Relative velocity in 2D

1. Julia can swim at 3.5 km/hr in still water. She is swimming in a river with a current flowing at 1.2 km/hr [W].

a. What is her resultant velocity, $\vec{v}_{og}$ if she attempts to head north? (3.7 km/hr [19°W of N])

b. If the river is 250 m wide, how long will it take her to cross? (257 s)

c. How far downstream will she land? (85.7 m)

d. At what angle must she aim in order to land directly north from her starting point? [20°E of N]

e. How long will it take to cross the river now? (274 s)

2. An aircraft has an airspeed of 230 km/hr [N]. What is the plane's speed relative to the ground if it:

a. Flies with a tailwind of 50 km/hr? (280 km/hr [N])

b. Flies into a headwind of 50 km/hr? (180 km/hr [N])

c. Flies due [N] while the wind blows at 50 km/hr [E]? (235 km/hr [12°E of N])

3. An aircraft leaves Albany for New York, which is due south. The aircraft can fly at 450 km/hr and the wind is blowing to the west at 40 km/hr.

a. What must be the aircraft's heading in order to fly due south? ([5°E of S])
(**Heading** is the angle of the plane's velocity relative to the ground)

b. What is the ground speed of the aircraft? (448 km/hr)
(**Ground speed** is the magnitude of the plane's velocity relative to the ground)

4. A navy vessel is patrolling the Straits of Hormuz for oil smugglers. The ship can travel at 30 km/hr in still water. If the current is 3 km/hr [W], what must be the ship's heading to maintain a course due [N]? ([5.7°E of N])

5. A swimmer jumps into a river and swims straight north at 1.5 km/hr relative to the water. There is a current in the river of 2.0 km/hr [W]. What is the swimmer's velocity relative to the shore? (2.5 km/hr [53°W of N])

6. A conductor in a train travelling at 12.0 km/hr [N] walks east across the aisle at 5.0 km/hr relative to the train. What is his velocity relative to the ground?

(13.0 km/hr [23°E of N])

7. A mouse is crawling inside a box which is being pushed across the deck of a moving boat. The mouse is travelling at 0.5 m/s [E] relative to the box. The box is moving at 1.2 m/s [E] relative to the boat. The boat is moving at 4.0 m/s [N] relative to the water. What is the velocity of the mouse relative to the water?

(4.3 m/s [67°N of E])

8. A plane has a velocity of 300 km/hr relative to the air. If the pilot points the plane straight north, when there is a wind of 80 km/hr blowing towards the west, what will the resultant velocity of the plane be? (310 km/hr [15°W of N])

9. A blimp pilot wants to travel north. The blimp can move at 26 km/hr in still air. There is a wind of 10 km/hr east.

a. What is the required heading ([23°W of N])
b. How fast will the blimp travel over the ground? (24 km/hr)
c. How long will it take the blimp to travel 140 km? (5.8 hr)

10. A plane wants to travel east. The plane has a velocity of 500 km/hr relative to the air. A wind is blowing at 50.0 km/hr [N]. Calculate

a. the proper heading ([5.7°S of E])
b. the magnitude of the plane's velocity relative to the ground (497 km/hr)

One Dimensional Kinematics

1. How far would a car move in 4.8 s if its velocity changed from 14.0 m/s to 16.0 m/s? 72 m

2. What is the displacement of a car accelerating from 15.0 m/s forward to 10.0 m/s forward in 8.0 s? 100 m

3. Apollo 10's re-entry speed was 39 897 km/h. How many seconds would it take the spacecraft to stop in a distance of 3.0×10^6 m? 540 s

4. The speed of light is 3.0×10^8 m/s. The speed of sound is 344 m/s. A flash of lightning occurs in a storm 1.0×10^4 m away. How many seconds does it take for us to see the lightning and hear the thunder? 3.3×10^{-5} s, 29 s

5. How long would it take a laser beam to go to the Moon and back if the distance to the Moon is 3.8×10^8 m? 2.5 s

6. If Donovan Bailey reaches a top speed of 10.2 m/s in 2.5 s from rest, what is his acceleration? 4.1 m/s^2

7. If a sprinter accelerates at 2.2 m/s^2 for 2.5 s, what is her velocity after this time, assuming initial $\vec{v}_0 = 0$? 5.5 m/s

8. If it takes 0.0800 s for an airbag to stop a person, what is the acceleration of a person moving 13.0 m/s and coming to a complete stop in that time? -162 m/s^2

9. A fastball pitcher can throw a baseball at 101 km/h. If the windup and throw take 1.5 s, what is the acceleration of the ball? 19 m/s^2

10. A car moving at 10.0 m/s north ends up moving 10.0 m/s south after a period of 12 s. What is its acceleration? -1.7 m/s^2

11. A dragster accelerates from rest for 450 m at 14 m/s^2. A parachute is then used to slow it down to a stop. If the parachute gives the dragster an acceleration of - 7.0 m/s^2, how far has the dragster travelled before stopping? 1300 m

Projectiles

1. An object is thrown into the air with a velocity of 15.0 m/s and an angle of 35° with the horizontal and returns to the same height.

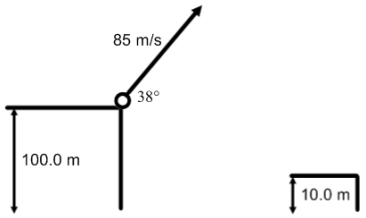
    a) How long is the projectile in the air?
    b) What is the range of the projectile?
    c) How long does it take to reach its max altitude?
    d) What is the max altitude?
    e) What is the x-component of velocity at t = 0.62 s?
    f) What is the y-component of velocity at t = 0.62 s?
    g) What is the net velocity at t = 0.62 s (magnitude and direction)?

A	1.75 s	E	12.3 m/s
B	21.5 m	F	2.5 m/s
C	0.88s	G	12.5 m/s [11° above horizontal]
D	3.77 m		

2. A projectile is shot horizontally at 20 m/s from a cannon located on a cliff 200.0 m high.
    a) How long is the projectile in the air?
    b) What is the range?
    c) What is the final velocity of the projectile? (ensure you include both magnitude and direction)

3. A cannonball is fired from a cannon at an angle of 38° to the horizontal at a velocity of 85.0 m/s. The cannon sits on a 100.0 m high cliff as in diagram 1, and the projectile lands on a 10.0 m high box.

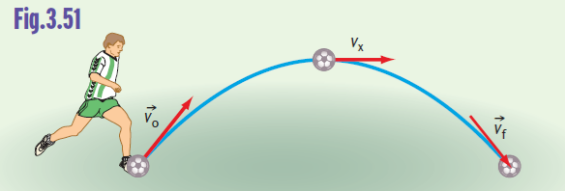
    a) Calculate the range to the box and,
    b) The max height the projectile reaches



4. A plane in horizontal flight at a velocity of 800 km/hr releases an “aid package”. From what altitude can the package be released in order to hit a target 1600 m ahead of the aircraft?

1a	t = 6.4 s	2a	range = 812 m
1b	Range = 128 m	2b	d_y = 138.0 m (above cliff)
1c	v = 65.8 m/s [72° below horizontal]	3	d_y = 254 m

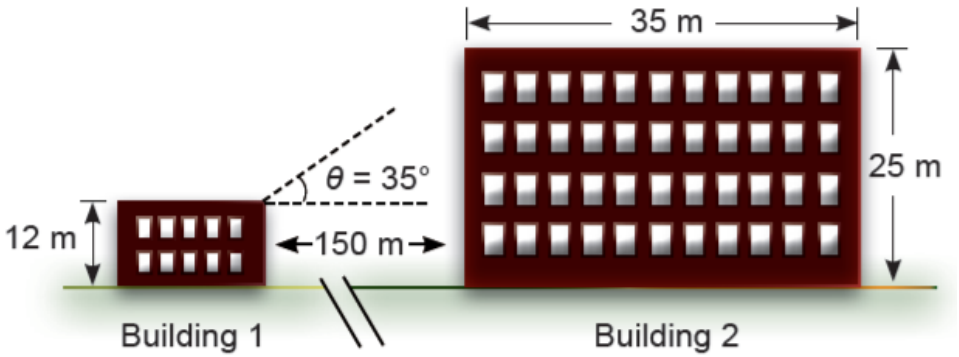
1. Does the acceleration of a projectile ever go to zero?
2. What factors affect real world projectile problems that we ignore?
3. If a projectile is launched at the same speed at an angle of 30° and again at an angle of 45° and finally at an angle of 60°, which angle would maximize range? Which would maximize flight time?
4. What are some examples of sports that use projectile motion without spin and of ports that use projectile motion with spin? What effect does spin have on a projectile? **Google me*
5. At what point in a projectile's path is the speed a
   a) maximum?
   b) minimum?
6. On the diagram below sketch the vector components at the indicated locations.



7. A pitcher throws a baseball at 140 km/h. If the plate is 28.3 m away, how far does the ball drop if we assume the ball started travelling toward the plate horizontally? (2.6 m)
8. Two pennies are sitting on a table 1.2 m high. Both fall off the table at the same time, except one is given a significant push. If the pushed penny is moving at 4.1 m/s horizontally at the time it leaves the table,
   a) which penny lands first?
   b) how far from the table does the pushed penny land? (2.0 m)
   c) what is the final velocity of each penny? (4.9 m/s [D] and 6.4 m/s [47° below the horizontal])
9. A plane is flying horizontally with a speed of 90.0 m/s. If a skydiver jumps out and free falls for 10.6 s, find:
   a) how far the skydiver falls. (550 m)
   b) how far the skydiver moves horizontally. (950 m)
   c) the final vertical velocity of the skydiver. (104 m/s)
   d) the final velocity of the skydiver. (140 m/s [50° below the horizontal])
10. A plane flying level at 80.0 m/s releases a package from a height of 1.000 km. Find
    a) the time it takes for the package to hit the ground (14 s)
    b) the distance it travelled horizontally (1100 m)
    c) the final velocity of the package. (100 m/s [60° below the horizontal])

1. Juliet throws a letter to Romeo who is on a balcony 3.0 m above the ground. If she throws it with a velocity of 6.4 m/s [45° above the horizontal] can the letter reach him? (No. You must show why or why not not to get marks)
2. A fish at the surface of a pond shoots a stream of water at a bug 0.26 m above the water with a range of 3.0 m. If the initial velocity of the water is 6.0 m/s at 30.0° above the horizontal, does the water hit the bug? (No. You must show why or why not not to get marks)

3. A projectile launcher launches a snowball at a velocity of 45 m/s [35° above the horizontal] from the top of building 1. Does the snowball land on top of building 2? Support your answer with calculations. (Yes. You must show why or why not not to get marks)



4. A biker hits a jump on his motorbike at 27.0 m/s 35° above the horizontal. The jump is 120.0 m above the ground. The biker lands on a platform of unknown height 145.0 m away from the cliff. How high is the platform that the biker lands on? (No higher than 10.6 m above the ground)

5. Three projectiles are launched at different angles, 25°, 43°, and 75° respectively, but with the same initial speed. All the projectiles are launched from and land on the ground. A student argues that the projectile launched at 43° will have the longest flight time because it has the largest range. Is the student correct? Explain. (No. It will have the longest range (closest angle to 45°) but not the longest flight time (that would be closest angle to 90°)

2D Collisions

1. Two identical curling stones (m = 19.5 kg) collide. Stone 1 is initially at rest and travels 3.2 m/s [30.0° W of N] after the collision. Stone 2 was travelling 5.0 m/s [N] before the collision. What is the velocity of stone 2 after the collision? (2.74 m/s [54° N of E])

2. Two billiard balls with identical mass collide (m = 0.160 kg). Prior to the collision, ball 1 was travelling 2.20 m/s [S] and ball 2 was travelling 3.10 m/s [W]. After the collision, ball 1 was travelling 2.56 m/s [14.0° N of W]. Determine the velocity of ball 2 after the collision. (2.89 m/s [77.7° S of W])

3. A 1200.0 kg car (A) strikes a stationary 1350.0 kg car (B) off centre from behind. Accident analysis showed that after the collision, car B moved at 8.30 m/s [35° N of E], and car A moved 12.8 m/s [53° N of W]. What was the speed of the car just before collision? (15.4 m/s)

4. Two bumper cars collide and stick together. Car 1 (m = 150 kg) is travelling 3.5 m/s [N] when it strikes car 2 (m = 95 kg), travelling 2.5 m/s [E]. What is their combined velocity after colliding? (2.34 m/s [65.6° N of E])

5. A 0.058 kg firecracker that is at rest explodes into three fragments. A 0.018 kg fragment moves at 2.40 m/s [N] while a 0.021 kg fragment moves at 1.60 m/s [E]. What will be the velocity of the third fragment? (2.87 m/s [52.2° S of W])

6. The police are investigating an accident. They have determined that the mass of car A is 2275 kg and was traveling North before the collision, while car B has a mass of 1525 kg and was traveling East just before the collision. Accident analysis has determined that the cars, when they were locked together, had a velocity of 31 km/h [43° N of E]. If the speed limit was 40 km/h on both streets, should one or both cars be ticketed for speeding? (A should not, moving at 36 km/hr, B should be, moving at 56 km/hr)