PHYS 1441 – Section 001
Lecture #7

Thursday, June 12, 2014

Dr. Jaehoon Yu

- Projectile Motion
- Maximum Range and Height
- What is the Force?
- Newton's Second Law
- Free Body Diagram
- Newton's Third Law
- Categories of forces

Today's homework is homework #4, due 11pm, Tuesday, June 17!!

Announcements

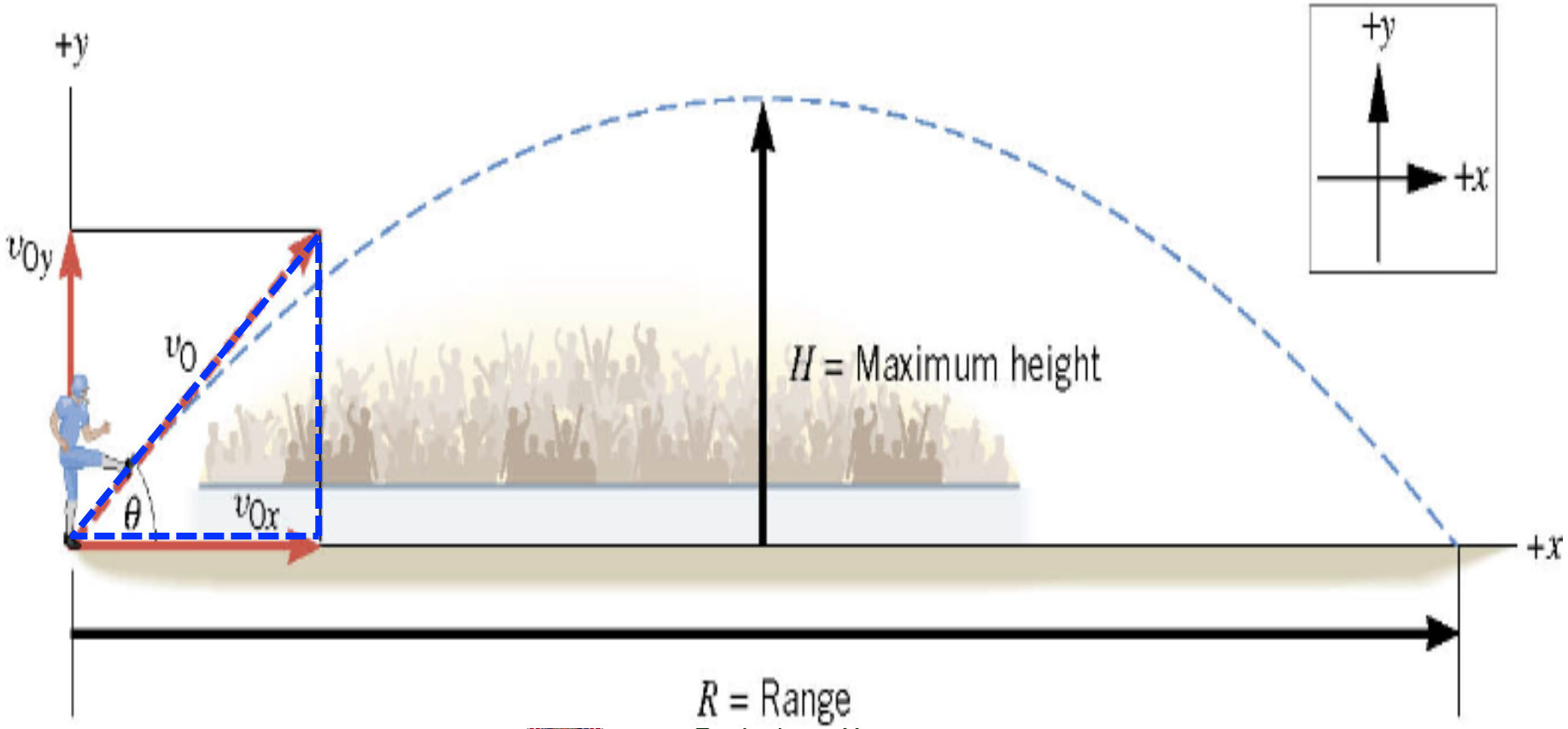
- Reading Assignment
  - CH4.1 – 4.3
- Mid-term exam
  - In the class coming Tuesday, June 17
  - Comprehensive exam
    - Covers CH1.1 to what we finish Monday, June 16+ Appendix A
  - Bring your calculator but DO NOT input formula into it!
    - Your phones or portable computers are NOT allowed as a replacement!
  - You can prepare a one 8.5x11.5 sheet (front and back) of **handwritten** formulae and values of constants for the exam ➔ no solutions, derivations or definitions!
    - No additional formulae or values of constants will be provided!

Reminder: Special Project #2

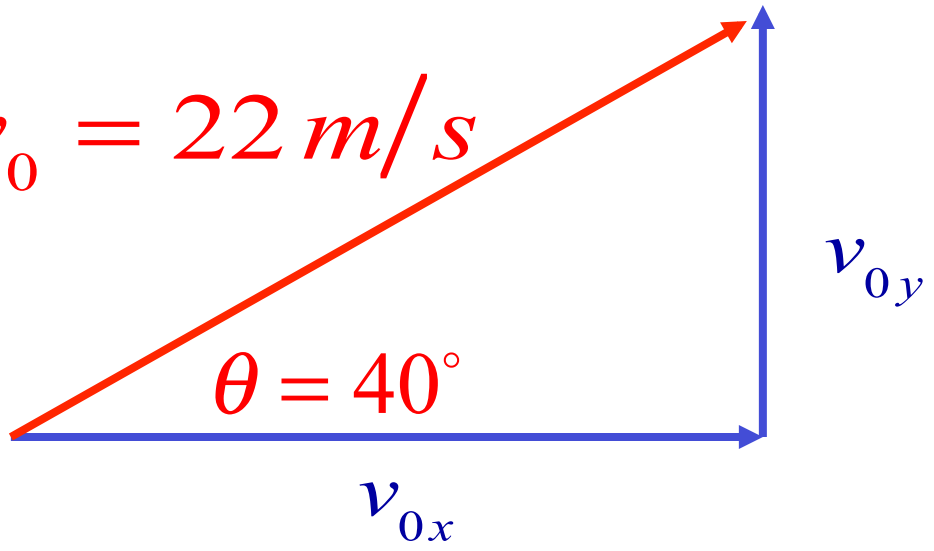
- Show that the trajectory of a projectile motion is a parabola!!
  - 20 points
  - Due: Monday, June 16
  - You MUST show full details of your OWN computations to obtain any credit
    - Beyond what was covered in this lecture note and in the book!

Ex.3.5 The Height of a Kickoff

A placekicker kicks a football at an angle of 40.0 degrees and the initial speed of the ball is 22 m/s. Ignoring air resistance, determine the maximum height that the ball attains.



First, the initial velocity components



$$v_{0x} = v_o \cos\theta = (22\,\text{m/s})\cos 40^\circ = 17\,\text{m/s}$$

$$v_{0y} = v_o \sin\theta = (22\,\text{m/s})\sin 40^\circ = 14\,\text{m/s}$$

Example for a Projectile Motion

- A stone was thrown upward from the top of a cliff at an angle of 37° to horizontal with initial speed of 65.0m/s. If the height of the cliff is 125.0m, how long is it before the stone hits the ground?

$$v_{xi} = v_i \cos\theta_i = 65.0 \times \cos 37^\circ = 51.9 m/s$$

$$v_{yi} = v_i \sin\theta_i = 65.0 \times \sin 37^\circ = 39.1 m/s$$

$$y_f = -125.0 = v_{yi} t - \frac{1}{2} g t^2$$

Becomes

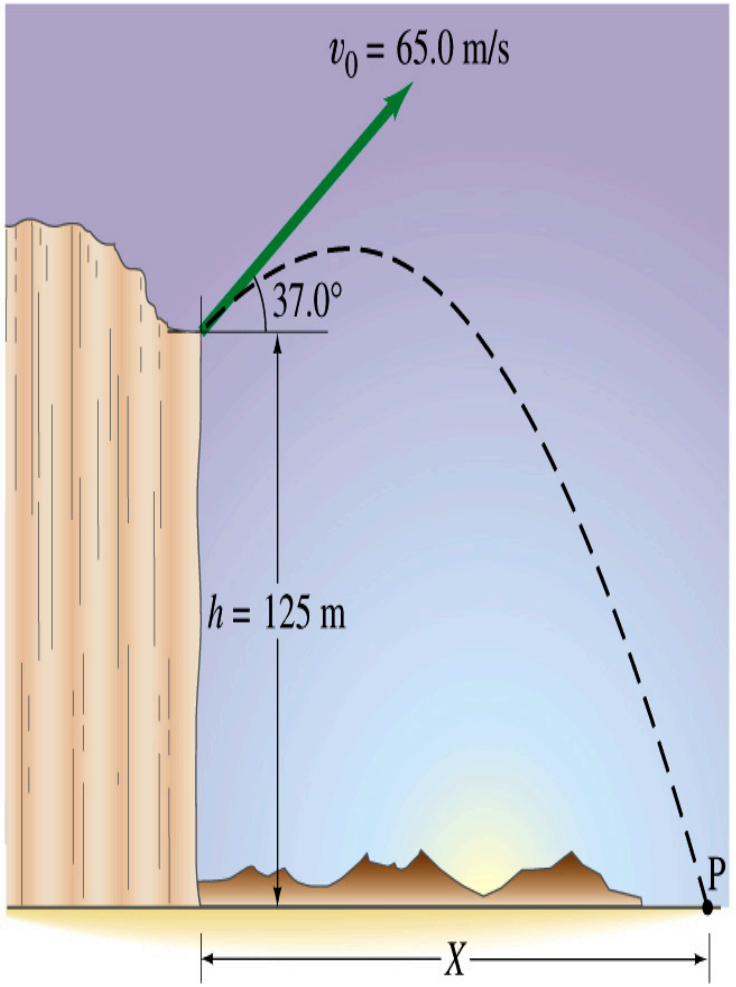
$$gt^2 - 78.2t - 250 = 9.80t^2 - 78.2t - 250 = 0$$

$$t = \frac{78.2 \pm \sqrt{(-78.2)^2 - 4 \times 9.80 \times (-250)}}{2 \times 9.80}$$

$$t = -2.43s \quad \text{or} \quad t = 10.4s$$

$t = 10.4s$

Since negative time does not exist.



Example cont'd

- What is the speed of the stone just before it hits the ground?

$$v_{xf} = v_{xi} = v_i \cos\theta_i = 65.0 \times \cos 37^\circ = 51.9 m/s$$

$$v_{yf} = v_{yi} - gt = v_i \sin\theta_i - gt = 39.1 - 9.80 \times 10.4 = -62.8 m/s$$

$$|v| = \sqrt{v_{xf}^2 + v_{yf}^2} = \sqrt{51.9^2 + (-62.8)^2} = 81.5 m/s$$

- What are the maximum height and the maximum range of the stone?

Do these yourselves at home for fun!!!

Horizontal Range and Max Height

- Based on what we have learned previously, one can analyze the projectile motion in more detail
  - Maximum height an object can reach
  - Maximum range

What happens at the maximum height?

- For a projectile fired with initial speed v_0 at angle θ_0, the time for it to reach maximum height can be obtained:

At the maximum height the object's vertical motion stops to turn around!!

$g=9.8 m/s^2$

$$v_{yf} = v_{0y} + a_y t = v_0 \sin\theta_0 - g t_A = 0$$

Solve for t_A

$$\therefore t_A = \frac{v_0 \sin\theta_0}{g}$$

Time to reach to the maximum height!!

Horizontal Range and Max Height

Since no acceleration is in x direction, it still flies even if v_y=0.

$$R = v_{0x}t = v_{0x}(2t_A) = 2v_0\cos\theta_0\left(\frac{v_0\sin\theta_0}{g}\right)$$

Range

$$R = \left(\frac{v_0^2\sin 2\theta_0}{g}\right)$$

$$y_f = h = v_{0y}t + \frac{1}{2}(-g)t^2 = v_0\sin\theta_0\left(\frac{v_0\sin\theta_0}{g}\right) - \frac{1}{2}g\left(\frac{v_0\sin\theta_0}{g}\right)^2$$

Height

$$y_f = h = \left(\frac{v_0^2\sin^2\theta_0}{2g}\right)$$

Maximum Range and Height

- What are the conditions that give maximum height and range of a projectile motion?

$$h = \left(\frac{v_0^2 \sin^2 \theta_0}{2g} \right)$$

This formula tells us that the maximum height can be achieved when θ_0=90°!!!

$$R = \left(\frac{v_0^2 \sin 2\theta_0}{g} \right)$$

This formula tells us that the maximum range can be achieved when $2\theta_0$=90°, i.e., θ_0=45°!!!