A LEVEL
H2 MATHEMATICS
DIFFERENTIATION TECHNIQUES

CHAPTER ANALYSIS

MASTERY

- Basic Differentiation Rules
- Derivatives of Trigonometric & Inverse Trigonometric Functions
- Higher Order Derivatives
- Implicit Differentiation
- Parametric Differentiation

EXAM

- Need to know for many subsequent chapters, such as differentiation applications, maclaurin series, differential equations
- Usually tested within these other chapters

WEIGHTAGE

- Rarely appears on its own, you're expected to differentiate usually in contextual/application questions
- That being said, considered as high weightage

Standard Differentiation Rules

$f(x)$	$f'(x)$
x^n	nx^{n-1}
e^x	e^x
$\ln x$	$\frac{1}{x}$
$\sin x$	$\cos x$
$\cos x$	$-\sin x$
$\tan x$	$\sec^2 x$

$f(x)$	$f'(x)$
$[f(x)]^n$	$n[f(x)]^{n-1}f'(x)$
$e^{f(x)}$	$e^{f(x)}f'(x)$
$\ln f(x), f(x) > 0$	$\frac{1}{f(x)}f'(x)$
$\sin f(x)$	$[\cos f(x)]\, f'(x)$
$\cos f(x)$	$[-\sin f(x)]\, f'(x)$
$\tan f(x)$	$[\sec^2 f(x)]\, f'(x)$

$f(x)$	$f'(x)$
$\cot x$	$-\operatorname{cosec}^2 x$
$\sec x$	$\sec x \tan x$
$cosec\ x$	$-cosec\ x \cot x$

$f(x)$	$f'(x)$
$\cot f(x)$	$[-\operatorname{cosec}^2 f(x)]f'(x)$
$\sec f(x)$	$[\sec f(x) \tan f(x)]f'(x)$
$cosec\ f(x)$	$[-cosec\ f(x) \cot f(x)]f'(x)$

Basic Differentiation Rules

$$\frac{d}{dx}[\, a\, f(x) \pm b\, g(x)\,] = af'(x) \pm bg'(x)$$

$$\frac{d}{dx}[\, f(x)\, g(x)\,] = f(x)g'(x) + g(x)f'(x) \quad \text{Product Rule}$$

$$\frac{d}{dx}\left[\frac{f(x)}{g(x)}\right] = \frac{g(x)f'(x) - f(x)g'(x)}{(g(x))^2} \quad \text{Quotient Rule}$$

$$\frac{dy}{dx} = \frac{dy}{dt} \times \frac{dt}{dx} \quad \text{Chain Rule}$$

$$\frac{dx}{dy} = \frac{1}{\frac{dy}{dx}}$$

Inverse Trigonometric Functions

$f(x)$	$f'(x)$
$\sin^{-1} x$	$\frac{1}{\sqrt{1-x^2}}, \lvert x\rvert < 1$
$\cos^{-1} x$	$-\frac{1}{\sqrt{1-x^2}}, \lvert x\rvert < 1$
$\tan^{-1} x$	$\frac{1}{1+x^2}, x \in \mathbb{R}$

$f(x)$	$f'(x)$
$\sin^{-1} f(x)$	$\frac{f'(x)}{\sqrt{1-[f(x)]^2}}, \lvert f(x)\rvert < 1$
$\cos^{-1} f(x)$	$-\frac{f'(x)}{\sqrt{1-[f(x)]^2}}, \lvert f(x)\rvert < 1$
$\tan^{-1} f(x)$	$\frac{f'(x)}{1+[f(x)]^2}, f(x) \in \mathbb{R}$

Grey boxes represent differentiation rules you would have already learnt about at O Levels, while the **orange boxes** represent basic differentiation rules that are only introduced at A Levels

Higher Order, Implicit & Parametric Differentiation

Higher Order Derivatives		
y	$f(x)$	y
First Derivative	$f'(x)$	$\frac{dy}{dx}$
Second Derivative	$f''(x)$	$\frac{d^2y}{dx^2}$
Third Derivative	$f'''(x)$	$\frac{d^3y}{dx^3}$
Nth Derivative	$f^n(x)$	$\frac{d^ny}{dx^n}$

Parametric Differentiation

Sometimes we express x and y in terms of another parameter i.e. t

$$x = f(t), y = g(t)$$

We solve this using Chain Rule

$$\frac{dy}{dx} = \frac{dy}{dt} \times \frac{dt}{dx}$$

Implicit Differentiation

Basically differentiation without separating x and y. We differentiate every term with respect to (w.r.t.) x.

$x^2 + xy - y^2 = 3 \implies$ differentiating w.r.t. x,

Use Product Rule

$$2x + \left(x\frac{dy}{dx} + y\right) - 2y\frac{dy}{dx} = 0$$

$$\frac{dy}{dx} = \frac{-y - 2x}{x - 2y}$$

Notice the trend. We differentiate x w.r.t. x normally
But when we differentiate w.r.t. x, we need to add in a $\frac{dy}{dx}$

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