DLI Physics **Mechanics Problem Set 1** **Applied Derivatives in Mechanics**

Name_____ **Date**_____

1. A honeycrisp apple moves in a straight line with its position, x, given by the following equation:
$x(t) = t^4 - 4t^3 + 2t^2 + 3t + 6$
   a. Find its position after 1 second.
   b. Find its velocity after 2 seconds.
   c. Find its acceleration after 3 seconds.
   d. What is the rate of change of the acceleration at 1 second.
   e. Use Python to graph the position, velocity and acceleration as functions of time from t=0 to t=4 seconds.
   f. Use Python to graph the rate of change of acceleration vs. time.

a. $1^4 - 4 \cdot 1^3 + 2 \cdot 1^2 + 3 \cdot 1 + 6 = 1 - 4 + 2 + 3 + 6 = 8\text{m}$

b. $\frac{dx}{dt}$ $4t^3 - 12t^2 + 4t + 3$.

$32 - 48 + 8 + 3 = -5\ \text{m/s}$

c. $12t^2 - 24t + 4$

$108 - 72 + 4 = 40\ \text{m/s}^2$

d. $24t - 24 \neq 0$

e.

3. Oompa-Loompas are pulling a 2 kg crate of golden eggs along a rough, but level, surface. In one case it is determined that the position of the block as a function of time is given by : $x(t) = .3t^3 - .1t^2 + .2t$.

a. Find the speed of the block at $t = 2$ sec.
b. Find an expression for acceleration as a function of time.
c. Find an expression for force as a function of time. ($\bar{a} = \frac{\bar{F}}{m}$)
d. Find the initial kinetic energy of the block ($KE = \frac{1}{2}mv^2$)
e. Find the change in kinetic energy of the block from $t = 0$ to $t = 2$ sec.
f. Another lab group determines that the Oompa-Loompa force as a function of distance is given by:

$F(x) = x^2 + 2x - 2$ ~~and the block is pulled at an angle of 15° to the horizontal.~~

Find the change in kinetic energy from $x = 0$ to $x = 2$ meters.

g. For the above group find a differential equation for power (Power = the time rate of change of kinetic energy).

a. $.3(2)^3 - .1(2)^2 + .2(2) = 2.4 - 0.4 + 0.4$

$3.6 - 0.4 + 0.2 = 3.4\ m/s$

b. $a(t) = 1.8t - 0.2$

c. $\frac{F}{m} = 1.8t - 0.2$

$F = (1.8 - 0.2)m$

d. $KE = \frac{1}{2}mv^2$

$= \frac{1}{2} \cdot 2 \cdot (0.2\ m/s)^2 = 0.04J$

e. $KE^{(2)} = \frac{1}{2} \cdot 2kg \cdot (3.4\ m/s)^2 = 11.56\ kJg$

$\Delta KE = 11.52J$

f. ~~$F(x) = x^2 + 2x - 2$~~ $\frac{x^3}{3} + \frac{2x^2}{2} + 2x$

~~$2x^2 + 2x - 6$~~ $\frac{8}{3} + \frac{8}{2} + 4 =$ ~~$\frac{8}{5} + 4 =$~~

~~$KE = \frac{1}{2}mv^2$ $\frac{1}{2} \cdot 2kg \cdot 6^2 = 36$~~

g. $P(t) = 2(1.8t - 0.2)(0.9t^2 - 0.2t + 0.2)$ $\frac{16}{6} + \frac{24}{6} + \frac{24}{6} = \frac{64}{6}$ ~~10.67J~~

$= 3.24t^3 - 1.08t^2 + 0.8t - 0.08$ $10.67J$