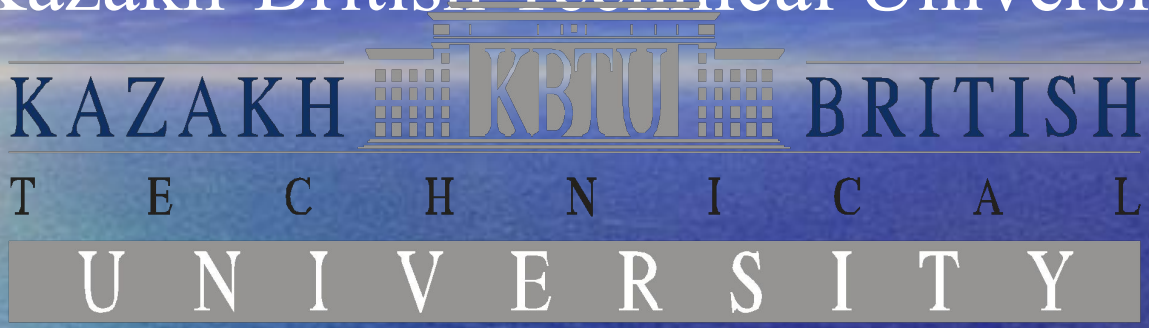
Republic of Kazakhstan

Ministry of Education and Science

Kazakh-British Technical University



Faculty of Power and Oil and Gas Industry

Physical Engineering Department

Physics 1

Voronkov Vladimir Vasilyevich

Physics 1

- Mechacnics
- Molecular physics and Thermodynamics
- Electricity
- Magnetism

Lecture 1

SUBJECTS:

- Mechanics
- Kinematics
- Rectilinear motion
- Projectile motion
- Uniform circular motion

Mechanics

- **Mechanics** is the science of motion and its cause.
- **Kinematics** is the mathematical description of motion.

Main terms of Kinematics

- **Displacement** is the change in the position of an object.

  one-dimensional: $\Delta x = x_2 - x_1$

  many-dimensional: $\Delta \vec{x} = \vec{x}_1 - \vec{x}_2$

- **Average velocity** is the distance traveled per unit of time:

$$\vec{v} = \frac{\Delta \vec{x}}{\Delta t}$$

- **Instantaneous velocity** is the velocity at infinitely small interval:

$$\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t}$$

or the same

$$\vec{v} = \frac{d\vec{x}}{dt}$$

- **Average acceleration** is the total change in velocity per unit of time:

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$$

- **Instantaneous acceleration** is the change in velocity per unit of time at infinitely small time:

$$\vec{a} = \frac{d\vec{v}}{dt}$$

- **Gravitational motion** is the motion when gravitational acceleration $g=9.8\ m/s^2$ takes part. For example: rocket motion.

- Displacement at constant acceleration in rectilinear motion :

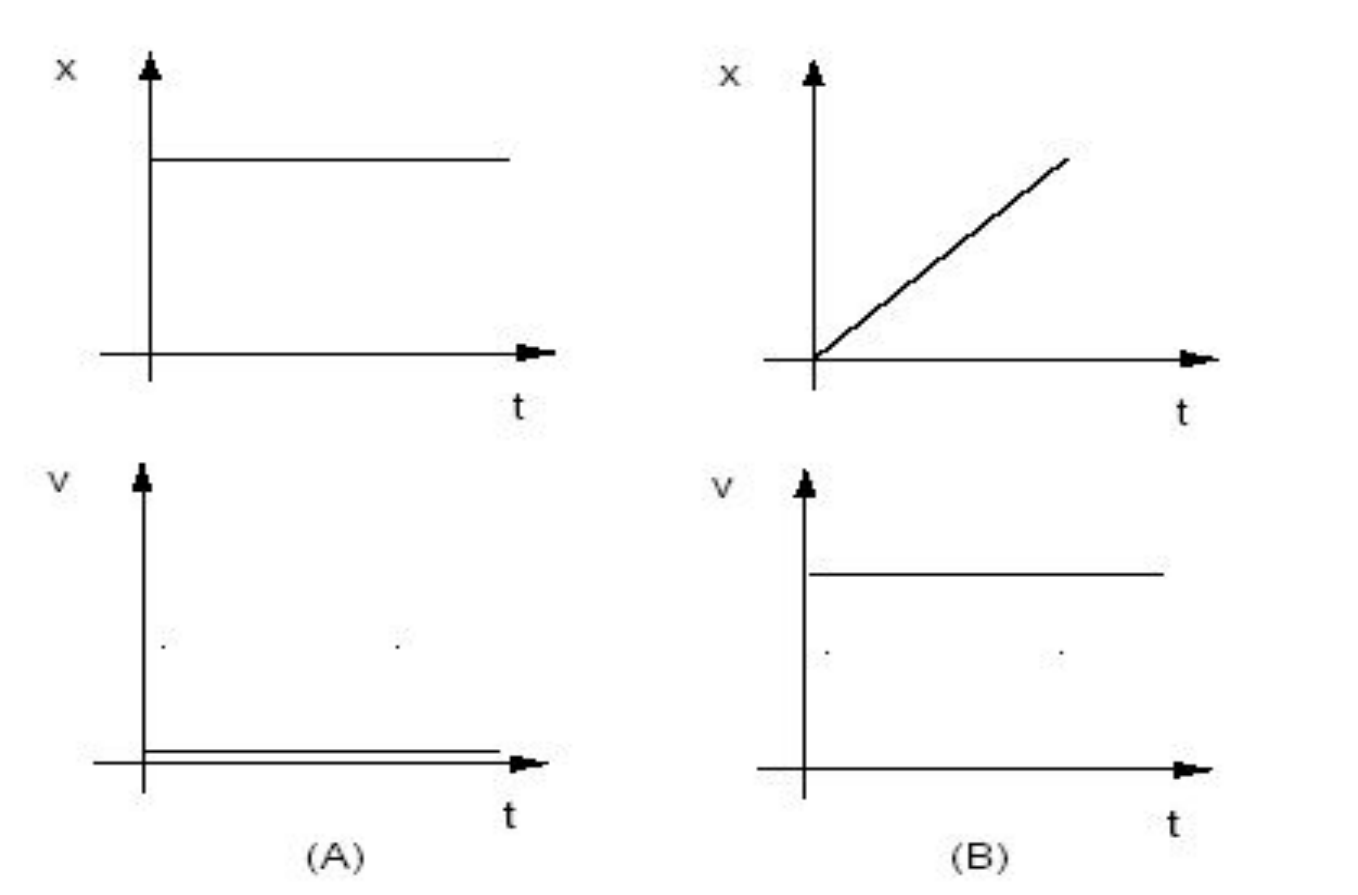
$$r = r_0 + V_0 t + \frac{at^2}{2}$$

- Where r_0 and V_0 is initial displacement and velocity at t=0, a is constant acceleration.

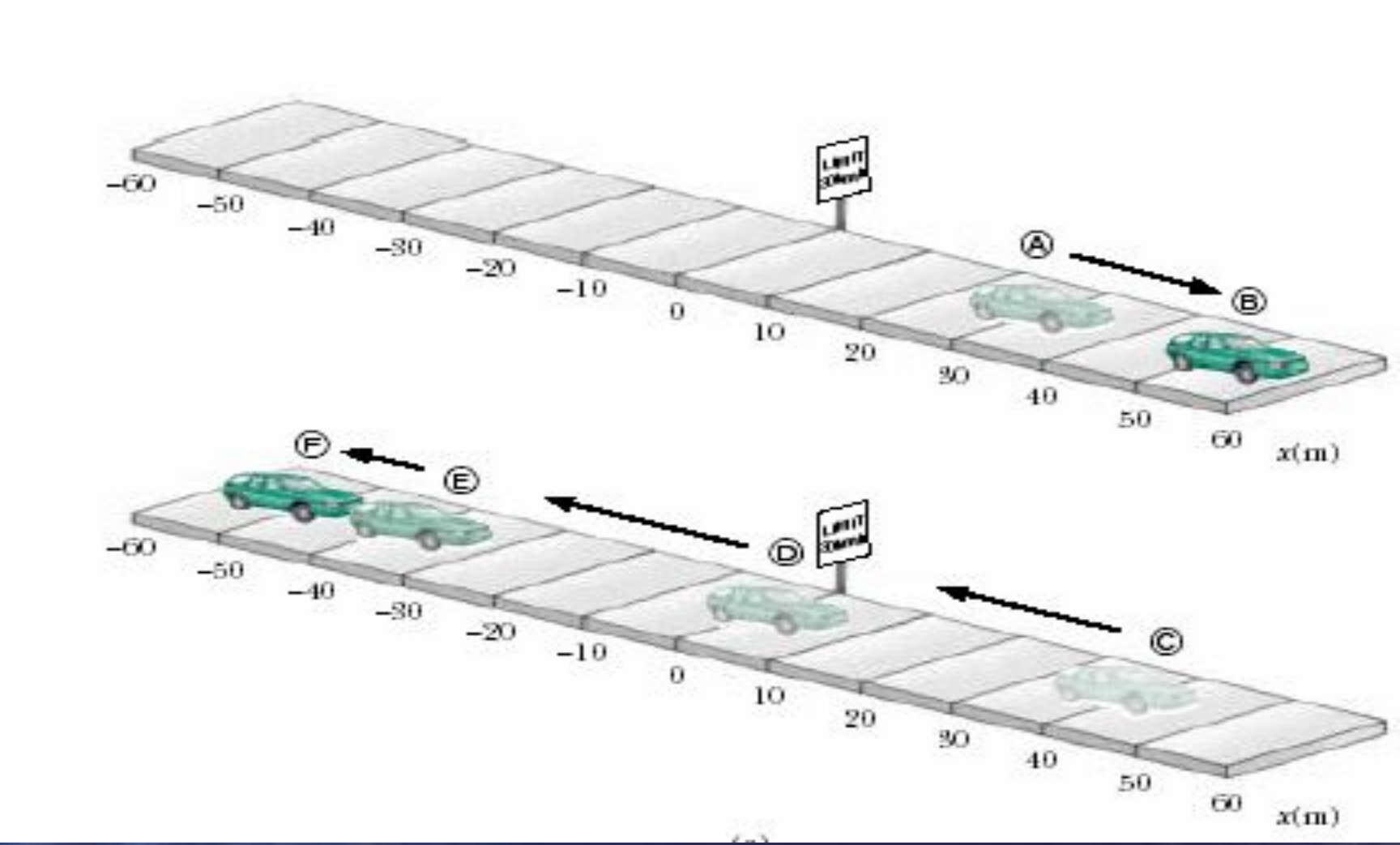
Rectilinear motion in graphics

A) Object stands still.

B) Object moves with constant speed.



Another example of rectilinear motion



- The car motion in table

Position of the Car at Various Times

Position	t(s)	x(m)
A	0	30
B	10	52
C	20	38
D	30	0
E	40	−37
F	50	−53

Position of the Car at Various Times

Position	t(s)	x(m)
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Ⓑ	10	52
Ⓒ	20	38
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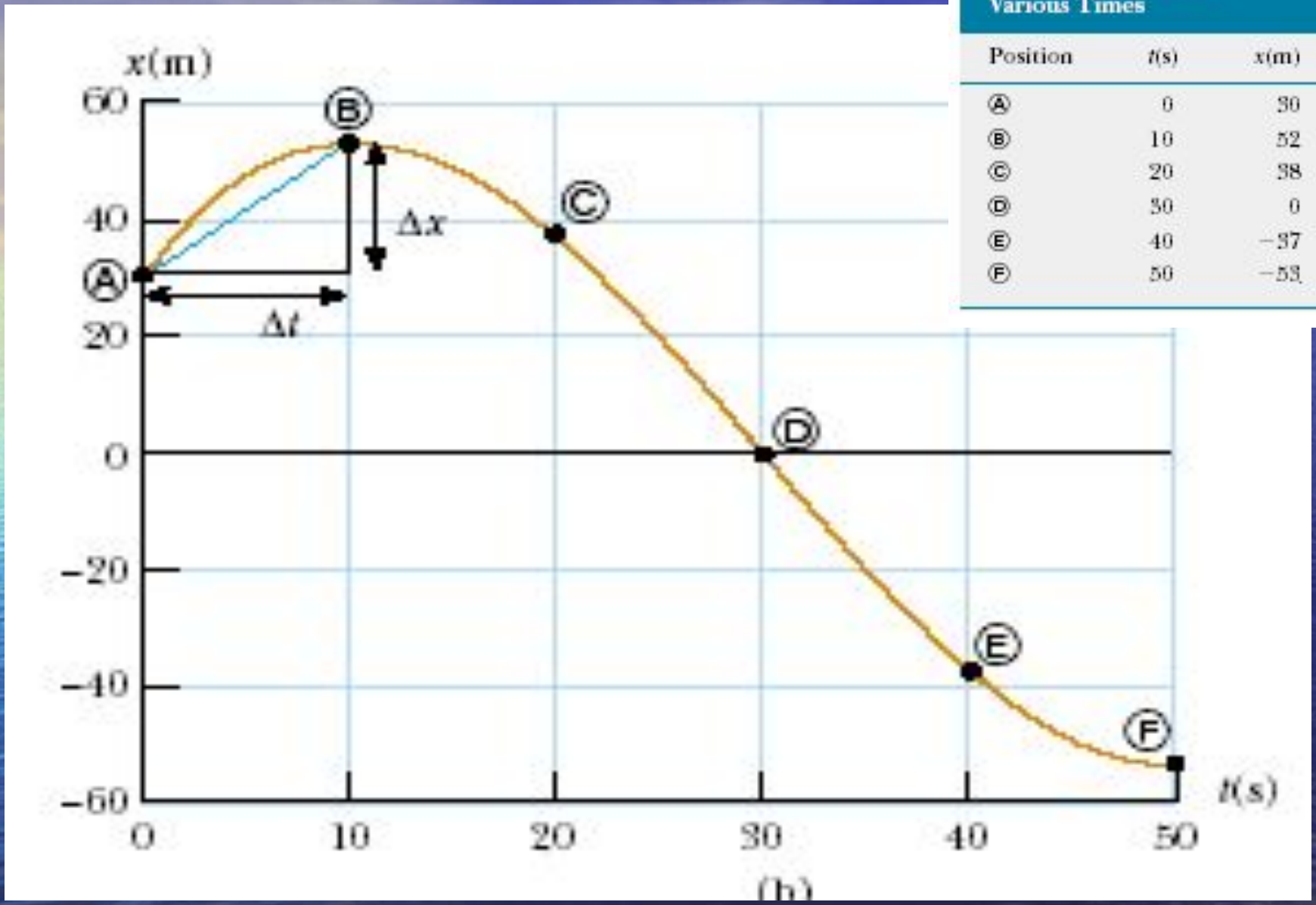
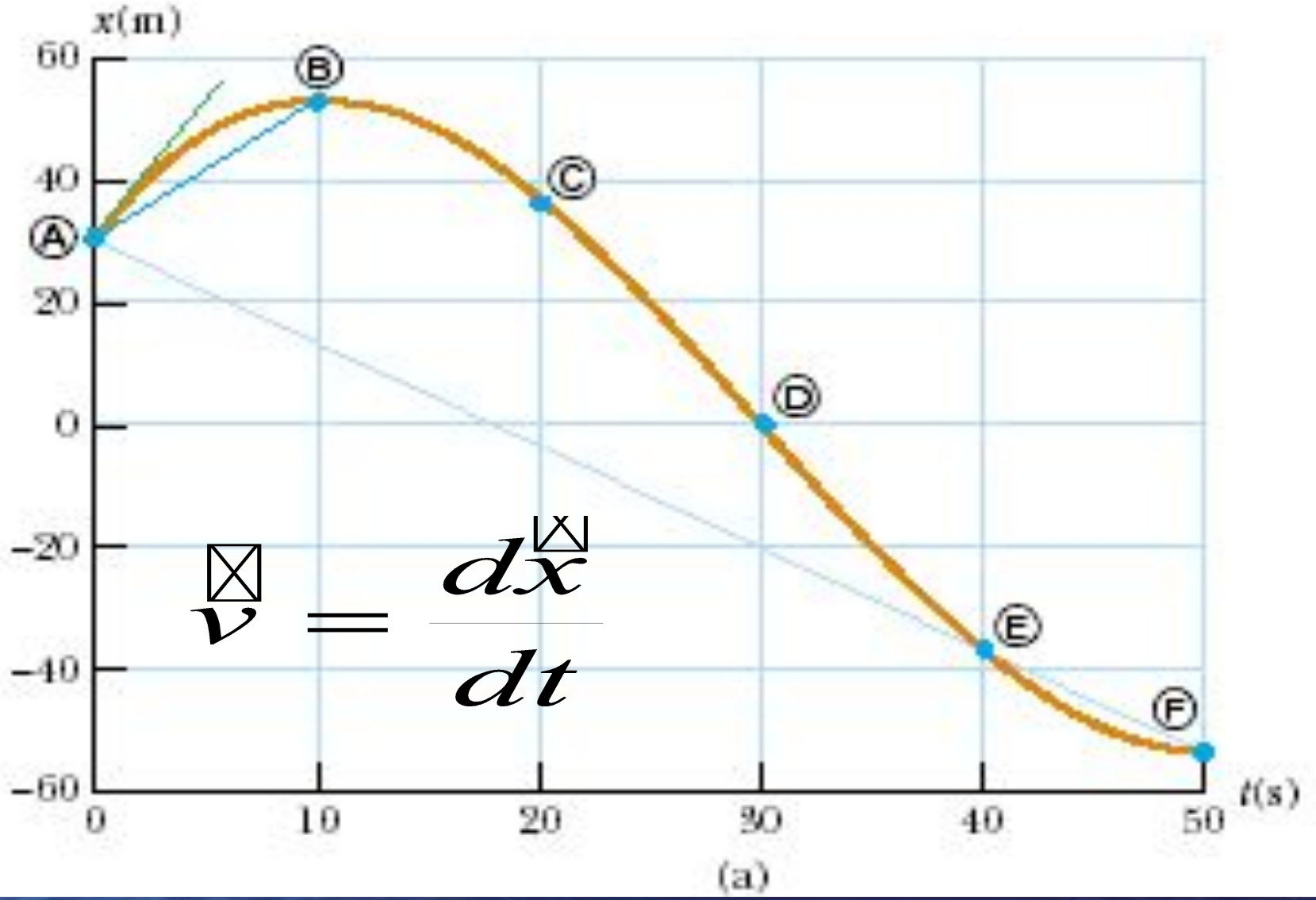
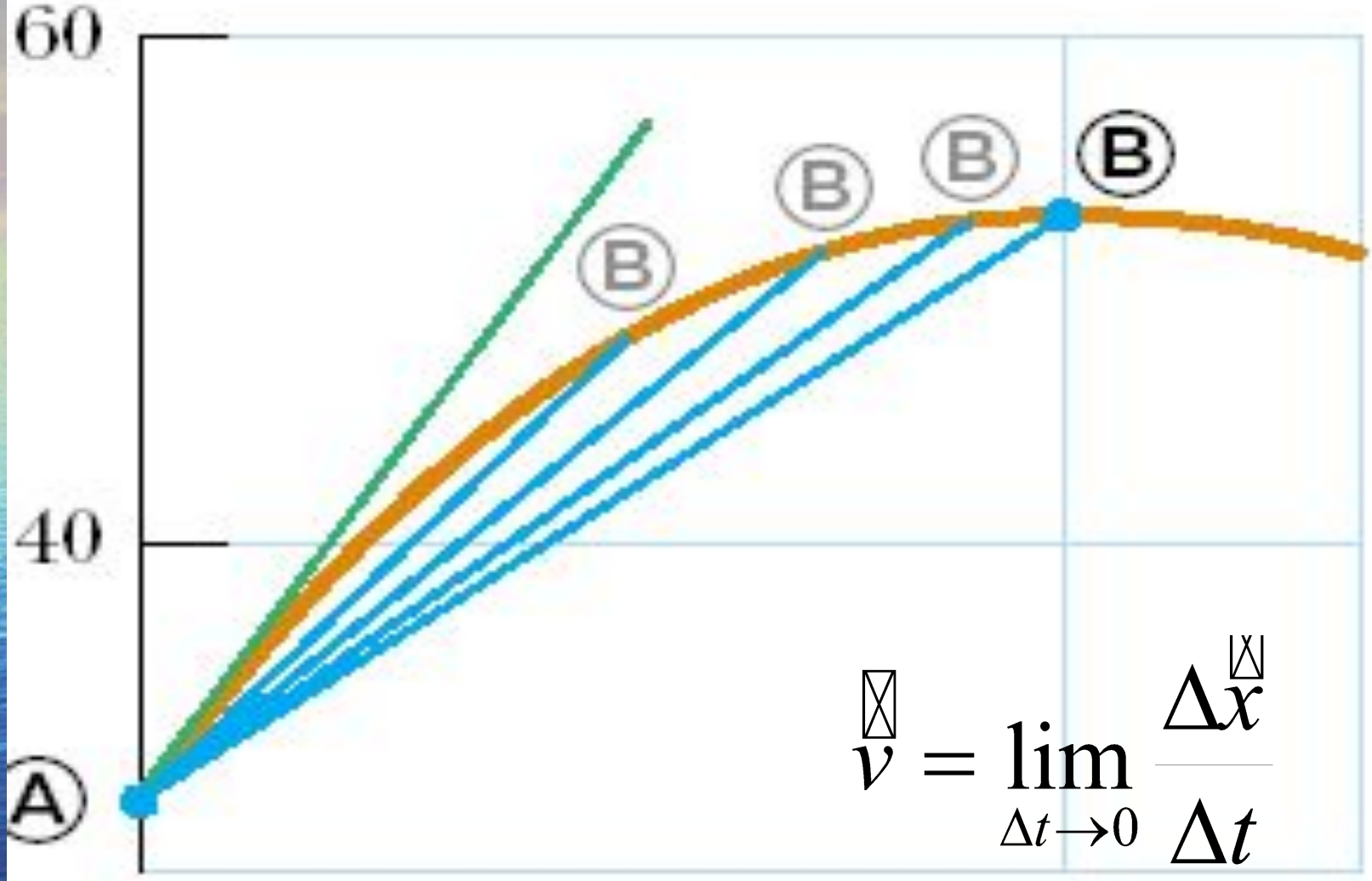


(b)

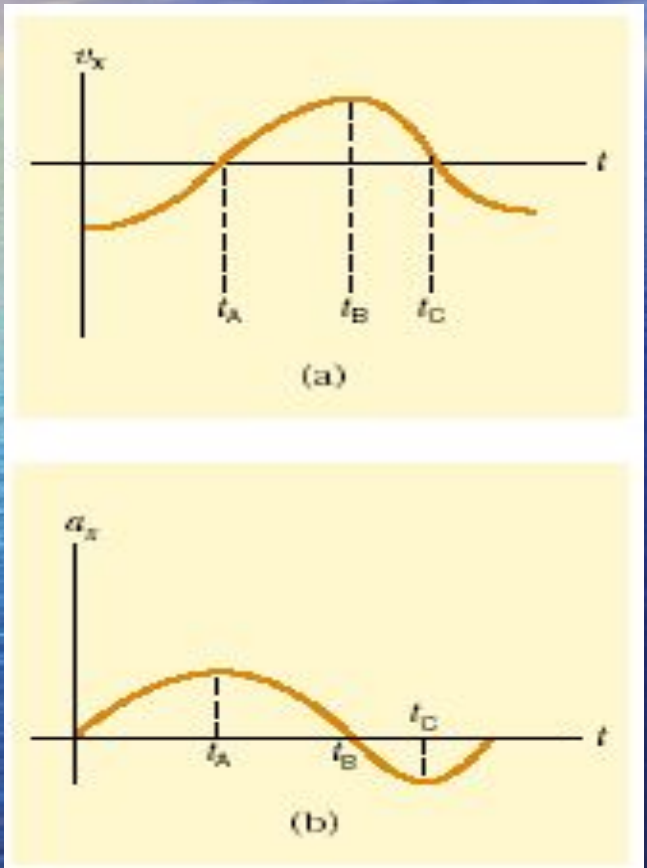


$$\vec{v} = \frac{d\vec{x}}{dt}$$

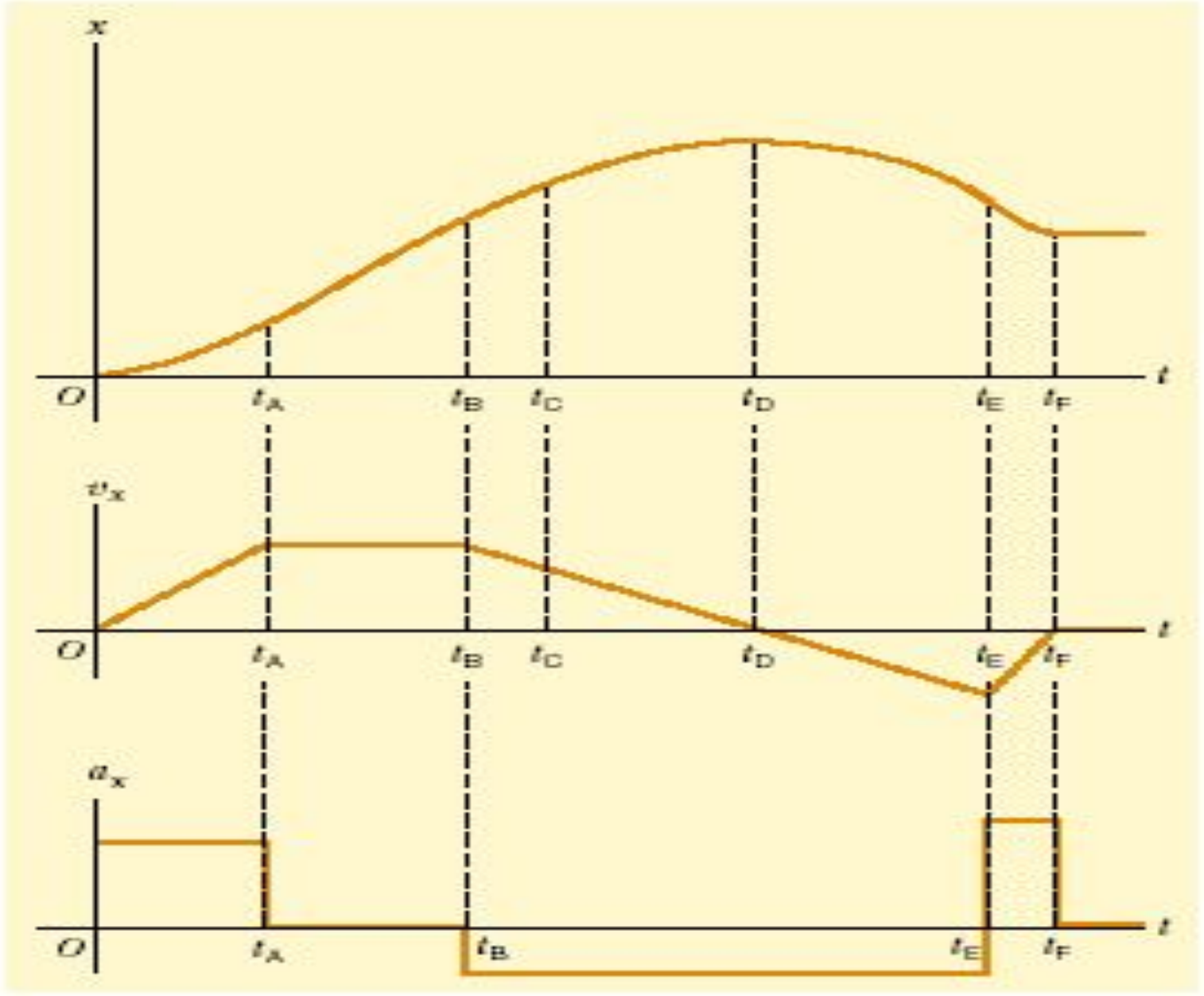


$$\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t}$$

Velocity and acceleration



$$\vec{a} = \frac{d\vec{v}}{dt}$$


x
O
t_A
t_B
t_C
t_D
t_E
t_F
t
v_x
O
t_A
t_B
t_C
t_D
t_E
t_F
t
a_x
O
t_A
t_B
t_E
t_F
t

- **Projectile motion** is a gravitational motion but the object has no its own acceleration. So the motion goes with constant gravitational acceleration. For example: cannonball motion.
- Usual method for solving projectile motion problems:
  - Separate the motion into two parts: vertical and horizontal: so we have:
    - two coordinates x and y
    - two velocities V_x and V_y
    - one acceleration $a_y = -g$, and $a_x = 0$

- Then one should determine the elevation angle Θ_0 - the initial angle to horizon.
- So the trajectory of an object in the gravitational field can be described as following:

$x = V_0 \mathrm{Cos}\Theta_0 \; t,$

$y = V_0 \mathrm{Sin}\Theta_0 \; t - gt^2/2.$

Let's designate R as the range the object travels from zero height (y=0) till its fall (y=0 again) then we can calculate it as

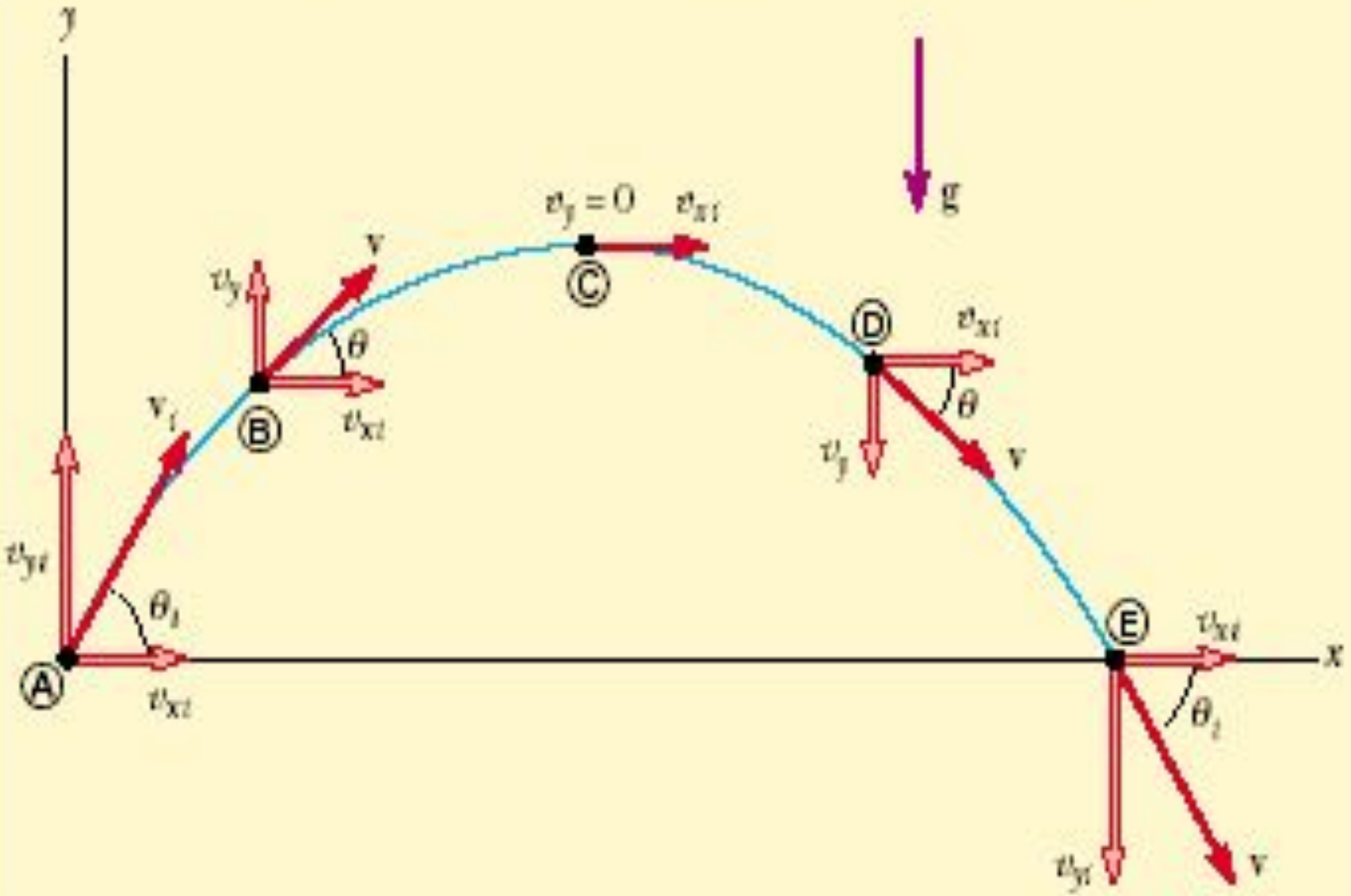
$R = V_0^2 \mathrm{Sin}(2\Theta_0)/g.$

Flight time t: it's easy (using the equation dy/dt = 0) to find that the time of ascent is $V_0 \mathrm{Sin}\Theta_0/g$, then the full flight time is double:

$t_{flight} = 2V_0 \mathrm{Sin}\Theta_0/g.$

Using the flight time one can find:

- the maximal height,
- the range of flight (the maximum range of flight from zero height (y=0) till the fall of the object (y=0 again)).


y
x
g
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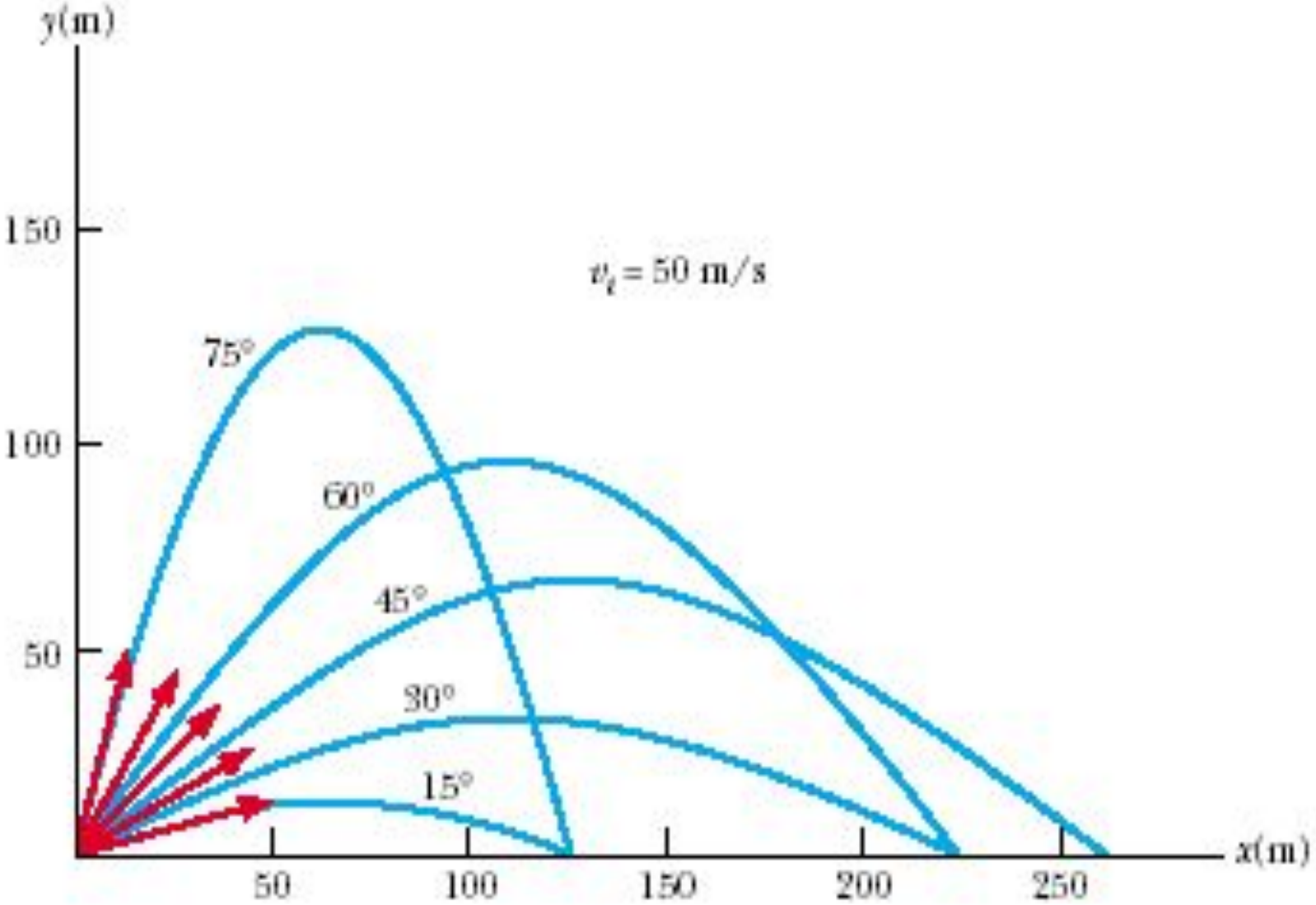
B
C
D
E
v_{yi}
v_{xi}
θ_i
v_i
$v_y = 0$
v_{xi}
v_y
v
θ
v_{xi}
v_{xi}
θ
v_y
v
v_{xi}
θ_i
v_{yi}
v

$R = V_0^2 \mathrm{Sin}(2\Theta_0)/g$



Circular uniform motion

- Uniform circular motion is performed with constant speed along a circular path. Circular motion is a special case of motion on a plane. Its coordinates is angular coordinate φ and radius r. The angular speed ω is defined as:

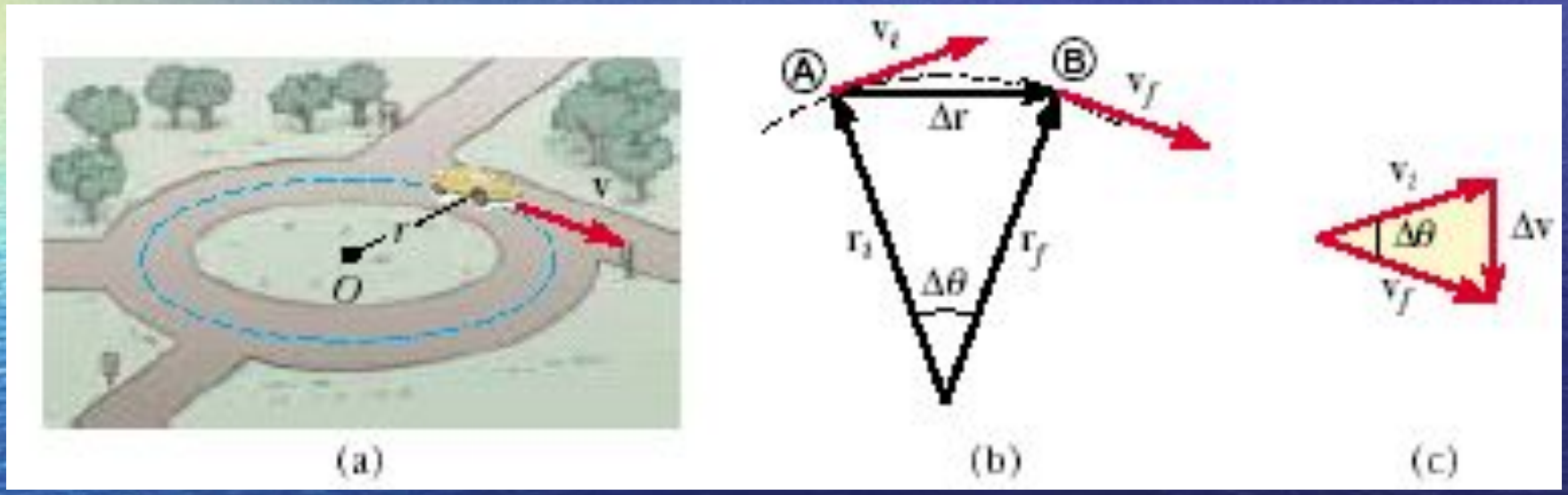
$$\omega = \frac{d\varphi}{dt}$$

- The linear speed relates to the angular speed as:

$$\vec{v} = \vec{\omega} r$$

- Period T is the time of one full revolution:

$$T = 2\pi/\omega.$$


v
r
O
(a)
v_i
A
B
v_f
Δr
r_i
r_f
$\Delta\theta$
(b)
v_i
$\Delta\theta$
Δv
v_f
(c)

Units in SI

- Displacement x,y m
- Velocity V m/s
- Acceleration a,g m/s^2
- Angle φ rad
- Angular speed ω rad/s
- Period T s

Read before the next Lecture

- Fishbane Chapters 4,5 pp.87-150
- Russian equivalents:
  - Трофимова Т.И. Курс физики. Глава 2 Динамика материальной точки.
  - Савельев И.В. Курс общей физики. Т.1. Глава 2 Динамика материальной точки.