Physics 504
December 22, 2010

Name: key

Test: Projectile Motion

Each question is worth 4 marks.

Part A: Multiple Choice (2 marks each)

1) A golfer drives her golf ball from the tee down the fairway in a high arcing shot. When the ball is at the highest point of its flight:
   A) The velocity and acceleration are both zero.
   B) The horizontal velocity is zero and the vertical velocity is zero.
   C) The horizontal velocity is non-zero and the vertical velocity is zero.
   D) The velocity is non-zero and the acceleration is zero.

2) Which of the following does not exhibit projectile motion?
   A) a frog jumping from land into water
   B) a bullet fired from a gun
   C) a baseball thrown to home plate
   D) a train moving along a flat track

Part B: Extended Answers (4 marks each)

3) A soccer player kicks a ball with an initial speed of 15 m/s at an angle of 33° above the horizontal. **What is the maximum height reached by the ball?**

$v_x = 15\frac{m}{s}\cos 33^\circ = 12.58\,m/s$

$v_{iy} = 15\frac{m}{s}\sin 33^\circ = 8.17\frac{m}{s}$

Vert

$\Delta d_y = 0$

$v_{iy} = 8.17\frac{m}{s}$

$v_f = 0$

$a = -9.8\frac{m}{s^2}$

$v_f^2 = v_i^2 + 2a\Delta d$ ($v_f \to 0$)

$\Delta d_y = \frac{-v_i^2}{2a}$

$= \frac{-(8.17\frac{m}{s})^2}{2(-9.8\frac{m}{s^2})}$

$= 3.4\,m$

horizontal

4) A reindeer standing on the roof of a house 11 m high kicks a rock. The rock rolls off the roof and hits the ground 1.5 s later, 6.0 m away from the house. **What is the velocity of the rock just before it hits the ground?**

Hor

$\Delta t = 1.5\,s$

$\Delta d_x = 6.0\,m$

$V_x = \frac{6.0\,m}{1.5\,s} = 4\,\frac{m}{s}$

Vert

$\Delta t = 1.5\,s$

$V_{iy} = 0$

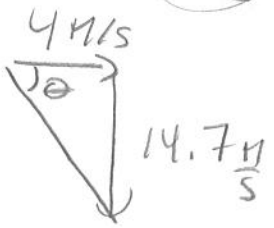
$V_f = ?$

$a = -9.8\,\frac{m}{s^2}$

$V_f = V_i + at$

$= (9.8\,\frac{m}{s})(1.5\,s)$

$= 14.7\,\frac{m}{s}$



$V_{mag} = \sqrt{4^2 + 14.7^2}$

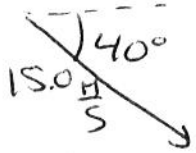
$= 15\,\frac{m}{s}$

$\theta = \tan\left(\frac{14.7}{4}\right)$

$= 75°$

Ans $15\,\frac{m}{s}, -75°$

5) From the edge of a roof where he is waiting for Santa, an elf throws a snowball at a snowman on the ground, 25.0 m from apartment building. The snowball leaves the elf's hand at a velocity of 15.0 m/s at an angle of 40.0 ° below the horizontal. The snowball hits the ground right at the snowman's feet. **How high is the roof of this apartment building?**



$V_x = 11.49\,\frac{m}{s}$

$V_{iy} = -9.64\,\frac{m}{s}$

Hor

$V_x = 11.49\,\frac{m}{s}$

$\Delta t = ?$

$\Delta d_x = 25\,m$

$\Delta t = \frac{25\,m}{11.49\,\frac{m}{s}} = 2.18\,s$

Vert

$\Delta d_y = ?$

$V_{iy} = -9.64\,\frac{m}{s}$

$a = -9.8\,\frac{m}{s^2}$

$\Delta t = 2.18\,s$

$\Delta d_y = V_i \Delta t + \frac{1}{2} a (\Delta t)^2$

$= (-9.64\,\frac{m}{s})(2.18\,s) + \frac{1}{2}(-9.8\,\frac{m}{s^2})(2.18\,s)^2$

$= -44.3\,m$

Ans: 44.3 m

6) Because it was overflowing, Santa's sled dropped a present while traveling 44.1 m above the ground. The present was found on the ground beneath, 87.0 m away from the point directly below where it was dropped. **How fast was Santa's sled going when it dropped the present?**

Hor

$\Delta d_x = 87.0\,m$

$\Delta t = ?$ (5)

$v_x = ?$ 3s

$v_x = \frac{87.0\,m}{3s}$

$= 29.0\,\frac{m}{s}$

Ans: $29.0\,\frac{m}{s}$

Vert

$\Delta d_y = -44.1\,m$

$a = -9.8\,\frac{m}{s^2}$

$v_{iy} = 0$

$\Delta t = ?$

$\Delta d_y = v_i \Delta t + \frac{1}{2} a (\Delta t)^2$ ($v_i = 0$)

$(\Delta t)^2 = \frac{2\Delta d_y}{a}$

$= \frac{2(-44.1\,m)}{-9.8\,\frac{m}{s^2}}$

$(\Delta t)^2 = 9\,s^2$ $\quad \Delta t = 3s$

7) While Ms. McRae wasn't looking, Ms. Broden threw a snowball at her. When the ball left Ms. Broden's hand, it was 1.22 m above the ground, and traveling at 8.00 m/s at an angle of 30.0 ° above the horizontal. On its way down, the snowball hit Ms. McRae in the head, 1.62 m above the ground. **How far from Ms. McRae was Ms. Broden standing when she threw the snowball?** $v_{iy} = 4.0\,m/s$ $\quad v_x = 6.93\,m/s$

Vert

$\Delta d_y = +0.4\,m$

$v_{iy} = 4.0\,m/s$

$a = -9.8\,\frac{m}{s^2}$

$\Delta t = ?$

$v_f =$

$v_f^2 = v_i^2 + 2a\Delta d$

$= (4.0\,\frac{m}{s})^2 + 2(-9.8\,\frac{m}{s^2})(0.4\,m)$

$= 8.16\,\frac{m^2}{s^2}$

$v_f = -2.86\,\frac{m}{s}$

$v_f = v_i + a\Delta t$

$\Delta t = \frac{v_f - v_i}{a}$

$= \frac{-2.86\,\frac{m}{s} - 4.0\,\frac{m}{s}}{-9.8\,\frac{m}{s^2}}$

$= 0.700\,s$

Hor

$\Delta d = v_x \Delta t$

$= (6.93\,\frac{m}{s})(0.7s)$

$\Delta d_x = 4.85\,m$

8) During a race, Kevin and Isabelle are both running at a constant speed of 3.0 m/s. Kevin is 20 m ahead of Isabelle. Seeing that the finish line is quickly approaching, Isabelle starts to accelerate at a rate of 1.0 m/s^2. Kevin and Isabelle cross the finish line at the same time.

When Isabelle started to accelerate, how far was she from the finish line?

Kevin

$v = 3.0\,m/s$

$\Delta d = x$

$\Delta t = y$

$\Delta d = v\Delta t$

$x = 3.0\frac{m}{s}y$

Isabella

$v_i = 3.0\,m/s$

$a = 1.0\,m/s^2$

$\Delta d = x + 20\,m$

$\Delta t = y$

$\Delta d = v_i\Delta t + \frac{1}{2}a(\Delta t)^2$

$x + 20\,m = 3.0\frac{m}{s}y + \frac{1}{2}(1.0\frac{m}{s^2})y^2$

① $3.0\frac{m}{s}y + 20\,m = 3.0\frac{m}{s}y + \frac{1}{2}(1.0\frac{m}{s^2})y^2$

$20\,m = \frac{1}{2}(1.0\frac{m}{s^2})y^2$

$40\,s^2 = y^2$

$6.32\,s = y$

② $x = 3.0\frac{m}{s}y$

$= 3.0\frac{m}{s}(6.32\,s)$

$= 18.96\,m$

③ Isabelle

$\Delta d = x + 20\,m$

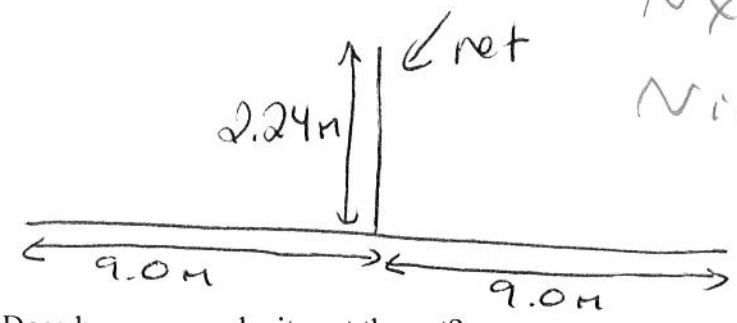
$= 18.96\,m + 20\,m$

$= 39\,m$

9) During a volleyball game, a player serves the ball. She hits the ball while standing 1.00 m behind the line. When the ball leaves her hand, it is 1.86 m above the ground and travels at a velocity of 12.0 m/s 28.0° above the horizontal. Consider the dimension of a volleyball court illustrated below.

$N_x = 10.59$

$N_{iy} = 5.63$



a) Does her serve make it past the net?

Hor

$\Delta d_x = 10m$

$N_x = 10.59 m/s$

$\Delta t = \frac{\Delta d_x}{N_x}$

$= \frac{10m}{10.59 m/s}$

$= 0.944 s$

Vert

$\Delta t = 0.944 s$

$N_{iy} = 5.63 \frac{m}{s}$

$\Delta d_y = N_{iy}\Delta t + \frac{1}{2} a(\Delta t)^2$

$= (5.63 \frac{m}{s})(0.944 s) + \frac{1}{2}(-9.8 \frac{m}{s^2})(\Delta t)^2$

$= 0.948$

$+ \quad 1.86$

$2.81 m \rightarrow$ yess!!

b) Does it land in or out?

Vert

$N_{iy} = 5.63 \frac{m}{s}$

$\Delta d = -1.86m$

$a = -9.8 \frac{m}{s^2}$

Δt?

$N_f^2 = N_i^2 + 2a\Delta d$

$N_f = -8.26 \frac{m}{s}$

$N_f = N_i + a\Delta t$

$\Delta t = \frac{N_f - N_i}{a}$

$= \frac{-8.26 - 5.63}{-9.8}$

$= 1.42 s$

Hor

$\Delta d_x = N_x \Delta t$

$= (10.59)(1.42)$

$= 15m$

$\rightarrow$ in!