Name:

Physics 161  
Exam #1  
6/15/2001  
Summer I ’01  
Jeff Simpson

There are 4 questions worth 20 points each with point breakdowns listed in square brackets. **Show ALL your work. If you need more workspace, use the back of the same page and write a note indicating this.**

1. **A few questions**

(a) [6 pts] Give an order of magnitude estimate for the number of blades of grass in the lawn of an average east coast suburban home. Be sure to state all assumptions.

(b) [6 pts] A student knows that the force of air resistance $F_{\text{drag}}$ on an object is given by $F_{\text{drag}} = \frac{1}{2} D \rho A v^n$ where $D$ is the dimensionless drag coefficient, $\rho$ is the air density, $A$ is the cross-sectional area of the object, and $v$ is the speed of the object raised to some power $n$ which the student does not remember. Write down the dimensions of each of the quantities, $F, \rho, A,$ and $v$. Use dimensional analysis to help the student find the power $n$.

(c) [8 pts] A particle of mass $m$ moves in the $xy$ plane with a time dependent velocity given by $\mathbf{v}(t) = (5t \mathbf{i} + 10t^2 \mathbf{j})$ m/s. Find the position $\mathbf{r}$, the acceleration $\mathbf{a}$, and the net force $\mathbf{F}_{\text{net}}$ of the particle as a function of time.
2. A stone is projected with an initial velocity of 35 m/s directed at an angle $60^\circ$ above the horizontal, at a cliff of height $h$ as shown. The stone strikes the ground at point A 5.5 s later.

(a) [7 pts] Find the height $h$ of the cliff.

(b) [7 pts] Write the velocity and acceleration, in vector form, for the stone just before impact at A.

(c) [6 pts] Find the maximum height $H$ above the ground which the stone reaches. What are the velocity and acceleration, in vector form, at this point?
3. Consider the motion of a cart on a frictionless airtrack inclined at an angle $\theta = 30^\circ$ above the horizontal. The cart is given an initial velocity directed along the track, $v_i = 4.0 \text{ m/s}$, then travels up the track, and finally returns to the starting point. Be sure to label your coordinate(s).

![Cart on Inclined Track]

(a) [2 pts] What is the cart’s acceleration along the track as a function of time?

(b) [6 pts] Find the maximum displacement of the cart. At this point, how far has the cart traveled in the vertical direction?

(c) [2 pts] What is the velocity of the cart when it returns to the starting point?

(d) [10 pts] Sketch a separate graph for the position, velocity, and acceleration of the cart as a function of time. Be sure to appropriately label the axes of each graph ($x$, $v$, or $a$ as a function of time $t$) and label the point of maximum displacement on each graph.
4. A ball tied to the end of a 1.0 m long string is rotated counter-clockwise in a horizontal plane. The angle $\theta$ is defined counter-clockwise from the $x$-axis.

I. [5 pts] First consider the ball moving with a constant speed of 5.0 m/s. 
(a) Sketch the velocity vector using a single arrow and the acceleration vector using a double arrow at four points on the circle: $\theta = 0^\circ$, $90^\circ$, $270^\circ$, and $360^\circ$.

(b) [4 pts] What is the magnitude of the centripetal acceleration? Write the centripetal acceleration in vector component form when the ball is at $\theta = 120^\circ$.

(c) [2 pts] How long does it take the ball to make one revolution?

II. [5 pts] Next consider the ball moving with an increasing speed. 
(a) Again sketch the velocity vector and acceleration vector at the four points listed in part Ia above.

(b) [4 pts] If the speed of the ball is 1.73 m/s at $\theta = 0^\circ$ and the tangential acceleration is 4.0 m/s$^2$ $\mathbf{j}$, what is the magnitude and direction of the total acceleration?