University of Massachusetts at Dartmouth Physics 313, Fall 2026
Mechanics
Homework 0, Due 9/11/2025 in class
Reading : Taylor Ch. 1, 5

1. Projectile Motion

   (a) Consider a projectile motion near the surface of the Earth, as shown in figure 1. Show that two times elapsed between points at the same elevation, t_A and t_B, as indicated on the figure are related by

$$t_A^2 - t_B^2 = \frac{8h}{g} \tag{1}$$

   where h is the height between the two elevations.

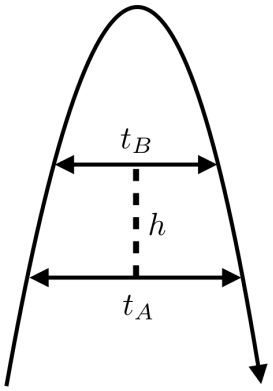

Figure 1: Projectile motion diagram for problem 2.

   (b) Show that this formula reduces to the standard time-of-flight result

$$t = \frac{2v_{yo}}{g} \tag{2}$$

   where v_{yo} is the initial velocity in the y-direction, when $t_B = 0$.

2. Find the velocity $\dot{x}$ and the position x as functions of the time t for a particle of mass m, which starts from rest at $x = 0$ and $t = 0$, subject to the following force functions :

   (a) $F_x = F_0 + ct$

   (b) $F_x = F_0 \sin(ct)$

   (c) $F_x = F_0 \exp(ct)$, where F_0 and c are positive constants.

3. Find the potential energy function $V(x)$ for each of the following force functions :

(a) $F_x = F_0 + cx$

(b) $F_x = F_0 \exp(-cx)$

(c) $F_x = F_0 \cos(cx)$, where F_0 and c are positive constants.

4. Find the velocity $\dot{x}$ as a function of the displacement x for a particle of mass m, which starts from rest at $x = 0$, subject to the force functions given in the previous problem.

5. (a) Show that the kinetic energy K of a particle with constant mass m moving at velocity v in 1D under the influence of a force F satisfies the equation

$$\frac{dK}{dt} = Fv \tag{3}$$

(b) Now, consider the same situation as part a, except for a particle whose mass m is not constant. Show that the kinetic energy K satisfies

$$\frac{d(mK)}{dt} = Fp \tag{4}$$

Note that in the special case when m is constant, the result of part b reduces to that of part a.