

# Assignment No. 2

Physics 2P20

Due February 8, 2019

1. *EFTS*: Ex.5, the two-pulley system (K&K2 Pr. 2.8). Complete the solution started in class to show that

$$\ddot{x}_m = \frac{2M - m}{4M + m} g.$$

2. A particle of mass  $m$  moves along a frictionless, horizontal plane with a speed given by  $v(x) = \alpha/x$ , where  $x$  is its distance from the origin and  $\alpha$  is a positive constant. Find the force  $F(x)$  to which the particle is subject.
3. A gun is fired straight up. Assuming that the air drag on the bullet varies quadratically with speed, show that the speed varies with the height according to the equations

$$\begin{aligned} v^2 &= Ae^{-2kx} - \frac{g}{k} && \text{(upward motion)} \\ v^2 &= \frac{g}{k} - Be^{2kx} && \text{(downward motion)} \end{aligned}$$

in which  $A$  and  $B$  are constants of integration,  $g$  is the acceleration of gravity, and  $k = c_2/m$  where  $c_2$  is the drag constant and  $m$  is the mass of the bullet. (*Note*:  $x$  is measured positive upward, and the gravitational force is assumed to be constant.)

4. 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  $t$ .

5. (a) A particle travels along a straight line with constant acceleration  $1 \text{ ms}^{-2}$  for 1 s, and then with acceleration of  $-1 \text{ ms}^{-2}$  for 1 s. Assuming zero initial velocity, use **physica** to plot  $a(t)$ ,  $v(t)$ , and  $x(t) - x(0)$ .

*Hint*: Generate a time vector **t**, then use **physica**'s ability to include conditional operations in algebraic expressions to get **a**:

```
PHYSICA:generate t 0,,2 1000
PHYSICA:a=1.0*(t<1.0) + (-1.0)*(t>=1.0)
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Use numerical integration and differentiation (use the help facility to find out about the **analysis\_functions** **integral()** and **deriv()**) to get  $v(t)$ , and  $x(t) - x(0)$ .

- (b) What is the maximum velocity reached during the motion, and when did the particle have its maximal velocity? What is the total distance travelled?
- (c) Separately, plot  $v$  as a function of  $x$ . What kind of a function is represented by this plot? Try to guess at the functional form, then confirm your guess algebraically.