Chapter 2
Two Dimensional Kinematics

Homework # 09

Pythagorean Theorem

$$a^2 + b^2 = c^2$$

Trigonometric Definitions

$$\cos\theta = \frac{a}{h}$$

$$\sin\theta = \frac{o}{h}$$

$$\tan\theta = \frac{o}{a}$$

Trigonometric Identities

$$\tan\theta = \frac{\sin\theta}{\cos\theta}$$

$$\cos^2\theta + \sin^2\theta = 1$$

$$2 \cdot \sin\theta \cdot \cos\theta = \sin 2\theta$$

Projectile Motion Equations

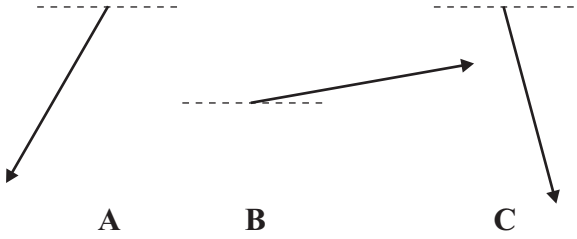
x	y
$v_x = v_{xo}$	$v_y = v_{yo} + gt$
$x = v_{xo}t$	$y = y_o + v_{yo}t + \frac{1}{2}gt^2$
	$v_y^2 = v_{yo}^2 + 2g(y - y_o)$
	$\bar{v}_y = \frac{v_{yo} + v_y}{2}$

Chapter 2
Two Dimensional Kinematics
2.1 Graphical Addition of Vectors — Homework # 10

For each of numbers 1-3, execute the following operations on vectors **A**, **B**, and **C**: a.) **A + B + C** and b.) **A + B - C**
Note: Include the arrowhead in any measurements of length. A margin of error of ± 0.3 cm and ± 4° is allowed.

01.

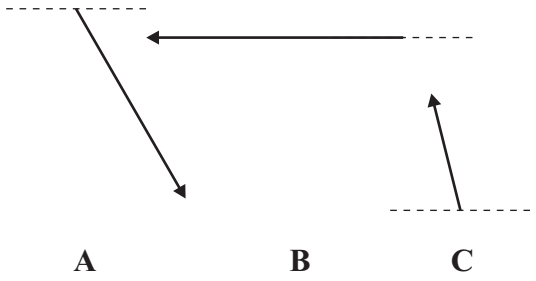
a.) Resultant = _____ @ _____
Magnitude Direction



b.) Resultant = _____ @ _____
Magnitude Direction

02.

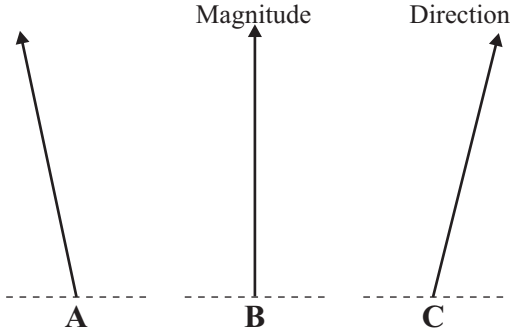
a.) Resultant = _____ @ _____
Magnitude Direction



b.) Resultant = _____ @ _____
Magnitude Direction

03.

a.) Resultant = _____ @ _____
Magnitude Direction



b.) Resultant = _____ @ _____
Magnitude Direction

ANSWERS: **01.** a.) 5.0 cm @ 63° S of E b.) 1.2 cm @ 40° N of E
02. a.) 2.5 cm @ 23° S of W b.) 4.4 cm @ 69° S of W **03.** a.) 10.6 cm @ 89° N of E b.) 4.0 cm @ 66° N of W

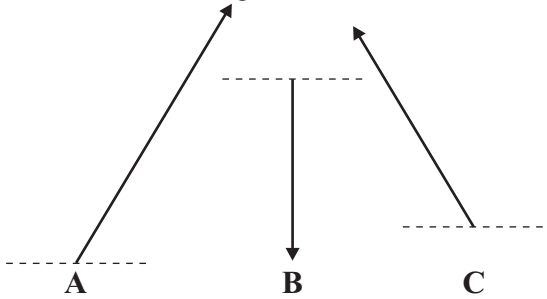
Chapter 2
Two Dimensional Kinematics
2.1 Graphical Addition of Vectors — Homework # 11

For each of numbers 4-6, execute the following operations: a.) **A + B + C** and b.) **A + B - C**

Note: Include the arrowhead in any measurements of length. A margin of error of ± 0.3 cm and ± 4° is allowed.

04.

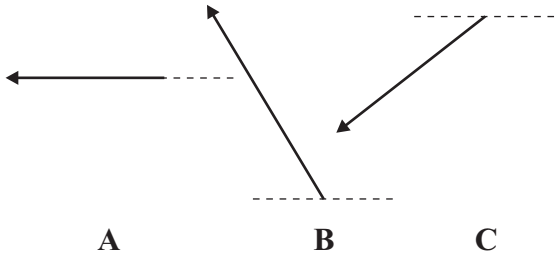
a.) Resultant = _____ @ _____
Magnitude Direction



b.) Resultant = _____ @ _____
Magnitude Direction

05.

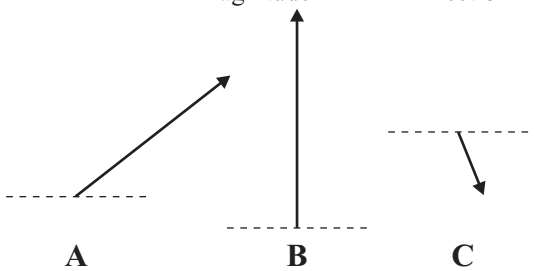
a.) Resultant = _____ @ _____
Magnitude Direction



b.) Resultant = _____ @ _____
Magnitude Direction

06.

a.) Resultant = _____ @ _____
Magnitude Direction

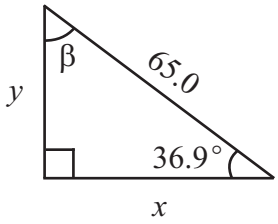


b.) Resultant = _____ @ _____
Magnitude Direction

ANSWERS: **04.** a.) 3.7 cm @ 83° N of E b.) 4.0 cm @ 24° S of E
05. a.) 5.7 cm @ 11° N of W b.) 4.4 cm @ 68° N of W **06.** a.) 4.4 cm @ 57° N of E b.) 5.6 cm @ 72° N of E

Chapter 2
Two Dimensional Kinematics
2.2 Trigonometry and Vector Components — Homework # 12

01.

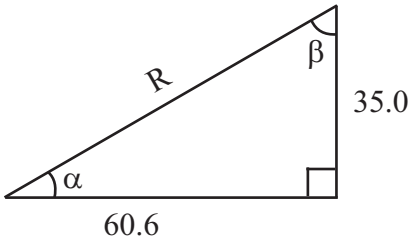


x = _____

y = _____

β = _____

02.

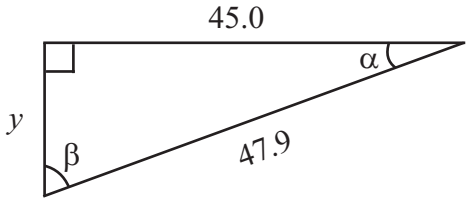


R = _____

α = _____

β = _____

03.



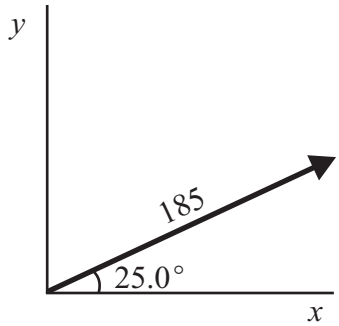
y = _____

α = _____

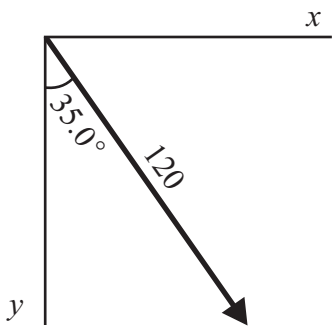
β = _____

04. Break each of the following vectors into components.

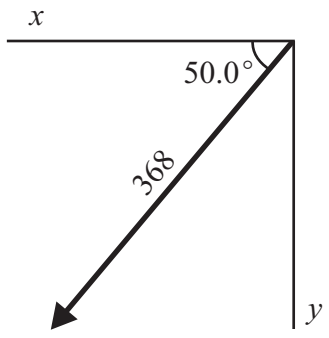
a.)



b.)



c.)

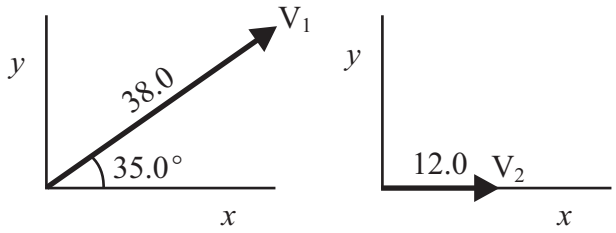


ANSWERS: **01.** $x = 52.0$, y = 39.0, $\beta = 53.1°$ **02.** R = 70.0, $\alpha = 30°$, $\beta = 60°$ **03.** $y = 16.4$,$\alpha = 20°$, $\beta = 70°$
04. a.) $x = 168$, $y = 78.2$ b.) $x = 68.8$, $y = -98.3$ c.) $x = -237$, $y = -282$

Chapter 2
Two Dimensional Kinematics
2.3 Analytical Vector Addition — Homework # 13

01. For each of the following, add the two vectors shown.

a.)



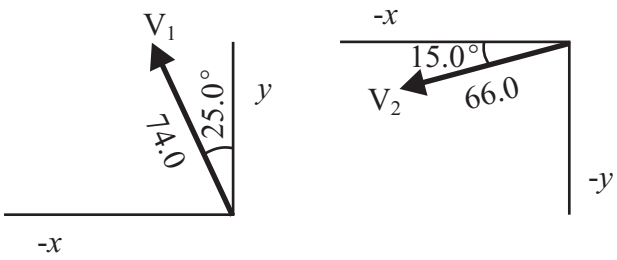
V_{1x} = _____ V_{1y} = _____

V_{2x} = _____ V_{2y} = _____

V_{Rx} = _____ V_{Ry} = _____

V_R = _____ @ _____

b.)



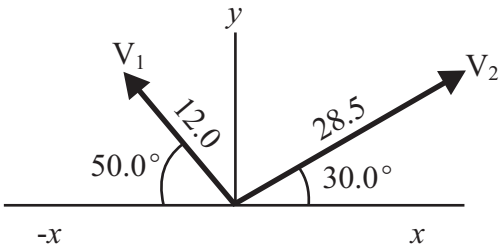
V_{1x} = _____ V_{1y} = _____

V_{2x} = _____ V_{2y} = _____

V_{Rx} = _____ V_{Ry} = _____

V_R = _____ @ _____

c.)



V_{1x} = _____ V_{1y} = _____

V_{2x} = _____ V_{2y} = _____

V_{Rx} = _____ V_{Ry} = _____

V_R = _____ @ _____

02. A 4.80-m clothesline is hung between two poles that are 4.76 m apart. If a weight is hung in the very center, how much below the level of knots will the weight sit. (Assume the knots of the clothesline on each pole is at the same height and ignore any loss in the length of the line needed to tie the line on each pole).

03. A person walks 80.0 m east, then 25.0 m north. What is his final displacement?

04. A person walks 120 m west, then 65.0 m north, then 30.0 m east. What is his final displacement?

05. A person walks 40.0 m at 28.0° N of W, then walks 15.0 m at 37.0° N of E. What is his final displacement?

ANSWERS: **01.** a.) 48.3 @ 26.8° N of E b.) 107 @ 27.7° N of W c.) 28.9 @ 54.0° N of E **02.** 0.309 m
03. 83.8 m @ 17.4° N of E **04.** 111 m @ 35.8° N of W **05.** 36.2 m @ 49.9° N of W

Chapter 2
Two Dimensional Kinematics
2.4 Relative Velocities — Homework # 14

I

01. A train is traveling down a track in a straight line at a constant velocity of 85 m/s. A boy is sitting on the floor at the back of a railroad car facing toward the front, while his sister is sitting at the front of the car facing him.
    a.) If the boy rolls a ball toward the girl with a speed of 25 m/s relative to the train, what is the velocity of the ball as seen by an observer on the Earth?
    b.) If the girl rolls a ball toward the boy with a speed of 25 m/s relative to the train, what is the velocity of the ball as seen by an observer on the Earth?

02. A cyclist, we'll call him rider A, is riding a bike in an easterly direction at 40 km/h. A second rider, rider B, is riding his bike at 25 km/h at a distance in front of rider A.
    a.) If rider B is heading west, what is the velocity of rider A to B?
    b.) If rider B is heading west, what is the velocity of rider B to A?
    c.) If rider B is heading east, what is the velocity of rider A to B?
    d.) If rider B is heading east, what is the velocity of rider B to A?

II

03. A boat, capable of traveling 12.2 km/h in still water, motors at full speed in a heading that is directly across an 820-m wide river with a current of 5.40 km/h.
    a.) What is the velocity of the boat as seen by an observer on the shore?
    b.) How far downstream will the boat land?
    c.) How long will it take for the boat to cross the river?
    d.) What is the net displacement of the boat as seen by an observer on the shore?

04. A motorboat, capable of traveling 3.85 m/s in still water, wishes to land at a port directly across a 428-m wide river. At what upstream angle must the boat head if the speed of the current is 1.12 m/s?

05. A boat, capable of traveling 10.8 km/h in still water, motors at full speed in a heading that is directly across a 740-m wide river with a current of 4.65 km/h. What is the net displacement of the boat as seen by a person on the shore?

III

06. A ferryboat, capable of traveling 1.95 m/s in still water, is crossing a 340-m wide river. The captain wishes to land at a port that is 120 m upstream. He calculates that to do so he must head the boat, motoring at full speed, at an angle of 40° upstream to successfully arrive at this port. What is the speed of the river's current?

07. An airplane, whose airspeed is 440 km/h, is heading on a course that is 23.0° N of W when it encounters a wind of 38.5 km/h that is blowing 65.0° S of E. What is the velocity of the plane as seen by an observer on the ground?

08. A plane traveling at 480 km/h is heading due north when it encounters a 42.0 km/h wind blowing **FROM** the SW.
    a.) What is the velocity of the plane as seen by an observer on the ground?
    b.) How far off course will the plane be after 20 minutes?

ANSWERS: **01.** a.) 110 m/s b.) 60 m/s
02. a.) 65 km/h East b.) 65 km/h West c.) 15 km/h East d.) 15 km/h West
03. a.) 13.3 km/h @ 23.9°with a line perpendicular to the shore b.) 363 m c.) 0.0673 h = 242 s
03. d.) 897 m @ 23.9° with a line perpendicular to the shore **04.** 16.9°
05. 806 m @ 23.3° with a line perpendicular to the shore **06.** 0.724 m/s **07.** 412 km/h @ 19.4° N of W
08. a.) 511 km/h @ 86.7° N of E b.) 9.90 km E (or 14.0 km NE)

Chapter 2
Two Dimensional Kinematics
2.4 Relative Velocities — Homework # 15

I

01. A cat walks at a speed of 1.65 m/s along the deck of a boat towards the bow. The boat is traveling at 6.60 m/s with respect to the water.
    a.) What is the velocity of the cat with respect to the water?
    b.) What would be the velocity of the cat with respect to the water if it were walking toward the stern at this speed?

02. Two trains approach each other on parallel tracks. One is moving at a speed of 65 km/h relative to the earth while the other is moving in the opposite direction at 80 km/h relative to the earth. If they are initially 18 km apart, how long will it take before they pass each other?

II

03. A vacationer walks 3.50 km/h directly across (from starboard to port) a cruise ship whose speed relative to the earth is 11.4 km/h. What is the velocity of the vacationer with respect to the earth?

04. A swimmer is capable of swimming 1.35 m/s in still water. He heads directly across a 180-m wide river with a current of 0.85 m/s.
    a.) What is the velocity of the swimmer as seen by his friend on the shore?
    b.) How far downstream will he land?
    c.) How long will it take him to reach the other side?
    d.) What is his displacement as seen by his friend?

05. At what upstream angle must the swimmer in problem 04 aim if he is to arrive at a point directly across the river?

06. Two cars approach a street corner at right angles to each another. Car A travels at 55.0 km/h while car B at 47.5 km/h.
    a.) What is the velocity of car A as seen by car B?
    b.) What is the velocity of car B as seen by car A?

III

07. A motorcycle traveling 95.0 km/h approaches a car in front of it traveling 83.5 km/h in the same direction. When the motorcycle is 65.0 m behind the car, the rider turns the throttle to accelerate and passes the car 12.0 s later. What was the acceleration of the motorcycle?

08. An unmarked police car traveling at 95.0 km/h is passed by a speeder traveling at a constant 125.0 km/h. Exactly 1.00 s after the speeder passes, the policeman steps on the accelerator. If the police car's acceleration is 2.25 m/s^2, how much time elapses between when the police car is first passed and he overtakes the speeder?

09. A helicopter heads due south with an air speed of 40.0 km/h. The pilot observes, however, that he has covered 20.0 km in the previous 45.0 minutes in a southwesterly direction. What is the wind speed and direction?

ANSWERS: **01.** a.) 8.25 m/s to the bow b.) 4.95 m/s to the bow **02.** 0.124 h = 7.45 min
03. 11.9 km/h @ 17.1° **04.** a.) 1.60 m/s @ 32.2°with a line perpendicular to the shore b.) 113 m c.) 133 s
04. d.) 213 m @ 32.2°with a line perpendicular to the shore **05.** 39.0°
06. a.) 72.7 km/h @ 49.2° from the path of car B b.) 72.7 km/h @ 40.8° from the path of car A **07.** 0.370 m/s^2
08. 9.30 s **09.** 28.3 km/h @ 48.1° N of W

Chapter 2
Two Dimensional Kinematics
2.5 Projectile Motion — Homework # 16

I

01. A marble is launched horizontally off a 93.0-cm high table causing the marble to land on the floor 1.85 m from the base of the table.
    a.) How long was the ball in the air?
    b.) With what velocity must the marble have left the tabletop?

02. A baseball is thrown horizontally off a 92.8-m high cliff with a velocity of 16.7 m/s.
    a.) How long was the ball in the air?
    b.) How far from the base of the cliff did the ball land?

03. A projectile is fired with an initial velocity of 80.0 m/s at a 30.0° angle from the top of a 120.0-m high cliff.
    a.) What is the horizontal component of the projectile's initial velocity?
    b.) What is the vertical component of the projectile's initial velocity?
    c.) How high is the projectile above the ground below when it is at its highest point in the trajectory?
    d.) What is the velocity of the projectile when it is at its highest point of the trajectory?
    e.) How long does it take to reach the highest point of the trajectory?
    f.) How long does it take to return to the height of the cliff?
    g.) What is the velocity of the projectile when it is at the height of the cliff?
    h.) How long does it take to hit the ground below?
    i.) How far from the base of the cliff will the projectile land?
    j.) With what velocity will the projectile hit the ground?

II

04. A tennis ball is to be thrown horizontally from the top of a 86.4-m tall building to the roof of an adjacent 57.3-m tall building that is 25.0 m away. With what minimum speed must the ball be thrown?

05. A football is kicked from a tee at an angle of 40.0°. If the ball lands 38.6 m away and is in the air for 2.57 s, what was the initial speed of the ball?

06. A golf ball is hit with a velocity of 55.0 m/s as it leaves the tee and is angled at 50.0° from the top of a platform at a golf range that is 20.0 m above the ground.
    a.) What horizontal distance does the golf ball travel?
    b.) With what velocity does the golf ball hit the ground below?

07. A bullet is fired with an initial velocity of 160.0 m/s at a 45.0° angle from the top of a 135.0-m high cliff.
    a.) How high is the bullet above the ground below when it is at its highest point in the trajectory?
    b.) How far from the base of the cliff will the projectile land?
    c.) With what velocity does the bullet hit the ground below?

III

08. Water leaves the nozzle of a sprinkler at ground level with a speed of 8.65 m/s and is observed to hit the ground 5.25 m away. At what angles could the hose be held? Why are there two answers?

ANSWERS: **01.** a.) 0.436 s b.) 4.25 m/s **02.** a.) 4.35 s b.) 72.6 m **03.** a.) 69.3 m/s b.) 40.0 m/s
03. c.) 202 m d.) 69.3 m/s e.) 4.08 s f.) 8.16 s g.) 80 m/s @ 30° below the horizontal h.) 10.5 s
03. i.) 728 m j.) 93.6 m/s @ 42.2° below the horizontal **04.** 10.3 m/s **05.** 19.6 m/s
06. a.) 320 m b.) 58.5 m/s @ 52.8° below the horizontal **07.** a.) 786 m b.) 2732 m
07. c.) 168 m/s @ 47.7° below the horizontal **08.** 21.7°, 68.3°

Chapter 2
Two Dimensional Kinematics
2.5 Projectile Motion — Homework # 17

I

01. A diver running 2.15 m/s dives out horizontally from the edge of a cliff and reaches the water below 2.50 s later.
    a.) How high is the cliff?
    b.) How far from the base of the cliff did the diver hit the water?

02. A tiger leaps horizontally from a 12.3-m-high cliff with a speed of 4.25 m/s. How far from the base of the rock will the tiger land?

II

03. A stone is cast horizontally at 25.0 m/s from a bridge spanning a river. If the stone lands 35.0 m away from the supports of the bridge, how high must be the height of the bridge?

04. A football is kicked from a tee at 18.5 m/s at a 40.0° angle to the horizontal.
    a.) How high will the ball go?
    b.) What's its hang time? (for non-Americans, hang time is how long the ball is in the air)
    c.) How far from the initial placement of the tee will the ball land?

05. A marksman aims a rifle directly at a target that is 185 m away and on the same level as his rifle. If the bullet leaves his gun at 480 m/s, by how much will he miss his target?

06. A shotputter puts the shot (mass = 7.3 kg) with an initial speed of 15.0 m/s at a 35.0° angle to the horizontal. If the shot leaves the athletes hand at a height of 2.25 m, what horizontal distance will the athlete score?

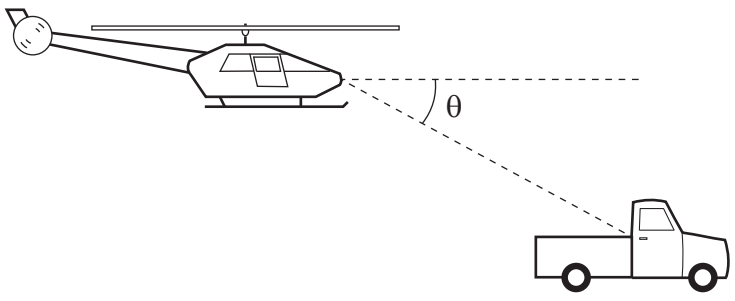
07. A long jumper leaves the ground at a 30.0° angle and travels 8.50 m. What was his takeoff speed?

08. An apple sits atop the head of William Tell's son who is 40.0 m away from his father. If William Tell is to launch an arrow at 37.5 m/s, at what upward angle must he aim the arrow to split the apple on his son's head? Assume the arrow leaves the bow at the same level as the apple.

09. A cannon sits on top of a castle built upon a cliff overlooking the sea. The cannon rests 185.0 m above the sea. When the cannon is fired the cannonball leaves the barrel at speed of 28.0 m/s. The cannon is be raised to a 20.0° angle above the horizontal. How far away must a ship be if the cannonball is to hit the ship?

III

10. A military helicopter is flying at a constant 240 km/h horizontally. The soldiers inside wish to drop an explosive onto an enemy truck traveling at a constant speed of 125.0 km/h on a level straight highway that is 112.0 m below. At what angle below the horizontal (as shown to the right) should the truck be in their sights when the bomb is dropped?



ANSWERS: **01.** a.) 30.6 m b.) 5.38 m **02.** 6.73 m **03.** 9.60 m **04.** a.) 7.21 m b.) 2.43 s c.) 34.4 m
05. 0.728 m **06.** 24.4 m **07.** 9.81 m/s **08.** 8.09° **09.** 187.0 m **10.** 36.2°

Chapter 2
Two Dimensional Kinematics

Conceptual Review — Homework # 18

01. Does the odometer measure a scalar or vector quantity? What about the speedometer? Explain.
02. Give several examples of an object's motion in which a great distance is traveled but the displacement is zero?
03. Can the displacement vector for a particle moving in two dimensions ever be longer than the length of the path traveled by the particle over the same time interval? Can it ever be less? Can it ever be equal? Explain.
04. A baseball player hits a very high popfly, then runs in a straight line and catches it. Which had the greater displacement, the player or the ball? Which had the greater average velocity? Explain.
05. If $\vec{\mathbf{V}}_{\mathbf{R}} = \vec{\mathbf{V}}_{\mathbf{1}} + \vec{\mathbf{V}}_{\mathbf{2}}$, is V_R necessarily greater than V_1 and/or V_2? Explain.
06. Two vectors have length of $V_1 = 3.5$ km and $V_2 = 4.0$ km. What are the maximum and minimum magnitudes of their vector sum?
07. Can two vectors of unequal magnitude add up to give the zero vector? Can three unequal vectors? Under what conditions? Explain.
08. Can the magnitude of a vector ever be equal to one of its components? Can it ever be less than one of its components? Explain.
09. Can a vector of magnitude zero have a nonzero component? Explain.
10. One car travels due east at 40 km/h, and a second car travels north at 40 km/h. Are their velocities equal? Discuss.
11. Two rowers, who can row at the same speed in still water, set off across a river at the same time. One heads straight across and is pulled downstream somewhat by the current. The other one heads upstream at an angle so as to arrive at a point opposite the starting point. Which rower reaches the other side first? Explain.
12. Two cars with equal speed approach an intersection at right angles to each other. Will they necessarily collide? Show that when the relative velocity of approach is collinear (along the same line) with the relative displacement, we use the nautical maxim "constant bearing means collision."
13. What physical factors are important for an athlete doing the broad jump? What about the high jump?
14. A projectile has the least speed at what point in its path?
15. A child wishes to determine the speed a slingshot imparts to a rock. How can this be done using only a meter stick and a calculator?