Welcome back, Bill Wiecking

>>Working in AP Physics B (SC651)

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# ch 4

## Chapter 4: Motion in Two and Three Dimensions

### Section 0: Introduction

**4.0.2** **(5.00)** Use the simulation in the cannon interactive in Section 4.0 to answer the following questions. (a) Does the cannonball's horizontal velocity change as it moves through the air? (b) Does its vertical velocity change? (c) If you increase the cannonball's horizontal velocity, does it stay in the air longer, the same amount of time, or shorter? (d) Who is inside the left haystack?

(a) Yes No
(b) Yes No
(c)
(d)

### Section 1: Displacement in two dimensions

**4.1.1** **(5.00)** Calculate the displacement of a ladybug that starts at (12.0, 5.0, 5.0) m and ends at (*a*, 2.0, 4.0) m.

( , , ) m

**4.1.2** **(5.00)** In a visit to the nation's capital, a foreign head of state travels from (−3.0, −4.0) km to (4.0, 7.0) km. She then travels with a displacement of (−5.0, *a*) km. Calculate the her total displacement over the course of the trip.

( , ) km

**4.1.5** **(5.00)** Sara's golf ball is 5 meters south and 4 meters west of a hole. What is the displacement vector from the ball's current position to the hole in rectangular coordinates? Assume that north and east are in the positive direction.

( , ) m

### Section 2: Velocity in two dimensions

**4.2.1** **(5.00)** A golf ball is launched at a 37.0° angle from the horizontal at an initial velocity of 48.6 m/s. State its initial velocity in rectangular coordinates.

( [ ] , [ ] ) m/s

**4.2.3** **(5.00)** An airplane is flying horizontally at 115 m/s, at a 20.5 degree angle north of east. State its velocity in rectangular coordinates. Assume that north and east are in the positive direction.

( [ ] , [ ] ) m/s

## Section 4: Acceleration in two dimensions

**4.4.2** **(5.00)** A spaceship accelerates at (6.30, 3.50) $m/s^2$ for *t* s. Given that its final velocity is (450, 570) m/s, find its initial velocity.

( [ ] , [ ] ) m/s

**4.4.3** **(5.00)** An airplane is flying with velocity (152, 0) m/s. It is accelerated in the *x* direction by its propeller at 8.92 $m/s^2$ and in the negative *y* direction by a strong downdraft at 1.21 $m/s^2$. What is the airplane's velocity after *t* seconds?

( [ ] , [ ] ) m/s

**4.4.4** **(5.00)** An electron starts at rest. Gravity accelerates the electron in the negative *y* direction at 9.80 $m/s^2$ while an electric field accelerates it in the positive *x* direction at $3.80\times10^6$ $m/s^2$. Find its velocity 2.45 s after it starts to move.

( [ ] , [ ] ) m/s

## Section 7: Projectile motion

**4.7.1** **(5.00)** A friend throws a baseball horizontally. He releases it at a height of 2.0 m and it lands 21 m from his front foot, which is directly below the point at which he released the baseball. (a) How long was it in the air? (b) How fast did he throw it?

(a) [ ] s

(b) [ ] m/s

**4.7.2** **(5.00)** A cannon mounted on a pirate ship fires a cannonball at 125 m/s horizontally, at a height of 17.5 m above the ocean surface. Ignore air resistance. (a) How much time elapses until it splashes into the water? (b) How far from the ship does it land?

(a) [ ] s

(b) [ ] m

**4.7.3** **(5.00)** A juggler throws a ball straight up into the air and it takes *t* seconds to reach its peak. How many seconds will it take after that to fall back into his hand? Assume he throws and catches the ball at the same height.

s

**4.7.4** **(5.00)** A juggler throws a ball with an initial horizontal velocity of +1.1 m/s and an initial vertical velocity of +5.7 m/s. What is its acceleration at the top of its flight path? Make sure to consider the sign when responding. Consider the upward direction as positive.

$m/s^2$

**4.7.5** **(5.00)** The muzzle velocity of an armor-piercing round fired from an M1A1 tank is 1770 m/s (nearly 4000 mph or mach 5.2). A tank is at the top of a cliff and fires a shell horizontally. If the shell lands 6520 m from the base of the cliff, how high is the cliff?

m

**4.7.7** **(5.00)** A box is dropped from a spacecraft moving horizontally at 27.0 m/s at a distance of 155 m above the surface of a moon. The rate of freefall acceleration on this airless moon is 2.79 $m/s^2$. (a) How long does it take for the box to reach the moon's surface? (b) What is its horizontal displacement during this time? (c) What is its vertical velocity when it strikes the surface? (d) At what speed does the box strike the moon?

(a) s
(b) m
(c) m/s
(d) m/s

**4.7.9** **(7.00)** A ball rolls at a constant speed on a level table a height $h$ above the ground. It flies off the table with a horizontal velocity $v$ and strikes the ground. Choose the correct expression for the horizontal distance it travels, as measured from the table's edge.

**4.7.12** **(7.00)** Sam tosses a ball horizontally off a footbridge at *v* m/s. How much time passes after he releases it until its speed doubles?

[ ] s

## Section 9: Interactive problem: the monkey and the professor

**4.9.1** **(5.00)** Using the simulation in the interactive problem in Section 4.9, where should the monkey aim the bazooka? Why?

## Section 11: Projectile motion: juggling

**4.11.2** **(5.00)** You are returning a tennis ball that your five-year-old neighbor has accidentally thrown into your yard, but you need to throw it over a 3.0 m fence. You want to throw it so that it barely clears the fence. You are standing 0.50 m away from the fence and throw underhanded, releasing the ball at a height of 1.0 m. State the initial velocity vector you would use to accomplish this.

( [ ] , [ ] ) m/s

## Section 14: Projectile motion: aiming a cannon

**4.14.7** **(7.00)** The infamous German "Paris gun" was used to launch a projectile with a flight time of 170 s for a horizontal distance of 122 km. Based on this information, and ignoring air resistance as well as the curvature of the Earth, calculate (a) the gun's muzzle speed and (b) the angle, measured above the horizontal, at which it was fired.

(a) [ ] m/s
(b) [ ] °

## Section 20: The range and elevation equations

**4.20.1** **(5.00)** You have a cannon with a muzzle velocity of 155 m/s and a target 1950 m away. State (a) the smaller angle and (b) the larger angle at which you can aim the cannon and reach the target.

(a) The smaller angle [ ] °
(b) The greater angle [ ] °

**4.20.3** **(7.00)** Natalya Lisovskaya set a track and field record in 1987 when she put the shot so that its horizontal displacement was 22.63 m. Assume that the angle of the initial velocity of the shot was such that it maximized the range, and for simplicity, assume the height of the ball when it landed was the same as the height at which it left her hand. If she were to put the shot vertically with the same speed, what is the maximum height above her hand that the shot would reach?

m

## Section 22: Relative velocity

**4.22.1** **(7.00)** Agent Bond is in the middle of one of his trademark, nearly impossible getaways. He is in a convertible driving west at a speed of 23.0 m/s (this is the reading on his speedometer) on top of a train, heading toward the back end. The train is moving horizontally, due east at 15.0 m/s. As the convertible goes over the edge of the last train car, Bond jumps off. With what horizontal velocity relative to the convertible should he jump to hit the ground with a horizontal velocity of 0 m/s, so that he merely shakes, but does not spill (nor stir) his drink? Consider east to be the positive direction.

m/s

## Section 23: Sample problem: relative velocity

**4.23.2** **(5.00)** A plane is pointed in the positive *x* direction and is flying with an speed of (200, 0, 0) m/s relative to the air. However, due to an exceptionally strong updraft, the air is moving in the positive *z* direction at 50.0 m/s with respect to the ground. Find the velocity of the plane with respect to the ground.

( , , ) m/s

**4.23.3** **(5.00)** You have a boat with a motor that propels it at $v_{boat}$ = 4.5 m/s relative to the water. You point it directly across the river and find that when you reach the other side, you have traveled a total distance of 27 m (indicated by the dotted line in the diagram) and wound up *L* m downstream. What is the speed of the current?

m/s

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