# Simulated Friction and Acceleration Lab

In everyday life, we know that an object will eventually come to rest, but we have also learned that Newton's Third Law requires a force to slow or stop an object from moving. In many cases, that force is the force due to friction. If a box slides across the floor, the two imperfect surfaces rub against one another causes in force in the direction that opposes the motion. In this simulated lab, we will explore how different surfaces will cause different forces of friction.

## Procedure

1. Start Virtual Physics and select Acceleration and Friction from the list of assignments. The lab will open in the Mechanics laboratory.

2. The laboratory will be set up with a block on a table. The surface of the table can be changed to be made of different materials. Attached to the block is a small rocket that will be used to push the block.

3. Click on the red Recording button to save the position versus time data in the Lab Book. Click on the Force button to start moving the block. The rocket will turn off automatically after two seconds. When the block has stopped moving, click on the Pause button to stop the experiment and stop recording data. A new data link should appear in the Lab Book. Record what happens to the block in the data table on the next page.

4. You will try other types of materials of the block and the table to see how long it takes them to stop. Remember to click the Reset button before trying new materials. In the Parameters Palette choose the materials under the Frictions tab. Choose a variety of different types. Record the material of the block and table, the distance it travels until it stops and the time it takes to stop for each trial in the Table below. If the block reaches the end of the table, the experiment will stop automatically. Click next to each link in the Lab Book to label the link with the materials.

5. Fill out the table below with the different materials used for the object and the surface, the sliding distance, and the amount of time it takes the object to stop.

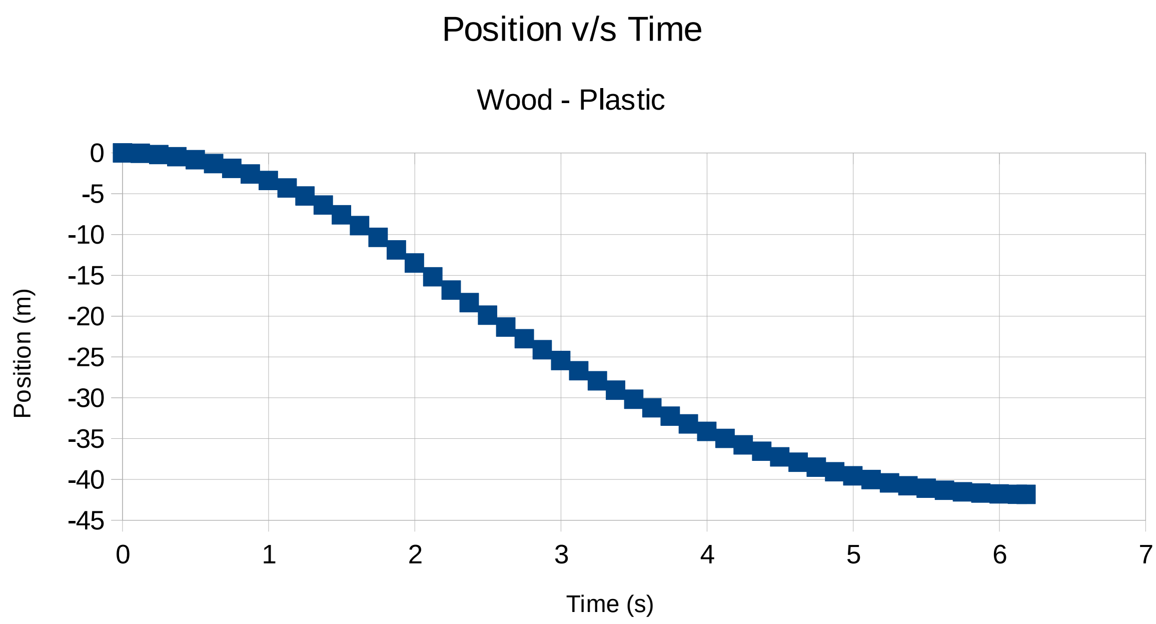
| Object Material | Surface Material | Distance (m) | Time (s) |
|---|---|---|---|
| Wood | Plastic | 41.8241 | 6.182 |
| Wood | Steel | 33.6924 | 5.369 |
| Wood | Wood | 17.1037 | 3.71 |
| Plastic | Steel | 25.3439 | 4.534 |
| Plastic | Rubber | 4.0165 | 2.401 |

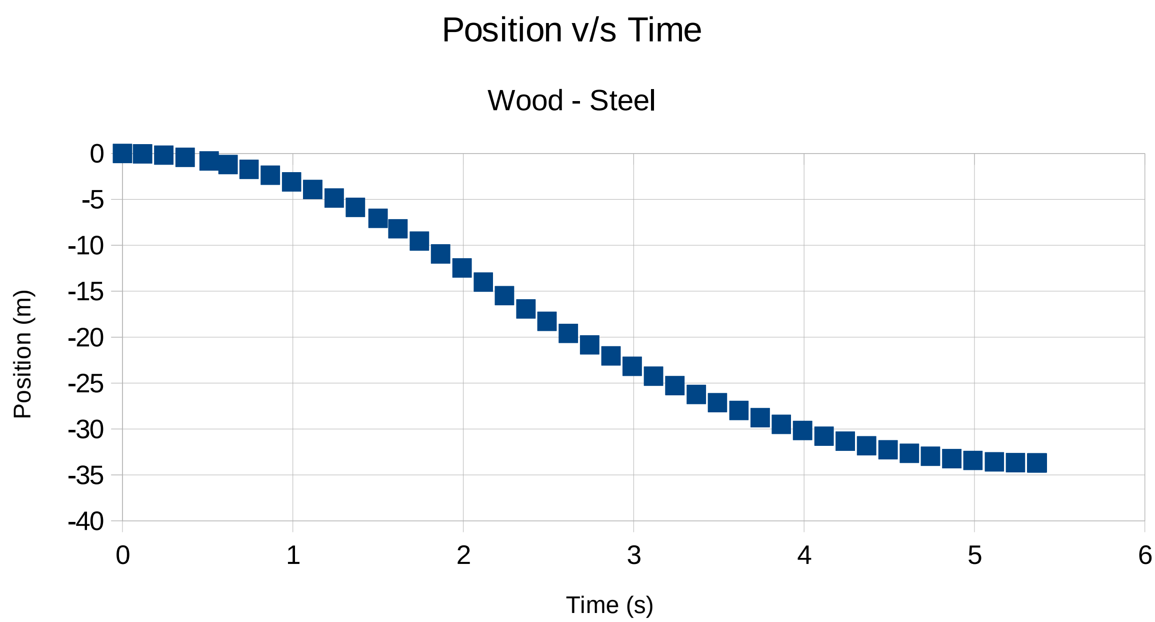
## Questions and Data Analysis

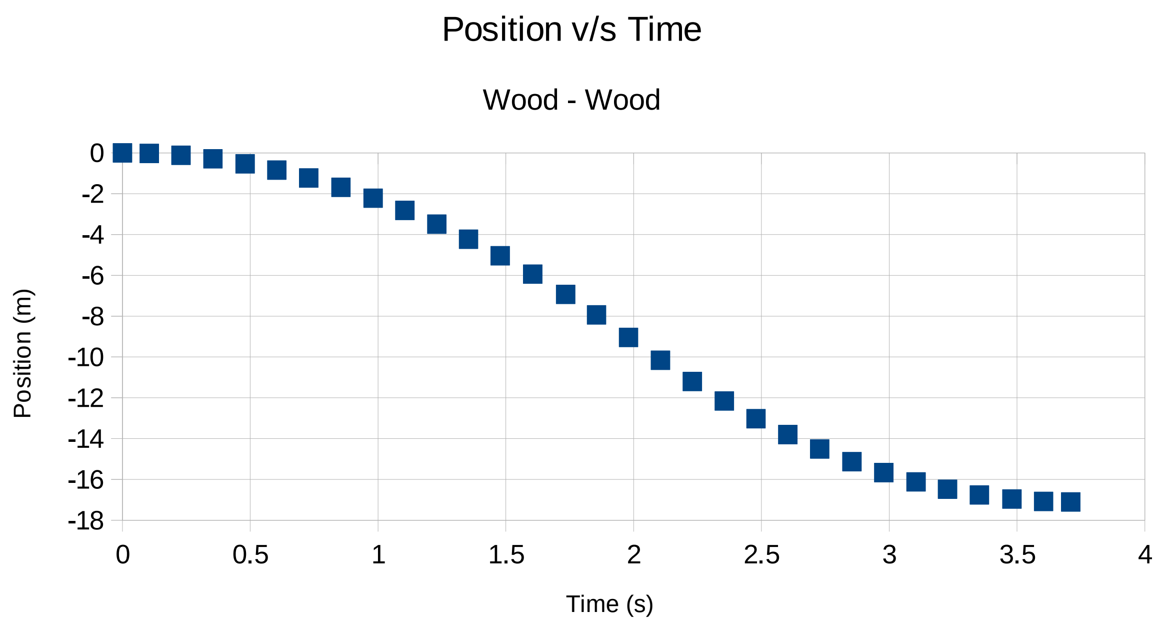
1. From the data table above, which combination of materials causes the greatest frictional force?

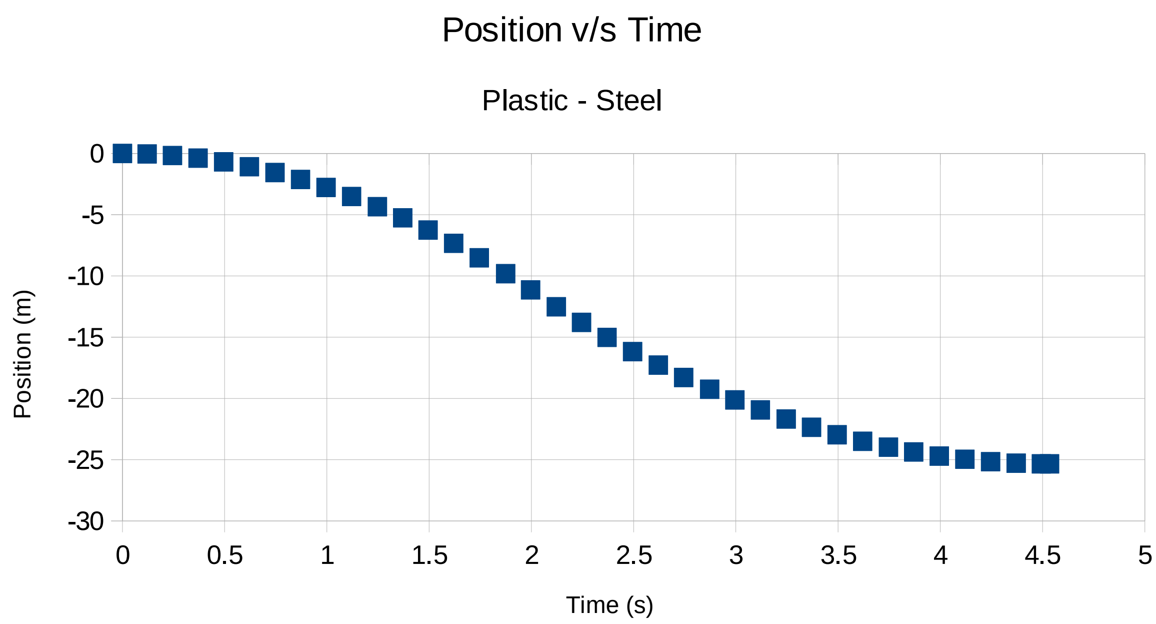
Plastic-Rubber pair causes the largest frictional force.

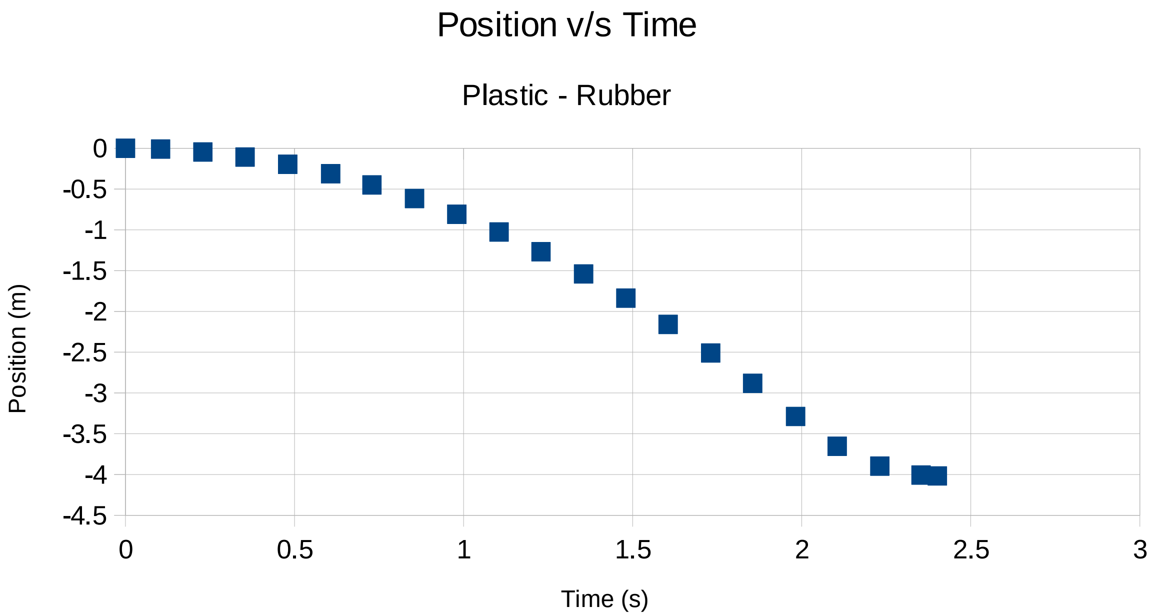
2. Plot the distance vs. time graph for each of the 5 runs corresponding to the 5 different combinations of materials. Make sure each graph is properly labeled and has the correct units.


Position v/s Time
Wood - Plastic
Position (m)
Time (s)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
0
1
2
3
4
5
6
7


Position v/s Time
Wood - Steel
Position (m)
Time (s)
0
-5
-10
-15
-20
-25
-30
-35
-40
0
1
2
3
4
5
6


Position v/s Time
Wood - Wood
Position (m)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
0
0.5
1
1.5
2
2.5
3
3.5
4
Time (s)

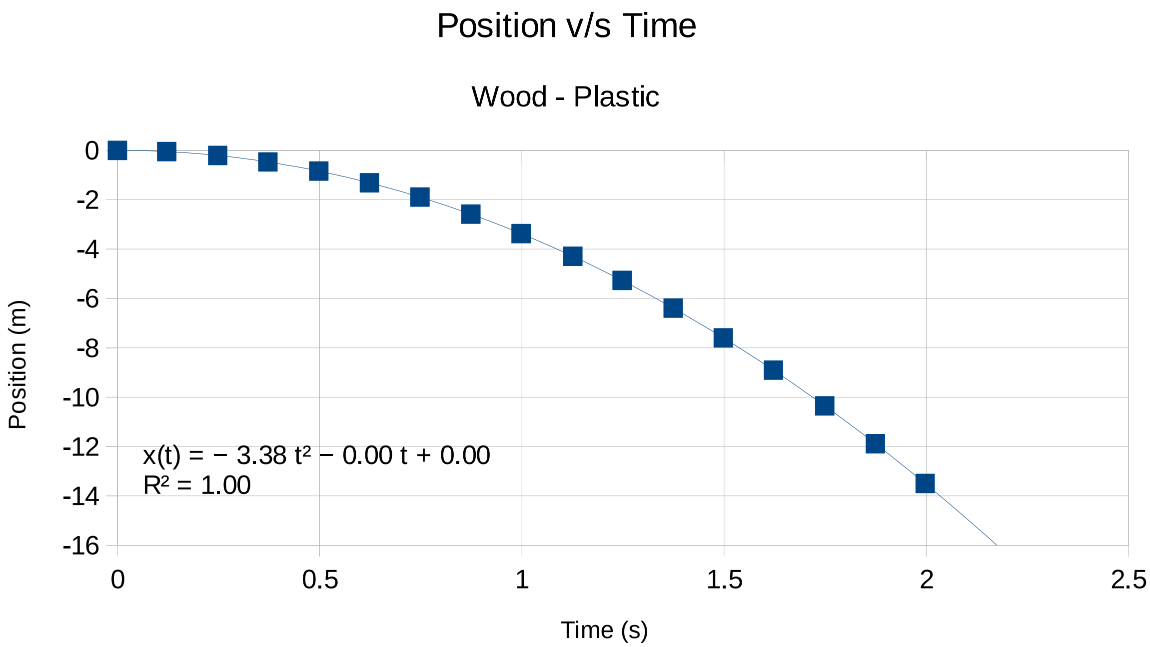

Position v/s Time
Plastic - Steel
Position (m)
0
-5
-10
-15
-20
-25
-30
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Time (s)

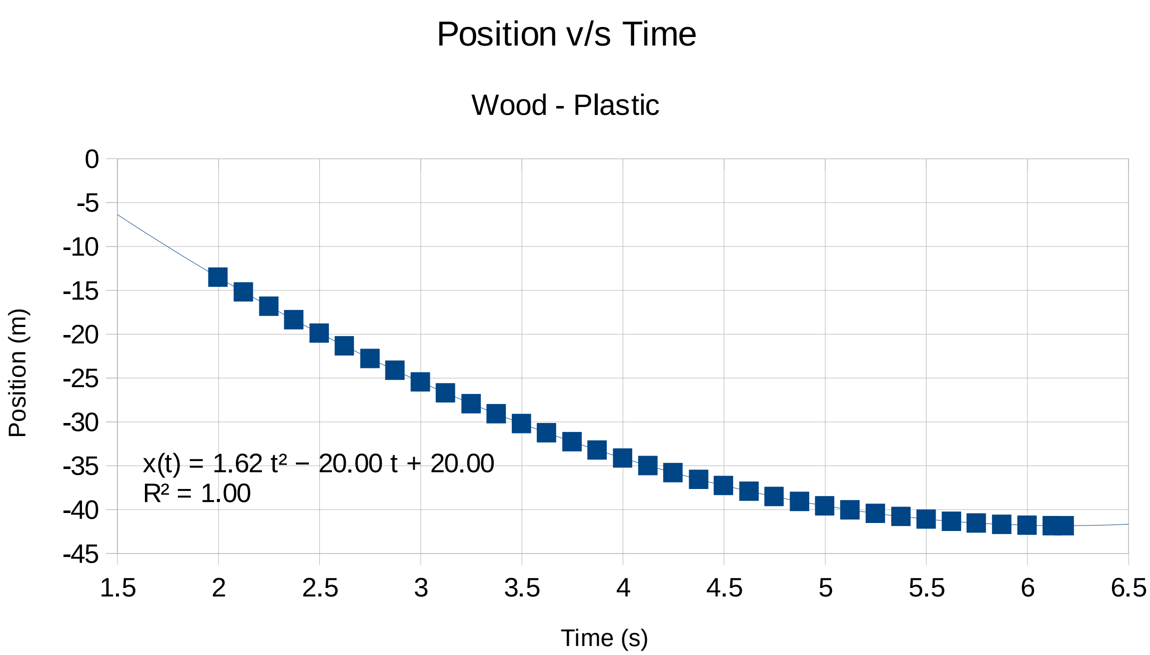


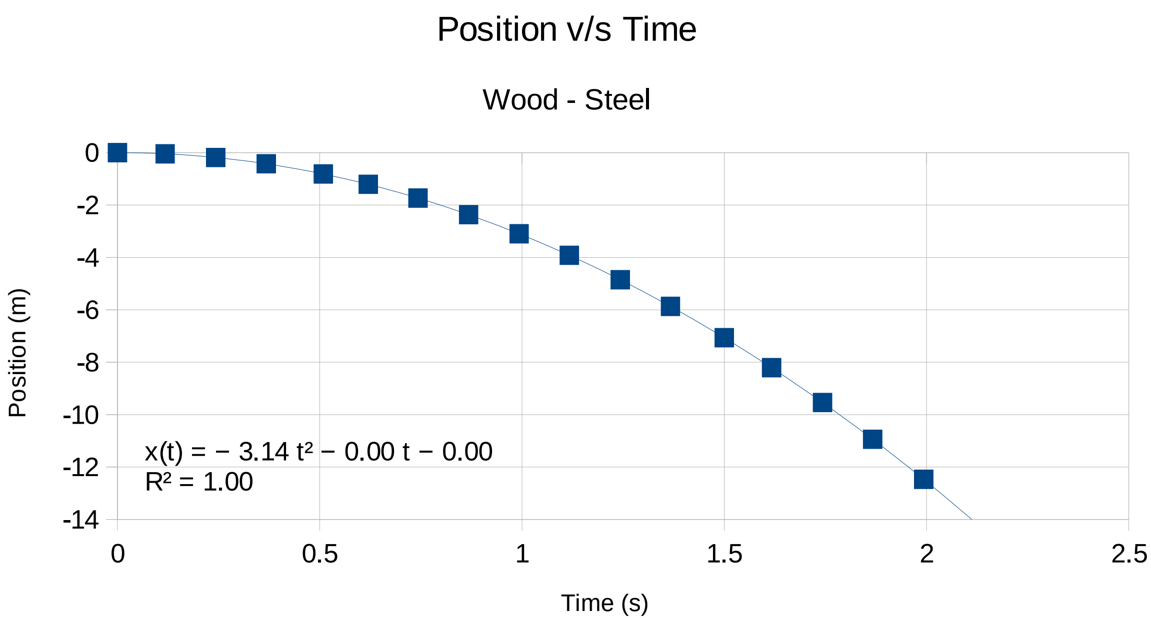

3. Given that the rocket is only turned on for two seconds and then instantaneously turned off, how does the shape of the distance vs. time graph change as it crosses the 2 s mark?

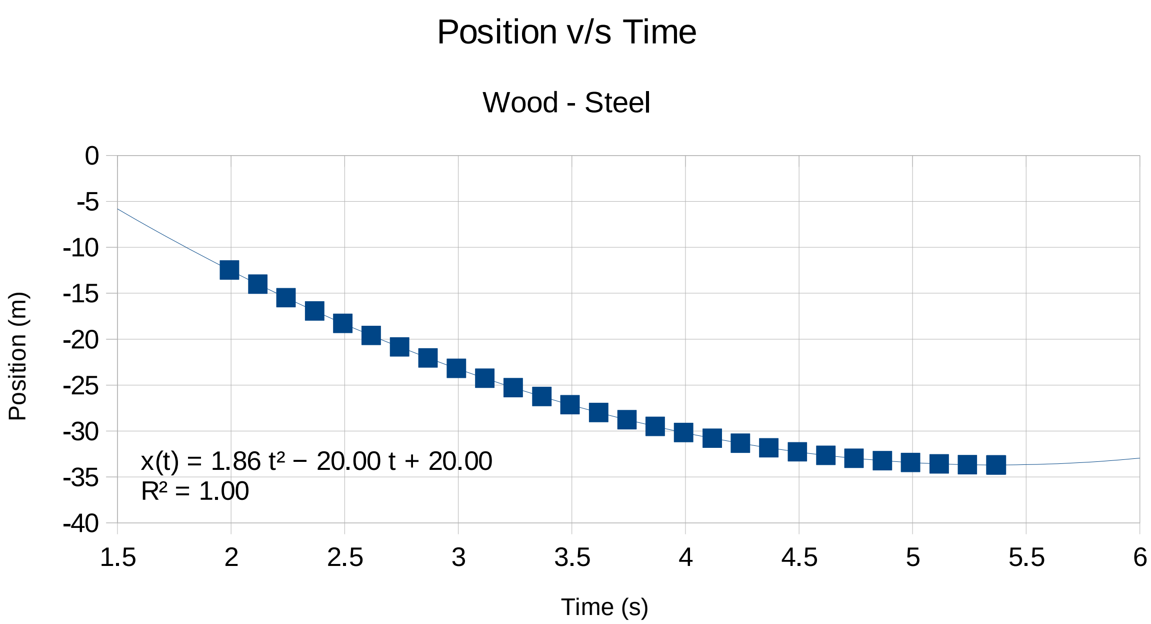
The graph changes from concave down(accelerating) to concave up(decelerating) at time t=2s.

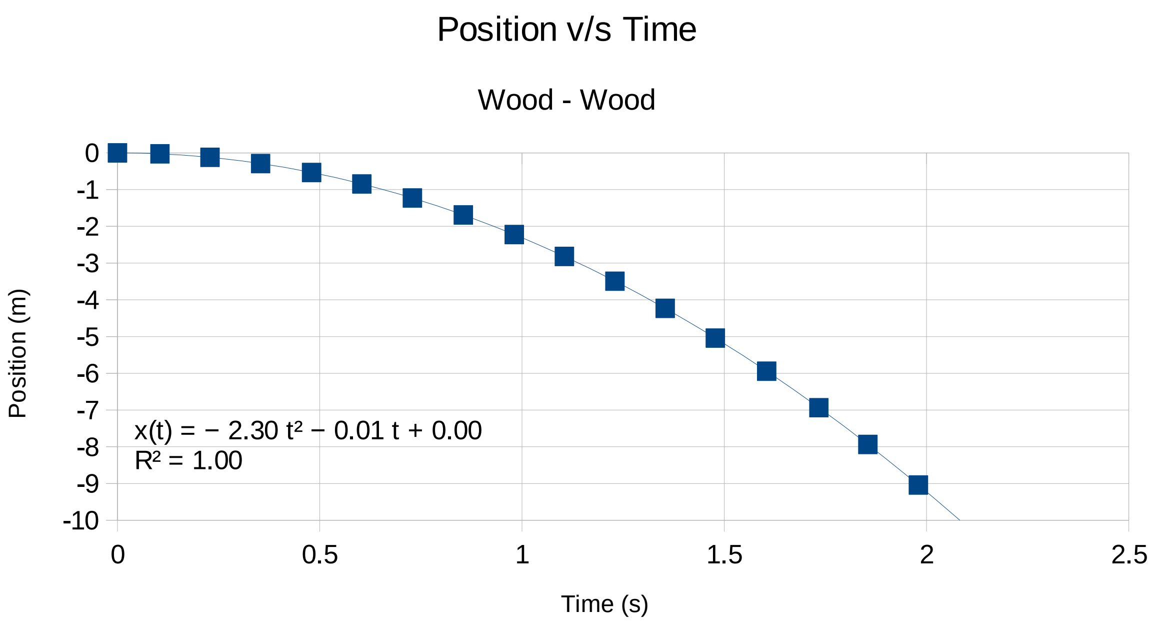
4. Now break each graph down into two graphs. One graph should span from $t=0$ to $t=2s$ and the second graph should span from $t=2s$ until the end of the trajectory. For the second graph, delete the data after the object stops moving. This data will not allow excel to fit accurately. Make sure each graph has the proper labels and units and paste them below.

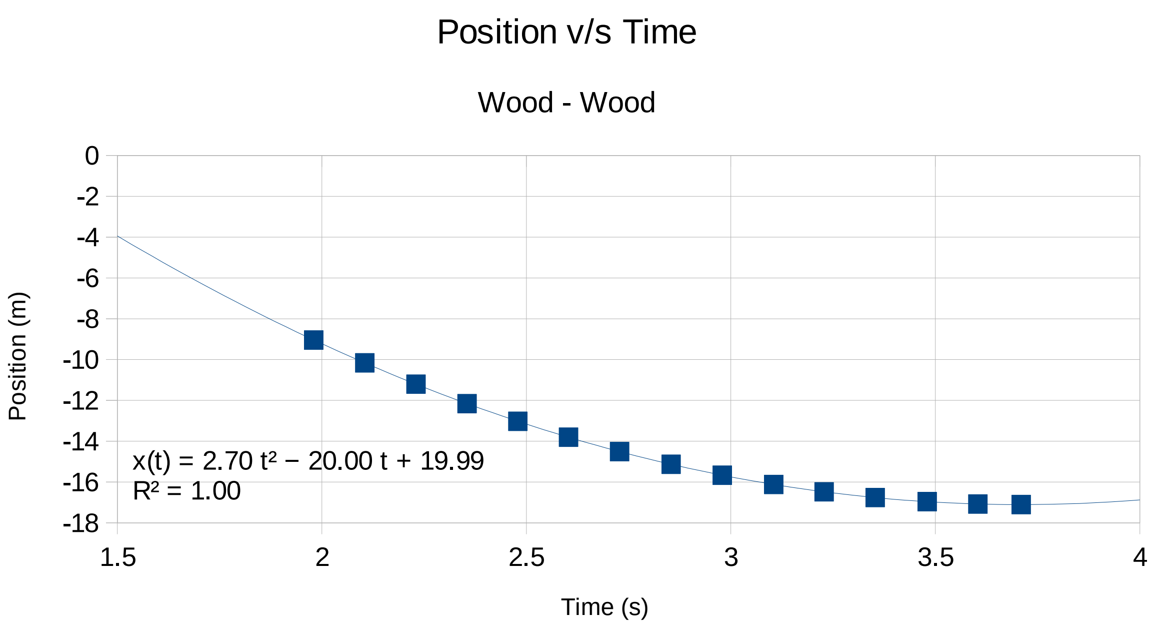

Position v/s Time
Wood - Plastic
x(t) = − 3.38 t² − 0.00 t + 0.00
R² = 1.00
Position (m)
Time (s)
0
-2
-4
-6
-8
-10
-12
-14
-16
0
0.5
1
1.5
2
2.5

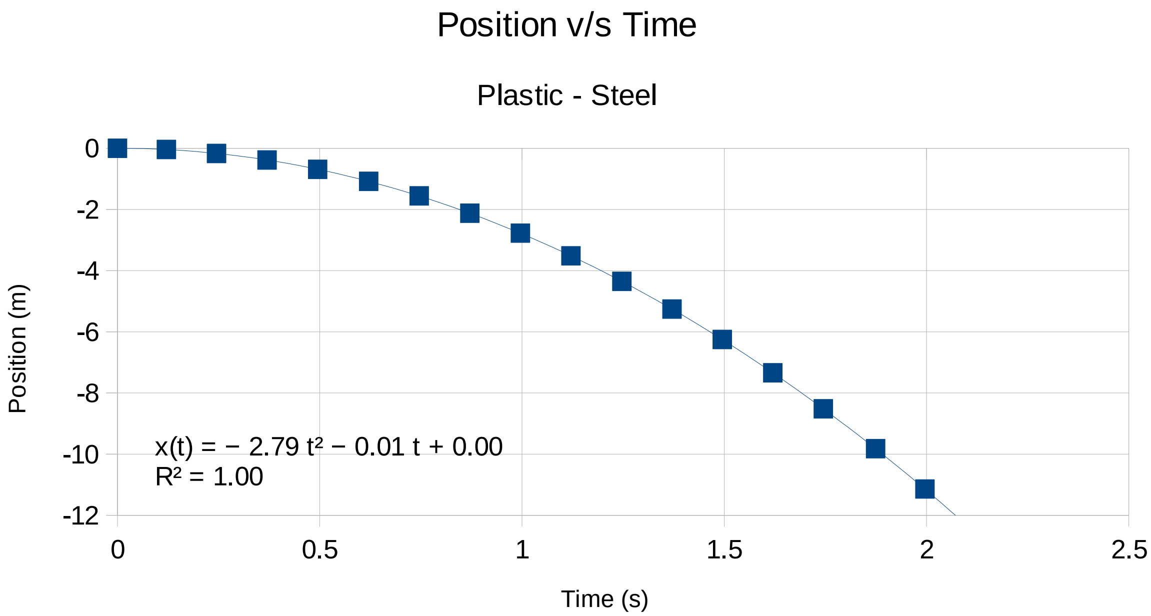

Position v/s Time
Wood - Plastic
x(t) = 1.62 t² − 20.00 t + 20.00
R² = 1.00
Position (m)
Time (s)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5

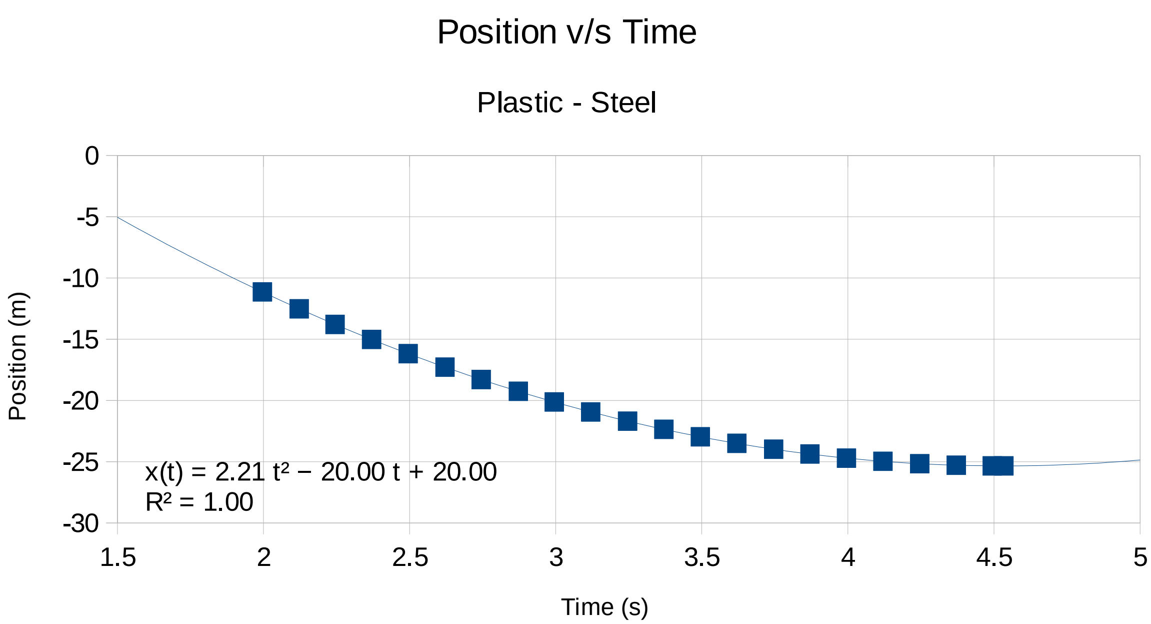

Position v/s Time
Wood - Steel
0
-2
-4
-6
-8
-10
-12
-14
0
0.5
1
1.5
2
2.5
Position (m)
Time (s)
x(t) = − 3.14 t² − 0.00 t − 0.00
R² = 1.00

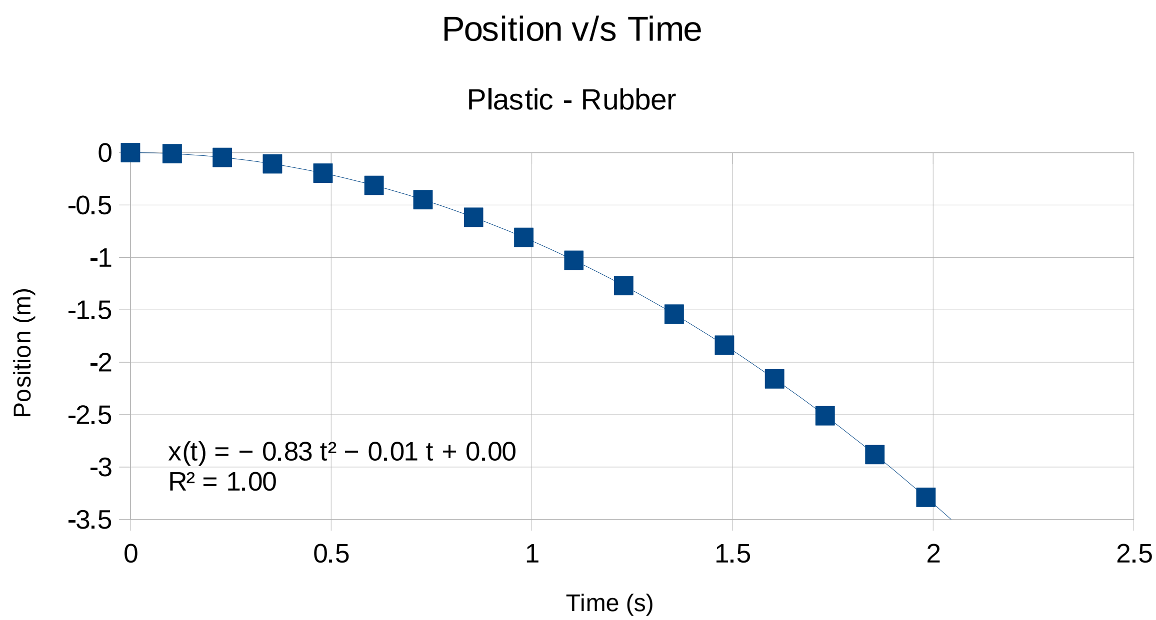

Position v/s Time
Wood - Steel
0
-5
-10
-15
-20
-25
-30
-35
-40
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
Position (m)
Time (s)
x(t) = 1.86 t² − 20.00 t + 20.00
R² = 1.00

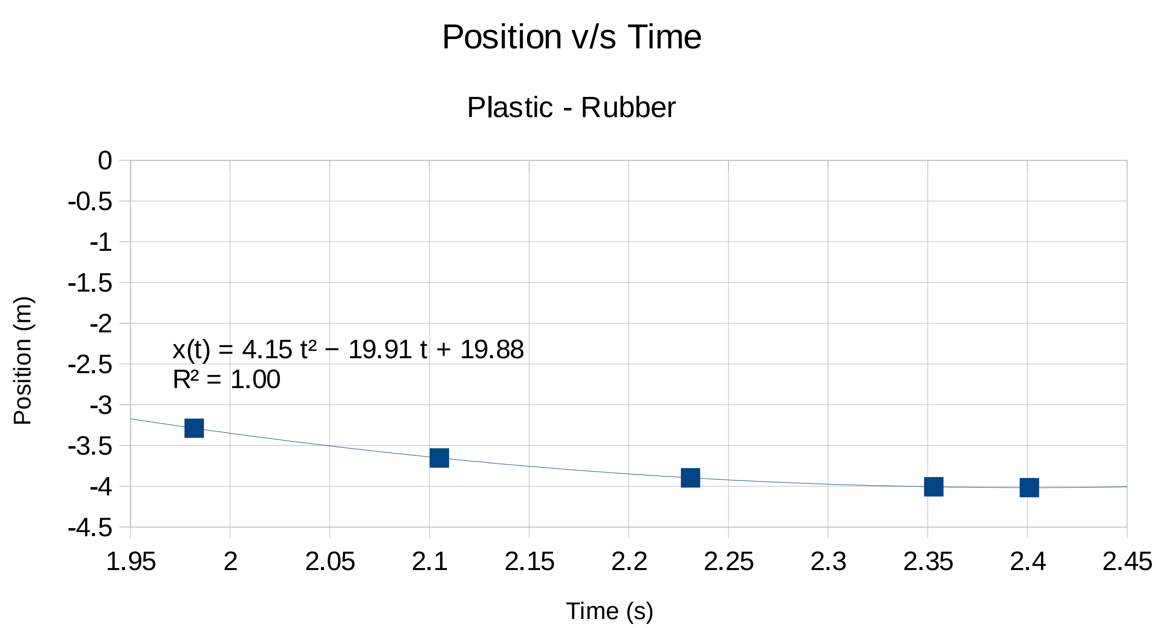

Position v/s Time
Wood - Wood
Position (m)
Time (s)
x(t) = − 2.30 t² − 0.01 t + 0.00
R² = 1.00
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
0
0.5
1
1.5
2
2.5


Position v/s Time
Wood - Wood
Position (m)
Time (s)
x(t) = 2.70 t² − 20.00 t + 19.99
R² = 1.00
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
1.5
2
2.5
3
3.5
4


Position v/s Time
Plastic - Steel
Position (m)
Time (s)
x(t) = − 2.79 t² − 0.01 t + 0.00
R² = 1.00
0
-2
-4
-6
-8
-10
-12
0
0.5
1
1.5
2
2.5


Position v/s Time
Plastic - Steel
Position (m)
Time (s)
x(t) = 2.21 t² − 20.00 t + 20.00
R² = 1.00
0
-5
-10
-15
-20
-25
-30
1.5
2
2.5
3
3.5
4
4.5
5


Position v/s Time
Plastic - Rubber
Position (m)
Time (s)
x(t) = − 0.83 t² − 0.01 t + 0.00
R² = 1.00
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
0
0.5
1
1.5
2
2.5


Position v/s Time
Plastic - Rubber
Position (m)
Time (s)
x(t) = 4.15 t² − 19.91 t + 19.88
R² = 1.00
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
1.95
2
2.05
2.1
2.15
2.2
2.25
2.3
2.35
2.4
2.45

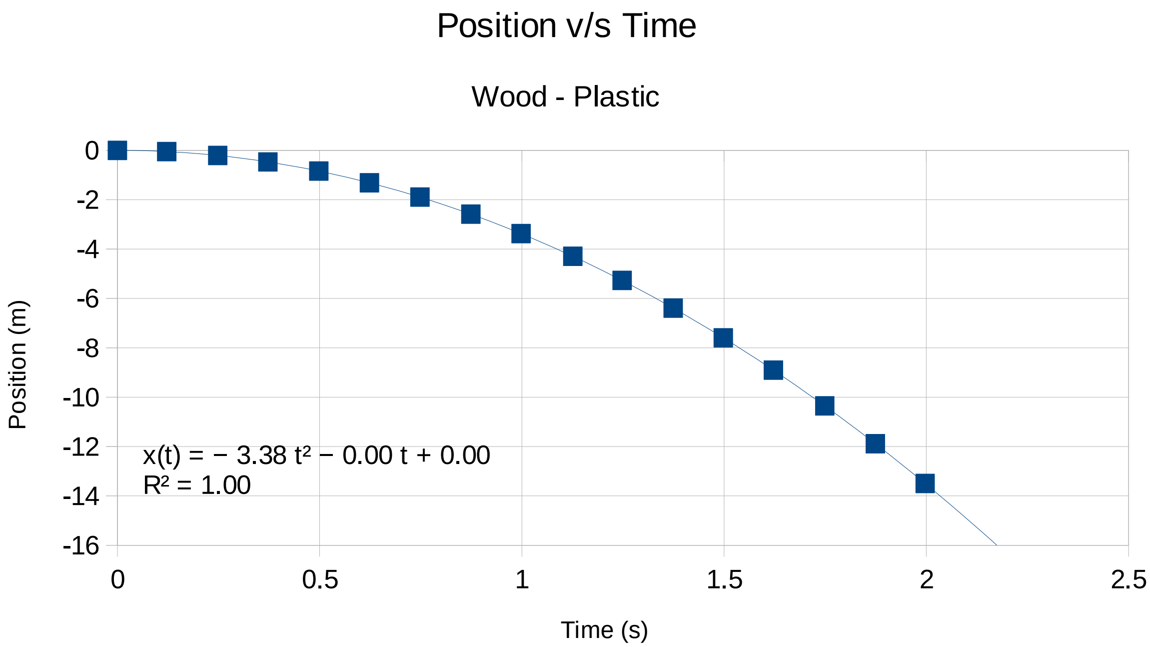
5. What kind of forces are present before and after the $t=2s$?

Before t = 2s there are four forces gravity, normal reaction force, force due to rocket and frictional force. After t = 2s the force due to rocket stops, others remain as is.

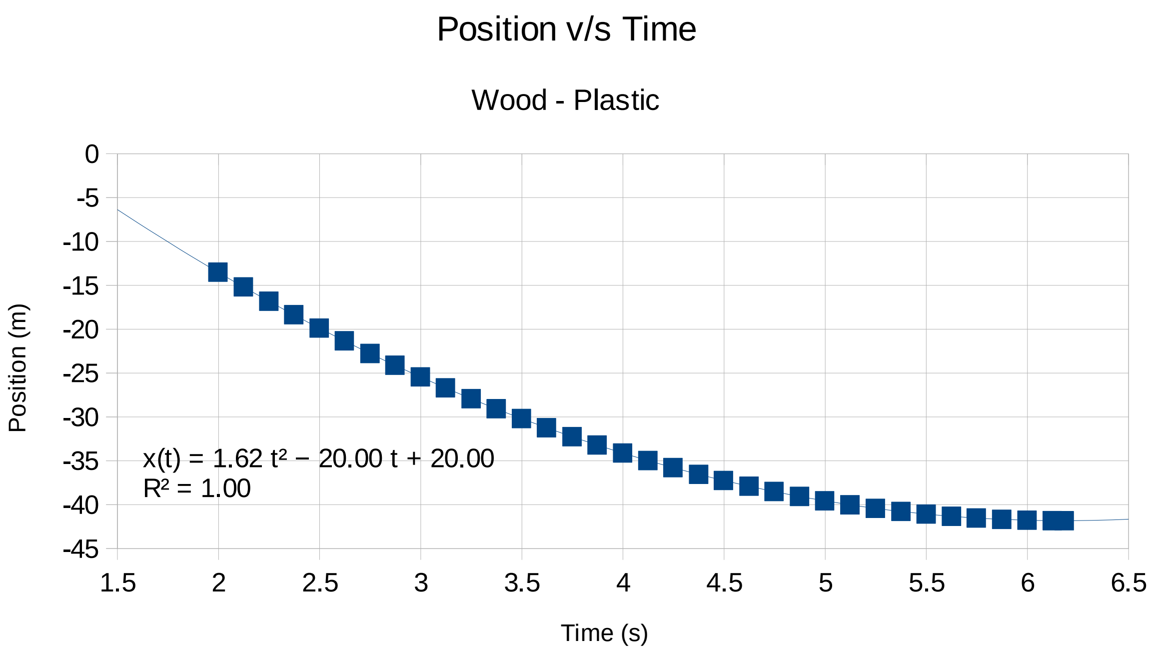
6. What type of equation will best fit the data for all the graphs (from step 4)? Will it be the same type of equation for each graph? Remember the type of equation you pick should correspond to one of the kinematic equations we learned about in the kinematic labs. (*hint: constant acceleration)

A quadratic equation should fit all the graphs from step 4, this is because the block experiences a piecewise constant acceleration and we expect the second equation of motion ($s = ut + at^2/2$) to hold.

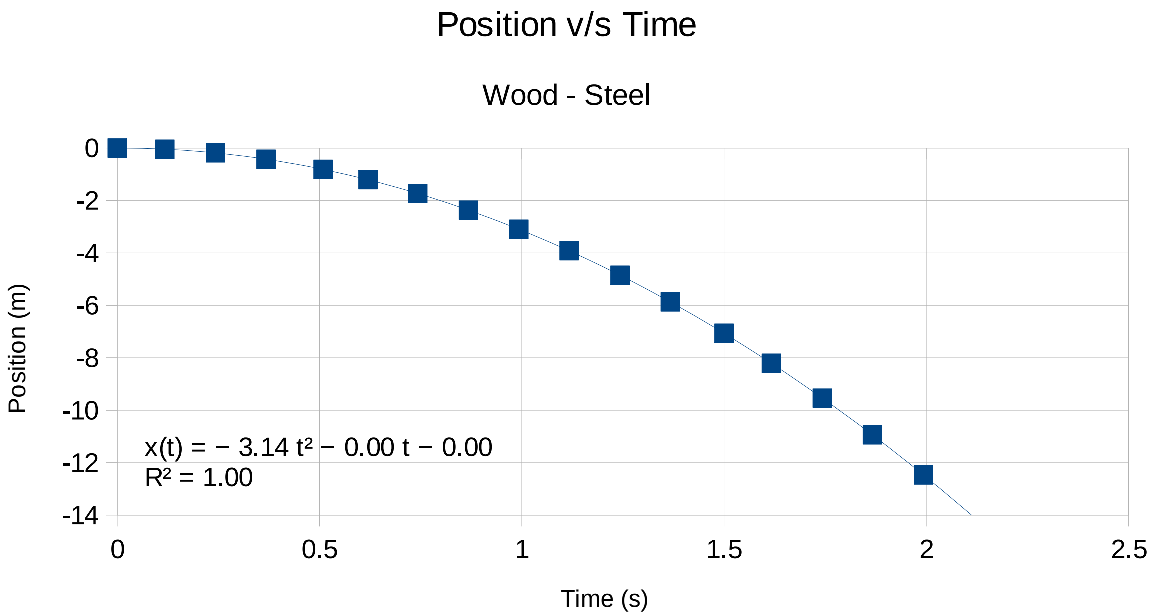
7. By fitting each of the graphs, determine the acceleration of the object before and after the $t=2s$ mark. Paste each of the graphs below with the proper labels, equations of best fit, and the R-squared value.



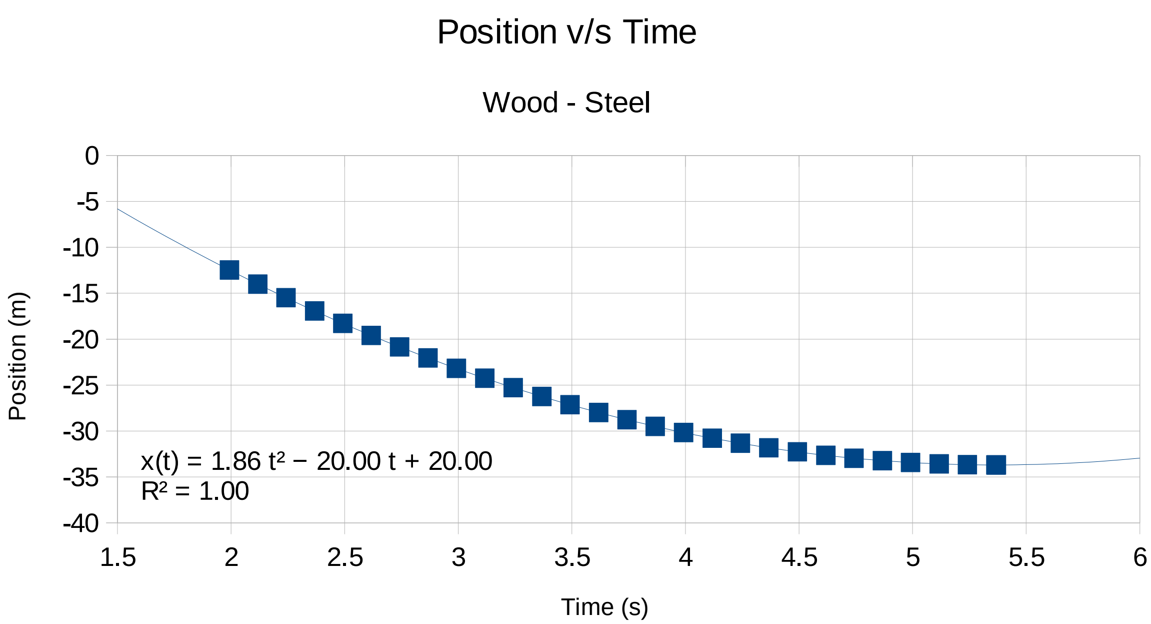

$a = 6.76 m/s^2$ (in direction of motion)



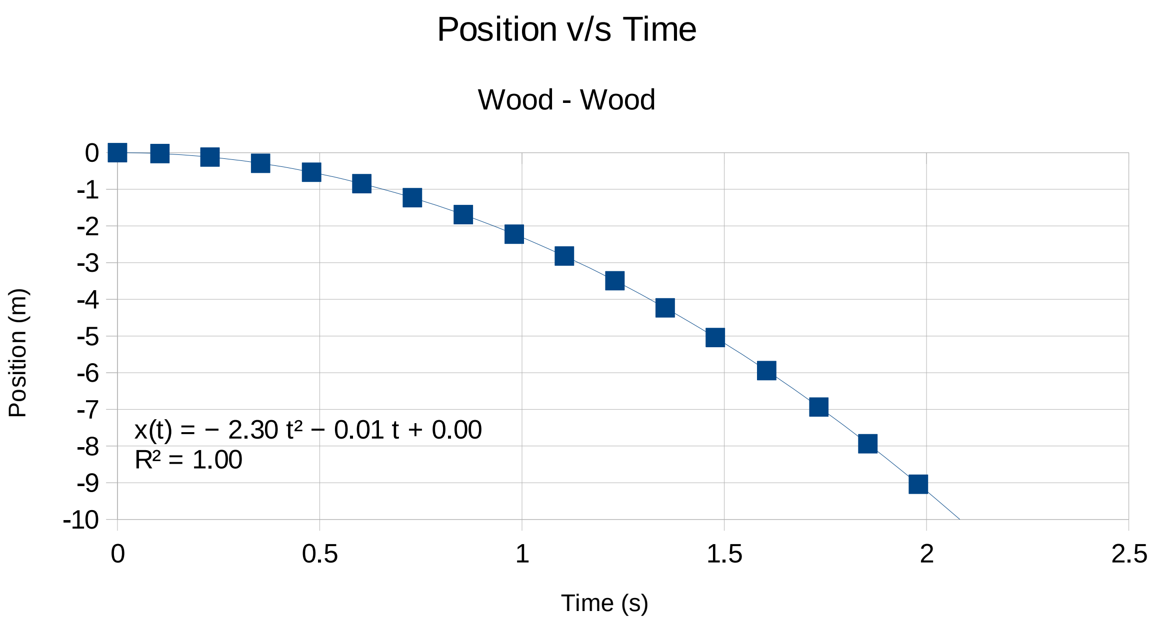

$a = 3.24 m/s^2$ (against the direction of motion)



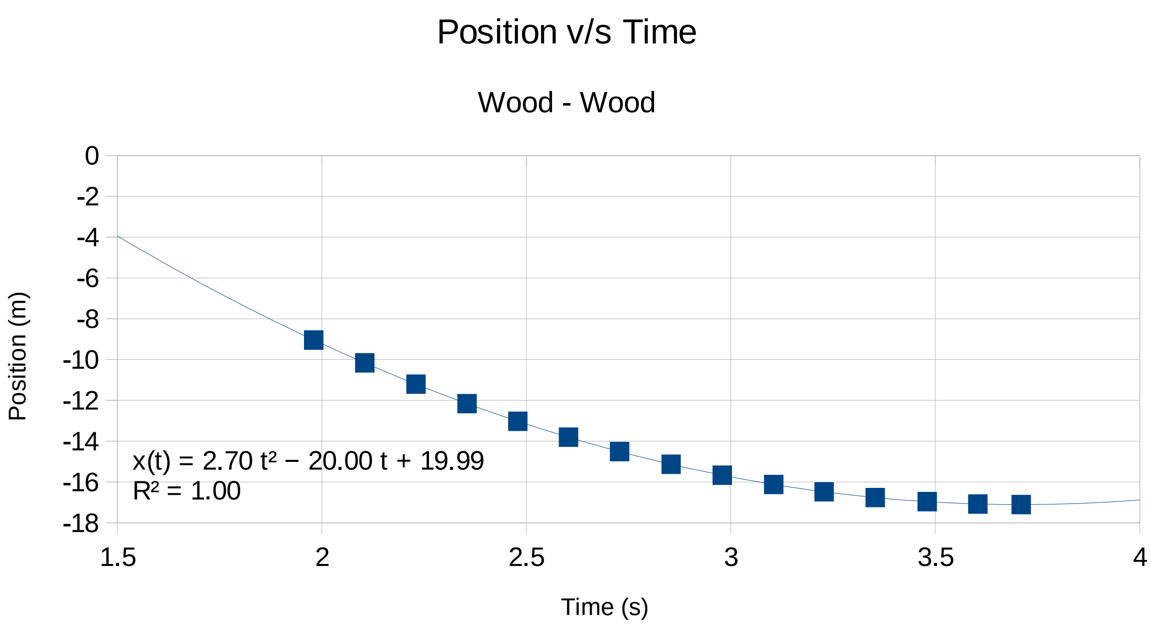

a = 6.28m/s$^2$ (in direction of motion)



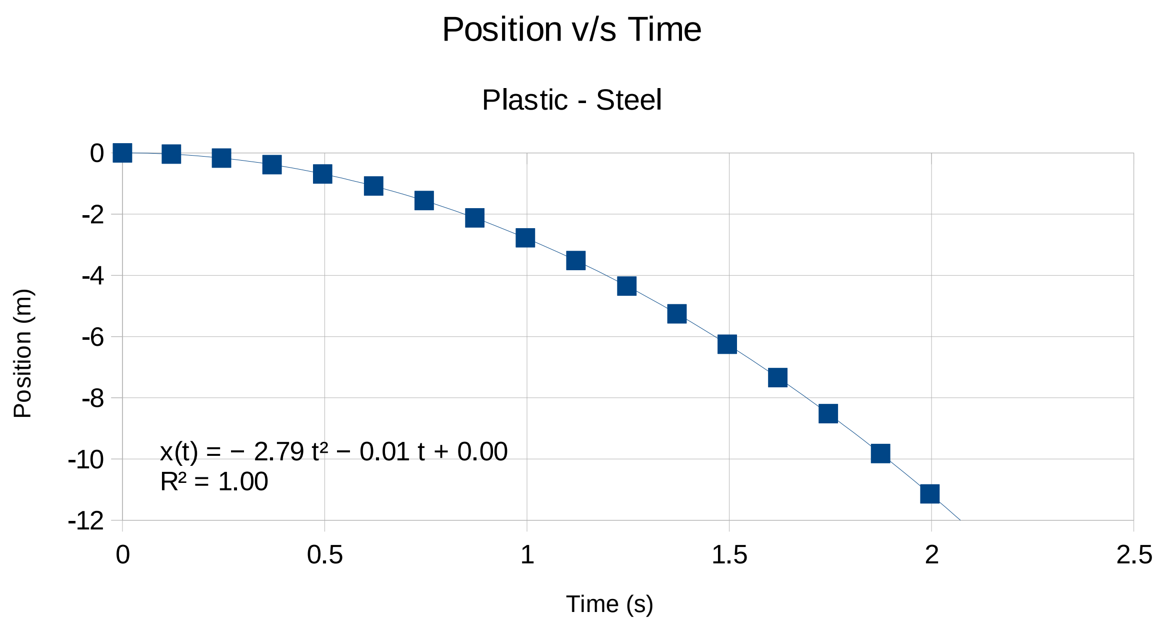

a = 3.72m/s$^2$ (against the direction of motion)



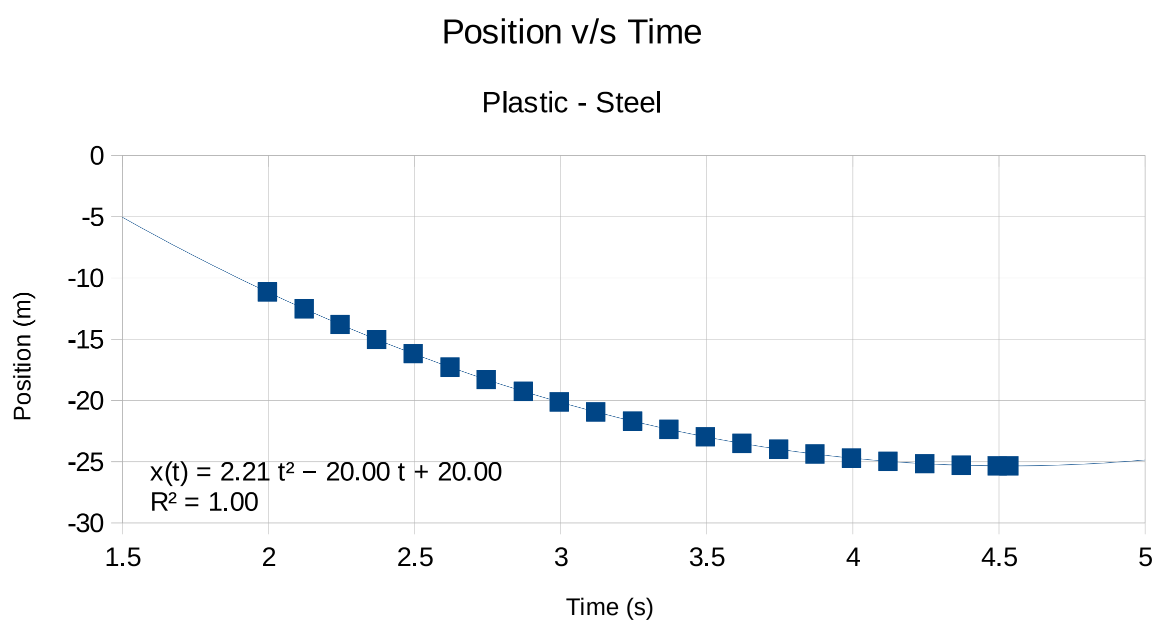

a = 4.6m/s$^2$ (in direction of motion)



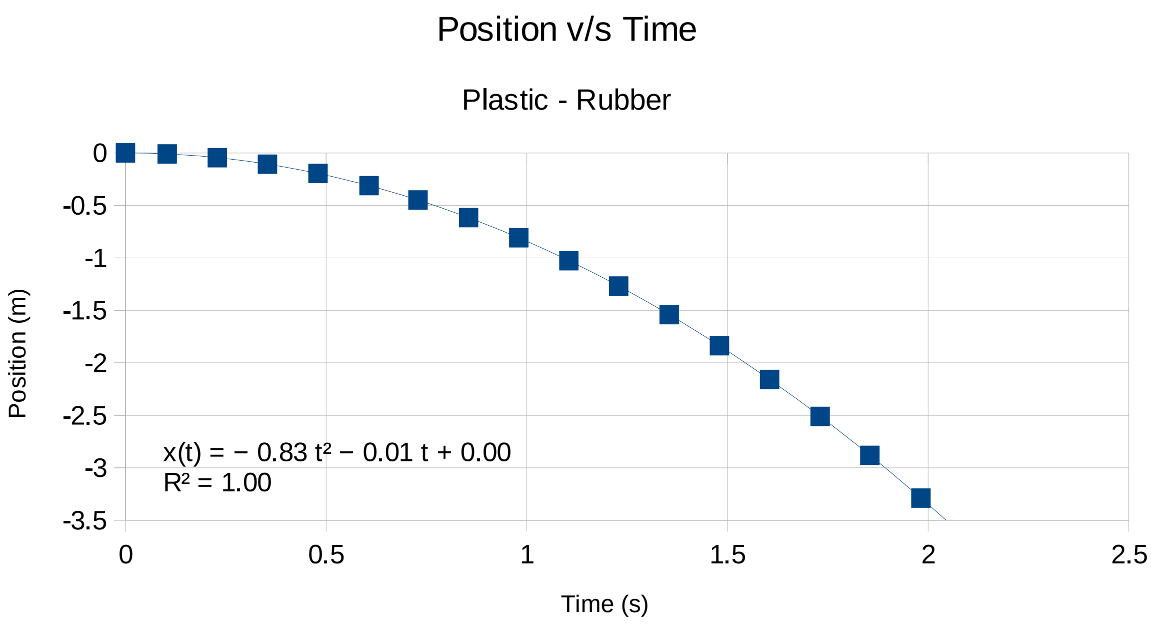

a = 5.4m/s$^2$ (against the direction of motion)



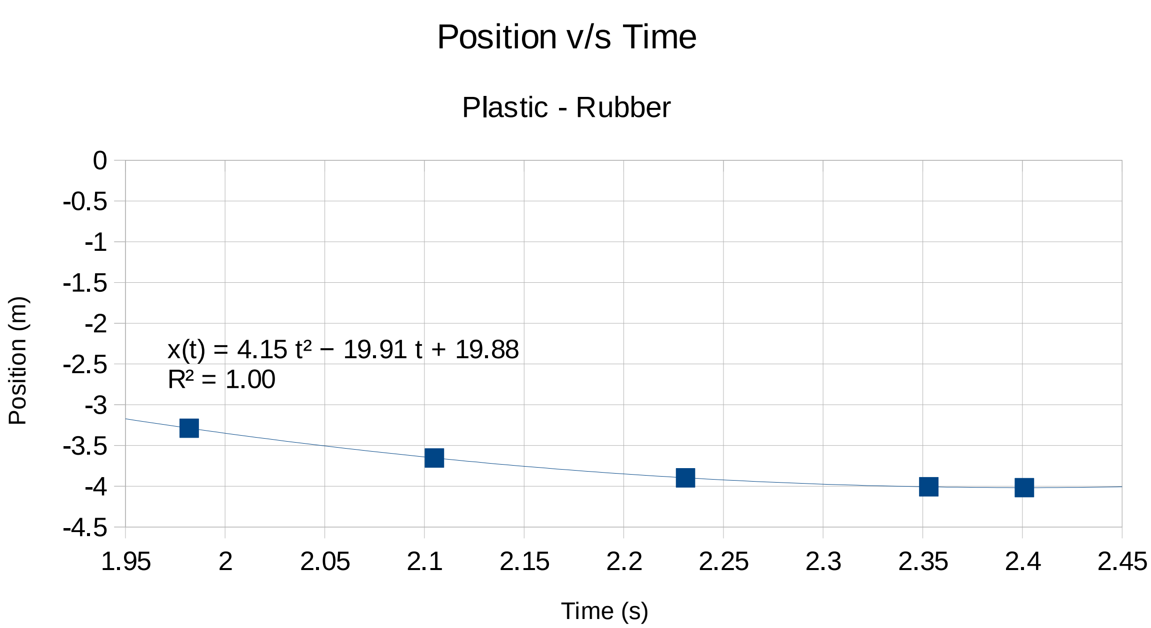

a = 5.58m/s$^2$ (in direction of motion)




a = 4.42m/s$^2$ (against the direction of motion)




a = 1.66m/s$^2$ (in direction of motion)




a = 8.3m/s$^2$ (against the direction of motion)

8. What happens to the sign of the acceleration before and after the $t=2s$ mark?

The sign of the acceleration flips after t=2s mark.

Extra Credit: Determine the coefficient of kinetic friction between each of the combination of surfaces with the data collected.