Physics 2311 – Physics I, Week 4
Dr. J. Pinkney

Outline for Day W4,D1

Finish up 1D kinematics: examples, free fall
2D kinematics (Ch. 3)
- Vectors
- 2D kinematics with vectors
- Projectile Motion

Homework

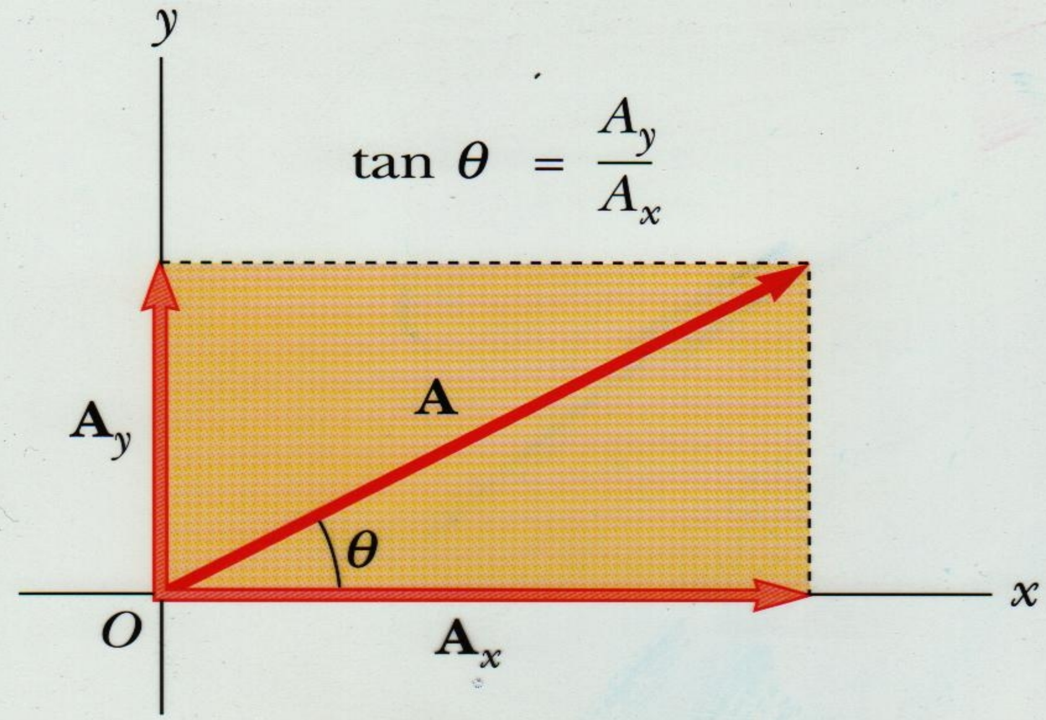
Ch. 3 P. 1,3,6,7,10,11,19,20,23,24,
32,33,37,38,39 Due Fri.

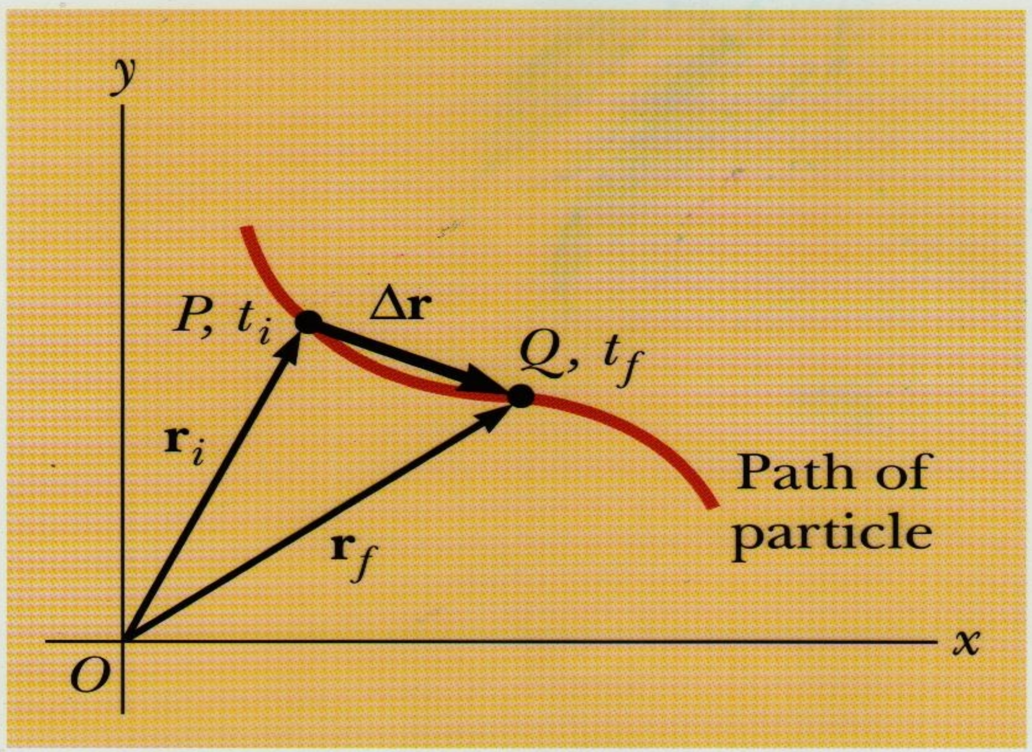
Notes: Lab this week: "Acceleration of Gravity"
Quiz 2 on Friday (1D motion, vectors).
See online "Week 3-5" practice quiz.

Motion in 2D.

Top: position vector in 2-D.

Bottom: change of a position vector **r** gives a displacement Δ**r**.





Motion in 2-D

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

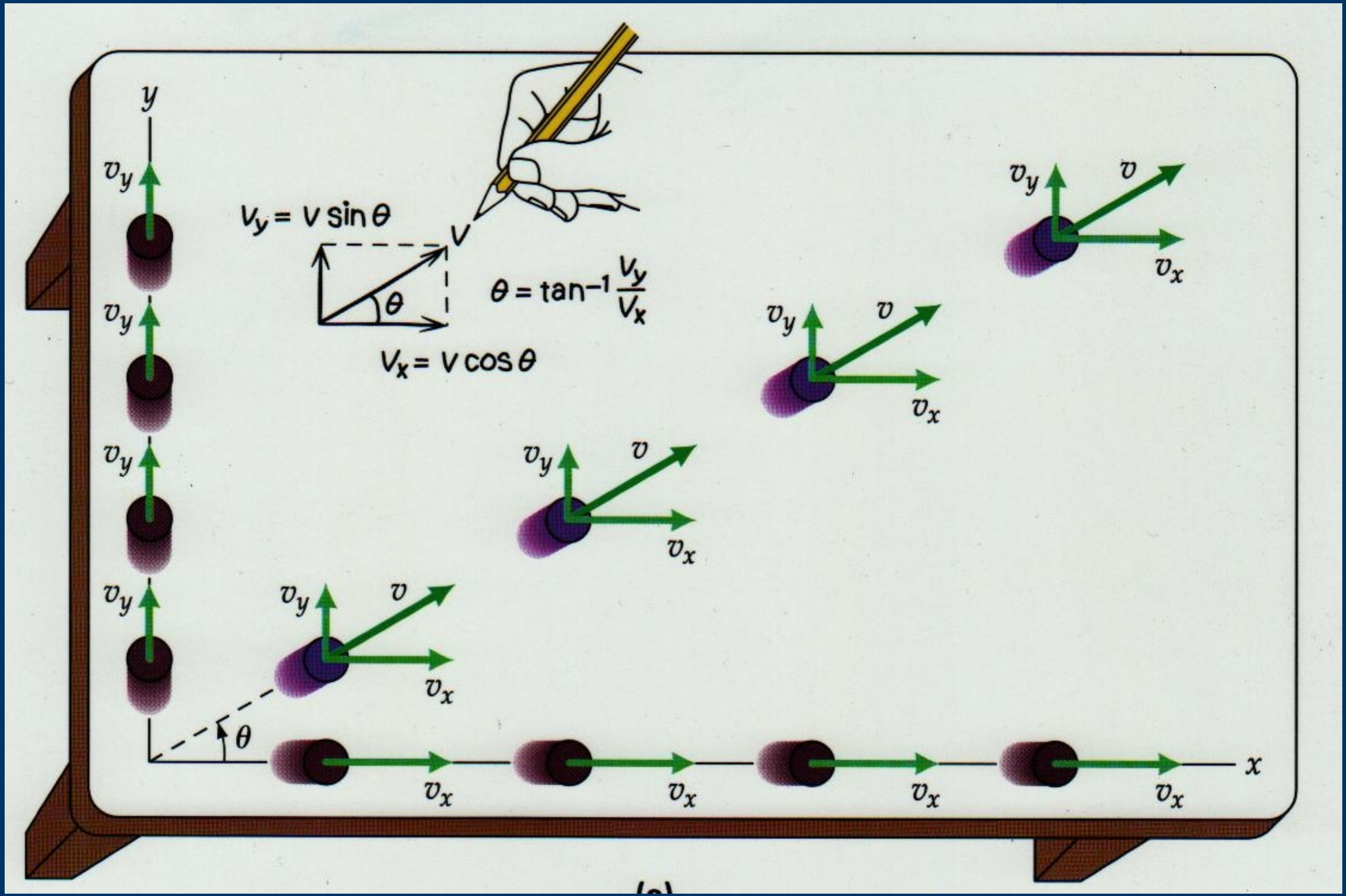
Average Velocity $\vec{v}_{avg} = \dfrac{\vec{v}_i + \vec{v}_f}{2}$

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

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

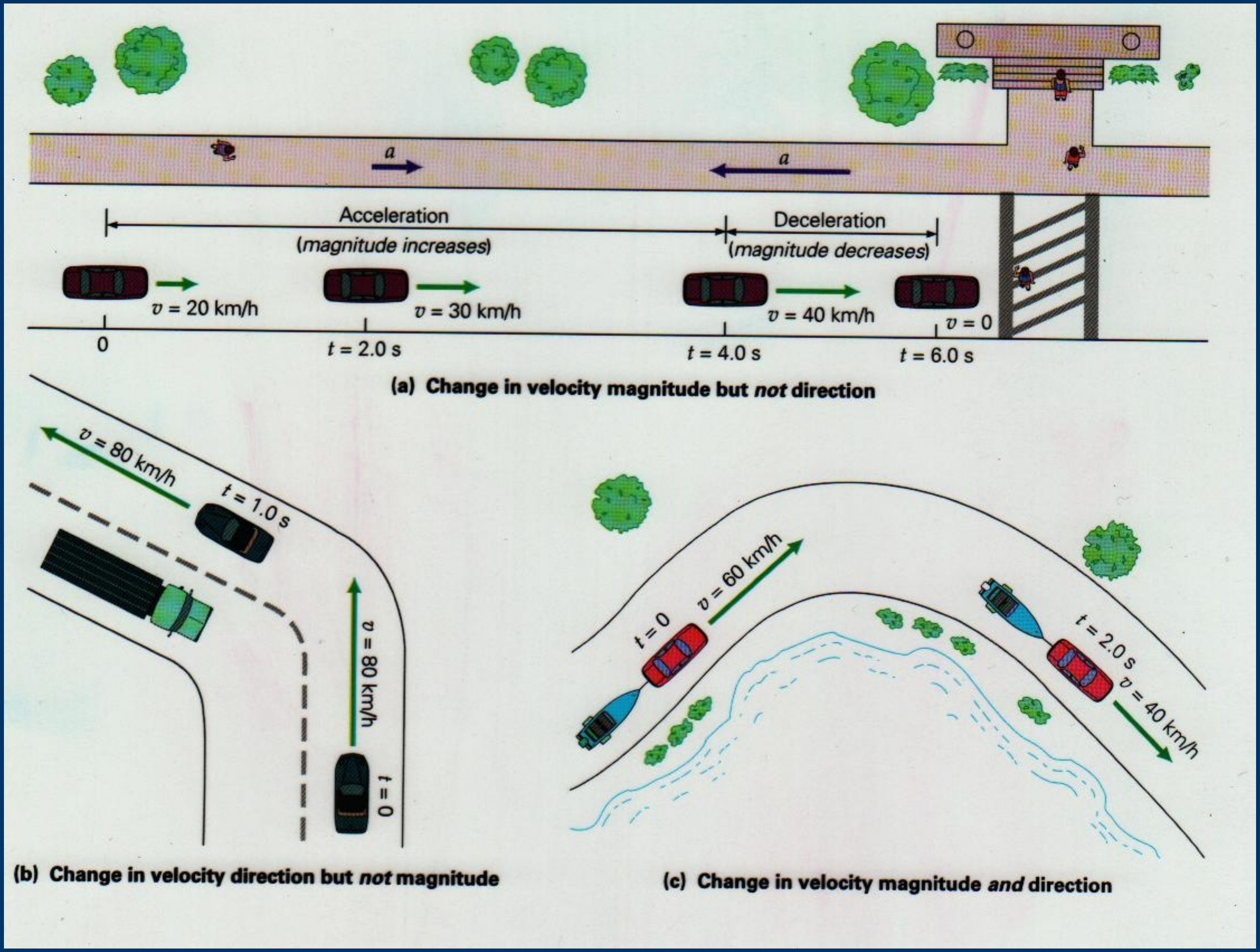
Velocity change related to position change: $\vec{v}_f \cdot \vec{v}_f - \vec{v}_i \cdot \vec{v}_i = 2\,\vec{a} \cdot (\vec{r}_f - \vec{r}_i)$

Velocity components in 2-D.



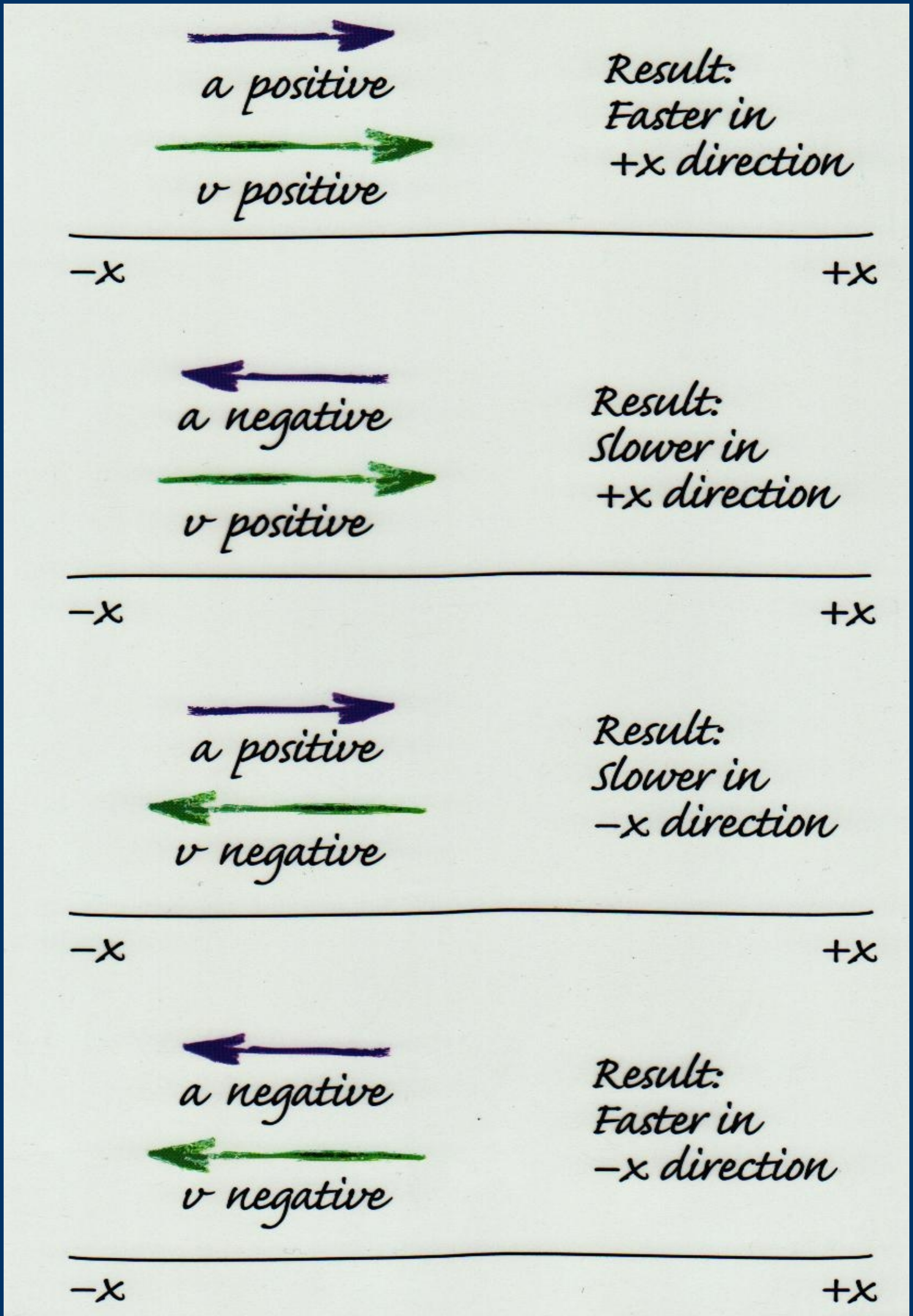
Notice that this motion is all in a straight line and so could be expressed with 1 dimension (using a rotated axis).

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



Motion in 1D.

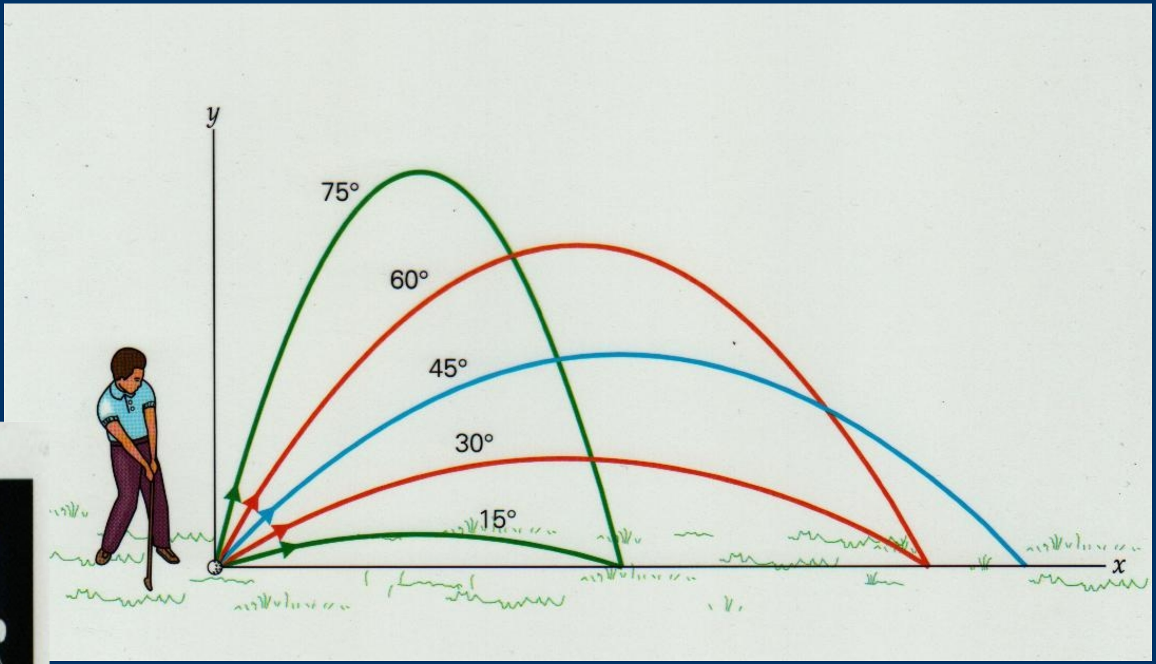
The sign of acceleration and velocity is used to indicate the direction of these vectors.

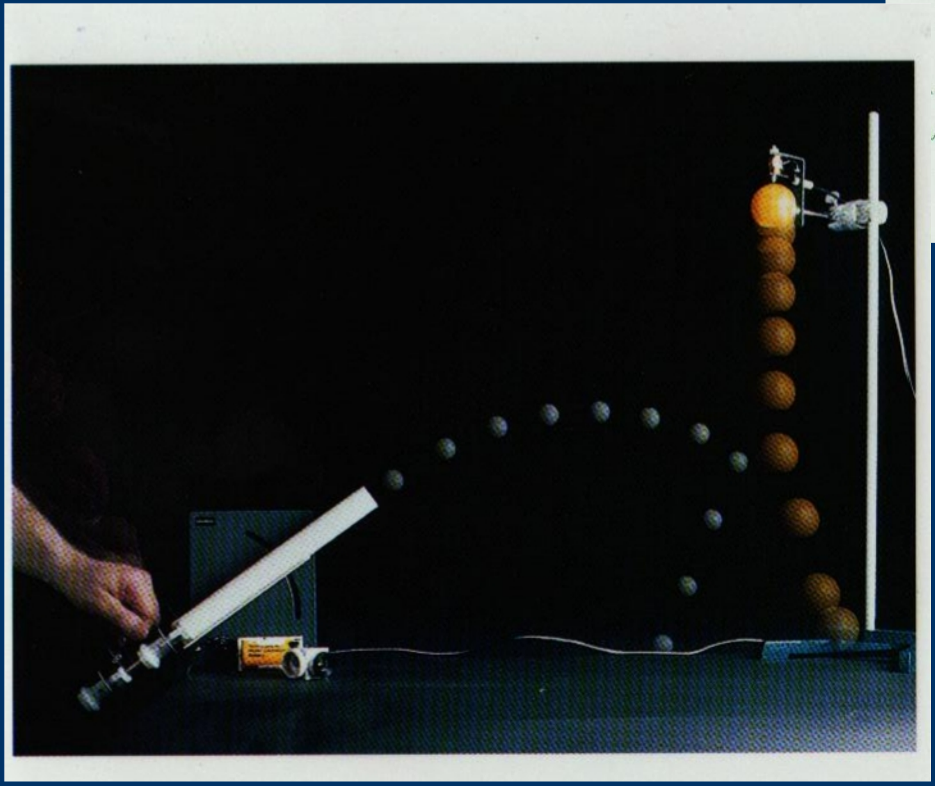


Motion in 2 dimensions.

Uniform downward acceleration leads to parabolic trajectories …

“Projectile Motion”.



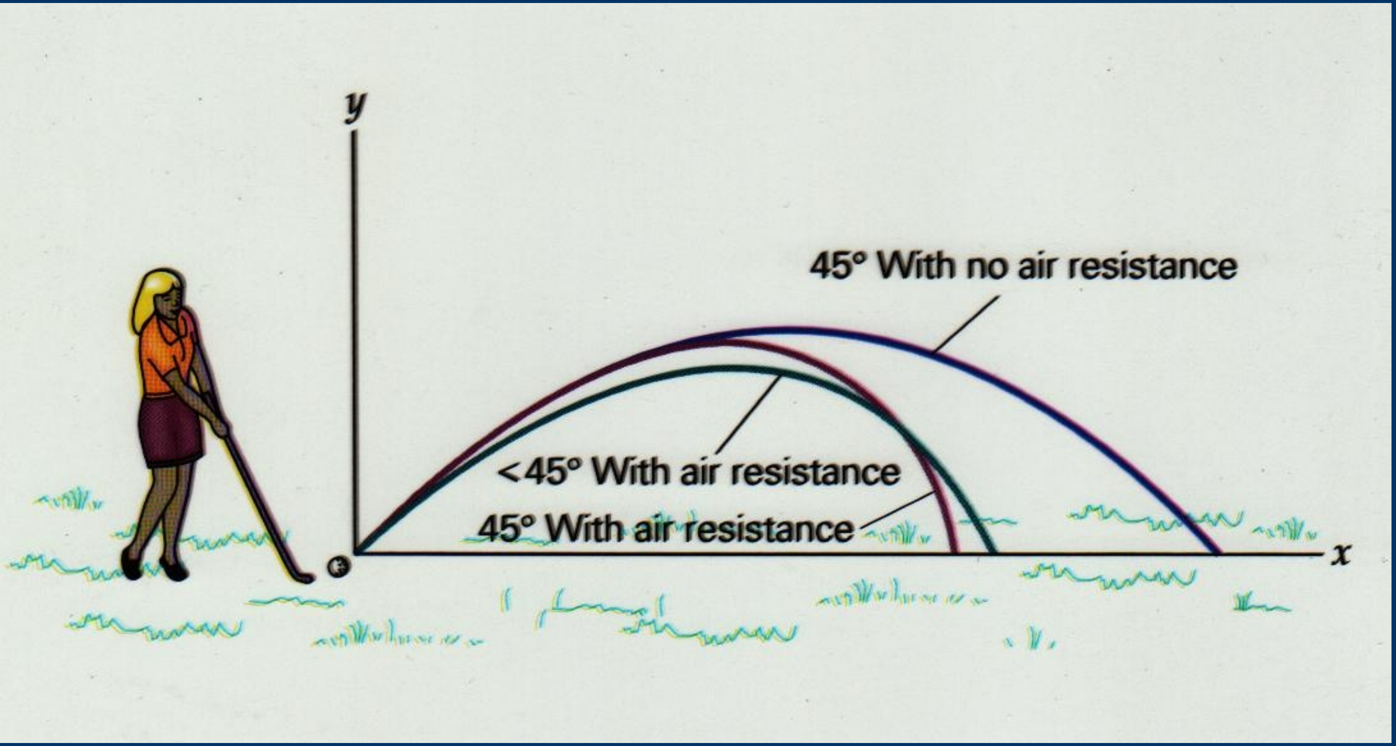


Notice that 2 initial angles lead to the same final range, except 45 degrees.

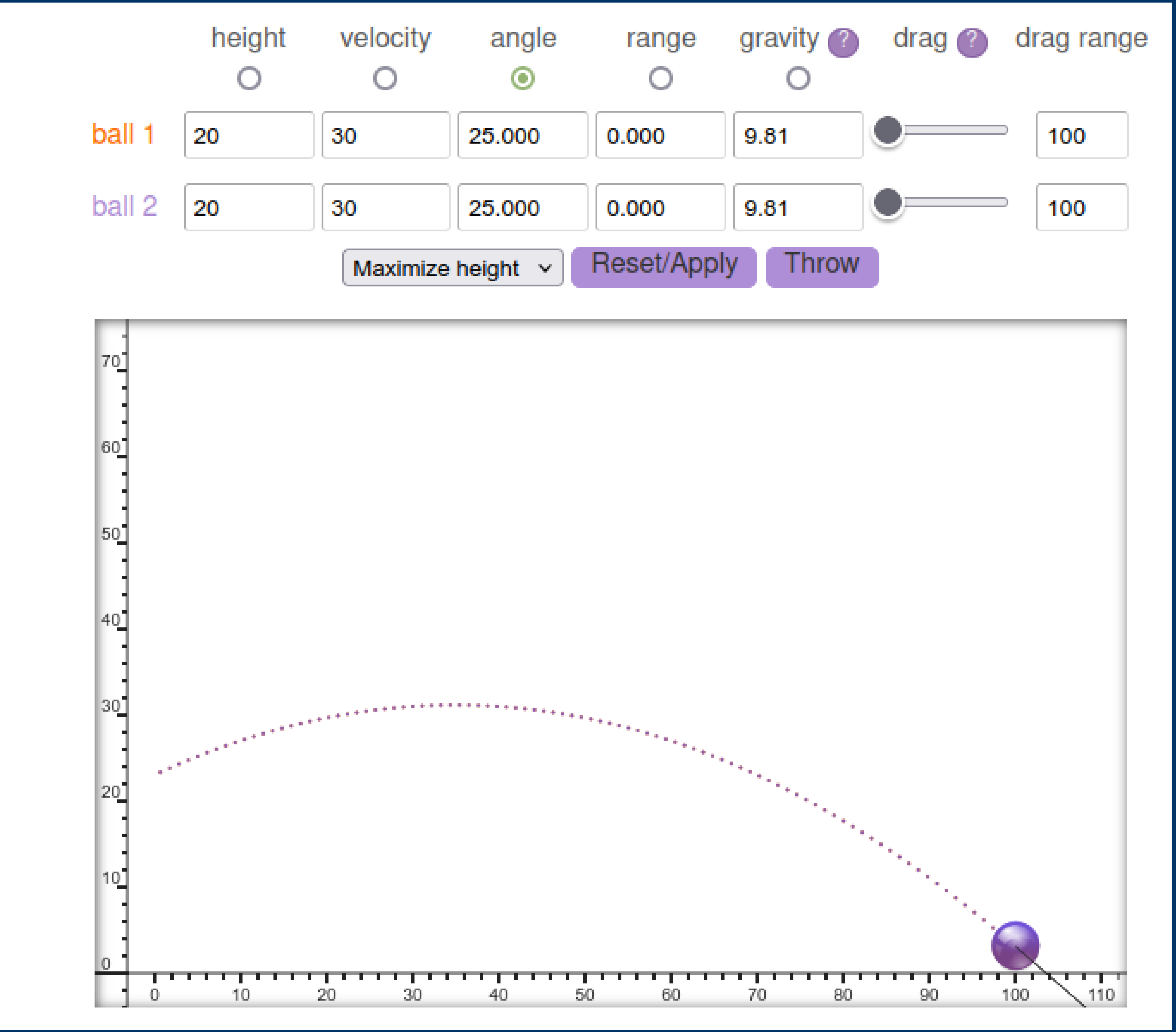
$$R = \frac{v_0^{\,2} \sin 2\theta}{g}$$

PHYS 2311 Motion in 2 dimensions.

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



Motion in 2 dimensions. Projectile Motion

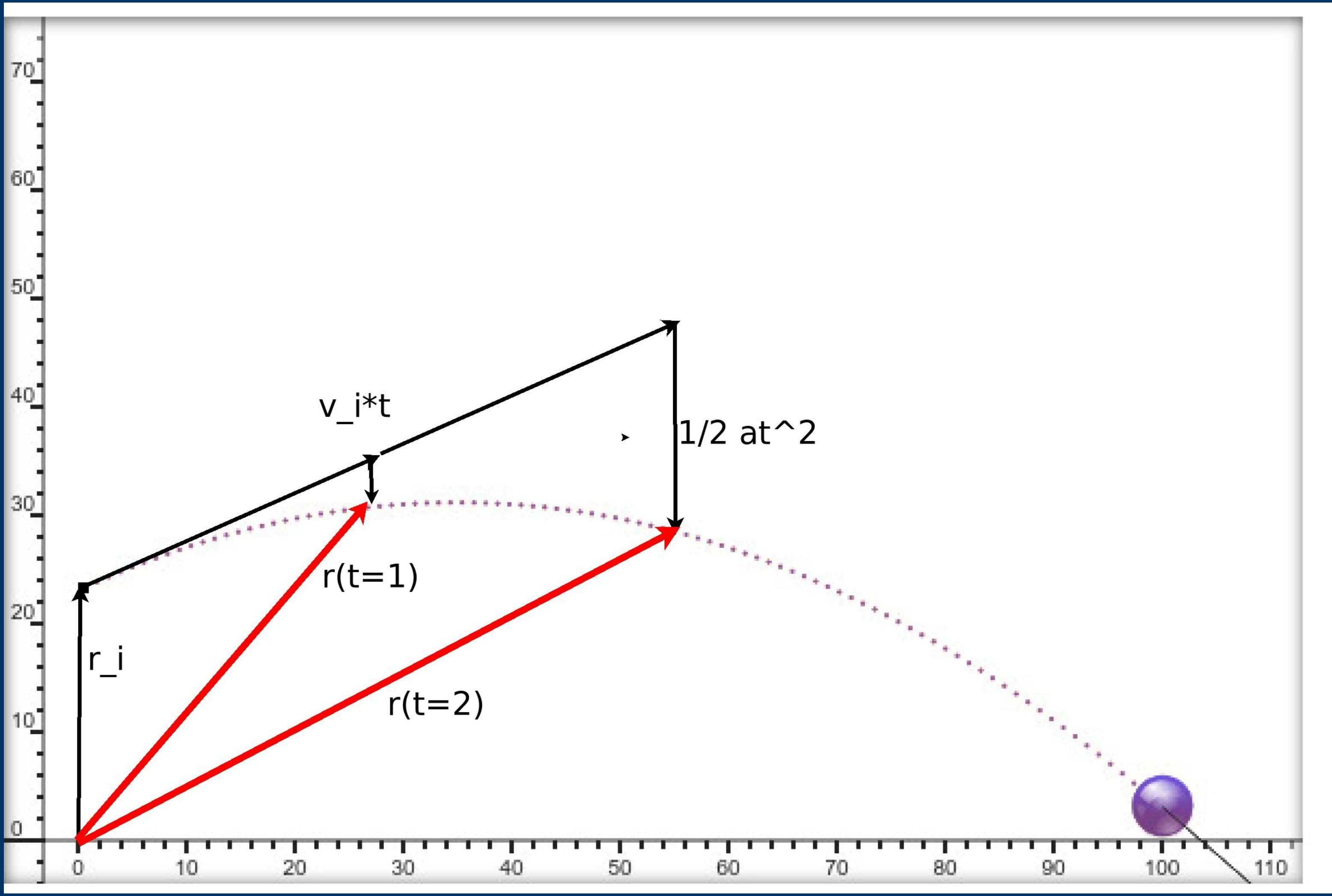


Trajectories are specified with an initial position, velocity, inclination angle (or altitude), and acceleration.

Motion in 2 dimensions. Projectile Motion

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

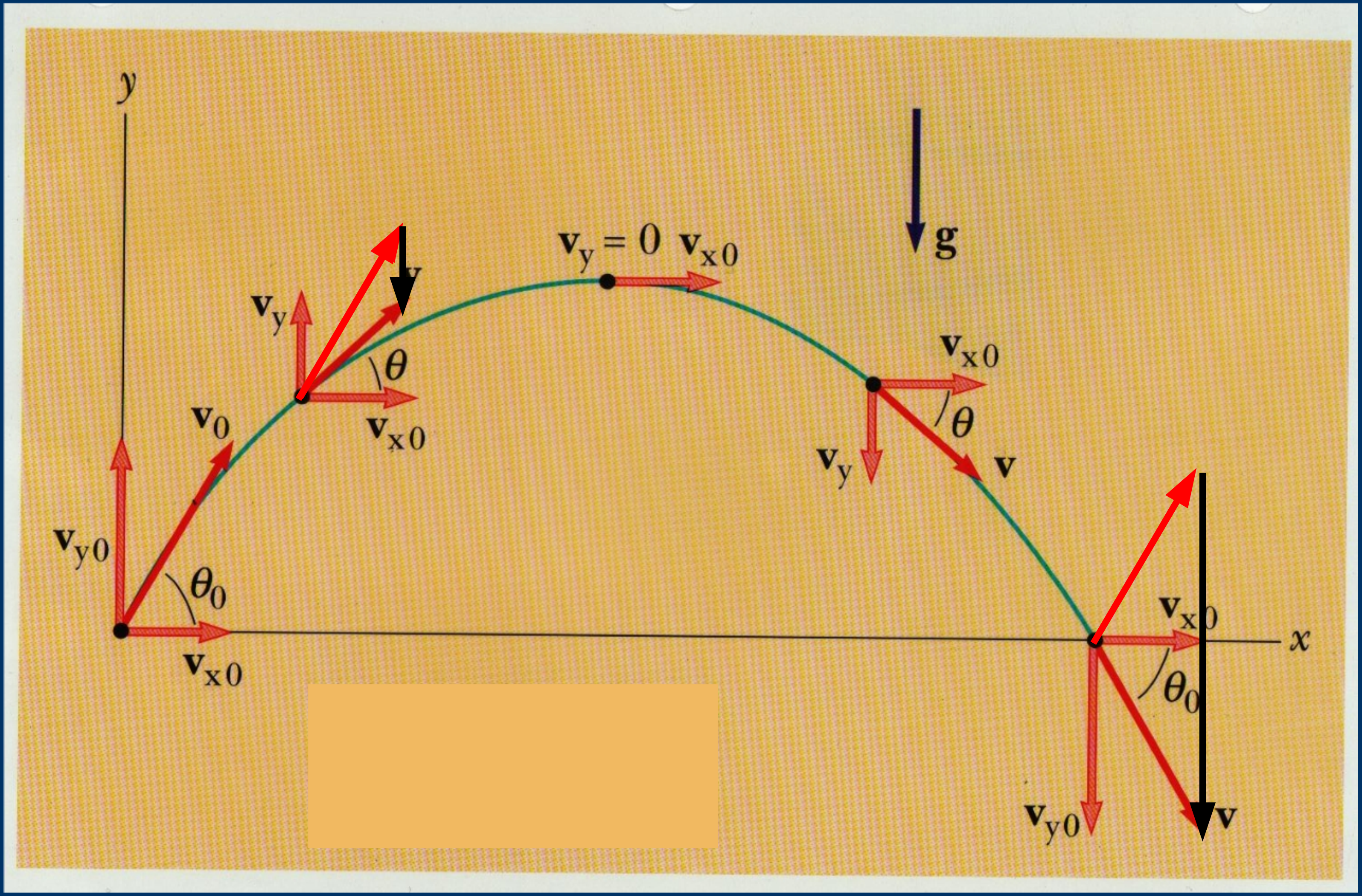
$$\vec{r}(t)=\vec{r}_i+\vec{v}_i t+\frac{1}{2}\vec{a}t^2$$



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: $\boxed{t_{max}=\frac{v_i \sin\theta_i}{g}}$ (v_i is the magnitude of the initial velocity)

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

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