NCTM Annual Meeting and Exposition

Boston, MA

Tour sessions
April 16, 2015 - 8am or 2pm
April 17, 2015 - 8am or 2pm

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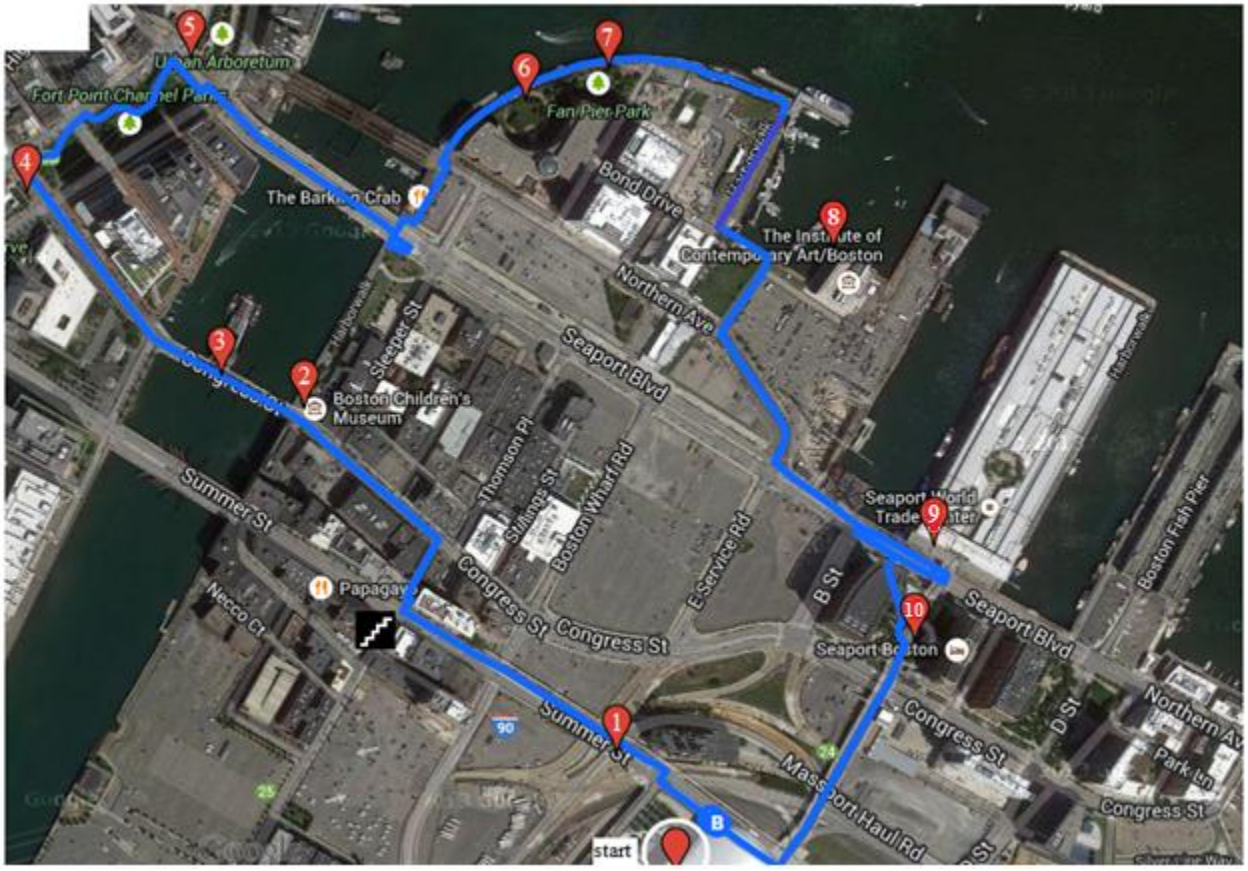
Map of Tour



1. South Boston
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8. Institute of Contemporary Art
9. World Trade Center
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Mathematics Challenge Tour: An Introduction

Welcome to Boston's Mathematics Challenge Tour, created especially for the 2015 NCTM Annual Meeting! This two-mile tour is along the South Boston waterfront. If you choose to attend the scheduled walking time, Boston University guides will greet you. You can also take this tour on your own! This tour was designed in the late fall by graduate students and faculty members from Boston University. Due to recent construction and the Marathon bombing trial proceedings, you may have to take detours or skip challenges.

Within this packet, there are 10 different mathematical challenges related to stops along the tour. It helps to have a calculator and you will need a pen or pencil. We invite you to discuss how you might solve the challenges with others. Please revisit the sites such as the Boston Tea Party Museum to learn more history or to develop new problems at your leisure.

We have included a variety of types of problems in the tour. Some problems ask you to calculate an answer and some ask you to simply plan out a solution strategy. The problems come from different mathematical domains and have connections to other disciplines such as history, city planning, architecture, and physics. We hope this tour will remind you how mathematics can be found everywhere and inspire you to think about how you can integrate mathematics into lessons that examine your own city or town. Mathematical tours can be designed to take place anywhere — consider putting together a tour that explores a school, mall, park, or museum. Tours can also focus on a specific mathematical content or a CCSS Mathematical Practice. The website, http://www.mathsinthecity.com/find-list, can help you get started. It is also a place to share your own tour ideas.

Thanks for taking the Boston Mathematics Challenge Tour. Please send your comments and share your experiences with us — Laura Callis at lkcallis@bu.edu or Suzanne Chapin at schapin@bu.edu.

Now, let's get touring!

Note: This tour requires participants to walk 2 miles and navigate stairs and cobblestones. The tour will take approximately 90 minutes. To start the tour at the Convention Center, turn onto Summer Street and proceed along the overpass.

Challenge 1: South Boston

Summer Street Overpass, 250 Summer St., Boston, MA 02210

Fort Point, South Boston, 1925

About This Site

Welcome to South Boston, one of the U.S.'s oldest and most historic neighborhoods! Known as an Irish-American working class neighborhood, South Boston, or "Southie" attracts many visitors with restaurants, museums, a convention center, as well as a gorgeous shoreline. South Boston still maintains a community atmosphere making it one of the friendliest and most popular places to visit!

Mathematical Challenge:

This challenge starts as we walk along the Summer Street overpass. Do you know the length of your walking pace? The ability to use your stride to estimate lengths and distances is very handy since most of us don't travel with measuring devices in our back pockets!

Use the time we are walking on the overpass to calculate the length of your own stride. The parking meters are spaced at intervals of 30 feet each. Check your measures by conducting more than one trial!

After passing over the highways on Summer Street, you will go one more block and **then take stairs down to the lower-level streets, onto A Street.** When you are on A Street, go under Summer Street, up one block, and then take a left onto Congress Street. Walk down Congress Street until you reach the big Hood milk bottle outside of the Children's Museum, where we will stop for Challenge 2.

Challenge 2: Boston Children's Museum

Milk Bottle Kiosk, 308 Congress Street, Boston, MA 02210

About This Site

The milk bottle kiosk was built in 1933 by Arthur Gagner. He used it to sell homemade ice cream in Taunton, MA (about 30 miles south of Boston). It was one of the first fast-food drive-in restaurants!

In 1977, Hood bought and renovated the kiosk, and then donated it to the Children's Museum. The giant milk bottle was cut into 3 pieces and transported to this location by a barge in the "Great Bottle Sail." It has been standing here since April 20, 1977. It is 40 feet tall and has a diameter of 18 feet.

Fun fact: If the kiosk were a real milk bottle it would hold 58,620 gallons (or 221,901 liters) of milk.

Mathematical Challenges:

1. The average 3-year old child is about 3 feet tall and a real milk bottle is 10 inches tall. How tall should a model of a 3-year old be in order to match the proportions of the kiosk?

2. How might you calculate or estimate the volume of the milk bottle kiosk? Talk to your colleagues.

3. What are the different ways the milk bottle could be cut into 3 pieces? What would the pieces look like?

To get to Challenge 3, turn right out of the Children's Museum and continue walking on Congress Street until you reach the Boston Tea Party Museum.

Challenge 3: Boston Tea Party

Boston Tea Party Museum, 306 Congress Street, Boston, MA 02210

About This Site

The Boston Tea Party took place on December 16, 1773. That evening, between the hours of 7pm and 10pm, 116 people protested the taxes imposed on them earlier that year by throwing containers of tea overboard from three ships: the Dartmouth, Eleanor, and Beaver. The revolutionaries threw 342 containers overboard, containing 90,000 pounds of tea. Tea was stored in both small containers that held 100 pounds and large containers the held 400 pounds of tea. The total damage due to lost tea was approximately £10,000.

In reaction to the Boston Tea Party, the British government passed a series of Intolerable Acts in 1774 as punishment. These include the Boston Port Act (passed March 31), Administration of Justice (May 20), Massachusetts Government Act (May 20), and Quartering Act (June 2). These acts continued to escalate tensions between Great Britain and the colonies, leading to the American Revolution.

Mathematical Challenge:

Given the numerical facts about the Boston Tea Party shared above, talk with a partner and come up with a question that can be answered using mathematics. Then proceed to answer your question.

To get to Challenge 4, continue walking on Congress St until you reach the corner of Atlantic Ave. and Congress St. Cross the street onto the Greenway.

Challenge 4: Boston Greenway

Atlantic Avenue and Congress Street, Boston

About This Site

The Boston Greenway is a ribbon of six connected parks that extend from Chinatown to the North End. This used to be the site of an elevated highway, but thanks to the Central Artery Project (also known as the Big Dig), this highway was relocated underground and by 2006 was completely replaced with these parks.

The parts of the Greenway that you currently see are the Fort Point Channel Parks. These extend along Atlantic Avenue from Congress Street to Oliver Street.

Mathematical Challenges:

1. The average American city is 11.6% green space. The city of Boston's total land acreage is 31,000 acres. If 26,000 of these acres are **not** green space, what percent of land in Boston is used for green space?

2. How does Boston compare to these other cities?

    1. New York - 19.6%
    2. Washington D.C. - 19.4%
    3. San Francisco - 18.0%
    4. Jersey City - 17.1%

3. Boston, among high population density cities, ranks only behind Washington DC in the ratio of park acreage to city residents. There are 8.1 acres per 1,000 residents in Boston (Washington DC has 13.1 acres per 1000 residents). How many residents did Boston have when this ratio was calculated?

To get to Challenge 5, turn right on Atlantic Avenue and walk to the corner of Atlantic and Seaport Blvd.

Challenge 5: Big Dig

Seaport Boulevard and Atlantic Avenue

About This Site

The Central Artery/Tunnel Project (known as the Big Dig) was a massive public works project in Boston. It replaced the elevated interstate highway that ran through the downtown with an underground tunnel.

The project took 15 years and cost over 14 billion dollars. It is still the most expensive public works project in U.S. history. Another expensive public works project was the San Francisco bridge replacement that cost 6.3 billion dollars — less than half the cost of the Big Dig!

Mathematical Challenges:

1. Sixteen (16) million cubic yards of dirt were removed to make way for the Big Dig tunnels. If a truck that is 40-feet long holds 30 cubic yards of dirt, how many trucks were needed to move all of this dirt?

2. It the trucks were lined up end-to-end starting in Boston, would they stretch all the way to the start of the Boston Marathon in Hopkinton? (Hint: There are 5280 feet in 1 mile and a marathon is 26.2 miles.) Would they stretch to Florida? To San Francisco?

To get to Challenge 6, take a right onto Seaport Boulevard and walk over the water. Take a left on Sleeper St. and a second left on Northern Ave to get to the HarborWalk. Continue to the Moakley Courthouse.

Challenge 6: Moakley Federal Courthouse

One Courthouse Way, Boston, MA 02210

About This Site

The John Joseph Moakley United States Courthouse is an architectural masterpiece that was completed in 1998. Henry Cobb designed the courthouse to include an 88-foot tall glass wall overlooking the Boston Harbor and 2.25-acre public walkway.

There are 27 courtrooms in the courthouse; more space is dedicated to the public than in any other courthouse. The courthouse encourages the public to use the space by hosting educational visits for students, tours, and a grassy spot to relax by the harbor!

Mathematical Challenges:

1. Estimate the diameter of the circular lawn between the courthouse and Boston Harbor. Think about how the length of your pace might be used.
2. Talk about how you could determine the center of the circle.
3. Consider the advantages and disadvantages of using an actual location such as this park to investigate circumference, diameter and pi. How does this type of learning experience differ from using a circle printed on paper?

To get to Challenge 7, continue walking along the HarborWalk. Stop at the one of the plaques along the walkway.

Challenge 7: Fan Pier

Fan Pier, Marina Park Drive, Boston

About This Site

This area along the waterfront is known as Fan Pier though it no longer resembles a pier. It was created in the 1860s and was shaped like the prongs of a fan, making it an ideal place for transporting cargo from the ocean inland via the railroad.

Like Fan Pier, much of the land of Boston was created with fill. Boston was originally a hilly peninsula, nearly an island, but many of the hills were dismantled to fill in mud flats and bays to make more room for the growing city and to take care of landfill and sewage issues.

Boston's changing coastline and disappearing hills are one reason why the city has streets that twist and turn.

Mathematical Challenge:

As you walk along the HarborWalk, read the plaques that describe the history of Fan Pier. Ask your guide to point out important landmarks such as the Tobin Bridge and Logan Airport.

Use the map on the next page to estimate the percent of increase in Boston's land area.

The link below enables you to see how Boston has grown throughout time by adding fill:
http://www.bc.edu/bc_org/avp/cas/fnart/fa267/sequence.html

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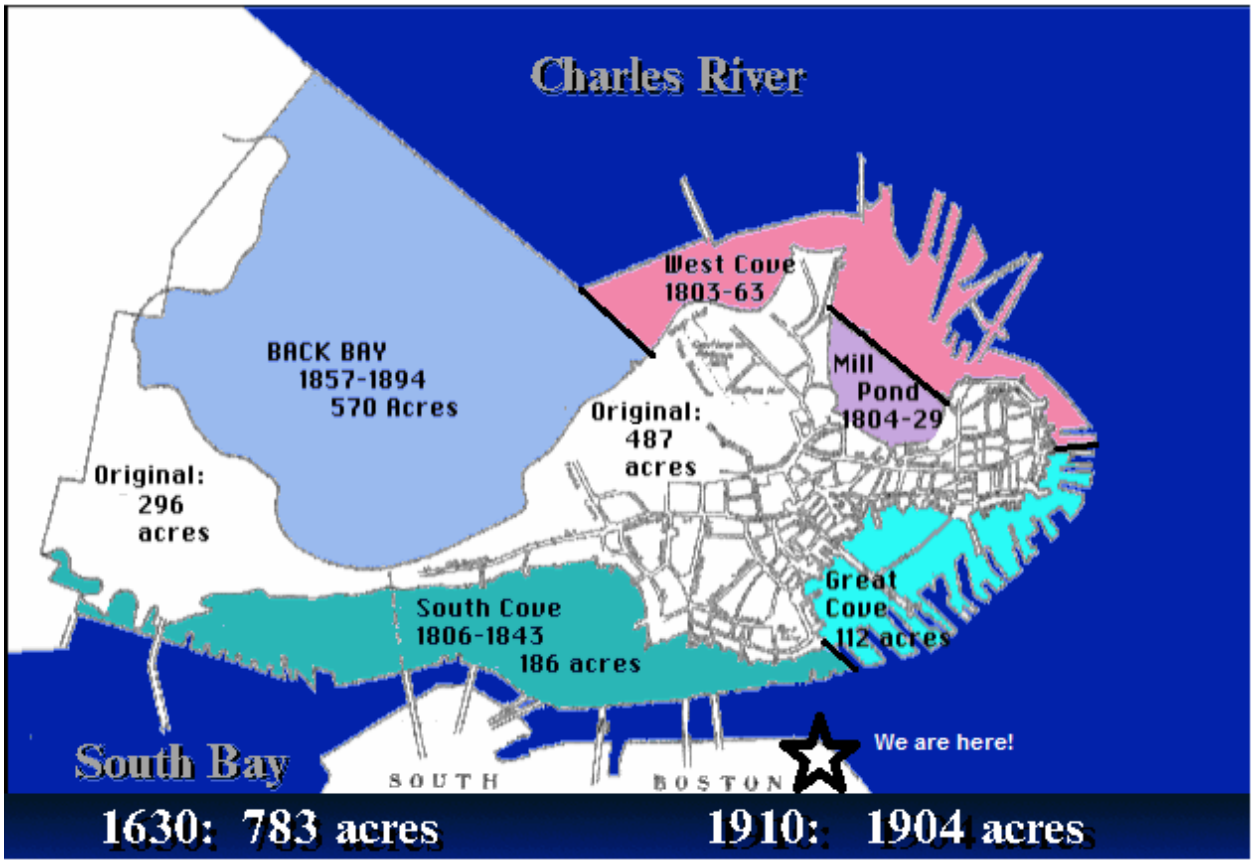


The above map is of "Downtown Boston," a subset of the city. Boston consists of many neighborhoods such as Back Bay, the North End, Southie and Fenway. Many of these neighborhoods were created using fill but are not included on this map (see interactive website for a complete picture). The white portion of the map above indicates the original landmass. Some of the additions are shown.

To get to Challenge 8, follow the HarborWalk. Some of it is blocked by construction. Cut across a small park and turn left to reach the Institute of Contemporary Art.

Challenge 8: Institute of Contemporary Art

Institute of Contemporary Art, 100 Northern Ave, Boston, MA 02210

About This Site

The Institute of Contemporary Art is a small modern art museum with rotating exhibits. Built in 2005, the building hosts arts and cultural events. It also hosts the *Red Bull Cliff Diving World Series* where the world's best high divers leap 90 feet into the Boston Harbor. A short film about the event is here: http://www.icaboston.org/red_bull_cliff_diving/

Mathematical Challenge:

Given that gravity results in a constant acceleration of about 32 feet/sec^2, estimate how fast a diver would be moving as he or she hit the surface of the Harbor, approximately 90 feet below.
(Hint: $d(t) = \frac{1}{2} at^2$ and $d(v) = at$)

To get to Challenge 9, walk through the parking lot to Seaport Boulevard, take a left, cross the street, and go up the stairs next to the wire sculpture of a dragon. On your left is the World Trade Center.

Challenge 9: World Trade Center

Boston World Trade Center, 200 Seaport Boulevard, Boston 02210

About This Site

The Boston World Trade Center was built in 1901. It was then called Commonwealth Pier and was used as a maritime cargo facility handling both freight and passenger traffic. It was the largest pier building in the world at that time. During World War II, it was used as a debarkation point for soldiers.

This building and pier were transformed into the Boston World Trade Center in 1986. It is now operated by the Seaport Hotel for conventions, functions, and meetings.

Mathematical Challenge:

On January 15, 1919, a tank filled with molasses collapsed in the North End neighborhood of Boston, releasing a wave of molasses that flooded the streets. The Boston Post headline read: "Giant wave of 2,300,000 gallons of molasses, 50 feet high, sweeps everything before it —100 men, women and children caught in sticky stream—buildings, vehicles, and L-structure crushed." Imagine that the molasses made it to the World Trade Center and flowed right in. Would the molasses cover the floors of the 5 salons of the World Trade Center? If so, to what depth?

SQUARE FOOTAGE KEY

SPACE	SQ. FT.
Salon A	10,400
Salon B	7,200
Salon C	7,200
Salon D	10,200
Salon E	9,600

1 gallon = 0.133 cubic feet

To get to challenge 10, continue walking on Seaport Boulevard toward Summer Street.

Challenge 10: MBTA

MBTA World Trade Center Station, Boston

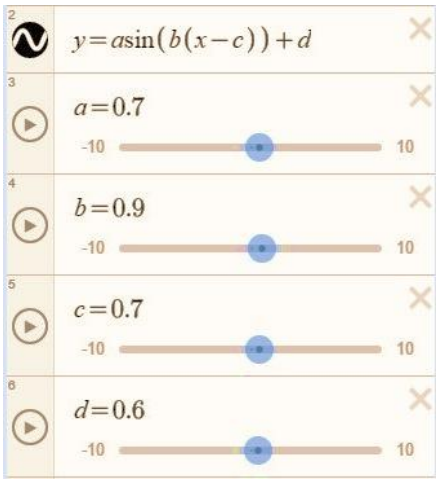
About This Site

The final stop of our tour brings us to a structure right outside of the World Trade Center Station of the MBTA. Did you know that Boston is the birthplace of American mass transportation? In terms of ridership, the MBTA is the nation's 5th largest transit system.

Commuters in Boston faced more than their share of challenges this year. During this winter's record-setting snowfall (108.6 inches!), portions of the MBTA were out of service for days and even weeks at a time.

Mathematical Challenge:

Look at the example of a sinusoidal curve outside of the MBTA stop. One way to explore this mathematics is graphically. Are you and your students using www.desmos.com? If not, you are definitely missing out! The graphing utility is completely free, web-based, and extremely user-friendly. One of the things that you can do on the site is upload a photo to serve as the background of a graph and then have students try to model some part of that photo mathematically. Notice in the picture below how the picture is incorporated — students then use sliders to help understand transformations of functions.



Take a picture of the curve for your own use. What questions might your students explore?

The tour guides will now lead you back to the convention center, but feel free to revisit any of the challenges. Thank you so much for participating in our mathematical tour of the South Boston waterfront!

Reference List

Challenge 1: South Boston
http://www.bpl.org/research/print/fortpoint/fortpt_img3.htm

Challenge 2: Boston Children's Museum
http://en.wikipedia.org/wiki/Boston_Children%27s_Museum#Hood_Milk_Bottle (image)
http://www.boston.com/travel/boston/2014/06/10/boston-hood-milk-bottle-quirkiest-landmark-america/KQE01CC0OTMKgYJQHmfMYJ/story.html
http://www.boston.com/thingstodo/family/gallery/042007hood_bottle/

Challenge 3: Boston Tea Party
http://www.bostonteapartyship.com/
http://www.boston-tea-party.org/facts-numbers.html

Challenge 4: Boston Greenway
http://www.bostongreenscene.net/2009/08/public-green-space---how-does-boston-measure-up.html
http://www.landscapeonline.com/research/lasn/2011/07/img/21302/21302-5.jpg

Challenge 5: Big Dig
http://en.wikipedia.org/wiki/Big_Dig http://www.massdot.state.ma.us/highway/TheBigDig/FactsFigures.aspx
http://en.wikipedia.org/wiki/List_of_most_expensive_U.S._public_works_projects

Challenge 6: Moakley Federal Courthouse
www.moakleycourthouse.com
Image:
http://www.yelp.com/biz_photos/john-joseph-moakley-courthouse-boston#GcDpER-OkSqAySq0nBX9ig

Challenge 7: Fan Pier
Images:
http://affordablehousinginstitute.org/blogs/us/2005/09/the_curse_of_to.html
http://www.archboston.org/community/showthread.php?t=4389
Maps and Apps:
http://www.iboston.org/rg/backbayImap.htm
http://bostongeology.com/boston/casestudies/fillingbackbay/fillingbackbay.htm
http://maps.bpl.org/sites/default/files/mapactivities/Boston%20over%20time%20activity.pdf
http://www.bc.edu/bc_org/avp/cas/fnart/fa267/boston/sequ_ani.gif

Challenge 8: Institute of Contemporary Art
http://www.icaboston.org/red_bull_cliff_diving/

Challenge 9: World Trade Center - Molasses Disaster
http://www.seaportboston.com/Commonwealth-Pier/Commonwealth-Pier-100th-Anniversary.aspx

Challenge 10: MBTA
https://www.desmos.com/

Answers, Tips, & Tricks

Challenge 2: Boston Children's Museum

1. $\frac{36\ in}{x\ in} = \frac{10\ in}{480\ in}$
   x = 1728 inches or 144 feet
2. Answers will vary.
3. Answers will vary

Challenge 4: Boston Greenway

1. There are 5000 acres that are green space (31,000 - 26,000).
2. 5,000/31,000 or about 16% of the land area is green.
   Boston is well above the average American city and just under the other cities listed.
3. $\frac{8.1\ acres}{1000\ residents} = \frac{5000\ acres}{x\ residents}$
   x ≈ 617,284 people

Challenge 5: Big Dig

1. 16,000,000 ÷ 30 ≈ 533,333.3 About 533,334 trucks were used.
2. 533,334 • 40 = 21,333,360 The length of the trucks placed end-to-end is about 21,333,360 ft.
   21,333,360 ÷ 5280 ≈ 4,040 The trucks placed end-to-end would cover a distance of about 4040 miles.
   They would stretch across the country!

Challenge 7: Fan Pier

Some estimates indicate that the percent of increase is about 143%, when including both the peninsula and the part of Boston attached to the mainland in the 1600s. This mainland piece was called the "Boston Neck" and was originally separated from the Boston peninsula by a city gate. Some estimates do not use this mainland piece in finding the percent increase and determine that there is an over 200% increase in the land area from the 1600s to the early 1900's. An interesting cross-curricular question is to ask students why historians might choose to use different numbers.

Challenge 8: Institute of Contemporary Art

About 77 feet per second, if initial velocity is assumed to be zero.

($d(t)$ = 90 = ½ at^2 = ½ •(32)•(t^2), so t^2 ≈ 5.6 and t ≈ 2.4 seconds

v(t) = at = 32 • 2.4 so v(t) ≈ 76.8 The diver is going about 77 feet per second (or 52 mph).

Challenge 9: World Trade Center

Total floor area of the salons: 44,600 sq. feet

2,300,000 • 0.133 ≈ 305,900 cubic feet

Height of molasses in the salons is about 6.86 ft