PHYS 3344
Fall 2019
TE Coan
Due: 6 Sep '19 6:00 pm

Homework 1

1. This problem is originally from the remote, misty past (PHYS 1303). During a ferocious blizzard, a rancher is forced to drop hay bales from an airplane to feed her cattle. She flies her plane horizontally at a speed $v = 160\,\text{km/hr}$ and drops the bales a height $H = 80\,\text{m}$ above the flat range. Ignore air friction for both questions below.

a) She wants the bales to land $s = 30\,\text{m}$ behind the cattle so as not to hit them. Where should she push the bales out of the airplane with respect to the edge of the cattle crowd? A figure may help. **Box** your numerical answer.

b) To not hit the longhorns, what is the longest time error Δt she could make while pushing the bales out of the plane? (I have no idea how she simultaneously flies the plane and pushes out the bales.) **Box** your answer.

2. This problem is less hard than it may look at first glance and can be solved with PHYS 1303 knowledge. A baseball is launched by an air cannon with a velocity $\mathbf{v_0}$ such that it passes through two points both a distance h above the horizontal. Show that if the gun is adjusted for maximum range (ignore air friction), the separation d of the two points is

$$d = \frac{v_0}{g}\sqrt{v_0^2 - 4gh}.$$

Hint: Think about the shape of the curve the baseball follows. **Do Not** start with answer and then work backwards to "derive" some trivial answer. **Box** the final answer for d.

3. Here is another review problem that can be solved with PHYS 1303 techniques (although Taylor chapter 2 material may help). Consider the motion of a particle of mass m that starts from rest in a constant gravitational field. If a resisting force force proportional to the square of the speed (i.e., kmv^2) is encountered, show that the distance s the particle falls in accelerating from speed v_0 to speed v_f is given by:

$$s(v_0 \to v_f) = \frac{1}{2k}\ln\left[\frac{g - kv_0^2}{g - kv_f^2}\right].$$

You may find the chain rule useful: $d^2x/dt^2 = dv/dt = dv/dx\ dx/dt = v\,dv/dx$.

4. A homogeneous rope of total length L and total mass M_T is placed on a very smooth table so that a distance x_0 of the rope is initially hanging vertically off the table. The rope is released and gravity pulls the rope off the table so that it falls straight down. As a function of time t, what length $x(t)$ of the rope hangs off the table? The figure may help.