Three methods to determine acceleration on BART:

1. Rolling a ball and measuring the time to travel a specific distance.
2. Jumping and recording the time in the air and the distance traveled.
3. Hanging a bob and recording the angle from vertical.

Equations:

(I) $x = 0.5at^2 + v_i t + x_i$

Re-written to solve for acceleration:

(II) $a = (x - x_i - v_i t) / (0.5t^2)$

Re-written to solve for v_i:

(III) $v_i = (x - x_i - 0.5at^2) / t$

Rolling a ball

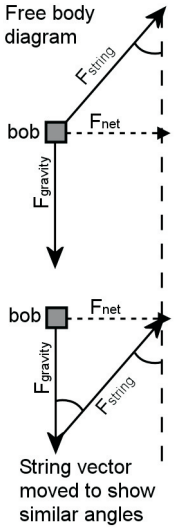
Allow a ball to roll along a track as the car accelerates. Measuring the time it takes to roll (from rest) a measurable distance will provide all the needed variables for equation (II).

Jumping

Jump as high in the air as you can when the train starts to accelerate. Measure the time you are in the air and how far you travel (in the x direction) during your jump, you will have all the variables necessary for equation (II). (Also, calculate your initial jump speed using equation (III)).

Hanging Bob

A *bob* is a device that hangs due to gravity. Using a protractor and a mass, you can measure the change in the angle of the bob as the train accelerates. Draw a free body diagram showing the force vectors of gravity (y) and the string's pull. Since the acceleration of the train is in the forward (x) direction, you can assume that the resultant vector from the addition of the force of gravity and the string's pull must be in the forward (x) direction. Using tangent, write out the equation that uses the gravity (y) and acceleration (net) vectors. If you substitute (ma) for F, and 9.8 m/s^2 for g, you can solve for the acceleration of the train.



The assignment:

You are to measure nine accelerations and nine decelerations of the train as it leaves or enters a station. Use each of the above method three times each for acceleration and deceleration.

1. Collect the data as the train begins its motion.
2. Calculate the acceleration between stations, but be ready to measure the deceleration when the train enters the station.

Bonus: Through the East Bay Hills tunnel, the train maintains about constant speed. Can you determine a way to calculate the steepness of the tunnel? (Think about Galileo's ramp.)

Name Period: Date:

Row	**Acc/Dec**	**Station**	**Experiment**	**Measurements** (include units)	**Calculations** (write out equation with data)	**Acceleration**
Positive Acceleration (leaving a station)						
1	Acc					
2	Acc					
3	Acc					
4	Acc					
5	Acc					
6	Acc					
7	Acc					
8	Acc					
9	Acc					
				Average		

Row	**Acc/Dec**	**Station**	**Experiment**	**Measurements** (include units)	**Calculations** (write out equation with data)	**Acceleration**
Negative Acceleration (entering a station)						
10	Dec					
11	Dec					
12	Dec					
13	Dec					
14	Dec					
15	Dec					
16	Dec					
17	Dec					
18	Dec					
				Average:		

Name: Period: Date:

In class assignment for those not attending the BART field trip.

Below is a list of "observations" made by a hypothetical group of students on BART. Using the attached tables, calculate the acceleration of the train in each case. When you have finished the work, you may work on assignments from other classes. Please remain quite and respectful of the class you are visiting.

Length of the track that ball rolls on: 1.824 m

Station	Entering		Leaving	
	Expt.	Data	Expt.	Data
Pleasant Hill			Rolling	1.74 s
Concord	Rolling	1.65 s	Rolling	1.72 s
N Concord/ Martinez	Rolling	1.82 s	Rolling	1.59 s
Pittsburg/ Bay Point	Rolling	1.78 s	Jumping	0.25 m; 0.65 s
N Concord/ Martinez	Jumping	0.35 m; 0.74 s	Jumping	0.15 m; 0.52 s
Concord	Jumping	0.28 m; 0.71 s	Jumping	0.22 m; 0.65 s
Pleasant Hill	Jumping	0.18 m; 0.53 s	Bob	7°
Walnut Creek	Bob	6°	Bob	8°
Lafayette	Bob	7°	Bob	6°
Orinda	Bob	7°		

Other problems:

1. Calculate the initial velocity for each jump listed above and record it in your table (show your work in the "calculations" cell of the table.

2. BART's maximum speed is 80 miles per hour.
   A. Convert this speed into meters per second. (1 inch = 2.54 cm; 1 mile = 5,280 ft.)
   B. Take your average deceleration and calculate how many seconds will it take BART to stop from 80 miles per hour.
   C. Use equation (I) to calculate *how far* the train travels in this time (remember the sign for deceleration is *negative*). Convert your answer from meters to miles.