Area Under the Curve

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Outline

- Students obtain straight lines graphs from different experiments
- Students figure out quickly that the slope of a linear graph has a physical meaning
- Additional physical meaning in certain graphs: area under the curve
- Today we will analyze three experiments
  - Uniform Motion v – t graph
  - Accelerated Motion v – t graph
  - Work F – d graph

Uniform and Accelerated Motion: Students' Beliefs

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- Same position means same speed
- Position and velocity graphs show the path of the particle
- Difficulty relating real world motion to a graph
- Leading particle moves at a faster speed
- Velocity must always be positive
- The meaning of the phrase "graph a-versus-b".
- Identify quantity in a graph that will answer the question (coordinate, slope, area)
- Same velocity means same acceleration for two objects
- Zero velocity means zero acceleration

Uniform and Accelerated Motion: Big Ideas

- Position, distance and displacement have different meanings.
- Uniform motion means that an object travels equal distance in equal time intervals.
- Uniform accelerated motion means that velocity changes by equal amounts in equal time intervals
- An object that accelerates is speeding up, slowing down, or turning.
- Motion can be described in different ways: with words, graphs, motion diagrams and mathematical models.

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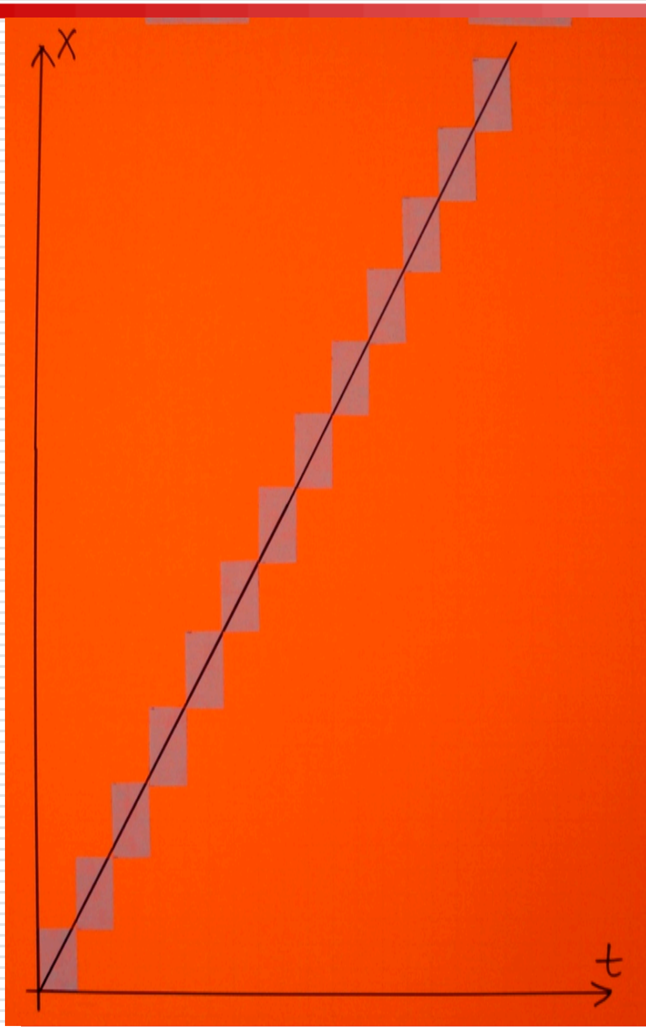
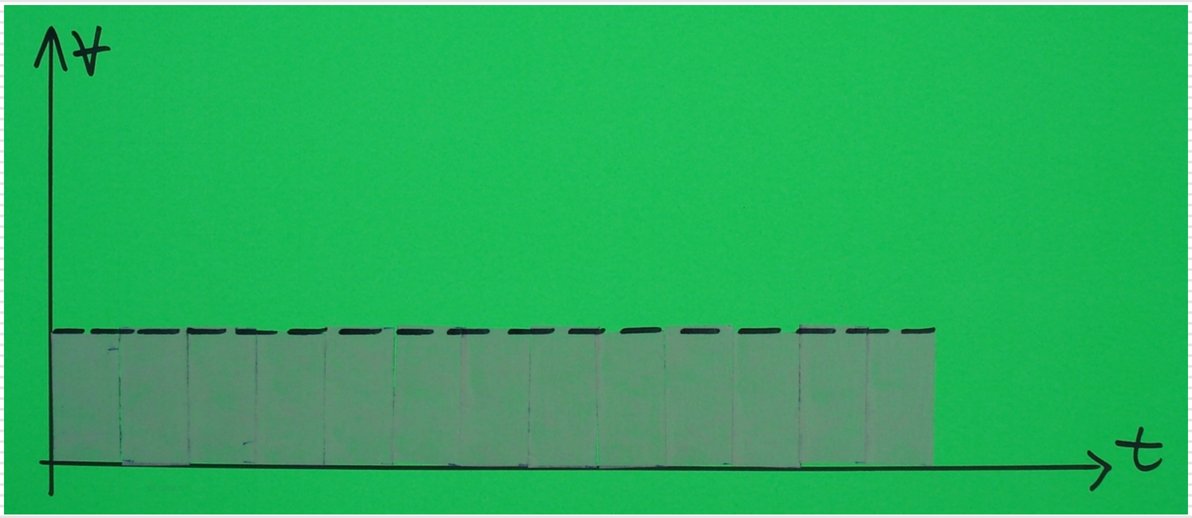
Uniform Motion: Constant Speed Car Lab

Uniform Motion: x vs t graph from experiment



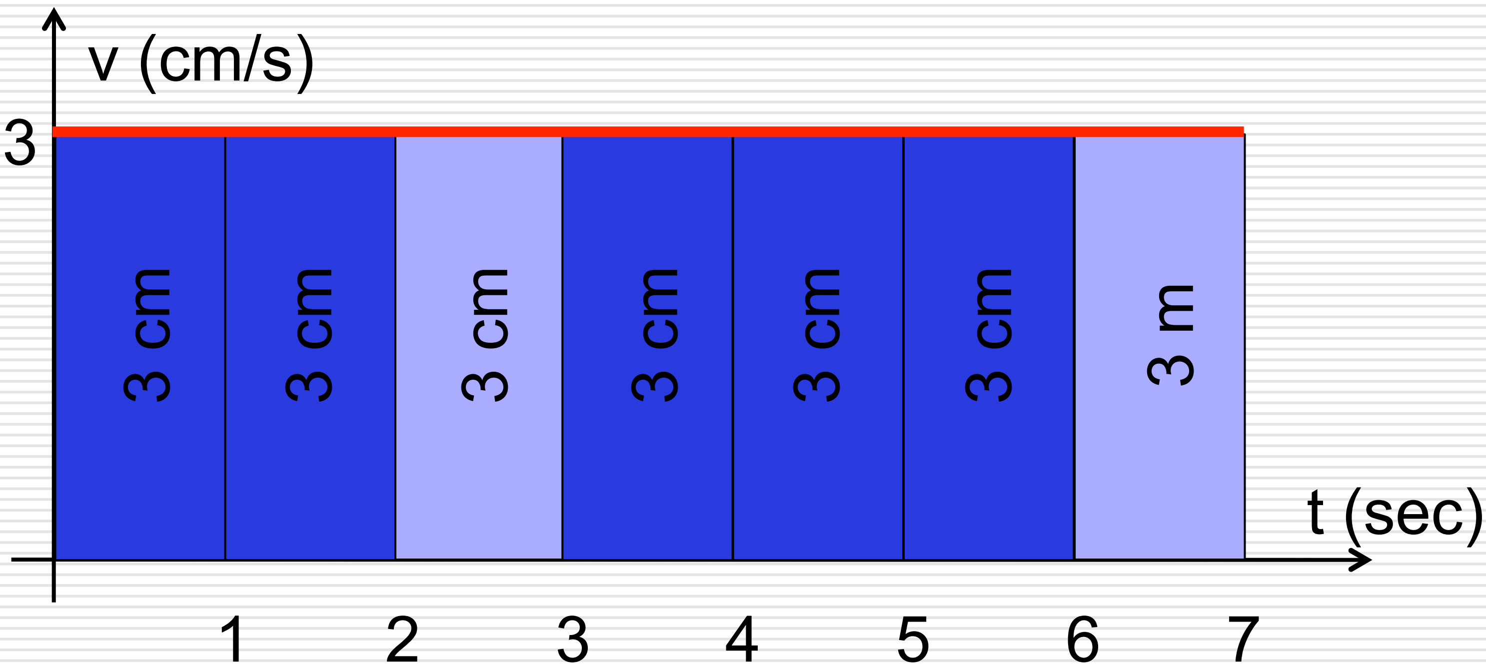
- position changes linearly with time
- the rate of change of position with time = velocity
- slope of graph = velocity
- slope is constant => velocity is constant
- length of distance travelled in unit time is the same

Uniform Motion: v vs t graph from experiment



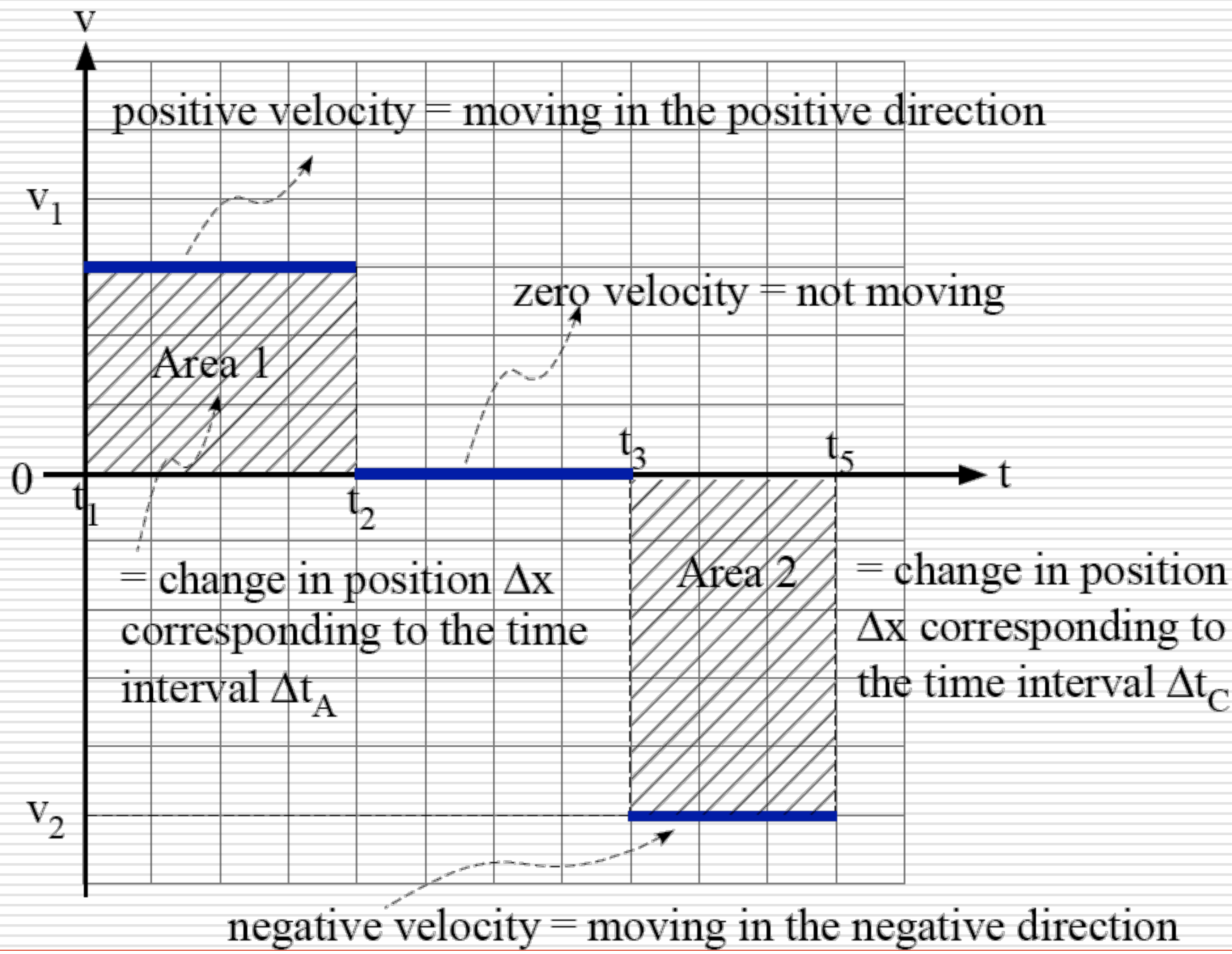
- same distance travelled in the same time interval
- velocity is constant
- calculate the distance traveled as the area under the v vs t graph

Uniform Motion: Distance traveled



- What is the distance traveled in the first second?
- What is the distance traveled in the first 2 seconds?
- What is the distance traveled between 3 s and 6 s?

Uniform Motion: Displacement vs distance



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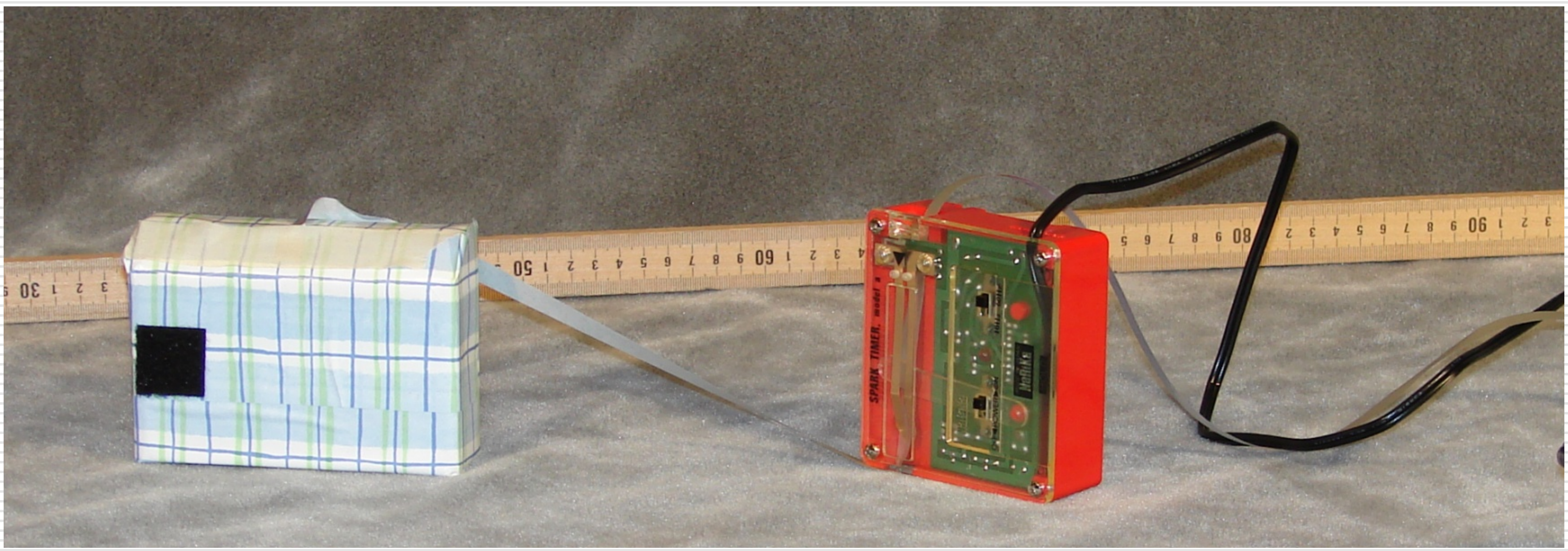
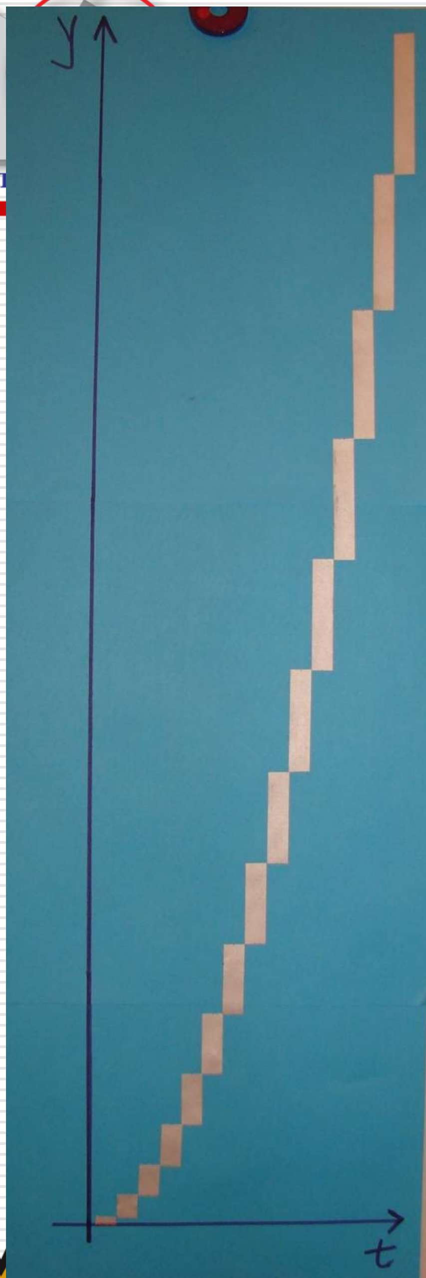
Accelerated Motion

- How is the v vs t different for the accelerated motion?
- Demo: the spark timer

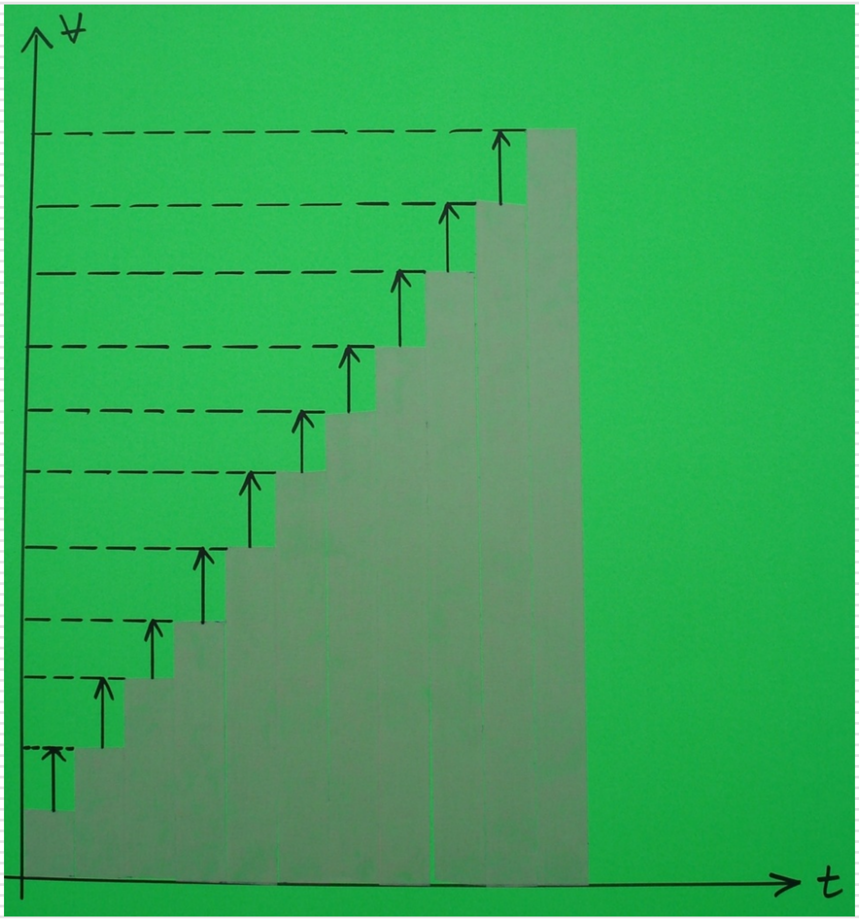


Accelerated Motion: x vs t graph from experiment



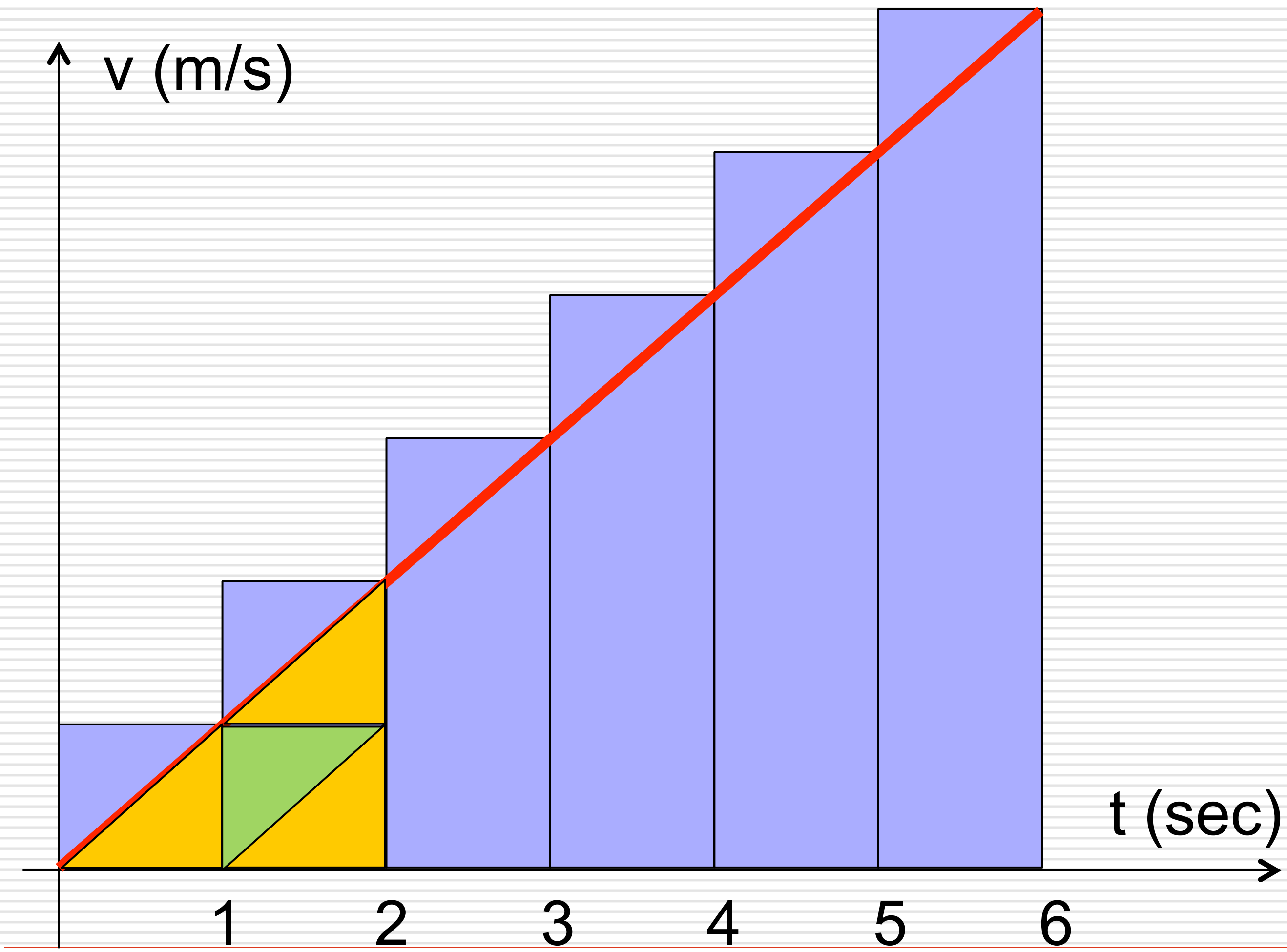
- graph is not linear => velocity is not constant
- slope is not constant => can only calculate slope at a point = instantaneous velocity
- length of distance traveled in unit time increases

Accelerated Motion: v vs t graph from experiment

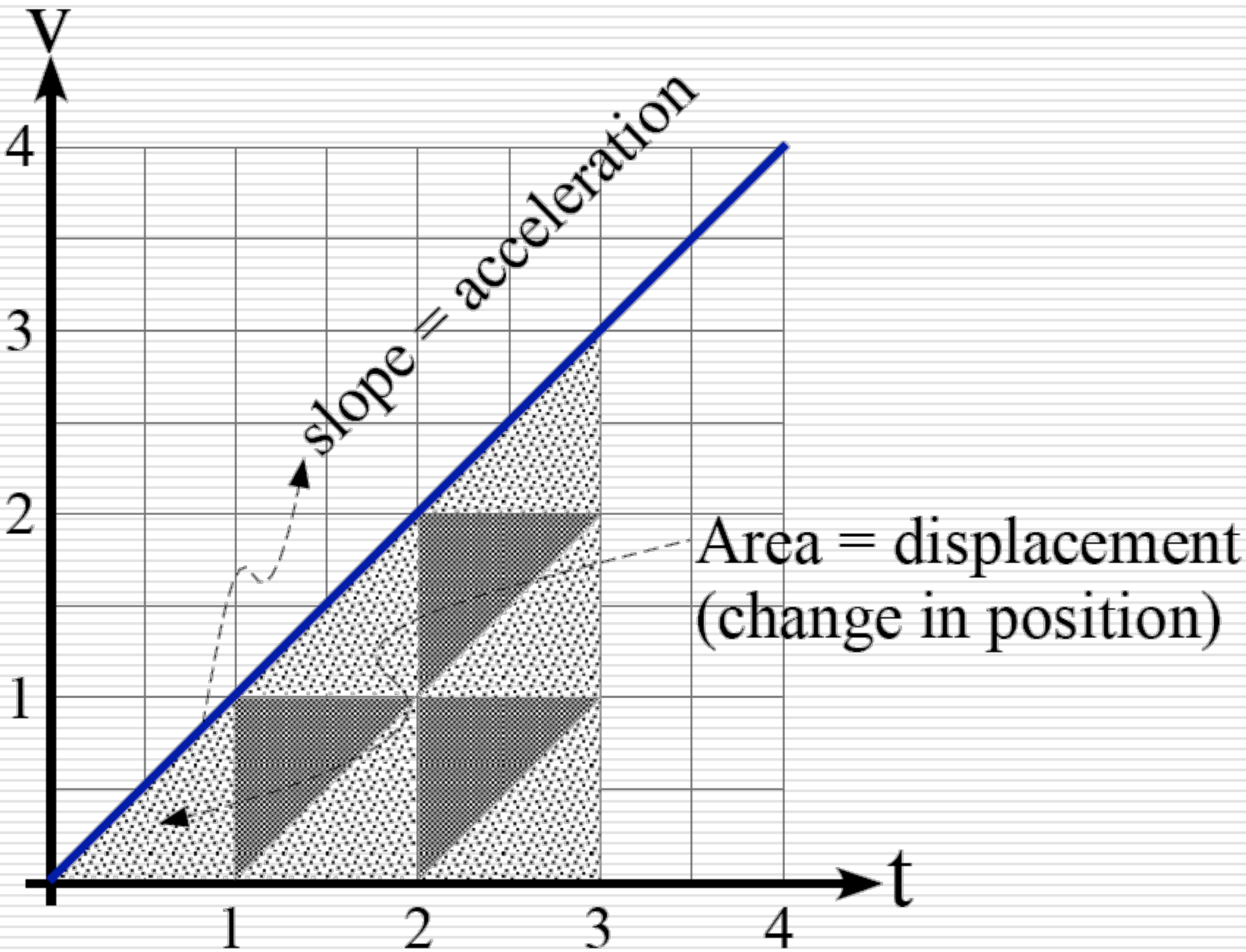


- velocity is not constant, changes linearly with time
- slope of velocity graph represents the rate at which velocity changes = acceleration
- calculate acceleration as the slope of the v vs t graph.
- calculate the distance traveled as the area under the v vs t graph

Accelerated Motion: Distance travelled



Accelerated Motion: Displacement



Work

Students' Beliefs

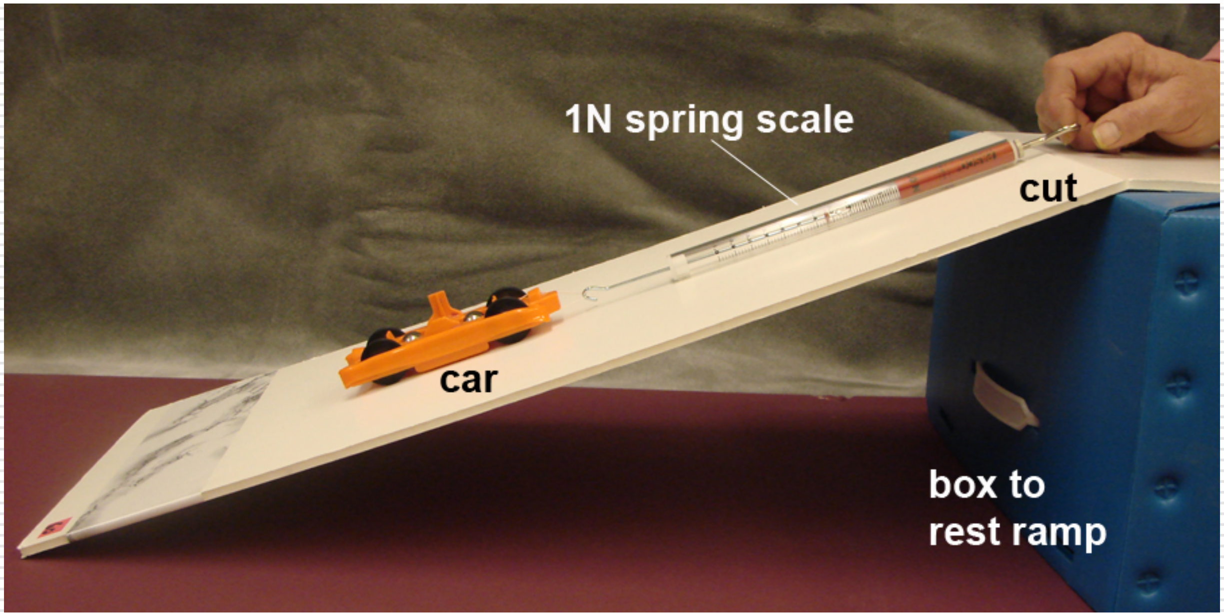
- From the non-scientific point of view, "work" is synonymous with "labor".

Big Ideas

- Work is defined as force x distance moved along direction of force
- Work can be calculated as the area under the F vs distance graph

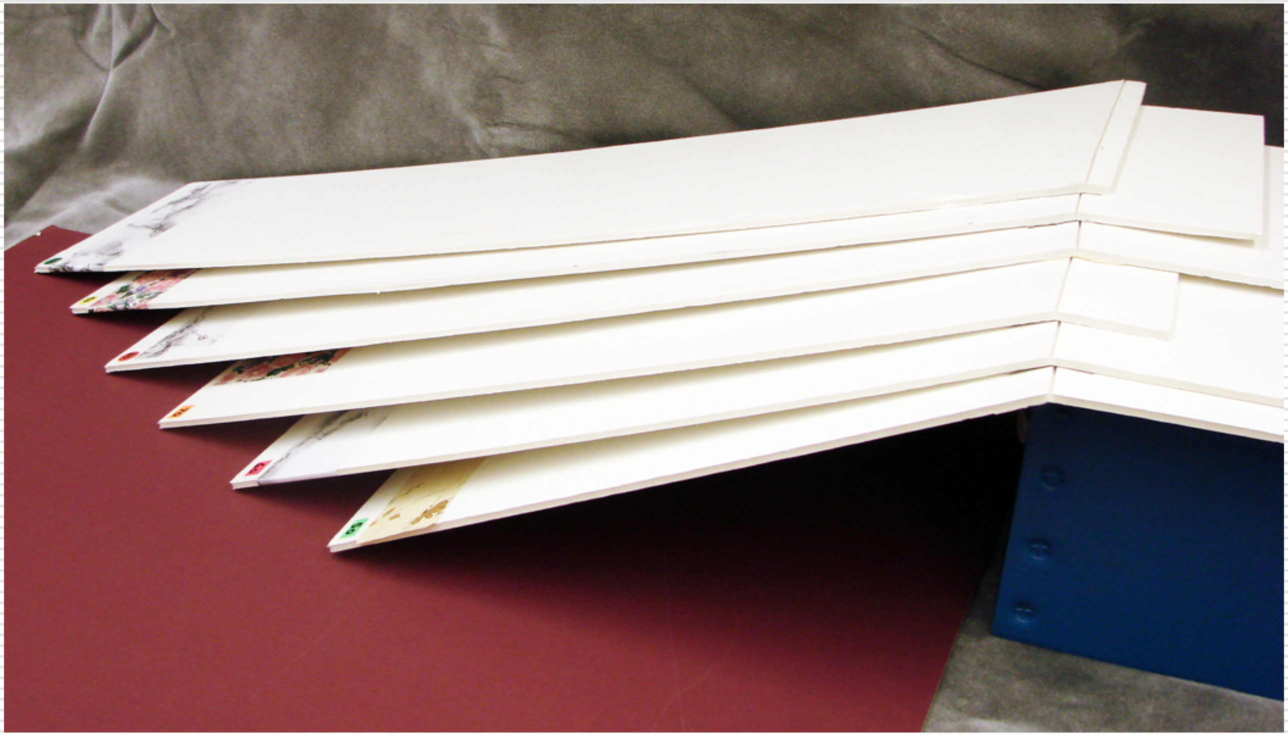
Doing Work Lab

- A car is pulled up a ramp so it reaches the top.
- Pull object up the length of the ramp at a constant velocity.
- A constant force will be applied over the entire distance.



Work: Force and displacement

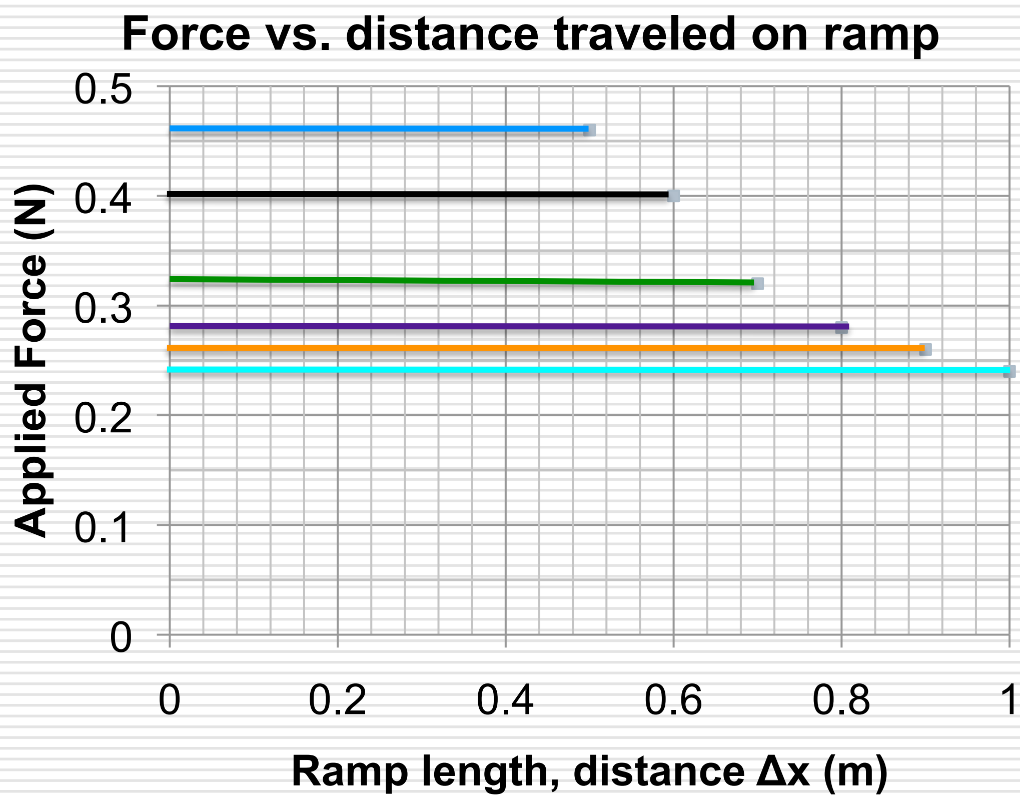
In order to develop the relationship between force, work and distance, we need to measure force required to travel up each ramp and compare them



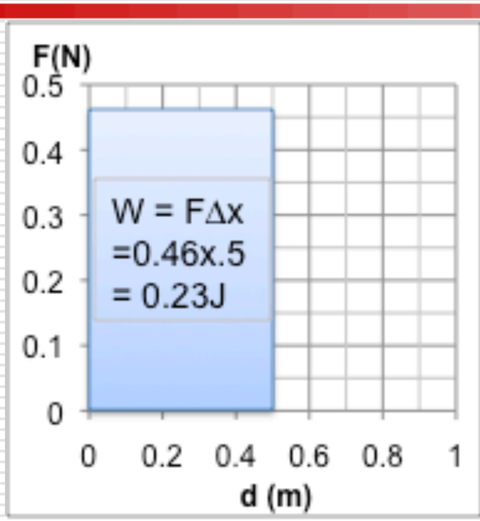
Work: Data and Analysis

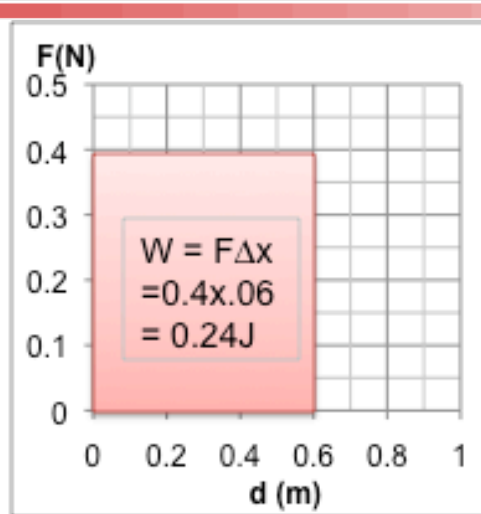
Table: Force F required for different lengths of ramp, Δx (height of ramp =16.5 cm)

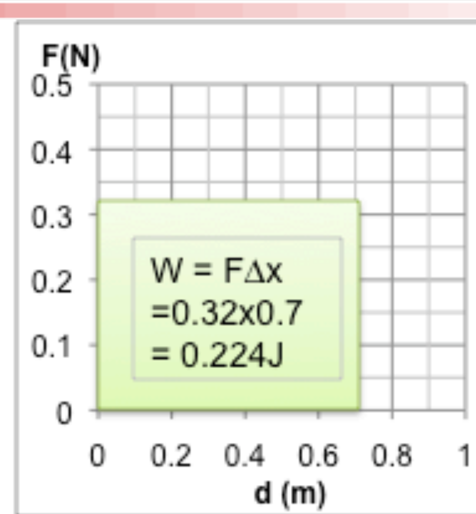
Δx (m)	F (N)
1	0.24
0.9	0.26
0.8	0.28
0.7	0.32
0.6	0.4
0.5	0.46

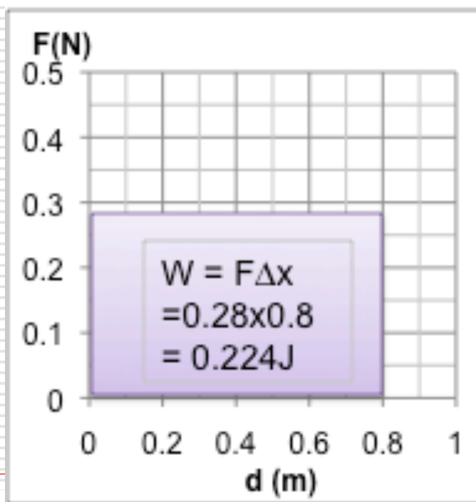


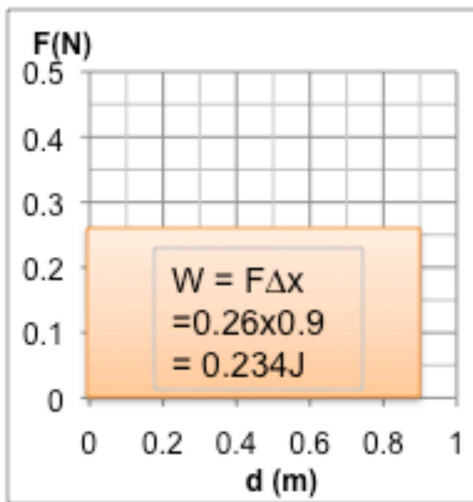
What is Work? –Data and Analysis

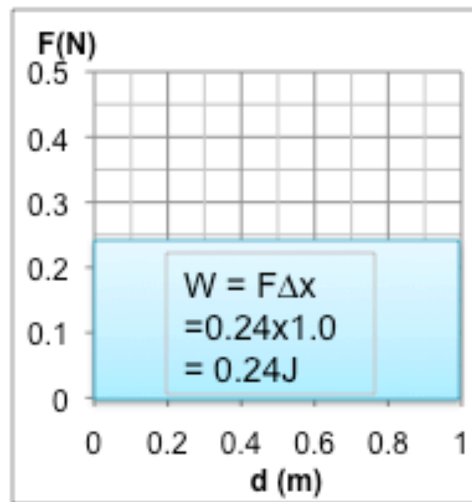












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Summary

- Today we analyzed three experiments
  - Uniform Motion v – t graph
  - Accelerated Motion v – t graph
  - Work F – d graph
- This method can be used whenever the product of the variables on the two axes has physical meaning