Prof. Anchordoqui

Problems set # 2 **Physics 168**

1. A Shelter Island ferryboat moves with constant velocity $v_0 = 8$ m/s for $T = 60$ s. It then shuts off its engines and coasts. Its coasting velocity is given by $v_x = v_0 T^2/t^2$. What is the displacement of the boat for the interval $0 < t < \infty$?

2. A pilot wishes to fly a plane due north relative to ground. The airspeed of the plane is 200 km/h and the wind is blowing from north to east at 90 km/h. *(i)* In which direction should the plane head? *(ii)* What is the ground speed of the plane.

3. A boat whose speed in still water is 1.70 m/s, must cross a 260-m-wide river and arrive at a point 110 m upstream from where it starts. To do so, the pilot must head the boat 45° upstream angle. What is the speed of the river's current? (See Fig. 1)

4. A delighted physics graduate throws her cap into the air with an initial velocity of 24.5 m/s at 36.9° above the horizontal. The cap is later caught by another student at the same height. Find (a) the total time the cap is in the air, and (b) the horizontal distance traveled.

5. The 2004 World Series represented the 100th time two modern Major League Baseball teams met to decide the championship, and began on October 23. After winning four consecutive games, on October 27 at 10:40 p.m. CT, the American League champion Boston Red Sox defeated the National League champion St. Louis Cardinals to claim the 2004 World Series Trophy. It had been 86 years since Boston last claimed the prize by defeating the Chicago Cubs in the 1918 World Series. With their Series sweep, Boston had finally broken the "Curse of the Bambino". To make the championship sweeter, it came on the heels of the largest comeback in postseason MLB history (a 0-3 deficit against the archrival New York Yankees in the AL Championship Series). The position of a thrown baseball by Pedro Martinez is given by

$$\vec{r} = [1.5 \text{ m} + (12\text{m/s})\, t]\hat{i} + [(16\text{m/s})t - (4.9\text{m/s}^2)\, t^2]\hat{j}$$

Find its velocity and acceleration as a function of time

6. A police officer chases a master jewel thief across city rooftops. They are both running when they come to a gap between buildings that is 4.00 m wide and has a drop of 3.00 m. The thief having studied a little of physics, leaps at 5.00 m/s at an angle of 45 degrees above the horizontal, and clears the gap easily. The police officer did not study physics and thinks he should maximize his horizontal velocity, so he leaps horizontally at 5.00 m/s. *(i)* Does the police clear the gap? *(ii)* By how much does the thief clear the gap?

7. Argentina rocked tournament hosts France with a sensational 17-12 victory in the opening match of the 2007 Rugby World Cup in Paris. The inspired Pumas outplayed an error-ridden and nervous-looking France and took control with a first-half try from full-back Ignacio Corleto. Centre Felipe Contepomi chipped in with 12 points to leave the 80,000-strong Stade de France crowd stunned. France could only muster four penalties from struggling fly-half David Skrela. At the kick-off the football went up at a 37° angle with a velocity of 20 m/s. Calculate: (a) the maximum height; (b) the time of travel before the football hits the ground; (c) how far away it hits the ground; (d) the velocity vector at the maximum height; (e) the acceleration vector at maximum height. Assume the ball leaves the foot at ground level, and ignore air resistance and rotation of the ball.

8. Romeo is chucking pebbles gently up to Juliet's window, and he wants the pebbles to hit the window with only horizontal component of velocity. He is standing at the edge of a rose garden 4.5 m below her window and 5 m from the base of the wall. How fast are the pebbles going when they hit the window? See Fig. 2.

9. A rescue plane wants to drop supplies to isolated mountain climbers on a rocky ridge 235 m below. If the plane is traveling horizontally with a speed of 250 km/h, how far in advance of the recipients (horizontal distance) must the goods be dropped? See Fig. 3.

10. Suppose, instead, that the plane releases the supplies a horizontal distance of 425 m in advance of the mountain climbers. What vertical velocity (up or down) should the supplies be given so that they arrive precisely at the climbers position? With what speed do the supplies land in the latter case? See Fig. 4.

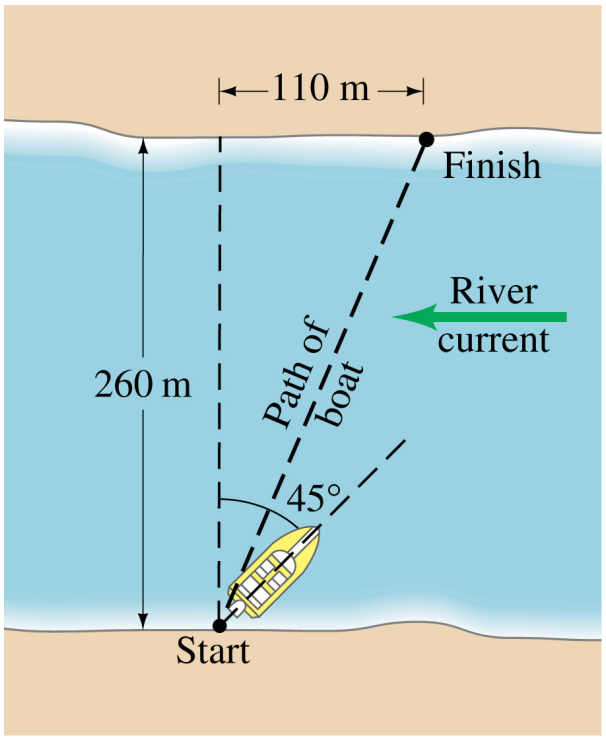
11. At $t = 0$ a batter hits a baseball with an initial speed of 32 m/s at a 55° angle to the horizontal. An outfielder is 85 m from the batter at $t = 0$, and as seen from home plate, the line of sight to the outfielder makes a horizontal angle of 22° with the plane in which the ball moves. What speed and direction must the fielder take in order to catch the ball at the same height from which it was struck? Give angle with respect to the outfielder's line of sight to home plate.

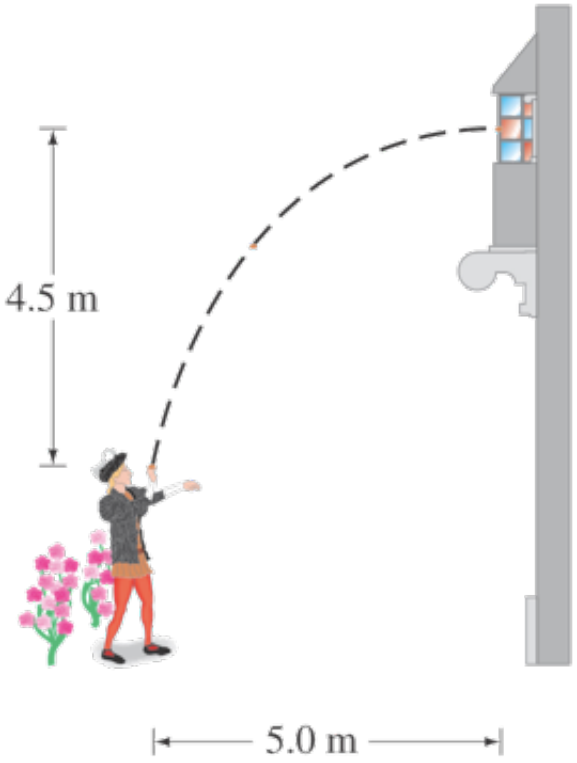
12. A projectile is shot from the edge of a cliff 125 m above ground level with an initial speed of 65.0 m/s at an angle of 37° with the horizontal. (a) Determine the time taken by the projectile to hit point P at ground level. (b) Determine the range X of the projectile as measured from the base of the cliff. At the instant just before the projectile hits point P, find (c) the horizontal and vertical components of its velocity (d) the magnitude of the velocity and (e) the angle made by the velocity vector with the horizontal. (f) Find the maximum height above the cliff top reached by the projectile. (See Fig. 5)

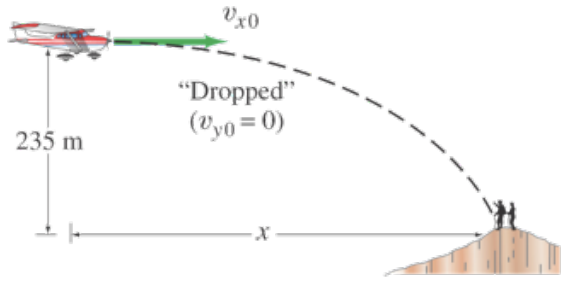
13. A skier is accelerating down a 30° hill at 1.80 m/s^2. What is the vertical component of her acceleration? How long will it take her to reach the bottom of the hill, assuming she starts from rest and accelerates uniformly, if the elevation change is 335 m. (See Fig. 6)

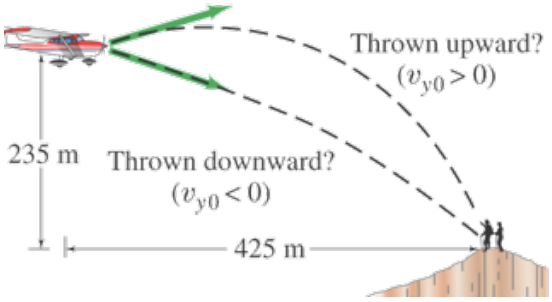
14. At serve, a tennis player aims to hit the ball horizontally. What minimum speed is required for the ball to clear the 0.90-m-high net about 15.0 m from the server if the ball is "launched" from a height of 2.50 m? Where will the ball land if it just clears the net (and will it be "good" in the sense that it lands within 7.0 m of the net). How long will it be in the air? (See Fig. 7)

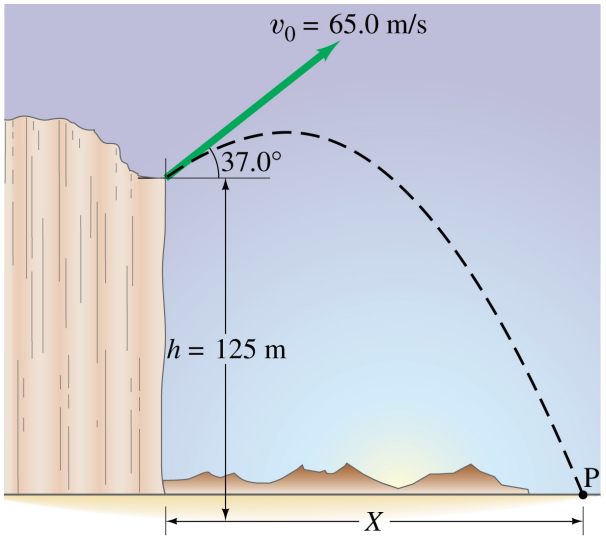
15. Catapults date from thousands of years ago, and were used historically to launch everything from stones to horses. During a battle on what is now Bavaria, inventive artillerymen from the united German clans launched giant spaetzle from their catapults towards a Roman fortification whose walls were 8.5 m high. The catapults launched the spaetzle projectiles from a height of 4.00 m above the ground and a distance of 38.0 m from the walls of the fortification at an angle of 60° above the horizontal. If the projectiles were to hit the top of the wall, splattering the Roman soldiers atop the wall with pulverized pasta (a) what launch speed was necessary? (b) How long where the spaetzle in the air? (c) At what speed did the projectiles hit the wall? Ignore any effects due to air resistance. See Fig. 8.

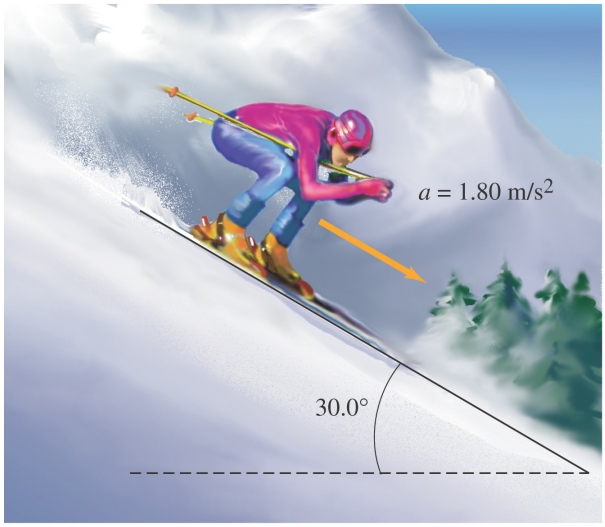

110 m
Finish
River
current
260 m
Path of
boat
45°
Start

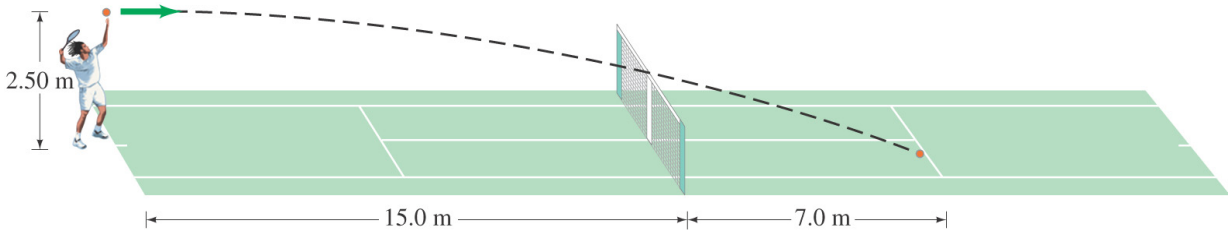

4.5 m
5.0 m


v_{x0}
"Dropped"
($v_{y0} = 0$)
235 m
x


Thrown upward?
($v_{y0} > 0$)
235 m
Thrown downward?
($v_{y0} < 0$)
425 m


v_0 = 65.0 m/s
37.0°
h = 125 m
P
X


a = 1.80 m/s²
30.0°


2.50 m
15.0 m
7.0 m