This Week

Tutorial and Test 1, **in the lab**
(chapters 1 and 2)

Next Week

Experiment 1:
Measurement of Length and Mass

WileyPLUS Assignment 1 now available
Due Monday, October 5 at 11:00 pm
Chapters 2 & 3

Projectile Motion

(y-axis pointing upward, x-axis is horizontal)

For projectile motion in absence of air resistance: $a_x = 0$, $a_y = -g$

$$v_x = v_{0x}$$

$$x - x_0 = v_{0x}t$$

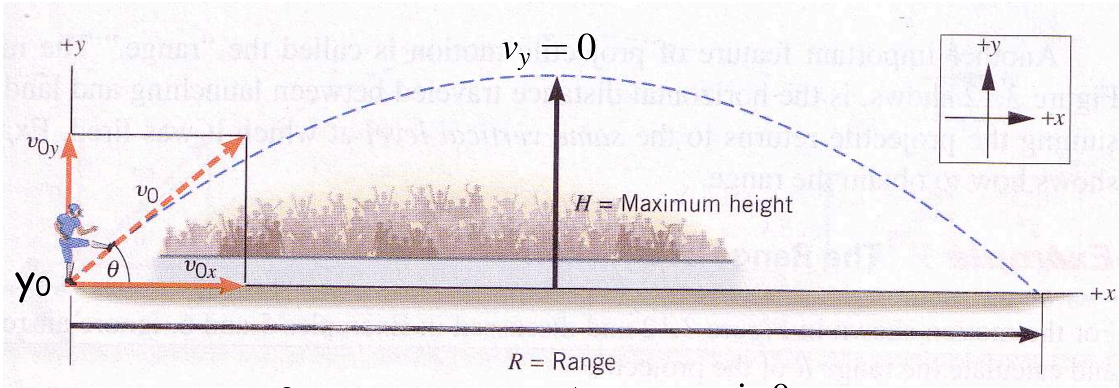
$$v_y = v_{0y} - gt$$

$$y - y_0 = v_{0y}t - \frac{1}{2}gt^2$$

$$y - y_0 = \frac{1}{2}(v_{0y} + v_y)t$$

$$v_y^2 = v_{0y}^2 - 2g(y - y_0)$$

Projectile Motion - Range, Maximum Height



$v_x = v_{0x} = v_0 \cos\theta \qquad v_y = v_{0y} + a_y t = v_0 \sin\theta - gt$

In a time t, the projectile travels a distance R (range) to the right

$R = v_x t \quad \rightarrow t = R/v_x$ and v_x is constant

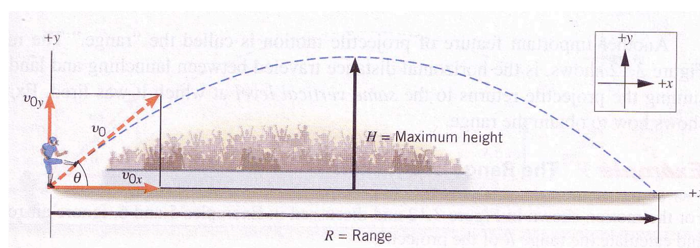
In the same time, the projectile falls back to the ground, at $y = y_0$

$$y - y_0 = v_{0y}t - \frac{1}{2}gt^2$$

$$0 = v_{0y}t - \frac{1}{2}gt^2 \quad \rightarrow t = 2v_{0y}/g$$

$$t = \frac{R}{v_x} = \frac{2v_{0y}}{g} \rightarrow R = \frac{2v_x v_{0y}}{g}$$

Range of a projectile



$$R = \frac{2v_x v_{0y}}{g} = \frac{2v_0^2 \sin\theta\cos\theta}{g}$$

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

$[2\sin\theta\cos\theta = \sin 2\theta]$

Maximum range when $\theta = 45°$

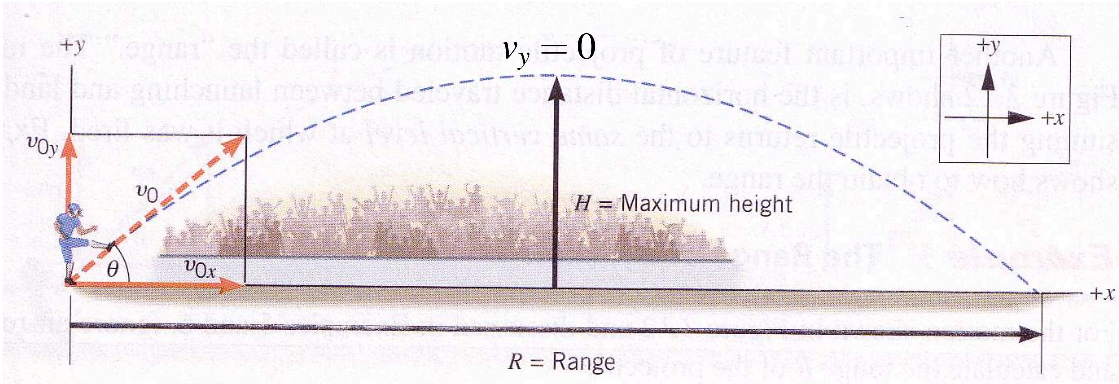
Projectile reaches maximum height, H, when $v_y = 0$

$v_y^2 = v_{0y}^2 - 2g(y - y_0) \qquad$ so, $0 = (v_0 \sin\theta)^2 - 2gH$

$$\boxed{\text{Therefore } H = \frac{(v_0 \sin\theta)^2}{2g}}$$

eg $v_0 = 100$ m/s, $\theta = 30° \rightarrow R = 884$ m, $H = 128$ m

Projectile Motion – Range, Maximum Height



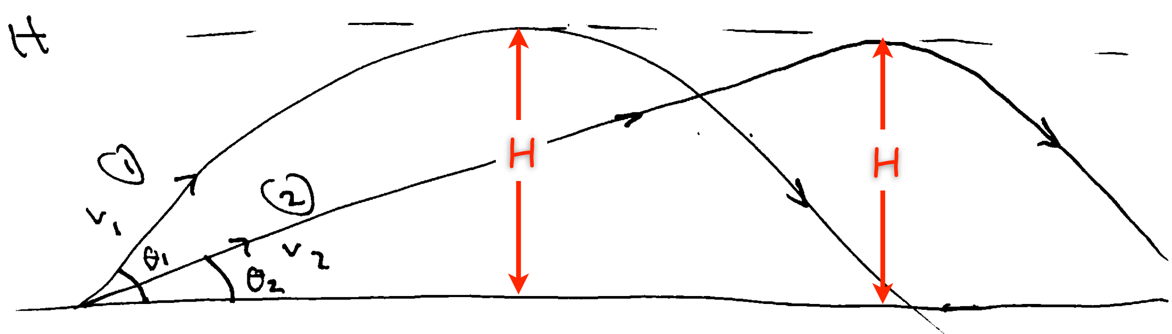
The projectile travels the horizontal distance R in the same time that is travels up to height H and back down to the initial height.

$$\boxed{R = \frac{v_0^2 \sin 2\theta}{g}, \quad \text{greatest range when } \theta = 45^\circ \qquad H = \frac{(v_0 \sin\theta)^2}{2g}}$$

Clickers!

Balls 1 and 2 are launched from the same spot at different angles to the ground. They both reach the same maximum height, H, but ball 2 has the greater range.

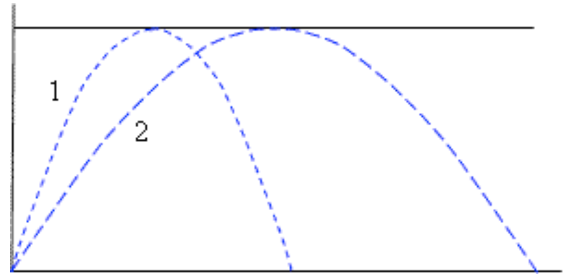
Decide which ball, if either, has the greater initial speed.



A) Ball 1 is faster, B) Ball 2 is faster

As they reach the same maximum height, they must have the same initial speed in upward direction, $v_{oy1} = v_{oy2}$, so $v_1 \sin\theta_1 = v_2 \sin\theta_2$

Clicker Question: Focus on Concepts, Question 8: Two objects are fired into the air. The drawing shows that they reach the same height, but the ranges of their projectile motions are different. Which one is in the air for the greater amount of time?



A) Both projectiles are in the air for the same amount of time.

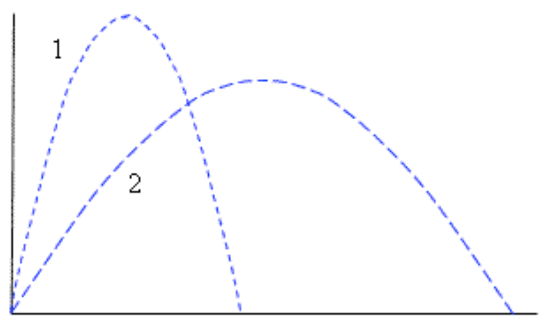
B) Projectile 1, because it has the smaller initial speed and, therefore, travels more slowly than projectile 2.

C) Projectile 2, because it has the greater range.

D) Projectile 1, because it has the smaller range and, hence, the horizontal component of its velocity is smaller than that of projectile 2.

Clicker Question: Focus on Concepts, Question 9

Two objects are fired into the air, and the drawing shows the projectile motions. Projectile 1 reaches the greater height, but projectile 2 has the greater range. Which one is in the air for the greater amount of time?



A) Projectile 1, because it travels higher than projectile 2

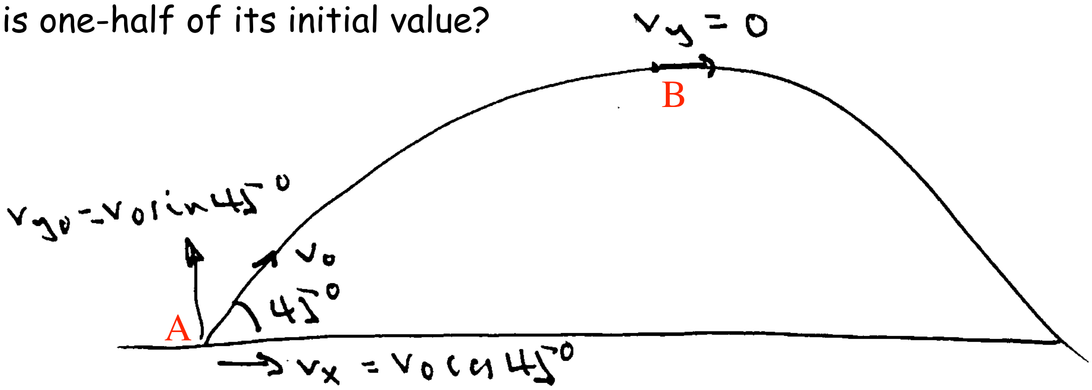
B) Projectile 2, because it has the greater range.

C) Projectile 2, because it has the smaller initial speed and, therefore, travels more slowly than projectile 1.

D) Both projectiles spend the same amount of time in the air.

A leopard springs upward at a 45^0 angle and then falls back to the ground.

Does the leopard, at any point on its trajectory, ever have a speed that is one-half of its initial value?

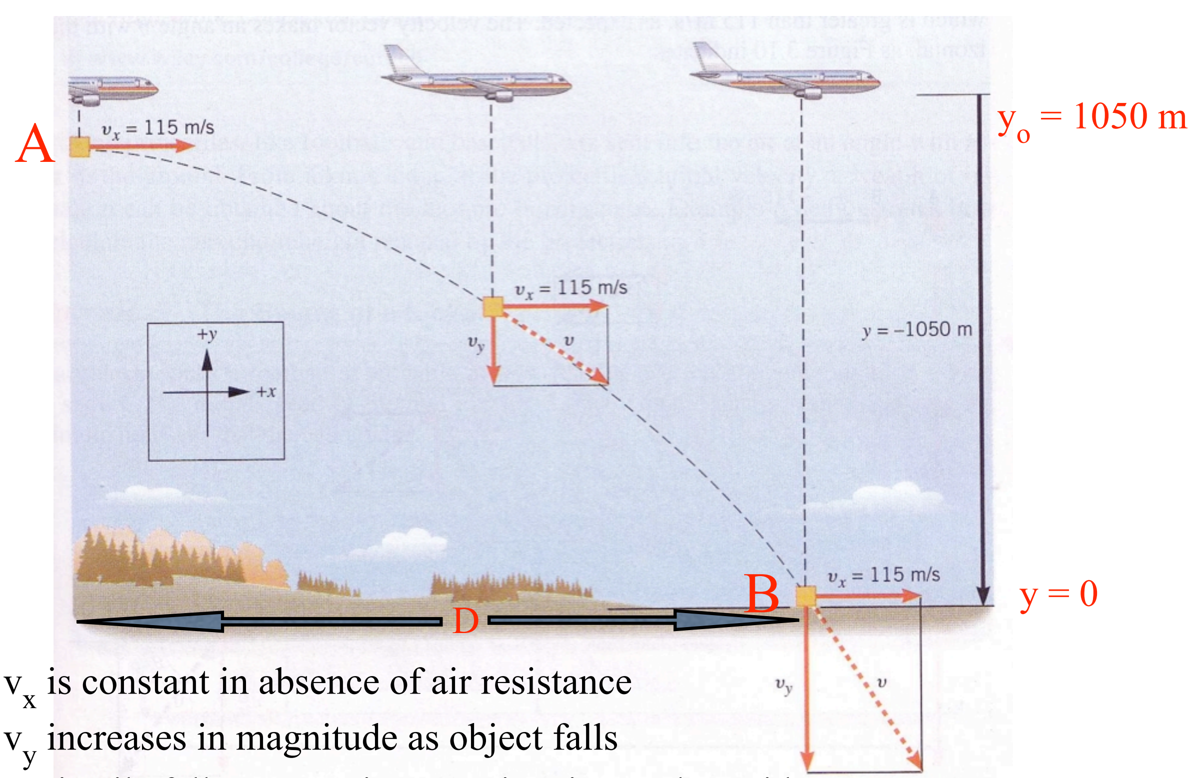


At any point: $v = \sqrt{v_x^2 + v_y^2}$, and $v_x = v_0 \cos 45^\circ = v_0/\sqrt{2}$

At B: $v_y = 0$, so $v = v_x = v_0/\sqrt{2} \approx 0.7 v_0$, which is the smallest v

$\rightarrow$ The speed never falls to half its initial value.

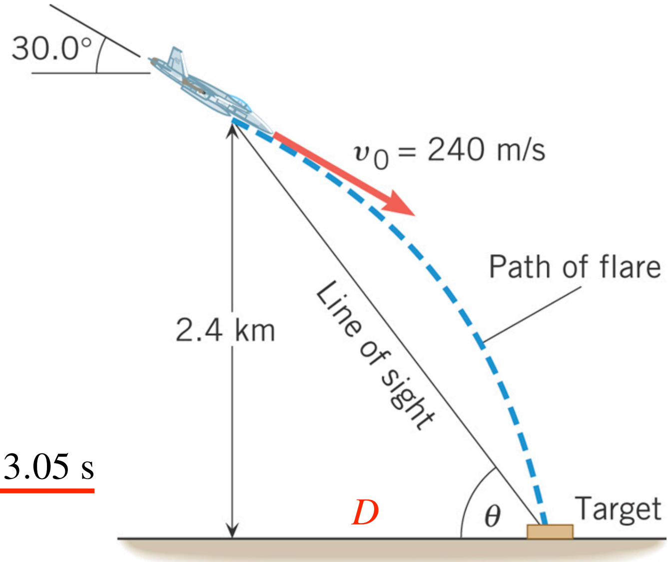
Projectile Motion



v_x is constant in absence of air resistance
v_y increases in magnitude as object falls
Projectile falls 1050 m in same time it travels *D* sideways

3.75/37: An airplane is flying with a velocity of 240 m/s at an angle of 30⁰ below the horizontal. When the altitude of the place is 2.4 km, a flare is released from the plane. The flare hits the target on the ground. What is the angle θ?

$$\boxed{\tan\theta = \frac{2.4\text{ km}}{D}, \quad \text{What is } D? \qquad D = v_x t = v_0 t\cos 30^\circ. \quad \text{What is } t?}$$



$$y - y_0 = v_{0y}t - \frac{1}{2}gt^2$$

$$0 - 2400 = -v_0 t\sin 30^\circ - \frac{1}{2}gt^2$$

$$4.9t^2 + 120t - 2400 = 0 \quad \rightarrow \quad \underline{t = 13.05\text{ s}}$$

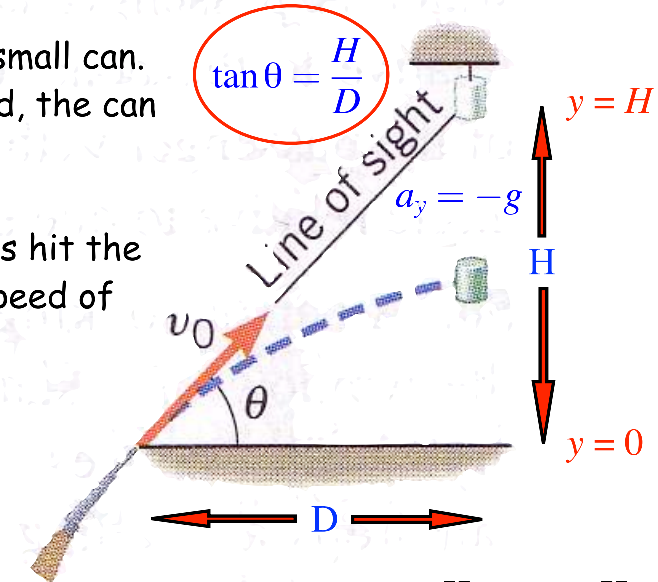
$$\rightarrow D = v_0 t\cos 30^\circ = 240 \times 13.05 \times \cos 30^\circ = 2712\text{ m}$$

$$\rightarrow \tan\theta = \frac{2400}{2712} \quad \rightarrow \quad \theta = 41.5^\circ$$

3.50/46: A rifle is aimed at a small can. At the instant the rifle is fired, the can is released.

Show that the bullet will always hit the can, regardless of the initial speed of the bullet.

$$\tan\theta = \frac{H}{D}$$



Bullet:

$$y_b = v_{0y}t - \frac{1}{2}gt^2$$

Can:

$$y_c = H - \frac{1}{2}gt^2$$

Bullet: $x = v_x t = v_0\cos\theta \dfrac{H}{v_0\sin\theta} = \dfrac{H}{\tan\theta}$

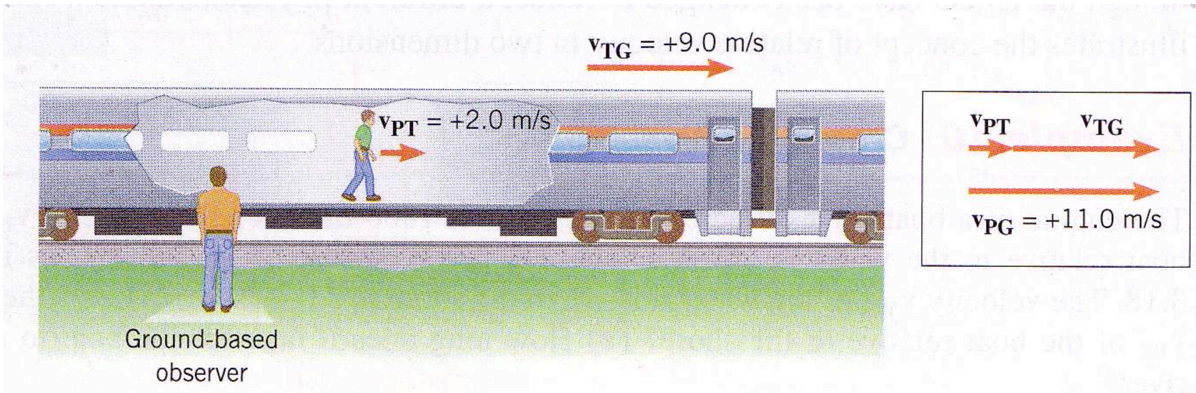
Bullet and can meet when $y_b = y_c$:

$$v_{0y}t - \frac{1}{2}\cancel{gt^2} = H - \frac{1}{2}\cancel{gt^2} \quad \rightarrow \quad t = \frac{H}{v_{0y}}$$

$$x = D$$

That is, bullet and can are at the same place at the same time.

Relative Velocity



$\vec{v}_{PT} =$ velocity of passenger relative to train

$\vec{v}_{TG} =$ velocity of train relative to ground

$$\vec{v}_{PG} = \vec{v}_{PT} + \vec{v}_{TG}$$

$\vec{v}_{PG} =$ velocity of passenger relative to ground

Relative Velocity

If: A moves at velocity $\vec{v}_A$ (relative to the ground)

and: B moves at velocity $\vec{v}_B$ (relative to the ground)

then, the velocity of ***B*** **relative to** ***A*** is:

$$\boxed{\vec{v}_{BA} = \vec{v}_B - \vec{v}_A}$$

This is the velocity of *B* as seen by *A*.

3.57/51: Two trains are passing each other. Train A is moving east at 13 m/s, train B is travelling west at 28 m/s.

a) What is the velocity of train A relative to train B?

b) What is the velocity of train B relative to train A?

A 13 m/s $\vec{v}_A$ E

B 28 m/s $\vec{v}_B$ W

a) $\vec{v}_A - \vec{v}_B$? $\quad \vec{v}_A \quad -\vec{v}_B \quad$ E

$\vec{v}_R$ 13+28 = 41 m/s to E

B sees A travelling to E at 41 m/s relative to it

b) $\vec{v}_B - \vec{v}_A$? $\quad \vec{v}_B \quad -\vec{v}_A$

$\vec{v}_R$

41 m/s to W

Clicker Question: Focus on Concepts, Question 12

A slower moving car is travelling behind a faster moving bus. The velocities of the two vehicles are:

$\mathbf{v}_{CG}$ = velocity of the **C**ar relative to the **G**round = +12 m/s

$\mathbf{v}_{BG}$ = velocity of the **B**us relative to the **G**round = +16 m/s

What is the velocity $\mathbf{v}_{BC}$ of the **B**us relative to the **C**ar? In other words, what is the velocity of the bus as measured by the driver of the car?

A) $\mathbf{v}_{BC}$ = +16 m/s + 12 m/s = +28 m/s

B) $\mathbf{v}_{BC}$ = +16 m/s - 12 m/s = +4 m/s

C) $\mathbf{v}_{BC}$ = +16 m/s

D) $\mathbf{v}_{BC}$ = +12 m/s