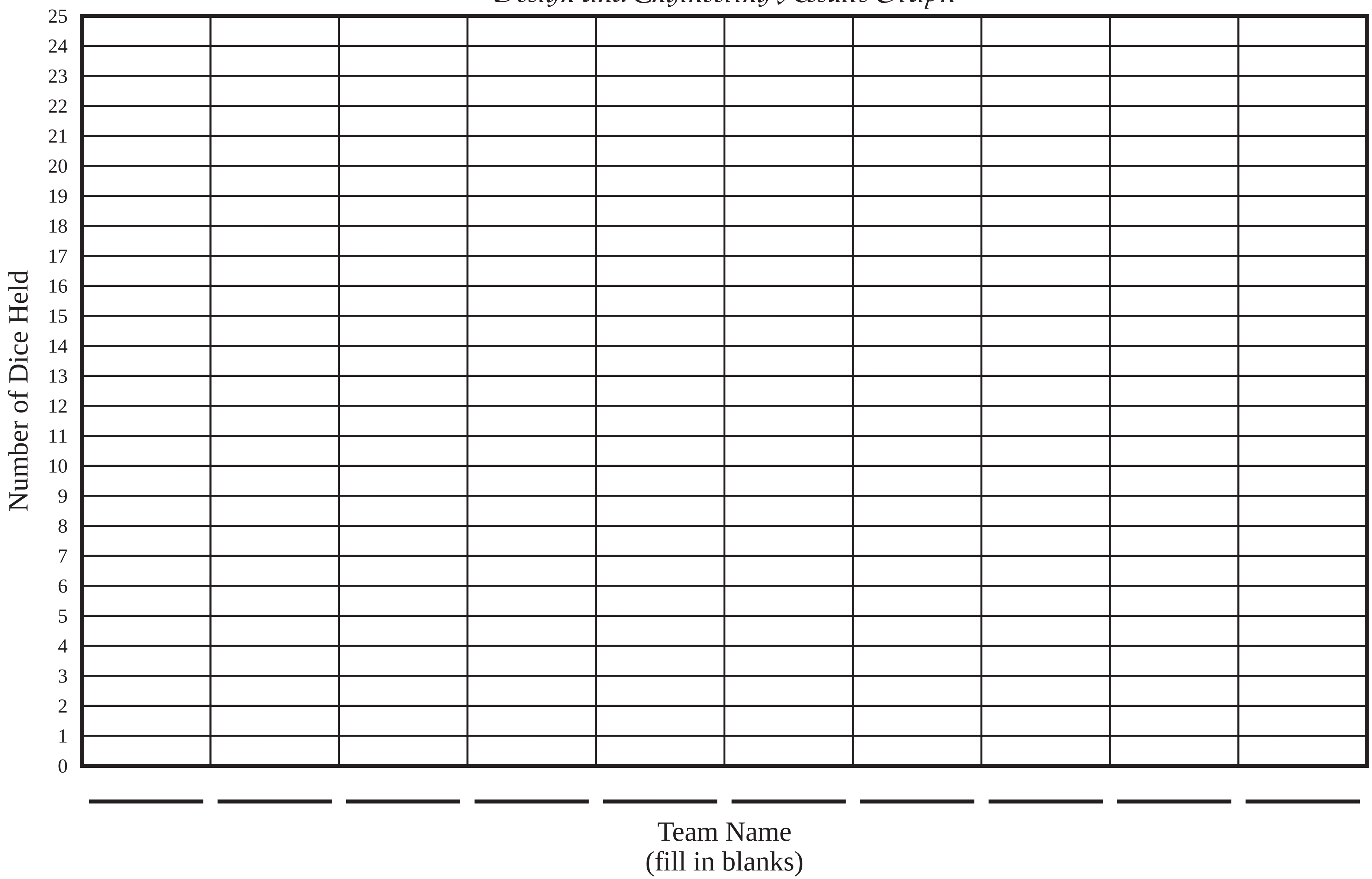
Design and Engineering Cost Analysis Chart

Team Name	How many dice do we need to carry?	How many dice did the team's best boat hold?	How many boats will it take to hold all of the dice?	How much does the team's best boat cost?	How much will it cost to buy all of the boats needed?

LET'S MAKE A GRAPH!

Directions: Create a **bar graph** showing how many dice each team's best boat held.

Design and Engineering Results Graph



Writing About Inventions

DURING THE DESIGN AND ENGINEERING ACTIVITY AT JEFFERSON LAB, YOU USED CREATIVITY TO DESIGN A BOAT TO HOLD AS MANY DICE AS YOU COULD.

Write about a new invention designed to make life easier. You may already have an original idea about an invention you wish you could have, or you might have some good ideas about how to make an invention that already exists, better. Write about what your invention would be able to do. How much would it cost? Who would be most interested in your invention? Write about what you would do with this invention if you had it. How would it change the way you live? After you finish describing your invention, draw a picture of what it would look like. You may want to label any special parts or features that it has, and be sure to give it a name!

Team Name: *Student team 1*

Team Members: *Student 1*

Student 2

Student 3

Student 4

Price for our best boat: $ *7.00*

Prototype	Number of Dice Held
1	12
2	8
3	17
4	2

TAKE A CLOSER LOOK!

Directions: Calculate the **mean**, **median** and **mode** of your data.

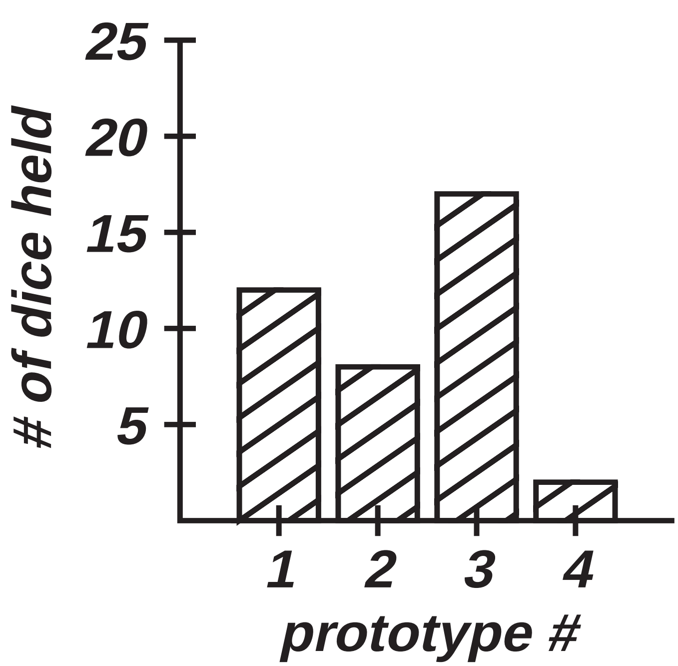
Mean	Median	Mode
9.75	10	NA

LET'S MAKE A GRAPH!

Directions: Make a **bar graph** showing how many dice each of your boats held. Don't forget to label and title your graph! **Extra:** Why didn't we make a line graph?

Extra: Line graphs are used for continuous data while bar graphs are used for descrete data. No boats exist 'in between' boats 1, 2, 3 and 4, so a bar graph is appropriate.

How many dice did our boats float?



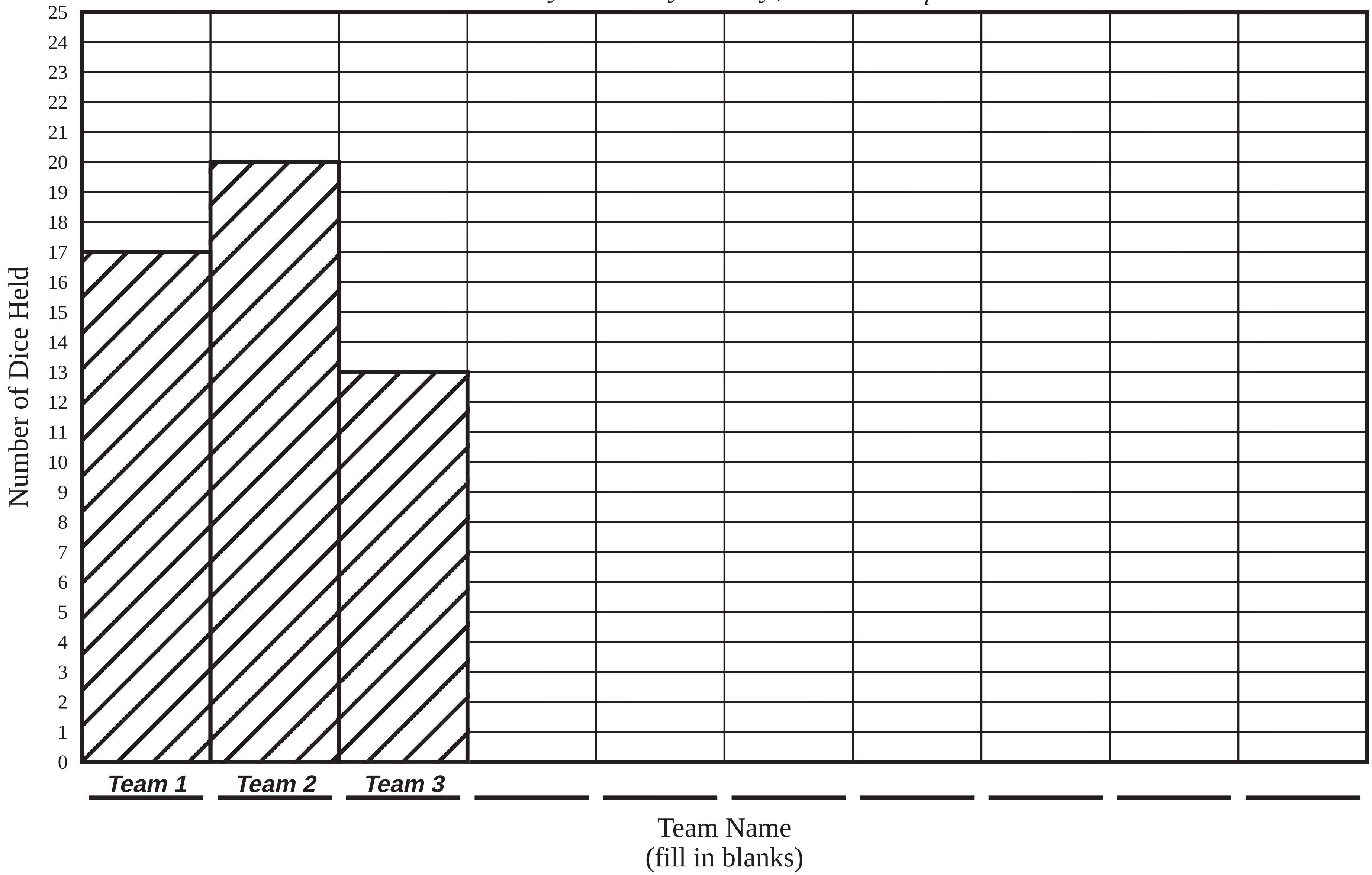
Design and Engineering Cost Analysis Chart

Team Name	How many dice do we need to carry?	How many dice did the team's best boat hold?	How many boats will it take to hold all of the dice?	How much does the team's best boat cost?	How much will it cost to buy all of the boats needed?
Student team 1	***100***	***17***	***6***	***$7.00***	***$42.00***
Student team 2	***100***	***20***	***5***	***$8.50***	***$42.50***
Student team 3	***100***	***13***	***8***	***$4.30***	***$34.40***

LET'S MAKE A GRAPH!

Directions: Create a **bar graph** showing how many dice each team's best boat held.

Design and Engineering Results Graph



Design and Engineering

This is an activity in which students work in teams to design and build aluminum boats that will carry the most cargo.

Objectives:

In this activity students will:

- work in teams
- design four boats from squares of aluminum foil
- build the boats they designed
- test their boats by floating them and loading them with cargo (dice) to measure their strength
- record data
- place a value on their best boat
- create a bar graph depicting how many dice each of their boats held
- compare the cost effectiveness of their best boat with the boats of other teams using the amount of cargo held, how many of their boats it would take to deliver a specified amount of cargo, and the cost of all the boats that would be needed
- create a bar graph depicting how many dice each team's best boat held

Questions to Ask:

1. How did the way you loaded your cargo affect the stability of your boats?
2. Can you see a pattern in your boats and how many dice they held?
3. If you owned the company that needed to transport cargo by sea, would you purchase the best boat your team was able to build? Why or why not?

Travel Book Activities:

- Writing About Inventions

Virginia State Standards of Learning

English 6.1 Oral Language
- by oral participation in small group activities

Math 6.1 Number and Number Sense
- by determining the cost involved in moving large amounts of cargo

Math 6.2 Number and Number Sense
- by comparing the number of boats needed to carry cargo depending on a boat's limit

Science 6.1 Plan and Conduct Investigations
- by recording precise and approximate measures
- by stating hypotheses in a way that identifies the independent and dependent variables
- by manipulating one variable over time with many repeated trials
- by collecting, recording and analyzing data
- by organizing and communicating data through graphical representations

Science 6.2 Demonstrate Scientific Reasoning and Logic
- by investigating, testing, and analyzing "boat" designs
- by basing conclusions on scientific evidence from a variety of sources

LS.1 Plan and Conduct Investigations
- by organizing data into tables showing repeated trials and means
- by defining variables
- by establishing criteria for evaluating a prediction
- by identifying sources of experimental error
- by identifying independent variables, dependent variables and constants
- by controlling variables with repeated trials to test hypotheses

PS.1 Plan and Conduct Investigations
- by recording and interpreting data from bar graphs
- by identifying independent and dependent variables, constants, controls and repeated trials
- by using research methods to investigate practical problems

Design and Engineering
Teacher Overview and Materials List

Background:

The purpose of this activity is to provide an opportunity for students to go through the planning, designing, model-building and cost analysis process that many scientists and engineers use as they solve problems and develop new technologies.

Minimum Materials Needed for Each Student Group:

Four square sheets of heavy duty aluminum foil measuring 12 centimeters (~4.5 inches) on a side

A small bowl of water

~25 dice

Notes:

- If you use pennies in place of dice, be aware that pennies minted after 1982 contain a lot of zinc and are lighter than older pennies.

Materials for Design and Engineering