Newtonian Mechanics—Single Particle

PHYS 301: Analytical Mechanics

T. Brian Bunton, 08/22/19

Problem 1

You're driving and you approach a green traffic light with speed v_0 when the light turns yellow.

a) If your reaction time is τ, during which you make the decision to stop and apply your foot to the brake, and if your maximum braking acceleration is a, what is the minimum distance s_{min} from the intersection at the moment the light turns yellow in which you can bring your car to a stop?

b) If the yellow light remains on for a time t before turning red, what is the maximum distance s_{max} from the intersection at the moment the light turns yellow such that you can continue into the intersection at speed v_0 without running the red light?

c) Show that if your initial speed v_0 is greater than $v_{0,\text{max}} = 2\,a(t-\tau)$, there will be a range of distances from the intersection such that you can neither stop in time nor continue through without running the red light.

d) Make some reasonable estimates of τ, t, and a, and calculate $v_{0,\text{max}}$ in miles per hour. If $v_0 = \frac{2}{3}\,v_{0,\text{max}}$, calculate s_{min} and s_{max}. Use these estimates to plot graphs (in *Mathematica* or some other computer program) of s_{min} and s_{max} versus v_0 on the same set of axes.

Problem 2

A boat is slowed by a frictional force $F(v)$. Its velocity decreases according to the formula $v(t) = k\sqrt{t - t_s}$, where k is a constant and t_s is the time at which the boat stops. Find the force $F(v)$.

Problem 3

A boat with an initial velocity v_0 is slowed by a frictional force $F = -b\,e^{\alpha v}$. Find its motion, and the time and the distance required to stop.

Problem 4

Two blocks of unequal mass are connected by a string over a smooth pulley at the top of an incline. The hanging block is twice the mass of the block sitting on the incline. If the coefficient of kinetic friction is

μ_k, what angles θ of the incline allow the masses to move at a constant speed?