



The **topics** and **types of questions** examined in this Achievement Standard. Use this sheet to plan and organise your study so that you cover everything that is required.

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3.1 DIFFERENTIATION AS 90635

Differentiate functions and use derivatives to solve problems

3.1 1. Differentiate functions A

- functions include: power, exponential (base e), logarithmic (base e), trigonometric (including reciprocal functions)
- use of chain rule, product rule and quotient rule

► Differentiate the following functions.

- (a) $y = (2x - 7)^{\frac{1}{4}}$ (b) $y = 3e^{4x} + \ln(5x + 6)$
- (c) $y = \sqrt{x} + 5e^{7x}$ (d) $y = \frac{\sin x}{x + 3}$
- (e) $g(x) = \frac{\sin(\pi x)}{x^{\frac{1}{3}}}$ (f) $y = \cos(9x + 1)$

3.1 2. Applications of differentiation A M

- finding equations of tangents and normals
- locating maxima and minima of polynomial functions
- rates of change, which may involve kinematics
- optimisation of a given function

► A curve has the equation $y = (x^2 - 3x)^3$. Write the equation of the tangent to the curve at the point (2, -8).

► Find the coordinates of the turning points of the curve $f(x) = 8x^2 - x^4$ and determine their nature.

► A teenager breeds mice for pet shops.

The number of mice for the first nine months of his production can be modelled by: $N(t) = 10e^{0.5t} + 12 \ln(2t + 7)$, $0 \leq t \leq 9$

where N is the total number of mice and t is the time in months.

At what rate is the number of mice increasing at 7 months?

Show any derivatives that you need to find when solving this problem.

3.1 3. Differentiate more complex functions M

- differentiation from first principles
- differentiation of more complex products and quotients
- parametric differentiation and implicit differentiation

► Use the definition of the derivative

$$f'(x) = \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h}$$

to show that the derivative of $f(x) = 3x^2 + x + 5$ is $f'(x) = 6x + 1$

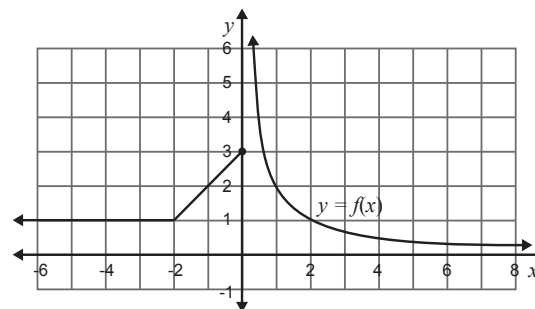
► Find $\frac{dy}{dx}$ when $y = \frac{2x^2 + 1}{e^{3x}}$. You do not need to simplify your answer.

► A curve has parametric equations $x = 5t^2$, $y = 10t$

Find the gradient of the tangent to this curve at the point where $t = 3$.

3.1 4. Features of graphs M

- sketching the derived function from a given function
- identifying features: limits, differentiability, discontinuity, gradients, concavity, turning points, points of inflection
- sketching graphs



From the graph of $y = f(x)$ state:

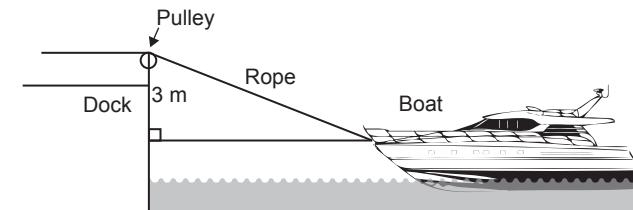
- (a) $\lim_{x \rightarrow -2} f(x)$ (b) $\lim_{x \rightarrow \infty} f(x)$
- (c) the value(s) of x when $y = f(x)$ is not differentiable.

3.1 5. Related rates of change M

- involving two directly related rates

► A boat is pulled into dock by means of a rope running through a pulley on the dock. The rope is attached to the bow of the boat at a point 3 metres below the level of the pulley.

The rope is being pulled through the pulley at a rate of 8 metres per minute.



At what rate will the boat be approaching the dock when there is 12 metres of rope between the boat and the pulley?

Show any derivatives that you need to find when solving this problem.

3.1 6. Solve more complex differentiation problems E

- establishing a model or completing a proof
- testing the nature of turning points and verifying points of inflection
- related rates of change involving more than two related rates
- higher derivatives including parametric and implicit differentiation

► In the morning, the angle of elevation of the sun is increasing at a rate of $\frac{\pi}{540}$ radians per minute. The height of a building is 150 metres.

Find the rate of change of the length of the building's shadow when the angle of elevation of the sun is $\frac{\pi}{6}$.

► Find the values of t when the function defined by $x = 4t^3 + 1$ and $y = 3t^2 - 7t$ is concave up.

Give any derivatives you need to find when solving this problem.