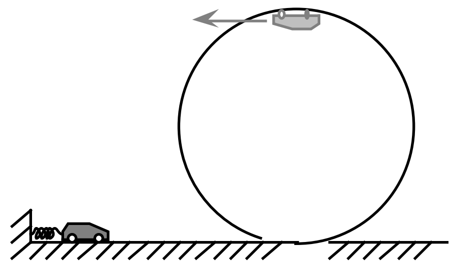
# Second Midterm Exam



Name ___________________________________________

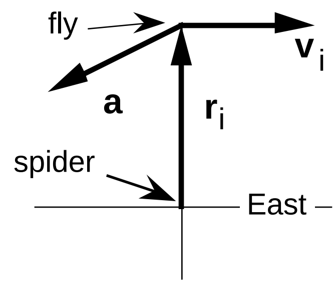
PLEASE READ THIS FIRST: Work the problems on separate sheets of paper and staple this sheet to the front. Read each problem carefully. Show your work and/or give explanations for *all* answers. Make sure that all numerical answers are given with a reasonable number of sig figs and that you have included appropriate units. Check your answers for physical *reasonableness* whenever possible. I do give partial credit, but *only* if I can follow your work, so try to be clear about what you are doing.

1. A child launches an 80 gram toy car along a frictionless track using a spring with force constant $3 \times 10^3$ N/m that she had first compressed by 2.0 cm. After being launched, the car travels around a circular loop-the-loop of radius 25 cm as shown at right.



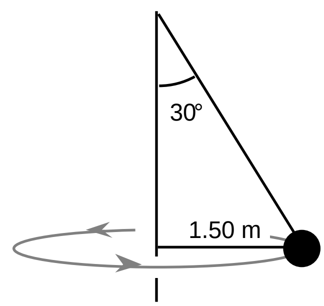
   a) [15 pts] What is the speed of the car when it is at the top of the loop-the-loop as shown? (No friction, so energy is conserved!)
   b) [10 pts] What force does the track exert on the car at the top of the loop? (Just apply Newton's Second Law to the car.)
   c) [**extra credit**, 5 pts] What minimum initial compression of the spring would be required for the car to make it all the way around the loop without losing contact with the track?

2. As shown at right, a fly starts out (at t = 0) at a position $\mathbf{r}_i$ = 4.0 m, north relative to a spider (who defines the "origin"), and flying with an initial velocity $\mathbf{v}_i$ = 3 m/s, east. It has a constant acceleration
   $\mathbf{a}$ = 2.0 m/s$^2$, 30° south of west.



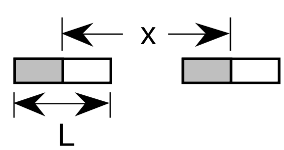

   a) [5 pts] At t = 0, is the fly's speed *increasing* or *decreasing*?
   b) [20 pts] Since $\mathbf{a}$ is constant, the fly's position at any later time is given by the vector sum $\mathbf{r}_f = \mathbf{r}_i + \mathbf{v}_i t + (1/2)\mathbf{a}t^2$. Find the fly's position at t = 4.0 s by performing this vector sum.
   c) [**extra credit**, 5 pts] What is the angle between $\mathbf{a}$ and $\mathbf{v}$ at t = 4.0 s?

3. A ball moves in a horizontal circle around a vertical pole to which it is attached by two strings as shown at right. The ball moves at *just* the right speed to make the tension *the same* in both strings.




   a) [20 pts] What *is* the ball's speed? (Just apply Newton's Second Law to the ball and see what the resulting equations tell you!)
   b) [5 pts] Would the tension in the longer string increase, decrease, or remain the same if the ball moved faster?

4. Two identical bar magnets of length L held as shown at right exert an *attractive* force on each other with a magnitude given approximately by $F = \beta/x^3$ where x is the center-to-center distance.




   a) [5 pts] What are the dimensions of β (in terms of M, L, and T as always)?
   b) [20 pts] If the two magnets start out in contact (*i.e.*, $x_i = L$), how *much* work must you do to *separate* them by twice their length, (*i.e.*, $x_f = 3L$). Express your answer *in terms of* β and L.
   c) [**extra credit**, 5 pts] How much *more* work would you have to do to separate them "to infinity."



Score __________/100