PHYSICS 105

Assignment #3 Due by 10 pm September 29, 2009

NAME: __________________________________________

DISCUSSION SECTION: [ ] D7 – W 9 am [ ] D8 – W 10 am [ ] HS – W 10 am
[ ] D9 – W 11 am [ ] F1 – W 1 pm [ ] F2 – W 2 pm [ ] F3 – W 3 pm
[ ] F4 – W 4 pm [ ] F5 – W 7 pm [ ] D1 – F 9 am [ ] D2 – F 10 am
[ ] D3 – F 11 am [ ] D4 – F 12 pm [ ] D5 – F 1 pm (John) [ ] D6 – F 1 pm (Alex)

PLEASE CHECK OFF YOUR DISCUSSION SECTION ABOVE!

INSTRUCTIONS:

1. Please include appropriate units with all numerical answers.

2. Please show all steps in your solutions! If you need more space for calculations, use the back of the page preceding the question. For example, calculations for problem 3 should be done on the back of the page containing question 2. You must show correct work to receive full credit. Support your answers with brief written explanations and/or arguments based on equations.

3. Indicate clearly which part of your solution is the final answer.

4. Try answering these problems, as much as possible, without a calculator and using only the equation sheet to help you. This will help you prepare for the test.

5. Grading scheme for each problem: each part of each problem is worth 2 points. You get 0 if your answer is wrong or mostly wrong, 2 if your answer is correct, and 1 if your answer is mostly correct.

Please do your draft work of the assignment elsewhere, and copy your work over neatly when you hand in the assignment. The graders will deduct points for work that is difficult to follow.

<table>
<thead>
<tr>
<th>Angle (θ)</th>
<th>sin(θ)</th>
<th>cos(θ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30°</td>
<td>$\frac{1}{2}$</td>
<td>$\frac{\sqrt{3}}{2}$</td>
</tr>
<tr>
<td>45°</td>
<td>$\frac{\sqrt{2}}{2}$</td>
<td>$\frac{\sqrt{2}}{2}$</td>
</tr>
<tr>
<td>60°</td>
<td>$\frac{\sqrt{3}}{2}$</td>
<td>$\frac{1}{2}$</td>
</tr>
</tbody>
</table>

\[
tan\theta = \frac{\sin\theta}{\cos\theta}
\]
On their way to play soccer in the World Cup, Cindy and Mia get stranded in the Chicago airport because of bad weather. Late at night, with nobody else around, they decide to have a race to prove who is faster. They start at the same time, run at top speed a distance of \( L = 120 \) m through the airport terminal, and then turn around and run back to the starting point. Cindy runs at a constant speed of \( v \). Mia runs on a moving sidewalk that travels at a speed of 4.00 m/s; she runs at a constant speed of 8.00 m/s relative to the moving sidewalk. The race turns out to be a tie. For your analysis below, neglect the time it takes the women to turn around.

(a) How long does it take Mia to reach the turn-around point? How long does it take her to get from the turn-around point back to the start?

(b) What is Cindy’s constant speed \( v \)?

(c) Who is the faster runner?

[ ] Mia  [ ] Cindy  [ ] Neither, they’re equally fast

Briefly justify your answer:

(d) At what time in the race is the distance between the women the largest? What is the distance between them at this time?

(e) In addition to the start and end of the race, at what other location(s) is/are the women the same distance from the start/finish line at the same time? Express the location(s) in terms of the distance from the start/finish line.
PROBLEM 2 – 10 points

You are flying a small plane from Boston to Buffalo, which is located 660 km due west of Boston. Immediately after taking off, you point your plane due west, set the autopilot to cruise at a speed of 220 km/h relative to the air, and then you take a nap. You wake up later and, after checking your watch, you expect to be directly over your destination (you assumed there was no wind at all). Instead, you find yourself 240 km south and 480 km west of Boston, over Harrisburg, Pennsylvania instead.

(a) Sketch a diagram, showing the locations of Boston, Buffalo, and Harrisburg.

(b) How long after taking off did you wake up from your nap?

(c) Assuming the autopilot did exactly what you told it to do, what was the average velocity of the wind acting on your airplane during the flight? You can express this in terms of its components.

(d) When you realize that the wind has blown you off course, you immediately change direction so that you will reach Buffalo. Accounting for the wind, do you point your plane directly toward Buffalo, or not? Explain your answer.

(e) Assuming your speed is still 220 km/h with respect to the air, how long does it take for you to travel from Harrisburg to Buffalo? The wind is still blowing.
PROBLEM 3 – 10 points

In solving physics problems, it can be helpful to use a systematic approach. In this problem, we will work through an approach that you should be able to use for all projectile-motion problems.

Working as an accident reconstruction expert, you find that a car that was driven off a horizontal road over the edge of a 15-m-high cliff traveled 45 m horizontally before impact. Use $g = 10 \text{ m/s}^2$.

(a) Sketch a diagram of this situation from where the car is off the road to where it hits the bottom of the cliff. On your diagram, show the origin, and the coordinate system (show the directions you are taking for positive $x$ and positive $y$).

(b) Fill in the table, to help you stay organized. This also reminds you to keep the $x$ information separate from the $y$ information when you use the equations.

<table>
<thead>
<tr>
<th></th>
<th>$x$-direction</th>
<th>$y$-direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>displacement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>initial velocity</td>
<td></td>
<td>We’ll find this is (d)</td>
</tr>
<tr>
<td>acceleration</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Use the information in the table to help answer the questions below.

(c) How long after leaving the road did the impact at the bottom of the cliff occur?

(d) At what speed was the car moving when it left the road? Express the speed in m/s and km/h.

(e) At what speed was the car moving just before impact?
PROBLEM 4 – 10 points

The motion diagram shows a ball’s position at intervals of exactly 1.00 seconds as the ball flies from left to right through the air, after being launched from the origin at \( t = 0 \). Only gravity acts on the ball throughout the motion.

Use \( g = 10 \text{ m/s}^2 \).

(a) Calculate the \( y \)-component of the ball’s initial velocity.

(b) Calculate the maximum height reached by the ball.

(c) Calculate the \( x \)-component of the ball’s initial velocity.

(d) On the graph above, sketch the motion diagram for a second ball that has the same starting point, half the initial vertical velocity, and three times the horizontal velocity, of the original ball. By “sketch a motion diagram,” we mean “show the position of this ball at 1.00-second intervals”.

(e) Calculate the maximum height reached by the second ball.
PROBLEM 5 – 8 points

Three students are trying to solve a problem that involves a ball being launched, at a 30° angle above the horizontal, from the top of a cliff, and landing on the flat ground some distance below. The students know the launch speed, the acceleration due to gravity, and the height of the cliff. They are looking for the time the ball spends in the air. A snippet of their conversation is recorded below.

Avi: I think we have to do the problem in two steps. First, we find the point where the ball reaches its maximum height, and then we go from that point down to the ground.

T.J.: I think we can do it all in one step. The equations can handle it, just going all the way from the initial point to the ground.

Kristin: I think we need two steps, too, but I would do it differently than Avi. What if we first find the point where the ball comes down to the same height from where it was launched, and then we go from that point down to the ground?

(a) Can you do the problem in two steps, like Avi and Kristin suggest? If so, comment on which approach, Avi or Kristin’s, you prefer.

(b) Can you do the problem all in one step, like T.J. says? If so, is this preferred or not compared to a two-step method?

(c) If T.J. is correct, can you identify a single equation that can take all the known quantities, and that you can solve for the time? If so, what equation would you use?

(d) Using a cliff height of 20 m, a launch speed of 8.0 m/s, and \( g = 10 \text{ m/s}^2 \), solve for the time of flight.