PHYS 225
Fundamentals of Physics: Mechanics

Prof. Meng (Stephanie) Shen

Fall 2024

Lecture 9: Projectile motion: Examples

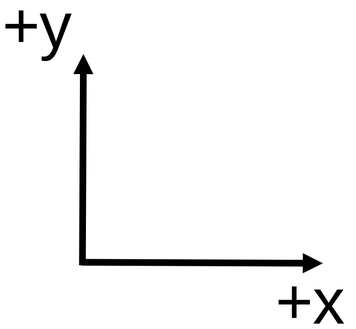
CALIFORNIA STATE UNIVERSITY
FULLERTON

Learning goals

- Practice on projectile motion

Projectile motion — Decomposed

- Projectile motion is the superposition of two independent motions:
  1. Vertical motion: constant acceleration
  2. Horizontal motion: constant velocity



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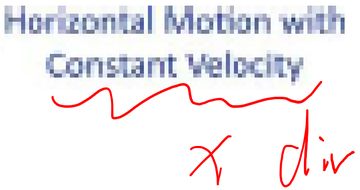
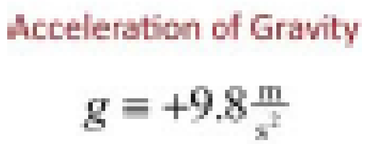


Free fall

y dir

x dir

Vertical and horizontal motions are connected by the time!



$$a_y\hat{j} = -g\hat{j}$$

$$v_y\hat{j} = (v_{y0} - gt)\hat{j}$$

$$y\hat{j} = \left(y_0 + v_{0y}t - \frac{1}{2}gt^2\right)\hat{j}$$

$$a_x = 0$$

$$v_x\hat{i} = v_{x0}\hat{i}$$

$$x\hat{i} = (x_0 + v_{0x}t)\hat{i}$$

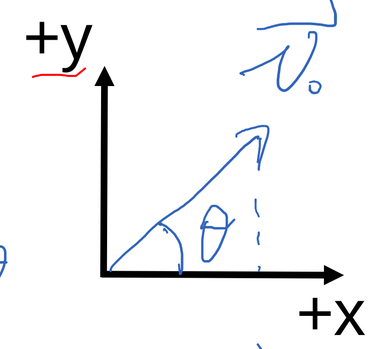
Clicker question 4

- How are the horizontal and vertical components of the projectile motion related to each other?

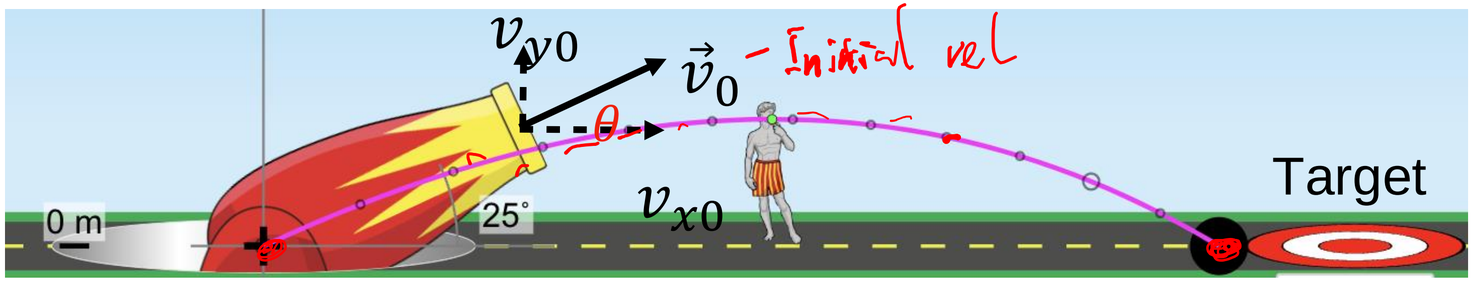
A The vertical component of the acceleration is the same as the horizontal component of the acceleration.

B The two components of the motion share the same initial and final time.

Example 2 (more details in Lecture 8)



- The cannon is aimed at an angle θ above the +x direction at an initial speed of $|\vec{v}_0|$ .Suppose the initial speed of the cannon, $|\vec{v}_0|$ is fixed. What is the aiming angle θ (the angle between $\vec{v}_0$ and +x direction) to make it farthest in the horizontal direction? (Assume the initial and final y-coordinates are the same.)



Step 1: $\Delta x = v_{x0}\Delta t$

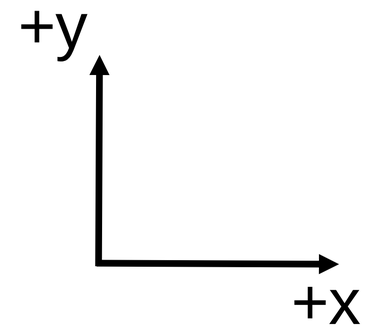
Step 2: $\Delta y = v_{y0}\Delta t - \frac{1}{2}g\Delta t^2$

Step 3: Substitute Δt in Step 2 to Step 1,

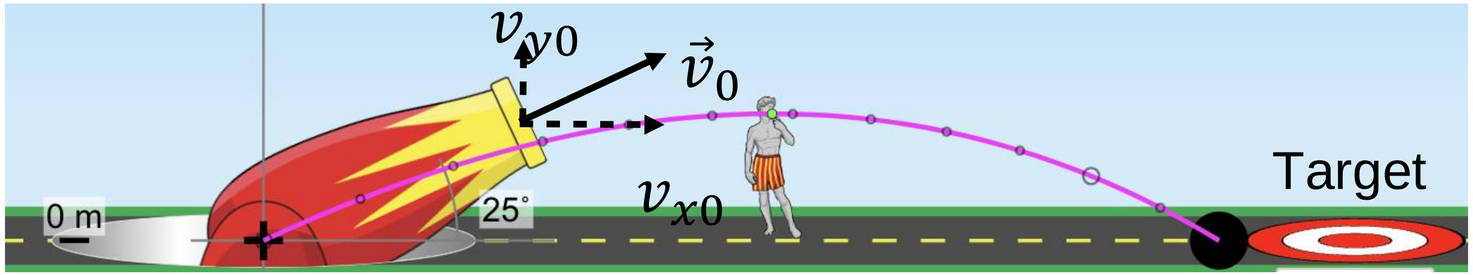
$$\Delta x = \frac{|v_0|^2 \sin 2\theta}{g}$$

For maximum Δx at a fixed $|v_0|$, $\theta = 45°$

Clicker question 5



- The cannon is aimed 25° above the +x direction at an initial speed of $|\vec{v}_0|$,but it didn't make it to the target. Suppose the initial speed of the cannon, $|\vec{v}_0|$ is fixed. How would you adjust the aiming angle (the angle between $\vec{v}_0$ and +x direction) to make it further in the horizontal direction? (Assume the initial and final y- coordinates are the same.)



A Decrease the aiming angle

B Increase the aiming angle

Clicker question 6

Given: Δx, $\vec{a}$, θ, $\Delta y = 0$

Goal: t

$|\vec{v}_0|$?

- The current world-record motorcycle jump is 77.0 m, set by Jason Renie. Assume that he left the take-off ramp at 13.0° to the horizontal and that the take-off and landing heights are the same. Neglecting air drag, which of the following equations is sufficient to find the time that the athlete is in air?

A — y- motion: $\Delta y = v_{0y}t - \frac{1}{2}gt^2$

B — x- motion: $\Delta x = v_{0x}t$

C — Neither is sufficient. Both are needed.

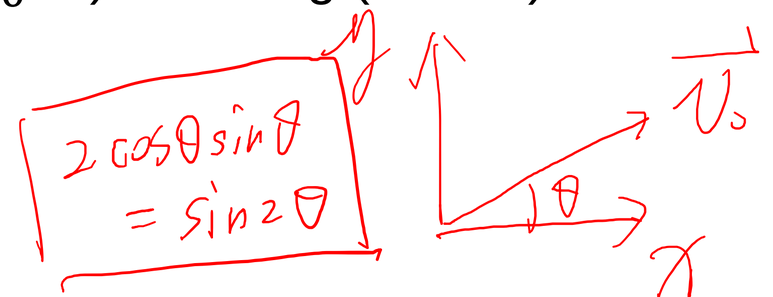
Practice question (work in group of 2-3 people)

- The current world-record motorcycle jump is 77.0 m, set by Jason Renie. Assume that he left the take-off ramp at 13.0° to the horizontal and that the take-off and landing heights are the same. Neglecting air drag, a) determine his take-off speed, v_0. b) how long (in time) is the jump?

Step 1: Set up the equation for the x- dir motion.

Step 2: Set up the equation for the y- dir motion.

Step 3: Eliminate time and calculate the initial speed.



Practice question

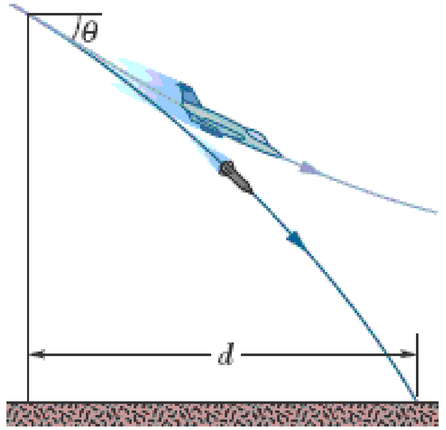
- The current world-record motorcycle jump is 77.0 m, set by Jason Renie. Assume that he left the take-off ramp at 13.0° to the horizontal and that the take-off and landing heights are the same. Neglecting air drag, a) determine his take-off speed, v_0. b) how long (in time) is the jump?

Clicker question 7

Given: $|v_0|$, θ, $\vec{a}$, Δx

Goal: t

- A certain airplane has a speed of 298.2 km/h and is diving at an angle of θ = 26.0° below the horizontal when the pilot releases a radar decoy (see the figure). The horizontal distance between the release point and the point where the decoy strikes the ground is d = 667 m. To find how long (in time) the decoy is in the air, which of the following equation is used?



A

y- motion: $\Delta y = v_{0y}t - \frac{1}{2}gt^2$

B

x- motion: $\Delta x = v_{0x}t$

Reminders

- Pre-lecture survey 4.1.2 before the next class
- Midterm 1:
  - Date: Oct. 17
  - Chapters: 1 to 5, any content covered before the exam
  - Same time and location as regular classes