Physics 2311 – Physics I, Week 4

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Outline for Day W3,D1

1D kinematics

  Equations of uniform acceleration, including free-fall

  Examples

2D kinematics - Vectors

Homework

Ch. 2 Prob. 2,3,5-7,14,23-27,35-38,53-56 for 2-day

Ch. 3 P. 1,3,6,7,10,11,19,20,23,24,
32,33,37,38,39 Do by next Mon.

Notes: Lab this week: “Graphs and Tracks”

Under NEW STUFF: “Exam like problems” for Ch. 1
And “Week 3-5” practice quiz.

Motion in 1D.

Equations for Uniform Acceleration

A) [Text: 2-12a] $$\vec{v}_f = \vec{v}_i + \vec{a}\,t$$

B) [Text: 2-12d] $$\vec{v}_{avg} = \frac{\vec{v}_i + \vec{v}_f}{2}$$

C) [Text: 2-8] $$\vec{x}_f = \vec{x}_i + \frac{\vec{v}_i + \vec{v}_f}{2}\,t$$

D) [Text: 2-12b] $$\vec{x}_f = \vec{x}_0 + \vec{v}_0\,t + \frac{1}{2}\vec{a}\,t^2$$

E) [Text: 2-12c] $$v_f^2 - v_i^2 = 2a\left(x_f - x_i\right)$$

Motion in 1D.

Examples using Equations for Uniform Acceleration

1) A car passes x=10m at t=0 going 10 m/s with a constant accelerating of 4 m/s^2 . Where will the car be in 5 seconds?

$$\vec{x}_f = \vec{x}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$$

2) A car accelerates uniformly, starting at v_i=5 m/s at x_i=20, and reaching x_f=100 only 5 seconds later. How fast did it cross the x_f=100 m mark?

$$\vec{x}_f = \vec{x}_i + \frac{\vec{v}_i + \vec{v}_f}{2} t$$

Motion in 1D.

Examples using Equations for Uniform Acceleration

3) A rock thrown down a well at 10 m/s reaches the bottom at 40 m/s. What was the average velocity? (Uniform acceleration of 9.8 m/s^2 downward.)

$$\vec{v}_{avg} = \frac{\vec{v}_i + \vec{v}_f}{2}$$

4) Find the depth of the well in the previous problem, assuming the rock was thrown straight down.

$$v_f^2 - v_i^2 = 2a(x_f - x_i)$$

Motion in 1D.

Examples using Equations for Uniform Acceleration

5) A car on ice is sliding backwards to the left at 5 m/s while accelerating uniformly to the right at 3 m/s^2. What is its velocity after 7 seconds?

$$\vec{v}_f = \vec{v}_i + \vec{a}\,t$$

Motion in 1D.

Free Fall problems

Assumes downward acceleration, g, near the surface of a planet (usually Earth!)

The Equations for Uniform Acceleration apply!

Assumes no air resistance or other forces on the object.

Object can be move downwards OR upwards!

Motion in 1D.

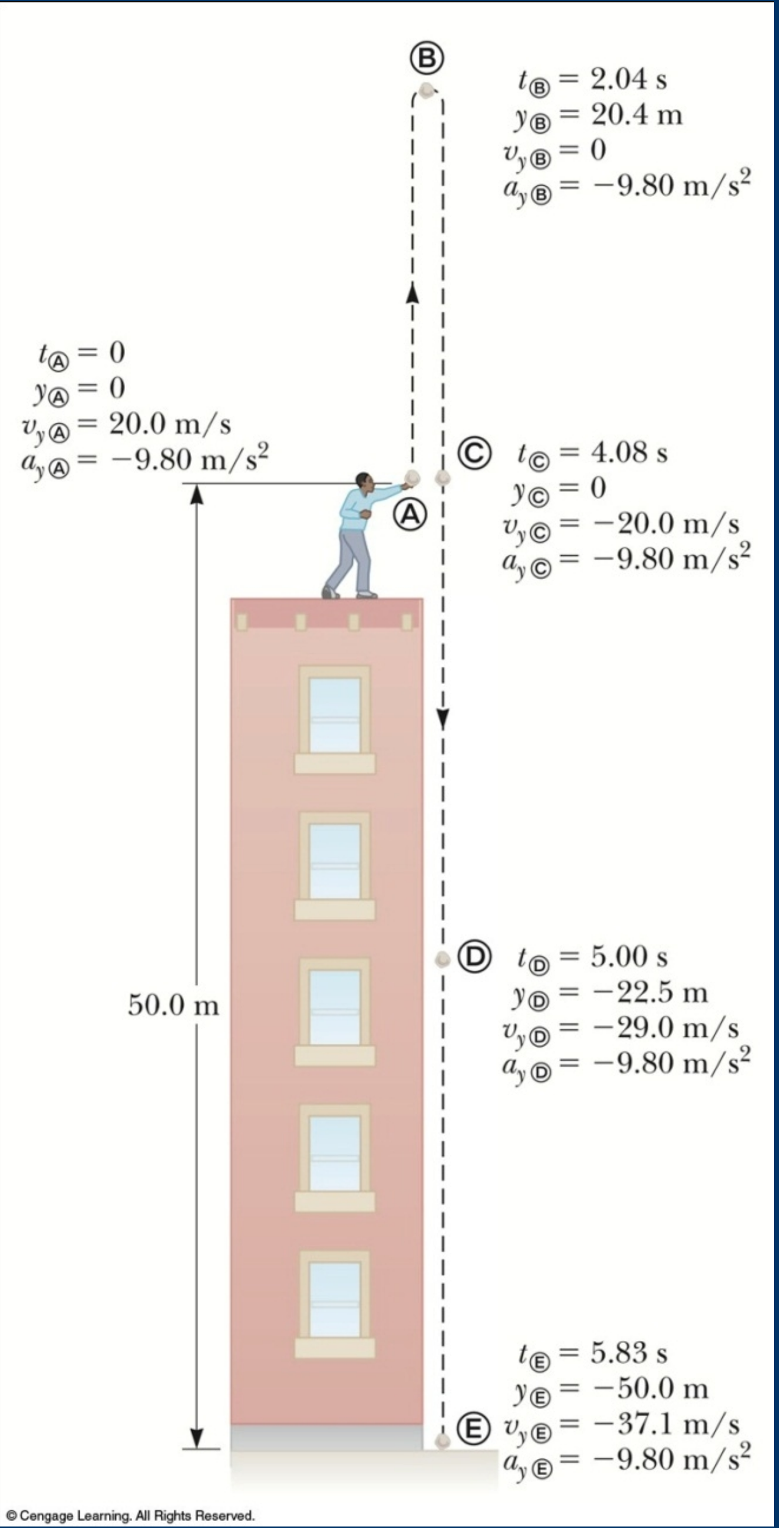
Free Fall problems

Initial velocity at A is upward (+) and acceleration is -*g* (-9.8 m/s²).

At B, the velocity is 0 and the acceleration is -*g* (-9.8 m/s²).

At C, the velocity has the same magnitude as at A, but is in the opposite direction.

The displacement is –50.0 m (it ends up 50.0 m below its starting point).



Motion in 1D.

Free Fall problems

Example) Verify that the ball hits the ground at t_f=5.83 seconds if it is thrown from an initial height of y_i=0 upwards at v_i=20 m/s.

Also given: y_f=-50 m, a=-9.8 m/s^2

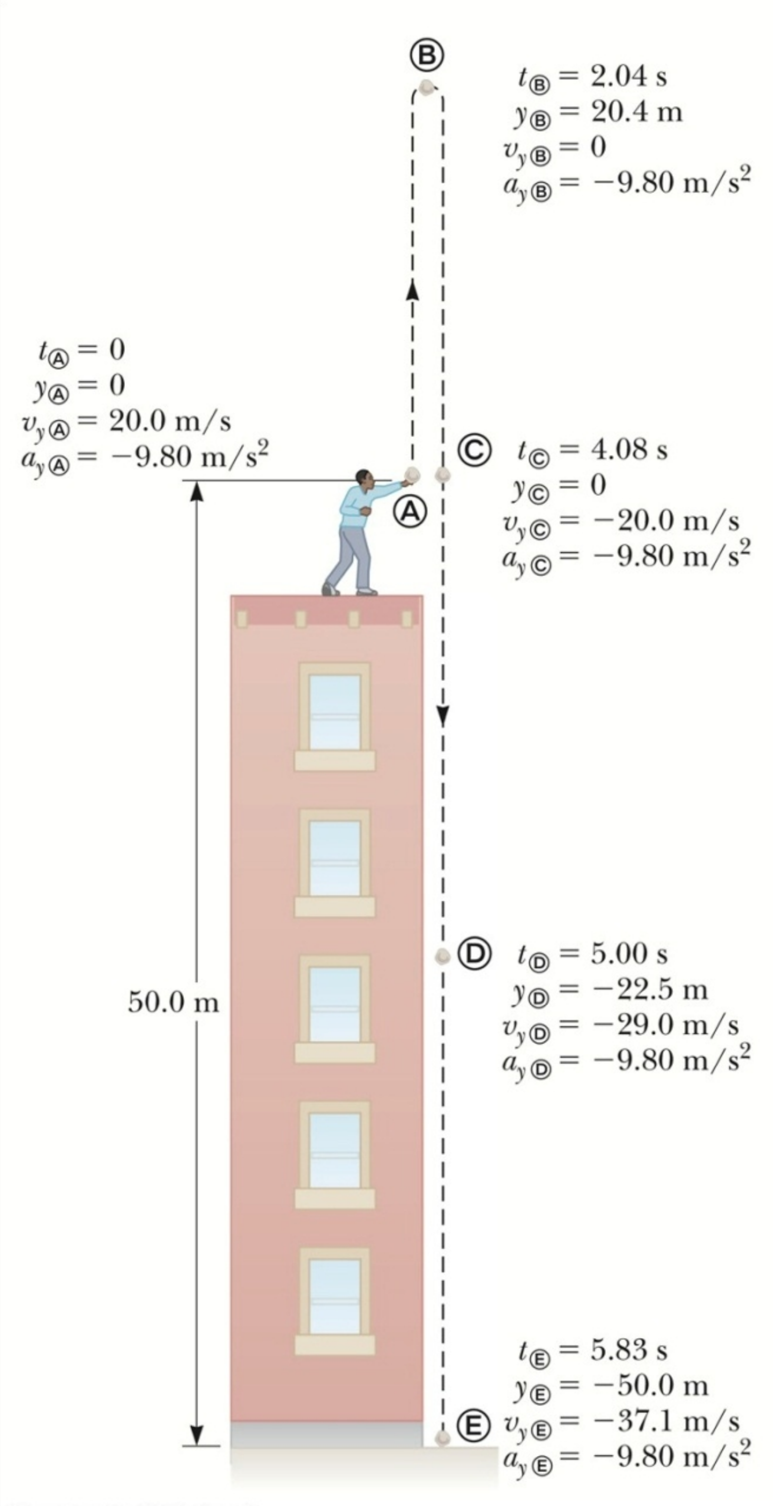
Use: $\vec{y}_f = \vec{y}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}\,t^2$

$-50 = 0 + 20t - 4.9t^2$

Quadratic eqn. $0 = -4.9t^2 + 20t + 50$

$0 = at^2 + bt + c$

Quadratic formula: $t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$



Motion in 2D.

Requires knowledge of vectors and vector components.

Top: position vector **A** in 2-D. Vector components are:

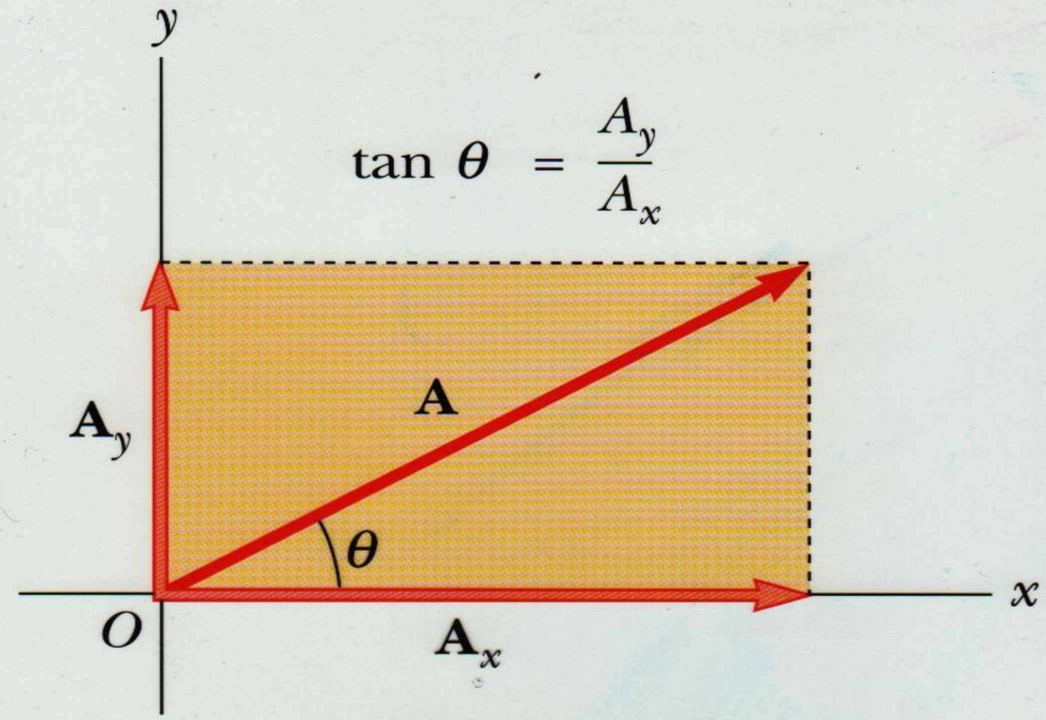
$A_x = |\mathbf{A}|\cos\theta$

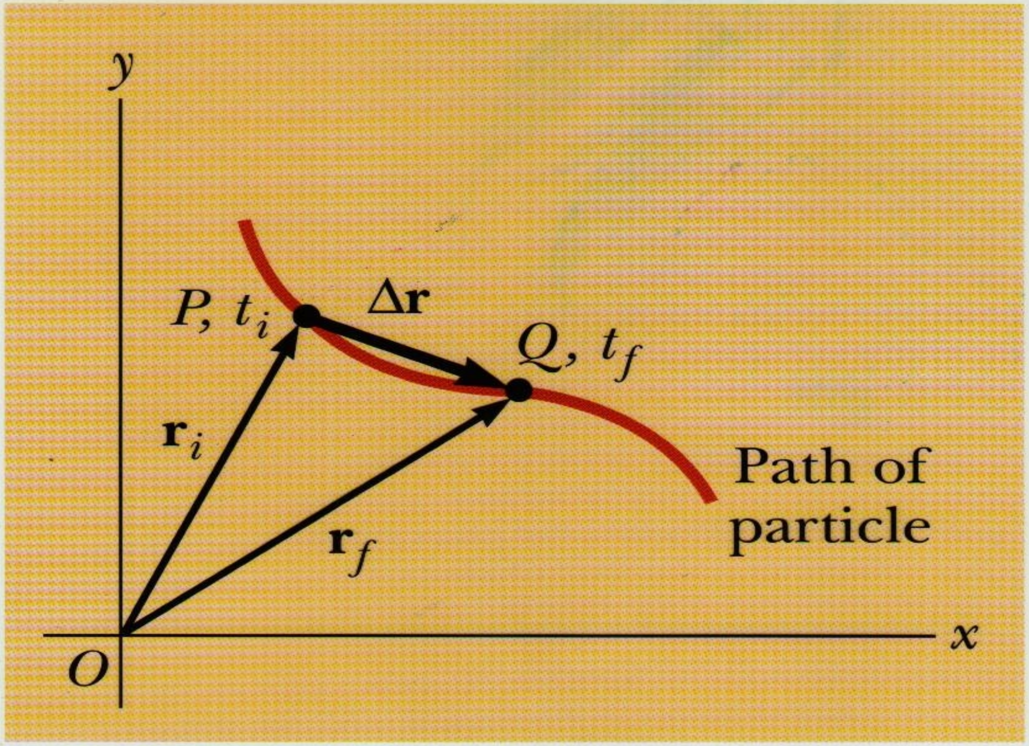
$A_y = |\mathbf{A}|\sin\theta$

so $\mathbf{A} = A_x\,\hat{\imath} + A_y\,\hat{\jmath}$

$|\mathbf{A}| = (A_x^2 + A_y^2)^{1/2}$

Bottom: change of a position vector **r** gives a displacement $\Delta\mathbf{r}$.





Motion in 2-D (and beyond)
Definitions

Definitions ... (Most of these are very similar to the Ch. 2 equations)

Position vector: $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

Displacement: $\Delta\vec{r} = \vec{r}_f - \vec{r}_i$

Average velocity: $\vec{v}_{avg} = \dfrac{\Delta\vec{r}}{\Delta t}$. Instantaneous velocity: $\vec{v}_{inst} = \dfrac{d\vec{r}}{dt}$

Average acceleration: $\vec{a}_{avg} = \dfrac{\Delta\vec{v}}{\Delta t}$. Instantaneous acceleration: $\vec{a}_{inst} = \dfrac{d\vec{v}}{dt}$

Equations of Uniform acceleration

Final velocity $\vec{v}_f = \vec{v}_i + \vec{a}\,t$

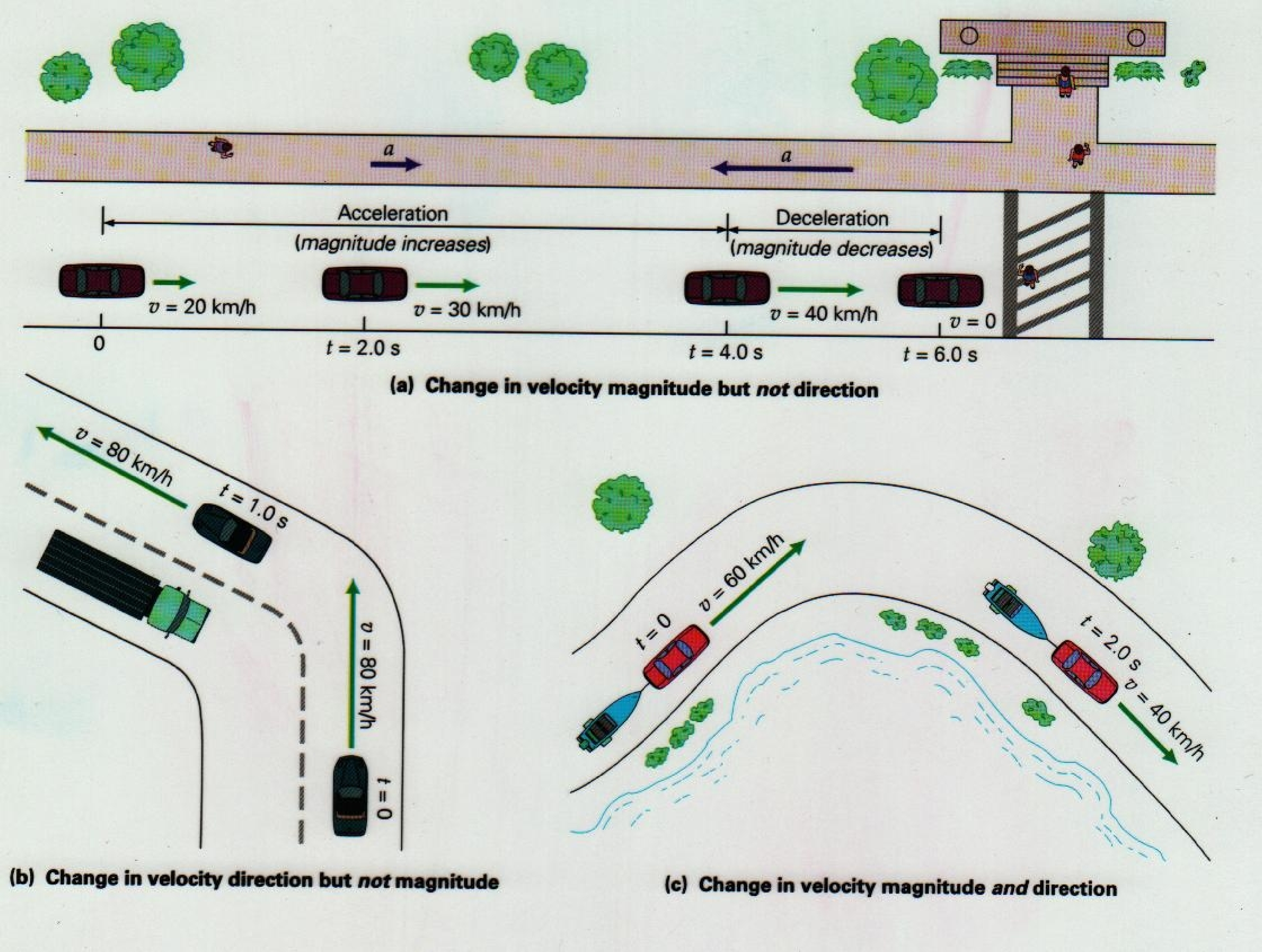
Average Velocity $\vec{v}_{avg} = \dfrac{\vec{v}_i + \vec{v}_f}{2}$

Position as function of time: $\vec{r}_f = \vec{r}_i + \vec{v}_{avg}\,t$

Position as function of time: $\vec{r}_f = \vec{r}_i + \vec{v}_i t + \dfrac{1}{2}\vec{a}\,t^2$

Velocity change related to position change: $\vec{v}_f \cdot \vec{v}_f - \vec{v}_i \cdot \vec{v}_i = 2\vec{a} \cdot (\vec{r}_f - \vec{r}_i)$

Top: Motion in 1D
Bottom: Motion in 2D.



(a) Change in velocity magnitude but *not* direction

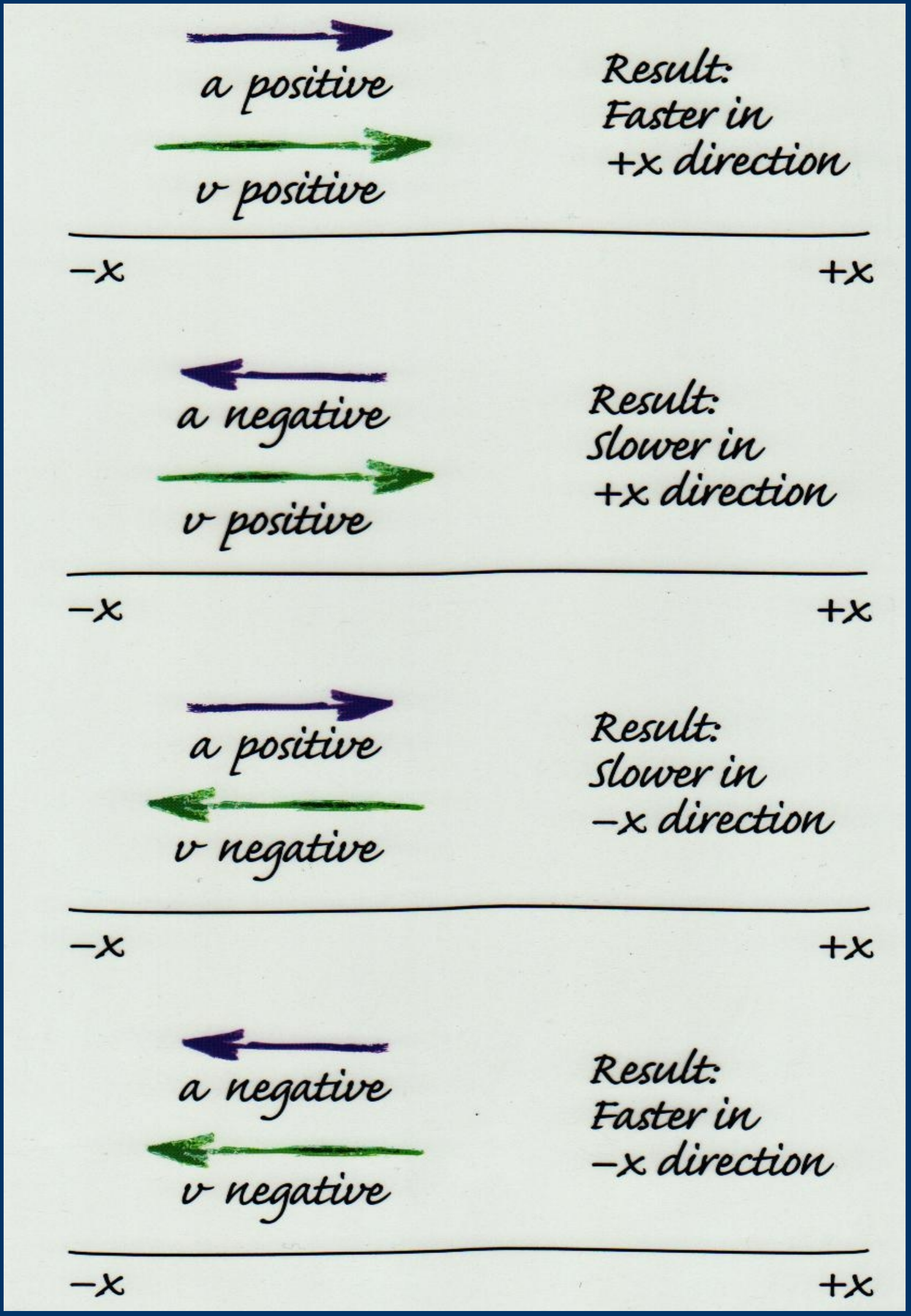
(b) Change in velocity direction but *not* magnitude

(c) Change in velocity magnitude *and* direction

Show 4.16.swf - acceleration has a radial and tangential component.

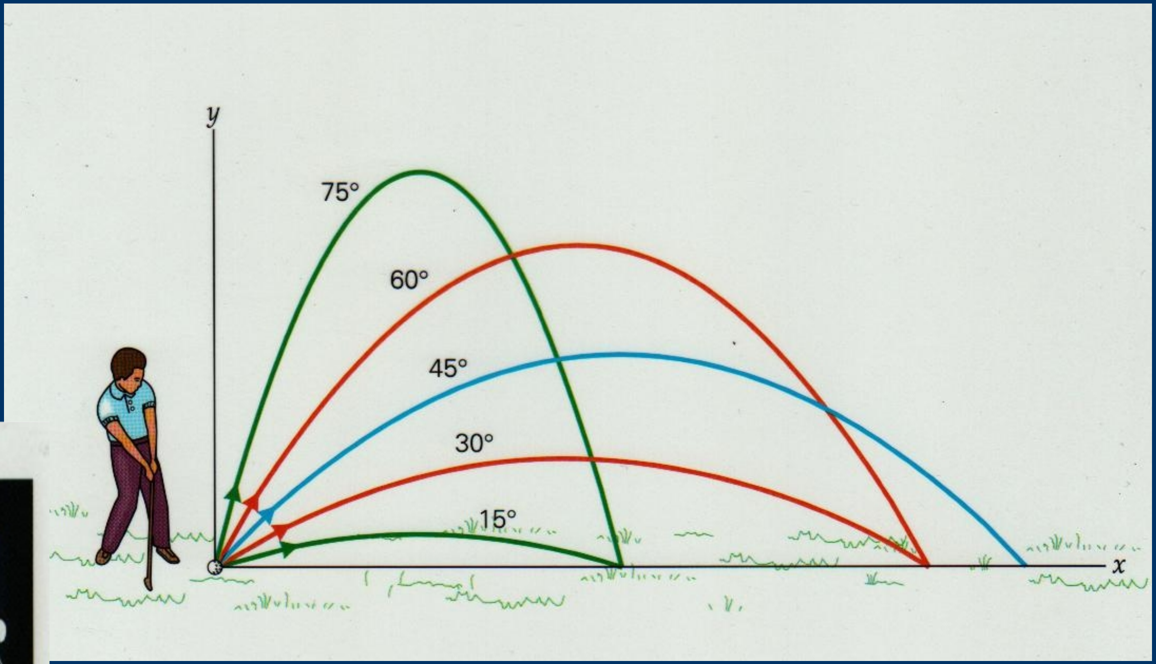
Recall for motion in 1D...

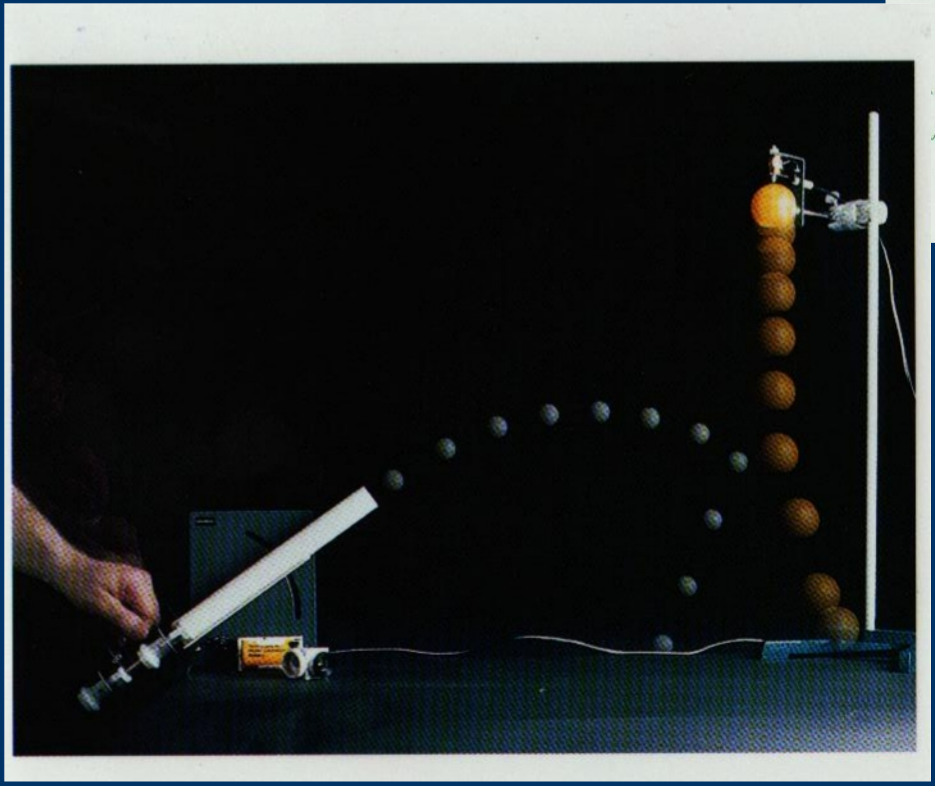
The sign of acceleration and velocity is used to indicate the direction of these vectors.



Motion in 2 dimensions. "Projectile Motion".

Uniform downward acceleration leads to parabolic trajectories.



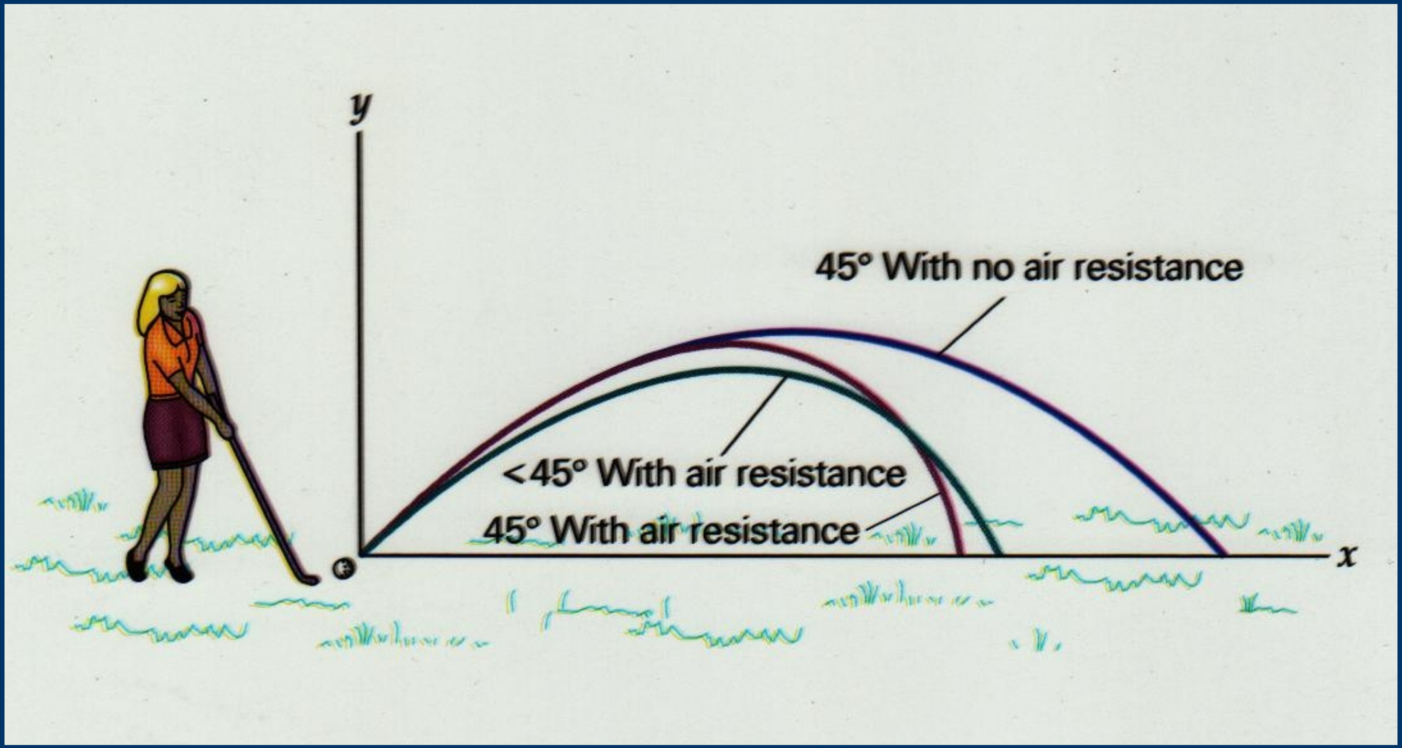


Notice that 2 initial angles lead to the same final range, except 45 degrees.

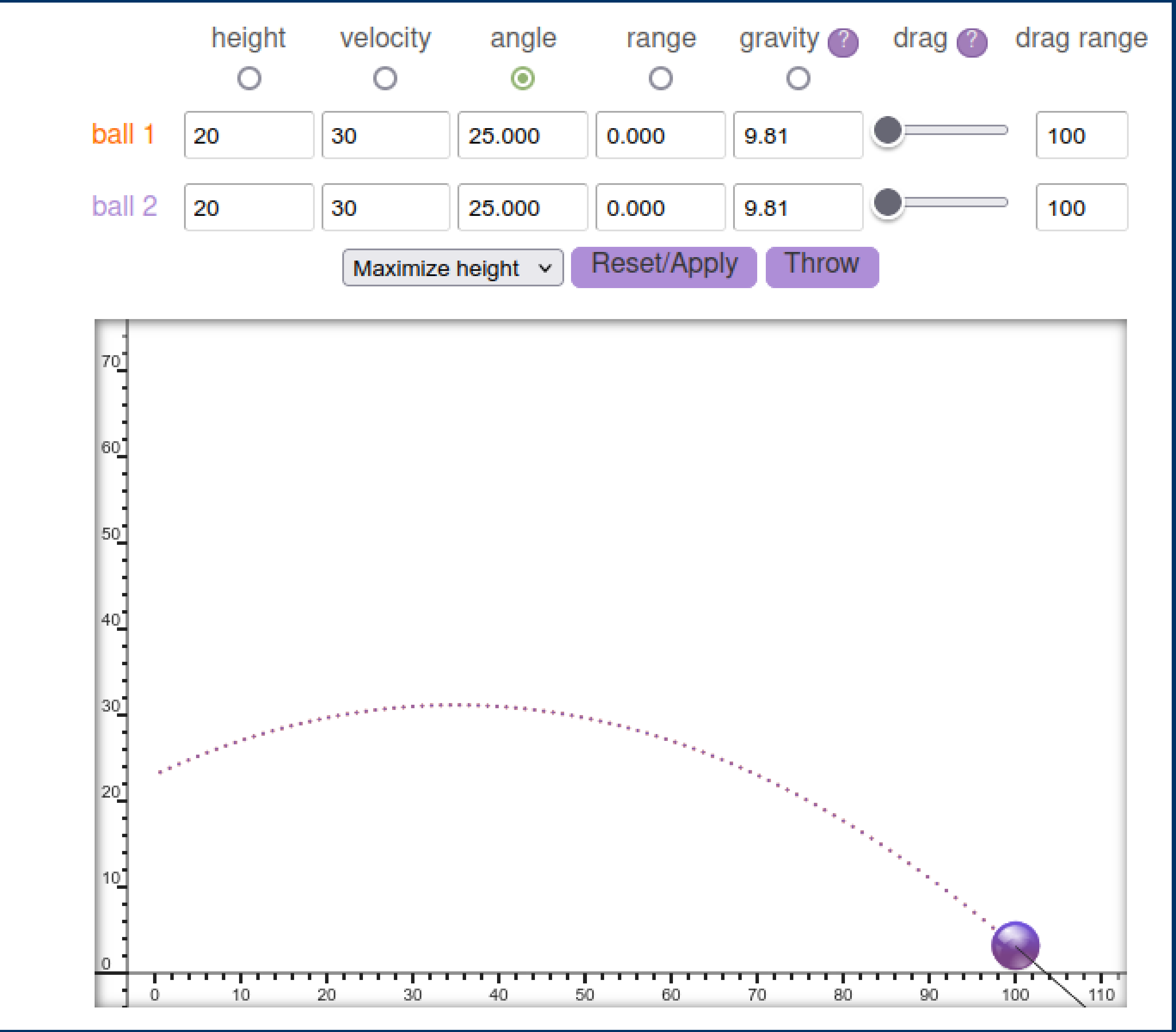
$$R = \frac{v_0^{\,2} \sin 2\theta}{g}$$

PHYS 2311 Motion in 2 dimensions.

Actual trajectories: parabolas distorted by air resistance (drag).



Motion in 2 dimensions. Projectile Motion

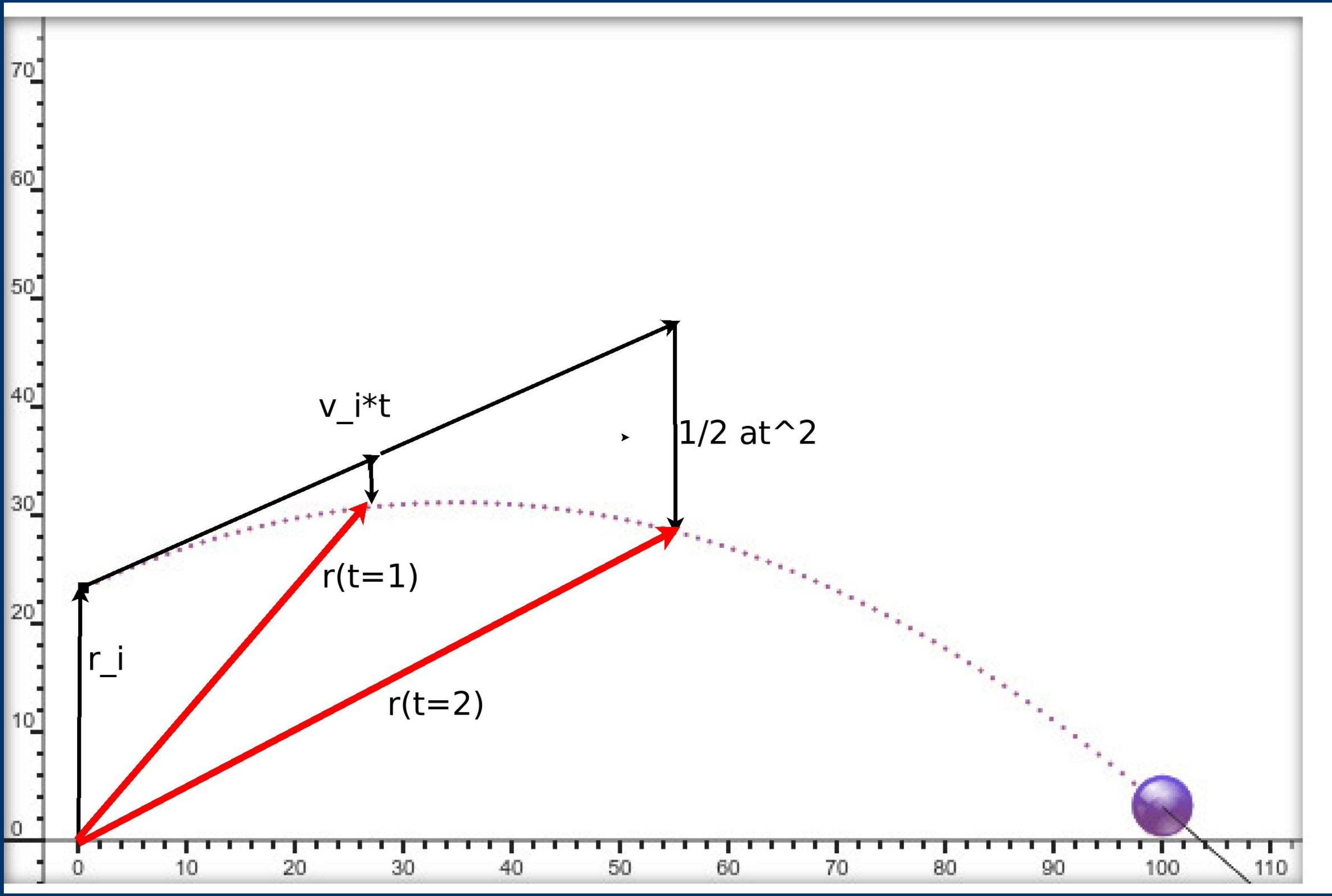


Trajectories are specified with an initial position, velocity, inclination angle (or altitude), and acceleration.

Motion in 2 dimensions. Projectile Motion

Trajectories: the position vector (red) is a sum of 3 vectors!

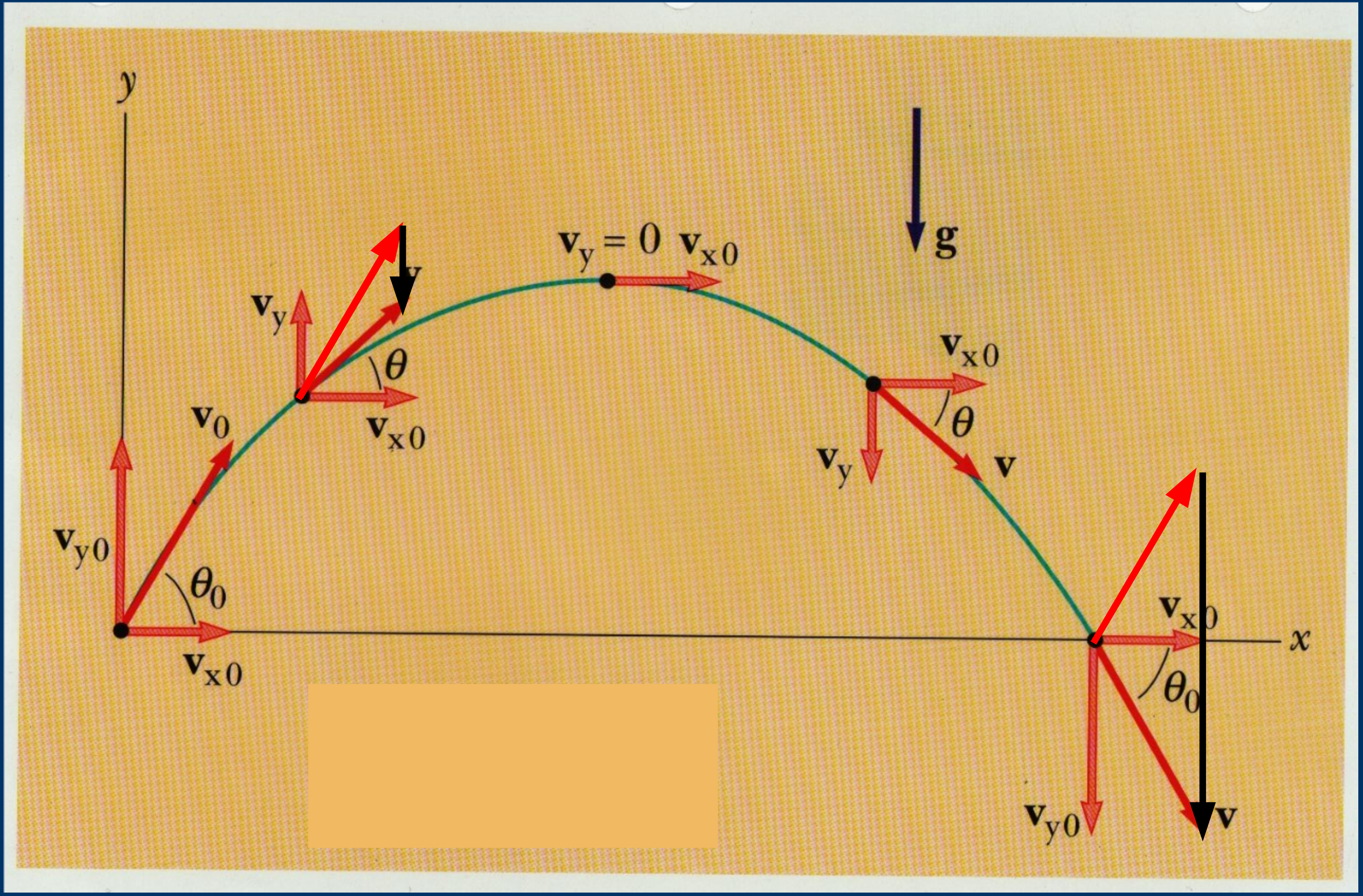
$$\vec{r}(t) = \vec{r}_i + \vec{v}_i t + \frac{1}{2}\vec{a}t^2$$



Motion in 2 dimensions. Projectile Motion

Trajectories: the velocity vector is a sum of 2 vectors.

$$\vec{v}(t)=\vec{v}_0+\vec{a}\,t \qquad \text{or} \qquad \vec{v}(t)=v_{x,0}\,\hat{i}+v_y\,\hat{j}$$



Motion in 2-D
Projectile Motion formulas

Time to reach max height: $\boxed{t_{max} = \dfrac{v_i \sin\theta_i}{g}}$ (v_i is the magnitude of the initial velocity)

Maximum height: $\boxed{h_{max} = \dfrac{v_i^2 \sin^2\theta}{2g}}$

Range: $\boxed{R = \dfrac{v_i^2 \sin 2\theta}{g}}$