You will need the XL file "APhys-NumInteg Data.xls" that accompanies this document.

1. TOYOTA ACCELERATION DATA

Given the data on the worksheet "Toyota Acceleration Data," determine the velocity and position of the car (as determined by "numeric integration": ($\Delta v = \Sigma a_{ave}\Delta t$ and $\Delta s = \Sigma v_{ave}\Delta t$) as a function of "elapsed" time ($t_0 = 0$).

a. Plot the acceleration and velocity as a function of elapsed time. Use a "secondary axis" to expand the acceleration data. Discuss your observations of these plots. Graphically estimate the maximum velocity of the car.

b. Assuming that the car has a mass of 3000 kg, determine the net force on the car as a function of time and, by numeric integration, find the work done by the net force ($\Sigma F_{ave}\Delta x = W = \Delta KE$) as a function of position. Plot the net force and ΔKE as a function of position. (Use a "secondary axis" to expand the net force data).

c. Compare the two plots. Note any similarities and differences. During what portion of the acceleration does the greatest speed increase occur? During what portion of the acceleration does the greatest KE increase occur? Explain why these regions are different.

2. LAMINAR VISCOUS FRICTION

Laminar viscous friction is the resistive force that can act on an object as it falls through a viscous fluid. This force is proportional to the object's instantaneous velocity ($F(v) = -bv$, where b is a constant with units of N·sec/m). For an object that is released into a viscous fluid so that is falls under the influence of gravity and viscosity, the net force felt by the object is $F_{net} = mg-bv$. Given the data on the worksheet "Laminar Viscous Ff—a vs t data"

a. Determine the velocity and position of the object as a function of time. Plot a, v and s vs. t. Describe the motion of the object as it falls through this fluid.

b. Graphically estimate when the object achieves its maximum speed ("terminal velocity") and using the =AVERAGE() function, determine its value. Use this value to determine the value for the viscosity constant, b.

c. The mathematical relationship for v(t) of an object falling through a fluid under the influence of both gravity and laminar viscous friction is $v(t) = \frac{mg}{b}\left(1 - ke^{-\frac{b}{m}t}\right)$ where $k = (1 - \frac{bv_0}{mg})$. Plot this relationship and compare the results to the experimental results. (Use your graphically estimated value of b and a mass of 2 kg).

d. Given the net force relationship for the object, derive the acceleration of the object as a function of velocity. Use the v(t) model used in (c) to find the acceleration of the object as a function of time. Plot these values and compare this model to the given acceleration data.