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

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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. $1 - 4 + 2 + 3 + 6 = 8$

b. $4t^3 - 12t^2 + 4t + 3$

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

c. $12t^2 - 24t + 4 = 40\ m/s^2$

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

d. $24t - 24 = 0$

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 : $x(t) = .3t^3 - .1t^2 + .2t$.

$3.(0.3)^2$

$3.6 - 0.4 + 0.2$

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. ($\vec{a} = \frac{\vec{F}}{m}$)
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) ~~2.4 - 0.4 + 0.4~~

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

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

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

$F = (1.8t - 0.2)m$

d) $KE = \frac{1}{2} \cdot 2kg \cdot (0.2 m/s)^2$

$= 0.04 J$

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

$= 11.56\ kgg$

$\Delta KE = 11.52 J$

f) ~~KE at x = 0 = 0.04 J~~

$2 = 0.9t^2 - 0.2t \times 2$

f) $f'(x) = 2x + 2$

$V(2) = (2)(2) + 2 = 6$

$KE(2) = \frac{1}{2}mv^2$

$= (\frac{1}{2})(2kg)(6^2) = 36$

$KE(0) = (\frac{1}{2})(2kg)(2^2) = 4$

$\Delta KE = 36 - 4 = 32 J$

g) $\frac{d}{dt}\left[\frac{1}{2}mv^2\right] = 2 \cdot \frac{1}{2} mv \cdot \frac{dv}{dt}$

mva