Unit 5: Advanced Physics Practice Projectile Problems (Preparation for the quizzes)

Type 1 (quiz 5-1)
Type 2 (quiz 5-2)
Type 3 (quiz 5-3)

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Preparation for Type 1 Quiz

1. A stone is thrown horizontally at a speed of 5.0 m/s from the top of a cliff 78.4 m high.
   a) How long does it take the stone to reach the bottom of the cliff?
   b) How far from the base of the cliff does the stone strike the ground?
   c) What are the horizontal and vertical components of the velocity of the stone as it hits the ground?
   d) What is the final velocity (magnitude and direction) of the stone as it hits the ground?
   [answers: a) 4 seconds; b) 20 m; c) v_{fx} = 5 m/s and v_{fy} = -39.2 m/s; d) v_f = 39.5 m/s at an angle of -82.7 degrees or 82.7 degrees below the horizontal]

2. How would the answers to a), b) and c) of question 1 change if

   a) the stone were thrown with twice the horizontal speed, or

   b) the stone were thrown with the same original speed but the cliff were twice as high?

Solution a:
a) The time of fall would not change since it is determined by the vertical motion only.
b) The stone would strike 40 m from the base of the cliff because the horizontal velocity has been doubled while the time of flight remains the same.
c) v_x would double since it is always equal to the initial horizontal velocity. v_y would not change since the vertical motion does not change.

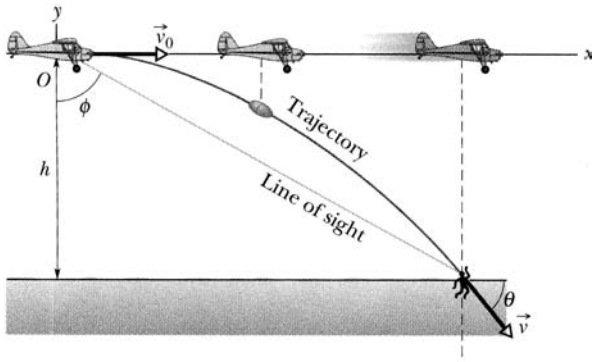
Solution b:
a) The time of fall would increase by the factor $\sqrt{2} = 1.41$ since this time varies directly with the square root of the cliff height.
b) The stone would strike $\sqrt{2}$ times as far from the cliff since $x = v_x t$ and t has increased by a factor of $\sqrt{2}$.
c) v_x would not change since it always equals the initial horizontal velocity. v_y increases by a factor of $\sqrt{2}$.

3. A steel ball rolls with constant velocity on a tabletop 0.950 m high. It rolls off and hits the ground +0.352 m from the edge of the table. How fast was the ball rolling? (answer = 0.8 m/s)

4. A beach ball, moving with a speed of +1.27 m/s, rolls off a pier and hits the water 0.75 m from the end of the pier. How high is the pier above the water? (answer = 1.7 m)

5. A rescue plane flies at 55 m/s at a constant elevation of 500 m towards a point directly over a boating accident victim struggling in the water. The pilot wants to release a rescue capsule so that it hits the water very close to the victim.

a) What should the angle, ϕ, of the pilot's line of sight to the victim when the release should be made?
b) Right before the capsule's impact, what is its velocity vector (magnitude and angle)



Answers: Angle = 48 degrees, velocity vector 113 m/s at angle of 61 degrees below horizontal.

Preparation for Type 2 Quiz

1. A golf ball is hit with a velocity of 24.5 m/s at 35.0 degrees above the horizontal. Find a) the range of the ball, and b) the maximum height of the ball. (answers: range = around 57 m and the maximum height = 10.1 m)

2. A player kicks a football from ground level at 27.0 m/s at an angle of 30.0 degrees above the horizontal. Find a) its “hang time” (time that the ball is in the air), b) the distance the ball travels before it hits the ground, and c) its maximum height. (answers = hang time = 2.75 or 2.76 seconds, distance = 64 or 65 m, and the height = 9.3 m)

3. On the Apollo 14 mission to the moon, astronaut Alan Shepard hit a golf ball. The acceleration due to gravity on the moon is 1/6 of its value on the earth. On earth, golf balls are driven at about 70 m/s with a loft angle of about 15 degrees and have a range of about 200 meters. Assuming a type 2 parabola, and given the same initial speed and loft angle as on the earth, what was (a) the time of flight for the golf ball and (b) how far did it travel horizontally on the moon? (22.2 sec; around 1500 m)

4. Here is another example from football. A football player punts the football so that it will have a hang-time (time of flight) of 4.5 seconds and lands 46 meters away from his initial position. If we assume a type 2 parabola for the football's trajectory, what is the magnitude and direction (angle) of the ball's initial velocity? (answers: 24 m/s at 65 degrees above the horizontal).

Preparation for Type 3 Quiz

1. In a fit of temporary insanity, a student throws his physics book off of the roof with a speed of 10 m/s at an angle of 30 degrees above the horizontal. The ball is thrown from a height of 11 m above the ground. Find the answers to the following questions.

   a. What is the ball's initial velocity in the x direction? (answer = 8.66 m/s)

   b. What is the ball's initial velocity in the y direction? (answer = 5 m/s)

   c. How long does it take (seconds) for the ball to reach the apex after it is launched? (answer = 0.51 s)

   d. What is the total time (seconds) of the ball's flight (launch to when it hits the floor)? (answer = 2.1 s)

   e. What is the maximum height (meters) the ball will get **above the roof**? (answer = 1.28 m)

   f. What is the ball's range (horizontal displacement, Δx) from the edge of the roof? (answer = 18 m)

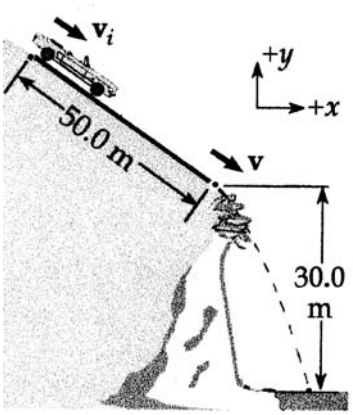
   g. What is the ball's final velocity (impact velocity) *in the y direction?* (answer = -15.6 m/s)

   h. What is the ball's final velocity (impact velocity) *in the x direction*? (answer = 8.66 m/s)

   i. Now, using the ideas from the previous two questions, what is the ball's impact velocity vector (magnitude and angle). Give the angle as reference from the horizontal. (17.8 m/s, 61 degrees below horizontal)

2. A tennis player hits a ball 2 m above the ground. The ball leaves his racquet with a speed of 10 m/s at an angle of 15 degrees above the horizontal. The horizontal distance to the net is 7 m and the net is 1 m high. Does the ball clear the net? If so, by how much? (answer: clears by around 0.3 m)

3. A car is parked on a cliff overlooking the ocean on an incline that makes an angle of 24 degrees below the horizontal. The negligent driver leaves the car in neutral and forgets to set the emergency brake. The car rolls from rest down the incline with a constant acceleration of 4 m/s/s for a distance of 50 m to the edge of the cliff. The cliff is 30 m above the ocean. Find (a) the length of time the car is in the air and (b) the car's horizontal position relative to the base of the cliff when the car lands in the ocean and (answers: a = 1.78 seconds and b = 32.5 m)



Resources used:
http://homepage.usask.ca/~dln136/projectile/pages/pm_homeage.html
Fundamentals of Physics (Halliday, Resnick, and Walker)
Physics for Scientists and Engineers (Randall Knight)
Student Solutions Manual and Study Guide for College Physics (Gordon, Teague, and Serway)