The total number of enrolled people in this course reached 190 people. This is the maximum capacity of classroom. No more extra enrollment will be approved.

Week	Date	Content
1	9/13(Tue.)	Course Information
		Fundamental Tools: measurement & unit
1	9/16(Fri.)	Fundamental Tool: vector & basic calculus
2	9/20(Tue.)	Kinetics: motion in 1D
2	9/23(Fri.)	Kinetics: motion in 2D and 3D
3	9/27(Tue.)	Newton's law: Newton's first and second law I
3	9/30(Fri.)	Newton's law: Newton's first and second law II (Homework 1)

GENERAL PHYSICS B1 KINETICS

Dynamics Motion in one dimension 2022/09/20

Today's topic

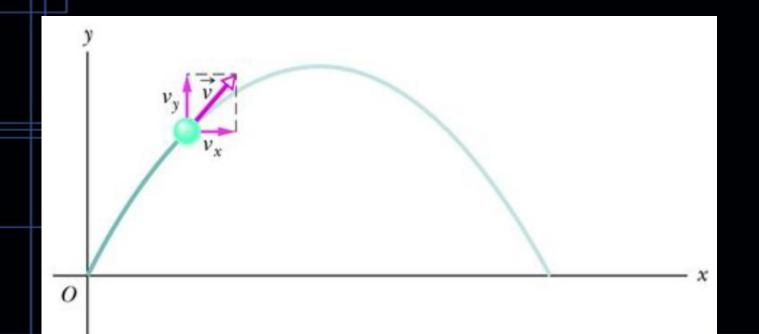
- What is dynamics and why do we study about it.
- Motion in 1D
- Definitions and relationship between position, velocity and acceleration.

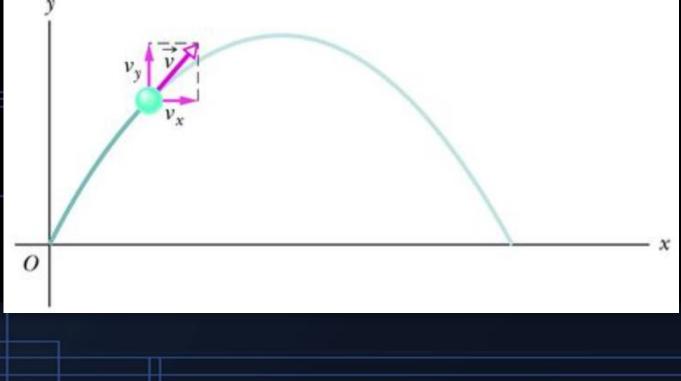
Dynamics: physical quantities evolving with time

- Physics is based on measurement and comparison of physical quantities. The main goal of physicists is finding out the relationships between physical quantities.
- If the physical quantities that we are interested in are a function of time. The study of how these physical quantities change with time is called dynamics.

Why do we study dynamical systems?

By observing <u>how</u> the dynamical systems we are interested in <u>change with time</u>, we can <u>deduce the</u> <u>law</u> of the nature of the subject and use the law to <u>describe or even predict the evolution of the systems</u> for better human life.



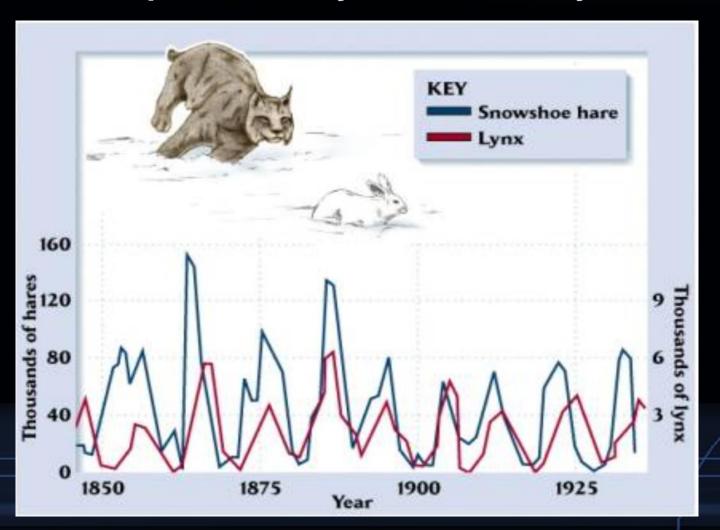




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https://www.nasdaq.com/

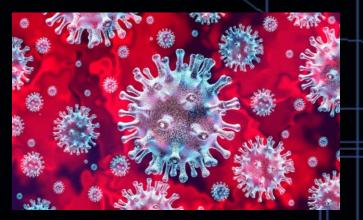
For understanding a dynamical system ...

To study a dynamical system, we need to know

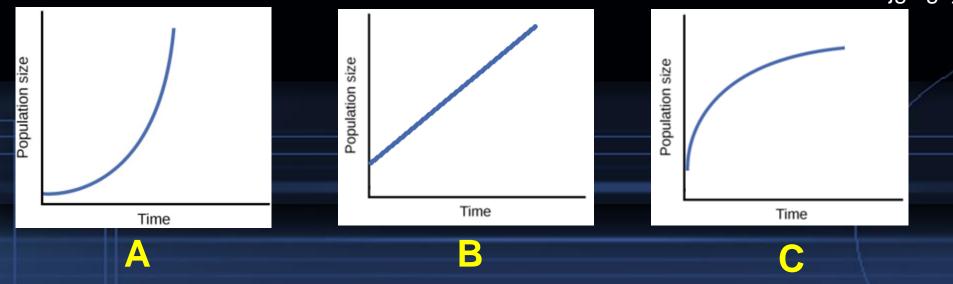
- Which quantity we're interested in
- Concepts of units
- Relation between different quantities
- Mathematical descriptions
- Solutions/Predictions

Think About It...

Without any controlling, the spreading rate of a disease is proportional to the population got infected. Which plot can represent the trend of population got infected? Why?

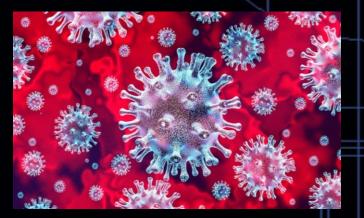


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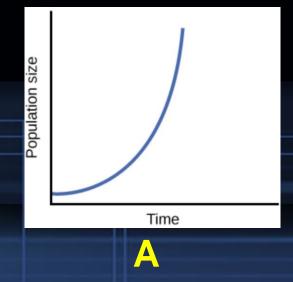


Think About It...

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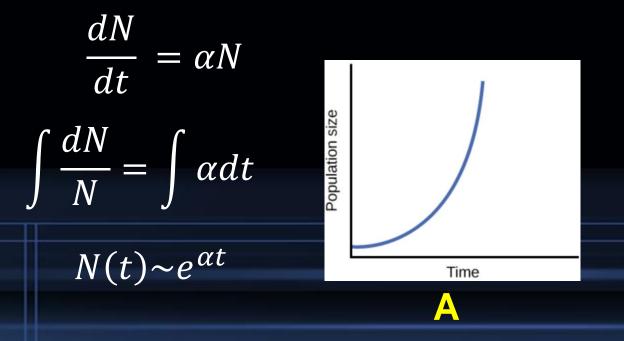


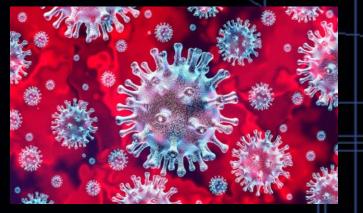
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Think About It...

Without any controlling, the spreading rate of a disease is proportional to the population got infected.





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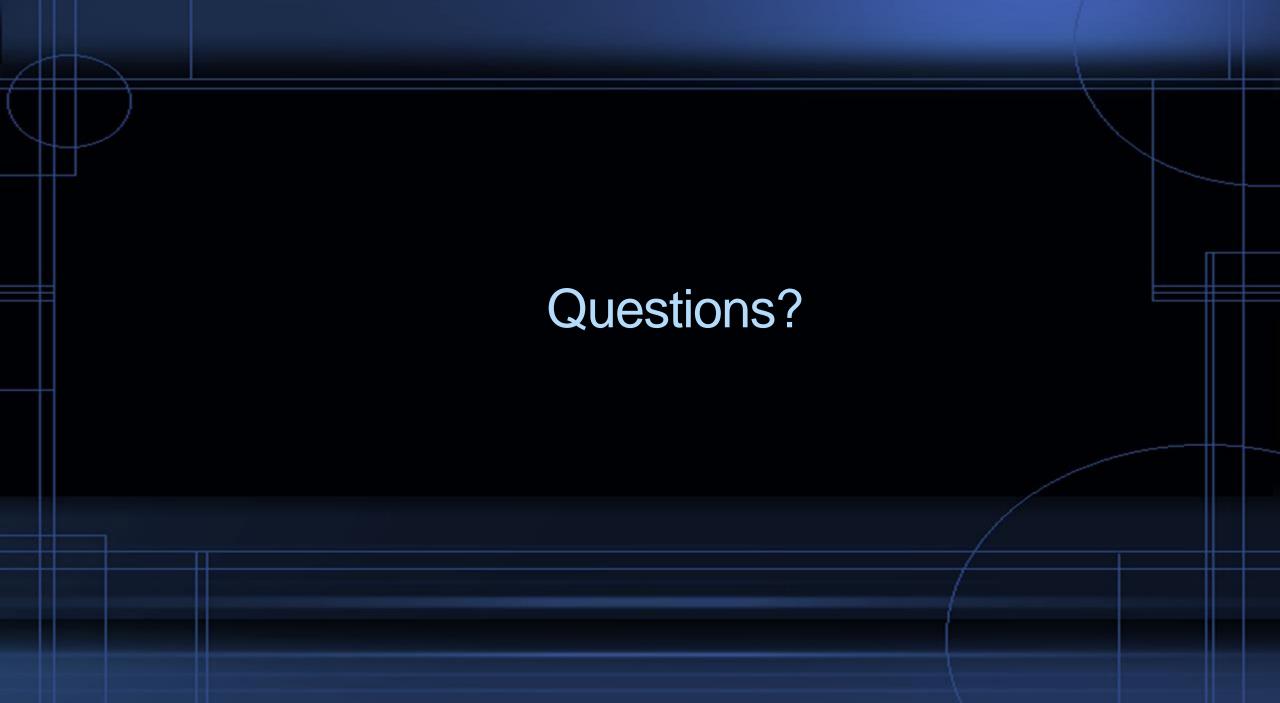
Worldwide COVID-19 at the end of 2021

Cumulative confirmed COVID-19 cases by world region Our World in Data 7-day rolling average. Due to limited testing, the number of confirmed cases is lower than the true number of infections. □ Relative 500 million Africa Oceania South America 400 million North America 300 million Europe 200 million 100 million Asia excl. China China 0 Dec 21, 2021 Feb 9, 2022 Sep 27, 2021 Apr 26, 2022

Source: Johns Hopkins University CSSE COVID-19 Data

OurWorldInData.org/coronavirus • CC BY

https://ourworldindata.org/grapher/cumulative-covidcases-region?time=2021-09-27..2022-04-26



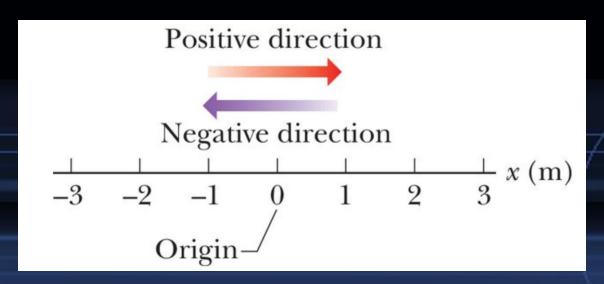
Motion in one dimension

- One of the simplest dynamical system: motion in 1D
- Physical quantities that we are interested in to describe the motion of an object along a straight line:

position, velocity, and acceleration.

Position and displacement

- Position: the location of the object relative to reference point, often the origin of an axis.
- Displacement: A change from position x_1 to position x_2 is called a displacement $\Delta x = x_2 x_1$ (a vector, the sign is its direction)



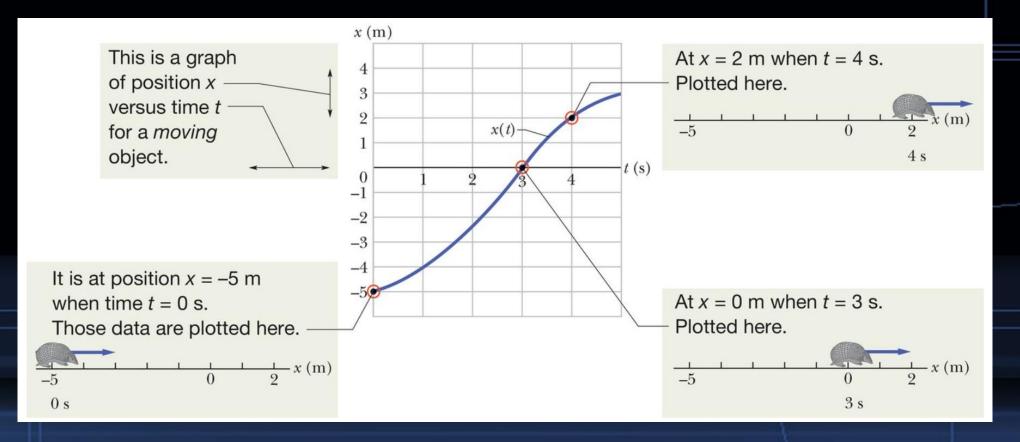
Change of position as function of time

We use position vs. time to represent the motion of an object.



Change of position as function of time

We use position vs. time to represent the motion of an object.



Average velocity and average speed

 Average velocity: ratio of displacement Δx that occurs during a period time to the interval of time Δt: (a vector)

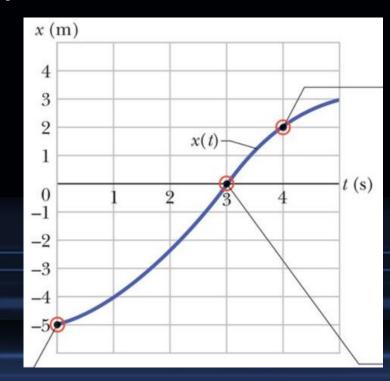
$$v_{
m avg} = rac{\Delta x}{\Delta t} = rac{x_2 - x_1}{t_2 - t_1}$$

 Average speed: ratio of total distance of the object travels, independent of direction, that occurs during a period time to the interval of time Δt: (a scalar)

$$S_{
m avg} = rac{ ext{total distance}}{\Delta t}$$

Think about it

In the case of the armadillo moving along x-axis.
 What is average velocity from 1st second to 4th second?
 What is average speed from 1st second to 4th second?



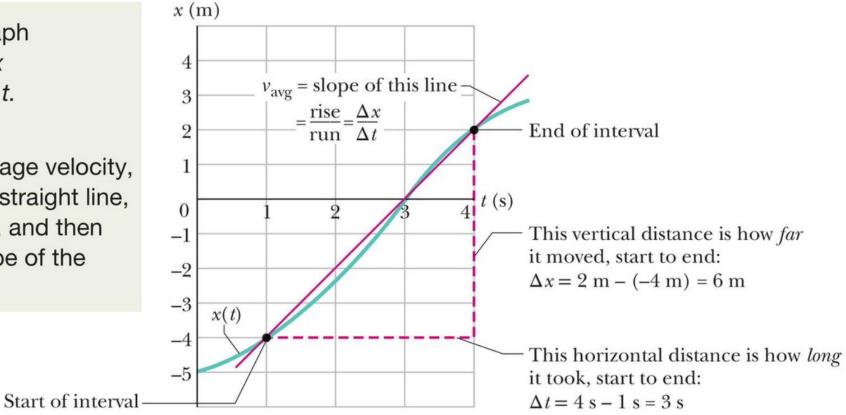
Average velocity and average speed

$$v_{\mathrm{avg}} = rac{\Delta x}{\Delta t} = rac{x_2 - x_1}{t_2 - t_1}$$

$$S_{
m avg} = rac{ ext{total distance}}{\Delta t}$$

This is a graph of position x versus time t.

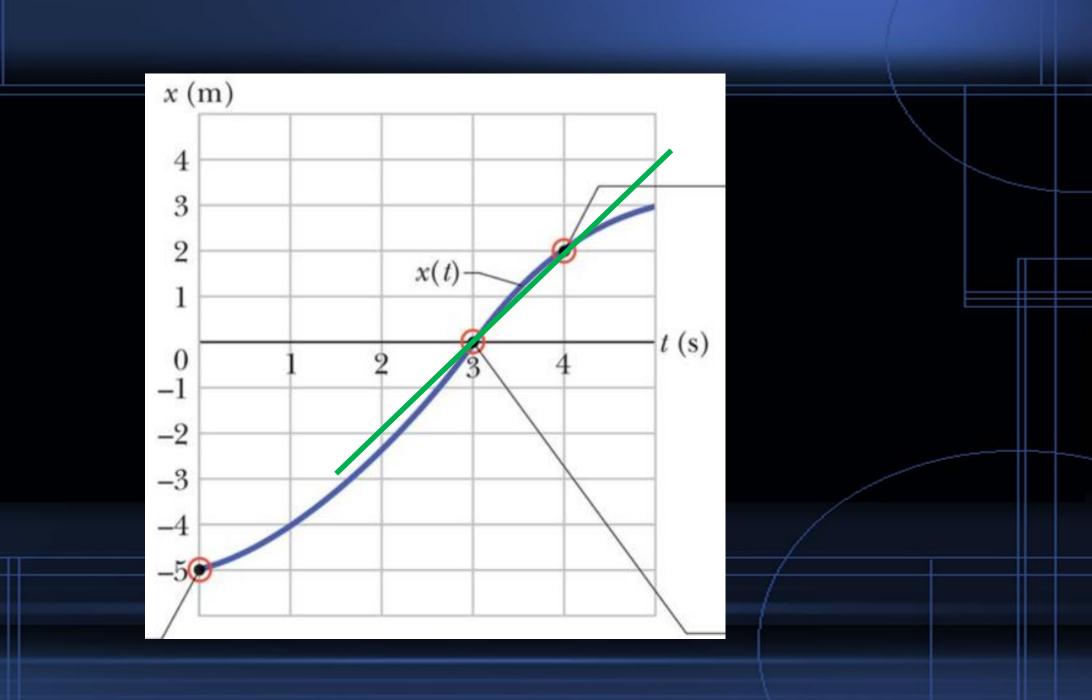
To find average velocity, first draw a straight line, start to end, and then find the slope of the line.

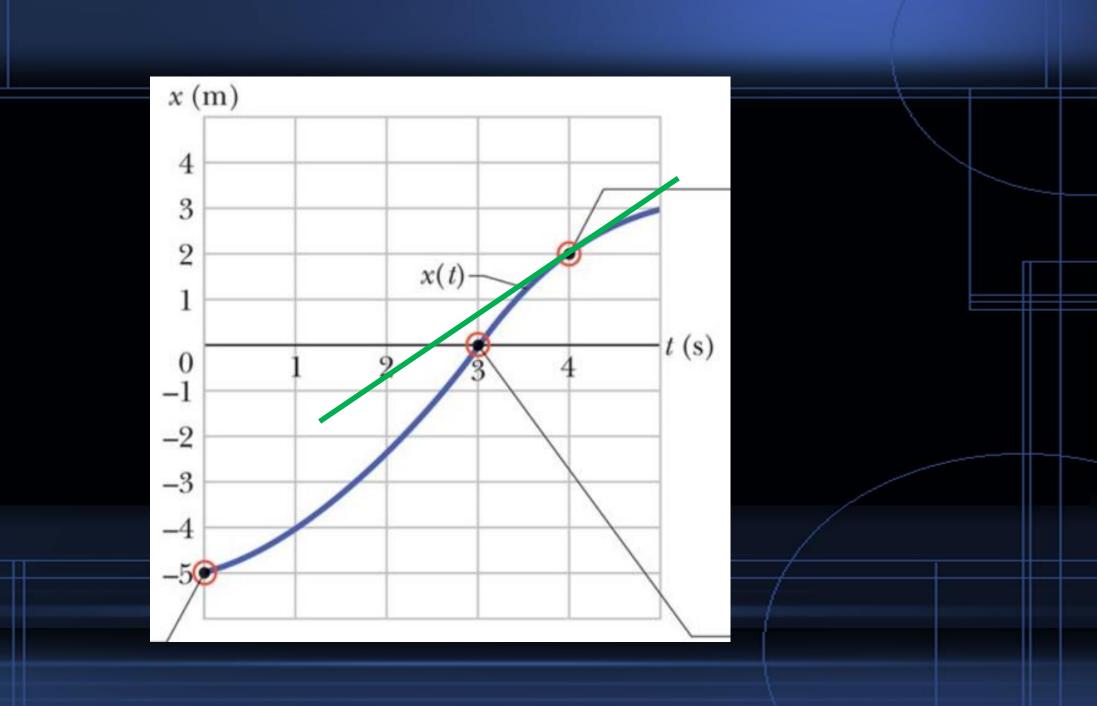


Instantaneous velocity and speed

Instantaneous velocity: the average velocity by shrinking the time interval Δt closer and closer to 0.

$$v = \lim_{\Delta t o 0} rac{\Delta x}{\Delta t} = rac{dx}{dt}$$





Acceleration

• Average acceleration: change of velocity Δv over a time interval Δt .

$$a_{\mathrm{avg}} = rac{v_2 - v_1}{t_2 - t_1} = rac{\Delta v}{\Delta t}$$

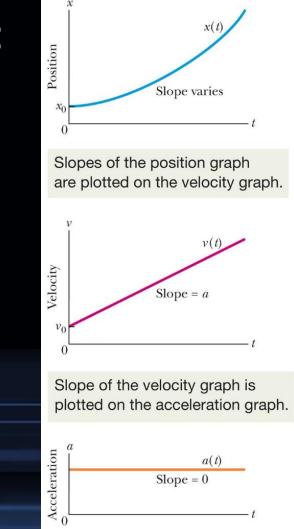
• Instantaneous acceleration (or simply acceleration) : change of velocity Δv over a time interval Δt nearly 0

$$a = rac{dv}{dt} = rac{d}{dt} \left(rac{dx}{dt}
ight) = rac{d^2x}{dt^2}$$

Constant acceleration motion

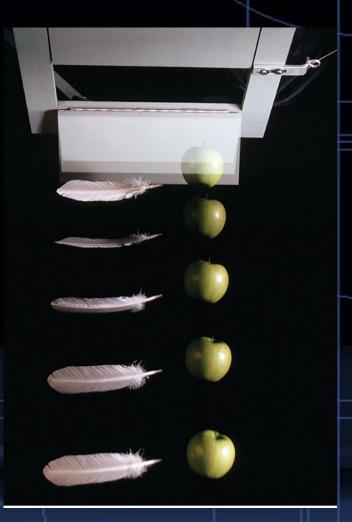
When acceleration is constant, we have:

Equation	Missing Quantity
$v = v_0 + at$	$x - x_0$
$x-x_0=v_0t+rac{1}{2}at^2$	υ
$v^{2}=v_{0}^{2}+2a\left(x-x_{0} ight)$	t
$x-x_0=rac{1}{2}(v_0+v)t$	а
$x-x_0=vt-rac{1}{2}at^2$	ν _o



Free fall acceleration

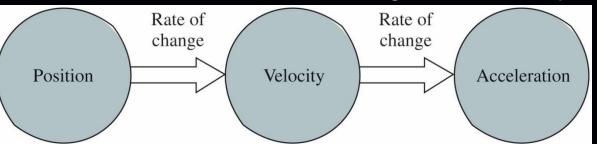
If you tossed an object either up or down and could somehow eliminate the effects of air on its flight, you would find that the object accelerates downward at a certain constant rate. That rate is called the freefall acceleration, and its magnitude is represented by g.



$$g=9.8~{
m m/s^2}$$

Summary

- Position, velocity, and acceleration are the quantities that characterize motion:
 - Velocity is the rate of change of position.
 - Acceleration is the rate of change of velocity.



- When acceleration is constant, simple equations relate position, velocity, acceleration, and time.
 - An important case is the acceleration due to gravity near Earth's surface, where we set

$$g=9.8~{
m m/s}^2$$

 Equation
 Missing Quantity

 $v = v_0 + at$ $x - x_0$
 $x - x_0 = v_0 t + \frac{1}{2}at^2$ v

 $v^2 = v_0^2 + 2a (x - x_0)$ t

 $x - x_0 = \frac{1}{2}(v_0 + v)t$ a

 $x - x_0 = vt - \frac{1}{2}at^2$ v_0