

PHYS 3201 — Assignment #3

Due: 9/11/20

1. A metal block of mass m slides on a horizontal surface that has been lubricated with a heavy oil so that the block suffers a viscous resistance that varies as the $\frac{3}{2}$ power of the speed:

$$F(v) = -cv^{3/2}$$

If the initial speed of the block is v_0 at $x = 0$, show that the block cannot travel further than $2mv_0^{1/2}/c$.

2. A particle of mass m is released from rest a distance b from a fixed origin of force that attracts the particle according to the inverse square law:

$$F(x) = -kx^{-2}$$

Show that the time required for the particle to reach the origin is

$$\pi \left(\frac{mb^3}{8k} \right)^{1/2}$$

(Hint: A trigonometric substitution may help with the last integral.)

3. The force acting on a particle of mass m is given by

$$F = kvx$$

in which k is a positive constant. The particle passes through the origin with speed v_0 at time $t = 0$. Find x as a function of t .

4. A particle of mass m moves under a conservative force with potential energy function given by

$$V(x) = \begin{cases} \frac{1}{2}k(a^2 - x^2) & \text{for } |x| < a, \\ 0 & \text{for } |x| \geq a, \end{cases}$$

where a and k are constants, and $a > 0$. What is the force on the particle? Sketch the function V , for both cases $k > 0$ and $k < 0$, and describe the possible types of motion.

5. A boat with initial speed v_0 is launched on a lake. The boat is slowed by the water by a force $F = -\alpha e^{\beta v}$. (a) Find an expression for the speed $v(t)$. (b) Find the time and (c) distance for the boat to stop. (Hint: For part (c) the integral $\int \ln(ax + b)dx = ((ax + b)/a) \ln(ax + b) - x$ will be helpful.)