**Colorado Technical University**

**Course:** MATH205 – Differential Calculus

#### Unit 4 Part 8 Readings – Higher Order Derivatives

**Higher order derivatives**

The first derivative of a function is denoted: y'

You can take a derivative of y’ denoted: y''

The derivative of y'' is y''' and so on

You can take as many derivatives of a function as the highest power of x in the y equation

 Plus one more where the derivative is zero

**Derivatives as Rates of Change**

For location “s” at a given time, the function is called the position function

For movement over time t, the function becomes a displacement function: ∆s = f(a + ∆t) – f(a)

The average velocity between t1 and t2 will be: (f(t2) – f(t1))/(t2 – t1)

The first derivative of the position function is the speed function

The second derivative is the acceleration function

The third derivative is called the “jerk”

For growth models, the first derivative is the instantaneous rate of growth

**These are all different ways to say the same thing:**

instantaneous velocity exact rate of change

y'

derivative slope of a tangent line

$$\frac{dy}{dx}$$

$$\frac{∆y}{∆x}$$

 lim

Δ *x* → 0

$$\frac{dy}{dx}$$

 lim

*dx* → 0

**Derivatives in kinematic physics**

In most real-life situations, forces and accelerations are not fixed quantities but vary with time. Algebraic formulas can only approximate the situation, but calculus can give exact solutions.

If a function gives the position of something as a function of time, the first derivative gives its

velocity, and the second derivative gives its acceleration.

So, you differentiate position to get velocity, and you differentiate velocity to get acceleration.

****s = ƒ(t) the position function

ƒ'(t) ds/dt velocity

ƒ''(t) d2s/dt2 acceleration

ƒ'''(t) d3s/dt3 “jerk”

ƒ''''(t) d4s/dt4 “jounce” or “snap”

ƒ'''''(t) d5s/dt5 “crackle”

ƒ''''''(t) d6s/dt6 “pop”



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**Derivatives in Engineering**

If you have an energy function *w*

*w*'(t) = power

*w*''(t) = change in power

P = dW/dt Power is the time derivative of work

ω = dθ/dt Angular velocity

α = dω/dt Angular acceleration

τ = dL/dt Torque is the derivative of angular momentum

m d²x/dt² = -k x(t) A spring in simple harmonic motion

d²θ/dt² = -g/l θ(t) Equation of a pendulum, if θ is small such that sin(θ) ≈ θ