4-Series Problem

4.1) A motorcycle moves southward at 20.0 m/s for three minutes, then westward for two minutes at 25.0 m/s, then northwest for sixty seconds at 30.0 m/s.

a.) What is the bike's net displacement (as a vector)?
b.) What is the bike's average speed?
c.) What is the bike's average velocity? Assume the *+x-axis* is to the *east.*

4.3.) A kid with a slingshot fires a rock off a rooftop. As a function of time, the rock's *x* and *y-coordinates* are $x = 18.0t$ (meters) and $y = 4.00t - 4.90t^2$ (meters), where time is in seconds.

a.) Write out the rock's *position vector* in *unit vector notation*.
b.) Derive an expression for the rock's *velocity* $\vec{v}(t)$, characterized in *unit vector notation*.
c.) Derive an expression for the rock's *acceleration* $\vec{a}(t)$, characterized in *unit vector notation*.
d.) Noting that it's a very tall building, determine the rock's *position*, *velocity* and *acceleration* at *t = 3.00 seconds.*

4.5) An object's *position vector* is $\vec{r} = 3.00\hat{i} - 6.00t^2\hat{j}$ (meters).

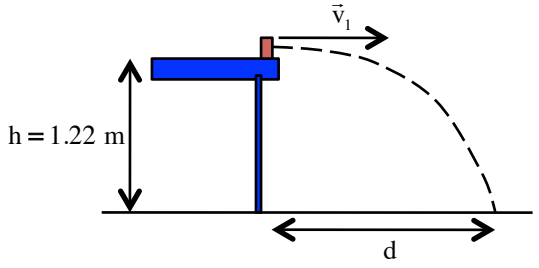
a.) Derive an expression for the object's *velocity*, characterized in *unit vector notation*.
c.) Derive an expression for the object's *acceleration*, characterized in *unit vector notation*.
d.) Determine the object's *position* and *velocity* at *t = 1.00 seconds*

4.7) Relative to a pier on a lake, a boat moving with velocity $\vec{v} = 4.00\hat{i} + 1.00\hat{j}$ (m/s) is positioned at $\vec{r} = 10.0\hat{i} - 4.00\hat{j}$ (meters) at a given instant. After 20.0 seconds of *constant acceleration*, its *velocity* is $\vec{v} = 20.0\hat{i} - 5.00\hat{j}$ (m/s).

a) Derive an expression for the boat's *acceleration* components?
b.) If you had characterized the "final" acceleration in *polar notation,* what angle would you have quoted?
c.) Assume the boat maintains this constant acceleration, what is its displacement vector at *t = 25.0 seconds*.

4.9) A kid with a toy car runs the car across a flat, 1.22 meter high tabletop. The car leaves the surface at its edge and, after falling, hits the floor a distance 1.40 meters out.

a.) What was the car's *velocity* as it leaves the tabletop?
b.) Just before it hits the floor, it had some velocity. What was the *direction* of that *velocity vector*?



4.11) What is the angle of projection required for an object to have its *horizontal-distance-traveled* equal *three times its maximum height*?

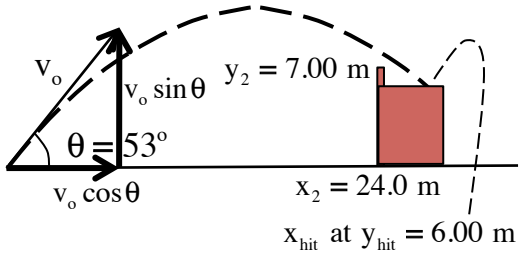
4.15) A water hose is used to direct a stream of water toward the side of a building. If the water's velocity out of the hose is v_i and the angle of the hose is θ_i, where on the building will the water hit if the hose is located a distance *D units* from the building?

4.17) A field goal is attempted at the end of a football game. The ball needs to travel 36.0 horizontal meters to reach the cross bar, which is 3.15 meters above the ground. If the kicker strikes the ball, giving it a *velocity* of 20.0 m/s at an angle of 53^o (relative to the horizontal):

a.) What is the ball's *y-coordinate* as it crosses the *plane of the goal post* (i.e., will the kicker score or not), and;

b.) Will the ball be rising or falling as it passing the *plane of the goal post*?

4.19) A man wants to kick a ball onto the roof of a building that is 6.00 meters above the ground, but the roof has a 1.00 meter high wall around its perimeter (so the ball will have to clear a 7.00 meter vertical height). The man is 24.0 meters from the base of the building and kicks the ball at an angle of 53^o. If it takes 2.20 seconds to reach a point above the perimeter:

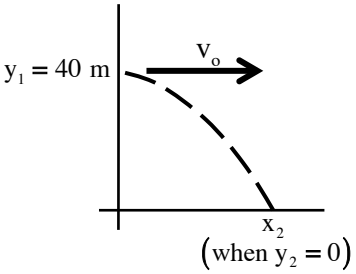


a.) At what *speed* must the ball have been launched?

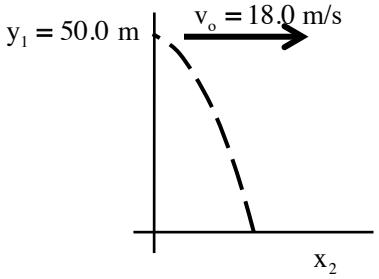
b.) By how much does the ball clear the perimeter wall?

c.) How far will the ball travel horizontally by the time it lands on the roof?

4.21) A kid throws a rock horizontally off a cliff and into a pond. If the cliff is 40.0-meters high, and if it takes 3.00 seconds for the sound of the splash to get back to the kid, how fast was the rock moving as it left the kid's hand? The speed of sound in air can be taken to be 343 m/s.



4.23) A man throws a rock horizontally from the edge of a 50.0-meter high cliff into a pool. If the coordinate origin is located at the base of the cliff:



a.) What is the *initial position vector* of the stone in both *unit vector notation* and *polar notation*?

b.) What is the *initial velocity vector* of the stone in both *unit vector notation* and *polar notation*?

c.) What key theoretical observation must be made before writing out the equations associated with the rock's vertical motion?

d.) What key theoretical observation must be made before writing out equations associated with the rock's horizontal motion?

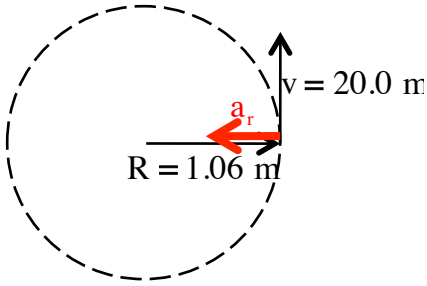
e.) Write out a *general algebraic expression* for the rock's *velocity* $\vec{v}(t)$ in *unit vector notation*.

f.) Write out a *general algebraic expression* for the rock's *position* $\vec{r}(t)$ in *unit vector notation*.

g.) Derive an expression for the *time of flight* to the water.

h.) What is the rock's *velocity*, in *unit vector notation*, just before impact?

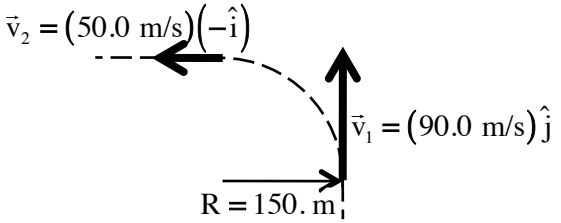
4.27) The discus throw is a standard event at track meets. What is the magnitude of the maximum *radial acceleration* of a discus at the end of the extended arm of a whirling athlete if the radius of discus's motion is 1.06 meters, its mass is 1.00 kg and its translational velocity is 20.0 m/s.



4.30) A hammer thrower swings a ball at 8.00 rev/sec when the chain length is .600 meters long. Increasing the length to .900 meters allows her to swing the ball at only 6.00 rev/sec.

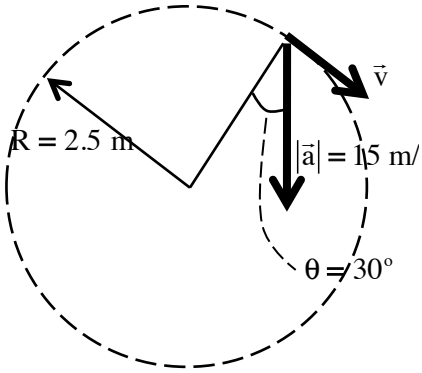
a.) Which rate effects the greatest translational speed?
b.) When moving at 8.00 rev/sec, what is the ball's *centripetal acceleration*?
c.) When moving at 6.00 rev/sec, what is the ball's *centripetal acceleration*?

4.31) A car slows continuously as it rounds a horizontal, 150-meter radius, right-angle curve (that is, it ends up going perpendicular to its original direction). If this entails going from 90.0 km/hr to 50.0 km/hr in 15.0 seconds, what is its *acceleration* as it passes through the 50.0 km/hr point? (You may assume it would have continued with the acceleration even beyond that point.)



4.32) The figure shows a snapshot of the acceleration of an object moving clockwise in a circular path of radius 2.50 meters. For that instant:

a.) Determine the *radial acceleration* of the particle;
b.) Determine the *speed of the particle* and;
c.) Determine the *tangential acceleration* of the particle.



4.36) A people-mover at an airport consists of a long track of length L moving with velocity v_1. A mother stands stationary on the track. Her exuberant husband runs down along the track with velocity v_2, relative to the moving track.

a.) How long does it take for the woman to traverse the length of the track?
b.) How long does it take for the husband to traverse the length of the track?
c.) An identical track sits next to the first track moving in the opposite direction. Just as the husband steps onto his track and starts to run, a pre-teen ("the child") steps onto the second track moving in the opposite direction, standing still for his part. How long does it take for the husband and pre-teen to pass one another?

4.37) An airplane flies 750 km north moving at a constant 630 km/hr, relative to the air.

a.) If the plane hits a headwind of 35.0 km/hr south, how long will it take to reach its destination?
b.) If the plane runs into a tailwind of 35.0 km/hr north, how long will it take to reach its destination?

c.) If the plane runs into a crosswind of 35.0 km/hr oriented east (relative to the ground), how long will it take to reach its destination?

4.40) A student swims upstream for a distance of 1.00 km, then back to her start point. The river has a steady speed of .500 m/s.

a.) How long will the round trip take if the girl can swim 1.20 m/s in still water?
b.) How long will the round trip take if the girl is in still water?
c.) Why is there a discrepancy between the two times?

4.42) A girl in the back of a pick-up truck moving 9.50 m/s throws a coke bottle upward. The girl, who hasn't moved on the truck bed, catches the bottle 16.0 meters down the road.

a.) Relative to the truck, at what angle must the bottle have been thrown?
b.) Relative to the truck, what was the initial speed of the bottle?
c.) What did the bottle's motion look like from the perspective of the girl?
d.) An observer watches the motion from a stationary point on the ground. From that frame of reference, what did the motion look like.
e.) From the frame of the stationary observer, what was the velocity of the bottle just after it left the girl's hand?

4.43) An astronaut riding on a flatbed moon mobile (no air friction) travels straight and true at 10.0 m/s. He throws a wrench along his path of motion at an angle he approximates at 60^{o} with the horizontal, relative to the flatbed mobile. Another astronaut, standing nearby, observes the wrench to move straight upward in the vertical. After leaving the first astronaut's hand, how high will the wrench go?