PHYS 2210 Fall 2011 Homework Set 2 Due at 4 PM on **Sept 1, 2011**

Show and explain all of your work! Correct answers for which we cannot follow your work are worth no credit.

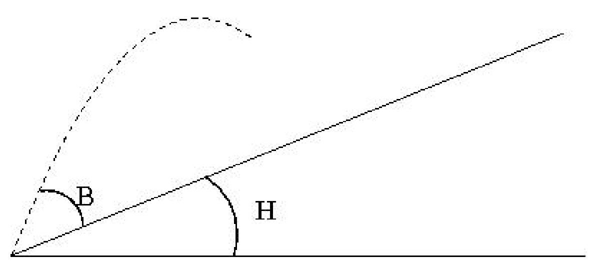
1. Point P sits on the rim of wheel of radius ρ that is rolling on the ground in the positive x direction. Its position vector can be described by the sum of a vector v_1 for circular motion about the center of the wheel plus a vector v_2 that describes the horizontal motion of the center of the wheel along the line $y = \rho$ at constant velocity. In other words, its position at time t is given by

$$\vec{r} = \vec{v_1} + \vec{v_2} = (\rho \sin(\omega t)\hat{x} + \rho \cos(\omega t)\hat{y}) + (\rho\omega t\hat{x} + \rho\hat{y})$$

   a) (1 point) Find an expression for the velocity of Point P.

   b) (1 point) Are there any times when the velocity is 0? Where is Point P on the wheel at these times (on the top, on the front edge, etc)? Does this make sense?

2. A slingshot launches an angry bird[1] up in the air with a speed v_o at an angle of B (with respect to the ramp) up a hill of with an incline of H above the horizontal.



   a) (1 point) Show that distance *along the hill* where the bird lands can be expressed as $\dfrac{2v_0^2 \sin(B)\cos(B+H)}{g\cos^2(H)}$. (Hint: use tilted coordinates where one axis is along the slope of the hill, and some angle addition identities might be helpful here.)

   b) (1 point) For a given H, at what angle should the bird be launched to achieve the maximum distance?

   c) (1 point) Show that the expression for the maximum distance is $d_{max} = \frac{v_o^2}{g(1+sin(H))}$

   d) (1 point) For $H = 20°$, use *Mathematica* to make a plot of the expression you obtained in part a from B=0 to 90°. Attach the plot to this assignment, and verify that the maximum distance value occurs at the angle given by your answer to part b.

3. (2 points) Taylor Problem 1.48. Note that the problem is asking you to express $\hat{\rho}$, $\hat{\phi}$, and $\hat{z}$ in terms of their $\hat{x}$, $\hat{y}$, and $\hat{z}$ components, but these expressions may include the coordinates ρ, ϕ and z.

[1] Apparently the bird is so upset over some stolen eggs that it can't fly.

4. A honeybee exits its hive and flies in spiral path. Its position $\mathbf{r}$ at time t is given in polar coordinates by

$$r = be^{kt} \qquad \qquad \phi = ct$$

where b, c, and k are constants.

   a) (1 point) Use the expressions that we found for $\dot{\mathbf{r}}$ and $\ddot{\mathbf{r}}$ in polar coordinates to find the velocity and acceleration vectors for the bee. Are the velocity and acceleration vectors orthogonal to each other?

   b) (1 point) Show that the angle between the velocity and acceleration vector remains constant as the bee moves away.