

EXTENSION 1

Stage 6

Calculus (EXT1), C1 Rates of Change (Y11)

Related Rates of Change (EXT)

Rates of Change with respect to time (EXT)

Teacher: Christy Cheung

Exam Equivalent Time: 175.5-minutes (based on allocation of 1.5 minutes per mark)



C1 Rates of Change



Growth and Decay
Related Rates of Change

"SmartMaths analysis based on the average contribution to Extension 1 exams since 2000"

HISTORICAL CONTRIBUTION

- C1 Rates of Change has contributed 4.6% per new syllabus Ext1 exam since it was introduced in 2000.
- This topic has been split into three sub-categories for analysis purposes which are: 1-Growth and Decay (3.4%), 2-Motion and Time (9%), and 3-Related Rates of Change (1.2%).
- This analysis looks at Related Rates of Change.

HSC ANALYSIS - What to expect and common pitfalls

- Related Rates of Change (1.4%) has been examined in 2 out of 4 new syllabus exams, below in the longer answer section.
- Allocated marks in new syllabus exams are below this topic's historical average. Notwithstanding this, effective revision should include high mark "old syllabus" examples which are well represented in the database.
- 2023 Ext1 12a combined this topic with differential equations in an extremely challenging "must-revise" question.
- The toughest examination of this topic was between 2011-2013 where sub-50% mean marks resulted each year. Any revision should include these examples.
- The most popular underlying subject matter of recent past questions is earth rotating areas/volumes (2 times) and Pythagoras (twice) (4 times).
- Markov's comments have flagged that students can often achieve half-marks by simply stating a correct chain rule and that students who draw diagrams in their solution are more successful. Good advice. Follow it.
- Pitfalls: The use of non-right angled trig in this context was examined in 2012 and poorly answered. Not tested again since and worthy of a revision focus.
- If a constant rate of change is established, students have struggled with follow up questions in 2013 Ext1 12a and 2020 Ext1 15a. A red-flagged knowledge gap worthy of attention.

4. Calculus, EXT1* C1 2013 HSC 10 MC

A particle is moving along the x -axis. The displacement of the particle at time t seconds is s metres.

At a certain time, $s = -3 \text{ m s}^{-1}$ and $\frac{ds}{dt} = 2 \text{ m s}^{-2}$.

Which statement describes the motion of the particle at that time?

- The particle is moving to the right with increasing speed.
- The particle is moving to the left with increasing speed.
- The particle is moving to the right with decreasing speed.
- The particle is moving to the left with decreasing speed.

5. Calculus, EXT1 C1 EQ-Bank 12

A tank is initially full. It is drained so that at time t seconds the volume of water, V , in litres, is given by

$$V = 50 \left(1 - \frac{t}{100} \right)^2 \quad \text{for } 0 \leq t \leq 100$$

- How much water was initially in the tank? (1 mark)
- After how many seconds was the tank completely full? (1 mark)
- At what rate was the water draining out the tank when it was one-quarter full? (2 marks)

6. Calculus, EXT1 C1 2019 HSC 12a

Distance A is inversely proportional to distance B such that $A = \frac{10}{B}$ where A and B are measured in metres. The two distances vary with respect to time. Distance B is increasing at a rate of 0.2 m s^{-1} .

What is the value of $\frac{dA}{dt}$ when $A = 12$? (2 marks)

7. Calculus, EXT1 C1 EQ-Bank 1

A particle is moving along the x -axis with a velocity u in metres per second at t seconds, is given by the function

$$u = \sqrt{5t + 4t^2} - t^2$$

Find the acceleration of the particle when $t = 3$. (2 marks)

Questions

1. Calculus, EXT1 C1 2017 HSC 8 MC

A stone drops into a pond, creating a circular ripple. The radius of the ripple increases from 0 cm, at a constant rate of 5 cm s^{-1} .

At what rate is the area enclosed within the ripple increasing when the radius is 15 cm?

- $25\pi \text{ cm}^2 \text{ s}^{-1}$
- $30\pi \text{ cm}^2 \text{ s}^{-1}$
- $150\pi \text{ cm}^2 \text{ s}^{-1}$
- $225\pi \text{ cm}^2 \text{ s}^{-1}$

2. Calculus, EXT1 C1 2020 HSC 10 MC

The quantities P , Q and R are connected by the related rates

$$\frac{dR}{dt} = -P^2$$

$$\frac{dP}{dt} = -P + \frac{dR}{dt}$$

$$\frac{dP}{dt} = m^2 = \frac{dQ}{dt}$$

where m , l and n are non-zero constants.

Which of the following statements is true?

- P is increasing and Q is increasing
- P is increasing and Q is decreasing
- P is decreasing and Q is increasing
- P is decreasing and Q is decreasing

3. Calculus, EXT1* C1 2019 HSC 10 MC

A particle is moving along a straight line with displacement s at time t .

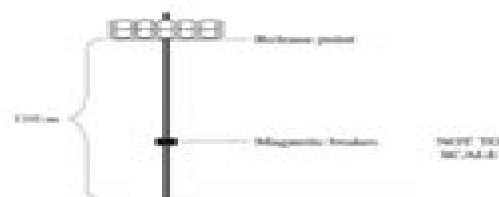
The particle is stationary when $t = 11$ and when $t = 15$.

Which of the following MUST be true in this case?

- The particle changes direction at some time between $t = 11$ and $t = 15$.
- The displacement function of the particle has a stationary point at some time between $t = 11$ and $t = 15$.
- The acceleration of the particle is 0 at some time between $t = 11$ and $t = 15$.
- The acceleration function of the particle has a stationary point at some time between $t = 11$ and $t = 15$.

8. Calculus, EXT1* C1 2015 HSC 14a

In a theme park ride, a chair is released from a height of 110 metres and falls vertically. Magnetic brakes are applied when the velocity of the chair reaches -20 metres per second.



The height of the chair at time t seconds is h metres. The acceleration of the chair is given by $\frac{dh}{dt} = -20$ at the release point, $t = 0$, $h = 110$ and $\frac{dh}{dt} = 0$.

i. Using calculus, show that $h = -5t^2 + 110$. (2 marks)

ii. How far has the chair fallen when the magnetic brakes are applied? (2 marks)

9. Calculus, EXT1 C1 2004 HSC 3c

A ferry wheel consists of a floating pontoon linked to a jetty by a 4 metre long walkway. Let A metres be the difference in height between the top of the pontoon and the top of the jetty and let x metres be the horizontal distance between the pontoon and the jetty.



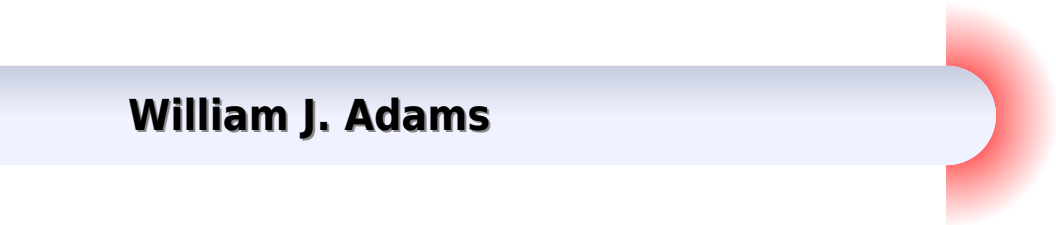
i. Find an expression for x in terms of A . (2 marks)

When the top of the pontoon is 1 metre lower than the top of the jetty, the tide is rising at a rate of 0.3 metres per hour.

ii. At what rate is the pontoon moving away from the jetty? (2 marks)

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