PHYS 321 Homework Assignment
Due: Friday, 13 September 2002

1. A monkey is hanging from a tree limb at height \( h \) above the ground. A hunter 50 yards away from the base of the tree sees him, raises his gun and fires. Just as he pulls the trigger, the monkey (who, when he saw the hunter, said “Oh, oh. Trouble!”) lets go of the branch and drops, hoping to make the hunter miss. But the hunter has anticipated the monkey’s evasive maneuver, and has aimed accordingly. Where did the hunter aim, in order to hit the falling monkey?

2. A damped, driven harmonic oscillator satisfies the differential equation

\[
\ddot{x} + 2\gamma \dot{x} + \Omega^2 x = f(t).
\]

If the driving force is periodic,

\[
f(t) = f(t + 2\pi/\omega),
\]

and has the sawtooth form

\[
f(t) = \begin{cases} 
-1 + \frac{2\omega}{\pi}, & 0 < t < \pi/\omega \\
3 - \frac{2\omega t}{\pi}, & \pi/\omega < t < 2\pi/\omega
\end{cases}
\]

find the solution \( x(t) \) for times sufficiently far in the future that the system has “forgotten” its initial conditions. Use the operator method and the method of superposition suggested in B&O, Problem 1-26.

3. An open coal car is coasting along the track and passes under a coal chute, from which a steady stream of coal falls vertically into the car. If the car has length \( L \), mass \( M \), and initial speed \( v \), and if the rate at which the coal is falling is \( m \), what is the speed of the car when it has gone past the hopper?

4. How much energy must be given to a space probe of mass \( m \), initially in a low parking orbit about the Moon, to put it into an orbit that will escape from the Moon’s gravitational well?

5. Communications satellites are commonly placed in geosynchronous orbits (that is, they orbit above the Equator, with an orbital period that
just matches the Earth’s rotational period so they always remain above one point on the Earth’s surface).

A space shuttle is launched to service a geosynchronous satellite. It first attains a circular, low-earth parking orbit, then must accelerate to match the satellite’s orbit. What is the minimum number of times the pilot must turn on the rocket engines, to perform this matching maneuver? How much change of velocity, and in what direction, is needed at each maneuver? (Assume each application of thrust is essentially instantaneous.)