

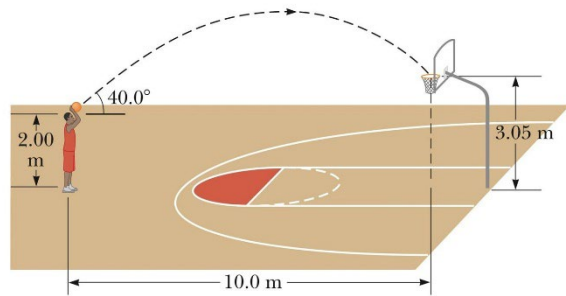
University Physics I

Homework Set 5

- Suppose the position vector for a particle is given by $\vec{r}(t) = x(t)\hat{x} + y(t)\hat{y}$, with $x(t) = at + b$ and $y(t) = ct^2 + d$, where $a = 1.00 \text{ m/s}$, $b = 1.00 \text{ m}$, $c = 0.125 \text{ m/s}^2$, and $d = 1.00 \text{ m}$.
 - Calculate the magnitude of the average velocity during the time interval from $t = 2.00 \text{ s}$ to 4.00 s
 - Determine the velocity vector and the speed (*magnitude of the velocity*) at $t = 2.00 \text{ s}$.
- A rabbit runs in a garden such that the x and y components of its displacement as functions of time are given by $x(t) = -0.45t^2 - 6.5t + 25$ and $y(t) = 0.35t^2 + 8.3t + 34$, with x and y in meters and t in seconds.
 - Determine the rabbit's position vector (\vec{r}) at $t = 10.0 \text{ s}$.
 - Determine the rabbit's velocity vector (\vec{v}) at $t = 10.0 \text{ s}$.
 - Determine the rabbit's acceleration vector (\vec{a}) at $t = 10.0 \text{ s}$.
- A golf ball is hit off a tee at the edge of a cliff. Its x and y coordinates as functions of time are given by $x(t) = 18.0t$ and $y(t) = 4.00t - 4.90t^2$, where x and y are in meters and t is in seconds.
 - Determine the golf ball's position vector (\vec{r}).
 - Determine the golf ball's velocity vector (\vec{v}).
 - Determine the golf ball's acceleration vector (\vec{a}).
 - Calculate the golf ball's position, velocity and acceleration vectors at $t = 3.00 \text{ s}$.
- A physics book slides off a horizontal table top with a speed of 1.10 m/s and strikes the floor in 0.480 s . Ignoring air resistance:
 - Find the height of the table top above the floor.
 - The horizontal distance from the edge of the table to the point where the book lands.
 - The horizontal and vertical components of the book's velocity just before impact.
- A skier launches off a ski jump with a horizontal velocity of 30.0 m/s (*and no vertical velocity component*). What is the magnitude of her velocity the instant before she lands 2.00 s later?
- A football is punted with an initial speed of 27.5 m/s and a launch angle of 56.7° .
 - What is its hang time (*the time until it hits the ground again*)?
 - How far has the football traveled horizontally during this time (*in yds*)?
- A 6-ft rookie quarterback throws a football with an initial upward velocity component of 12.0 m/s and a horizontal velocity component of 20.0 m/s . Ignoring air resistance:
 - How much time is required to reach the highest point of the trajectory?
 - How high is this point off the ground?
- The froghopper, *Philaenus spumarius*, holds the world record for insect jumps. When leaping at an angle of 58.0° above the horizontal, some of the tiny critters have reached a maximum height of 58.7 cm above the level ground. (See *Nature*, Vol. 424, July 31, 2003, pg. 509)
 - What was the takeoff speed for such a leap (*in m*)?
 - What horizontal distance did the froghopper cover for this world record leap (*in m*)?

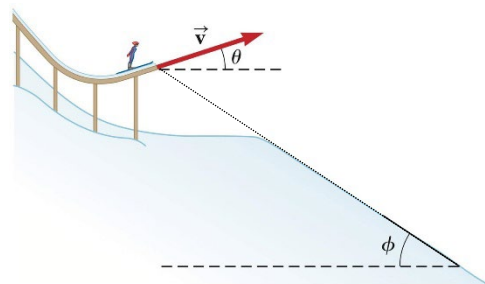
9. Your friend's car is parked on a cliff overlooking the ocean on an incline that makes an angle of 17.0° below the horizontal. The brakes fail, and the car rolls from rest down the incline for a distance of 29.0 m to the edge of the cliff in 4.5 sec , which is 55.0 m above the ocean, and, unfortunately, continues over the edge and lands in the ocean.
- What was the magnitude of cars velocity as it left the cliff?
 - Find the length of time the car was in the air.
 - Find the car's horizontal position relative to the base of the cliff when it lands in the ocean.
10. Firemen use a high-pressure hose to shoot a stream of water at a burning building. The water has a speed of 25.0 m/s as it leaves the end of the hose and then exhibits projectile motion through the air. The firemen adjust the angle of elevation α of the hose until the water takes 3.00 s to reach a building 45.0 m away. Ignoring air resistance and assuming the hose is at ground level:
- Find α .
 - Find the velocity and acceleration vectors of the water at the highest point in its trajectory.
 - How high about the ground does the water strike the building?

11. A 2.00 m tall basketball player is standing on the floor 10.0 m from the basket as shown in the figure at right. The height of the basket is 3.05 m and he shoots the ball at an angle of 40.0° .



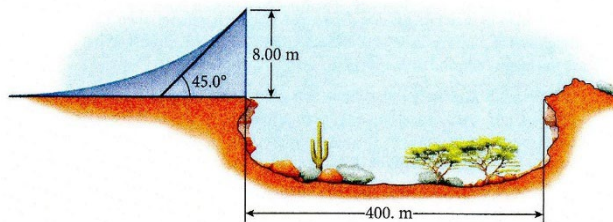
- What is the acceleration vector of the basketball at its highest point in its trajectory?
 - At what speed must the player throw the basketball so that the ball goes through the hoop without striking the backboard (*i.e. nothing but net*)?
12. If you want to use a catapult to throw rocks and the maximum range you need these projectiles to have is 0.67 km :
- What is the best launch angle to use?
 - What initial speed do the rocks have to have as they leave the catapult at this angle?
 - Suppose you use decrease your angle in part (a) by 10° . What is the new launch speed?
13. A cannon is fired from a hill 116.7 m high at an angle of 22.7° above the horizontal. If the muzzle velocity is 36.1 m/s , how far horizontally from the cannon does a 4.35 kg cannonball land when it hits the ground 116.7 m below?

14. A skier leaves the ramp of a ski jump with a velocity of $v = 10.0\text{ m/s}$ at $\theta = 15.0^\circ$ about the horizontal as shown in the figure at right. The slope where she will land is inclined downward at $\phi = 50.0^\circ$. Ignoring air resistance:



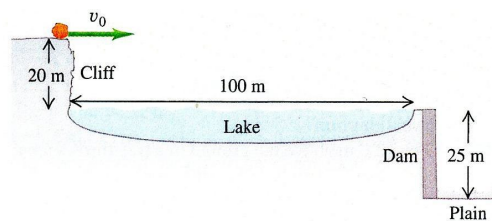
- Find the total distance from the end of the ramp to where the jumper lands.
Hint: Find the equation of the incline and set equal to ELF. It's easiest if the origin is set at the end of the ramp.
- Find her velocity components just before she lands.

15. A copy-cat daredevil tries to reenact Evel Knievel's 1974 attempt to jump the Snake River Canyon in a rocket powered motorcycle. The canyon is 400 m wide with the opposite rim of the canyon at the same height. The height of the launch ramp at one rim of the canyon is 8.00 m above the rim and the angle it makes at the end of the ramp is 45° with respect to the horizontal. Ignoring air resistance and wind (*not wise in a real attempt*):



- What is the minimum launch speed required for the daredevil to make it across the canyon?
- Famous after his successful first jump, but still recovering from the injuries sustained in the crash caused by a strong bounce upon landing, the daredevil decides to jump again but is going to add a landing ramp with a slope to match the angle of his velocity at landing. If he uses a landing ramp with a height of 3.00 m, what is the new launch speed required for a successful jump?

16. A bullet is fired horizontally from the top of a vertical cliff that is 20 m above the surface of a lake as shown in the figure at right. The top of the vertical face of a dam is located 100 m from the foot of the cliff, with the top of the dam level with the surface of the water in the lake. A level plain is 25.0 m below the top of the dam.



- What must be the minimum speed of the bullet as it leaves the cliff so that it will reach the plain below without striking the dam?
 - How far from the foot of the dam does the bullet hit the plain?
17. ** You have constructed a hair-spray powered potato gun and want to find the muzzle speed v_o of the potatoes as they leave the gun barrel. Using a launch tower that has several launching heights, you fire the potato gun horizontally with the same amount of hair-spray for each attempt. Your brave friend down below measures the distance the potatoes travel from the base of the tower after being launched from the various heights. The results of all your hard work is summarized in the following table:

Launch height (h) in m	Horizontal range (R) in m
2.00	10.4
6.00	17.1
9.00	21.3
12.00	25.8

Each of the values of h and R have some measurement error (*the muzzle speed is not always exactly the same and not always exactly horizontal when fired*). Ignoring air resistance and noting that there was no wind that day:

- Determine an expression for R^2 in terms of h **Hint: Use ELF!**
- Using the data above, graph R^2 vs h .
- Use the slope of the trendline from your graph in part (b) and your expression from part (a) to determine the value of v_o .